December 3, 2014

FOUNDATION INVESTIGATION AND DESIGN REPORT

HIGHWAY 540 ICE LAKE CULVERT, SITE 49-072
TOWNSHIP OF ALLAN, MANITOULIN ISLAND, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5057-07-00, WP 5062-07-01

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REPORT

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PART A

FOUNDATION INVESTIGATION REPORT

HIGHWAY 540, ICE LAKE CULVERT, SITE 49-072

TOWNSHIP OF ALLAN, MANITOULIN ISLAND, ONTARIO

MINISTRY OF TRANSPORTATION, ONTARIO

GWP 5057-07-00, WP 5062-07-01

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the replacement of the Ice Lake culvert (Site 49-072) in the Township of Allan on Manitoulin Island, Ontario. The Key Plan showing the general location of this section of Highway 540 and the location of the investigated area are shown on Drawing 1.

The purpose of this investigation is to establish the subsurface conditions at the location of the culvert by borehole drilling, in situ testing and laboratory testing on selected samples.

2.0 SITE DESCRIPTION

The Ice Lake culvert is located on Highway 540 about 700 m west of Beange Road west of Kagawong, Ontario. The land use in the area is generally rural (i.e., farm land) with a few residences in the vicinity of the site.

In general, the topography in the area of the overall project limits is flat. The creek flows from north to south. Photographs taken at the site are included following the text of the report.

The existing culvert is 3.4 m long, 1 m high and 12.4 m wide and the highway grade at the bridge is at about Elevation 227.7 m. The creek level was measured by Golder on May 28, 2014, at Elevation 226.1 m.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation was carried out between May 28 and June 18 and 19, 2014, during which time a total of four boreholes (Boreholes IC-1 to IC-4) were advanced at the locations shown on Drawing 1.

The field investigation was carried out using a truck-mounted CME-55 drill rig and portable equipment supplied and operated by Landcore Drilling of Sudbury, Ontario. The boreholes were advanced through the overburden using 108 mm inside diameter hollow-stem augers. Soil samples were obtained at intervals of depth of about 0.75 m, using a 50 mm outer diameter split-spoon sampler, operated by an automatic hammer on the drill rig, in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-08a). Samples of the bedrock were obtained using NW casing and ‘NQ’ size rock core barrels in each of the boreholes. The groundwater levels in the open boreholes were observed during the drilling operations as described on the Record of Borehole sheets in Appendix A. The boreholes were backfilled upon completion in accordance with Ontario Regulation 903 (as amended).

The fieldwork was supervised throughout by members of our technical staff who: located the boreholes; arranged for the clearance of underground services; supervised the drilling and sampling operations; logged the boreholes; and examined and cared for the soil and bedrock samples. The 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. Classification testing (water contents and grain size distribution) was carried out on selected soil samples. In addition, uniaxial compressive strength (UCS) testing was carried out on selected specimens of the bedrock core recovered from the boreholes. The geotechnical laboratory testing was completed according to MTO LS standards.

A sample of the creek water was obtained using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters.

The as-drilled borehole locations and ground surface elevations were measured and surveyed by members of our technical staff, referenced to stations on the highway. The MTM NAD 83 northing and easting coordinates, ground surface elevations referenced to Geodetic datum and borehole depths at each borehole location are presented on the Record of Borehole sheets in Appendix A and are summarized below.

Borehole	Location (m)		Water or Ground Surface Elevation (m)	Borehole Depth (excludes water but including bedrock core) (m)
	Northing	Easting		
IC-1	5084085.4	314517.5	226.1*	2.2
IC-2	5084090.6	314523.7	227.7	5.4
IC-3	5084095.6	314514.0	227.7	5.0
IC-4	5084101.1	314516.9	226.1*	2.3

*Water surface elevation (0.7 m and 0.9 m deep at the respective boreholes).

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on surficial geology mapping from the Ministry of Natural Resources[1], the site is located within a glaciolacustrine deposit consisting of silt and clay.

Based on bedrock geology mapping from the Ministry of Natural Resources[2], the bedrock in the area consists of shale, sandstone, dolostone and limestone units of the Clinton-Cataract Group.

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 samples, are given on the attached Record of Borehole and Drillhole sheets in Appendix A. The results of the laboratory testing are provided in Appendix B. The results of the analytical testing on the samples of creek water are summarized in Table B1 in Appendix B. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of SPTs. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. The inferred soil stratigraphy based on the results of the boreholes is shown in profile on Drawing 1.

[1] Ministry of Natural Resources, electronic mapping obtained 2014, MRD128, 2007
[2] Ministry of Natural Resources, electronic mapping obtained 2014, MRD219, 2006

A detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Water

Boreholes IC-1 and IC-4 were advanced in the creek on either side of the embankment and the water was 0.7 m and 0.9 m deep.

4.2.2 Embankment Fill

A 100 mm thick layer of asphalt was encountered at ground surface in Boreholes IC-2 and IC-3.

Embankment fill was encountered below the asphalt in both boreholes as follows:

- in Borehole IC-2, a 1.9 m thick layer of brown gravelly sand to sand some gravel is underlain by a 0.2 m thick layer of grey clayey silt; and
- in Borehole IC-3, a 1.7 m thick layer of brown sand and gravel to sand, some silt.

Standard Penetration Test (SPT) 'N'-values in the embankment fill range between 4 blows and 17 blows per 0.3 m of penetration indicating a loose to compact relative density.

A grain size distribution test was carried out on one sample of the gravelly sand fill and the result is shown on Figure B1 in Appendix B.

The natural water content measured on a sample of the fill is about 9 per cent.

4.2.3 Sand and Gravel to Gravelly Sand to Sand

In Boreholes IC-1 and IC-4, a 0.4 m and 0.2 m thick layer of gravelly sand and sand and gravel to sand was encountered at the creek bed.

4.2.4 Bedrock/Refusal

Bedrock was cored in all of the boreholes and the depth to the bedrock surface and bedrock surface elevations are presented below.

Borehole No.	Depth to Bedrock (below ground surface) (m)	Bedrock Surface Elevation (m)	Notes
IC-1	0.4*	225.0	Bedrock Cored for 1.8 m
IC-2	2.2	225.5	Bedrock Cored for 3.2 m
IC-3	1.8	225.9	Bedrock Cored for 3.2 m
IC-4	0.2*	225.0	Bedrock Cored for 2.1 m

*Excludes the water column.

The retrieved bedrock core is described as a fine grained, fresh, grey, dolomitic limestone, as presented on the Record of Drillhole sheets in Appendix A. Photographs of the retrieved bedrock core samples are shown on Figure B2 in Appendix B.

The Total Core Recovery of the bedrock cored is 100 per cent. The Rock Quality Designation measured on the core samples ranges from 91 per cent to 100 per cent, indicating a rock mass of excellent quality as per Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006)[3].

Laboratory Uniaxial Comprehensive Strength (UCS) testing was carried out on four core samples of the bedrock and the Laboratory test sheet is presented in Appendix B. The UCS values are presented on the Record of Drillhole sheets and summarized below and the test results indicate that the bedrock is strong to very strong as per Table 3.5 of the CFEM (2006).

Borehole	Depth/Elevation (m)	UCS (MPa)
IC-1	1.8/224.3	71
IC-2	2.6/225.1	79
IC-3	2.0/225.7	104
IC-4	1.5/225.6	88

4.2.5 Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The water level in the creek was measured at Elevation 226.7 m on May 28, 2014 and Elevation 226.1 m on June 18 and 19, 2014.

[3] Canadian Geological Society, 2003. Canadian Foundation Engineering Manual, 4th Edition.

Borehole No.	Depth to Groundwater Level (m)	Groundwater Elevation (m)
IC-1	Creek Surface	226.1
IC-2	0.9	226.8
IC-3	1.0	226.7
IC-4	Creek Surface	226.1

Groundwater levels in the area are subject to seasonal fluctuations and to fluctuations after precipitation events and snowmelt.

5.0 CLOSURE

The field drilling program was supervised by Mr. Mathew Riopelle and Mr. Ed Savard and this report was prepared by Mr. André Bom, P.Eng. Mr. Jorge Costa, P.Eng., Golder's Designated MTO Contact for this project, carried out a quality control review and reviewed the technical aspects of the report.

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PART B

FOUNDATION DESIGN REPORT

HIGHWAY 540, ICE LAKE CULVERT, SITE 49-072

TOWNSHIP OF ALLAN, MANITOULIN ISLAND, ONTARIO

MINISTRY OF TRANSPORTATION, ONTARIO

GWP 5057-07-00, WP 5062-07-01

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

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

6.1 General

The existing Ice Lake culvert is a 12.4 m long, 3.4 m wide and 1 m high open footing culvert and will be replaced with a 12 m long, 3.6 m wide and 0.9 m high culvert. Concrete wing walls will be constructed at each of the four corners of the structure extending parallel to Highway 540 to a distance of 3.0 m from the ends of the structure. The grade of the highway will essentially remain the same (Elevation 227.7 m) with only a minor grade raise as required for pavement reconstruction.

From a foundations perspective, an open footing culvert is recommended due to the shallow bedrock present at this site. Recommendations for a precast box culvert have been provided in the event that a box culvert is selected as the replacement structure.

6.2 Geotechnical Resistance

6.2.1 Open Footing Culvert

A factored geotechnical axial resistance at Ultimate Limit States (ULS) of 1,000 kPa may be used for design of the strip footings founded directly on bedrock. The geotechnical reaction at Serviceability Limit States (SLS) for footings founded on the bedrock will be equal to or greater than the factored geotechnical axial resistance at ULS and, therefore, the ULS values will govern for design. Depending on the bedrock surface elevation along the culvert alignment relative to the culvert invert elevation, leveling/lowering of the bedrock may be required.

The geotechnical resistances are given for loads applied perpendicular to the surface of the base of the culvert footings. Where loads are not applied perpendicular to the base of the footings, inclination of the loads should be taken into account in accordance with Section 6.7.4 and Section C6.7.4 of the Canadian Highway Bridge Code (CHBDC) and its Commentary.

6.2.2 Precast Concrete Box Culvert

A factored geotechnical axial resistance at ULS of 1,000 kPa may be used for design of a precast box culvert founded on a granular bedding layer overlying the bedrock. The geotechnical reaction at SLS for the box culvert founded on the bedrock will be equal to or greater than the factored geotechnical axial resistance at ULS and, therefore, the ULS values will govern for design. Depending on the bedrock surface elevation along the culvert alignment relative to the culvert invert elevation, leveling/lowering of the bedrock may be required to accommodate bedding placement. Details regarding the granular bedding requirement are provided in Section 6.5.

6.2.3 Resistance to Lateral Loads/Sliding Resistance

Resistance to lateral forces/sliding resistance between the concrete culvert or concrete wing wall footings and the bedrock surface should be calculated in accordance with Section 6.7.5 of the *CHBDC*. For cast-in-place footings founded directly on bedrock, the coefficient of friction is tan δ = 0.7. For the precast concrete culvert placed on compacted granular material, the coefficient of friction tan δ = 0.45.

These values are unfactored.

6.2.4 Frost Protection

The estimated frost penetration depth at this site is 1.6 m, as per OPSD 3090.101 (Foundation, Frost Penetration Depths for Southern Ontario).

Where the footings are to be founded directly on bedrock, frost protection is not considered necessary.

Closed bottom box culverts are typically not provided with the standard depth for frost protection as close bottom box culverts are tolerant to small magnitudes related to freeze-thaw cycles should these occur. The granular bedding placed below the culvert should be kept to a limited thickness to bring the grade from the bedrock surface to founding level.

6.3 Stability, Settlement and Horizontal Strain

The following sections summarize the results of stability, settlement and horizontal strains analyses along the culvert beneath the influence of the proposed embankment loading.

6.3.1 Stability

Based on the existing/proposed embankment geometry and the subsurface conditions at this site, granular fill embankments at this site will be stable at side slopes not steeper than 2 Horizontal to 1 Vertical (2H:1V).

6.3.2 Settlement

As the proposed culvert footings would be founded directly on the bedrock surface, settlement of the culvert footings would not occur. As the proposed box culvert will be founded on a granular bedding layer over bedrock, total settlement of the culvert is expected to be less than 25 mm.

It is recommended that OPSS.PROV1010 (Aggregates) Granular ‘A’ or ‘B’ Type I or II be used for embankment reconstruction at the culvert location. Where granular fill will be placed below the groundwater/water level, Granular ‘B’ Type II should be used. The material placed above the water level should be compacted in accordance with OPSS 501 (Compacting). Compression settlement of the granular fill placed below water and from properly compacted embankment fill placed above water is expected to occur during construction.

6.3.3 Horizontal Strain

As the culvert will be founded on bedrock or on a granular bedding layer over bedrock, horizontal strain along the culvert will be negligible. As a result, culvert construction concurrent with the embankment construction can be carried out without the need for any foundation mitigation measures or culvert camber.

6.4 Lateral Earth Pressures

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

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

- Select, free draining granular fill meeting the requirements of OPSS.PROV 1010 (Aggregates) Granular ‘A’ or Granular ‘B’ Type II but with less than 5 per cent passing the 200 sieve (0.075 mm) should be used as backfill behind the culvert and wing walls. Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill. Other aspects of the granular backfill requirements with respect to sub drains and frost taper should be in accordance with OPSD 3101.150 (Wall, Abutment, Backfill) and OPSD 3121.150 (Walls Retaining, Backfill).
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the culvert and wing walls, in accordance with CHBDC Section 6.9.3 and Figure 6.6. Compaction equipment should be used in accordance with OPSS 501 (Compacting). Other surcharge loadings should be accounted for in the design as required.
- Granular fill may be placed either in a zone with the width equal to at least 1.6 m behind the back of the walls for a restrained wall (see Figure C6.20(a) of the Commentary to the CHBDC), or within the wedge shaped zone defined by a line drawn at 1.5 H:1V extending up and back from the rear face of the base of the walls for an unrestrained wall (see Figure C6.20(b) of the Commentary to the CHBDC). The pressures are based on the proposed embankment fill material and the following parameters (unfactored) may be used:

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

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

6.5 Culvert Construction Considerations

6.5.1 Excavations, Subgrade Preparation, Backfill

As the proposed culvert structure will be founded on the bedrock surface, a temporary support system comprised of sheet piling will not be feasible at this site. Soldier piles and lagging (with the piles socketted into bedrock or supported by tie backs or rakers) may be used for support of the excavation along the structure, as well as along the roadway for traffic protection. Temporary excavation support systems should be designed and constructed in accordance with OPSS 539 (Temporary Protection Systems). Temporary excavation support systems should be designed to Performance Level 2 for any excavation adjacent to existing roadways. Alternatively, the culvert may be installed using open-cut excavations with a maximum temporary side slope of 1.5H:1V or flatter within the existing fill (short-term excavations). The existing fill at this site may be classified as Type 3 soil. All excavations must be carried out in accordance with Ontario Regulation 213 Ontario *Occupational Health and Safety Act* for Construction Projects (as amended). In addition, provisions for traffic control measures should be included in the Contract Documents to maintain the safe operation of the existing Highway 540.

Given the proposed dimensions of the replacement culvert, it is assumed that the new culvert will be constructed with the same alignment as the existing culvert and to the same invert level. As the boreholes encountered the bedrock surface at varying elevations, with up to 0.9 m difference between the inlet/outlet and centre of the culvert, bedrock excavation will be required to found the culvert and/or wing wall footings at an adequate depth to accommodate the culvert height. The bedrock is classified as strong to very strong (generally strong) it would require pre-drilling and hoe ramming to allow it to be excavated.

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

- Where excavations will be unwatered to allow for construction of the culvert in dry conditions (see Section 6.5.3), the bedding should be placed in lifts not exceeding 200 mm loose thickness, and compacted to at least 95 per cent of the Standard Proctor Maximum Dry Density (SPMDD) of the material as specified in OPSS 501 (Compacting). The structural design of the culvert should take into consideration the conditions for bedding placement and compaction in accordance with the requirements of Section 7.8.3.6 of the CHBDC.

- Alternatively, the culvert could be installed in wet conditions depending on the season of construction and water level at the time of installation. The water level should be lower than the proposed surface of the bedding. In this case, the bedding should consist of Granular 'B' Type II and be nominally compacted by the construction equipment. The design of the culvert should be based on the bedding having achieved a moderate level of compaction – if a degree of compaction is needed for design, a relative density of 90 per cent of the SPMDD should be assumed.

Groundwater control will be required as further discussed in Section 6.5.3 to construct the footings in-the-dry.

Prior to placing any fill for new construction, all fill, organics and native soils should be excavated to expose the bedrock surface within the plan limits of the proposed culvert footings.

The thickness of fill placed during backfilling should be maintained equal on both sides of the culvert with one side not exceeding the other by more than 400 mm as per OPSS 422 (Concrete Box Culverts).

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

The structure should be designed for the full overburden stress and appropriate live loads, assuming a fill unit weight of 22 kN/m^3 for Granular 'A' and 21 kN/m^3 for Granular 'B' Type II backfill above and surrounding the structure. Inspection and field density testing should be carried out by qualified personnel during fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved.

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

6.5.2 Erosion Protection

We understand that a concrete cut-off wall will be provided at the culvert inlet and outlet in order to prevent surface water from flowing either beneath the culvert (potentially causing undermining and scouring) or around the culvert (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles). The requirements for and design of erosion protection measures for the inlet and outlet of the culvert should be assessed by the hydraulics design engineer.

6.5.3 Control of Groundwater and Surface Water

The creek flow will need to be diverted/piped during construction of the culvert. Surficial water seepage into the excavation should be expected and will be heavier during periods of sustained precipitation. Seepage from the granular fills should be expected, particularly after precipitation events. It is anticipated that this surficial seepage can be controlled by using properly filtered sumps within the excavation.

Unwatering will be required for placement of concrete in-the-dry. The excavations will be advanced through or into water-bearing non-cohesive fill soils and appropriate unwatering of the water-bearing granular fill and seepage from fractures within the dolomitic limestone bedrock will be required to maintain the water level below the founding level for the culvert during excavation and construction. It is recommended that an NSSP be included in the Contract to address unwatering for the culvert site; a sample NSSP is included in Appendix C.

6.5.4 Analytical Testing for Construction Materials

The analytical test results on a sample of creek water taken adjacent to the existing structure are presented in Table B1. The suite of parameters tested is intended to allow the structural engineer to assess the requirements for the appropriate type of cement to be used in construction and the need for corrosion protection.

7.0 CLOSURE

This report was prepared by Mr. André Bom, P.Eng. Mr. Jorge Costa, P.Eng., Golder’s Designated MTO Contact, carried out a quality control review and reviewed the technical aspects of the report.

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

Ministry of Natural Resources, electronic mapping obtained 2014, MRD128, 2007.

Ministry of Natural Resources, electronic mapping obtained 2014, MRD219, 2006.

STANDARDS

ASTM International:

ASTM D1586-08a	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

Contract Design Estimation and Documentation (CDED):

SP 422S01	Precast Concrete Box Culvert Ontario Occupational Health and Safety Act

Ontario Regulation 213 Construction Projects (as amended)

Ontario Provincial Standard Drawing

OPSD 208.010	Benching of Earth Slopes
OPSD 3090.101	Foundation, Frost Penetration Depths for Southern Ontario
OPSD 3101.150	Walls, Abutment, Backfill, Minimum Granular Requirement
OPSD 3121.150	Walls, Retaining, Backfill, Minimum Granular Requirement

Ontario Provincial Standard Specification

OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut
OPSS 501	Construction Specification for Compacting
OPSS 511	Construction Specification for Rip Rap, Rock Protection and Granular Sheeting
OPSS 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Ontario Water Resources Act

Ontario Regulation 372/97	Amendment to Ontario Regulation 903

Photograph 1: Looking North (June 2014)

Photograph 2: Looking West (May 2014)

METRIC

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

CONT No.
WP No. 5062-07-01

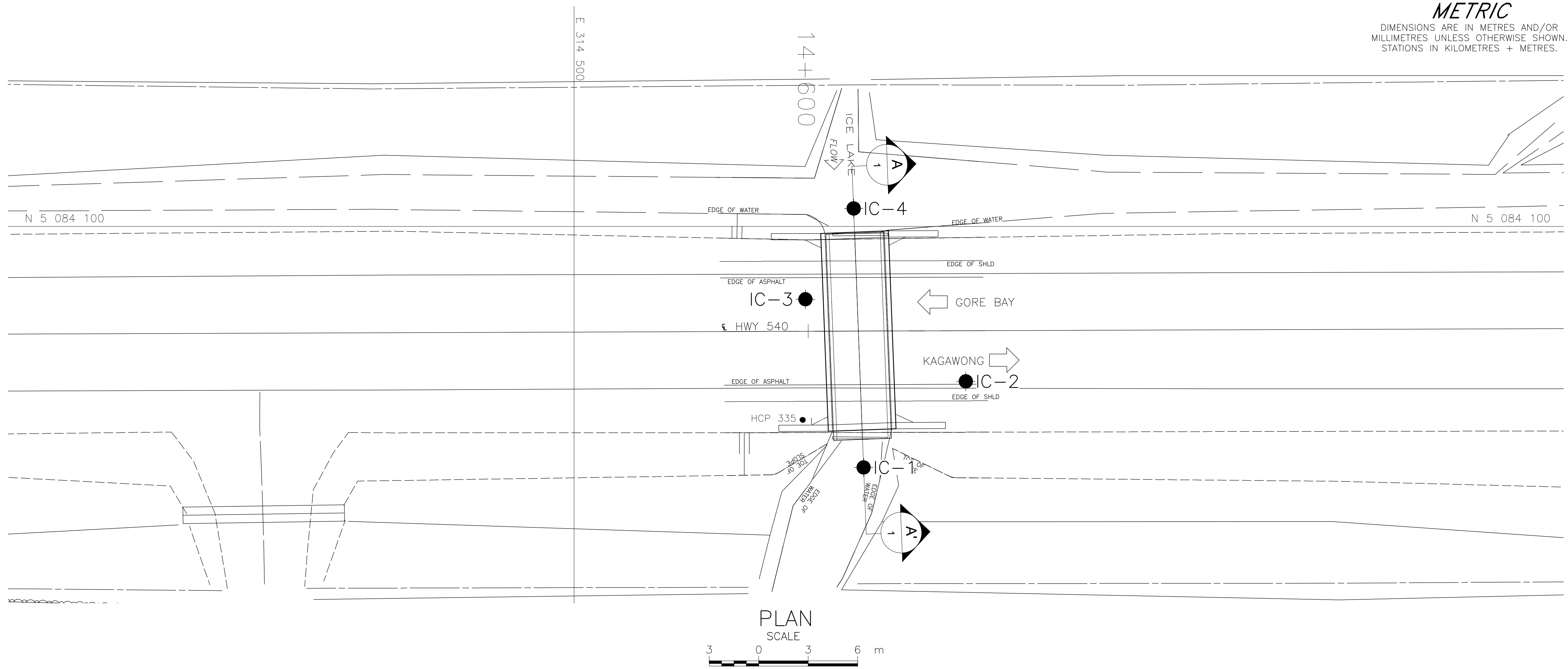
SHEET

HIGHWAY 540

ICE LAKE CULVERT STA 14+603

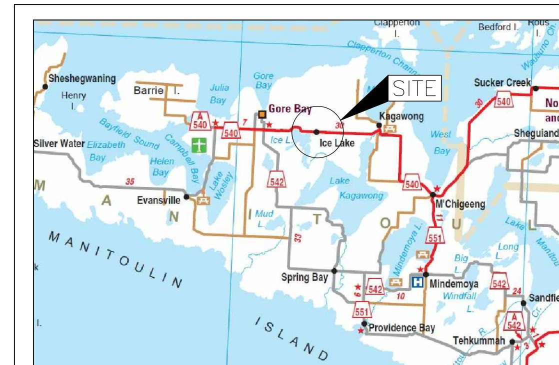
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates



PLAN

SCALE 3 0 3 6 m



KEY PLAN

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

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
IC-1	226.1	5084085.4	314517.5
IC-2	227.7	5084090.6	314523.7
IC-3	227.7	5084095.6	314514.0
IC-4	226.1	5084101.1	314516.9

NOTES

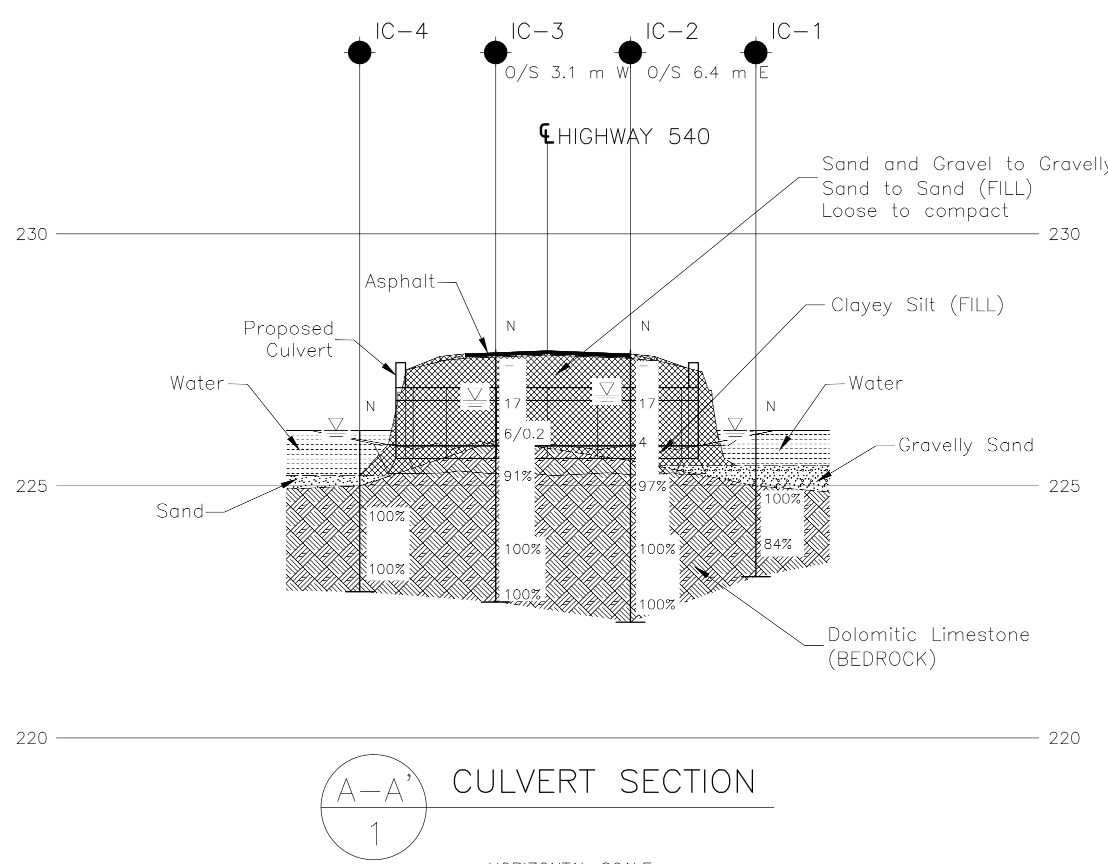
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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 plans provided in digital format by AECOM, drawing file nos. GWP 5057-07-00.dwg, received AUG 08, 2014 and Ice Lake 49-072.dwg, received NOV 27, 2014.



A-A' / 1 CULVERT SECTION

HORIZONTAL SCALE 3 0 3 6 m

1.5 0 1.5 3 m VERTICAL SCALE

LICENSED PROFESSIONAL ENGINEER A.J.K. BOM 100075715 DEC 01, 2014 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER J.M.A. COSTA DEC 01, 2014 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 41G-17

HWY. 540	PROJECT NO. 13-1191-0005		DIST.
SUBM'D.	CHKD.	DATE: DEC 2014	SITE: 49-072
DRAWN: TB	CHKD. AB	APPD. JMAC	DWG. 1

MINISTRY OF TRANSPORTATION, ONTARIO

PLOT DATE: December 3, 2014
FILENAME: \\golder.gds\gal\Sudbury\CAD-GIS\CAD\Projects\2013\13-1191-0005 Manitoulin (Kagawong, Ice Lake)\CIVIL 30\1311910005A001.dwg

APPENDIX A

Record of Boreholes and Drillholes

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

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

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

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

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

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

(d)	**Shear Strength**
τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

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

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d:

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

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

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

(b) Cohesive Soils
Consistency

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

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

WEATHERINGS STATE

Fresh: no visible sign of weathering

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

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

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

Description and Notes

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

Abbreviations

JN	Joint	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		

Golder Associates

RECORD OF BOREHOLE No IC-1

 METRIC

PROJECT 13-1191-0005

W.P. 5062-07-01

DIST ____ HWY 540

DATUM GEODETIC

LOCATION N 5084085.4; E 314517.5

BOREHOLE TYPE Portable Equipment

DATE June 19, 2014

ORIGINATED BY EHS

COMPILED BY JJL

CHECKED BY AB

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
226.1	WATER LEVEL					▽					
0.0	Water						226				
225.4	Gravelly SAND, trace organics										
225.0 1.1	DOLOMITIC LIMESTONE (BEDROCK) Bedrock cored from 1.1 m depth to 2.9 m depth. For coring details see Record of Drillhole IC-1.		1	RC	REC 100%		225				RQD = 100%
			2	RC	REC 100%		224				RQD = 84%
223.2 2.9	END OF BOREHOLE										

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

SUD-MTO 001 13-1191-0005.GPJ GAL-MISS.GDT 11/09/14 DATA INPUT:

RECORD OF DRILLHOLE: IC-1

PROJECT: 13-1191-0005
LOCATION: N 5084085.4 ;E 314517.5
INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: June 19, 2014
DRILL RIG: Portable Drill
DRILLING CONTRACTOR: Landcore

DATUM: GEODETIC

JN - Joint, FLT - Fault, SHR- Shear, VN - Vein, CJ - Conjugate; BD- Bedding, FO- Foliation, CO- Contact, OR- Orthogonal, CL - Cleavage; PL - Planar, CU- Curved, UN - Undulating, ST - Stepped, IR - Irregular; PO- Polished, K - Slickensided, SM- Smooth, Ro - Rough, MB- Mechanical Break; BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX METRES	B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		TOP OF BEDROCK		225.0																
	CME 55; NW	Dolomitic Limestone Fine grained Fresh Grey Strong		1.1	1	GREY 100%														
2	CME 55; NQ CORING	All joints rough			2	GREY 100%														UCS = 71 MPa
				223.2																
3		END OF DRILLHOLE		2.9																
4																				
5																				
6																				
7																				
8																				
9																				
10																				
11																				

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: EHS
CHECKED: AB

SUD-RCK 13-1191-0005.GPJ GAL-MISS.GDT 11/09/14 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No IC-2

 METRIC

PROJECT 13-1191-0005
W.P. 5062-07-01
LOCATION N 5084090.6; E 314523.7
ORIGINATED BY MR
DIST
HWY 540
BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring
COMPILED BY JJL
DATUM GEODETIC
DATE May 28, 2014
CHECKED BY AB

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
227.7	GROUND SURFACE								
0.0 / 0.1	ASPHALT (100 mm)								
	Gravelly sand to sand, some gravel, some silt (FILL) Loose to compact Brown Moist to wet	1	AS	-					
					▽	227			
		2	SS	17			○		22 62 (16)
		3	SS	4		226			
225.7	CLAYEY SILT, trace organics (FILL) Grey								
2.2	DOLOMITIC LIMESTONE (BEDROCK) Bedrock cored from 2.2 m depth to 5.4 m depth. For coring details see Record of Drillhole IC-2.	1	RC	REC 100%		225			RQD = 97%
		2	RC	REC 100%		224			RQD = 100%
		3	RC	REC 100%		223			RQD = 100%
222.3 / 5.4	END OF BOREHOLE Note: 1. Water level at a depth of 0.9 m below ground surface (Elev. 226.8 m) upon completion of drilling.								

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

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

RECORD OF DRILLHOLE: IC-2

PROJECT: 13-1191-0005
LOCATION: N 5084090.6 ;E 314523.7
INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: May 28, 2014
DRILL RIG: CME 55 Truck Mount
DRILLING CONTRACTOR: Landcore

DATUM: GEODETIC

JN - Joint, FLT - Fault, SHR- Shear, VN - Vein, CJ - Conjugate, BD- Bedding, FO- Foliation, CO- Contact, OR- Orthogonal, CL - Cleavage, PL - Planar, CU- Curved, UN- Undulating, ST - Stepped, IR - Irregular, PO- Polished, K - Slickensided, SM- Smooth, Ro - Rough, MB- Mechanical Break, BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	RUN No.	FLUSH COLOUR % RETURN	NOTES WATER LEVELS INSTRUMENTATION
		TOP OF BEDROCK				
	CME 55 / NW, NQ CORING	Dolomitic Limestone Fine grained Fresh Grey Strong	225.5 2.2	1	GREY 100%	UCS = 79 MPa
3						
4				2	GREY 100%	
5				3	GREY 100%	
		END OF DRILLHOLE	222.3 5.4			
6						
7						
8						
9						
10						
11						
12						

Other columns: RECOVERY (TOTAL CORE %, SOLID CORE %), R.Q.D. %, FRACT. INDEX METRES, DISCONTINUITY DATA (B Angle, DIP w.r.t. CORE AXIS, TYPE AND SURFACE DESCRIPTION, Jr, Ja, Jn), HYDRAULIC CONDUCTIVITY k, cm/s, Diametral Point Load Index (MPa), RMC -Q' AVG.

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: MR
CHECKED: AB

RECORD OF BOREHOLE No IC-3

 METRIC

PROJECT 13-1191-0005
W.P. 5062-07-01
LOCATION N 5084095.6; E 314514.0
ORIGINATED BY MR
DIST HWY 540
BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring
COMPILED BY JJL
DATUM GEODETIC
DATE May 28, 2014
CHECKED BY AB

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
227.7	GROUND SURFACE							
0.0	ASPHALT (100 mm)							
0.1	Sand and gravel to sand, some silt (FILL) Compact Brown Moist		1	AS	-			
			2	SS	17	∇	227	
225.9			3	SS	6/0.2		226	
1.8	DOLOMITIC LIMESTONE (BEDROCK) Bedrock cored from 1.8 m depth to 5.0 m depth. For coring details see Record of Drillhole IC-3.		1	RC	REC 100%		225	RQD = 91%
			2	RC	REC 100%		224	RQD = 100%
222.7			3	RC	REC 100%		223	RQD = 100%
5.0	END OF BOREHOLE Note: 1. Water level at a depth of 1.0 m below ground surface (Elev. 226.7 m) upon completion of drilling.							

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED: 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%): 20 40 60
UNIT WEIGHT γ kN/m³

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

PROJECT: 13-1191-0005

RECORD OF DRILLHOLE: IC-3

SHEET 2 OF 2

LOCATION: N 5084095.6 ;E 314514.0

DRILLING DATE: May 28, 2014

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Truck Mount

DRILLING CONTRACTOR: Landcore

JN - Joint, FLT - Fault, SHR - Shear, VN - Vein, CJ - Conjugate, BD - Bedding, FO - Foliation, CO - Contact, OR - Orthogonal, CL - Cleavage, PL - Planar, CU - Curved, UN - Undulating, ST - Stepped, IR - Irregular, PO - Polished, K - Slickensided, SM - Smooth, Ro - Rough, MB - Mechanical Break, BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH / COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA	HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		TOP OF BEDROCK		225.9 / 1.8											
2–5	CME 55, NQ CORING; NW	Dolomitic Limestone Fine grained Fresh Grey Very strong All joints rough. Vertical joint from 2.1 m to 2.3 m depth.			1	GREY 100%									UCS = 104 MPa
					2	GREY 100%									
				222.7	3	GREY 100%									
5		END OF DRILLHOLE		5.0											

SUD-RCK 13-1191-0005.GPJ GAL-MISS.GDT 11/09/14 DATA INPUT:

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MR

CHECKED: AB

Golder Associates

RECORD OF BOREHOLE No IC-4

 METRIC

PROJECT 13-1191-0005
W.P. 5062-07-01
DIST ____ HWY 540
DATUM GEODETIC
LOCATION N 5084101.1; E 314516.9
BOREHOLE TYPE Portable Equipment
DATE June 18, 2014
ORIGINATED BY EHS
COMPILED BY JJL
CHECKED BY AB

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
226.1	WATER LEVEL					▽					
0.0	Water						226				
225.2	SAND, some gravel						225				
1.1	DOLOMITIC LIMESTONE (BEDROCK) Bedrock cored from 1.1 m depth to 3.2 m depth. For coring details see Record of Drillhole IC-4.		1	RC	REC 100%		224				RQD = 100%
			2	RC	REC 100%						RQD = 100%
222.9							223				
3.2	END OF BOREHOLE										

Legend: ○ UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × REMOULDED. Plot scales: 20 40 60 80 100. PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT scale 20 40 60.

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

SUD-MTO 001 13-1191-0005.GPJ GAL-MISS.GDT 11/09/14 DATA INPUT:

RECORD OF DRILLHOLE: IC-4

PROJECT: 13-1191-0005

LOCATION: N 5084101.1 ;E 314516.9

INCLINATION: -90°   AZIMUTH: ---

DRILLING DATE: June 18, 2014

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: Landcore

DATUM: GEODETIC

JN - Joint, FLT - Fault, SHR - Shear, VN - Vein, CJ - Conjugate, BD - Bedding, FO - Foliation, CO - Contact, OR - Orthogonal, CL - Cleavage, PL - Planar, CU - Curved, UN - Undulating, ST - Stepped, IR - Irregular, PO - Polished, K - Slickensided, SM - Smooth, Ro - Rough, MB - Mechanical Break, BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	NOTES WATER LEVELS INSTRUMENTATION
		TOP OF BEDROCK		225.0			
	CME 55, NQ CORING, NW	Dolomitic Limestone Fine grained Fresh Grey Strong All joints rough.		1.1	1	GREY 100%	UCS = 88 MPa
2							
					2	GREY 100%	
3				222.9 3.2			
		END OF DRILLHOLE					

Columns also present (FLUSH; RECOVERY: TOTAL CORE %, SOLID CORE %; R.Q.D. %; FRACT. INDEX METRES; DISCONTINUITY DATA: B Angle, DIP w.r.t. CORE AXIS, TYPE AND SURFACE DESCRIPTION, Jr, Ja, Jn; HYDRAULIC CONDUCTIVITY k, cm/s; Diametral Point Load Index (MPa); RMC -Q' AVG.) contain graphical data only.

DEPTH SCALE

1 : 50

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LOGGED: EHS

CHECKED: AB

SUD-RCK 13-1191-0005.GPJ GAL-MISS.GDT 11/09/14 DATA INPUT:

APPENDIX B

Laboratory Test Results

Table B1 - Summary of Analytical Testing of Creek Water

Parameter	Units	Method Detection Limit	Result
Resistivity	ohm-cm	n/a	2300
Conductivity	µmho/cm	1	430
pH	n/a	n/a	7.85
Sulphate	mg/L	1	Not Detected
Chloride	mg/L	1	4

Notes:
1. Sample obtained May 28, 2014.
2. Analytical testing carried out by Maxxam Analytics Inc.

Prepared by: DAM
Reviewed by: AB

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Fax: (705) 524-1984

TABLE B2 - SUMMARY OF ROCK CORE TEST DATA

PROJECT NO.: 13-1191-0005

JOB NAME: Ice Lake Culvert

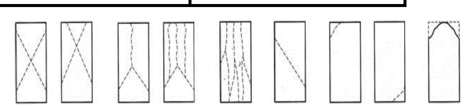
TYPE OF UNIT: Bedrock Core

GOLDER LAB NUMBER	GO504	G0387	G0388	GO505
BOREHOLE	IC-1	IC2	IC3	IC-4
DATE TESTED	July 1, 2014	June 16, 2014	June 16, 2014	July 1, 2014
DEPTH OF TESTED CORE (m)	1.8	2.6	2.0	1.5
LENGTH AS CUT (mm)	92.0	97.5	98.0	89.2
DIAMETER (mm)	42.5	47.0	47.0	42.5
DENSITY (kg/m3)	2543.5	2832	2779	2514
COMPRESSIVE STRENGTH (KN)	100.9	137.2	180.9	124.8
COMPRESSIVE STRENGTH (MPa)	**71**	**79**	**104**	**88**
TYPE OF FRACTURE	**3**	**3**	**3**	**3**

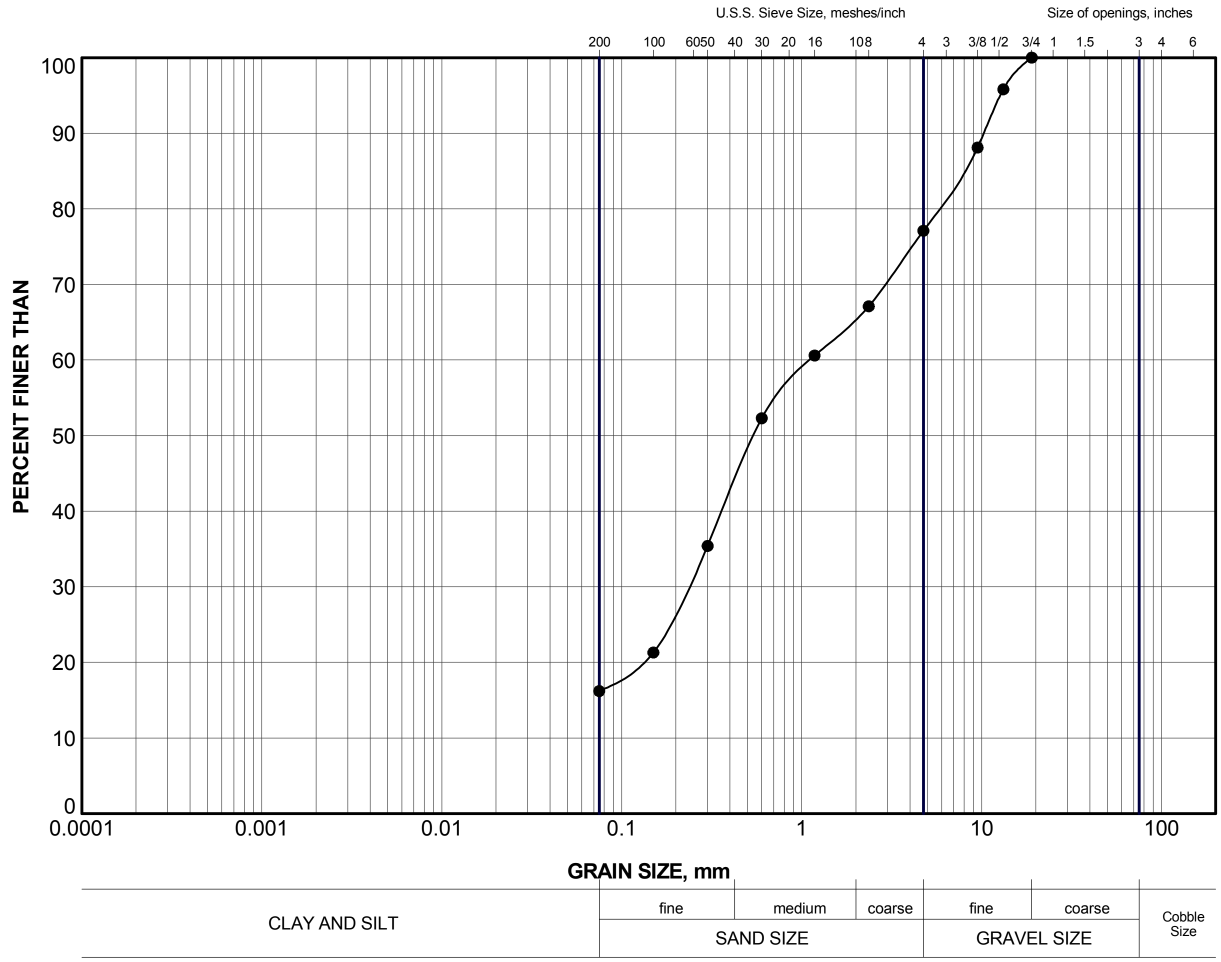
Tested by: SA

Reviewed by : TG

Type of Fracture



1 2 3 4 5 6



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	IC-2	2	226.6

PROJECT

HIGHWAY 540
ICE LAKE CULVERT

TITLE

GRAIN SIZE DISTRIBUTION

SAND (FILL)

PROJECT No.	13-1191-0005		FILE No.	13-1191-0005.GPJ
DRAWN	TB	Sep 2014	SCALE N/A	REV.
CHECK	AB	Sep 2014		
APPR	JMAC	Sep 2014	FIGURE B1	

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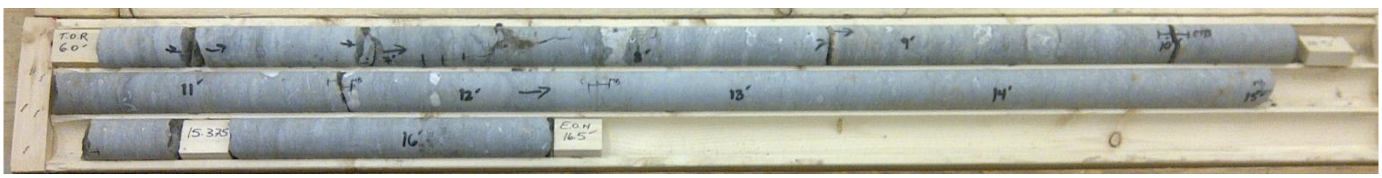
SUD-MTO GSD (NEW) GLDR_LDN.GDT

Borehole IC-1
Elevation 225.0 m to 223.2 m

Borehole IC-2
Elevation 225.5 m to 222.3 m



Borehole IC-3
Elevation 225.9 m to 222.7 m

Borehole IC-4
Elevation 225.0 m to 222.9 m

0 m 0.3 m 0.6 m

PROJECT

HIGHWAY 11
ICE LAKE CULVERT

TITLE

BEDROCK CORE PHOTOGRAPHS

Golder Associates

PROJECT No.	13-1191-0005		FILE No. ----
DESIGN			SCALE AS SHOWN / REV.
CADD	--		
CHECK	AB	Sept. 2014	**FIGURE B2**
REVIEW			

APPENDIX C

Non-Standard Special Provisions

GROUNDWATER CONTROL - Item No.

Non-Standard Special Provision

Foundations for the Ice Lake culvert replacement will require excavations to extend below the groundwater level at the site. The non-cohesive fill materials (sand and gravel to gravelly sand to sand) that are present below the groundwater table will slough, run, boil or cave into the excavation unless appropriate groundwater controls are in place. The Contractor is to design and install an appropriate groundwater control system for the culvert site to enable construction of the culvert footings/walls and wing walls in dry conditions, and prevent disturbance to the founding stratum.

Basis of Payment

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

END OF SECTION

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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