REPORT

December 18, 2013

FOUNDATION INVESTIGATION AND DESIGN 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:
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Golder Associates

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PART A

FOUNDATION INVESTIGATION REPORT

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Golder Associates

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.

The Terms of Reference for the foundation investigation are outlined in MTO's Request for Proposal, dated January 2013. Golder's proposal (Scope of Work) for foundation engineering services associated with the culvert replacements is contained in Section 6.8 of LEA's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project dated May 10, 2013.

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:

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[1] 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)[2].

1 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.

[2] 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

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PART B

FOUNDATION DESIGN REPORT

HIGHWAY 60 CULVERT REPLACEMENTS

NORWAY CREEK CULVERT, SITE 43-146/C

OPEONGO LAKE CULVERT, SITE 43-147/C

MINISTRY OF TRANSPORTATION, ONTARIO

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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

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

6.1 General

Golder has been retained by LEA to provide foundation design recommendations for the replacement of the Norway Creek Culvert (Site 43-146/C) and the Opeongo Lake Culvert (Site 43-147/C) crossing Highway 60 in Algonquin Park, Ontario. The details of the two existing culverts addressed in this report are summarized in Table 1. The replacement culverts will be approximately the same size as the existing culverts, the new culvert lengths will be generally consistent with the existing culvert lengths and the culvert invert will either remain the same as the existing invert or may change slightly to address hydraulic requirements. We understand that a grade raise is not required for the existing embankments.

We understand from LEA that the culverts will be replaced in stages using roadway protection. Temporary widening of the embankment, benched in the upper portion at the embankment crests, may be required for traffic staging such that detours or modification to the existing embankment toes are not required.

6.2 Culvert Types

Foundation design recommendations are provided for an open footing culvert and for a box culvert, with wing walls constructed at each end of both culvert types to minimize the culvert length. Table 3 presents a comparison of the two culvert alternatives. From a foundations perspective, a box culvert is recommended.

6.3 Design Recommendations for Concrete Culverts

6.3.1 Geotechnical Resistance

Section 6.5 outlines the recommended factored geotechnical axial resistance at Ultimate Limit States (ULS) and the geotechnical axial reaction at Serviceability Limit States (SLS) for 25 mm settlement for design of either a precast concrete box culvert and an open footing culvert founded on a properly prepared subgrade/granular bedding material (as discussed in Section 6.6.1) for each individual culvert site. The geotechnical resistances provided are for loads applied perpendicular to the surface of the base of the culverts. Where loads are not applied perpendicular to the base of the culvert, inclination of the loads should be taken into account in accordance with Section 6.7.4 and Section C6.7.4 of the Canadian Highway Bridge Design Code (CHBDC, 2006) and its Commentary.

The loading on the foundation soils below the culverts and the associated total settlement at the culvert locations will be governed by the design height of the overlying and adjacent embankment fills. As such, it is recommended that the structural engineer exercise caution when utilizing the values of the geotechnical axial resistance at SLS (as provided in Section 6.5) in the design of the culverts and that consideration be given to the sequence and staging of construction. Where embankment widening is not required, there will likely be minimal settlement and where temporary embankment widening is required, the post-construction total settlement of the foundation soils will likely be greater than that of the existing embankment and the settlement will vary along the length of the culverts. However, the SLS values as provided may be used in the design for culvert settlement of up to 25 mm.

Table 4 presents a summary of the ULS/SLS axial resistance values based on the assumed culvert sizes identified in Section 6.5 for each individual culvert.

6.3.2 Resistance to Lateral Loads/Sliding Resistance

Resistance to lateral forces/sliding resistance between the base of the concrete box culverts and the existing granular fill/bedding, or the cast-in-place open footing on the native silts/sands, placed following sub-excavation should be calculated in accordance with Section 6.7.5 of the CHBDC. The following summarizes the coefficient of friction for the interface materials for a precast and cast in place culvert, for the culverts founded at the elevations given in Section 6.5.1 and 6.5.2 for the Norway Creek Site and the Opeongo Lake Site, respectively.

Interface Materials	Coefficient of Friction
Precast Concrete Box Culvert on Compacted Granular 'B' Type II	tan δ = 0.45
Cast-in-Place Concrete Box Culvert on Silts/Sands	tan δ = 0.40

6.3.3 Frost Protection

The estimated frost penetration depth for the Whitney area of Algonquin Park is 1.8 m, as per OPSD 3090.101 (Foundation Frost Penetration Depths for Southern Ontario).

Box culverts are typically not provided with frost protection where water flows year-round through the culvert. Where the creek freezes in winter and frost protection may extend to 1.8 m below the invert, it would be prudent/recommended that the subsoils from below the proposed culvert alignment be sub-excavated to a depth of 1.8 m below the culvert invert and replaced with non frost susceptible (OPSS.PROV1010) Granular 'B' material.

Spread footings for an open footing concrete culvert should be provided with a minimum of 1.8 m of conventional soil cover for frost protection.

6.4 Stability, Settlement and Horizontal Strain

The following sections summarize the methods utilized to: assess embankment stability at the culvert sites; estimate settlement of the foundation soils where the temporary embankment widening is required; and evaluate horizontal strains along the culverts beneath the zone of influence where the existing embankment will be widened for the reconstructed embankment geometry and type of fill material to be used.

As both of the existing embankments will only be temporarily widened at the culvert locations, it is anticipated that any settlement of the cohesionless founding soils will occur during construction and that horizontal strain along the culvert will not develop. Should the embankment require permanent widening or the existing grade be raised, then stability, settlement and horizontal strain analysis should be carried out and recommendations for mitigation should be provided, as appropriate.

The analyses are based on the construction condition that all organic soils beneath the culvert alignments will be removed prior to construction as discussed in Section 6.6.3, and that granular fill (i.e., sand and gravel material such as OPSS.PROV.1010 Granular 'B' Type II) will be used for replacement of sub-excavated material.

The piezometric conditions required in the analyses are based on the groundwater levels observed during drilling.

6.4.1 Stability

The methodology used to evaluate embankment stability at each culvert location is described below. In addition, the parameters used in the analyses for each culvert location are also presented. The results of the analyses for each culvert location are discussed in Section 6.5.

6.4.1.1 Methodology

Limit equilibrium slope stability analyses were performed using the commercially available program GeoStudio 2007 (Version 7.21), produced by Geo-Slope International Ltd., employing the Morgenstern Price method of analysis. For all analyses, the Factor of Safety (FoS) of numerous potential failure surfaces was computed in order to establish the minimum FoS. The FoS is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure. A target minimum FoS of 1.3 is normally adopted for the design of embankment slopes under static conditions for MTO sites. This FoS is considered adequate for the embankments at these sites considering the design requirements and the field data available and is based on deep-seated, global failure surfaces that would affect the operation of the roadway. The stability analyses were performed to check that the target minimum FoS was achieved for the various embankment heights and geometries at the culvert locations.

6.4.1.2 Parameter Selection

The analysis assumes that the widening of the upper portion of the embankments will be constructed with new granular fill (sand and gravel, Granular 'A' or 'B' Type II) having a unit weight of 21 kN/m^3 and an effective friction

angle of 35°. The stability of the embankments constructed of granular fill was analyzed using a slope geometry 2H:1V side slopes and with temporary rock fill side slopes of 1.5H:1V for staged excavations.

For the subsurface cohesionless soils, the effective stress parameters employed in the analysis were estimated from empirical correlations based on the results of the in situ SPT, in conjunction with engineering judgment based on experience in similar soil conditions.

The simplified stratigraphy together with the associated strengths and unit weight values assigned to the different native soil types at the various culvert locations are summarized in Table 5.

6.4.2 Settlement

Temporary widening is required to facilitate culvert replacement at both sites, with single lane traffic switched to cross over one side of the existing culverts and then to the side of the section of permanent culvert to allow for completion of construction of the permanent culverts, as discussed in Section 6.6.2. Settlement of the foundations soils below the proposed culverts can be expected due to the temporary widening, but is estimated to be less than 25 mm. Should the reconstructed embankment be widened for a permanent condition or raised relative to the existing embankment grade, settlement analysis will be required and recommendations for mitigation of settlement issues would need to be provided, as appropriate.

It is recommended that consideration be given to the use of OPSS.PROV1010 (Aggregates) Granular ‘B’ Type I or II for embankment reconstruction at the culvert location. Where granular fill will be placed below the water level, Granular ‘B’ Type II should be used. The material placed below the water level will compress/settle under its self-weight as additional fill is placed over it. The material placed above the water level should be compacted in accordance with OPSS 501 (Compacting). Compression settlement of the fill placed below water and from properly compacted embankment fill above water is expected to occur during construction. It is recommended that the fines content of the Granular ‘B’ Type II fill used for embankment construction below the water be restricted to a maximum of 5 percent passing the No. 200 sieve, to reduce the potential for segregation of fines during placement and to reduce the potential post-construction settlement and associated maintenance needs.

6.4.3 Horizontal Strain

Horizontal strain along the culverts is not expected to occur provided the proposed permanent embankment geometry does not change from the current geometry. Should the overall embankment be widened or raised compared with the existing geometry, a reassessment of the potential magnitude of horizontal strain will be required.

As a result, culvert construction concurrent with embankment re-construction can be carried out without the need for any foundation mitigation measures or culvert camber.

6.5 Results of Geotechnical Resistances, Stability and Settlement Analysis

The results of the stability analysis and the geotechnical axial resistances are provided for each of the culvert locations in the following sections.

The results of analysis for each culvert are also summarized in Table 4. Details of the subsurface conditions are summarized for each culvert in the following sections and selected photographs of local site conditions are presented in Appendices A and B for the respective culvert.

Details on the requirements for backfilling and bedding are provided in Section 6.6.1.

6.5.1 Norway Creek Culvert, Site 43-146/C

The existing 22 m long CSP culvert, which is 5 m wide and 3.1 m high and crosses Highway 60 at about STA 16+899 in Sproule Township, will be replaced with a 5 m wide by 3 m high precast concrete open footing culvert and a length of 20 m with precast concrete wingwalls at the inlet and outlet. The existing embankment is about 4 m high and following culvert replacement the new embankment will be re-constructed to the existing grade.

Details of the subsurface conditions along the culvert alignment are presented in Section 4.3 and shown on Drawing A1 in Appendix A. The subsoils along the culvert alignment generally consist of either rock fill embankment or peat beyond the embankment toes underlain by a deposit of generally compact silt to sand.

The footings for an open footing culvert should be placed at least 1.8 m below the culvert creek bed/invert for protection from frost penetration (approximately Elevation 414 m), such that the footings will generally be founded on the existing granular fill (Boreholes NC2 and NC3) or the native sand and silt deposit below the peat (Borehole NC1). The factored geotechnical axial resistance at ULS and the geotechnical reaction at SLS (for 25 mm settlement) for a 2 m wide footing/tremie plug founded on the properly prepared subgrade may be taken as 400 kPa and 150 kPa, respectively.

If a box culvert is selected to replace the existing CSP culvert at this location, sub-excavation of the peat deposit (if encountered) and replacement with Granular ‘B’ Type II will be required below culvert invert. Further, we recommend that the existing rock fill below the culvert footprint (where encountered) be sub-excavated and replaced with Granular ‘B’ Type II. Alternatively, a 600 mm thick transition layer consisting of 300 mm-minus crushed rock could be placed between the underlying rock fill and a minimum 300 mm thick layer of Granular ‘B’ Type II. The factored geotechnical axial resistance at ULS and the geotechnical reaction at SLS (for 25 mm settlement) for a 5 m wide box culvert founded on a properly prepared subgrade/granular bedding overlying the native non-cohesive soils (or rock fill if left in place) may be taken as 500 kPa and 100 kPa, respectively.

The stability analysis performed on the existing embankment geometry at the culvert location indicates that after completion of construction, the embankment will have a FoS greater than 1.3 for a deep-seated, global failure surface that would impact the operation of the roadway. The stability analysis performed on the proposed staging geometry also indicates a FoS greater than 1.3.

As the existing embankment will not be raised and the widening of the upper portion of the embankment is only temporary at the location of the replacement culvert, settlement of the foundation soils and horizontal strain along the culvert are not expected to occur and a camber is not necessary.

Based on the above, construction of the replacement culvert concurrent with embankment construction can be carried out without the need for any additional special foundation mitigation measures.

6.5.2 Opeongo Lake Culvert, Site 43-147/C

The existing 32 m long CSP culvert, which is 4.3 m in diameter at about STA 20+456 in Sproule Township, will be replaced with a 4 m wide by 3.6 m high precast concrete open footing culvert and 30 m long with precast concrete wingwalls at the inlet and outlet. The existing embankment is about 6.5 m high and following culvert replacement the new embankment will be re-constructed to the existing grade.

Details of the subsurface conditions along the culvert alignment are presented in Section 4.4 and shown on Drawing B1 in Appendix B. The subsoils along the culvert alignment generally consist of either rock fill embankment or peat beyond the embankment toes underlain by generally compact silt to sand.

The footings for an open footing culvert should be placed at least 1.8 m below the culvert creek bed/invert for protection from frost penetration (approximate Elevation 417 m), such that the footings will generally be founded on the native silt/sand deposits below the peat (Boreholes OC1 and OC2). The factored geotechnical axial resistance at ULS and the geotechnical resistance at SLS (for 25 mm settlement) for a 2.0 m wide footing/tremie plug founded on the properly prepared subgrade (native non-cohesive soils) may be taken as 500 kPa and 350 kPa, respectively. Given the potential for hydrostatic pressures being present within the lower portion of the sand and silt to silty sand deposit as reflected by the groundwater level being 0.4 m above the creek water level measured within the casing a day after completion of drilling Borehole OC3, it is recommended that the excavation for footing construction be carried out in the wet within the groundwater control system and a tremie concrete plug of adequate thickness be constructed at the base of the excavation to mitigate the potential for piping/boiling of the native cohesionless soils.

If a box culvert is selected to replace the existing CSP culvert at this location, sub-excavation of the peat deposit (if encountered) and replacement with Granular ‘B’ Type II will be required below culvert invert. Further, we recommend that the existing rock fill below the culvert footprint (where encountered) be sub-excavated and replaced with Granular ‘B’ Type II. Alternatively, a 600 mm thick transition layer consisting of 300 mm-minus crushed rock could be placed between the underlying rock fill and a minimum 300 mm thick layer of Granular ‘B’ Type II. The factored geotechnical axial resistance at ULS and the geotechnical resistance at SLS (for 25 mm settlement) for a 4 m wide box culvert founded on a properly prepared subgrade/granular bedding overlying the native non-cohesive soils (or rock fill if left in place) may be taken as 600 kPa and 250 kPa, respectively.

The stability analysis performed on the existing embankment geometry at the culvert location indicates that after completion of construction, the embankment will have a FoS greater than 1.3 for a deep-seated, global failure surface that would impact the operation of the roadway. The stability analysis performed on the proposed staging geometry also indicates a FoS greater than 1.3.

As the existing embankment will not be raised and the widening of the upper portion of the embankment is only temporary at the location of the replacement culvert, settlement of the foundation soils and horizontal strain along the culvert are not expected to occur and a camber is not necessary.

Based on the above, construction of the replacement culvert concurrent with embankment construction can be carried out without the need for any additional special foundation mitigation measures.

6.6 Construction Considerations

6.6.1 Bedding and Backfill above Base of Culvert

Precast box culverts should be constructed in accordance with SP 422S01 (Precast Concrete Box Culvert). The box culvert should be constructed on a minimum 300 mm thick layer of OPSS.PROV.1010 (Aggregates) Granular 'B' Type II material for bedding purposes. Bedding for the box culvert could be constructed in either dry or wet conditions as follows:

- Where excavations will be unwatered to allow for construction of the culvert in dry conditions (see Section 6.6.3), the bedding should be placed in lifts not exceeding 300 mm loose thickness, and compacted to at least 95 per cent of the Standard Proctor Maximum Dry Density (SPMDD) of the material as specified in OPSS 501 (Compacting). The structural design of the culvert should take into consideration the conditions for bedding placement and compaction in accordance with the requirements of Section 7.8.3.6 of the CHBDC.
- Alternatively, the culvert could be installed in wet conditions depending on the season of construction and water level at the time of installation. The water level should be lower than the proposed surface of the bedding. In this case, the bedding should consist of Granular 'B' Type II and be nominally compacted by the construction equipment. The design of the culvert should be based on the bedding achieving a density of 90 per cent of the SPMDD.

It should be noted that bedding thicknesses will be greater than 300 mm where sub-excavation of organic soils or rock fill is required at specific culvert locations, as identified in Section 6.5.

The culverts should be designed for the full overburden stress and appropriate live loads, assuming a fill unit weight of 22 kN/m3 for Granular 'A' and 21 kN/m3 for Granular 'B' Type II backfill above and surrounding the culvert.

Prior to placement of the roadway granular subbase and base courses, the final lift of embankment fill should be compacted to 100 per cent of the SPMDD. Inspection and field density testing should be carried out by qualified personnel during fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved.

6.6.2 Construction Staging, Temporary Shoring and Excavations

We understand that staged construction is being considered at this site for replacement of the culvert. The proposed Norway Creek and Opeongo Lake culvert staging sketches provided by LEA are included for reference as Figure A7 in Appendix A and as Figure B8 in Appendix B, respectively, and generally consist of the following:

- Stage 1: widening of the south side of the upper portion of the embankment for traffic use and the installation of roadway protection system to facilitate the replacement of the north end of the culvert; and
- Stage 2: roadway protection to facilitate the replacement of the south end of the culvert.

We understand that due to environmental considerations regarding the watercourse that altering the current slope geometry (i.e., full detours or minor widening of existing embankment toes) is not desirable.

All excavations must be carried out in accordance with Ontario Regulation 213, Ontario Occupational Health and Safety Act for Construction Projects (as amended by Ontario Regulation 443). The fills and granular native soils above the water level are considered to be Type 3 soil and the existing peat and granular soils below the water level are considered to be Type 4 soils. Provisions for traffic control measures should be included in the Contract Documents to maintain the safe operation of Highway 60 during the excavation and backfilling operations. Based on stability analysis of the sections of embankment configuration/geometry proposed for the staging construction period, we recommend that the temporary excavation side slopes during culvert replacement be no steeper than 1.5H:1V and excavation and backfilling operations be completed simultaneously in accordance with OPSS 209 (Embankments over Swamps and Compressible Soils) to at least the culvert invert level.

Given that the roadway embankment throughout the culvert areas is constructed of rock fill and that cobble and boulder size materials could be present at/below the invert, it will likely not be possible to install conventional shoring (i.e., sheet-pile wall) through these deposits to facilitate replacement of the existing culverts. If conventional shoring is considered, the existing rock fill within the footprint of the shoring should be sub-excavated and replaced with Granular 'B' Type II through which the conventional shoring would be driven. Alternatively, a soldier or tube pile and lagging system may be used for support of the excavation provided pre-drilling through the existing rock fill would be completed in advance to allow for pile installation. Between the piles, the rock fill may have to be line-drilled to break up the rock fill into smaller pieces to facilitate lagging installation and to minimize loosening of the embankment rock fill matrix. The temporary excavation support systems should be designed and constructed in accordance with OPSS 539 (Temporary Protection Systems). Temporary excavation support systems should be designed to Performance Level 2 for any excavation adjacent to existing roadways. The Contractor should be alerted to the presence of cobble and boulder size material within the rock fill and the presence of cobbles and boulders within the native cohesionless soils; an example NSSP (or Notice to Contractor) to be included in the Contract is presented in Appendix C.

New granular fill should be keyed into the existing embankment side slope or cut slopes as per the requirements of OPSD 208.010 (Benching of Earth Slopes) to minimize differential settlement between the existing embankment slopes and the newly placed embankment fill.

6.6.3 Subgrade Preparation and Control of Groundwater and Surface Water

All organic and softened/loosened soils should be sub-excavated from below the culvert prior to placement of bedding or new fill. Granular fill materials should conform to, and placement should be carried out in accordance with, the requirements outlined in SP 206S03 (Earth Excavation, Grading; Earth Embankment).

Creek/ditch flows via the culverts at the time of construction of the replacement culverts will need to be diverted/piped away from the excavation areas during the construction period. Surface water should be directed

away from the excavation areas to prevent ponding of water that could result in disturbance and weakening of the foundation subgrade.

The subgrade soils along both culvert alignments are comprised of non-cohesive materials. The non-cohesive materials are generally susceptible to disturbance from construction or foot traffic and/or ponded water or groundwater. In order to limit this degradation, it is recommended that a concrete working slab be placed on the subgrade within four hours after preparation, inspection and approval of the subgrade. A sample NSSP to address this requirement is included in Appendix C.

Groundwater flow into the excavation can be expected to occur at both culvert locations due to the presence of relatively permeable subsoils and the near surface water level observed at the culvert locations. As discussed in Section 6.5.2, given the potential for hydrostatic pressures being present within the lower portion of the sand and silt to silty sand deposit at the Opeongo Lake Culvert site, it is recommended that the excavation for footing construction be carried out in the wet within the groundwater control system and a tremie concrete plug of adequate thickness be constructed at the base of the excavation to mitigate the potential for piping/boiling of the native cohesionless soils. Control of groundwater will be necessary at the culvert sites to allow for excavation and construction to be carried out in dry conditions where applicable. Appropriate unwatering within the excavation will be required to maintain the water level below the base level of the culverts during construction. An NSSP should be included in the Contract to alert the contractor to the potential issues associated with unwatering of the soils at the culvert sites and that the excavation must be unwatered and kept stable during construction; a sample NSSP is included in Appendix C.

Excavations for an open footing culvert will require excavations below groundwater water level. In this regard, groundwater control will be required and could be in the form of a sheet-pile cut-off wall or cofferdam advanced to an appropriate depth to control groundwater inflow. At these sites, we recommend placement of a tremie concrete plug at the base of the excavation directly below the footing within the sheet-pile cofferdam to guard against the basal heave method of failure. The tremie concrete plug should have a minimum compressive strength of 1 MPa. Once the tremie plug is in place, water can be pumped out of the excavation for construction of the footings.

It should be noted that at both the Norway Creek and Opeongo Lake sites, the tremie concrete plug forms an integral part of the footing system and it is the tremie concrete that will extend to the recommended footing founding elevation and therefore, placement of this tremie concrete is not optional for the construction of an open footing culvert.

6.6.4 Erosion Protection

Provision should be made for scour and erosion protection at both culvert locations. In order to prevent surface water from flowing either beneath the culvert (potentially causing undermining and scouring) or around the culvert (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles), a clay seal or concrete cut-off wall should be provided at the upstream end of the culvert. If a clay seal is adopted, the clay material should meet the requirements of OPSS 1205 (Clay Seal), and the seal should extend from a depth of 1 m below the scour level to a minimum horizontal distance of 2 m on either side of the culvert inlet opening, and a minimum vertical height equivalent to the high water level including along the embankment slope. Alternatively, a 0.6 m thick clay blanket may be constructed, extending upstream three

times the culvert height and along the adjacent slopes to a height of two times the culvert height or the high water level, whichever is greater.

The requirements for and design of erosion protection measures for the inlet and outlet of the culvert should be assessed by the hydraulics design engineer. As a minimum, rip rap treatment for the outlet of the culvert should be consistent with the standard presented in OPSD 810.010 (Rip Rap Treatment). Erosion protection for the inlet of the culverts should also follow the standard presented in OPSD 810.010 (Rip Rap Treatment) similar to the outlet but with the rip rap placed up to the toe of slope level, in combination with the cut off measures noted above. Similarly, rip rap should be provided over the full extent of the clay blanket, including the creek side slopes and fill slope over the culvert.

6.6.5 Analytical Testing for Construction Materials

The results of analytical tests on a sample of creek water taken adjacent to each culvert site are presented in Table 2. The suite of parameters tested is intended to allow the structural engineer to assess the requirements for the appropriate type of cement to be used in construction and the need for corrosion protection of steel reinforcing elements.

6.7 Lateral Earth Pressures for Wing Walls

The lateral earth pressures acting on any wing walls that may be ultimately required will depend on the type and method of placement of backfill materials, the nature of soils/embankment fill behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls.

The following recommendations are made concerning the design of the culverts and wing walls. It should be noted that these design recommendations and parameters assume level backfill and ground surface behind the walls. Where there is sloping ground behind the head/wing walls, the coefficient of lateral earth pressure must be adjusted to account for the slope.

- Select, free draining granular fill meeting the requirements of OPSS.PROV1010 (Aggregates) Granular ‘A’ or Granular ‘B’ Type II but with less than 5 per cent passing the 200 sieve (0.075 mm) should be used as backfill behind any head/wing walls. Longitudinal drains and weep holes should be installed behind head/wing walls to provide positive drainage of the granular backfill. Other aspects of the granular backfill requirements with respect to sub drains and frost taper for head/wing walls should be in accordance with OPSD 3121.150 (Retaining Wall Backfill).
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the head/wing walls, in accordance with CHBDC Section 6.9.3 and Figure 6.6. Compaction equipment should be used in accordance with SP105S10 (Compacting). Other surcharge loadings should be accounted for in the design as required.
- For restrained walls, granular fill may be placed either in a zone with the width equal to at least 1.8 m behind the back of the wall (see Figure C6.20(a) of the Commentary to the CHBDC). For unrestrained walls, granular fill should be placed within the wedge shaped zone defined by a line drawn at 1.5 horizontal

to 1 vertical (1.5H:1V) extending up and back from the rear face of the wall (in accordance with Figure C6.20(b) of the Commentary to the CHBDC). The pressures are based on the proposed embankment fill material and the following parameters (unfactored) may be used:

Fill Type	Unit Weight	Coefficients of Static Lateral Earth Pressure	
		At-Rest, K_o	Active, K_a
Granular 'A'	22 kN/m^3	0.43	0.27
Granular 'B' Type II	21 kN/m^3	0.43	0.27

If the culvert structure and wing walls allow for lateral yielding, active earth pressures may be used in the geotechnical design of the structures. If the culvert structure and wing walls do not allow lateral yielding, at-rest earth pressures should be assumed for geotechnical design. The movement required to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.9.1 and Table C6.6 of the Commentary to the CHBDC.

7.0 CLOSURE

This report was prepared by Mr. Evan Childerhose, P.Eng. and Mr. André Bom. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project and a Principal with Golder, reviewed the technical aspects of and conducted an independent quality control review of the report.

Report Signature Page

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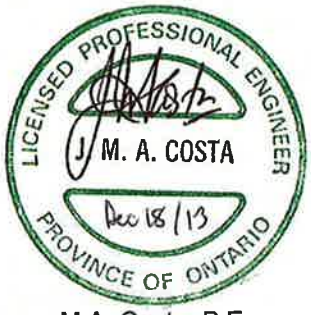

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REFERENCES

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

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

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

ASTM International:

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

Commercial Software

GeoStudio (Version 7.21) by Geo-Slope International Ltd.

Contract Design Estimating and Documentation (CDED):

Special Provision 105S10	Construction Specification for Compacting.
Special Provision 422S01	Precast Concrete Box Culvert
Special Provision 206S03	Earth Excavation, Grading; Earth Embankment; Rock Excavation, Grading; Rock Embankment

Ontario Occupational Health and Safety Act:

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

Ontario Provincial Standard Drawings:

OPSD 208.010	Benching of Earth Slopes
OPSD 810.010	Rip-Rap Treatment for Sewer and Culvert Outlets
OPSD 3090.101	Foundation Frost Penetration Depths for Southern Ontario.
OPSD 3121.150	Walls, Retaining, Backfill, Minimum Granular Requirement

Ontario Provincial Standard Specification:

OPSS 209	Construction Specification for Embankments Over Swamps and Compressible Soils
OPSS 501	Construction Specification for Compacting
OPSS 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 1002	Material Specification for Aggregates – Concrete
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

OPSS 1205	Material Specification for Clay Seal

Ontario Water Resources Act:

Ontario Regulation 372/97	Amendment to Ontario Regulation 903

Table 1: Summary of Culvert Details

Culvert Location Highway 60 (Township)	Approximate Existing Embankment Height[1] (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.

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 (µS/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

Table 3: Evaluation of Culvert Types

Options	Rank	Advantages	Disadvantages	Relative Costs
Box Culvert (concrete)	1	■ Frost protection generally not required for box culvert. ■ Straightforward construction. ■ Installation for pre-cast culvert is relatively quick compared with cast-in-place open footing culvert. ■ Dewatering/unwatering likely not required for culvert bedding.	■ Bedding will be required below footprint of the box culverts: Removal of existing rock fill at Norway Creek (BH NC2) and replacement with Granular 'B' Type II in the wet is required prior to bedding placement. At Opeongo Lake, bedding could be placed directly on the granular fill (BHOC2), however, if rock fill is present below culvert footprint, removal of existing rock fill is required.	■ Additional costs incurred due to transportation of pre-cast culvert units.
Open Footing Culvert (concrete)	2	■ Bedding not required, footings can be founded on native subgrade provided concrete is placed in-the-dry. ■ Suitable for sites where reduced impact to creek bed is required.	■ Deep Excavation for footings required. ■ Cofferdam likely required to allow for dewatering/unwatering for construction of cast-in-place footings in the dry. ■ Frost protection required for culvert footings (deeper founding level).	■ Additional cost for form work for concrete placement. ■ Additional cost for cofferdam and dewatering for footing construction in-the-dry.

Table 4: Summary of Design Parameters for Culvert Construction

Culvert Location Highway 11 (Township)	Approximate Existing Embankment Height [1] (m)	Preferred Option for Culvert Construction	Estimated Total Settlement for Permanent Culvert [2] (mm)	Founding Soil at and Immediately Below[3,4]	Geotechnical Axial Resistance				Culvert Strain	
					Box Culvert		Open Footing Culvert			
					Factored ULS (kPa)	SLS (for 25 mm Settlement) (kPa)	Factored ULS (kPa)	SLS (for 25 mm Settlement) (kPa)	Culvert Length (m)	Estimated Maximum Joint Opening (mm)
Norway Creek STA 16+899 (Sproule)	4.0	Concurrent with embankment construction	<25	Existing Sand and Gravel Fill/ Silt to Sand	500	100	400	150	20	N/A
Opeongo Lake STA 20+456 (Sproule)	6.5	Concurrent with embankment construction	<25	Existing Sand Fill/Silt to Silty Sand to Sand	600	250	500	350	30	N/A

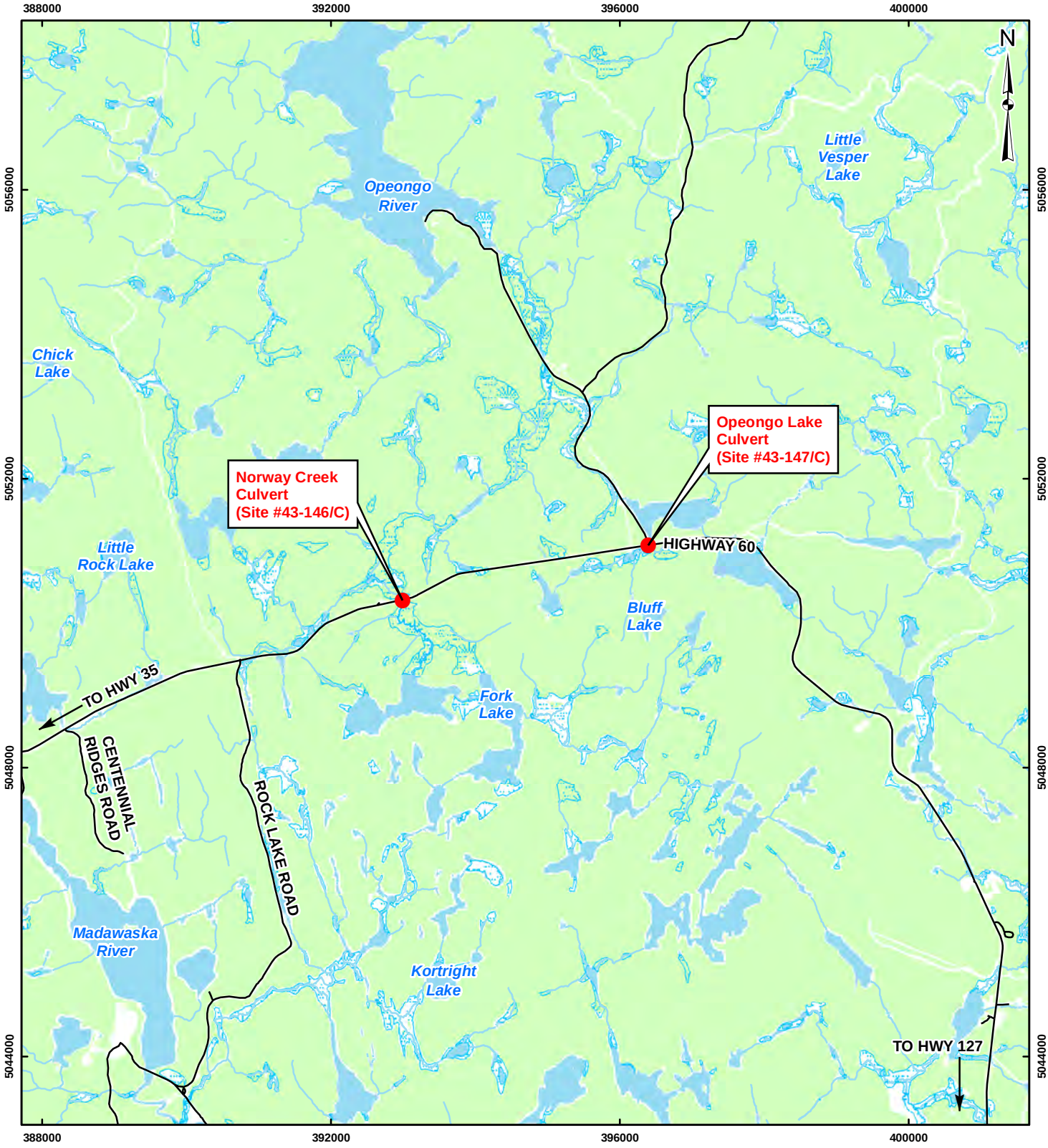
Notes:
1. Embankment height is relative to existing ground surface level near toe of embankment.
2. Total settlement refers to the immediate settlement of the native soil deposits.
3. All organic deposits are to be removed prior to culvert construction.
4. Bedding for box culvert should be at least 300 mm thick and consist of Granular 'B' Type II.

Prepared by: MT
Checked by: AB/JMAC

Table 5: Summary of Foundation Engineering Parameters

Culvert Location Highway 60 (Township)	Stratigraphic Unit[1]	Top Elevation (m)	Thickness (m)	γ' (kN/m^3)	Φ' (^{o})	E' (MPa)
Norway Creek STA 16+899 (Sproule)	Existing Embankment Fill (at midpoint)	420.1	8.2	20	30	N/A
	Peat	416.8 to 415.6	0.9 to 3.1	12	27	-
	Silt to Sand	416.4 to 411.9	4.7 to >11.6	19	30	18
	Gravelly Sand	411.7	>6.8	20	35	15
Opeongo Creek STA 20+456 (Sproule)	Existing Embankment Fill (at midpoint)	424.9	7.3	20	30	N/A
	Peat/Topsoil	423.7 to 417.9	0.3 to 1.9	12	27	-
	Silt	417.6	1.4	18	30	18
	Sand and Silt to Gravelly Sand	423.7 and 416.0	3.6 and 5.4	19	30	27
	Gravel, Cobbles and Boulders	412.6	>2.2	19	40	40

Prepared by: MT
Checked by: AB



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

1 0.5 0 1 2 3
SCALE 1:75,000 KILOMETRES

PROJECT
NORWAY AND OPEONGO CULVERT REPLACEMENTS
ALGONQUIN PARK, ONTARIO

TITLE
KEY PLAN

Golder Associates
Mississauga, Ontario

PROJECT NO. 13-1191-0003			SCALE AS SHOWN	REV. 0.0
DESIGN	ME	6 Aug. 2013	FIGURE: 1	
GIS	ME	7 Aug. 2013		
CHECK	JH	7 Aug. 2013		
REVIEW	ACB	7 Aug. 2013		

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

LIST OF SYMBOLS

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

I. GENERAL

π	3.1416
ln x,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan\delta$
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

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

2 shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d:

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

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

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

(b) Cohesive Soils

Consistency

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

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

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

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or 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^{o} 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

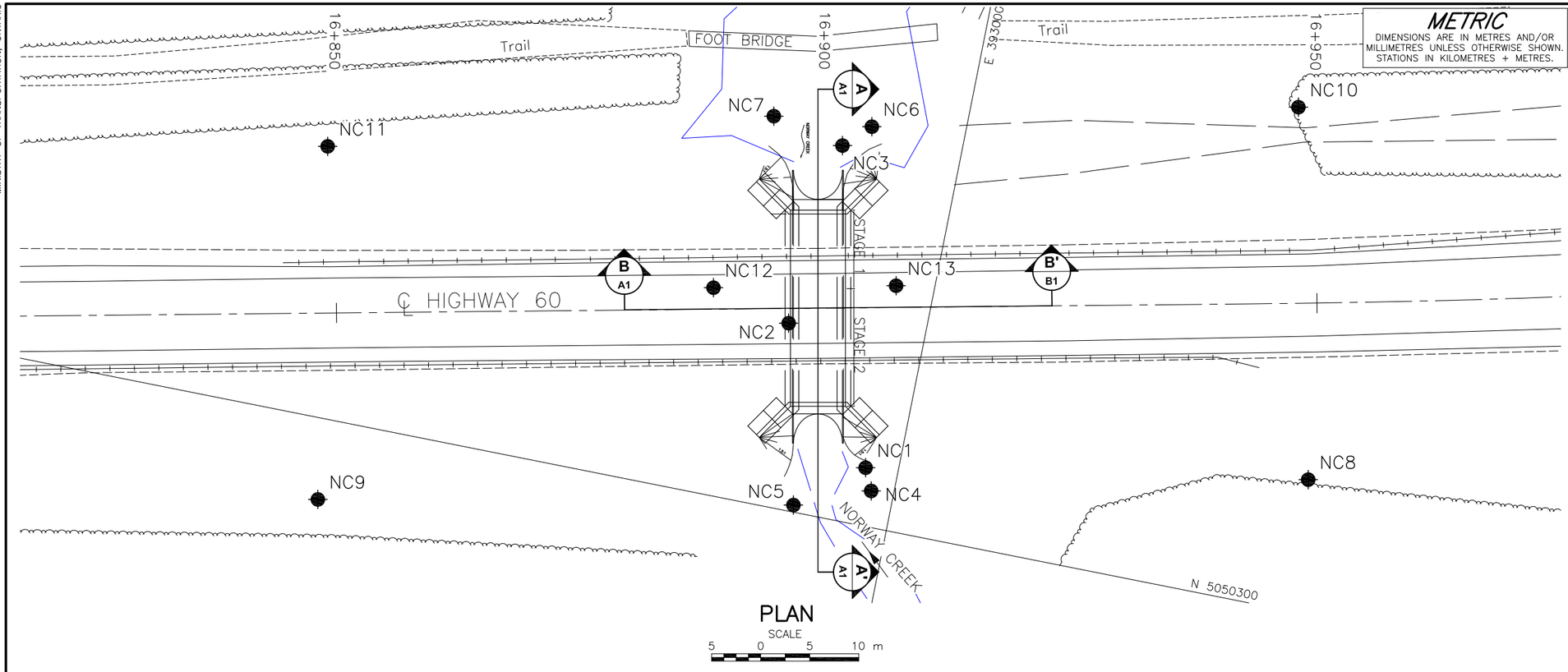
JN Joint
FLT Fault
SH Shear
VN Vein
FR Fracture
SY Stylolite
BD Bedding
FO Foliation
CO Contact
AXJ Axial Joint
KV Karstic Void
MB Mechanical Break

PL Planar
CU Curved
UN Undulating
IR Irregular
K Slickensided
PO Polished
SM Smooth
SR Slightly Rough
RO Rough
VR Very Rough

APPENDIX A

Norway Creek Culvert, Site 43-146/C

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

SCALE

5 0 5 10 m

METRIC

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

CONT No.

WP No. 5141-11-01

HIGHWAY 60

NORWAY CREEK CULVERT

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Golder Associates

Golder Associates Ltd.

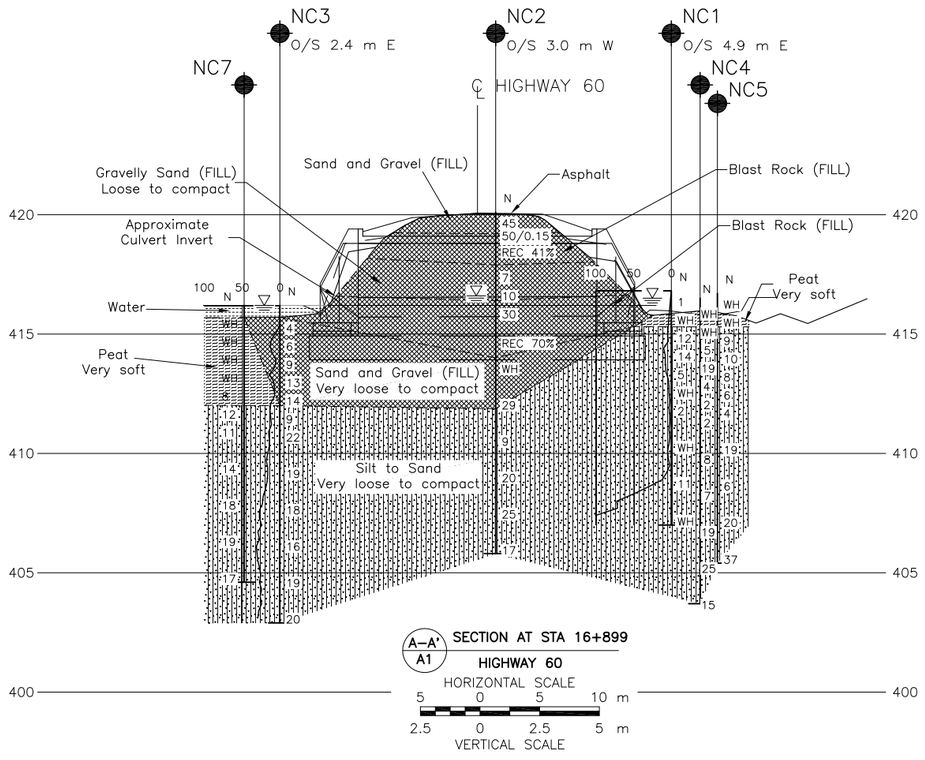
SUDBURY, ONTARIO, CANADA

KEY PLAN

12 0 12 km

LEGEND

- Borehole – Current Investigation
- 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



A–A' A1 SECTION AT STA 16+899

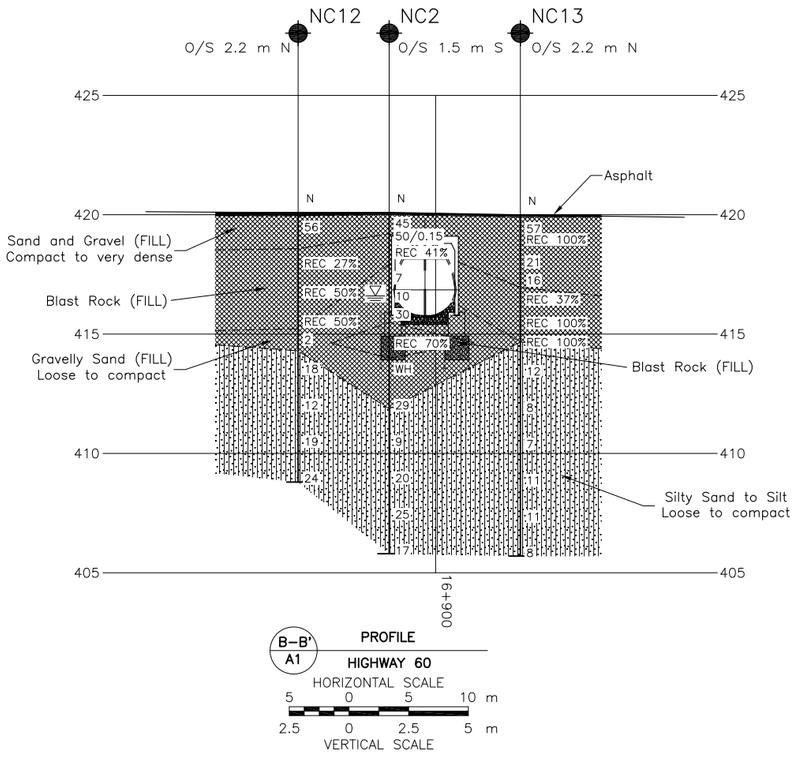
HIGHWAY 60

HORIZONTAL SCALE

5 0 5 10 m

2.5 0 2.5 5 m

VERTICAL SCALE



B–B' A1 PROFILE

HIGHWAY 60

HORIZONTAL SCALE

5 0 5 10 m

2.5 0 2.5 5 m

VERTICAL SCALE

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
NC1	416.8	5050305.9	392996.7
NC2	420.1	5050318.8	392986.1
NC3	416.2	5050337.6	392987.9
NC4	416.5	5050303.7	392997.7
NC5	416.7	5050300.7	392990.2
NC6	416.2	5050340.1	392990.5
NC7	416.2	5050339.2	392980.5
NC8	417.4	5050313.5	393041.2
NC9	417.3	5050291.8	392942.5
NC10	417.0	5050350.6	393032.8
NC11	417.3	5050327.3	392936.5
NC12	420.1	5050320.9	392977.9
NC13	420.0	5050324.7	392996.1

NOTES

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

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

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

REFERENCE

Base plans provided in digital format by LEA, drawing file HWY 60 –norway.dwg received JULY 26, 2013.

NO.	DATE	BY	REVISION

Geocres No. 31E-329

HWY. 60	PROJECT NO. 13-1191-0003		DIST.
SUBM'D. AC	CHKD.	DATE: DEC 2013	SITE: 43-146/C
DRAWN: JJL	CHKD. AB	APPD. JMAC	DWG. A1

PLOT DATE: December 17, 2013
FILENAME: \\golder.gds\GAL\Sudbury\CAD-GIS\CAD\Projects\2013\13-1191-0003 - LEA Hwy 60-35-118\1319100\3A0001 Norway.dwg

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

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

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

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

Golder Associates

RECORD OF BOREHOLE No NC1

1 OF 1 **METRIC**

PROJECT 13-1191-0003
W.P. 5141-11-01
DIST HWY 60
DATUM GEODETIC

LOCATION N 5050305.9; E 392996.7
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers
DATE June 13, 2013

ORIGINATED BY SA
COMPILED BY AC
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
416.8	GROUND SURFACE								
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	1	▽			
			2	SS	WH				
415.3									
1.5	SAND and SILT, trace clay Very loose to compact Grey Wet		3	SS	12				
			4	SS	14				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				
			7	SS	2				
	Approximately 0.9 m of heave inside augers at 6.1 m depth.		8	SS	WH				0 50 47 3
	Approximately 0.6 m of heave inside augers at 7.6 m depth.		9	SS	11				
	Approximately 1.5 m of heave inside augers at 9.1 m depth.		10	SS	WH				
407.0									
9.8	END OF BOREHOLE								

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
20 40 60

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.

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

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

Golder Associates

RECORD OF BOREHOLE No NC2

1 OF 2 **METRIC**

PROJECT 13-1191-0003 | W.P. 5141-11-01 | LOCATION N 5050318.8; E 392986.1 | ORIGINATED BY SA

DIST | HWY 60 | BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring | COMPILED BY AC

DATUM GEODETIC | DATE June 19, 2013 | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
420.1	GROUND SURFACE						420				
0.0	ASPHALT (100 mm)										
0.1	Sand and gravel, some silt (FILL) Dense Brown		1	SS	45						
419.2	Moist		2	SS	50/0.15						
0.9	Blast rock (FILL)		3	RC	REC 41%		419				
417.9											
2.2	Gravelly sand, trace to some silt (FILL) Loose to compact Brown to grey Moist to wet		4	SS	7		418				
			5	SS	10	▽	417		○		21 71 (8)
			6	SS	30		416				
415.5											
4.6	Blast rock (FILL)		7	RC	REC 70%		415				
414.0											
6.1	Sand and gravel, some silt, trace organics (FILL) Very loose to compact Grey to black Moist		8	SS	WH		414				
			9	SS	29		413		○		29 53 (18)
411.9							412				
8.2	SAND and SILT to SILT, trace clay Loose to compact Grey Wet		10	SS	9		411				
			11	SS	20		410				
			12	SS	25		409		○		0 7 88 5
			13	SS	17		408				
405.8							407				
14.3							406				

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No NC2

2 OF 2 **METRIC**

PROJECT 13-1191-0003
W.P. 5141-11-01
LOCATION N 5050318.8; E 392986.1
ORIGINATED BY SA
DIST HWY 60
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring
COMPILED BY AC
DATUM GEODETIC
DATE June 19, 2013
CHECKED BY AB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
	END OF BOREHOLE Note: 1. Water level at a depth of 3.5 m below ground surface (Elev. 416.6 m) upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No NC3

1 OF 2 **METRIC**

PROJECT 13-1191-0003
W.P. 5141-11-01
DIST ____ HWY 60
DATUM GEODETIC
LOCATION N 5050337.6; E 392987.9
BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring
DATE July 11, 2013
ORIGINATED BY SA
COMPILED BY AC
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
416.2	WATER SURFACE										
0.0 / 415.7	WATER						416				
0.5	Sand and gravel, trace organics, trace silt, trace clay (FILL) Loose to compact Brown to grey Wet		1	SS	4		415				
			2	SS	6						
			3	SS	9		414				
			4	SS	13		413		○		43 48 7 2
412.0			5	SS	14		412				
4.2	SAND to Sandy SILT, trace gravel, trace clay Loose to compact Grey Wet		6	SS	9						
			7	SS	22		411		○		4 89 (7)
			8	SS	19		410				
			9	SS	18		409				
			10	SS	16		408				
			11	SS	19		407		○		2 27 (71)
402.9			12	SS	20		406				
13.3							405				
							404				
							403				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No NC3

2 OF 2 **METRIC**

PROJECT 13-1191-0003
W.P. 5141-11-01
LOCATION N 5050337.6; E 392987.9
ORIGINATED BY SA
DIST HWY 60
BOREHOLE TYPE Portable Equipment, NW Casing and 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 (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	--- 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.										

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

Golder Associates

RECORD OF BOREHOLE No NC4

1 OF 1 **METRIC**

PROJECT 13-1191-0003 | 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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
416.5	GROUND SURFACE										
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	WH	▽	416				
415.3			2	SS	WH						
1.2	SAND and SILT to SILT Very loose to compact Grey Wet		3	SS	5		415				
			4	SS	19		414		○		0 55 41 4
			5	SS	4		413				
			6	SS	2						
			7	SS	2		412				
			8	SS	8		411		○		0 25 71 4
			9	SS	7		410				
			10	SS	19		409				
			11	SS	25		408		○		0 6 89 5
			12	SS	15		407				
403.7							406				
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.						405				
							404				

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

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

Golder Associates

RECORD OF BOREHOLE No NC5

1 OF 1 **METRIC**

PROJECT 13-1191-0003
W.P. 5141-11-01
LOCATION N 5050300.7; E 392990.2
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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
416.7	GROUND SURFACE										
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	WH	▽					
			2	SS	WH		416		464.5		
415.2											
1.5	SAND and SILT to Silty SAND, trace clay Loose to dense Grey Wet		3	SS	9		415				
			4	SS	10		414				
			5	SS	8				○		0 52 (48)
			6	SS	6		413				
			7	SS	4		412				
							411				
			8	SS	19						
							410				
			9	SS	6		409		○		0 77 22 1
							408				
			10	SS	20		407				
							406				
405.4	0.4 m of heave inside casing at bottom of borehole.		11	SS	37				○		0 67 (33)
11.3	END OF BOREHOLE Note: 1. Water level at a depth of 0.6 m below ground surface (Elev. 416.1 m) upon completion of drilling.										

+ 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:

Golder Associates

RECORD OF BOREHOLE No NC6

1 OF 1 **METRIC**

PROJECT 13-1191-0003
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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
416.2	WATER SURFACE					▽	416				
0.0	WATER										
415.6											
0.6	PEAT (Fibrous) Very soft Black Wet		1	SS	WH		415				
			2	SS	WH						
414.2							414				
2.0	PEAT (Amorphous) Very soft Black Wet		3	SS	WR						
413.1											
3.1	SAND and SILT, trace gravel, trace clay Compact Grey Wet		4	SS	12		413		345.5		
			5	SS	11						
			6	SS	12		412				0 55 (45)
			7	SS	10		411				
			8	SS	15		410				
			9	SS	14		409				
			10	SS	19		408				3 47 (50)
			11	SS	25		407				
404.3							406				
11.9	END OF BOREHOLE						405				

+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:

Golder Associates

RECORD OF BOREHOLE No NC7

1 OF 1 **METRIC**

PROJECT 13-1191-0003
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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
416.2	WATER SURFACE										
0.0 / 415.9	WATER						416				
0.3	PEAT (Amorphous) Very soft Black Wet		1	SS	WH						
			2	SS	WH		415		474.9		
			3	SS	WH		414				
			4	SS	WH						
412.8							413				
3.4	SAND and SILT, trace gravel, trace clay Loose to compact Grey Wet		5	SS	8						
			6	SS	12		412				0 40 (60)
			7	SS	11		411				
			8	SS	14		410				
			9	SS	18		409				2 35 (63)
			10	SS	19		408				
			11	SS	17		407				
404.6							406				
11.6	END OF BOREHOLE						405				

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

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

Golder Associates

RECORD OF BOREHOLE No NC8

1 OF 1 **METRIC**

PROJECT 13-1191-0003
W.P. 5141-11-01
DIST _____ HWY 60
DATUM GEODETIC
LOCATION N 5050313.5; E 393041.2
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring
DATE July 2, 2013
ORIGINATED BY GM
COMPILED BY AC
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
417.4	GROUND SURFACE										
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	WH	▽	417				
			2	SS	WH		416		362.9		
			3	SS	WH		415				
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		414		○		1 73 23 3
			6	SS	4		413				
			7	SS	4		412				
			8	SS	4		411				
			9	SS	8		410		○		0 32 64 4
			10	SS	10		409				
			11	SS	15		408				
			12	SS	34		407				
404.6							406				
12.8	END OF BOREHOLE						405				

Note:

1. Water level at a depth of 1.1 m below ground surface (Elev. 416.3 m) upon completion of drilling.

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

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

Golder Associates

RECORD OF BOREHOLE No NC9

1 OF 1 **METRIC**

PROJECT 13-1191-0003
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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
417.3	GROUND SURFACE										
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	WH	▽	417		○		
416.3											
1.0	Silty SAND to SILT, some gravel, trace clay Loose to compact Grey Wet		2	SS	7		416				
			3	SS	3				○		13 65 (22)
			4	SS	16		415				
			5	SS	5		414		○		0 55 (45)
			6	SS	2						
			7	SS	3		413				
							412				
			8	SS	16		411				
							410				
			9	SS	13				○	NP	0 7 (94)
408.8							409				
8.5	END OF BOREHOLE CASING REFUSAL (HAMMER BOUNCING)										

Note:

1. Water level at a depth of 0.5 m below ground surface (Elev. 416.8 m) upon completion of drilling.

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

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

Golder Associates

RECORD OF BOREHOLE No NC10

1 OF 1 **METRIC**

PROJECT 13-1191-0003
W.P. 5141-11-01
DIST HWY 60
DATUM GEODETIC
LOCATION N 5050350.6; E 393032.8
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring
DATE July 3, 2013
ORIGINATED BY GM
COMPILED BY AC
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
417.0	GROUND SURFACE										
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	WH	▽					
			2	SS	WH		416		361.8		
415.2											
1.8	SAND and SILT, trace gravel, trace clay Very loose to compact Grey Wet		3	SS	10		415				
			4	SS	8						
			5	SS	2		414		○		0 57 43 0
			6	SS	3		413				
			7	SS	2		412				
			8	SS	4		411				
			9	SS	5		410		○		1 51 46 2
			10	SS	14		409				
			11	SS	17		408				
			12	SS	18		407				
404.2							406				
12.8	END OF BOREHOLE						405				

Note:

1. Water level at a depth of 0.8 m below ground surface (Elev. 416.2 m) upon completion of drilling.

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

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

Golder Associates

RECORD OF BOREHOLE No NC11

1 OF 1 **METRIC**

PROJECT 13-1191-0003
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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
417.3	GROUND SURFACE						417				
0.0	PEAT (Fibrous) Very soft Black Moist		1	SS	WH				312.3		
416.4						▽	416				
0.9	Silty SAND to SAND and SILT, trace gravel, trace clay Very loose to compact Grey Wet		2	SS	3						
			3	SS	11		415		○		1 74 (25)
			4	SS	17						
			5	SS	11		414		○	NP	1 41 52 6
			6	SS	5		413				
			7	SS	4						
411.7							412				
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		411		○		22 74 (4)
			9	SS	4		410				
			10	SS	11		409				
			11	SS	9		408				
404.9			12	SS	34/0.22		407				
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.						406				
							405				

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

Golder Associates

RECORD OF BOREHOLE No NC12

1 OF 1 **METRIC**

PROJECT 13-1191-0003 | W.P. 5141-11-01 | DIST | HWY 60 | DATUM GEODETIC

LOCATION N 5050320.9; E 392977.9 | BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring | DATE July 8 and 9, 2013

ORIGINATED BY GM | COMPILED BY AC | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
420.1	GROUND SURFACE						420			
0.0	ASPHALT (150 mm)									
0.2	Sand and gravel (FILL) Very dense Brown Moist		1	SS	56					
418.6							419			
1.5	Blast rock (FILL)		2	RC	REC 27%					
			3	RC	REC 50%		418			
			4	RC	REC 50%		417			
415.2							416			
4.9	Gravelly sand, some silt (FILL) Loose Brown Wet		5	SS	2		415	○		30 59 10 1
414.3							414			
5.8	Silty SAND to SILT, trace clay Compact Grey Wet		6	SS	18					
			7	SS	12		413			
			8	SS	19		412			
			9	SS	24		411	○		0 10 (90)
408.8							410			
11.3	END OF BOREHOLE Note: 1. Unable to obtain water level, borehole caved at 4.8 m depth (Elev. 415.3 m).						409			

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

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

Golder Associates

RECORD OF BOREHOLE No NC13

1 OF 2 **METRIC**

PROJECT 13-1191-0003
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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
420.0	GROUND SURFACE										
0.0	ASPHALT (100 mm)										
0.1	Sand and gravel to gravelly sand, trace to some silt (FILL) Compact to very dense Brown Moist		1A	SS	57		419				
			1B	RC	REC 100%						
			2	SS	21		418				
			3	SS	16				○		23 68 8 1
417.0							417				
3.0	Blast rock (FILL)		4	RC	REC 37%						
			5	RC	REC 100%		416				
414.7			6	RC	REC 100%		415				
5.3	Silty SAND to SAND and SILT, trace clay Loose to compact Grey Wet		7	SS	12		414				
			8	SS	8		413		○		0 77 21 2
			9	SS	7		412				
			10	SS	11		411				
			11	SS	11		410				
			12	SS	8		409				
405.7							408				
14.3							407				
							406				

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No NC13

2 OF 2 **METRIC**

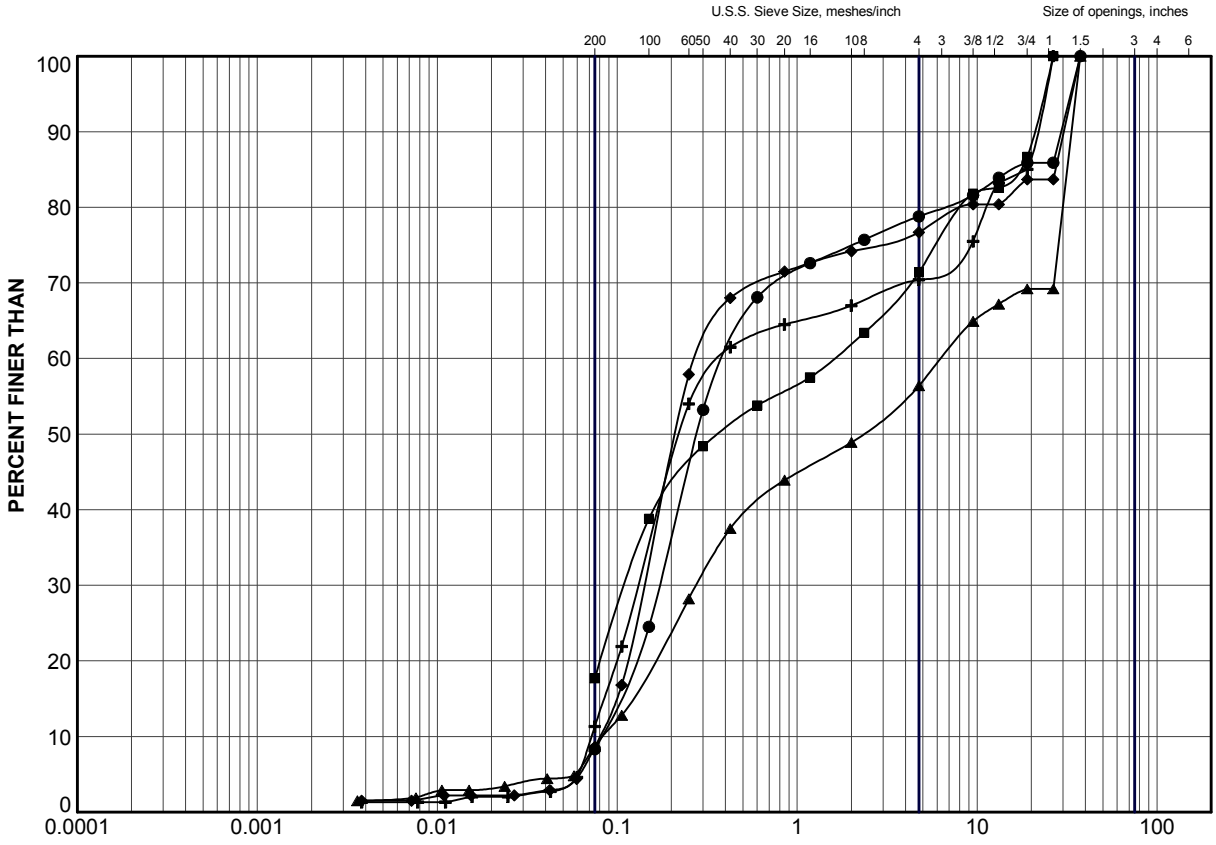
PROJECT 13-1191-0003 | W.P. 5141-11-01 | LOCATION N 5050324.7; E 392996.1 | ORIGINATED BY GM

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 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	--- 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).										

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



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

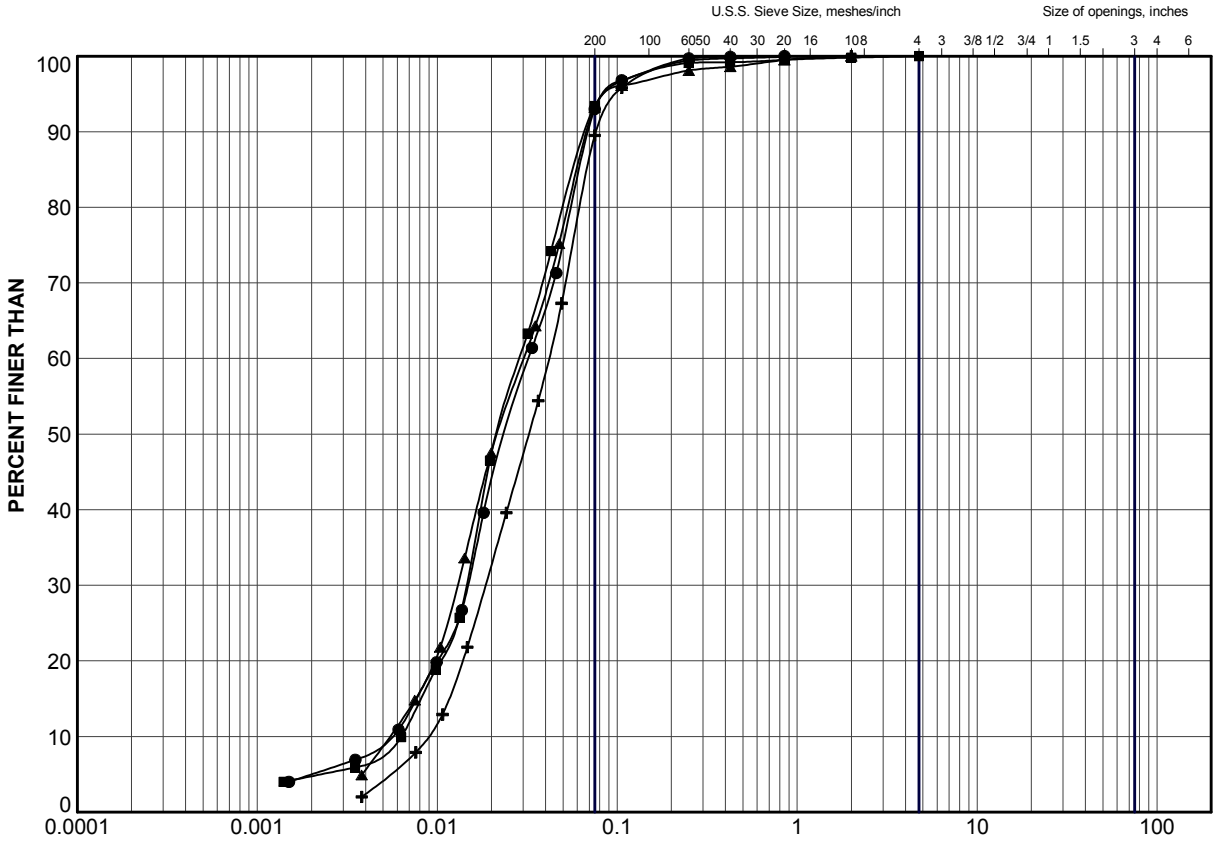
GRAIN SIZE DISTRIBUTION

SAND and GRAVEL to GRAVELLY SAND (FILL)

Golder Associates
SUDBURY, ONTARIO

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	**FIGURE A1**	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



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

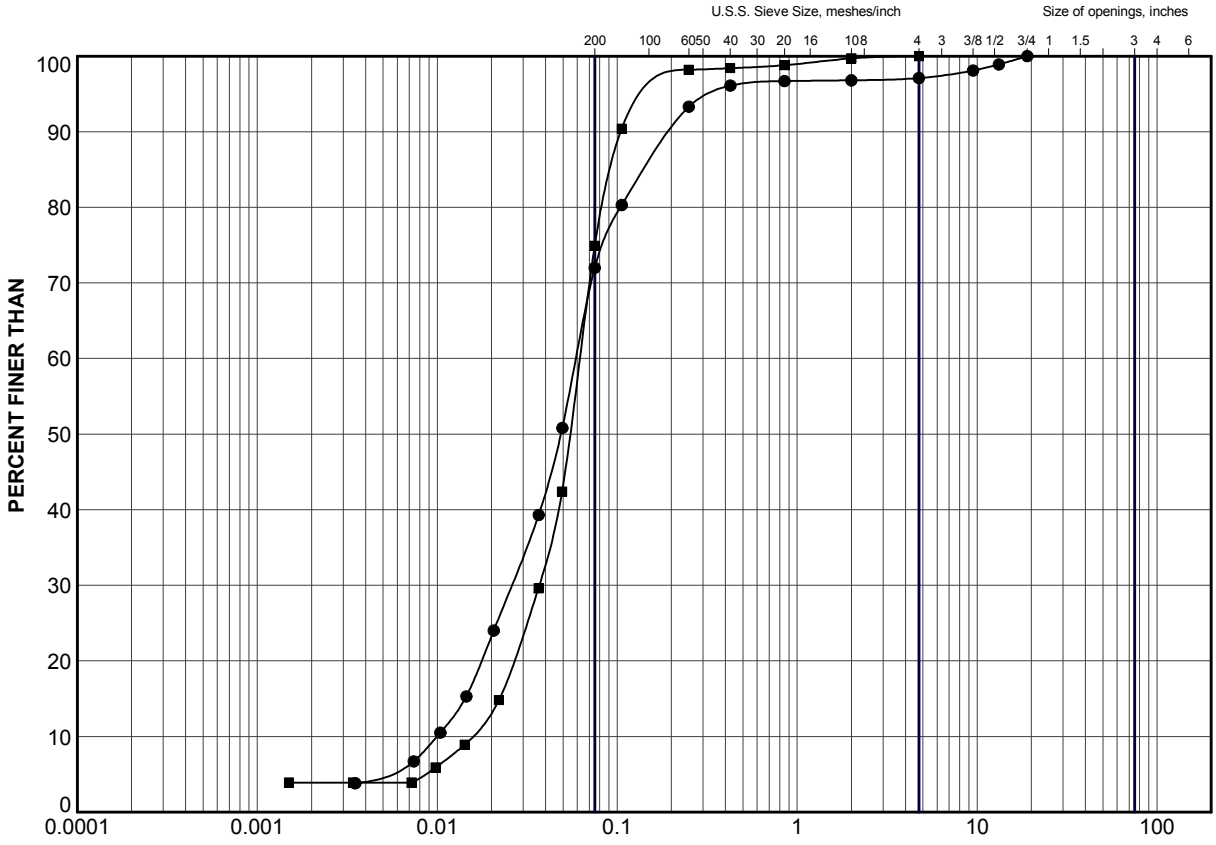
GRAIN SIZE DISTRIBUTION

SILT

Golder Associates
SUDBURY, ONTARIO

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	**FIGURE A2**	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



LEGEND

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

PROJECT

HIGHWAY 60
NORWAY CREEK CULVERT

TITLE

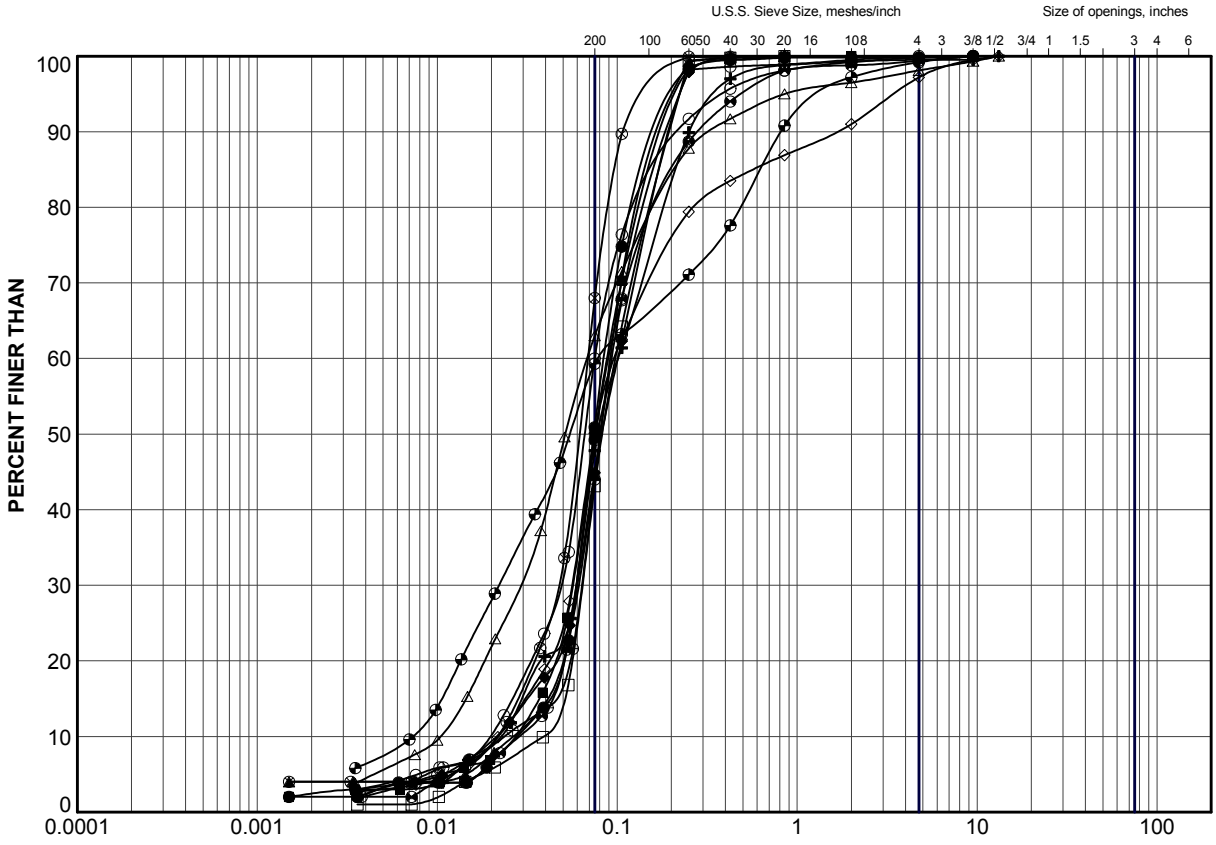
GRAIN SIZE DISTRIBUTION

SANDY SILT

Golder Associates
SUDBURY, ONTARIO

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	**FIGURE A3**	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



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

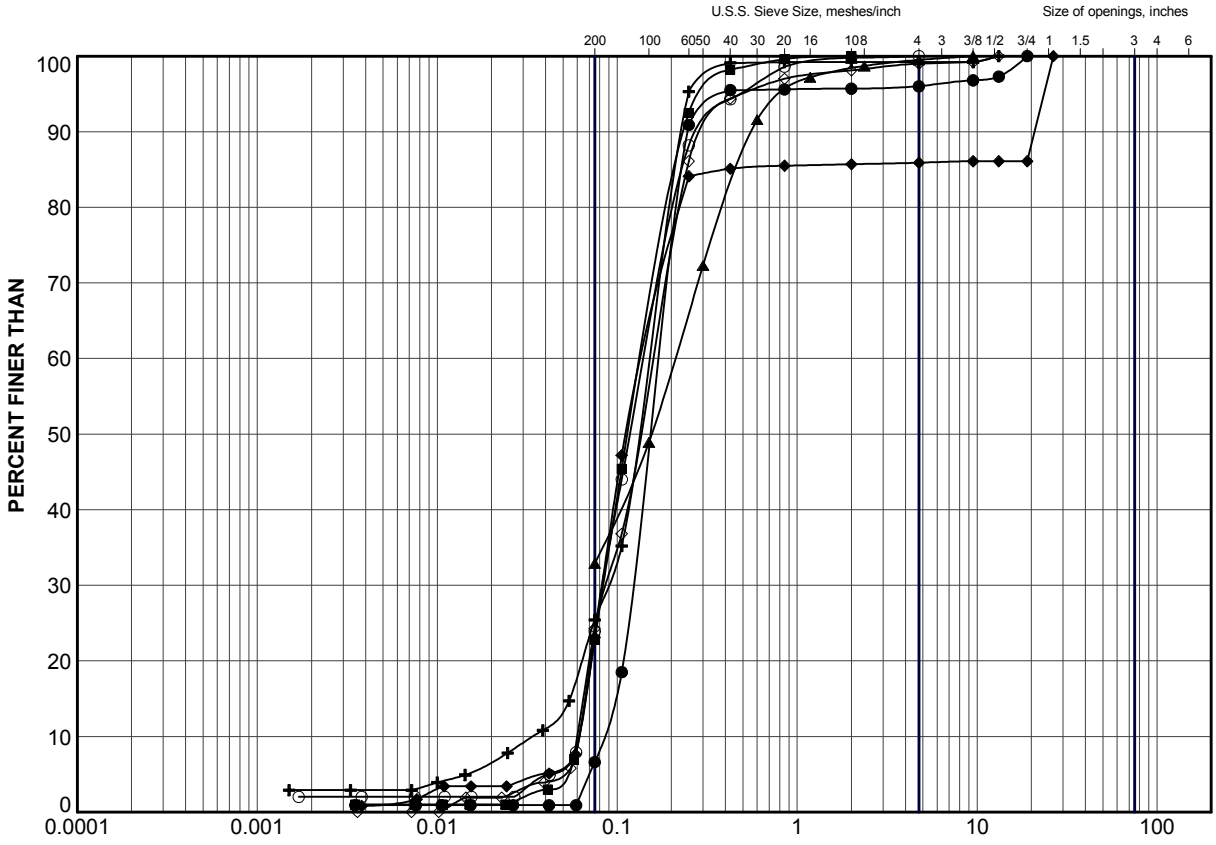
GRAIN SIZE DISTRIBUTION

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	REV.
CHECK	AB	Sep 2013			
APPR	JMAC	Sep 2013	**FIGURE A4**		

SUD-MTO GSD (NEW) GLDR_LDN.GDT



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

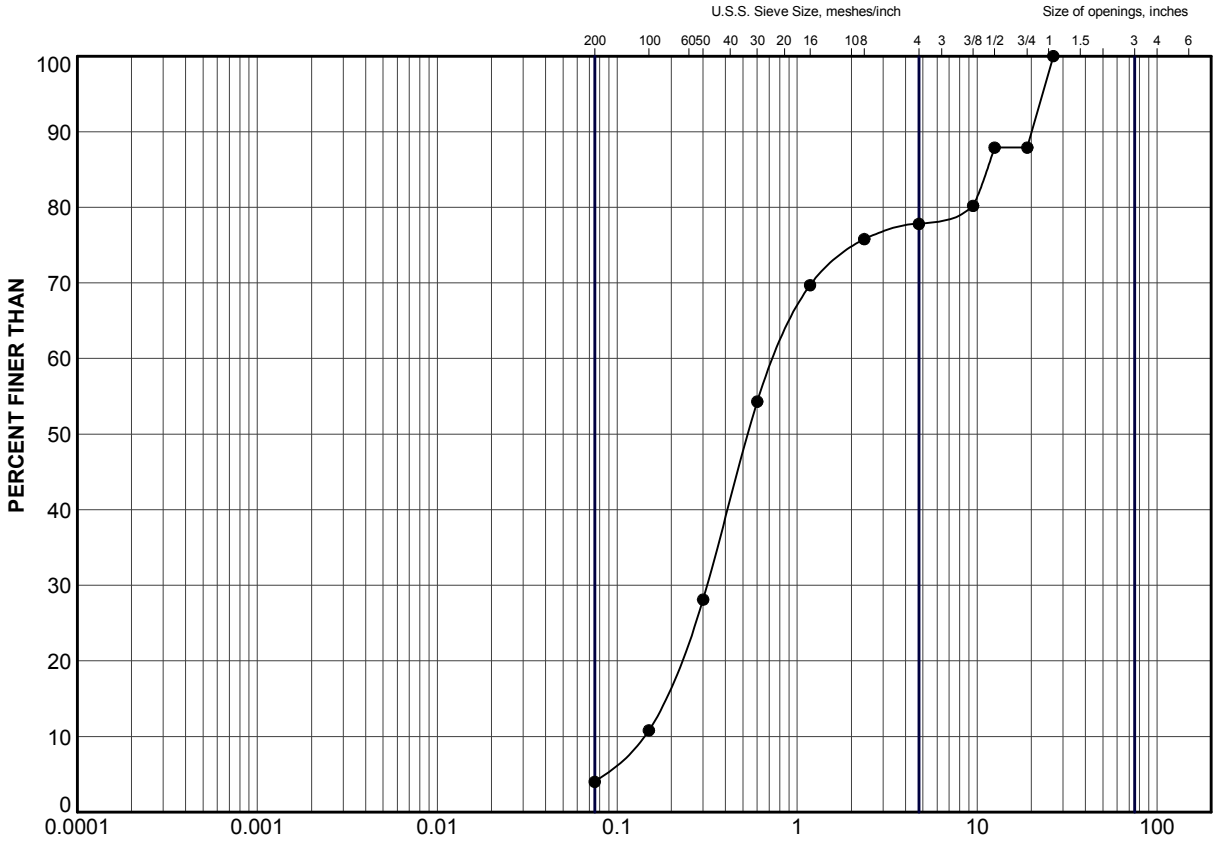
GRAIN SIZE DISTRIBUTION

SILTY SAND to SAND

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	**FIGURE A5**	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	NC11	8	410.9

PROJECT

HIGHWAY 60
NORWAY CREEK CULVERT

TITLE

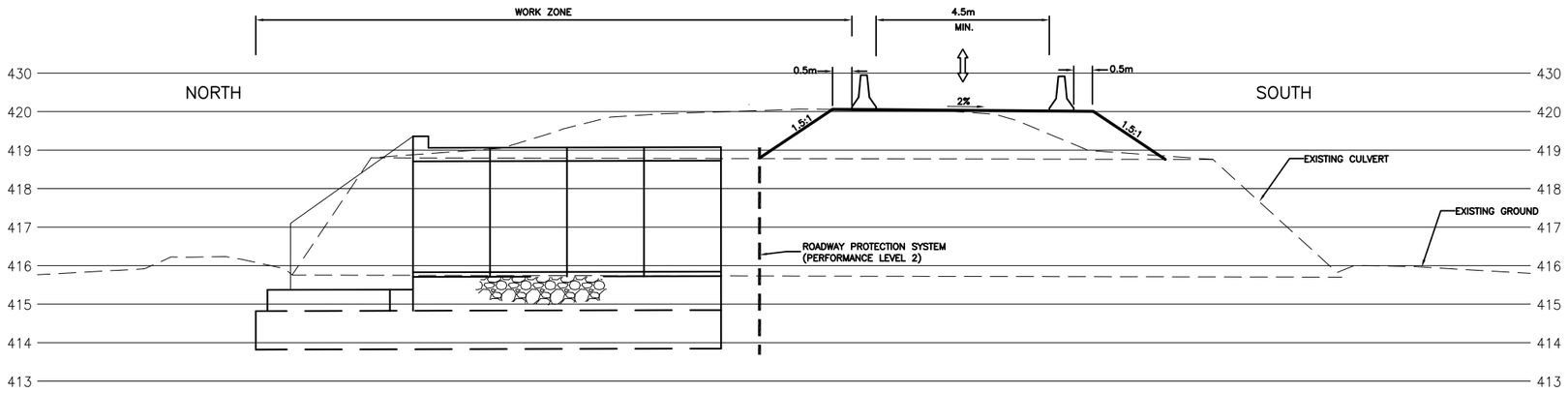
GRAIN SIZE DISTRIBUTION

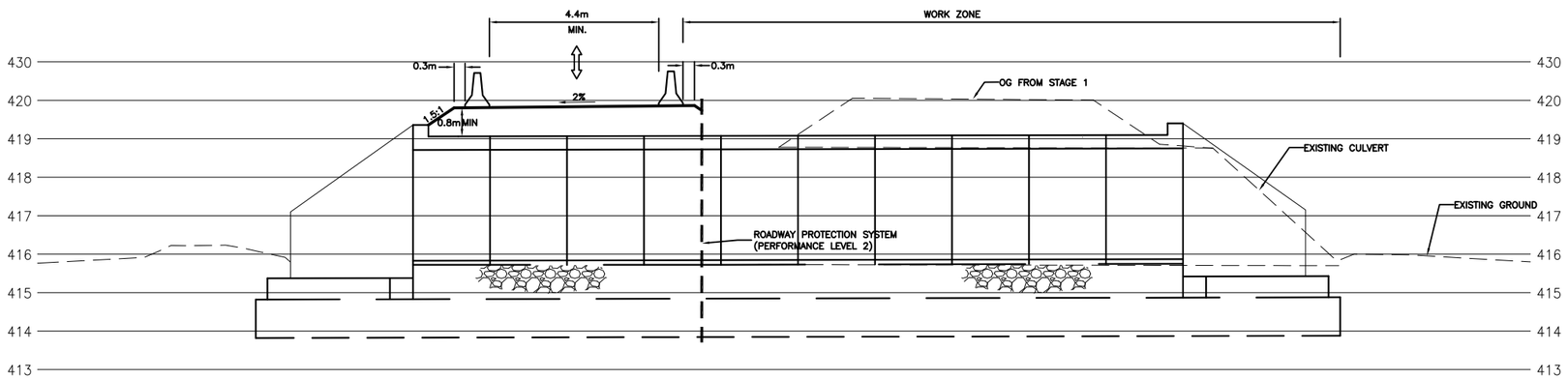
GRAVELLY SAND

Golder Associates
SUDBURY, ONTARIO

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	**FIGURE A6**	

SUD-MTO GSD (NEW) GLDR_LDN.GDT





HORIZONTAL SCALE
3 0 3 m
3 0 3 m
VERTICAL SCALE

CONSTRUCTION STAGING

STAGE 1:

- Widen south side of embankment to 1.5H:1V using Granular 'B' Type II.
- Predrill through existing rock fill embankment and install roadway protection system.
- Switch traffic to south side.
- Replace north portion of culvert.

STAGE 2:

- Install roadway protection.
- Switch traffic to north side of culvert.
- Replace south portion of culvert.
- Reconstruct embankment/roadway over/adjacent to culvert.

REFERENCE:

Based on drawing x9255 Norway Staging Sections.dwg, received from LEA on December 11, 2013.

TITLE

HIGHWAY 60 NORWAY CREEK CULVERT CULVERT STAGING DETAILS

Golder Associates
Sudbury, Ontario, Canada

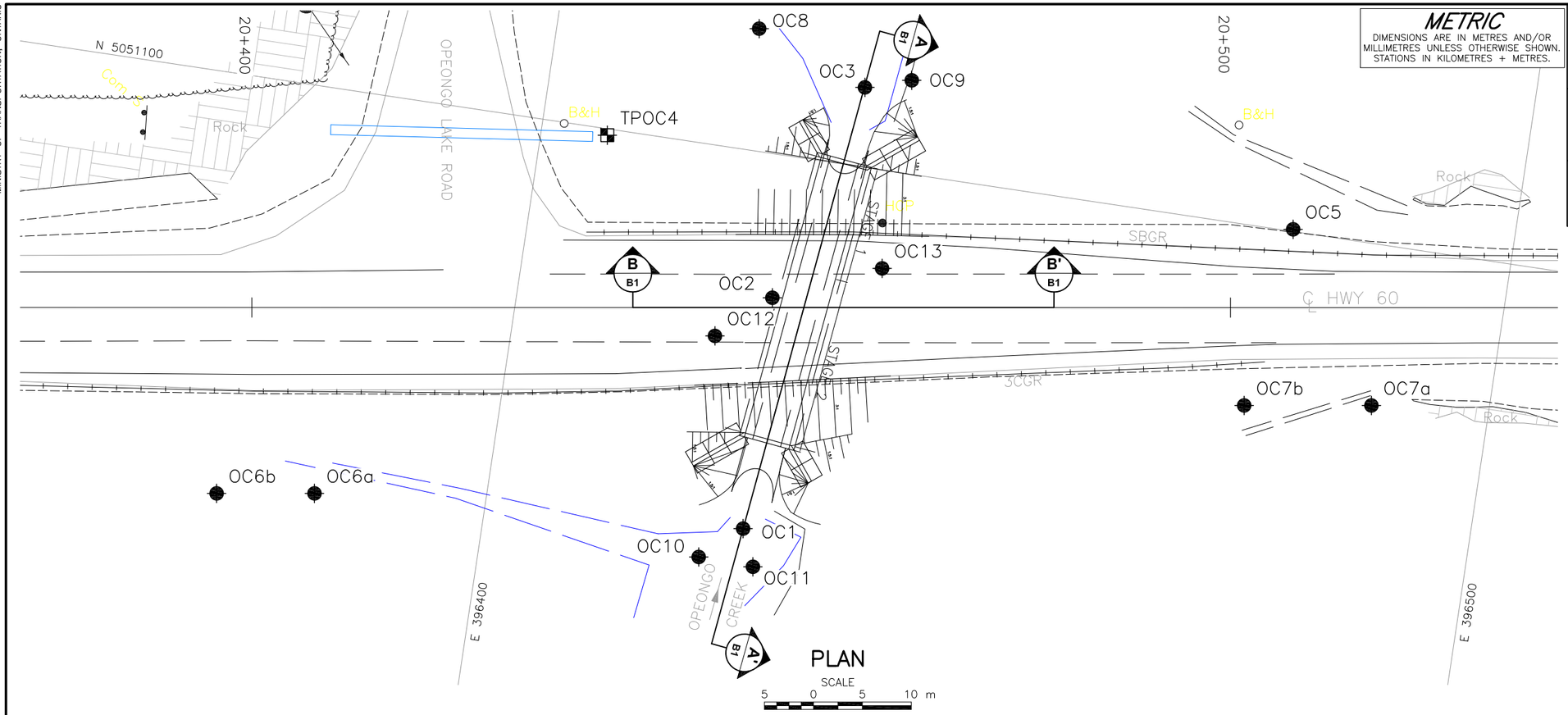
PROJECT No.		13-1191-0003	FILE No. 1311910003 Stage.Culv.dwg
DESIGN			SCALE AS SHOWN REV.
CAD	TB	DEC 2013	FIGURE No.
CHECK	AB	DEC 2013	A7
REVIEW			

PLOT DATE: December 17, 2013
FILENAME: \\golder.gds\GAL\Sudbury\CAD-GIS\CAD\Projects\2013\13-1191-0003 - LEA Hwy 60-35-118\Culvert Staging Details\1311910003 Stage.Culv.dwg

APPENDIX B

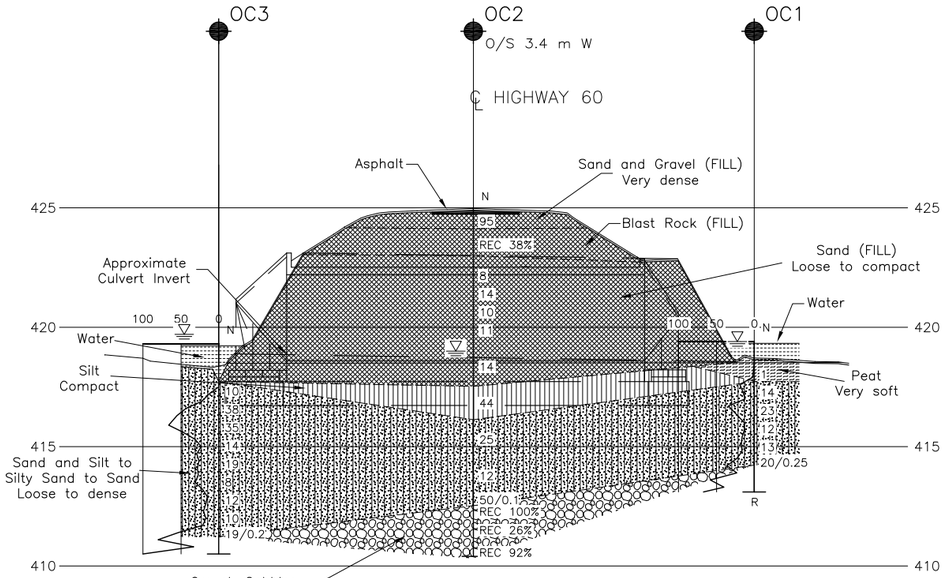
Opeongo Lake Culvert, Site 43-147/C

MINISTRY OF TRANSPORTATION, ONTARIO

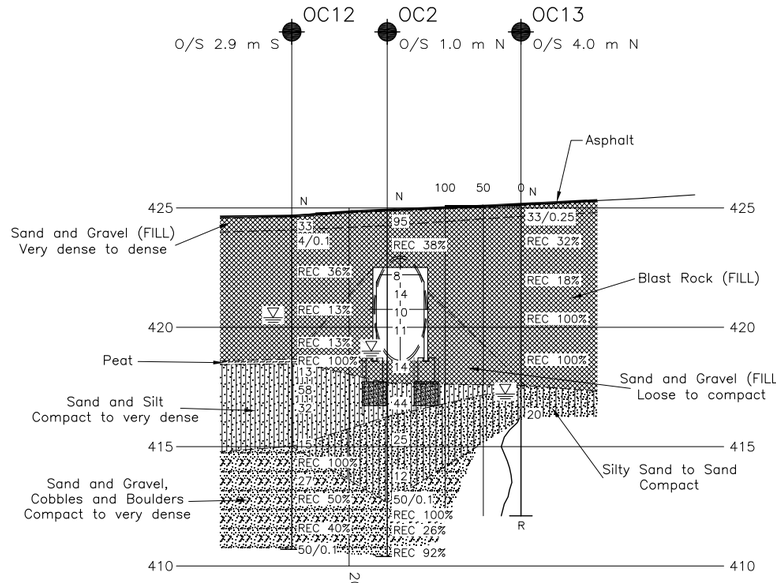


PLAN

SCALE
5 0 5 10 m



A–A' B1 SECTION AT STA 20+456
HIGHWAY 60
HORIZONTAL SCALE
5 0 5 10 m
2.5 0 2.5 5 m
VERTICAL SCALE



B–B' B1 PROFILE
HIGHWAY 60
HORIZONTAL SCALE
5 0 5 10 m
2.5 0 2.5 5 m
VERTICAL SCALE

METRIC

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

CONT No.
WP No. 5143–11–01

SHEET

HIGHWAY 60
OPEONGO LAKE CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA

KEY PLAN
12 0 12 km

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.

REFERENCE

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

NO.	DATE	BY	REVISION

Geocres No. 31E–329

HWY. 60	PROJECT NO. 13–1191–0003		DIST.
SUBM'D. AC	CHKD.	DATE: DEC 2013	SITE:43–147/C
DRAWN: TB	CHKD. AB	APPD.	DWG. B1

PLOT DATE: December 17, 2013
FILENAME: \\golder.gds\GAL\Sudbury\CAD–GIS\GAD\Projects\2013\13–1191–0003 – LEA Hwy 60–35–118\13191000SMA001 Opeongo.dwg

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

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

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

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

Golder Associates

RECORD OF BOREHOLE No OC1

1 OF 1 **METRIC**

PROJECT 13-1191-0003
W.P. 5143-11-01
DIST ____ HWY 60
DATUM GEODETIC
LOCATION N 5051061.7; E 396426.4
BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring
DATE July 14, 2013
ORIGINATED BY GM
COMPILED BY AC
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
419.4	WATER SURFACE					▽					
0.0	WATER						419				
418.5											
0.9	PEAT (Fibrous) Very soft Black		1	SS	1				○		
417.8	Wet						418				
1.6	Silty SAND to SAND, some silt, trace clay, trace gravel Compact Grey Wet		2	SS	14						
			3	SS	23		417		○		1 77 22 0
			4	SS	12		416				
			5	SS	13		415		○		0 89 (11)
414.3			6	SS	20/0.25						
5.1	END OF BOREHOLE CASING REFUSAL (HAMMER BOUNCING)						414				
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.

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

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

Golder Associates

RECORD OF BOREHOLE No OC2

1 OF 2 **METRIC**

PROJECT 13-1191-0003 | W.P. 5143-11-01 | LOCATION N 5051085.4; E 396425.9 | ORIGINATED BY SA

DIST | HWY 60 | BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring | COMPILED BY AC

DATUM GEODETIC | DATE June 18, 2013 | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
424.9	GROUND SURFACE										
0.0	ASPHALT (100 mm)										
0.1	Sand and gravel, some silt (FILL) Very dense Brown		1	SS	95						
424.2											
0.7	Moist Blast rock (FILL)		2	RC	REC 38%		424				
423.1											
1.8	Sand, trace to some gravel, trace to some silt (FILL) Loose to compact Brown Moist		3	SS	8		423		○		12 82 (6)
			4	SS	14		422				
			5	SS	10		421				
	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.		6	SS	11		420				
			7	SS	14	▽	419				
417.6							418				
7.3	SILT, trace sand Compact Grey Wet		8	SS	44		417		○		0 1 94 5
416.2											
8.7	Silty SAND to SAND, trace gravel Compact Grey Wet		9	SS	25		416				
			10	SS	12		415				
412.6			11	SS	50/0.1		414				
12.3	GRAVEL, COBBLES and BOULDERS 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		12A	RC	REC 100%		413				
			12B	RC	REC 26%		412				
			13	RC	REC 92%		411				
410.4											
14.5											

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No OC2

2 OF 2 **METRIC**

PROJECT 13-1191-0003 | W.P. 5143-11-01 | LOCATION N 5051085.4; E 396425.9 | ORIGINATED BY SA

DIST _____ HWY 60 | BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring | COMPILED BY AC

DATUM GEODETIC | DATE June 18, 2013 | CHECKED BY AB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	END OF BOREHOLE Note: 1. Water level at a depth of 5.9 m below ground surface (Elev. 419.0 m) upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No OC3

1 OF 1 **METRIC**

PROJECT 13-1191-0003 | W.P. 5143-11-01 | DIST ____ HWY 60 | DATUM GEODETIC

LOCATION N 5051108.1; E 396432.1 | BOREHOLE TYPE NW Casing, Wash Boring | DATE October 10, 2013

ORIGINATED BY AC | COMPILED BY AC | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
419.3	WATER SURFACE										
0.0	WATER						419				
417.8							418				
1.5	SAND and SILT to Silty SAND, trace gravel, trace clay Loose to dense Grey Wet		1	SS	10		417		○	NP	1 43 53 3
			2A 2B	SS	38		416				
			3	SS	35		415				
			4	SS	14		414				
			5	SS	19		413				
			6	SS	8		412		○		1 75 22 2
			7	SS	12		411				
			8	SS	10						
411.3			9	SS	19/0.2						
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.

+ 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:

Golder Associates

RECORD OF BOREHOLE No OC5

1 OF 1 **METRIC**

PROJECT 13-1191-0003
W.P. 5143-11-01
DIST HWY 60
DATUM GEODETIC
LOCATION N 5051100.2; E 396477.5
BOREHOLE TYPE Portable Equipment
DATE July 15, 2013
ORIGINATED BY GM
COMPILED BY AC
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
425.4	GROUND SURFACE										
0.0	Sand and gravel, some silt, trace clay (FILL) Dense to very dense Brown		1	SS	22		425		○		46 34 19 1
424.5	Dry		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.

SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED

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

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

Golder Associates

RECORD OF BOREHOLE No OC6a

1 OF 1 **METRIC**

PROJECT 13-1191-0003
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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
421.8	GROUND SURFACE										
0.0 / 421.5	TOPSOIL Brown Moist		1a 1b	SS	11				○		27 53 (20)
0.3	Gravelly SAND, some silt, trace clay, trace organics Loose to compact Brown Moist to wet		2	SS	29		421				
			3	SS	4	▽	420				
			4	SS	16		419		○		
418.5			5a 5b	SS	28				○		0 68 (32)
3.3 / 418.0	SAND and SILT, trace clay Compact Grey Wet						418				
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.										

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

Golder Associates

RECORD OF BOREHOLE No OC6b

1 OF 1 **METRIC**

PROJECT 13-1191-0003
W.P. 5143-11-01
DIST HWY 60
DATUM GEODETIC
LOCATION N 5051057.2; E 396372.7
BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring
DATE July 12 and 13, 2013
ORIGINATED BY GM
COMPILED BY AC
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
421.9	GROUND SURFACE										
0.0 / 421.6	TOPSOIL Brown Moist		1	SS	8						
0.3	SAND, some gravel, some silt Loose to compact Brown to grey Moist to wet		2	SS	6		421				
			3	SS	4	▽	420				
			4	SS	28				○		14 70 (16)
			5	SS	16		419				
			6	SS	20		418				
			7	SS	20		417		○		18 65 (17)
416.6			8	SS	8/0.05						
5.3	END OF BOREHOLE 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.										

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

Golder Associates

RECORD OF BOREHOLE No OC7a

1 OF 1 **METRIC**

PROJECT 13-1191-0003
W.P. 5143-11-01 LOCATION N 5051083.6; E 396488.1 ORIGINATED BY GM
DIST HWY 60 BOREHOLE TYPE Portable Equipment COMPILED BY AC
DATUM GEODETIC DATE July 14, 2013 CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
423.7	GROUND SURFACE										
0.0 423.2	SAND, some silt, some gravel, trace organics Compact Brown Moist		1	SS	10						
0.5	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.

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

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

Golder Associates

RECORD OF BOREHOLE No OC7b

1 OF 1 **METRIC**

PROJECT 13-1191-0003
W.P. 5143-11-01 LOCATION N 5051081.7; E 396475.2 ORIGINATED BY GM
DIST HWY 60 BOREHOLE TYPE Portable Equipment COMPILED BY AC
DATUM GEODETIC DATE July 15, 2013 CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
423.7	GROUND SURFACE										
0.0 423.3	Sandy TOPSOIL Brown Moist		1	SS	12/0.2						
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.

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

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

Golder Associates

RECORD OF BOREHOLE No OC8

1 OF 1 **METRIC**

PROJECT 13-1191-0003
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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
419.7	GROUND SURFACE										
0.0	Sand, some gravel (FILL) Loose to compact Brown Moist to wet		1	SS	5	▽	419				
			2	SS	11						
418.3							418				
1.4	PEAT (Fibrous), some sand Very soft to firm Black Wet		3	SS	7						
			4	SS	WH		417				
416.3			5A 5B	SS	11				○	NP	
416.0	SILT, some sand Compact Grey Wet						416				
3.7	SAND, GRAVEL, COBBLES, BOULDERS Very dense Grey Wet			RC	REC 100%						
				RC			415				
414.3	Boulder 0.6 m thick at 3.7 m depth.		6	CS	-				○		0 73 26 1
5.4	Silty sand seam at 5.1 m depth. GNEISS (BEDROCK)		1	RC	REC 100%		414				RQD = 17%
	Bedrock cored from 5.4 m depth to 8.5 m depth. For coring details see Record of Drillhole OC8.		2	RC	REC 100%		413				RQD = 66%
			3	RC	REC 100%		412				RQD = 50%
411.2											
8.5	END OF BOREHOLE Note: 1. Water level at a depth of 0.5 m below ground surface (Elev. 419.2 m) upon completion of drilling.										

+ 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:

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.

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.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR / % RETURN / FLUSH	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		REFER TO PREVIOUS PAGE		414.3																
6	October 15, 2013 NW NQ Core	GNEISS Slightly weathered Grey to pink Very coarse grained		5.4	1	GREY 100%							Broken Core							
					2	GREY 100%							Broken Core JNIRRo JNPLRo JNIRRo JNFORo JNIRRo							
7													MB MB Heavily Jointed							
					3	GREY 100%							JNPLRo JNPLRo JNIRRo							
8				411.2									Broken Core							
		END OF DRILLHOLE		8.5																
9																				
10																				
11																				
12																				
13																				
14																				
15																				

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: EHS
CHECKED: AB

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

Golder Associates

RECORD OF BOREHOLE No OC9

1 OF 1 **METRIC**

PROJECT 13-1191-0003
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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
421.2	GROUND SURFACE										
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.

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

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

Golder Associates

RECORD OF BOREHOLE No OC10

1 OF 1 **METRIC**

PROJECT 13-1191-0003
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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
419.4	WATER SURFACE					▽					
0.0	WATER						419				
418.5											
0.9	Sand, some silt, trace organics (FILL) Very loose Dark brown Wet		1	SS	2						
417.9							418				
1.5	PEAT (Amorphous) Very soft Black Wet		2	SS	1						
			3	SS	WH		417		162.5		
416.0											
3.4	SAND and SILT to SAND, trace to some gravel Loose to compact Brown to grey Wet		4	SS	19		416				
			5	SS	26		415		○		0 41 57 2
			6	SS	8						
			7	SS	10		414				
							413				
			8	SS	17		412				
			9	SS	19		411		○		15 67 (18)
410.0											
9.4	END OF BOREHOLE CASING REFUSAL (HAMMER BOUNCING)						410				

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

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

Golder Associates

RECORD OF BOREHOLE No OC11

1 OF 1 **METRIC**

PROJECT 13-1191-0003
W.P. 5143-11-01
DIST ____ HWY 60
DATUM GEODETIC
LOCATION N 5051057.9; E 396428.0
BOREHOLE TYPE Portable Equipment, HQ Casing, Wash Boring
DATE July 13 and 14, 2013
ORIGINATED BY GM
COMPILED BY AC
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
419.4	GROUND SURFACE										
0.0	WATER						419				
418.5											
0.9	PEAT (Fibrous) Very soft Black Wet		1	SS	WH		418				
417.4			2	SS	14						
2.0	SAND and SILT, trace gravel Compact to dense Grey Wet		3	SS	33		417		○		2 50 (48)
			4	SS	11		416				
415.3			5	SS	6/0.1						
4.1	END OF BOREHOLE SPOON AND CASING REFUSAL (HAMMER BOUNCING)										

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

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

Golder Associates

RECORD OF BOREHOLE No OC12

1 OF 2 **METRIC**

PROJECT 13-1191-0003
W.P. 5143-11-01
LOCATION N 5051080.7; E 396420.7
ORIGINATED BY EHS
DIST HWY 60
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring
COMPILED BY AC
DATUM GEODETIC
DATE October 3, 2013
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
424.7	GROUND SURFACE										
0.0	ASPHALT (110 mm)										
0.1	Sand and gravel, some silt (FILL) Dense Brown		1	SS	33		424				
424.0											
0.7	Wet		2	SS	4/0.1						
	Blast rock (FILL)										
				RC	REC 36%		423				
							422				
				RC	REC 13%		421				
						▽					
				RC	REC 13%		420				
							419				
418.6			3	SS	REC 100%						
	PEAT (Fibrous)		4A								
6.3	Brown Wet		4B	SS	13		418		○		2 46 50 2
	SAND and SILT, trace gravel, trace clay Compact to very dense Grey Wet		5	SS	58						
	Approximately 0.6 m thick silt layer at 7.7 m dept.		6	SS	32		417		○		0 5 90 5
							416				
414.9			7	SS	15						
9.8	SAND, GRAVEL, COBBLES and BOULDERS, some silt Compact to very dense			RC	REC 100%		415				
	Depth (m) / Thickness (mm): 9.9 / 175; 10.1 / 600; 11.6 / 100; 11.9 / 180; 12.2 / 280		8	SS	27		414		○		48 40 11 1
				RC	REC 50%		413				
							412				
				RC	REC 40%						
410.7			9	SS	50/0.1		411				
14.0											

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No OC12

2 OF 2 **METRIC**

PROJECT 13-1191-0003 | W.P. 5143-11-01 | LOCATION N 5051080.7; E 396420.7 | ORIGINATED BY EHS

DIST _____ HWY 60 | BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring | COMPILED BY AC

DATUM GEODETIC | DATE October 3, 2013 | CHECKED BY AB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	END OF BOREHOLE Note: 1. Water level at a depth of 4.3 m below ground surface (Elev. 420.4m) upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No OC13

1 OF 1 **METRIC**

PROJECT 13-1191-0003 | 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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
425.1	GROUND SURFACE						425				
0.0	ASPHALT (100 mm)										
424.6	Sand and gravel (FILL) Dense Brown Moist		1	SS	33/0.25						
0.5	Blast rock (FILL)		2	RC	REC 32%		424				
			3	RC	REC 18%		423				
			4a	RC	REC 100%		422				
	300 mm void at 5.4 m depth.						421				
			4b	RC	REC 100%		420				
417.5							419				
7.6	SAND, some silt Compact Brown Wet					▽	418				
416.2			5	SS	20		417		○		0 82 (18)
8.9	START OF DCPT						416				
412.1							415				
13.0	END OF DCPT END OF BOREHOLE REFUSAL TO FURTHER PENETRATION (HAMMER BOUNCING)						414				
	Note: 1. Water level at a depth of 7.9 m below ground surface (Elev. 417.2 m) upon completion of drilling.						413				

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

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

Golder Associates

RECORD OF TEST PIT No TPOC4

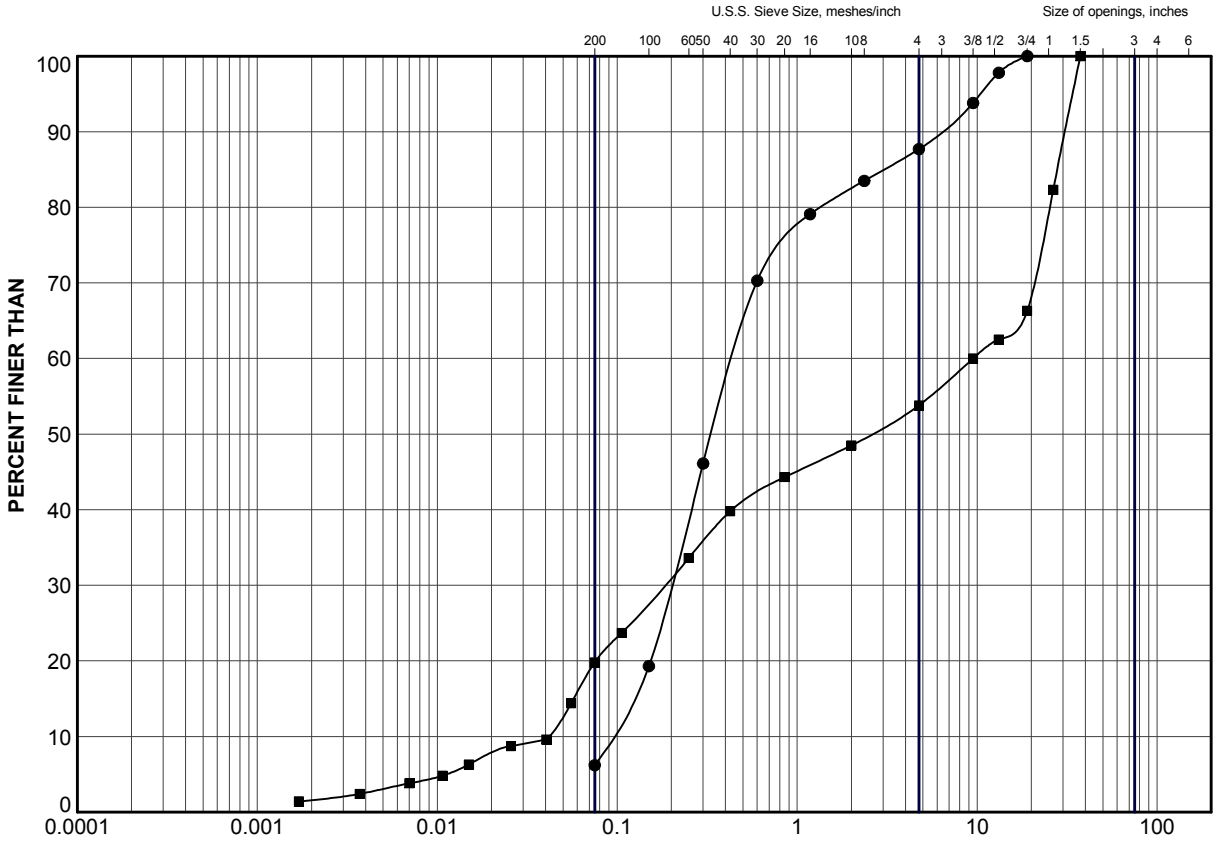
1 OF 1 **METRIC**

PROJECT 13-1191-0003
W.P. 5143-11-01
DIST ____ HWY 60
DATUM GEODETIC
LOCATION N 5051099.4; E 396406.7
BOREHOLE TYPE Test Pit Excavation
DATE September 14, 2013
ORIGINATED BY CW
COMPILED BY AC
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
422.0	GROUND SURFACE										
0.0 / 421.4	Blast rock (FILL)										
0.6 / 419.4	Silty sand, some gravel, cobbles, boulders (FILL) Brown Moist						421 420				
2.7 / 418.5	PEAT Gravelly SAND, some silt, cobbles, boulders					▽	419				
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).										

+ 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:



LEGEND

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

PROJECT

HIGHWAY 60
OPEONGO LAKE CULVERT

TITLE

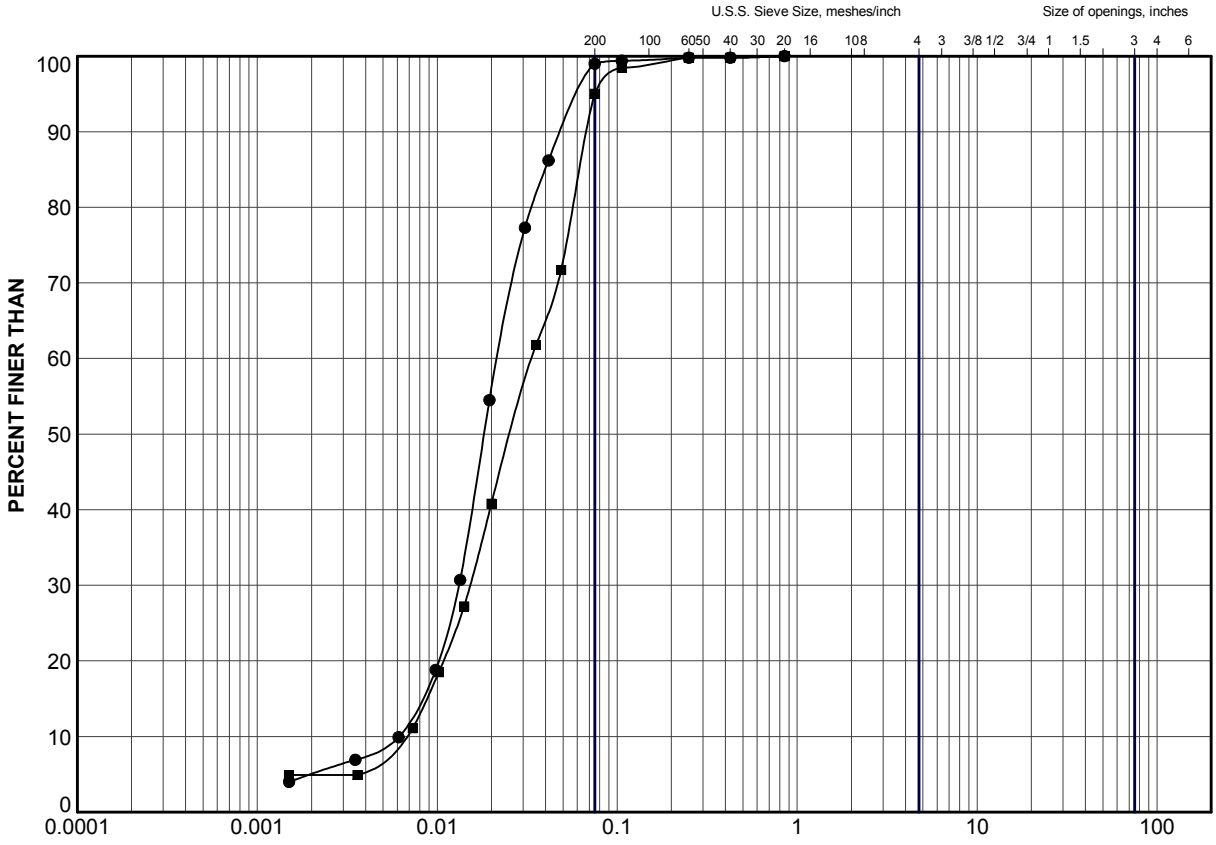
GRAIN SIZE DISTRIBUTION

SAND and GRAVEL to SAND (FILL)

Golder Associates
SUDBURY, ONTARIO

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 B1**	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



LEGEND

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

PROJECT

HIGHWAY 60
OPEONGO LAKE CULVERT

TITLE

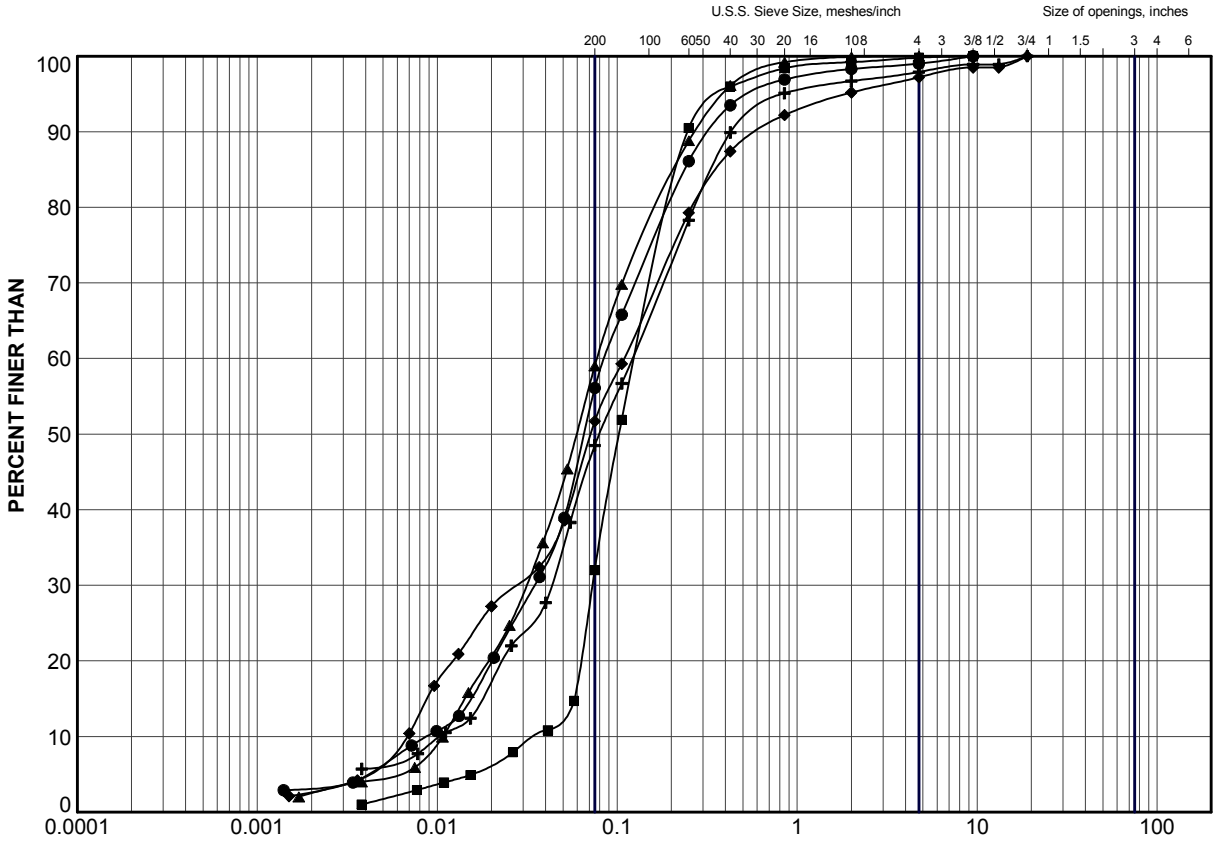
GRAIN SIZE DISTRIBUTION

SILT

Golder Associates
SUDBURY, ONTARIO

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 B2**	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



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

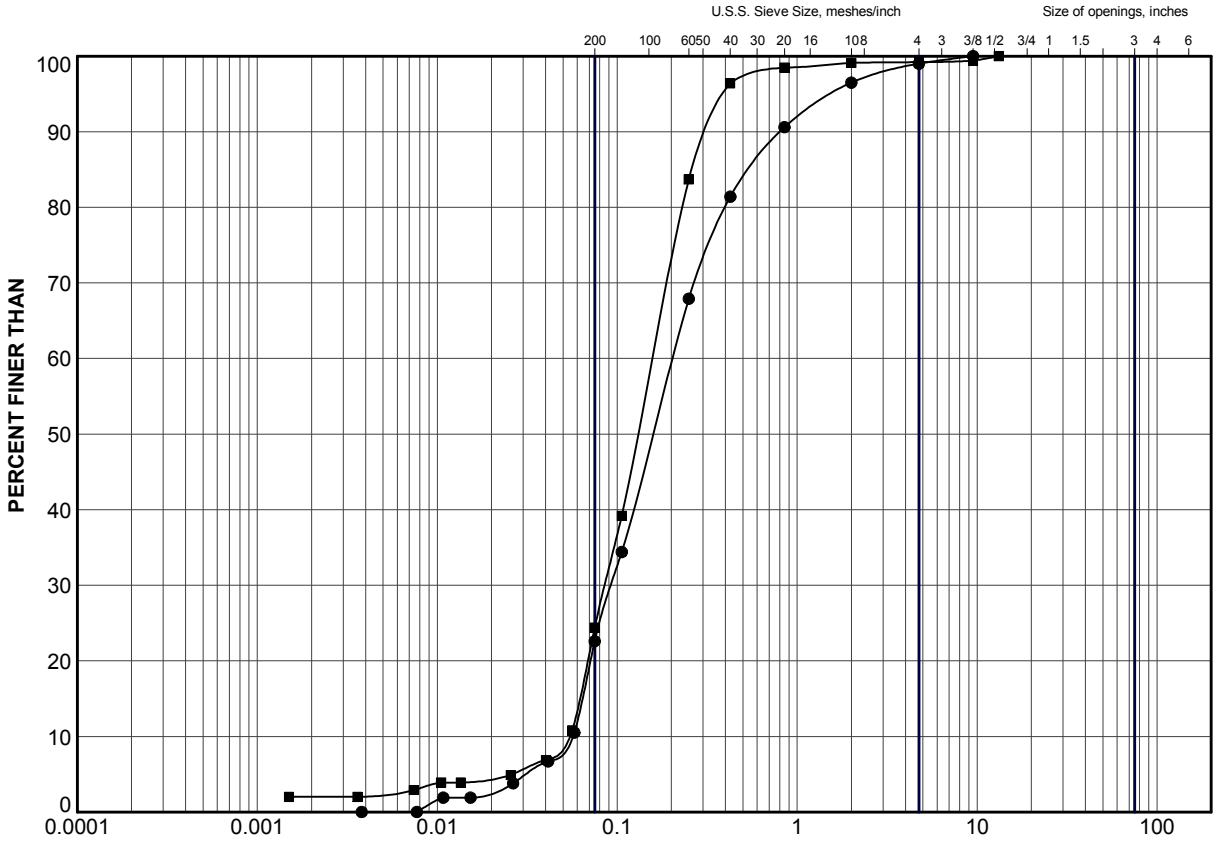
GRAIN SIZE DISTRIBUTION

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	REV.
CHECK	AB	Dec 2013		
APPR	JMAC	Dec 2013	**FIGURE B3**	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



LEGEND

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

PROJECT

HIGHWAY 60
OPEONGO LAKE CULVERT

TITLE

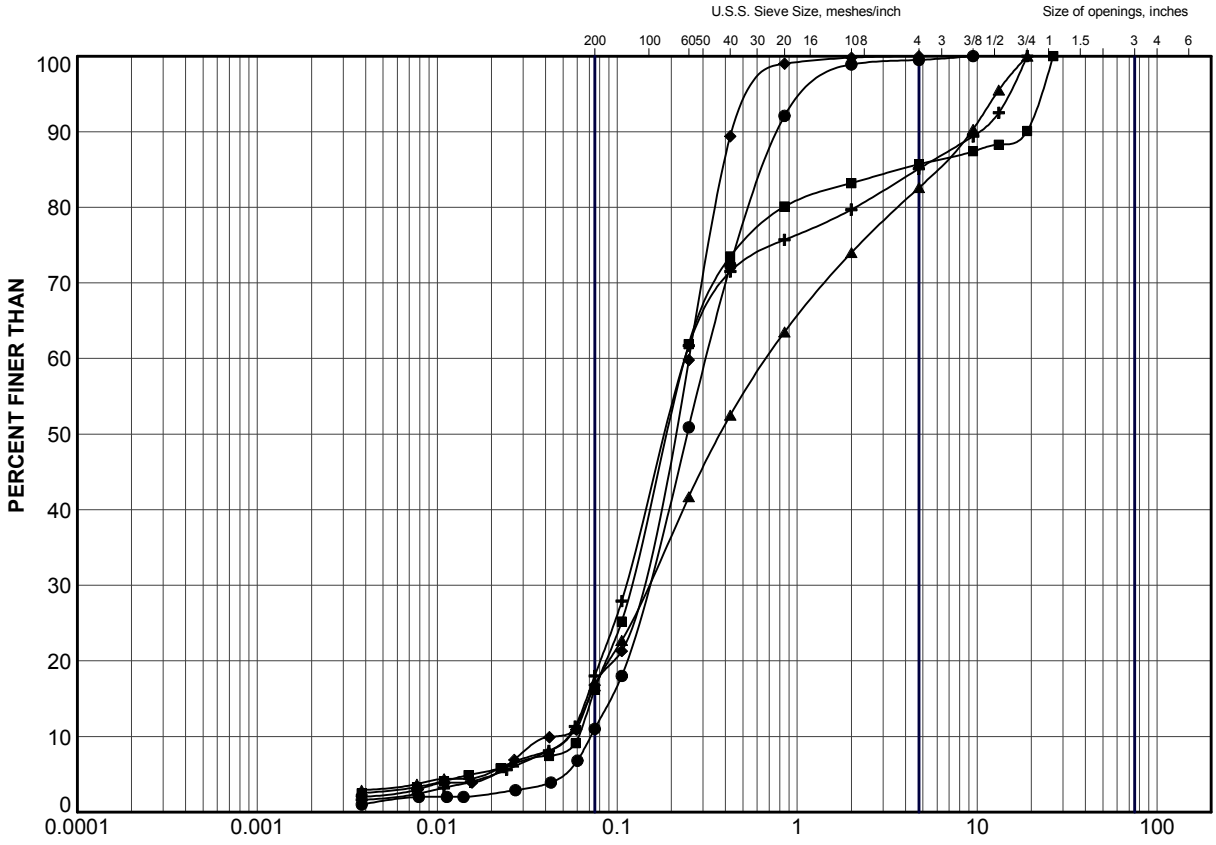
GRAIN SIZE DISTRIBUTION

SILTY SAND

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 B4**	

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

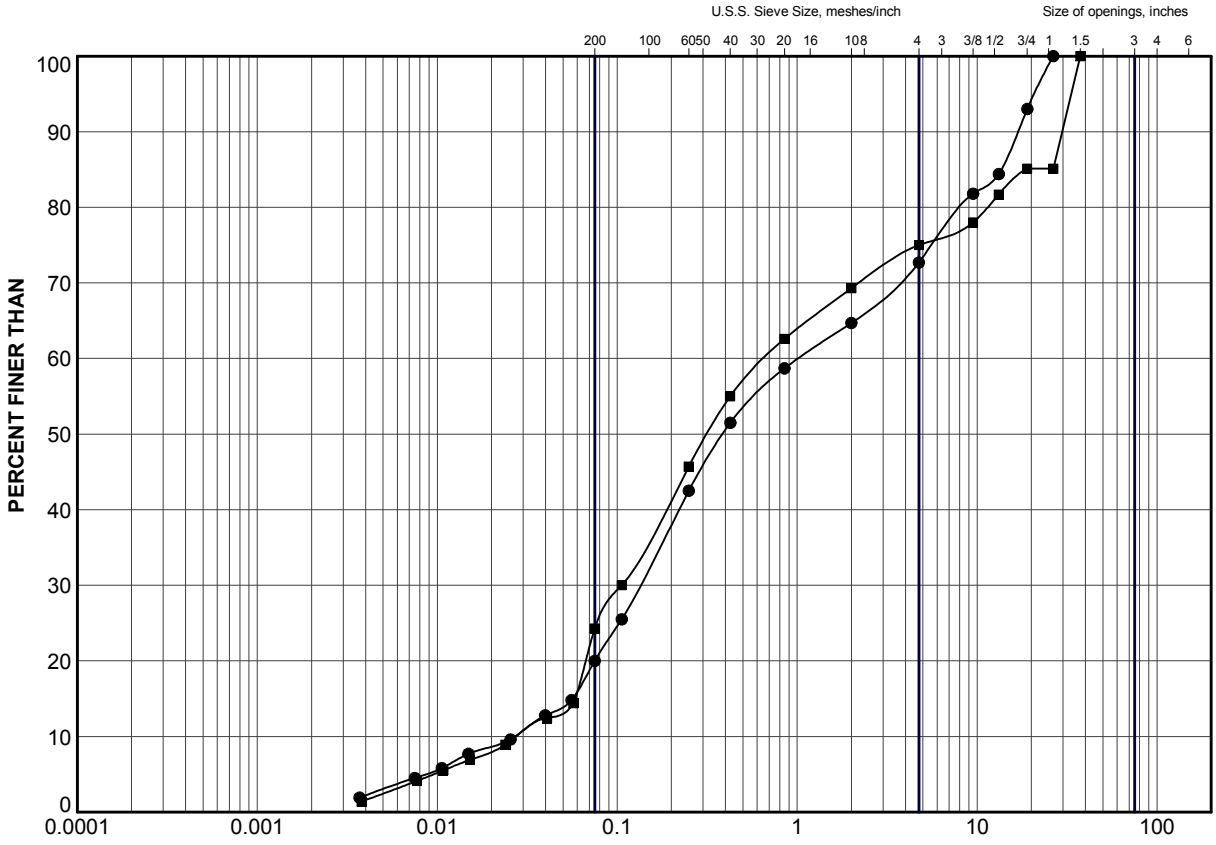
GRAIN SIZE DISTRIBUTION

SAND

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 B5**	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



LEGEND

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

PROJECT

HIGHWAY 60
OPEONGO LAKE CULVERT

TITLE

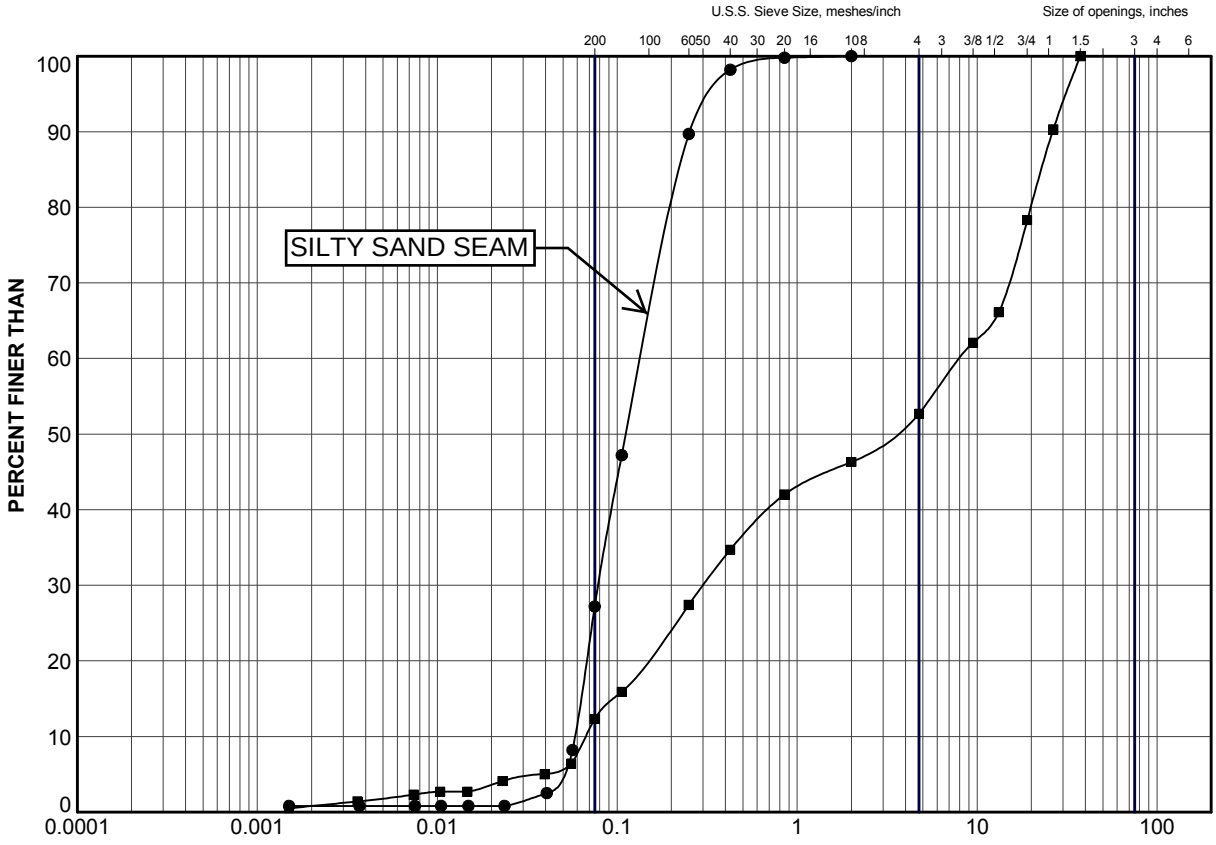
GRAIN SIZE DISTRIBUTION

GRAVELLY SAND

Golder Associates
SUDBURY, ONTARIO

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 B6**	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



LEGEND

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

PROJECT

HIGHWAY 60
OPEONGO LAKE CULVERT

TITLE

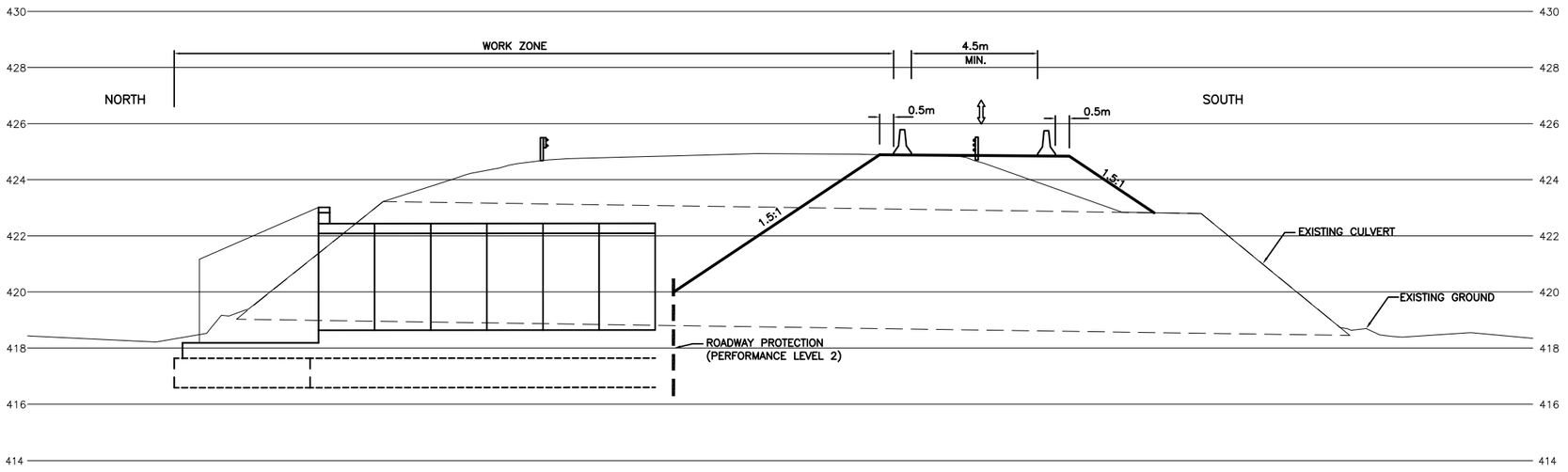
GRAIN SIZE DISTRIBUTION

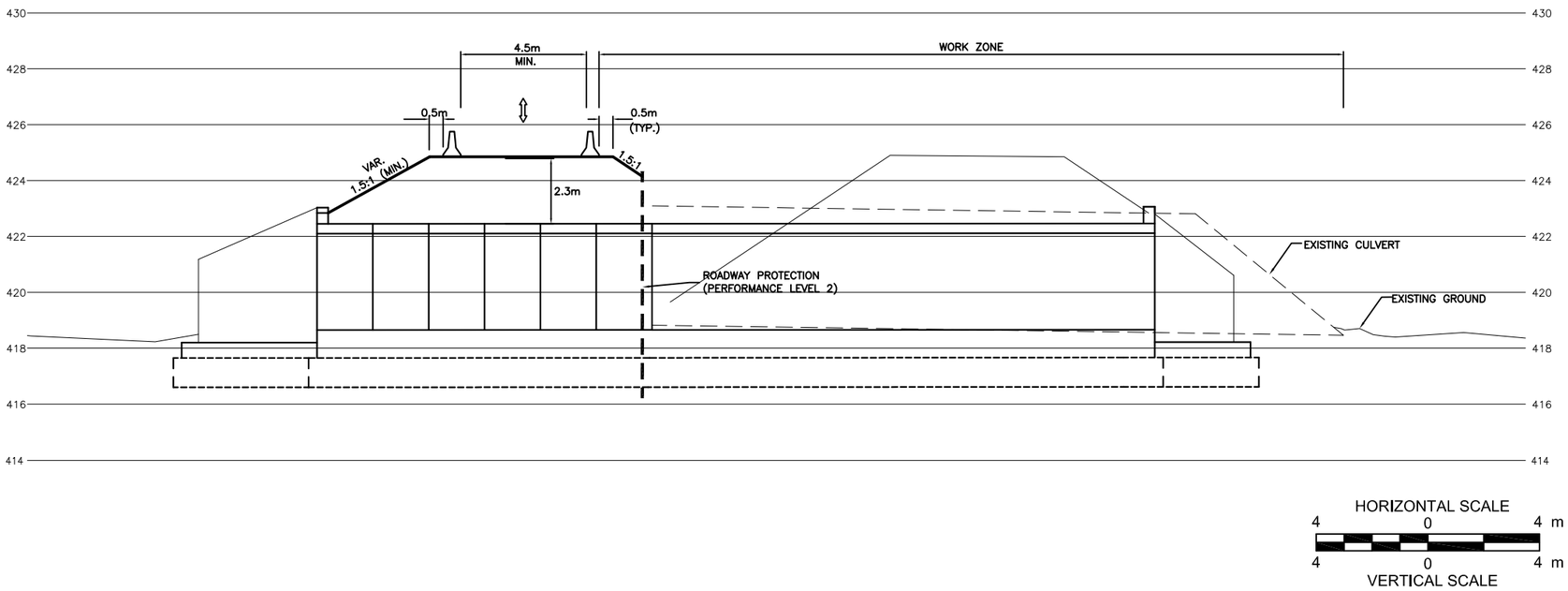
SAND and GRAVEL

Golder Associates
SUDBURY, ONTARIO

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**		

SUD-MTO GSD (NEW) GLDR_LDN.GDT





CONSTRUCTION STAGING

STAGE 1:

- Widen south side of embankment to 1.5H:1V using Granular 'B' Type II.
- Predrill through existing rock fill embankment and install roadway protection system.
- Switch traffic to south side.
- Replace north portion of culvert.

STAGE 2:

- Install roadway protection.
- Switch traffic to north side of culvert.
- Replace south portion of culvert.
- Reconstruct embankment/roadway over/adjacent to culvert.

REFERENCE:

Based on drawing Opeongo Staging Sections.dwg, received from LEA on December 11, 2013.

TITLE

HIGHWAY 60 OPEONGO LAKE CULVERT
CULVERT STAGING DETAILS

Golder Associates
Sudbury, Ontario, Canada

PROJECT No.		13-1191-0003	FILE No. 1311910003 Stage.Culv.dwg
DESIGN			SCALE AS SHOWN REV.
CAD	TB	DEC 2013	FIGURE No.
CHECK	AB	DEC 2013	**B8**
REVIEW			

PLOT DATE: December 17, 2013
FILENAME: \\golder.gds\GAL\Sudbury\CAD-GIS\CAD\Projects\2013\13-1191-0003 - LEA Hwy 60-35-118\Culvert Staging Details\1311910003 Stage.Culv.dwg

APPENDIX C

Non Standard Special Provisions

WORKING SLAB – Item No.

Non-Standard Special Provision

Scope of Work

The subgrade soils for the box culvert foundations may be susceptible to disturbance and loosening from construction traffic and ponded water.

Where precast box culverts are used, if all of the box segments are not placed on the prepared subgrade within four hours of its inspection and approval, a concrete working slab of 20 MPa compressive strength at 28 days with minimum thickness of 100 mm, shall be placed on the foundation subgrade. A minimum 75 mm thick uncompacted levelling pad consisting of Granular 'A' material (OPPS.PROV 1010) or concrete fine aggregate (meeting the grading requirements specified in OPSS.PROV 1002) shall be provided on top of the concrete working slab.

Basis of Payment

Payment at the lump sum contract price for the above tender item includes full compensation for all labour, equipment and material for completion of the work.

END OF SECTION

UNWATERING OF STRUCTURE EXCAVATION - Item No.

Non-Standard Special Provision

Construction of both the Norway Creek and Opeongo Lake culverts will require excavations to extend below the groundwater level. The cohesionless soils that are present below the groundwater table will slough, run, boil or cave into the excavation unless appropriate groundwater controls are in place. The Contractor is to design and install an appropriate excavation protection and unwatering system to enable construction in dry conditions, to prevent disturbance to the founding soils.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

OBSTRUCTIONS

Non-Standard Special Provision

As part of the work for the culvert installation at the Norway Creek and Opeongo Lake Culvert Replacement sites, the Contactor shall be alerted to the presence of cobbles and boulders within the embankment fill and in the native soil.

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.

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