REPORT

April 10, 2018

PRELIMINARY FOUNDATION INVESTIGATION REPORT

FLOODWOOD RIVER BRIDGE REPLACEMENT - SITE NO. 39E-203
LAT 49.490886; LONG. -80.312558
HIGHWAY 652, COCHRANE DISTRICT
TOWNSHIP OF TWEED
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5416-15-00, WP 5416-15-04

Submitted to:
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GEOCRES NO.: 42H-77

Report Number: **1651997-WO5-R04**

Distribution:

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Golder Associates

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PART A

PRELIMINARY FOUNDATION INVESTIGATION REPORT
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HIGHWAY 652, COCHRANE DISTRICT
TOWNSHIP OF TWEED
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5416-15-00; WP 5416-15-04

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Golder Associates

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation, Ontario (MTO), to provide preliminary foundation engineering services for the replacement of the Floodwood River Bridge (Site No. 39E-203). The existing Floodwood River bridge is located on Highway 652 north of Cochrane, Ontario in the Township of Tweed at about Sta. 10+330 (approximately 66 km north of Translimit Road). The key plan showing the general location of this section of Highway 652 and the location of the investigated area is shown on Drawing 1.

2.0 SITE DESCRIPTION AND BACKGROUND INFORMATION

It should be noted that the orientation (i.e., north, south, east, west) stated in the text of the report is referenced to project north and therefore may differ from magnetic north shown on Drawing 1. Highway 652 is considered to be oriented in a north-south direction at this site.

In general, the topography surrounding the Floodwood River bridge site consists of undulating to rolling terrain with densely forested areas immediately beyond the Highway 652 Right-of-Way. The existing Floodwood River bridge consist of an approximately 42.6 m long by 5.4 m wide, three-span, single lane Temporary Modular Bridge (TMB). Based on information presented in the previous 1981 bridge General Arrangement (GA) drawings (Contract 81-456, WP 7-81-12 and GEOCRES 42H-019) we understand that the existing north and south abutments are founded on shallow foundations constructed on granular pads while the piers are founded on driven steel piles. Based on the survey drawing provided by AECOM, the existing bridge deck is at Elevation 284.8 m at the south abutment and Elevation 284.7 m at the north abutment.

The front slopes of the existing approach embankments are approximately 5 m to 6 m high relative to the river bottom and are inclined at profiles ranging from 1.3 horizontal to one vertical (1.3H:1V) to 2H:1V. The side slopes of the existing embankments are about 2.5 m and 3.5 m high, based on the approximate ground surface elevations of the toe of slope boreholes at the north and south approaches, respectively, and are inclinded at profiles of about 2.5H:1V. The ground surface conditions in the vicinity of the bridge are shown on Photographs 1 to 4. Based on the 2015 Ontario Structure Inspection Manual (OSIM) report, our July 2017 site review, and the available site photographs, the existing embankments appear to be performing satisfactorily.

3.0 INVESTIGATION PROCEDURE

The field work for the subsurface investigation was carried out from July 23 to 26 and on July 30, 2017, during which time a total of four boreholes (FR-1 to FR-4) were advanced at the locations shown on Drawing 1. Boreholes FR-1 and FR-3 were advanced through the existing embankments immediately behind the existing abutments. Boreholes FR-2 and FR-4 were advanced at the east toes of the north and south approach embankments, respectively.

The boreholes were advanced using a track-mounted CME 55LC drill rig supplied and operated by George Downing Estate Drilling Ltd. of Grenville-sur-la-Rouge, Quebec. Boreholes FR-1 and FR-3 were advanced using 108 mm inside diameter hollow-stem augers and Boreholes FR-2 and FR-4 employed the use of NW casing and wash boring techniques. Soil samples were obtained at depth intervals of 0.75 m and 1.5 m, using 50 mm outer

diameter split-spoon samplers driven by an automatic hammer, carried out in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). The groundwater level in the open boreholes was observed during the drilling operations as described on the Record of Borehole sheets in Appendix A. The boreholes advanced at the existing bridge abutments were backfilled with a full column of bentonite grout. The boreholes advanced at the toe of the embankment slopes were backfilled with bentonite pellets and soil cuttings upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The fieldwork was supervised by a member of our technical staff, who observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and took custody of the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury Geotechnical Laboratory where the samples underwent further visual examination and laboratory testing. Index and classification testing consisting of water content, grain size distribution and Atterberg limits was carried out on selected samples. The geotechnical laboratory testing was performed in accordance with MTO LS standards.

Select soil samples were obtained on July 29 and 30, 2017, from Boreholes FR-1 and FR-3 respectively, using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters including pH, resistivity, conductivity, sulphates and chlorides. The results of the analytical testing are presented in Table B1 in Appendix B.

The as-drilled borehole locations and ground surface elevations at the boreholes were measured and surveyed by a member of our technical staff, referenced to the highway centerline and existing bridge structure and converted to northings/easting coordinates on the plan drawing. The ground surface elevations were referenced to local benchmarks in the vicinity of the bridge and the benchmark elevations were obtained from the survey drawing [Feature_B652TWE2 (Floodwood River).dwg] provided by AECOM on September 26, 2017. 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 location are presented on the Record of Borehole Sheets in Appendix A and summarized below.

Borehole	Location (MTM NAD 83, Zone12)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (Latitude)	Easting (Longitude)		
FR-1	5483918.4 (49.4910509)	354607.3 (-80.3124551)	284.7	6.7
FR-2	5483911.3 (49.4909861)	354618.5 (-80.3123014)	282.0	37.2
FR-3	5483875.4 (49.4906658)	354588.5 (-80.31272)	285.0	6.7
FR-4	5483872.0 (49.4906341)	354601.8 (-80.3125369)	281.2	21.8

4.0 SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS)[1] mapping, the Floodwood River Bridge site is located within an esker complex, crevasse filling plain deposit consisting primarily of clay till bordered by a clay till ground moraine deposit immediately east of the site.

Based on geological mapping by the Ontario Ministry of Northern Development and Mines (MNDM)[2], the site is underlain by massive to foliated granodiorite to granite bedrock bordered by mafic to intermediate metavolcanic rocks comprising of basaltic and andesitic flows, tuffs and breccias, chert, iron formation, minor metasedimentary and intrusive rocks, related migamites.

4.2 Subsoil Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the laboratory testing carried out on selected soil samples, are presented on the borehole records in Appendix A and the laboratory test sheets in Appendix B. The results of the in situ tests (i.e., SPT 'N'-values) as presented on the borehole records and described in Section 4 are uncorrected. The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic profile on Drawing 1 and in the section on Drawing 2 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.

At the time of the previous 1981 foundation investigation (GEOCRES 42H-19), prior to construction of the existing embankments and bridge, the subsurface soil conditions encountered at this site are described as generally consisting of a 1.7 m to 6.9 m thick deposit of slightly plastic, soft to firm silty clay to silt underlain by deposits of compact to very dense silty sand and/or compact to very dense granular till. The subsoil conditions encountered during the current borehole investigation consist of granular embankment fill overlying deposits of compact silt and/or loose to very dense sandy gravel to gravelly silty sand to sand. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes as part of the current investigation is provided below.

Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows/0.3 m) Consistency or Relative Density	Laboratory Testing
Asphalt	FR-1, FR-3	0.1	285.0 - 284.7	n/a	n/a
Topsoil	FR-2 and FR-4	0.1 – 0.6	282.0 - 281.2	2 **Very loose**	n/a
		0.5 – 5.5	284.9 - 281.9	N = 1 – 19	w = 2% – 21%

[1] Ontario Ministry of Natural Resources and Forestry. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 42HNE

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

Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows/0.3 m) Consistency or Relative Density	Laboratory Testing
(FILL) Gravelly Sand to Sand trace to some gravel, trace to some silt; brown; moist to wet	FR-1 to FR-3			**Very loose to compact**	4 – M (Fig. B1)
PEAT (Amorphous); trace sand; black; wet	FR-2	0.9	281.4	N = 5 **Loose**	w = 52 %
Silt, trace sand, trace to some clay, silty clay laminations; grey; wet	FR-1 and FR-2	>0.9 – 7.0	279.1 - 280.5	N = 11 – 20 **Compact**	w = 21% - 24% 3 - MH (Fig. B2) 2 – AL (NP)
Sandy Gravel to Gravelly Silty Sand to Sand[1,2], trace to some silt, trace clay; grey; wet	FR-2 to FR-4	>1.1 – >28.7 (not fully penetrated)	280.6 - 273.5	N = 7 – 197 **Loose to Very Dense**	w = 8% – 15% 1 - M (Fig. B3) 10 MH (Fig. B3)

Where:
N = SPT 'N'-value; number of blows for 0.3 m of penetration (uncorrected)
w = Natural Moisture Content (%)
M = Sieve analysis for particle size
MH = Combined Sieve and Hydrometer analysis
AL = Atterberg Limits Test
NP = Non-Plastic test result

Notes:
1. Silt and Sand and Sandy Silt layers were noted within the Sandy Gravel to Gravelly Silty Sand to Sand deposit as noted on the Records of Boreholes.
2. A 500 mm diameter boulder was encountered in Borehole FR-2 at 22.3 m depth (Elevation 259.7 m).

4.3 Groundwater Conditions

The unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The river water level was measured by others at approximately 5.2 m below the existing structure grade, corresponding to Elevation 279.6 m in August 2017. Groundwater and river water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

Borehole	Depth to Unstabilized Groundwater Level (m)	Approximate Groundwater Elevation (m)
FR-1	dry	n/a
FR-2	0.5	281.5
FR-3	dry	n/a
FR-4	0.2	281.0

Boreholes FR-2 and FR-4 were advanced using NW casing and wash boring techniques. As such, the water levels may not be representative of stabilized groundwater conditions.

5.0 CLOSURE

The field drilling program was supervised by Mr. Mathew Riopelle. This Foundation Investigation Report was prepared by Ms. Aronne-Kay De Souza, EIT, and the technical aspects were reviewed by Mr. André Bom, P.Eng., a geotechnical engineer and Associate of Golder. Mr. Paul Dittrich, P.Eng., an MTO Foundations Designated Contact and Principal of Golder, conducted an independent quality control review and technical audit of this report.

Report Signature Page

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Principal, MTO Foundations Designated Contact

AD/AB/JPD/kp/ca

https://golderassociates.sharepoint.com/sites/19476g/wo5 5 bridges hwy 652/11. reporting/004 - floodwood river/final/1651997-r03-r-rev0 aecom mto floodwood river fir 10apr_18.docx

Photograph 1: Floodwood River Bridge
South approach, West side of bridge, looking North (July 2017)

Photograph 2: Floodwood River Bridge
South approach embankment, East side of bridge, looking South (July 2017)

Photograph 3: Floodwood River Bridge
Borehole FR-4, South approach, East side of bridge, looking North (July 2017)

Photograph 4: Floodwood River Bridge
West elevation looking South-East (OSIM Report June 2015)

MINISTRY OF TRANSPORTATION, ONTARIO

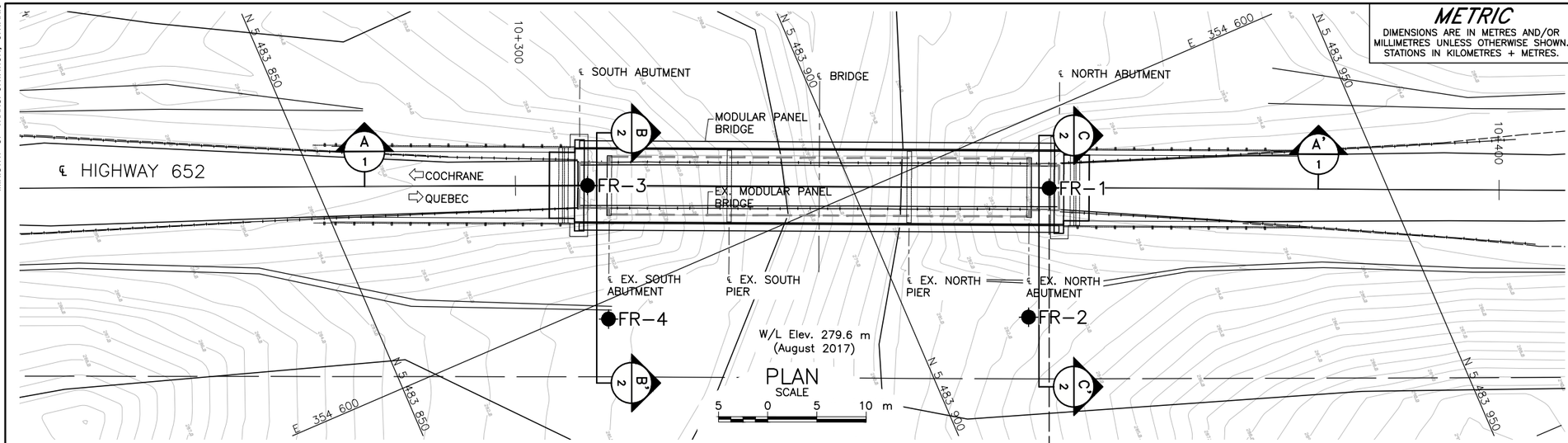
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

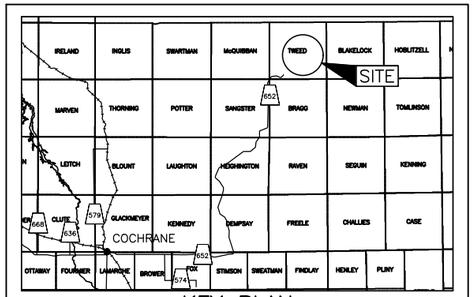
CONT No.
GWP No. 5416-15-00

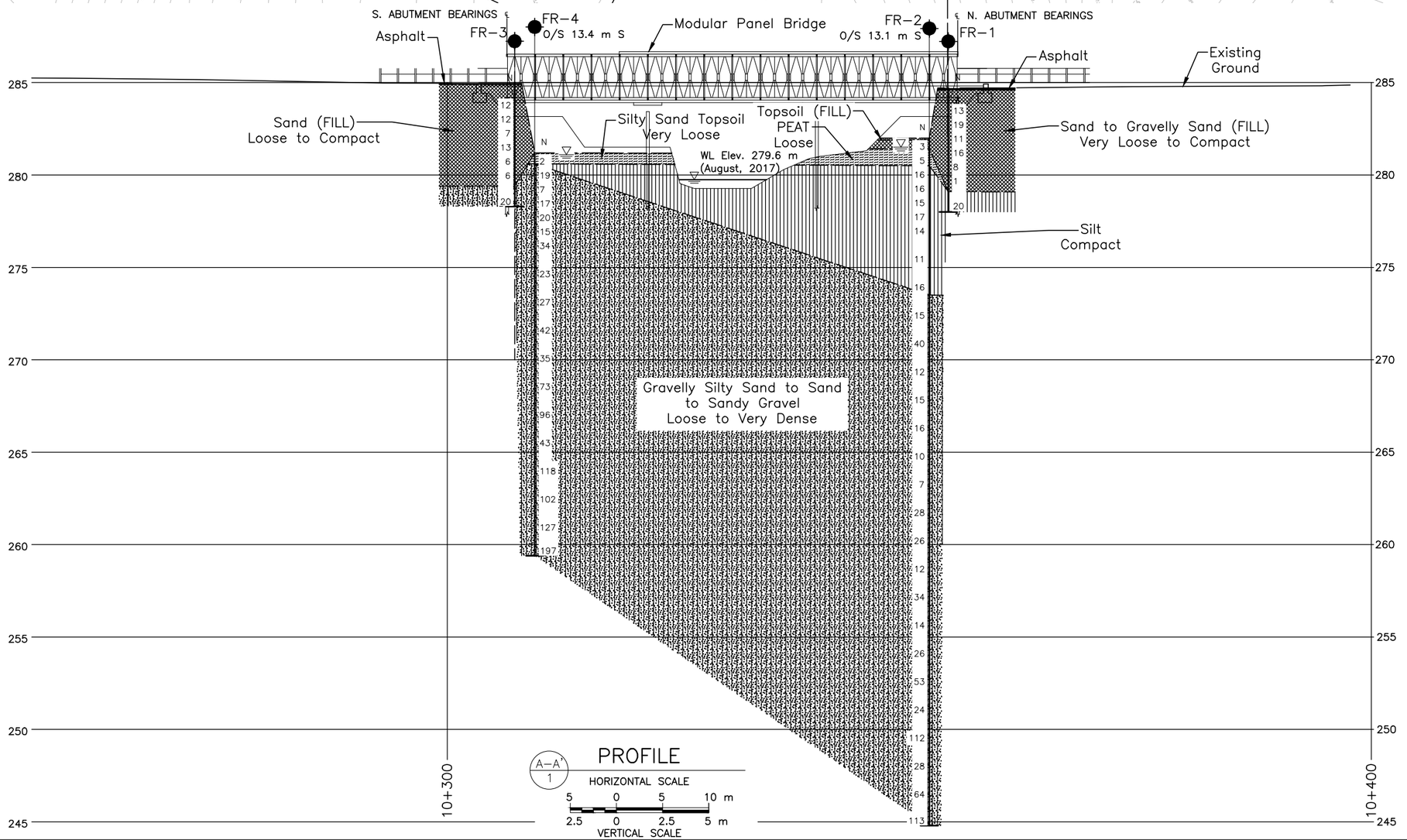
SHEET

HIGHWAY 652
FLOODWOOD RIVER BRIDGE
LAT. 49.490886, LONG. -80.312558
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates







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

BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 12)

No.	ELEVATION	NORTHING	EASTING
FR-1	284.7	5483918.4	354607.3
FR-2	282.0	5483911.3	354618.5
FR-3	285.0	5483875.4	354588.5
FR-4	281.2	5483872.0	354601.8

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.

REFERENCE

Base plans provided in digital format by AECOM, drawing file nos. Floodwood.dwg, received SEPT 26, 2017 and Features_B652TWE2 (Floodwood River).dwg, received OCT 26, 2017. General Arrangement provided by AECOM, drawing file no. 60547656-P30.dwg, received DEC 20, 2017.

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J.P. DITTRICH
April 10, 2018
PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 42H-77

HWY. 652	PROJECT NO. 1651997		DIST. .
SUBM'D. AC	CHKD. .	DATE: 4/10/2018	SITE: 39E-203
DRAWN: TB	CHKD. AB	APPD. JPD	DWG. 1

PLOT DATE: April 10, 2018
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METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
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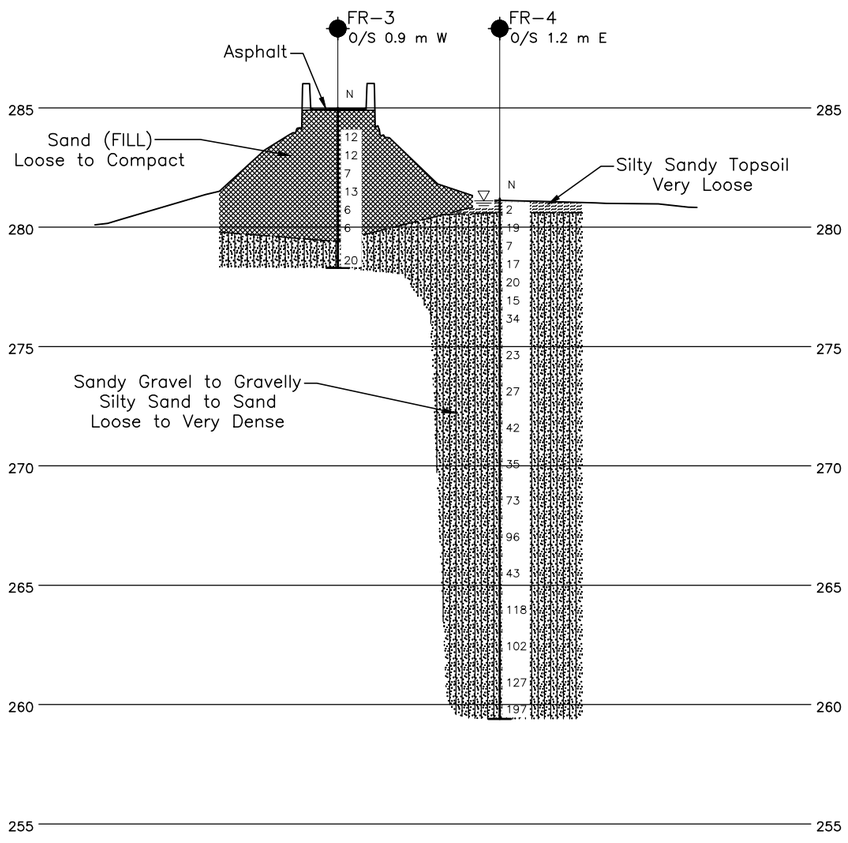
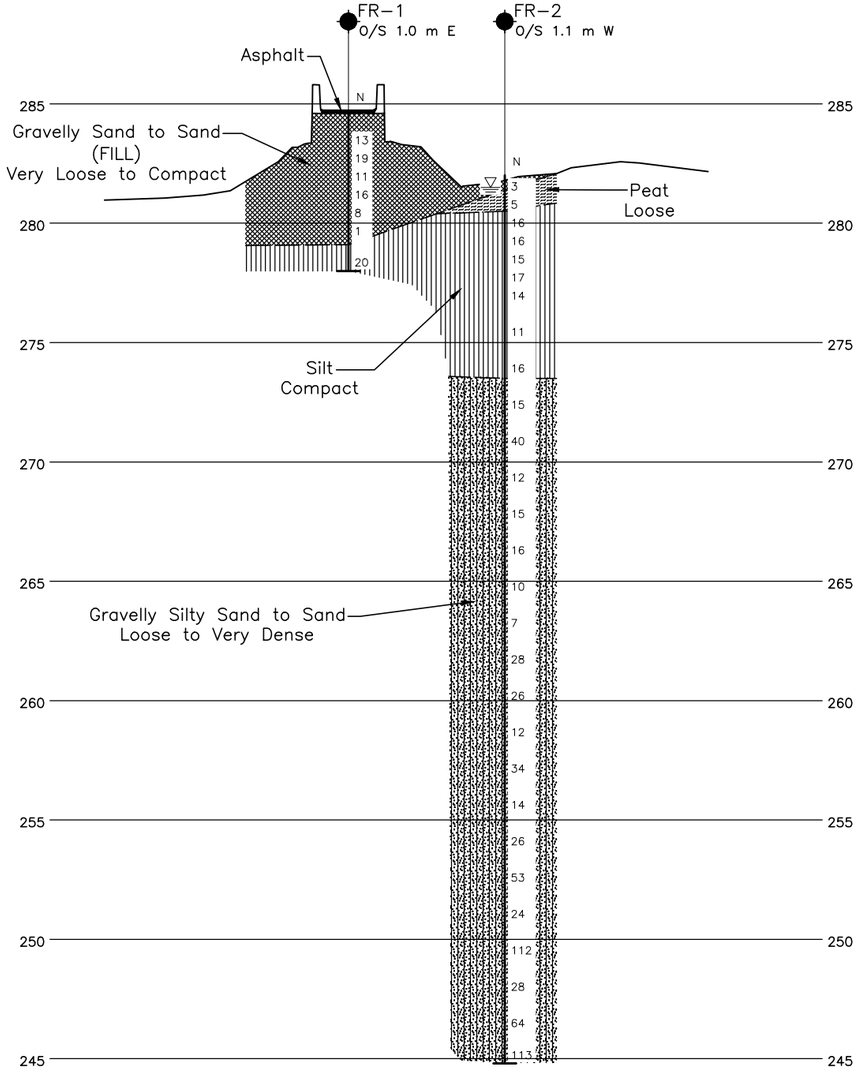
CONT No.
GWP No. 5416-15-00

HIGHWAY 652
FLOODWOOD RIVER BRIDGE
LAT. 49.490886, LONG. -80.312558
SOIL STRATA

SHEET



B-B' / 1 CROSS-SECTION
STA 10+308
HORIZONTAL SCALE
5 0 5 10 m
2.5 0 2.5 5 m
VERTICAL SCALE



C-C' / 1 CROSS-SECTION
STA 10+353
HORIZONTAL SCALE
5 0 5 10 m
2.5 0 2.5 5 m
VERTICAL SCALE

LEGEND

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- WL upon completion of drilling

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NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 42H-77

HWY. 652	PROJECT NO. 1651997		DIST. .
SUBM'D. AC	CHKD. .	DATE: 4/10/2018	SITE: 39E-203
DRAWN: TB	CHKD. AB	APPD. JPD	DWG. 2

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 (DCPT); 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	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	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

RECORD OF BOREHOLE No FR-1

1 OF 1 **METRIC**

PROJECT 16519971651997-WO5
G.W.P. 5416-15-00
DIST _____ HWY 652
DATUM GEODETIC

LOCATION N 5483918.4; E 354607.3 NAD83 MTM ZONE 12 (LAT. 49.4910509; LONG. -80.3124551)
BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing
DATE July 30, 2017

ORIGINATED BY MR
COMPILED BY AD
CHECKED BY AB

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
284.7	GROUND SURFACE										
0.0	ASPHALT (100 mm)										
0.1	Gravelly sand (FILL) Brown Moist										
284.1							284				
0.6	Sand, trace to some gravel, trace to some silt (FILL) Very loose to compact Brown Moist to wet		1	SS	13						
			2	SS	19		283				
			3	SS	11		282		○		15 77 (8)
			4	SS	16						
			5	SS	8		281				
			6	SS	1		280		○		1 98 (1)
279.1											
5.6	SILT, trace clay Compact Grey Wet		7	SS	20		279		○	NP	0 0 95 5
278.0											
6.7	END OF BOREHOLE Note: 1. Borehole dry upon completion of drilling.						278				

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

SUD-MTO 001 MTM ZN INC LAT/LONG S:\CLIENTS\MTO\1651997 AECOM_5015-E-0045_NE RETAINER\02_DATA\GINT\1651997.GPJ GAL-MISS.GDT 4/9/18 TB

GOLDER

RECORD OF BOREHOLE No FR-2

1 OF 4 **METRIC**

PROJECT 16519971651997-WO5
G.W.P. 5416-15-00
DIST _____ HWY 652
DATUM GEODETIC

LOCATION N 5483911.3; E 354618.5 NAD83 MTM ZONE 12 (LAT. 49.4909861; LONG. -80.3123014)
BOREHOLE TYPE NW Casing and Wash Boring
DATE July 23 to 25, 2017

ORIGINATED BY MR
COMPILED BY AD
CHECKED BY AB

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
282.0	GROUND SURFACE										
0.0	TOPSOIL										
0.1	Sand, trace gravel (FILL) Very loose Brown		1	SS	3	▽					
281.4	Moist										
0.6	Amorphous PEAT, trace sand Loose Black Wet		2	SS	5		281		○		
280.5											
1.5	SILT, trace sand, trace to some clay, silty clay laminations Compact Grey Wet		3	SS	16		280				
			4	SS	16				○	NP	0 0 92 8
			5	SS	15		279				
			6	SS	17		278				
			7	SS	14		277		○		0 3 89 8
							276				
			8	SS	11						
							275				
			9	SS	16		274				
273.5											
8.5	Gravelly SILTY SAND to SAND, some gravel, trace to some silt, trace clay Loose to very dense Grey Wet						273				
			10	SS	15				○		23 62 15 0
							272				
			11	SS	40		271				

Continued Next Page

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

GOLDER

PROJECT 16519971651997-WO5

RECORD OF BOREHOLE No FR-2

 METRIC

G.W.P. 5416-15-00 LOCATION N 5483911.3; E 354618.5 NAD83 MTM ZONE 12 (LAT. 49.4909861; LONG. -80.3123014) ORIGINATED BY MR

DIST HWY 652 BOREHOLE TYPE NW Casing and Wash Boring COMPILED BY AD

DATUM GEODETIC DATE July 23 to 25, 2017 CHECKED BY AB

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 ---										
	Gravelly SILTY SAND to SAND, some gravel, trace to some silt, trace clay Loose to very dense Grey Wet		12	SS	12		269				
			13	SS	15		268		○		3 89 (8)
			14	SS	16		267				
			15	SS	10		266				
			16	SS	7		265		○		22 48 28 2
			17	SS	28		264				
			18	SS	26		263				
	A 500 mm boulder was encountered at 22.3 m depth.		19	SS	12		262				
							261				
							260				
							259				

Continued Next Page

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

PROJECT 16519971651997-WO5

RECORD OF BOREHOLE No FR-2

 METRIC

G.W.P. 5416-15-00 LOCATION N 5483911.3; E 354618.5 NAD83 MTM ZONE 12 (LAT. 49.4909861; LONG. -80.3123014) ORIGINATED BY MR

DIST HWY 652 BOREHOLE TYPE NW Casing and Wash Boring COMPILED BY AD

DATUM GEODETIC DATE July 23 to 25, 2017 CHECKED BY AB

SOIL PROFILE			SAMPLES			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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	Gravelly SILTY SAND to SAND, some gravel, trace to some silt, trace clay Loose to very dense Grey Wet										
			20	SS	34		257				
	Silt and sand layer at 25.9 m depth.		21	SS	14		256		○		12 41 46 1
							255				
			22	SS	26		254				
			23	SS	53		253				
							252				
			24	SS	24		251				
			25	SS	112		250		○		12 76 11 1
							249				
			26	SS	28		248				
							247				
			27	SS	64						

Continued Next Page

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

GOLDER

PROJECT 16519971651997-WO5

RECORD OF BOREHOLE No FR-2

 METRIC

G.W.P. 5416-15-00 LOCATION N 5483911.3; E 354618.5 NAD83 MTM ZONE 12 (LAT. 49.4909861; LONG. -80.3123014) ORIGINATED BY MR

DIST HWY 652 BOREHOLE TYPE NW Casing and Wash Boring COMPILED BY AD

DATUM GEODETIC DATE July 23 to 25, 2017 CHECKED BY AB

SOIL PROFILE			SAMPLES			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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					kN/m³	GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	Gravelly SILTY SAND to SAND, some gravel, trace to some silt, trace clay Loose to very dense Grey Wet										
			28	SS	113		245				
244.8											
37.2	END OF BOREHOLE										
	Note: 1. Water level at a depth of 0.5 m below ground surface (Elev. 281.5 m) upon completion of drilling.										

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

GOLDER

RECORD OF BOREHOLE No FR-3

1 OF 1 **METRIC**

PROJECT 16519971651997-WO5
G.W.P. 5416-15-00
DIST _____ HWY 652
DATUM GEODETIC

LOCATION N 5483875.4; E 354588.5 NAD83 MTM ZONE 12 (LAT. 49.4906658; LONG. -80.31272)
BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers
DATE July 30, 2017

ORIGINATED BY MR
COMPILED BY AD
CHECKED BY AB

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
285.0	GROUND SURFACE										
0.0	ASPHALT (100 mm)										
0.1	Sand, trace to some gravel, trace to some silt (FILL) Loose to compact Brown Moist to wet		1	SS	12		284				
			2	SS	12		283		○		20 73 (7)
			3	SS	7		282				
			4	SS	13						
			5	SS	6		281		○		0 83 (17)
			6	SS	6		280				
279.4											
5.6	SAND, some silt, trace gravel, trace clay Compact Grey Wet		7	SS	20		279		○		3 79 16 2
278.3											
6.7	END OF BOREHOLE Note: 1. Borehole dry upon completion of drilling.										

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

SUD-MTO 001 MTM ZN INC LAT/LONG S:\CLIENTS\MTO\1651997 AECOM_5015-E-0045_NE RETAINER\02_DATA\GINT\1651997.GPJ GAL-MISS.GDT 4/9/18 TB

GOLDER

RECORD OF BOREHOLE No FR-4

1 OF 2 **METRIC**

PROJECT 16519971651997-WO5

G.W.P. 5416-15-00 LOCATION N 5483872.0; E 354601.8 NAD83 MTM ZONE 12 (LAT. 49.4906341; LONG. -80.3125369) ORIGINATED BY MR

DIST ____ HWY 652 BOREHOLE TYPE NW Casing and Wash Boring COMPILED BY AD

DATUM GEODETIC DATE July 25 to 26, 2017 CHECKED BY AB

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
281.2	GROUND SURFACE										
0.0	Silty Sandy TOPSOIL, trace gravel Very loose Black to dark brown Wet		1	SS	2	▽	281				
280.6											
0.6	Sandy GRAVEL, some silt to Gravelly Silty SAND to SAND, trace clay Loose to very dense Grey Wet		2	SS	19		280				
	No recovery in Sample 3.		3	SS	7		279				
			4	SS	17				○		56 30 13 1
			5	SS	20		278				
			6	SS	15		277				
	Sandy silt layer at 4.6 m depth.		7	SS	34				○		5 25 68 2
			8	SS	23		276				
			9	SS	27		275				
			10	SS	42		274		○		22 45 28 5
			11	SS	35		273				
							272				
							271				
							270				

Continued Next Page

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

GOLDER

RECORD OF BOREHOLE No FR-4

2 OF 2 **METRIC**

PROJECT 16519971651997-WO5

G.W.P. 5416-15-00 LOCATION N 5483872.0; E 354601.8 NAD83 MTM ZONE 12 (LAT. 49.4906341; LONG. -80.3125369) ORIGINATED BY MR

DIST _____ HWY 652 BOREHOLE TYPE NW Casing and Wash Boring COMPILED BY AD

DATUM GEODETIC DATE July 25 to 26, 2017 CHECKED BY AB

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 ---										
	Sandy GRAVEL, some silt to Gravelly Silty SAND to SAND, trace clay Loose to very dense Grey Wet						269				
			12	SS	73						
							268				
			13	SS	96				○		28 49 21 2
							267				
							266				
			14	SS	43						
							265				
			15	SS	118						
							264				
	Silt and sand layer at 18.3 m depth.						263				
			16	SS	102				○		1 60 38 1
							262				
			17	SS	127						
							261				
							260				
259.4			18	SS	197						
21.8	END OF BOREHOLE Note: 1. Water level at a depth of 0.2 m below ground surface (Elev. 281.0 m) upon completion of drilling.										

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

APPENDIX B

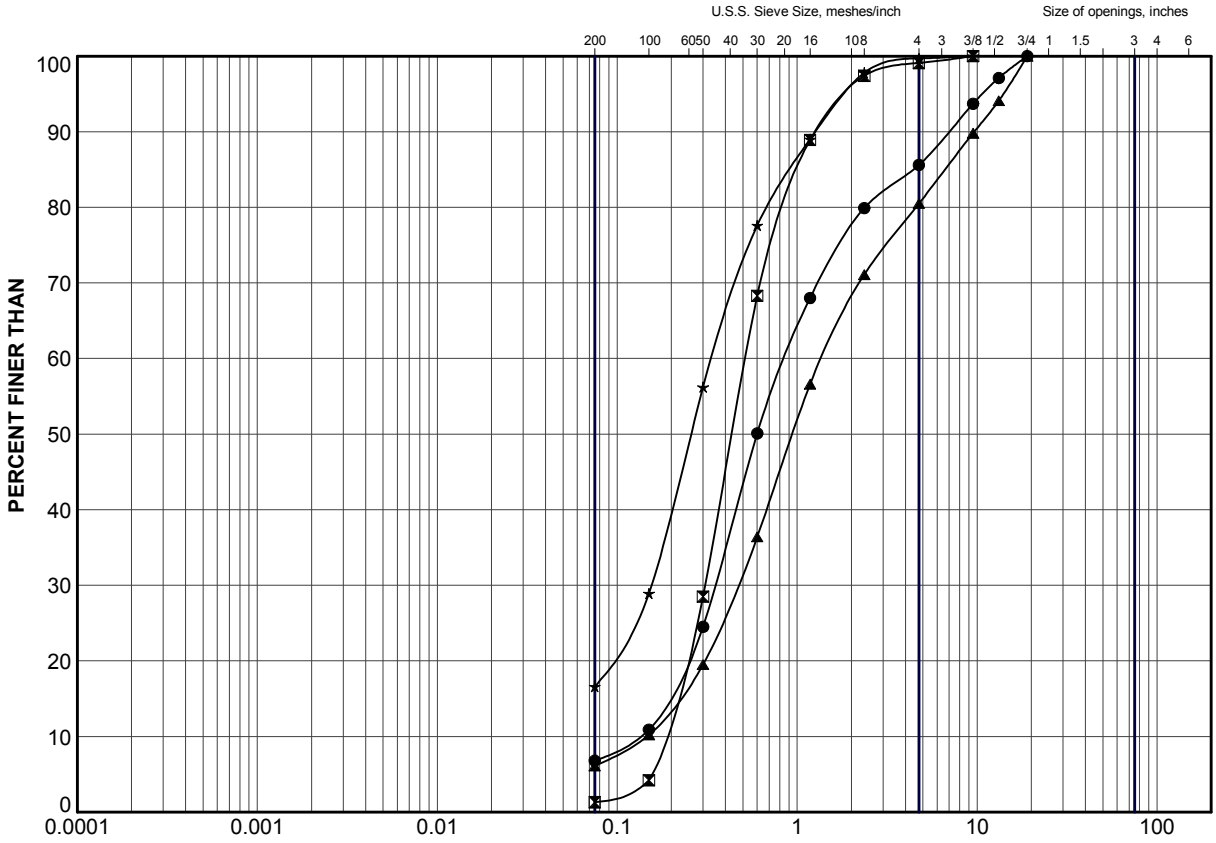
Laboratory Test Results

Table B1: Summary of Analytical Testing of Floodwood River Soil Samples

Location	***Parameter***	***Units***	***Result***
North Abutment (Borehole FR-1, Sample 5)	*Chloride (CL)*	*ug/g*	*ND*
	Sulphate (SO4)	*ug/g*	*ND*
	Conductivity (EC)	*umho/cm*	98
	Resistivity	*ohm-cm*	10,000
	pH	*n/a*	7.81
South Abutment (Borehole FR-3, Sample 6)	*Chloride (CL)*	*ug/g*	*ND*
	Sulphate (SO4)	*ug/g*	90
	Conductivity (EC)	*umho/cm*	185
	Resistivity	*ohm-cm*	5,400
	pH	*n/a*	7.70

Notes: 1. Samples from Boreholes FR-1 and FR-3 obtained on July 30, 2017, respectively and submitted to Maxxam on November 22, 2017, which is beyond the standard hold time.
2. Analytical testing carried out by Maxxam.

Prepared by: AC
Checked by: AB



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	FR-1	3	282.1
⊠	FR-1	6	279.8
▲	FR-3	2	283.2
★	FR-3	5	280.9

PROJECT

HIGHWAY 652
FLOODWOOD RIVER BRIDGE

TITLE

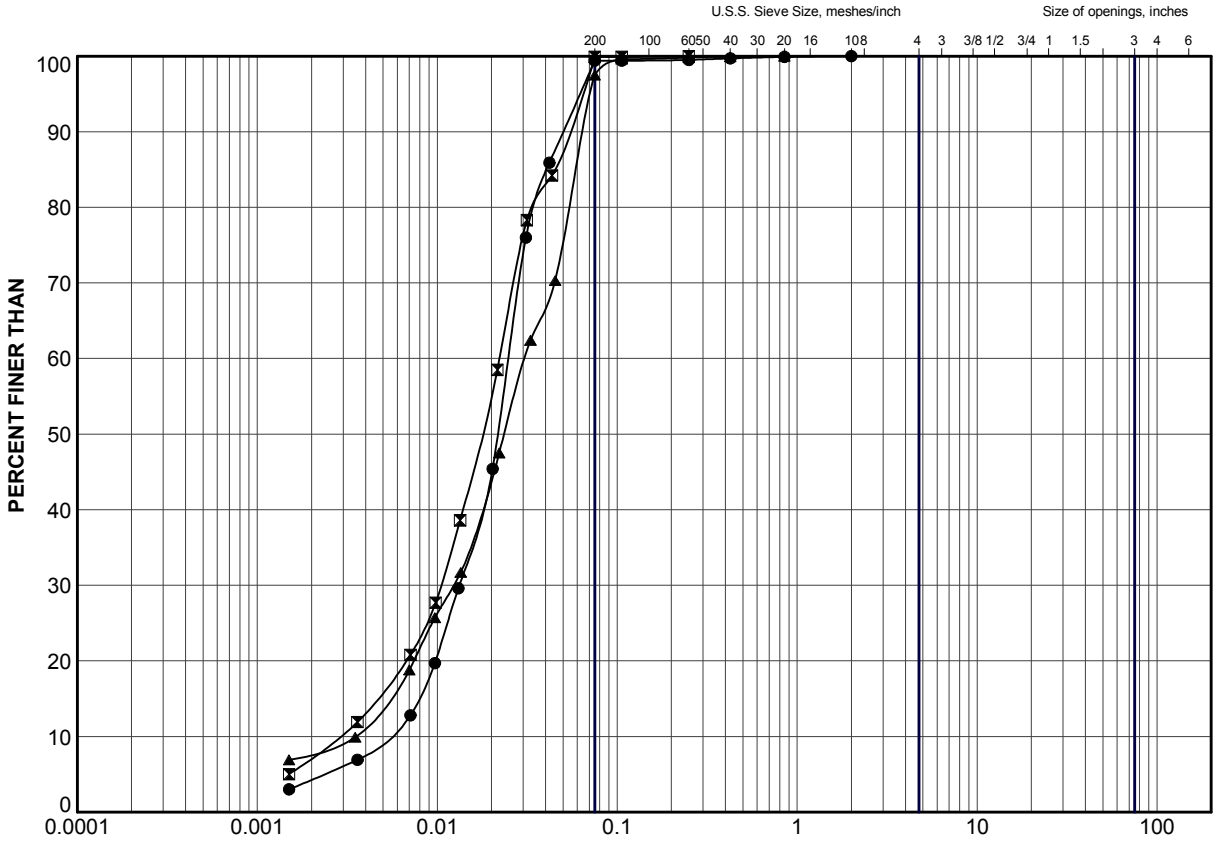
GRAIN SIZE DISTRIBUTION

SAND (FILL)

Golder Associates
SUDBURY, ONTARIO

PROJECT No.			FILE No.	1651997.GPJ
DRAWN	JJL	Dec 2017	SCALE N/A	REV.
CHECK	AB	Dec 2017		
APPR	JPD	Dec 2017	**FIGURE B1**	

SUD-MTO GSD (2016) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	FR-1	7	278.3
⊠	FR-2	4	279.4
▲	FR-2	7	277.1

PROJECT

HIGHWAY 652
FLOODWOOD RIVER BRIDGE

TITLE

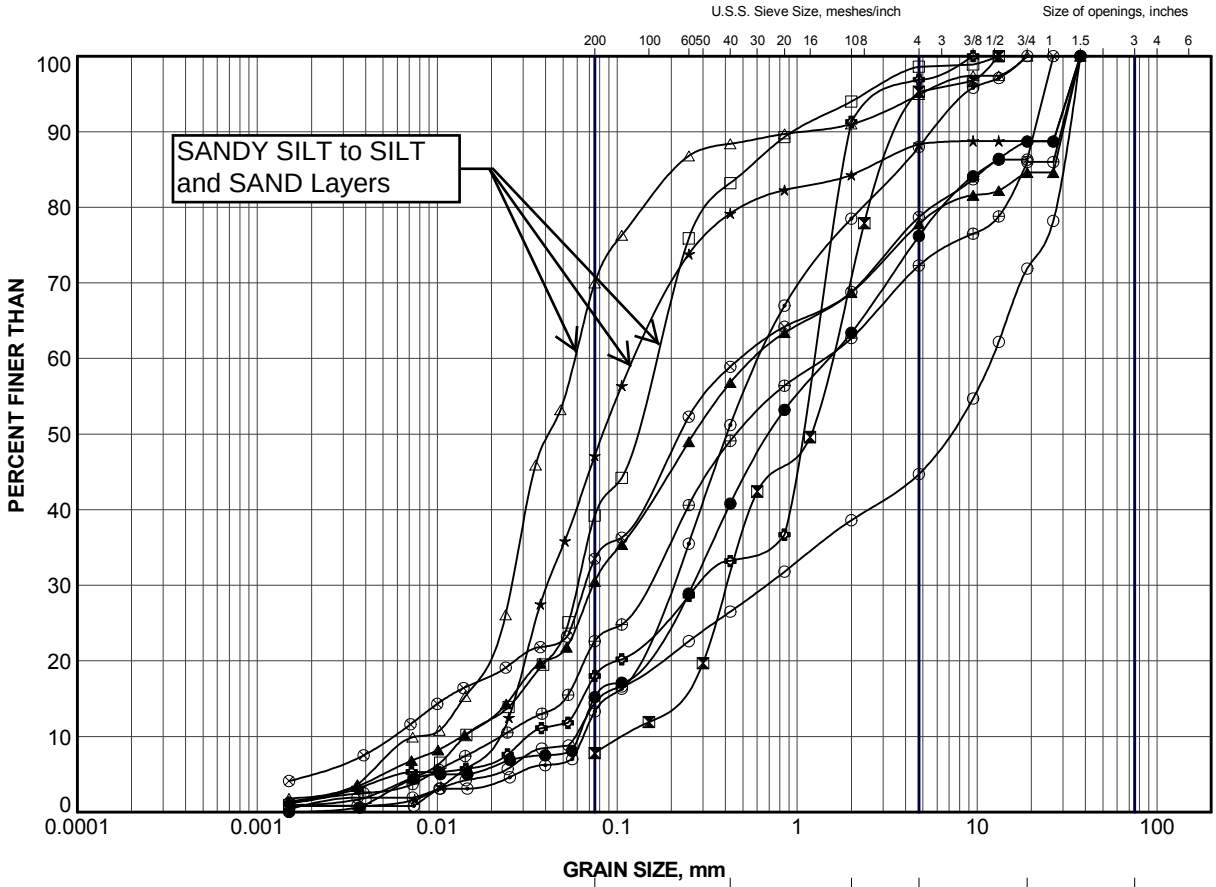
GRAIN SIZE DISTRIBUTION

SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.			FILE No.	1651997.GPJ
DRAWN	JJL	Dec 2017	SCALE N/A	REV.
CHECK	AB	Dec 2017		
APPR	JPD	Dec 2017	**FIGURE B2**	

SUD-MTO GSD (2016) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	FR-2	10	272.6
⊠	FR-2	13	268.0
▲	FR-2	16	263.4
★	FR-2	21	255.8
⊙	FR-2	25	249.7
✪	FR-3	7	278.6
○	FR-4	4	278.6
△	FR-4	7	276.3
⊗	FR-4	10	271.8
⊕	FR-4	13	267.2
□	FR-4	16	262.6

PROJECT

HIGHWAY 652
FLOODWOOD RIVER BRIDGE

TITLE

GRAIN SIZE DISTRIBUTION

SANDY GRAVEL to GRAVELLY SILTY SAND to SAND

Golder Associates
SUDBURY, ONTARIO

PROJECT No.			FILE No.	1651997.GPJ	
DRAWN	JJL	Dec 2017	SCALE	N/A	REV.
CHECK	AB	Dec 2017			
APPR	JPD	Dec 2017	**FIGURE B3**		

SUD-MTO GSD (2016) GLDR_LDN.GDT

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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