



December 18, 2013

## FOUNDATION INVESTIGATION REPORT

**HIGHWAY 60 CULVERT REPLACEMENTS  
NORWAY CREEK CULVERT, SITE 43-146/C  
OPEONGO LAKE CULVERT, SITE 43-147/C  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 5095-13-00**

**Submitted to:**

LEA Consulting Ltd  
625 Cochrane Drive, Suite 900  
Markham, Ontario  
L3R 9R9



**GEOCRES NO.: 31E-329**

**Report Number: 13-1191-0003-R01**

**Distribution:**

- 1 PDF Copy - Ministry of Transportation, Ontario, North Bay, Ontario (Northeastern Region)
- 1 PDF Copy - Ministry of Transportation, Ontario, Downsview, Ontario (Foundations Section)
- 1 Copy - LEA Consulting Ltd., Markham, Ontario
- 1 PDF Copy - Golder Associates Ltd., Sudbury, Ontario



REPORT





## Table of Contents

### PART A – FOUNDATION INVESTIGATION REPORT

<b>1.0 INTRODUCTION.....</b>	<b>1</b>
<b>2.0 SITE DESCRIPTION.....</b>	<b>1</b>
<b>3.0 INVESTIGATION PROCEDURES .....</b>	<b>1</b>
<b>4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS .....</b>	<b>3</b>
4.1 Regional Geology .....	3
4.2 General Overview of Local Subsurface Conditions.....	4
4.3 Norway Creek Culvert, Site 43-146/C.....	4
4.4 Opeongo Creek Culvert, Site 43-147/C .....	7
<b>5.0 CLOSURE.....</b>	<b>10</b>

### TABLES

Table 1	Summary of Culvert Details
Table 2	Summary of Analytical Testing of Surface Water

### FIGURES

Figure 1	Key Plan
----------	----------

### LIST OF SYMBOLS AND ABBREVIATIONS

### LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

### APPENDICES

<b>Appendix A</b>	<b>Norway Creek Culvert, Site 43-146/C (Sproule Township)</b>
Drawing A1	Borehole Locations and Soil Strata
Photographs	
Record of Boreholes	NC1 to NC13
Figure A1	Grain Size Distribution – Sand and Gravel to Gravelly Sand (Fill)
Figure A2	Grain Size Distribution – Silt
Figure A3	Grain Size Distribution – Sandy Silt
Figure A4	Grain Size Distribution – Sand and Silt
Figure A5	Grain Size Distribution – Silty Sand to Sand
Figure A6	Grain Size Distribution – Gravelly Sand



**Appendix B**

**Opeongo Lake Culvert, Site 43-147/C (Sproule Township)**

Drawing B1	Borehole Locations and Soil Strata
Photographs	
Record Boreholes	OC1, OC2, OC3, OC5, OC6a, OC6b, OC7a, OC7b, OC8, to OC13
Record of Drillhole	OC8
Record of Test Pit	TPOC4
Figure B1	Grain Size Distribution – Sand and Gravel to Sand (Fill)
Figure B2	Grain Size Distribution – Silt
Figure B3	Grain Size Distribution – Sand and Silt
Figure B4	Grain Size Distribution – Silty Sand
Figure B5	Grain Size Distribution – Sand
Figure B6	Grain Size Distribution – Gravelly Sand
Figure B7	Grain Size Distribution – Sand and Gravel



# **PART A**

**FOUNDATION INVESTIGATION REPORT  
HIGHWAY 60 CULVERT REPLACEMENTS  
NORWAY CREEK CULVERT, SITE 43-146/C  
OPEONGO LAKE CULVERT, SITE 43-147/C  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 5095-13-00**



## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by LEA Consulting Limited (LEA) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the replacement of the Norway Creek Culvert (Site 43-146/C) and the Opeongo Lake Culvert (Site 43-147/C) on Highway 60 in Algonquin Park, Ontario. The general locations of the culverts are shown on the Key Plan on Figure 1.

This report addresses the investigation carried out for the Norway Creek and Opeongo Lake culverts only. Separate reports will be submitted detailing the foundation investigations for other culvert replacements for this project.

The purpose of this investigation is to establish the subsurface conditions at the locations of the proposed culverts by methods of borehole drilling, in situ testing and laboratory testing on selected soil samples.

## **2.0 SITE DESCRIPTION**

The Norway Creek and Opeongo Lake culverts are located on the existing Highway 60 alignment about 21.5 km and 18 km west of Highway 127, respectively, in Sproule Township. The culvert locations and approximate details (size, length, type, etc.) are summarized in Table 1.

In general, the topography of the two sites consists of numerous bedrock outcrops separated by creeks and swamps containing areas of standing water and various types of vegetation and organic soils, including dense tree cover in non-swamp areas.

## **3.0 INVESTIGATION PROCEDURES**

The fieldwork for the investigation for the Norway Creek and Opeongo Lake culverts was carried out between June 13 and July 15, 2013 and on September 14, October 3, October 10 and October 15, 2013, during which period a total of twenty-seven (27) boreholes, one (1) Test Pit and five (5) Dynamic Cone Penetration Tests (DCPTs) were advanced at the two culvert sites. Table 1 presents a summary of the boreholes advanced at each culvert site and the locations of the boreholes and culvert sites are shown on Drawings A1 and B1 in Appendices A and B, respectively.

The field investigations between June 13 and July 15, 2013, were carried out using a track mounted CME 55 or portable equipment mounted on a raft (where required) supplied and operated by Landcore Drilling Inc. of Chelmsford, Ontario. The field investigations in September and October were carried out using an excavator, a truck mounted CME-55 or CME-45 mounted on a raft (where required), supplied and operated by George Downing Estate Drilling Ltd. of Grenville-Sur-La-Rouge, Quebec.

The boreholes were advanced through the overburden using 108 mm inside diameter hollow stem augers, or NW casing with wash boring techniques. Where coring was required, a NQ size core barrel was used. 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 operated by an automatic hammer on the track-mounted drill rig, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). Boreholes advanced by portable equipment generally employed a full weight hammer lifted manually and dropped from the SPT height. At some



borehole locations where portable equipment was used, as noted on the Record of Borehole sheets where applicable, half weight hammers were used and the SPT 'N' values were corrected, as appropriate. All open boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The boreholes were advanced to depths ranging from 0.4 m to 14.5 m below existing ground surface or water surface, generally to refusal at the Opeongo Lake Site, or penetrating 3 m into competent material at the Norway Creek Site, which is defined as material that will provide resistance to settlement or instability of the embankment. Bedrock was exposed in Test Pit OC4 after excavating to a depth of 3.5 m.

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. Groundwater elevations as encountered in the boreholes may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized on completion of drilling. Furthermore, groundwater elevations will vary depending on seasonal fluctuations, precipitation and local soil permeability.

A sample of the 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 results of the analytical testing are summarized in Table 2, following the text of this report.

The fieldwork was observed by members of our engineering and technical staff, who located the boreholes, 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 samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury geotechnical laboratory where the samples and core 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 (water content and grain size distribution) was carried out on selected soil samples.

The as-drilled borehole locations were measured in reference to the existing culverts and were subsequently converted into MTM NAD 83 coordinates in AutoCAD. Borehole elevations were surveyed by a member of our technical staff in reference to a temporary benchmark consisting of the top of the existing culverts or the pavement surface at the Highway 60 roadway centreline at the culvert, the elevations of which were obtained from the survey provided by LEA. The 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:



## FOUNDATION REPORT - HIGHWAY 60 CULVERT REPLACEMENTS GWP 5095-13-00

Culvert Location	Borehole	Location (m)		Ground/Water Surface Elevation (m)	Borehole/TP/DCPT Depth (m) (Includes Water Column)
		Northing	Easting		
Norway Creek Culvert (43-146/C) (Sproule Township)	NC1*	5050305.9	392996.7	416.8	9.8/9.6
	NC2	5050318.8	392986.1	420.1	14.3
	NC3*	5050337.6	392987.9	416.2	13.3/13.2
	NC4	5050303.7	392997.7	416.5	12.8
	NC5	5050300.7	392990.2	416.7	11.3
	NC6	5050340.1	392990.5	416.2	11.9
	NC7	5050339.2	392980.5	416.2	11.6
	NC8	5050313.5	393041.2	417.4	12.8
	NC9	5050291.8	392942.5	417.3	8.5
	NC10	5050350.6	393032.8	417.0	12.8
	NC11	5050327.3	392936.5	417.3	12.4
	NC12	5050320.9	393977.9	420.1	11.3
	NC13	5050324.7	392996.1	420.0	14.3
Opeongo Creek Culvert (43-147/C) (Sproule Township)	OC1*	5051061.7	396426.4	419.4	5.1/6.3
	OC2	5051085.4	396425.9	424.9	14.5
	OC3*	5051108.1	396432.1	419.3	8.0/8.8
	TPOC4	5051099.4	396406.7	422.0	3.5
	OC5	5051100.2	396477.5	425.4	0.9
	OC6a	5051058.7	396382.6	421.8	3.8
	OC6b	5051057.2	396372.7	421.9	5.3
	OC7a	5051083.6	396488.1	423.7	0.5
	OC7b	5051081.7	396475.2	423.7	0.4
	OC8	5051112.4	396420.5	419.7	8.5
	OC9	5051109.5	396436.7	421.2	0.9
	OC10	5051058.1	396422.4	419.4	9.4
	OC11	5051057.9	396428.0	419.4	4.1
	OC12	5051080.7	396420.7	424.7	14.0
	OC13*	5051090.1	396436.5	425.1	8.9/13.0

\* Note: DCPT driven adjacent to or from the bottom of the respective borehole.

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

Based on NOEGTS<sup>1</sup> Mapping, the subsoils at the two culvert sites consists of bedrock outcrops separated by organic deposits and glaciofluvial deposits.

Published literature indicates that the bedrock in the area typically consists of magmatic rocks and gneisses within the Central Gneiss Belt, a subdivision of the Grenville Structural Province (OGS, 1991)<sup>2</sup>.

<sup>1</sup> Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Map Reference Number 32DSW.





## 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 Norway Creek Culvert Site and the Opeongo Lake Culvert Site, respectively. The stratigraphic boundaries shown on the Record of Borehole sheets 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.

The inferred subsurface stratigraphy as encountered in the boreholes advanced for the culverts are shown in profile on Drawings A1 and B1. The orientation (i.e., north, south, east, west) stated in the text of the report is typically referenced to project north. For the purposes of this report, the Highway 60 alignment is in an east-west orientation and therefore may differ from those shown on the drawings which represent magnetic north.

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.

## 4.3 Norway Creek Culvert, Site 43-146/C

The plan and profile along the Norway Creek culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 16+899 in Sproule Township are shown on Drawing A1. The height of the embankment at this location is about 4 m and the existing CSP culvert is about 3.1 m high, 5 m wide and 22 m long. A total of 13 boreholes and 2 DCPTs were advanced at the culvert site:

- Boreholes NC1 to NC3 were advanced along at the culvert inlet/outlet and midpoint;
- Boreholes NC4 and NC5 were advanced south of the south end of the culvert;
- NC6 and NC7 were advanced north of the north end of the culvert;
- Boreholes NC8 to NC11 were advanced approximately 50 m away from the culvert along the toe of slope; and
- Boreholes NC12 and NC13 were advanced through the roadway approximately 8 m on either side of the culvert location.

### Water

Boreholes NC3, NC6 and NC7 were advanced in the creek and encountered between 0.3 m and 0.6 m deep water column with the surface of the water at Elevation 416.2 m.

<sup>2</sup> 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.





### ***Embankment Fill***

Boreholes NC2, NC12 and NC13 were advanced through the existing roadway and encountered a 100 mm to 150 mm thick layer of asphalt with the roadway surface between Elevation 420.1 m and 420.0 m. Below the asphalt, embankment fill consisting of sand and gravel to gravelly sand and blast rock was encountered. The thickness of the overall fill deposit ranges from 5.2 m to 8.1 m with the blast rock zone ranging in thickness from 1.3 m to 3.0 m and located directly below the sand and gravel fill in Borehole NC13, within the sand and gravel fill in Borehole NC12 and interlayered with the sand and gravel fill in Borehole NC2. The top of the blast rock was encountered between 0.9 m and 3.4 m below existing ground surface, corresponding to Elevation 419.2 m to 417.0 m. NW and NQ coring techniques were used to advance the boreholes through the blast rock portions of the borehole.

Below about 0.5 m of water in Borehole NC3, a 3.7 m thick deposit of sand and gravel fill was encountered with the surface of the fill at Elevation 415.7 m.

The SPT 'N'-values measured within the fill deposit range between 0 blows (weight of hammer) to 57 blows per 0.3 m of penetration, suggesting a very loose to very dense relative density.

The grain size distributions of five samples of the sand and gravel to gravelly sand fill are presented on Figure A1 in Appendix A.

The natural water content measured on samples of the fill range from 9 per cent to 26 per cent.

### ***Peat***

In Boreholes NC1, NC4 and NC5 to NC11, a deposit of black fibrous and/or amorphous peat was encountered from ground surface or beneath the water. The top of the peat deposit was encountered between Elevation 416.8 m and 415.6 m and the deposit is between 0.9 m and 3.1 m thick.

The SPT 'N'-values measured within the peat are either 0 blows (weight of rods) or 1 blow per 0.3 m of penetration, suggesting a very soft consistency.

The natural water content measured on samples of the peat range from about 78 per cent to 475 per cent.

### ***Silt to Sand***

A deposit of grey silt, sandy silt, sand and silt, silty sand or sand containing trace to some gravel and trace clay was encountered underlying the peat or the embankment fill in all boreholes. The top of the deposit was encountered between Elevation 416.4 m and 411.9 m. The thickness of the deposit is 4.7 m in Borehole NC11 and was not fully penetrated in the remaining boreholes after exploring the deposit for thicknesses between 5.5 m and 11.6 m. Casing refusal was encountered at or near the bottom of the deposit in Borehole NC9 after exploring the deposit for 7.5 m.

The SPT 'N'-values measured within this deposit range between 0 blows (weight of hammer) and 37 blows per 0.3 m of penetration, indicating a very loose to dense relative density, with the majority of the deposit having a compact relative density.



The grain size distributions of thirty samples of the silt to sand and silt deposit grouped by similar gradation characteristics are shown on the following figures in Appendix A:

- Figure A2 – Silt
- Figure A3 – Sandy Silt
- Figure A4 – Sand and Silt
- Figure A5 – Silty Sand to Sand

Atterberg limits tests were carried out on a sample of the silt and of the sand and silt portions of the deposit and indicate that these materials are non-plastic.

The natural water content measured on samples of this deposit range from about 16 per cent to 29 per cent.

### ***Gravelly Sand***

Underlying the silty sand to sand and silt in Borehole NC11, a deposit of grey, gravelly sand was encountered at Elevation 411.7 m (5.6 m below ground surface) and the borehole was terminated on split spoon refusal after penetrating the deposit for 6.8 m.

The SPT 'N'-values measured within the gravelly sand deposit range between 4 blows and 11 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The grain size distribution of a sample of the gravelly sand deposit is shown on Figure A6 in Appendix A.

The natural water content measured on one sample of this deposit is 19 per cent.

### ***Refusal***

Refusal to further split-spoon or casing advancement was encountered in Boreholes NC9 and NC11 at a depth of 8.5 m and 12.4 m, respectively, corresponding to Elevation 408.8 m and 404.9 m.

### ***Groundwater Conditions***

Boreholes NC3, NC6 and NC7 were advanced from the water surface at Elevation 416.2 m. The water levels observed in Boreholes NC1, NC2, NC4, NC5, and NC8 to NC11, upon completion of drilling were measured between Elevation 416.8 m and 416.1 m, between 0.3 m and 3.5 m below ground surface. The unstabilized groundwater levels in Boreholes NC12 and NC13 were not obtained due to soil caving inside the open borehole at Elevation 415.3 m and 417.1 m, respectively. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.



## **4.4 Opeongo Creek Culvert, Site 43-147/C**

The plan and profile along the Opeongo Lake culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 20+456 in Sproule Township are shown on Drawing B1. The height of the embankment at this location is about 6.5 m and the existing CSP culvert is about 4.3 m diameter and 32 m long. A total of 14 boreholes, 2 DCPTs and one test pit were advanced at the culvert site:

- Boreholes OC1, OC2 and OC3 were advanced at the culvert inlet, midpoint and outlet, respectively;
- Boreholes OC5, OC6a, OC6b, OC7a and OC7b and Test Pit TPOC4 were advanced approximately 50 m away from the culvert along the toes of the roadway embankment;
- Borehole OC8 and OC9 were advanced north of the north end of the culvert;
- Boreholes OC10 and OC11 were advanced south of the south end of the culvert; and
- Borehole OC12 and OC13 was advanced through the roadway approximately 8 m east and west of the culvert.

### **Water**

Boreholes OC1, OC3, OC10 and OC11 were advanced in the creek and encountered a 0.9 m to 1.5 m deep water column, with the surface of the water at Elevation 419.4 m or 419.3 m.

### **Embankment Fill**

Boreholes OC2, OC12 and OC13 were advanced through the existing roadway and encountered a 100 mm to 110 mm thick layer of asphalt with the roadway surface at Elevations 424.7 m and 425.1 m, respectively. Below the asphalt, embankment fill consisting of sand and gravel, sand and blast rock was encountered. The overall thickness of the fill deposit ranges from 6.1 m to 7.5 m, with the component of blast rock ranging from 1.1 m to 7.1 m thick, located between the sand and gravel fill and sand fill in Borehole OC2 and below the sand and gravel fill in Borehole OC12 and OC13. The surface of the blast rock was encountered at depths of 0.7 m and 0.5 m below existing ground surface, corresponding to Elevations 424.0 m and 424.6 m. NW and NQ coring techniques were used to advance the boreholes through the blast rock portions of the borehole. In Borehole OC2 gravel and cobbles zones were inferred within the sand fill between the depths of 5.3 m and 5.6 m and between 6.7 m and 7.2 m.

From ground surface in Boreholes OC5 and OC8 and below the water in Borehole OC10, a deposit of sand and gravel to sand fill was encountered ranging from Elevations 425.4 m to 418.3 m, , and the thickness of the deposit ranging from 0.6 m to 1.4 m.

In Test Pit TPOC4 the fill deposit was encountered at ground surface and consists of a 0.6 m thick layer of blast rock underlain by a 2.0 m thick layer of silty sand and cobbles and boulders.

The SPT 'N'-values measured within the fill deposit range between 2 blows to 95 blows per 0.3 m of penetration, suggesting a very loose to very dense relative density.



The grain size distribution of two samples of the sand and gravel to sand fill are presented on Figure B1 in Appendix B.

The natural water content measured on samples of the fill range from 7 per cent to 17 per cent.

### ***Peat / Topsoil***

A 0.1 m to 2.0 m thick deposit of peat / topsoil was encountered from ground surface, below the water or underlying the fill in Boreholes OC1, OC6a, OC6b, OC7b, OC8, OC11 and OC12 and Test Pit TPOC4, between Elevation 423.7 m and 417.9 m.

The SPT 'N'-values measured within the peat deposit are 0 blows (weight of hammer) and 7 blow per 0.3 m of penetration, suggesting a very soft to firm consistency.

The natural water content measured on samples of the peat deposit range from about 51 per cent to 171 per cent.

### ***Silt***

An approximately 0.3 m to 1.4 m thick deposit or pocket of grey silt was encountered below the embankment fill in Borehole OC2 and underlying the peat deposit in Borehole OC8, at Elevations 417.6 m and 416.3 m, respectively. In Borehole OC12, an approximately 0.6 m thick silt layer was encountered within the sand and silt deposit at a depth of about 7.7 m. SPT 'N'-values measured within the silt deposit and 11 blows and 44 blows per 0.3 m of penetration, indicating a compact to dense relative density.

The grain size distributions of two samples of the silt deposit are shown on Figure B2 in Appendix B.

The natural water content measured on two samples of this deposit are about 24 per cent and 43 per cent.

### ***Sand and Silt to Gravelly Sand***

A deposit of brown to grey sand and silt, silty sand, sand, gravelly silty sand to gravelly sand was encountered at ground surface in Boreholes OC7a and OC9, from the riverbed in Borehole OC3, underlying the fill in Borehole OC13, underlying the peat in Boreholes OC1, OC6a, OC6b, OC10, OC11 and OC12 and TPOC4, underlying the silt deposit in Borehole OC2. The top of the deposit was encountered between Elevation 423.7 m and 416.0 m. The thicknesses of the deposit is 3.6 m in Borehole OC2 and between 0.5 m and 6.5 m in the remaining boreholes inferred from split-spoon or casing refusal and inferred to be up to 5.4 m thick in Borehole OC13 based on the DCPT driven from the bottom of the boreholes. As noted above, in Borehole OC12, an approximately 0.6 m thick layer of silt was encountered at about 7.7 m depth within the sand and silt deposit.

SPT 'N'-values measured within the sand and silt to sand and gravel deposit range from 4 blows to 58 blows per 0.3 m of penetration, indicating a loose to very dense relative density, with the majority of the deposit having a compact relative density.



The grain size distributions of 14 samples of the sand and silt to gravelly sand deposit are shown on the following figures:

- Figure B3 – Sand and Silt;
- Figure B4 – Silty Sand;
- Figure B5 – Sand; and
- Figure B6 – Gravelly Sand.

The natural water content measured on samples of the deposit range from about 7 per cent to 39 per cent.

### ***Sand, Gravel, Cobbles and Boulders***

A deposit of sand, gravel, cobbles and boulders was encountered underlying the silt and sand to silty sand to sand deposit in Borehole OC2 and OC12, underlying the silt in Borehole OC8, ranging from Elevations 416.0 m to 412.6 m. In Borehole OC8 the deposit is 2.0 m thick and Borehole OC2 was terminated after penetrating 2.2 m into the deposit. Cobbles and boulders ranging in size from 100 mm to 600 mm were cored. In Borehole OC8, a 0.1 m thick silty sand seam was encountered within the deposit at a depth of about 5.1 m.

The grain size distribution of one sample of the sand and gravel deposit is shown on Figure B7 in Appendix B, as well as the sample of the silty sand seam encountered within this deposit from Borehole OC8.

The natural water content measured on a sample of the deposit is about 12 per cent.

### ***Refusal/Bedrock***

Refusal to further spilt spoon or casing advancement or DCPT penetration was encountered in Boreholes OC5 to OC7b, OC9 to OC11 and OC13 at depths between 0.4 m and 13 m below ground surface, between Elevations 424.5 m and 412.1 m.

In Test Pit TPOC4, bedrock was exposed by the borehole at a depth of 3.5 m below ground surface, corresponding to Elevation 418.5 m.

In Borehole OC8, the top of the bedrock was encountered at a depth of 5.4 m below ground surface, corresponding to Elevation 414.3 m. The bedrock was cored for a length of 3.1 m and of the core is described as very coarse grained, slightly weathered, grey to pink, gneiss.

The Total Core Recovery of the bedrock core is 100 per cent. The RQD measured ranges from 17 per cent to 66 per cent, indicating a rock mass of very poor to fair quality.

### ***Groundwater Conditions***

Boreholes OC1, OC3, OC10 and OC11 were advanced from the water surface ranging from Elevation 419.4 m to 419.3 m. The depth to the water level in Boreholes OC2, OC6a, OC6b, OC8, OC12 and OC13 upon completion of drilling was measured to be between 0.5 m and 7.9 m below ground surface, between



Elevation 420.4 m and 417.2 m. In Borehole OC3, after completion of the borehole and leaving the casing in the borehole overnight, the water level was noted to be 0.4 m above the creek water surface corresponding to Elevation 419.7 m. Boreholes OC4, OC5, OC7a, OC7b and OC9 were observed to be dry upon completion of drilling. In Test Pit TPOC4, water was noted to be seeping into the excavation at a depth of 3.4 m below the ground surface from immediately above the bedrock surface corresponding to Elevation 418.6 m. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events and snow melt.

## **5.0 CLOSURE**

The drilling program was supervised by Mr. Shane Albert and Mr. Gabriel Mathieu. This report was prepared by Mr. Adam Core, E.I.T. The technical aspects were reviewed by Mr. André Bom, P.Eng., and Mr. Jorge M. A. Costa, P.Eng., Principal and Golder's Designated MTO Contact for this project, carried out a quality control review of the report.



## Report Signature Page

GOLDER ASSOCIATES LTD.

Adam Core, E.I.T.  
Geotechnical Engineering Intern



André Bom, P.Eng.  
Geotechnical Engineer



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

AC/AB/JMAC/kp

Golder, Golder Associates and the GA globe design are trademarks of Golder Associates Corporation.

n:\active\2013\1190 sudbury\1191\13-1191-0003 - lea hwy 60-35-118\1191 - foundations\reporting\c1 culverts\final\13-1191-0003 rpt01 13dec18 final hwy 60 fdr.docx





**FOUNDATION REPORT - HIGHWAY 60 CULVERT REPLACEMENTS**  
**GWP 5095-13-00**

**Table 1: Summary of Culvert Details**

Culvert Location Highway 60 (Township)	Approximate Existing Embankment Height <sup>1</sup> (m)	Existing Culvert			Approximate Inlet/Outlet Invert Elevation (m)	Modification to Existing Embankment Geometry	Boreholes	Reference Appendix
		Type	Diameter or Rise X Span (m)	Length (m)				
Norway Creek STA 16+899 (Sproule)	4	Corrugated Steel Pipe	3.1 X 5.0	22	416	Not required, detour may be required during construction	13 Boreholes and 2 DCPTs (NC1 to NC13)	A
Opeongo Lake STA 20+456 (Sproule)	6.5	Corrugated Steel Pipe	4.3	32	419	Not required, detour may be required during construction	14 Boreholes and 3 DCPTS (OC1, OC2, OC3, OC5, OC6a, OC6b, OC7a, OC7b, OC8, OC9, OC10, OC11, OC12, OC13) 1 Test Pit (TPOC4)	B

Notes: 1. Embankment height is relative to existing ground surface at toe of embankment near the culvert.



**FOUNDATION REPORT - HIGHWAY 60 CULVERT REPLACEMENTS**  
**GWP 5095-13-00**

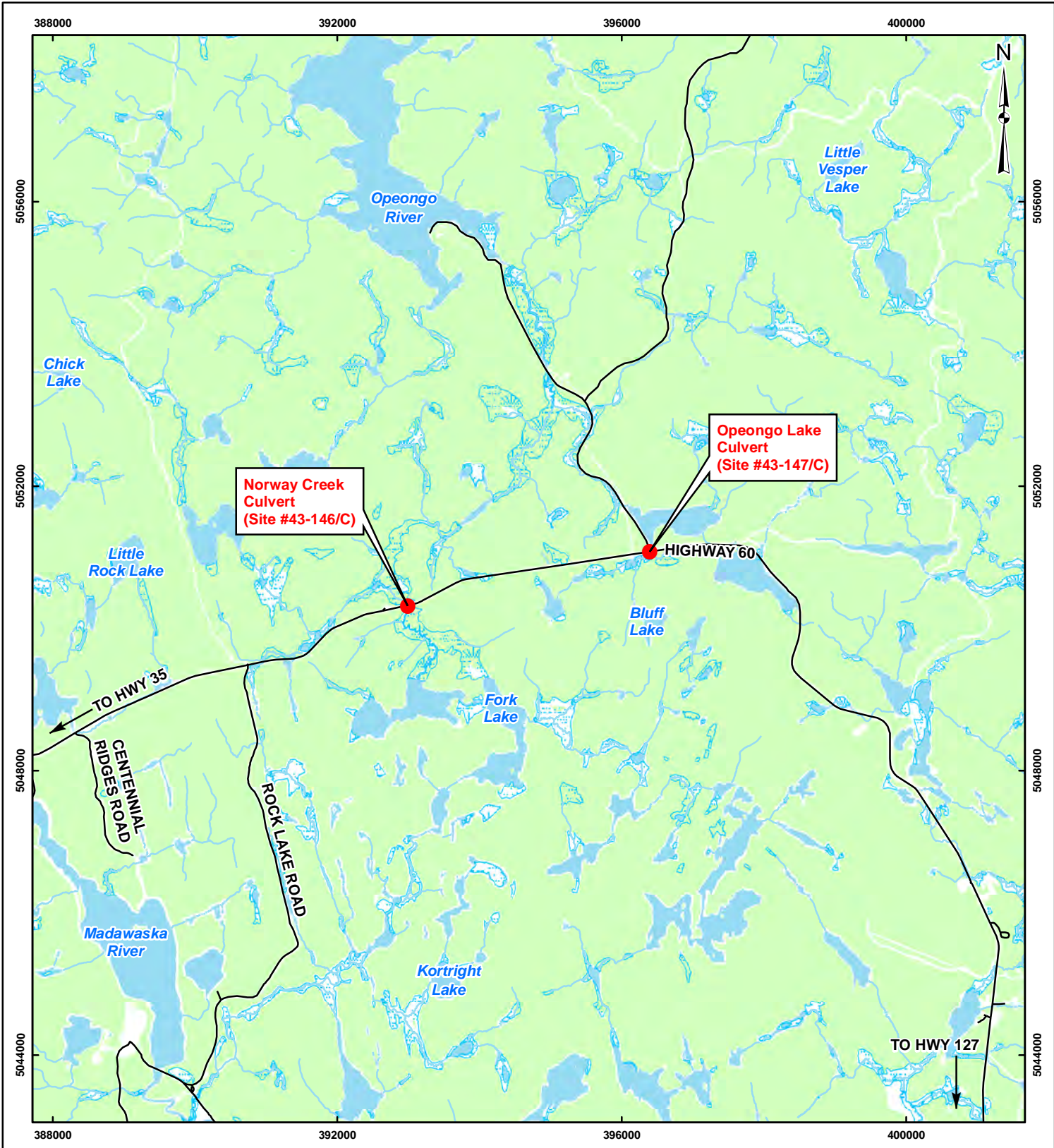
**Table 2: Summary of Analytical Testing of Surface Water**

Culvert Location Highway 60 (Township)	Parameter (Units, Detection Limit)				
	Chloride (mg/L, 0.2)	Sulfate (mg/L, 1)	Conductivity ( $\mu$ S/cm, 1)	Resistivity (Mohm-cm)	pH
Norway Creek STA 16+899 (Sproule)	27	ND	120	8100	7.02
Opeongo Lake STA 20+456 (Sproule)	44	3	150	6800	6.80

Notes: 1. Samples obtained August 10, 2013.  
2. Analytical testing carried out by Maxam.

Prepared by: AC  
Checked by: AB

G:\Projects\2013\13-1191-0003\GIS\MapDocs\Reporting\KeyPlan.mxd

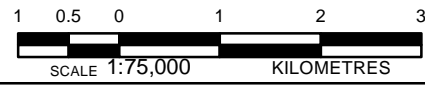


**LEGEND**

- Site Location
- Roads
- Watercourse
- Waterbody
- Wetland
- Wooded Areas

**REFERENCE**

Base Data - MNR LIO, obtained 2009  
Produced by Golder Associates Ltd under licence from  
Ontario Ministry of Natural Resources, © Queens Printer 2012  
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 17



PROJECT		NORWAY AND OPEONGO CULVERT REPLACEMENTS ALGONQUIN PARK, ONTARIO																																
TITLE		KEY PLAN																																
Golder Associates Mississauga, Ontario		<table border="1"><tr><td>PROJECT NO.</td><td>13-1191-0003</td><td>SCALE</td><td>AS SHOWN</td><td>REV.</td><td>0.0</td></tr><tr><td>DESIGN</td><td>ME</td><td>6 Aug. 2013</td><td></td><td></td><td></td></tr><tr><td>GIS</td><td>ME</td><td>7 Aug. 2013</td><td></td><td></td><td></td></tr><tr><td>CHECK</td><td>JH</td><td>7 Aug. 2013</td><td></td><td></td><td></td></tr><tr><td>REVIEW</td><td>ACB</td><td>7 Aug. 2013</td><td></td><td></td><td></td></tr></table>	PROJECT NO.	13-1191-0003	SCALE	AS SHOWN	REV.	0.0	DESIGN	ME	6 Aug. 2013				GIS	ME	7 Aug. 2013				CHECK	JH	7 Aug. 2013				REVIEW	ACB	7 Aug. 2013				FIGURE: 1	
PROJECT NO.	13-1191-0003	SCALE	AS SHOWN	REV.	0.0																													
DESIGN	ME	6 Aug. 2013																																
GIS	ME	7 Aug. 2013																																
CHECK	JH	7 Aug. 2013																																
REVIEW	ACB	7 Aug. 2013																																



## 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

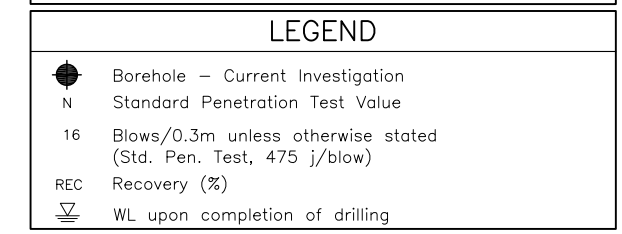
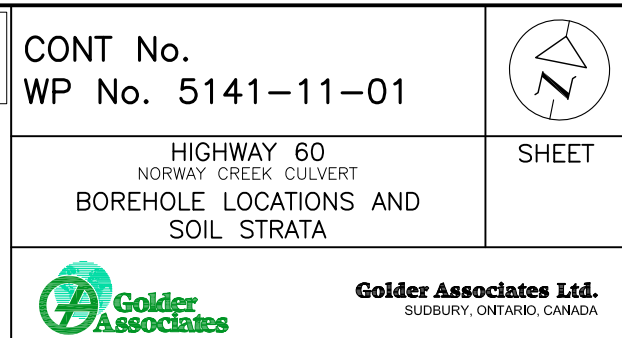
JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	



# APPENDIX A

Norway Creek Culvert, Site 43-146/C





**NOTES**

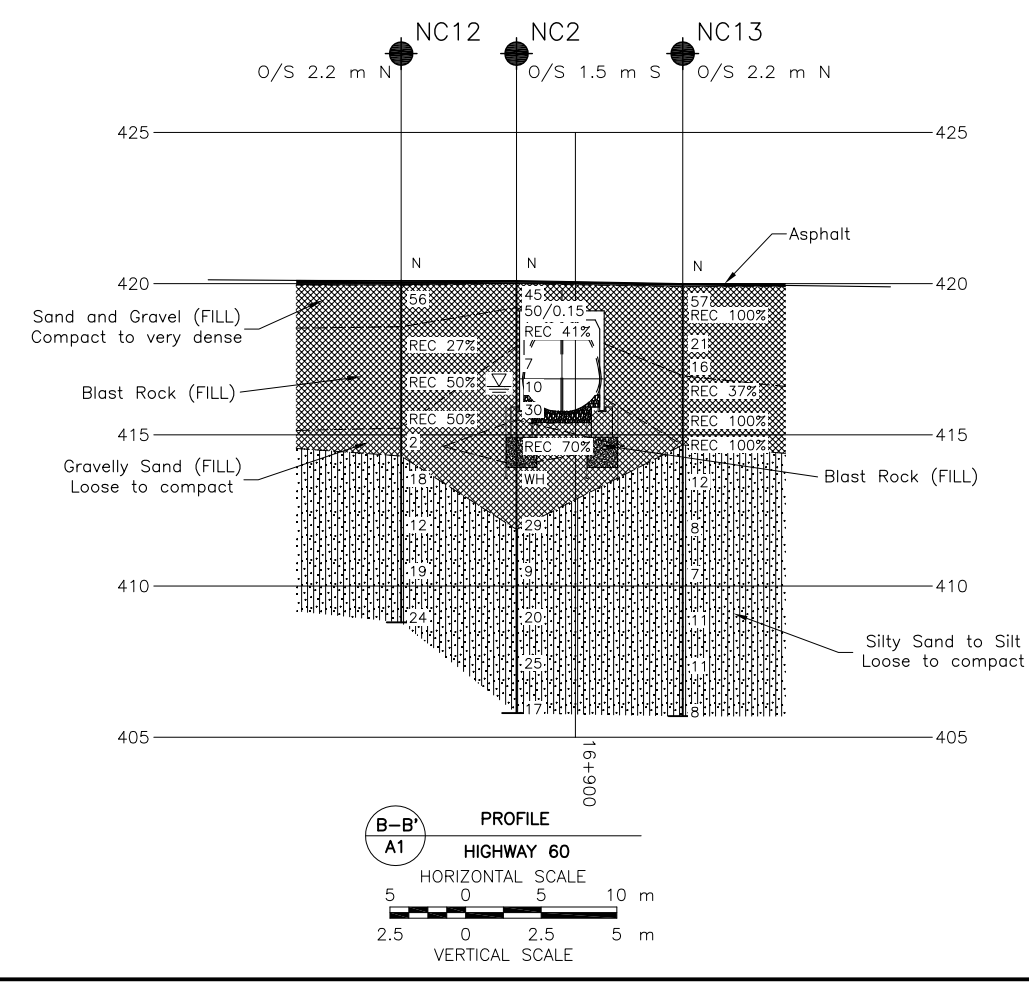
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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 LEA, drawing file HWY 60  
 -norway.dwg received JULY 26, 2013.





## PHOTOGRAPHS

---

**Photograph 1: Norway Creek Culvert, Looking South East (June 2013)**



**Photograph 2: Norway Creek Culvert, Looking North East (June 2013)**







## PHOTOGRAPHS

---

**Photograph 3: Norway Creek Culvert, Looking South (June 2013)**



**Photograph 4: Norway Creek Culvert, Looking North (June 2013)**



PROJECT <u>13-1191-0003</u>		<b>RECORD OF BOREHOLE No NC1</b>		1 OF 1 <b>METRIC</b>	
W.P. <u>5141-11-01</u>		LOCATION <u>N 5050305.9; E 392996.7</u>		ORIGINATED BY <u>SA</u>	
DIST <u>        </u> HWY <u>60</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers</u>		COMPILED BY <u>AC</u>	
DATUM <u>GEODETIC</u>		DATE <u>June 13, 2013</u>		CHECKED BY <u>AB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE LIMIT 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			SHEAR STRENGTH kPa		WATER CONTENT (%)					
								20 40 60 80 100	20 40 60 80 100		20 40 60				
								○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × REMOULDED							
416.8	GROUND SURFACE														
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	1		416								
			2	SS	WH										
415.3								415							
1.5	SAND and SILT, trace clay Very loose to compact Grey Wet		3	SS	12										
			4	SS	14			414							0 50 48 2
			5	SS	5										
	Approximately 0.5 m of heave inside augers between 3.0 m and 4.6 m depth.		6	SS	WH			413							
			7	SS	2			412							
								411							
	Approximately 0.9 m of heave inside augers at 6.1 m depth.		8	SS	WH			410							0 50 47 3
	Approximately 0.6 m of heave inside augers at 7.6 m depth.		9	SS	11		409								
							408								
	Approximately 1.5 m of heave inside augers at 9.1 m depth.		10	SS	WH										
407.0							407								
9.8	END OF BOREHOLE														
	Note:  1. Water level at a depth of 0.3 m below ground surface (Elev. 416.5 m) upon completion of drilling.  2. Advanced DCPT 0.5 m east of Borehole NC1 and terminated DCPT at 9.3 m depth at 100 blows per 0.3 m of penetration.														

SUD\_MTO\_003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

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



SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

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

PROJECT		13-1191-0003		<b>RECORD OF BOREHOLE No NC3</b>		1 OF 2 <b>METRIC</b>								
W.P.		5141-11-01		LOCATION		N 5050337.6; E 392987.9								
DIST		HWY 60		BOREHOLE TYPE		Portable Equipment, NW Casing and Wash Boring								
DATUM		GEODETIC		DATE		July 11, 2013								
				ORIGINATED BY		SA								
				COMPILED BY		AC								
				CHECKED BY		AB								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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		W <sub>p</sub>	W	W <sub>L</sub>		
416.2	WATER SURFACE													
0.0	WATER													
415.7														
0.5	Sand and gravel, trace organics, trace silt, trace clay (FILL) Loose to compact Brown to grey Wet		1	SS	4									
			2	SS	6									
			3	SS	9									
			4	SS	13									
			5	SS	14									
412.0														
4.2	SAND to Sandy SILT, trace gravel, trace clay Loose to compact Grey Wet		6	SS	9									
			7	SS	22									
			8	SS	19									
			9	SS	18									
			10	SS	16									
			11	SS	19									
			12	SS	20									
402.9														
13.3														

SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

Continued Next Page

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



PROJECT <u>13-1191-0003</u>		<b>RECORD OF BOREHOLE No NC3</b>		2 OF 2 <b>METRIC</b>	
W.P. <u>5141-11-01</u>		LOCATION <u>N 5050337.6; E 392987.9</u>		ORIGINATED BY <u>SA</u>	
DIST <u>        </u> HWY <u>60</u>		BOREHOLE TYPE <u>Portable Equipment, NW Casing and Wash Boring</u>		COMPILED BY <u>AC</u>	
DATUM <u>GEODETIC</u>		DATE <u>July 11, 2013</u>		CHECKED BY <u>AB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE   LIQUID CONTENT   LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100	20	40	60						
	--- CONTINUED FROM PREVIOUS PAGE ---  END OF BOREHOLE  Note:  1. Advanced DCPT 0.5 m south of borehole.  2. Originally advanced borehole immediately at north end of culvert but refusal was encountered at about 2.0 m below water surface. Relocated borehole to the north away from culvert.																				

SUD\_MTO\_003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

PROJECT		13-1191-0003		<b>RECORD OF BOREHOLE No NC4</b>				1 OF 1 <b>METRIC</b>									
W.P.		5141-11-01		LOCATION		N 5050303.7; E 392997.7		ORIGINATED BY		GM							
DIST		HWY 60		BOREHOLE TYPE		108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring		COMPILED BY		AC							
DATUM		GEODETIC		DATE		July 3, 2013		CHECKED BY		AB							
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									
416.5	GROUND SURFACE																
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	WH												
415.3			2	SS	WH												
1.2	SAND and SILT to SILT Very loose to compact Grey Wet		3	SS	5												
			4	SS	19												0 55 41 4
			5	SS	4												
			6	SS	2												
			7	SS	2												
			8	SS	8												0 25 71 4
			9	SS	7												
			10	SS	19												
			11	SS	25												0 6 89 5
			12	SS	15												
403.7																	
12.8	END OF BOREHOLE																
	Note:  1. Water level at a depth of 0.3 m below ground surface (Elev. 416.2 m) upon completion of drilling.																

SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

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

PROJECT 13-1191-0003			RECORD OF BOREHOLE No NC6				1 OF 1 METRIC									
W.P. 5141-11-01			LOCATION N 5050340.1; E 392990.5				ORIGINATED BY SA									
DIST _____ HWY 60			BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring				COMPILED BY AC									
DATUM GEODETIC			DATE July 10, 2013				CHECKED BY AB									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	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									
416.2	WATER SURFACE						20	40	60	80	100					
0.0	WATER															
415.6	PEAT (Fibrous) Very soft Black Wet		1	SS	WH											
			2	SS	WH											
414.2	PEAT (Amorphous) Very soft Black Wet		3	SS	WR											
2.0																
413.1	SAND and SILT, trace gravel, trace clay Compact Grey Wet		4	SS	12											
3.1			5	SS	11											
			6	SS	12											
			7	SS	10											
			8	SS	15											
			9	SS	14											
			10	SS	19											
			11	SS	25											
404.3	END OF BOREHOLE															
11.9																




SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

PROJECT 13-1191-0003			RECORD OF BOREHOLE No NC7			1 OF 1 METRIC						
W.P. 5141-11-01			LOCATION N 5050339.2; E 392980.5			ORIGINATED BY SA						
DIST HWY 60			BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring			COMPILED BY AC						
DATUM GEODETIC			DATE July 9, 2013			CHECKED BY AB						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID UNIT WEIGHT REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60	W <sub>p</sub> W W <sub>L</sub>	γ	GR SA SI CL
416.2	WATER SURFACE											
0.0	WATER											
415.9												
0.3	PEAT (Amorphous) Very soft Black Wet		1	SS	WH		416					
			2	SS	WH		415				474.5	
			3	SS	WH		414					
			4	SS	WH		413					
412.8												
3.4	SAND and SILT, trace gravel, trace clay Loose to compact Grey Wet		5	SS	8		412					0 40 (60)
			6	SS	12		411					
			7	SS	11		410					
			8	SS	14		409					
			9	SS	18		408					2 35 (63)
			10	SS	19		407					
			11	SS	17		406					
404.6							405					
11.6	END OF BOREHOLE											

SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

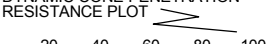
PROJECT 13-1191-0003		<b>RECORD OF BOREHOLE No NC8</b>				1 OF 1 <b>METRIC</b>										
W.P. 5141-11-01		LOCATION N 5050313.5; E 393041.2				ORIGINATED BY GM										
DIST _____ HWY 60		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring				COMPILED BY AC										
DATUM GEODETIC		DATE July 2, 2013				CHECKED BY AB										
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								WATER CONTENT (%)
417.4	GROUND SURFACE						20	40	60	80	100					
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	WH											
			2	SS	WH											
			3	SS	WH											
414.8			4	SS	10											
2.6	Silty SAND to SAND and SILT, trace gravel, trace clay Loose to dense Grey Wet		5	SS	8											
			6	SS	4											
			7	SS	4											
			8	SS	4											
			9	SS	8											
			10	SS	10											
			11	SS	15											
			12	SS	34											
404.6	END OF BOREHOLE															
12.8	Note:  1. Water level at a depth of 1.1 m below ground surface (Elev. 416.3 m) upon completion of drilling.															

SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

PROJECT		13-1191-0003		<b>RECORD OF BOREHOLE No NC9</b>				1 OF 1 <b>METRIC</b>										
W.P.		5141-11-01		LOCATION		N 5050291.8; E 392942.5		ORIGINATED BY		GM								
DIST		HWY 60		BOREHOLE TYPE		108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring		COMPILED BY		AC								
DATUM		GEODETIC		DATE		July 10, 2013		CHECKED BY		AB								
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										WATER CONTENT (%)
417.3	GROUND SURFACE							20	40	60	80	100						
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	WH		417											
416.3							416											
1.0	Silty SAND to SILT, some gravel, trace clay Loose to compact Grey Wet		2	SS	7		416											
			3	SS	3		415											13 65 (22)
			4	SS	16		415											
			5	SS	5		414											0 55 (45)
			6	SS	2		413											
			7	SS	3		412											
			8	SS	16		411											
						410												
			9	SS	13	409											NP 0 7 (94)	
408.8	END OF BOREHOLE CASING REFUSAL (HAMMER BOUNCING)						409											
8.5	Note:  1. Water level at a depth of 0.5 m below ground surface (Elev. 416.8 m) upon completion of drilling.																	

SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:



PROJECT 13-1191-0003			<b>RECORD OF BOREHOLE No NC10</b>				1 OF 1 <b>METRIC</b>				
W.P. 5141-11-01		LOCATION N 5050350.6; E 393032.8				ORIGINATED BY GM					
DIST _____ HWY 60		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring				COMPILED BY AC					
DATUM GEODETIC		DATE July 3, 2013				CHECKED BY AB					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W   LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
417.0	GROUND SURFACE										
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	WH		416				
			2	SS	WH						
415.2	SAND and SILT, trace gravel, trace clay Very loose to compact Grey Wet		3	SS	10		415				
1.8			4	SS	8		414				
			5	SS	2						
			6	SS	3		413				
			7	SS	2		412				
							411				
			8	SS	4		410				
			9	SS	5		409				
							408				
			10	SS	14		407				
			11	SS	17		406				
							405				
			12	SS	18						
404.2	END OF BOREHOLE										
12.8	Note:  1. Water level at a depth of 0.8 m below ground surface (Elev. 416.2 m) upon completion of drilling.										

SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

PROJECT 13-1191-0003			RECORD OF BOREHOLE No NC11			1 OF 1 METRIC																		
W.P. 5141-11-01			LOCATION N 5050327.3; E 392936.5			ORIGINATED BY GM																		
DIST _____ HWY 60			BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring			COMPILED BY AC																		
DATUM GEODETIC			DATE July 4, 2013			CHECKED BY AB																		
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			ELEVATION SCALE			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES																			
417.3	GROUND SURFACE																							
0.0	PEAT (Fibrous) Very soft Black Moist		1	SS	WH																			
416.4																								
0.9	Silty SAND to SAND and SILT, trace gravel, trace clay Very loose to compact Grey Wet		2	SS	3																			
			3	SS	11																			
			4	SS	17																			
			5	SS	11																			
			6	SS	5																			
			7	SS	4																			
411.7																								
5.6	Gravelly SAND, trace silt Loose to compact Grey Wet  Casing grinding at 5.6 m to 6.1 m and 8.2 m to 9.1 m depth.		8	SS	8																			
			9	SS	4																			
			10	SS	11																			
			11	SS	9																			
404.9																								
12.4	END OF BOREHOLE SPOON REFUSAL  Note:  1. Water level at a depth of 0.9 m below ground surface (Elev. 416.4 m) upon completion of drilling.		12	SS	34/0.22																			

SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

PROJECT 13-1191-0003				<b>RECORD OF BOREHOLE No NC12</b>				1 OF 1 <b>METRIC</b>									
W.P. 5141-11-01				LOCATION N 5050320.9; E 392977.9				ORIGINATED BY GM									
DIST _____ HWY 60				BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring				COMPILED BY AC									
DATUM GEODETIC				DATE July 8 and 9, 2013				CHECKED BY AB									
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									
420.1	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT (150 mm)						420										
0.2	Sand and gravel (FILL) Very dense Brown Moist		1	SS	56		419										
418.6	Blast rock (FILL)		2	RC	REC 27%		418										
1.5			3	RC	REC 50%		417										
			4	RC	REC 50%		416										
415.2	Gravelly sand, some silt (FILL) Loose Brown Wet		5	SS	2		415										30 59 10 1
414.3	Silty SAND to SILT, trace clay Compact Grey Wet		6	SS	18		414										
5.8							413										
			7	SS	12		412										
							411										
			8	SS	19		410										
							409										0 10 (90)
408.8	END OF BOREHOLE		9	SS	24												
11.3	Note:  1. Unable to obtain water level, borehole caved at 4.8 m depth (Elev. 415.3 m).																

SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

<b>PROJECT</b> 13-1191-0003		<b>RECORD OF BOREHOLE No NC13</b>		1 OF 2 <b>METRIC</b>	
W.P. 5141-11-01		LOCATION N 5050324.7; E 392996.1		ORIGINATED BY GM	
DIST _____ HWY 60		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring		COMPILED BY AC	
DATUM GEODETIC		DATE July 9, 2013		CHECKED BY AB	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL LIMIT   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	20	40	60	80	100	W <sub>P</sub>	W		W <sub>L</sub>			
420.0	GROUND SURFACE																			
0.9	ASPHALT (100 mm)		1A	SS	57															
	Sand and gravel to gravelly sand, trace to some silt (FILL) Compact to very dense Brown Moist		1B	RC	REC 100%															
			2	SS	21															
			3	SS	16															
417.0	Blast rock (FILL)		4	RC	REC 37%															
3.0			5	RC	REC 100%															
			6	RC	REC 100%															
414.7	Silty SAND to SAND and SILT, trace clay Loose to compact Grey Wet		7	SS	12															
5.3			8	SS	8															
			9	SS	7															
			10	SS	11															
			11	SS	11															
			12	SS	8															
405.7																				
14.3																				

SUD\_MTO\_003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

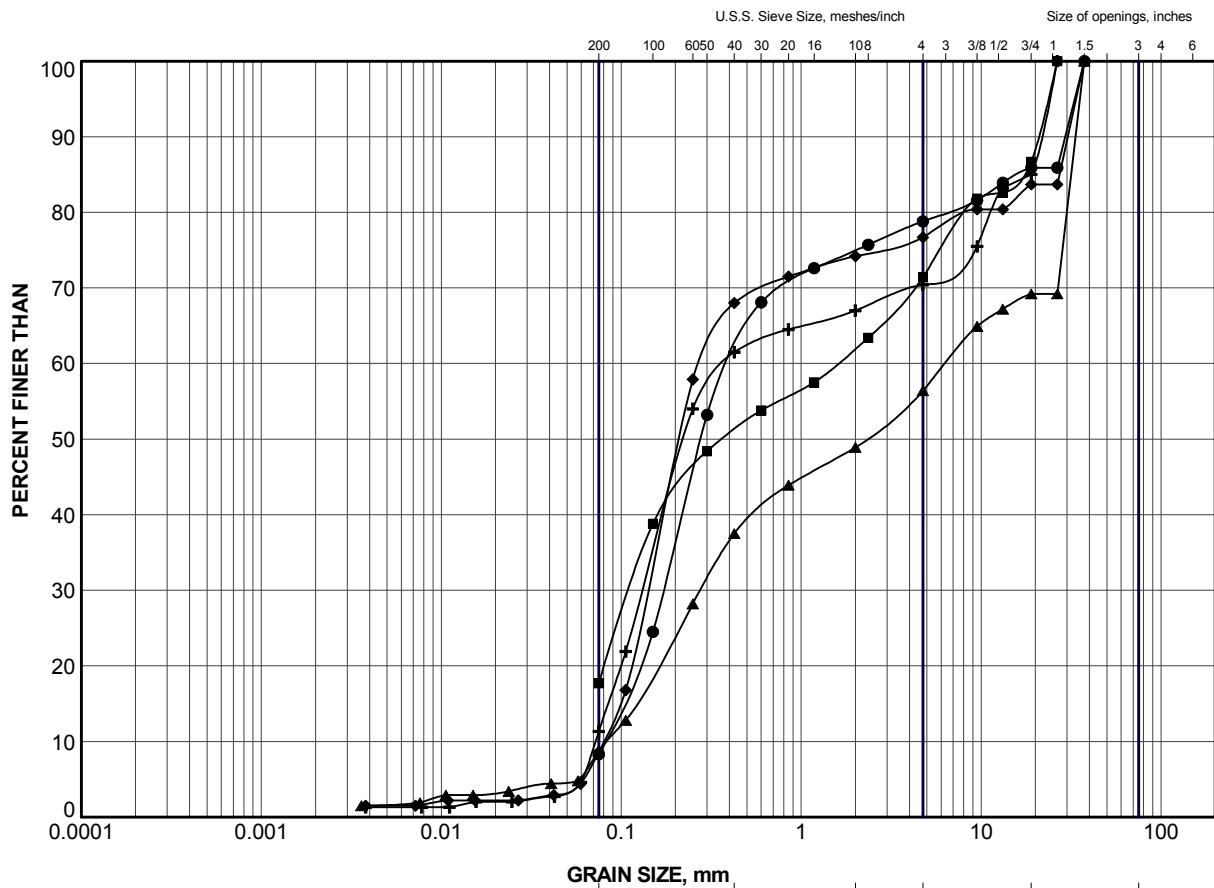
Continued Next Page

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

PROJECT <u>13-1191-0003</u>	<b>RECORD OF BOREHOLE No NC13</b>	2 OF 2 <b>METRIC</b>
W.P. <u>5141-11-01</u>	LOCATION <u>N 5050324.7; E 392996.1</u>	ORIGINATED BY <u>GM</u>
DIST <u>        </u> HWY <u>60</u>	BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring</u>	COMPILED BY <u>AC</u>
DATUM <u>GEODETIC</u>	DATE <u>July 9, 2013</u>	CHECKED BY <u>AB</u>

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE   LIQUID CONTENT   LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100	20	40	60						
	--- CONTINUED FROM PREVIOUS PAGE ---																				
	END OF BOREHOLE																				
	Note:  1. Unable to obtain water level, borehole caved at 2.9 m depth (Elev. 417.1 m).																				


SUD\_MTO\_003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

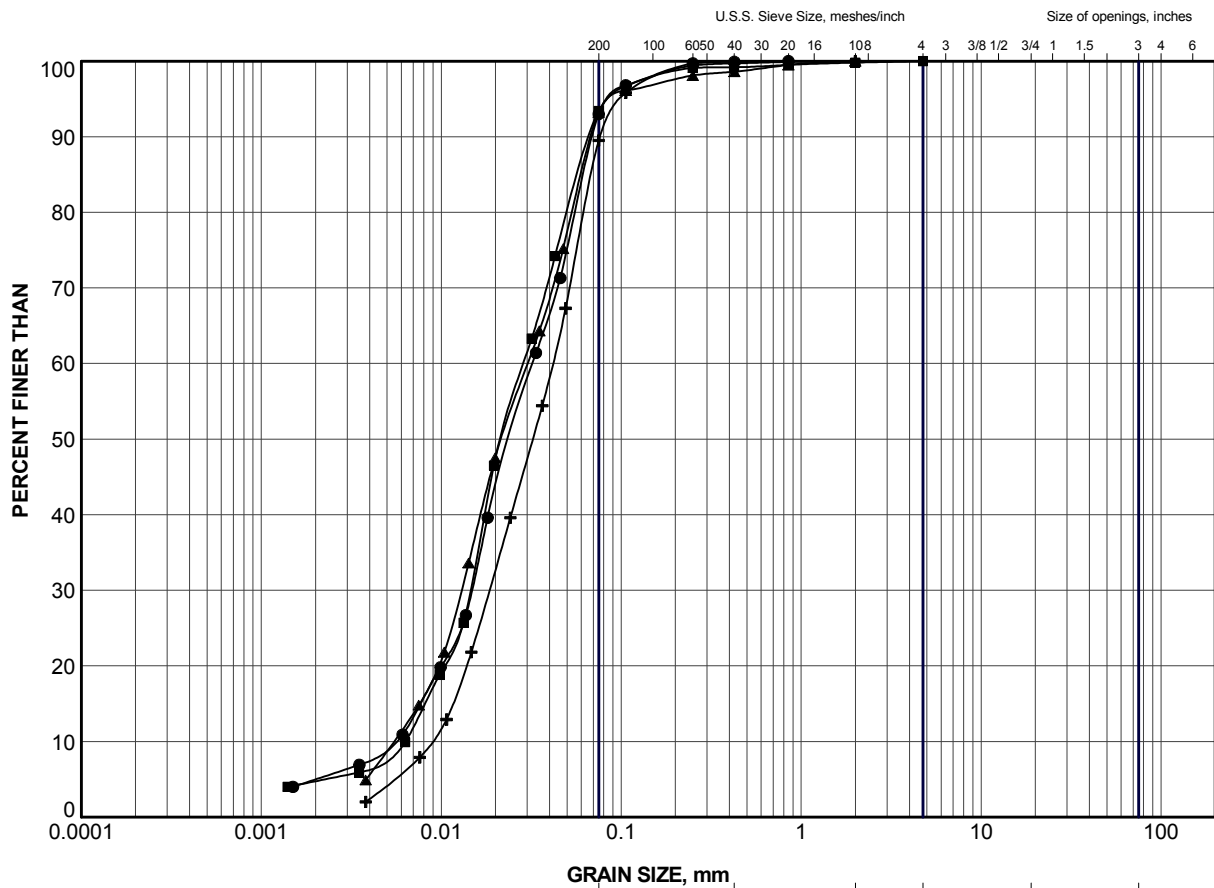


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	NC2	5	416.8
■	NC2	9	412.2
▲	NC3	4	413.1
+	NC12	5	414.9
◆	NC13	3	417.4


PROJECT					
HIGHWAY 60 NORWAY CREEK CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION SAND and GRAVEL to GRAVELLY SAND (FILL)					
PROJECT No.		13-1191-0003		FILE No. 13-1191-0003.GPJ	
DRAWN	JJL	Sep 2013	SCALE	N/A	REV.
CHECK	AB	Sep 2013			
APPR	JMAC	Sep 2013			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE A1</b>		

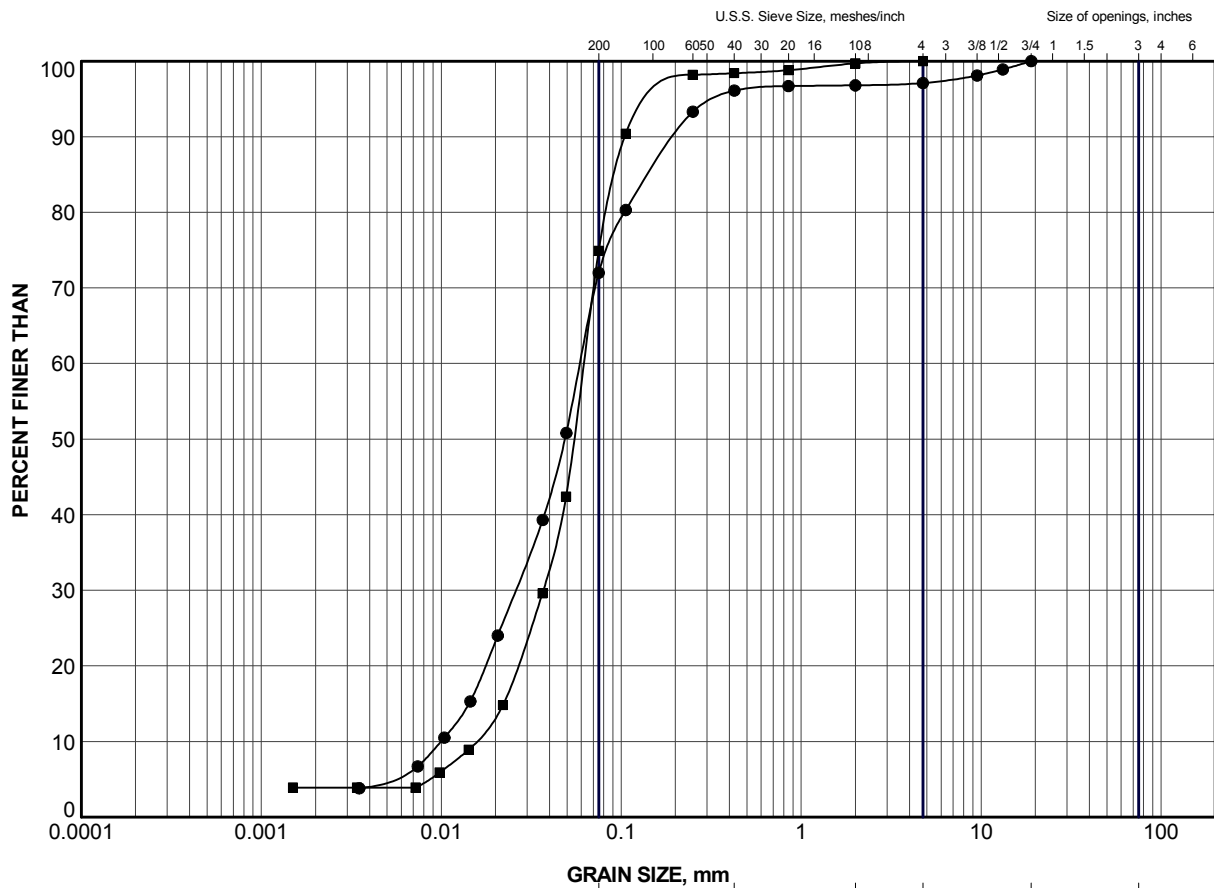


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	NC2	12	407.6
■	NC4	11	405.5
▲	NC9	9	409.4
+	NC12	9	409.2

PROJECT					
HIGHWAY 60 NORWAY CREEK CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION SILT					
PROJECT No.		13-1191-0003		FILE No. 13-1191-0003.GPJ	
DRAWN	JJL	Sep 2013	SCALE	N/A	REV.
CHECK	AB	Sep 2013			
APPR	JMAC	Sep 2013			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE A2</b>		



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

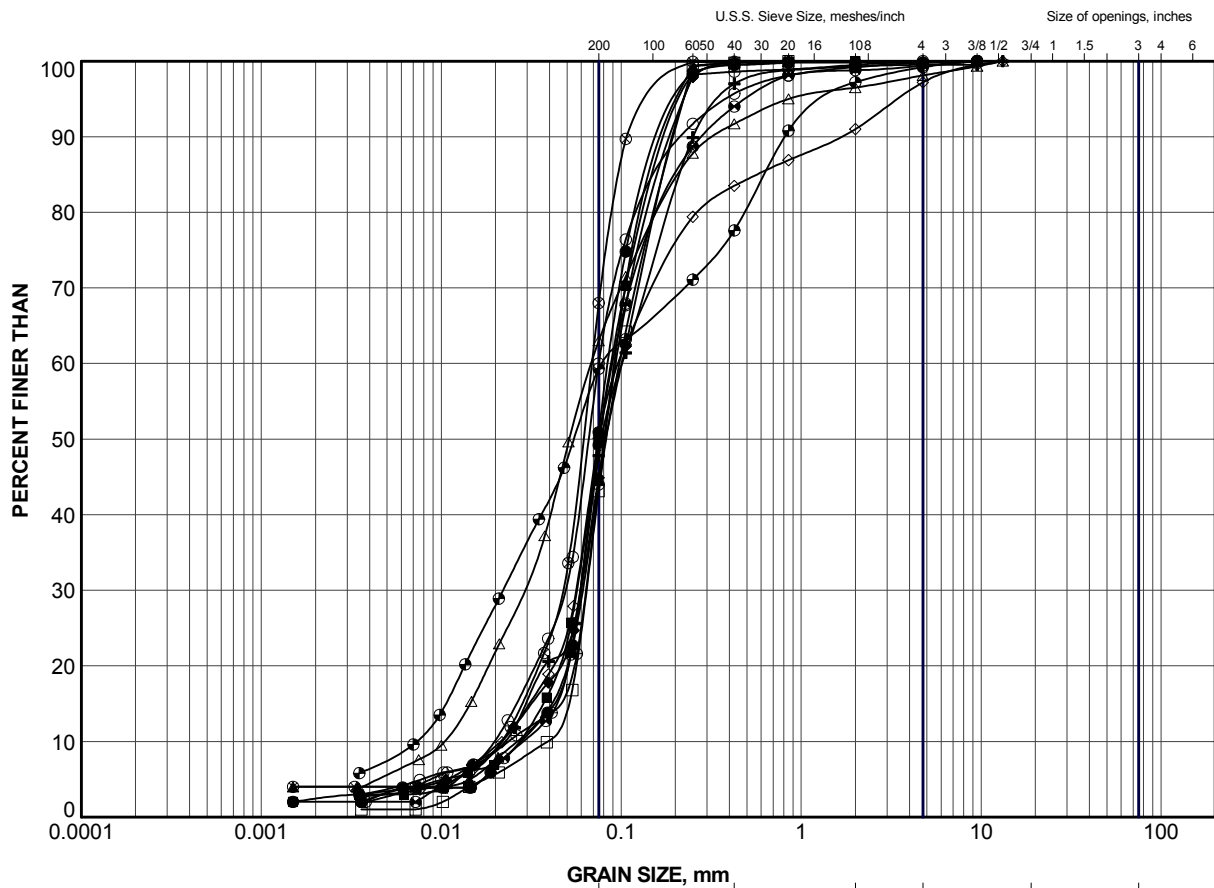
#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	NC3	11	404.7
■	NC4	8	410.1

PROJECT					
HIGHWAY 60 NORWAY CREEK CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION SANDY SILT					
PROJECT No.		13-1191-0003		FILE No. 13-1191-0003.GPJ	
DRAWN	JJL	Sep 2013	SCALE	N/A	REV.
CHECK	AB	Sep 2013	FIGURE A3		
APPR	JMAC	Sep 2013			







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

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	NC1	4	414.2
■	NC1	8	410.4
▲	NC4	4	413.9
+	NC5	5	413.3
◆	NC6	6	411.5
◇	NC6	10	406.2
○	NC7	6	411.8
△	NC7	9	408.0
⊗	NC8	9	409.5
⊕	NC9	5	413.9
□	NC10	5	413.6
⊙	NC10	9	409.1
⊛	NC11	5	413.9

PROJECT

HIGHWAY 60  
NORWAY CREEK CULVERT

TITLE

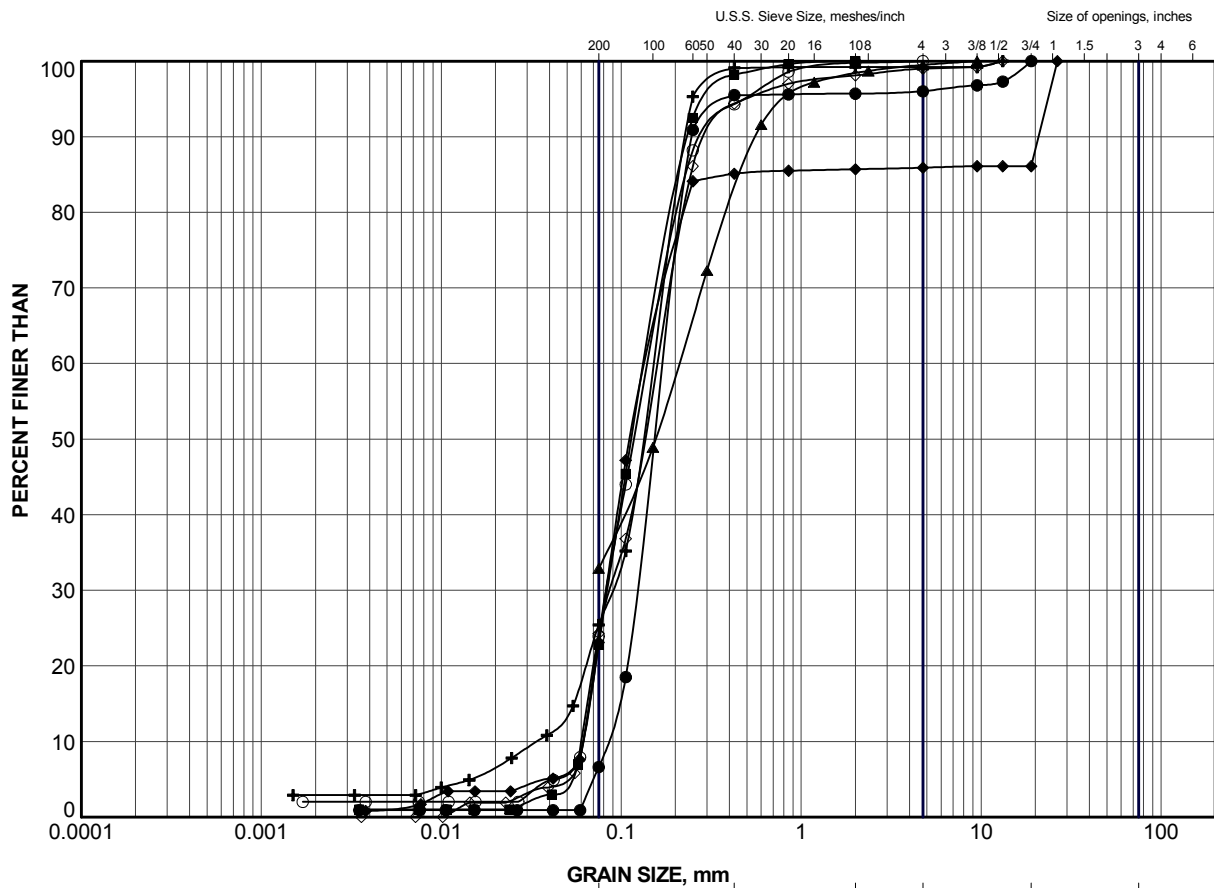
## GRAIN SIZE DISTRIBUTION

SAND and SILT



**Golder Associates**  
SUDBURY, ONTARIO

PROJECT No. 13-1191-0003		FILE No. 13-1191-0003.GPJ	
DRAWN	JJL	Sep 2013	SCALE N/A
CHECK	AB	Sep 2013	REV.
APPR	JMAC	Sep 2013	<b>FIGURE A4</b>



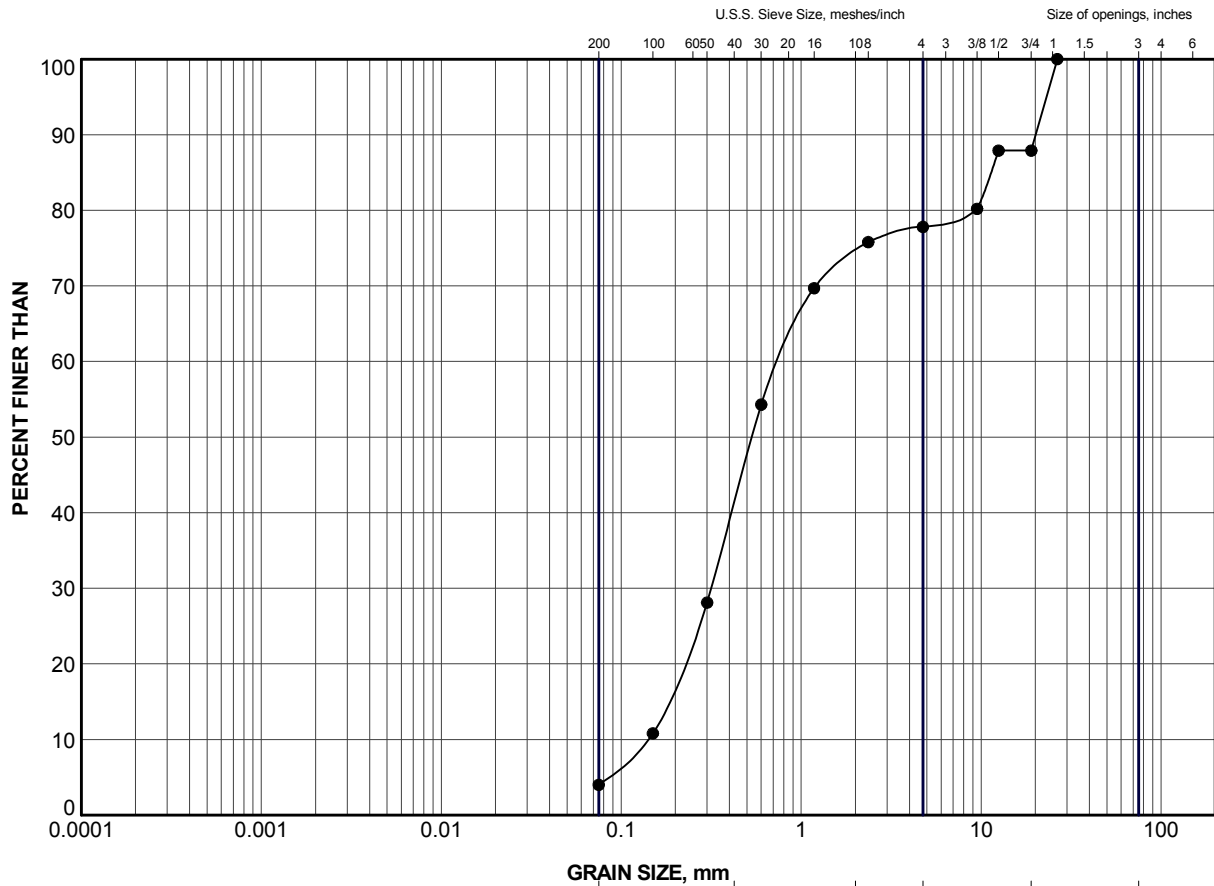
CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	NC3	7	410.8
■	NC5	9	408.8
▲	NC5	11	405.7
+	NC8	5	414.0
◆	NC9	3	415.5
◇	NC11	3	415.5
○	NC13	8	412.1

PROJECT					
HIGHWAY 60 NORWAY CREEK CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION SILTY SAND to SAND					
PROJECT No.		13-1191-0003		FILE No. 13-1191-0003.GPJ	
DRAWN	JJL	Sep 2013	SCALE	N/A	REV.
CHECK	AB	Sep 2013	FIGURE A5		
APPR	JMAC	Sep 2013			





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

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	NC11	8	410.9

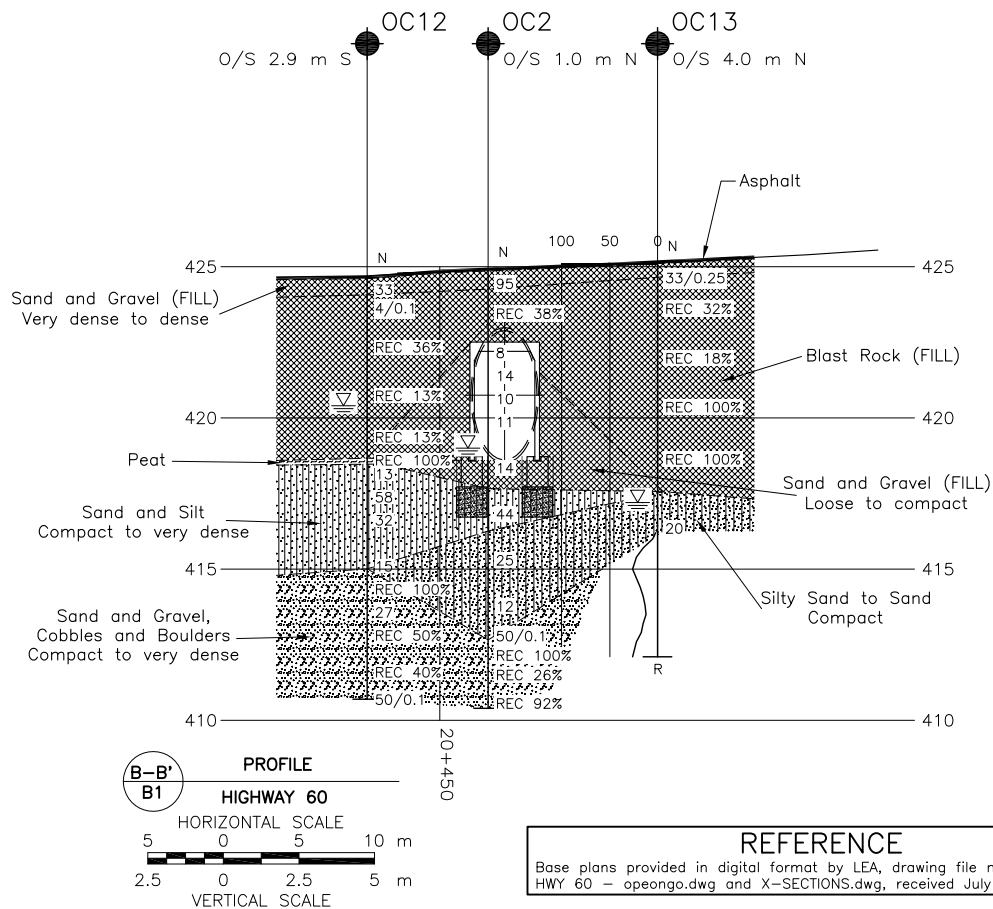
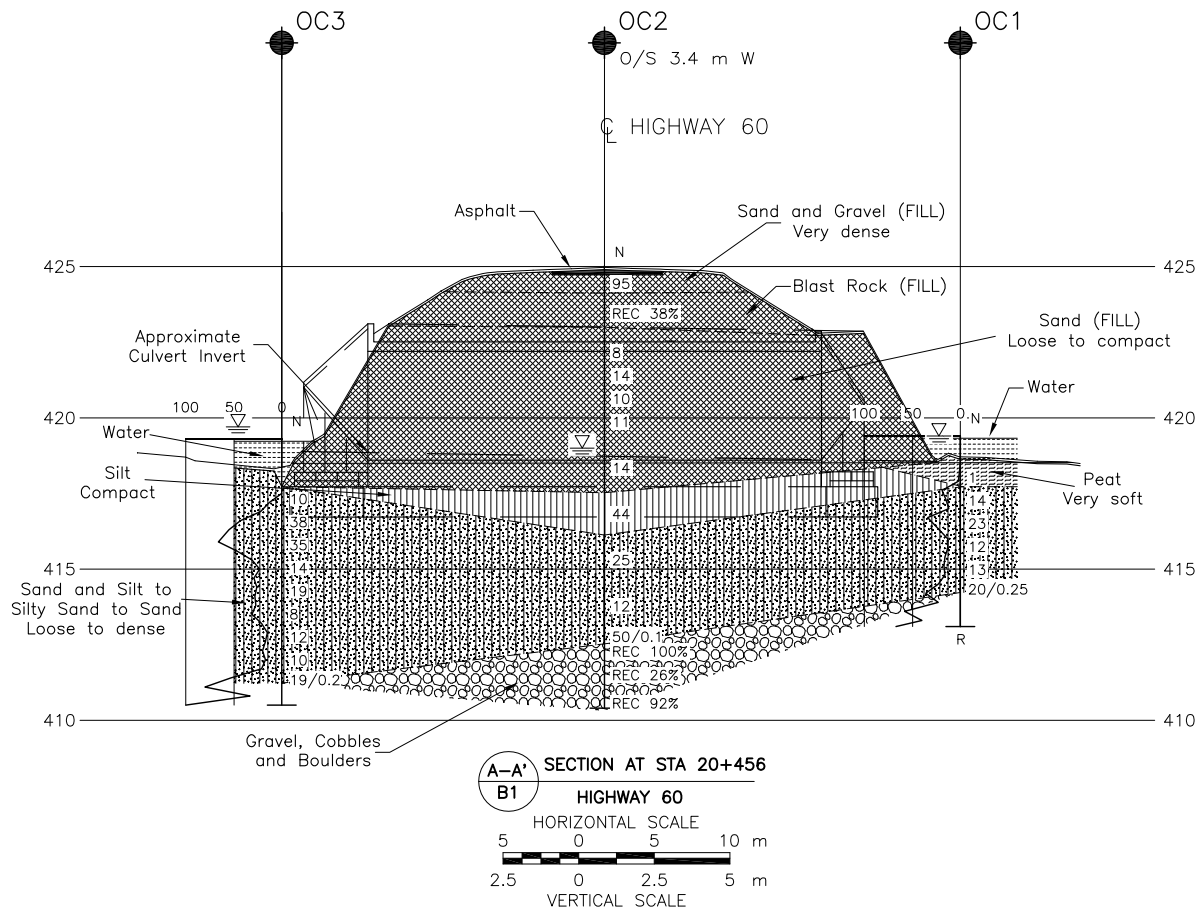
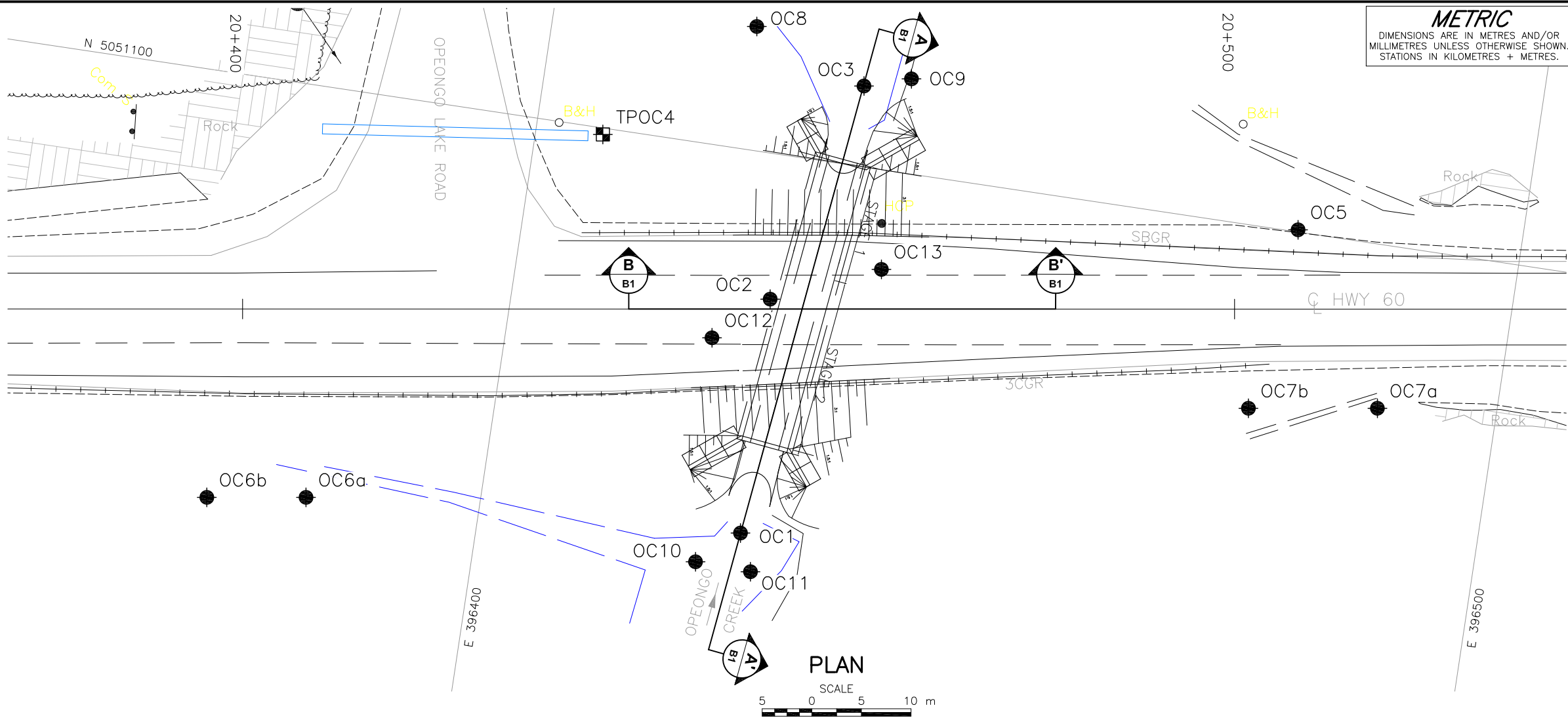
PROJECT					
HIGHWAY 60 NORWAY CREEK CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION GRAVELLY SAND					
PROJECT No.		13-1191-0003		FILE No. 13-1191-0003.GPJ	
DRAWN	JJL	Sep 2013	SCALE	N/A	REV.
CHECK	AB	Sep 2013	FIGURE A6		
APPR	JMAC	Sep 2013			





# APPENDIX B

Opeongo Lake Culvert, Site 43-147/C



**REFERENCE**  
Base plans provided in digital format by LEA, drawing file nos.  
HWY 60 - opeongo.dwg and X-SECTIONS.dwg, received July 26, 2013.

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

CONT No.  
WP No. 5143-11-01

HIGHWAY 60  
OPEONGO LAKE CULVERT  
BOREHOLE LOCATIONS AND  
SOIL STRATA

**Golder Associates Ltd.**  
SUDBURY, ONTARIO, CANADA

SHEET



**LEGEND**

- Borehole
- Test Pit
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- REC Recovery (%)
- WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
OC1	419.4	5051061.7	396426.4
OC2	424.9	5051085.4	396425.9
OC3	419.3	5051108.1	396432.1
OC5	425.4	5051100.2	396477.5
OC6a	421.8	5051058.7	396382.6
OC6b	421.9	5051057.2	396372.7
OC7a	423.7	5051083.6	396488.1
OC7b	423.7	5051081.7	396475.2
OC8	419.7	5051112.4	396420.5
OC9	421.2	5051109.5	396436.7
OC10	419.4	5051058.1	396422.4
OC11	419.4	5051057.9	396428.0
OC12	424.7	5051080.7	396420.7
OC13	425.1	5051090.1	396436.5
TPOC4	422.0	5051099.4	396406.7

**NOTES**

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

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

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.

NO.	DATE	BY	REVISION
Geocres No. 31E-329			
HWY. 60		PROJECT NO. 13-1191-0003	
SUBM'D. AC		CHKD.	DATE: DEC 2013
DRAWN: TB		CHKD. AB	APPD.
		SITE: 43-147/C	
		DWG. B1	





## PHOTOGRAPHS

---

**Photograph 1: Opeongo Lake Culvert, Looking East (June 2013)**



**Photograph 2: Opeongo Lake Culvert, Looking West (June 2013)**







## PHOTOGRAPHS

---

**Photograph 3: Opeongo Lake Culvert, Looking South (June 2013)**



**Photograph 4: Opeongo Lake Culvert, Looking North (June 2013)**



PROJECT 13-1191-0003				RECORD OF BOREHOLE No OC1				1 OF 1 METRIC					
W.P. 5143-11-01				LOCATION N 5051061.7; E 396426.4				ORIGINATED BY GM					
DIST _____ HWY 60				BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring				COMPILED BY AC					
DATUM GEODETIC				DATE July 14, 2013				CHECKED BY AB					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT		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 (%)			
419.4 0.0	WATER SURFACE WATER												
418.5 0.9	PEAT (Fibrous) Very soft Black Wet		1	SS	1								
417.8 1.6	Silty SAND to SAND, some silt, trace clay, trace gravel Compact Grey Wet		2	SS	14								
			3	SS	23								1 77 22 0
			4	SS	12								
			5	SS	13								0 89 (11)
			6	SS	20/0.25								
414.3 5.1	END OF BOREHOLE CASING REFUSAL (HAMMER BOUNCING)												
413.1 6.3	END OF DCPT REFUSAL TO FURTHER PENETRATION (HAMMER BOUNCING)  Note:  1. Advanced DCPT 1 m south of borehole. Refusal to further penetration at 6.3 m depth.												

SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:



PROJECT		13-1191-0003		RECORD OF BOREHOLE No OC2		1 OF 2 METRIC	
W.P.		5143-11-01		LOCATION		N 5051085.4; E 396425.9	
DIST		HWY 60		BOREHOLE TYPE		108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring	
DATUM		GEODETIC		DATE		June 18, 2013	
				ORIGINATED BY		SA	
				COMPILED BY		AC	
				CHECKED BY		AB	
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		DYNAMIC CONE PENETRATION RESISTANCE PLOT	
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	UNCONFINED
424.9	0.0	GROUND SURFACE					
424.2	0.7	ASPHALT (100 mm)		1	SS	95	
		Sand and gravel, some silt (FILL)					
		Very dense					
		Brown					
		Moist					
		Blast rock (FILL)		2	RC	REC 38%	
423.1	1.8	Sand, trace to some gravel, trace to some silt (FILL)					
		Loose to compact					
		Brown					
		Moist		3	SS	8	
				4	SS	14	
				5	SS	10	
				6	SS	11	
		Gravel and cobbles inferred from resistance to casing advancement between depths of 5.3 m and 5.6 m and 6.7 and 7.3 m.					
417.6	7.3	SILT, trace sand					
		Compact					
		Grey					
		Wet		8	SS	44	
416.2	8.7	Silty SAND to SAND, trace gravel					
		Compact					
		Grey					
		Wet		9	SS	25	
				10	SS	12	
412.6	12.3	GRAVEL, COBBLES and BOULDERS		11	SS	50/0.1	
				12A	RC	REC 100%	
		Depth (m) Size (mm)					
		12.3 300					
		12.7 100					
		12.9 100					
		13.1 50					
		13.2 25					
		13.4 75					
		13.9 600		12B	RC	REC 26%	
410.4	14.5			13	RC	REC 92%	

Continued Next Page


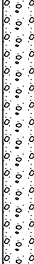

+ 3, × 3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

PROJECT <u>13-1191-0003</u>		<b>RECORD OF BOREHOLE No OC2</b>				2 OF 2 <b>METRIC</b>										
W.P. <u>5143-11-01</u>		LOCATION <u>N 5051085.4; E 396425.9</u>				ORIGINATED BY <u>SA</u>										
DIST <u>          </u> HWY <u>60</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring</u>				COMPILED BY <u>AC</u>										
DATUM <u>GEODETIC</u>		DATE <u>June 18, 2013</u>				CHECKED BY <u>AB</u>										
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								
	--- CONTINUED FROM PREVIOUS PAGE ---															
	END OF BOREHOLE  Note:  1. Water level at a depth of 5.9 m below ground surface (Elev. 419.0 m) upon completion of drilling.															

SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

PROJECT 13-1191-0003				RECORD OF BOREHOLE No OC3				1 OF 1 METRIC					
W.P. 5143-11-01				LOCATION N 5051108.1; E 396432.1				ORIGINATED BY AC					
DIST _____ HWY 60				BOREHOLE TYPE NW Casing, Wash Boring				COMPILED BY AC					
DATUM GEODETIC				DATE October 10, 2013				CHECKED BY AB					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT		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 (%)			
419.3 0.0	WATER SURFACE WATER												
417.8 1.5	SAND and SILT to Silty SAND, trace gravel, trace clay Loose to dense Grey Wet		1	SS	10							NP	1 43 53 3
			2A	SS	38								
			2B	SS	35								
			3	SS	14								
			4	SS	19								
			5	SS	8								
			6	SS	12								
			7	SS	10								
			8	SS	19/0.2								
411.3 8.0	END OF BOREHOLE SPOON REFUSAL (HAMMER BOUNCING)												
410.5 8.8	END OF DCPT REFUSAL TO FURTHER PENETRATION (100 Blows/0.25m)  Note: 1. Water level 0.4 m above water surface (Elev. 419.7 m) inside casing on the morning of October 11, 2013.  2. Advanced DCPT 1 m north of borehole.												

PROJECT 13-1191-0003		<b>RECORD OF BOREHOLE No OC5</b>				1 OF 1 <b>METRIC</b>										
W.P. 5143-11-01		LOCATION N 5051100.2; E 396477.5				ORIGINATED BY GM										
DIST _____ HWY 60		BOREHOLE TYPE Portable Equipment				COMPILED BY AC										
DATUM GEODETIC		DATE July 15, 2013				CHECKED BY AB										
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								
							20	40	60	80	100					
							○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × REMOULDED					WATER CONTENT (%)				
							20	40	60	80	100					
425.4	GROUND SURFACE															
0.0	Sand and gravel, some silt, trace clay (FILL) Dense to very dense Brown Dry		1	SS	22		425									
424.5			2	SS	9/0.1											
0.9	END OF BOREHOLE SPOON REFUSAL (HAMMER BOUNCING)  Note:  1. Borehole dry 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.  3. Relocated 2 m east and refusal at 0.2 m depth.  4. Bedrock exposed approximately 10 m east of borehole.															


PROJECT 13-1191-0003			RECORD OF BOREHOLE No OC6a			1 OF 1 METRIC											
W.P. 5143-11-01			LOCATION N 5051058.7; E 396382.6			ORIGINATED BY GM											
DIST _____ HWY 60			BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring			COMPILED BY AC											
DATUM GEODETIC			DATE July 12, 2013			CHECKED BY AB											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	20 40 60					
421.8	GROUND SURFACE																
0.0 421.5 0.3	TOPSOIL Brown Moist		1a 1b	SS	11		421										27 53 (20)
	Gravelly SAND, some silt, trace clay, trace organics Loose to compact Brown Moist to wet		2	SS	29		420										
			3	SS	4		419										
			4	SS	16		418										
418.5 3.3	SAND and SILT, trace clay Compact Grey Wet		5a 5b	SS	28												0 68 (32)
418.0 3.8	END OF BOREHOLE CASING REFUSAL (HAMMER BOUNCING)																
Note: 1. Water level at a depth of 2.0 m below ground surface (Elev. 419.8 m) upon completion of drilling. 2. Relocated borehole twice due of shallow refusal an cobbles and boulders.																	

SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

PROJECT 13-1191-0003			RECORD OF BOREHOLE No OC6b			1 OF 1 METRIC											
W.P. 5143-11-01			LOCATION N 5051057.2; E 396372.7			ORIGINATED BY GM											
DIST HWY 60			BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring			COMPILED BY AC											
DATUM GEODETIC			DATE July 12 and 13, 2013			CHECKED BY AB											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m³	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	20 40 60					
421.9	GROUND SURFACE																
0.0	TOPSOIL		1	SS	8												
421.6	Brown																
0.3	Moist																
	SAND, some gravel, some silt		2	SS	6		421										
	Loose to compact																
	Brown to grey		3	SS	4		420										
	Moist to wet																
			4	SS	28		419									14 70	(16)
			5	SS	16		418										
			6	SS	20												
			7	SS	20		417									18 65	(17)
416.6	END OF BOREHOLE		8	SS	8/0.05												
5.3	SPOON AND CASING REFUSAL (HAMMER BOUNCING)																
	Note:																
	1. Water level at a depth of 2.0 m below ground surface (Elev. 419.9 m) upon completion of drilling.																

PROJECT <u>13-1191-0003</u>		<b>RECORD OF BOREHOLE No OC7a</b>				1 OF 1 <b>METRIC</b>											
W.P. <u>5143-11-01</u>		LOCATION <u>N 5051083.6; E 396488.1</u>				ORIGINATED BY <u>GM</u>											
DIST <u>          </u> HWY <u>60</u>		BOREHOLE TYPE <u>Portable Equipment</u>				COMPILED BY <u>AC</u>											
DATUM <u>GEODETIC</u>		DATE <u>July 14, 2013</u>				CHECKED BY <u>AB</u>											
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 (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)				
423.7	GROUND SURFACE																
0.0	SAND, some silt, some gravel, trace organics		1	SS	10												
423.2	Compact																
0.5	Brown Moist																
	END OF BOREHOLE SPOON REFUSAL (HAMMER BOUNCING)																
	Note:  1. Borehole dry 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.																



PROJECT <u>13-1191-0003</u>		<b>RECORD OF BOREHOLE No OC7b</b>				1 OF 1 <b>METRIC</b>											
W.P. <u>5143-11-01</u>		LOCATION <u>N 5051081.7; E 396475.2</u>				ORIGINATED BY <u>GM</u>											
DIST <u>          </u> HWY <u>60</u>		BOREHOLE TYPE <u>Portable Equipment</u>				COMPILED BY <u>AC</u>											
DATUM <u>GEODETIC</u>		DATE <u>July 15, 2013</u>				CHECKED BY <u>AB</u>											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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 (%)				
423.7	GROUND SURFACE																
0.0	Sandy TOPSOIL		1	SS	12/0.2												
423.3	Brown Moist																
0.4	END OF BOREHOLE SPOON REFUSAL (HAMMER BOUNCING)																
Note:  1. Borehole dry 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.																	

PROJECT		13-1191-0003		<b>RECORD OF BOREHOLE No OC8</b>				1 OF 1 <b>METRIC</b>										
W.P.		5143-11-01		LOCATION		N 5051112.4; E 396420.5		ORIGINATED BY EHS										
DIST		HWY 60		BOREHOLE TYPE		NW Casing and NQ Coring		COMPILED BY AC										
DATUM		GEODETIC		DATE		October 15, 2013		CHECKED BY AB										
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 (%)
419.7 0.0	GROUND SURFACE Sand, some gravel (FILL) Loose to compact Brown Moist to wet		1	SS	5	▽	419										NP	
			2	SS	11													
418.3 1.4	PEAT (Fibrous), some sand Very soft to firm Black Wet		3	SS	7		418											
			4	SS	WH		417											
416.3			5A	SS	11													
416.0 3.7	SILT, some sand Compact Grey Wet		5B				416											
	SAND, GRAVEL, COBBLES, BOULDERS Very dense Grey Wet			RC	REC 100%													
				RC			415											
414.3 5.4	Boulder 0.6 m thick at 3.7 m depth.		6	CS	-													
	Silty sand seam at 5.1 m depth. GNEISS (BEDROCK)		1	RC	REC 100%		414											
	Bedrock cored from 5.4 m depth to 8.5 m depth.		2	RC	REC 100%	413										RQD = 17%		
	For coring details see Record of Drillhole OC8.		3	RC	REC 100%	412										RQD = 66%		
411.2 8.5	END OF BOREHOLE															RQD = 50%		
	Note: 1. Water level at a depth of 0.5 m below ground surface (Elev. 419.2 m) upon completion of drilling.																	

SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

PROJECT: 13-1191-0003

**RECORD OF DRILLHOLE: OC8**

SHEET 1 OF 1

LOCATION: N 5051112.4 ; E 396420.5

DRILLING DATE: October 15, 2013

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 45 SKID

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

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		Diametral Point Load Index (MPa)	RMC -Q AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	k, cm/s	10 <sup>-6</sup>	10 <sup>-6</sup>	10 <sup>-6</sup>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
		REFER TO PREVIOUS PAGE		414.3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

SUD-RCK 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:



PROJECT		13-1191-0003				RECORD OF BOREHOLE No OC9				1 OF 1 METRIC								
W.P.		5143-11-01		LOCATION		N 5051109.5; E 396436.7		ORIGINATED BY		GM								
DIST		HWY 60		BOREHOLE TYPE		Portable Equipment		COMPILED BY		AC								
DATUM		GEODETIC		DATE		July 15, 2013		CHECKED BY		AB								
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 (%)
421.2	GROUND SURFACE							20	40	60	80	100						
0.0	Gravelly Silty SAND Compact Brown Dry		1	SS	7		421											
420.3			2	SS	13/0.25													25 50 (25)
0.9	END OF BOREHOLE SPOON REFUSAL (HAMMER BOUNCING)  Note:  1. Borehole dry upon completion of drilling.																	

SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

PROJECT 13-1191-0003			<b>RECORD OF BOREHOLE No OC10</b>			1 OF 1 <b>METRIC</b>										
W.P. 5143-11-01			LOCATION N 5051058.1; E 396422.4			ORIGINATED BY GM										
DIST _____ HWY 60			BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring			COMPILED BY AC										
DATUM GEODETIC			DATE July 13, 2013			CHECKED BY AB										
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								
419.4	WATER SURFACE															
0.0	WATER															
418.5																
0.9	Sand, some silt, trace organics (FILL) Very loose Dark brown Wet		1	SS	2											
417.9																
1.5	PEAT (Amorphous) Very soft Black Wet		2	SS	1											
			3	SS	WH											
416.0																
3.4	SAND and SILT to SAND, trace to some gravel Loose to compact Brown to grey Wet		4	SS	19											
			5	SS	26											
			6	SS	8											
			7	SS	10											
			8	SS	17											
			9	SS	19											
410.0																
9.4	END OF BOREHOLE CASING REFUSAL (HAMMER BOUNCING)															

SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

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

PROJECT <u>13-1191-0003</u>		<b>RECORD OF BOREHOLE No OC11</b>		1 OF 1 <b>METRIC</b>	
W.P. <u>5143-11-01</u>		LOCATION <u>N 5051057.9; E 396428.0</u>		ORIGINATED BY <u>GM</u>	
DIST <u>          </u> HWY <u>60</u>		BOREHOLE TYPE <u>Portable Equipment, HQ Casing, Wash Boring</u>		COMPILED BY <u>AC</u>	
DATUM <u>GEODETIC</u>		DATE <u>July 13 and 14, 2013</u>		CHECKED BY <u>AB</u>	

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
419.4	GROUND SURFACE																
0.0	WATER																
418.5																	
0.9	PEAT (Fibrous) Very soft Black Wet		1	SS	WH												
417.4																	
2.0	SAND and SILT, trace gravel Compact to dense Grey Wet		2	SS	14												
			3	SS	33												
			4	SS	11												
415.3																	
4.1	END OF BOREHOLE SPOON AND CASING REFUSAL (HAMMER BOUNCING)		5	SS	6/0.1												

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




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



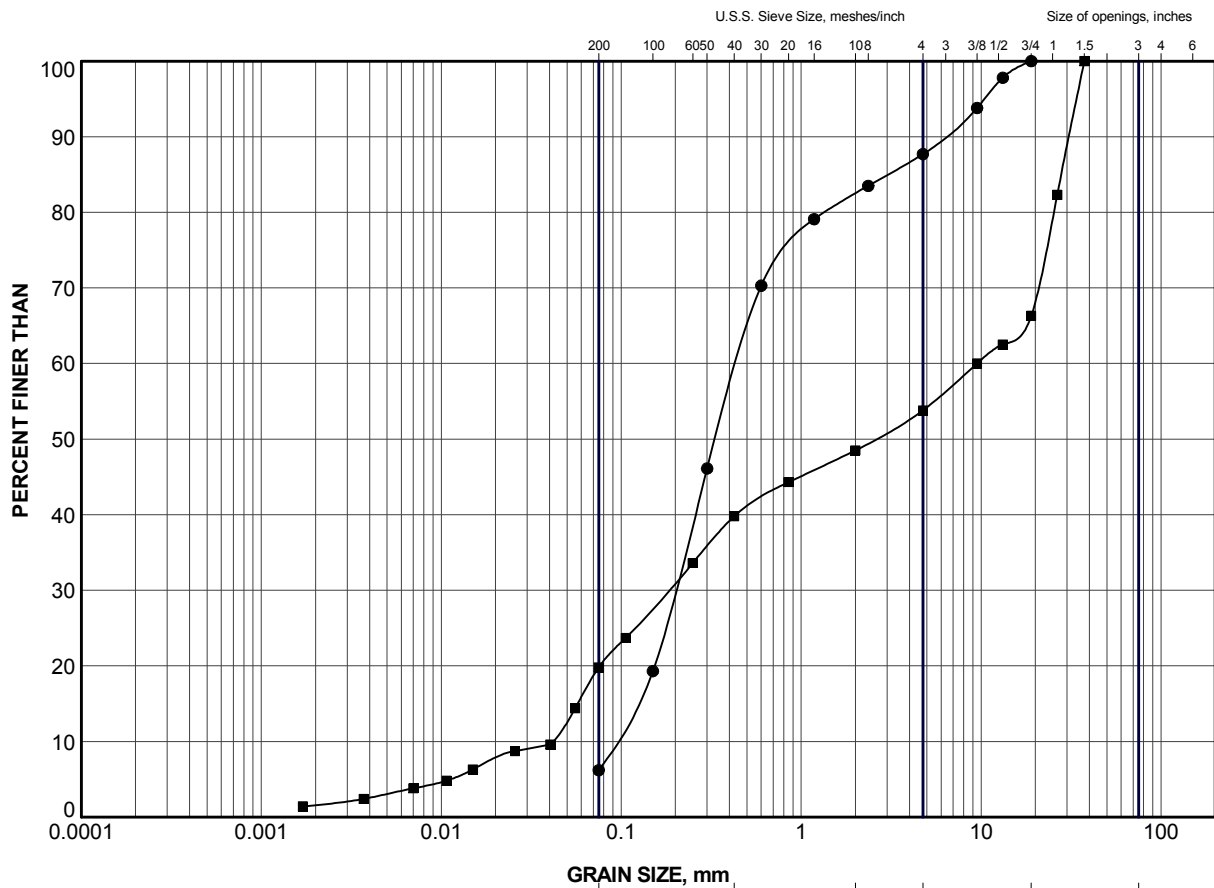
PROJECT 13-1191-0003				<b>RECORD OF BOREHOLE No OC13</b>				1 OF 1 <b>METRIC</b>										
W.P. 5143-11-01				LOCATION N 5051090.1; E 396436.5				ORIGINATED BY GM										
DIST _____ HWY 60				BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring				COMPILED BY AC										
DATUM GEODETIC				DATE July 11, 2013				CHECKED BY AB										
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 (%)
425.1	GROUND SURFACE							20	40	60	80	100						
0.0	ASPHALT (100 mm)		1	SS	33/0.25		425											
424.6	Sand and gravel (FILL)		2	RC	REC 32%		424											
0.5	Dense Brown Moist Blast rock (FILL)		3	RC	REC 18%		423											
			4	RC	REC 100%		422											
			4a	RC	REC 100%		421											
	300 mm void at 5.4 m depth.		4b	RC	REC 100%		420											
							419											
							418											
417.5	SAND, some silt Compact Brown Wet		5	SS	20		417											
416.2	START OF DCPT						416										0 82 (18)	
8.9							415											
							414											
							413											
412.1	END OF DCPT END OF BOREHOLE REFUSAL TO FURTHER PENETRATION (HAMMER BOUNCING)																	
13.0	Note:  1. Water level at a depth of 7.9 m below ground surface (Elev. 417.2 m) upon completion of drilling.																	

SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:

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

PROJECT <u>13-1191-0003</u>		<b>RECORD OF TEST PIT No TPOC4</b>				1 OF 1 <b>METRIC</b>					
W.P. <u>5143-11-01</u>		LOCATION <u>N 5051099.4; E 396406.7</u>				ORIGINATED BY <u>CW</u>					
DIST <u>          </u> HWY <u>60</u>		BOREHOLE TYPE <u>Test Pit Excavation</u>				COMPILED BY <u>AC</u>					
DATUM <u>GEODETIC</u>		DATE <u>September 14, 2013</u>				CHECKED BY <u>AB</u>					
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			
422.0 0.0	GROUND SURFACE Blast rock (FILL)							20 40 60 80 100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	20 40 60	
421.4 0.6	Silty sand, some gravel, cobbles, boulders (FILL) Brown Moist							421			
419.4	PEAT							420			
2.7	Gravelly SAND, some silt, cobbles, boulders							419			
418.5 3.5	END OF TEST PIT BEDROCK EXPOSED  Note:  1. Water seepage into test pit at 3.4 m depth below ground surface (Elev. 418.6 m).										

SUD\_MTO 003 13-1191-0003.GPJ GAL-MISS.GDT 10/12/13 DATA INPUT:



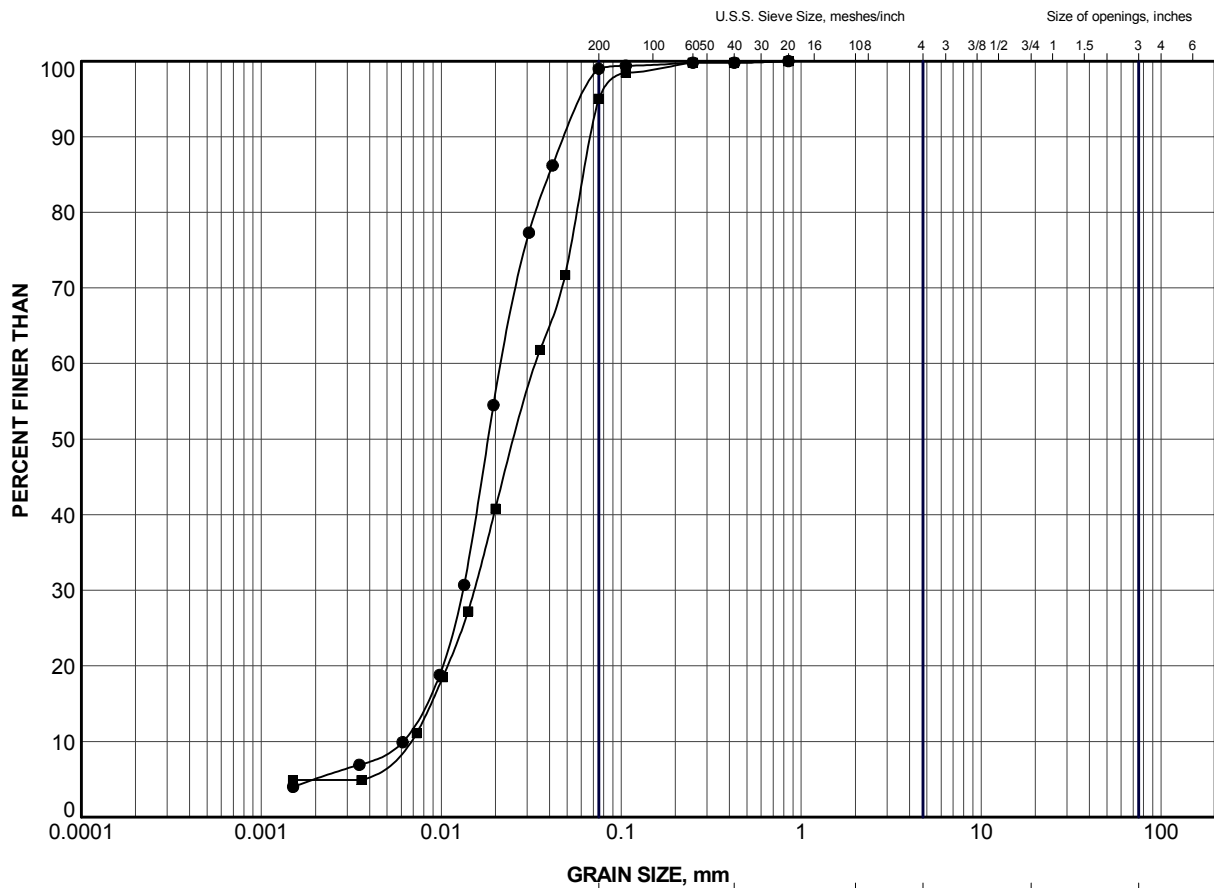
GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	OC2	3	422.3
■	OC5	1	425.1

PROJECT						HIGHWAY 60 OPEONGO LAKE CULVERT					
TITLE						<b>GRAIN SIZE DISTRIBUTION</b> SAND and GRAVEL to SAND (FILL)					
PROJECT No.			13-1191-0003			FILE No.			13-1191-0003.GPJ		
DRAWN	TB	Dec 2013	SCALE	N/A	REV.						
CHECK	AB	Dec 2013									
APPR	JMAC	Dec 2013									
									<b>FIGURE B1</b>		





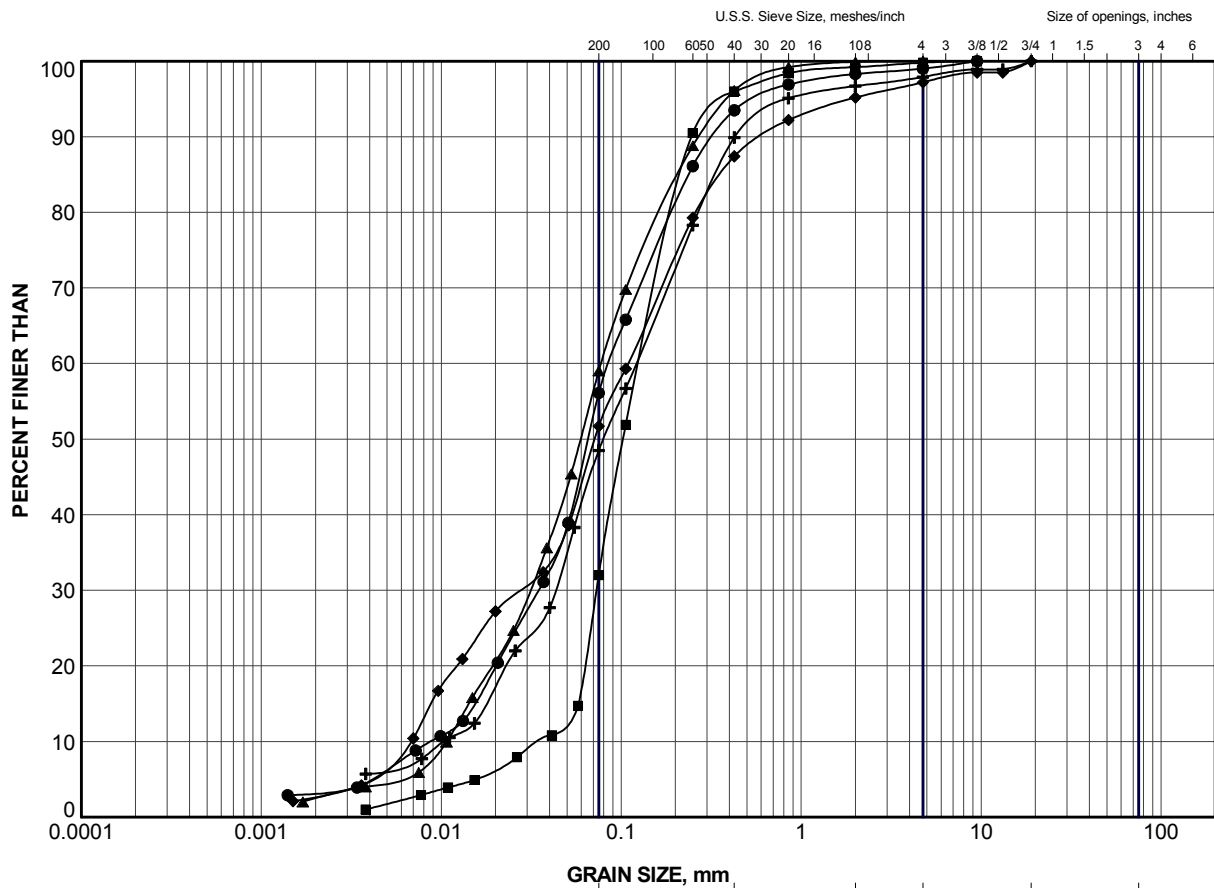
GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	OC2	8	417.0
■	OC12	6	416.8

PROJECT					
HIGHWAY 60 OPEONGO LAKE CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION SILT					
PROJECT No.		13-1191-0003		FILE No. 13-1191-0003.GPJ	
DRAWN	TB	Dec 2013	SCALE	N/A	REV.
CHECK	AB	Dec 2013	FIGURE B2		
APPR	JMAC	Dec 2013			





### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	OC3	1	417.5
■	OC6a	5b	418.4
▲	OC10	5	415.1
+	OC11	3	416.7
◆	OC12	4B	418.1

PROJECT

HIGHWAY 60  
OPEONGO LAKE CULVERT

TITLE

## GRAIN SIZE DISTRIBUTION

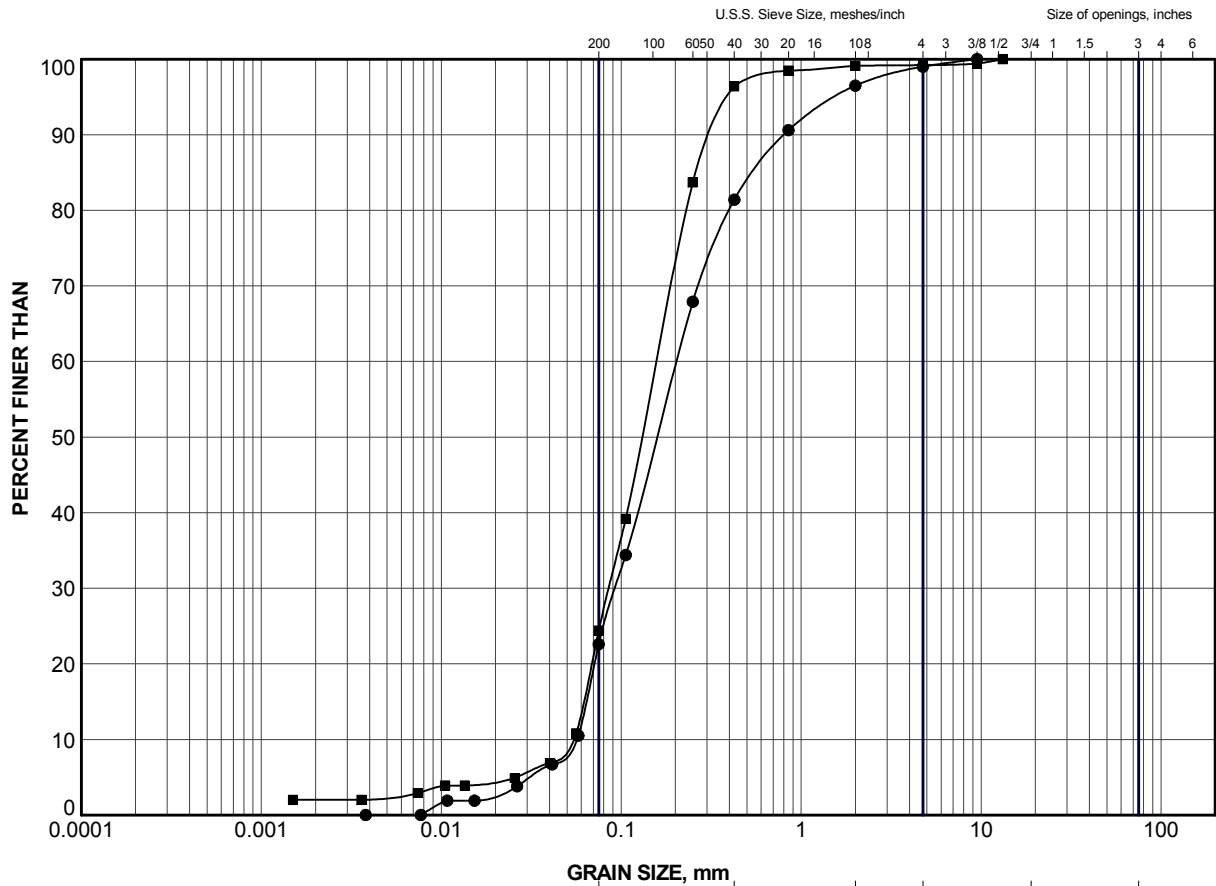
SAND and SILT



**Golder  
Associates**  
SUDBURY, ONTARIO

PROJECT No.	13-1191-0003	FILE No.	13-1191-0003.GPJ
DRAWN	TB	Dec 2013	SCALE N/A
CHECK	AB	Dec 2013	REV.
APPR	JMAC	Dec 2013	

**FIGURE B3**



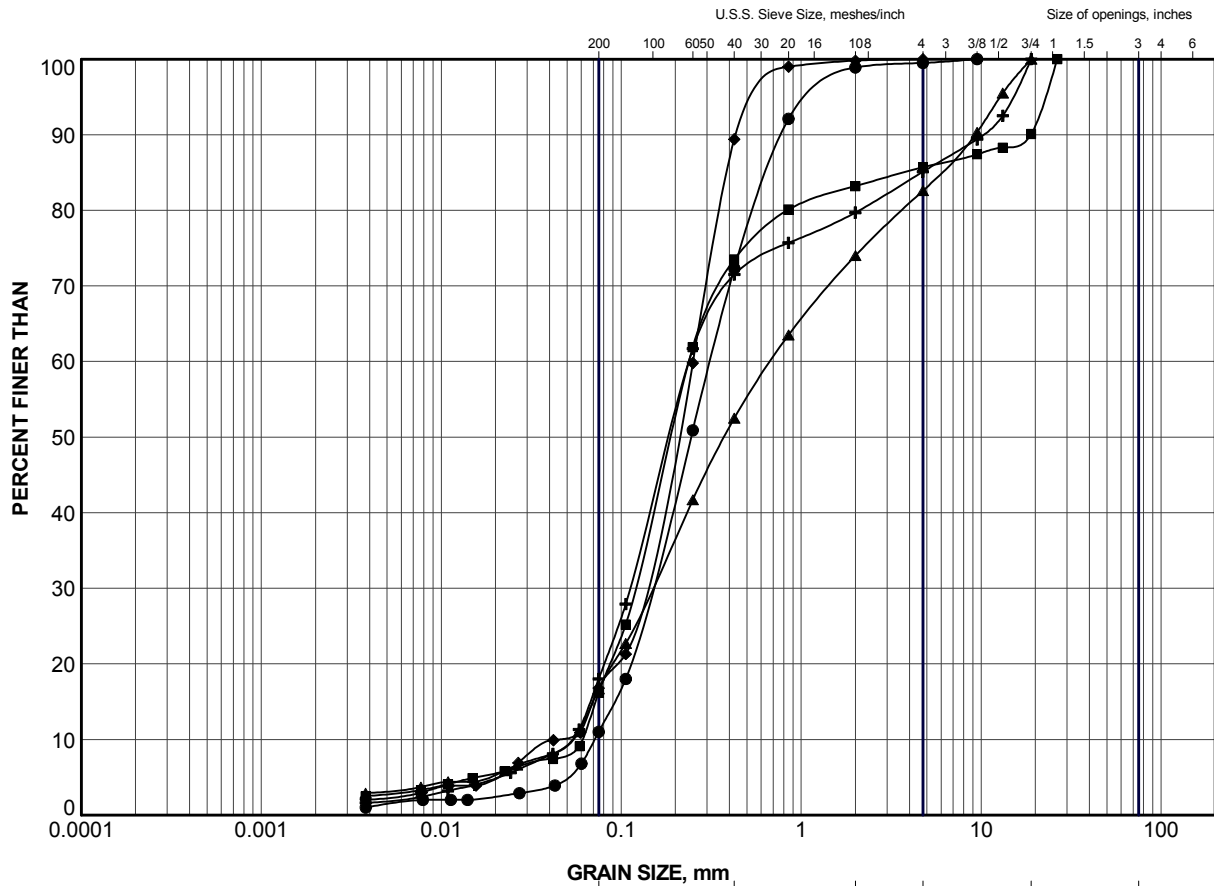
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	OC1	3	416.7
■	OC3	6	413.7

PROJECT						HIGHWAY 60 OPEONGO LAKE CULVERT					
TITLE						GRAIN SIZE DISTRIBUTION SILTY SAND					
PROJECT No.			13-1191-0003			FILE No.			13-1191-0003.GPJ		
DRAWN	TB	Dec 2013	SCALE	N/A	REV.	FIGURE B4					
CHECK	AB	Dec 2013									
APPR	JMAC	Dec 2013									



SUD-MTO GSD (NEW) GLDR\_LDN.GDT

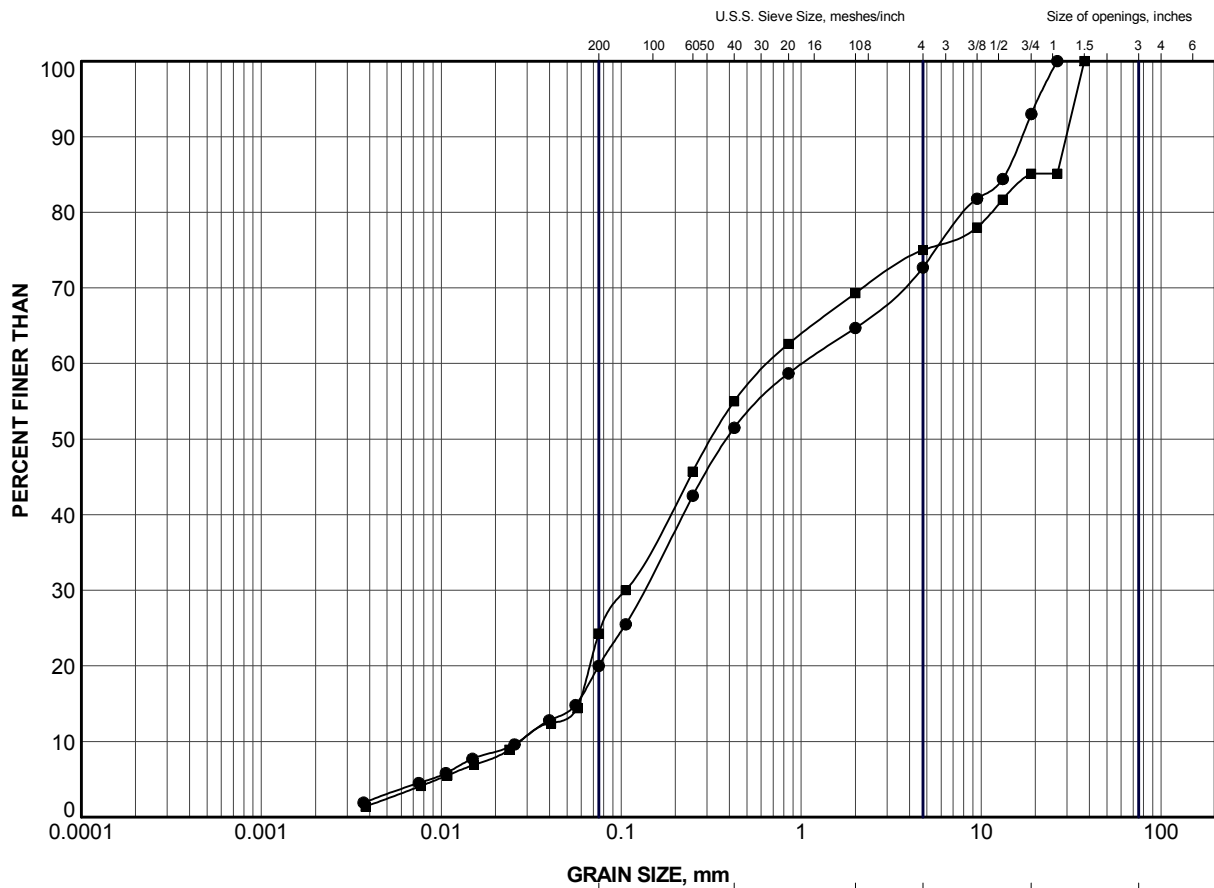


#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	OC1	5	415.1
■	OC6b	4	419.3
▲	OC6b	7	417.0
+	OC10	9	410.6
◆	OC13	5	416.5

PROJECT					
HIGHWAY 60 OPEONGO LAKE CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION SAND					
PROJECT No.		13-1191-0003		FILE No. 13-1191-0003.GPJ	
DRAWN	TB	Dec 2013	SCALE	N/A	REV.
CHECK	AB	Dec 2013	FIGURE B5		
APPR	JMAC	Dec 2013			





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

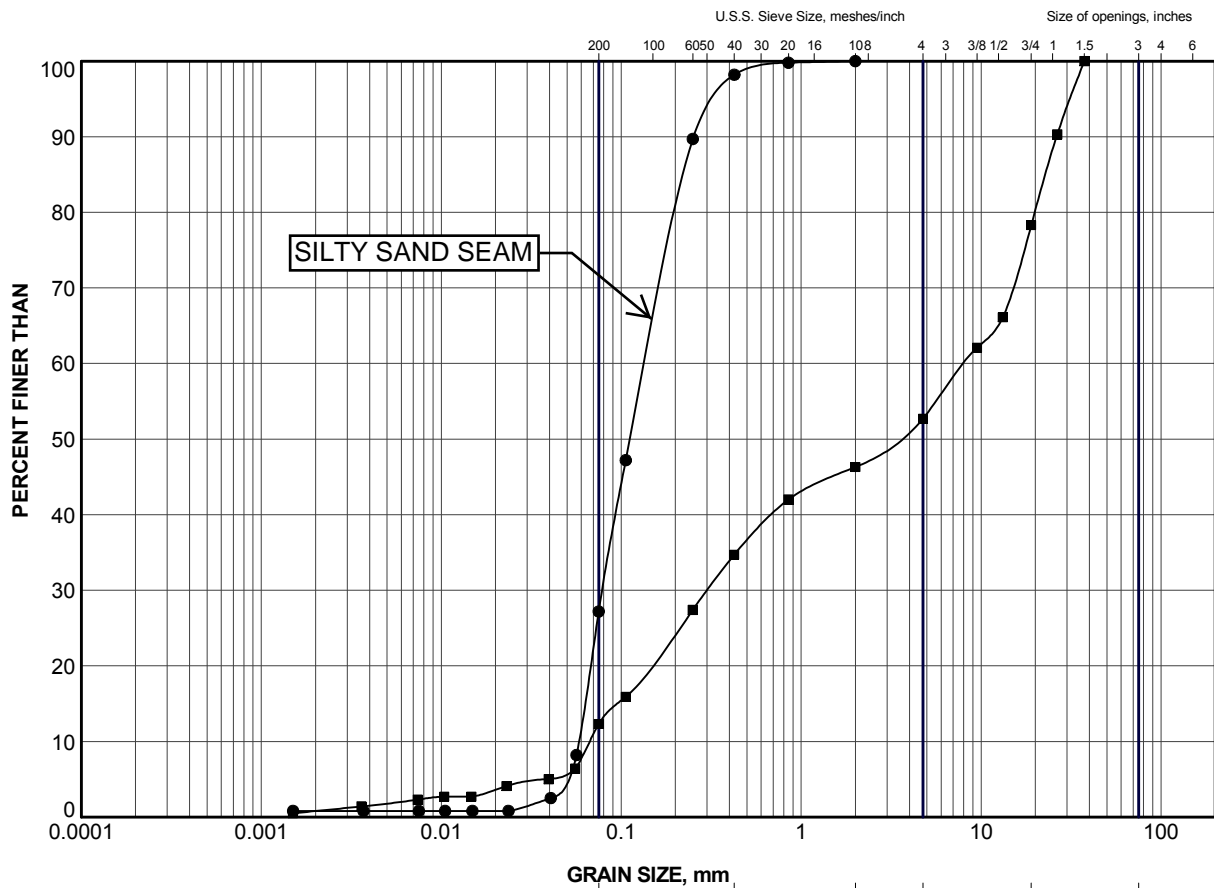
#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	OC6a	1b	421.4
■	OC9	2	420.4

PROJECT					
HIGHWAY 60 OPEONGO LAKE CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION GRAVELLY SAND					
PROJECT No.		13-1191-0003		FILE No. 13-1191-0003.GPJ	
DRAWN	TB	Dec 2013	SCALE	N/A	REV.
CHECK	AB	Dec 2013	FIGURE B6		
APPR	JMAC	Dec 2013			







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

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	OC8	6	414.6
■	OC12	8	413.7

PROJECT					
HIGHWAY 60 OPEONGO LAKE CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION SAND and GRAVEL					
PROJECT No.		13-1191-0003		FILE No. 13-1191-0003.GPJ	
DRAWN	TB	Dec 2013	SCALE	N/A	REV.
CHECK	AB	Dec 2013			
APPR	JMAC	Dec 2013			
			FIGURE B7		



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](mailto:solutions@golder.com)  
[www.golder.com](http://www.golder.com)

**Golder Associates Ltd.**  
**1010 Lorne Street**  
**Sudbury, Ontario, P3C 4R9**  
**Canada**  
**T: +1 (705) 524 6861**

