



October 7, 2016

FOUNDATION INVESTIGATION REPORT

**HIGHWAY 11 CULVERT REHABILITATIONS
POSTAGONI RIVER AND BLACKWATER RIVER TRIBUTARY CULVERTS
SITES 48C-2/C AND 48C-180/C
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 6166-04-00, WP 6314-14-01 and WP 6313-14-01**

Submitted to:

Hatch Ltd.
2699 Speakman Drive
Mississauga Ontario, Canada
L5k 1B1



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REPORT





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POSTAGONI RIVER AND BLACKWATER RIVER TRIBUTARY CULVERTS,
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PART A

**DETAIL FOUNDATION INVESTIGATION REPORT
HIGHWAY 11 CULVERT REHABILITATIONS
POSTAGONI RIVER AND BLACKWATER RIVER TRIBUTARY CULVERTS
SITES 48C-2/C AND 48C-180/C
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Hatch Ltd. (Hatch) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the rehabilitation of the Postagoni River culvert (Site No. 48C-2/C) and the Blackwater River Tributary culvert (Site No. 48C-180/C) on Highway 11 in the District of Thunder Bay, Ontario. The general locations of the culverts are shown on the Location Plan on Figure 1.

2.0 SITE DESCRIPTION

The existing Postagoni River and Blackwater River Tributary culvert details (size, length, type, etc.) are summarized in Table 1, following the text of this report.

It should be noted that the orientation (i.e., north, south, east, west) stated in the text of the report is typically referenced to project north and therefore may differ from magnetic north shown on the drawings.

2.1 Postagoni River Culvert

The Postagoni River culvert is located on Highway 11 at approximately STA. 12+348 in the Township of Kilkenny approximately 46 km north of Highway 17 near Nipigon, Ontario. For the purposes of this report Highway 11 runs in a north-south direction at the Postagoni River culvert location with the culvert perpendicular to the highway in an east-west orientation.

In general the topography in the area is undulating/hilly terrain with moderate to dense tree cover. The Postagoni River flows from east to west draining into Lake Nipigon. At the Postagoni River culvert location, the highway grade is at Elevation 267.3 m and the existing culvert invert, as provided by MTO, is at Elevation 260.0 m at both the inlet (east end) and outlet (west end). The river ice level, as surveyed by Golder on January 24, 2016, was at Elevation 260.0 m at the outlet end. The river was level, as surveyed by others in September 2014, was at Elevation 260.0 m at both the inlet and outlet ends. Ground surface conditions at the culvert location are shown on Photographs A1 to A4 in Appendix A.

2.2 Blackwater River Tributary Culvert

The Blackwater River Tributary culvert is located on Highway 11 at STA 13+322 in the District of Thunder Bay Unsurveyed Territory approximately 9.9 km south of Highway 580 in Beardmore, Ontario. For the purposes of this report Highway 11 runs in a north-south direction at the Blackwater River Tributary location with the culvert perpendicular to the highway in an east-west orientation.

In general the topography in the area is generally low-lying grassy/swamp terrain with moderate to dense tree cover beyond the highway right of way. The Blackwater River Tributary flows east to west. The highway grade is at Elevation 375.8 m and the existing culvert invert, as provided by MTO, is at Elevation 372.7 m and 372.5 m at the inlet end and outlet ends, respectively. The tributary ice level, as surveyed by Golder on February 18, 2016, was at Elevation 373.3 m at both the inlet (east end) and outlet (west end). The tributary water level, as surveyed by others in September 2014, was at Elevation 373.7 m at both the inlet and outlet ends. Ground surface conditions at the culvert location are shown on Photographs B1 to B4 in Appendix A.



3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation at the Postagoni River and Blackwater River Tributary culvert sites was carried out between January 23 and 25, 2016, and between February 10 and 18, 2016, for the respective culvert sites, during which period a total of six (boreholes and one dynamic cone penetration test (DCPT) were advanced at the two culvert sites: two boreholes at Postagoni River; and four boreholes and one DCPT at Blackwater River Tributary. A summary of the boreholes advanced at each culvert site is presented and the locations of the boreholes and culvert sites are shown on Drawings A1 and B1 in Appendices A and B, respectively.

The field investigation was carried out using a track mounted CME 55 and CME 850 drill rigs supplied and operated by Cartwright Drilling Ltd. of Thunder Bay, Ontario and a portable tripod drill rig supplied and operated by Landcore Drilling of Sudbury, Ontario. The boreholes were advanced through the overburden using 108 mm inside diameter hollow stem augers and/or HW/NW casing with wash boring techniques. Where coring was required to advance the boreholes through cobbles and boulders and/or to obtain bedrock cores, NQ and HQ sized core barrels were utilized. In general, soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m, using a 50 mm outer diameter split-spoon sampler, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). All open boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The fieldwork 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; observed the drilling, sampling and in situ testing operations; logged the boreholes and examined and cared for the soil samples. The soil and bedrock samples were identified in the field, placed in appropriate containers/box, labelled and transported to our Sudbury Geotechnical Laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO Laboratory Standards and/or ASTM Standards, as appropriate. Classification testing consisting of water content, grain size distributions and Atterberg limits were carried out on selected soil samples. Unconfined compressive strength tests were carried out on selected specimens of the recovered bedrock cores.

A sample of the river/tributary water was obtained during the field investigation at each culvert location, 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 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 coordinates on the plan drawings. The ground surface elevation of the highway centerline at each culvert location was obtained from the profile drawings provided by MTO (drawings e295111.dwg and e493880111.dwg). The MTM NAD83 (Zone 14) 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 Appendices A and B and summarized below.



Culvert	Borehole	MTM NAD 83 Coordinates (m)		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing	Easting		
Postagoni River Culvert (Site 48C-2/C)	PG-1	5476342.5	223383.5	267.9	17.4
	PG-2	5476371.8	223375.0	266.7	17.4
Blackwater River Tributary Culvert (Site 48C-180/C)	BW-1	5489550.8	232179.5	374.3	9.8
	BW-2	5489542.0	232176.5	374.2	4.2
	BW-3	5489557.1	232156.4	374.0	6.5*
	BW-4	5489548.8	232152.0	373.9	5.3*

*Includes 3.1 m and 3.3 m of bedrock coring in the respective boreholes.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

4.1.1 Postagoni River Culvert

Based on Northern Ontario Engineering Geology Terrain Study (NOEGTS) mapping by the Ministry of Natural Resources (MNR)¹, the subsoils at the Postagoni River culvert site consists of ground moraine deposits comprised primarily of sand till bordered by glaciolacustrine plain deposits of silt and knobby/hummocky bedrock knobs

Based on geological mapping by the Ministry of Northern Development and Mines (MNDM)², the Postagoni River culvert site is underlain by mafic and related intrusive bedrock of the Logan and Nipigon sills and diabase sills.

4.1.2 Blackwater River Tributary Culvert

Based on NOEGTS mapping by the MNR, the subsoils at the Blackwater River Tributary site consist of jagged/rugged/cliffed bedrock ridges bordered by undulating/rolling bedrock knobs.

Based on geological mapping by the MNDM, the Blackwater River Tributary culvert site is underlain by metasedimentary bedrock including arkose, argillite, slate, marble, chert, bordered closely to the north by mafic to intermediate metavolcanic rocks comprised of wacke, arkose, argillite, slate, chert, iron formations and minor metavolcanic rocks.

4.2 General Overview of Local Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are presented on the Record of Borehole sheets and the laboratory test sheets in Appendices A and B for the Postagoni River and Blackwater River Tributary culverts, respectively. The results of in situ field tests (i.e., SPT 'N'-values) as

¹ Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society. Electronic Mapping, Maps 52HSE and 52HNE.

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



presented on the Record of Borehole sheets and in Section 4 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the stratigraphic profile and cross-sections on Drawings A1 and B1 are inferred from non-continuous sampling, observations of drilling progress and in situ testing. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

Detailed descriptions of the subsurface conditions at each investigated culvert crossing are provided in the following sections of this report. Where relatively significant thicknesses of overburden were encountered, the various soil types are described in detail for each main deposit or stratum.

4.2.1 Postagoni River Culvert

A total of two boreholes (Boreholes PG-1 and PG-2) were advanced at the Postagoni River culvert site. The borehole locations, ground surface elevations and interpreted stratigraphic conditions are shown on Drawing A1.

In summary, the subsoil conditions encountered at the Postagoni River culvert site consist of asphalt and granular fill underlain by deposits of clayey silt and silt. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes is presented below.

Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows)	Laboratory Testing
				Relative Density/ Consistency	
Asphalt	PG-1 & PG-2	0.125 & 0.100	267.9 & 266.7	n/a	n/a
Silty Sand to Sand and Gravel (Fill) ¹ ; brown, moist to wet	PG-1 & PG-2	10.1 & 8.7	267.8 & 266.6	N = 6 - 100 ² Loose to Very Dense	w = 7% -10 % 4 – M/MH (Fig. A1)
Clayey Silt , some sand, trace to some gravel; grey, wet	PG-1	1.6	257.8	N = 26 Very Stiff	w = 24% 1 – MH (Fig. A2)
Silt ³ , trace to some clay, trace sand; grey, wet	PG-1 & PG-2	>5.7 & >8.7 (boreholes terminated in this deposit)	256.2 & 258.0	N = 5 -15 Loose to Compact	w = 25% – 29% 3 – MH (Fig. A3) 2 – AL (NP)

N = SPT 'N'-value; number of blows for 0.3 m of penetration

w = Natural Moisture Content (%)

M = Sieve analysis

MH = Combined Sieve and Hydrometer analysis

AL = Atterberg Limits Test

NP = Non-Plastic Atterberg Limits Test Result

Notes:

¹ Cobbles and boulders were encountered within the embankment fill as indicated in the Record of Borehole sheets.



² An SPT 'N'-value of 55 blows per 0.23 m of penetration was noted in the silty sand fill in Borehole PG-1; however this is likely due to the presence of coarse gravel and/or inferred cobbles/boulders and not representative of the relative density of the embankment fill.

³ The silt deposit contains approximately 2 mm to 25 mm thick clayey silt seams at about 100 mm to 150 mm spacing through the deposit and the clayey silt seams are similar in composition to the deposit encountered in Borehole PG-1.

Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The river ice level was surveyed by Golder on January 24, 2016 at Elevation 260.0 m at the outlet end. Groundwater and river water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

Borehole No.	Depth to Groundwater Level (m)	Groundwater Elevation (m)
PG-1	7.5	260.4
PG-2	3.6	263.1

Note: Boreholes PG-1 and PG-2 were advanced using NW casing and wash boring techniques and as such, the measured groundwater levels may not be representative of the in-situ groundwater conditions.

4.2.2 Blackwater River Tributary Culvert

A total of four boreholes (Boreholes BW-1 to BW-4) and one DCPT immediately adjacent to Borehole BW-2 were advanced at the Blackwater River Tributary culvert site. The borehole locations, ground surface elevations and interpreted stratigraphic conditions are shown on Drawing B1.

In summary, the subsoil conditions encountered at the site consist of ice and/or peat underlain by a deposit of sand (in one borehole) and a deposit of silt and sand till to gravelly silty sand till further underlain by metabasalt bedrock. A more detailed description of the soil deposits, bedrock and groundwater conditions encountered in the boreholes is presented below.

Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows)	Laboratory Testing
				Relative Density	
ICE	BW-2	0.1	374.2	n/a	n/a
Peat (Amorphous/Fibrous), trace wood; black; frozen to wet	BW-1 to BW-4	1.4 – 2.6	374.3 – 373.9	N = 0 (WH) ¹	w = 117% - 525%
				Very Loose	



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Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows)	Laboratory Testing
				Relative Density	
Sand , trace silt, trace organics; dark grey to black; wet	BW-1	2.3	372.1	N = 11- 25 Compact	w = 21% 1 – M (Fig. B1)
Silt and Sand (TILL) to Gravelly Silty Sand (TILL)² , some clay; grey; wet	BW-1 to BW-4	0.6 to 2.0 in BW-2 to BW-4 (where fully penetrated) >5.3 in BW-1 (terminated in this deposit)	372.5 – 371.4 <369.8 in BW-1	N = 14 – 187 ³ Compact to Very Dense	w = 9% - 11% 3 – MH (Fig. B2) 2 – AL (Fig. B3) w _p = 16% w _l = 12% I _p = 4%

N = SPT 'N'-value; number of blows for 0.3 m of penetration

WH = Weight of Hammer

w = Natural Moisture Content (%)

M = Sieve analysis

MH = Combined Sieve and Hydrometer analysis

AL = Atterberg Limits Test

w_p = Plastic Limit (%)

w_l = Liquid Limit (%)

I_p = Plasticity Index (%)

Notes:

¹ SPT 'N'-values of 1 blow and 2 blows per 0.3 m of penetration were noted within the peat deposit in Boreholes BW-1 and BW-2; however, this is indicative of the frozen state of the material and not representative of the relative density/consistency of this deposit.

² Cobbles were encountered within the silt and sand till deposit in Borehole BW-1 as indicated in the Record of Borehole sheet.

³ SPT 'N'-values of 36 blows, 24 blows and 104 blows per 0.23 m of penetration indicative of the split-spoon refusing on the bedrock or inferred bedrock surface.

Bedrock/Refusal

Bedrock was cored in Boreholes BW-3 and BW-4 and refusal to further casing penetration and split-spoon/DCPT penetration was encountered in Borehole BW-2. The depth to the confirmed/inferred bedrock surface and bedrock surface elevations are presented below.

Borehole No.	Depth to Bedrock (below ground surface) (m)	Bedrock Surface Elevation (m)	Core Length (m)
BW-2	4.2	370.0	Casing and split-spoon refusal *
BW-3	3.4	370.6	3.1
BW-4	2.0	371.9	3.3

* A dynamic cone penetration test (DCPT) was advanced approximately 0.8 m west of the Borehole BW-2. DCPT refusal was encountered at 4.2 m below the exiting ground surface (Elev. 370.0 m).



The retrieved bedrock core is described as fine grained, dark grey, slightly weathered, medium strong metabasalt as presented in the Record of Drillhole sheets in Appendix B. Photographs of the retrieved bedrock core samples are shown on Figure B4. A description of the bedrock properties encountered in the boreholes is provided below.

Borehole No.	Total Core Recovery	Rock Quality Designation	Quality Classification Table 3.10 of CFEM 2006³	Uniaxial Compressive Strength (MPa)	Strength Classification Table 3.5 of CFEM 2006³
BW-3	100%	32% - 79%	Poor to Good	27	(R3) Medium Strong
BW-4	100%	20% - 51%	Very Poor to Fair	39	(R3) Medium Strong

Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The tributary ice level was surveyed by Golder on February 18, 2016 at Elevations 373.3 m at the both the inlet and outlet ends. The tributary water level was surveyed by others in September 2014 at Elevation 373.7 m both the inlet and outlet ends. Groundwater and tributary ice/water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

Borehole No.	Depth to Groundwater Level (m)	Groundwater Elevation (m)
BW-1	0.9	373.4
BW-2	1.1	373.1
BW-3	Ground surface	374.0
BW-4	Ground surface	373.9

5.0 CLOSURE

The drilling program was supervised by Mr. Shane Albert, Mr. Matthew Riopelle and Mr. Mike Arthur under the direction of Adam Core P.Eng. This report was prepared by Mr. Adam Core, P.Eng and the technical aspects were reviewed by Mr. David Muldowney, P.Eng. Mr. Jorge M. A. Costa, P.Eng., a Designated MTO Foundations Contact and Senior Consultant for Golder, carried out a quality control review of the report.

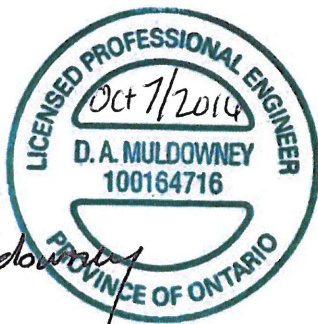
³ Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition.



Report Signature Page

GOLDER ASSOCIATES LTD.

Adam Core, P.Eng.
Geotechnical Engineer



David Muldowney, P.Eng.
Geotechnical Engineer



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

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**FOUNDATION REPORT - HIGHWAY 11 CULVERT REHABILITATIONS
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Table 1: Summary Details of Existing Culverts

Culvert	Approximate Existing Embankment Height ¹ (m)	Existing Culvert ²			Approximate Inlet/Outlet Invert Elevation (m) ²	Boreholes	Reference Appendix
		Type	Span x Height (m)	Length (m)			
Postagoni River Culvert (Site 48C-2/C)	7.3 (~ 2.2 m soil cover)	Concrete Open Footing Arch	14.1 x 4.8	14.5	260.0	PG-1 and PG-2	A
Blackwater River Tributary Culvert (Site 48C-180/C)	3.2 (~1.4 m soil cover)	Concrete Open Footing Culvert	3.1 x 1.5	17.9	372.7 / 372.5	4 Boreholes (BW-1 to BW-4)	B

Note: 1. Embankment height is relative to the ground surface at the centerline of the roadway and the existing culvert invert.
2. Culvert dimensions and invert elevations are based on the plan and profile drawings provided by MTO (e295111.dwg and e493880111.dwg for the respective culverts)

Prepared by: AC
Checked by: DAM
Reviewed by: FJH



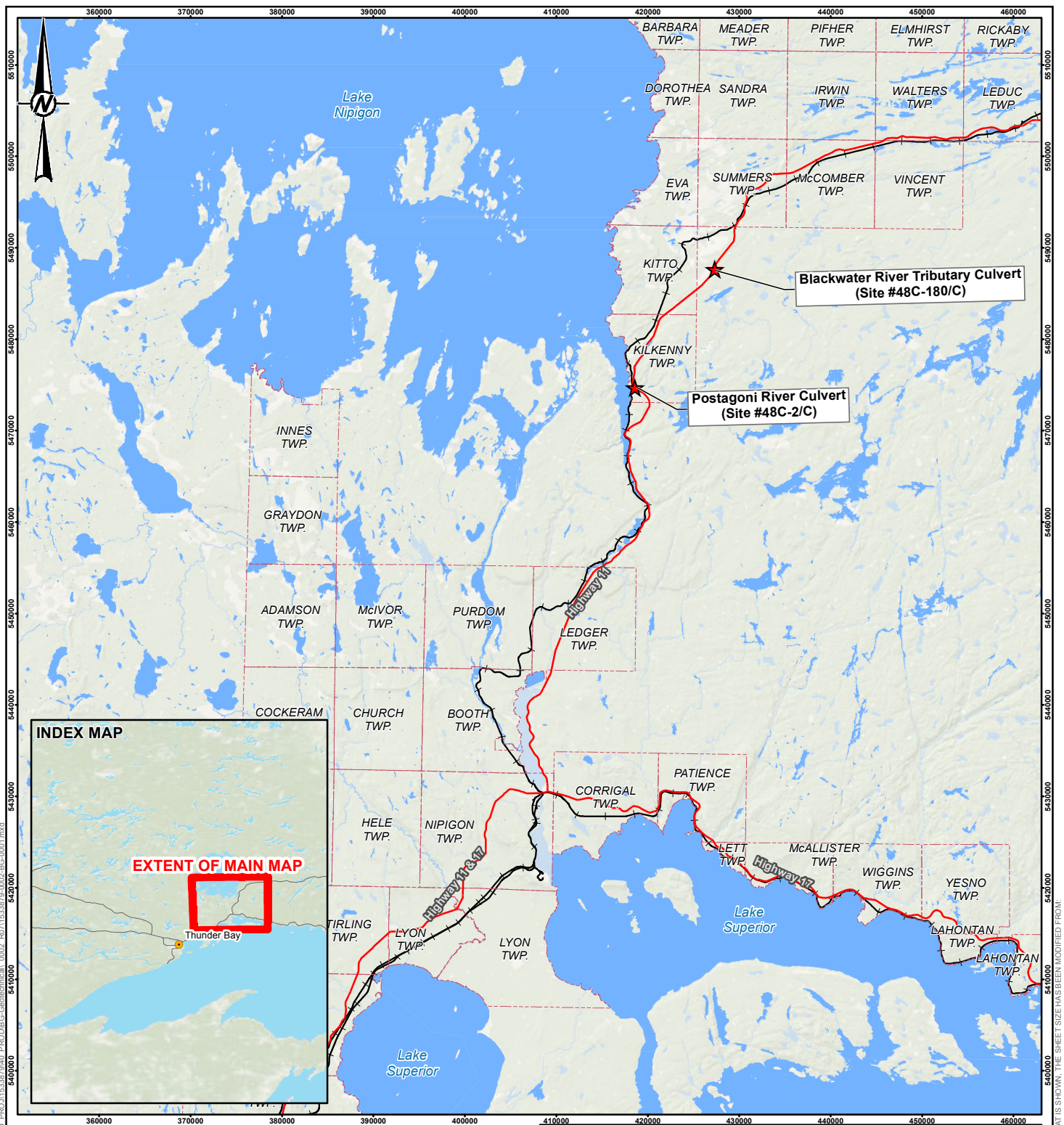
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Table 2: Summary of Analytical Testing of Postagoni River and Blackwater River Tributary Water Samples

Culvert	Parameter (Units, Detection Limit)				
	Chloride (mg/L)	Sulphate (mg/L)	Conductivity (μ S/cm)	Resistivity (ohm-cm)	pH
Postagoni River Culvert (Site 48C-2/C)	11.4	1.50	96	10,400	7.39
Blackwater River Tributary Culvert (Site 48C-180/C)	296	7.11	1,170	856	7.38

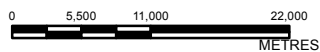
Notes: 1. Samples obtained January 16, 2016.
2. Analytical testing carried out by ALS Environmental.

Prepared by: AC
Checked by: DAM
Reviewed by: FJH



Legend

- ★ Site Location
- Highway
- Townships
- Railways



NOTE(S)

THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1533879-R07

REFERENCE(S)

SERVICE LAYER CREDITS: ESRI, DELORME, GEBCO, NOAA NGDC, AND OTHER CONTRIBUTORS CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - ONTARIO.
[HTTPS://WWW.ONTARIO.CA/GOVERNMENT/OPEN-GOVERNMENT-LICENCE-ONTARIO](https://www.ontario.ca/government/open-government-licence-ontario)
 PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
 COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

CLIENT
 ONTARIO MINISTRY OF TRANSPORTATION

PROJECT
 POSTAGONI RIVER AND BLACKWATER RIVER TRIBUTARY
 CULVERT REHABILITATIONS

TITLE
LOCATION PLAN

CONSULTANT



YYYY-MM-DD 2016-08-12

DESIGNED	---
PREPARED	RRD
REVIEWED	DAM
APPROVED	FJH

PROJECT NO.
 1533879

CONTROL
 1000

REV.
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FIGURE
1



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; 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



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.

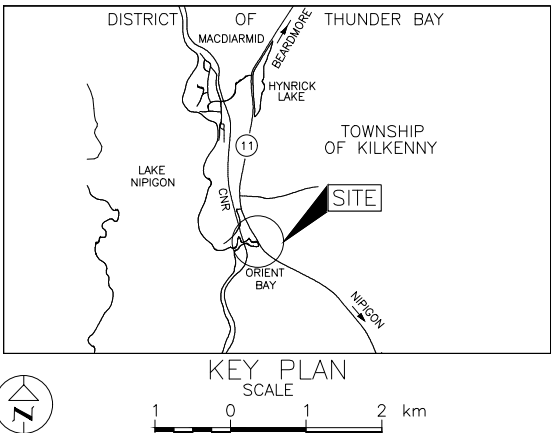
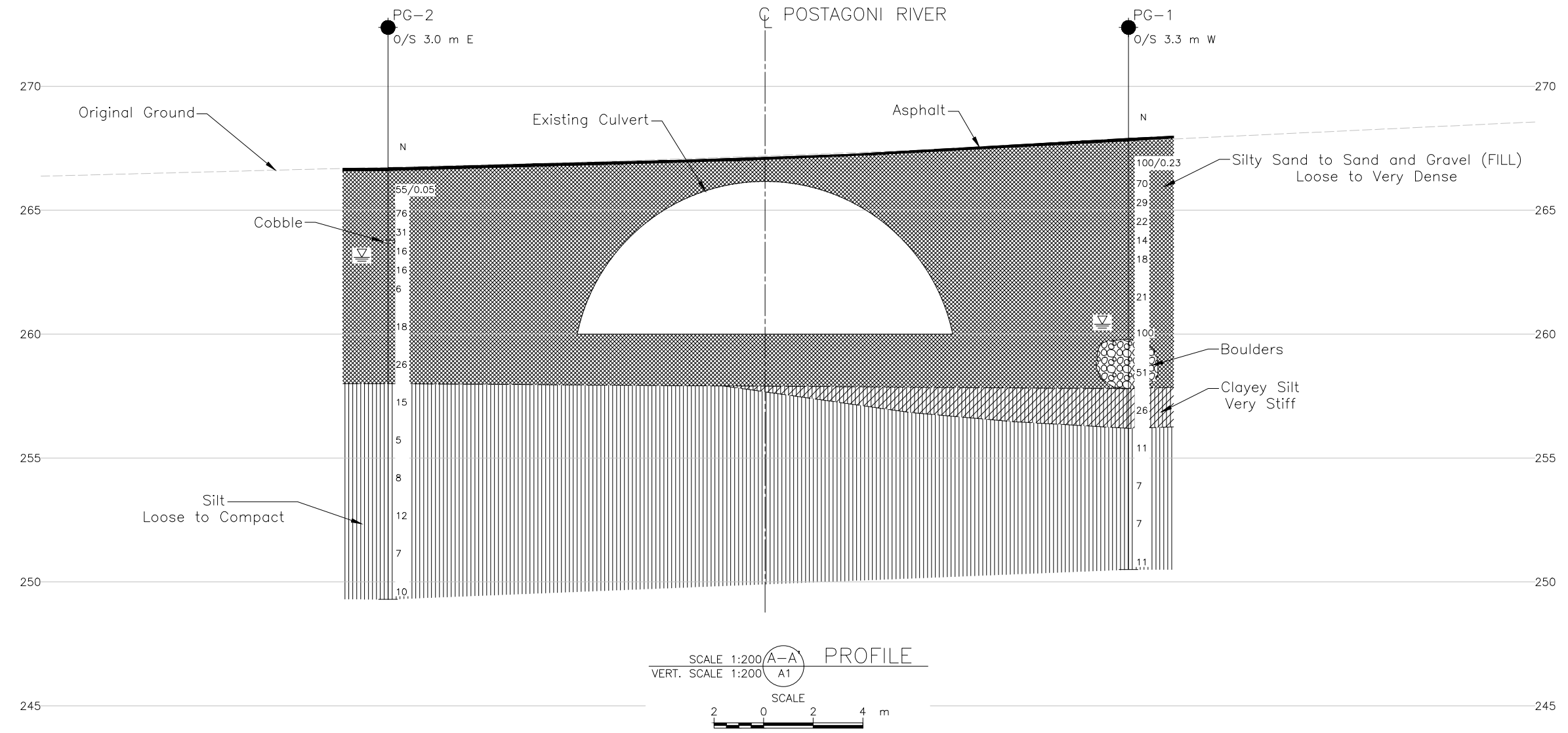
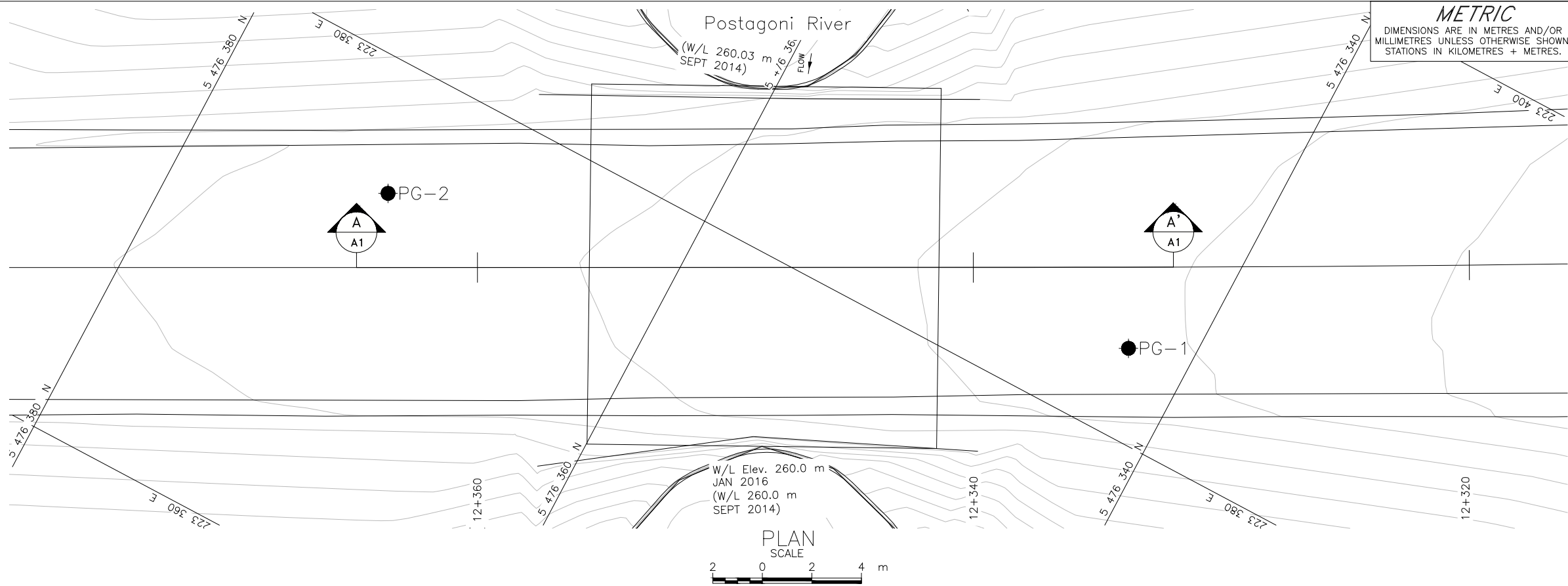
Abbreviations

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	



APPENDIX A

Postagoni River Culvert (Site 48C-2/C)



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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
PG-1	267.9	5476342.5	223383.5
PG-2	266.7	5476371.8	223375.0

NOTES

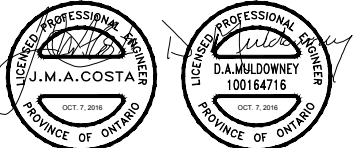
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

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

REFERENCE

Base plans provided in digital format by MTO, drawing file nos. E295111.dwg received Dec. 11, 2015.



NO.	DATE	BY	REVISION
Geocres No. 52H-41			
HWY. 11	PROJECT NO. 1533879		DIST. .
SUBM'D. AC	CHKD. .	DATE: 10/7/2016	SITE: 48C-2/C
DRAWN: JJL	CHKD. DAM	APPD. JMAC	DWG. A1



PHOTOGRAPHS – Postagoni River Culvert

**Photograph A1: Postagoni River Culvert
Looking North at the Culvert Inlet (East End)**



**Photograph A2: Postagoni River Culvert
Looking West at the Culvert Outlet (West End)**





PHOTOGRAPHS – Postagoni River Culvert

**Photograph A3: Postagoni River Culvert
Looking South at the Culvert Inlet (East End)**



**Photograph A4: Postagoni River Culvert
Looking North at the Culvert Outlet (West End)**





1 OF 2 **METRIC**

ORIGINATED BY MA

COMPILED BY AC

CHECKED BY DAM

Continued Next Page

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

PROJECT 1533879		RECORD OF BOREHOLE No PG-1				2 OF 2 METRIC											
G.W.P. 6166-04-00		LOCATION N 5476342.5; E 223383.5				ORIGINATED BY MA											
DIST _____ HWY 11		BOREHOLE TYPE NW Casing and Wash Boring				COMPILED BY AC											
DATUM GEODETIC		DATE January 23 and 24, 2016				CHECKED BY DAM											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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 (%)				
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100					W _p W W _L 20 40 60					
	SILT, some clay, trace sand Loose to compact Grey Wet Approximately 2 mm to 25 mm thick clayey silt seams / layers throughout at approximately 100 mm to 150 mm spacing.		11	SS	11		255										
			12	SS	7		254							o			0 1 82 17
							253										
			13	SS	7		252										
							251										
250.5			14	SS	11												
17.4	END OF BOREHOLE Note: 1. Water level at a depth of 7.5 m below ground surface (Elev. 260.4 m) upon completion of drilling.																

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 10/08/16 DATA INPUT:

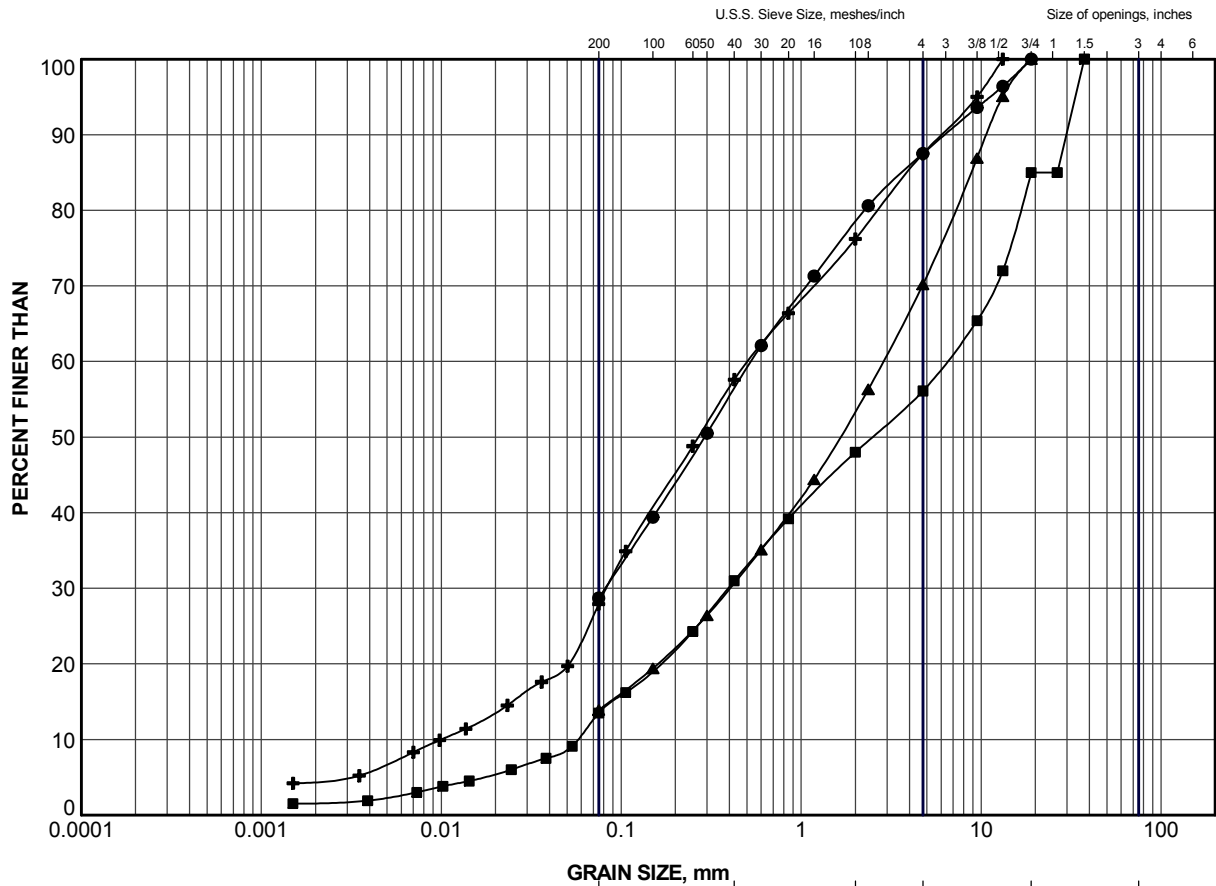
PROJECT 1533879		RECORD OF BOREHOLE No PG-2				1 OF 2 METRIC						
G.W.P. 6166-04-00		LOCATION N 5476371.8; E 223375.0				ORIGINATED BY MA						
DIST _____ HWY 11		BOREHOLE TYPE NW Casing and Wash Boring				COMPILED BY AC						
DATUM GEODETIC		DATE January 25, 2016				CHECKED BY DAM						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W _p W W _L			20 40 60
266.7	GROUND SURFACE											
0.0	ASPHALT (100 mm)											
0.1	Gravelly sand, some silt (FILL) Compact to very dense Brown Moist		1	SS	55/0.05		266					30 56 (14)
			2	SS	76		265					
			3	SS	31		264					
	A 120 mm cobble encountered at 2.9 m depth.		4	SS	16		263					
263.0	Silty sand, some gravel, trace clay (FILL) Loose to compact Brown Moist to wet		5	SS	16		262					12 60 24 4
3.7			6	SS	6		261					
			7	SS	18		260					
			8	SS	26		259					
258.0	SILT, trace to some clay, trace sand Loose to compact Grey Wet Approximately 2 mm to 25 mm thick clayey silt seams / layers throughout at approximately 100 mm to 150 mm spacing.		9	SS	15		258					NP 0 3 86 11
8.7			10	SS	5		257					
							256					
							255					

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 10/08/16 DATA INPUT:

Continued Next Page

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

PROJECT 1533879		RECORD OF BOREHOLE No PG-2				2 OF 2 METRIC																		
G.W.P. 6166-04-00		LOCATION N 5476371.8; E 223375.0				ORIGINATED BY MA																		
DIST _____ HWY 11		BOREHOLE TYPE NW Casing and Wash Boring				COMPILED BY AC																		
DATUM GEODETIC		DATE January 25, 2016				CHECKED BY DAM																		
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT CONTENT			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 (%)											
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED </div>					<div style="display: flex; justify-content: space-between;"> W_p W W_L </div>												
	SILT, trace to some clay, trace sand Loose to compact Grey Wet		11	SS	8		254																	
							253										NP	0 1 86 13						
			12	SS	12		252																	
							251																	
			13	SS	7		250																	
			14	SS	10																			
249.3	END OF BOREHOLE																							
17.4	Note: 1. Sheared NW Casing at 4.0 m depth. Moved borehole 1 m north and advanced new borehole to 17.4 m depth. No sampling in upper 4.0 m of new borehole. 2. Water level at a depth of 3.6 m below ground surface (Elev. 263.1 m) upon completion of drilling.																							



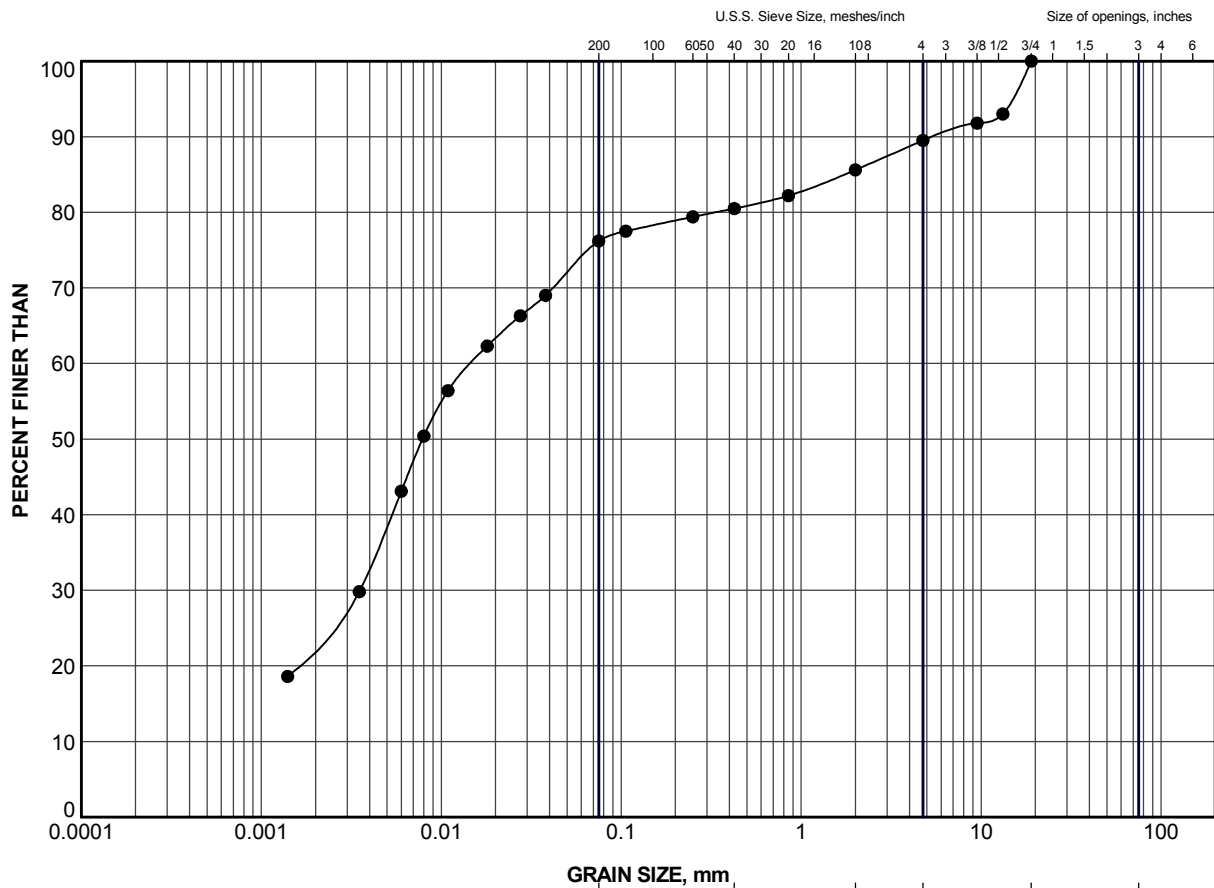
CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	PG-1	3	265.3
■	PG-1	6	263.0
▲	PG-2	1	265.8
+	PG-2	5	262.6

PROJECT					
HIGHWAY 11 POSTAGONI RIVER CULVERT STA 12+348					
TITLE					
GRAIN SIZE DISTRIBUTION SILTY SAND to SAND and GRAVEL (FILL)					
PROJECT No.		1533879		FILE No. 1533879.GPJ	
DRAWN	JJL	Aug 2016	SCALE	N/A	REV.
CHECK	DAM	Aug 2016			
APPR	JMAC	Aug 2016			
			FIGURE A1		




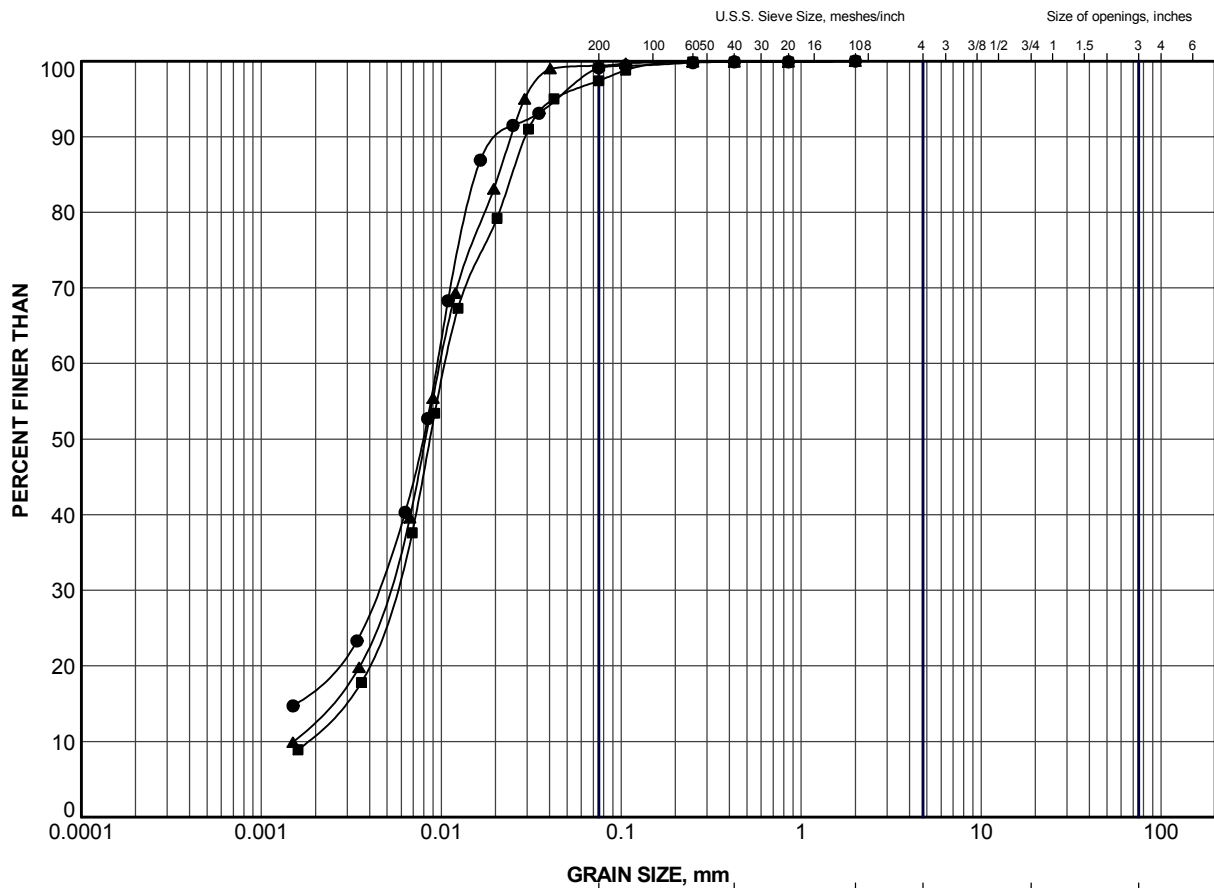


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	PG-1	10	256.9

PROJECT					
HIGHWAY 11 POSTAGONI RIVER CULVERT STA 12+348					
TITLE					
GRAIN SIZE DISTRIBUTION CLAYEY SILT					
PROJECT No.		1533879		FILE No. 1533879.GPJ	
DRAWN	JJL	Aug 2016	SCALE	N/A	REV.
CHECK	DAM	Aug 2016			
APPR	JMAC	Aug 2016			
 Golder Associates SUDBURY, ONTARIO			FIGURE A2		



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	PG-1	12	253.9
■	PG-2	9	257.3
▲	PG-2	12	252.7

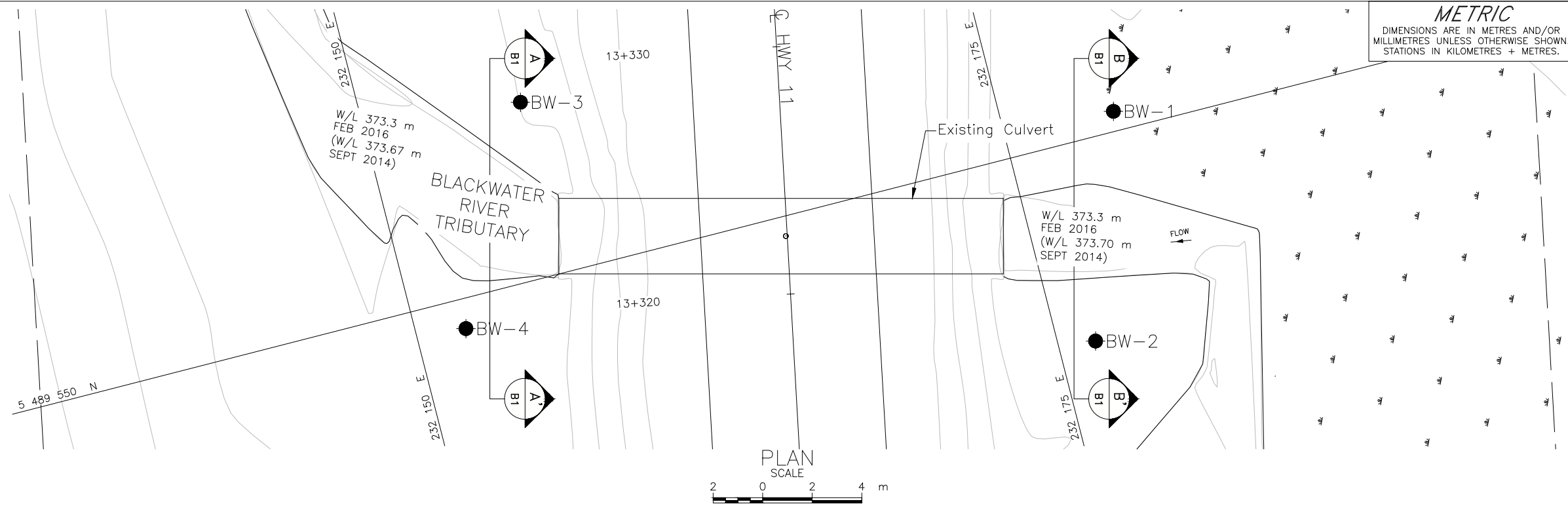
PROJECT					
HIGHWAY 11 POSTAGONI RIVER CULVERT STA 12+348					
TITLE					
GRAIN SIZE DISTRIBUTION SILT					
PROJECT No.		1533879		FILE No. 1533879.GPJ	
DRAWN	JJL	Aug 2016	SCALE	N/A	REV.
CHECK	DAM	Aug 2016			
APPR	JMAC	Aug 2016			
			FIGURE A3		





APPENDIX B

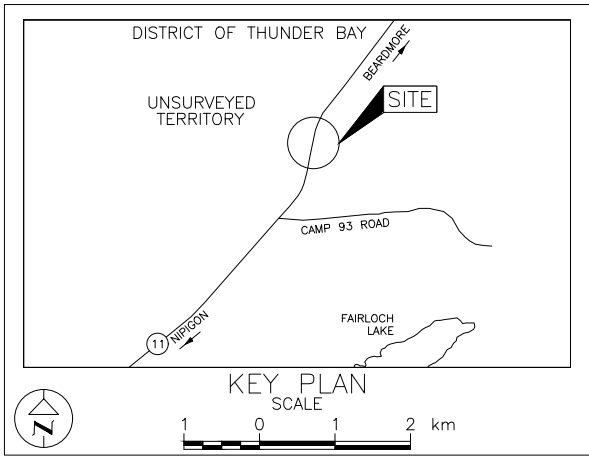
Blackwater River Tributary Culvert (Site 48C-180/C)



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

CONT No.
GWP No. 6166-04-00

HIGHWAY 11
BLACKWATER RIVER TRIBUTARY CULVERT STA 13+322
BOREHOLE LOCATIONS AND
SOIL STRATA



LEGEND

N

16

100%

R

Borehole – Current Investigation

Standard Penetration Test Value

Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow)

Rock Quality Designation (RQD)

Refusal

WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
BW-1	374.3	5489550.8	232179.5
BW-2	374.2	5489542.0	232176.5
BW-3	374.0	5489557.1	232156.4
BW-4	373.9	5489548.8	232152.0

NOTES

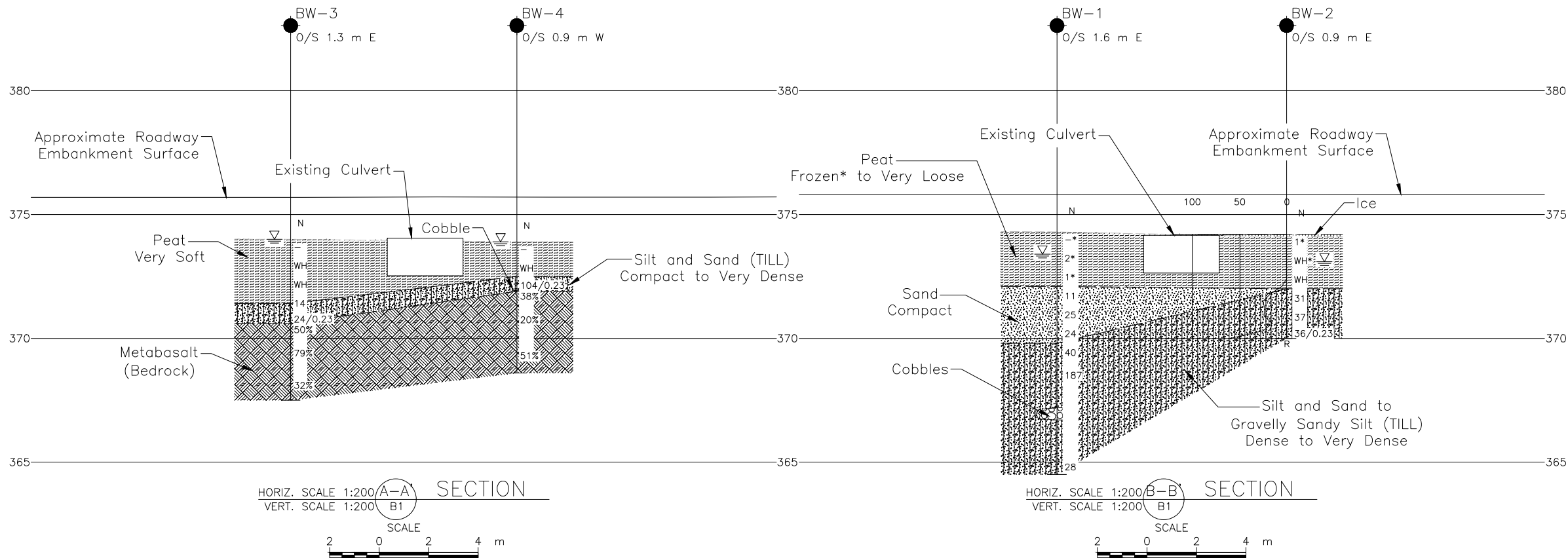
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REFERENCE

Base plans provided in digital format by MTO, drawing file nos. E493880111.dwg received Dec. 11, 2015.



NO.	DATE	BY	REVISION
Geocres No. 52H-41			
HWY. 11	PROJECT NO. 1533879		DIST. .
SUBM'D. AC	CHKD. .	DATE: 10/7/2016	SITE: 48C-180/C
DRAWN: JJL	CHKD. DAM	APPD. JMAC	DWG. B1



PHOTOGRAPHS – Blackwater River Tributary Culvert

**Photograph B1: Blackwater River Tributary Culvert
Looking East at the Culvert Inlet (East End)**



**Photograph B2: Blackwater River Tributary Culvert
Looking West at the Culvert Outlet (West End)**







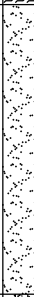
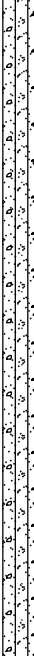
PHOTOGRAPHS – Blackwater River Tributary Culvert

**Photograph B3: Blackwater River Tributary Culvert
Looking North at the Culvert Inlet (East End)**



**Photograph B4: Blackwater River Tributary Culvert
Looking South at the Culvert Outlet (West End)**



PROJECT 1533879		RECORD OF BOREHOLE No BW-1				1 OF 1 METRIC																			
G.W.P. 6166-04-00		LOCATION N 5489550.8; E 232179.5				ORIGINATED BY MR																			
DIST _____ HWY 11		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, HW Casing and NQ/HQ Coring				COMPILED BY AC																			
DATUM GEODETIC		DATE February 18, 2016				CHECKED BY DAM																			
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										WATER CONTENT (%)							
374.3	GROUND SURFACE							20	40	60	80	100													
0.0	PEAT (Amorphous), trace wood Black Frozen* to wet		1	AS	-*		374																		
			2	SS	2*		373																		
			3	SS	1*																				
372.1	SAND, trace silt Compact Dark grey to black Wet Trace organics in Sample 4.		4	SS	11		372																		
			5	SS	25		371																		
			6	SS	24		370																		
369.8	SILT and SAND, some clay, trace to some gravel (TILL) Dense to very dense Grey Wet		7	SS	40		369																		
			8	SS	187		368																		
							367																		
	Switched to HW casing and wash boring at 5.4 m depth. Advanced borehole from 6.1 to 9.1 m depth using NQ core barrel.						366																		
	Cobbles encountered from 7.1 m to 7.6 m depth as follows.						365																		
	<table border="1" style="margin-left: 40px;"> <thead> <tr> <th>Size (mm)</th> <th>Depth (m)</th> </tr> </thead> <tbody> <tr> <td>150</td> <td>7.10</td> </tr> <tr> <td>180</td> <td>7.25</td> </tr> <tr> <td>180</td> <td>7.44</td> </tr> </tbody> </table>	Size (mm)	Depth (m)	150	7.10	180	7.25	180	7.44																
Size (mm)	Depth (m)																								
150	7.10																								
180	7.25																								
180	7.44																								
	Switched to HQ Core barrel below 7.6 m depth.																								
364.5	END OF BOREHOLE		9	SS	28																				
9.8	Note: 1. Water level at a depth of 0.9 m below ground surface (Elev. 373.4 m) upon completion of drilling.																								

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 10/08/16 DATA INPUT:

PROJECT 1533879		RECORD OF BOREHOLE No BW-2				1 OF 1 METRIC								
G.W.P. 6166-04-00		LOCATION N 5489542.0; E 232176.5				ORIGINATED BY SA								
DIST _____ HWY 11		BOREHOLE TYPE NW Casing and Wash Boring				COMPILED BY AC								
DATUM GEODETIC		DATE February 10, 2016				CHECKED BY DAM								
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						
374.2	GROUND SURFACE							20 40 60 80 100	20 40 60					
0.0	ICE (100 mm)													
0.1	PEAT (Fibrous) Very loose Black Frozen* to wet		1	SS	1*		374						116.2	
			2	SS	WH*		373							
			3	SS	WH		372							
372.0	Gravelly Sandy SILT, trace to some clay (TILL) Dense Grey Wet		4	SS	31		371							
			5	SS	37									
			6	SS	36/0.23									
370.0	END OF BOREHOLE SPLIT-SPOON REFUSAL AND REFUSAL TO FURTHER CASING PENETRATION Note: 1. Water level at a depth of 1.1 m below ground surface (Elev. 373.1 m) upon completion of drilling. 2. Advanced DCPT 0.8 m west of borehole. DCPT refusal (i.e. DCPT bouncing) at a depth of 4.2 m below ground surface (Elev. 370.0 m).						370							28 28 35 9

PROJECT 1533879		RECORD OF BOREHOLE No BW-3				1 OF 2 METRIC						
G.W.P. 6166-04-00		LOCATION N 5489557.1; E 232156.4				ORIGINATED BY MR						
DIST _____ HWY 11		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, HW Casing and HQ Coring				COMPILED BY AC						
DATUM GEODETIC		DATE February 16, 2016				CHECKED BY DAM						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa				W _p W W _L
374.0 0.0	GROUND SURFACE PEAT (Amorphous) Very soft Black Wet		1	AS	-							
			2	SS	WH		373					
			3	SS	WH		372					
371.4 2.6	SILT and SAND, some clay, trace to some gravel (TILL) Compact Grey Wet		4A	SS	14							
			4B									
370.6 3.4	Trace organics in Sample 4B. METABASALT (BEDROCK) Bedrock cored from 3.4 m depth to 6.5 m depth. For coring details see Record of Drillhole BW-3.		5	SS	24/0.23							11 36 41 12
			1	RC	REC 100%		370					RQD = 50%
			2	RC	REC 100%		369					RQD = 79%
			3	RC	REC 100%		368					RQD = 32%
367.5 6.5	END OF BOREHOLE Note: 1. Water level at ground surface upon completion of drilling.											

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 10/08/16 DATA INPUT:

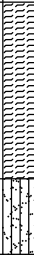
SHEET 2 OF 2

DATUM: GEODETIC

DRILLING CONTRACTOR: Cartwright Drilling

CHECKED: DAM

SUD-RCK 1533879.GPJ GAL-MISS.GDT 10/08/16 DATA INPUT:

PROJECT 1533879		RECORD OF BOREHOLE No BW-4				1 OF 2 METRIC												
G.W.P. 6166-04-00		LOCATION N 5489548.8; E 232152.0				ORIGINATED BY MR												
DIST _____ HWY 11		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, HW Casing and HQ Coring				COMPILED BY AC												
DATUM GEODETIC		DATE February 17, 2016				CHECKED BY DAM												
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 (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
373.9 0.0	GROUND SURFACE PEAT (Fibrous) Very loose Black Wet Amorphous below 0.7 m depth.		1	AS	-	373												
372.5 1.4	SILT and SAND, some clay, trace to some gravel (TILL) Very dense Grey Wet		2	SS	WH													
371.9 2.0	A 75 mm cobble encountered at 1.9 m depth. METABASALT (BEDROCK) Bedrock cored from 2.0 m depth to 5.3 m depth. For coring details see Record of Drillhole BW-4.		3	SS	104/0.23													
			1	RC	REC 100%	372											RQD = 38%	
			2	RC	REC 100%	371											RQD = 20%	
			3	RC	REC 100%	370											RQD = 51%	
368.6 5.3	END OF BOREHOLE Note: 1. Water level at ground surface upon completion of drilling.					369												

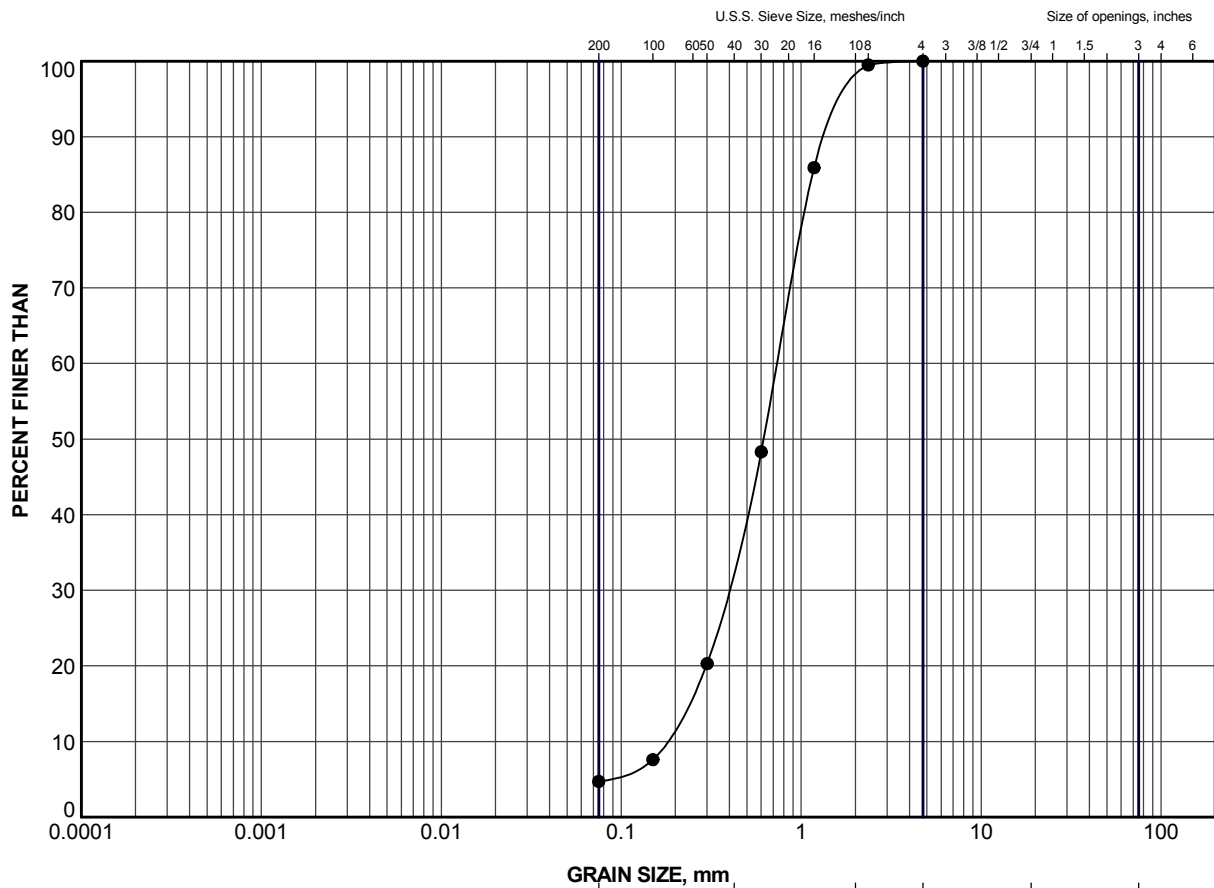
[illegible]

DEPTH SCALE

1 : 60

LOGGED: MR


CHECKED: DAM

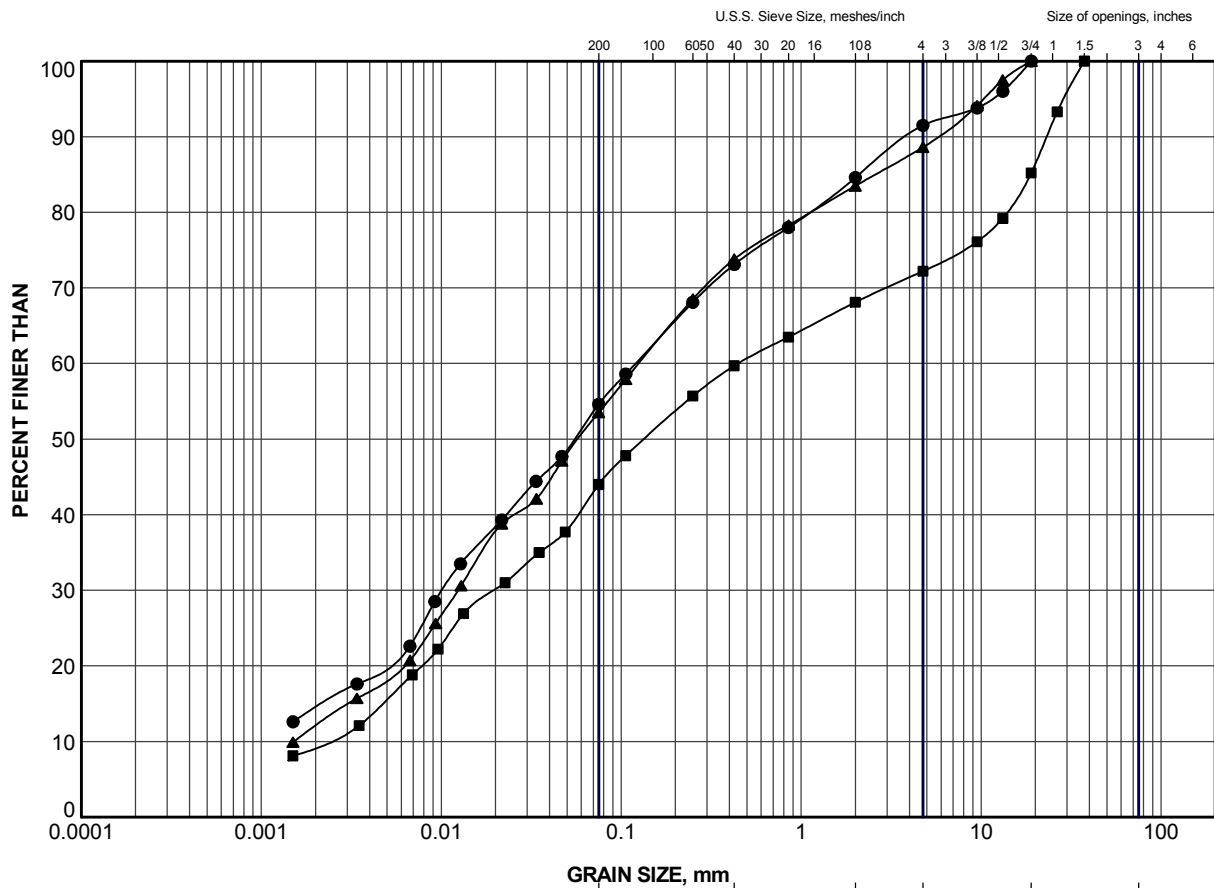


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BW-1	6	370.2


PROJECT						HIGHWAY 11 BLACKWATER RIVER TRIBUTARY CULVERT STA 13+322					
TITLE											
GRAIN SIZE DISTRIBUTION SAND											
PROJECT No. 1533879				FILE No. 1533879.GPJ							
DRAWN	JJL	Aug 2016	SCALE	N/A	REV.						
CHECK	DAM	Aug 2016									
APPR	JMAC	Aug 2016									
 Golder Associates SUDBURY, ONTARIO			FIGURE B1								

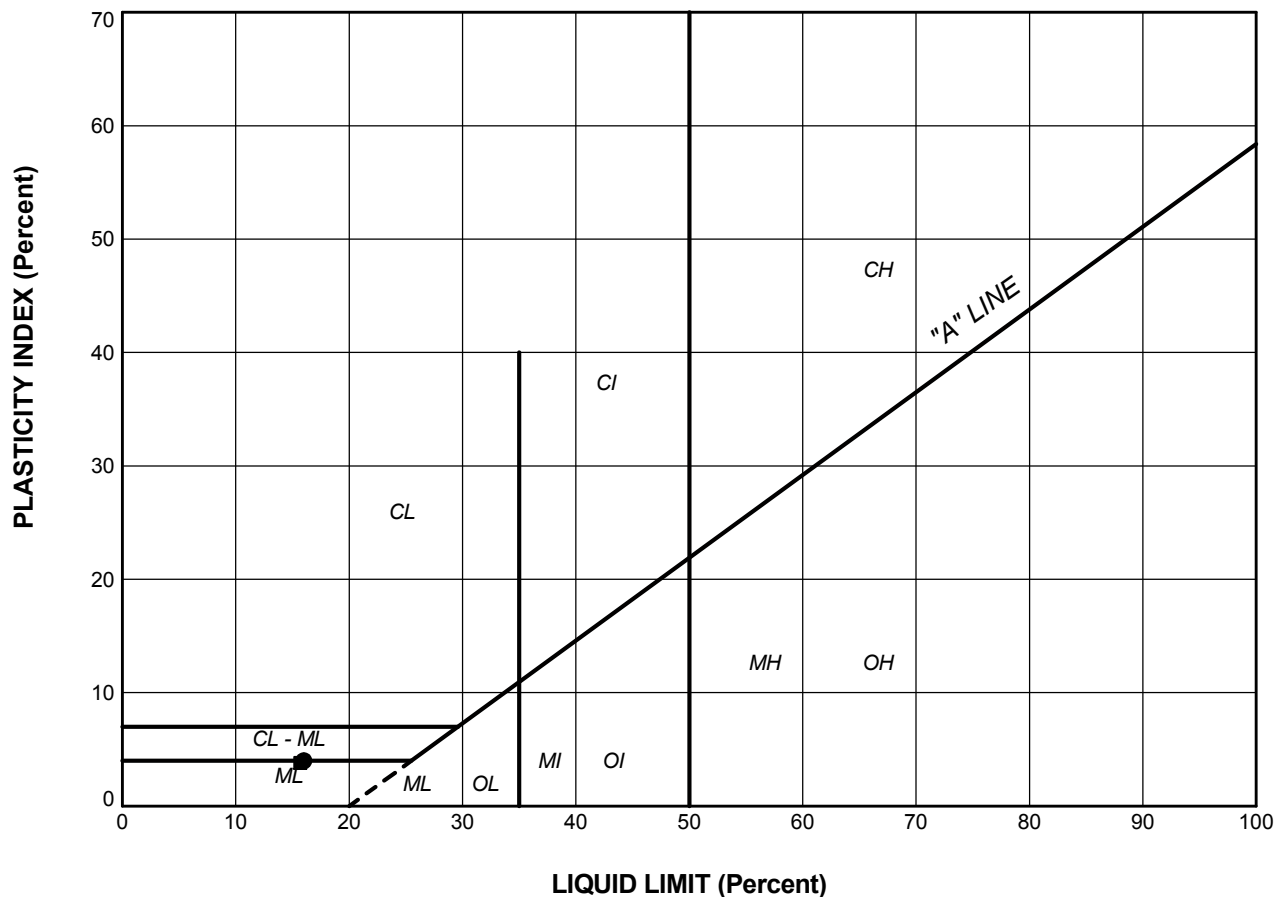


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BW-1	8	368.5
■	BW-2	6	370.1
▲	BW-3	5	370.8

PROJECT					
HIGHWAY 11 BLACKWATER RIVER TRIBUTARY CULVERT STA 13+322					
TITLE					
GRAIN SIZE DISTRIBUTION SILT and SAND to GRAVELLY SANDY SILT (TILL)					
PROJECT No.		1533879		FILE No. 1533879.GPJ	
DRAWN	JJL	Aug 2016	SCALE	N/A	REV.
CHECK	DAM	Aug 2016			
APPR	JMAC	Aug 2016			
 Golder Associates SUDBURY, ONTARIO			FIGURE B2		



SOIL TYPE
 C = Clay
 M = Silt
 O = Organic

PLASTICITY
 L = Low
 I = Intermediate
 H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	BW-2	6	16.0	12.0	4.0
■	BW-3	5	15.7	11.9	3.8

PROJECT					
HIGHWAY 11 BLACKWATER RIVER TRIBUTARY CULVERT STA 13+322					
TITLE					
PLASTICITY CHART SILT and SAND to GRAVELLY SANDY SILT (TILL)					
PROJECT No.		1533879		FILE No.	
DRAWN		J.J.L.		Aug 2016	
CHECK		DAM		Aug 2016	
APPR		JMAC		Aug 2016	
SCALE		N/A		REV.	
FIGURE		B3			

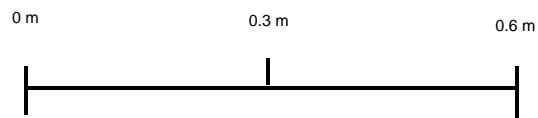





Borehole BW-3
Elevation 370.6 m to 367.5



Borehole BW-4
Elevation 371.9 m to 368.6 m



PROJECT		HIGHWAY 11	
BLACKWATER RIVER TRIBUTARY CULVERT STA13+322			
TITLE			
BEDROCK CORE PHOTOGRAPHS			
	PROJECT No. 1533879		FILE No.----
	DESIGN		SCALE AS SHOWN REV.
	CADD	AC	Aug 2016
	CHECK	DAM	Aug 2016
	REVIEW	JMAC	Aug 2016
	FIGURE B4		

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. 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 who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
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
Sudbury, Ontario, P3C 4Y1
Canada
T: +1 (705) 524 6861

