



May 22, 2018

PRELIMINARY FOUNDATION INVESTIGATION REPORT

LAWAGAMAU (FORMERLY KATTAWAGAMI) RIVER BRIDGE
SITE NO. 39N-009
LAT. 49.916291; LONG. -80.117385
HIGHWAY 652, COCHRANE UNORGANIZED (NORTH PART)
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5416-15-00, WP 5416-15-05

Submitted to:

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GEOCRES No.: 42H-78

Report Number: 1651997-WO5-R05

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REPORT





PRELIMINARY FOUNDATION REPORT LAWAGAMAU (FORMERLY KATTAWAGAMI) RIVER BRIDGE

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**PRELIMINARY FOUNDATION REPORT
LAWAGAMAU (FORMERLY KATTAWAGAMI) RIVER BRIDGE**

PART A

**PRELIMINARY FOUNDATION INVESTIGATION REPORT
LAWAGAMAU (FORMERLY KATTAWAGAMI) RIVER BRIDGE
SITE NO. 39N-009
HIGHWAY 652, COCHRANE UNORGANIZED (NORTH PART)
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5146-15-00, WP 5416-15-05**



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 Lawagamau (formerly Kattawagami) River Bridge (Site 39N-009). The bridge is located in the Cochrane Unorganized (North Part) District on Highway 652 at about Station 10+477, approximately 145 km north of Highway 11. The general location of this section of Highway 652 is shown in 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 the 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 oriented in a west-east direction at this site.

In general, the topography in the area of the structure is relatively flat terrain with densely forested areas immediately beyond the Highway 652 right-of-way and in the vicinity of the river. The existing bridge at the site consists of an approximately 54 m long by 4.6 m wide, three-span, single-lane Temporary Modular Bridge (TMB). Based on the information presented in the previous (August 1981) General Arrangement (GA) drawing (GEOCRES 42H-21), the existing bridge abutments are supported by timber cribs founded on rock fill pads with the piers founded on driven steel friction piles (HP 310x79). Based on the survey drawing provided by AECOM, the existing bridge deck is at approximately Elevations 300.4 m and 300.2 m at the west and east abutments, respectively.

The existing embankment front slopes are about 5 m high relative to the river bottom and inclined at profiles ranging from about 1.3 Horizontal to 1 Vertical (1.3H:1V) to 1.6H:1V. The existing approach embankment sides slopes are about 1.5 m to 2.5 m high and inclined at profiles ranging from about 1.7H:1V to 3H: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. However, as noted in the OSIM report, there is some minor erosion of the exposed granular front slope under the east abutment.

3.0 INVESTIGATION PROCEDURES

3.1 Previous Investigation

A previous foundation investigation was completed at the site in 1981 prior to construction of the existing bridge with the details of the investigation presented in the following report:

- Ministry of Transportation and Communications, 1981. Foundation Investigation Report for Detour Lake Access Road Line 'A', Kattawagami River Structure, W.P. 7-81-13, Site 39E-204. Geocres No. 42H-021.

Boreholes No. 1 and 2 advanced as part of the 1981 investigation, which were located at the west and east abutments respectively, were considered suitable for supplementing the current investigation. The locations of the 1981 boreholes have been approximated based on the previous Borehole Location and Soil Strata drawing and converted to approximate northing/easting coordinates in MTM NAD83 (Zone 12). Further, we understand from



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AECOM that the elevations of the ground surface at Boreholes No. 1 and 2 were originally surveyed to a local datum; for the purposes of this report, the ground surface elevations at Boreholes No. 1 and 2 have been converted to the geodetic datum based on the 2017 survey provided by AECOM.

Borehole No.	Approx. Location (MTM NAD 83, Zone12)		Approx. Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
1	5531357.0	368155.3	296.8	10.8
2	5531356.2	368210.1	298.0	9.6

The approximate locations of Boreholes No. 1 and 2 are shown on Drawing 1. Record of Boreholes No. 1 and 2 are presented in Appendix A.

3.2 Current Investigation

The fieldwork for the current subsurface investigation was carried out on July 30 and 31, 2017, during which time two boreholes (KR-1 and KR-2) were advanced at the approximate locations shown on Drawing 1. Boreholes KR-1 and KR-2 were advanced through the existing highway embankment at the east and west abutments, respectively, using a track-mounted CME 55LC drill rig equipped with 108 mm inside diameter hollow-stem augers. The drill rig was supplied and operated by George Downing Estate Drilling Ltd. of Grenville-sur-la-Rouge Quebec.

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). No groundwater was encountered in the open boreholes during the drilling operations as described on the Record of Borehole sheets in Appendix A. Boreholes KR-1 and KR-2 were backfilled with bentonite pellets and soil 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 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 determinations, grain size distributions and Atterberg limits were carried out on selected soil samples. The geotechnical laboratory testing was performed in accordance with MTO LS standards.

Selected soil samples from Boreholes KR-1 and KR-2 were obtained 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. It should be noted that the samples were submitted beyond the standard hold times and as such some parameters may not be reliable.



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The as-drilled borehole locations were measured and surveyed by a member of our technical staff, referenced to the highway centreline and existing bridge structure and converted to northing/easting coordinates on the plan drawing. The ground surface elevations were referenced to a local benchmark in the vicinity of the bridge and the benchmark elevation was obtained from the survey drawing (drawing 60546679-P40.dwg) provided by AECOM. The MTM NAD83 Zone12 northing/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)		Location (World Geodetic System 84)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting	Latitude	Longitude		
KR-1	5531356.2	368211.7	49.916284	-80.116982	300.5	5.2
KR-2	5531357.0	368153.8	49.916297	-80.117788	300.2	5.2

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS)¹ mapping, the Lawagamau River Bridge site is located within a ground moraine deposit consisting primarily of clay till, bordered by organic terrain deposits of peat and muck.

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.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the previous and current boreholes and the results of the 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) as presented on 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 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.

In general, the subsoil conditions consist of asphalt and granular embankment fill (for the current boreholes advanced through the embankment) and peat (for the previous boreholes advanced from the original ground surface prior to construction of the existing bridge and roadway embankment) underlain by deposits of clayey silt, sand and gravel, silty

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



PRELIMINARY FOUNDATION REPORT LAWAGAMAU (FORMERLY KATTAWAGAMI) RIVER BRIDGE

clay and silty clay glacial till. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes is provided below.

Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	SPT N-Values (blows/0.3 m)	Laboratory Testing
				Consistency or Compactness	
Asphalt	KR-1 and KR-2	0.09 and 0.05	300.5 and 300.2	n/a	n/a
(FILL) Sand and Gravel to Sand , trace to some silt, brown to grey; moist	KR-1 and KR-2	2.2 and 3.7	300.4 and 300.1	N = 6 to 23	w = 3% 2 – M (Fig. B1)
				Loose to Compact	
Peat	Boreholes No. 1 and 2	0.9	296.8 and 298.0	Very Soft	n/a
Clayey Silt , with sand to some sand, trace to some gravel, brown to grey; wet	KR-1 and KR-2 Boreholes No. 1 and 2	>2.9 and >1.4 (not fully penetrated in Boreholes KR-1 and KR-2) 3.4 and 4.9 (where fully penetrated in)	298.2 to 295.9	N = 3 to 51	w = 11% – 14% 2 – MH (Fig. B2) 2 – MH (Fig. No. 1) w _l = 16% – 24% w _p = 8% – 11% I _p = 5% – 14% 6 – AL (Fig. B3)
				Soft to Hard (but typically Stiff to Hard)	
Sand and Gravel , trace silt, trace clay	Boreholes No. 1 and 2	1.2 and 0.9	292.5 and 292.2	N ≥ 100	w = 6% and 18%
				Very Dense	
Silty Clay , trace sand	Borehole No. 1	1.2	291.3	N = 110	w = 25% 1 – MH (Borehole log only)
				Hard	
Het. mixture of silty clay and sand and gravel (GLACIAL TILL)	Boreholes No. 1 and 2	>4.1 and >2.9 (not fully penetrated)	290.1 and 291.3	N = >100 to 196	w = 6% – 36% 2 – MH (Fig. No. 2) w _l = 32% and 37% w _p = 14% and 16% I _p = 18% and 21%
				Hard/Very Dense	

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

w_p = plastic limit (%)

w_l = liquid limit (%)

I_p = plasticity index (%)



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Sand and Gravel

In three sampling attempts, the split-spoon did not penetrate the full sample depth with SPT 'N'-values of 100 blows per 8 cm to 13 cm of penetration, indicating a very dense state of compaction of the sand and gravel deposit.

Glacial Till

In four sampling attempts, the split-spoon did not penetrate the full sample depth with resulting SPT 'N'-values of 100 blows per 8 cm to 15 cm of penetration, indicating a very dense state of compaction or hard consistency in the glacial till deposit. In one instance, the split-spoon sampler was advanced full depth with an SPT 'N' value of 196 blows per 0.3 m of penetration. Although not noted in the previous (1981) investigation and not encountered within the borehole depths in the current investigation, consideration should be given to the potential presence of cobbles and boulders, which are typically present within glacially derived till deposits.

4.3 Groundwater Conditions

Groundwater was not encountered in the open boreholes during the current drilling investigation and the groundwater level(s) are not noted on the borehole records from the previous investigation. However, comments on the potential presence of perched water conditions based the wetness of the recovered samples is summarized below. The water level in the Lawagamau River near the bridge site was measured by others to be at Elevation 296.5 m in August 2017. Groundwater and river water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

Borehole	Ground Surface Elevation (m)	Depth to Groundwater (mbgs)	Groundwater Elevation (m)
KR-1	300.5	Dry (samples wet below 2.4 m)	Possible perched water at about 298.1
KR-2	300.2	Dry (samples wet below 3.8 m)	Possible groundwater level at about 296.4

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. David Muldowney, P.Eng. Mr. Paul Dittrich, P.Eng, a Designated MTO Foundations Contact and Principal of Golder, conducted an independent quality control review and technical audit of this report.

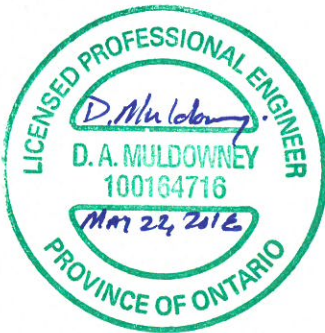


PRELIMINARY FOUNDATION REPORT LAWAGAMAU (FORMERLY KATTAWAGAMI) RIVER BRIDGE

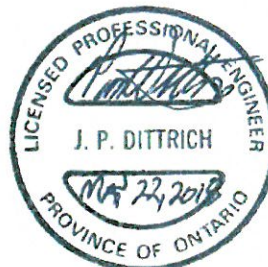
Report Signature Page

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MTO Foundations Designated Contact, Principal

AD/AC/DAM/JPD/ca

[https://golderassociates.sharepoint.com/sites/19476g/wo5_5_bridges_hwy_652/11_reporting/005-lawagamau\(kattawagami\)river/final/1651997-r005-r-rev0_aecom_mto_lawagamau\(kattawagami\)river_fir_22may_18.docx](https://golderassociates.sharepoint.com/sites/19476g/wo5_5_bridges_hwy_652/11_reporting/005-lawagamau(kattawagami)river/final/1651997-r005-r-rev0_aecom_mto_lawagamau(kattawagami)river_fir_22may_18.docx)



PHOTOGRAPHS



**Photograph 1: Lawagamau River Bridge
West Approach Facing East (July 2017)**



**Photograph 2: Lawagamau River Bridge
South Elevation Looking North-West (OSIM – June 2015)**



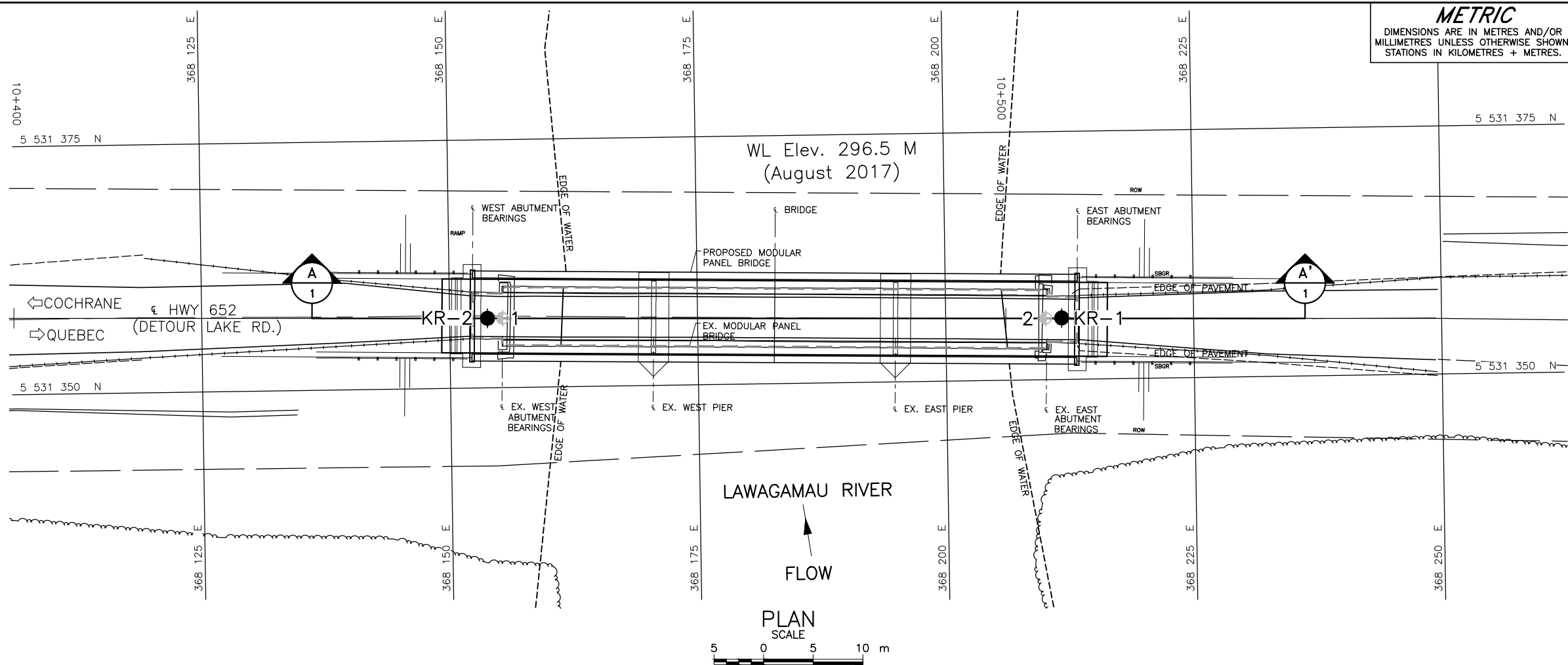
PHOTOGRAPHS



**Photograph 3: Lawagamau River Bridge
East Approach Looking West (OSIM Report - June 2015)**



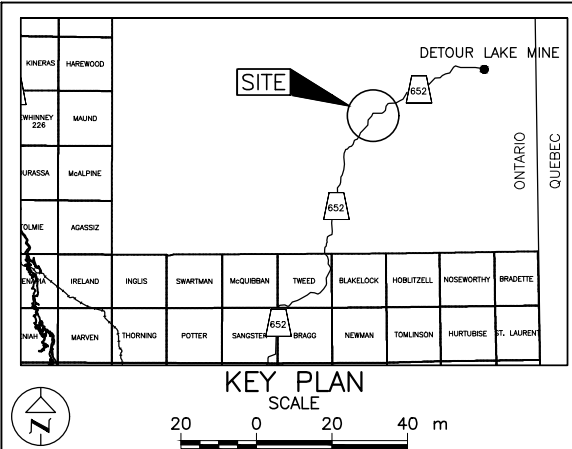
**Photograph 4: Lawagamau River Bridge
West Abutment looking West (OSIM Report – June 2015)**



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

CONT No. WP No.5416-15-05

HIGHWAY 652
LAWAGATAU RIVER BRIDGE
LAT. 49.916291; LONG. -80.117385
**BOREHOLE LOCATIONS AND
SOIL STRATA**



- LEGEND**
- Borehole - Current Investigation
 - Borehole - Previous Investigation by others (Approx. Location)
 - 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
KR-1	300.5	5531356.2	368211.7
KR-2	300.2	5531357.0	368153.8
1	296.8	5531357.0	368155.3
2	298.0	5531356.2	368210.1

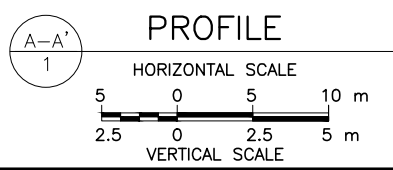
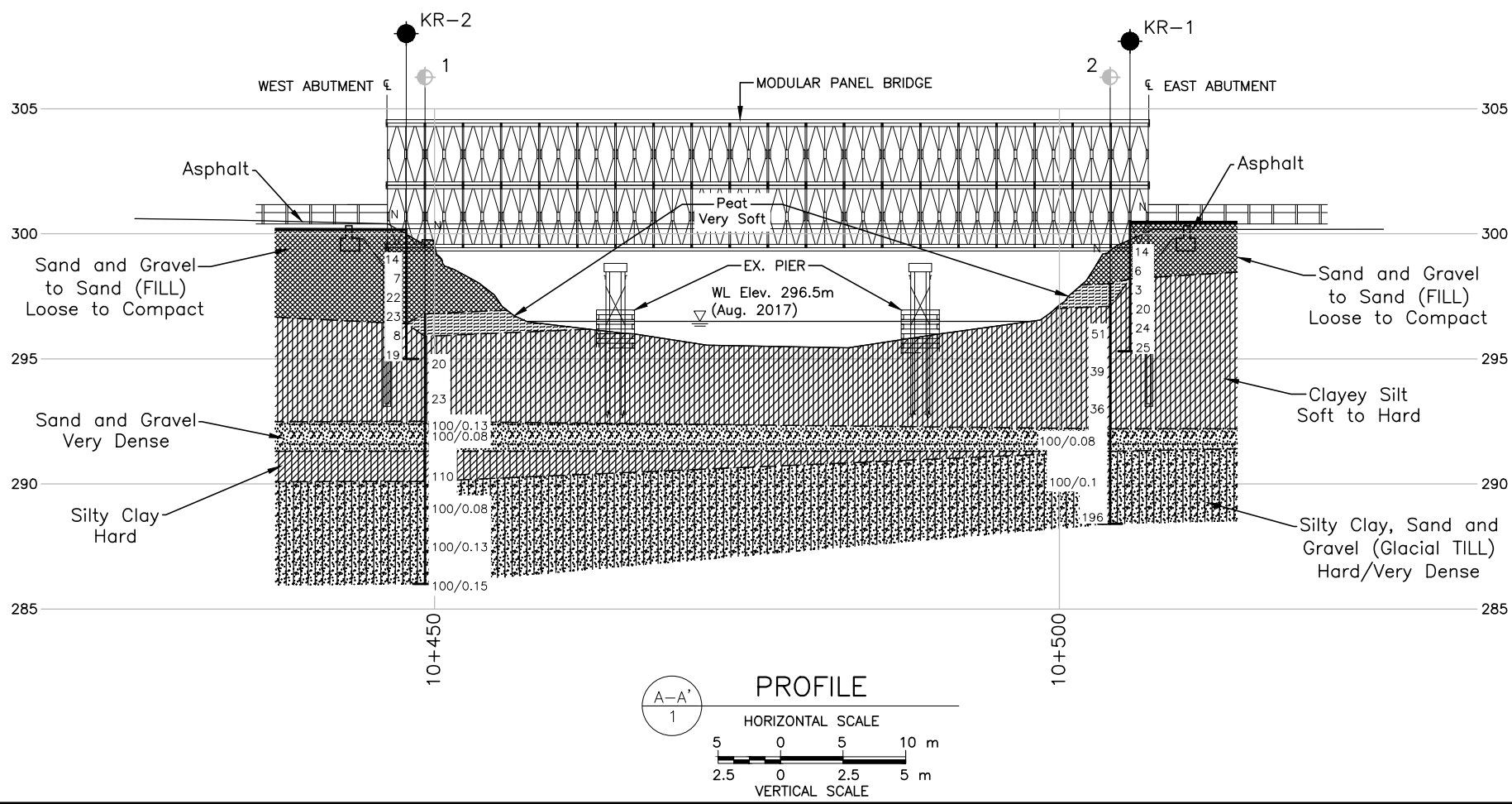
NOTES

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

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

REFERENCE

Base plans provided in digital format by AECOM, drawing file no. 60546679-P40.dwg, received DEC 20, 2017.



NO.	DATE	BY	REVISION
1	5/18/2018	JPD	1

Geocres No. 42H-78

HWY. 652	PROJECT NO. 1651997	DIST. .
SUBM'D. AD	CHKD. .	DATE: 5/18/2018
DRAWN: TB	CHKD. DAM	APPD. JPD
SITE: 39N-009	DWG. 1	



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

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

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

	c_u, s_u	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

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

V. MINOR SOIL CONSTITUENTS

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

PROJECT <u>16519971651997</u>		RECORD OF BOREHOLE No KR-1		1 OF 1 METRIC	
G.W.P. <u>5416-15-05</u>		LOCATION <u>N 5531356.2; E 368211.7 NAD83 MTM ZONE 12 (LAT. 49.916284; LONG. -80.116982)</u>		ORIGINATED BY <u>MR</u>	
DIST <u> </u> HWY <u>652</u>		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers</u>		COMPILED BY <u>TB</u>	
DATUM <u>GEODETIC</u>		DATE <u>July 30, 2017</u>		CHECKED BY <u>DAM</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	20	40	60	80	100	w _p	w		w _L			
300.5	GROUND SURFACE																			
0.0	ASPHALT (90 mm)																			
0.3	Sand and gravel, crushed (FILL)																			
	Sand, some gravel, trace to some silt (FILL)																			
	Loose to compact																			
	Brown to grey																			
	Moist		1	SS	14															
			2	SS	6								○					15	78 (7)	
298.2																				
2.3	CLAYEY SILT with SAND, trace to some gravel																			
	Soft to very stiff																			
	Brown		3	SS	3															
	Wet																			
			4	SS	20															
			5	SS	24								⊕					7	31 43 19	
			6	SS	25															
295.3																				
5.2	END OF BOREHOLE																			
	Note:																			
	1. Borehole dry 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 5-11-18 TB

PROJECT <u>16519971651997</u>		RECORD OF BOREHOLE No KR-2				1 OF 1 METRIC											
G.W.P. <u>5416-15-05</u>		LOCATION <u>N 5531357.0; E 368153.8 NAD83 MTM ZONE 12 (LAT. 49.916297; LONG. -80.117788)</u>				ORIGINATED BY <u>MR</u>											
DIST <u> </u> HWY <u>652</u>		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers</u>				COMPILED BY <u>TB</u>											
DATUM <u>GEODETIC</u>		DATE <u>July 31, 2017</u>				CHECKED BY <u>DAM</u>											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	20	40	60		
300.2	GROUND SURFACE																
0.9	ASPHALT (50 mm)																
299.6	Sand and gravel, crushed (FILL)																
0.6	Sand, some gravel, trace silt (FILL)																
	Loose to compact		1	SS	14												
	Brown to grey		2	SS	7												
	Moist		3	SS	22												
			4	SS	23												
296.4	CLAYEY SILT with SAND, trace gravel																
3.8	Stiff to very stiff		5	SS	8												
	Grey		6	SS	19												
	Wet																
295.0	END OF BOREHOLE																
5.2	Note: 1. Borehole dry 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 5-11-18 TB

RECORD OF BOREHOLE No 1

9

W P 7-81-3 LOCATION Sta. 52+620.2, & Line 'A' ORIGINATED BY R.M.
DIST 16 HWY Detour Lake Road BOREHOLE TYPE BX Casing, Washboring, Cone Test COMPILED BY O.J.
DATUM Assumed DATE 81 03 20 - 81 03 22 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

ELEV	SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
296.8 m	517.8	Ground Level											
295.9 m	516.9	Peat Very Soft											
	0.9												
		Silty Clay (Low Plasticity) Some Sand Traces of Gravel Very Stiff		1	SS	20		516					5 30 37 28
				2	SS	23		514					
292.5 m	513.5			3	SS	100	13 cm						
	4.3	Sand & Gravel, Traces of Silt & Clay		4	SS	100	8 cm						
291.3 m	512.3	V. Dense											
	5.5	Silty Clay (Stratified) Traces of Sand, Hard		5	SS	110		512					0 1 39 60
290.1 m	511.1												
	6.7	Het. Mixture of Silty Clay, Sand and Gravel		6	SS	100	8 cm	510					
		Hard		7	SS	100	13 cm	508					13 47 29 11
		Glacial Till		8	SS	100	15 cm						3 52 36 9
286.0 m	507.0												
	10.8	End of Borehole						506					

+³, x⁵: Numbers refer to Sensitivity
20
15 5 (%) STRAIN AT FAILURE
10

+3, x5: Numbers refer to Sensitivity



APPENDIX B

Laboratory Testing



**PRELIMINARY FOUNDATION REPORT
LAWAGAMAU (FORMERLY KATTAWAGAMI) RIVER BRIDGE**

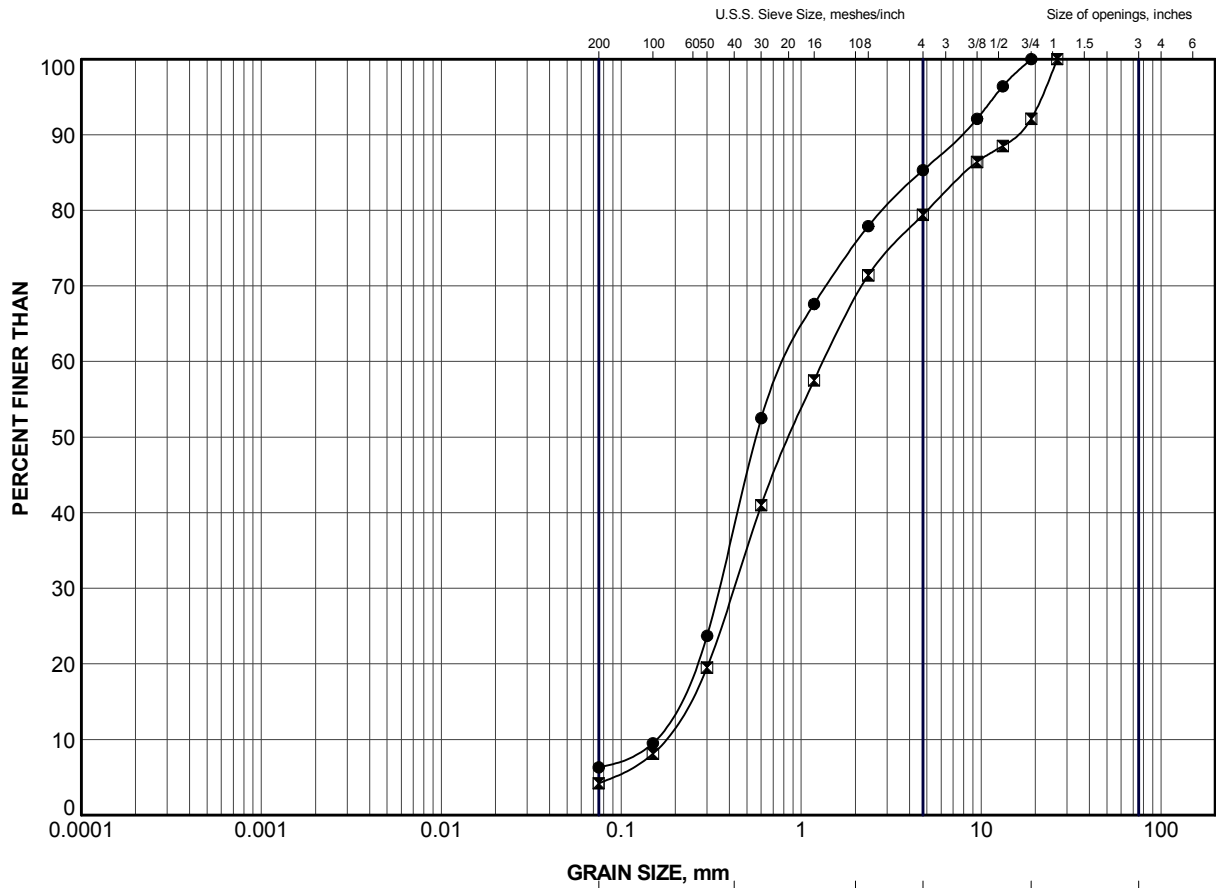
Table B1: Summary of Analytical Testing of Lawagamau River Soil Samples

Location	Parameter	Units	Result
East Abutment (KR-1, Sa #4)	Chloride (CL)	ug/g	35
	Sulphate (SO4)	ug/g	ND
	Conductivity (EC)	umho/cm	170
	Resistivity	ohm-cm	5900
	pH	n/a	7.8
West Abutment (KR-2, Sa #5)	Chloride (CL)	ug/g	28
	Sulphate (SO4)	ug/g	420
	Conductivity (EC)	umho/cm	516
	Resistivity	ohm-cm	1900
	pH	n/a	7.77

Notes: 1. Samples from Boreholes KR-1 and KR-2 obtained on July 30, 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: DAM



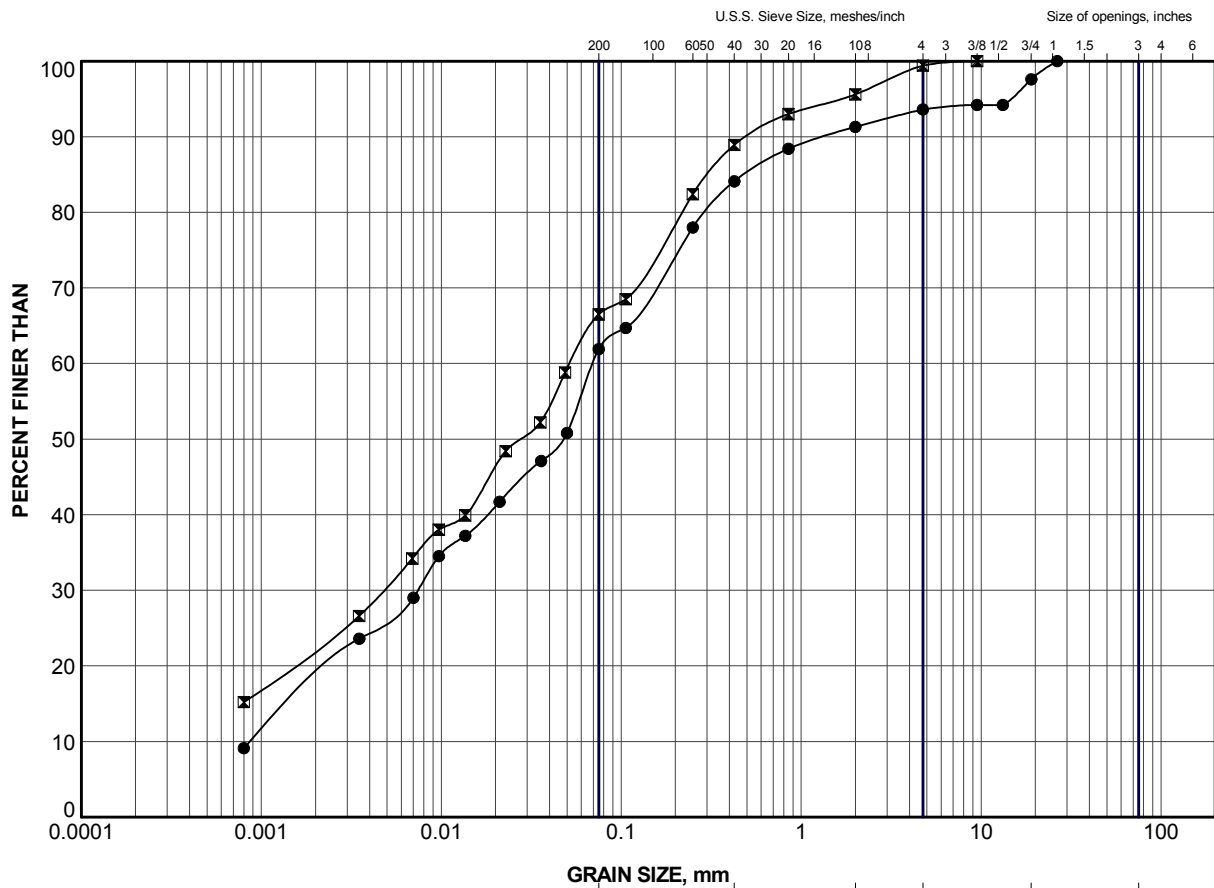
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	KR-1	2	298.7
⊠	KR-2	2	298.4

PROJECT						HIGHWAY 652 LAWAGAMAU RIVER BRIDGE					
TITLE						GRAIN SIZE DISTRIBUTION SAND (FILL)					
PROJECT No.						FILE No. 1651997.GPJ					
DRAWN	TB	Feb 2018	SCALE	N/A	REV.	FIGURE B1					
CHECK	DAM	Feb 2018									
APPR	JPD	Feb 2018									




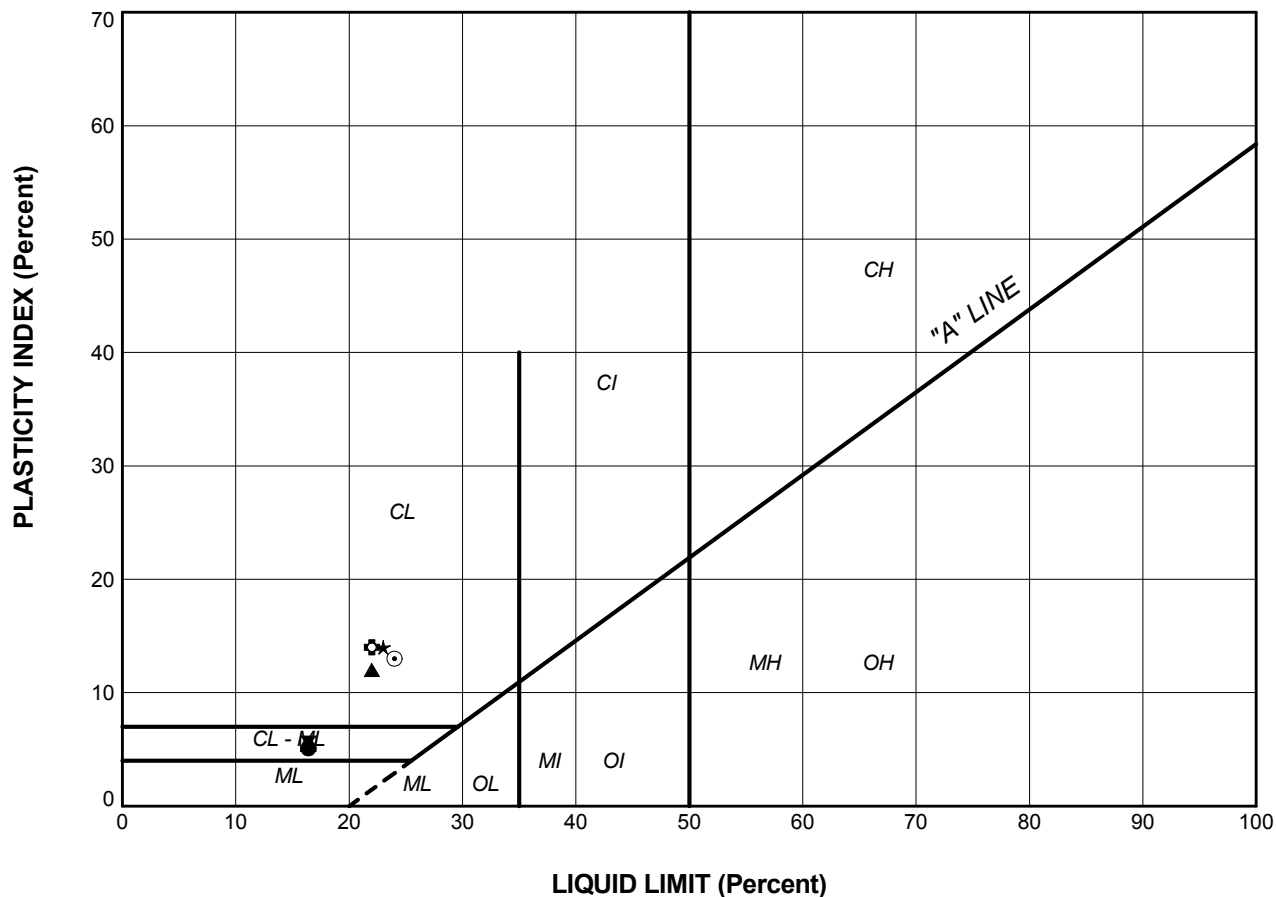


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	KR-1	5	296.4
×	KR-2	6	295.3

PROJECT						HIGHWAY 652 LAWAGAMAU RIVER BRIDGE					
TITLE						GRAIN SIZE DISTRIBUTION CLAYEY SILT					
PROJECT No.						FILE No. 1651997.GPJ					
DRAWN	TB	Feb 2018	SCALE	N/A	REV.						
CHECK	DAM	Feb 2018				FIGURE B2					
APPR	JPD	Feb 2018									
 Golder Associates SUDBURY, ONTARIO											



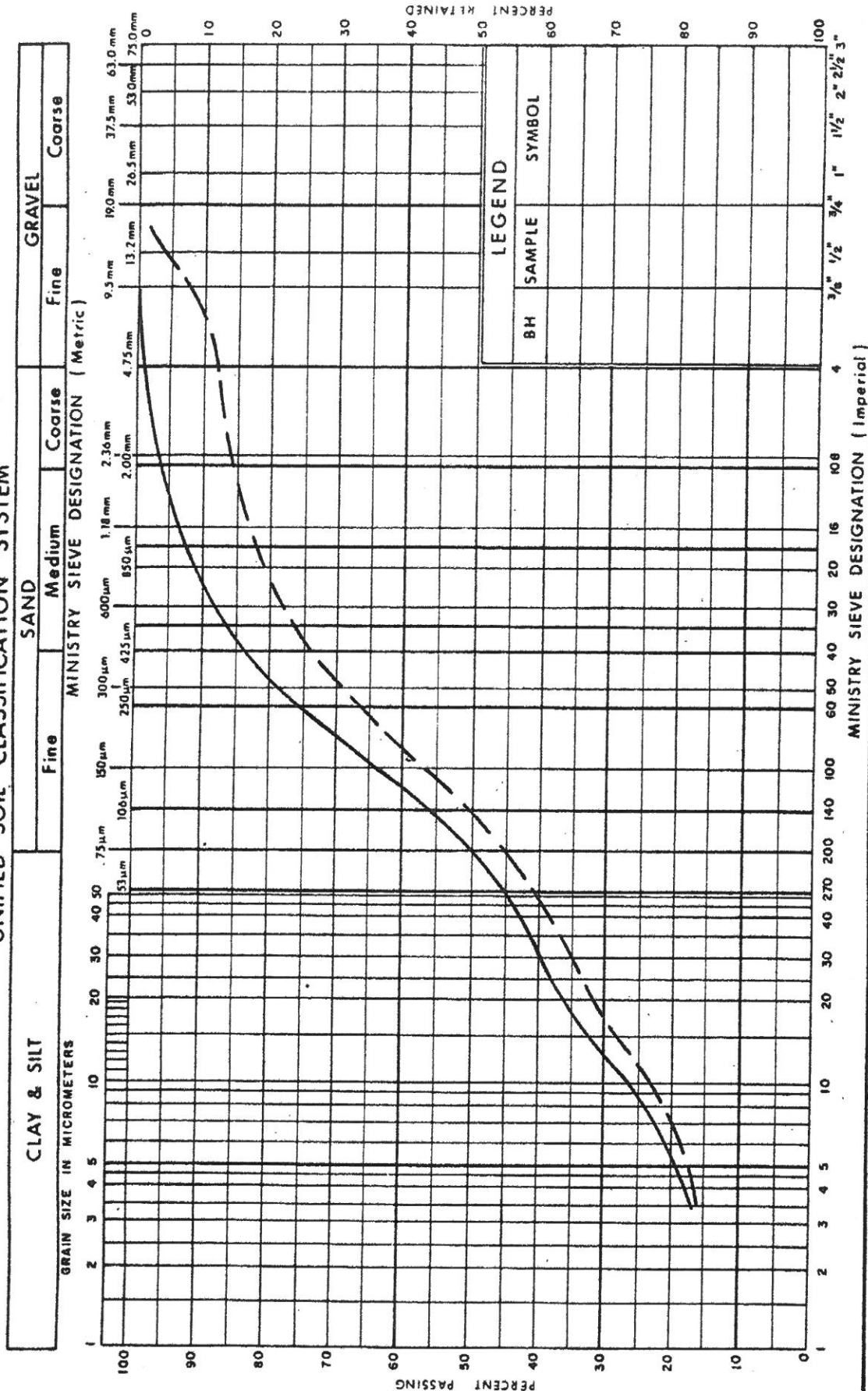
LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	KR-1	5	16.4	11.3	5.1
⊠	KR-2	6	16.4	10.9	5.5
▲	NO 1	1	22.0	10.0	12.0
★	NO 1	2	23.0	9.0	14.0
⊙	NO 2	2	24.0	11.0	13.0
⊕	NO 2	3	22.0	8.0	14.0

PROJECT					HIGHWAY 652 LAWAGAMAU RIVER BRIDGE				
TITLE					PLASTICITY CHART CLAYEY SILT				
PROJECT No.			FILE No.		1651997.GPJ				
DRAWN	TB	Feb 2018	SCALE	N/A	REV.				
CHECK	DAM	Feb 2018	FIGURE B3						
APPR	JPD	Feb 2018							



UNIFIED SOIL CLASSIFICATION SYSTEM

Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION GLACIAL TILL

FIG No 2

WP 7-81-13

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.

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