DRAFT REPORT

March 18, 2016

DRAFT DETAIL FOUNDATION INVESTIGATION REPORT

MCINTYRE RIVER CULVERT
SITE NO. 48C-36/C
HIGHWAY 589, DISTRICT OF THUNDER BAY
TOWNSHIP OF GORHAM
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P 6301-14-00, W.P. 6301-14-01

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GEOCRES No.

Report Number: **1411523-D7**
Distribution:

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Golder Associates

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PART A

DETAIL FOUNDATION INVESTIGATION REPORT
MCINTYRE RIVER CULVERT – SITE NO. 48C-36/C
HIGHWAY 589, DISTRICT OF THUNDER BAY
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Golder Associates

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Hatch Mott MacDonald (HMM), on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the replacement of the McIntyre River culvert (Site No. 48C-36/C). The McIntyre River culvert is located in the District of Thunder Bay on Highway 589 at STA 17+459 in the Township of Gorham, approximately 11.4 km north of Highway 102. The key plan showing the general location of this section of Highway 589 and the location of the investigated area are shown on Drawing 1.

2.0 SITE DESCRIPTION

The existing culvert consists of a Steel Plate Corrugated Steel Pipe Arch (SPCSPA), the details of which (i.e., width, height, length, etc.) are summarized in Table 1 following the text of the report.

In general, the topography in the area of the culvert is relatively flat with moderate to dense tree cover bordering the Highway right-of-way and McIntyre River. At the culvert location, the highway grade is at Elevation 418.6 m, the invert is at about Elevation 413.3 m and the river flows in an easterly direction.

Surface conditions in the culvert area from the inspection report dated February 2014 and from the field investigation in December 2014 are shown on Photographs 1 to 4, attached.

3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out on December 5 and 6, 2014, during which time a total of five boreholes (Boreholes MR-1 to MR-5) were advanced. Boreholes MR-1, MR-4 and MR-5 were advanced using a track-mounted CME-55 drill rig and Boreholes MR-2 and MR-3 were advanced using a truck-mounted CME 55 drill rig. Both drill rigs were supplied by and operated by George Downing Estate Drilling Ltd. of Grenville-Sur-La-Rouge, Quebec.

Boreholes MR-1, MR-4 and MR-5 were advanced at the toe of slope near the culvert inlet/outlet using 108 mm inside diameter hollow stem augers. Boreholes MR-2 and MR-3 were advanced from the existing highway platform using 108 mm inside diameter hollow stem augers and/or NW casing and wash boring techniques. Soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). Field vane shear tests were conducted in cohesive soils for determination of undrained shear strengths (ASTM D2573) using MTO Standard 'N' size vanes. The groundwater levels in the open boreholes were observed during the drilling operations as described on the Record of Borehole sheets in Appendix A. The boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The field work was supervised on a full-time basis by a member of Golder's technical staff who located the boreholes in the field, arranged for the clearance of underground services; supervised the drilling and sampling operations, logged the boreholes; and examined and cared for the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's geotechnical laboratory in Sudbury for further examination and laboratory testing. Index and classification testing consisting of water content determinations, grain size distributions, and Atterberg limits tests were carried out on selected soil samples. The geotechnical laboratory testing was completed according to MTO LS standards.

A sample of the river water was obtained during the field investigation, 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 were measured and surveyed by members of our technical staff, referenced to the highway centerline and existing culvert and converted into Northing/Easting on the plan drawing. The ground surface elevation of the highway centerline was obtained from the profile drawing provided by MTO (BC7355895.dwg). The MTM NAD83 northing and easting 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 Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
MR-1	5382090.6	352310.3	416.1	9.0
MR-2	5382088.0	352323.5	418.6	11.6
MR-3	5382099.5	352329.0	418.5	14.4
MR-4	5382094.6	352337.1	417.3	1.5
MR-5	5382107.7	352339.8	415.3	10.2

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on the Northern Ontario Engineering Geology Terrain (NOEGTS)[1] mapping, the subsoils in the vicinity of the McIntyre River culvert site generally consist of glaciolacustrine plain deposits, comprised primarily of clayey subsoils.

Based on geological mapping by the Ministry of Northern Development and Mines (Map 2542)[2], the site is underlain by bedrock of the Archean Era, comprised of mafic to intermediate metavolcanic rocks, consisting of basaltic and andesitic flows, tuffs and breccia's, chert, iron formation, minor metasedimentary and intrusive rocks, related migmatites.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole sheets contained in Appendix A. The results of geotechnical laboratory testing are contained in Appendix B. The results of the in situ field tests (i.e., SPT 'N' values and undrained shear strengths from field vanes) as presented on the Record of Borehole sheets and in Section 4 are uncorrected. The stratigraphic boundaries shown on the boreholes records and on the interpreted stratigraphic section on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions

[1] Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 52ANW

[2] Ministry of Northern Development of Mines. Bedrock Geology of Ontario – West Central Sheet, Ontario Geological Survey – Map 2542.

between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

Subsoil Conditions

In summary, the subsoil conditions encountered at the site consist of asphalt and granular fill (for boreholes through the embankment), or cohesive silty clay fill underlain by an organic silt to organic silty clay deposit (for the boreholes advanced at the toe of the embankment). The fill or organic deposits are underlain by a cohesive deposit of clayey silt to clay, which is underlain in one instance by a deposit of sand and gravel. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes is provided in the following table and sections.

Deposit/Layer Description	Boreholes	Thickness (m)	Elevation (m)	N Values (blows) / Shear Strength (kPa) Consistency or Relative Density	Laboratory Testing
Asphalt	MR-2, MR-3	0.065 – 0.075	418.6 – 418.5	n/a	n/a
(FILL)[1] sand to sand and gravel, some cobbles, trace to some silt, trace clay, brown, frozen to wet	MR-2, MR-3	5.5	418.5 – 418.4	N = 9 – 25 [2] **Loose to Compact**	w = 9% – 33 % 1 – MH and 2 – M (Fig. B1)
(FILL) silty clay, trace organics, some gravel, some sand, reddish brown to dark brown, frozen	MR-1, MR-5	0.8	416.1 – 415.3	N = 17 – 24 **Frozen**	w = 20 %
Organic Silt to Organic Silty Clay, trace to some sand, dark brown, wet	MR-1, MR-5	1.6 – 2.6	415.3 – 414.5	N = 2 – 6 s_u = 40 **Soft to Firm**	w = 33% – 39% 2 – MH (Fig. B2) 2 – AL (Fig. B3) w_p = 26% – 31% w_l = 47% – 54% I_p = 21% – 23% 2- OC = 5% - 7%
Clayey Silt to Clay[3], trace sand, trace organics, reddish brown, wet	MR-1, MR-2, MR-3 and MR-5	MR-3 = 8.0, All other boreholes terminated in this deposit	413.0 – 412.7	N = 2 – 11 s_u = 38 – >100[4] **Firm to Very Stiff**	w = 30% – 67%; 31%[3] 8 – MH (Fig. B4) 8 – AL (Fig. B5) w_p = 16% – 29%; 16%[3] w_l = 32% – 79%; 22%[3] I_p = 16% – 50%; 5%[3] 2 - OC = 1%
Sand and Gravel, trace to some silt, grey, wet	MR-3	0.8	404.9	N = 37 **Dense**	w = 10% 1 – M (Fig. B6)

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)
w = Natural Moisture Content (%)
MH = Combined Sieve and Hydrometer analysis
M = Sieve analysis
AL = Atterberg Limits Test
w_p = Plastic Limit (%)
w_l = Liquid Limit (%)
I_p = Plasticity Index (%)
OC = Organic Content (%)

Notes:
[1] Cobbles were encountered throughout the fill deposit in Boreholes MR-2 and MR-3 ranging from 120 mm to 225 mm diameter, requiring NW casing and NQ coring techniques to advance the boreholes through this deposit.

Borehole MR-4 was terminated at Elevation 415.8 m within the fill deposit likely due to the presence of cobbles and/or boulders, and an additional Borehole, MR-5, was advanced on the opposite side of the river.

[2] In the granular fill, two SPT 'N'-values of 41 blows and 87 blows per 0.3 m of penetration were recovered, however these are likely indicative of the frozen state of the material and are not representative. Further, one SPT 'N'-value of 20 blows for 0.05 m of penetration was recovered, likely indicative of the presence of a cobble and/or boulder.

[3] A clayey silt to silt seam was encountered in Borehole MR-2 within the clayey silt to clay deposit at approximately 9.1 m depth. The natural moisture content measured on a sample of the clayey silt to silt seam is about 31 per cent. The result of a grain size distribution test completed on the clayey silt to silt seam within the clayey silt to clay deposit is shown on Figure B4. One Atterberg limit test was carried out on a sample of the clayey silt to silt seam within the clayey silt to clay deposit yielded a liquid limit of about 22 per cent, a plastic limit of about 16 per cent and a corresponding plasticity index of about 5 as shown on Figure B5. Based on the results of the Atterberg limit test the material is classified as clayey silt to silt of slight plasticity.

[4]Typically, the deposit is stiff in consistency in the boreholes drilled through the existing embankment.

Refusal

Refusal to further casing and split spoon penetration was encountered in Borehole MR-3, corresponding to Elevation 404.1 m.

Groundwater Conditions

Boreholes MR-1, MR-4 and MR-5 were noted to be dry upon completion of drilling. Boreholes MR-2 and MR-3 caved at depths of 3.8 m and 3.9 m, respectively upon completion of drilling and boreholes were noted to be dry to the caved depths. The river ice level was measured at Elevation 414.6 m on December 4, 2014. Groundwater and river water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

5.0 CLOSURE

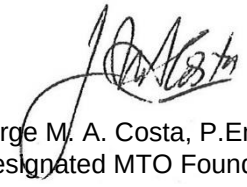
The field drilling program was carried out under the supervision of Mr. Cody Walter and Mr. Mathew Riopelle, under the overall direction of Mr. David Muldowney, P.Eng. This Detail Foundation Investigation Report was prepared by Mr. Adam Core, P.Eng., and Ms. Sarah E. M. Poot, P.Eng., an Associate of Golder provided a technical review of the report. Mr. Jorge M. A. Costa, P.Eng., the Designated MTO Foundations Contact and Principal of Golder conducted an independent quality control review and technical audit of this report.

Report Signature Page

GOLDER ASSOCIATES LTD.

Adam Core, P.Eng.
Geotechnical Engineer

Sarah E. M. Poot, P.Eng.
Geotechnical Engineer, Associate



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

AC/SEMP/JMAC/kp

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Table 1: Summary Details of Existing Culvert

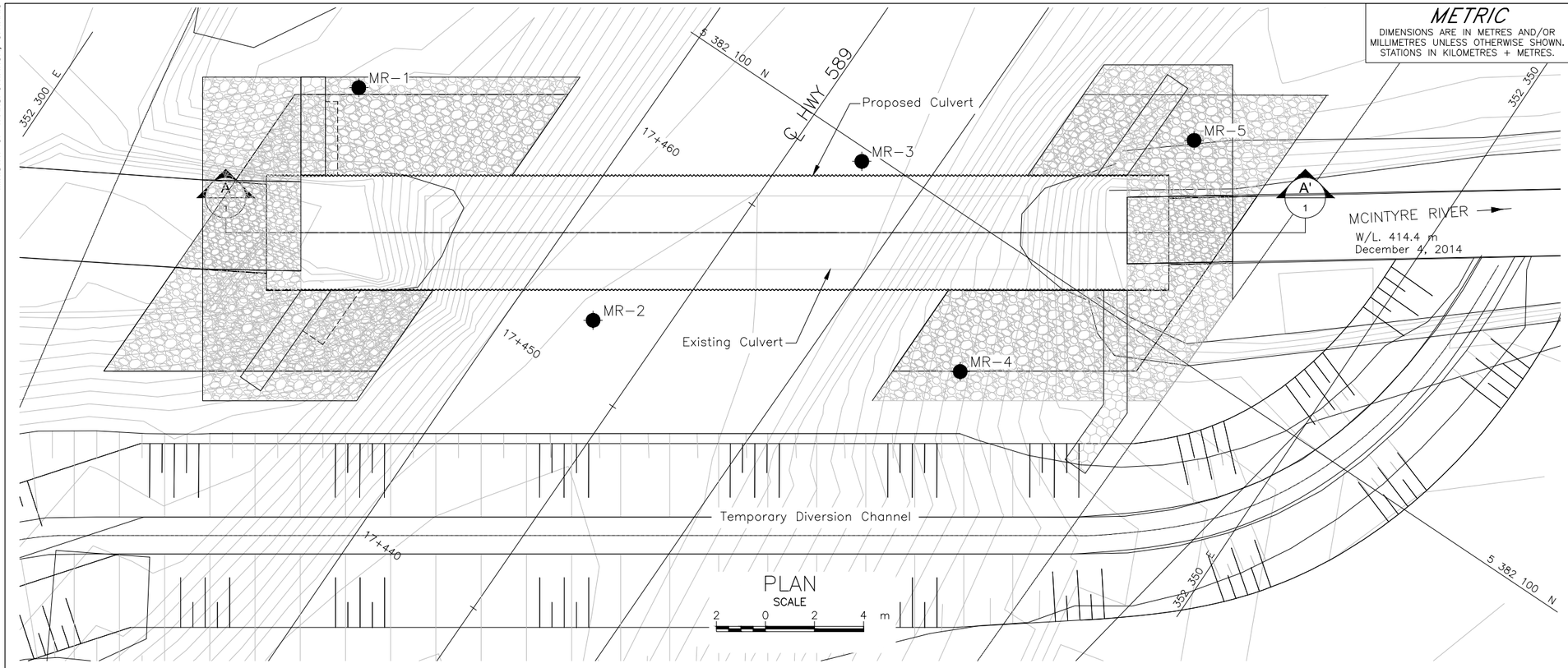
Culvert Location (Township)	Site #	Approximate Height of Embankment[1] (m)	Existing Culvert			Approximate Invert Elevation[2] (m)
			Type	Approximate Dimension[2] (m)	Approximate Length (m)	
Hwy 589 STA 17+459 (Township of Gorham)	48C-36/C	5.3	Steel Plate Corrugated Steel Pipe Arch (SPCSPA)	4.3 m x 2.7 m	21	413.3

Notes: 1. Embankment height is relative to existing ground surface at the centreline of the roadway and the invert elevation of the culvert.

2. Culvert dimensions are based on the RFP and invert elevation are based on the plan and profile drawing provided by MTO on drawing BC7355895.dwg.

Prepared by: AC
Checked by: SEMP
Reviewed by: FJH/JMAC

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN
SCALE
2 0 2 4 m

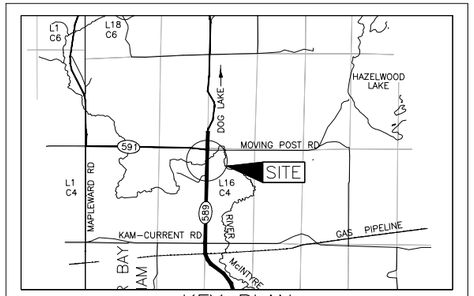
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 6301-14-00

HIGHWAY 589
MCINTYRE RIVER CULVERT STA 17+459
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

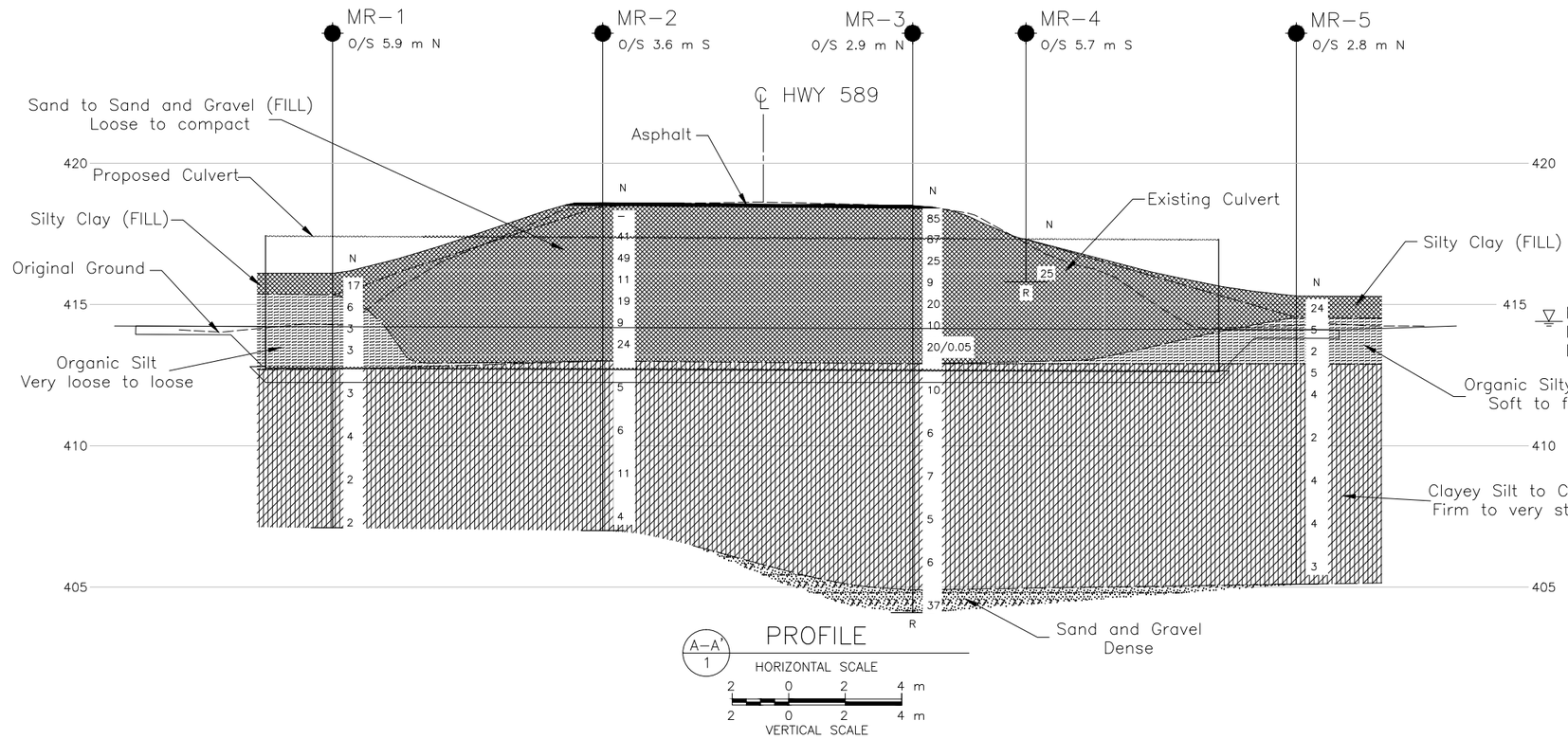
Golder Associates



KEY PLAN

LEGEND

- Borehole
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- R Refusal



A-A'
1
PROFILE
HORIZONTAL SCALE
2 0 2 4 m
VERTICAL SCALE
2 0 2 4 m

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
MR-1	416.1	5382090.6	352310.3
MR-2	418.6	5382088.0	352323.5
MR-3	418.5	5382099.5	352329.0
MR-4	417.3	5382094.6	352337.1
MR-5	415.3	5382107.7	352339.8

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.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by Hatch Mott MacDonald, drawing file no. ST-343033-MCINTYRE RIVER ARCH CULVERT-01-GENERAL ARRANGEMENT.dwg, dated MAR 2016, received MAR 8 2016.

DRAFT

NO.	DATE	BY	REVISION
.	.	.	.

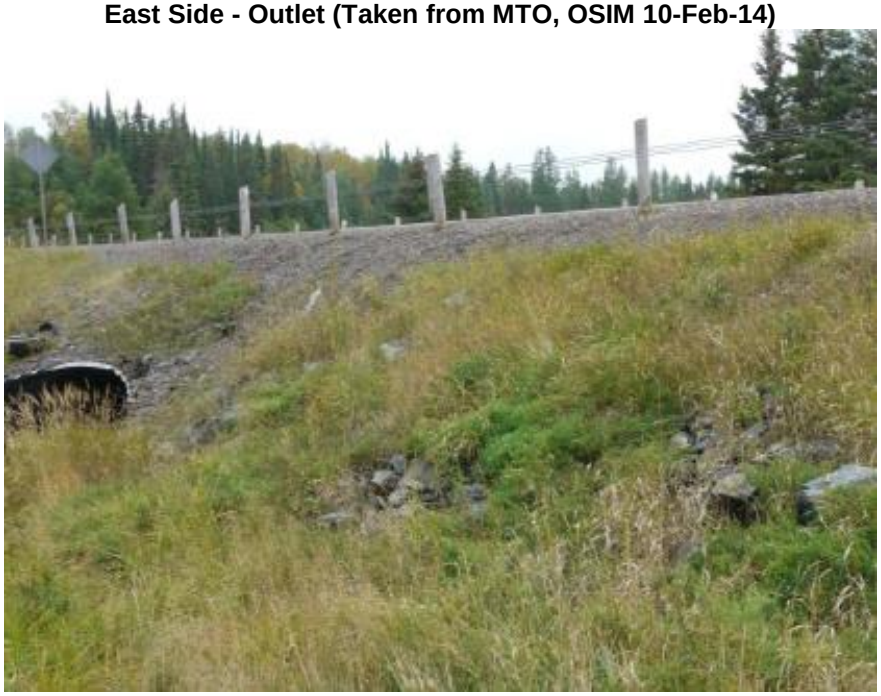
Geocres No. .

HWY. 589	PROJECT NO. 1411523		DIST. .
SUBM'D. AC	CHKD. DAM	DATE: 3/15/2016	SITE: 48C-36/C
DRAWN: JJL	CHKD. SEMP	APPD. JMAC	DWG. 1

PLOT DATE: March 18, 2016
FILENAME: H:\CAD\Projects\2014\1411523 HMM 26 Culverts Thunder Bay\CIVIL 3D\1411523_McIntyre River.dwg

Photograph 1: McIntyre River Culvert
West Side - Inlet (Taken from MTO, OSIM 10-Feb-14)

Photograph 2: McIntyre River Culvert
East Side - Outlet (Taken from MTO, OSIM 10-Feb-14)



Photograph 3: McIntyre River Culvert
Looking West at Culvert (Golder – 3-Dec-14)

Photograph 4: McIntyre River Culvert
Looking West at Culvert (Golder – 3-Dec-14)

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 δ
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d:

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

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

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

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RECORD OF BOREHOLE No MR-1

1 OF 1 **METRIC**

PROJECT 1411523 | G.W.P. 6301-14-00 | LOCATION N 5382090.6; E 352310.3 | ORIGINATED BY CW

DIST | HWY 589 | BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers | COMPILED BY SEMP

DATUM GEODETIC | DATE December 3, 2014 | CHECKED BY DAM

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 + FIELD VANE ● QUICK TRIAXIAL × 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
416.1	GROUND SURFACE						416			
0.0	Silty clay with organics (FILL) Reddish-brown Frozen		1	SS	17					
415.3							415			
0.8	ORGANIC SILT, trace to some sand Soft to firm Reddish-brown Wet		2	SS	6					
			3	SS	3		414			OC=7.0% 0 7 73 20
			4	SS	3					
412.7							413	2 1		
3.4	SILTY CLAY to CLAY, trace sand, trace organics Firm to stiff Reddish-brown Wet		5	SS	3		412			OC=1.4% 0 5 45 50
			6	SS	4		411	2 2		
			7	SS	2		410	3 3		
			8	SS	2		409			0 0 15 85
407.1							408	3 2		
9.0	END OF BOREHOLE Note: 1. Borehole dry upon completion of drilling.									

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

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RECORD OF BOREHOLE No MR-2

1 OF 1 **METRIC**

PROJECT 1411523 | G.W.P. 6301-14-00 | LOCATION N 5382088.0; E 352323.5 | ORIGINATED BY MR

DIST | HWY 589 | BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers, NW Casing, Wash Boring | COMPILED BY SEMP

DATUM GEODETIC | DATE December 3, 2014 | CHECKED BY DAM

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)	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
418.6	GROUND SURFACE										
0.0	ASPHALT (75 mm)										
0.1	Sand, some gravel, trace to some silt, trace clay (FILL) Loose to compact Brown Frozen / wet Upper 1.4 m frozen. 225 mm cobble at 1.7 m depth. 150 mm cobble at 2.1 m depth. 175 mm cobble at 2.9 m depth.		1	AS	-		418		○		14 74 10 2
			2	SS	41						
			3	SS	49		417				
			4	SS	11		416				
			5	SS	19		415				
			6	SS	9				○		18 74 (8)
			7	SS	24		414				
413.0											
5.6	SILTY CLAY, trace sand Stiff to very stiff Reddish-brown Wet		8	SS	5		413				
							412	>100 >100			
			9	SS	6		411		⊢○		0 2 53 45
							410	+ 2 + 2			
	Clayey silt to silt seam encountered at 9.1 m depth.		10	SS	11		409		⊢○		0 0 74 26
							408				
			11	SS	4						
407.0							407	2			
11.6	END OF BOREHOLE Note: 1. Refusal on cobble at 1.7 m depth. Samples 4 through 11 obtained from additional borehole advanced 1.2 m north of MR-2. 2. Borehole caved at 3.8 m depth upon completion of drilling. Borehole dry to 3.8 m depth upon completion of drilling.										

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

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 09/03/15 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No MR-3

1 OF 2 **METRIC**

PROJECT 1411523 | G.W.P. 6301-14-00 | LOCATION N 5382099.5; E 352329.0 | ORIGINATED BY MR

DIST | HWY 589 | BOREHOLE TYPE NW Casing, Wash Boring | COMPILED BY SEMP

DATUM GEODETIC | DATE December 4 and 5, 2014 | CHECKED BY DAM

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
418.5	GROUND SURFACE										
0.0	ASPHALT (65 mm)										
0.1	Sand and gravel, some silt (FILL) Loose to compact Brown Frozen / wet		1	SS	85		418				
	Upper 1.4 m frozen.		2	SS	87				○		33 54 (13)
	120 mm cobble at 1.4 m depth.		3	SS	25		417				
	180 mm cobble at 2.0 m depth.		4	SS	9		416				
			5	SS	20		415				
			6	SS	10				○		
			7	SS	20/0.05		414				
	200 mm cobble at 5.1 m depth.										
412.9							413				
5.6	CLAYEY SILT, trace to some sand Stiff to very stiff Reddish-brown Wet		8	SS	10		412				
								>100 >100			
			9	SS	6		411				0 8 59 33
							410	2 2			
			10	SS	7		409				
								2 2			
			11	SS	5		408				0 6 45 49
							407	2 2			
			12	SS	6		406				
								>100 >100			
404.9							405				
13.6	SAND and GRAVEL, trace to some silt Dense Grey Wet		13	SS	37				○		34 60 (6)
404.1											
14.4											

Continued Next Page

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

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 09/03/15 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No MR-3

2 OF 2 **METRIC**

PROJECT 1411523 | G.W.P. 6301-14-00 | LOCATION N 5382099.5; E 352329.0 | ORIGINATED BY MR

DIST | HWY 589 | BOREHOLE TYPE NW Casing, Wash Boring | COMPILED BY SEMP

DATUM GEODETIC | DATE December 4 and 5, 2014 | CHECKED BY DAM

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 ---										
	END OF BOREHOLE CASING AND SPLIT-SPOON REFUSAL (HAMMER BOUNCING) Note: 1. Borehole caved at 3.9 m depth upon completion of drilling. Borehole dry to 3.9 m depth upon completion of drilling.										

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

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

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 09/03/15 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No MR-4

1 OF 1 **METRIC**

PROJECT 1411523 | G.W.P. 6301-14-00 | LOCATION N 5382094.6; E 352337.1 | ORIGINATED BY CW

DIST | HWY 589 | BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers | COMPILED BY SEMP

DATUM GEODETIC | DATE December 3 and 4, 2014 | CHECKED BY DAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × 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
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					
417.3	GROUND SURFACE									
0.0 / 416.5	ROCK FILL						417			
0.8 / 415.8	Sand and gravel, some silt, some rock fragments (FILL) Compact Brown Moist		1	SS	25		416		○	
1.5	END OF BOREHOLE AUGER REFUSAL									

Note:

1. Borehole dry upon completion of drilling.

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

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 09/03/15 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No MR-5

1 OF 1 **METRIC**

PROJECT 1411523 | G.W.P. 6301-14-00 | LOCATION N 5382107.7; E 352339.8 | ORIGINATED BY CW

DIST | HWY 589 | BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers | COMPILED BY SEMP

DATUM GEODETIC | DATE December 4, 2014 | CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
415.3	GROUND SURFACE										
0.0	Silty clay some organics, some sand (FILL) Dark brown Frozen		1	SS	24		415				
414.5											
0.8	ORGANIC SILTY CLAY, trace to some sand Soft to firm Dark brown Wet		2	SS	5		414			OC=5.2%	0 10 67 23
			3	SS	2		413				
412.9											
2.4	SILTY CLAY to CLAY, trace sand, trace organics Firm to very stiff Reddish-brown Wet		4a 4b	SS	5		412			OC=1.0%	0 3 67 30
			5	SS	4						
			6	SS	2		411				
			7	SS	4		410				
			8	SS	4		409				
			9	SS	3		408				
							407				
405.1							406	>100			0 0 37 63
10.2	END OF BOREHOLE										

Note:

1. Borehole caved at 6.0 m depth upon completion of drilling. Borehole dry upon completion of drilling.

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

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 10/03/15 DATA INPUT:

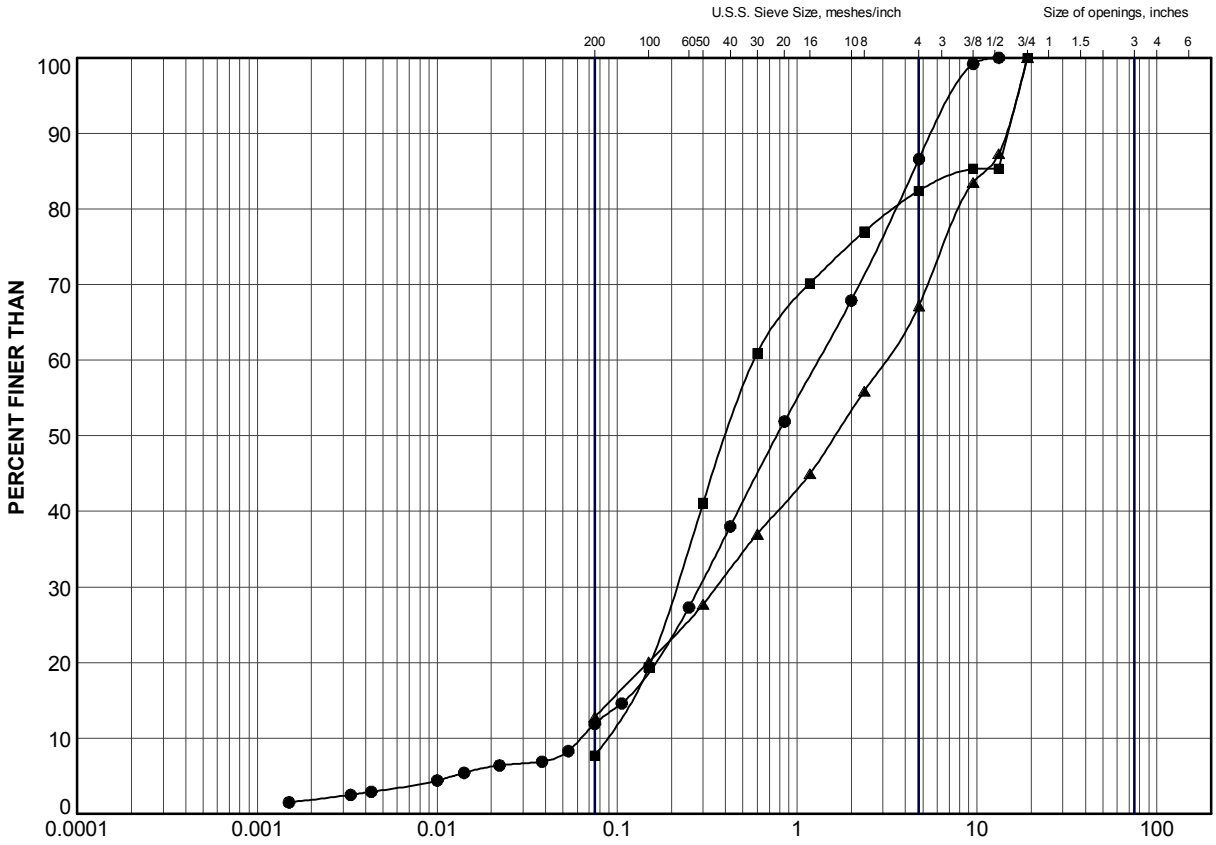
APPENDIX B
LABORATORY TEST RESULTS

Table B1: Summary of Analytical Testing of McIntyre River Water Sample

Parameter	Units	Result
Chloride (CL)	mg/L	6.41
Sulphate (SO4)	mg/L	6.63
Conductivity (EC)	µS/cm	129
Resistivity	ohms*cm	7752
pH	n/a	7.10

Notes:
1. Sample obtained on February 9, 2015.
2. Analytical testing carried out by ALS Canada Ltd.

Prepared by: AC
Checked by: SEMP
Reviewed by: JMAC



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	MR-2	1	418.3
■	MR-2	6	414.5
▲	MR-3	2	417.4

PROJECT

HIGHWAY 589
MCINTYRE RIVER CULVERT STA 17+459

TITLE

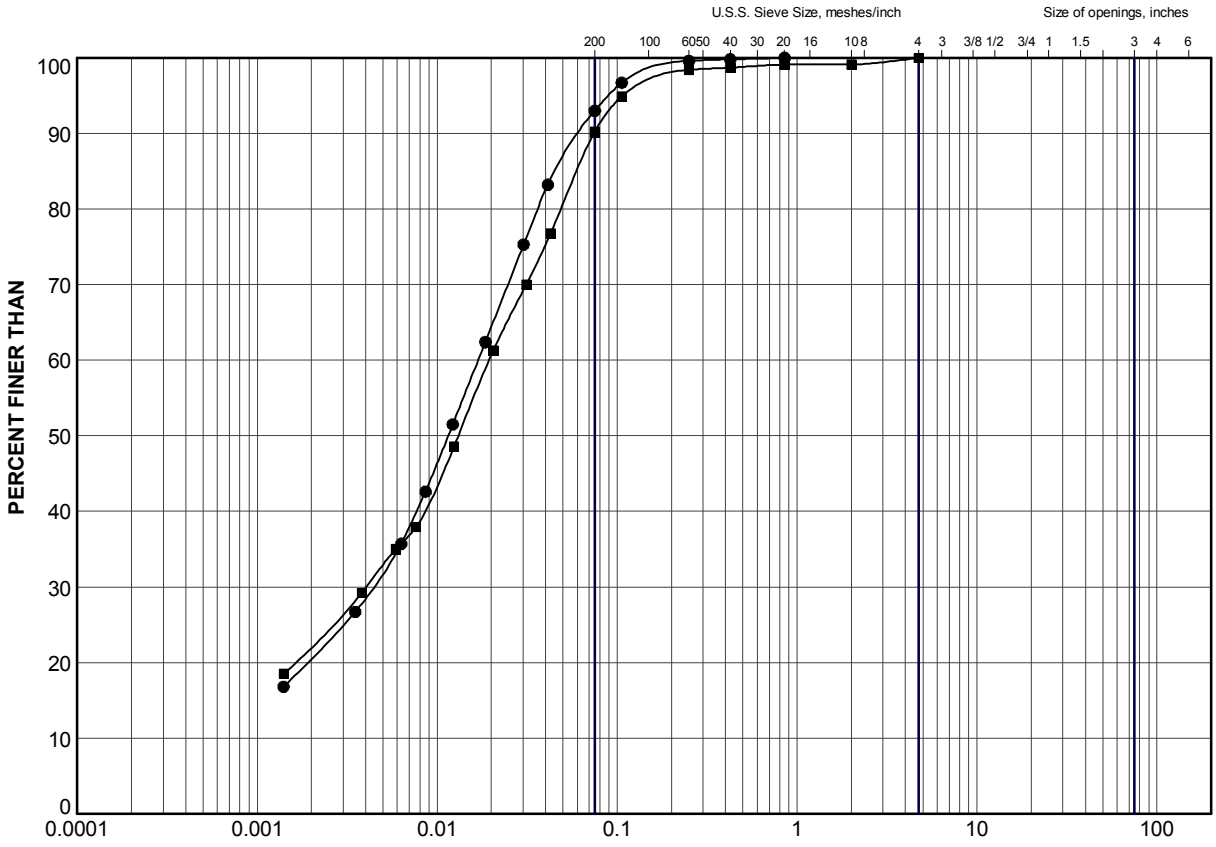
GRAIN SIZE DISTRIBUTION

SAND to SAND and GRAVEL (FILL)

Golder Associates
SUDBURY, ONTARIO

PROJECT No.		1411523	FILE No.	1411523.GPJ
DRAWN	JJL	Mar 2015	SCALE N/A	REV.
CHECK	DAM	Mar 2015		
APPR	FJH	Mar 2015	**FIGURE B1**	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	MR-1	3	414.3
■	MR-5	2	414.2

PROJECT

HIGHWAY 589
MCINTYRE RIVER CULVERT STA 17+459

TITLE

GRAIN SIZE DISTRIBUTION

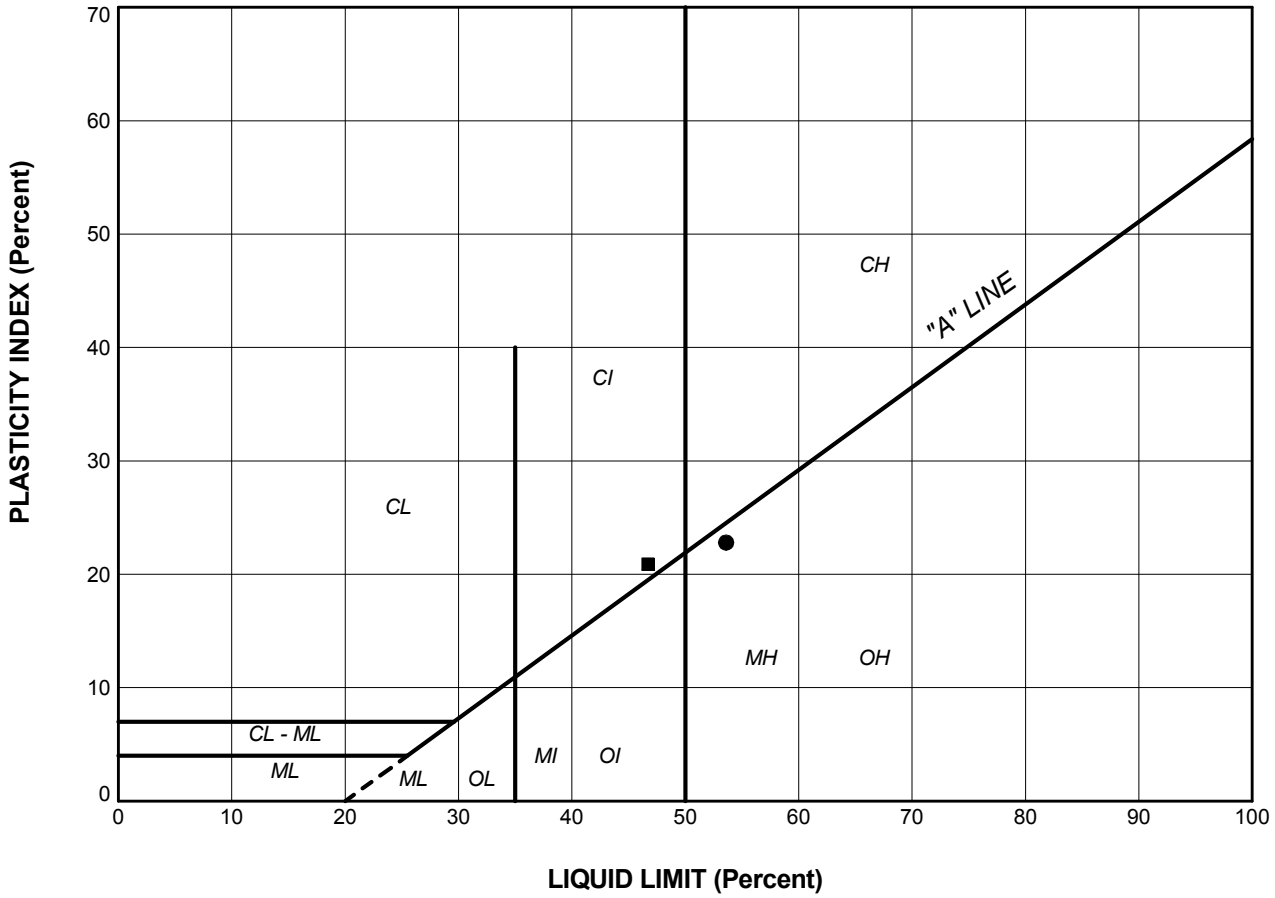
ORGANIC SILT to ORGANIC SILTY CLAY

Golder Associates
SUDBURY, ONTARIO

PROJECT No.		1411523	FILE No.		1411523.GPJ
DRAWN	JJL	Mar 2015	SCALE	N/A	REV.
CHECK	DAM	Mar 2015			
APPR	FJH	Mar 2015			

FIGURE B2

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	MR-1	3	53.6	30.8	22.8
■	MR-5	2	46.7	25.8	20.9

PROJECT

HIGHWAY 589
MCINTYRE RIVER CULVERT STA 17+459

TITLE

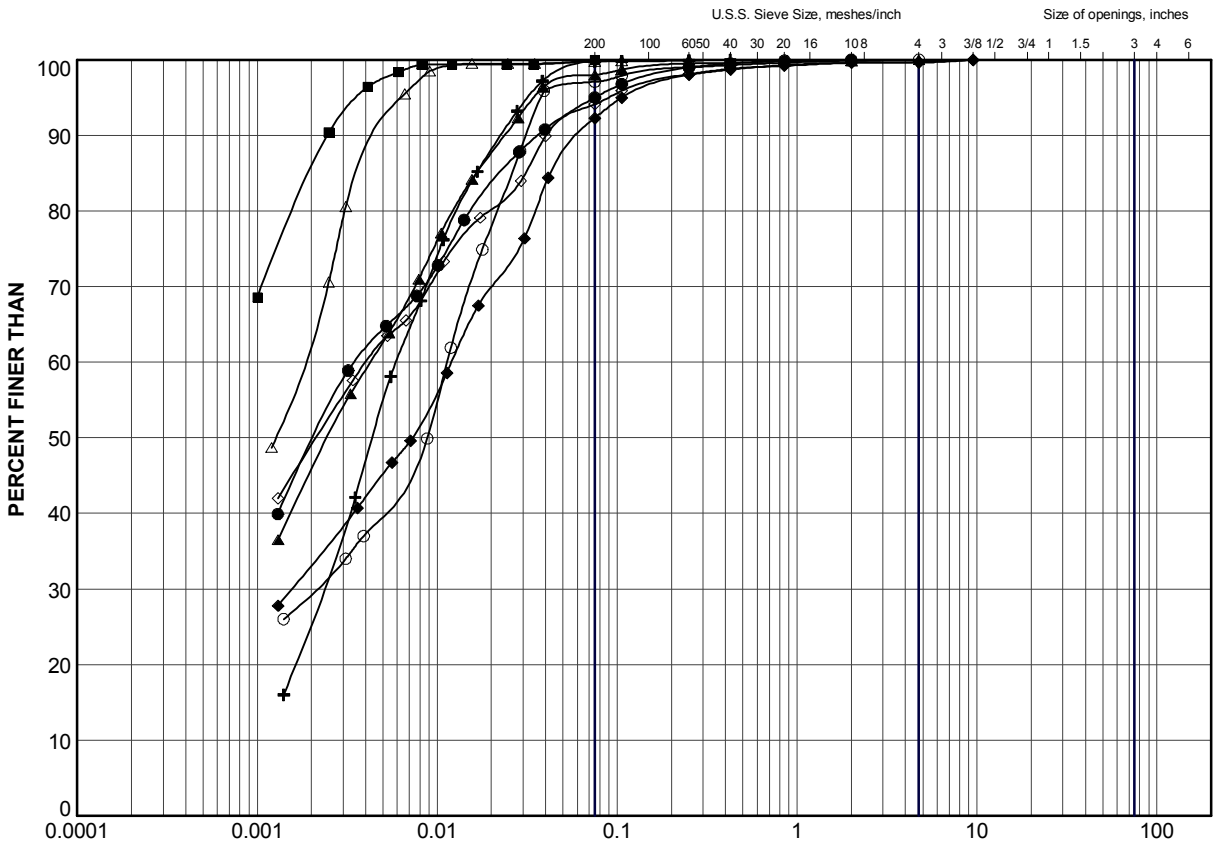
PLASTICITY CHART

ORGANIC SILT to ORGANIC SILTY CLAY

Golder Associates
SUDBURY, ONTARIO

PROJECT No.		1411523	FILE No.	1411523.GPJ
DRAWN	JJL	Mar 2015	SCALE N/A	REV.
CHECK	DAM	Mar 2015		
APPR	FJH	Mar 2015	**FIGURE B3**	

SUD-MTO PL (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)	
●	MR-1	5	412.0	
■	MR-1	8	407.4	
▲	MR-2	9	410.7	
+	MR-2	10	409.2	Clayey Silt to Silt seam
◆	MR-3	9	410.6	
◇	MR-3	11	407.5	
○	MR-5	5	411.9	
△	MR-5	9	405.9	

PROJECT

HIGHWAY 589
MCINTYRE RIVER CULVERT STA 17+459

TITLE

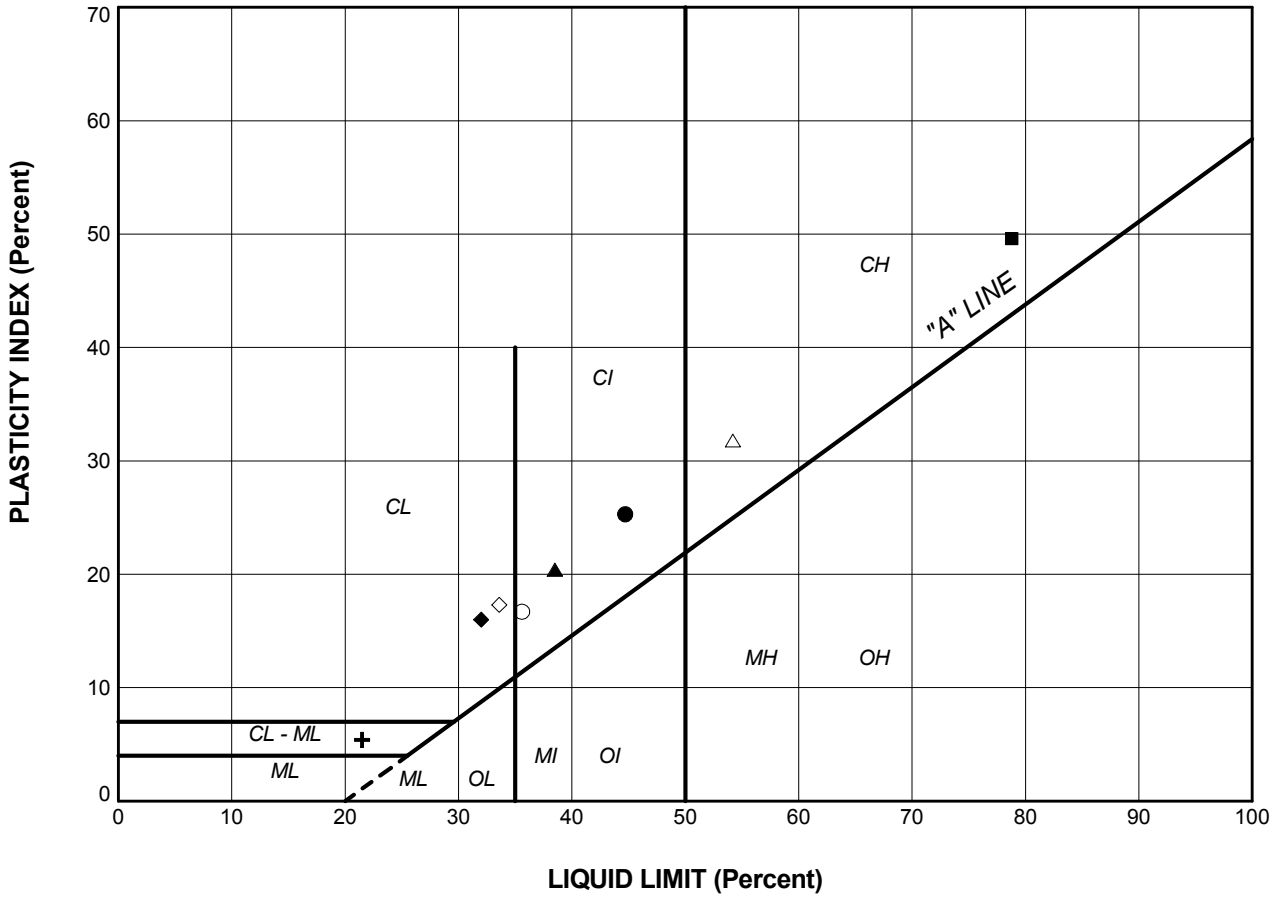
GRAIN SIZE DISTRIBUTION

CLAYEY SILT to CLAY

Golder Associates
SUDBURY, ONTARIO

PROJECT No.		1411523	FILE No.	1411523.GPJ	
DRAWN	JJL	Mar 2015	SCALE	N/A	REV.
CHECK	DAM	Mar 2015			
APPR	FJH	Mar 2015	**FIGURE B4**		

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI	
●	MR-1	5	44.7	19.4	25.3	
■	MR-1	8	78.8	29.2	49.6	
▲	MR-2	9	38.5	18.1	20.4	
+	MR-2	10	21.5	16.1	5.4	Clayey Silt to Silt seam
◆	MR-3	9	32.0	16.0	16.0	
◇	MR-3	11	33.6	16.3	17.3	
○	MR-5	5	35.6	18.9	16.7	
△	MR-5	9	54.2	22.4	31.8	

PROJECT

HIGHWAY 589
MCINTYRE RIVER CULVERT STA 17+459

TITLE

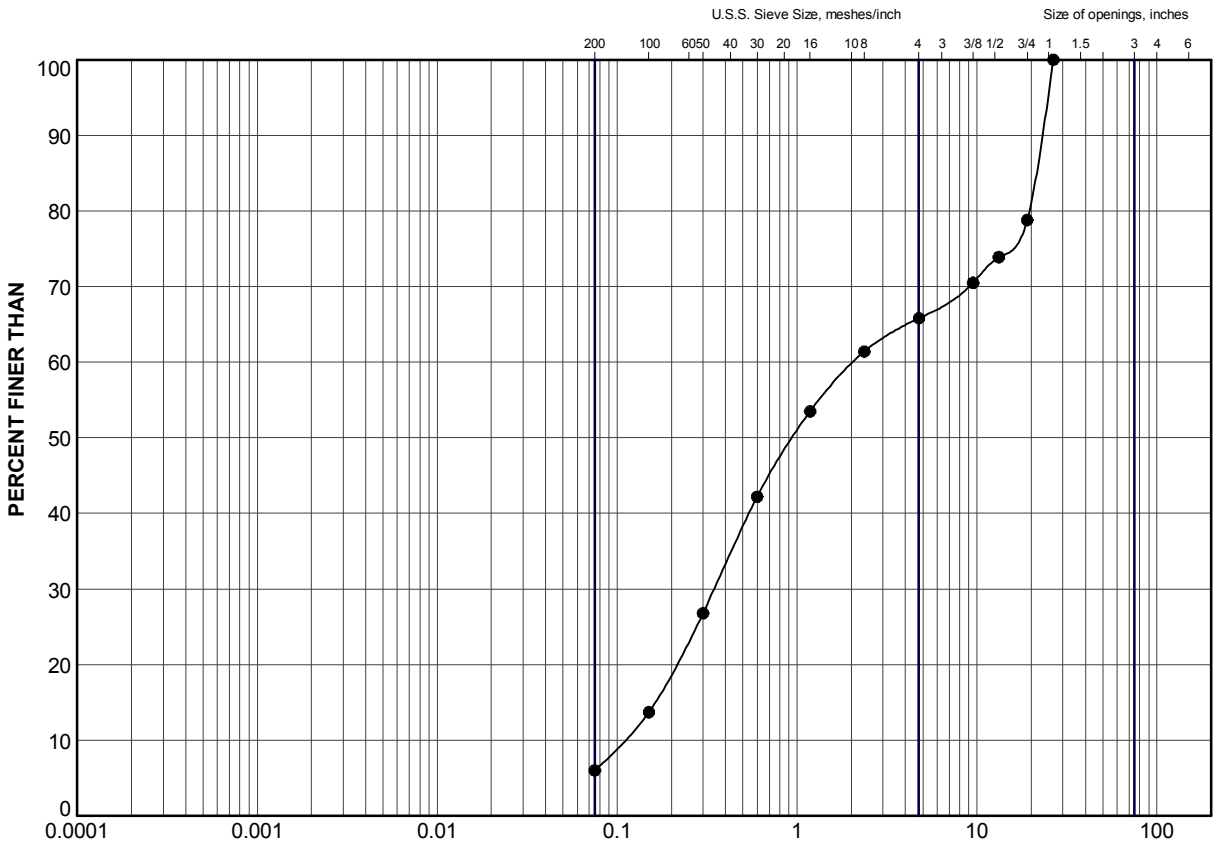
PLASTICITY CHART

CLAYEY SILT to CLAY

Golder Associates
SUDBURY, ONTARIO

PROJECT No.		1411523	FILE No.	1411523.GPJ
DRAWN	JJL	Mar 2015	SCALE N/A	REV.
CHECK	DAM	Mar 2015		
APPR	FJH	Mar 2015	**FIGURE B5**	

SUD-MTO PL (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	MR-3	13	404.5

PROJECT

HIGHWAY 589
MCINTYRE RIVER CULVERT STA 17+459

TITLE

GRAIN SIZE DISTRIBUTION

SAND and GRAVEL

Golder Associates
SUDBURY, ONTARIO

PROJECT No.		1411523	FILE No.	1411523.GPJ
DRAWN	JJL	Mar 2015	SCALE N/A	REV.
CHECK	DAM	Mar 2015		
APPR	FJH	Mar 2015	**FIGURE B6**	

SUD-MTO GSD (NEW) GLDR_LDN.GDT

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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