



November 24, 2016

## FOUNDATION INVESTIGATION REPORT

**Replacement of Twin Lake Culverts, Site No. 38C-047  
Detail Design of Highway 519 from Highway 17 easterly  
to Dubreuilville, 30.7 km  
Ministry of Transportation, Ontario  
G.W.P. 327-99-00, W.P. 5296-06-01**

**Submitted to:**

D.M. Wills Associates Ltd.  
150 Jameson Drive  
Peterborough, ON  
K9J 0B9



REPORT

**GEOCRES NO.: 42C-38**

**Report Number: 1521770-1**

**Distribution:**

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- 1 Copy – D.M. Wills Associates Limited
- 1 Copy – Golder Associates Ltd., Mississauga, Ontario





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## FOUNDATION REPORT - REPLACEMENT OF TWIN LAKE CULVERTS, SITE NO. 38C-047 - HIGHWAY 519

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# **PART A**

**FOUNDATION INVESTIGATION REPORT  
REPLACEMENT OF TWIN LAKE CULVERTS, SITE NO. 38C-047  
DETAIL DESIGN OF HIGHWAY 519 FROM HIGHWAY 17  
EASTERLY TO DUBREUILVILLE, 30.7 km  
MINISTRY OF TRANSPORTATION, ONTARIO  
G.W.P. 327-99-00, W.P. 5296-06-01**





## FOUNDATION REPORT - REPLACEMENT OF TWIN LAKE CULVERTS, SITE NO. 38C-047 - HIGHWAY 519

### 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by D. M. Wills and Associates Limited (D. M. Wills) on behalf of Ministry of Transportation, Ontario (MTO) to provide Foundation Engineering services for the replacement of the Twin Lake culverts, located at about STA 20+800 (Site No. 38C-047) on Highway 519 in the Township of Dumas, approximately 9 km west of Dubreuilville, Ontario.

The Terms of Reference and the Scope of Work for the foundation investigation are outlined in MTO's Request for Proposal, dated March 2015. Golder's proposal for the foundation engineering services associated with the Twin Lake culvert replacement is contained in Section 6.8 of D. M. Wills' Technical Proposal for this assignment and in the Change Request No. 2 letter, dated May 18, 2016. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project, dated July 22, 2015.

This report addresses the investigation carried out for the double culverts at Twin Lake centered at about STA 20+794 and STA 20+800 (Site No. 38C-047) in the Township of Dumas on Highway 519 which have been identified for replacement. The foundation investigation and design associated with the other culverts for this assignment are presented in separate reports.

The purpose of this investigation is to establish the subsurface conditions at the replacement culvert locations, by borehole drilling and in situ and laboratory testing on selected soil and rock samples. The investigation area is shown in plan on Drawing 1.

### 2.0 SITE DESCRIPTION

The double structural culverts requiring replacement are located at approximately STA 20+794 and STA 20+800 on Highway 519 in the Township of Dumas, approximately 9 km west of Dubreuilville, Ontario. The existing culverts are both 3690 mm wide by 2380 mm high corrugated steel elliptical structures contained in embankment fill between about 3 m and 4.5 m thick on the north side and south side of the highway, respectively. Details of the culvert are also summarized in Table 1 following the text of this report.

In general, the topography in the area of the culverts consists of rolling terrain, including sparsely populated treed areas, lakes and areas of standing water. Twin Lake is present on the north and south sides of Highway 519 at this site. The ground surface at the borehole locations advanced for the foundation investigation varies between Elevation 334.1 m at Highway 519 roadway surface and Elevation 330.2 m at the embankment toes, referenced to Geodetic datum.

### 3.0 INVESTIGATION PROCEDURES

The fieldwork for the foundation investigation associated with the Twin Lake culverts was carried out between July 5 and 12, 2016 in which time a total of eight boreholes (Boreholes C60-1 to C60-8) were advanced at, or in the immediate vicinity of the culvert alignments and proposed temporary widening to the north. In addition, Dynamic Cone Penetration Tests (DCPTs) were advanced from the bottom of Boreholes C60-7 and C60-8.

The field investigation was carried out using a CME 55 truck-mounted drill rig and portable drilling equipment, which were supplied and operated by Landcore Drilling of Sudbury, Ontario and OGS Drilling of Almonte, Ontario, respectively.



## FOUNDATION REPORT - REPLACEMENT OF TWIN LAKE CULVERTS, SITE NO. 38C-047 - HIGHWAY 519

Boreholes completed with the CME 55 truck-mounted drill rig were advanced through the overburden using nominal 152 mm diameter solid stem augers. The boreholes completed with the portable equipment were advanced through the overburden using BW size casing with wash boring techniques. Soil samples were obtained continuously or at intervals of depth up to about 1.5 m using nominal 50 mm outside diameter (O.D.) split-spoon samplers, operated by an automatic hammer on the drill rig and performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). Boreholes advanced by portable equipment employed a full-weight hammer lifted manually and dropped from the SPT height. Bedrock was cored in Boreholes C60-3 to C60-6 using thin-walled NQ sized core barrels for lengths between 2.9 m and 3.5 m.

All open boreholes were backfilled with bentonite upon completion in accordance with R.R.O 1990, Regulation 903 (Wells) (as amended). The groundwater conditions and water levels in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets in Appendix A.

The fieldwork was observed by members of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined the soil samples. The soil and bedrock core samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's Mississauga geotechnical laboratory where the samples underwent further visual examination and laboratory testing. Rock quality (i.e., TCR, SCR, RQD, weathering and strength index), discontinuity characteristics and classification data were recorded in the field based on visual inspection of the recovered rock cores upon extraction from the core barrel. Classification testing (water content, organic content, Atterberg limits and grain size distribution) was carried out on selected soil samples, and strength testing (uniaxial unconfined compression and point load index) were completed on selected rock samples. All of the laboratory tests were carried out to MTO Laboratory Standards and/or ASTM Standards, as appropriate. The results of the laboratory testing are summarized on the Record of Borehole sheets in Appendix A and presented in the laboratory test figures provided in Appendix B.

A sample of lake water was obtained during the field investigation at the inlet of the culverts, and submitted to a specialist analytical laboratory under chain of custody procedures for corrosivity package testing. The results of the analytical testing are included in Appendix C.

Classification of the rock mass quality of the bedrock with respect to the Rock Quality Designation (RQD) is described based on Table 3.10 of the Canadian Foundation Engineering Manual CFEM<sup>1</sup>. The degree of weathering of the bedrock samples and the strength classification of the intact rock mass based on field identification are described in accordance with the International Society for Rock Mechanics (ISRM)<sup>2</sup> standard classification system. Point load strength index tests, both perpendicular to the core axis (diametral) and along the core axis (axial) were performed on selected samples of the rock core to provide an indication of the point load strength index ( $Is_{50}$ ) of the rock. The bedrock strength was classified with respect to strength is based on the  $Is_{50}$  values as suggested in Table 3.5 of CFEM<sup>1</sup>.

Temporary benchmarks were placed in the field by Tulloch Engineering, Ontario Land Surveyors. The as-drilled borehole locations, in stations and offsets, were measured in reference to the roadway station given on the temporary benchmarks and were subsequently converted into MTM NAD 83 (Zone 13) coordinates in AutoCAD. Borehole elevations were surveyed by a member of our technical staff in reference to the temporary benchmark elevations. The borehole locations shown on Drawing 1 are positioned relative to MTM NAD 83 northing and

<sup>1</sup> Canadian Foundation Engineering Manual. 2006. Fourth Edition, Canadian Geotechnical Society.

<sup>2</sup> International Society for Rock Mechanics Commission on test Methods. 1985. Int. J. Rock Mech. Min. Sci. & Geomech. Abstr. Vol 22, No. 2, pp.51-60.



## FOUNDATION REPORT - REPLACEMENT OF TWIN LAKE CULVERTS, SITE NO. 38C-047 - HIGHWAY 519

easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are summarized below.

Culvert Location	Borehole	Location (m)		Ground/Water Surface Elevation (m)	Depth of Borehole / DCPT (m)
		Northing	Easting		
STA 20+794 and STA 20+800 (Township of Dumas)	C60-1	5,355,970.9	254,818.2	331.0	2.6
	C60-2	5,355,969.1	254,831.2	331.0	4.7
	C60-3	5,355,965.8	254,819.6	331.0	5.2*
	C60-4	5,355,965.3	254,830.8	331.0	7.3*
	C60-5	5,355,955.4	254,817.5	334.1	7.1*
	C60-6	5,355,949.8	254,832.9	333.8	11.4*
	C60-7	5,355,940.3	254,819.7	330.5	5.9 / 7.4
	C60-8	5,355,940.0	254,830.5	330.5	8.2 / 10.8

Note: \* Includes between 2.8 m and 3.3 m length of bedrock coring.

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

Highway 519 is located in the Abitibi Uplands physiographic region, within the Canadian Shield as delineated by *The Geomorphic Systems of North America*.<sup>3</sup> The Abitibi Uplands generally slopes down towards Hudson Bay and is typically characterized by low broad hills with gently sloping, rolling or undulating topography and subdued relief. This region is underlain by massive, mainly crystalline rocks covered by Quaternary glaciofluvial outwash and till deposits typically consisting of gravel and sand, including pro-glacial river and deltaic deposits, as well as more recent organic deposits within the depressions between bedrock knobs.<sup>4</sup>

Highway 519 is located directly north of the Michipicoten greenstone belt, within the Pukaskwa batholith within the Wawa Subprovince<sup>5</sup>. The bedrock at this section of Highway 519 consists of tonalite to granodiorite-foliated to gneissic with minor supracrustal inclusions.

### 4.2 General Overview of Local Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil and bedrock core samples, are presented on the Record of Borehole sheets and the laboratory test sheets in Appendices A and B, respectively. The results of the in situ field tests (i.e. SPT "N"-values) as presented on the Record of Borehole sheets and in Section 4.2 are uncorrected. The stratigraphic boundaries shown on the Record of Boreholes sheets are inferred from generally non-continuous sampling, observations of drilling progress and in situ testing and are approximate. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. Where

<sup>3</sup> Graf, W. L. 1987. *Geomorphic systems of North America*. Geological Society of America, Inc.: Boulder, Colorado.

<sup>4</sup> The Ministry of Natural Development and Mines, Ontario, 2016. OGSEarth: Quaternary Geology [Electronic Map] 1:1,000,000.

<sup>5</sup> Williams H. R., Stott G. M., Heather K. B., Muir T. L. and Sage R. P. 1991. Wawa subprovince; in *Geology of Ontario*, Ontario Geological Survey, Special Volume 4, Part 1, p.485-539.



applicable, the thickness of the overburden at the site is also inferred from the resistance to DCPT results as shown on the Record of Borehole sheets in Appendix A and the profile/cross-section drawings. It should be noted that the interpreted stratigraphy shown on Drawings 2 and 3 is a simplification of the subsurface conditions.

The stratigraphy at the borehole locations at the culvert sites consists of embankment fill over a native stratum of silt to sand which in places contains trace organics. The native silt to sand deposit is underlain in places by a deposit of sand and gravel which is underlain by diorite bedrock, and in other places it is directly underlain by diorite bedrock. A detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

### 4.3 Twin Lake Culverts (Culvert C60 – STA 20+800 Township of Dumas)

The plan and profile along the centreline of the existing culverts C60 at about STA 20+800 showing the borehole locations and interpreted stratigraphy are provided on Drawing 2. Additionally, cross-sections showing the soil stratigraphy along the proposed and existing embankment toes, or ends of the culverts, and crest are provided on Drawing 3. The existing culverts are about 17 m long, 3690 mm wide by 2380 mm high corrugated steel elliptical structures contained within embankment fill between about 3 m and 4.5 m thick on the north and south ends, respectively. Details of the culverts are also summarized in Table 1 following the text of this report. A total of eight boreholes were completed to investigate the subsurface conditions at the culverts location: two boreholes (Boreholes C60-1 and C60-2) were advanced at the proposed north toe of the temporary embankment widening; four boreholes (Boreholes C60-3, C60-4, C60-7 and C60-8) were advanced near the ends of the existing culverts; and two boreholes (Boreholes C60-5 and C60-6) were advanced through the Highway 519 roadway embankment, on the west and east side of the existing culverts alignment, respectively. Photographs of the site are shown on Figures 1A and 1B following the text of the report.

#### 4.3.1 Lake Water

Boreholes C60-2 to C60-4, C60-7 and C60-8 were advanced near the shores of Twin Lake and encountered between 0.2 m to 0.9 m depth of standing water.

#### 4.3.2 Asphalt and Fill

Boreholes C60-5 and C60-6 were advanced from the Highway 519 roadway surface and encountered an approximately 75 mm thick layer of asphalt at Elevations 334.1 m and 333.8 m, respectively.

A deposit of non-cohesive fill comprised of sand, some gravel to gravelly sand to sand and gravel are encountered below the asphalt or below the water in Boreholes C60-2 to C60-7. The fill in places contains rock fragments. The top of the fill layer ranges from Elevations 334.0 m at one of the boreholes drilled from the roadway to 329.6 m at the toe of the embankment, and the thickness of the deposit varies between 0.6 m and 3.7 m.

The SPT 'N'-values measured within the non-cohesive fill range from 8 blows per 0.30 m of penetration to 72 blows per 0.25 m of penetration, indicating a loose to very dense relative density. An SPT 'N'-value of 96 blows per 0.30 m of penetration was measured at the interface of the fill and underlying native silt to sand deposit.



## FOUNDATION REPORT - REPLACEMENT OF TWIN LAKE CULVERTS, SITE NO. 38C-047 - HIGHWAY 519

The natural water content measured on seven samples of the fill deposit ranges from about 2 per cent to 13 per cent.

The results of grain size distribution tests completed on three samples of the sand to sand and gravel fill are shown on Figure B1 in Appendix B.

### 4.3.3 Silt to Sand

A deposit of interlayered non-cohesive soils comprised of silt to sandy silt to silt and sand to silty sand to sand was encountered at the ground surface, below the water or below the fill in all boreholes except Borehole C60-5. The deposit generally contains trace organic material. The surface of the interlayered deposit ranges from Elevations 331.0 m to 329.0 m. The overall thickness of the deposit ranges from 1.4 m to at least 7.9 m, and may be up to 9.3 m thick as inferred from the DCPT in Borehole C60-8; with individual interlayers ranging in thickness between 0.6 m and 3.8 m, and potentially greater than 6.7 m as inferred from the DCPT in Borehole C60-8. Boreholes C60-1 and C60-2 were terminated in the silt to sand deposit at depths of 2.6 m and 4.7 m below ground, surface / water (Elevations 328.7 m to 325.3 m) upon split-spoon sampler refusal and Boreholes C60-7 and C60-8 were terminated in the inferred silt and sand or silt deposits at depths of 7.4 m and 10.8 m below water surface (Elevations 323.1 m and 319.7 m) upon refusal to further DCPT advancement.

The SPT 'N'-values measured within the silt to sand deposit range from 0 blows (weight of hammer) to 27 blows per 0.3 m of penetration, indicating a very loose to compact relative density. Higher SPT 'N'-values and split-spoon sampler bouncing were noted at the interface of the silt to sand deposit with the underlying bedrock.

The natural water content measured on eleven samples of the silt to sand deposit ranges from about 13 per cent to about 55 per cent.

The organic content measured on a sample of the silt layer and a sample of the sand layer of the non-cohesive deposit is 5 per cent and 3 per cent, respectively.

The grain size distributions of twelve samples of the silt to sand deposit are shown on Figures B2-A and B2-B in Appendix B.

Atterberg limits tests were completed on the fines content of three samples of the silt to sand deposit. The results of two Atterberg limits tests indicate that the fines material is non-plastic; and the sample of sandy silt yielded a liquid limit of 19 per cent and a plastic limit of 15 per cent, corresponding to a plasticity index of about 4 per cent. The result of this Atterberg limits test is shown on the plasticity chart on Figure B3 in Appendix B, and indicates that the fines material is classified as a silt with slight plasticity.

### 4.3.4 Sand and Gravel

Boreholes C60-2 and C60-4 penetrated a 0.8 m and 0.7 m thick layer of sand and gravel, trace to some silt underlying the non-cohesive silt to sand deposit at about Elevations 327.1 m and 327.6 m, respectively. Borehole C60-2 was terminated within this deposit upon split spoon sampler refusal.

SPT 'N'-values of 16 blows and 39 blows per 0.30 m of penetration were measured within the sand and gravel deposit, indicating a compact to dense relative density. Split-spoon sampler bouncing was noted at the interface of this layer with the underlying bedrock.



## FOUNDATION REPORT - REPLACEMENT OF TWIN LAKE CULVERTS, SITE NO. 38C-047 - HIGHWAY 519

The natural water content measured on one sample of the sand and gravel layer is about 12 per cent.

### 4.3.5 Bedrock / Refusal

Bedrock was encountered in Boreholes C60-3 to C60-6 at depths ranging from 2.3 m to 8.5 m below ground surface, between Elevations 330.3 m and 325.3 m and cored for depths between 2.9 m and 3.3 m. Refusal to further advancement of DCPT was encountered in Boreholes C60-7 and C60-8 at depths of 7.4 m and 10.8 m, respectively, corresponding to Elevations 323.1 m and 319.7 m.

Based on the review of the bedrock core samples, the bedrock consists of diorite and is generally described as fresh, crystalline, white to black, medium grained, non-porous, medium strong (R3, 25 MPa < UCS < 50 MPa) to very strong (R5, 100 MPa < UCS < 250 MPa) with interlayers or veins of andesite and quartz. The bedrock descriptions are shown on the Record of Drillhole sheets in Appendix A and the photographs of core samples are shown on Figures B4 and B5 in Appendix B.

The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are between 81 per cent and 100 per cent and between 48 per cent and 100 per cent, respectively. The Rock Quality Designation (RQD) of the core samples obtained ranges from 50 per cent to 100 per cent, indicating a rock mass of fair to excellent quality as per Table 3.10 of the CFEM (2006).

A Unconfined Compression (UC) test performed on a core sample of the bedrock from Borehole C60-3 measured a uniaxial compressive strength (UCS) of about 65 MPa. Based on the laboratory UC test, the bedrock is classified as strong (R4, 50 MPa < UCS < 100 MPa). The UC test result is presented in Figure B6 in Appendix B.

Point load strength index tests, diametral and axial, were carried out on two selected samples of the bedrock core. The corrected point load strength index values ( $Is_{50}$ ) are shown in Table B1 in Appendix B. The axial tests measured  $Is_{50}$  values of 1.8 MPa and 2.2 MPa and the diametral tests measured  $Is_{50}$  values of 4 MPa and 5.6 MPa.

Based on the laboratory UC test and  $Is_{50}$  values, the bedrock is classified as medium strong (R3, 25 MPa < UCS < 50 MPa) to very strong (R5, 100 MPa < UCS < 250 MPa).

### 4.3.6 Groundwater Conditions

In general, the recovered soil samples were moist to wet. Boreholes C60-2 to C60-4, C60-7 and C60-8 were drilled off-shore of Twin Lake and encountered 0.2 m to 0.9 m depths of standing water. The groundwater level was measured in Boreholes C60-1, C60-5 and C60-6 upon completion of drilling operations at depths between 0.1 m and 3.4 m below ground surface, ranging from Elevations 330.9 m to 330.4 m. The groundwater level should be expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is higher during the wet seasons and thereafter periods of heavy precipitation.



## **5.0 CLOSURE**

The borehole investigation program was supervised by Mr. Lubo Kosci, P.Eng., and Ms. Madison Kennedy, B.A.Sc. This report was prepared by Mr. Al Varshoi, M.E.Sc., P.Eng., and was reviewed by Christopher Ng, P.Eng., a senior geotechnical engineer and an Associate of Golder. Mr. Jorge M. A. Costa, P.Eng., a Senior Consultant with Golder and Designated MTO Foundations Contact conducted an independent quality control review of this report.



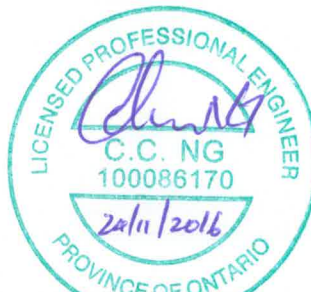


## FOUNDATION REPORT - REPLACEMENT OF TWIN LAKE CULVERTS, SITE NO. 38C-047 - HIGHWAY 519

### Report Signature Page

GOLDER ASSOCIATES LTD.

Al Varshoi, M.E.Sc., P.Eng.  
Geotechnical Engineering Group



Christopher Ng, P.Eng.  
Senior Geotechnical Engineer, Associate



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

ARV/MCK/CN/JMAC/mck

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## FOUNDATION REPORT - REPLACEMENT OF TWIN LAKE CULVERTS, SITE NO. 38C-047 - HIGHWAY 519

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### STANDARDS:

ASTM International:

ASTM D1586	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
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Ontario Water Resources Act:

Ontario Regulation 903 Wells (as amended)



# TABLES



## FOUNDATION REPORT - REPLACEMENT OF TWIN LAKE CULVERTS, SITE NO. 38C-047- HIGHWAY 519

Table 1: Summary of Existing Culvert Details

Culvert Location (Township)	Culvert ID	Approximate Height of Embankment <sup>1</sup>	Existing Culvert			Approximate Invert Elevation		Boreholes	Dynamic Cone Penetration Tests
			Type	Approximate Dimension	Approximate Length	Inlet of Culvert (W/E)	Outlet of Culvert (W/E)		
STA 20+800 (Dumas)	C60	Up to about 4.5 m	Elliptical CSP	3690 mm wide x 2380 mm high	17 m	330.7 m / 330.6 m (North End)	330.6 m / 330.4 m (South End)	8 Boreholes (C60-1 to C60-8)	Advanced from the bottom of Boreholes C60-7 and C60-8

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

Prepared By: MCK  
Checked By: CN  
Review ed By: JMAC



# FIGURES



South side of Highway 519 at about STA 20+800, Twin Lakes Culvert, looking North. July 12, 2016.

PROJECT

**Detail Design for Replacement of Twin Lakes Culverts  
Highway 519  
G.W.P. 327-99-00, W.P. 5296-06-01**

TITLE

**Site Photographs  
Twin Lakes Culvert C60 STA 20+800—Highway 519**



PROJECT No. 1521770			FILE No. — —		
DESIGN	MCK	SEPT 16	SCALE	NTS	REV.
CADD	— —		<b>FIGURE 1A</b>		
CHECK	CN	SEPT 16			
REVIEW	JMAC	SEPT 16			





North side of Highway 519 at about STA 20+800, Twin Lakes Culvert, looking South. July 12, 2016.

PROJECT

**Detail Design for Replacement of Twin Lakes Culverts  
Highway 519  
G.W.P. 327-99-00, W.P. 5296-06-01**

TITLE

**Site Photographs  
Twin Lakes Culvert C60 STA 20+800—Highway 519**



PROJECT No. 1521770

FILE No. — —

DESIGN MCK SEPT 16

SCALE NTS REV.

CADD — —

CHECK CN SEPT 16

REVIEW JMAC SEPT 16

**FIGURE 1B**



# DRAWINGS

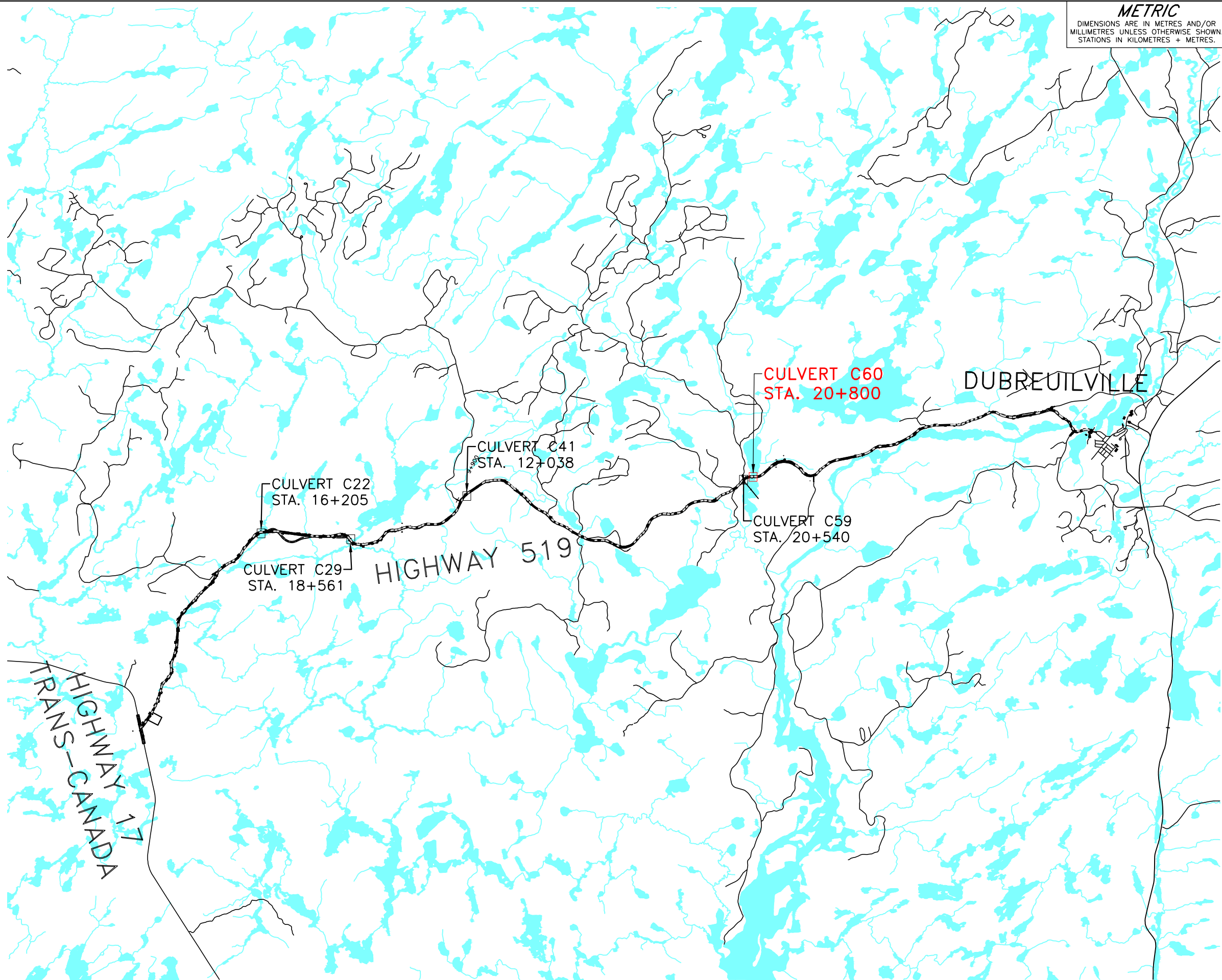
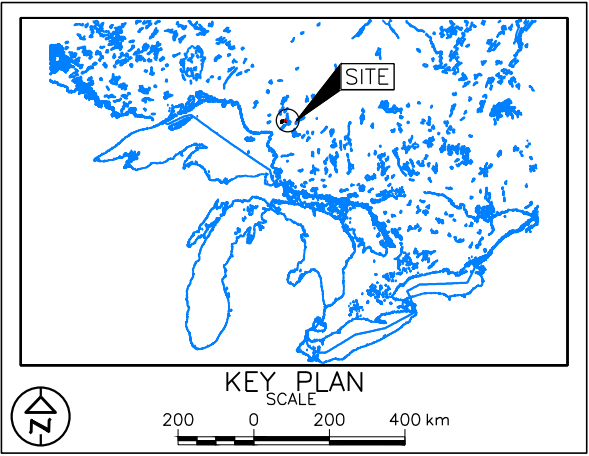
**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
WP No. 5296-06-01

HIGHWAY 519  
TWIN LAKE CULVERTS STA. 20+800

INDEX PLAN

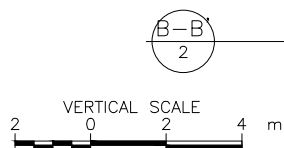
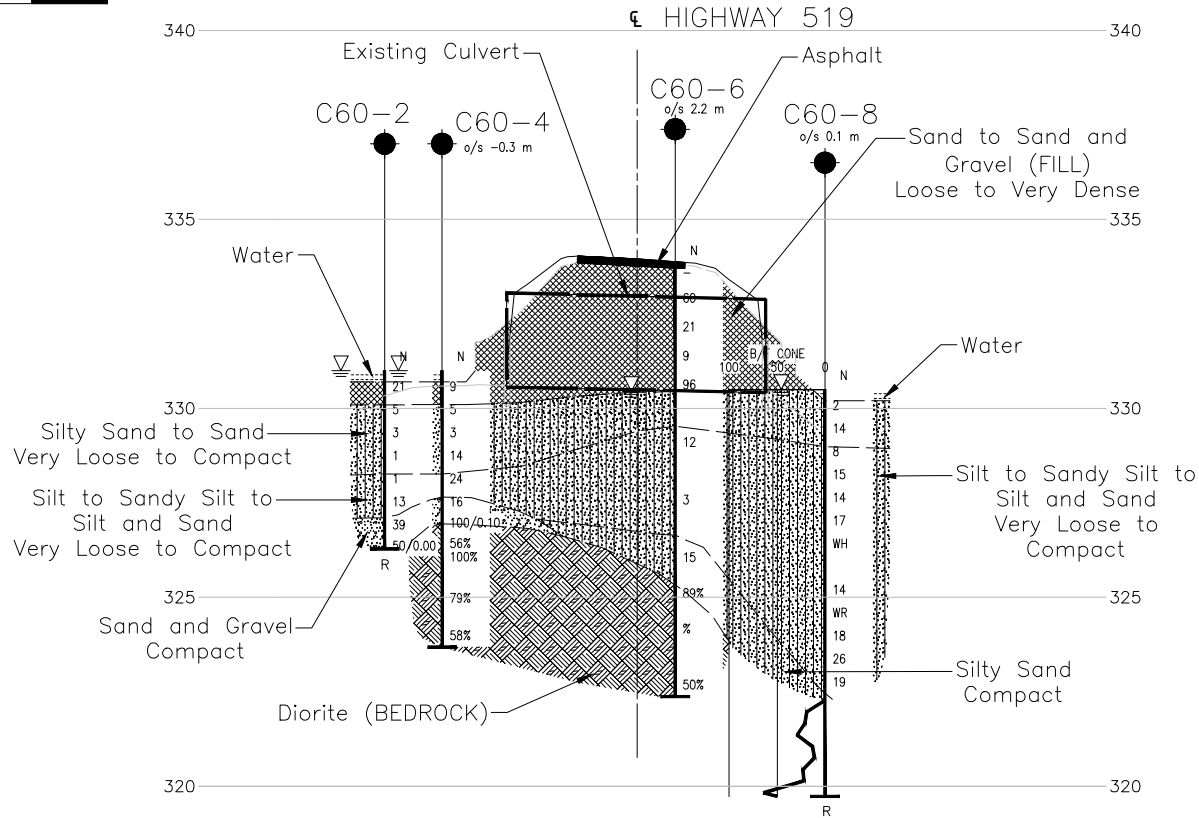
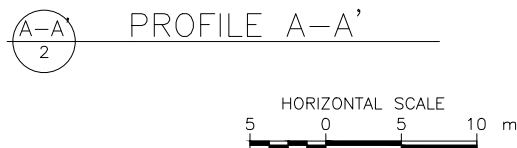
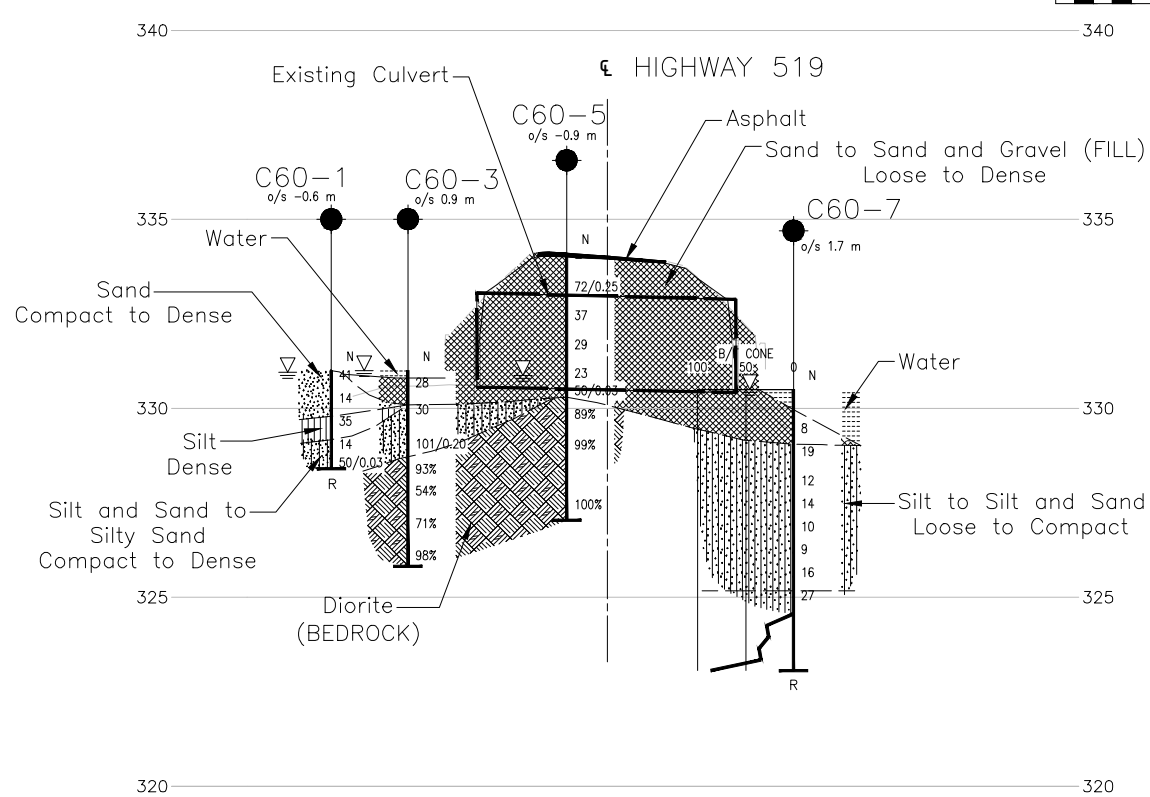
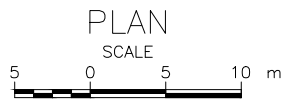
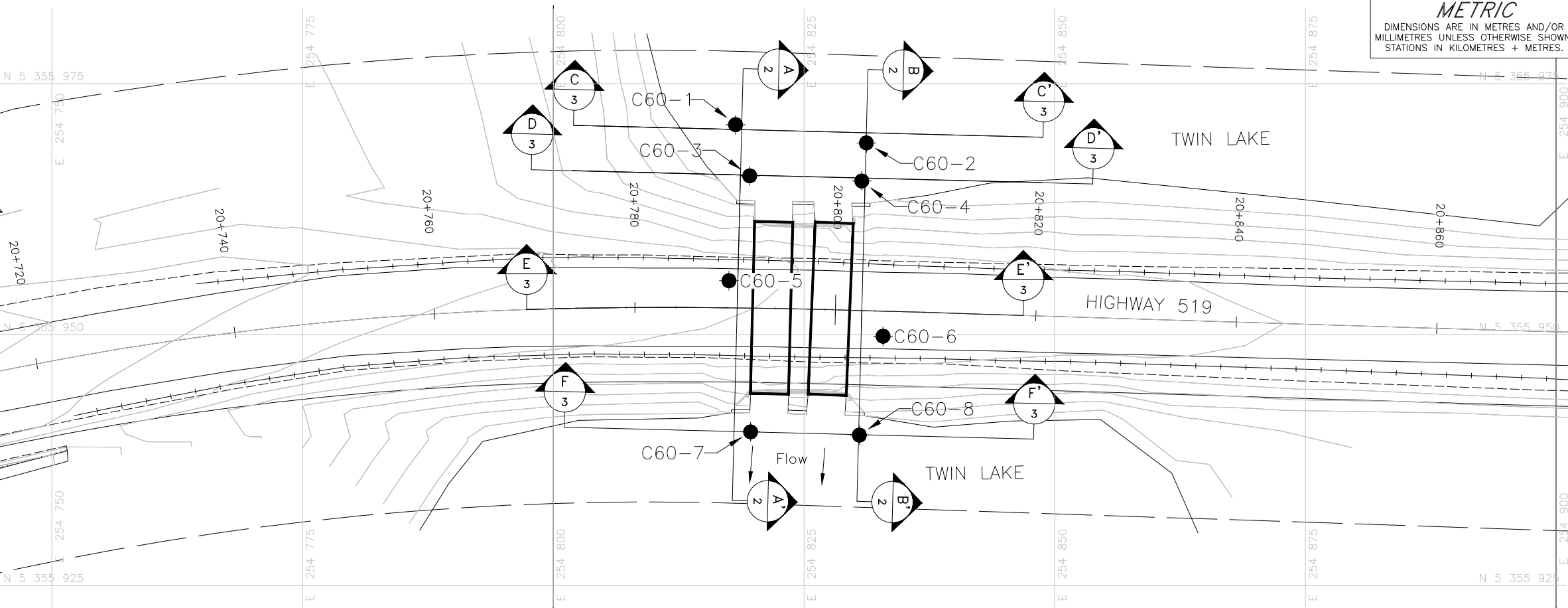
  
SHEET



**REFERENCE**  
Base plans and sections provided in digital format by D.M.Wills Associates, drawing file nos. 4539- HWY 519- BP (New Survey).dwg and Foundations X-Sec sent to Chris Ng July 8.dwg, received March 11, 2016.  
Base data - CANVEC, obtained 2016.

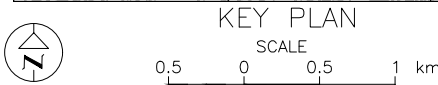
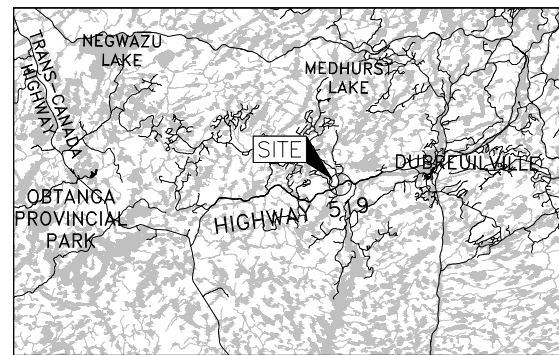
NO.	DATE	BY	REVISION
Geocres No. 42C-38			
HWY. 519		PROJECT NO. 1521770	DIST.
SUBM'D. MCK	CHKD. MCK	DATE: 9/29/2016	SITE: 38C-047
DRAWN: MR	CHKD. CN	APPD. JMAC	DWG. 1





CONT No. .  
WP No. 5296-06-01

HIGHWAY 519  
TWIN LAKE CULVERTS STA. 20+800  
BOREHOLE LOCATIONS AND  
SOIL STRATA



#### LEGEND

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C60-1	331.0	5355970.9	254818.2
C60-2	331.0	5355969.1	254831.2
C60-3	331.0	5355965.8	254819.6
C60-4	331.0	5355965.3	254830.8
C60-5	334.1	5355955.4	254817.5
C60-6	333.8	5355949.8	254832.9
C60-7	330.5	5355940.3	254819.7
C60-8	330.5	5355940.0	254830.5

#### NOTES

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

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

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

#### REFERENCE

Base plans and sections provided in digital format by D.M.Wills Associates, drawing file nos. 4539- HWY 519- BP (New Survey).dwg and Foundations X-Sec sent to Chris Ng July 8.dwg, received March 11, 2016.

NO.	DATE	BY	REVISION
1	2016	JMAC	Initial Design
2	2016	JMAC	Revised Design
3	2016	JMAC	Final Design
4	2016	JMAC	As Built

Geocres No. 42C-38

HWY. 519	PROJECT NO. 1521770	DIST. .
SUBM'D. MCK	CHKD. ARV	DATE: 8/31/2016
DRAWN: MR	CHKD. ARV	APPD. JMAC
		SITE: 38C-047
		DWG. 2

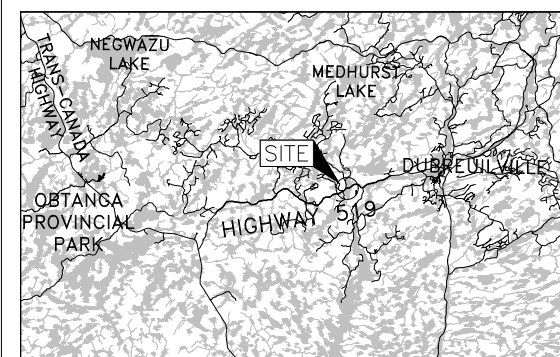


**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
WP No. 5296-06-01

HIGHWAY 519  
TWIN LAKE CULVERTS STA. 20+800

SHEET



KEY PLAN  
SCALE  
2.5 0 2.5 5 km

LEGEND

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

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
C60-1	331.0	5355970.9	254818.2
C60-2	331.0	5355969.1	254831.2
C60-3	331.0	5355965.8	254819.6
C60-4	331.0	5355965.3	254830.8
C60-5	334.1	5355955.4	254817.5
C60-6	333.8	5355949.8	254832.9
C60-7	330.5	5355940.3	254819.7
C60-8	330.5	5355940.0	254830.5

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.

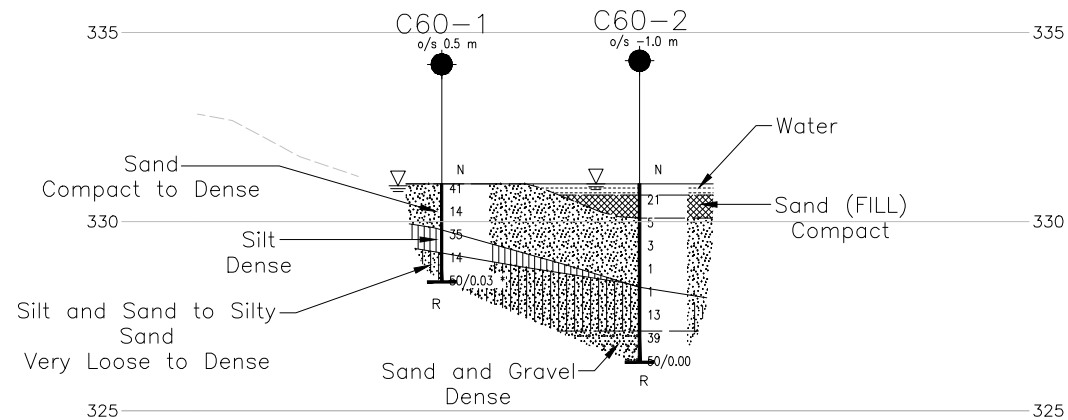
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

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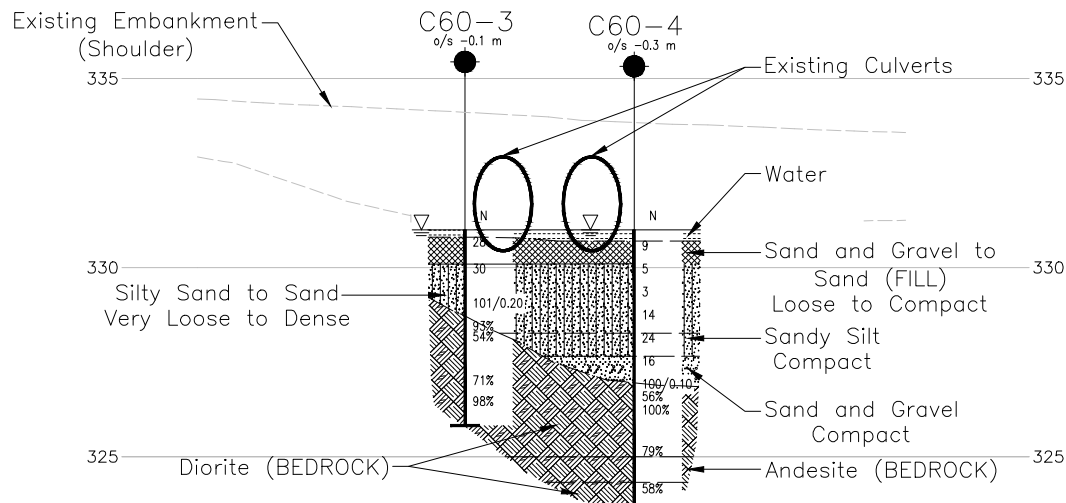
REFERENCE

Base plans and sections provided in digital format by D.M.Wills Associates, drawing file nos. 4539- HWY 519- BP (New Survey).dwg and Foundations X-Sec sent to Chris Ng July 8.dwg, received March 11, 2016.

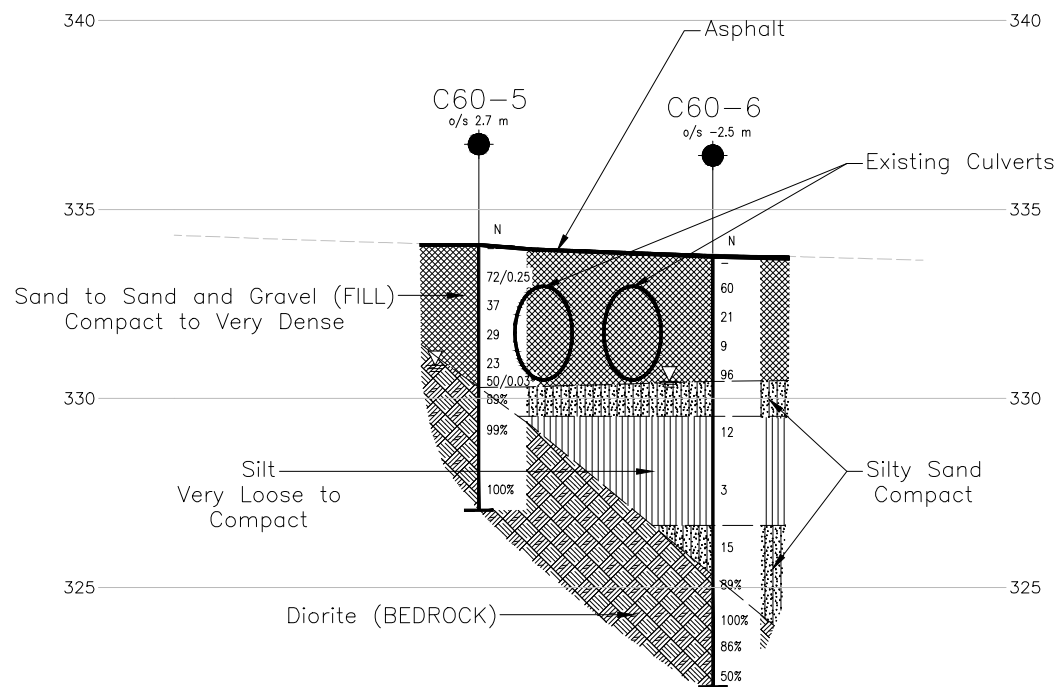
NO.	DATE	BY	REVISION
Geocres No. 42C-38			
HWY. 519	PROJECT NO. 1521770		DIST. .
SUBM'D. MCK	CHKD. ARV	DATE: 8/31/2016	SITE: 38C-047
DRAWN: MR	CHKD. ARV	APPD. JMAC	DWG. 3



C-C'  
2 PROFILE  
TOE OF DETOUR EMBANKMENT

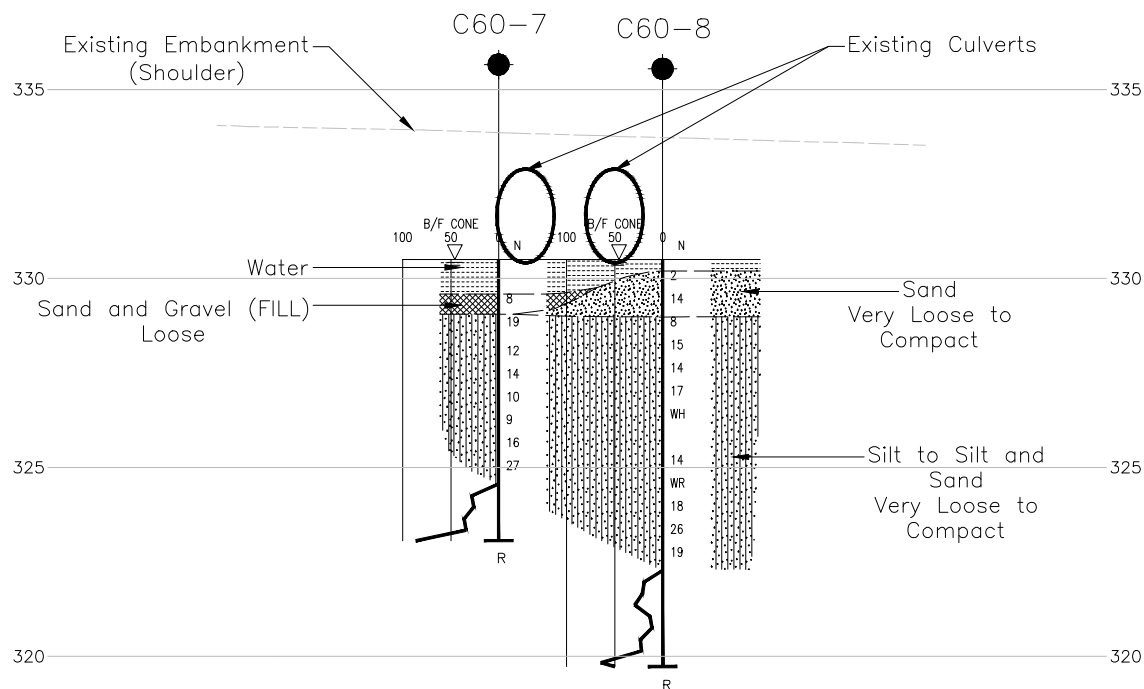


D-D'  
2 CROSS-SECTION D-D'  
EXISTING NORTH END OF CULVERT



E-E'  
2 CROSS-SECTION E-E'  
HIGHWAY 519 CENTERLINE PROFILE

HORIZONTAL SCALE  
5 0 5 10 m



F-F'  
2 CROSS-SECTION F-F'  
EXISTING SOUTH END OF CULVERT

VERTICAL SCALE  
2 0 2 4 m





# **APPENDIX A**

## **Record of Borehole and Drillhole Sheets**



## LIST OF SYMBOLS

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

### I. GENERAL

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

### II. STRESS AND STRAIN

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

### III. SOIL PROPERTIES

#### (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

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

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

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

#### (b) Hydraulic Properties

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

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

$C_c$	compression index (normally consolidated range)
$C_r$	recompression index (over-consolidated range)
$C_s$	swelling index
$C_{\alpha}$	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

Notes: 1  
2

$\tau = c' + \sigma' \tan \phi'$   
shear strength = (compressive strength)/2



## LIST OF ABBREVIATIONS

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

### I. SAMPLE TYPE

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

### II. PENETRATION RESISTANCE

#### Standard Penetration Resistance (SPT), $N_s$ :

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

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

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

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

**WH:** Sampler advanced by static weight of hammer

**WR:** Sampler advanced by weight of sampler and rod

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

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

### III. SOIL DESCRIPTION

#### (a) Non-Cohesive Soils

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

#### (b) Cohesive Soils Consistency

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

### IV. SOIL TESTS

w	water content
$w_p$	plastic limit
$w_l$	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	relative density (specific gravity, $G_s$ )
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO <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.

### V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



## LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

### WEATHERING STATE

**Fresh:** no visible sign of weathering

**Faintly weathered:** weathering limited to the surface of major discontinuities.

**Slightly weathered:** penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

**Moderately weathered:** weathering extends throughout the rock mass but the rock material is not friable.

**Highly weathered:** weathering extends throughout rock mass and the rock material is partly friable.

**Completely weathered:** rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

### BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

### JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

### GRAIN SIZE

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

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

### CORE CONDITION

#### Total Core Recovery (TCR)

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

#### Solid Core Recovery (SCR)

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

#### Rock Quality Designation (RQD)

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

### DISCONTINUITY DATA

#### Fracture Index

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

#### Dip with Respect to Core Axis

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

#### Description and Notes

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

#### Abbreviations





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

PROJECT 1521770		RECORD OF BOREHOLE No C60-1				SHEET 1 OF 1		METRIC									
W.P. 5296-06-01		LOCATION N 5355970.9; E 254818.2				ORIGINATED BY MCK											
DIST _____ HWY 519		BOREHOLE TYPE Portable Equipment, BW Casing, Manual Hammer				COMPILED BY MR											
DATUM Geodetic		DATE July 7, 2016				CHECKED BY ARV											
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									
331.0	GROUND SURFACE							20	40	60	80	100					
0.0	SAND, some gravel, trace organics, containing clayey silt lenses Compact to dense Brown to grey Wet		1	SS	41												
329.8			2	SS	14												
1.2	SILT, some sand Dense Grey Wet		3	SS	35												
329.2																	
1.8	SILT and SAND, trace to some gravel Compact Grey Moist		4	SS	14												
328.4			5	SS	50/0.03												
2.6	END OF BOREHOLE SPLIT-SPOON SAMPLER REFUSAL																
	NOTE:  1. Water level in open borehole at a depth of 0.1 m below ground surface (Elev. 330.9 m) upon completion of drilling.  * Split-Spoon Bouncing																

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PROJECT <u>1521770</u>		<b>RECORD OF BOREHOLE No C60-2</b>		SHEET 1 OF 1		<b>METRIC</b>	
W.P. <u>5296-06-01</u>		LOCATION <u>N 5355969.1 ; E 254831.2</u>		ORIGINATED BY <u>MCK</u>			
DIST <u>          </u> HWY <u>519</u>		BOREHOLE TYPE <u>Portable Equipment, BW Casing, Manual Hammer</u>		COMPILED BY <u>MR</u>			
DATUM <u>Geodetic</u>		DATE <u>July 9, 2016</u>		CHECKED BY <u>ARV</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
331.0	WATER SURFACE																
330.7	WATER																
0.3	Sand, some gravel (FILL) Compact Grey Wet		1	SS	21												
330.1	SAND, some silt, trace gravel, trace organics Very loose to loose Brown Wet		2	SS	5												
0.9			3	SS	3												
			4	SS	1												
328.3	SILT and SAND, trace clay, trace organics Very loose to compact Brown Wet		5	SS	1											1 82 (17)	
2.7			6A	SS	13												
327.1			6B														
3.9	SAND and GRAVEL, trace silt Dense Grey Wet		7	SS	39												
326.3			8	SS	50/0.00												
4.7	END OF BOREHOLE SPLIT-SPOON SAMPLER REFUSAL  * Split-Spoon Bouncing																

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PROJECT 1521770		RECORD OF BOREHOLE No C60-3		SHEET 1 OF 1		METRIC														
W.P. 5296-06-01		LOCATION N 5355965.8 ; E 254819.6		ORIGINATED BY MCK																
DIST _____ HWY 519		BOREHOLE TYPE Portable Equipment, BW Casing, Manual Hammer, NQ Rock Coring		COMPILED BY MR																
DATUM Geodetic		DATE July 5 and 6, 2016		CHECKED BY ACK/MCK																
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%) W <sub>p</sub> — W — W <sub>L</sub>			γ	GR	SA	SI	CL
331.0	WATER SURFACE							20	40	60	80	100	20	40	60					
0.0	WATER																			
0.2	Sand and gravel, some rock fill gravel sizes (FILL) Compact Brown		1	SS	28															
330.1	Wet Silty SAND, trace to some gravel, trace clay Compact to dense Grey Moist		2	SS	30		330						○							14 62 21 3
0.9																				
328.7	DIORITE (BEDROCK)		3	SS	01/0.20		329						○							
2.3	Bedrock cored from depths of 2.3 m to 5.2 m.  For bedrock coring details refer to Record of Drillhole C60-3.		1	RC	REC 100%															RQD = 93%
			2	RC	REC 100%		328													RQD = 54%
			3	RC	REC 100%		327													RQD = 71%
			4	RC	REC 98%		326													RQD = 98%
325.8	END OF BOREHOLE																			
5.2																				

PROJECT: 1521770

## RECORD OF DRILLHOLE: C60-3

SHEET 1 OF 1

LOCATION: N 5355965.8 ;E 254819.6

DRILLING DATE: July 6, 2016

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Hilti Portable Equipment

DRILLING CONTRACTOR: OGS Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	COLOUR % RETURN	FLUSH	RECOVERY		R.Q.D. %	FRACT INDEX PER 0.25 m	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY			Diametral Point Load		RMC -Q AVG	NOTES		
				DEPTH (m)	TOTAL CORE %				SOLID CORE %	B Angle			DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	K, cm <sup>3</sup> /sec	10 <sup>-6</sup>	10 <sup>-5</sup>	10 <sup>-4</sup>	10 <sup>-3</sup>	N			T	E

| 3    4    5 | BY Casing | Continued from Record of Borehole C60-3  Fresh, crystalline, white to black, medium grained, non-porous, medium strong to very strong DIORITE  - Quartz bands between depths of 2.28 m and 4.35 m |  | 328.72 2.28 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

DEPTH SCALE

1 : 50



LOGGED: MCK

CHECKED: ACK/ARV

GTA-RCK 018 S:\CLIENTS\MTOWHWY\_519\02\_DATA\GINT\HWY\_519.GPJ GAL-MISS.GDT 11/22/16

PROJECT 1521770		RECORD OF BOREHOLE No C60-4		SHEET 1 OF 1		METRIC											
W.P. 5296-06-01		LOCATION N 5355965.3 ; E 254830.8		ORIGINATED BY MCK													
DIST _____ HWY 519		BOREHOLE TYPE Portable Equipment, BW Casing, Manual Hammer, NQ Rock Coring		COMPILED BY MR													
DATUM Geodetic		DATE July 9 and 10, 2016		CHECKED BY ACK/MCK													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL
								20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
331.0	WATER SURFACE																
330.7	WATER																
0.3	Sand, some rock fill gravel sizes (FILL)		1	SS	9												
330.1	Loose Grey Wet		2	SS	5												
0.9	SAND, some silt, trace organics		3	SS	3												
	Very loose to compact		4	SS	14												
328.3	Brown Moist to wet																
2.7	Sandy SILT, trace to some clay		5	SS	24												
327.6	Compact Grey Wet		6	SS	16												
3.4	SAND and GRAVEL, trace to some silt		7	SS	100/100												
326.9	Compact Grey Wet		1	RC	REC 92%												
4.1	DIORITE / ANDESITE (BEDROCK)		2	RC	REC 100%												
	Bedrock cored from depths of 4.1 m to 7.3 m.		3	RC	REC 100%												
	For bedrock coring details refer to Record of Drillhole C60-4.		4	RC	REC 88%												
323.7	END OF BOREHOLE																
7.3																	

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PROJECT: 1521770

**RECORD OF DRILLHOLE: C60-4**

SHEET 1 OF 1

LOCATION: N 5355965.3 ;E 254830.8

DRILLING DATE: July 10, 2016

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Hilti Portable Equipment

DRILLING CONTRACTOR: OGS Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY			FRACT. INDEX PER 0.25	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec			Diametral Point Load Index (MPa)	RMC -Q AVG	NOTES	
									TOTAL CORE %	SOLID CORE %	R.Q.D. %		B Angle	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 10 10 10				10 10 10 10
5	BW Casing	NQ RC Double Tube Sampling	Continued from Record of Borehole C60-4		326.94																		
			Fresh, crystalline, white and black, medium grained, non-porous, medium strong to very strong DIORITE	1																			
				2																			
				3																			
7			Fresh, crystalline, white and black, medium grained, non-porous, very strong ANDESITE		324.50																		
8			Fresh, crystalline, white and black, medium grained, non-porous, strong DIORITE		323.79																		
			END OF DRILLHOLE																				
9																							
10																							
11																							
12																							
13																							
14																							

DEPTH SCALE

1 : 50



LOGGED: MCK

CHECKED: ACK/ARV

PROJECT 1521770		RECORD OF BOREHOLE No C60-5		SHEET 1 OF 1		METRIC											
W.P. 5296-06-01		LOCATION N 5355955.4 ;E 254817.5		ORIGINATED BY LK													
DIST HWY 519		BOREHOLE TYPE 150 mm Cont. Flight Solid Stem Augers, NW Casing and NQ Coring		COMPILED BY MR													
DATUM Geodetic		DATE July 5, 2016		CHECKED BY ACK/MCK													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W <sub>p</sub> W W <sub>L</sub> WATER CONTENT (%)			γ	GR SA SI CL
334.1	PAVEMENT SURFACE							20 40 60 80 100									
0.0	ASPHALT (75 mm)		1	AS	-		334										
333.4	Sand and gravel (FILL) Brown Moist		2	SS	72/0.25		333										29 60 10 1
0.7	Sand, some gravel to gravelly, trace to some silt, trace clay, some rock fill gravel sizes (FILL) Compact to very dense Brown Moist		3	SS	37		332										
			4	SS	29		331										15 77 (8)
			5	SS	23		330										
330.3	DIORITE (BEDROCK)		6	SS	60/0.03		329										RQD = 89%
3.8	Bedrock cored from depths of 3.8 m to 7.1 m.  For bedrock coring details refer to Record of Drillhole C60-5.		1	NQ RC	REC 94%		328										RQD = 99%
			2	NQ RC	REC 100%												RQD = 100%
			3	NQ RC	REC 100%												
327.0	END OF BOREHOLE																
7.1	NOTE:  1. Water level in open borehole at a depth of 3.2 m below ground surface (Elev. 330.9 m) upon completion of drilling.  * Split-Spoon Bouncing																

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PROJECT 1521770		RECORD OF BOREHOLE No C60-6		SHEET 1 OF 1		METRIC														
W.P. 5296-06-01		LOCATION N 5355949.8 ; E 254832.9		ORIGINATED BY LK																
DIST _____ HWY 519		BOREHOLE TYPE 150 mm Continuous Flight Solid Stem Augers, NQ Rock Coring		COMPILED BY MR																
DATUM Geodetic		DATE July 5 and 6, 2016		CHECKED BY ACK/MCK																
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL			
								20 40 60 80 100	20 40 60 80 100	20 40 60	W <sub>p</sub> W W <sub>L</sub>	20 40 60								
333.8 0.0	PAVEMENT SURFACE ASPHALT (75 mm) Sand and gravel, trace to some silt, trace clay (FILL) Loose to very dense Brown Moist		1	AS	-		333													
			2	SS	60															
			3	SS	21		332													
			4	SS	9															
			5A				331													
			5B	SS	96															
330.4 3.4	Silty SAND, trace gravel, trace organics Black Moist						330													
329.5 4.3	SILT, trace to some clay, trace sand Very loose to compact Grey Wet		6	SS	12		329													
							328													
			7	SS	3															
							327													
326.6 7.2	Silty SAND, some gravel Compact Grey Wet		8	SS	15		326													
325.3 8.5	DIORITE (BEDROCK)  Bedrock cored from depths of 8.5 m to 11.4 m.  For bedrock coring details refer to Record of Drillhole C60-6.		1	RC	REC 100%		325													
			2	RC	REC 100%		324													
			3	RC	REC 81%		323													
322.4 11.4	END OF BOREHOLE  NOTE:  1. Water level in open borehole at a depth of 3.4 m below ground surface (Elev. 330.4 m) upon completion of drilling.																			

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PROJECT: 1521770

**RECORD OF DRILLHOLE: C60-6**

SHEET 1 OF 1

LOCATION: N 5355949.8 ;E 254832.9

DRILLING DATE: July 6, 2016

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: Landcore Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SH - Shear VN - Vein CJ - Conjugate	BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage	PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular	PO - Polished K - Slickensided SM - Smooth RO - Rough VR - Very Rough	MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES
FLUSH	RECOVERY	R.Q.D. %	FRACT. INDEX PER 0.25	B Angle	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q AVG
325.32	8.48											
1	100					JN,PL,RO SA	15	2	3			
2	100					JN,RO SA JN,UN,RO SA JN,RO	3	2	2			
3	100						3	1	3			
322.37	11.43											
END OF DRILLHOLE												
12												
13												
14												
15												
16												
17												
18												

2.2 MPa (Axial)  
5.6 MPa- Vertical joint from  
11.28 m to 11.40 m

DEPTH SCALE

1 : 50



LOGGED: LK

CHECKED: ACK/ARV



PROJECT 1521770		RECORD OF BOREHOLE No C60-7		SHEET 1 OF 1		METRIC										
W.P. 5296-06-01		LOCATION N 5355940.3 ; E 254819.7		ORIGINATED BY MCK												
DIST _____ HWY 519		BOREHOLE TYPE Portable Equipment, BW Casing, Manual Hammer		COMPILED BY MR												
DATUM Geodetic		DATE July 11 and 12, 2016		CHECKED BY ACK/MCK												
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								
330.5	WATER SURFACE															
0.0	WATER															
329.6																
0.9	Sand and gravel (FILL)		1A	SS	8											
329.0	Loose Brown Wet		1B													
1.5	SILT, some clay, trace to some sand Loose to compact Grey Wet		2	SS	19											
			3	SS	12											
			4	SS	14											
			5	SS	10											
			6	SS	9											
			7	SS	16											
325.2																
5.3	SILT and SAND, trace gravel Compact Grey Wet		8	SS	27											
324.6																
5.9	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)															
323.1																
7.4	END OF DCPT REFUSAL TO FURTHER PENETRATION (86 Blows / 0.28 m) (HAMMER BOUNCING)															

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PROJECT		1521770		RECORD OF BOREHOLE		No C60-8		SHEET 1 OF 1		METRIC				
W.P.		5296-06-01		LOCATION		N 5355940.0 ; E 254830.5		ORIGINATED BY		MCK				
DIST		HWY 519		BOREHOLE TYPE		Portable Equipment, BW Casing, Manual Hammer		COMPILED BY		MR				
DATUM		Geodetic		DATE		July 10, 2016		CHECKED BY		ACK/MCK				
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						
330.5	WATER SURFACE													
0.0	WATER													
330.2														
0.3	SAND, trace to some silt, trace gravel, trace organics Very loose to compact Brown to black Wet		1	SS	2		330							5 87 7 1
			2	SS	14									
329.0							329							
1.5	SILT, trace to some sand, trace to some gravel, trace to some clay Very loose to compact Grey Wet		3	SS	8									
			4	SS	15		328							1 4 82 13
			5	SS	14									
			6	SS	17		327							
			7	SS	WH									Non-Plastic
							326							
			8	SS	14		325							
			9	SS	WR									
			10	SS	18		324							9 6 78 7
			11	SS	26		323							
			12A	SS	19									
			12B											
322.3	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)						322							
8.2														
							321							
							320							
319.7	END OF DCPT REFUSAL TO FURTHER PENETRATION (50 Blows / 0.10 m) (HAMMER BOUNCING)													
10.8														

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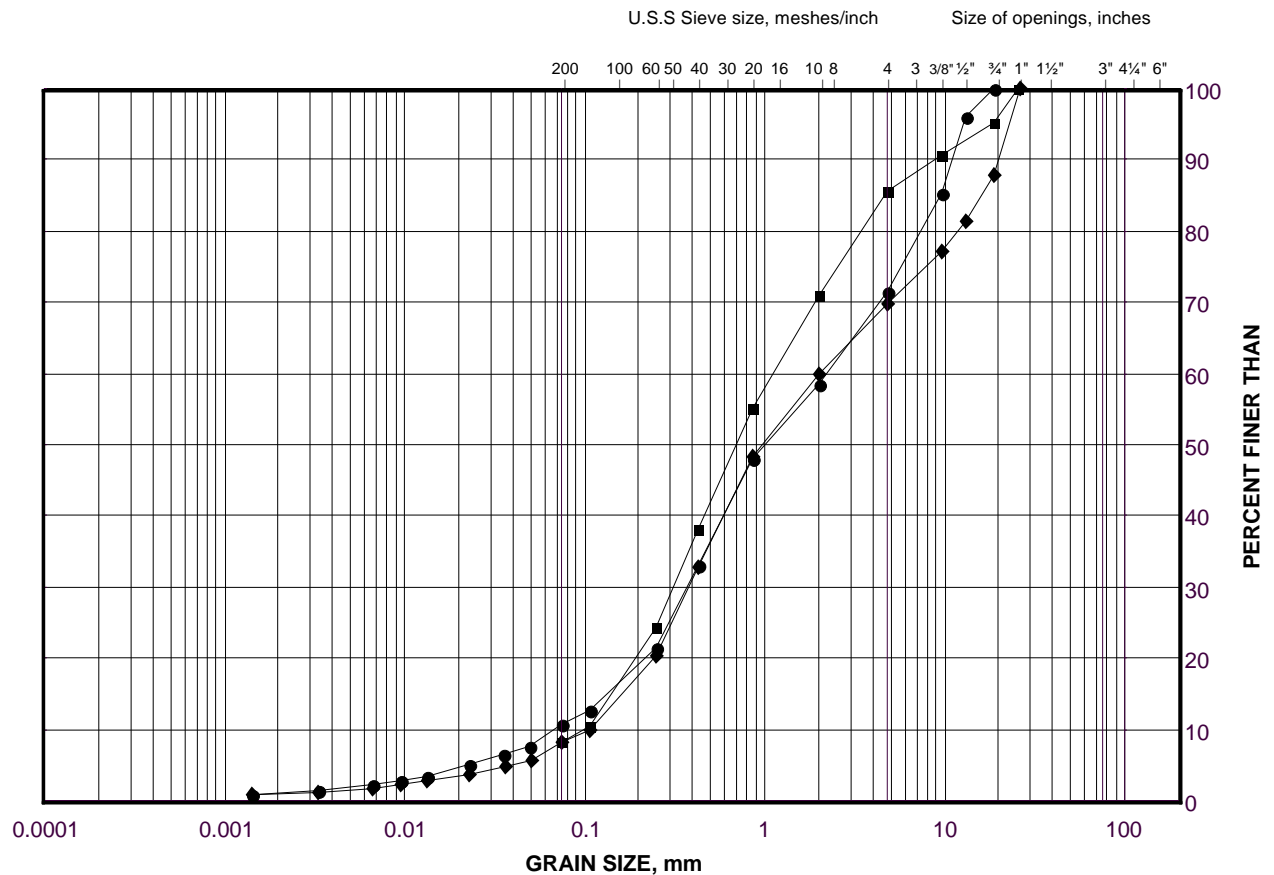
# **APPENDIX B**

## **Laboratory Results**

# GRAIN SIZE DISTRIBUTION

Sand to Sand and Gravel (Fill)

FIGURE B1



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C60-5	2	333.2
■	C60-5	4	331.6
◆	C60-6	4	331.1

Project Number: 1521770

Checked By: ARV

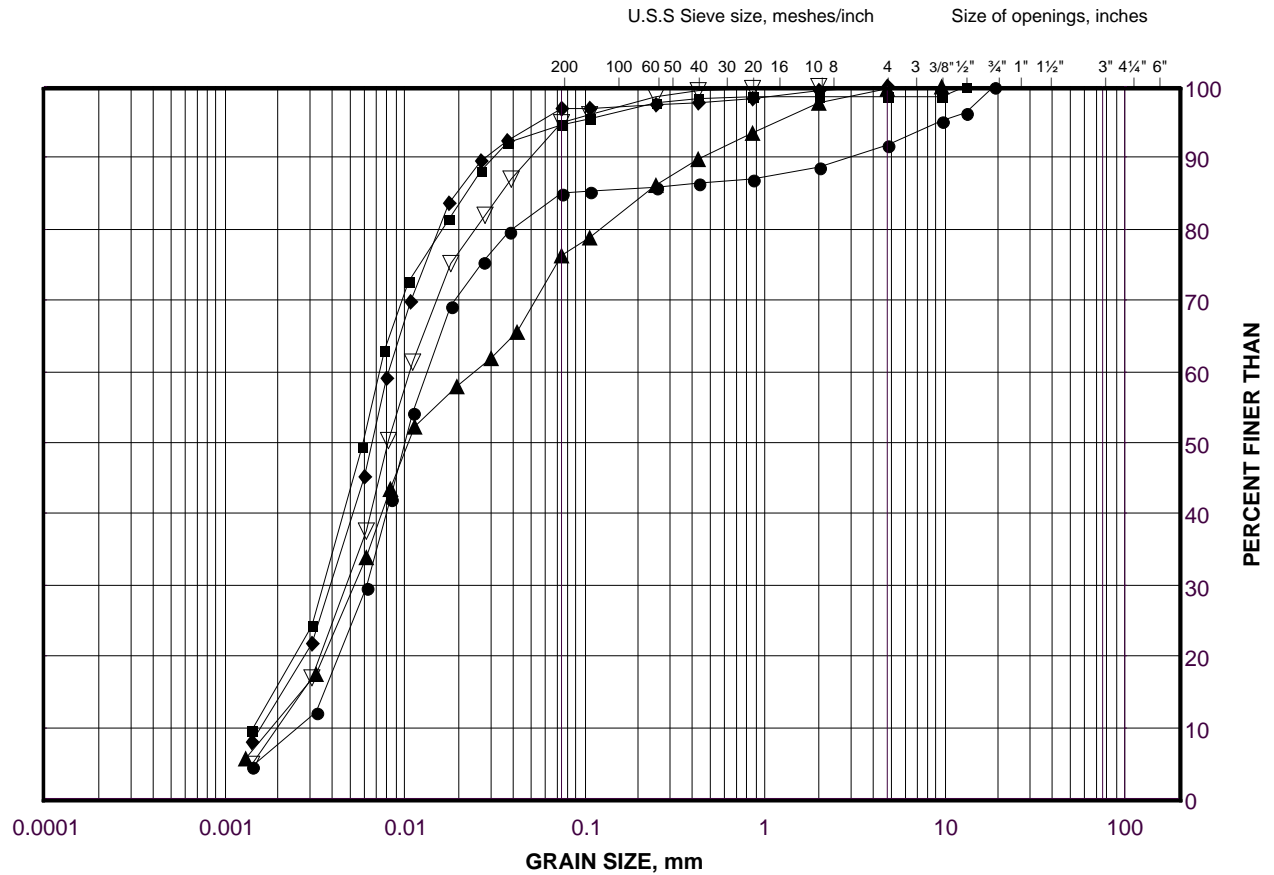
**Golder Associates**

Date: 13-Sep-16

# GRAIN SIZE DISTRIBUTION

Silt to Sandy Silt

FIGURE B2-A



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C60-8	10	323.8
■	C60-8	4	328.1
◆	C60-7	4	327.3
▲	C60-4	5	328.0
▽	C60-6	6	328.9

Project Number: 1521770

Checked By: ARV

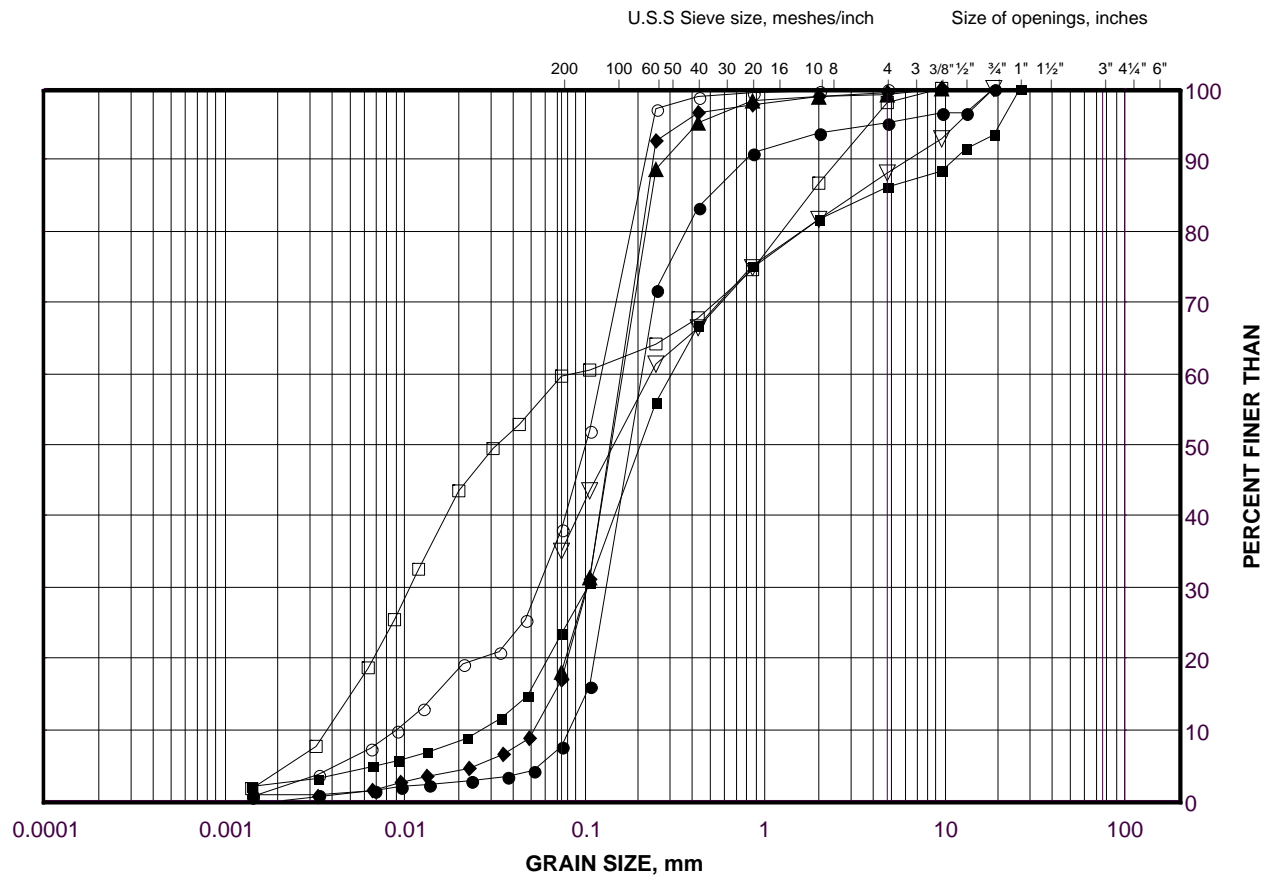
**Golder Associates**

Date: 29-Sep-16

# GRAIN SIZE DISTRIBUTION

Silt and Sand to Sand

FIGURE B2-B



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

## LEGEND

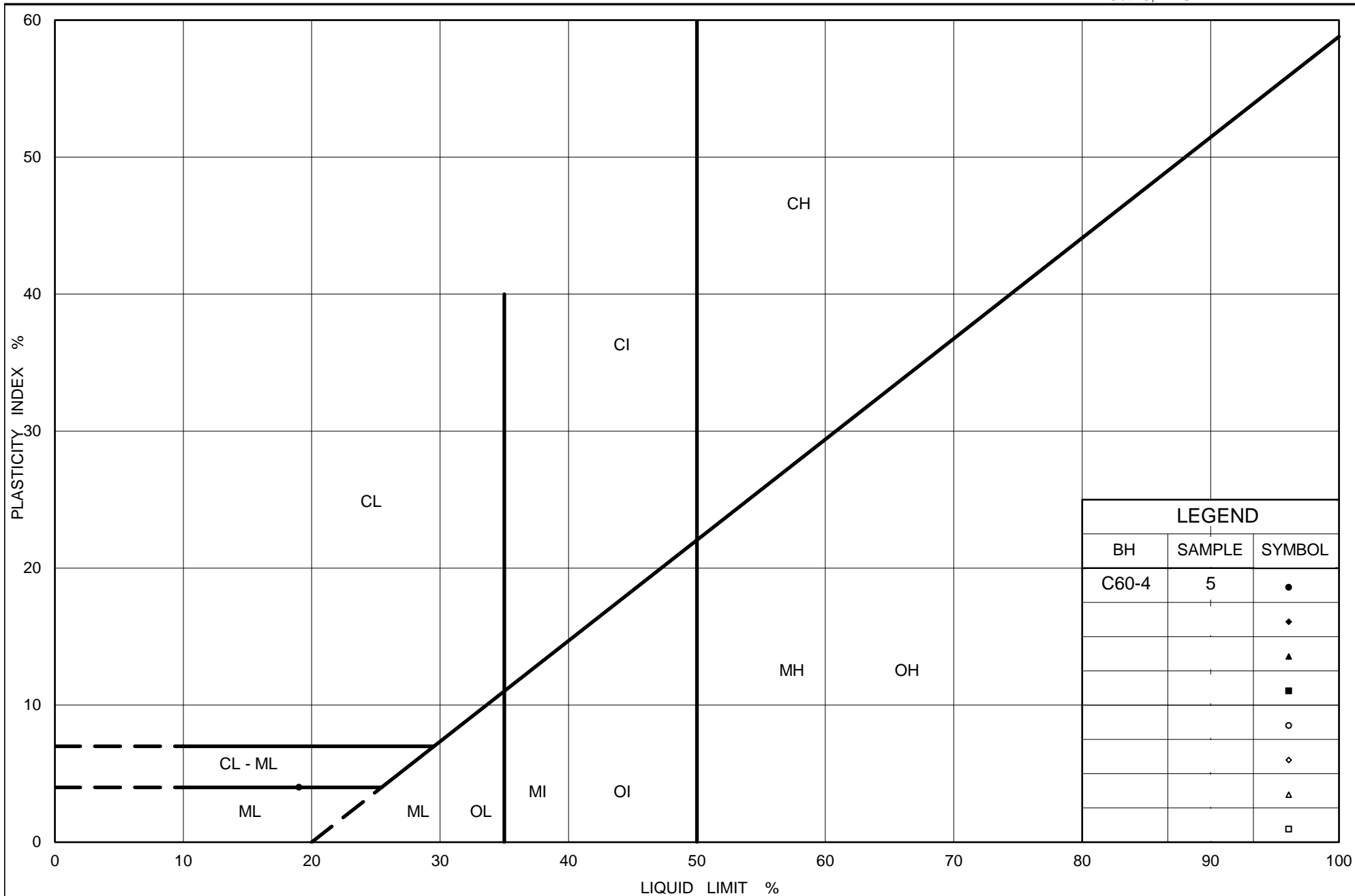
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C60-8	2	329.3
■	C60-3	2	329.8
◆	C60-4	3	329.2
▲	C60-2	4	328.6
▽	C60-1	5	328.5
○	C60-2	5	327.9
□	C60-7	8	324.9

Project Number: 1521770

Checked By: ARV

**Golder Associates**

Date: 29-Sep-16



Ministry of Transportation

Ontario

## PLASTICITY CHART Sandy Silt

Figure No. B3

Project No. 1521770

Checked By: ARV

### Borehole C60-3



Box 1: 2.28 m – 5.18 m

### Borehole C60-4



Box 1: 4.06 m – 5.51 m

### Borehole C60-4



Box 2: 5.51 m – 7.31 m

REVISION DATE: September 19, 2016 BY: MK Project: 1521770

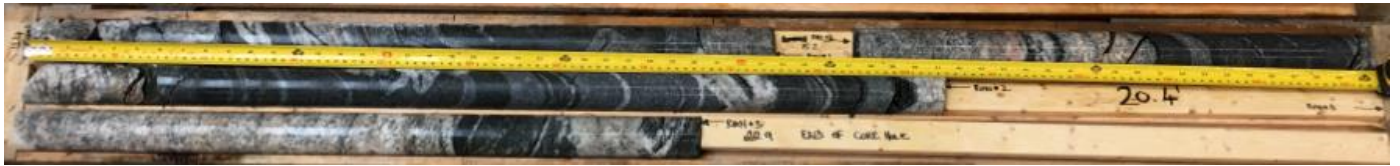
0 m	0.25 m	0.5 m	0.75 m	1.0 m	1.25 m	1.5 m
0 ft	1 ft	2 ft	3 ft	4 ft	5 ft	

PROJECT <b>Detail Design for Replacement of Twin Lakes Culverts Highway 519 G.W.P. 327-99-00, W.P. 5296-06-01</b>					
TITLE <b>Bedrock Core Photographs – Highway 519 Boreholes C60-3 and C60-4</b>					
PROJECT N6521770			FILE No. ----		
DESIGN	MK	SEP 16	SCALE	NTS	REV.
CADD	--	--	<b>FIGURE B4</b>		
CHECK	CN	SEP 16			
REVIEW	JMAC	SEP 16			





## Borehole C60-5

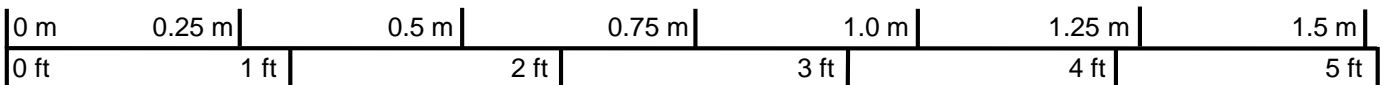


Box 1: 3.81 m – 7.06 m

## Borehole C60-6



Box 1: 8.48 m – 11.43 m



PROJECT <b>Detail Design for Replacement of Twin Lakes Culverts Highway 519 G.W.P. 327-99-00, W.P. 5296-06-01</b>					
TITLE <b>Bedrock Core Photographs – Highway 519 Boreholes C60-5 and C60-6</b>					
PROJECT N6521770			FILE No. ----		
DESIGN	MK	SEP 16	SCALE	NTS	REV.
CADD	--		<b>FIGURE B5</b>		
CHECK	CN	SEP 16			
REVIEW	JMAC	SEP 16			



**UNCONFINED COMPRESSION TEST (UC)****FIGURE B6****ASTM D7012****SAMPLE IDENTIFICATION**

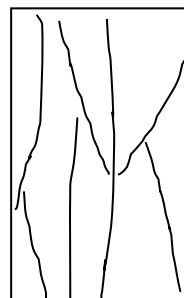
PROJECT NUMBER	1521770	SAMPLE NUMBER	Run 2
PROJECT NAME	DM Wills/5014-E-0035/Hwy 519	SAMPLE DEPTH, m	6.09-6.36
BOREHOLE NUMBER	C60-5	DATE:	2016-09-19

**TEST CONDITIONS**

MACHINE SPEED, mm/min	N/A	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.23

**SPECIMEN INFORMATION**

SAMPLE HEIGHT, cm	10.56	WATER CONTENT, (specimen) %	0.05
SAMPLE DIAMETER, cm	4.73	UNIT WEIGHT, kN/m <sup>3</sup>	26.69
SAMPLE AREA, cm <sup>2</sup>	17.58	DRY UNIT WT., kN/m <sup>3</sup>	26.68
SAMPLE VOLUME, cm <sup>3</sup>	185.69	SPECIFIC GRAVITY	-
WET WEIGHT, g	505.55	VOID RATIO	-
DRY WEIGHT, g	505.31		

**VISUAL INSPECTION****FAILURE SKETCH****TEST RESULTS**

STRAIN AT FAILURE, %	N/A	COMPRESSIVE STRENGTH, MPa	64.5
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Checked By: MCK

**Golder Associates**

**TABLE B1**  
**SUMMARY OF POINT LOAD TESTS ON ROCK SAMPLES**

PROJECT NO. 1521770						
DATE September 2016						
Borehole Number	Run Number	Sample Depth (m)	Sample Elevation (m)	Bedrock Description	Test Type	Is (50mm) (MPa)
C60-5	2	6.2	327.9	Diorite	Axial	1.8
C60-5	2	6.2	327.9	Diorite	Diametral	4.0
C60-6	1	9.0	324.8	Diorite	Axial	2.2
C60-6	1	9.0	324.8	Diorite	Diametral	5.6

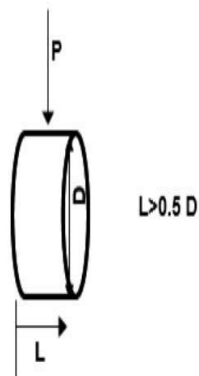
(1)  $I_{s50} \times C$  (actual value will have to be confirmed by UCS testing), from ISRM ("Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock. Mech. Min. Sci. and Geomechanical Abstr., Vol 22, No. 2 1985, pp. 51-60.

(2) Actual distance between point load cones at time of failure.

**DIAMETRAL SPECIMEN SHAPE REQUIREMENTS**

note: Diametral tests are perpendicular to core axis

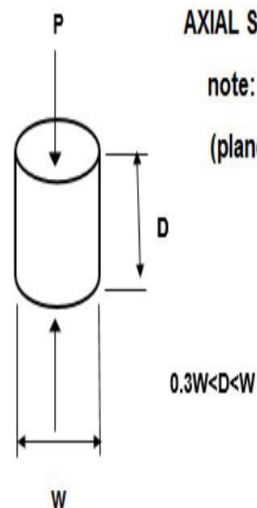
(planes of weakness)



**AXIAL SPECIMEN SHAPE REQUIREMENTS**

note: Axial tests are parallel to core axis

(planes of weakness)





# **APPENDIX C**

## **Analytical Test Result**

Your Project #: 1521770  
Your C.O.C. #: 568328-01-01

**Attention:Chris Ng**

Golder Associates Ltd  
Mississauga - Standing Offer  
6925 Century Ave  
Suite 100  
Mississauga, ON  
CANADA L5N 7K2

**Report Date: 2016/07/20**  
Report #: R4073825  
Version: 1 - Final

**CERTIFICATE OF ANALYSIS**

**MAXXAM JOB #: B6E9276**

**Received: 2016/07/18, 17:15**

Sample Matrix: Water  
# Samples Received: 5

Analyses	Date		Date Analyzed	Laboratory Method	Reference
	Quantity	Extracted			
Chloride by Automated Colourimetry	5	N/A	2016/07/20	CAM SOP-00463	EPA 325.2 m
Conductivity	5	N/A	2016/07/19	CAM SOP-00414	SM 22 2510 m
pH	5	N/A	2016/07/19	CAM SOP-00413	SM 4500H+ B m
Resistivity of Water	5	2016/07/18	2016/07/20	CAM SOP-00414	SM 22 2510 m
Sulphate by Automated Colourimetry	5	N/A	2016/07/20	CAM SOP-00464	EPA 375.4 m

**Remarks:**

Maxxam Analytics has performed all analytical testing herein in accordance with ISO 17025 and the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act. All methodologies comply with this document and are validated for use in the laboratory. The methods and techniques employed in this analysis conform to the performance criteria (detection limits, accuracy and precision) as outlined in the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act.

Maxxam Analytics is accredited for all specific parameters as required by Ontario Regulation 153/04. Maxxam Analytics is limited in liability to the actual cost of analysis unless otherwise agreed in writing. There is no other warranty expressed or implied. Samples will be retained at Maxxam Analytics for three weeks from receipt of data or as per contract.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

\* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

**Encryption Key**

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Ema Gitej, Senior Project Manager

Email: EGitej@maxxam.ca

Phone# (905)817-5829

=====

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

### RESULTS OF ANALYSES OF WATER

<b>Maxxam ID</b>		CSN276	CSN277		CSN278	CSN278		CSN279			
<b>Sampling Date</b>		2016/07/17 10:30	2016/07/17 10:20		2016/07/17 08:20	2016/07/17 08:20		2016/07/17 09:00			
<b>COC Number</b>		568328-01-01	568328-01-01		568328-01-01	568328-01-01		568328-01-01			
	<b>UNITS</b>	<b>C22</b>	<b>C29</b>	<b>RDL</b>	<b>C41</b>	<b>C41 Lab-Dup</b>	<b>RDL</b>	<b>C59</b>	<b>RDL</b>	<b>QC Batch</b>	<b>MDL</b>

<b>Calculated Parameters</b>											
Resistivity	ohm-cm	19000	18000		820			11000		4583855	
<b>Inorganics</b>											
Conductivity	umho/cm	53	56	1.0	1200		1.0	88	1.0	4584773	0.20
pH	pH	6.97	7.31		7.07			7.32		4584771	
Dissolved Sulphate (SO <sub>4</sub> )	mg/L	<1.0	<1.0	1.0	4.9	4.7	1.0	<1.0	1.0	4585013	0.10
Dissolved Chloride (Cl)	mg/L	3.8	3.2	1.0	320	320	4.0	<1.0	1.0	4585005	0.30
RDL = Reportable Detection Limit											
QC Batch = Quality Control Batch											
Lab-Dup = Laboratory Initiated Duplicate											

<b>Maxxam ID</b>		CSN280			
<b>Sampling Date</b>		2016/07/17 09:30			
<b>COC Number</b>		568328-01-01			
	<b>UNITS</b>	<b>C60</b>	<b>RDL</b>	<b>QC Batch</b>	<b>MDL</b>
<b>Calculated Parameters</b>					
Resistivity	ohm-cm	12000		4583855	
<b>Inorganics</b>					
Conductivity	umho/cm	82	1.0	4584773	0.20
pH	pH	7.79		4584771	
Dissolved Sulphate (SO <sub>4</sub> )	mg/L	<1.0	1.0	4585013	0.10
Dissolved Chloride (Cl)	mg/L	<1.0	1.0	4585005	0.30
RDL = Reportable Detection Limit					
QC Batch = Quality Control Batch					

## TEST SUMMARY

**Maxxam ID:** CSN276  
**Sample ID:** C22  
**Matrix:** Water

**Collected:** 2016/07/17  
**Shipped:**  
**Received:** 2016/07/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	4585005	N/A	2016/07/20	Deonarine Ramnarine
Conductivity	AT	4584773	N/A	2016/07/19	Surinder Rai
pH	AT	4584771	N/A	2016/07/19	Surinder Rai
Resistivity of Water		4583855	2016/07/20	2016/07/20	Automated Statchk
Sulphate by Automated Colourimetry	KONE	4585013	N/A	2016/07/20	Deonarine Ramnarine

**Maxxam ID:** CSN277  
**Sample ID:** C29  
**Matrix:** Water

**Collected:** 2016/07/17  
**Shipped:**  
**Received:** 2016/07/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	4585005	N/A	2016/07/20	Deonarine Ramnarine
Conductivity	AT	4584773	N/A	2016/07/19	Surinder Rai
pH	AT	4584771	N/A	2016/07/19	Surinder Rai
Resistivity of Water		4583855	2016/07/20	2016/07/20	Automated Statchk
Sulphate by Automated Colourimetry	KONE	4585013	N/A	2016/07/20	Deonarine Ramnarine

**Maxxam ID:** CSN278  
**Sample ID:** C41  
**Matrix:** Water

**Collected:** 2016/07/17  
**Shipped:**  
**Received:** 2016/07/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	4585005	N/A	2016/07/20	Deonarine Ramnarine
Conductivity	AT	4584773	N/A	2016/07/19	Surinder Rai
pH	AT	4584771	N/A	2016/07/19	Surinder Rai
Resistivity of Water		4583855	2016/07/20	2016/07/20	Automated Statchk
Sulphate by Automated Colourimetry	KONE	4585013	N/A	2016/07/20	Deonarine Ramnarine

**Maxxam ID:** CSN278 Dup  
**Sample ID:** C41  
**Matrix:** Water

**Collected:** 2016/07/17  
**Shipped:**  
**Received:** 2016/07/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	4585005	N/A	2016/07/20	Deonarine Ramnarine
Sulphate by Automated Colourimetry	KONE	4585013	N/A	2016/07/20	Deonarine Ramnarine

**Maxxam ID:** CSN279  
**Sample ID:** C59  
**Matrix:** Water

**Collected:** 2016/07/17  
**Shipped:**  
**Received:** 2016/07/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	4585005	N/A	2016/07/20	Deonarine Ramnarine
Conductivity	AT	4584773	N/A	2016/07/19	Surinder Rai
pH	AT	4584771	N/A	2016/07/19	Surinder Rai
Resistivity of Water		4583855	2016/07/20	2016/07/20	Automated Statchk
Sulphate by Automated Colourimetry	KONE	4585013	N/A	2016/07/20	Deonarine Ramnarine

## TEST SUMMARY

**Maxxam ID:** CSN280  
**Sample ID:** C60  
**Matrix:** Water

**Collected:** 2016/07/17  
**Shipped:**  
**Received:** 2016/07/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	4585005	N/A	2016/07/20	Deonarine Ramnarine
Conductivity	AT	4584773	N/A	2016/07/19	Surinder Rai
pH	AT	4584771	N/A	2016/07/19	Surinder Rai
Resistivity of Water		4583855	2016/07/20	2016/07/20	Automated Statchk
Sulphate by Automated Colourimetry	KONE	4585013	N/A	2016/07/20	Deonarine Ramnarine



### GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	6.0°C
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**Results relate only to the items tested.**

## QUALITY ASSURANCE REPORT

Golder Associates Ltd  
Client Project #: 1521770  
Sampler Initials: MK

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
4584771	pH	2016/07/19			102	98 - 103			0.38	N/A
4584773	Conductivity	2016/07/19			100	85 - 115	<1.0	umho/cm	0.23	25
4585005	Dissolved Chloride (Cl)	2016/07/20	NC	80 - 120	102	80 - 120	<1.0	mg/L	1.2	20
4585013	Dissolved Sulphate (SO4)	2016/07/20	99	75 - 125	99	80 - 120	<1.0	mg/L	NC	20

N/A = Not Applicable

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

### VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).



Brad Newman, Scientific Specialist

---

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

INVOICE TO:				REPORT TO:				PROJECT INFORMATION:				Laboratory Use Only:							
Company Name: #1326 Golder Associates Ltd				Company Name: Chris Ng				Quotation #: B63104				Maxxam Job #:							
Attention: Chris Ng				Attention: Chris Ng				P.O.#: 1521770				Bottle Order #:							
Address: 6925 Century Ave Suite 100 Mississauga ON L5N 7K2				Address:				Project:				<div><div></div><div>568328</div></div>							
Tel: (905) 567-4444 Fax: (905) 567-6561				Tel:				Project Name:				COC #:							
Email: chris_ng@golder.com				Email: chris_ng@golder.com				Site #:				Project Manager:							
								Sampled By: Madison Kennedy				<div><div></div><div>C#568328-01-01</div></div>							
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY												Turnaround Time (TAT) Required: Please provide advance notice for rush projects							
<b>Regulation 153 (2011)</b> <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Medium/Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/Other <input type="checkbox"/> For RSC <input type="checkbox"/> Table _____				<b>Other Regulations</b> <input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw <input type="checkbox"/> Reg 558 <input type="checkbox"/> Storm Sewer Bylaw <input type="checkbox"/> MISA    Municipality _____ <input type="checkbox"/> PWQO <input type="checkbox"/> Other _____				Special Instructions				ANALYSIS REQUESTED (PLEASE BE SPECIFIC)							
Include Criteria on Certificate of Analysis (Y/N)?								Field Filtered (please circle): Metals / Hg / Cr VI				Corrosively Package for Water							
Sample Barcode Label		Sample (Location) Identification		Date Sampled	Time Sampled	Matrix													
1		C22		16/07/17	10:30 am	Surface Water	N	X											
2		C29		2016/07/17	10:20 am	Surface Water	N	X											
3		C41		2016/07/17	8:20 am	Surface Water	N	X											
4		C59		2016/07/17	9:00 am	Surface Water	N	X											
5		C60		2016/07/17	9:30 am	Surface Water	N	X											
6																			
7																			
8																			
9																			
10																			
RELINQUISHED BY: (Signature/Print) <i>Madison Kennedy</i>				Date: (YY/MM/DD) 16/07/18		Time 5:12		RECEIVED BY: (Signature/Print) <i>[Signature]</i>				Date: (YY/MM/DD) 2016/07/18		Time 17:15		# Jars used and not submitted		Laboratory Use Only	
																Time Sensitive		Temperature (°C) on Receipt 4/7/7	
																Custody Seal Present		Yes	
																Intact		No	

\* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

White: Maxxam Yellow: Client

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

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

**Golder Associates Ltd.**  
**6925 Century Avenue, Suite #100**  
**Mississauga, Ontario, L5N 7K2**  
**Canada**  
**T: +1 (905) 567 4444**

