



May 4, 2016

## FOUNDATION INVESTIGATION AND DESIGN REPORT

**OSKONDAGA RIVER TRIBUTARY #1 AND TRIBUTARY #2 CULVERTS  
SITE NOS. 48W-185/C AND 48W-186/C  
HIGHWAY 17, DISTRICT OF THUNDER BAY  
GOLDIE TOWNSHIP AND SOPER TOWNSHIP  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 6943-10-00, WP 6905-12-01 & 6906-12-01**

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REPORT





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OSKONDAGA RIVER TRIBUTARY #1 AND #2 CULVERTS,  
GWP 6943-10-00, WP 6905-12-01 & 6906-12-01**

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# **PART A**

**FOUNDATION INVESTIGATION REPORT  
OSKONDAGA RIVER TRIBUTARY #1 & #2 CULVERTS (48W-185/C & 48W-186/C)  
HIGHWAY 17, DISTRICT OF THUNDER BAY  
TOWNSHIPS OF GOLDIE AND SOPER  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 6943-10-00, WP 6905-12-01 & 6906-12-01**



## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by Hatch on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the temporary roadway protection associated with the rehabilitation of the Oskondaga River Tributary #1 and #2 culverts, Sites 48W-185/C and 48W-186/C, respectively. The Oskondaga River Tributary #1 and #2 culverts are located in the District of Thunder Bay in the Townships of Goldie and Soper, respectively, on Highway 17. The key plan showing the general locations of the culverts are shown on Figure 1.

## **2.0 SITE DESCRIPTION**

The existing Oskondaga River Tributary #1 and #2 culverts consist of Concrete Boxes, the details of which (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. For the purposes of this report, Highway 17 is oriented in a north-south direction for this section of roadway with the culvert perpendicular to the highway in an east-west orientation.

The Oskondaga River Tributaries generally flow southeast, discharging into the Shebandowan River. The Shebandowan River drains into the Matawin River, which ultimately flows into Lake Superior.

### **2.1 Oskondaga River Tributary #1 Culvert**

The Oskondaga River Tributary #1 culvert is located in the District of Thunder Bay in the Township of Goldie on Highway 17 at about STA 12+939, approximately 190 m north of the Highway 17-Ivar Road junction in Shebandowan, Ontario.

In general, the topography in the area is relatively level to gently undulating with the exception of the steep roadway embankments at the creek location. There is dense tree cover beyond the highway right-of-way at the culvert location. At Oskondaga River Tributary #1 culvert, the highway grade is at Elevation 415.2 m. The existing culvert invert is at Elevation 406.75 m at the inlet (west end) and at Elevation 406.7 m at the outlet (east end). The inlet water level was at Elevation 406.9 m and the outlet water level was at Elevation 406.5 m, measured by others in December 2015. Ground surface conditions at the culvert location are shown on Photographs A-1 to A-4 in Appendix A.

### **2.2 Oskondaga River Tributary #2 Culvert**

The Oskondaga River Tributary #2 culvert is located the District of Thunder Bay in the Township of Soper on Highway 17 at approximately STA 13+458, about 10 km generally south of Raith, Ontario.

In general, the topography in the area is relatively level to gently undulating with the exception of the steep roadway embankments at the creek location. There is dense tree cover beyond the highway right-of-way at the culvert location. At Oskondaga River Tributary #2 culvert, the highway grade is at Elevation 432.4 m. The existing culvert invert, is at Elevation 426.3 m at the inlet (east end) and at about Elevation 426.2 m at the outlet (west end). The inlet water level was at Elevation 427.0 m and the outlet water level was at Elevation 426.9 m, measured by others in December 2015. Ground surface conditions at the culvert location are shown on Photographs B-1 to B-4 in Appendix B.



### **3.0 INVESTIGATION PROCEDURES**

The fieldwork for the investigation at the Oskondaga River Tributary #1 and #2 culvert sites was carried out between December 12 and 19, 2015, and January 13 and 21, 2016, during which period a total of eight boreholes were drilled at the two culvert sites. Two boreholes were drilled at Tributary #1 culvert (Boreholes OS1-1 and OS1-2) and six boreholes were advanced at Tributary #2 culvert (Boreholes OS2-1 to OS2-6). A dynamic cone penetration test (DCPT) was driven from the bottom of Borehole OS-2-2 at Tributary #2 culvert. A summary of the boreholes advanced at each culvert site is presented in Table 1 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 truck-mounted and track-mounted CME-55 drill rigs supplied and operated by Cartwright Drilling Ltd. of Thunder Bay, Ontario, and truck-mounted buggy CME-75 and portable equipment supplied and operated by RPM Drilling Ltd. of Thunder Bay, Ontario.

The boreholes were advanced using a combination of 108 mm inside diameter hollow stem augers, NW casing, wash boring techniques, and NQ coring 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). At the borehole location where portable equipment was used, as noted on the applicable Record of Borehole sheet, a half weight hammer was used and the SPT 'N'-values were corrected, as appropriate. Field vane shear tests were conducted in cohesive soils for determination of undrained shear strengths (ASTM D2573, Standard Test Method for Field Vane Shear Strength Test) using MTO Standard 'N'-size vanes. The groundwater conditions and water levels in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets in Appendices A and B.

All open boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The boreholes were advanced to depths ranging from 7.4 m to 18.3 m below existing ground surface to refusal or penetrating up to about 3 m into competent material, which is defined as material that will provide resistance to settlement or instability of the embankment, or into bedrock. Bedrock was cored in Borehole OS1-1.

The field work was supervised on a full-time basis by members 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 and bedrock samples. The soil and bedrock 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, Atterberg limits and grain size distributions were carried out on selected soil samples. In addition, unconfined compressive strength tests were carried out on selected specimens of the bedrock core recovered from one borehole. The geotechnical laboratory testing was completed according to MTO LS standards.

A sample of the Tributary (creek) 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.

The as-drilled borehole locations and elevations were measured and surveyed by members of our technical staff, referenced to the highway centreline and existing culvert. The locations were subsequently converted into MTM NAD 83 coordinates in AutoCAD. The borehole elevations converted to Geodetic datum using the highway



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centreline elevation provided by MTO in Drawings BC-1071-17-3 and E-1038-17-1. Borehole locations given on the Record of Borehole sheets and shown on Drawings A1 and B1 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations and ground surface elevations are as follows:

Culvert Location (Township)	Borehole	MTM NAD 83 Coordinates (m)		Ground Surface Elevation (m)	Borehole/DCPT Depth (m)
		Northing	Easting		
Oskondaga River Tributary #1 Culvert Site 48W-185/C, STA 12+939 (Goldie)	OS1-1	5,389,962.9	312,678.1	415.1	18.3
	OS1-2	5,389,944.7	312,684.2	415.2	16.3
Oskondaga River Tributary #2 Culvert Site 48W-186/C, STA 13+458 (Soper)	OS2-1	5,399,145.9	313,353.1	427.6	7.4
	OS2-2*	5,399,133.0	313,350.6	427.6	5.9/7.5
	OS2-3	5,399,151.9	313,330.0	432.4	15.7
	OS2-4	5,399,132.4	313,332.6	432.4	11.0
	OS2-5	5,399,151.9	313,311.7	427.4	9.7
	OS2-6	5,399,136.5	313,311.1	427.5	9.3

Note: \*DCPT driven from the bottom of the borehole.

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS)<sup>1</sup> mapping, the subsoils in the vicinity of the Oskondaga River Tributary #1 and #2 culvert sites consists of esker glaciolacustrine plain deposits comprised primarily of sand and gravel bordered by bedrock outcrops and a ground moraine deposits comprised mainly of till.

Based on geological mapping by the Ministry of Northern Development and Mines (MNDM)<sup>2</sup>, the Tributary #1 culvert site is underlain by metasedimentary rocks, comprised of wacke arkose, argillite, slate, marble, chert and iron formations, and contains minor metavolcanic rocks. The site is bordered by muscovite-bearing granitic rocks. The Tributary #2 culvert site is underlain by muscovite-bearing granitic rocks, comprised of muscovite-biotite, cordierite-biotite granite and granodiorite-tonalite. The site is bordered by metasedimentary rock formation.

### 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 and Appendix B for Tributary #1 and #2 culvert sites, respectively. 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

<sup>1</sup> Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping.

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





uncorrected, except that the 'N'-values obtained by the use of the half-weight hammer have been corrected as noted in Section 3.0. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted cross-section and stratigraphic profile on Drawings A1 and B1, respectively, 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.

## 4.2.1 Oskondaga River Tributary #1 Culvert

A total of two boreholes, Boreholes OS1-1 and OS1-2, were advanced at the Tributary #1 culvert site. In addition, bedrock coring was completed in Borehole OS1-1. The borehole locations, ground surface elevations and interpreted stratigraphic conditions are shown on Drawing A1.

In summary, the subsoil conditions encountered at the site consist of asphalt, granular fill and clay fill, underlain by deposits of clayey silt to silty clay and gravelly silty sand, further underlain by greywacke 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)/ $S_u$ Shear Strength (kPa)	Laboratory Testing
				Relative Density or Consistency	
<b>Asphalt</b>	OS1-1, OS1-2	0.2, 0.3	415.1, 415.2	n/a	n/a
<b>(FILL) Sand<sup>1,2</sup></b> , some gravel to <b>Sand and Gravel</b> , trace to some silt; brown; moist to wet	OS1-1, OS1-2	3.5, 8.4	414.9	N = 11 - 46 <sup>2</sup>	w = 2% - 10% 3 - M (Fig. A1)
				<b>Compact to Very Dense</b>	
<b>(FILL) Clay</b> ; reddish brown; wet	OS1-1	3.5	411.4	N = 3 - 6 $S_u$ = 67 S = 7	w = 50% $w_p$ = 26% $w_L$ = 70% $I_p$ = 44% 1 - AL (Fig. A2)
				<b>Firm to Stiff</b>	
<b>Sandy Clayey Silt to Sandy Silty Clay</b> , trace gravel, trace to some organics; grey; wet	OS1-1, OS1-2	1.5, 2.9	407.9, 406.5	N = 4 - 18 $S_u$ > 100	w = 24%, 30% $w_p$ = 17%, 18% $w_L$ = 29%, 41% $I_p$ = 13%, 24% 2 - MH (Fig. A3) 2 - AL (Fig. A4)
				<b>Firm to Very Stiff</b>	
<b>Gravelly Silty Sand<sup>3</sup></b> , trace clay; grey; wet	OS1-1, OS1-2	6.5, >4.7	406.4, 403.6	N = 8 - 34 and 100 / 0.13	w = 10%, 12% 2 - MH (Fig. A5)
				<b>Compact to Very Dense</b>	

**Notes:**

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

$S_u$  = Undrained Shear Strength (kPa)

S = Sensitivity

M = Sieve analysis





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MH = Combined Sieve and Hydrometer analysis

w = Natural Moisture Content (%)

w<sub>p</sub> = Plastic Limit (%)

w<sub>l</sub> = Liquid Limit (%)

I<sub>p</sub> = Plasticity Index (%)

AL = Atterberg Limits Test

<sup>1</sup> 300 mm to 400 mm size boulders were encountered within the sand fill in both boreholes.

<sup>2</sup> SPT "N"-values of 105 blows for 0.15 m of penetration and 101 blows for 0.28 m of penetration were recorded on inferred cobbles/boulder.

<sup>3</sup> Cobbles were encountered from 12.8 m to 13.7 m in depth in Borehole OS1-1.

### Bedrock

Bedrock was encountered at a depth of 15.2 m (Elevation 399.9 m) in Borehole OS1-1 and cored for a length of 3.1 m.

The retrieved bedrock core is described as a fine to medium grained, moderately foliated, grey, greywacke as presented in the Record of Drillhole sheet in Appendix A. A photograph of the retrieved bedrock core samples is shown on Figure A6.

Borehole No.	Total Core Recovery	Rock Quality Designation	Quality Classification Table 3.10 of CFEM 2006 <sup>3</sup>	Uniaxial Compressive Strength (MPa)	Strength Classification Table 3.5 of CFEM 2006 <sup>3</sup>
OS1-1	92% - 100%	78% - 100%	Good to Excellent	31	(R3) Medium Strong

### Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The water levels at the inlet (west end) and outlet (east end) at the culvert were surveyed at Elevations 406.9 m and 406.5 m, respectively, measured by others in December 2015, respectively. Groundwater and creek 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)
OS1-1	7.7	407.4
OS1-2	11.6	403.6

### Analytical Testing of Tributary Water

The results of an analytical test on a sample of tributary water taken at the culvert site are presented in Table 2. The suite of parameters tested include pH, sulphate, chloride, resistivity and conductivity.

<sup>3</sup> Canadian Geological Society, 2006. Canadian Foundation Engineering Manual, 4th Edition.



## 4.2.2 Oskondaga River Tributary #2 Culvert

A total of six boreholes, Boreholes OS2-1 to OS2-6, were advanced at the Tributary #2 culvert site. In addition, a DCPT was driven from the bottom of Borehole OS2-2. 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 asphalt and embankment granular fill and clay fill for those boreholes drilled on the existing highway platform, topsoil and an organic silt deposit in those boreholes drilled on the south of the existing culvert, and a silty clay deposit at ground surface in those boreholes drilled on the north side of the existing culvert, underlain by a deposit of silty clay to clay, layers of sand and silt, sand to sand and gravel, all underlain by a deposit of silt and sand till. A more detailed description of the soil deposits, bedrock and groundwater conditions encountered in the boreholes is below.

Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows)/ $S_u$ Shear Strength (kPa)	Laboratory Testing
				Relative Density or Consistency	
<b>Asphalt</b>	OS2-3, OS2-4	0.3	432.4	n/a	n/a
<b>(FILL) Sand</b> , some gravel to <b>Sand and Gravel</b> , trace to some silt; brown; frozen to wet	OS2-3, OS2-4	1.8, 2.8	432.1	N = 7 - 22	w = 3% 2 - M (Fig. B1)
				<b>Loose to Compact</b>	
<b>(FILL) Silty Clay to Clay</b> ; trace to some sand, trace to some gravel; reddish brown; frozen to wet		1.3, 2.6	430.3, 429.4	N = 4 - 7	w = 17%
				<b>Firm</b>	
<b>(FILL) Clayey Silt</b> , trace organics; brown to grey; wet	OS2-3	2.2	429.0	N = 6 - 7	w = 26% w <sub>p</sub> = 22% w <sub>L</sub> = 31% I <sub>p</sub> = 9% 1 - MH (Fig. B2) 1 - AL (Fig. B3)
				<b>Firm</b>	
<b>Topsoil</b> , trace sand to sand, trace silt to silty; brown-black; moist	OS2-2, OS2-6	0.8, 1.4	427.6, 427.5	N = 4, 14*	n/a
				<b>Loose</b>	
<b>Organic Silt</b> , trace to some sand, trace to some gravel; dark brown to black; wet		0.7, 0.8	426.8, 426.1	N = 2, 5	w = 57%, 72% w <sub>p</sub> = 44% w <sub>L</sub> = 92% I <sub>p</sub> = 48% 1 - AL (Fig. B4)
				<b>Soft to Firm</b>	
<b>Clayey Silt</b> , some organics; grey; wet	OS2-3	0.7	426.8	n/a	n/a
<b>Silty Clay</b> , trace sand, trace to some organics; brown to grey; wet	OS2-1, OS2-5	2.2, 1.4	427.6, 427.4	N = 2 - 4	w = 44%, 72% w <sub>p</sub> = 23%, 26% w <sub>L</sub> = 43%, 48% I <sub>p</sub> = 20%, 22% 2 - AL (Fig. B5)
				<b>Soft to Firm</b>	



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Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows)/ $s_u$ Shear Strength (kPa)	Laboratory Testing
				Relative Density or Consistency	
<b>Clay</b> <sup>1</sup> , trace sand; reddish brown; wet	OS2-1 to OS2-6	1.1 - 3.2	426.8 - 425.3	N = WH - 12 $s_u$ = 34 - 72 S = 2 - 3  <b>Firm to Stiff</b>	w = 67% - 81% $w_p$ = 27% - 32% $w_l$ = 58% - 93% $I_p$ = 35% - 67% 4 - MH (Fig. B6) 8 - AL (Fig. B5)
<b>Silt</b> , trace clay; grey; wet	OS2-2	0.6	422.9	N = 24  <b>Compact</b>	n/a
<b>Sand</b> , trace gravel to <b>Sand and Gravel</b> , trace to some silt; grey; wet	OS2-1 to OS2-3, OS2-5 to OS2-6	0.6 - 1.4	424.5 - 421.9	N = 9 - 41 and 112/0.23  <b>Loose to Very Dense</b>	w = 7% - 15% 4 - MH (Fig. B7)
<b>(TILL) Silt and Sand to Silty Sand</b> <sup>2,3,4</sup> , trace gravel to and gravel	OS2-1, OS2-3 to OS2-6	0.9 - 5.6	423.7 - 420.5	N = 13 to 75/0.08  <b>Compact to Very Dense</b>	w = 8% - 10% 2 - MH (Fig. B8)

Notes:

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

$s_u$  = Undrained Shear Strength (kPa)

S = Sensitivity

M = Sieve analysis

MH = Combined Sieve and Hydrometer analysis

w = Natural Moisture Content (%)

$w_p$  = Plastic Limit (%)

$w_l$  = Liquid Limit (%)

$I_p$  = Plasticity Index (%)

AL = Atterberg Limits Test

\* Frozen

<sup>1</sup> Trace organics noted between 5.6 m and 7.2 m in Borehole OS2-4.

<sup>2</sup> 60 mm to 230 mm cobbles encountered in Boreholes OS2-3 from depths of 11.0 to 12.5 m, in Borehole OS2-4 from depths of 9.4 m to 10.5 m, in Borehole OS2-5 from depths of 5.4 m to 7.6 m, and in Borehole OS2-6 from depths of 7.0 m to 9.1 m.

<sup>3</sup> SPT "N"-values for various drives for less than 0.3 m of penetration inferred to be indicative of the split-spoon refusing on an obstruction, likely cobbles.

<sup>4</sup> A 0.4 m size boulder was encountered underlying the till deposit in Borehole OS2-5 at Elevation 418.1 m.

## Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The water level at the inlet (east end) and outlet (west end) at the culvert was surveyed at Elevations 427.0 m and 426.9 m, respectively, measured by others in December 2015. Groundwater and creek water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.



<b>Borehole No.</b>	<b>Depth to Groundwater Level (m)</b>	<b>Groundwater Elevation (m)</b>
OS2-1	0.4	427.2
OS2-2	0.4	427.2
OS2-3	3.8	428.6
OS2-4	3.5	428.9
OS2-5	0.0	427.4
OS2-6	0.1	427.4

### ***Analytical Testing of Tributary Water***

The results of an analytical test on a sample of tributary water taken at the culvert site are presented in Table 2. The suite of parameters tested include pH, sulphate, chloride, resistivity and conductivity.

## **5.0 CLOSURE**

The drilling program was supervised by Mr. Mathew Riopelle, Mr. Randy Axford and Mr. Mike Arthur under the direction of Mr. David Muldowney, P.Eng. This report was prepared by Ms. Sarah Nhan, E.I.T. The technical aspects were reviewed by Ms. Nikol Kochmanová, P.Eng., and Mr. Jorge M. A. Costa, P.Eng., Principal and Golder's Designated MTO Foundations Contact for this project, carried out a quality control review of the report.



## Report Signature Page

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# **PART B**

**FOUNDATION DESIGN REPORT  
OSKONDAGA RIVER TRIBUTARY #1 & #2 CULVERTS (48W-185/C & 48W-186/C)  
HIGHWAY 17, DISTRICT OF THUNDER BAY  
TOWNSHIPS OF GOLDIE AND SOPER  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 6943-10-00, WP 6905-12-01 & 6906-12-01**



## **6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS**

This section of the report provides an interpretation of the factual geotechnical data obtained during the subsurface investigation and recommendations on the excavation aspects of design of the proposed works. The recommendations provided are intended for the guidance of the design engineer. Where comments are made on construction, they are provided to highlight aspects of construction that could affect the design of the project. Those requiring information on aspects of construction must make their own interpretation of the subsurface information provided as it affects their proposed construction methods, costs, equipment selection, scheduling and the like.

### **6.1 General**

The following sections of this report provide foundation recommendations for the design of temporary roadway protection for the rehabilitation of the Oskondaga River Tributary #1 and #2 culverts, Sites 48W-185/C and 48W-186/C, respectively, and for cofferdams for the Tributary #2 culvert, crossing Highway 17 in the District of Thunder Bay, Ontario. The details of the two existing culverts addressed in this report are summarized in Table 1. It is understood that:

- The rehabilitation of Oskondaga River Tributary #1 culvert will include crack injections, localized concrete repair and patching inside the culvert barrel and concrete repair consisting of patching and re-facing of the exterior of the culvert walls;
- The rehabilitation of Oskondaga River Tributary #2 culvert will include crack injection and localized patching at the exposed culvert ends;
- Minor modifications to vegetation and embankment grading will be completed to allow for the proposed rehabilitation works; and
- The culverts will be rehabilitated with both lanes of traffic maintained open during the rehabilitation works.

It is understood that to rehabilitate the ends of the culverts, the embankment will be stripped to expose the top slab at both culvert sites, and the embankment backfill will be stripped from the sidewalls at Oskondaga River Tributary #1 culvert. At this time, it is not expected that material will be excavated from the sidewalls at Oskondaga River Tributary #2 culvert. It is understood that Hatch is proposing that the excavation be backfilled with the excavated material once the repair works are completed.

The embankment fill at both Oskondaga River Tributary culvert sites is comprised of an upper layer of sand with varying amounts of gravel to sand and gravel, and a lower layer of silty clay to clay at the Tributary #1 culvert site, and clay at Tributary #2 culvert site. It is anticipated that the excavations required to allow for rehabilitation works of the culvert walls at the Tributary #1 culvert site will extend to the full depth of fill present, to the level of the base slab.

### **6.2 Excavations and Temporary Cut Slopes**

The proposed works will require excavations through the embankment fill to expose the top of each culvert as well as from the sidewalls of Tributary #1 culvert. Based on the groundwater conditions observed during the subsurface





investigation and the proposed rehabilitation works, groundwater is not expected to be encountered to the bottom of an excavation extending to the top of the roof slabs at either culvert but may be encountered at the base of the excavation at the invert level at Tributary #1 culvert.

The rehabilitation work will be carried out in dewatered conditions at both Tributary #1 and Tributary #2 culverts, and therefore groundwater cut-offs (cofferdam or similar measure) will be required. A cut-off/cofferdam could consist of interlocking steel sheetpiles driven to a suitable depth. The design of the cofferdam system, and temporary protection system if required, is the responsibility of the contractor. The groundwater level is subject to fluctuations, likely occurring with the fluctuations in the adjacent creek water level at each site, and therefore the depth of excavation above or below the groundwater will depend on the time of year of construction. Also, perched groundwater may be present within the granular fill layers. Surficial water seepage into the excavations may also occur during periods of sustained precipitation. Pumping from properly filtered sumps located at the base of the excavations may be required to provide groundwater control but should be located outside of the actual excavation limits required for the rehabilitation works. Surface water runoff should be directed away from the excavations at all times.

All excavations should be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. The fill materials at this site would be classified as Type 3 soils. Temporary open cut slopes within the fill materials and native soils should be maintained no steeper than 1 horizontal to 1 vertical. Flatter side slopes may be necessary in areas with saturated or loose granular fills.

## **6.3 Temporary Roadway Protection and Cofferdam Support Systems**

Temporary protection systems may be required to support embankment fills during rehabilitation at each culvert site. It is understood that at this time the culvert rehabilitation will be limited to the culvert extension portions, as such, excavation will be limited to the area of the construction joint between the old culvert and the culvert extension. Assuming the maximum depth of excavation is required to approximately Elevation 408 m at Tributary #1 culvert, as shown on the preliminary drawings provided by Hatch, an excavation in the order of 7 m deep below existing roadway surface will be required. At Tributary #2 culvert, the excavation would extend to the top of the culvert roof slab at approximately Elevation 429 m.

The temporary support system, or cofferdam at the ends of the culverts required to allow for repair works to be carried out in-the-dry, could consist of either driven steel sheet piling or soldier piles and lagging where the H-piles would be driven to a suitable depth and horizontal lagging installed as the excavation proceeds. It is noted that the subsurface conditions underlying the embankment fill at the Tributary #1 culvert site consist of a 1.5 m to 2.9 m thick stratum of firm to very stiff sandy clayey silt to sandy silty clay, underlain by a deposit of compact to very dense gravelly silty sand which may not readily allow for the installation of conventional steel sheet pile shoring. Support to the system could be in the form of struts and walers or rakers and anchors.

Where necessary, adequate support must be provided for other structures or existing utilities which may be present adjacent to the excavations.

The temporary excavation support system and the cofferdams at the ends of the Tributary #1 and Tributary #2 culverts should be designed and constructed in accordance with Ontario Provincial Standard Specification (OPSS). PROV 539 (Temporary Protection Systems). The lateral movement of the temporary shoring system



**FOUNDATION REPORT - HIGHWAY 17 CULVERT REPLACEMENTS  
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should meet Performance Level 2 as specified in OPSS.PROV 539. The contractor is responsible for the complete detailed design of the temporary protection and cofferdam systems.

The design of braced soldier pile and lagging walls should be based on a rectangular earth pressure distribution (CFEM 2006; NAVFAC 1982) using the design parameters given below. Where the support to the wall is provided by anchors or rakers, the wall design should be based on a triangular earth pressure distribution using the design parameters given below. The raker/anchor support must be designed to accommodate the loads applied from pressures and surcharge pressures from area, line or point loads as well as the impact of sloping ground behind the system. Passive toe restraint to the soldier piles may be determined using a triangular pressure distribution acting over an equivalent width equal to three times the pile socket diameter.

Site	Soil Type	Internal Angle of Friction ( $\phi$ , degrees)	Unit Weight ( $\gamma$ , kN/m <sup>3</sup> )	Undrained Shear Strength ( $S_u$ , kPa)	Coefficients of Earth Pressure		
					Active, $K_a$	At-Rest, $K_o$	Passive, $K_p$
Tributary #1 Culvert	Sand to Sand and Gravel Fill	30	20	-	0.33	0.50	3.0
	Clay Fill	27	17	50	0.37	0.55	2.7
	Sandy Clayey Silt to Sandy Silty Clay	27	19	75	0.38	0.55	2.7
	Gravelly Silty Sand	32	21	-	0.31	0.47	3.3
Tributary #2 Culvert	Sand to Sand and Gravel Fill	30	20	-	0.33	0.50	3.0
	Silty Clay to Clay Fill	27	17	50	0.37	0.55	2.7
	Clayey Silt Fill	27	17	50	0.37	0.55	2.7
	Clayey Silt	27	17	50	0.37	0.55	2.7
	Silty Clay to Clay	23	17	30	0.44	0.61	2.3
	Silt	30	20	-	0.33	0.5	3.0
	Sand to Sand and Gravel	32	21	-	0.31	0.47	3.3
	Silt and Sand to Gravelly Silty Sand Till (with Cobbles/Boulder zones)	34	21	-	0.28	0.44	3.54

The temporary shoring design should be assessed for both the drained and undrained cases, based on the more conservative earth pressure conditions. The earth pressure coefficients noted above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present, the coefficient of earth pressure should be adjusted accordingly.



Design of the temporary roadway support system and cofferdam system should include an evaluation of base stability ("base heave" or soil squeezing stability) and hydraulic uplift stability as defined in the Canadian Foundation Engineering Manual (CFEM 2006).

The total passive resistance below the base of the excavation and below the base of the dewatered area within the sheet pile cofferdam should be calculated based on the values of  $K_p$  given above and then reduced by an appropriate factor of safety which considers the allowable wall movement as extrapolated from Figure C6.16 of the Canadian Highway Bridge Design Code (CHBDC 2006) to account for the fact that a large strain would be required for full mobilization of the passive resistance.

## 6.4 Backfill Materials

Based on the construction drawings from Hatch, it is expected that excavated material will be re-used to backfill the excavations. Lateral pressures on the sidewalls of the culvert after backfill and protection from frost penetration should be considered in the type of backfill material to be used, as follows:

- Select, free draining granular fill meeting the requirements of OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type I, II or III should be used as backfill behind the culvert walls, and on top of the culvert for a thickness of up to 300 mm. Based on the subsurface conditions encountered, it is expected that the granular embankment fill is similar to a Granular 'B' Type I fill and should be suitable for backfill, although cobbles and boulders were encountered in this layer at Tributary #1 culvert. If cobbles and boulders are present in the fill excavated, these should be removed prior to backfilling the excavations. If the excavated material is not sufficient for backfilling the excavation, new fill meeting the requirements of OPSS.PROV 1010 noted above should be used.
- Backfilling should be carried out in accordance with OPSS.PROV 902 (Excavating and Backfilling-Structures) with backfill placed in maximum 200 mm loose lift thickness and compacted as per OPSS.PROV 501 (Compacting) to not less than 95 per cent of the standard Proctor maximum dry density (SPMDD) of the material.
- Granular fill should be placed against the culvert walls in a zone with the width equal to or greater than the equivalent depth of frost penetration (as per OPSD 3090.100 (Foundation Frost Penetration Depths for Northern Ontario), which at this site is 2.4 m behind the back of the walls for a restrained wall (see Figure C6.20(a) of the Commentary to the CHBDC).

Backfill material to be placed above the initial 300 mm cover over the culverts should consist of granular material of a composition similar to the immediately adjacent (existing) embankment fill to reduce the potential for incompatibility of roadway performance between the existing and newly placed backfill.

## 7.0 CLOSURE

This report was prepared Ms. Sarah Nhan, E.I.T. and Ms. Nikol Kochmanová, P.Eng. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project and a Principal with Golder, reviewed the technical aspects of and conducted an independent quality control review of the report.



## Report Signature Page

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Canadian Highway Bridge Design Code (CHBDC) and Commentary, 2006. CAN/CSA-S6-06 and CSA Special Publication S6.1 06, Canadian Standards Association.

Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Map Reference Number 32DSW.

Ontario Geological Survey, 1991. Geology of Ontario, Special Volume 4, Part 1. Eds P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott, Ministry of Northern Development and Mines, Ontario.

Unified Facilities Criteria, NAVFAC Design Manual, DM-7.2. Soil Mechanics, Foundation and Earth Structures. U.S. Navy, 1982, Alexandria, Virginia.

### ASTM International:

ASTM D1586                      Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils

ASTM D2573                      Standard Test Method for Field Vane Shear Strength Test

### Ontario Occupational Health and Safety Act:

Ontario Regulation 213/91   Construction Projects as amended by O. Reg. 443/09

### Ontario Provincial Standard Drawings:

OPSD 3090.100                  Foundation, Frost Penetration Depths for Northern Ontario

### Ontario Provincial Standard Specification:

OPSS.PROV 501                  Construction Specifications for Compacting

OPSS.PROV 539                  Construction Specification for Temporary Protection Systems

OPSS.PROV 902                  Construction Specifications for Excavating and Backfilling - Structures

OPSS.PROV 1010                  Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

### Ontario Water Resources Act:

Regulation 903                  Wells (as amended)



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**Table 1: Summary Details of Existing Culverts**

Culvert Location Highway 17 (Township)	Approximate Existing Embankment Height <sup>1</sup> (m)	Existing Culvert			Approximate Inlet/Outlet Invert Elevation (m)	Boreholes	Reference Appendix
		Type	Height x Span (m)	Length (m)			
Oskondaga River Tributary #1 Culvert, Site 48W-185/C, STA 12+939 (Goldie)	7.5 (4 m over culvert)	Cast-in-Place Reinforced Concrete Box	3.6 x 6.1	45.7	406.9/406.5	2 Boreholes	A
Oskondaga River Tributary #2 Culvert, Site 48W-186/C, STA 13+458 (Soper)	5.5 (3 m over culvert)	Cast-in-Place Reinforced Concrete Box	2.5 x 6.1	36	427.0/426.9	6 Boreholes 1 DCPT (OS2-2)	B

Note: 1. Embankment height is relative to existing ground surface level near toe of embankment adjacent to culvert.

Prepared by: SN  
Reviewed by: NK



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OSKONDAGA RIVER TRIBUTARY #1 AND #2 CULVERTS,  
GWP 6943-10-00, WP 6905-12-01 & 6906-12-01**

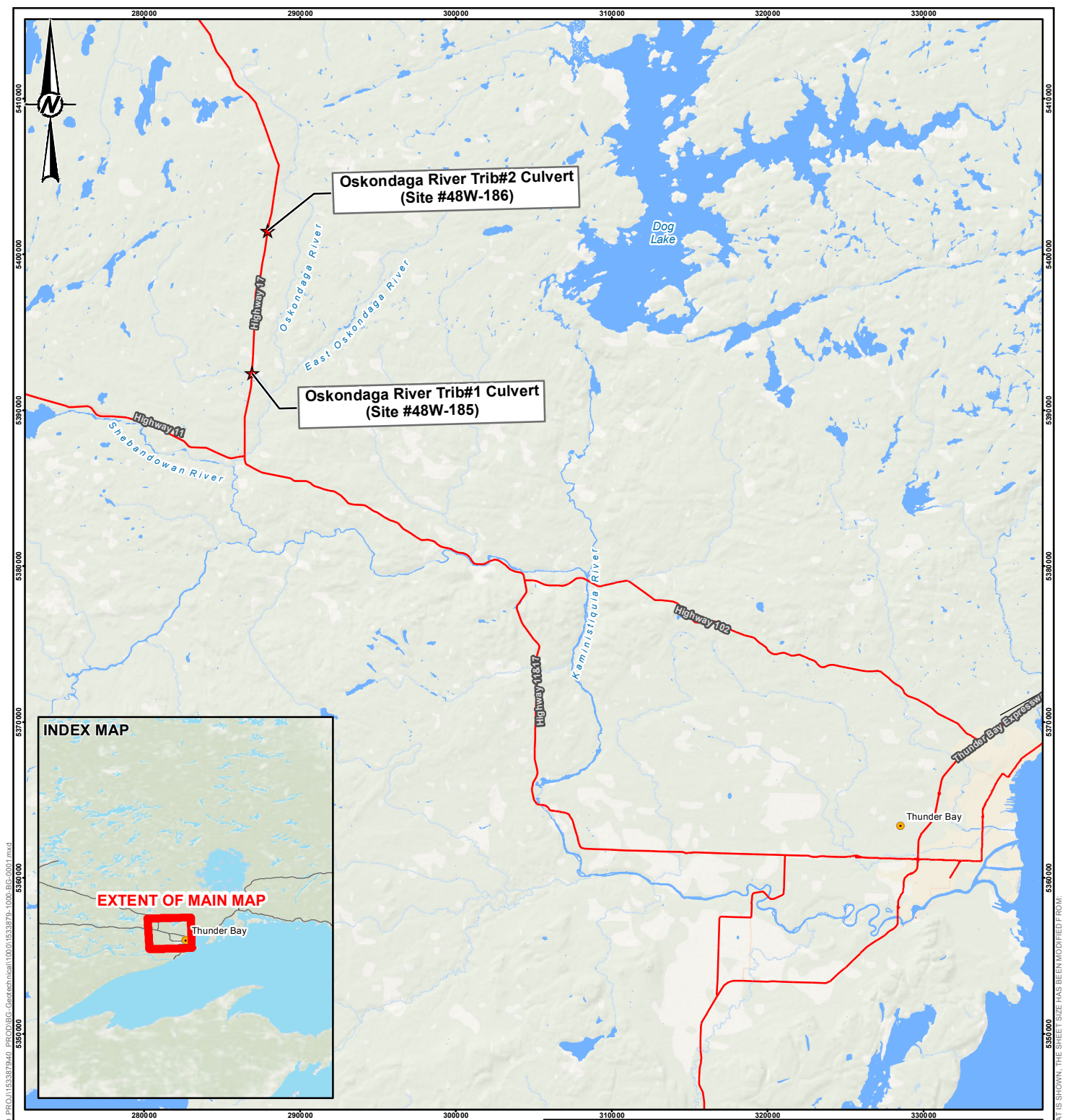
**Table 2: Summary of Analytical Testing of Oskondaga River Tributary Surface Water Samples**

<b>Culvert Location Highway 17 (Township)</b>	<b>Parameter (Units, Detection Limit)</b>				
	<b>Chloride (mg/L, 0.1)</b>	<b>Sulphate (mg/L, 0.3)</b>	<b>Conductivity (µS/cm, 3)</b>	<b>Resistivity (ohm-cm, 0.33)</b>	<b>pH (0.1)</b>
Oskondaga River Tributary #1 Culvert, Site 48W-185/C, STA 12+939 (Goldie)	1.6	2.3	50	20,040	7.01
Oskondaga River Tributary #2 Culvert, Site 48W-186/C, STA 13+458 (Soper)	2.0	2.3	55	18,292	6.97




Notes: 1. Samples obtained December 17, 2015.  
2. Analytical testing carried out by ALS Environmental.

Prepared by: SN  
Reviewed by: NK





### Legend

-  Site Location  
 Highway  
 Waterbodies

**NOTE(S)**  
THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING  
GOLDER ASSOCIATES LTD. REPORT NO. 1533879/1000

#### REFERENCE(S)

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>  
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83  
COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

CLIENT  
ONTARIO MINISTRY OF TRANSPORTATION

PROJECT  
OSKONDAGA RIVER TRIBUTARY #1 AND #2  
CULVERTS REHABILITATION

TITLE  
**LOCATION PLAN**

CONSULTANT

YYYY-MM-DD 2016-03-24

DESIGNED	RRD
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PREPARED	RRD
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REVIEWED	AC
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APPROVED JMAC

PROJECT NO.  
1533879

CONTROL  
1000REV.  
AFIGURE  
1



## LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

### I. GENERAL

$\pi$	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

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

### III. SOIL PROPERTIES

<b>(a)</b>	<b>Index Properties</b>
$\rho(\gamma)$	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
$\gamma'$	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
$C_\alpha$	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
$\sigma'_p$	pre-consolidation stress
OCR	over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$

### (d) Shear Strength

$\tau_p, \tau_r$	peak and residual shear strength
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	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  $\rho$ . Unit weight symbol is  $\gamma$  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 cm<sup>2</sup> 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 <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	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)
$\gamma$	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

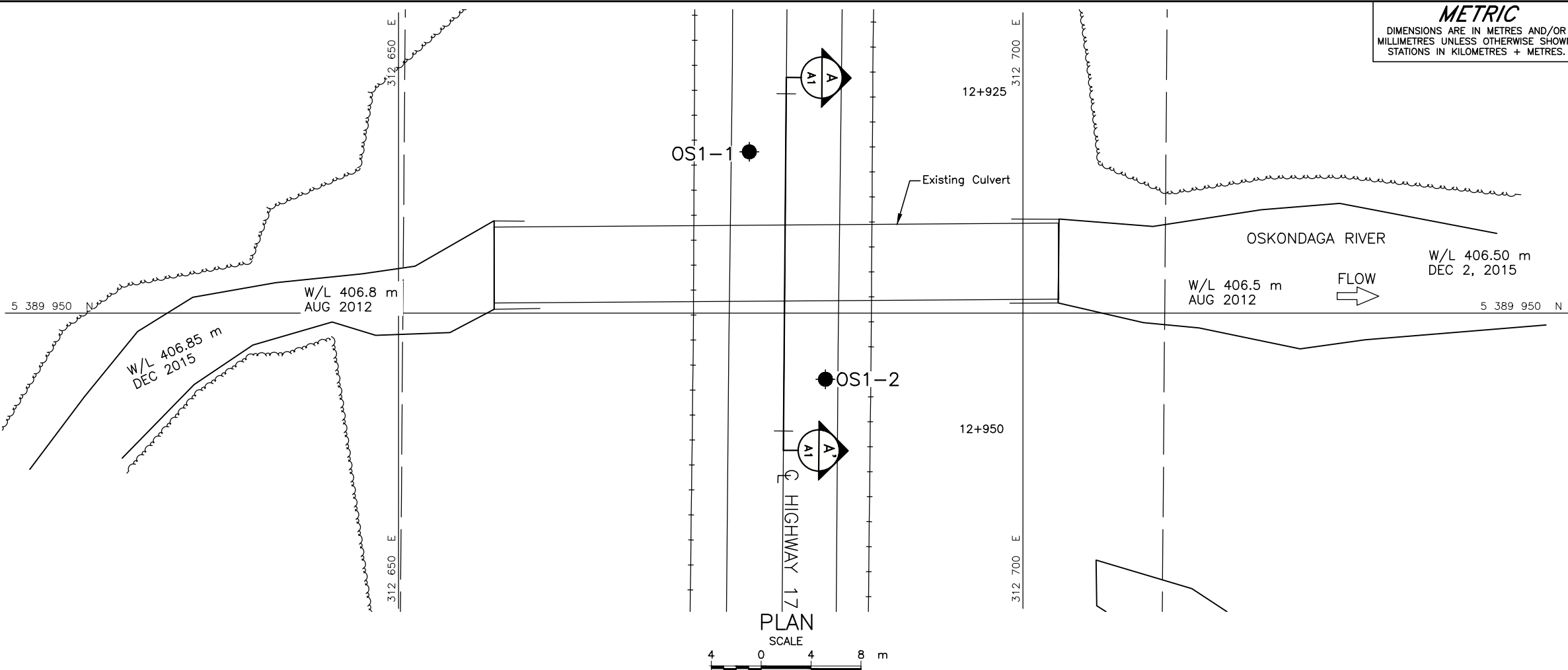
JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	



# **APPENDIX A**

**Oskondaga River Tributary #1 Culvert, Site No. 48W-185/C  
(Goldie Township)**





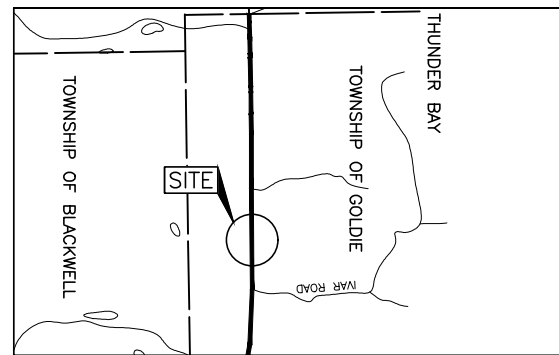
**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
GWP No.6943-10-00



HIGHWAY 17  
OSKONDAGA RIVER TRIBUTARY #1 CULVERT STA 12+939  
BOREHOLE LOCATIONS AND  
SOIL STRATA

SHEET



### LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated  
(Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- R Refusal
- WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
OS1-1	415.1	5389962.9	312678.1
OS1-2	415.2	5389944.7	312684.2

### NOTES

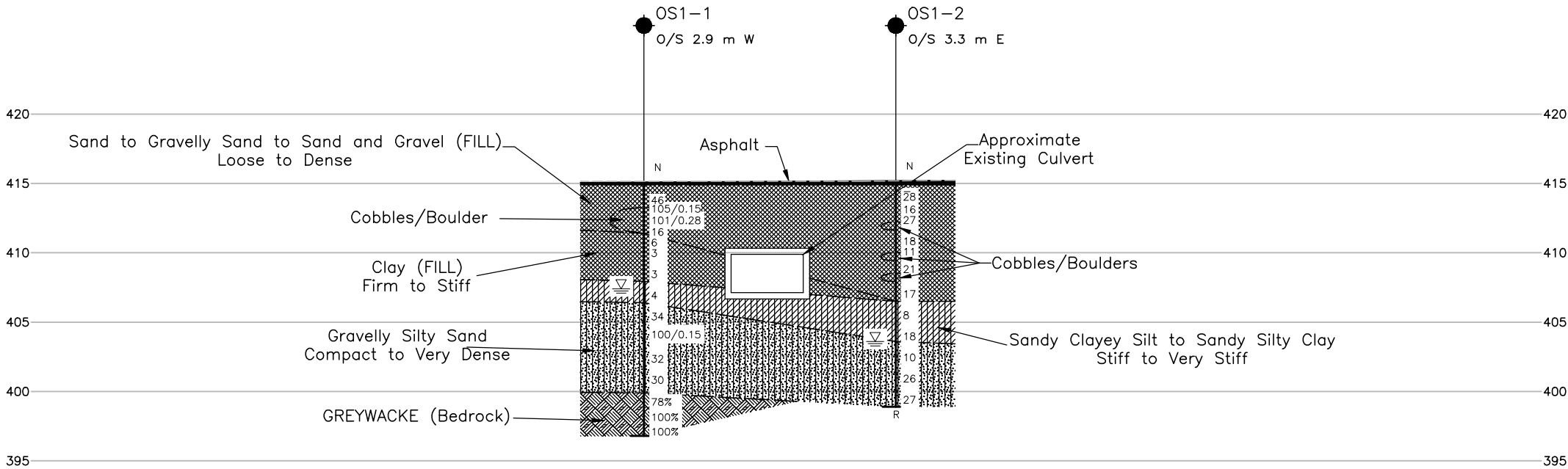
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

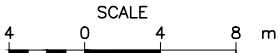
The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS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

### REFERENCE

Base plans provided in digital format by MTO, drawing file nos. BC1071173 received Dec. 11, 2015.



SCALE 1:200 A-A  
VERT. SCALE 1:200 A1



NO.	DATE	BY	REVISION
Geocres No. 52A-220			
HWY. 17	PROJECT NO. 1533879		DIST. .
SUBM'D. AC	CHKD. .	DATE: 4/28/2016	SITE: 48W-185
DRAWN: JJL	CHKD. NK	APPD. JMAC	DWG. A1



## PHOTOGRAPHS

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**Photograph A-1: Oskondaga River Tributary #1 Culvert  
Looking North at Culvert Area (December 2015)**



**Photograph A-2: Oskondaga River Tributary #1 Culvert  
Looking South at Culvert (December 2015)**







## PHOTOGRAPHS

**Photograph A-3: Oskondaga River Tributary #1 Culvert  
Looking East at West Side Inlet (December 2015)**



**Photograph A-4: Oskondaga River Tributary #1 Culvert  
Looking West at East Side Outlet (December 2015)**



<b>PROJECT</b> 1533879		<b>RECORD OF BOREHOLE No OS1-1</b>		1 OF 3 <b>METRIC</b>	
<b>G.W.P.</b> 6943-10-00		<b>LOCATION</b> N 5389962.9; E 312678.1		<b>ORIGINATED BY</b> MA	
<b>DIST</b> _____ <b>HWY</b> 17		<b>BOREHOLE TYPE</b> 108 mm I.D. Hollow Stem Augers, NW Casing, NQ Coring		<b>COMPILED BY</b> AC	
<b>DATUM</b> GEODETIC		<b>DATE</b> January 20 and 21, 2016		<b>CHECKED BY</b> NK	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	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	W <sub>P</sub>	W		W <sub>L</sub>			
415.1	GROUND SURFACE																	
0.0	ASPHALT (200 mm)																	
0.2	Gravelly sand, trace silt (FILL) Loose to dense Brown Moist  Spoon refusal in Sample 2, no recovery.  A 300 mm boulder was encountered at 1.8 m depth.  Gravel and cobbles encountered between 2.1 m and 3.7 m depth.		1	SS	46											28	66 (6)	
			2	SS	105/0.15													
			3	SS	101/0.28													
			4	SS	16													
411.4	Clay (FILL) Firm to stiff Reddish Brown Wet		5	SS	6													
3.7			6	SS	3													
			7	SS	3													
407.9	Sandy CLAYEY SILT, trace to some organics (Rootlets) Firm to very stiff Grey Wet		8	SS	4											1	29 42 28	
7.2			9	SS	34													
406.4	Gravelly SILTY SAND Compact to very dense Grey Wet		10	SS	100/0.15													
8.7																		

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 28/03/16 DATA INPUT:

PROJECT 1533879		RECORD OF BOREHOLE No OS1-1				2 OF 3 METRIC											
G.W.P. 6943-10-00		LOCATION N 5389962.9; E 312678.1				ORIGINATED BY MA											
DIST _____ HWY 17		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing, NQ Coring				COMPILED BY AC											
DATUM GEODETIC		DATE January 20 and 21, 2016				CHECKED BY NK											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	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						
	Gravelly SILTY SAND Compact to very dense Grey Wet		11	SS	32												27 45 27 1
	Cobbles encountered from 12.8 m to 13.7 m depth.																
			12	SS	30												
399.9	GREYWACKE (BEDROCK)																
15.2	Bedrock cored from 15.2 m depth to 18.3 m depth.  For coring details see Record of Drillhole OS1-1.		1	RC	REC 92%												RQD = 78%
			2	RC	REC 100%												RQD = 100%
			3	RC	REC 100%												RQD = 100%
396.8	END OF BOREHOLE																
18.3	Note:  1. Water level at a depth of 7.7 m below ground surface (Elev. 407.4 m) upon completion of drilling.																

PROJECT: 1533879

## RECORD OF DRILLHOLE: OS1-1

SHEET 3 OF 3

LOCATION: N 5389962.9;E 312678.1

DRILLING DATE: January 21, 2016

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Cartwright Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SHR- Shear VN - Vein CJ - Conjugate												BD- Bedding FO- Foliation CO- Contact OR- Orthogonal CL - Cleavage												PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular												PO- Polished K - Slickensided SM- Smooth Ro - Rough MB- Mechanical Break												BR - Broken Rock	NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
							FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA												HYDRAULIC CONDUCTIVITY		Diameter Point Load Index (MPa)	RMC -Q' AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION														k, cm/s																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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DEPTH SCALE

1 : 60



LOGGED: MA

CHECKED: NK

SUD-RCK 1533879 GPJ GAL-MISS.GDT 28/03/16 DATA INPUT:

1 OF 2 **METRIC**

CHECKED BY NK

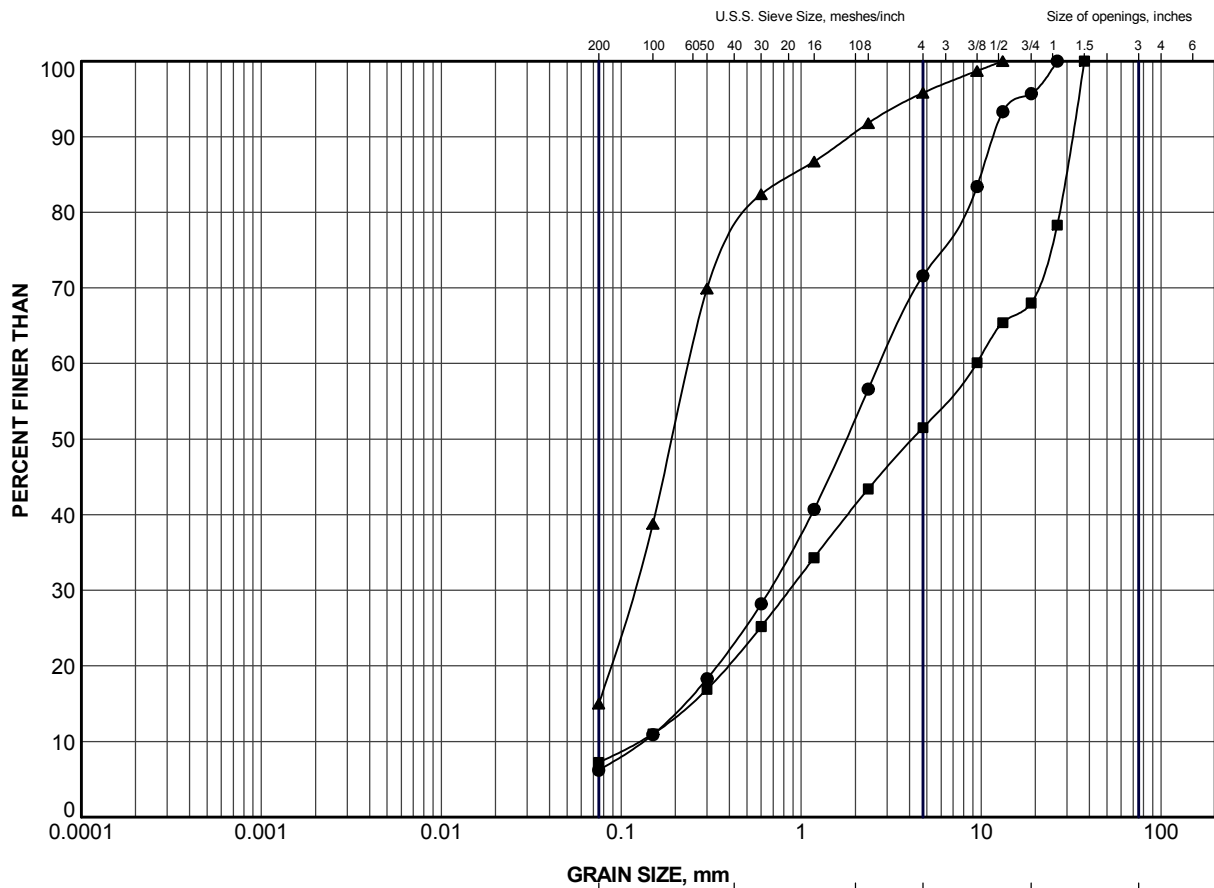
SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 28/03/16 DATA INPUT:

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT 1533879		<b>RECORD OF BOREHOLE No OS1-2</b>		2 OF 2 <b>METRIC</b>	
G.W.P. 6943-10-00		LOCATION N 5389944.7; E 312684.2		ORIGINATED BY MA	
DIST _____ HWY 17		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing and Wash Boring		COMPILED BY AC	
DATUM GEODETIC		DATE January 13, 16, 17, 18 and 19, 2016		CHECKED BY NK	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT  w <sub>p</sub>	NATURAL MOISTURE CONTENT  w	LIQUID LIMIT  w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	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						
	--- CONTINUED FROM PREVIOUS PAGE ---																						
	Gravelly SILTY SAND, trace clay Compact Grey Wet		12	SS	10																		
			13	SS	26								○					23	54				
																		21	2				
			14	SS	27																		
398.9																							
16.3	END OF BOREHOLE AUGER AND SPLIT SPOON REFUSAL  Note:  1. Water level at a depth of 11.6 m below ground surface (Elev. 403.6 m) upon completion of drilling.																						




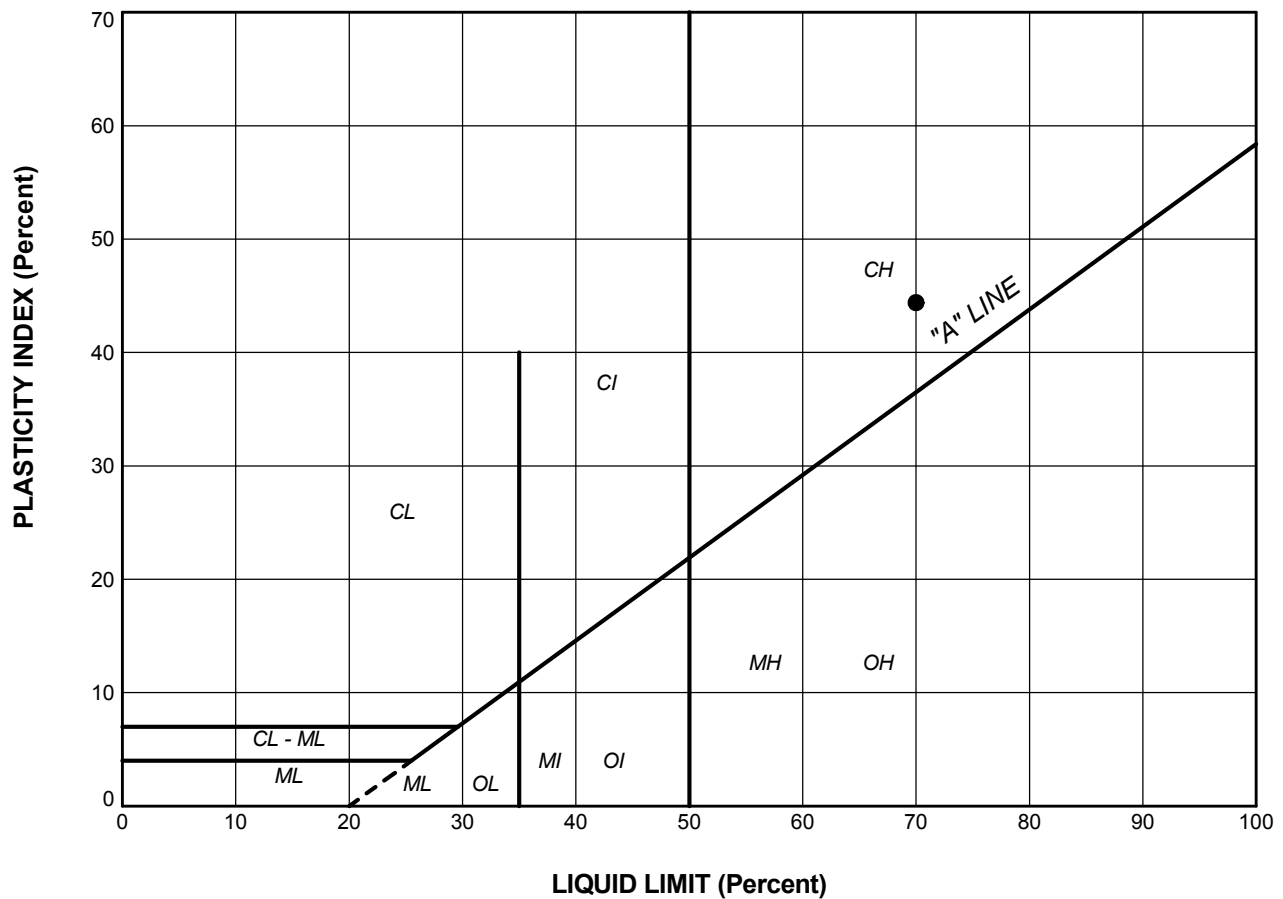


CLAY AND SILT		SAND SIZE, mm			GRAVEL SIZE, mm		Cobble Size
		fine	medium	coarse	fine	coarse	
		SAND SIZE			GRAVEL SIZE		

#### LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	OS1-1	1	414.0
■	OS1-2	1	414.7
▲	OS1-2	4	412.6

PROJECT						HIGHWAY 17 OSKONDAGA RIVER TRIBUTARY #1 CULVERT STA 12+939					
TITLE						GRAIN SIZE DISTRIBUTION SAND to SAND and GRAVEL (FILL)					
PROJECT No.				1533879		FILE No.				1533879.GPJ	
DRAWN	TB	Mar 2016		SCALE	N/A	REV.					
CHECK	NK	Mar 2016									
APPR	JMAC	Mar 2016						FIGURE A1			
 <b>Golder Associates</b> SUDBURY, ONTARIO											

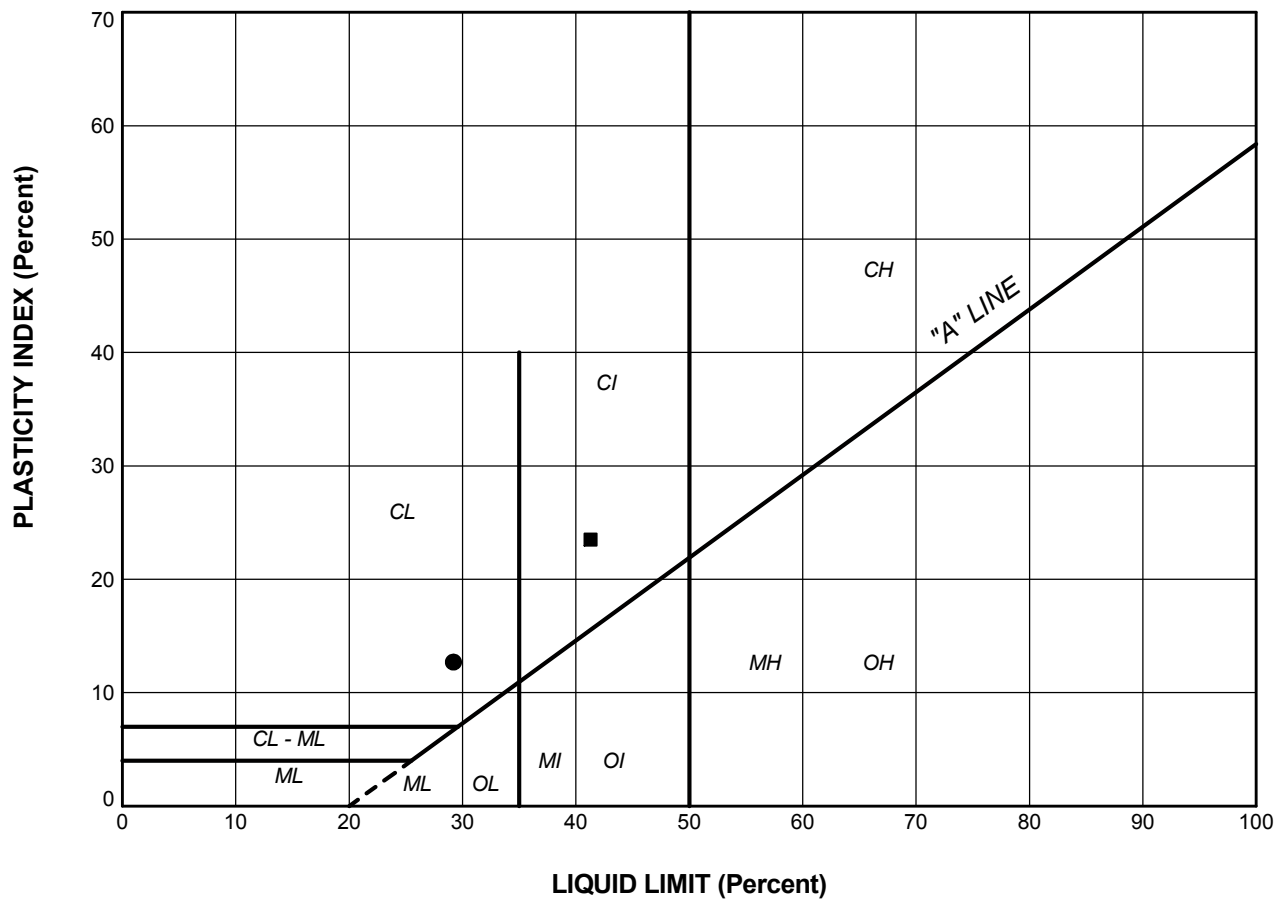


### LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	OS1-1	6	70.0	25.6	44.4


PROJECT		HIGHWAY 17 OSKONDAGA RIVER TRIBUTARY #1 CULVERT STA 12+939			
TITLE		PLASTICITY CHART CLAY (FILL)			
PROJECT No.		1533879		FILE No.	
DRAWN		TB		Mar 2016	
CHECK		NK		Mar 2016	
APPR		JMAC		Mar 2016	
SCALE		N/A		REV.	
 <b>Golder Associates</b> SUDBURY, ONTARIO		<b>FIGURE A2</b>			

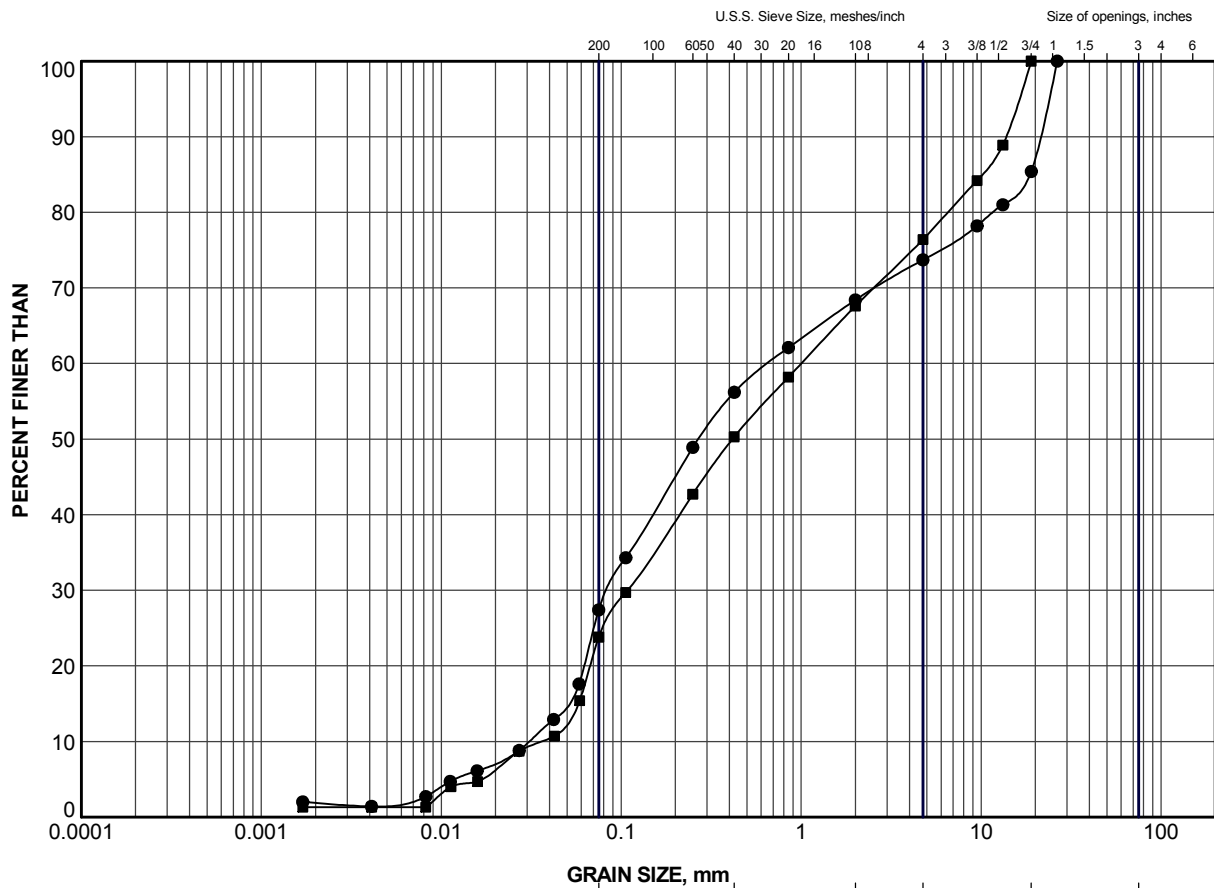




### LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	OS1-1	8	29.2	16.5	12.7
■	OS1-2	11	41.3	17.8	23.5


PROJECT						HIGHWAY 17 OSKONDAGA RIVER TRIBUTARY #1 CULVERT STA 12+939					
TITLE											
<b>PLASTICITY CHART</b> SANDY CLAYEY SILT and SANDY SILTY CLAY											
PROJECT No. 1533879				FILE No. 1533879.GPJ							
DRAWN	TB	Mar 2016	SCALE	N/A	REV.						
CHECK	NK	Mar 2016									
APPR	JMAC	Mar 2016									
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE A4</b>								

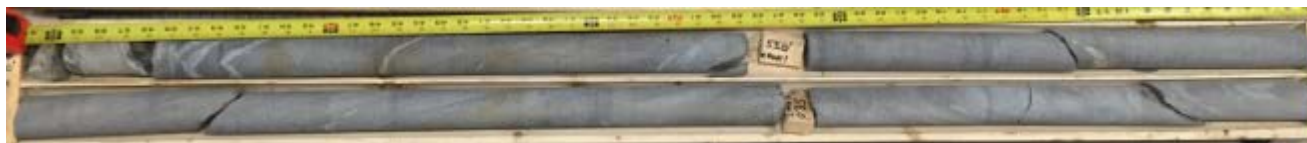


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

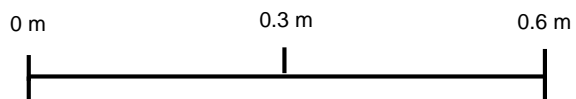
#### LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	OS1-1	11	402.6
■	OS1-2	13	401.2

PROJECT						HIGHWAY 17 OSKONDAGA RIVER TRIBUTARY #1 CULVERT STA 12+939					
TITLE						GRAIN SIZE DISTRIBUTION GRAVELLY SILTY SAND					
PROJECT No.			1533879			FILE No.			1533879.GPJ		
DRAWN	TB	Mar 2016	SCALE	N/A	REV.						
CHECK	NK	Mar 2016									
APPR	JMAC	Mar 2016									
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE A5</b>								



Borehole OS1-1  
Elevation 399.9 m to 396.8 m



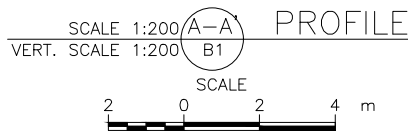
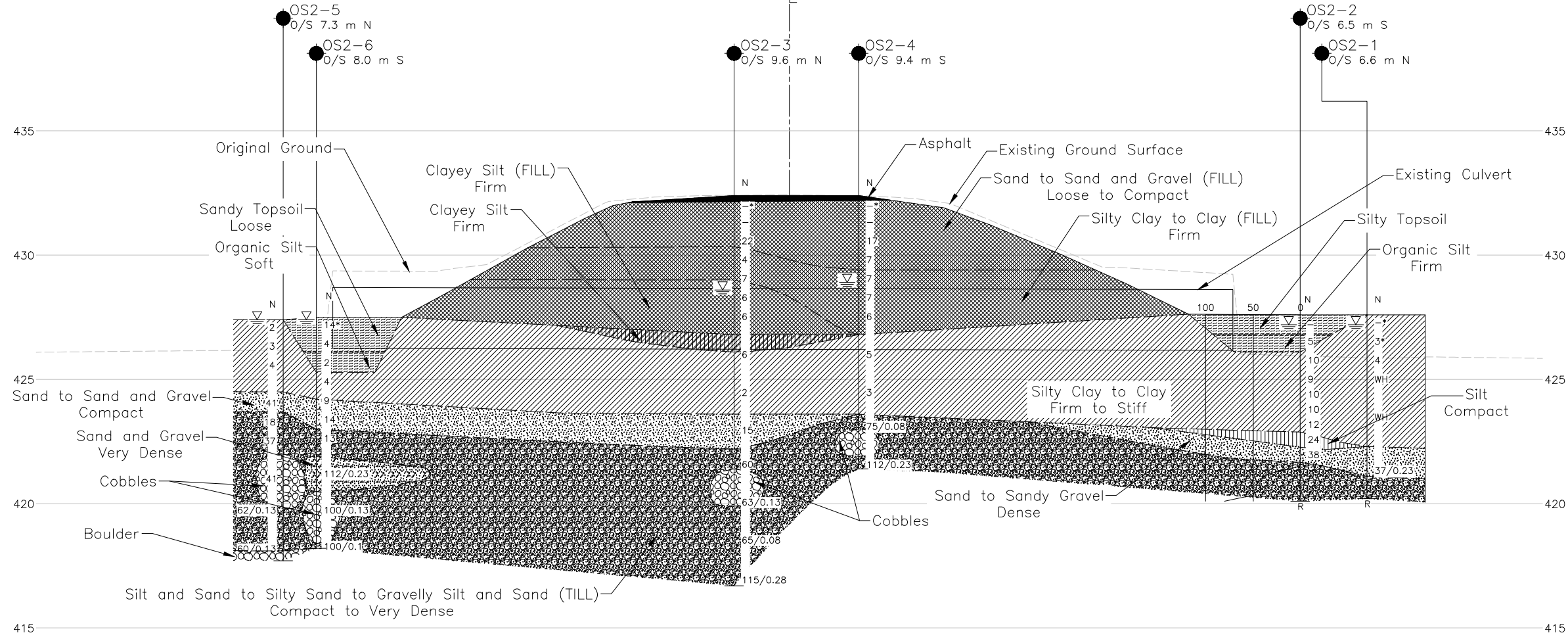
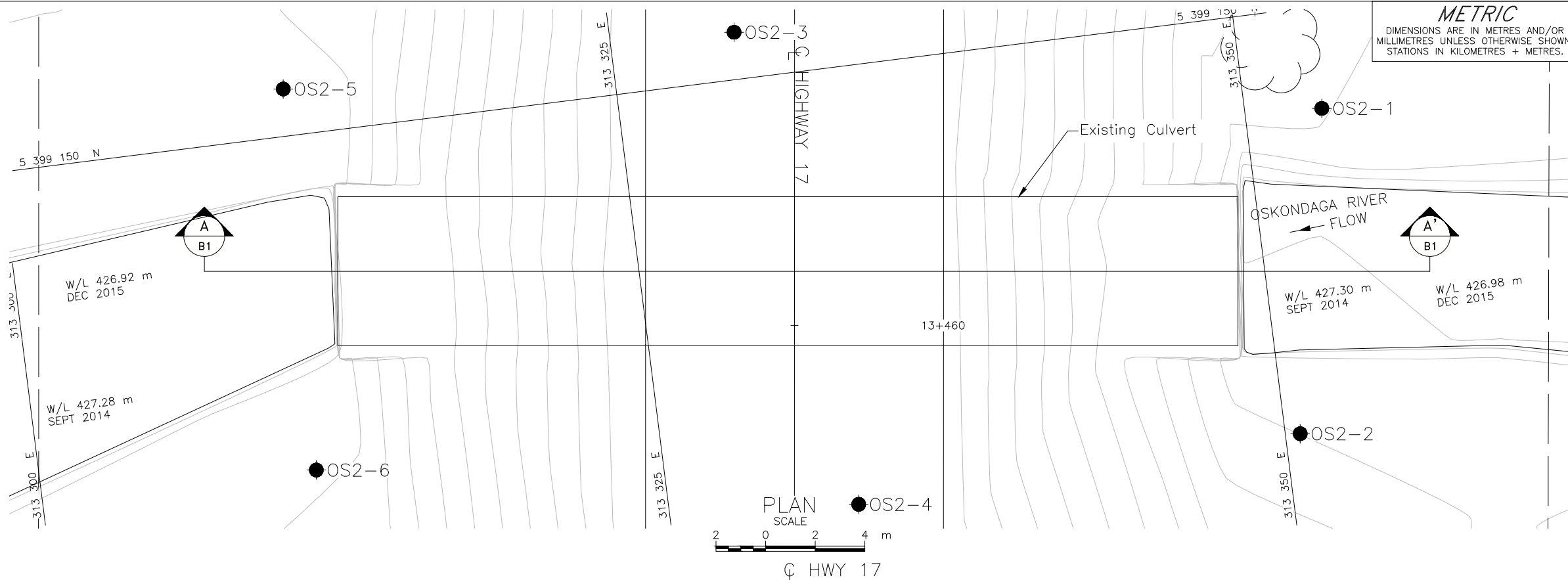
PROJECT		HIGHWAY 17 OSKONDAGA RIVER TRIBUTARY #1 CULVERT STA 12+939			
TITLE		BEDROCK CORE PHOTOGRAPH			
		PROJECT No. 1533879		FILE No. ----	
		DESIGN	SN	Feb. 2016	SCALE AS SHOWN
		CADD	--		REV.
		CHECK	NK	Feb. 2016	FIGURE A6
		REVIEW	JMAC	Feb. 2016	





## **APPENDIX B**

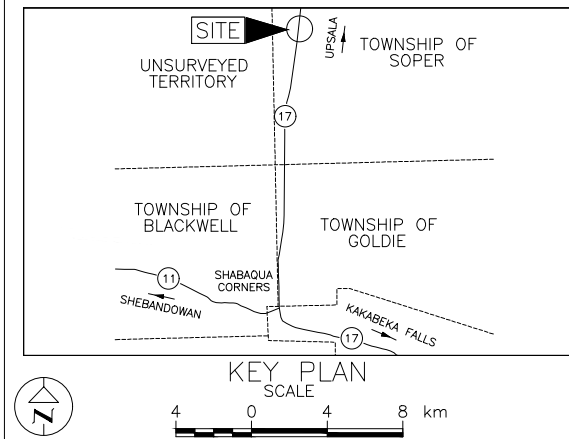
**Oskondaga River Tributary #2 Culvert, Site No. 48W-186/C (Soper Township)**



CONT No.  
GWP No.6943-10-00

HIGHWAY 17  
OSKONDAGA RIVER TRIBUTARY #2 CULVERT  
STA 13+458  
BOREHOLE LOCATIONS AND  
SOIL STRATA

SHEET



LEGEND

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
OS2-1	427.6	5399145.9	313353.1
OS2-2	427.6	5399133.0	313350.6
OS2-3	432.4	5399151.9	313330.0
OS2-4	432.4	5399132.4	313332.6
OS2-5	427.4	5399151.9	313311.7
OS2-6	427.5	5399136.5	313311.1

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.

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. E1038171 received Dec. 11, 2015.

NO.	DATE	BY	REVISION
Geocres No. 52A-220			
HWY. 17	PROJECT NO. 1533879		DIST. .
SUBM'D. AC	CHKD. .	DATE: 4/28/2016	SITE: 48W-186
DRAWN: JJL	CHKD. NK	APPD. JMAC	DWG. B1



## PHOTOGRAPHS

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**Photograph B-1: Oskondaga River Tributary #2 Culvert  
Looking North at Culvert (December 2015)**



**Photograph B-2: Oskondaga River Tributary #2 Culvert  
Looking South at Culvert (December 2015)**







## PHOTOGRAPHS




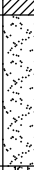

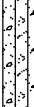
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**Photograph B-3: Oskondaga River Tributary #2 Culvert  
Looking West at East Side Inlet (December 2015)**



**Photograph B-4: Oskondaga River Tributary #2 Culvert  
Looking East at West Side Outlet (December 2015)**



PROJECT 1533879		RECORD OF BOREHOLE No OS2-1				1 OF 1 METRIC											
G.W.P. 6943-10-00		LOCATION N 5399145.9; E 313353.1		ORIGINATED BY MR													
DIST _____ HWY 17		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers		COMPILED BY AC													
DATUM GEODETIC		DATE January 14, 2016		CHECKED BY NK													
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
427.6	GROUND SURFACE						20	40	60	80	100	20	40	60			
0.0	SILTY CLAY, trace sand, trace organics Firm Brown - grey Frozen* to wet		1	AS	-*		427										
			2	SS	3*		426										
			3	SS	4												
425.4	CLAY Stiff Reddish Brown Wet		4	SS	WH		425										
2.2							424										
			5	SS	WH		423										
422.3	SAND, some gravel Dense Grey Wet						422										
5.3			6	SS	37/0.23		421										
421.1	Gravelly SILT and SAND (TILL)  Augers grinding from 6.5 m to 7.4 m depth.						421										
6.5																	
420.2	END OF BOREHOLE AUGER AND SPLIT-SPOON REFUSAL  Note:  1. Water level at a depth of 0.4 m below ground surface (Elev. 427.2 m) upon completion of drilling.																
7.4																	

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 28/03/16 DATA INPUT:

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

PROJECT 1533879		RECORD OF BOREHOLE No OS2-2				1 OF 1 METRIC								
G.W.P. 6943-10-00		LOCATION N 5399133.0; E 313350.6		ORIGINATED BY RA										
DIST _____ HWY 17		BOREHOLE TYPE Portable Equipment		COMPILED BY AC										
DATUM GEODETIC		DATE December 12 and 13, 2015		CHECKED BY NK										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)	GR SA SI CL		
427.6	GROUND SURFACE													
0.0	Silty TOPSOIL, trace sand Brown to black Moist		1	AS	-									
426.8														
0.8	ORGANIC SILT, trace to some sand, trace to some gravel Firm Black Wet		2	SS	5									
426.1														
1.5	CLAY, trace sand Stiff Reddish brown Wet		3	SS	10									
			4	SS	9									
			5	SS	10									
			6	SS	10									
			7	SS	12									
422.9														
4.7	SILT, trace clay Compact Grey Wet		8	SS	24									
422.3														
5.3	Sandy GRAVEL Dense Grey Wet		9	SS	38									
421.7														
5.9	END OF BOREHOLE START OF DCPT													
420.1														
7.5	END OF DCPT REFUSAL TO FUTURE PENETRATION (HAMMER BOUNCING)													
	Note:  1. Water level at a depth of 0.4 m below ground surface (Elev. 427.2 m) upon completion of drilling.  2. Split Spoon samples obtained by driving with a 1/2 weight hammer. SPT 'N' values have been adjusted to the inferred values that would be obtained using a standard weight hammer.													

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 28/03/16 DATA INPUT:



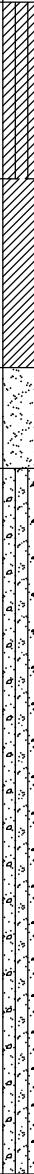

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT 1533879		<b>RECORD OF BOREHOLE No OS2-3</b>				2 OF 2 <b>METRIC</b>					
G.W.P. 6943-10-00		LOCATION N 5399151.9; E 313330.0				ORIGINATED BY MR					
DIST _____ HWY 17		BOREHOLE TYPE NW Casing, NQ Coring and Wash Boring				COMPILED BY AC					
DATUM GEODETIC		DATE December 15, 2015				CHECKED BY NK					
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa			
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	20 40 60	
	SILT and SAND, trace to some gravel, trace to some clay (TILL) Very dense Grey Wet		12	SS	63/0.13		420				
							419				
			13	SS	65/0.08		418				
							417				
416.7 15.7	END OF BOREHOLE  Note:  1. Water level at a depth of 3.8 m below ground surface (Elev. 428.6 m) upon completion of drilling.		14	SS	115/0.28						9 41 40 10

[illegible]

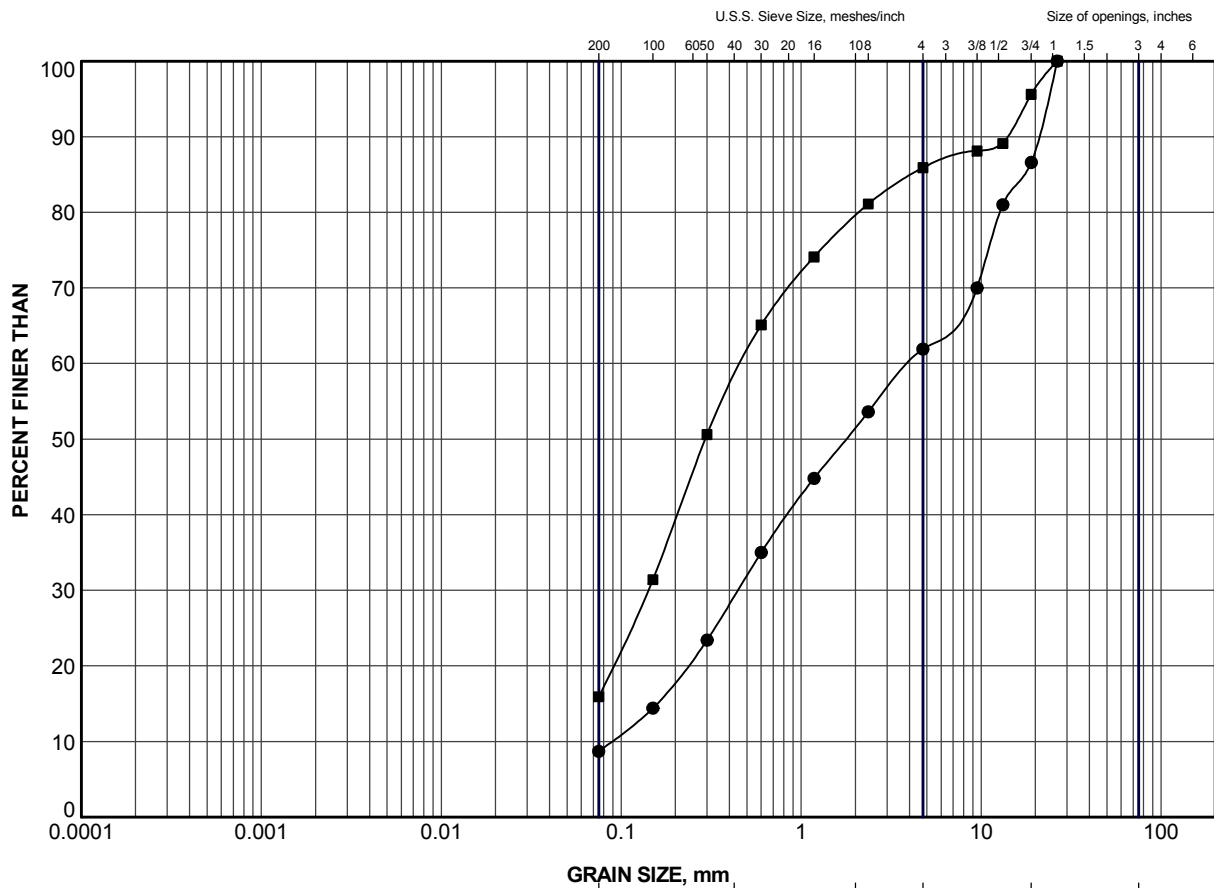
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT 1533879				RECORD OF BOREHOLE No OS2-5				1 OF 1 METRIC									
G.W.P. 6943-10-00				LOCATION N 5399151.9; E 313311.7				ORIGINATED BY MR									
DIST _____ HWY 17				BOREHOLE TYPE 78 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY AC									
DATUM GEODETIC				DATE December 13 and 14, 2015				CHECKED BY NK									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
427.4 0.0	GROUND SURFACE SILTY CLAY, trace to some organics Soft Brown to grey Wet		1	SS	2		427										
			2	SS	3		426										
426.0 1.4	CLAY Firm Reddish brown Wet	3	SS	4	425												
					424												
424.5 2.9	SAND, trace to some gravel Compact Brown Wet	4	SS	41	423												
		5	SS	18	422												
423.7 3.7	Gravelly SILT and SAND, trace to some clay (TILL) Compact to very dense Grey Wet	6	SS	37	421												
		7	SS	41	420												
		8	SS	62/0.08	419												
					418												
418.1 9.3	BOULDER	9	SS	60/0.15													
417.7 9.7	END OF BOREHOLE  Note:  1. Water level at ground surface (Elev. 427.4 m) upon completion of drilling.																

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 28/03/16 DATA INPUT:

PROJECT 1533879		RECORD OF BOREHOLE No OS2-6				1 OF 1 METRIC										
G.W.P. 6943-10-00		LOCATION N 5399136.5; E 313311.1				ORIGINATED BY MR										
DIST _____ HWY 17		BOREHOLE TYPE Solid Stem Augers, NW Casing, NQ Coring and Wash Boring				COMPILED BY AC										
DATUM GEODETIC		DATE December 19, 2015				CHECKED BY NK										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
427.5	GROUND SURFACE															
0.0	Sandy TOPSOIL Loose Brown to black Frozen* to wet		1	SS	14*											
			2	SS	4											
426.1																
1.4	ORGANIC SILT Soft Dark brown Wet		3	SS	2											
425.3																
2.2	CLAY Firm Reddish brown Wet		4	SS	4											
424.2																
3.3	SAND and GRAVEL, trace to some silt Loose to compact Grey Wet		5	SS	9											
			6	SS	14											
423.0																
4.5	Gravelly SILT and SAND to SAND and GRAVEL (TILL) Compact to very dense Grey Wet		7	SS	13											
421.9																
5.6	SAND and GRAVEL, trace silt Very dense Grey WET		8	SS	112/0.23											
420.5																
7.0	Gravelly SILT and SAND (TILL) Very dense Grey Wet  Cobbles ranging from 120 mm to 250 mm diameter encountered between 7.0 m and 9.1 m depth.		9	SS	100/0.13											
418.2																
9.3	END OF BOREHOLE  Note:  1. Water level at a depth of 0.1 m below ground surface (Elev. 427.4 m) upon completion of drilling.		10	SS	100/0.1											


SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 28/03/16 DATA INPUT:



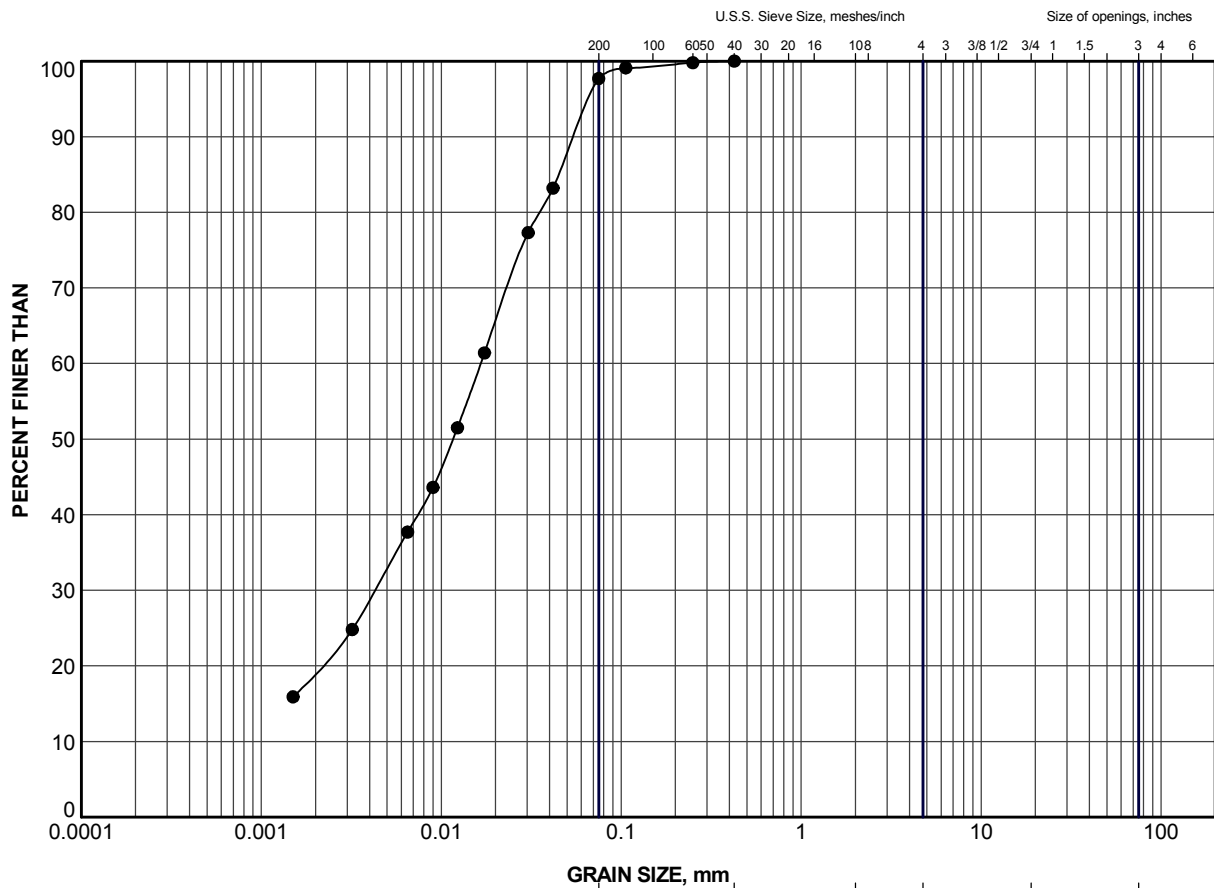
GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	OS2-3	3A	430.6
■	OS2-4	2	431.3

PROJECT						HIGHWAY 17 OSKONDAGA RIVER TRIBUTARY #2 CULVERT STA 13+458					
TITLE						GRAIN SIZE DISTRIBUTION SAND to SAND and GRAVEL (FILL)					
PROJECT No.				1533879		FILE No.				1533879.GPJ	
DRAWN		JJL		Mar 2016		SCALE		N/A		REV.	
CHECK		NK		Mar 2016							
APPR		JMAC		Mar 2016							
 <b>Golder Associates</b> SUDBURY, ONTARIO						<b>FIGURE B1</b>					




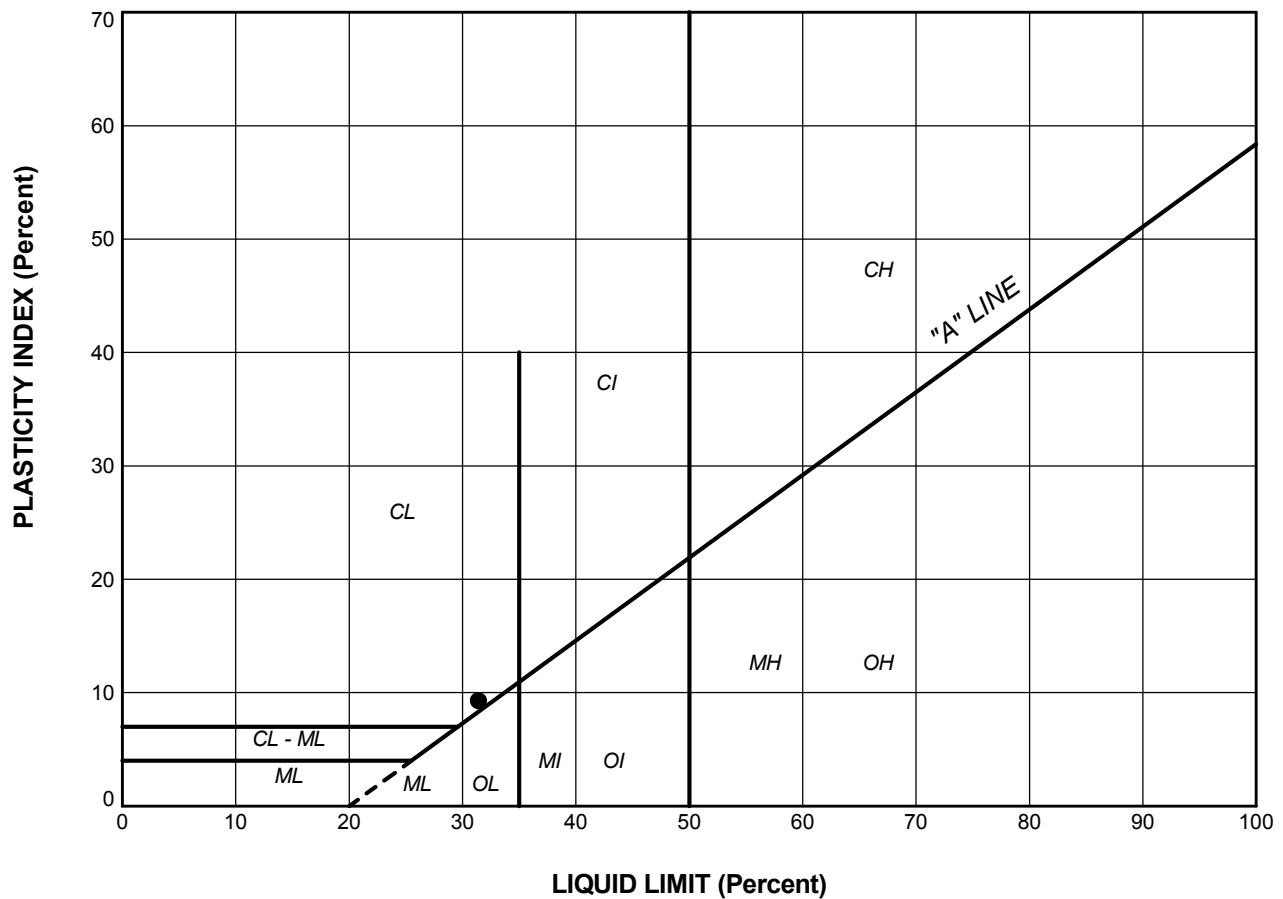


CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	OS2-3	6	428.3

PROJECT		HIGHWAY 17 OSKONDAGA RIVER TRIBUTARY #2 CULVERT STA 13+458			
TITLE		GRAIN SIZE DISTRIBUTION CLAYEY SILT (FILL)			
PROJECT No.		1533879		FILE No. 1533879.GPJ	
DRAWN	JJL	Mar 2016	SCALE	N/A	REV.
CHECK	NK	Mar 2016			
APPR	JMAC	Mar 2016			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B2</b>		




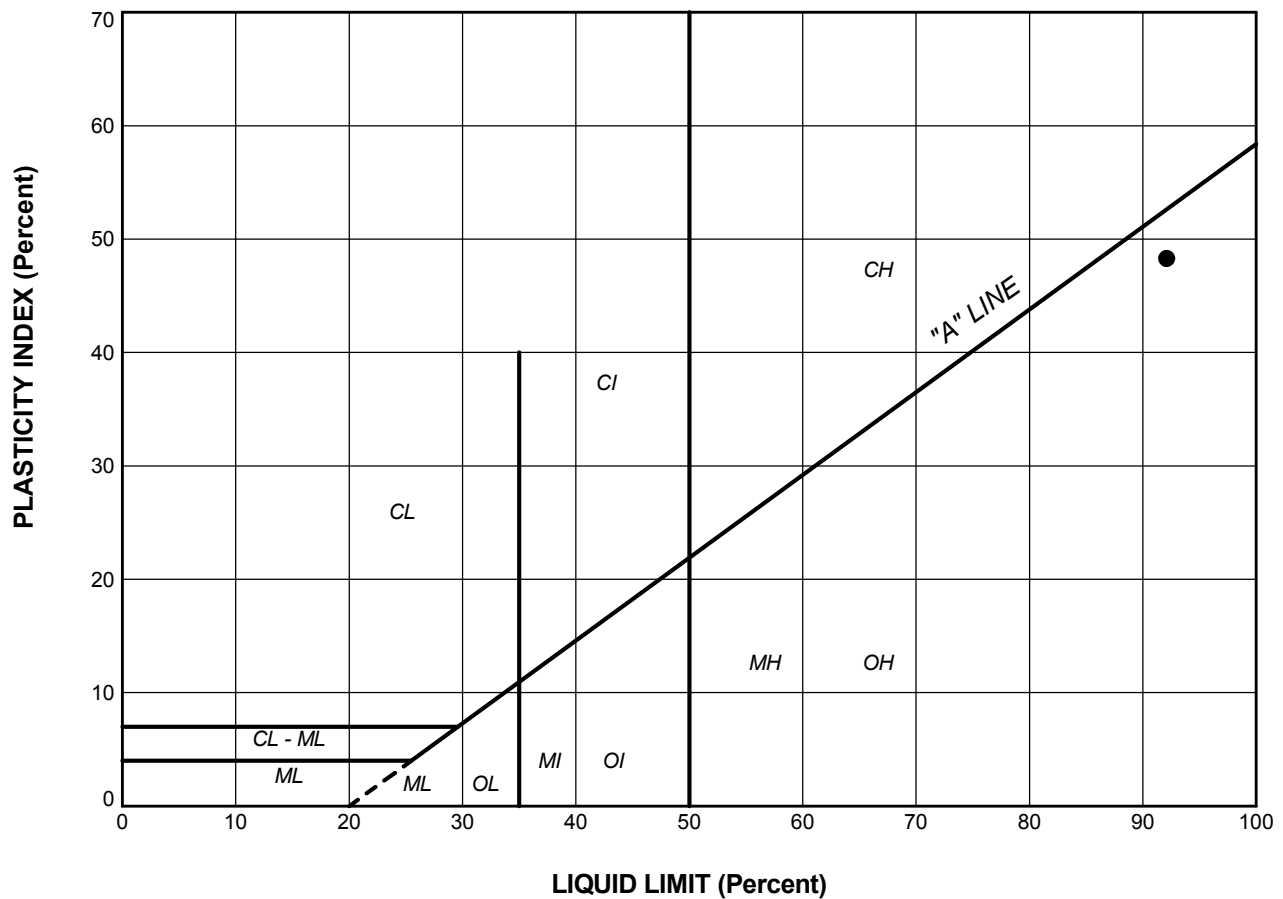
**SOIL TYPE**  
 C = Clay  
 M = Silt  
 O = Organic

**PLASTICITY**  
 L = Low  
 I = Intermediate  
 H = High

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	OS2-3	6	31.4	22.1	9.3

PROJECT		HIGHWAY 17 OSKONDAGA RIVER TRIBUTARY #2 CULVERT STA 13+458			
TITLE		<b>PLASTICITY CHART</b> CLAYEY SILT (FILL)			
PROJECT No.		1533879		FILE No. 1533879.GPJ	
DRAWN	JJL	Mar 2016	SCALE	N/A	REV.
CHECK	NK	Mar 2016			
APPR	JMAC	Mar 2016			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B3</b>		

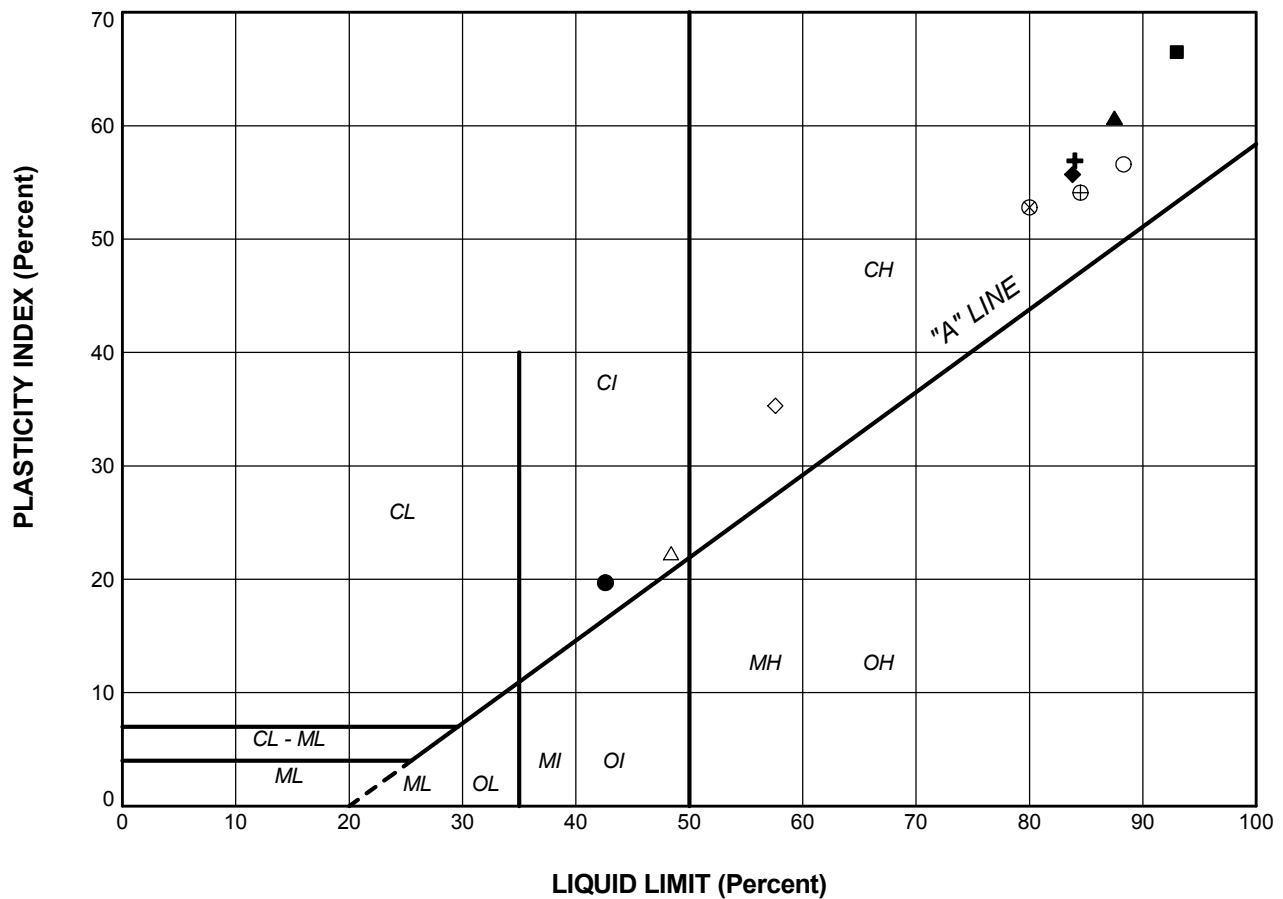


### LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	OS2-6	3	92.1	43.8	48.3


PROJECT		HIGHWAY 17 OSKONDAGA RIVER TRIBUTARY #2 CULVERT STA 13+458			
TITLE		<b>PLASTICITY CHART</b> ORGANIC SILT			
PROJECT No.		1533879		FILE No.	
DRAWN		JJL	Mar 2016	SCALE N/A	
CHECK		NK	Mar 2016	REV.	
APPR		JMAC	Mar 2016	FIGURE B4	

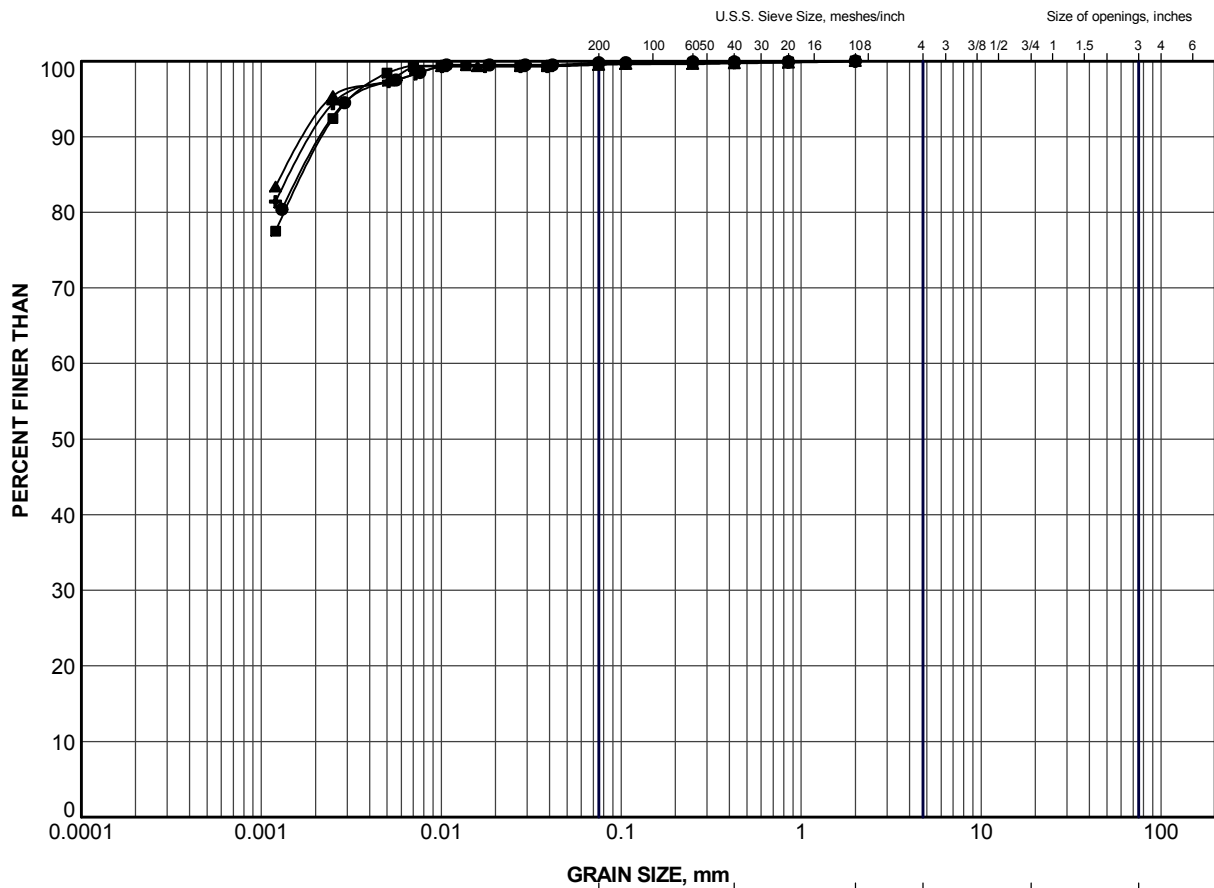




### LEGEND


SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	OS2-1	3	42.6	22.9	19.7
■	OS2-1	4	93.0	26.5	66.5
▲	OS2-2	4	87.5	26.8	60.7
+	OS2-2	5	84.0	27.1	56.9
◆	OS2-2	7	83.8	28.1	55.7
◇	OS2-3	8B	57.6	22.3	35.3
○	OS2-4	9	88.3	31.7	56.6
△	OS2-5	1	48.4	26.1	22.3
⊗	OS2-5	3	80.0	27.2	52.8
⊕	OS2-6	4	84.5	30.4	54.1

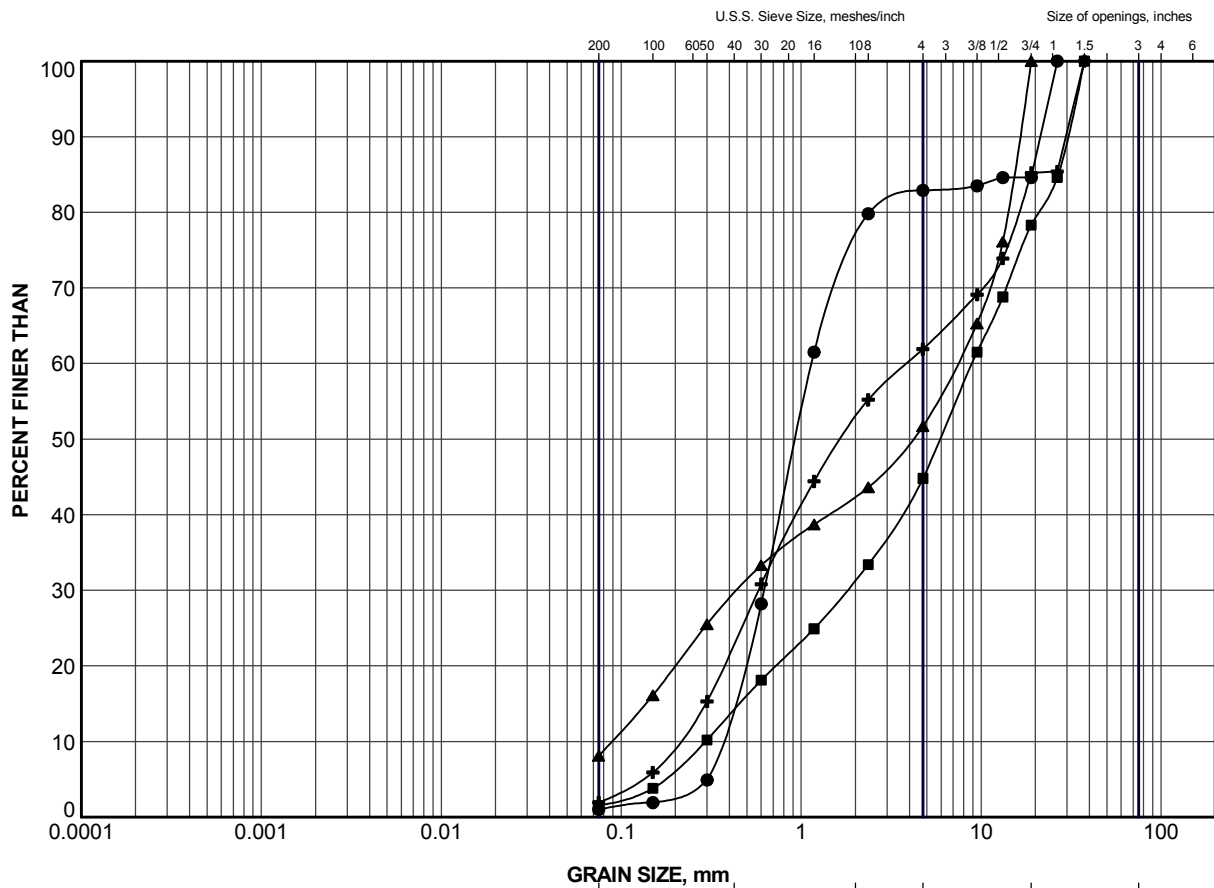
PROJECT		HIGHWAY 17 OSKONDAGA RIVER TRIBUTARY #2 CULVERT STA 13+458		
TITLE		<b>PLASTICITY CHART</b> SILTY CLAY to CLAY		
PROJECT No. 1533879		FILE No. 1533879.GPJ		
DRAWN	JJL	Mar 2016	SCALE	N/A
CHECK	NK	Mar 2016	REV.	
APPR	JMAC	Mar 2016		
 <b>Golder Associates</b> SUDBURY, ONTARIO		<b>FIGURE B5</b>		



### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	OS2-1	4	425.0
■	OS2-2	7	423.2
▲	OS2-4	9	424.5
+	OS2-6	4	424.9


PROJECT						HIGHWAY 17 OSKONDAGA RIVER TRIBUTARY #2 CULVERT STA 13+458					
TITLE						GRAIN SIZE DISTRIBUTION CLAY					
PROJECT No.				1533879		FILE No.				1533879.GPJ	
DRAWN		J.J.L.		Mar 2016		SCALE		N/A		REV.	
CHECK		NK		Mar 2016							
APPR		JMAC		Mar 2016							
 <b>Golder Associates</b> SUDBURY, ONTARIO						<b>FIGURE B6</b>					

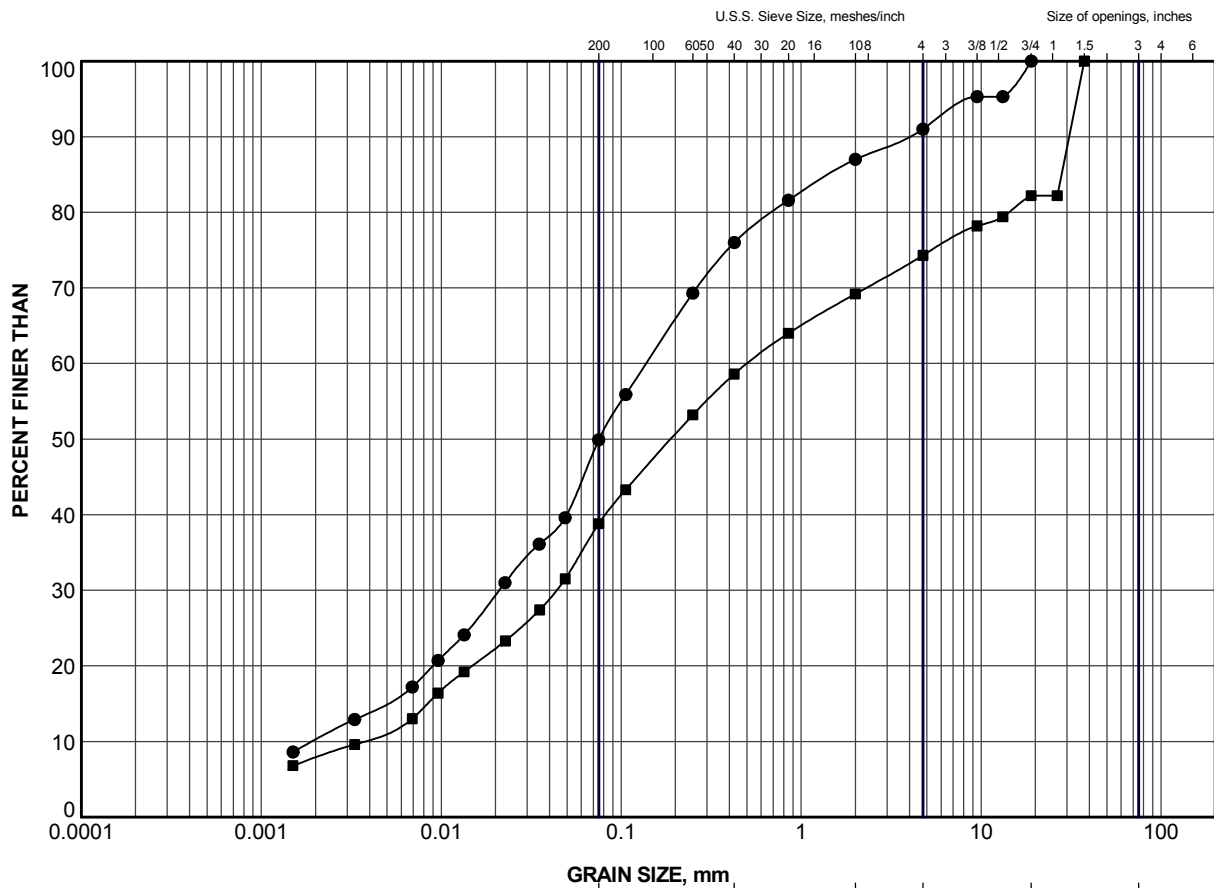


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

#### LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	OS2-1	6	421.4
■	OS2-3	10	423.0
▲	OS2-6	6	423.4
+	OS2-6	8	421.2

PROJECT						HIGHWAY 17 OSKONDAGA RIVER TRIBUTARY #2 CULVERT STA 13+458					
TITLE						GRAIN SIZE DISTRIBUTION SAND to SAND and GRAVEL					
PROJECT No.				1533879		FILE No.				1533879.GPJ	
DRAWN		JUL		Apr 2016		SCALE		N/A		REV.	
CHECK		NK		Apr 2016							
APPR		JMAC		Apr 2016							
 <b>Golder Associates</b> SUDBURY, ONTARIO						<b>FIGURE B7</b>					



### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	OS2-3	14	416.9
■	OS2-5	6	422.5

PROJECT						HIGHWAY 17 OSKONDAGA RIVER TRIBUTARY #2 CULVERT STA 13+458					
TITLE						GRAIN SIZE DISTRIBUTION GRAVELLY SILT and SAND to SAND and GRAVEL (TILL)					
PROJECT No.				1533879		FILE No.				1533879.GPJ	
DRAWN		JJL		Apr 2016		SCALE		N/A		REV.	
CHECK		NK		Apr 2016							
APPR		JMAC		Apr 2016							
 <b>Golder Associates</b> SUDBURY, ONTARIO						<b>FIGURE B8</b>					

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