



February 7, 2013

## FOUNDATION INVESTIGATION REPORT

**CULVERT - PHASE 2  
HIGHWAY 69 FOUR-LANING  
FROM 0.4 KM NORTH OF HIGHWAY 7182  
(SHEBESHEKONG ROAD) NORTHERLY 11 KM  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 5005-08-00**

**Submitted to:**  
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- 1 e-copy Ministry of Transportation, Ontario, Downsview, Ontario (Foundations Section)
- 1 e-copy MMM Group, Thornhill, Ontario
- 1 Copy Golder Associates Ltd., Sudbury, Ontario

REPORT





## Table of Contents

**1.0 INTRODUCTION..... 1**

**2.0 SITE DESCRIPTION..... 1**

**3.0 INVESTIGATION PROCEDURES ..... 1**

**4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS ..... 4**

    4.1 Regional Geology ..... 4

    4.2 Subsurface Conditions..... 4

    4.3 Highway 69 NBL – STA 14+010 (Site No. 44-595/C1) ..... 5

    4.4 Highway 69 SBL – STA 14+075 (Site No. 44-595/C2)..... 6

    4.5 Highway 69 NBL – STA 14+220 (Site No. 44-596/C1) ..... 8

    4.6 Highway 69 SBL – STA 14+220 (Site No. 44-596/C2)..... 9

    4.7 Highway 69 NBL – STA 14+734 ..... 10

    4.8 Highway 69 NBL – STA 15+375 (Site No. 44-597/C1) ..... 12

    4.9 Highway 69 SBL – STA 15+375 (Site No. 44-597/C2)..... 14

    4.10 Highway 69 SBL – STA 15+775 (Site No. 44-598/C2)..... 16

    4.11 Highway 69 NBL – STA 15+790 (Site No. 44-598/C1) ..... 17

    4.12 Highway 69 NBL – STA 16+286 (Site No. 44-599/C1) ..... 18

    4.13 Highway 69 SBL – STA 16+312 (Site No. 44-599/C2)..... 19

**5.0 CLOSURE..... 21**

### TABLES

Table 1                      Summary of Culvert Details

### DRAWINGS

Drawing 1                  Site Location Plan  
Drawing 2                  Highway 69 – Culverts – Index Plan

List of Symbols and Abbreviations  
Lithological and Geotechnical Rock Description Terminology



**APPENDICES**

**Appendix A Highway 69 NBL STA 14+010 and SBL STA 14+075**

Drawing A1	Borehole Locations and Soil Strata
Record of Test Pits	I-1-TP, I-2-TP, I-4-TP, I-5-TP
Record of Boreholes	I-3 and I-6
Record of Drillholes	I-6
Figure A1	Grain Size Distribution – Sand and Silt
Figure A2	Plasticity Chart – Silty Clay
Figure A3	Grain Size Distribution – Silty Clay

**Appendix B Highway 69 NBL and SBL STA 14+220**

Drawing B1	Borehole Locations and Soil Strata
Record of Boreholes	J-1 to J-5
Record of Drillholes	J-5

**Appendix C Highway 69 NBL STA 14+734**

Drawing C1	Borehole Locations and Soil Strata
Record of Boreholes	C88-1 to C88-3
Record of Drillholes	C88-1 to C88-3
Table C1	Uniaxial Compression Strength Test Results
Table C2	Point Load Strength Test Results
Figure C1	Grain Size Distribution – Sand to Sand and Gravel

**Appendix D Highway 69 NBL and SBL STA 15+375**

Drawing D1	Borehole Locations and Soil Strata
Record of Boreholes	K-1 to K-5
Record of Drillholes	K-4
Figure D1	Grain Size Distribution – Sand and Silt
Figure D2	Grain Size Distribution – Sand and Gravel
Figure D3	Plasticity Chart – Clay

**Appendix E Highway 69 SBL STA 15+775 and NBL STA 15+790**

Drawing E1	Borehole Locations and Soil Strata
Record of Boreholes	L-1 to L-6
Record of Drillholes	L-2
Figure E1	Grain Size Distribution – Silty Sand
Figure E2	Grain Size Distribution – Sand and Gravel



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## FOUNDATION REPORT CULVERTS - PHASE 2 - HIGHWAY 69 GWP 5005-08-00

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<b>Appendix F</b>	<b>Highway 69 NBL STA 16+286 and SBL STA 16+312</b>
Drawing F1	Borehole Locations and Soil Strata
Record of Boreholes	M-1 to M-5
Figure F1	Grain Size Distribution –Sand to Sand and Silt
Figure F2	Grain Size Distribution – Sand and Gravel



## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by MMM Group (MMM) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for eleven (11) culverts on Highway 69 Northbound Lanes (NBL) and Southbound Lanes (SBL). This project is part of the detail design for the four-laning of Highway 69 from 0.4 km north of Highway 7182 (Shebeshekong Road) northerly for a total distance of 11 km. The general location of this section of the Highway 69 four-laning alignment is shown on the Site Location Plan on Drawing 1.

This report addresses the investigation carried out for the Phase 2 culverts only, including one water conveyance culvert and ten Species at Risk (SAR) culverts. A detailed list of the Phase 2 culverts is presented in Table 1. Separate reports will be submitted detailing the foundation investigations for the Phase 1 culverts, as well as for the related swamp and pond crossings and structures for the project.

The purpose of this investigation is to establish the subsurface conditions at the proposed culverts associated with the new Highway 69 by borehole drilling, rock coring, in situ testing and laboratory testing on selected samples. The culverts were located in the field by Golder relative to centreline stakes installed by MMM referencing plan and section drawings provided by MMM. The investigated areas are shown in plan on Drawing 2.

## **2.0 SITE DESCRIPTION**

The section of the new highway being addressed by this report extends from the north side of Shawanaga River to about 8.8 km northerly to the town of Pointe au Baril Station. The future Highway 69 will run generally in a southeast-northwest direction with the project limits spanning from Shawanaga Township at the south end to Harrison Township at the north end. The proposed highway alignment approximately follows the existing alignment of Highway 69 for about 4.4 km northerly from Shawanaga River. About 4.4 km north of Shawanaga River, the proposed alignment will be straightened relative to the existing alignment northerly for about 2 km and will bypass the existing alignment to the east of the town of Pointe au Baril Station. Re-aligned and/or newly proposed highways and access/service roads associated with the four-laning of the new Highway 69 in this area include Site 9 Road and adjoining ramps for the proposed Highway 529 Interchange.

In general, the topography of the section of the overall project limits consists of rolling terrain, including sparsely treed areas and numerous bedrock outcrops separated by low-lying swamps containing areas of standing water and various vegetation types and surficial organic soils. The ground surface within the investigated areas for the culverts varies between about Elevation 204.0 m and 192.0 m, referenced to Geodetic datum, and is gently sloping downward from northeast to southwest towards Georgian Bay. A detailed description of each investigated culvert crossing is presented in Section 4.0.

## **3.0 INVESTIGATION PROCEDURES**

The fieldwork for the investigation associated with the Phase 2 culvert crossings was carried out in two stages, with a total of twenty-six (26) boreholes and four (4) test pits were advanced at or near the culvert locations as follows:



## FOUNDATION REPORT CULVERTS - PHASE 2 - HIGHWAY 69 GWP 5005-08-00

- Three (3) boreholes (C88-1 to C88-3) were advanced between March 10 and 12, 2009; and
- Twenty-three (23) boreholes (I-3 and I-6, J-1 to J-5, K-1 to K-5, L-1 to L-6 and M-1 to M-5) were advanced and four (4) test pits (I-1-TP, I-2-TP, I-4-TP and I-5-TP) were excavated between February 8 and 22, May 4 and 9, July 11 and 27 and on August 10, 2011.

The location of the boreholes is shown on the drawings in Appendices A to F following the text of this report.

The field investigation was carried out using a variety of drilling and excavating equipment due to the varying nature of the terrain within the Phase 2 project limits. The details of the drilling and excavating equipment and suppliers are listed below.

Drilling/Excavation Equipment	Supplied and Operated By
Truck-Mounted CME-55 Track-Mounted CME-55	Landcore Drilling of Sudbury, Ontario
Portable Equipment	OGS Inc. of Almonte, Ontario Landcore Drilling of Sudbury, Ontario
Track Excavator	Weeks Construction

The boreholes were advanced through the overburden using BW casing and wash boring method. Soil samples were obtained continuously or at intervals of depth of about 0.75 m and 1.5 m, using a 50 mm outer diameter (O.D.) split-spoon sampler, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586) or using a thin-wall NQ core barrel. Boreholes employed ½ weight hammer lifted manually to the SPT height and the 'N'-values were corrected for the lower energy drive. Samples of the bedrock were obtained using a thin-wall NQ core barrel, which fits inside BW casing. All boreholes were backfilled with bentonite upon completion in accordance with Ontario Reg. 903 (as amended by Ontario Reg. 372).

The boreholes were advanced to depths ranging between 5.6 m and 9.4 m below the ice/water surface, including coring of bedrock for depths ranging from about 3.5 m to 4.1 m below the surface of the bedrock. The test pits were excavated to depths between 0.2 m and 1.1 m.

The groundwater conditions and water levels in the open boreholes and test pits were observed during the drilling and excavation operations and are described on the Record of Borehole and Test Pit sheets in the respective appendices. It should be noted that groundwater elevations as encountered in the boreholes and test pits may not be representative of static groundwater levels since the groundwater levels in the boreholes and test pits may not have stabilized on completion of drilling or excavating. Furthermore, groundwater elevations will vary depending on seasonal fluctuations, precipitation and local soil permeability.

The fieldwork was supervised throughout by a member of our technical staff, who located the boreholes and test pits, arranged for the clearance of underground services, observed the drilling and excavation, sampling and in situ testing operations, logged the boreholes and test pits, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing



## FOUNDATION REPORT CULVERTS - PHASE 2 - HIGHWAY 69 GWP 5005-08-00

(water content and grain size distribution) was carried out on selected soil samples. Strength testing (uniaxial compressive and point load index) was also carried out on selected specimens of the rock core.

The centreline of the highway was surveyed and staked in the field by MMM prior to drilling. The as-drilled borehole and test pit locations and ground surface elevations were measured/surveyed by members of our technical staff, referenced to the survey stakes. The borehole and test pit locations shown the drawings in Appendices A to F are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum.

Highway Lane	Borehole/ DCPT	Location (m)		Ground Surface Elevation (m)	Drilled Depth (m)	Appendix
		Northing	Easting			
STA 14+010 NBL	I-1-TP	5,050,536.6	237,088.9	199.1	1.1	A
	I-2-TP	5,050,534.9	237,075.0	198.9	0.5	
	I-3	5,050,533.0	237,060.2	198.3	2.5	
STA 14+075 SBL	I-4-TP	5,050,596.5	237,044.2	202.5	0.2	A
	I-5-TP	5,050,594.6	237,029.3	201.3	0.8	
	I-6	5,050,593.0	237,015.4	197.8	6.2	
STA 14+220 NBL and SBL	J-5	5,050,745.2	237,052.6	200.8	2.7	B
	J-4	5,050,743.0	237,040.6	199.8	0.3	
	J-3	5,050,740.3	237,025.9	199.5	1.8	
	J-2	5,050,737.4	237,010.2	199.1	1.1	
	J-1	5,050,735.2	236,998.2	198.8	0.3	
STA 14+734 NBL	C88-1	5,051,243.8	236,917.8	195.5	5.6	C
	C88-2	5,051,247.1	236,932.1	195.5	8.3	
	C88-3	5,051,250.8	236,948.9	195.1	9.4	
STA 15+375 NBL and SBL	K-5	5,051,874.9	236,806.9	202.6	3.4	D
	K-4	5,051,871.1	236,790.3	202.1	3.4	
	K-3	5,051,867.4	236,773.7	202.6	2.8	
	K-2	5,051,863.7	236,757.1	202.7	4.0	
	K-1	5,051,860.0	236,740.5	202.8	4.1	
STA 15+790 NBL	L-4	5,052,265.9	236,658.3	203.5	0	E
	L-5	5,052,271.5	236,671.1	203.7	0.7	
	L-6	5,052,277.5	236,684.9	204.0	0.2	
STA 15+775 SBL	L-1	5,052,236.4	236,628.5	202.5	0	E
	L-2	5,052,242.5	236,642.2	203.4	3.2	
	L-3	5,052,249.3	236,657.8	203.8	0.9	
STA 16+286 NBL and STA 16+312 SBL	M-5	5,052,700.8	236,437.7	194.0	6.7	F
	M-4	5,052,698.6	236,413.5	193.3	4.0	
	M-3	5,052,693.7	236,386.2	193.9	4.7	
	M-2	5,052,692.6	236,363.4	192.3	4.8	
	M-1	5,052,691.2	236,334.0	192.0	9.3	



## **4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS**

### **4.1 Regional Geology**

As delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)<sup>1</sup>, this section of Highway 69 lies within the physiographic region known as the Georgian Bay Fringe, which extends along the east side of Georgian Bay through the Parry Sound and Muskoka areas, then eastward from Muskoka in patches into the area north of the Kawartha Lakes.

This part of the Georgian Bay Fringe physiographic region was never submerged during periods of glacial recession. As a result, the surficial soils in this area consist of very shallow deposits of sand, silt and clay overlying metamorphic bedrock and numerous bare knobs and ridges of bedrock are present throughout the area. Localized low-lying swampy areas, containing peat and/or organic soils overlying soft/loose native soils, are present in valleys between the bedrock knobs and ridges.

The bedrock in the area consists typically of gneisses of the Britt Domain of the Central Gneiss Belt, a subdivision of the Grenville Structural Province, as described in *Geology of Ontario*, OGS Special Volume 4<sup>2</sup>. Deposition of Paleozoic strata and later erosion during glaciation exposed these Precambrian rocks.

### **4.2 Subsurface Conditions**

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced for this investigation, together with the results of the laboratory tests carried out on selected soil and rock core samples, are given on the attached Record of Borehole and Drillhole sheets in Appendix A. Detailed results of the laboratory testing are provided in Appendix B. The stratigraphic boundaries shown on the Record of Borehole and Drillhole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of SPTs and in situ testing. These boundaries, therefore, represent transitions between soil and rock types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

The inferred stratigraphy as encountered in the boreholes is shown on Drawing 1. It should be noted that the orientation (i.e. north, south, east, west) stated in the text of the report is typically referenced to project north (along the proposed Highway 69 alignment) and therefore may differ from that shown on the drawings which represents magnetic north.

In general, the subsurface stratigraphy along the culvert alignment consists of a surficial layer of peat, underlain by a deposit of sand to sand and gravel containing cobbles and boulders and bedrock.

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<sup>11</sup> Chapman, L.J. and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000.

<sup>2</sup> *Geology of Ontario*, 1991. Ontario Geological Society Special Volume 4, Part 2. Ministry of Northern Development and Mines, Ontario.



### **4.3 Highway 69 NBL – STA 14+010 (Site No. 44-595/C1)**

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 14+010 in Harrison Township are shown on Drawing A1 in Appendix A. The culvert will extend across the proposed Highway 69 NBL embankment and the embankment at the proposed culvert location is about 3.9 m high above the existing grade. A total of two test pits and one borehole were completed to investigate the subsurface conditions at this culvert location: one test pit and one borehole (Test Pit I-1-TP and Borehole I-3) were advanced near the ends of the culvert and one test pit (Test Pit I-2-TP) was advanced near the midpoint of the culvert. The topography of the area in this section of proposed roadway is generally flat and slightly sloping down to the west, with dense tree cover. Bedrock is exposed in the vicinity of the culvert.

#### ***Sandy Topsoil***

A deposit of wet, black, sandy topsoil was encountered at ground surface in Test Pits I-1-TP and I-2-TP and in Borehole I-3. The thickness of this deposit is 0.2 m and the top of the deposit was encountered between Elevation 199.1 m and 198.3 m.

#### ***Silty Sand to Sand and Silt***

A deposit of brown, wet silty sand to sand and silt containing trace clay, some gravel and trace organics was encountered underlying the sandy topsoil in Test Pit I-2-TP and Borehole I-3. The thickness of this deposit is from 0.3 m and 0.6 m at the test pit and borehole location, respectively, and the top of the deposit was encountered at Elevation 198.7 m and 198.1 m. A 0.6 m thick layer of this deposit was encountered underlying the silty clay (discussed below) in Borehole I-3 at a depth of 1.9 m below ground surface (Elevation 196.4 m). The bottom of this deposit was defined by exposing bedrock in Test Pit I-2-TP, at Elevation 198.4 m.

An SPT 'N'-value measured within this deposit is 1 blow per 0.3 m of penetration, indicating a very loose relative density.

A grain size distribution of one sample of the sand and silt is shown on Figure A1 in Appendix A.

The water content measured on two samples of this deposit is about 23 per cent and 24 per cent.

#### ***Silty Clay***

A deposit of brown to grey silty clay containing trace sand, cobbles and organics was encountered underlying the sandy topsoil in Test Pit I-1-TP and interlayered within the sand and silt deposit in Borehole I-3. The thickness of this deposit is from 0.9 m and 1.1 m and the top of the deposit was encountered at Elevation 198.9 m and 197.5 m in the test pit and borehole, respectively. The bottom of this deposit was defined by exposing bedrock in Test Pit I-1-TP at Elevation 198.0 m.

SPT 'N'-values measured within this deposit are 5 blows and 11 blows per 0.3 m of penetration, suggesting a firm to stiff consistency.



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

Bedrock was exposed in Test Pits I-1-TP and I-2-TP at depths of 1.1 m and 0.5 m, respectively, corresponding to Elevation 198.0 m and 198.4 m. In Borehole I-3, refusal to further split-spoon and auger advancement was encountered at the depth of 2.5 m below ground surface (Elevation 195.8 m).

### ***Groundwater Conditions***

The unstabilized water level in Test Pits I-1-TP and I-2-TP and Borehole I-3 was measured at depths of between 0.2 m and 0.8 m below ground surface, corresponding to between Elevations 198.7 m and 197.5 m. The groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

## **4.4 Highway 69 SBL – STA 14+075 (Site No. 44-595/C2)**

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 14+075 in Harrison Township are shown on Drawing A1 in Appendix A. The culvert will extend across the proposed Highway 69 SBL embankment and the proposed embankment at the proposed culvert location is about 2.7 m high above the existing grade. A total of two test pits and one borehole were completed to investigate the subsurface conditions at this culvert location: one test pit and one borehole (Test Pit I-4-TP and Borehole I-6) were advanced near the ends of the culvert; and one test pit (Test Pit I-5-TP) was advanced near the midpoint of the culvert. The topography of the area in this section of proposed roadway is generally sloping down from east to west, with dense tree cover. Bedrock is exposed in the vicinity of the culvert.

### ***Sandy Topsoil***

A deposit of moist to wet, brown to black, sandy topsoil containing trace gravel and cobbles (in one test pit) was encountered at ground surface in Test Pits I-4-TP and I-5-TP. The thickness of this deposit is 0.2 m and the top of the deposit was encountered at Elevation 202.5 m and 197.8 m. The bottom of this deposit was defined by exposing bedrock in Test Pit I-4-TP at Elevation 202.3 m.

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

A deposit of brown, moist sand to sand and silt containing trace gravel, cobbles and boulders (in one test pit) or organics was encountered underlying the sandy topsoil in Test Pit I-5-TP and Borehole I-6. The thickness of this deposit is 0.6 m and 0.8 m and the top of the deposit was encountered at Elevation 201.1 m and 197.6 m. In Borehole I-6, a 0.7 m thick layer of sand and silt was encountered underlying the silty clay (discussed below) at Elevation 185.8 m. The bottom of this deposit was defined by exposing bedrock in Test Pit I-5-TP at Elevation 200.5 m and coring bedrock in Borehole I-6.

The water content measured on two samples of this deposit is about 18 per cent and 36 per cent.



### ***Silty Clay***

A deposit of brown, wet silty clay containing trace sand was encountered interlayered within the sand to sand and silt deposit in Borehole I-6. The thickness of this deposit is 1.0 m and the top of the deposit was encountered at Elevation 196.8 m.

Two SPT 'N'-values measured within this deposit are 13 blows and 18 blows per 0.3 m of penetration, suggesting a stiff to very stiff consistency.

Atterberg limits testing was carried out on one sample of the cohesive stratum and the test results indicate a liquid limit of about 49 per cent, a plastic limit of about 20 per cent and a plasticity index of about 29 per cent. The results of the Atterberg limits test are shown on the plasticity chart on Figure A2 in Appendix A and indicate that the material is classified as a silty clay of medium plasticity.

A grain size distribution of one sample of the deposit is shown on Figure A3 in Appendix A.

The water content measured on a sample of the silty clay is about 31 per cent.

### ***Bedrock***

In Test Pits I-4-TP and I-5-TP, bedrock was exposed at depths of 0.2 m and 0.8 m below ground surface, corresponding to Elevation 202.3 m and 200.5 m, respectively.

Bedrock was encountered underlying the sand and silt deposit in Borehole I-6 at a depth of 2.7 m, corresponding to Elevation 195.1 m, and 3.8 m of core was obtained. Based on a review of the bedrock core samples, the bedrock generally consists of coarse grained, fresh, grey gneiss.

The Total Core Recovery (TCR) is 100 per cent for the core samples. The Solid Core Recovery (SCR) ranges from about 76 per cent to about 95 per cent. Rock Quality Designation (RQD) values measured on the recovered bedrock core samples range from 88 per cent to 100 per cent, indicating that the rock is of good to excellent quality according to Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006).

An Uniaxial Compressive Strength (UCS) test was carried out on a representative sample of the rock core taken from Borehole I-6 and the measured UCS is 78 MPa, indicating that the bedrock is strong ( $R_4$ ,  $50\text{MPa} < \text{UCS} < 100\text{MPa}$ ) according to Table 3.5 of CFEM (2006).

### ***Groundwater Conditions***

Test Pits I-4-TP and I-5-TP were dry upon completion of excavation operations and the unstabilized water level in Borehole I-6 was measured at a depth of 0.4 m below ground surface, corresponding to Elevation 197.4 m. The groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.



## **4.5 Highway 69 NBL – STA 14+220 (Site No. 44-596/C1)**

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 14+220 in Harrison Township are shown on Drawing B1 in Appendix B. The culvert will extend across the proposed Highway 69 NBL roadway embankment and the embankment at the proposed culvert location is about 2.8 m high above the existing grade. A total of three boreholes were completed to investigate the subsurface conditions at this culvert location: two boreholes (Boreholes J-4 and J-5) were advanced near the ends of the culvert; and one borehole (Borehole J-3) was advanced near the midpoint of the Highway 69 centreline to overlap with the SBL culvert. The topography of this section of the proposed highway is generally flat and low-lying within a mixed forest, with bedrock outcrops and a creek to the south of the proposed culvert alignment.

### ***Peat***

A deposit of wet, black, fibrous peat was encountered at ground surface in Boreholes J-3 to J-5. The thickness of the peat ranges from 0.3 m to 0.9 m and the top of the deposit was encountered between Elevation 200.8 m and 199.5 m. In Boreholes J-4 and J-5, the bottom of this deposit was defined by refusal to further split-spoon advancement or bedrock coring.

The SPT 'N'-values measured within the peat are 1 blow per 0.3 m of penetration, suggesting a very soft consistency.

The water content measured on two samples of this deposit is about 57 per cent and 69 per cent.

### ***Gravelly Sand***

A 0.9 m thick deposit of brown, wet gravelly sand was encountered underlying the peat in Borehole J-3. The top of this granular deposit was encountered at about 0.9 m below ground surface at Elevation 198.6 m. The bottom of this deposit was defined by refusal to further split-spoon advancement.

Two SPT 'N'-values measured within this deposit are 11 blows per 0.3 m of penetration and 17 blows per 0.15 m of penetration, generally indicating a compact relative density.

The water content measured on one sample of this deposit is about 31 per cent.

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

Refusal to further split-spoon advancement was encountered in Boreholes J-3 and J-4 at depths of 1.8 m and 0.3 m below ground surface, corresponding to Elevation 197.7 m and 199.5 m, respectively.

Bedrock was encountered underlying the peat in Borehole J-5 at a depth of 0.8 m below ground surface, corresponding to Elevation 200.0 m, and 1.9 m of bedrock core was recovered. Based on a review of the bedrock core samples, the bedrock consists of fine to medium grained, slightly weathered, pinkish grey gneiss.



The TCR is 100 per cent for the core samples. The SCR is about 28 per cent and about 57 per cent. RQD values measured on the recovered bedrock core samples are 28 per cent and 39 per cent, indicating that the rock is of poor quality according to Table 3.10 of the CFEM (2006).

A UCS test was carried out on a representative sample of the rock core taken from Borehole J-5 and the measured UCS is 105 MPa, indicating that the bedrock is very strong ( $R5, 100 \text{ MPa} < \text{UCS} < 250 \text{ MPa}$ ) according to Table 3.5 of CFEM (2006).

### **Groundwater Conditions**

The unstabilized water levels in Boreholes J-3 and J-4 were measured at depths of 0.3 m and 0.1 m below ground surface, corresponding to Elevation 199.2 m and 199.7 m, respectively, while Borehole J-5 was dry upon completion of drilling. The groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

## **4.6 Highway 69 SBL – STA 14+220 (Site No. 44-596/C2)**

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 14+220 in Harrison Township are shown on Drawing B1 in Appendix B. The culvert will extend across the proposed Highway 69 SBL roadway embankment and the embankment at the proposed culvert location is about 4.1 m high above the existing grade. A total of three boreholes were completed to investigate the subsurface conditions at this culvert location: two boreholes (Boreholes J-1 and J-2) were advanced near the ends of the culvert; and one borehole (Borehole J-3) was advanced near the midpoint of the Highway 69 centreline to overlap with the NBL culvert. The topography of this section of the proposed highway is generally flat and low-lying within a mixed forest, with bedrock outcrops and a creek to the south of the proposed culvert alignment.

### **Peat**

A deposit of wet, black, fibrous peat was encountered at ground surface in Boreholes J-1 to J-3. The thickness of the peat ranges from 0.3 m to 0.9 m and the top of the deposit was encountered between Elevation 199.5 m and 198.8 m. In Borehole J-1, the bottom of this deposit was defined by refusal to further split-spoon advancement.

The SPT 'N'-values measured within the peat are 1 blow per 0.3 m of penetration, suggesting a very soft consistency.

The water content measured on two samples of this deposit is about 54 per cent and 80 per cent.



### ***Gravelly Sand***

A 0.2 m and 0.9 m thick deposit of brown, wet gravelly sand was encountered in Boreholes J-2 and J-3 underlying the peat at 0.9 m below ground surface, corresponding to Elevation 198.2 m and 198.6 m in the respective boreholes. The bottom of this deposit was defined by refusal to further split-spoon advancement.

The SPT 'N'-values measured within this deposit are 11 blows per 0.3 m of penetration and 17 blows and 6 blows per 0.15 m of penetration, generally indicating a compact relative density.

The water content measured on one sample of this deposit is about 31 per cent.

### ***Refusal***

In Boreholes J-1 to J-3, refusal to further split-spoon penetration was encountered between the depths of 0.3 m and 1.8 m below ground surface, corresponding to between Elevations 198.5 m and 197.7 m.

### ***Groundwater Conditions***

The unstabilized water level in Boreholes J-1 to J-3 was measured at depths between 0.3 m and 0.1 m below ground surface, corresponding to between Elevation 199.2 m and 198.7m. The groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

### ***Ice/Water***

All boreholes were advanced from the ice surface and penetrated an ice/water layer between 0.4 m and 1.4 m thick.

## **4.7 Highway 69 NBL – STA 14+734**

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 14+734 in Harrison Township are shown on Drawing C1 in Appendix C. The culvert will extend across the proposed Highway 69 NBL roadway embankment and the embankment at the proposed culvert location is about 5.5 m high above the existing grade. A total of three boreholes were completed to investigate the subsurface conditions at this culvert location: two boreholes (Boreholes C88-1 and C88-3) were advanced near the ends of the culvert; and one borehole (Borehole C88-2) was advanced near the midpoint of the culvert. The topography of this section of the proposed highway generally consists of a creek about 5 m wide at the west end of the culvert and about 20 m at the east end of the culvert. Bedrock is exposed on either side of the creek.



### **Peat**

A deposit of brown, amorphous peat was encountered below the ice and water in Boreholes C88-2 and C88-3. The thickness of the peat deposit is 1.1 m and 3.4 m in Boreholes C88-2 and C88-3, respectively, and the top of the deposit was encountered at Elevation 194.1 m and Elevation 195.1, respectively.

The SPT 'N'-values measured within the peat are 0 blows (i.e. weight of hammer) and 1 blow per 0.3 m of penetration, indicating a very soft consistency.

The measured water content on two samples of the peat is 614 per cent and 980 per cent.

### **Sand to Sand and Gravel**

A deposit of grey sand to sand and gravel was encountered below the water in Borehole C88-1 and below the peat deposit in Boreholes C88-2 and C88-3. The top of this deposit varies between about Elevation 191.7 m and Elevation 194.7 m and the thickness of the deposit varies between about 1.3 m and 2.3 m. In Borehole C88-2, cobbles and boulders were encountered in the sand and gravel deposit.

The SPT 'N'-values measured within this deposit range between 4 blows and 18 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The grain size distributions of two samples of the deposit are shown on Figure C1 in Appendix C.

The measured water content on samples of this deposit varies between about 11 per cent and 23 per cent.

### **Bedrock**

Bedrock was encountered and cored in each of the boreholes. The bedrock surface ranges from Elevation 193.4 m to 190.2 m at depths ranging from 2.1 m to 5.3 m below the ice/water surface.

Based on a review of the rock core samples, the bedrock consists of gneiss except for the lower 2.3 m of core sample in Borehole C88-2, which consists of pegmatite. The core samples are described as slightly to moderately weathered, fine to coarse grained and grey. The Rock Quality Designation (RQD) measured on the core samples in Borehole C88-1 and the upper two core samples in Borehole C88-2 range from about 81 per cent to 98 per cent, indicating a rock mass quality ranging from good to excellent. In the bottom core sample of Borehole C88-2 and in each of the core samples in Borehole C88-3, the RQD ranges from 6 per cent to 76 per cent, but generally indicates a rock mass quality ranging from poor to fair. The Total Core Recovery (TCR) ranges from about 96 per cent to 100 per cent and the Solid Core Recovery (SCR) ranges from about 43 per cent to 94 per cent.

Laboratory Uniaxial Compression Strength test (UCS) performed on two core samples of the gneiss bedrock from Borehole C88-1 and C88-3 indicates Strengths of 72 MPa and 30 MPa, respectively (Table C1).

Point load strength tests were performed on selected samples of the bedrock. Diametral point load strength index values are shown on the Record of Drillhole sheets and are summarized in Table C2. The diametral point load index ( $I_{s50}$ ) results from the laboratory tests carried out on core samples of the gneiss range from about 1 MPa to 5 MPa for the gneiss bedrock. These index values correspond to estimated UCS values between



30 MPa and 138 MPa, as presented in Table C2, based on a relationship between  $I_s50$  and UCS which is given by a correlation factor (k) in accordance with ASTM D5731-08 and varies depending on the size of the core samples and the strength of the rock. For this site, these UCS values are based on an estimated average correlation factor (k) of 27 for the gneiss, which was calculated based on a comparison of the UCS test results and the point load strength test results. These values have been given for comparison only and should be interpreted together with the results of the UCS tests.

Based on the laboratory UCS tests and the point load strength test results, in accordance with Table 3.5 CFEM (2006), the gneiss is medium strong (R3, 25 MPa < UCS < 50 MA) to very strong (R5, 100 MPa < UCS < 250 MPa).

### **Groundwater Conditions**

In general, the samples taken in the boreholes were wet. Water levels observed in the all boreholes upon completion of drilling were at ice surface, Elevation 195.5 m. It should be noted that groundwater levels in the area are subject to seasonal fluctuations and precipitation events.

## **4.8 Highway 69 NBL – STA 15+375 (Site No. 44-597/C1)**

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 15+375 in Harrison Township are shown on Drawing D1 in Appendix D. The culvert will extend across the proposed Highway 69 NBL embankment and the embankment at the proposed culvert location is about 4.5 m high above the existing grade. A total of three boreholes were completed to investigate the subsurface conditions at this culvert location: two boreholes (Boreholes K-3 and K-5) were advanced near the ends of the culvert; and one borehole (Borehole K-4) was advanced near the midpoint of the culvert. The topography of the area in this section of proposed roadway is generally flat in a mixed forest. Bedrock is exposed in the vicinity of the culvert.

### **Peat**

A deposit of black, wet, fibrous peat was encountered at ground surface in Boreholes K-3 to K-5. The thickness of the peat deposit ranges from 0.1 m to 0.9 m and the top of the deposit was encountered between Elevation 202.6 m and 202.1 m. The bottom of this deposit was defined by bedrock coring in Borehole K-4.

One SPT 'N'-value measured within the peat is 0 blows (weight of hammer) per 0.3 m of penetration, suggesting a very soft consistency.

The water content measured on two samples of this deposit is about 144 per cent and 740 per cent.



### **Clay**

A 0.5 m thick deposit of grey, wet clay containing trace sand and trace organics was encountered in Boreholes K-3 and K-5 underlying the peat about 0.9 m and 0.3 m below ground surface, at Elevation 201.7 m and 202.3 m, in the respective boreholes.

Two SPT 'N'-values measured within the clay are 0 blows (weight of hammer) and 1 blow per 0.3 m of penetration, suggesting a very soft consistency.

The water content measured on one sample of this deposit is about 45 per cent.

### **Sand and Silt**

A 0.6 m and 0.7 m thick deposit of grey, wet sand and silt containing some clay was encountered in Boreholes K-3 and K-5 underlying the clay deposit at about 1.4 m and 0.8 m below ground surface, corresponding to Elevation 201.2 m and 201.8 m in the respective boreholes.

Two SPT 'N'-values measured within this deposit are 13 blows and 46 blows per 0.3 m of penetration, indicating a compact to dense relative density.

A grain size distribution of a sample of the deposit is shown on Figure D1 in Appendix D.

The water content measured on a sample of this deposit is about 23 per cent.

### **Sand and Gravel**

A 0.8 m and 1.9 m thick deposit of grey, wet sand and gravel containing trace to some silt and trace to some clay was encountered in Boreholes K-3 and K-5, underlying the sand and silt deposit at about 2.0 m and 1.5 m below ground surface, corresponding to Elevation 200.6 m and 201.1 m in the respective boreholes. The bottom of this deposit was defined by refusal to further split-spoon advancement in both boreholes.

The SPT 'N'-values measured within this deposit range between 31 blows and 85 blows per 0.3 m of penetration, indicating a dense to very dense relative density.

A grain size distribution of a sample of the deposit is shown on Figure D2 in Appendix D.

The water content measured on a sample of this deposit is about 13 per cent.

### **Bedrock/Refusal**

Refusal to further split-spoon advancement was encountered in Boreholes K-3 and K-5 at depths of 2.8 m and 3.4 m below ground surface, corresponding to Elevation 199.8 m and 199.2 m, respectively.

Bedrock was encountered underlying the peat in Borehole K-4 at a depth of 0.1 m, corresponding to Elevation 202.1 m, and 3.3 m of bedrock core was recovered. Based on a review of the bedrock core sample, the bedrock consists of fine grained, fresh, grey gneiss.



The TCR is 100 per cent for the core samples. The SCR ranges from about 53 per cent to about 97 per cent. RQD values measured on the recovered bedrock core samples range from 87 per cent to 97 per cent, indicating that the rock is of good to excellent quality according to Table 3.10 of the CFEM (2006).

A UCS test was carried out on a representative sample of the rock core taken from Borehole K-4 and the measured UCS is 116 MPa, indicating that the bedrock is very strong ( $R5, 100 \text{ MPa} < \text{UCS} < 250 \text{ MPa}$ ) according to Table 3.5 of CFEM (2006).

### **Groundwater Conditions**

The unstabilized water levels in Boreholes K-3 and K-5 were measured at ground surface corresponding to Elevation 202.6 m, while Borehole K-4 was dry upon completion of drilling. The groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

## **4.9 Highway 69 SBL – STA 15+375 (Site No. 44-597/C2)**

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 15+375 in Harrison Township are shown on Drawing D1 in Appendix D. The culvert will extend across the proposed Highway 69 SBL embankment and the embankment at the proposed culvert location is about 4.4 m high above the existing grade. A total of three boreholes were completed to investigate the subsurface conditions at this culvert location: two boreholes (Boreholes K-1 and K-3) were advanced near the ends of the culvert; and one borehole (Borehole K-2) was advanced near the midpoint of the culvert. The topography of the area in this section of proposed roadway is generally flat in a mixed forest. Bedrock is exposed in the vicinity of the culvert.

### **Peat**

A deposit of black, moist to wet, fibrous peat was encountered at ground surface in Boreholes K-1 to K-3. The thickness of the peat deposit ranges from 0.9 m to 2.2 m and the top of the deposit was encountered between Elevation 202.8 m and 202.6 m.

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

The water content measured on samples of this deposit is between about 669 per cent and 894 per cent.

### **Clay**

A deposit of grey, wet clay containing trace sand and trace organics was encountered underlying the peat in Boreholes K-1 to K-3. The thickness of this deposit ranges between 0.5 m and 1.6 m and the top of the deposit was encountered between Elevation 201.7 m and 200.6 m.

The SPT 'N'-values measured within this deposit are 0 blows (weight of hammer) per 0.3 m of penetration. In situ field vane testing carried out within this stratum measured undrained shear strengths of about 6 kPa and



21 kPa. The SPT 'N'-values together with the in situ field vane tests indicate the deposit has a very soft to soft consistency.

Atterberg limits testing was carried out on one sample of the clay and the test results indicate a liquid limit of about 53 per cent, a plastic limit of about 20 per cent and a plasticity index of about 33 per cent. The results of the Atterberg limits test are shown on the plasticity chart on Figure D3 in Appendix D and indicate that the material is classified as a clay of high plasticity.

The water content measured on two samples of this deposit is about 62 per cent and 107 per cent.

### ***Sand and Silt***

A 0.3 m and 0.6 m thick deposit of grey, wet sand and silt containing trace to some clay was encountered underlying the clay stratum in Boreholes K-2 and K-3. The top of this deposit was encountered at about 2.7 m and 1.4 m below ground surface, at Elevations 200.0 m and 201.2 m in the respective boreholes.

An SPT 'N'-value measured within this deposit is 13 blows per 0.3 m of penetration, indicating a compact relative density.

A grain size distribution of a sample of the deposit is shown on Figure D1 in Appendix D.

The water content measured on a sample of this deposit is about 23 per cent.

### ***Sand and Gravel***

A deposit of grey, wet sand and gravel containing trace to some silt was encountered underlying the clay stratum in Borehole K-1 and the sand and silt deposit in Boreholes K-2 and K-3. The thickness of this deposit ranges between 0.3 m and 1.0 m and the top of the deposit was encountered between about 2.0 m and 3.8 m below ground surface, corresponding to between Elevation 200.6 m and 199.0 m. The bottom of this deposit was defined by refusal to further split-spoon advancement.

Two SPT 'N'-values measured within this deposit are 43 blows and 50 blows per 0.3 m of penetration, indicating a dense relative density.

A grain size distribution of a sample of the deposit is shown on Figure D2 in Appendix D.

The water content measured on a sample of this deposit is about 10 per cent.

### ***Refusal***

In Boreholes K-1 to K-3, refusal to further split-spoon penetration was encountered between the depths of 2.8 m and 4.1 m below ground surface, corresponding to between Elevations 199.8 m and 198.7 m.



### ***Groundwater Conditions***

The unstabilized water level in Boreholes K-1 to K-3 was measured at ground surface corresponding to between Elevations 202.8 m and 202.6 m. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

### **4.10 Highway 69 SBL – STA 15+775 (Site No. 44-598/C2)**

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 15+775 in Harrison Township are shown on Drawing E1 in Appendix E. The culvert will extend across the proposed Highway 69 SBL embankment and the embankment at the proposed culvert location is about 4.5 m high above the existing grade. A total of three boreholes were completed to investigate the subsurface conditions at this culvert location: two boreholes (Boreholes L-1 and L-3) were advanced near the ends of the culvert; and one borehole (Borehole L-2) was advanced near the midpoint of the culvert. The topography of this section of the proposed highway is generally flat. Bedrock is exposed in the vicinity of the culvert.

#### ***Peat***

A deposit of brown, moist, fibrous peat was encountered at ground surface in Borehole L-3. The thickness of the peat deposit is 0.6 m and the top of the deposit was encountered at Elevation 203.8 m.

An SPT 'N'-value measured within the peat is 5 blows per 0.3 m of penetration, suggesting a firm consistency.

The water content measured on a sample of this deposit is about 43 per cent.

#### ***Sand and Gravel***

A deposit of brown, moist sand and gravel containing some silt and trace clay was encountered underlying the peat in Borehole L-3. The thickness of this deposit is 0.3 m and the top of the layer was encountered at Elevation 203.2 m. The bottom of this deposit was defined by refusal to split-spoon advancement.

The SPT 'N'-value measured within this deposit is 75 blows per 0.15 m of penetration, indicating a very dense relative density.

A grain size distribution of a sample of the deposit is shown on Figure E2 in Appendix E.

The water content measured on a sample of this deposit is about 16 per cent.

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

Bedrock is exposed at ground surface in Boreholes L-1 and L-2 at Elevation 202.5 m and 203.4 m and refusal to further split-spoon advancement was encountered in Borehole L-3 at a depth of 0.9 m below ground surface, corresponding to Elevation 202.9 m.



The bedrock in Borehole L-2 was cored for a depth of 3.2 m. Based on a review of the bedrock core sample, the bedrock consists of coarse grained, fresh, pinkish grey gneiss.

The TCR is 100 per cent for the core samples obtained and the SCR ranges from about 90 per cent to about 100 per cent. The RQD values measured on the recovered bedrock core samples range from about 96 per cent to 100 per cent, indicating that the rock is of excellent quality according to Table 3.10 of the CFEM (2006).

A UCS test was carried out on a representative sample of the rock core taken from Borehole L-2 and the measured UCS is 140 MPa, indicating that the bedrock is very strong ( $R5, 100 \text{ MPa} < \text{UCS} < 250 \text{ MPa}$ ) according to Table 3.5 of CFEM (2006).

### **Groundwater Conditions**

The unstabilized water level in Borehole L-3 was measured at ground surface corresponding to Elevation 203.8 m. The groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

## **4.11 Highway 69 NBL – STA 15+790 (Site No. 44-598/C1)**

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 15+790 in Harrison Township are shown on Drawing E1 in Appendix E. The culvert will extend across the proposed Highway 69 NBL embankment and the embankment at the proposed culvert location is about 4.1 m high above the existing grade. A total of three boreholes were completed to investigate the subsurface conditions at this culvert location: two boreholes (Boreholes L-4 and L-6) were advanced near the ends of the culvert; and one borehole (Borehole L-5) was advanced near the midpoint of the culvert. The topography of this section of the proposed highway is generally flat and slightly sloping down to the west. Bedrock is exposed at the west end of the culvert alignment.

### **Peat**

A 0.3 m and 0.2 m thick deposit of wet, brown to black, fibrous peat was encountered at ground surface in Boreholes L-5 and L-6 at Elevation 203.7 m and 204.0 m, respectively. In Borehole L-6, the bottom of this deposit was defined by refusal to split-spoon advancement.

### **Silty Sand**

A 0.4 m thick deposit of brown to grey, wet silty sand containing trace to some gravel and some clay was encountered underlying the peat in Borehole L-5 at Elevation 203.4 m. The bottom of this deposit was defined by refusal to split-spoon advancement.

A grain size distribution of a sample of the deposit is shown on Figure E1 in Appendix E.

The water content measured on one sample of this deposit is about 26 per cent.



An SPT 'N'-value of 8 blows per 0.3 m of penetration was measured at the interface with the overlying deposit of peat, indicating a loose relative density.

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

Bedrock is exposed at ground surface in Borehole L-4. In Boreholes L-5 and L-6, refusal to further split-spoon penetration was encountered between the depths of 0.7 m and 0.2 m below ground surface, respectively, corresponding to Elevations 203.0 m and 203.8 m.

### ***Groundwater Conditions***

The unstabilized water levels in Boreholes L-5 and L-6 were measured at ground surface corresponding to Elevations 203.7 m and 204.0 m. The groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

## **4.12 Highway 69 NBL – STA 16+286 (Site No. 44-599/C1)**

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 16+286 in Harrison Township are shown on Drawing F1 in Appendix F. The culvert will extend across the proposed Highway 69 NBL embankment on a skew to the embankment and the embankment at the proposed culvert location is about 9.1 m high above the existing grade. A total of three boreholes were completed to investigate the subsurface conditions at this culvert location: two boreholes (Boreholes M-3 and M-5) were advanced near the ends of the culvert; and one borehole (Borehole M-4) was advanced near the midpoint of the culvert. The topography of this section of the proposed highway is generally flat and low-lying with a pond and a beaver dam at the east end of the culvert alignment and a slight knoll at the west end of the culvert in the highway median.

### ***Water***

Borehole M-5 was advanced from water surface at Elevation 194.0 m through ponded water 0.9 m deep at the time of borehole drilling.

### ***Peat***

A 0.1 m thick layer of brown, moist, fibrous peat was encountered at ground surface in Boreholes M-3 and M-4.

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

A deposit of brown to grey, moist to wet sand, silty sand and/or sand and silt containing trace to some gravel, trace clay and trace organics was encountered underlying the peat in Boreholes M-3 and M-4 and at the bottom of the pond in Borehole M-5. The thickness of this deposit ranges from 3.7 m to 4.6 m and the top of the deposit



was encountered between Elevation 193.8 m and 193.1 m. In Borehole M-3, the bottom of this deposit was defined by refusal to split-spoon advancement. Borehole M-4 was terminated within this deposit at a depth of 3.9 m into the deposit.

The SPT 'N'-values measured within this deposit range between 3 blows and 24 blows per 0.3 m of penetration, but generally greater than 10 blows per 0.3 m of penetration, indicating a compact relative density.

Grain size distributions of five samples of this deposit are shown on Figure F1 in Appendix F.

The water content measured on samples of this deposit is between about 12 per cent and 24 per cent.

### ***Sand and Gravel***

A deposit of grey, wet sand and gravel containing trace silt was encountered underlying the sand to silty sand deposit in Borehole M-5. The top of the deposit was encountered at Elevation 189.4 m and the borehole was terminated within this deposit after drilling 2.1 m into the deposit.

Two SPT 'N'-values measured within this deposit are 14 blows and 62 blows per 0.3 m of penetration, indicating a compact to very dense relative density.

### ***Refusal***

In Borehole M-3, refusal to further split-spoon penetration was encountered at a depth of 4.7 m below ground surface, corresponding to Elevation 189.2 m.

### ***Groundwater Conditions***

The unstabilized water level in Boreholes M-3 and M-4 was measured at depths of 1.3 m and 0.6 m below ground surface, respectively, corresponding to Elevation 192.6 m and 192.7 m. Borehole M-5 was advanced from the water surface at Elevation 194.0 m. Groundwater and pond water levels in the area are subject to seasonal fluctuations and variations due to precipitation events. The pond water level is further affected by beaver activity locally.

## **4.13 Highway 69 SBL – STA 16+312 (Site No. 44-599/C2)**

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 16+312 in Harrison Township is shown on Drawing F1 in Appendix F. The culvert will extend across the proposed Highway 69 SBL embankment on a skew to the embankment and the embankment at the proposed culvert location is about 10.2 m high above the existing grade. A total of three boreholes were completed to investigate the subsurface conditions at this culvert location: two boreholes (Boreholes M-1 and M-3) were advanced near the ends of the culvert; and one borehole (Borehole M-2) was advanced near the midpoint of the culvert. The topography of this section of the proposed highway is generally flat and low-lying, with a pond at the west end of the culvert alignment and a slight knoll at the east end of the culvert in the highway median.



### ***Water***

Borehole M-1 was advanced from water surface at Elevation 192.0 m through ponded water 0.8 m deep at the time of borehole drilling.

### ***Peat***

A deposit of brown to black, moist to wet, fibrous/amorphous peat was encountered at ground surface in Boreholes M-2 and M-3 and at the pond bottom in Borehole M-1. The thickness of the peat ranges from 0.1 m to 1.8 m and the top of the deposit was encountered between Elevation 193.9 m and 191.2 m.

Two SPT 'N'-values measured within this deposit are 0 blows (weight of hammer) and 1 blow per 0.3 m of penetration, suggesting a very soft consistency.

The water content measured on a sample of this deposit is about 132 per cent.

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

A deposit of brown to grey, moist to wet sand, silty sand and/or sand and silt containing trace to some gravel, trace clay and trace organics was encountered underlying the peat in Boreholes M-1 to M-3. The thickness of this deposit ranges from 3.7 m to 4.6 m and the top of the deposit was encountered between Elevation 193.8 m and 189.4 m. In Borehole M-3, the bottom of this deposit was defined by refusal to split-spoon advancement.

The SPT 'N'-values measured within this deposit range between 2 blows and 24 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

Grain size distributions of five samples of this deposit are shown on Figure F1 in Appendix F.

The water content measured on samples of this deposit is between about 17 per cent and 24 per cent, while in the uppermost sample in Borehole M-2, it is about 43 per cent likely influenced by the trace organics in the sample.

### ***Sand and Gravel***

A 2.1 m and 1.0 m thick deposit of grey, wet sand and gravel containing trace to some silt was encountered in Boreholes M-1 and M-2 underlying the sand to sand and silt deposit at about 7.2 m and 3.8 m below ground surface, corresponding to Elevation 184.8 m and 188.5 m in the respective boreholes. The bottom of this deposit in both boreholes was defined by refusal to split-spoon advancement.

The SPT 'N'-values measured within this deposit are 15 blows and 37 blows per 0.3 m of penetration, indicating a compact to dense relative density; higher blow counts for lesser penetration depth were recorded at the refusal surface.

A grain size distribution of one sample of this deposit is shown on Figure F2 in Appendix F.

The water content measured on a sample of this deposit is about 13 per cent.



### ***Refusal***

In Boreholes M-1 to M-3, refusal to further split-spoon penetration was encountered at depths between 4.7 m and 9.3 m below ground surface, corresponding to between Elevation 189.2 m and 182.7m.

### ***Groundwater Conditions***

The unstabilized water level in Boreholes M-2 and M-3 was measured at depths of 0.4 m and 1.3 m below ground surface, corresponding to Elevation 191.9 m and 192.6 m. Borehole M-1 was advanced from the water surface at Elevation 192.0 m. Groundwater and ponded water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

## **5.0 CLOSURE**

The field drilling program was carried out under the supervision of Messrs. Indulis Dumpis and Ed Savard, senior field technicians with Golder, assisted by several field personnel from our Sudbury office, under the overall direction of Mr. André Bom, P.Eng. This report was prepared by Mr. Evan Childerhose, P.Eng., and the technical aspects were reviewed by Mr. André Bom, P.Eng. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project and Principal with Golder, also conducted an independent quality control review of the report.

## Report Signature Page

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## FOUNDATION REPORT CULVERTS - PHASE 2 - HIGHWAY 69 GWP 5005-08-00

**Table 1: Summary of Culvert Details**

Culvert Location (Associated Swamp)	Approximate Proposed Embankment Height (m)	Invert Elevations <sup>1</sup>		Culvert Dimensions <sup>1</sup>			Head Walls	Boreholes/Test Pits	Reference Appendix
		East End of Culvert (m)	West End of Culvert (m)	Width (m)	Height (m)	Length (m)			
Highway 69 NBL STA 14+010	3.9	199.3	198.1	3.0	2.4	29.0	No	2 Test Pits (I-1-TP and I-2-TP) and 1 Borehole (I-3)	Appendix A
Highway 69 SBL STA 14+075	2.7	197.7	197.3	3.0	2.4	29.0	No	2 Test Pits (I-4-TP and I-5-TP) and 1 Borehole (I-6)	Appendix A
Highway 69 NBL STA 14+220	2.8	200.9	199.8	3.0	1.2	17.0	Yes	3 Boreholes ( J-3 that is shared with SBL culvert, J-4 and J-5)	Appendix B
Highway 69 SBL STA 14+220	4.1	199.3	198.9	3.0	1.8	19.3	Yes	3 Boreholes (J-1, J-2 and J-3 that is shared with NBL culvert)	Appendix B
Highway 69 NBL STA 14+734	5.5	195.0	196.4	1.2 (Circular)		30.5	No	3 Boreholes (C88-1 to C88-3)	Appendix C
Highway 69 NBL STA 15+375	4.5	202.5	202.3	3.0	2.4	30.0	No	3 Boreholes (K-3 that is shared with SBL culvert, K-4 and K-5)	Appendix D
Highway 69 SBL STA 15+375	4.4	202.3	202.2	3.0	2.4	30.0	No	3 Boreholes (K-1, K-2 and K-3 that is shared with NBL culvert)	Appendix D
Highway 69 SBL STA 15+775	4.5	203.1	202.6	3.0	3.0	31.7	No	3 Boreholes (L-1, L-2 and L-3)	Appendix E
Highway 69 NBL STA 15+790	4.1	204.0	203.5	3.0	2.4	29.0	No	3 Boreholes (L-4, L-5 and L-6)	Appendix E
Highway 69 NBL STA 16+286	9.1	193.4	193.2	3.0	2.4	47.7	Yes (Median)	3 Boreholes (M-3 that is shared with SBL culvert, M-4 and M-5)	Appendix F
Highway 69 SBL STA 16+312	10.2	193.1	191.1	3.0	2.4	51.9	Yes (Median)	3 Boreholes (M-1, M-2 and M-3 that is shared with NBL culvert)	Appendix F

Note: <sup>1</sup> Invert elevations and culvert dimensions as provided by MMM.

Prepared by: EC

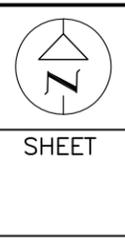
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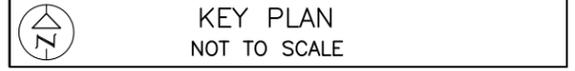
**METRIC**  
 DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.  
 GWP No. 5005-08-00

HIGHWAY 69  
 SITE LOCATION PLAN



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



**REFERENCE**  
 Base Data - MNR NRVIS, obtained 2004, CANMAP v2008.4  
 Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2009  
 Datum : NAD 83 Projection : MTM Zone 10

NO.	DATE	BY	REVISION
Geocres No. 41H-83			
HWY. 69	PROJECT NO. 07-1191-0020		DIST.
SUBM'D. AB	CHKD. AB	DATE: JAN 2013	SITE:
DRAWN: JUL	CHKD. AB	APPD. JMAC	DWG. 1

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

CONT No.  
 WP No. 5005-08-00

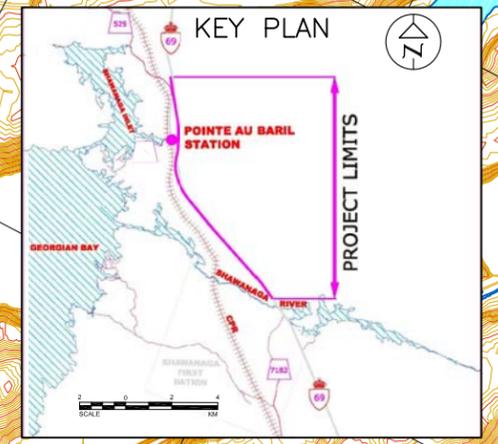
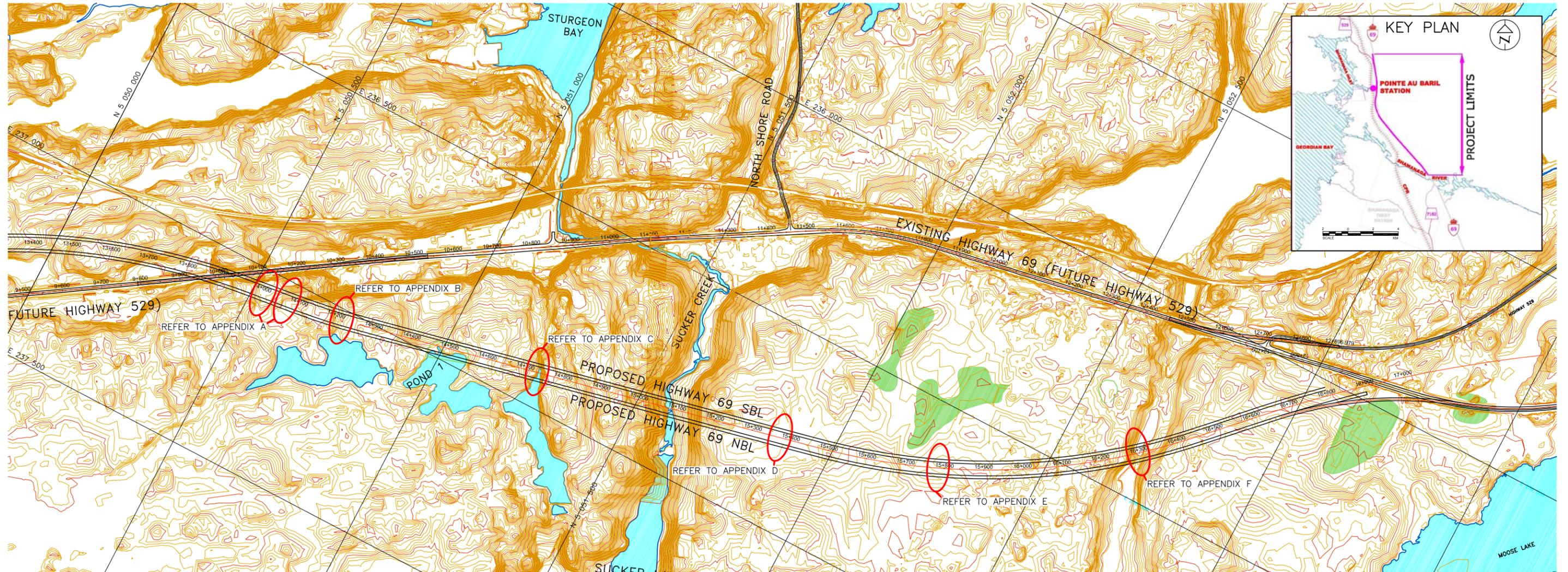


HIGHWAY 69  
 CULVERTS  
 INDEX PLAN

SHEET



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



**LEGEND**

	Approximate Swamp Limits Identified in RFP
	Pond/Open Water
	Actual Swamp Limits Observed in the Field

**REFERENCE**  
 Base plan provided in digital format by MMM Group, drawing file no. Hwy 69 5403-05-00 Design.dwg (received Oct. 2008) and key plan, drawing file no. Hwy 69-529-Project key plan (received Apr. 2008)

P:\E-MAIL - January 24, 2013 - Sudbury\1191\07-1191-0020\_MMM\_Hwy\_69\_Traffic\5005\_Drawing\Location\_Plan\_Drawing\07-1191-0020\_MMM\_Hwy\_69\_Traffic\5005\_Drawing\Location\_Plan.dwg  
 FILENAME: N:\Projects\2010\1191\_Sudbury\1191\07-1191-0020\_MMM\_Hwy\_69\_Traffic\5005\_Drawing\Location\_Plan.dwg

NO.	DATE	BY	REVISION
Geocres No. 41H-83			
HWY. 69			PROJECT NO.07-1191-0020 DIST.
SUBM'D. AB	CHKD. AB	DATE: JAN 2013	SITE:
DRAWN: JJJ	CHKD. SEMC	APPD.	DWG. 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
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

### II. PENETRATION RESISTANCE

#### Standard Penetration Resistance (SPT), N:

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

#### Dynamic Cone Penetration Resistance; $N_d$ :

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

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

#### Piezo-Cone Penetration Test (CPT)

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

### V. MINOR SOIL CONSTITUENTS

Percent 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 (cohesionless) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

### III. SOIL DESCRIPTION

#### (a) Cohesionless Soils

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

#### (b) Cohesive Soils Consistency

	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 <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	relative density (specific gravity, $G_s$ )
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO <sub>4</sub>	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	unit weight

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



## LIST OF SYMBOLS

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

### I. GENERAL

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

### II. STRESS AND STRAIN

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

### III. SOIL PROPERTIES

#### (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
$\gamma'$	unit weight of submerged soil ( $\gamma' = \gamma - \gamma_w$ )
$D_R$	relative density (specific gravity) of solid particles ( $D_R = \rho_s / \rho_w$ ) (formerly $G_s$ )
e	void ratio
n	porosity
S	degree of saturation

#### (a) Index Properties (continued)

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

#### (b) Hydraulic Properties

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

#### (c) Consolidation (one-dimensional)

$C_c$	compression index (normally consolidated range)
$C_r$	recompression index (over-consolidated range)
$C_s$	swelling index
$C_\alpha$	secondary compression index
$m_v$	coefficient of volume change
$C_v$	coefficient of consolidation (vertical direction)
$C_h$	coefficient of consolidation (horizontal direction)
$T_v$	time factor (vertical direction)
U	degree of consolidation
$\sigma'_p$	pre-consolidation stress
OCR	over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$

#### (d) Shear Strength

$\tau_p, \tau_r$	peak and residual shear strength
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	coefficient of friction = $\tan \delta$
$c'$	effective cohesion
$c_u, s_u$	undrained shear strength ( $\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
$p'$	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
$q_u$	compressive strength $(\sigma_1 - \sigma_3)$
$S_t$	sensitivity

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

Notes: 1  
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



# 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

<u>Description</u>	<u>Bedding Plane Spacing</u>
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

<u>Description</u>	<u>Spacing</u>
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

<u>Term</u>	<u>Size*</u>
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: \* Grains greater than 60 microns diameter are visible to the naked eye.

## CORE CONDITION

### Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

### Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

### Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

## DISCONTINUITY DATA

### Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

### Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

### Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

### Abbreviations

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



# **APPENDIX A**

**Highway 69 NBL STA 14+010 and SBL STA 14+075**



# RECORD OF TEST PIT

**Job Number:** 07-1191-0020      **Date:** May 2, 2011      **Datum:** Geodetic

**Contractor:** Weeks      **Machine Type:** Linkbelt 130

**Test Pit No:** I-1-TP    **Test Pit Size:** 1 m x 3 m    **Location:** N 5050536.6  
E 237088.9    **Ground Elevation:** 199.1 m

Depth (m)		Soil Description	Samples		Remarks
From	To		No.	Depth (m)	
0	0.2	Sandy TOPSOIL Black Moist			
0.2	1.1	Silty CLAY, trace sand and cobbles, and trace roots Grey Moist to wet	1	0.5 to 1.1	
1.1		End of Test Pit (Bedrock)			

**Comments**

**Water Conditions in Test Pit**

Seepage into test pit at a depth of 0.5 m below ground surface (Elev. 198.6 m)

**Test Pit No:** I-2-TP    **Test Pit Size:** 3 m x 3 m    **Location:** N 5050534.9  
E 237075.0    **Ground Elevation:** 198.9 m

Depth (m)		Soil Description	Samples		Remarks
From	To		No.	Depth (m)	
0	0.2	Sandy TOPSOIL Black Wet			
0.2	0.5	Silty SAND, some gravel and cobbles, and trace roots Brown Wet			
0.5		End of Test Pit (Bedrock)			

**Comments**

**Water Conditions in Test Pit**

Water level at a depth of 0.2 m below ground surface (Elev. 198.7 m) in open excavation upon completion.

# RECORD OF TEST PIT

**Job Number:** 07-1191-0020      **Date:** May 2, 2011      **Datum:** Geodetic

**Contractor:** Weeks      **Machine Type:** Linkbelt 130

**Test Pit No:** I-4-TP    **Test Pit Size:** 4 m x 4 m    **Location:** N 5050596.5  
E 237044.2    **Ground Elevation:** 202.5 m

Depth (m)		Soil Description	Samples		Remarks
From	To		No.	Depth (m)	
0	0.2	Sandy TOPSOIL, trace gravel, and cobbles Brown Moist			
0.2		End of Test Pit (Bedrock)			

**Comments**

**Water Conditions in Test Pit**  
Dry

**Test Pit No:** I-5-TP    **Test Pit Size:** 1 m x 3 m    **Location:** N 5050594.6  
E 237029.3    **Ground Elevation:** 201.3 m

Depth (m)		Soil Description	Samples		Remarks
From	To		No.	Depth (m)	
0	0.2	Sandy TOPSOIL Black Moist			
0.2	0.8	SAND, some silt, trace gravel, and cobbles and boulders Brown Moist	1	0.2 to 0.8	
0.8		End of Test Pit (Bedrock)			

**Comments**

**Water Conditions in Test Pit**  
Dry

PROJECT <u>07-1191-0020</u>	<b>RECORD OF BOREHOLE No I-3</b>	1 OF 1 <b>METRIC</b>
W.P. <u>5005-08-00</u>	LOCATION <u>N 5050533.0; E 237060.2</u>	ORIGINATED BY <u>EHS</u>
DIST <u>                    </u> HWY <u>69</u>	BOREHOLE TYPE <u>108mm I.D. Continuous Flight Hollow Stem Augers</u>	COMPILED BY <u>EC</u>
DATUM <u>Geodetic</u>	DATE <u>May 2, 2011</u>	CHECKED BY <u>AB</u>

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
198.3	GROUND SURFACE																
0.0	Sandy TOPSOIL		1a														
0.2	Black Moist to wet		1b	SS	1												
197.5	SAND and SILT, trace clay																
0.8	Very loose Brown Moist to wet		2	SS	11												
	SILTY CLAY, trace sand																
	Stiff Brown																
196.4	Wet		3a	SS	5												
1.9	SAND and SILT, some clay		3b														0 42 46 12
195.8	Compact Brown to grey		4	SS	8/0.1												
2.5	Wet																
	END OF BOREHOLE SPOON AND AUGER REFUSAL																
	Note:  1. Water level at a depth of 0.8 m below ground surface (Elev. 197.5 m) upon completion of drilling.																

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

PROJECT <u>07-1191-0020</u>	<b>RECORD OF BOREHOLE No I-6</b>	1 OF 1 <b>METRIC</b>
W.P. <u>5005-08-00</u>	LOCATION <u>N 5050593.0; E 237015.4</u>	ORIGINATED BY <u>EHS</u>
DIST <u>          </u> HWY <u>69</u>	BOREHOLE TYPE <u>108mm I.D. Continuous Flight Hollow Stem Augers</u>	COMPILED BY <u>EC</u>
DATUM <u>Geodetic</u>	DATE <u>May 2, 2011</u>	CHECKED BY <u>AB</u>

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
197.8	GROUND SURFACE																
0.0	Sandy TOPSOIL																
0.2	Black Moist to wet		1	AS	-	∇											
196.8	SAND containing organics, some silt, trace gravel		2a				197										
1.0	Brown Wet		2b	SS	13												0 5 38 57
	SILTY CLAY, trace sand Stiff to very stiff																
195.8	Brown Wet		3	SS	18		196										
2.0	SAND and SILT Very dense																
195.1	Brown to grey Wet		4	SS	86/0.2												
2.7	GNEISS (BEDROCK)						195										
	Bedrock cored from 2.7 m depth to 6.2 m depth.		1	RC	REC 100%												RQD = 88%
	For coring details see Record of Drillhole I-6.		2	RC	REC 100%		194										RQD = 100%
			3	RC	REC 100%		193										RQD = 100%
191.6	END OF BOREHOLE						192										
6.2	Note:  1. Water level at a depth of 0.4 m below ground surface (Elev. 197.4 m) upon completion of drilling.																

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

PROJECT: 07-1191-0020

# RECORD OF DRILLHOLE: I-6

SHEET 1 OF 1

LOCATION: N 5050593.0 ; E 237015.4

DRILLING DATE: May 2, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Landcore

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY		Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION				
							TOTAL CORE %	SOLID CORE %			TYPE AND SURFACE DESCRIPTION		Jr	Ja	Jn	k, cm/s				10 <sup>0</sup>	10 <sup>1</sup>	10 <sup>2</sup>	10 <sup>3</sup>
							FLUSH	FLT			BD	PL	PO	BR	NOTE: For additional abbreviations refer to list of abbreviations & symbols.								
		REFER TO PREVIOUS PAGE		195.1																			
3	NW	GNEISS Coarse grained Fresh Strong Grey		2.7	1						JUR												
4					2						JUR JUR JUR JPLR JIR JPLR JUR JFOR								UCS = 78 MPa				
5	NO Coring May 2, 2011				3						JIR												
6		END OF DRILLHOLE		191.6							JSTR												
6.2				6.2																			

SUD-RCK-07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

DEPTH SCALE

1 : 50



LOGGED: EHS

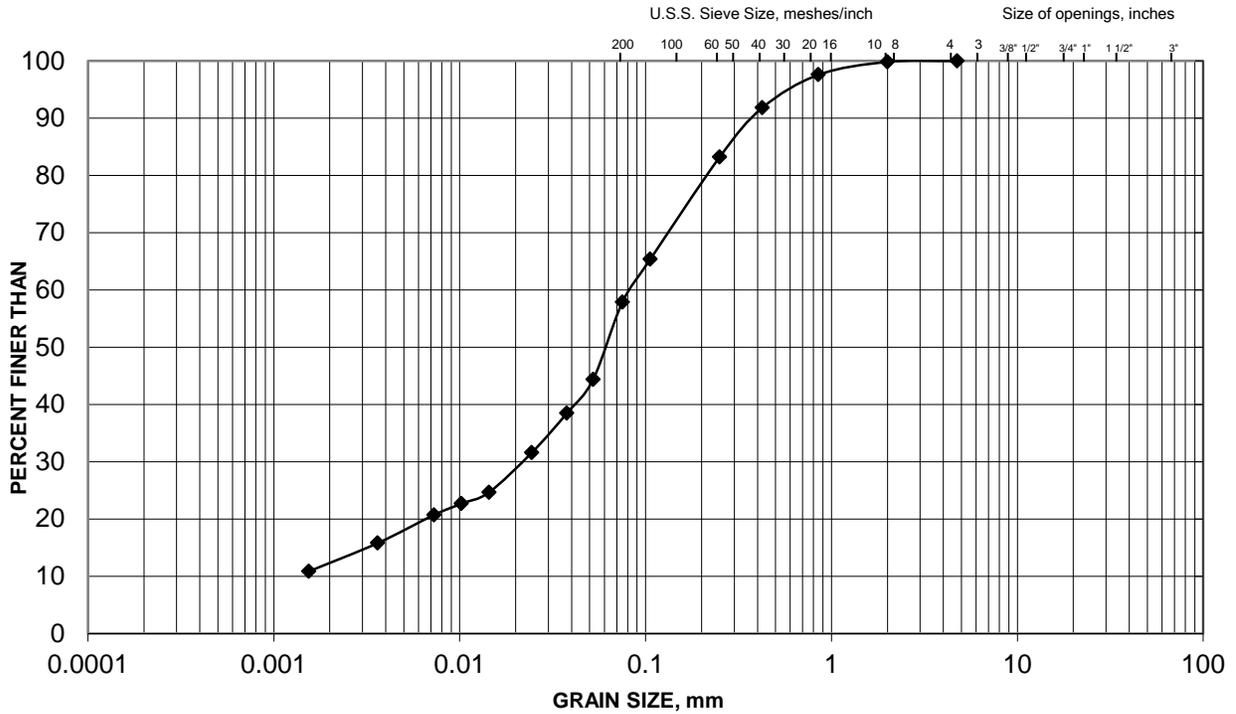
CHECKED: AB

# GRAIN SIZE DISTRIBUTION

**Sand and Silt**  
**Highway 69 NBL STA 14+010**

**FIGURE**

**A1**



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		

**LEGEND**

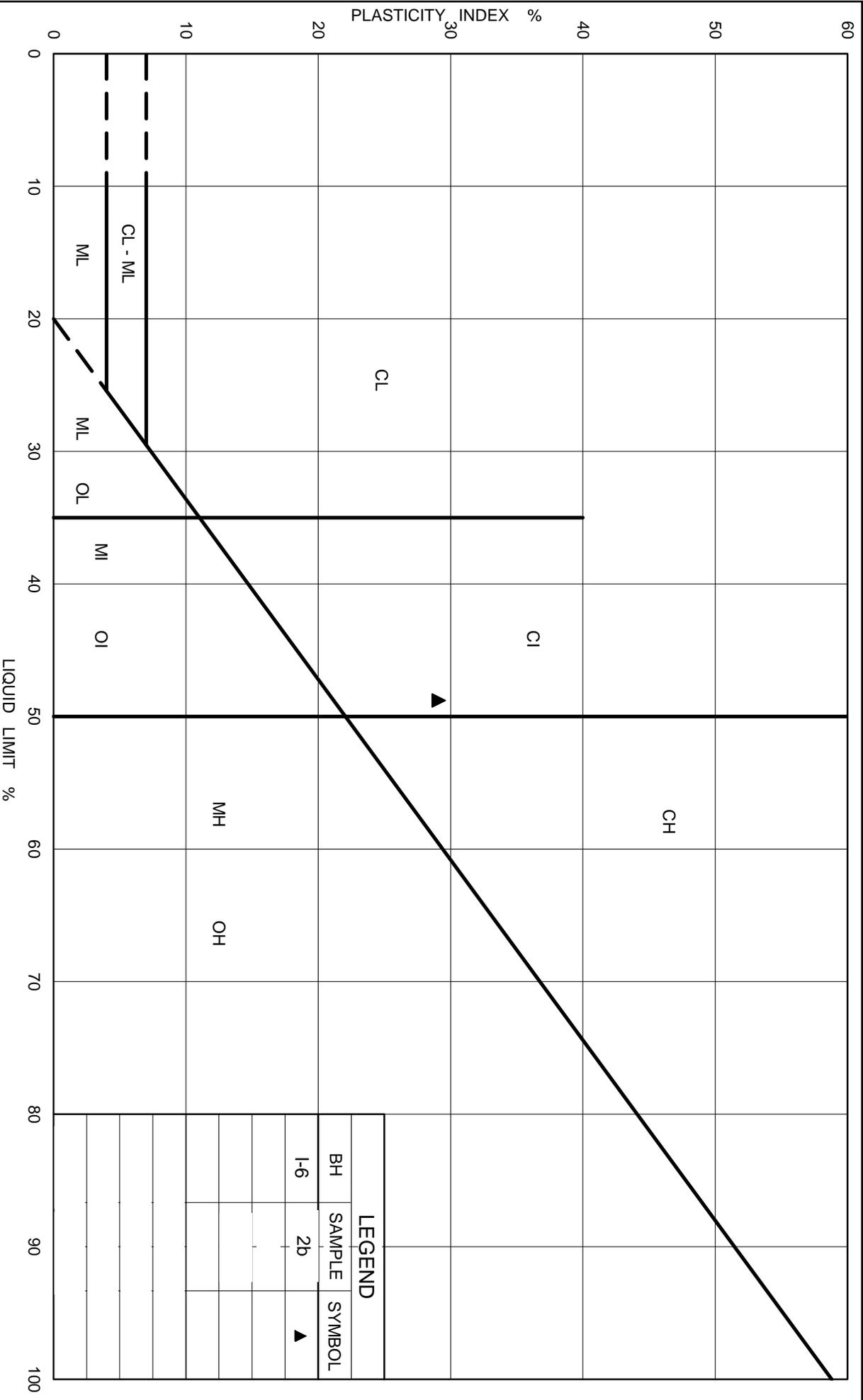
SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
◆	I-3	3b	196.3

Project Number: 07-1191-0020-C2

Checked By: EC/AB

**Golder Associates**

Date: January 2013



LEGEND		
BH	SAMPLE	SYMBOL
I-6	2b	▲

PLASTICITY CHART

Ministry of Transportation

Silty Clay  
Highway 69 SBL STA 14+075

Figure A2  
Project No. 07-1191-0020-C2  
Checked By: EC/AB



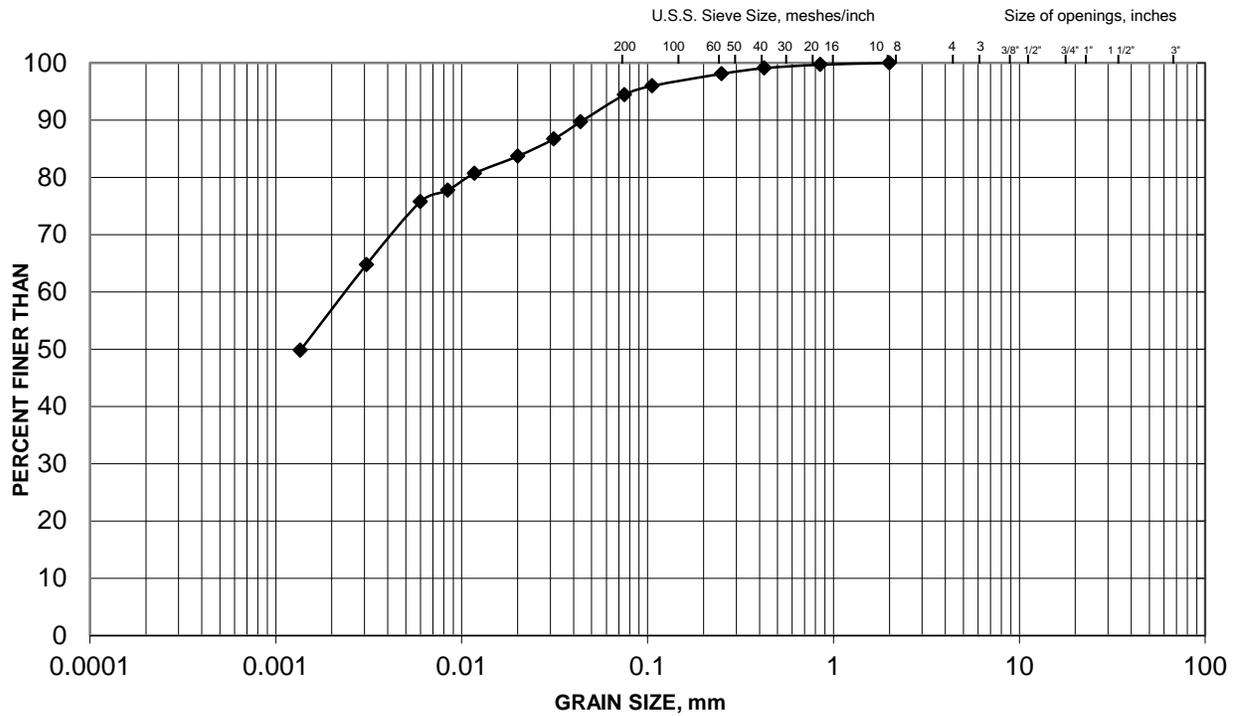
Ontario

**GRAIN SIZE DISTRIBUTION**

**FIGURE**

**Silty Clay  
Highway 69 SBL STA 14+075**

**A3**



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		

**LEGEND**

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—◆—	I-6	2b	196.7

Project Number: 07-1191-0020-C2

Checked By: EC/AB

**Golder Associates**

Date: January 2013



# **APPENDIX B**

## **Highway 69 NBL and SBL STA 14+220**

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

CONT No.  
WP No. 5133-12-24 & 25

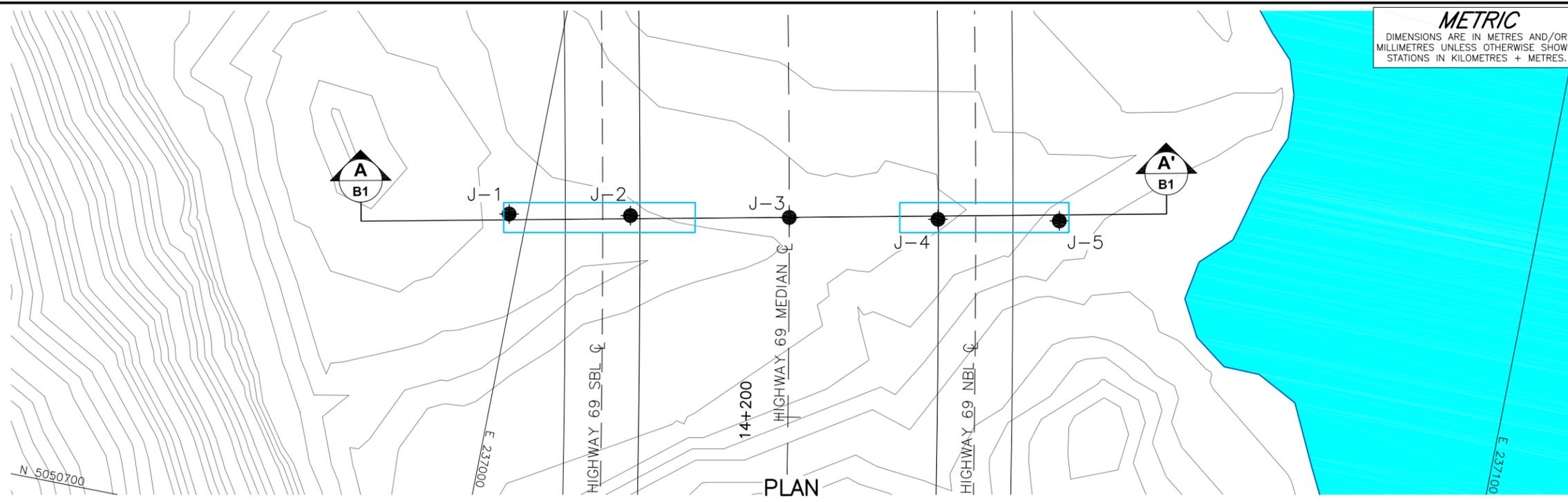


HIGHWAY 69  
CULVERT AT STA. 14+220 (NBL & SBL)  
BOREHOLE LOCATIONS AND SOIL STRATA

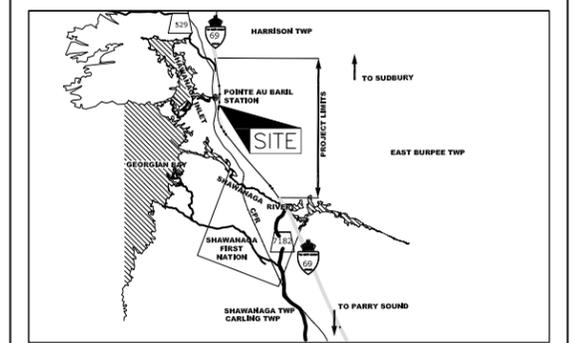
SHEET



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



**PLAN**  
SCALE  
5 0 5 10 m



**KEY PLAN**  
SCALE  
5 0 5 km

**LEGEND**

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

**BOREHOLE CO-ORDINATES**

No.	ELEVATION	NORTHING	EASTING
J-1	198.8	5050735.2	236998.2
J-2	199.1	5050737.4	237010.2
J-3	199.5	5050740.3	237025.9
J-4	199.8	5050743.0	237040.6
J-5	200.8	5050745.2	237052.6

**NOTES**

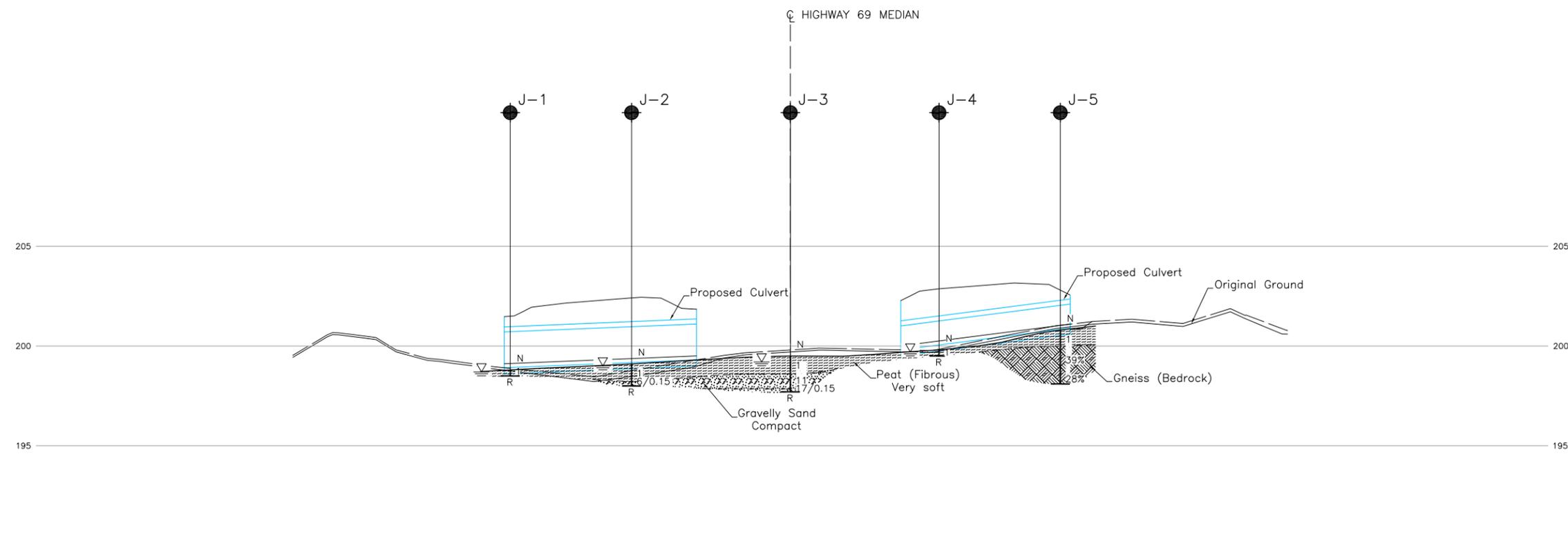
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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 plan provided in digital format by MMM Group, drawing file no. Hwy 69 5403-05-00 Design.dwg (received Oct. 2008) and key plan, drawing file no. Hwy 69-529-Project key plan (received Apr. 2008). Culvert locations provided by MMM in drawing file no. 5403-05-00 culverts.dwg (received Nov 2010)



**A-A' PROFILE ALONG CULVERT**  
HIGHWAY 69  
HORIZONTAL SCALE  
5 0 5 10 m  
VERTICAL SCALE  
2.5 0 2.5 5 m



NO.	DATE	BY	REVISION

Geocres No. 41H-83

Hwy. 69	PROJECT NO. 07-1191-0020	DIST.
SUBM'D. EC	CHKD. AB	DATE: JAN 2013
DRAWN: JJJ	CHKD.	APPD. JMAC
		SITE: 44-596/C1/C2
		DWG. B1



PROJECT 07-1191-0020 **RECORD OF BOREHOLE No J-1** 1 OF 1 **METRIC**

W.P. 5005-08-00 LOCATION N 5050735.2; E 236998.2 ORIGINATED BY ID

DIST HWY 69 BOREHOLE TYPE Portable Equipment COMPILED BY EC

DATUM Geodetic DATE February 23, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W <sub>p</sub>	W			W <sub>L</sub>	GR
198.8	GROUND SURFACE																	
0.0 198.8 0.3	PEAT (Fibrous) Very soft Black Wet  END OF BOREHOLE SPOON REFUSAL  Note:  1. Water level at a depth of 0.1 m below ground surface (Elev. 198.7 m) upon completion of drilling.		1	SS	1													

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

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

PROJECT <u>07-1191-0020</u>	<b>RECORD OF BOREHOLE No J-2</b>	1 OF 1 <b>METRIC</b>
W.P. <u>5005-08-00</u>	LOCATION <u>N 5050737.4; E 237010.2</u>	ORIGINATED BY <u>ID</u>
DIST <u>        </u> HWY <u>69</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>	COMPILED BY <u>EC</u>
DATUM <u>Geodetic</u>	DATE <u>February 23, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W <sub>p</sub>	W			W <sub>L</sub>	GR
199.1	GROUND SURFACE																	
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	1													
198.2																		
1.1	Gravelly SAND Compact Brown Wet  END OF BOREHOLE SPOON REFUSAL  Note:  1. Water level at a depth of 0.1 m below ground surface (Elev. 199.0 m) upon completion of drilling.		2	SS	6/0.15													

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

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



PROJECT 07-1191-0020 **RECORD OF BOREHOLE No J-3** 1 OF 1 **METRIC**

W.P. 5005-08-00 LOCATION N 5050740.3; E 237025.9 ORIGINATED BY ID

DIST HWY 69 BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring COMPILED BY EC

DATUM Geodetic DATE February 23, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80					
199.5	GROUND SURFACE															
0.0	PEAT, some sand (Fibrous) Very soft Black Wet		1	SS	1	▽										
198.6																
0.9	Gravelly SAND Compact Brown Wet		2	SS	11							o				
197.7																
1.8	END OF BOREHOLE SPOON REFUSAL  Note: 1. Water level at a depth of 0.3 m below ground surface (Elev. 199.2 m) upon completion of drilling.		3	SS	17/0.15											

SUD-MTD 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

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

PROJECT <u>07-1191-0020</u>	<b>RECORD OF BOREHOLE No J-4</b>	1 OF 1 <b>METRIC</b>
W.P. <u>5005-08-00</u>	LOCATION <u>N 5050743.0; E 237040.6</u>	ORIGINATED BY <u>ID</u>
DIST <u>        </u> HWY <u>69</u>	BOREHOLE TYPE <u>Portable Equipment</u>	COMPILED BY <u>EC</u>
DATUM <u>Geodetic</u>	DATE <u>February 23, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W <sub>p</sub>	W			W <sub>L</sub>	GR
199.8	GROUND SURFACE																	
0.0 199.5 0.3	PEAT (Fibrous) Very soft Black Wet  END OF BOREHOLE SPOON REFUSAL  Note:  1. Water level at a depth of 0.1 m below ground surface (Elev. 199.7 m) upon completion of drilling.		1	SS	1													

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

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

PROJECT <u>07-1191-0020</u>	<b>RECORD OF BOREHOLE No J-5</b>	1 OF 1 <b>METRIC</b>
W.P. <u>5005-08-00</u>	LOCATION <u>N 5050745.2; E 237052.6</u>	ORIGINATED BY <u>ID</u>
DIST <u>HWY 69</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>	COMPILED BY <u>EC</u>
DATUM <u>Geodetic</u>	DATE <u>February 23 to 25, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100
200.8	GROUND SURFACE																
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	1												
200.0	GNEISS (BEDROCK)  Bedrock cored from 0.8 m depth to 2.7 m depth.  For coring details see Record of Drillhole J-5.		1	RC	REC 100%	200										RQD = 39%	
0.8			199														
198.1			2	RC	REC 100%												
2.7	END OF BOREHOLE  Note: 1. Borehole dry upon completion of drilling.																

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

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

PROJECT: 07-1191-0020

# RECORD OF DRILLHOLE: J-5

SHEET 1 OF 1

LOCATION: N 5050745.2 ;E 237052.6

DRILLING DATE: February 23 to 25, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Equipment

DRILLING CONTRACTOR: Landcore

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY		Diameter Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION					
							TOTAL CORE %	SOLID CORE %			B Angle	DIP w/EL. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn				k, cm/s	10 <sup>0</sup>	10 <sup>1</sup>	10 <sup>2</sup>	10 <sup>3</sup>
							FLUSH	FLUSH			FLUSH	FLUSH	FLUSH	FLUSH	FLUSH	FLUSH				FLUSH	FLUSH	FLUSH	FLUSH	FLUSH
		REFER TO PREVIOUS PAGE		200.0																				
1	NQ Coring January 24 and 25, 2011	GNEISS Fine to medium grained Slightly weathered Very strong Pinkish grey		0.8																				
2				Grey 100																				
2				Grey 100																				
3		END OF DRILLHOLE		198.1																				
		Note: 1. Highly fractured between 1.1 m and 1.4 m and 2.4 m and 2.7m depth.		2.7																				

UCS = 105 MPa

SUD-RCK 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:





# **APPENDIX C**

**Highway 69 NBL and SBL STA 14+734**

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

CONT No.  
WP No. 5005-08-00

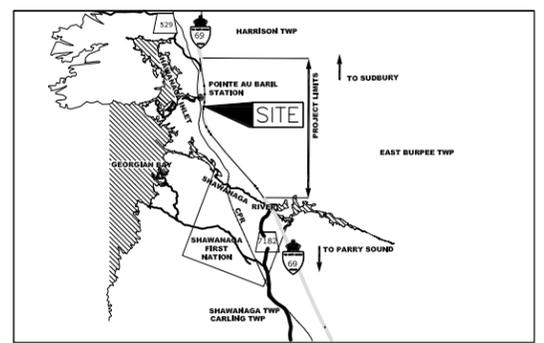


HIGHWAY 69  
CULVERT AT STA. 14+734 (NBL)  
BOREHOLE LOCATIONS AND SOIL STRATA

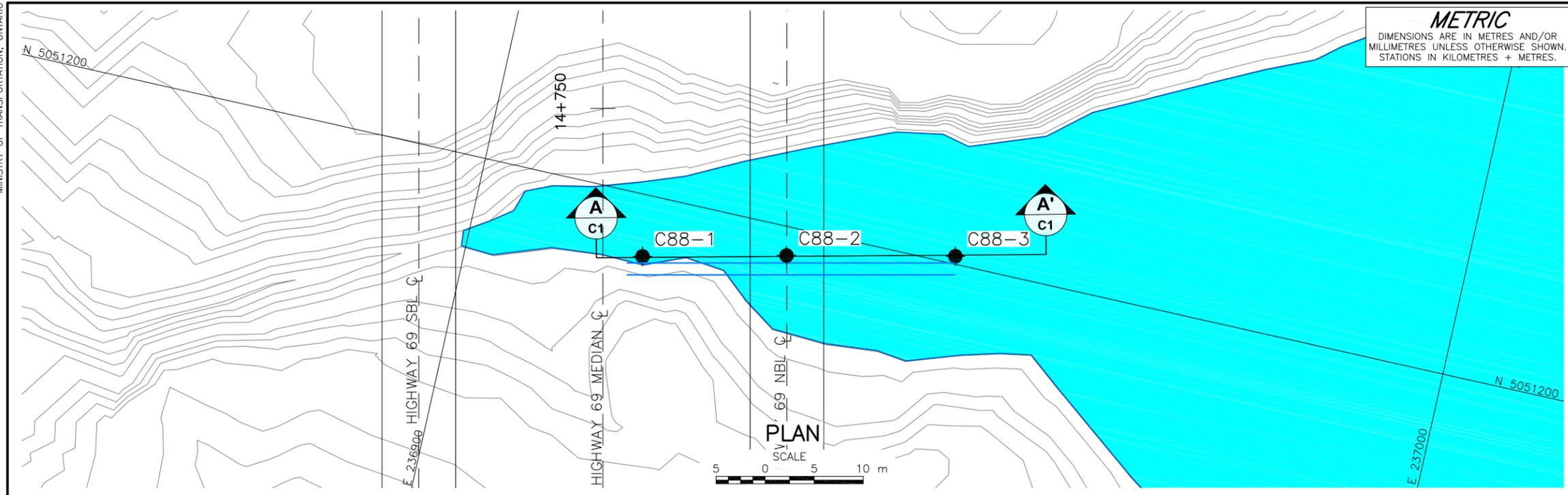
SHEET



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



**KEY PLAN**  
SCALE  
5 0 5 km



**PLAN**  
SCALE  
5 0 5 10 m

**LEGEND**

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

**BOREHOLE CO-ORDINATES**

No.	ELEVATION	NORTHING	EASTING
C88-1	195.5	5051243.8	236917.8
C88-2	195.5	5051247.1	236932.1
C88-3	195.5	5051250.8	236948.9

**NOTES**

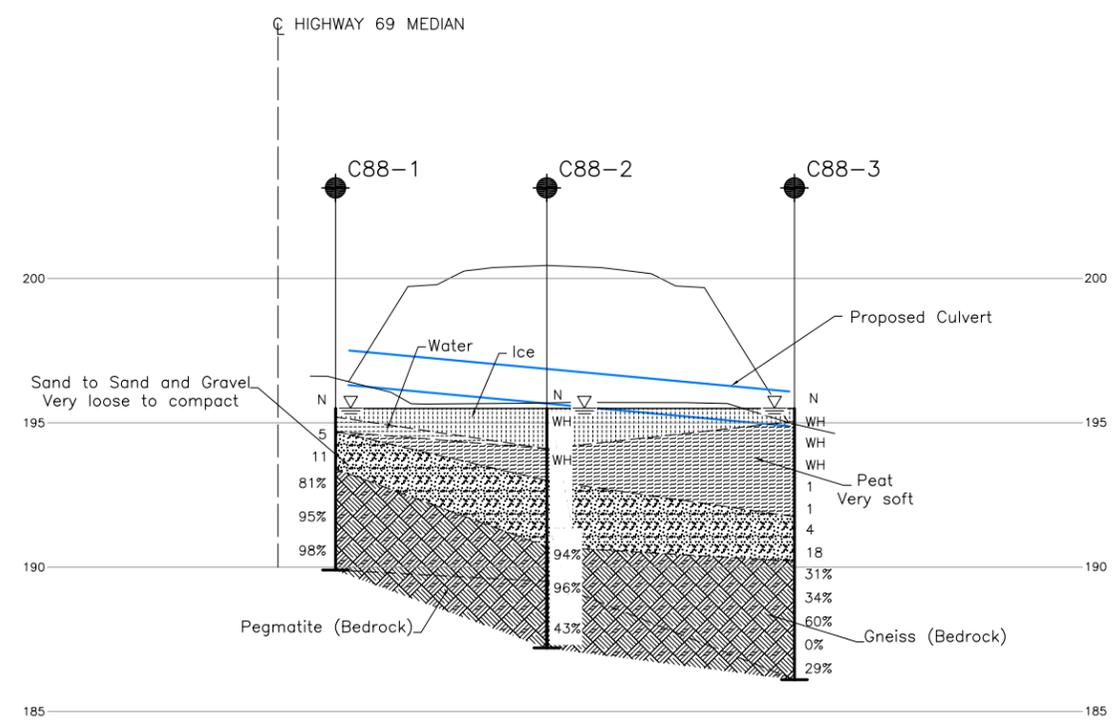
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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 plan provided in digital format by MMM Group, drawing file no. Hwy 69 5403-05-00 Design.dwg (received Oct. 2008) and key plan, drawing file no. Hwy 69-529-Project key plan (received Apr. 2008). Culvert locations provided by MMM in drawing file no. Plan & XS CV-203-( Hwy 69-Harrison-NBL-Sta 14+734).dwg (received March 2012)



**A-A' PROFILE ALONG CULVERT HIGHWAY 69**  
C1

HORIZONTAL SCALE  
5 0 5 10 m  
2.5 0 2.5 5 m



NO.	DATE	BY	REVISION

Geocres No. 41H-83

HWY. 69	PROJECT NO. 07-1191-0020	DIST.
SUBM'D. EC	CHKD. AB	DATE: JAN 2013
DRAWN: JJJ	CHKD.	APPD. JMAC
		SITE: -
		DWG. C1

PROJECT <u>07-1191-0020</u>	<b>RECORD OF BOREHOLE No C88-1</b>	1 OF 1 <b>METRIC</b>
W.P. <u>5403-05-00</u>	LOCATION <u>N 5051243.8; E 236917.8</u>	ORIGINATED BY <u>TDM</u>
DIST <u>                    </u> HWY <u>69</u>	BOREHOLE TYPE <u>Portable Equipment, BW Casing, Wash Boring</u>	COMPILED BY <u>MM</u>
DATUM <u>Geodetic</u>	DATE <u>March 10 and 11, 2009</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100						
195.5	ICE SURFACE															
0.0	ICE															
195.2																
0.3	WATER															
194.7																
0.8	SAND and GRAVEL Loose to compact Grey Wet		1	SS	5											
			2	SS	11											
193.4																
2.1	GNEISS (BEDROCK)															
	Bedrock cored from 2.1 m depth to 5.6 m depth.  For coring details refer to Record of Drillhole C88-1.		1	RC	REC 100%											RQD = 81%
			2	RC	REC 100%											RQD = 95%
			3	RC	REC 100%											RQD = 98%
189.9																
5.6	END OF BOREHOLE															
	Notes:  1. Water level at ice surface (Elev. 195.5 m) upon completion of drilling.  2. Borehole advanced using portable drilling equipment with a half weight hammer. SPT 'N'-values shown have been adjusted to infer values that would have been obtained with a standard weight hammer.															

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

PROJECT: 07-1191-0020

# RECORD OF DRILLHOLE: C88-1

SHEET 1 OF 1

LOCATION: N 5051243.8 ; E 236917.8

DRILLING DATE: March 10 and 11, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Equipment

DRILLING CONTRACTOR: OGS Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY			Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION				
							TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	Type and Surface Description	Jr	Ja	Jn				k, cm/s	10 <sup>0</sup>	10 <sup>1</sup>	10 <sup>2</sup>
							FLUSH	FLY			FR	FR	FR	FR	FR	FR				FR	FR	FR	FR
		Refer to Previous Page		193.4																			
3	Thin Wall NQ Coring March 11, 2009	GNEISS Fine to coarse grained Strong Sound Grey		2.1	1																		
4				2																			
5				3																			
6		END OF DRILLHOLE		189.9																			
				5.6																			

UCS = 72 MPa

SUD-RCK 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:



PROJECT <u>07-1191-0020</u>	<b>RECORD OF BOREHOLE No C88-2</b>	1 OF 1 <b>METRIC</b>
W.P. <u>5403-05-00</u>	LOCATION <u>N 5051247.1; E 236932.1</u>	ORIGINATED BY <u>TDM</u>
DIST <u>                    </u> HWY <u>69</u>	BOREHOLE TYPE <u>Portable Equipment, BW Casing, Wash Boring</u>	COMPILED BY <u>MM</u>
DATUM <u>Geodetic</u>	DATE <u>March 10 to 12, 2009</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100						
195.5	ICE SURFACE															
0.0	ICE															
194.1			1	SS	WH											
1.4	PEAT (Amorphous) Very soft Brown Wet		2	SS	WH									979.7		
193.0			3	SS	WH											
2.5	SAND and GRAVEL, with cobbles and boulders Grey Wet		4	RC	REC 100%											
190.7																
4.8	GNEISS to PEGMATITE (BEDROCK)		1	RC	REC 100%											RQD = 94%
	Bedrock cored from 4.8 m depth to 8.3 m depth.  For coring details refer to Record of Drillhole C88-2.		2	RC	REC 98%											RQD = 96%
			3	RC	REC 86%											RQD = 43%
187.2																
8.3	END OF BOREHOLE															
	Notes:  1. Water level at ice surface (Elev. 195.5 m) upon completion of drilling.  2. Borehole advanced using portable drilling equipment with a half weight hammer. SPT 'N'-values shown have been adjusted to infer values that would have been obtained with a standard weight hammer.															

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

PROJECT: 07-1191-0020

# RECORD OF DRILLHOLE: C88-2

SHEET 1 OF 1

LOCATION: N 5051247.1 ;E 236932.1

DRILLING DATE: March 10 to 12, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Equipment

DRILLING CONTRACTOR: OGS Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY			Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION	
							FLUSH	TOTAL CORE %			SOLID CORE %	B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja				Jn
								88888888			88888888									
		Refer to Previous Page		190.7																
5		GNEISS Fine to coarse grain Slightly to moderately weathered Pinkish grey		4.8								JFOR								
					1							JFOR								
6		PEGMATITE Fine to coarse grain Slightly to moderately weathered Brown		189.5								JIR								
					2							JUR								
7												JUR								
												JUR								
8		Broken core from 7.8 m to 8.3 m depth.			3							JUR								
												JUR								
												JUR								
		END OF DRILLHOLE		187.2																
				8.3																

DEPTH SCALE

1 : 50



LOGGED: TDM

CHECKED: AB

SUD-RCK 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

PROJECT <u>07-1191-0020</u>	<b>RECORD OF BOREHOLE No C88-3</b>	1 OF 1 <b>METRIC</b>
W.P. <u>5403-05-00</u>	LOCATION <u>N 5051250.8; E 236948.9</u>	ORIGINATED BY <u>TDM</u>
DIST <u>HWY 69</u>	BOREHOLE TYPE <u>Portable Equipment, BW Casing, Wash Boring</u>	COMPILED BY <u>MM</u>
DATUM <u>Geodetic</u>	DATE <u>March 10 and 12, 2009</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
195.5	ICE SURFACE															
0.0	ICE															
195.1			1	SS	WH											
0.4	PEAT (Amorphous) Very soft Brown Wet		2	SS	WH											
			3	SS	WH											
			4	SS	1											
			5	SS	1											
191.7																
3.8	SAND, some gravel Very loose to compact Grey Wet		6	SS	4											
			7	SS	18											17 70 (13)
190.2																
5.3	GNEISS (BEDROCK)  Bedrock cored from 5.3 m depth to 9.4 m depth.  For coring details refer to Record of Drillhole C88-3.		1	RC	REC 100%											RQD = 31%
			2	RC	REC 100%											RQD = 34%
			3	RC	REC 100%											RQD = 60%
			4	RC	REC 100%											RQD = 0%
			5	RC	REC 100%											RQD = 29%
186.1																
9.4	END OF BOREHOLE  Notes: 1. Water level at ice surface (Elev. 195.5 m) upon completion of drilling. 2. Borehole advanced using portable drilling equipment with a half weight hammer. SPT 'N'-values shown have been adjusted to infer values that would have been obtained with a standard weight hammer.															

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

PROJECT: 07-1191-0020

# RECORD OF DRILLHOLE: C88-3

SHEET 1 OF 1

LOCATION: N 5051250.8 ; E 236948.9

DRILLING DATE: March 10 and 12, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Equipment

DRILLING CONTRACTOR: OGS Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY			Diameter Point Load (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION				
							TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn				k, cm/s	10 <sup>0</sup>	10 <sup>1</sup>	10 <sup>2</sup>
							000000	000000			000000	000000	000000	000000	000000	000000				000000	000000	000000	000000
		Refer to Previous Page		190.2																			
6	Thin Wall (NO Coring) March 12, 2009	GNEISS Fine to coarse grained Slightly to moderately weathered Medium to strong Pinkish grey		5.3	1																		
		Heavily jointed from 5.3 m depth to 6.9 m depth, from 7.6 m depth to 8.7 m depth and from 9.0 m depth to 9.4 m depth.		2																			
7				3								JFOR											
8				4																			
9				5															UCS = 30 MPa				
9		END OF DRILLHOLE		186.1																			
10				9.4																			

SUD-RCK 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

DEPTH SCALE

1 : 50



LOGGED: TDM

CHECKED: AB

**TABLE C1  
UNIAXIAL COMPRESSION STRENGTH TEST RESULTS  
HIGHWAY 69 NBL – CULVERT AT STA 14+734  
GWP 5005-08-00**

<b>Borehole Number</b>	<b>Sample Depth (m)</b>	<b>Sample Elevation (m)</b>	<b>Rock Type</b>	<b>Core Diameter (mm)</b>	<b>Uniaxial Compressive Strength (MPa)</b>
C88-1	4.3	191.2	Gneiss	51	72
C88-3	8.8	186.7	Gneiss	51	30

Compiled by: AMW  
Checked by: AB  
Reviewed by: JMAC

**TABLE C2  
POINT LOAD STRENGTH TEST RESULTS  
HIGHWAY 69 NBL – CULVERT AT STA 14+734  
GWP 5005-08-00**

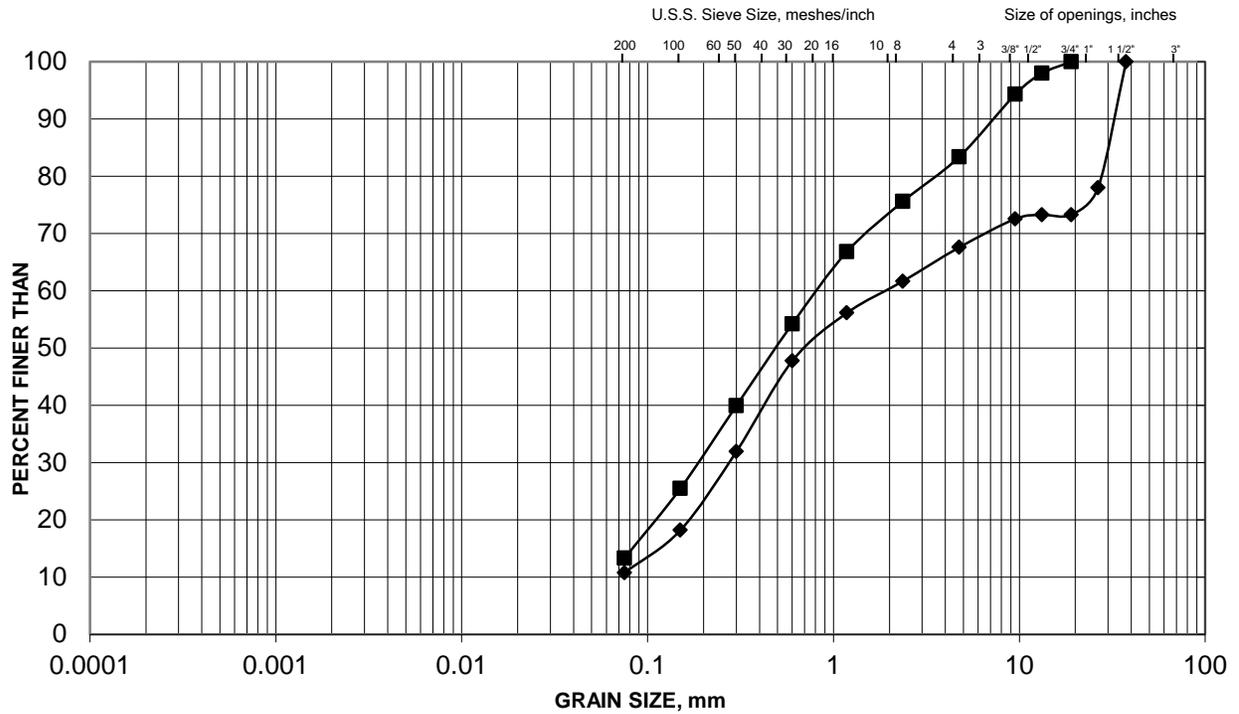
Borehole Number	Sample Depth <sup>1</sup> (m)	Sample Elevation (m)	Rock Type	Test Type <sup>2</sup>	Core Diameter (mm)	Ram Pressure (MPa)	Load (kN)	I <sub>s</sub> Diametral <sup>2</sup> (MPa)	I <sub>s</sub> 50 mm <sup>2</sup> (MPa)	Approximate UCS <sup>2</sup> (MPa)
C88-1	3.0	192.5	Gneiss	D	51	5.4	0.00512	2.0	2.0	54
C88-1	3.9	191.5	Gneiss	D	51	7.3	0.00690	2.7	2.7	73
C88-1	5.5	190.0	Gneiss	D	51	8.3	0.00791	3.1	3.1	84
C88-3	6.0	189.5	Gneiss	D	51	6.7	0.00633	2.5	2.5	59
C88-3	7.3	188.2	Gneiss	D	51	13.7	0.01299	5.1	5.1	138
C88-3	8.2	187.3	Gneiss	D	51	2.9	0.00279	1.1	1.1	30

- NOTES:**
1. Depths are given below the ground surface at the borehole location.
  2. Where: D = Diametral test;  
I<sub>s</sub> Diametral = Uncorrected point load strength;  
I<sub>s</sub> 50 mm = Corrected point load strength; and  
UCS = Uniaxial compressive strength = I<sub>s</sub> 50 mm X C. The value of 27 has been used for the Gneiss, based on correlation with UCS for this site (ASTM D5731-08 as presented in "Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock Mech. Sci. and Geomechanical Abst., Vol 22, No. 2, 1985, pp. 51-60.

Compiled by: AMW  
Checked by: AB  
Reviewed by: JMAC

**GRAIN SIZE DISTRIBUTION**  
**Sand to Sand and Gravel**

**FIGURE**  
**C1**



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		

**LEGEND**

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
◆	C88-1	2	193.7
■	C88-3	7	190.6

Project Number: 07-1191-0020-C2

Checked By: AB

**Golder Associates**

Date: January 2013



# **APPENDIX D**

## **Highway 69 NBL and SBL STA 15+375**

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

CONT No.  
WP No.5133-12-26 & 27

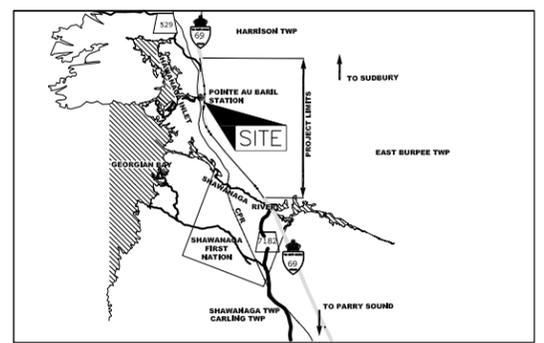


HIGHWAY 69  
CULVERT AT STA. 15+375 (NBL & SBL)  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



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



KEY PLAN  
SCALE  
0 5 km

**LEGEND**

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
K-1	202.8	5051860.0	236740.5
K-2	202.7	5051863.7	236757.1
K-3	202.6	5051867.4	236773.7
K-4	202.1	5051871.1	236790.3
K-5	202.6	5051874.9	236806.9

**NOTES**

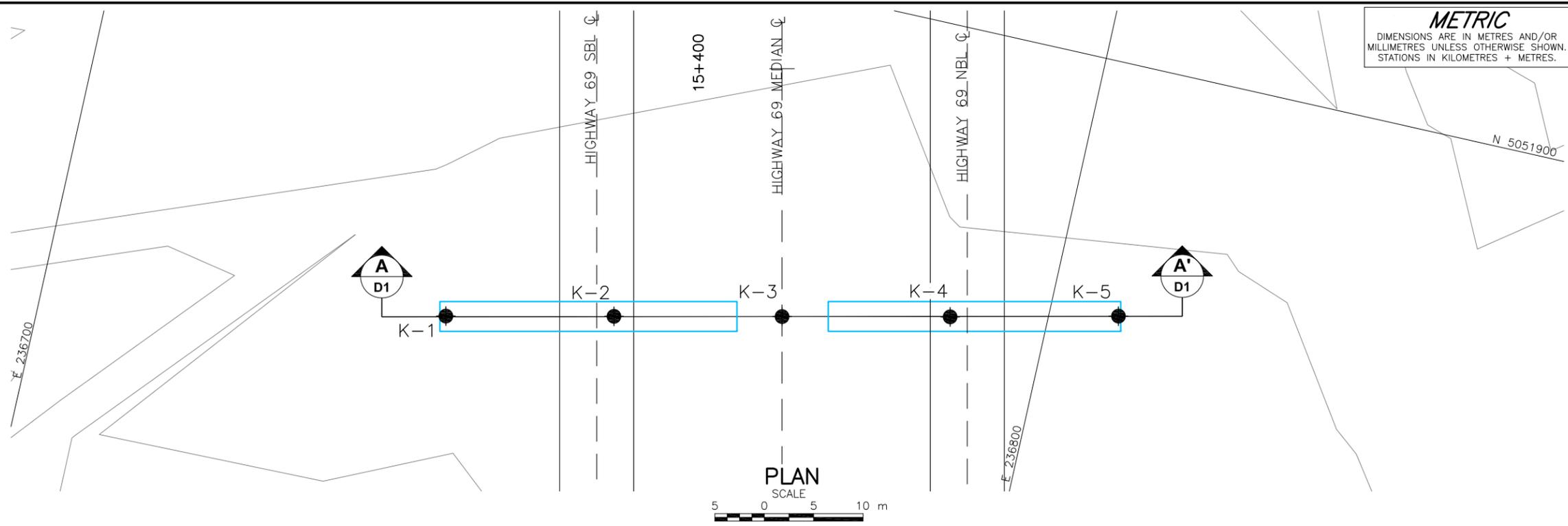
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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.

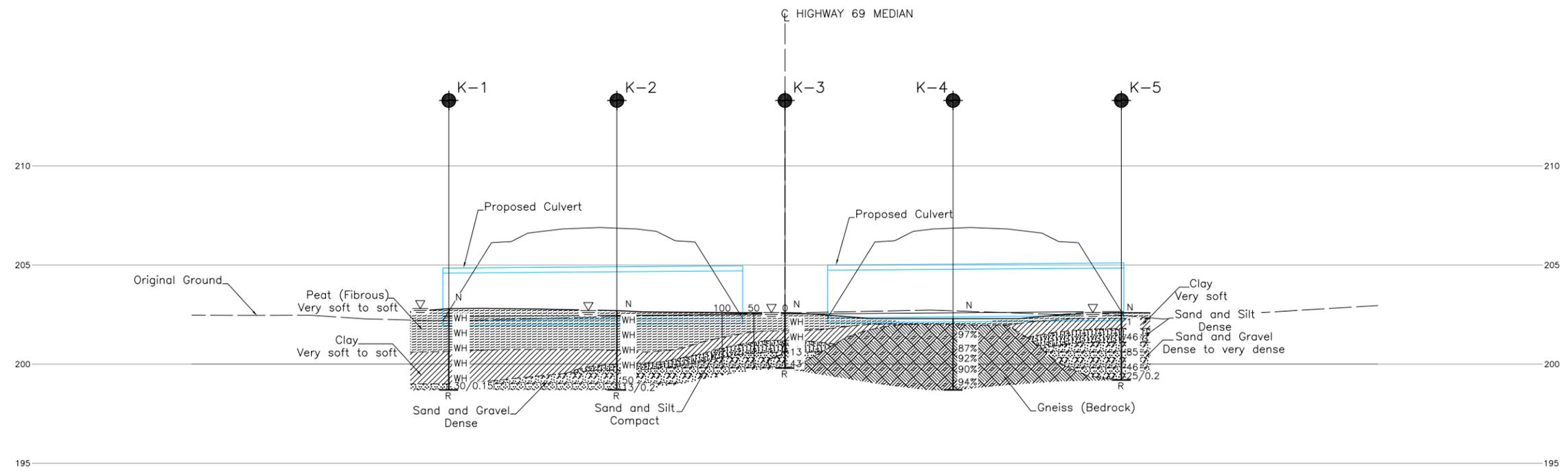
**REFERENCE**

Base plan provided in digital format by MMM Group, drawing file no. Hwy 69 5403-05-00 Design.dwg (received Oct. 2008) and key plan, drawing file no. Hwy 69-529-Project key plan (received Apr. 2008). Culvert locations provided by MMM in drawing file no. 5403-05-00 culverts.dwg (received Nov 2010)



**PLAN**

SCALE  
0 5 10 m



**PROFILE ALONG CULVERT**  
HIGHWAY 69

HORIZONTAL SCALE  
0 5 10 m

VERTICAL SCALE  
0 2.5 5 m

PLOT DATE: January 24, 2013  
 FILENAME: N:\action\2010\1191\07-1191-0020\MMM Hwy 69 Training\5000\Drawings\SAB\Culverts\Culverts 2.dwg



NO.	DATE	BY	REVISION

Geocres No. 41H-83

Hwy. 69	PROJECT NO. 07-1191-0020	DIST.
SUBM'D. EC	CHKD. AB	DATE: JAN 2013
DRAWN: JJJ	CHKD.	APPD. JMAC
		SITE: 44-597/C1/C2
		DWG. D1

PROJECT <u>07-1191-0020</u>	<b>RECORD OF BOREHOLE No K-1</b>	1 OF 1 <b>METRIC</b>
W.P. <u>5005-08-00</u>	LOCATION <u>N 5051860.0; E 236740.5</u>	ORIGINATED BY <u>EC</u>
DIST <u>                    </u> HWY <u>69</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>	COMPILED BY <u>EC</u>
DATUM <u>Geodetic</u>	DATE <u>March 16, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100						
202.8	GROUND SURFACE															
0.0	PEAT (Fibrous) Very soft Black Moist to wet		1	SS	WH											
			2	SS	WH											669.1
			3	SS	WH											
200.6																
2.2	CLAY Soft Grey Wet		4	SS	WH											107.4
	Vane advanced before split spoon for sample 5.		5	SS	WH											
199.0																
198.7	SAND and GRAVEL, trace to some silt Dense Grey Wet		6	SS	30/0.15											
4.1	END OF BOREHOLE SPOON REFUSAL															
	Note: 1. Water level at ground surface (Elev. 202.8 m) upon completion of drilling.															

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

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

**RECORD OF BOREHOLE No K-2** 1 OF 1 **METRIC**

PROJECT 07-1191-0020 W.P. 5005-08-00 LOCATION N 5051863.7; E 236757.1 ORIGINATED BY EC

DIST                      HWY 69 BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring COMPILED BY EC

DATUM Geodetic DATE March 16, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100						
202.7	GROUND SURFACE															
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	WH									893.8		
			2	SS	WH											
			3	SS	WH											
200.7																
2.0	CLAY Very soft Grey Wet															
200.0	Vane advanced before split spoon for sample 4.		4	SS	WH											
199.7	SAND and SILT, trace clay Grey Wet		5	SS	50											
3.0	SAND and GRAVEL, trace to some silt Dense Grey Wet		6	SS	13/0.2											
198.7	END OF BOREHOLE SPOON REFUSAL															
4.0	Note: 1. Water level at ground surface (Elev. 202.7 m) upon completion of drilling.															

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

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

PROJECT <u>07-1191-0020</u>	<b>RECORD OF BOREHOLE No K-3</b>	1 OF 1 <b>METRIC</b>
W.P. <u>5005-08-00</u>	LOCATION <u>N 5051867.4; E 236773.7</u>	ORIGINATED BY <u>EC</u>
DIST <u>HWY 69</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>	COMPILED BY <u>EC</u>
DATUM <u>Geodetic</u>	DATE <u>March 15, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100	20	40	60		GR SA SI CL	
202.6	GROUND SURFACE															
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	WH									740.2		
201.7																
0.9	CLAY, trace organics, trace sand Very soft		2	SS	WH											
201.2	Grey Wet															
1.4	SAND and SILT, some clay Compact		3a	SS	13										0	50 36 14
200.6	Grey Wet		3b													
2.0	SAND and GRAVEL, trace to some silt Dense		4	SS	43											
199.8	Grey Wet															
2.8	END OF BOREHOLE SPOON REFUSAL															
Note: 1. Water level at ground surface (Elev. 202.6 m) upon completion of drilling. 2. Advanced DCPT 1 m west of Borehole K-3. Refusal at a depth of 2.6 m.																

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

PROJECT <u>07-1191-0020</u>	<b>RECORD OF BOREHOLE No K-4</b>	1 OF 1 <b>METRIC</b>
W.P. <u>5005-08-00</u>	LOCATION <u>N 5051871.1; E 236790.3</u>	ORIGINATED BY <u>EC</u>
DIST <u>HWY 69</u>	BOREHOLE TYPE <u>Portable Equipment</u>	COMPILED BY <u>EC</u>
DATUM <u>Geodetic</u>	DATE <u>March 14, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W <sub>p</sub>	W		
						20 40 60 80 100	20 40 60 80 100	20 40 60								
202.1	GROUND SURFACE															
0.0	PEAT (Fibrous) Black Frozen	▨	1	RC	REC 100%										RQD = 97%	
	GNEISS (BEDROCK)	▨	2	RC	REC 100%										RQD = 87%	
	Bedrock cored from 0.1 m depth to 3.4 m depth.	▨	3	RC	REC 100%										RQD = 92%	
	For coring details see Record of Drillhole K-4.	▨	4	RC	REC 100%										RQD = 90%	
		▨	5	RC	REC 100%										RQD = 94%	
198.7	END OF BOREHOLE															
3.4	Note: 1. Borehole dry upon completion of drilling.															

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:



**PROJECT** 07-1191-0020 **RECORD OF BOREHOLE No K-5** **1 OF 1 METRIC**  
**W.P.** 5005-08-00 **LOCATION** N 5051874.9; E 236806.9 **ORIGINATED BY** EC  
**DIST** HWY 69 **BOREHOLE TYPE** Portable Equipment, NW Casing, Wash Boring **COMPILED BY** EC  
**DATUM** Geodetic **DATE** March 15, 2011 **CHECKED BY** AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100	20
202.6	GROUND SURFACE																	
0.0	PEAT (Fibrous)		1a	SS	1													
202.3	Very soft Black Wet		1b															
0.3																		
201.8	CLAY		2	SS	46													
0.8	Very soft Grey Wet		3	SS	85													
201.1	SAND and SILT, some clay		4	SS	46													
1.5	Dense Grey Wet		5	SS	25/0.2													
199.2	SAND and GRAVEL, some silt, trace to some clay																	
	Dense to very dense Grey Wet																	
3.4	END OF BOREHOLE SPOON REFUSAL																	
	Note: 1. Water level at ground surface (Elev. 202.6 m) upon completion of drilling.																	

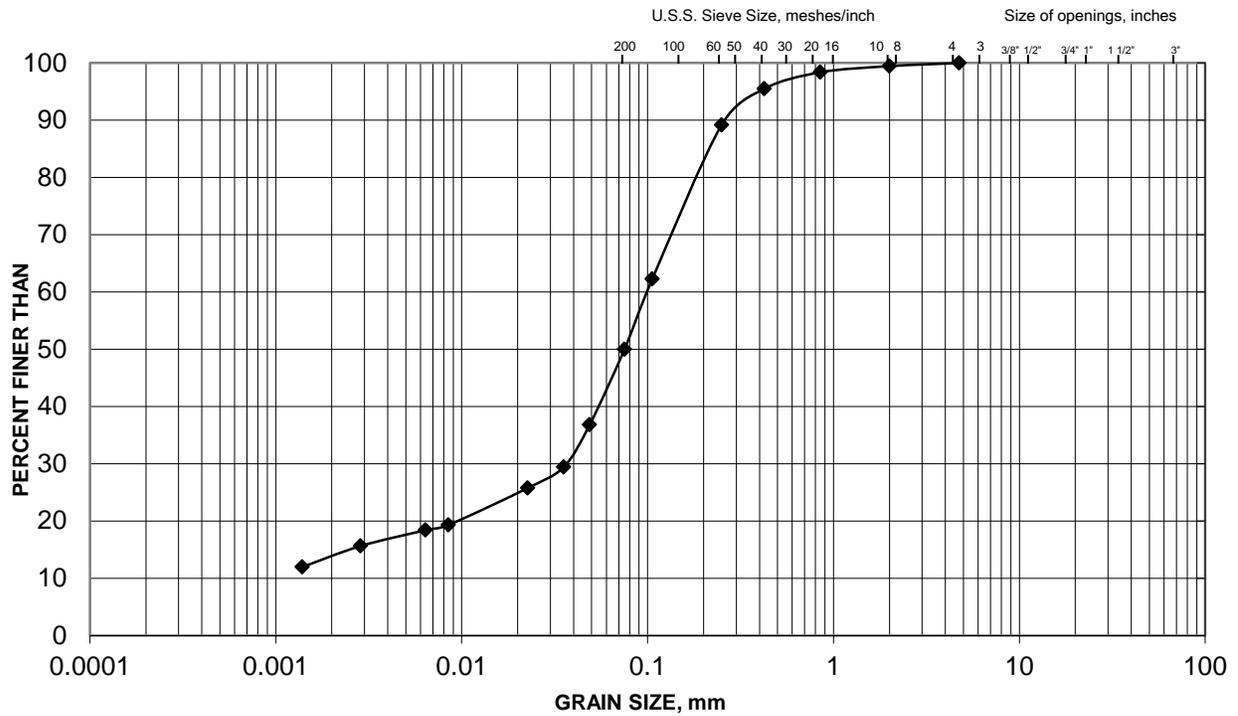
SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

# GRAIN SIZE DISTRIBUTION

**Sand and Silt**  
**Highway 69 NBL and SBL STA 15+375**

**FIGURE**

**D1**



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		

**LEGEND**

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
◆	K-3	3a	200.8

Project Number: 07-1191-0020-C2

Checked By: EC/AB

**Golder Associates**

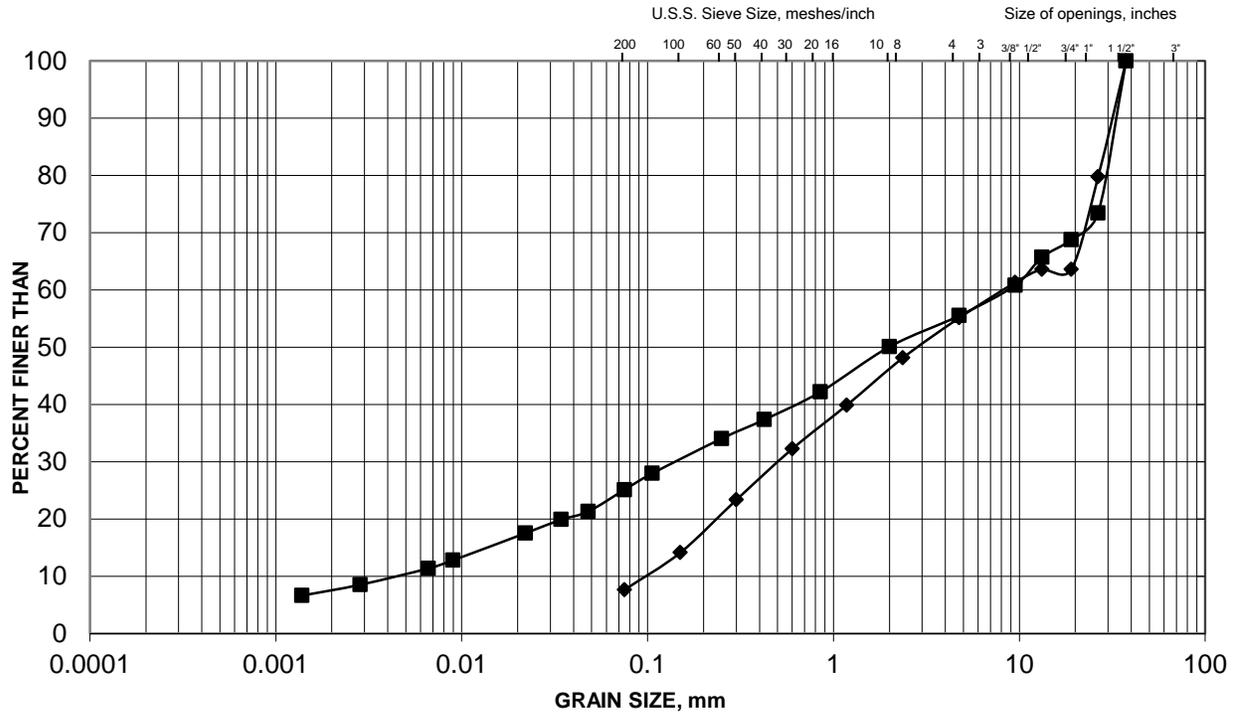
Date: January 2013

**GRAIN SIZE DISTRIBUTION**

**Sand and Gravel  
Highway 69 NBL and SBL STA 15+375**

**FIGURE**

**D2**



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		

**LEGEND**

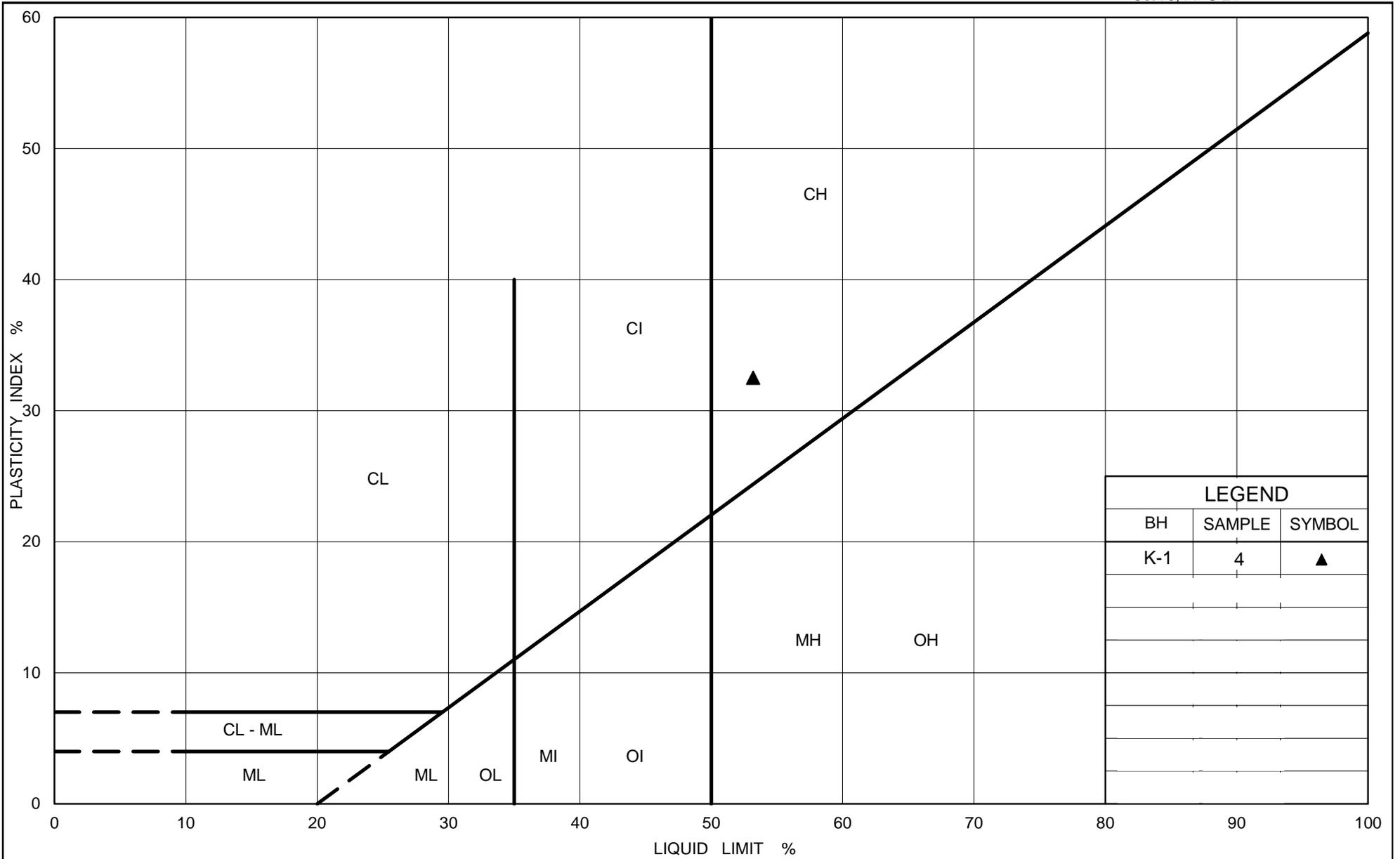
SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
◆	K-2	6	198.8
■	K-5	3	200.8

Project Number: 07-1191-0020-C2

Checked By: EC/AB

**Golder Associates**

Date: January 2013





# **APPENDIX E**

**Highway 69 SBL STA 15+775 and NBL STA 15+790**

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

CONT No.  
WP No.5133-12-28 & 29

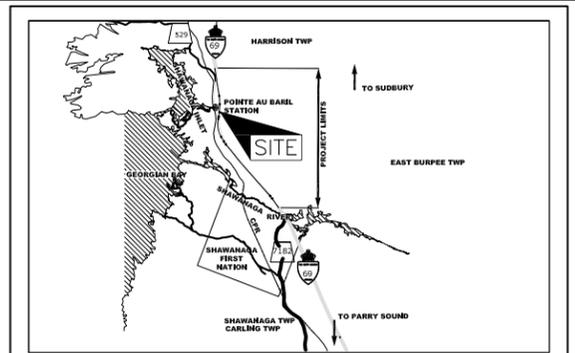


HIGHWAY 69  
CULVERT AT STA. 15+775 (SBL)  
AND 15+790 (NBL)  
BOREHOLE LOCATIONS AND SOIL STRATA

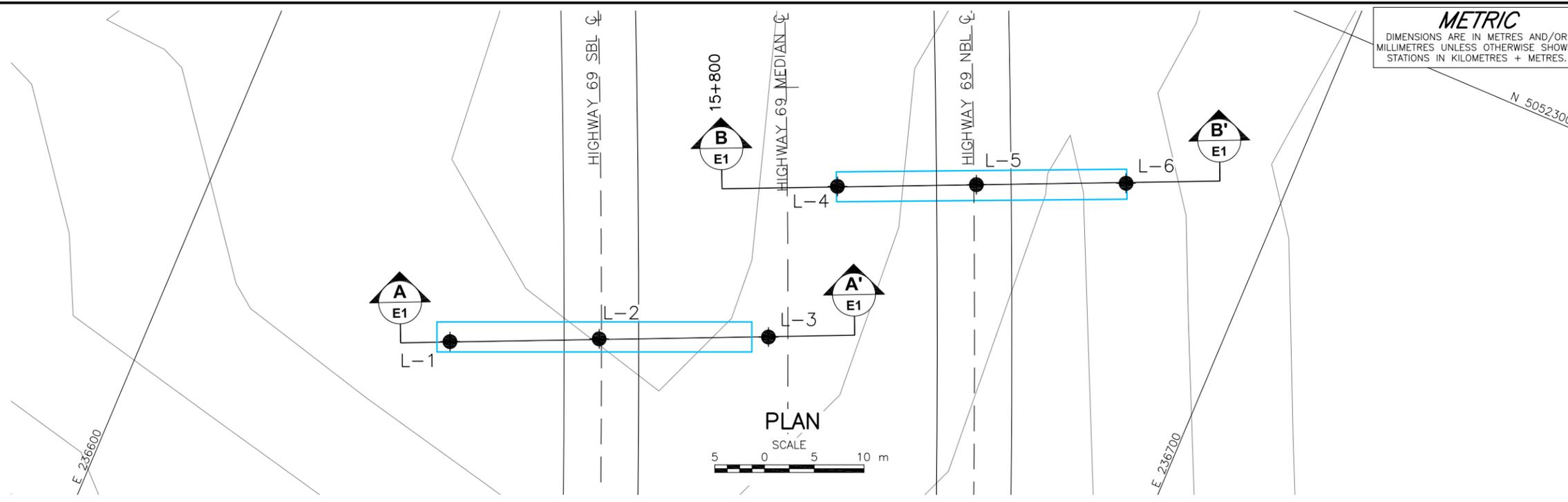
SHEET



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



**KEY PLAN**  
SCALE 5 0 5 km



**PLAN**  
SCALE 5 0 5 10 m

**LEGEND**

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

**BOREHOLE CO-ORDINATES**

No.	ELEVATION	NORTHING	EASTING
L-1	202.5	5052236.4	236628.5
L-2	203.4	5052242.5	236642.2
L-3	203.8	5052249.3	236657.8
L-4	203.5	5052265.9	236658.3
L-5	203.7	5052271.5	236671.1
L-6	204.0	5052277.5	236684.9

**NOTES**

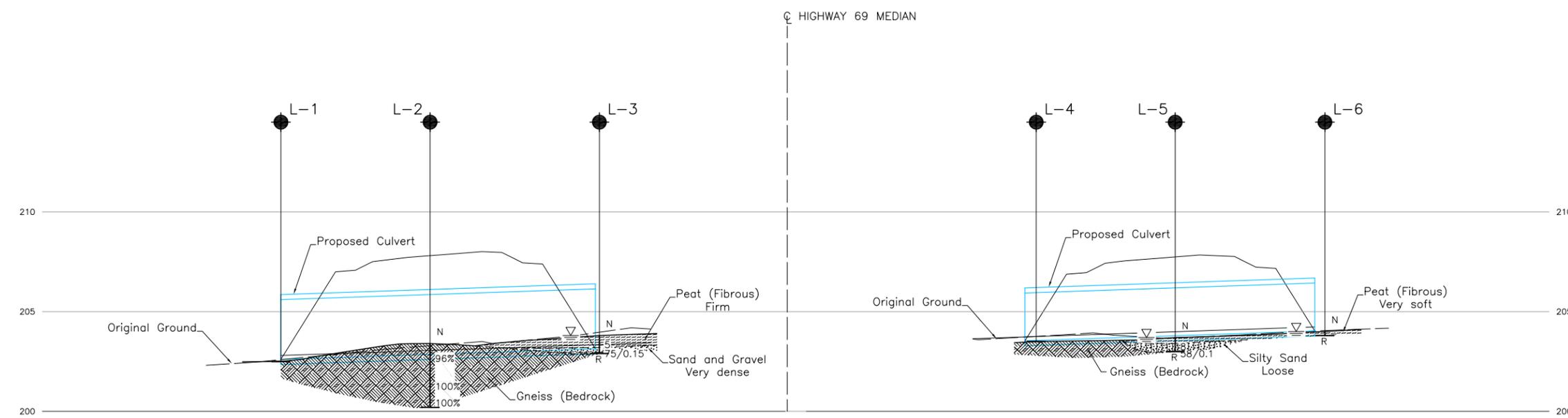
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

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**REFERENCE**

Base plan provided in digital format by MMM Group, drawing file no. Hwy 69 5403-05-00 Design.dwg (received Oct. 2008) and key plan, drawing file no. Hwy 69-529-Project key plan (received Apr. 2008). Culvert locations provided by MMM in drawing file no. 5403-05-00 culverts.dwg (received Nov 2010)



**A-A' PROFILE ALONG CULVERT**  
HIGHWAY 69 (SBL)  
HORIZONTAL SCALE 5 0 5 10 m  
VERTICAL SCALE 2.5 0 2.5 5 m

**B-B' PROFILE ALONG CULVERT**  
HIGHWAY 69 (NBL)  
HORIZONTAL SCALE 5 0 5 10 m  
VERTICAL SCALE 2.5 0 2.5 5 m



NO.	DATE	BY	REVISION

Geocres No. 41H-83

HWY. 69	PROJECT NO. 07-1191-0020	DIST.
SUBM'D. EC	CHKD. AB	DATE: JAN 2013
DRAWN: J.J.L.	CHKD.	APPD. JMAC
		DWG. E1



PROJECT 07-1191-0020 **RECORD OF BOREHOLE No L-1** 1 OF 1 **METRIC**

W.P. 5005-08-00 LOCATION N 5052236.4; E 236628.5 ORIGINATED BY EC

DIST  HWY 69 BOREHOLE TYPE N/A COMPILED BY EC

DATUM Geodetic DATE March 17, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W <sub>p</sub>	W			W <sub>L</sub>	GR
202.5	GROUND SURFACE																	
0.0	EXPOSED BEDROCK																	

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

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

PROJECT <u>07-1191-0020</u>	<b>RECORD OF BOREHOLE No L-2</b>	1 OF 1 <b>METRIC</b>
W.P. <u>5005-08-00</u>	LOCATION <u>N 5052242.5; E 236642.2</u>	ORIGINATED BY <u>EC</u>
DIST <u>HWY 69</u>	BOREHOLE TYPE <u>Portable Equipment</u>	COMPILED BY <u>EC</u>
DATUM <u>Geodetic</u>	DATE <u>March 17, 2011</u>	CHECKED BY _____

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W <sub>p</sub>	W			W <sub>L</sub>
203.4 0.0	GROUND SURFACE GNEISS (BEDROCK)  Bedrock cored from surface to 3.2 m depth.  For coring details see Record of Drillhole L-2.		1	RC	REC 100%												RQD = 96%
			2	RC	REC 100%												RQD = 100%
			3	RC	REC 100%												RQD = 100%
200.2 3.2	END OF BOREHOLE  Note: 1. Borehole dry upon completion of drilling.																

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

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

PROJECT: 07-1191-0020

# RECORD OF DRILLHOLE: L-2

SHEET 1 OF 1

LOCATION: N 5052242.5 ; E 236642.2

DRILLING DATE: March 17, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Hitti Drill

DRILLING CONTRACTOR: Landcore

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY			Diameter Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION				
							TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn				k, cm/s	10 <sup>0</sup>	10 <sup>1</sup>	10 <sup>2</sup>
							88888888	88888888			88888888	88888888	88888888	88888888	88888888	88888888				88888888	88888888	88888888	88888888
0		REFER TO PREVIOUS PAGE		203.4																			
0		GNEISS Coarse grained Fresh Very strong Pinkish grey		0.0																			
1					1																		
2	NQ Coring March 17, 2011				2													UCS = 140 MPa					
3					3																		
3		END OF DRILLHOLE		200.2																			
3.2				3.2																			
4																							
5																							
6																							
7																							
8																							
9																							
10																							

SUD-RCK 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

DEPTH SCALE

1 : 50



LOGGED: EC

CHECKED:





PROJECT 07-1191-0020 **RECORD OF BOREHOLE No L-4** 1 OF 1 **METRIC**

W.P. 5005-08-00 LOCATION N 5052265.9; E 236658.3 ORIGINATED BY EC

DIST          HWY 69 BOREHOLE TYPE N/A COMPILED BY EC

DATUM Geodetic DATE March 17, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>			GR
203.5	GROUND SURFACE																	
0.0	EXPOSED BEDROCK																	

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

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



PROJECT <u>07-1191-0020</u>	<b>RECORD OF BOREHOLE No L-6</b>	1 OF 1 <b>METRIC</b>
W.P. <u>5005-08-00</u>	LOCATION <u>N 5052277.5; E 236684.9</u>	ORIGINATED BY <u>EC</u>
DIST <u>        </u> HWY <u>69</u>	BOREHOLE TYPE <u>Portable Equipment</u>	COMPILED BY <u>EC</u>
DATUM <u>Geodetic</u>	DATE <u>March 17, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W <sub>p</sub>	W		
204.0	GROUND SURFACE	[Hatched Box]	1	SS	-	▽								kN/m <sup>3</sup>	GR SA SI CL	
0.0	PEAT, trace to some sand (Fibrous)															
0.2	Brown Wet END OF BOREHOLE SPOON REFUSAL  Note: 1. Water level at ground surface (Elev. 204.0 m) upon completion of drilling.															

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

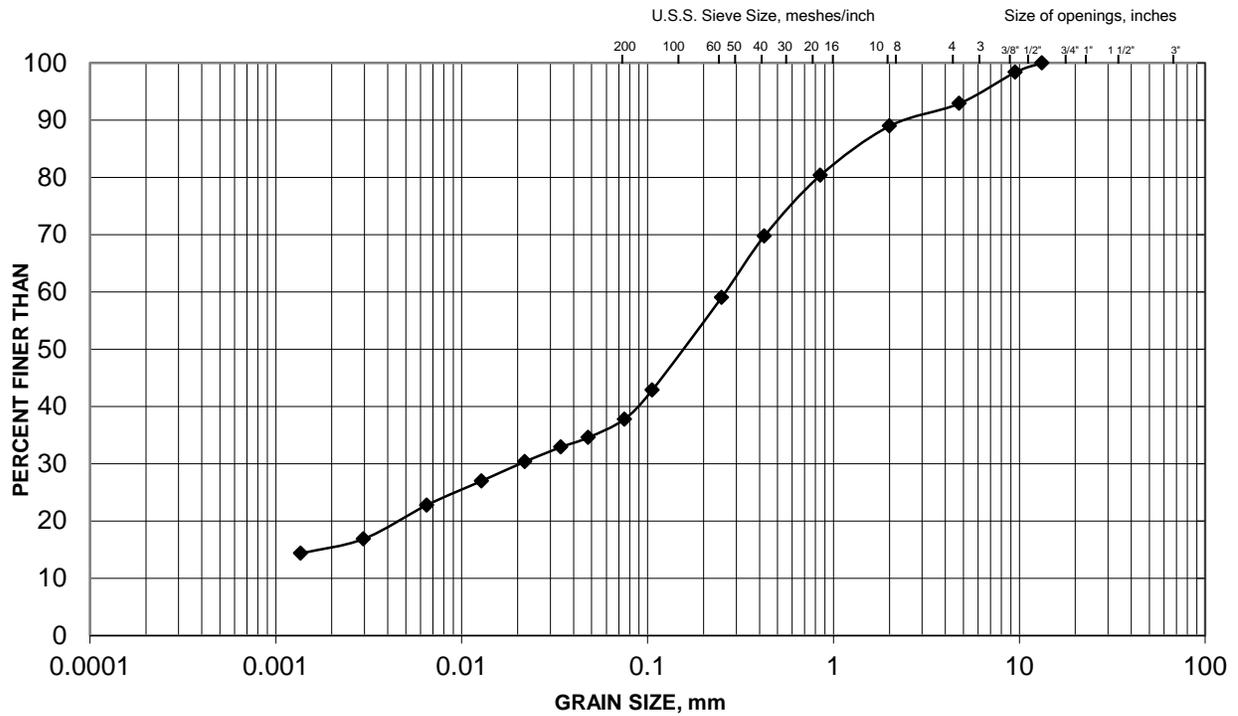
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

**GRAIN SIZE DISTRIBUTION**

**FIGURE**

**Silty Sand  
Highway 69 NBL STA 15+790**

**E1**



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		

**LEGEND**

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
◆	L-5	1b	203.2

Project Number: 07-1191-0020-C2

Checked By: EC/AB

**Golder Associates**

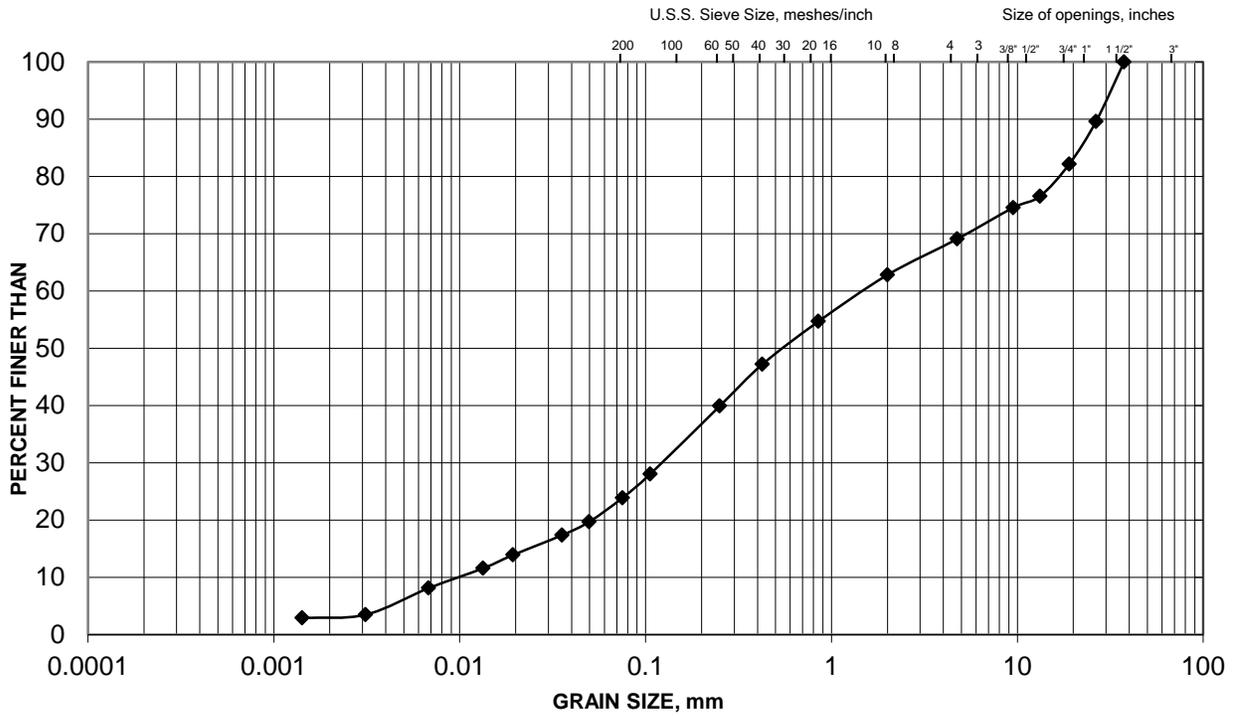
Date: January 2013

**GRAIN SIZE DISTRIBUTION**

**FIGURE**

**Sand and Gravel  
Highway 69 SBL STA 15+775**

**E2**



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		

**LEGEND**

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
◆	L-3	2	203.0

Project Number: 07-1191-0020-C2  
Checked By: EC/AB

**Golder Associates**

Date: January 2013



# **APPENDIX F**

**Highway 69 NBL STA 16+286 and SBL STA 16+312**

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

CONT No.  
WP No.5133-12-30 & 31

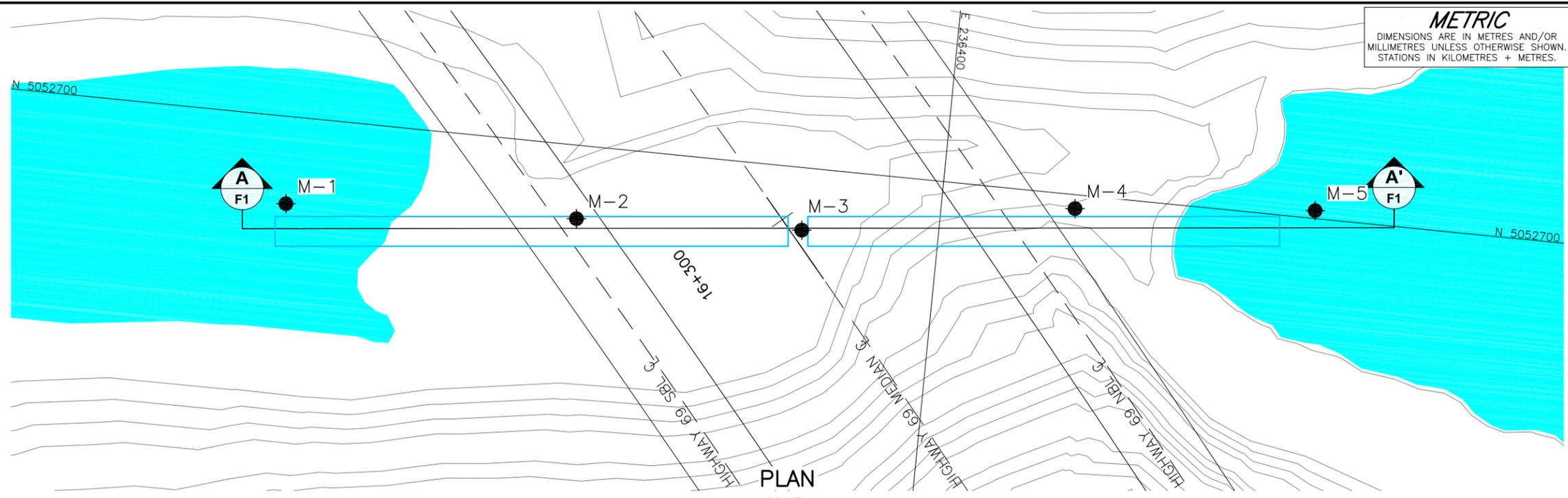


HIGHWAY 69  
CULVERT AT STA. 16+286 (NBL) and 16+312 (SBL)  
BOREHOLE LOCATIONS AND SOIL STRATA

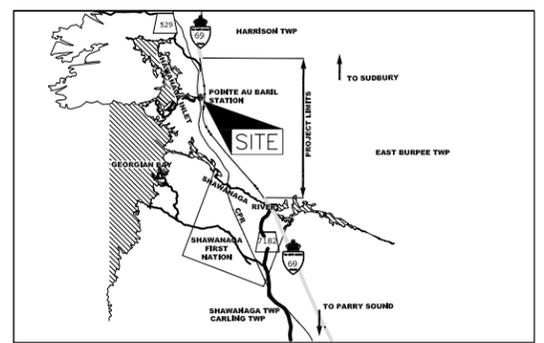
SHEET



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



**PLAN**  
SCALE  
5 0 5 10 m



**KEY PLAN**  
SCALE  
5 0 5 km

**LEGEND**

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

**BOREHOLE CO-ORDINATES**

No.	ELEVATION	NORTHING	EASTING
M-1	192.0	5052691.2	236334.0
M-2	192.3	5052692.6	236363.4
M-3	193.9	5052693.7	236386.2
M-4	193.3	5052698.6	236413.5
M-5	194.0	5052700.8	236437.7

**NOTES**

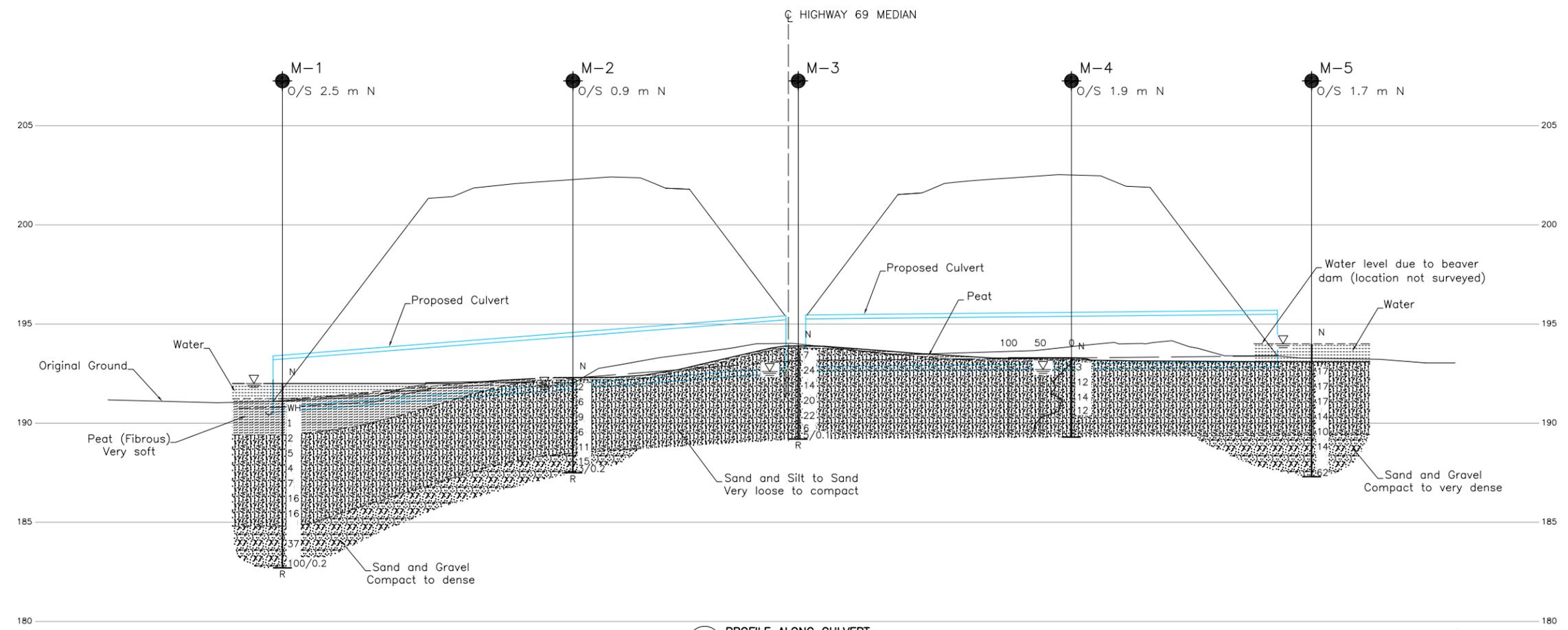
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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 plan provided in digital format by MMM Group, drawing file no. Hwy 69 5403-05-00 Design.dwg (received Oct. 2008) and key plan, drawing file no. Hwy 69-529-Project key plan (received Apr. 2008). Culvert locations provided by MMM in drawing file no. 5403-05-00 culverts.dwg (received Nov 2010)



**PROFILE ALONG CULVERT**  
HIGHWAY 69  
HORIZONTAL SCALE  
5 0 5 10 m  
VERTICAL SCALE  
2.5 0 2.5 5 m



NO.	DATE	BY	REVISION

Geocres No. 41H-83

HWY. 69	PROJECT NO. 07-1191-0020	DIST.
SUBM'D. EC	CHKD. AB	DATE: JAN 2013
DRAWN: JJJ	CHKD.	APPD. JMAC
		DWG. F1



PROJECT <u>07-1191-0020</u>	<b>RECORD OF BOREHOLE No M-2</b>	1 OF 1 <b>METRIC</b>
W.P. <u>5005-08-00</u>	LOCATION <u>N 5052692.6; E 236363.4</u>	ORIGINATED BY <u>LG</u>
DIST <u>          </u> HWY <u>69</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>	COMPILED BY <u>EC</u>
DATUM <u>Geodetic</u>	DATE <u>July 13, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)			
						20	40	60	80	100	20	40	60		GR	SA	SI	CL		
192.3	GROUND SURFACE																			
0.0	PEAT (Fibrous) Brown Moist		1a																	
	SAND to SAND and SILT, trace to some gravel, trace organics Loose to compact Brown Wet		1b	SS	2															
			2	SS	6															
			3	SS	9															
			4	SS	6												9	87	4	0
			5	SS	11															
188.5	SAND and GRAVEL, trace to some silt Compact Grey Wet		6	SS	15															
			7	SS	3/0.2															
187.5	END OF BOREHOLE SPOON REFUSAL																			
4.8	Note: 1. Water level at a depth of 0.4 m below ground surface (Elev. 191.9 m) upon completion of drilling.																			

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

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

PROJECT <u>07-1191-0020</u>	<b>RECORD OF BOREHOLE No M-3</b>	1 OF 1 <b>METRIC</b>
W.P. <u>5005-08-00</u>	LOCATION <u>N 5052693.7; E 236386.2</u>	ORIGINATED BY <u>LG</u>
DIST <u>          </u> HWY <u>69</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>	COMPILED BY <u>EC</u>
DATUM <u>Geodetic</u>	DATE <u>July 11, 2011</u>	CHECKED BY <u>AB</u>

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
							20 40 60 80 100	20 40 60									
193.9	GROUND SURFACE																
0.0	PEAT (Fibrous) Brown Moist		1a		7												
	SAND and SILT, trace to some gravel, trace clay Loose to compact Brown Moist to wet		1b	SS													
			2	SS	24											1 53 44 2	
			3	SS	14												
			4	SS	20												
			5	SS	22											10 51 37 2	
			6	SS	6												
189.2	END OF BOREHOLE SPOON REFUSAL		7	SS	5/0.1												
4.7	Note:  1. Water level at a depth of 1.3 m below ground surface (Elev. 192.6 m) upon completion of drilling.																

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

PROJECT <u>07-1191-0020</u>	<b>RECORD OF BOREHOLE No M-4</b>	1 OF 1 <b>METRIC</b>
W.P. <u>5005-08-00</u>	LOCATION <u>N 5052698.6; E 236413.5</u>	ORIGINATED BY <u>LG</u>
DIST <u>          </u> HWY <u>69</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>	COMPILED BY <u>EC</u>
DATUM <u>Geodetic</u>	DATE <u>July 14, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa				W <sub>p</sub>	W			W <sub>L</sub>	GR	SA
193.3	GROUND SURFACE																	
0.0 0.1	PEAT (Fibrous) Brown Moist	1a				▽	193											
	SAND, trace to some silt, trace organics	1b	SS	3			192											0 93 (7)
	Very loose to compact Brown Wet	2	SS	12			191											
		3	SS	14			190											
		4	SS	12														
	Difficult casing advancement between 2.7 m and 4.0 m depths.																	
189.3	END OF BOREHOLE																	
4.0	Note:  1. Water level at a depth of 0.6 m below ground surface (Elev. 192.7 m) upon completion of drilling.  2. Advanced DCPT 3 m north of Borehole M-4. Refusal at a depth of 3.7 m.																	

SUD-MTO 001 07-1191-0020-0100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:



PROJECT 07-1191-0020 **RECORD OF BOREHOLE No M-5** 1 OF 1 **METRIC**

W.P. 5005-08-00 LOCATION N 5052700.8; E 236437.7 ORIGINATED BY EC

DIST HWY 69 BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring COMPILED BY EC

DATUM Geodetic DATE July 21, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100	20	40	60		GR SA SI CL	
194.0	WATER SURFACE															
0.0	WATER															
193.1	SAND to Silty SAND, trace to some gravel, trace clay Compact Brown to grey Wet	[Strat Plot]	1	SS	17										20 60 18 2	
			2	SS	17											
			3	SS	17											
			4	SS	14											
			5	SS	10											1 75 22 2
189.4	SAND and GRAVEL, trace silt Compact to very dense Grey Wet	[Strat Plot]	6	SS	14											
4.6																
187.3	END OF BOREHOLE	[Strat Plot]	7	SS	62											
6.7																

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

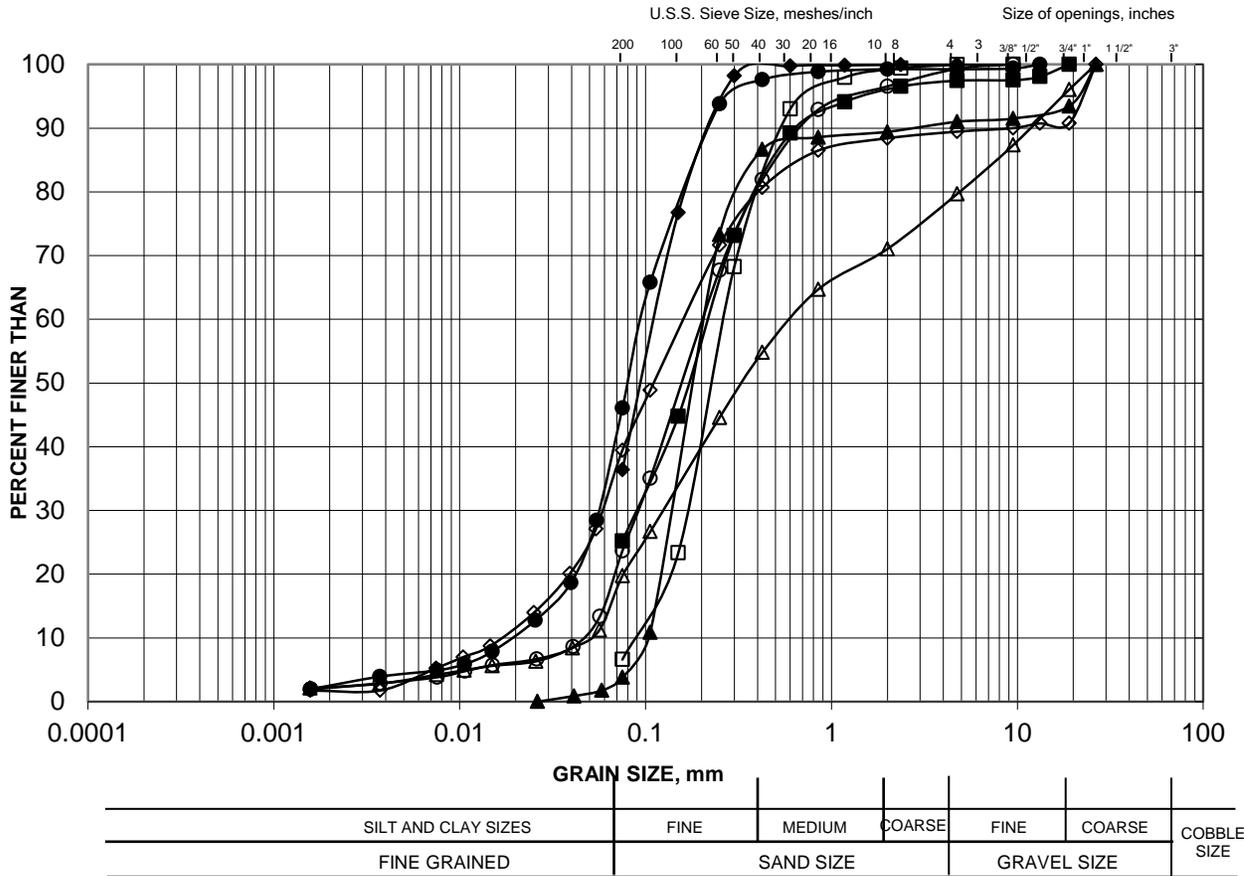
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

# GRAIN SIZE DISTRIBUTION

**Sand to Sand and Silt**  
**Highway 69 NBL STA 16+286 and SBL STA 16+312**

**FIGURE**

**F1**



**LEGEND**

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
◆	M-1	3	188.6
■	M-1	7	185.6
▲	M-2	4	189.7
●	M-3	2	192.8
◇	M-3	5	190.5
◻	M-4	2	192.2
▷	M-5	2	192.0
○	M-5	5	189.7

Project Number: 07-1191-0020-C2

Checked By: EC/AB

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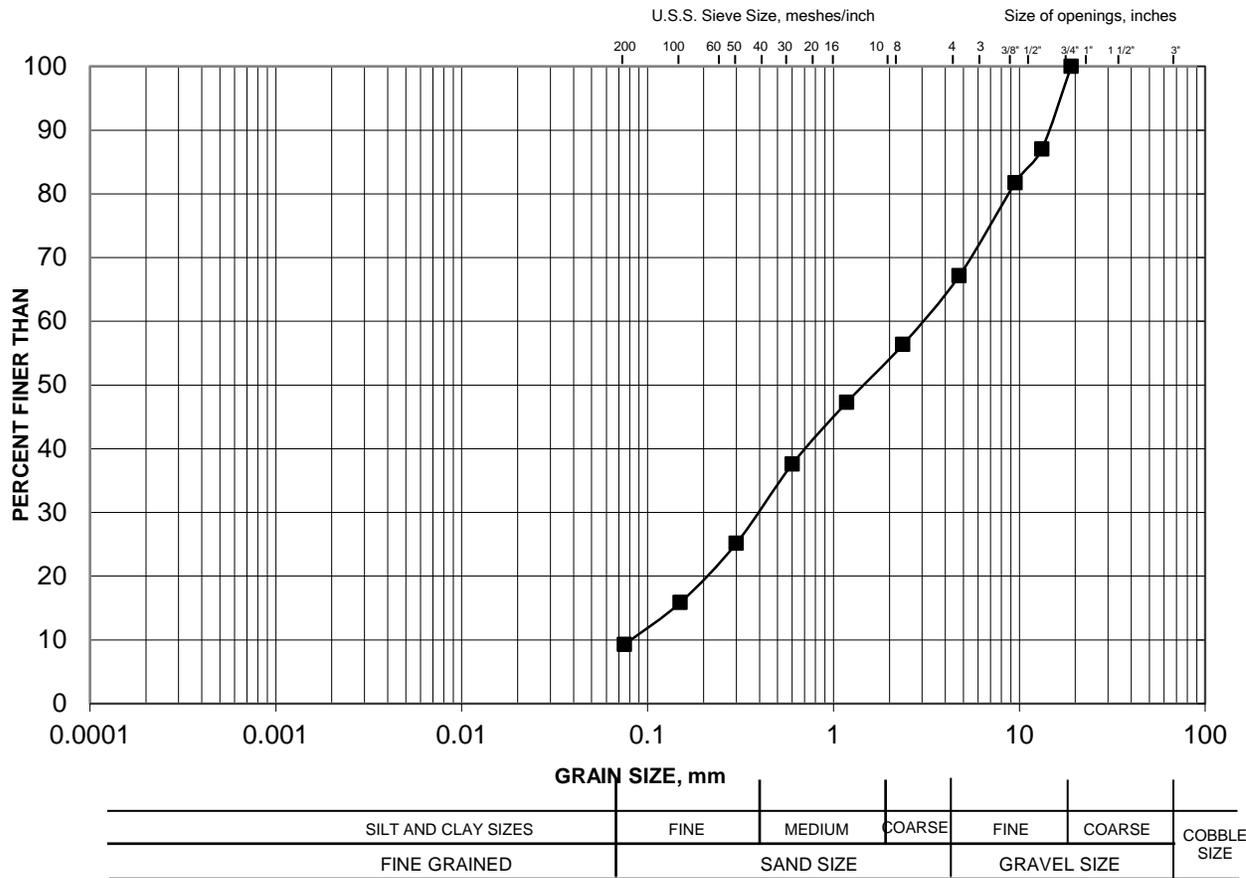
Date: January 2013

**GRAIN SIZE DISTRIBUTION**

**FIGURE**

**Sand and Gravel  
Highway 69 SBL STA 16+312**

**F2**



**LEGEND**

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
■	M-2	6	188.2

Project Number: 07-1191-0020-C2

Checked By: EC/AB

**Golder Associates**

Date: January 2013

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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Europe	+ 356 21 42 30 20
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