



April 11, 2018

PRELIMINARY FOUNDATION INVESTIGATION REPORT

LITTLE ABITIBI RIVER BRIDGE REPLACEMENT - SITE NO. 39E-201
LAT. 49.341686; LONG. -80.485177
HIGHWAY 652, COCHRANE DISTRICT
TOWNSHIP OF SANGSTER
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5416-15-00, WP 5416-15-02

Submitted to:

Kyle Hampton, P.Eng.
AECOM Canada Ltd.
189 Wyld Street, Suite 103
North Bay, ON P1B 1Z2



GEOCRE No.: 42H-75

Report Number: 1651997-WO5-002

Distribution:

- 1 Copy - AECOM Canada Ltd., North Bay, Ontario
- 1 Copy - Ministry of Transportation, Ontario, North Bay, Ontario (Northeastern Region)
- 1 Copy - Ministry of Transportation, Ontario, Downsview, Ontario (Foundations Section)
- 1 Copy - Golder Associates Ltd., Sudbury, Ontario

REPORT





Table of Contents

PART A – FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION.....	4
2.0 SITE DESCRIPTION.....	4
3.0 INVESTIGATION PROCEDURES	4
3.1 Previous Investigations	4
3.2 Current Investigation	5
4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS	6
4.1 Regional Geology	6
4.2 Subsurface Conditions.....	6
4.2.1 Bedrock/Refusal.....	8
4.3 Groundwater Conditions	8
5.0 CLOSURE.....	8

SITE PHOTOGRAPHS

Photographs 1 to 4

DRAWINGS

Drawing 1 Borehole Locations and Soil Strata
Drawing 2 Soil Strata

APPENDIX A RECORD OF BOREHOLES

Lists of Abbreviations and Symbols
Record of Boreholes LA-1 to LA-3
Record of Drillhole LA-3
Record of Boreholes 1 to 3 (GEOCRES 42H-015)

APPENDIX B LABORATORY TEST RESULTS

Table B1 Summary of Analytical Testing of Soil Sample
Figure B1 Grain Size Distribution – Sand (FILL)
Figure B2 Grain Size Distribution – Silt to Clayey Silt
Figure B3 Plasticity Chart – Clayey Silt to Silt of Slight Plasticity
Figure B4 Grain Size Distribution – Sand and Silt to Sand
Figure B5 Grain Size Distribution – Sand and Gravel (TILL)
Figure B6 Bedrock Core Photos
Figure B7 Summary of Rock Core Test Data
Figure No. 1 Grain Size Distribution – Silt to Silty Clay (GEOCRES 42H-015)



PART A

**PRELIMINARY FOUNDATION INVESTIGATION REPORT
LITTLE ABITIBI RIVER BRIDGE – SITE 39E-201
HIGHWAY 652, COCHRANE DISTRICT
TOWNSHIP OF SANGSTER
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5416-15-00, WP 5416-15-02**



PRELIMINARY FOUNDATION REPORT LITTLE ABITIBI RIVER BRIDGE REPLACEMENT SITE 39E-201 HIGHWAY 652

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 Little Abitibi River Bridge (Site No. 39E-201). The bridge is located on Highway 652, 65 km north of Highway 11 in the Township of Sangster, Ontario. The general location of this section of Highway 652 is shown on the Key Plan on Drawing 1.

2.0 SITE DESCRIPTION

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

In general, the topography in the area of the structure consists of rolling/valley terrain with densely forested areas immediately beyond the Highway 652 right-of-way and the vicinity of the river. The existing bridge consists of an approximately 42.7 m long by 4.6 m wide, three-span, single-lane Temporary Modular Bridge (TMB). Based on the previous General Arrangement (GA) drawing, the existing bridge abutments are supported by timber cribs founded on granular fill pads with the piers founded on driven steel H-piles (HP310x79). Based on the survey drawing provided by AECOM, the bridge deck is at approximately Elevation 263.2 m and 263.5 m at the east and west abutments, respectively. The existing embankment front slopes are about 5.5 m high relative to the river bottom and inclined at a profile ranging from about 1.5 Horizontal to 1 Vertical (1.5H:1V) to 2H:1V. The existing approach embankment side slopes are about 2 m to 3 m high and inclined at a profile ranging from about 1.5H:1V to 2H: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 INVESTIGATIONS

3.1 Previous Investigation

A previous foundation investigation was completed for the existing bridge in 1981 with the details of the investigation presented in the following report:

- Ministry of Transportation and Communications, 1981. Foundation Investigation Report for Detour Lake Rd. Line 'A', Little Abitibi River Structure, W.P. 7-81-10, Site 39E-201. Geocres No. 42H-015

Borehole 2 from the 1981 investigation, located at the west abutment, was considered suitable for supplementing the current investigation. The location of Borehole 2 has been converted from previous station and offset to approximate coordinates in MTM NAD83 (Zone 12). Further, we understand from AECOM that the elevation of the ground surface at Borehole 2 was originally surveyed to a local datum; for the purposes of this report, the elevation at Borehole 2 has been converted to the geodetic datum based on the 2017 survey provided by AECOM.



PRELIMINARY FOUNDATION REPORT LITTLE ABITIBI RIVER BRIDGE REPLACEMENT SITE 39E-201 HIGHWAY 652

Borehole	MTM NAD 83 Northing	MTM NAD 83 Easting	Approximate Ground Surface Elevation (m)	Borehole Depth (m)
2	5467200.1	342190.2	260.6	15.6

The approximate location of Borehole 2, along with the approximate locations of Boreholes 1 and 3 from the 1981 investigation (which have not been used to supplement the current investigation), are shown on Drawing 1. Records of Boreholes 1 to 3 are presented in Appendix A.

3.2 Current Investigation

The field work for the current subsurface investigation was carried out on July 27 and August 1, 2017, during which time a total of three boreholes (LA-1 to LA-3) were advanced at the approximate locations shown on Drawing 1. Boreholes LA-1 and LA-2 were advanced through the existing highway embankment at the east and west abutments, respectively. Borehole LA-3 was advanced at the north toe of the east approach embankment.

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. The boreholes were advanced using 108 mm inside diameter hollow-stem augers with Borehole LA-3 also using NW casing with wash boring, and NQ rock coring (as required to core the bedrock). Soil samples were obtained at depth intervals of 0.75 m and 1.5 m, using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer, carried out in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). One in-situ field vane shear test was completed within a cohesive layer in Borehole LA-2 in accordance with ASTM D2573, using an MTO Standard 'N' size vane. All boreholes were backfilled with bentonite and cuttings upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The field work was supervised on a full-time basis 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 and bedrock samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury Laboratory where the samples underwent further visual examination and laboratory testing. Index and classification testing consisting of water content, Atterberg limits and grain size distribution were carried out on selected soil samples. The geotechnical laboratory testing was performed in accordance with MTO LS standards.

Two soil samples were obtained on July 27, 2017, from Boreholes LA-1 and LA-2, 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 of the boreholes were measured and surveyed by a member of our technical staff, referenced to the highway centreline and existing bridge structure and converted to northings/eastings coordinates. 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 provided by AECOM. The MTM NAD83 Zone12 northing and easting coordinates and geographical coordinates, ground



PRELIMINARY FOUNDATION REPORT LITTLE ABITIBI RIVER BRIDGE REPLACEMENT SITE 39E-201 HIGHWAY 652

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	MTM NAD 83 Northing (Latitude)	MTM NAD 83 Easting (Longitude)	Ground Surface Elevation (m)	Borehole Depth (m)
LA-1	5467216.5 (49.3417584)	342229.5 (-80.4848852)	263.2	9.8
LA-2	5467200.3 (49.3416153)	342187.1 (-80.4854702)	263.5	8.2
LA-3	5467227.1 (49.3418541)	342222.7 (-80.4849777)	260.0	22.2

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain Study (NOEGTS)¹, the Little Abitibi River site is located within a glaciolacustrine plain consisting primarily of clays and silts.

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 and Matachewan and Hearst swarms of mafic and ultramafic bedrock.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the current boreholes and the results of current in-situ and laboratory testing are provided on the Record of Borehole sheets contained in Appendix A. The results of the geotechnical laboratory testing are contained in Appendix B. The results of the in-situ tests (i.e., SPT 'N'-values and field vane) as presented on the borehole records and described in Section 4 are uncorrected values. 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 (GEOCRE 42H-15), prior to construction of the existing embankments and bridge, the subsurface soil conditions at the site generally consisted of peat/mixed organics underlain by deposits of soft to firm, low plasticity silt to clayey silt overlying very dense sand and gravel (west abutment) and loose to very dense silty sand overlying bedrock (east abutment).

The subsoil conditions encountered during the current borehole investigation consist of granular embankment fill and/or organic soil underlain by silt to clayey silt, sand and silt to sand, and/or sand and gravel till, which is generally consistent

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

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



PRELIMINARY FOUNDATION REPORT LITTLE ABITIBI RIVER BRIDGE REPLACEMENT SITE 39E-201 HIGHWAY 652

with the results of the previous (1981) investigation. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes as part of the current investigation (including Borehole No. 2) is provided below.

Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	SPT N-Values (blows/0.3 m)	Laboratory Testing
				Field Vane Results (kPa)	
				Consistency or Relative Density	
Asphalt	LA-1 & LA-2	80 mm	263.2 & 263.5	n/a	n/a
(FILL) Sand and Gravel; Sand	LA-1 to LA-3	0.6 – 6.4	263.4 – 260.0	N = 1 – 18 n/a Very loose to compact	w = 4% - 25% 3 – M (Fig. B1)
Peat / Organic Silt	No. 2 & LA-3	0.9 & 0.8	260.6 & 259.4	N = 4 n/a Soft	n/a
Silty Sand (Upper)	LA-3	0.9	258.6	N = 4 Very Loose to Loose	n/a
Silt to Clayey Silt ¹	No. 2 & LA-1 to LA-3	0.5 – 12.1	259.7 – 256.7	N = 3 – 29 S _u = 15 - 47 kPa, S = 1 - 3 Loose to Compact (with Firm clayey silt layers/seams)	w = 18% – 31% 4 - MH (Fig. B2) 5 - MH (Fig. No.1) 4 - AL (Fig. B3) w _L = 18% - 25% w _p = 13% - 18% I _p = 4% - 8% 3 – AL (NP)
Sand and Silt to Sand	LA-1 & LA-3	>2.8 – 8.1	256.2 – 254.4	N = 3 – 25 n/a Very loose to compact	w = 19% – 45% 3 – M/MH (Fig.B4)
TILL- Sand and Gravel	LA-3	5.3	246.3	N = 46-106 n/a Dense to very dense	w = 7% 1 – M (Fig. B5)

Where:

N = SPT 'N'-value; number of blows for 0.3 m of penetration
 s_u = Undrained shear strength from in situ field 'N'-vane (kPa)
 S = Calculated sensitivity
 w = Natural Moisture Content (%)
 M = Sieve Analysis for Particle Size
 MH = Combined Sieve and Hydrometer Analysis

AL = Atterberg limits test
 w_p = Plastic Limit (%)
 w_L = Liquid Limit (%)
 I_p = Plasticity Index (%)
 NP = Non-plastic test result in Atterberg limits

Notes:

1. Plasticity of silt stratum ranges from non-plastic (NP) to low plasticity. Clayey silt layers/seams encountered within this stratum below a depth of 7.1 m (Elevation 256.4 m) in Borehole LA-2.



PRELIMINARY FOUNDATION REPORT LITTLE ABITIBI RIVER BRIDGE REPLACEMENT SITE 39E-201 HIGHWAY 652

4.2.1 Bedrock/Refusal

Bedrock was cored in Borehole LA-3 and the depth/elevation of the bedrock surface is presented below.

Borehole No.	Location	Depth to Bedrock (m)	Bedrock Surface Elevation (m)	Bedrock Coring (m)
No. 2	Existing west abutment	13	247.6	2.6
LA-3	East approach at toe of north slope	19	241.0	3.2

The bedrock core retrieved from the borehole is described as fresh, strongly foliated, dark grey to black, fine grained, biotite rich, metasedimentary bedrock with quartz veining. Additional details of the bedrock core are presented on the Record of Drillhole LA-3 in Appendix A, including data on the discontinuity frequency and type. Photographs of the bedrock core samples from Borehole LA-3 are shown on Figure B7 in Appendix B. The bedrock properties, as encountered in the cored boreholes and/or tested on selected samples, are summarized below.

Borehole No.	Total Core Recovery (TCR)	Rock Quality Designation (RQD)	Quality Classification (Table 3.10 of CFEM 2006 ³)	UCS (MPa)	Strength Classification (Table 3.5 of CFEM 2006)
No. 2	97% - 100%	-	-	-	-
LA-3	100%	90% - 98%	Excellent	45	(R3) Medium Strong

4.3 Groundwater Conditions

The un-stabilized groundwater level measured in the open Borehole LA-3 upon completion of drilling was 0.3 m below ground surface (Elevation 259.7 m). As this borehole was advanced using NW casing and wash boring techniques, the water level may not be representative of stabilized groundwater conditions. The river water level was measured by others to be at Elevation 259.8 m. Groundwater and river water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

5.0 CLOSURE

The field drilling program was supervised by Mr. Mathew Riopelle. This Foundation Investigation Report was prepared by David Muldowney, P.Eng., 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.

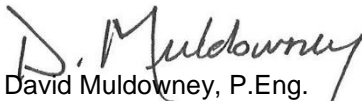
³ Canadian Geological Society, 2006. Canadian Foundation Engineering Manual, 4th Edition.



**PRELIMINARY FOUNDATION REPORT
LITTLE ABITIBI RIVER BRIDGE REPLACEMENT
SITE 39E-201 HIGHWAY 652**

Report Signature Page

GOLDER ASSOCIATES LTD.


David Muldowney, P.Eng.
Senior Geotechnical Engineer



André Bom, P.Eng.
Senior Geotechnical Engineer, Associate



Paul Dittrich, Ph.D., P.Eng.
Principal, MTO Foundations Designated Contact

AD/AC/AB/JPD/kp/ca

https://golderassociates.sharepoint.com/sites/19476g/wo5_5_bridges_hwy_652/11_reporting/002_little_abitibi_river/final/1651997-002-r-rev0_aecom_mto_little_abitibi_river_fir_11apr_18.docx



PHOTOGRAPHS



**Photograph 1: Little Abitibi River Bridge
North side of East embankment looking East (July 2017)**



**Photograph 2: Little Abitibi River Bridge
North side of East embankment looking West (July 2017)**



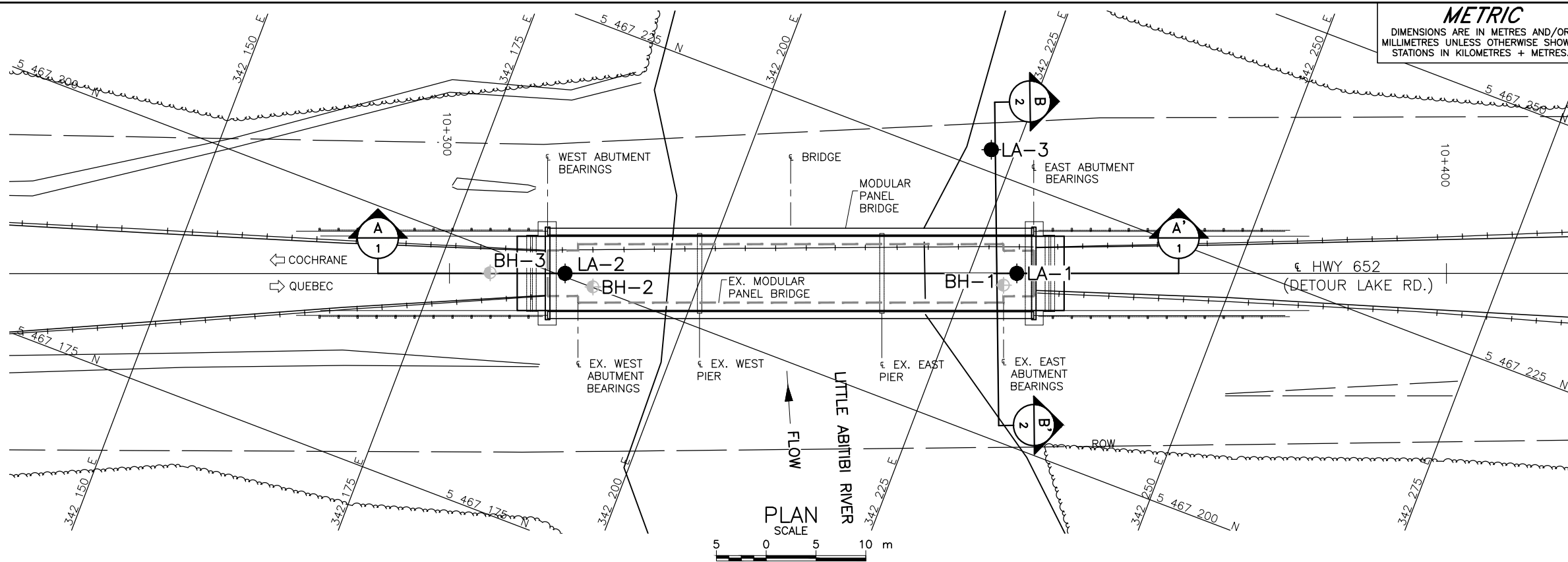
PHOTOGRAPHS



**Photograph 3: Little Abitibi River Bridge
West approach looking East (OSIM Report – November 2015)**



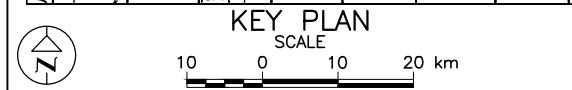
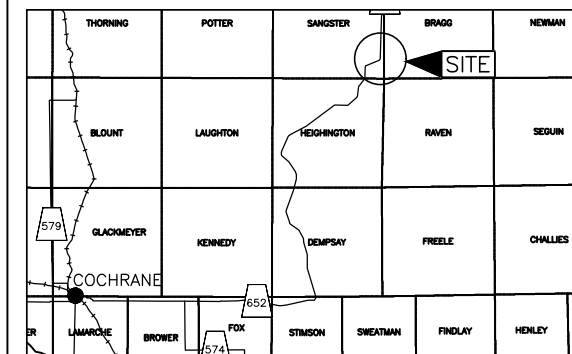
**Photograph 4: Little Abitibi River Bridge
North Elevation Looking South-West (OSIM Report – November 2015)**



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

CONT No.
WP No. 5416-15-02

HIGHWAY 652
LITTLE ABITIBI RIVER BRIDGE
LAT. 49.341686, LONG. -80.485177
BOREHOLE LOCATIONS AND SOIL STRATA



LEGEND

- Borehole - Current Investigation
- Borehole - Previous Investigation (Geocres 42H-015)
- Standard Penetration Test Value
- Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling
- 100% Rock Quality Designation (RQD)

BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 12)			
No.	ELEVATION	NORTHING	EASTING
BH-2	260.6	5467200.1	342190.2
LA-1	263.2	5467216.5	342229.5
LA-2	263.5	5467200.3	342187.1
LA-3	260.0	5467227.1	342222.7

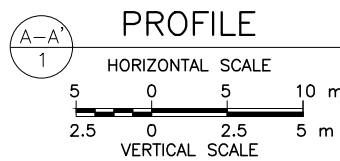
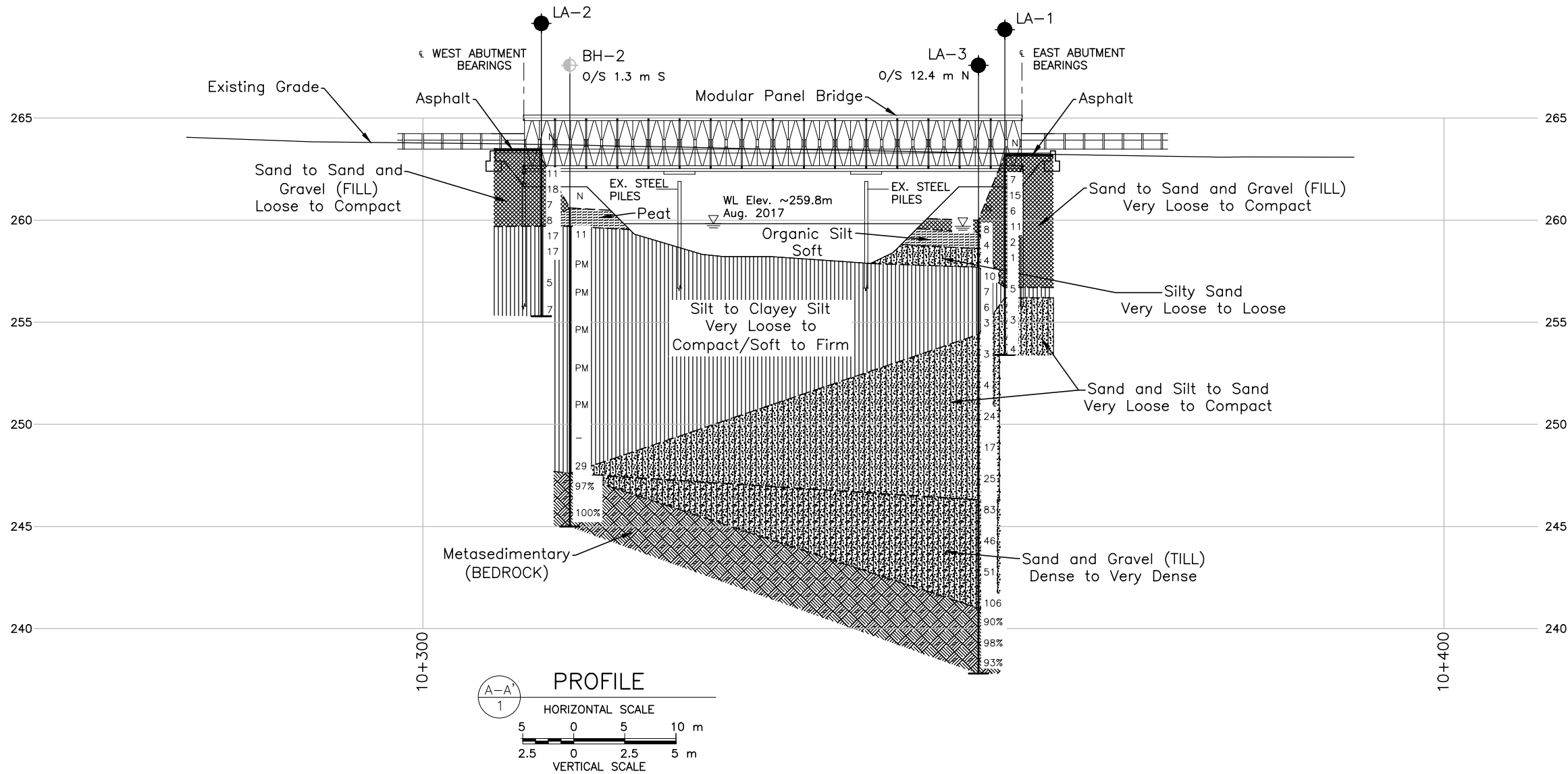
NOTES

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 no. 60546679-P10.dwg, received DEC 20, 2017.

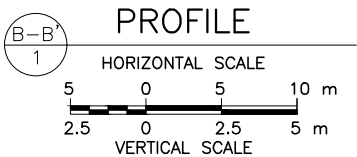
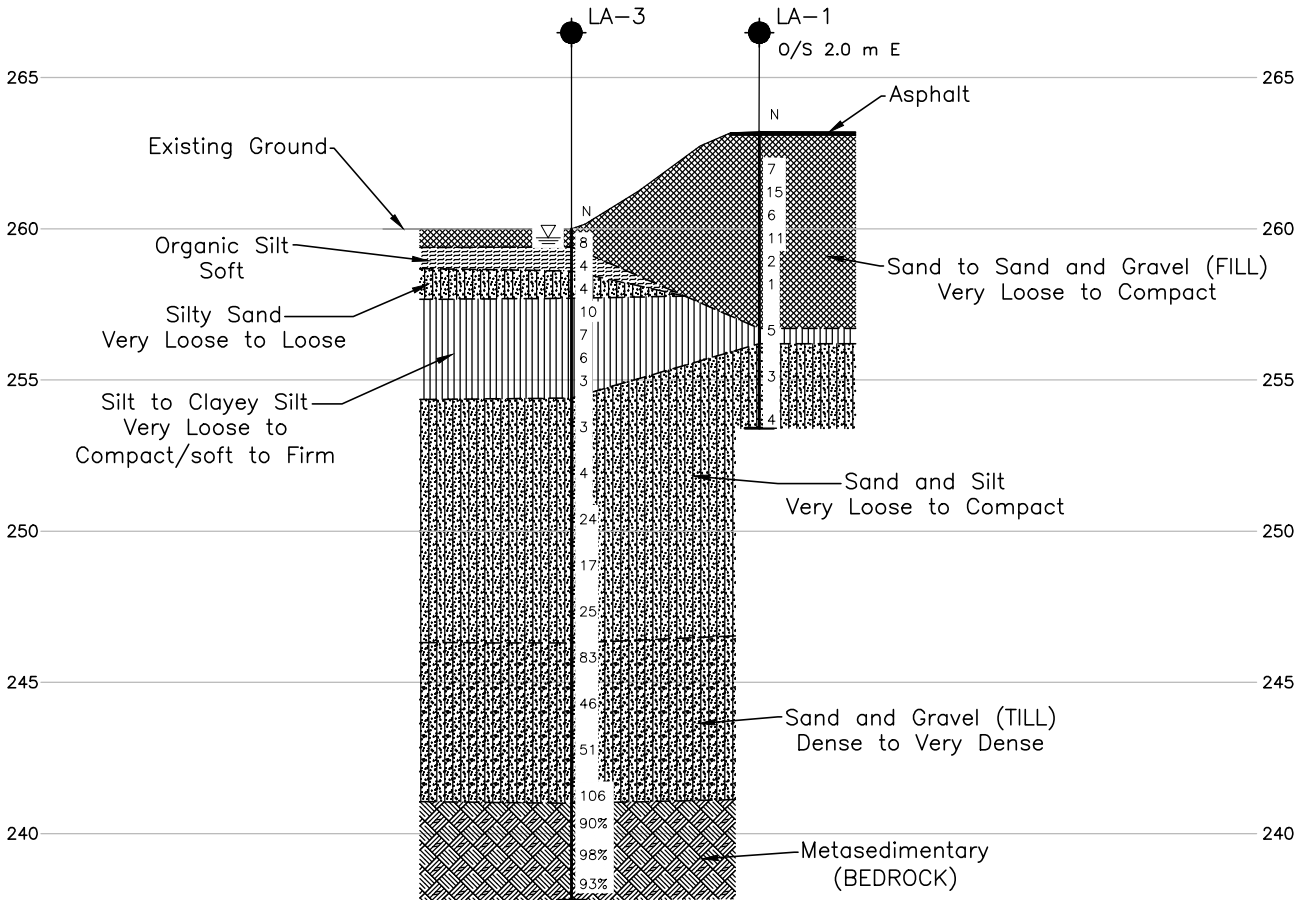


NO.	DATE	BY	REVISION
Geocres No. 42H-75			
HWY. 652	PROJECT NO. 1651997	DIST. .	
SUBM'D. AD	CHKD. AC	DATE: 4/11/2018	SITE: 39E-201
DRAWN: JJJ/TB	CHKD. AB	APPD. JPD	DWG. 1

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

CONT No.
WP No. 5416-15-02

HIGHWAY 652
LITTLE ABITIBI RIVER BRIDGE
LAT. 49.341686, LONG. -80.485177
SOIL STRATA



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
- 100% Rock Quality Designation (RQD)

BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 12)

No.	ELEVATION	NORTHING	EASTING
BH-2	260.6	5467200.1	342190.2
LA-1	263.2	5467216.5	342229.5
LA-2	263.5	5467200.3	342187.1
LA-3	260.0	5467227.1	342222.7

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 no. 60546679-P10.dwg, received DEC 20, 2017.



NO.	DATE	BY	REVISION
Geocres No. 42H-75			
HWY. 652	PROJECT NO. 1651997		DIST. .
SUBM'D.	CHKD. AC	DATE: 4/11/2018	SITE: 39E-201
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
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a)	Index Properties
$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

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

Notes: 1
2

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

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



LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

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

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.)

(b) Cohesive Soils Consistency

	kPa	Cu, Su	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

Dynamic Cone Penetration Resistance (DCPT); Nd:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Qt), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

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

Per cent by Weight	Modifier
0 to 5	Trace
5 to 12	Trace to Some (or Little)
12 to 20	Some
20 to 30	(ey) or (y)
over 30	And (non-cohesive (cohesionless)) or With (cohesive)

Example

Trace sand
Trace to some sand
Some sand
Sandy
Sand and Gravel
Silty Clay with sand / Clayey Silt with sand



LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	

PROJECT 1651997-5000			RECORD OF BOREHOLE No LA-1			1 OF 1 METRIC																
W.P. 5416-15-02			LOCATION N 5467216.5; E 342229.5 MTM ZONE 12 (LAT. 49.3417584; LONG. -80.4848852)			ORIGINATED BY MR																
DIST _____ HWY 652			BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers			COMPILED BY TB																
DATUM GEODETIC			DATE July 27, 2017			CHECKED BY AB																
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p W W _L WATER CONTENT (%)			γ kN/m ³			GR SA SI CL			
263.2	GROUND SURFACE							20 40 60 80 100														
0.0	ASPHALT (80 mm)						263															
	Sand and gravel (FILL)																					
0.3	Sand, trace to some gravel, trace to some fines (FILL) Very loose to compact Brown Moist to wet		1	SS	7		262															
			2	SS	15																	
			3	SS	6		261															
			4	SS	11		260															
			5	SS	2		259															
			6	SS	1																	
							258															
			7A	SS	5		257															
256.7	CLAYEY SILT, trace to some sand Grey Wet		7B																			
6.5																						
256.2	SAND, trace to some silt, trace clay Very loose to loose Grey Wet		8	SS	3		256															
7.0																						
							255															
			9	SS	4		254															
253.4	END OF BOREHOLE																					
9.8																						

SUD-MTO 001 MTM ZN INC LAT/LONG S:\CLIENTS\MT01651997 AECOM_5015-E-0045_NE RETAINER02_DATA\GINTV1651997.GPJ GAL-MISS.GDT 1/24/18 TB

PROJECT 1651997-5000		RECORD OF BOREHOLE No LA-2				1 OF 1 METRIC								
W.P. 5416-15-02		LOCATION N 5467200.3; E 342187.1 MTM ZONE 12 (LAT. 49.3416153; LONG. -80.4854702)				ORIGINATED BY MR								
DIST _____ HWY 652		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY TB								
DATUM GEODETIC		DATE July 27, 2017				CHECKED BY AB								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
263.5	GROUND SURFACE													
0.0	ASPHALT (80 mm)													
0.1	Sand and gravel (FILL)													
262.9														
0.6	Sand, trace to some gravel, trace to some fines (FILL) Loose to compact Brown to grey Moist to wet		1	SS	11									
			2	SS	18									
			3	SS	7									
			4	SS	8									
259.7														
3.8	SILT, trace to some clay Loose to compact Grey Wet		5	SS	17								NP	0 0 90 10
			6	SS	17									
			7	SS	5								NP	0 2 87 11
	Clayey silt layers/seams below 7.1 m depth													
255.3			8	SS	7									
8.2	END OF BOREHOLE													

SUD-MTO 001 MTM ZN INC LAT/LONG S:\CLIENTS\MTM01651997 AECOM_5015-E-0045_NE RETAINER02_DATA\GINTV1651997.GPJ GAL-MISS.GDT 1/24/18 TB

PROJECT 1651997-5000			RECORD OF BOREHOLE No LA-3			1 OF 2 METRIC												
W.P. 5416-15-02			LOCATION N 5467227.1; E 342222.7 MTM ZONE 12 (LAT. 49.3418541; LONG. -80.4849777)			ORIGINATED BY MR												
DIST _____ HWY 652			BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring and NQ Coring			COMPILED BY TB												
DATUM GEODETIC			DATE August 1, 2017			CHECKED BY AB												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)					
								20 40 60 80 100	20 40 60 80 100	20 40 60	W _p W W _L	γ	GR SA SI CL					
260.0	GROUND SURFACE																	
0.0	Sand, trace gravel (FILL) Loose Brown Moist		1	SS	8	▽												
259.4																		
0.6	ORGANIC SILT Soft Dark brown Wet		2	SS	4		259											
258.6																		
1.4	SILTY SAND, trace to some organics Very loose to loose Brown Wet		3	SS	4		258											
257.7																		
2.3	SILT, trace to some clay, trace to some sand Very loose to compact Grey Wet		4	SS	10		257											
			5	SS	7													
			6	SS	6		256											
			7	SS	3		255											
254.4																		
5.6	SAND and SILT to SAND, trace to some gravel, trace clay Very loose to compact Grey Wet		8	SS	3		254											
							253											
			9	SS	4		252											
							251											
			10	SS	24		250											
			11	SS	17		249											

Continued Next Page

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

SUD-MTO 001 MTM ZN INC LAT/LONG S:\CLIENTS\MTM\1651997 AECOM_5015-E-0045_NE RETAINER02_DATA\GINTV1651997.GPJ GAL-MISS.GDT 1/24/18 TB

PROJECT 1651997-5000		RECORD OF BOREHOLE No LA-3				2 OF 2 METRIC					
W.P. 5416-15-02		LOCATION N 5467227.1; E 342222.7 MTM ZONE 12 (LAT. 49.3418541; LONG. -80.4849777)				ORIGINATED BY MR					
DIST _____ HWY 652		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring and NQ Coring				COMPILED BY TB					
DATUM GEODETIC		DATE August 1, 2017				CHECKED BY AB					
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa			
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100	20 40 60		
246.3	SAND and SILT to SAND, trace to some gravel, trace clay Very loose to compact Grey Wet		12	SS	25		247				
13.7	SAND and GRAVEL, trace to some silt (TILL) Dense to very dense Grey Wet		13	SS	83		246				
			14	SS	46		245				
			15	SS	51		244				
			16	SS	106		243				
241.0	METASEDIMENTARY (BEDROCK)		1	RC	REC 100%		242				
19.0	Bedrock cored from 19.0 m depth to 22.2 m depth. For coring details see Record of Drillhole LA-3.		2	RC	REC 100%		241				
			3	RC	REC 100%		240				
							239				
237.8	END OF BOREHOLE						238				
22.2	Note: 1. Water level at a depth of 0.3 m below ground surface (Elev. 259.7 m) upon completion of drilling.										

SUD-MTO 001 MTM ZN INC LAT/LONG S:\CLIENTS\MTM\1651997 AECOM_5015-E-0045_NE RETAINER02_DATA\GINTV1651997.GPJ GAL-MISS.GDT 1/24/18 TB

PROJECT: 1651997-5000
LOCATION: N 5467227.1; E 342222.7
MTM ZONE 12 (LAT. 49.3418541; LONG. -80.4849777)
INCLINATION: -90° AZIMUTH: ---

RECORD OF DRILLHOLE: LA-3

SHEET 1 OF 1
DATUM: GEODETIC

DRILLING DATE: August 1, 2017
DRILL RIG: CME 55LC
DRILLING CONTRACTOR: Downing Drilling

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	COLOUR % RETURN	RECOVERY				FRACT. INDEX METRES	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY			Diametral Point Load Index (MPa)	RMC -Q AVG.
					DEPTH (m)	FLUSH			TOTAL CORE %	SOLID CORE %	R.Q.D. %	B Angle		DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	k, cm/s					
JN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate		BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage		PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular		PO - Polished K - Slickensided SM - Smooth Ro - Rough MB - Mechanical Break		BR - Broken Rock																
NOTE: For additional abbreviations refer to list of abbreviations & symbols.																								

19		REFER TO PREVIOUS PAGE		241.0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
----	--	------------------------	--	-------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

DEPTH SCALE
1 : 60



LOGGED: MR
CHECKED: AB



RECORD OF BOREHOLE No 1

W P 7-81-10 LOCATION Sta. 13+356.3 0.8 RT. of Detour Lake Rd. Line 'A' ORIGINATED BY RM
DIST 16 HWY Detour Lk. Rd BOREHOLE TYPE BX Casing & Wash COMPILED BY RM
DATUM Geodetic DATE 80 10 31 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV	ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100			
260.6 m	481.6 0.0	Ground Level													
		Mixture of Clay and Organics, Trace of Sand Some Undecayed Root Structures		1	SS	4									
		Soft													
256.8 m	477.8 3.8			2	SS	19									
		Silty Sand With Gravel and Trace of Clay		3	SS	9									
				4	SS	10									
				5	SS	31									
		Loose to Very Dense		6	SS	13/	10 cm								
				7	WS										
				8	SS	64									
				9	WS										
246.6 m	467.6 14.0			10	SS	90/	23 cm								
		Sand and Gravel Very Dense		11	WS										
243.9 m	464.9 16.7	End of Borehole Refusal													

+³, x⁵: Numbers refer to
Sensitivity

20
15
10

5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 2

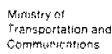
W P 7-81-10 LOCATION Sta. 13+314.0 2.0 RT of Detour Lake Rd. Line 'A' ORIGINATED BY RM
DIST 16 HWY Detour Lk. Rd. BOREHOLE TYPE BX Casing & Wash COMPILED BY RM
DATUM Geodetic DATE 80 11 16 CHECKED BY

ELEV	SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
	ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
									○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE						
									20 40 60 80 100							
260.6 m	481.6	Ground Level														
	0.0	Black Peat	~ ~													
259.7 m	480.7															
	0.9															
		Silt (Plastic)		1	SS	11									0 4 84 12	
		to														
		Silty Clay		2	SS	PM									0 3 79 18	
		(Low Plasticity)														
		Trace of Sand		3	SS	PM									0 5 90 5	
		Occ. Sand Layers														
				4	SS	PM									0 5 87 8	
				8	TW	PM										
		Soft														
		to		11	SS	PM										
		Firm														
				12	WS											
				13	SS	29										
247.6 m	468.6															
	13.0															
		Bedrock		14	RC	97%									0 5 91 4	
		Biotite Gneiss														
		Hard														
		Grey to Black		15	RC	100%										
		Sound														
247.0 m	466.0															
	15.6	End of Borehole														

+3, x⁵: Numbers refer to
Sensitivity

20
15
10

5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 3

W P 7-81-10 LOCATION Sta. 13+306.8 @ Detour Lake Rd. Line 'A' ORIGINATED BY RM
DIST 16 HWY Detour Lk. Rd. BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY RM
DATUM Geodetic DATE 80 11 20 CHECKED BY _____

[illegible]

+3, x5: Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLORATION



APPENDIX B

Laboratory Testing



**PRELIMINARY FOUNDATION REPORT
LITTLE ABITIBI RIVER BRIDGE REPLACEMENT
SITE 39E-201 HIGHWAY 652**

Table B1: Summary of Analytical Testing of Little Abitibi River Soil Samples

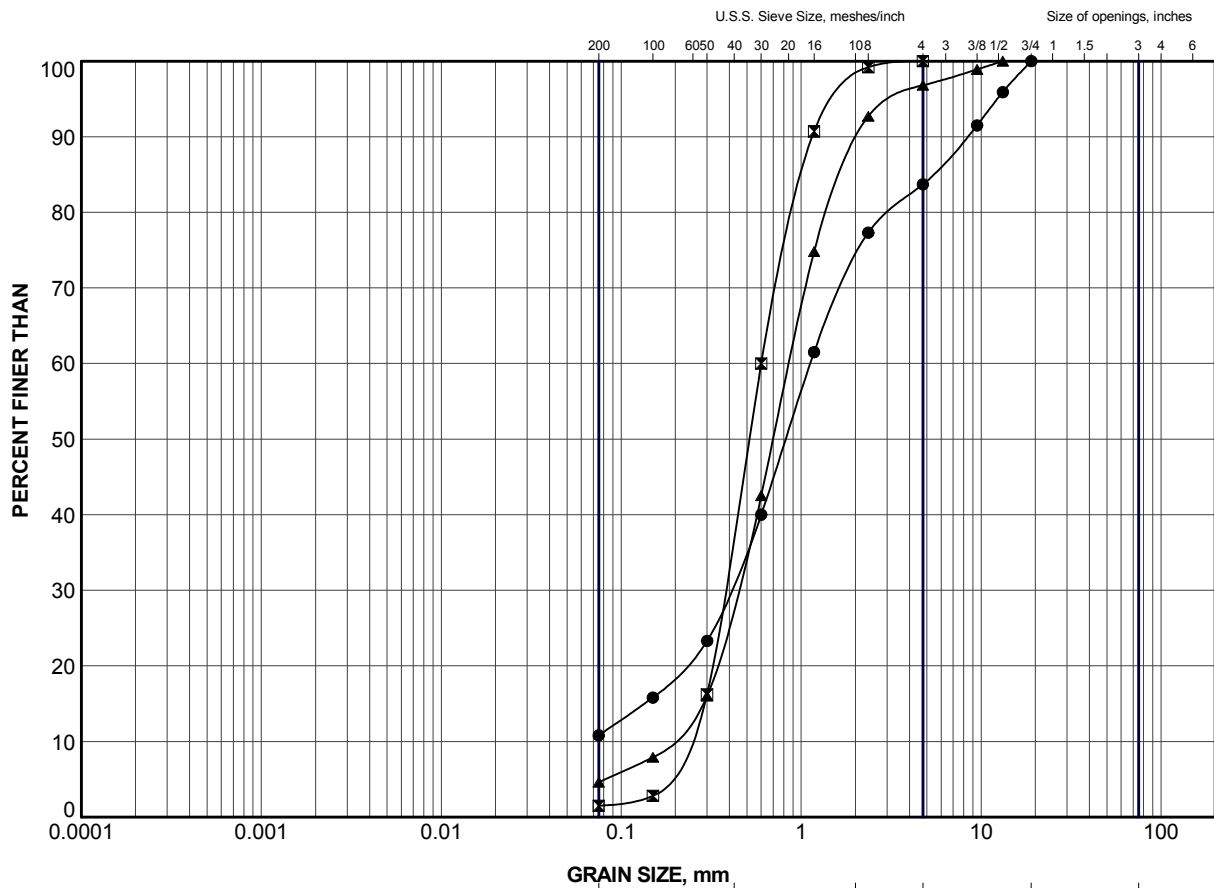
Location	Parameter	Units	Result
East Abutment (LA-1, Sa #5)	Chloride (CL)	ug/g	57
	Sulphate (SO4)	ug/g	ND
	Conductivity (EC)	umho/cm	159
	Resistivity	ohm-cm	6,300
	pH	n/a	7.82
West Abutment (LA-2, Sa #6)	Chloride (CL)	ug/g	32
	Sulphate (SO4)	ug/g	190
	Conductivity (EC)	umho/cm	331
	Resistivity	ohm-cm	3,000
	pH	n/a	7.84

Notes: 1. Samples from Boreholes LA-1 and LA-2 obtained on July 27, 2017, 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



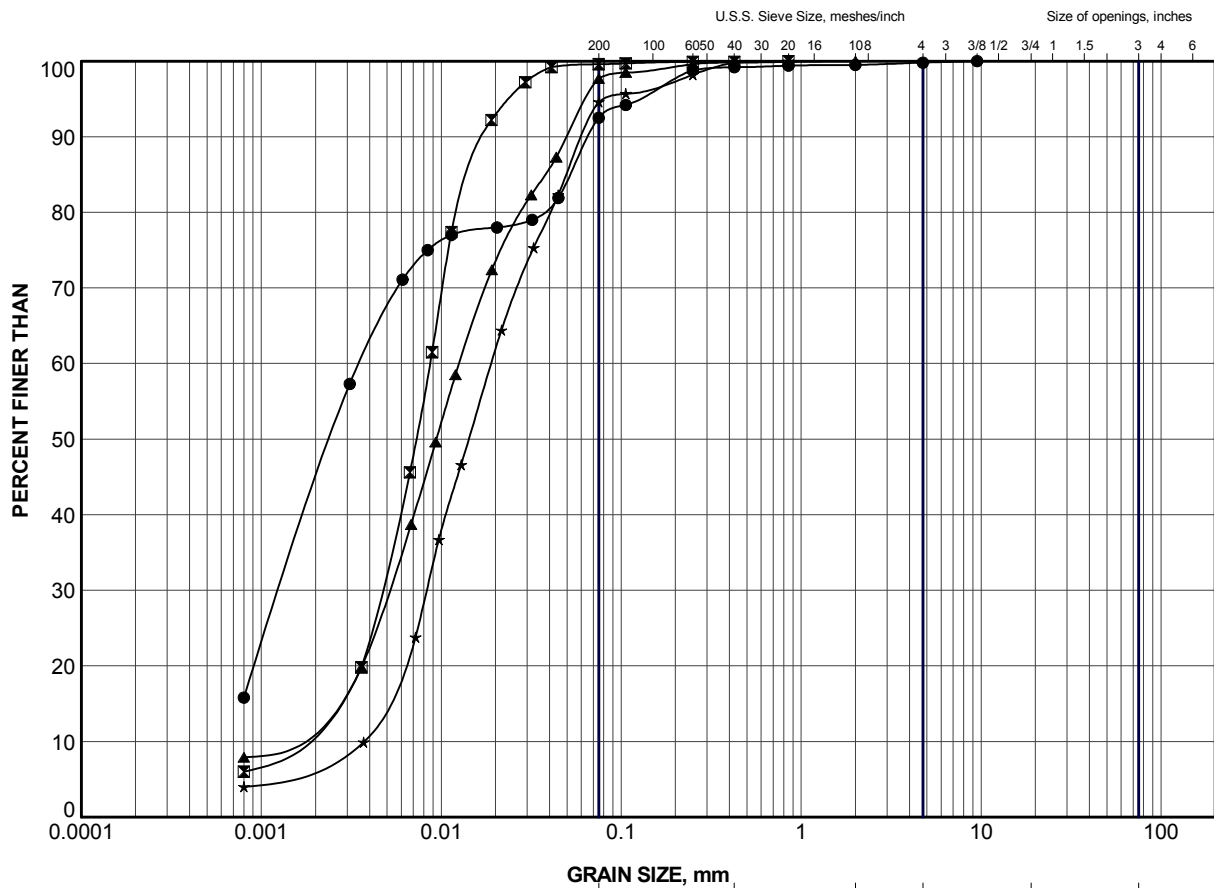
GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	LA-1	2	261.4
⊠	LA-1	6	258.3
▲	LA-2	3	260.9

PROJECT					
HIGHWAY 652 LITTLE ABITIBI RIVER					
TITLE					
GRAIN SIZE DISTRIBUTION SAND (FILL)					
PROJECT No.				FILE No. 1651997.GPJ	
DRAWN	TB	Jan 2018	SCALE	N/A	REV.
CHECK	AB	Jan 2018			
APPR	JPD	Jan 2018			
			FIGURE B1		



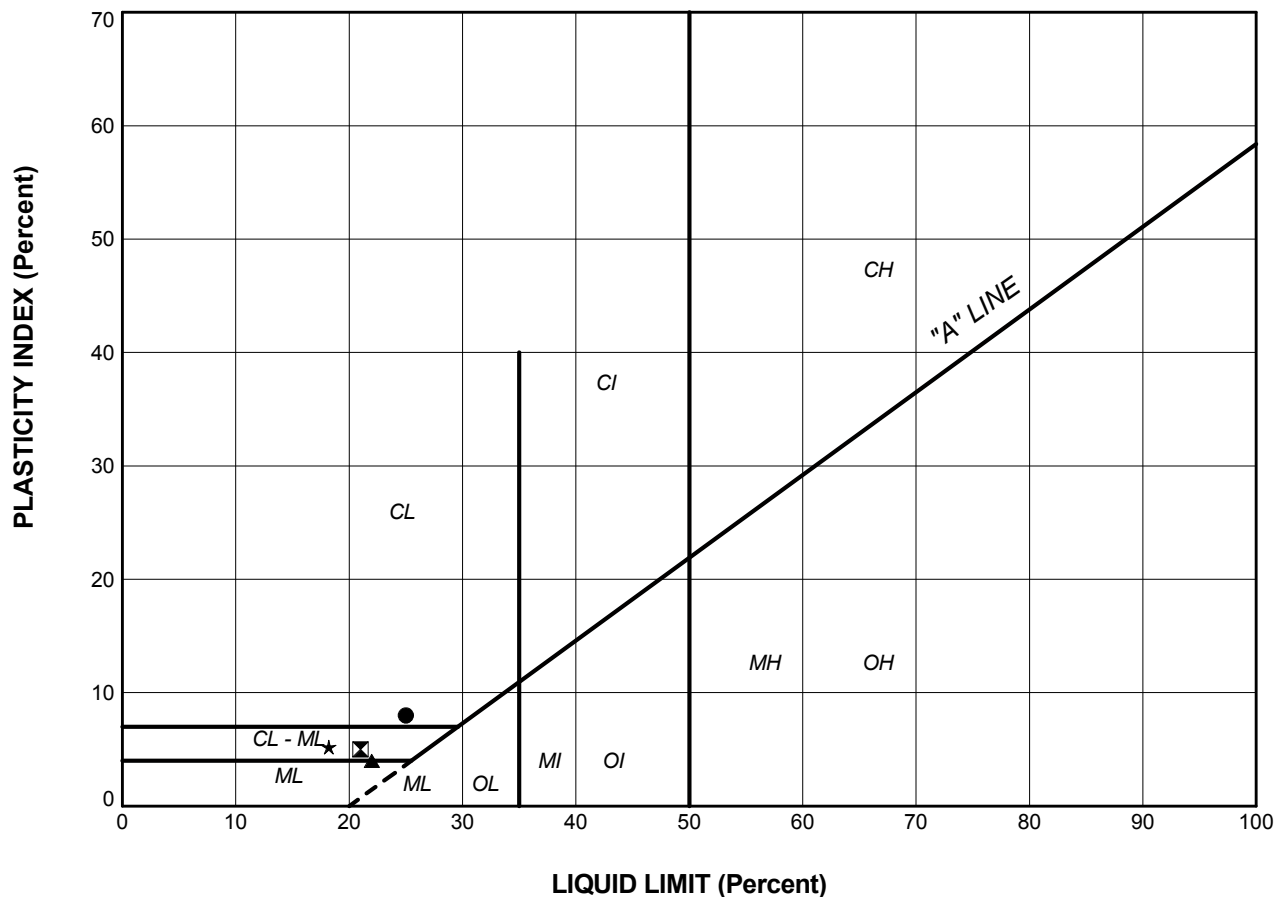


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	LA-1	7B	256.6
⊠	LA-2	5	259.4
▲	LA-2	7	257.1
★	LA-3	4	257.4

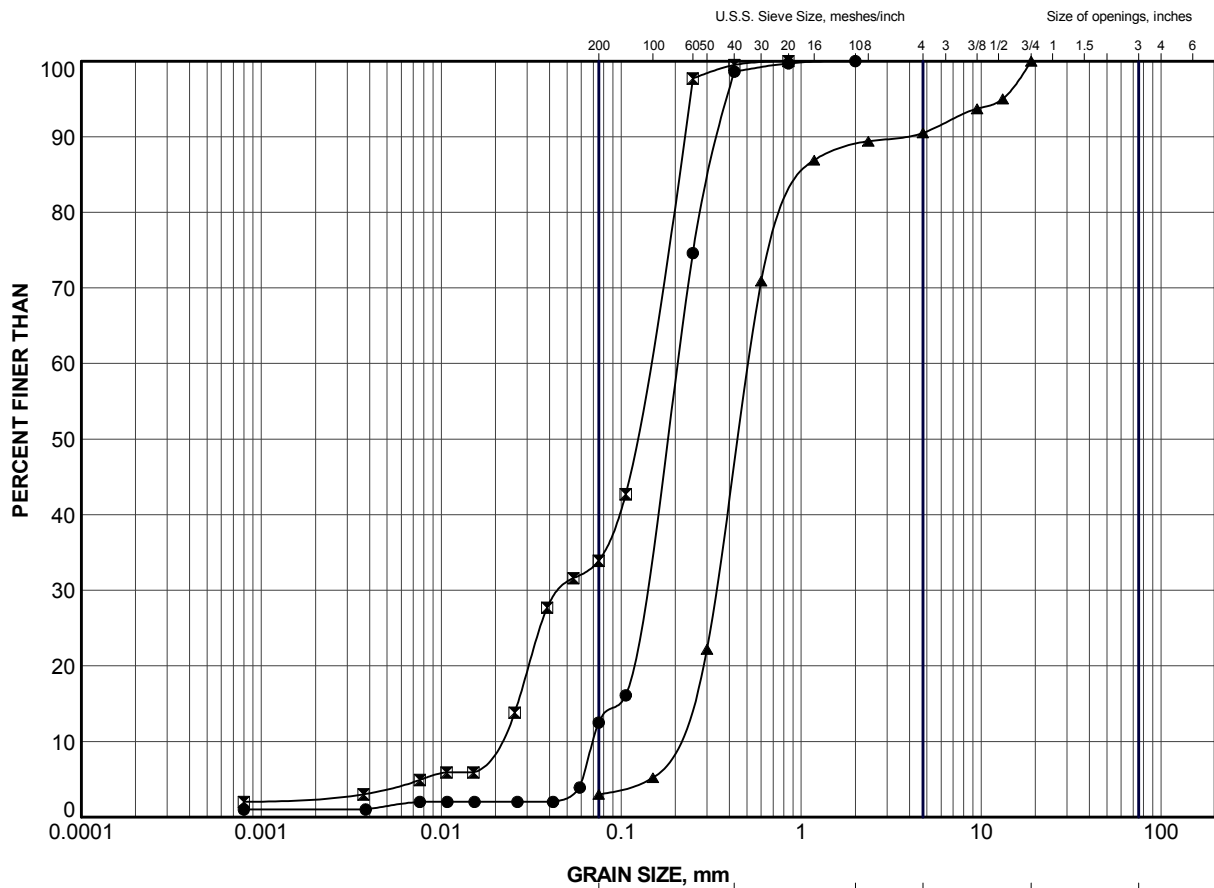
PROJECT					
HIGHWAY 652 LITTLE ABITIBI RIVER BRIDGE					
TITLE					
GRAIN SIZE DISTRIBUTION SILT to CLAYEY SILT					
PROJECT No.		1651997		FILE No. 1651997.GPJ	
DRAWN	TB	Apr 2018	SCALE	N/A	REV.
CHECK	AB	Apr 2018	FIGURE B2		
APPR	JPD	Apr 2018			
SUDBURY, ONTARIO					



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	2	1	25.0	17.0	8.0
⊠	2	2	21.0	16.0	5.0
▲	2	8	22.0	18.0	4.0
★	LA-1	7B	18.2	13.0	5.2

PROJECT					
HIGHWAY 652 LITTLE ABITIBI RIVER BRIDGE					
TITLE					
PLASTICITY CHART CLAYEY SILT to SILT of Slight Plasticity					
PROJECT No. 1651997			FILE No. 1651997.GPJ		
DRAWN	TB	Apr 2018	SCALE	N/A	REV.
CHECK	AB	Apr 2018			
APPR	JPD	Apr 2018			
GOLDER			FIGURE B3		
SUDBURY, ONTARIO					

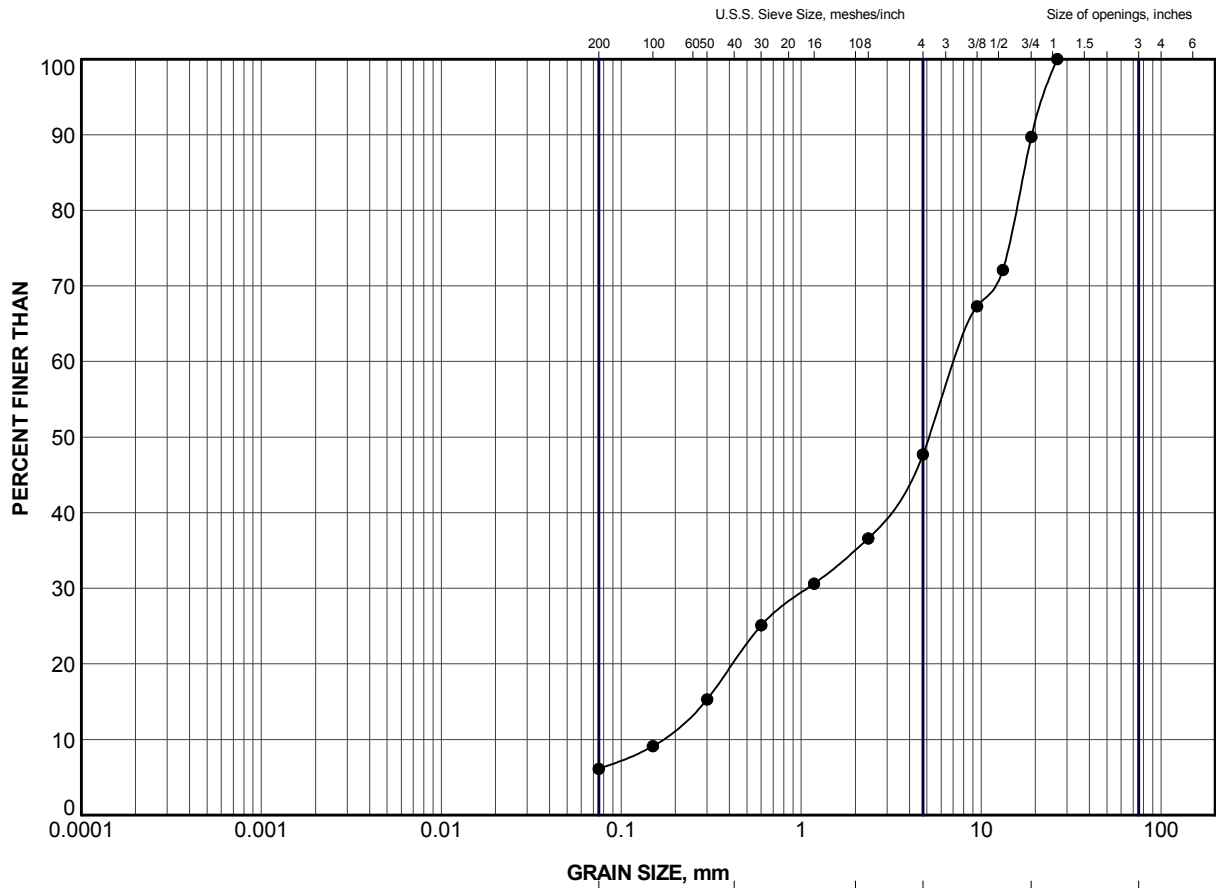


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	LA-1	8	255.3
⊠	LA-3	8	253.6
▲	LA-3	11	249.0

PROJECT					
HIGHWAY 652 LITTLE ABITIBI RIVER BRIDGE					
TITLE					
GRAIN SIZE DISTRIBUTION SAND and SILT to SAND					
PROJECT No.		1651997		FILE No. 1651997.GPJ	
DRAWN	TB	Apr 2018	SCALE	N/A	REV.
CHECK	AB	Apr 2018			
APPR	JPD	Apr 2018			
GOLDER SUDBURY, ONTARIO			FIGURE B4		



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

LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	LA-3	14	244.5

PROJECT					
HIGHWAY 652 LITTLE ABITIBI RIVER BRIDGE					
TITLE					
GRAIN SIZE DISTRIBUTION SAND and GRAVEL (TILL)					
PROJECT No.		1651997		FILE No. 1651997.GPJ	
DRAWN	TB	Apr 2018	SCALE	N/A	REV.
CHECK	AB	Apr 2018	FIGURE B5		
APPR	JPD	Apr 2018			
SUDBURY, ONTARIO					

Borehole LA-3



Box 1: 19.0 m – 22.2 m


PROJECT		Highway 652 Little Abitibi Bridge			
TITLE		Bedrock Core Photographs			
		PROJECT No. 1651997		FILE No. ----	
		DESIGN	AD	DEC 2017	SCALE NTS
		CADD	--	---	REV.
		CHECK	AB	JAN 2018	FIGURE B6
		REVIEW			

Golder Associates Ltd.

33 Mackenzie Street
Sudbury, Ontario, Canada P3C 4Y1
Telephone: (705) 524-8861
Fax: (705) 524-1984


**SUMMARY OF ROCK CORE TEST DATA**

PROJECT NO.: **1651997 5300**
PROJECT NAME: **AECOM/5015-E-0045/NE Retainer**
TYPE OF UNIT: **Rock Core**
TESTED BY: **JP**
DATE TESTED: **August 31, 2017**

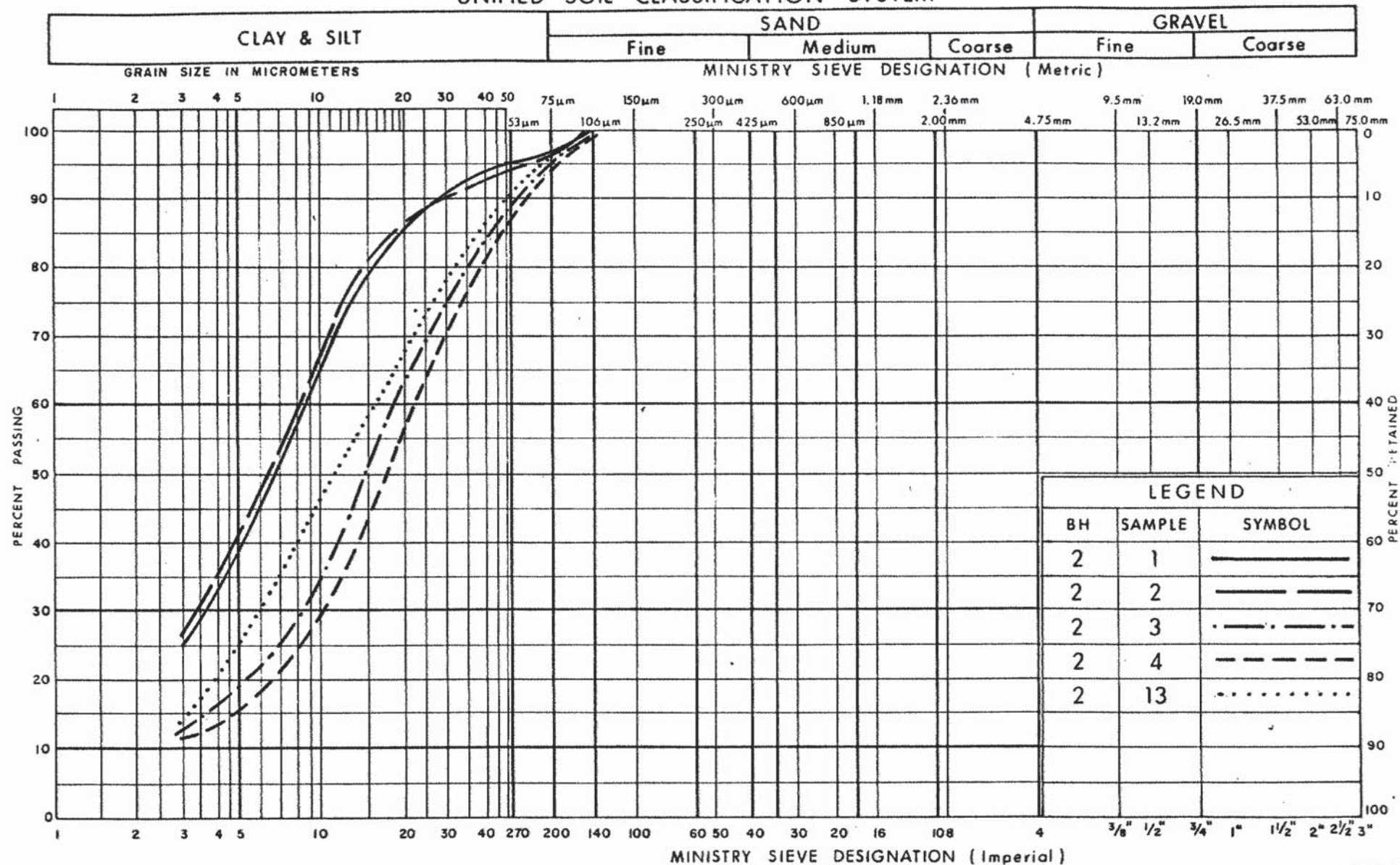
GOLDER LAB NUMBER	C1380				
BOREHOLE NUMBER:	LA-3				
SAMPLE NUMBER:	N/A				
DEPTH OF TESTED CORE (ft)	64.6				
LENGTH AS CUT (mm)	101.3				
DIAMETER (mm)	47.4				
DENSITY (kg/m3)	2745				
COMPRESSIVE STRENGTH (KN)	79.4				
CORRECTED STRENGTH (MPa)	45.0				
TYPE OF FRACTURE	3				
Type of Fracture  1 2 3 4 5 6					

COMMENTS:

Input by: SM
Reviewed by: [Signature]

PROJECT		Highway 652 Little Abitibi Bridge	
TITLE		Summary of Rock Core Test Data	
	PROJECT No.	1651997	FILE No. ---
	DESIGN	AD DEC 2017	SCALE NTS
	CADD	---	REV.
	CHECK	AC APR 2018	FIGURE B7
REVIEW			

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SILT TO SILTY CLAY
TRACE OF SAND

FIG No 1

WP 7-81-10

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
33 Mackenzie Street, Suite 100
Sudbury, Ontario, P3C 4Y1
Canada
T: +1 (705) 524 6861

