REPORT

September 16, 2016

FOUNDATION INVESTIGATION AND DESIGN REPORT

HIGHWAY 17 - VEUVE RIVER BRIDGE, SITE NO. 46-067
DISTRICT OF SUDBURY
TOWNSHIP OF HAGAR
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P. 5374-11-00

Submitted to:
Ministry of Transportation
447 McKeown Ave.
North Bay, Ontario
P1B 9S9

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3 Copies: Ministry of Transportation, Ontario, North Bay, ON (Northeastern Region)
1 Copy: Ministry of Transportation, Ontario, Foundations Section, Downsview, ON
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FOUNDATION INVESTIGATION REPORT
VEUVE RIVER BRIDGE - SITE NO. 46-067
HIGHWAY 17, DISTRICT OF SUDBURY
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for temporary protection systems in support of the rehabilitation of the Veuve River Bridge (Site No. 46-067). The Veuve River Bridge is located on Highway 17 in the Township of Hagar, approximately 1.4 km west of Markstay Road. The key plan showing the general location of this section of Highway 17 and the location of the investigated area are shown on Drawing 1.

The Terms of Reference and the Scope of Work for the foundation investigation and design input for the temporary protection systems at the Veuve River Bridge are outlined in MTO's Assignment #2 (Agreement Number 5015-E-0014) dated May 16, 2016. The Scope of Work for the temporary protection systems was subsequently clarified by MTO by email dated May 26, 2016 and detailed in Golder's Revised Work Order Response letter dated May 31, 2016.

2.0 SITE DESCRIPTION

The orientation (i.e., north, south, east, west) stated in the text of the report is typically referenced to project north and therefore may differ from magnetic north shown on the drawing. For the purpose of this report, Highway 17 is oriented in a west-east direction with Veuve River flowing perpendicular to the highway in a south-north direction at the bridge crossing.

In general, the topography in this area is undulating with moderate to dense tree cover in the vicinity of the structure. The existing Veuve River Bridge is an approximately 32.5 m long by 13.6 m wide, three-span structure supported on piles (deep foundations). Based on the General Arrangement (GA) drawing (dated June 6, 2014) provided by MTO, the bridge deck is at Elevation 212.2 m and 211.5 m at the west and east abutments, respectively. The west and east approach embankments are about 5.2 m and 4.0 m high and the embankment side slopes are inclined at about 2 horizontal to 1 vertical (2H:1V).

3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out on June 16, 2016, during which time two boreholes (Boreholes V-1 and V-2) were advanced at the bridge approaches. The boreholes were advanced using a truck-mounted CME-55 drill rig, supplied and operated by Landcore Drilling Ltd of Chelmsford Ontario.

The boreholes were advanced from the highway platform through the existing bridge approach slabs using NW casing and wash boring techniques. An NQ core barrel was used to advance the Borehole V-1 through a large (about 1.35 m diameter) boulder. Soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). The groundwater levels in the open boreholes were observed during the drilling operations as described on the Record of Borehole sheets in Appendix A. The boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The field work was supervised on a full-time basis by a members of Golder's technical staff who: located the boreholes in the field; arranged for the clearance of underground services; supervised 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 labelled containers and transported to Golder's geotechnical laboratory in Sudbury for further examination and laboratory testing. Index and classification testing consisting of water content determinations, grain size distributions, an Atterberg limits test and an organic content were carried out on selected soil samples.

The as-drilled borehole locations and ground surface elevations were measured and surveyed by member of our technical staff, referenced to the highway centerline at the existing abutments and converted into northing/easting coordinates on the plan drawing. The ground surface elevation of the highway centerline was obtained from the general arrangement drawing [(46-67) Hwy 17 – Veuve River Bridge Rehabilitation.dwg] provided by MTO. The MTM NAD83 (Zone 12) northing and easting coordinates and geographical coordinates, ground surface elevations referenced to Geodetic datum and borehole depths at each borehole locations are presented on the Record of Borehole sheets in Appendix A and summarized below.

Borehole Number	MTM NAD83 Northing (Latitude)	MTM NAD83 Easting (Longitude)	Ground Surface Elevation	Borehole Depth
V-1	5150302.4 m (46.4915219°)	338901.4 m (-80.55577936)	212.2 m	7.3 m
V-2	5150272.8 m (46.49125449°)	338923.3 m (-80.55549626°)	211.5 m	6.7 m

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS) mapping by the Ministry of Natural Resources (MNR) [1], the subsoils in the vicinity of the Veuve River Bridge site generally consist of undulating/rolling bedrock knobs closely bordered to the east by glaciolacustrine deposits comprised primarily of silt.

Based on geological mapping by the Ministry of Northern Development and Mines (MNDM)[2] the site is underlain by migmatitic rocks and gneisses of undetermined protolith comprised of commonly layered biotite gneisses and migmatites; and locally includes quartzofeldspathic gneisses, orthogneisses and paragneisses.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole sheets contained in Appendix A. The results of geotechnical laboratory testing are contained in Appendix B. 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 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic profile on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

[1] Ministry of Natural Resources. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 41ISE.
[2] Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East-Central Sheet, Ontario Geological Survey – Map 2543.

Subsoil Conditions

In summary, the subsoil conditions encountered at the site consist of an asphalt, concrete and granular fill roadway structure underlain by deposits of organic silt, silt and silt and sand. A more detailed description of the subsurface soils and groundwater conditions encountered in the boreholes is provided below.

Deposit/Layer Description	Boreholes		Thickness (m)		Elevation (m)		N Values (blows) / Relative Density	Laboratory Testing
	West Abut.	East Abut.	West Abut.	East Abut.	West Abut.	East Abut.		
Asphalt	V-1	V-2	0.090	0.115	212.2	211.5	n/a	n/a
Concrete	V-1	V-2	0.260	0.150	212.1	211.4	n/a	n/a
(FILL) Sand, trace to some silt, some gravel; brown, moist	V-1	V-2	2.7	2.7	211.9	211.2	N = 7 to 34 **Loose to Dense**	w = 10% 1 – M (Fig. B1)
Silt *, some clay, trace to some sand; brown to grey, wet	V-1	V-2	> 4.3 (borehole terminated in this deposit)	3.4	209.2	208.5	N = 1 - 15 **Very Loose to Compact**	w = 22% 2 – MH (Fig. B2) 1 – AL (NP)
Organic Silt	n/a	V-2	n/a	0.6	n/a	206.6	N = 1 Very Soft	w = 40% 1 – MH (Fig. B2) 1 – AL (NP) Org = 5.3%
Silt and Sand, some clay, trace gravel; grey, wet	n/a	V-2	n/a	>0.3 m (borehole terminated in this deposit)	n/a	205.1	N = 2 **Very Loose**	w = 40% 1 – MH (Fig. B3)

Where:
N = SPT 'N'-value; number of blows for 0.3 m of penetration
w = Natural moisture content (%)
M = Sieve analysis
MH = Combined sieve analysis and hydrometer
AL = Atterberg limits test
NP = Non-plastic Atterberg limits test result
Org = Organic content (%)

***** A 1.4 m diameter boulder was encountered within the Silt deposit in Borehole V-1 at approximately 5.5 m depth as noted in the Record of Borehole sheet.

** A 0.6 m pocket of organic silt was encountered within the silt deposit in Borehole V-2 at approximately 4.9 m depth as noted in the Record of Borehole sheet.

Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The river water level was surveyed by Golder at Elevation 205.6 m on June 16, 2016. Groundwater and river water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

Borehole No.	Depth to Groundwater Level * (m)	Groundwater Elevation (m)
V-1	3.7 **	208.5
V-2	3.4	208.1

* The boreholes were advanced using NW casing and wash boring techniques and as such, the measured groundwater levels may not be representative of the in-situ groundwater conditions.

** Borehole V-1 was noted to be dry to the caved depth of 3.7 m below the existing ground surface after removing the casing from the borehole upon completion of drilling. The groundwater level is inferred to be at 3.7 m below ground surface.

5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. Adam Core, P.Eng., under the overall direction of Mr. David Muldowney, P.Eng. This Foundation Investigation Report was prepared by Mr. David Muldowney, P.Eng., and Mr. Jorge M. A. Costa, P.Eng., a Senior Consultant with and Designated MTO Foundations Contact for Golder, conducted an independent quality control review audit of this report.

Report Signature Page

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Geotechnical Engineer

Jorge M. A. Costa, P.Eng.
Designated MTO Foundations Contact, Senior Consultant

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PART B

FOUNDATION DESIGN REPORT
VEUVE RIVER BRIDGE - SITE NO. 46-067
HIGHWAY 17, DISTRICT OF SUDBURY
TOWNSHIP OF HAGAR
MINISTRY OF TRANSPORTATION, ONTARIO
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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides engineering design recommendations for temporary protection systems in support of the rehabilitation of the existing Veuve River Bridge (Site No. 46-067). The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during this subsurface investigation. The discussion and recommendations presented are intended to provide the designer with sufficient information to assess the feasible alternatives and carry out the design. The foundation investigation report, discussion and recommendations are intended for the use of the Ministry of Transportation and shall not be used or relied upon for any other purpose or by any other parties, including the construction or design-build contractor. The contractors must make their own interpretation based on the factual data in Part A of the report. Where comments are made on construction, they are provided to highlight those aspects that could affect the future detail design of the project and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.1 General

The following sections of this report provide foundation recommendations for the design of temporary roadway protection to facilitate staged construction for rehabilitation of the Veuve River Bridge located on Highway 17 in the Township of Hagar (approximately 1.4 km west of Markstay Road). Based on discussions with MTO, we understand that excavations up to 2 m deep will be required for the proposed bridge rehabilitation.

6.2 Excavation and Dewatering

The proposed works will require removal of the asphalt and concrete approach slab and partial excavation of the existing embankment fill material. Open cut excavation side slopes in the existing embankment fill (i.e., sand) should remain stable during construction if the temporary side slopes are cut back no steeper than 1H:1V above the groundwater level and 3H:1V below the groundwater level (if encountered).

Based on the subsurface conditions encountered during this investigation, groundwater is not expected to be encountered within the proposed excavation depths. Perched water, if encountered, should be drained and sources of surface water should be diverted away from the excavation area prior to beginning the excavation. Some sloughing of excavated slopes due to perched water or surface water runoff may occur and flatter side slopes may become necessary.

During construction, stockpiles should be placed at a distance away from the edge of the excavation not less than 1.5 times the depth of the excavation, and their heights should be controlled to prevent surcharging the sides of the excavation and/or overall slope.

All excavations should be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. The existing embankment fill is classified as Type 3 soils above the groundwater level and Type 4 soils below.

6.3 Temporary Roadway Protection

Based on discussions with MTO, we understand that a temporary roadway protection system will be required to facilitate staged construction at this site. The temporary support system could consist of either driven steel sheet piling or soldier piles and lagging where the H-piles would be driven to a suitable depth and horizontal lagging installed as the excavation proceeds. Support to the system could be in the form of struts and wales and rakers or anchors. Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems). Temporary excavation support systems should be designed to Performance Level 2 for any excavation adjacent to existing roadway.

The design of the temporary roadway protection system, may be designed using the following parameters:

Soil Type	Unit Weight	Internal Angle of Friction	Coefficient of Earth Pressure		
	(γ, kN/m^3)	(ϕ, degrees)	Active, K_a	At Rest, K_o	Passive, K_p
New Granular 'A'	22	35	0.27	0.43	3.69
New Granular 'B' Type II	21	35	0.27	0.43	3.69
New Granular 'B' Type I	21	32	0.31	0.47	3.25
Existing Sand (Fill) (loose to dense)	20	30	0.33	0.50	3.00
Organic Silt to Silt (very loose to compact)	18	28	0.33	0.53	2.77
Silt and Sand (very loose)	19	29	0.35	0.52	2.88

The earth pressure coefficients noted above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present, the coefficient of earth pressure should be adjusted accordingly. Design of the temporary support system should include an evaluation of base stability, soil squeezing stability and hydraulic uplift stability as defined in the Canadian Foundation Engineering Manual (CFEM 2006).

The subsurface soils (organic silt to silt and silt and sand) at this site are sensitive to disturbance from vibration and/or driving operations for pile installation, which should be considered in the design and installation of the temporary protection systems. Further, the installation of sheet-piles for temporary roadway protection could potentially be impeded by the presence boulders within the silt deposit, as encountered in Boreholes V-1. It is recommended that an NSSP be included in the contract documents to address obstructions; a sample NSSP is included in Appendix C.

Consideration could be given to either partial or full removal of the temporary protection system upon completion of construction or each stage of construction (as required). Where possible, full removal of the temporary shoring

system should be considered to mitigate potential impediments to future rehabilitation/reconstruction work at the bridge site. However, where the temporary shoring system penetrates into cohesive soils, there is a potential risk that full removal will result in a void within the soil column due to adhesion along the sheet pile (or H-pile) walls (CFEM 2006). Given the limited depth of the proposed excavation for the bridge rehabilitation at this site, it is anticipated that the temporary shoring will primarily be installed within the existing granular embankment fill and into the organic silt to silt deposit. There is little to no risk of pile adhesion within the granular embankment fill, however if the temporary shoring systems, as designed and installed by the Contractor, extends into the organic silt deposit, there is a potential risk of adhesion which should be re-evaluated after pile installation depending on the depth of penetration. For piles installed to a toe Elevation 206.2 m or lower, penetrating greater than 1 m into the organic silt deposit consideration will need to be given to only partial depth removal.

7.0 CLOSURE

This Foundation Design Report was prepared by Mr. David Muldowney, P.Eng. Mr. Jorge M. A. Costa, P.Eng., a Senior Consultant with and Designated MTO Foundations Contact for Golder, conducted an independent quality control review of this report.

Report Signature Page

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REFERENCES

Canadian Geotechnical Society. 2006. Canadian Foundation Engineering Manual, 4th Edition. The Canadian Geotechnical Society c/o BiTech Publisher Ltd, British Columbia.

Occupational Health and Safety Act and Regulation for Construction Projects (as amended).

Ministry of Natural Resources. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 41ISE.

Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2543.

ASTM International:

ASTM D1586	Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils

Ontario Provincial Standard Specifications (OPSS) – Provincial Oriented

OPSS.PROV 539	Construction Specification for Temporary Protection Systems

Ontario Water Resource Act:

Regulation 903	Wells (as amended)

MINISTRY OF TRANSPORTATION, ONTARIO

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

CONT No. .
GWP No. 5347-11-00

VEUVE RIVER BRIDGE
HIGHWAY 17
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET .

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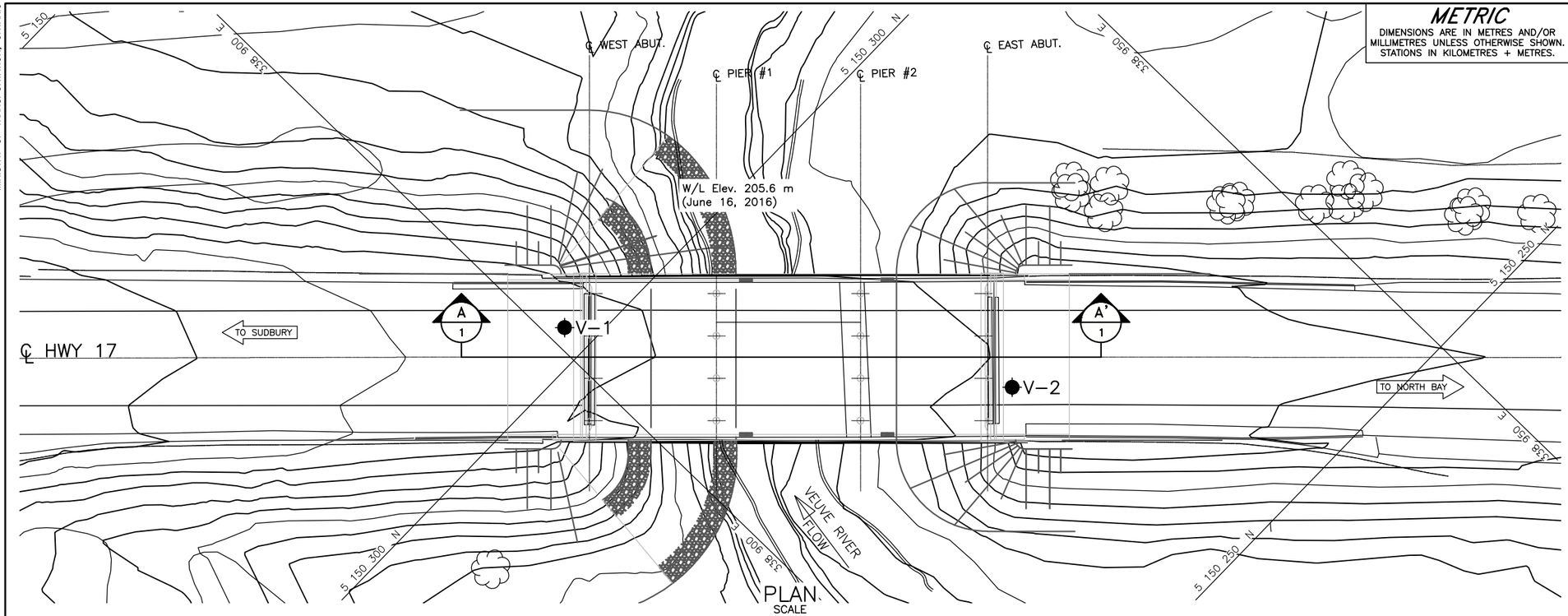
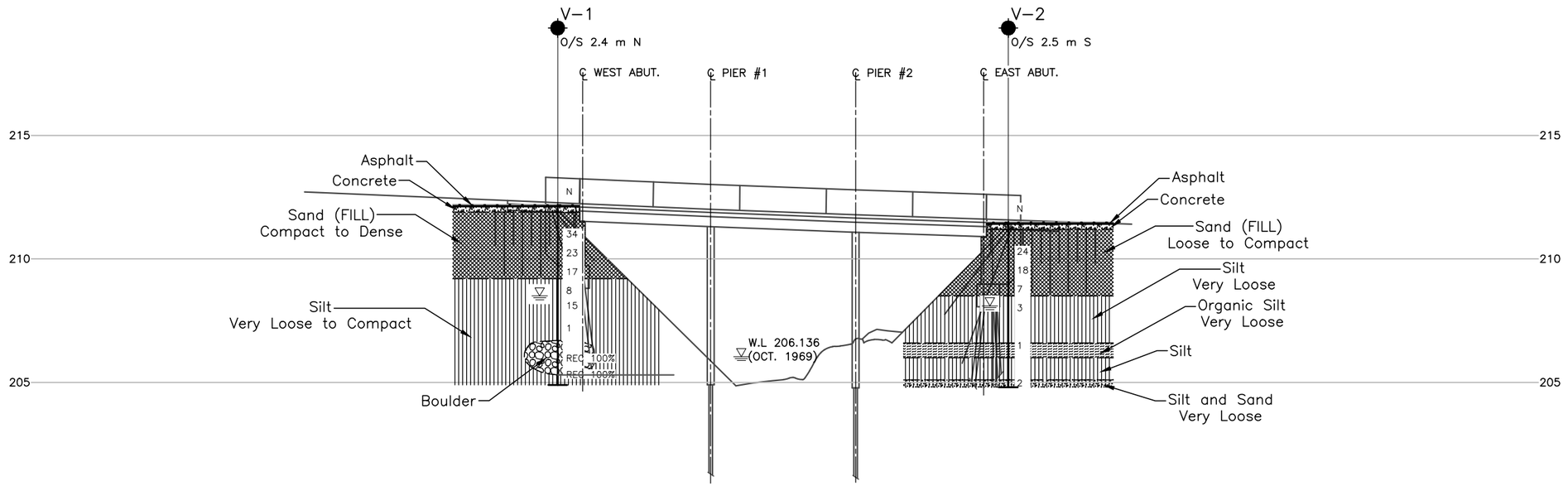
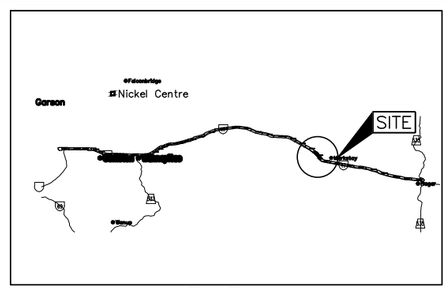




HORIZ. SCALE 1:400 m
VERT. SCALE 1:200 m
A-A' 1
PROFILE VIEW

HORIZONTAL SCALE
4 0 4 8 m
VERTICAL SCALE
2 0 2 4 m



KEY PLAN
N.T.S.

LEGEND

- Borehole – Current Investigation
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ▽ — WL upon completion of drilling
- REC — Recovery %

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
V-1	212.2	5150302.4	338901.4
V-2	211.5	5150272.8	338923.3

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 MTO, drawing file nos. ('~MASTER'~(46-068) HWY 17-CPR OVERHEAD REHABILITATION.dwg, received July 12, 2016. Drawing file nos. 141331.dwg and 141332.dwg, recieved July 27, 2016.

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NO.	DATE	BY	REVISION
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Geocres No. 41I-347

HWY. 17	PROJECT NO. 1648295		DIST. SUDBURY
SUBM'D. AC	CHKD. .	DATE: 09/07/2016	SITE: 46-067
DRAWN: JJL	CHKD. DAM	APPD. JMAC	DWG. 1

PLOT DATE: September 7, 2016
FILENAME: S:\Clients\MTO\1648295_mto_ratcliffe_assignment_2\09_PROJ\1648295_mto_ratcliffe_assignment_2\1648295_Veuve.dwg

Photograph 1: Veuve River Bridge
Looking East at West Abutment (August 2016)

Photograph 2: Veuve River Bridge
Looking West at East Abutment (August 2016)

Photograph 3: Veuve River Bridge
Looking Northwest at South Side of Bridge (August 2016)

APPENDIX A

Record of Boreholes

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

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

(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

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, 60º cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

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

Golder Associates

RECORD OF BOREHOLE No V-1

1 OF 1 **METRIC**

PROJECT 1648295

G.W.P. 5374-11-00 LOCATION N 5150302.4; E 338901.4 MTM ZONE 12 (LAT. 46.4915219; LONG. -80.55577936) ORIGINATED BY AC

DIST SUDBURY HWY 17 BOREHOLE TYPE NW Casing and Wash Boring with NQ Coring COMPILED BY TB

DATUM GEODETIC DATE June 16, 2016 CHECKED BY DAM

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
212.2	GROUND SURFACE										
0.0	ASHALT (90 mm)						212				
	CONCRETE (260 mm)										
0.3	Sand, trace to some silt, some gravel (FILL) Compact to dense Brown Moist		1	SS	34		211				
			2	SS	23				○		14 78 (8)
			3	SS	17		210				
209.2											
3.0	SILT, some clay, trace to some sand Very loose to compact Brown to grey Wet		4	SS	8	▽	209		○	NP	0 6 74 20
			5	SS	15						
			6	SS	1		208				
206.7											
5.5	Approximately 1.4 m diameter boulder encountered from 5.5 m to 6.9 m depth.		R1	RC	REC 100%		207				
205.3			R2	RC	REC 100%		206				
6.9											
204.9							205				
7.3	END OF BOREHOLE										

Notes:

1. Water level at ground surface upon completion of coring.

2. Borehole dry to caved depth of 3.7 m below ground surface (Elev. 208.5 m) after removing casing upon completion of drilling. Groundwater level inferred at Elevation 208.5 m.

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

SUD-MTO 001 MTM ZN 12 INC LAT/LONG 1648295_RET2.GPJ GAL-MISS.GDT 07/09/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No V-2

1 OF 1 **METRIC**

PROJECT 1648295

G.W.P. 5374-11-00 LOCATION N 5150272.8; E 338923.3 MTM ZONE 12 (LAT. 46.49125449; LONG. -80.55549626) ORIGINATED BY AC

DIST SUDBURY HWY 17 BOREHOLE TYPE NW Casing and Wash Boring COMPILED BY TB

DATUM GEODETIC DATE June 16, 2016 CHECKED BY DAM

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
211.5	GROUND SURFACE										
0.0	ASPHALT (115 mm)										
	CONCRETE (150 mm)										
0.3	Sand, trace to some silt, some gravel (FILL) Loose to compact Brown Moist		1	SS	24		211				
			2	SS	18		210				
			3	SS	7		209				
208.5											
3.0	SILT, some clay, trace to some sand, trace organics Very loose Grey Wet		4	SS	3	▽	208				
206.6			5A	SS	1		207				
4.9	ORGANIC SILT, some clay, trace to some sand Very loose Dark brown Wet		5B						○	NP	OC=5.3% 0 8 76 16
206.0							206				
5.5	SILT, some clay, trace to some sand Grey Wet										
205.1			6A	SS	2						
204.8	SILT and SAND, trace to some clay, trace gravel Very loose Grey Wet		6B				205		○		1 53 36 10
6.7	END OF BOREHOLE										

Note:

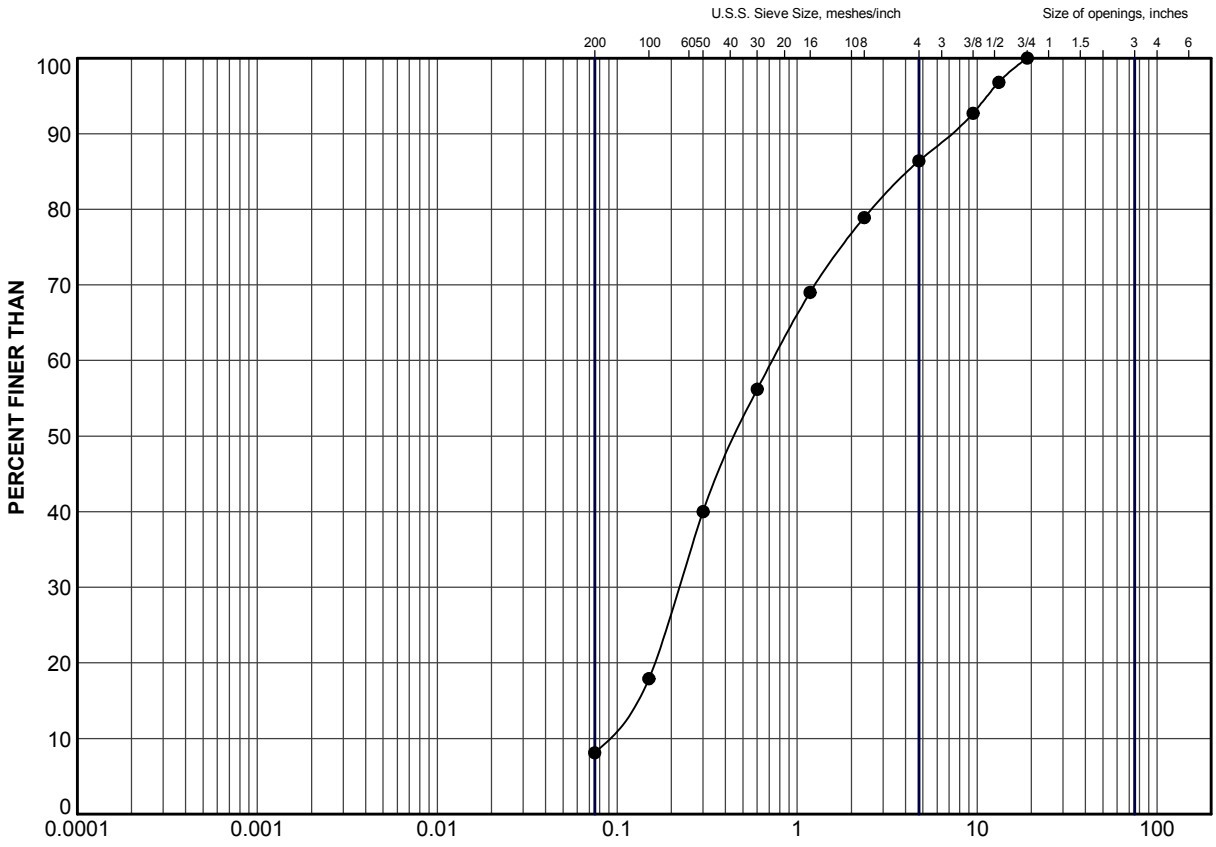
1. Water level at a depth of 3.4 m below ground surface (Elev. 208.1 m) upon completion of drilling.

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

SUD-MTO 001 MTM ZN 12 INC LAT/LONG 1648295_RET2.GPJ GAL-MISS.GDT 07/09/16 DATA INPUT:

APPENDIX B

Laboratory Test Results



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	V-1	2	210.4

PROJECT

HIGHWAY 17
VEUVE RIVER BRIDGE

TITLE

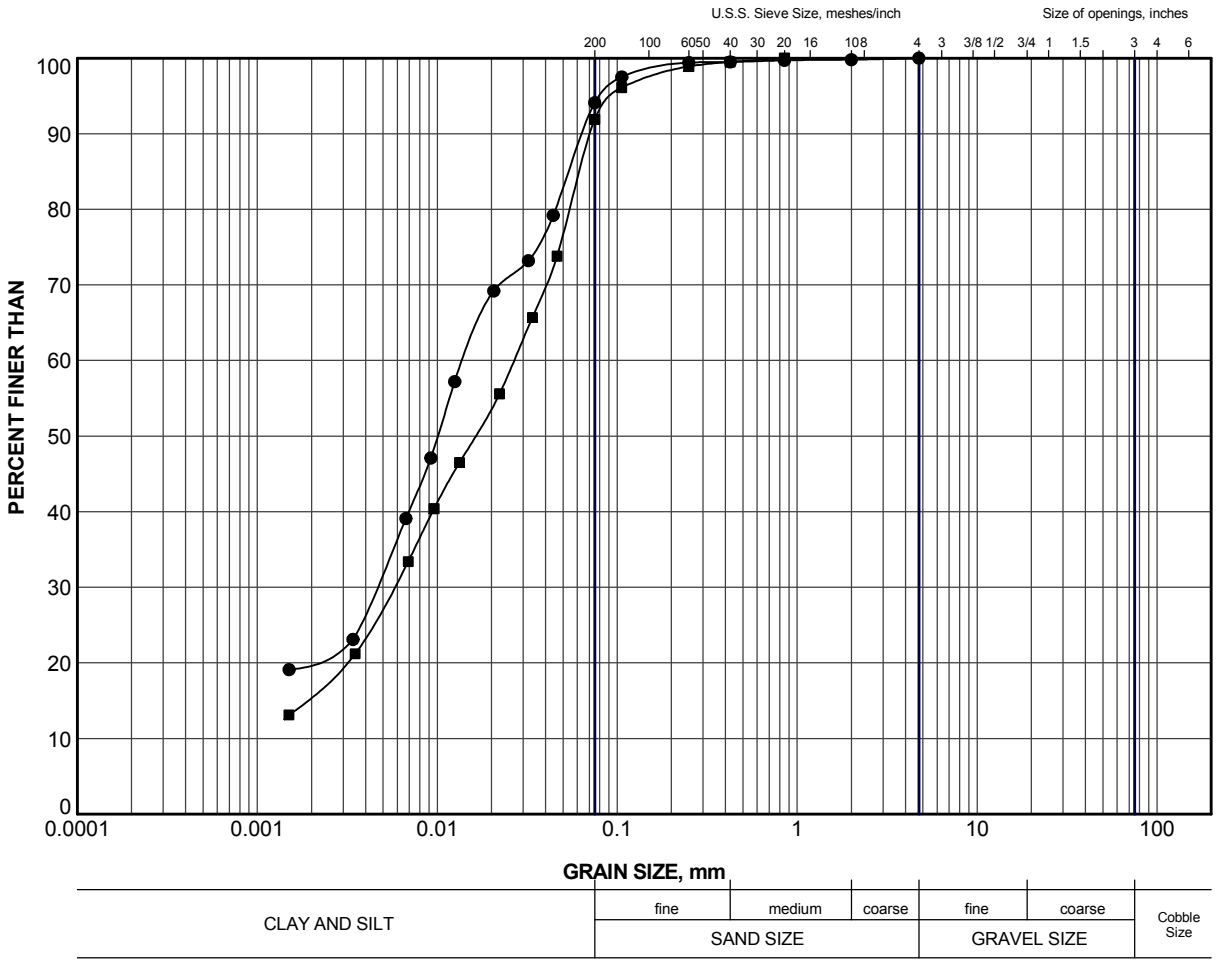
GRAIN SIZE DISTRIBUTION

SAND (FILL)

Golder Associates
SUDBURY, ONTARIO

PROJECT No.		1648295	FILE No.	1648295_RET2.GPJ
DRAWN	JJL	Aug 2016	SCALE N/A	REV.
CHECK	DAM	Aug 2016		
APPR	JMAC	Aug 2016	**FIGURE B1**	

SUD-MTO GSD (2016) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	V-1	4	208.8
■	V-2	5B	206.5

PROJECT

HIGHWAY 17
VEUVE RIVER BRIDGE

TITLE

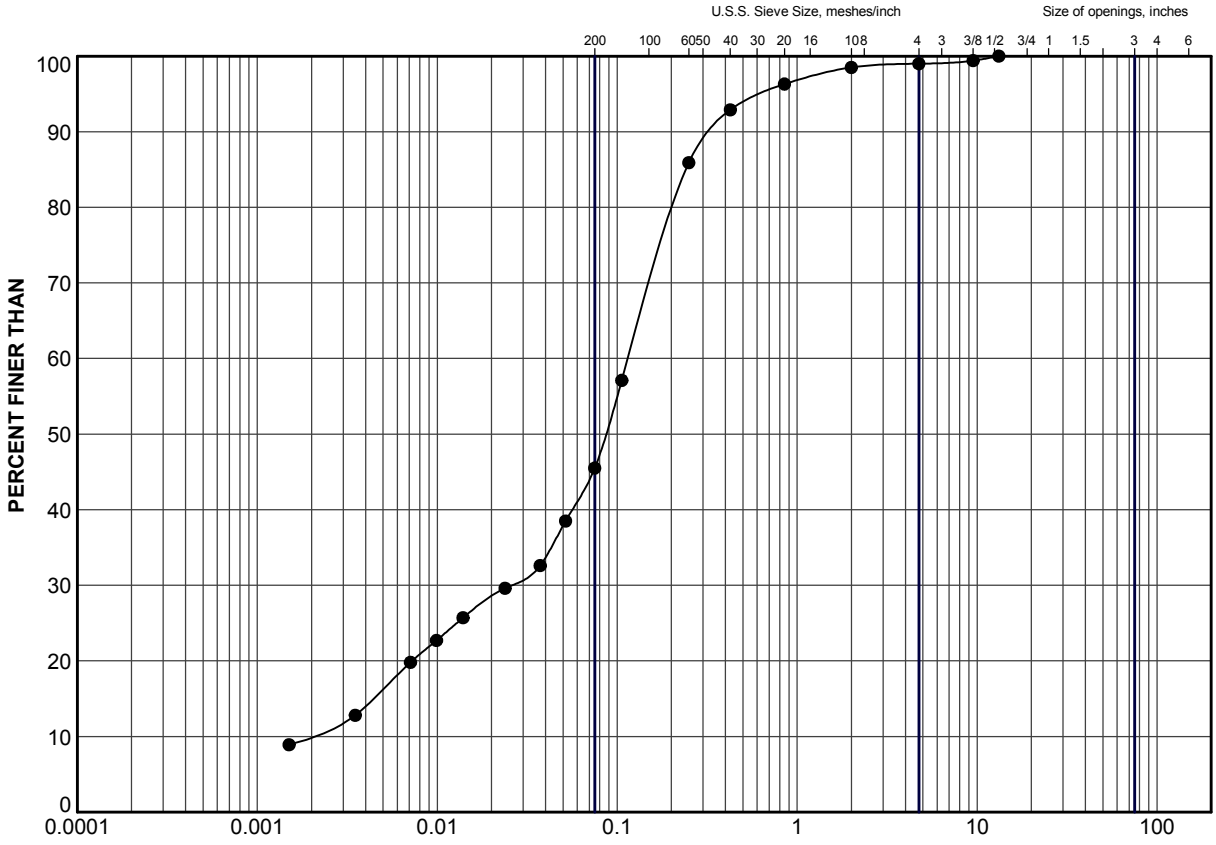
GRAIN SIZE DISTRIBUTION

SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.		1648295	FILE No.	1648295_RET2.GPJ
DRAWN	JJL	Aug 2016	SCALE N/A	REV.
CHECK	DAM	Aug 2016		
APPR	JMAC	Aug 2016	**FIGURE B2**	

SUD-MTO GSD (2016) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	V-2	6B	204.9

PROJECT

HIGHWAY 17
VEUVE RIVER BRIDGE

TITLE

GRAIN SIZE DISTRIBUTION

SILT and SAND

Golder Associates
SUDBURY, ONTARIO

PROJECT No.		1648295	FILE No.	1648295_RET2.GPJ
DRAWN	JJL	Aug 2016	SCALE N/A	REV.
CHECK	DAM	Aug 2016		
APPR	JMAC	Aug 2016	**FIGURE B3**	

SUD-MTO GSD (2016) GLDR_LDN.GDT

APPENDIX C

Non-Standard Special Provisions

OBSTRUCTIONS

Non-Standard Special Provision

As part of the work for the rehabilitation of the Veuve River Bridge, the Contactor shall be alerted to the presence of boulders within the silt deposit as encountered in Borehole V-1.

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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