



September 8, 2015

## PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT

**CHICKEN FARM LAKE CULVERT - SITE NO. 48E-127/C  
HIGHWAY 614, DISTRICT OF THUNDER BAY  
TOWNSHIP OF LESLIE  
MINISTRY OF TRANSPORTATION, ONTARIO  
G.W.P 6332-14-00**

**Submitted to:**

Hatch Mott MacDonald  
200 S. Syndicate Ave., Suite 301  
Thunder Bay, ON  
P7E 1C9



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REPORT





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CHICKEN FARM LAKE CULVERT - SITE NO. 48E-127/C**

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# **PART A**

**PRELIMINARY FOUNDATION INVESTIGATION REPORT  
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## PRELIMINARY FOUNDATION REPORT CHICKEN FARM LAKE CULVERT - SITE NO. 48E-127/C

### 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Hatch Mott MacDonald (HMM), on behalf of the Ministry of Transportation, Ontario (MTO) to provide preliminary foundation engineering services for the replacement of the Chicken Farm Lake culvert (Site No. 48E-127/C). The Chicken Farm Lake culvert is located in the District of Thunder Bay in the Township of Leslie on Highway 614 at STA 16+934, approximately 50 km north of the junction of Highway 17 and Highway 614. The key plan showing the general location of this section of Highway 614 and the location of the investigated area are shown on Drawing 1.

### 2.0 SITE DESCRIPTION

The Chicken Farm Lake culvert consists of twin-cell, open footing, timber “box”, the details of which (i.e., width, height, length, etc.) are summarized in Table 1 following the text of the report.

In general, the topography in the culvert area consists of gently rolling terrain with the highway grades rising towards the north and south with moderate to dense tree cover beyond the highway right-of-way. It should be noted that the orientation (i.e. north, south, east, west) stated in the text of the report is typically referenced to project north and therefore may differ from magnetic north shown on the drawing. For the purposes of this report, Highway 614 runs in a north-south direction with the culvert perpendicular to the roadway in a west-east orientation. Chicken Farm Lake is located east of the highway and drains to a stream that flows westerly via the Chicken Farm Lake culvert. At the culvert location, the highway grade is at Elevation 331.7 m and the culvert inverts, as provided by MTO, are at Elevation 329.6 m at the inlet (east end) and at Elevation 329.7 m at the outlet (west end). The stream water level was at Elevation 330.2 m as measured by others on November 8, 2014 and at Elevation 330.4 m as measured by Golder on March 18, 2015. Surface conditions in the culvert inlet and outlet areas are shown on Photographs 1 to 4, attached.

### 3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out between March 18 and 25, 2015, during which time four boreholes (Boreholes CK-1 to CK-4) were advanced at approximately the locations shown on Drawing 1. Boreholes CK-1 and CK-4 were advanced at the toe of slope near the culvert inlet/outlet and Boreholes CK-2 and CK-3 were advanced from the existing highway platform. All boreholes were advanced using a track-mounted CME-55 drill rig supplied and operated by George Downing Estate Drilling Ltd. of Grenville-Sur-La-Rouge, Quebec.

The boreholes were advanced by utilizing a combination of 108 mm inside diameter hollow stem augers, NW casing and wash boring, and NQ coring. Soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). The groundwater level in the open boreholes was 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 Wells (as amended).

The field work was supervised on a full-time basis by a member of Golder's technical staff who: located the boreholes in the field; 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 soil and



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bedrock samples were identified in the field, placed in labelled containers and transported to Golder's geotechnical laboratory in Sudbury for further examination and laboratory testing. Index and classification testing consisting of water content and organic content determinations, grain size distributions, and Atterberg limits were carried out on selected soil samples. In addition, unconfined compressive strength (UCS) tests were 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 Chicken Farm Lake stream water was obtained during the field investigation (on March 25, 2015) using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters, including pH, resistivity, conductivity, sulphates and chlorides.

The as-drilled borehole locations and ground surface elevations were measured and surveyed by member of our technical staff, referenced to the highway centerline and existing culverts and converted into northing/easting on the plan drawing. The ground surface elevation of the highway centerline was obtained from the profile drawing provided by MTO (Drawing BC10686145.dwg). The MTM NAD83 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 and Drillhole sheets in Appendix A and summarized below.

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
CK-1	5441390.4	388866.9	330.6	6.2
CK-2	5441399.7	388858.1	331.7	9.1
CK-3	5441394.6	388852.8	331.7	7.1
CK-4	5441405.5	388843.9	330.4	11.3

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS)<sup>1</sup> mapping, the subsoils in the vicinity of the Chicken Farm Lake culvert site generally consist of glaciolacustrine plain deposits comprised of sand and silt materials bordering with areas of organic terrain comprised of peat/muck and areas of bedrock knobs.

Based on geological mapping by the Ministry of Northern Development and Mines (Map 2543)<sup>2</sup>, the site is underlain by bedrock from the gneissic tonalite suite of the Archean Era, consisting of tonalite to granodiorite (foliated to gneissic) bordering with mafic to intermediate metavolcanic bedrock consisting of basaltic to andesitic flows, tuffs and breccias, chert, and iron formations.

<sup>1</sup> Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 42FSW.

<sup>2</sup> Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2543.



## 4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole and Drillhole sheets contained in Appendix A. The results of geotechnical laboratory testing are contained in Appendix B. The results of the in situ tests (i.e., SPT 'N'-values) as presented on the Record of Borehole sheets and in Section 4 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole and Drillhole sheets and on the interpreted stratigraphic profile on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

### Subsoil Conditions

In summary, the subsoil conditions encountered at the site consist of asphalt and granular fill/underlain by organic deposits of amorphous to fibrous peat and organic silt, underlain by deposits of silt, sand, silt to sandy silt, and/or till comprised of silt and sand to gravelly sandy silt, which are underlain by bedrock. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes is provided below.

Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	'N'-Values (blows)	Laboratory Testing
				Relative Density/ Consistency	
<b>Asphalt</b>	CK-2, CK-3	0.065 – 0.075	331.7	n/a	n/a
<b>(FILL)</b> Topsoil; black, frozen	CK-1, CK-4	0.1 – 0.4	330.6 – 330.4	n/a	n/a
<b>(FILL)</b> <sup>1</sup> Gravelly Silty Sand to Gravelly Sand, trace silt; brown; frozen to wet	CK-1 to CK-4	0.6 – 3.6	331.6 – 330.2	N = 3 – 14 <sup>2</sup> <b>Very Loose to Compact</b>	w = 12%
<b>Peat</b> , fibrous to amorphous, trace sand, trace wood; black; wet	CK-1, CK-4	1.6 – 1.8	329.8 – 329.0	N = 0 (weight of hammer) – 1 <b>Very Soft</b>	w = 333% – 531%
<b>Organic Silt to Silt</b> trace organics, trace sand; brown to dark grey; wet	CK-2, CK-4	0.2 – 0.8	328.0 – 327.4	N = 6 <b>Loose</b>	w = 23% – 39% 1 – MH (Fig. B1) 2 – AL = NP (on silt samples)
<b>Sand</b> , trace to some silt, trace gravel; grey; wet	CK-4	2.4	327.2	N = 3 – 10 <b>Very Loose to Loose</b>	w = 20% 1 – M (Fig. B2)
<b>Silt to Sandy Silt;</b> trace to some clay	CK-3 and CK-4	1.5 – 4.0	328.0 – 324.8	N = 4 – 19 <b>Loose to Compact</b>	w = 5% – 22% 2 – MH (Fig. B3)





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Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	'N'-Values (blows)	Laboratory Testing
				Relative Density/ Consistency	
<b>Silt and Sand to Gravelly Sandy Silt (TILL)</b> , trace to some clay; grey; wet	CK-1, CK-2 and CK-4	0.7 – 2.9	328.0 – 320.8	N = 10 – 96 <sup>3</sup>	w = 9%– 16% 3 – MH (Fig. B4)
				<b>Compact to Very Dense</b>	

### Where:

N = SPT 'N'-value; number of blows for 0.3 m of penetration

w = Natural Moisture Content (%)

M = Sieve analysis

MH = Combined Sieve and Hydrometer analysis

AL = Atterberg Limits Test

NP = Non-Plastic test result

### Notes:

<sup>1</sup> Auger grinding on inferred cobbles was noted within the granular fill in Boreholes CK-2 and CK-3.

<sup>2</sup> In the granular fill layer, five split-spoon samples did not penetrate the entire SPT depth due to the presence of coarse gravel and/or cobbles as inferred based on auger grinding. In addition, one SPT 'N'-value of 41 blows per 0.3 m of penetration was measured in the granular fill, however, this likely indicative of the frozen state of the material and is not representative of the relative density of the granular fill.

<sup>3</sup> In the gravelly sandy silt till deposit, one split-spoon samples did not penetrate the entire SPT depth due to the close proximity to the bedrock surface.

## Bedrock Conditions

Bedrock was cored in Boreholes CK-1 to CK-3 and the retrieved bedrock core is described as a black to white to pink, fine to coarse grained, granitic gniess, as presented on the Record of Drillhole sheets in Appendix A. Photographs of the retrieved bedrock core samples are shown on Figure B5. The depth to the bedrock surface, elevations and bedrock properties encountered in the boreholes is provided below.

Borehole No.	Depth to Bedrock <sup>1</sup> (m)	Bedrock Surface Elevation (m)	Core Length (m)	TCR (%)	RQD (%)	Rock Quality <sup>2</sup>	UCS Strength (MPa)	Strength Classification <sup>3</sup>
CK-1	3.3	327.3	2.9	100	79 – 100	Good to Excellent	77	(R4) Strong
CK-2	7.4	324.3	1.7	100	89 – 100	Good to Excellent	147	(R5) Very Strong
CK-3	5.2	326.5	1.9	100	92 – 100	Excellent	128	(R5) Very Strong

Notes:<sup>1</sup> Below ground surface; <sup>2</sup>Table 3.10 of CFEM 2006<sup>3</sup>; <sup>3</sup>Table 3.5 of CFEM 2006<sup>3</sup>

<sup>3</sup> Canadian Geological Society, 2006. Canadian Foundation Engineering Manual, 4th Edition.





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### Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The stream water level was measured at Elevation 330.4 m on March 18, 2015. Groundwater and stream water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

Borehole No.	Depth to Groundwater Level (m)	Groundwater Elevation (m)
CK-1	0.6	330.0
CK-2	1.4	330.3
CK-3	1.9	329.8
CK-4	0.6	329.8

### 5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. Rob Ireland, under the overall direction of Mr. David Muldowney, P.Eng. This Preliminary Foundation Investigation Report was prepared by Mr. Adam Core, P.Eng. and Mr. David Muldowney, P.Eng., provided a technical review of the report. Mr. Jorge M. A. Costa, P.Eng., the Designated MTO Foundations Contact and Principal of Golder, conducted an independent quality control review of this report.



## PRELIMINARY FOUNDATION REPORT CHICKEN FARM LAKE CULVERT - SITE NO. 48E-127/C

### Report Signature Page

GOLDER ASSOCIATES LTD.

Adam Core, P.Eng.  
Geotechnical Engineer



David Muldowney, P.Eng.  
Geotechnical Engineer



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

AC/DAM/JMAC/kp

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**PRELIMINARY FOUNDATION REPORT  
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# **PART B**

**PRELIMINARY FOUNDATION DESIGN REPORT  
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## **6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS**

### **6.1 General**

This section of the report provides preliminary foundation design recommendations for the proposed replacement of the Chicken Farm Lake culvert. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during this subsurface investigation.

The discussion and recommendations presented are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to carry out the preliminary design of the replacement culverts. Further investigation and analysis may be required during detail design, once the configuration of the proposed culvert and replacement strategy is finalized, to confirm and expand on the preliminary foundation recommendations provided in this report.

Where comments are made on construction, they are provided to highlight those aspects that could affect the future detail design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

It is assumed that the existing timber culvert will be replaced with a culvert of similar dimensions, along the same alignment and at similar invert elevations to that of the existing culvert. In addition, it is assumed that there will be no embankment grade raises or widening in the area of the new culvert as part of the Hwy 614 reinstatement.

### **6.2 Foundations**

#### **6.2.1 Foundation Options**

The Chicken Farm Lake culvert is located in the District of Thunder Bay in the Township of Leslie on Highway 614 at STA 16+934, approximately 50 km north of the junction of Highway 614 and Highway 17. The highway embankment is constructed of granular fill material and is approximately 2.1 m high relative to the culvert invert, with approximately 0.7 m of cover over the existing culvert. The existing culvert consists of twin-cell, open footing, timber “box”, the details of which (i.e., width, height, length, etc.) are summarized in Table 1.

Based on discussions with HMM and review of the preliminary General Arrangement (GA) drawings, we understand the following culvert types are being considered at this location:

- a pre-cast concrete box on a slight re-alignment; and
- a pre-cast open footing structure.

In this report we have considered the following options feasible/practical:

- a pre-cast concrete box culvert;
- an open footing box or arch culvert support on either cast-in-place or pre-cast footings; and
- a pipe culvert(s).



Given the relatively shallow depth to bedrock below the culvert invert at/along the central and eastern portion of the culvert and the variability of the bedrock surface, a culvert comprised of a pre-cast concrete cap supported on sheet pile abutments is not considered feasible at this site. A pipe culvert, including an elliptical culvert and/or a flexible arch culvert, is considered feasible but would provide less flow-through capacity compared to a box culvert or open footing culvert with a similar span and would likely require multiple, parallel pipes. If a pipe culvert is selected, a concrete structure would be preferred as a corrugated steel pipe (CSP) culvert generally has a shorter design life. Open footing arch culverts could be considered but the flow-through capacity for certain types and sizes or arches could be limited or restricted due to the need to provide adequate soil cover (including the roadway pavement structure) and the overall performance of such structures over the longer term is not known. From a foundation perspective, a concrete box culvert sufficiently wide to handle the stream flow is preferred. A pre-cast concrete box culvert is recommended over an open footing culvert as: the subsurface conditions at the foundation level are suitable for the support of such a box foundation; it can accommodate an accelerated construction schedule; and there are reduced dewatering requirements. Further, due to the presence of bedrock at relatively shallow depth, there are risks associated with dewatering to allow construction in-the-dry and risks associated with differential settlements as open footings would be need to be placed on a combination of bedrock, engineered fill and/or native soil. Other culvert types may be preferred due to construction staging or other considerations such as fisheries requirements related to natural channel substrate. A comparison of culvert types based on advantages, disadvantages and risk/consequence is presented in Table 2.

## **6.2.2 Foundation Elevations and Frost Protection**

### **6.2.2.1 Box Culvert**

It is not necessary to found a box culvert at the standard depth for frost protection purposes, as a box structure is tolerant of small magnitudes of movement related to freeze-thaw cycles, should these occur. We recommend that the replacement box culvert be founded on a granular pad (replacement fill) constructed on the generally compact native silt and sand deposits (i.e., sand, silt to sandy silt, and silt and sand to gravelly sandy silt till) below the existing fill and organic deposits (i.e., peat and organic silt) excavated to below about Elevations 328.0 m and 327.2 m, to between 2.6 m and 4.5 m below ground surface. In this regard, the culvert will have to be constructed on granular replacement fill as detailed in Section 6.4.2. Recommended foundation elevation and foundation conditions for a replacement box culvert are provided in Table 3.

#### **6.2.2.2 Open Footing Culvert**

Strip footings for an open footing culvert should be founded at a minimum depth of 2.5 m below the lowest surrounding grade to provide adequate protection against frost penetration, as per OPSD 3090.100 (Foundation, Frost Protection Depths for Northern Ontario). Given the proposed invert, the strip footings would be founded on a combination of the generally compact native soils, replacement fill and potentially partially on bedrock. Recommended founding elevations and foundation conditions for the replacement open footing culvert are provided in Table 3.



### **6.2.2.3 Pipe Culvert**

It is not necessary to found a pipe culvert at the standard depth for frost protection purposes, as such a culvert is tolerant to small magnitudes of movement related to freeze-thaw cycles, should these occur. We recommend that the replacement pipe culvert(s), if adopted, be founded on a granular pad (replacement fill) constructed on the native sand and silt deposits (i.e., sand, silt to sandy silt, and silt and sand to gravelly sandy silt till) below the existing fill and/or organic deposits (i.e., peat and organic silt). Similar to the box culvert option, the culvert would have to be constructed on a granular mat/pad of replacement fill placed along the entire length of the culvert footprint, as detailed in Section 6.4.2. Recommended founding elevations and foundation conditions for a pipe culvert are provided in Table 3.

## **6.2.3 Geotechnical Resistances**

### **6.2.3.1 Box Culvert**

A box culvert, placed on the properly prepared bedding/levelling course over a minimum of 1 m of granular replacement fill at or below the founding elevation identified in Table 3, should be based on the recommended factored geotechnical axial resistance at ULS and geotechnical reaction at SLS, for 25 mm of settlement, as provided in Table 3. These recommendations are based on an assumed box culvert width of 3 m (overall) as indicated in Table 3.

The factored geotechnical axial resistance at ULS and geotechnical reaction at SLS are dependent on the foundation size, configuration and applied loads; the geotechnical resistance/reaction should, therefore, be reviewed if the culvert width or founding elevation/condition differ from those given in Table 3.

The geotechnical resistance/reaction provided in Table 3 are based on loading applied perpendicular to the base of the culvert; where applicable, inclination of the load should be taken into account in accordance with Section 6.7.4 and Section C6.7.4 of the Canadian Highway Bridge Design Code (CHBDC 2006) and its Commentary.

The loading on the foundation soils below the culvert and the associated settlements at the culvert will be governed by the design height of the overlying and adjacent embankment fill, however it is assumed that no grade raise or embankment widening is planned. It is recommended that the structural engineer exercise caution when utilizing the values of the geotechnical resistance at SLS (as provided in Table 3) in the design of the culvert and that consideration be given to the sequence and staging of construction, particularly if a grade raise or widening is to take place as the magnitude of settlement that will occur under the culvert will be governed by the resulting soil loading (not culvert loading).

### **6.2.3.2 Open Footing Culvert**

Strip footings placed on the properly prepared subgrade, at or below the founding elevation recommended in Table 3, should be designed based on the factored geotechnical axial resistance at ULS and geotechnical reaction at Serviceability Limit State (SLS), for 25 mm of settlement, as provided in Table 3. These recommendations are based on an assumed footing width of 0.6 m or 1.2 m as noted in Table 3.



The factored geotechnical axial resistance at ULS and geotechnical reaction at SLS are dependent on the foundation size, configuration and applied loads; the geotechnical axial resistance/reaction should, therefore, be reviewed if the culvert footing width or founding elevation/condition differs from those given in Table 3.

The geotechnical resistance/reaction provided in Table 3 are based on loading applied perpendicular to the base of the footings; where applicable, inclination of the load should be taken into account in accordance with Section 6.7.4 and Section C6.7.4 of the CHBDC and its Commentary.

The loading on the foundation soils below the culvert and the associated settlements of the culvert will be governed by the design height of the overlying and adjacent embankment fill, however it is assumed that no grade raise or embankment widening is planned. It is recommended that the structural engineer exercise caution when utilizing the values of the geotechnical resistance at SLS (as provided in Table 3) in the design of the culvert and that consideration be given to the sequence and staging of construction, particularly if a grade raise or widening is to take place as the magnitude of settlement that will occur under the culvert will be governed by the resulting soil loading (not culvert loading).

#### **6.2.4 Resistance to Lateral Loads / Sliding Resistance**

Resistance to lateral forces/sliding resistance between the base of the box culvert and granular bedding material or between the base of the strip footing and bedrock should be calculated in accordance with Section 6.7.5 of the CHBDC. Table 4 provides the coefficients of friction between the base of the culvert/footing and potential interface materials.

If an open footing culvert is selected, depending on the slope of the bedrock and condition of the bedrock once exposed, dowelling of the footings into the bedrock may be required to increase sliding resistance. The horizontal resistance of the dowels is dependent on the strength of the bedrock, grout and steel. Where the rock mass is stronger than the concrete, the design of the dowels into the rock may be handled in the same way as the dowel embedment into the concrete for UCS of the grout is similar to that of the concrete. The dowels should have a minimum length within the very strong bedrock of 1 m, and the structural strength of the grout should not be exceeded. A Non-Standard Special Provision (NSSP) for construction of anchors (dowels) into bedrock should be developed at the detail design stage, if required depending on final culvert design and construction staging.

#### **6.2.5 Stability and Settlement**

Given that an embankment grade raise or widening is not proposed as part of the culvert replacement and highway embankment reconstruction, the existing native soils will not experience additional load, and therefore, settlement of the culvert if founded on a soil subgrade after embankment reconstruction is estimated to be less than 25 mm. It should be noted that the boreholes encountered a deposit of peat (and/or organic silt) below the embankment fill. Although the boreholes were drilled adjacent to the existing culvert, it may be inferred that organic materials will be present under the footprint of the replacement culvert. If not removed, loadings on such organic material would contribute to settlement of the culvert.





For the subsurface conditions and the proposed embankments height up to about 2.1 m relative to the culvert invert, granular fill embankments at this site will be stable at side slopes inclined at 2 Horizontal to 1 Vertical (2H:1V) or flatter.

While there would likely not be any stability issues associated with a grade raise or embankment widening, provided the organic deposits (i.e., peat and organic silt) are removed, immediate settlement of the subsoils should be expected during construction due to the presence of very loose to loose zones within the silt or sand deposits.

### 6.3 Lateral Earth Pressures

The lateral earth pressures acting on the side walls (or head/wing 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 culverts 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 I, II or III, but with less than 5 per cent passing the 200 sieve (0.075 mm) should be used as backfill behind the culvert walls, and on top of the culvert for a thickness of up to 300 mm. Backfill should be placed in a maximum of 200 mm loose lift thickness. Weep holes should be installed to allow for positive drainage of the granular backfill. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 (Compacting).
- The granular fill may be placed either in a zone with the width equal to at least 2.5 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 following parameters (unfactored) may be used to calculate the lateral earth pressures acting on the culvert:

Fill Type	Internal Angle of Friction ( $\phi$ , degrees)	Unit Weight (kPa)	Coefficients of Static Lateral Earth Pressure	
			At-Rest, $K_o$	Active, $K_a$
Granular 'A'	35	22	0.43	0.27
Granular 'B' Type II	35	21	0.43	0.27
Granular 'B' Type I or III	32	21	0.47	0.30



If the structure allows for lateral yielding, active earth pressures may be used in the design of the structure(s). If the structure does not allow for lateral yielding, at-rest earth pressures should be assumed for 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.

## **6.4 Construction Considerations**

### **6.4.1 Temporary Roadway Protection**

The temporary excavation for the culvert replacement will be made through the existing embankment fill, very soft/loose organic deposits and into the very loose to compact sand and silt deposits. All excavations must be carried out in accordance with Ontario Regulation 213, Ontario Occupational Health and Safety Act for Construction Projects (as amended). The granular fills and native soils are considered to be Type 3 soil above the groundwater table and Type 4 soil below. Temporary open-cut excavations in Type 3 soils should remain stable if side slopes are formed no steeper than 1 Horizontal to 1 Vertical (1H:1V). In Type 4 soils, the side slopes should be formed no steeper than 3H:1V.

Temporary protection support systems may be required along the highway to facilitate construction staging and maintain traffic during culvert replacement work. At this site, due to the relatively shallow depth to bedrock, a temporary support system comprised of sheet-piling will not be feasible. Soldier piles and lagging (with the piles socketed into bedrock or supported by tiebacks or rakers) may be used for support of the excavation along the structure, as well as along the roadway. In this context, a soldier pile and lagging system may not adequately prevent the loss of wet, fine grained materials (i.e. sand and silt) into the excavation and proper construction procedures must be adopted to mitigate for the potential loss of soil from behind the protection system.

Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems). Temporary excavation support systems should be designed to Performance Level 2 for any excavation adjacent to existing roadways.

### **6.4.2 Excavation and Replacement Fill Below Culvert**

Prior to placement of any concrete, engineered fill (replacement backfill) and bedding material, all organics (including peat, organic silt and mixed organic materials) should be sub-excavated from below the plan limits of the proposed works to the founding levels provided in Table 3. For footings placed directly on bedrock, the surface should be cleaned, scaled, loosened debris removed and inspected before placing concrete.

The culvert subgrade should be inspected by a Quality Verification Engineer following sub-excavation to ensure that all organics and other unsuitable materials have been removed, in accordance with OPSS 422 (Precast Reinforced Concrete Box Culverts) for a pre-cast box culvert and OPSS 902 (Excavating and Backfilling Structures) for an open footing culvert. For a box culvert replacement, the sub-excavated area should be backfilled with granular material meeting the requirements of OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type I, II or III that is placed and compacted in accordance with OPSS.PROV 501 (Compacting). The use of Granular 'B' Type II is recommended in wet ground conditions or below water and placement should be in accordance with OPSS.PROV 209 (Embankments over Swamps). For a pre-cast open footing culvert



option, uneven bedrock surfaces should be backfilled with mass concrete. An NSSP for mass concrete placement should be provided at the detail design stage, if required depending on final culvert design.

The bedrock surface elevation is variable between boreholes and localized areas of higher bedrock may require excavation to found the culvert at the depths given in Table 3 if pre-cast footings are utilized. As the bedrock is classified as strong to very strong, bedrock excavation would require pre-drilling and/or hoe ramming to allow it to be excavated. Should lowering of the bedrock be required over a large extent of the open base area, although not likely required at this site depending on the final invert elevation, pre-drilling and hoe ramming alone may not be feasible nor practical. Consideration could be given to controlled blasting excavation techniques as per OPSS.PROV 120 (Explosives) and OPSS.PROV 202 (Rock Removal - Manual or Blasting) in order to preserve the integrity of the rock mass in the area of the rock excavation. Pre-shearing, line-drilling or other specialized techniques may be required to maintain the excavation lines and preserve the integrity of the rock mass along the footprint of the footings.

### **6.4.3 Culvert Bedding and Backfill**

#### **6.4.3.1 Box Culvert**

The bedding and levelling pad requirements for a pre-cast box culvert should be accordance with OPSS 422 (Precast Reinforced Concrete Box Culverts). Given the potential for surface water flow and some groundwater seepage through the adjacent granular fill and relatively permeable native soils at this site, a minimum 300 mm thick layer of OPSS.PROV 1010 (Aggregates) Granular 'B' Type II material would typically be recommended for bedding purposes. However, given the presence of the organic deposits, an approximately 1 m to 2 m thick layer of Granular 'B' Type II replacement fill (as per Section 6.4.2) is likely required. The granular bedding (i.e., upper 0.3 m), if placed above water, should be placed in maximum 200 mm thick loose lifts and be compacted to 98 per cent of the SPMDD as specified in OPSS.PROV 501 (Compacting). In addition, a 75 mm thick uncompacted levelling pad consisting of OPSS.PROV 1010 (Aggregates) Granular 'A' or fine concrete aggregate meeting the grading requirements specified in OPSS.PROV 1002 (Aggregates – Concrete) should be provided similar to that shown on OPSD 803.010 (Backfill and Cover for Concrete Culverts).

A frost taper should be constructed in a similar configuration as that shown in OPSD 803.010 for box culverts with spans less than or equal to 3.0 m.

#### **6.4.3.2 Open Footing Culvert**

The excavation and backfilling requirements for the open footing culvert replacement should be in accordance with OPSS 902 (Excavating and Backfilling – Structures) and also in similar configuration to that shown on OPSD 803.010 (Backfill and Cover for Concrete Culverts).

Should a pre-cast open footing culvert be the selected replacement option, a bedding layer and levelling pad will be required above the native soil or bedrock surface (at the east end). The bedding layer and levelling pad for the pre-cast open footings should follow the recommendations as discussed in Section 6.4.3.2 for the box culvert replacement option.



A frost taper should be constructed in a similar configuration to that shown in OPSD 803.010. Although OPSD 803.010 also relates to an open footing culvert with spans less than or equal to 3.0 m, a similar frost taper at 10H:1V is considered acceptable for the assumed 4 m to 6 m (overall) wide open footing culvert replacement option shown on the preliminary GA drawings.

#### **6.4.3.3 Pipe Culvert**

The bedding, levelling and backfill for a circular concrete pipe, CSP culvert or SP CSP arch should be in accordance with OPSD 802.034 (Rigid Pipe Bedding and Cover in Embankment), OPSD 802.014 (Flexible Pipe, Embedment in Embankment) or OPSD 802.024 (Flexible Pipe Arch, Embedment in Embankment), respectively, and culvert construction should be in accordance with OPSS 421 (Pipe Culvert Installation in Open Cut). It is important that the backfill at the haunches be well compacted. The pipe culvert should be constructed on a minimum 300 mm thick layer of OPSS.PROV 1010 Granular 'A' or Granular 'B' Type II material for bedding purposes, however this layer thickness should be confirmed at the detail design stage for the actual culvert type and size selected.

A frost taper should be constructed in accordance with OPSD 803.031 (Frost Treatment).

#### **6.4.3.4 Backfill**

Backfill behind the culvert walls should consist of granular fill meeting the specifications for OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type I, II or III, but with less than 5 per cent passing the No. 200 (0.075 mm) sieve. The backfill should be placed in maximum 200 mm thick loose lifts and be compacted to at least 98 per cent of the SPMD in accordance with OPSS.PROV 501 (Compacting). The fill should also be placed concurrently on both sides of the culvert, ensuring that the backfill depth on one side does not exceed the other side by more than 400 mm.

Backfill placement for reconstruction of the roadway embankments along and over the culvert should be carried out as per OPSD 208.010 (Benching of Earth Slopes) to integrate the existing embankment fill and new fill along the cut faces.

Inspection and field density testing should be carried out by qualified geotechnical personnel during all engineered fill placement operations to ensure that appropriate materials are used, and that adequate levels of compaction have been achieved.

#### **6.4.4 Subgrade Protection**

The native silt to sandy silt and silt and sand to gravelly sandy silt till subgrade, will be susceptible to disturbance from construction traffic and/or ponded water. To limit the effect of this disturbance and as an alternative to placement of a minimum 300 mm layer of replacement backfill for protection of the excavated subgrade, a tremie concrete working slab could be placed on the subgrade if the culvert is not placed within four hours after preparation, inspection and approval of the foundation subgrade. The minimum thickness of the concrete working slab should be 100 mm and the concrete should have a minimum 28 day compressive strength of 20



MPa. Consideration should be given to include an NSSP in the contract to address subgrade protection at this site. An NSSP should be provided at the detail design stage, if required depending on final culvert design and construction staging.

#### **6.4.5 Erosion Protection**

Provision should be made for scour and erosion protection at the culvert location. In order to prevent surface water from flowing either beneath the box or pipe culvert (potentially causing undermining and scouring) or around the culvert (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles), a clay seal or concrete cut-off wall should be provided at the upstream end of the culvert. If a clay seal is adopted, the clay material should meet the requirements of OPSS 1205 (Clay Seal), and the seal should be a minimum thickness of 1 m, if constructed of natural clay or soil bentonite mix. The seal should also extend a minimum horizontal distance of 2 m on either side of the culvert inlet opening. Alternatively, a 0.6 m thick clay blanket may be constructed, extending upstream three times the culvert height and along the adjacent slopes to a height of two times the culvert height or the high water level, whichever is greater.

The requirements for and design of erosion protection measures for the inlet and outlet of the culvert should be assessed by the hydraulics design engineer. As a minimum, rip rap treatment for the outlet of the culvert should be consistent with the standard presented in OPSD 810.010 (Rip Rap Treatment). Erosion protection for the inlet of the culvert should also follow the standard presented in OPSD 810.010 (Rip Rap Treatment) similar to the outlet but with the rip rap placed up to the toe of embankment slope level.

#### **6.4.6 Control of Groundwater and Surface Water**

Excavation along the culvert alignment will be required to remove the existing embankment fill, peat/organic silt and potentially a portion of the native soils prior to placement of the replacement fill, bedding material, the actual culvert, backfill and roadway pavement structure. Groundwater flow into the excavation can be expected due to the depth of the excavations and the presence of relatively permeable embankment fill, replacement fill and native soils. Therefore, control of groundwater will be necessary to allow for construction to be carried out in dry conditions, where required. Surface water should be directed away from the excavation areas to prevent ponding of water that could result in disturbance and weakening of the foundation subgrade.

Depending on the stream flow, local surface water flow conditions and groundwater level at the time of construction, water flow could be passed through the area by means of a temporary culvert, using a portion of the existing twin-cell culvert or diverted by pumping from behind a temporary shoring system (i.e., soldier piles and lagging). A sheet-pile cofferdam is considered not feasible at this location.

Excavations for the box, open footing and pipe culvert options will extend below the stream water level, and the groundwater level, and will require temporary shoring with dewatering to allow the culvert to be constructed/placed in-the-dry, if required. Temporary shoring and dewatering could be in the form of soldier piles and lagging, however seepage into the excavation will occur between the bottom of the shoring system through the soils along the soil/bedrock interface. Depending on the soil or bedrock conditions at the founding level, standard pumping from sumps may not be adequate to maintain the excavation unwatered and careful consideration will have to be given to the design of the dewatering system. For the box culvert and pipe culvert



replacement options, dewatering may not be required as Granular 'B' Type II replacement fill and/or bedding material can be placed sub-aqueously.

Dewatering of all excavations should be carried out in accordance with OPSS 517 (Dewatering). Consideration should be given to include an NSSP in the contract to address unwatering at this site. An NSSP should be provided at the detail design stage, if required depending on final culvert design and construction staging.

At this preliminary stage, an accurate prediction of the groundwater pumping volumes cannot be made, as the flow rate would be dependent on construction methods adopted by the contractor. However, it is considered that groundwater pumping volumes will likely exceed 50 m<sup>3</sup>/day during initial drawdown stages and/or during periods of heavy precipitation. For this pumping volume, a Permit to Take Water (PTTW) would be required.

#### **6.4.7 Obstructions**

The contractor should be alerted to the presence of inferred cobbles within the embankment fill as noted in Boreholes CK-2 and CK-3. An NSSP should be developed at the detail design stage for inclusion into the Contract Documents to alert the contractor to the potential presence of such obstructions.

#### **6.4.8 Analytical Testing for Construction Materials**

The results of an analytical test on a sample of stream water taken at the culvert site are presented in Table B1 in Appendix B. The suite of parameters tested is intended to allow the design engineer to assess the requirements for the appropriate type of cement to be used in construction and the need for corrosion protection of steel reinforcing elements.

### **6.5 Recommendations for Further Work During Detail Design**

During the detail design phase, additional field investigation and testing may be required, depending on the final configuration and/or alignment of the culvert and the replacement strategy (i.e., staging). Due to the shallow depth to bedrock at this site and the size of the proposed culverts, consideration should be given to advancing additional boreholes across the proposed footprint to further delineate the bedrock surface if an open-footing replacement culvert is selected. In addition, if temporary shoring is required as part of the construction staging, additional boreholes are recommended to provide soils and bedrock information along the length of the roadway protection system. The scope and results of this investigation should be reviewed at the time of the detail design to determine if they meet the then-current MTO requirements for the culvert type or staging strategy under consideration, and if additional investigation and analysis is necessary. Further, the need for an application for a PTTW should be defined early in the detail design phase of the project as not to delay the start of construction.



## **7.0 CLOSURE**

This Preliminary Foundation Design Report was prepared by Mr. Adam Core, P.Eng. and the technical aspects were reviewed by Mr. David Muldowney, P.Eng. Mr. Jorge M. A. Costa, P.Eng., Designated MTO Foundations Contact and Principal of Golder, conducted an independent quality control review of this report.





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**PRELIMINARY FOUNDATION REPORT  
CHICKEN FARM LAKE CULVERT - SITE NO. 48E-127/C**

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## Report Signature Page

**GOLDER ASSOCIATES LTD.**

Adam Core, P.Eng.  
Geotechnical Engineer



David Muldowney, P.Eng.  
Geotechnical Engineer



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

AC/DAM/JMAC/kp

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## PRELIMINARY FOUNDATION REPORT CHICKEN FARM LAKE CULVERT - SITE NO. 48E-127/C

### REFERENCES

Canadian Geological Society, 2006. Canadian Foundation Engineering Manual, 4th Edition.

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

Occupational Health and Safety Act and Regulation for Construction Projects (as amended).

Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2543.

Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 42FSW.

ASTM International:

ASTM D1586	Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils
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Ontario Provincial Standard Specifications (OPSS)

OPSS 421	Construction Specification for Pipe Culvert Installation in Open Cut
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut
OPSS 517	Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS 902	Construction Specification for Excavating and Backfilling – Structures
OPSS 1205	Material Specification for Clay Seal

Ontario Provincial Standard Specifications (OPSS) – Provincial Oriented

OPSS.PROV 120	General Specification for the Use of Explosives
OPSS.PROV 202	Construction Specification for Rock Removal by Manual Scaling, Machine Scaling, Trim Blasting, or Controlled Blasting
OPSS.PROV 209	Construction Specification for Embankments over Swamps and Compressible Soils
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 1002	Material Specification for Aggregates - Concrete
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Ontario Provincial Standard Drawings (OPSD)

OPSD 208.010	Benching of Earth Slopes
OPSD 802.014	Flexible Pipe, Embedment in Embankment, Original Ground: Earth or Rock
OPSD 802.024	Flexible Pipe Arch, Embedment in Embankment Original Ground: Earth or Rock



## PRELIMINARY FOUNDATION REPORT CHICKEN FARM LAKE CULVERT - SITE NO. 48E-127/C

OPSD 802.034	Rigid Pipe Bedding and Cover in Embankment Original Ground: Earth or Rock
OPSD 803.010	Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3.0 m
OPSD 803.031	Frost Treatment – Pipe Culverts, Frost Penetration Line Between Top of Pipe and Bedding Grade
OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets
OPSD 3090.100	Foundation Frost Penetration Depths for Northern Ontario

Ontario Water Resource Act:

Regulation 903	Wells (as amended)
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**Table 1: Summary of Culvert Details**

Culvert Location	Site #	Approximate Height of Embankment <sup>1</sup> (m)	Existing Culvert			Approximate Invert Elevation <sup>2</sup>	
			Type	Approximate Dimension <sup>2</sup>	Approximate Length (m)	West End of Culvert (m)	East End of Culvert (m)
Hwy 614 STA 16+934	48E-127/C	2.1	Twin-Cell Open Footing Timber "Box"	1.3 m wide by 1.2 m high (each cell)	22	329.7	329.6

- Notes:
1. Embankment height is relative to existing ground surface at the centreline of the roadway and the invert elevation of the culverts.
  2. Culvert dimensions are based on the field review performed by HMM and the culvert invert elevations are based on the plan and profile drawings provided by MTO (Drawing BC10686145.dwg).

Prepared by: AC  
Checked by: DAM  
Reviewed by: JMAC



**PRELIMINARY FOUNDATION REPORT  
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**Table 2: Comparison of Foundation Alternatives**

Option	Advantages	Disadvantages	Risks/Consequences
Pre-Cast Box Culvert	<ul style="list-style-type: none"> <li>Allows faster construction compared to cast-in-place options resulting in shorter duration for dewatering and surface water pumping.</li> <li>Backfill/bedding under the culvert may be placed underwater (i.e. Granular 'B' Type II) minimizing or eliminating water pumping requirements.</li> <li>Existing culvert can likely be used for water diversion if multiple parallel boxes are constructed.</li> <li>Tolerant of total and differential settlement due to frost penetration into the subgrade soils and if the highway embankment is raised or widened at the culvert site or if remnants of the organic deposits are not fully removed.</li> </ul>	<ul style="list-style-type: none"> <li>Will require similar excavation depths and increased off-site disposal of organic materials compared to open footing option; sub-excavation to a similar depth as the open footing will require greater volume of backfill material but backfill/bedding may be placed underwater (i.e. Granular 'B' Type II).</li> <li>May not satisfy fisheries requirements related to natural channel substrate, if applicable.</li> <li>Concrete cut-off wall (or clay blanket) typically required at inlet to mitigate potential scour under culvert.</li> <li>Transportation to and on-site lifting of large, and potentially double the number of, pre-cast sections will be required.</li> </ul>	<ul style="list-style-type: none"> <li>Should bedrock surface be encountered higher than anticipated, bedrock excavation will be required to reach desired invert elevation.</li> <li>Limited risk related to settlement performance.</li> </ul>
Open Footing Culvert	<ul style="list-style-type: none"> <li>Reduced off-site disposal of excavation material compared to the box culvert option as organics will only need to be removed from within the limits of the footings.</li> <li>Minor variations in bedrock surface elevation can easily be accommodated with cast-in-place open footing option or mass concrete.</li> <li>May be feasible to build culvert on pre-cast footing sections, to accelerate construction schedule and reduce time for dewatering/unwatering (pumping) of surface water, but levelling of footing base (pad/native soil – backfill) will be required</li> <li>Existing culvert(s) can likely be used for water diversion while new footings are being constructed adjacent to the culvert.</li> <li>Readily suitable for construction using concrete or metal sections.</li> <li>Would likely satisfy fisheries requirements related to natural channel substrate, if applicable.</li> </ul>	<ul style="list-style-type: none"> <li>Dewatering will be required to allow construction in dry conditions, which will be difficult due to the presence of bedrock at shallow depth.</li> <li>Concrete or metal arch sections supported on concrete open (strip) footings may not allow for adequate soil cover to be placed for ordinary construction.</li> <li>Footings on combination of bedrock, engineered fill and soil could lead to differential settlement of the open footing structure.</li> </ul>	<ul style="list-style-type: none"> <li>Higher risk of unwatering issues related to footing construction in the dry as water seepage is anticipated between the bottom of the shoring and the soil/bedrock interface.</li> <li>High risk of differential settlements where footings transition from bedrock, replacement fill and/or native soils or if remnants of the organic deposits are not removed.</li> <li>High risk that bedrock excavation will be required for a pre-cast footing option in order to reach the desired invert elevation.</li> <li>Some risk of disturbance of the native sand and silt deposits; can be somewhat mitigated with use of a concrete working slab or granular working pad but would require greater depth of excavation and dewatering for footing construction in dry conditions (potentially requires a tremie plug at foundation level).</li> </ul>



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Option	Advantages	Disadvantages	Risks/Consequences
Circular Pipe Culvert	<ul style="list-style-type: none"><li>■ Allows for faster construction compared to cast-in-place options resulting in shorter duration for dewatering and surface water pumping.</li><li>■ Backfill under the culvert may be placed underwater (i.e. Granular 'B' Type II) minimizing or eliminating water pumping requirements.</li><li>■ More tolerant of total and differential settlement if the highway embankment is raised or widened or if remnants of the organic deposits are not fully removed.</li></ul>	<ul style="list-style-type: none"><li>■ Reduced flow-through capacity for the same overall culvert span compared to box culvert options. Multiple CSPs likely required to achieve required flow.</li><li>■ Cut-off wall or clay blanket may be required at inlet to mitigate potential scour under culvert.</li><li>■ CSP does not have as long of a design life compared to concrete culvert options.</li><li>■ Difficult to compact backfill under culvert haunches to the springline.</li></ul>	<ul style="list-style-type: none"><li>■ Some risk of disturbance of the native sand and silt deposits during construction; can be mitigated with use of a tremie concrete working slab or Granular B Type II working pad.</li><li>■ Limited risk of adequate performance due to settlement.</li></ul>



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**Table 3: Geotechnical Axial Resistance and Reaction for Pre-Cast Box and Open Footing Culvert Replacements**

Culvert Location	Approximate Invert Elevation <sup>1</sup>	Culvert Type	Approximate Backfill/Bedding Founding Elevation	Founding Condition	Factored Geotechnical Axial Resistance at ULS <sup>2</sup>	Geotechnical Reaction at SLS for 25 mm of Settlement <sup>2</sup>
Hwy 614 STA 16+934	329.6 m	Pre-Cast Box <sup>2</sup>	329.2 m (Organic removal potentially to Elev. 327.2 m)	Bedding/Levelling Pad and Replacement Fill over to Compact Silt, Sand and Silt Till Deposits	180 kPa	140 kPa
		Open Footing (0.6 m width)	327.0 m	Loose to Compact Silt, Sand and Till Deposits and Bedrock	140 kPa	125 kPa
		Open Footing (1.2 m width)	327.0 m	Loose to Compact Silt, Sand and Till Deposits and Bedrock	150 kPa	75 kPa
		Pipe <sup>3</sup>	329.3 m (Organic removal potentially to Elev. 327.2 m)	Bedding and Replacement Fill over Loose to Compact Silt, Sand and Till Deposits	N/A	N/A

- Notes:
1. Culvert invert elevations are based on the profile drawings provided by MTO (Drawing BC10686145.dwg).
  2. The factored geotechnical axial resistance at ULS and geotechnical reaction at SLS for 25 mm of settlement are estimated based on an assumed 3 m wide box culvert and a 0.6 m or 1.2 m wide open footing. The recommended geotechnical resistance/reaction should be reviewed if the founding elevation and/or the foundation widths differ from those given above.
  3. The foundation elevation may need to be adjusted based on the type and size of the pipe culvert and required bedding thickness.

Prepared by: AC  
Checked by: DAM  
Reviewed by: JMAC





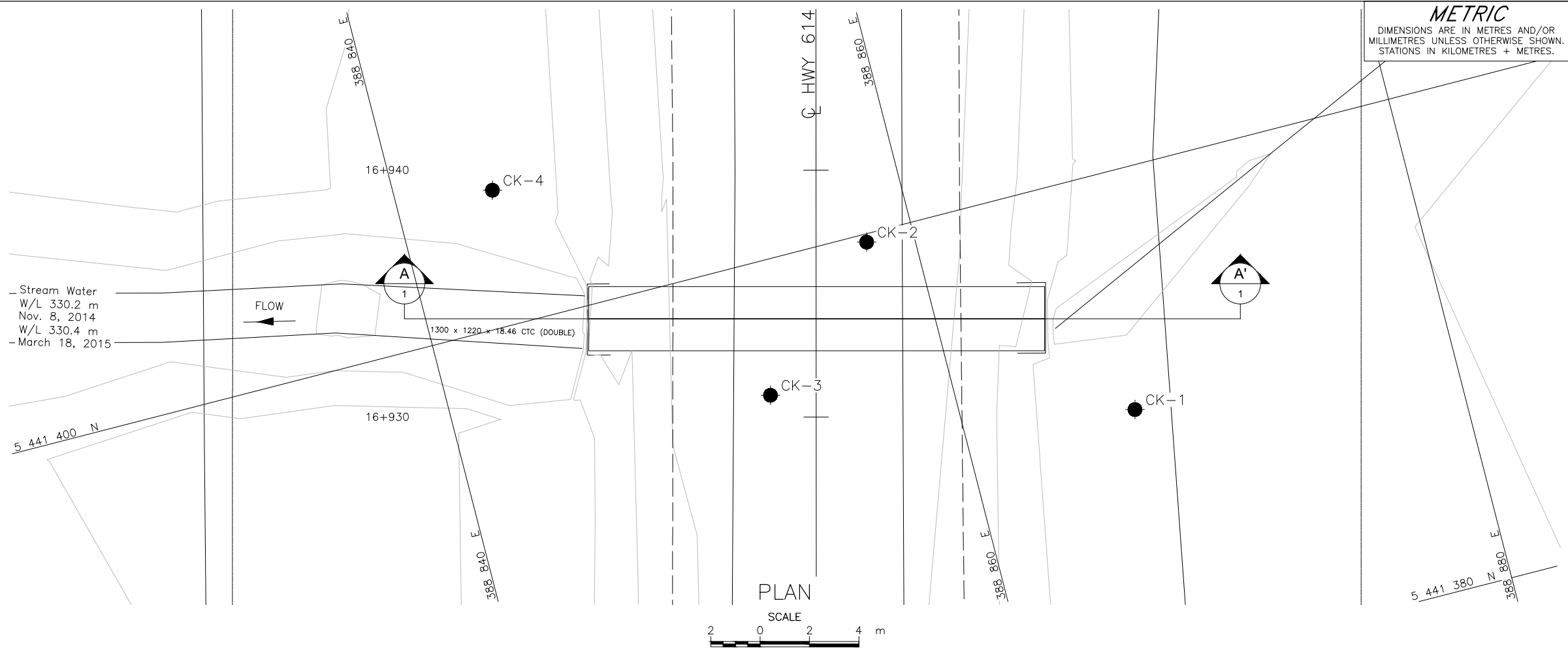
## PRELIMINARY FOUNDATION REPORT CHICKEN FARM LAKE CULVERT - SITE NO. 48E-127/C

**Table 4: Resistance to Lateral Loads/Sliding Resistance for Pre-Cast Box and Open Footing Culvert Replacements**

Culvert Location	Pre-Cast Box Culvert or Pre-cast Open Footing		Cast-in-place Open Footing	
	Interface Material	Coefficient of Friction <sup>1</sup> (tan $\delta$ )	Interface Material	Coefficient of Friction <sup>1</sup> (tan $\delta$ )
Hwy 527 STA 16+956	Compacted Granular Fill (Bedding Levelling Pad)	0.45	Loose to Compact Silt, Sand and Till Deposits	0.30
			Bedrock Surface / Mass Concrete on Bedrock	0.70

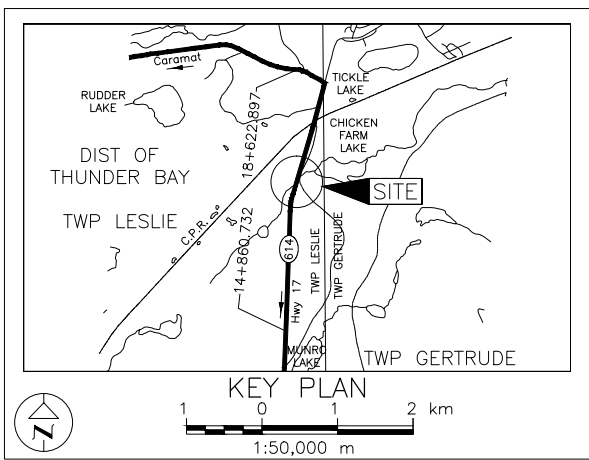
Notes: 1. These values are unfactored. In accordance with CHBDC, a factor of 0.8 is to be applied in calculating the horizontal resistances.

Prepared by: AC  
Checked by: DAM  
Reviewed by: JMAC



CONT No. GWP No. 6332-14-00

HIGHWAY 614  
CHICKEN FARM LAKE CULVERT STA 16+934  
BOREHOLE LOCATIONS AND SOIL STRATA



**LEGEND**

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
CK-1	330.6	5441390.4	388866.9
CK-2	331.7	5441399.7	388858.1
CK-3	331.7	5441394.6	388852.8
CK-4	330.4	5441405.5	388843.9

**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.

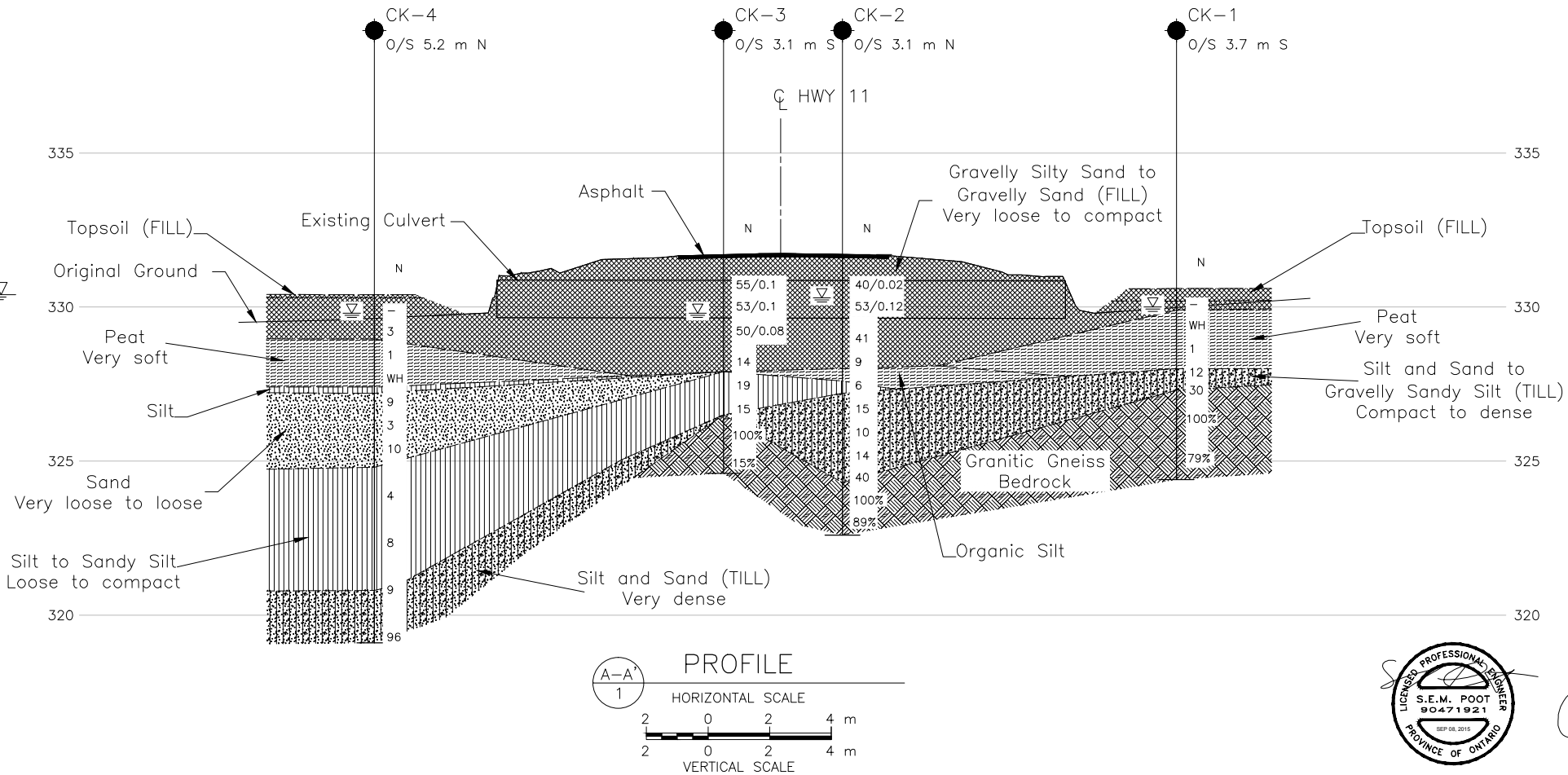
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

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 MTO, drawing file no. BC10686145, received FEB 20, 2015.

NO.	DATE	BY	REVISION
Geocres No. 42F-33			
HWY. 614	PROJECT NO. 1411523		DIST. .
SUBM'D. AC	CHKD. .	DATE: 8/26/2015	SITE: 48E-127/C
DRAWN: JJL	CHKD. SEMP	APPD. JMAC	DWG. 1





## PHOTOGRAPHS

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**Photograph 1: Chicken Farm Lake Culvert  
East Side - Inlet (Taken from MTO, OSIM\_08-28-2012)**



**Photograph 2: Chicken Farm Lake Culvert  
West Side - Outlet (Taken from MTO, OSIM\_08-28-2012)**







## PHOTOGRAPHS

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**Photograph 3: Chicken Farm Lake Culvert  
East Elevation - Inlet (Taken from MTO, OSIM\_08-28-2012)**



**Photograph 4: Chicken Farm Lake Culvert  
East Elevation - Inlet (Golder – March 18, 2015)**





# **APPENDIX A**

## **Record of Boreholes and Drillholes**



## LIST OF SYMBOLS

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

### I. GENERAL

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

### II. STRESS AND STRAIN

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

### III. SOIL PROPERTIES

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

### (a) Index Properties (continued)

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

### (b) Hydraulic Properties

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

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

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

### (d) Shear Strength

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

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

Notes: 1  
2

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



## LIST OF ABBREVIATIONS

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

### I. SAMPLE TYPE

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

### II. PENETRATION RESISTANCE

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

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

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

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

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

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

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

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

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

### III. SOIL DESCRIPTION

#### (a) Non-Cohesive (Cohesionless) Soils

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

#### (b) Cohesive Soils Consistency

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

### IV. SOIL TESTS

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

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

### V. MINOR SOIL CONSTITUENTS

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





## LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

### WEATHERINGS STATE

**Fresh:** no visible sign of weathering

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

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

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

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

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

### BEDDING THICKNESS

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

### JOINT OR FOLIATION SPACING

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

### GRAIN SIZE

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

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

### CORE CONDITION

#### Total Core Recovery (TCR)

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

#### Solid Core Recovery (SCR)

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

#### Rock Quality Designation (RQD)

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

### DISCONTINUITY DATA

#### Fracture Index

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

#### Dip with Respect to Core Axis

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

#### Description and Notes

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

#### Abbreviations

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

PROJECT 1411523		<b>RECORD OF BOREHOLE No CK-1</b>				1 OF 1 <b>METRIC</b>											
G.W.P. 6332-14-00		LOCATION N 5441390.4; E 388866.9				ORIGINATED BY RI											
DIST _____ HWY 614		BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers, NW Casing and NQ Coring				COMPILED BY AC											
DATUM GEODETIC		DATE March 25, 2015				CHECKED BY SEMP											
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									
330.6	GROUND SURFACE							20	40	60	80	100					
0.0	Topsoil (FILL)																
330.2	Black Frozen		1A	AS	-												
329.8	Gravelly sand (FILL)																
0.8	Brown Frozen		1B	SS	WH												
	PEAT (Fibrous to Amorphous), trace wood																
	Very soft		2	SS	1												
	Black Wet																
328.0			3A	SS	12												
2.6	Gravelly Sandy SILT, trace clay (TILL)		3B														
	Compact																
	Grey		4	SS	30/0.15												
	Wet																
327.3	GRANITIC GNEISS BEDROCK																
3.3	Bedrock cored from 3.3 m depth to 6.2 m depth.		1	RC	REC 100%												
	For coring details see Record of Drillhole CK-1.																
			2	RC	REC 100%												
324.4	END OF BOREHOLE																
6.2	Note:  1. Water level at a depth of 0.6 m below ground surface (Elev. 330.0 m) upon completion of drilling.  2. Split-spoon Sample 4, sliding along bedrock surface at 3.3 m depth.																

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 22/06/15 DATA INPUT:

DATUM: GEODETIC

DRILL RIG: CME 55

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

[illegible]

DEPTH SCALE

1 : 50

LOGGED: RI

CHECKED: SEMP

PROJECT 1411523		<b>RECORD OF BOREHOLE No CK-2</b>				1 OF 1 <b>METRIC</b>										
G.W.P. 6332-14-00		LOCATION N 5441399.7; E 388858.1				ORIGINATED BY RI										
DIST _____ HWY 614		BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers, NW Casing and NQ Coring				COMPILED BY AC										
DATUM GEODETIC		DATE March 18 and 20, 2015				CHECKED BY SEMP										
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								WATER CONTENT (%)
331.7	GROUND SURFACE						20	40	60	80	100					
0.9	ASPHALT (65 mm)															
	Gravelly sand, trace silt (FILL) Loose Brown Frozen* to wet		1	SS	40/ 0.02											
	Augers grinding from 0.8 m to 2.7 m depth on inferred cobbles.		2	SS	53/ 0.12											
			3	SS	41*											
			4	SS	9											
328.0	ORGANIC SILT															
327.6	Brown Wet		5A	SS	6											
327.2	SILT, trace organics		5B	SS												
4.5	Loose Brown to dark grey Wet		6	SS	15											
	SILT and SAND, trace to some gravel, trace to some clay (TILL) Compact to dense Grey Wet		7	SS	10											
			8	SS	14											
			9	SS	40											
324.3	GRANITIC GNEISS BEDROCK		1	RC	REC 100%											
7.4	Bedrock cored from 7.4 m depth to 9.1 m depth.		2	RC	REC 100%											
	For coring details see Record of Drillhole CK-2.															
322.6	END OF BOREHOLE															
9.1	Note:  1. Water level at a depth of 1.4 m below ground surface (Elev. 330.3 m) upon completion of drilling.  2. Auger refusal encountered at 7.4 m depth. Advanced additional borehole 1 m north of CK-2 and cored bedrock from 7.4 m to 9.1 m depth.															

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 03/09/15 DATA INPUT:

PROJECT: 1411523

**RECORD OF DRILLHOLE: CK-2**

SHEET 1 OF 1

LOCATION: N 5441399.7 ;E 388858.1

DRILLING DATE: March 20, 2015

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	CORRELATION LOG																	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
							FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY			Diametral Point Load Index (MPa)	RMC -Q AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	k, cm/s																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
																			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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										

DEPTH SCALE

1 : 50



LOGGED: RI

CHECKED: SEMP

SUD-RCK 1411523.GPJ GAL-MISS.GDT 030715 DATA INPUT:

<b>PROJECT</b> 1411523		<b>RECORD OF BOREHOLE No CK-3</b>		1 OF 1 <b>METRIC</b>	
<b>G.W.P.</b> 6332-14-00		<b>LOCATION</b> N 5441394.6; E 388852.8		<b>ORIGINATED BY</b> RI	
<b>DIST</b> _____ <b>HWY</b> 614		<b>BOREHOLE TYPE</b> 108 mm I. D. Hollow Stem Augers, NW Casing and NQ Coring		<b>COMPILED BY</b> AC	
<b>DATUM</b> GEODETIC		<b>DATE</b> March 18 and 20, 2015		<b>CHECKED BY</b> SEMP	

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		20   40   60		w <sub>p</sub> w   w <sub>L</sub>								
								UNCONFINED   +   FIELD VANE ●   QUICK TRIAXIAL   x   REMOULDED												
331.7	GROUND SURFACE																			
0.9	ASPHALT (75 mm)																			
	Gravelly sand, trace silt (FILL)		1	SS	55/0.1*															
	Compact																			
	Brown																			
	Frozen* to wet																			
	Augers grinding from 0.8 m to 3.0 m depth on inferred cobbles.		2	SS	53/0.1*															
			3	SS	50/0.08*															
			4	SS	14															
328.0																				
3.7	SILT, some sand, some clay		5	SS	19															
	Compact																			
	Grey																			
	Wet		6	SS	15															
326.5																				
5.2	GRANITIC GNEISS BEDROCK																			
	Bedrock cored from 5.2 m depth to 7.2 m depth.		1	RC	REC 100%															
	For coring details see Record of Drillhole CK-3.		2	RC	REC 100%															
324.6																				
7.1	END OF BOREHOLE																			
	Note:																			
	1. Water level at a depth of 1.9 m below ground surface (Elev. 329.8 m) upon completion of drilling.																			
	2. Auger refusal encountered at 5.2 m depth. Advanced additional borehole 1.1 m north of CK-3 and cored bedrock from 5.2 m to 7.1 m depth.																			

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 03/09/15 DATA INPUT:

PROJECT: 1411523

# RECORD OF DRILLHOLE: CK-3

SHEET 1 OF 1

LOCATION: N 5441394.6 ;E 388852.8

DRILLING DATE: March 20, 2015

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular PO - Polished K - Slickensided SM - Smooth RO - Rough MB - Mechanical Break BR - Broken Rock <b>NOTE:</b> For additional abbreviations refer to list of abbreviations & symbols.																NOTES WATER LEVELS INSTRUMENTATION	
								RECOVERY								DISCONTINUITY DATA									
	TOTAL CORE %							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		
	80 60 40 20	80 60 40 20						80 60 40 20	80 60 40 20					5 15 25	0 30 60 90 120 150 180 210 240 270	0 30 60 90				10 10 10 10	10 10 10 10			2 4 6 8	
			Refer to Previous Page		326.5																				
	CME 55 NQ Coring	NW	GRANITIC GNEISS Medium to fine grained Black to pink to white Very strong Fresh		5.2	1	GREY 100														UCS=128 MPa				
6																									
						2	GREY 100																		
7			END OF DRILLHOLE		324.6																				
					7.1																				
8																									
9																									
10																									
11																									
12																									
13																									
14																									
15																									

DEPTH SCALE

1 : 50



LOGGED: RI

CHECKED: SEMP

SUD-RCK 1411523.GPJ GAL-MISS.GDT 030715 DATA INPUT:

PROJECT 1411523		<b>RECORD OF BOREHOLE No CK-4</b>				1 OF 1 <b>METRIC</b>											
G.W.P. 6332-14-00		LOCATION N 5441405.5; E 388843.9				ORIGINATED BY RI											
DIST _____ HWY 614		BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers				COMPILED BY AC											
DATUM GEODETIC		DATE March 24, 2015				CHECKED BY SEMP											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
330.4	GROUND SURFACE							20	40	60	80	100					
0.9	Topsoil (FILL) Gravelly silty sand (FILL) Very loose Dark brown Frozen* to wet		1A	AS	1*												
			1B	SS	3												
329.0																	
1.4	PEAT (Amorphous), trace sand, trace wood Very soft Black Wet		2	SS	1												
			3	SS	WH												
327.4																	
3.2	SILT, trace organics, trace sand Brown Wet		4A	SS	9												
	SAND, trace to some silt, trace gravel Very loose to loose Grey Wet		4B	SS													
			5	SS	3												
			6	SS	10												
324.8																	
5.6	Sandy SILT, trace to some clay Loose Grey Wet		7	SS	4												
			8	SS	8												
320.8			9A	SS	9												
9.6	SILT and SAND, trace to some gravel, trace to some clay (TILL) Very dense Grey Wet		9B														
			10	SS	96												
319.1																	
11.3	END OF BOREHOLE																
	Note:  1. Water level at a depth of 0.6 m below ground surface (Elev. 329.8 m) upon completion of drilling.																

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 22/06/15 DATA INPUT:





# **APPENDIX B**

## **Laboratory Test Results**



## PRELIMINARY FOUNDATION REPORT CHICKEN FARM LAKE CULVERT - SITE NO. 48E-127/C

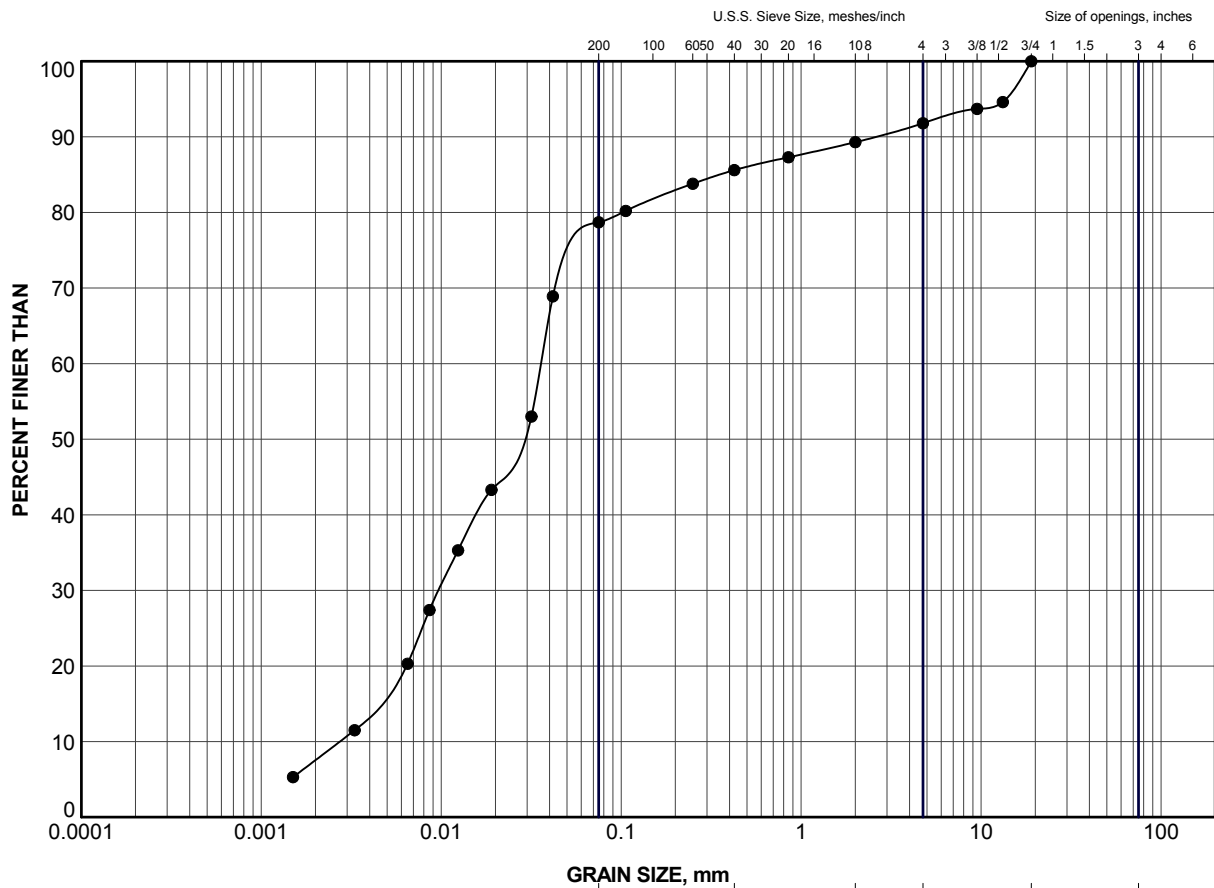
**Table B1: Summary of Analytical Testing of Chicken Farm Lake Stream Water Sample**

Parameter	Units	Result
Chloride (CL)	mg/L	56.8
Sulphate (SO4)	mg/L	1.97
Conductivity (EC)	µS/cm	433
Resistivity	µohm-cm	<0.33
pH	n/a	7.31

Notes:

1. Sample obtained on March 25, 2015.
2. Analytical testing carried out by ALS Canada Ltd.


Prepared by: AC  
Checked by: DAM  
Reviewed by: JMAC

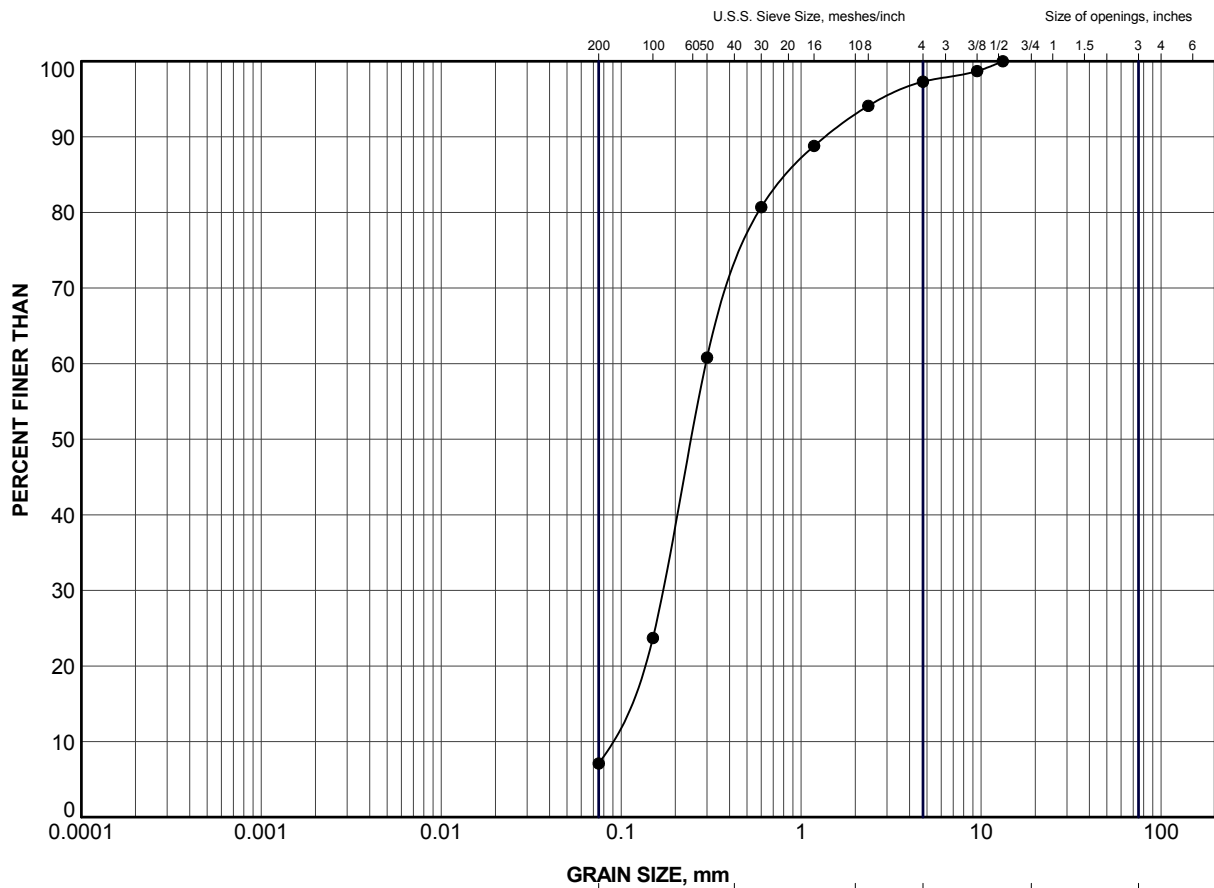


CLAY AND SILT	GRAIN SIZE, mm					Cobble Size
	fine		medium	coarse		
	SAND SIZE		GRAVEL SIZE			

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	CK-2	5B	327.5

PROJECT					
HIGHWAY 614 CHICKEN FARM LAKE CULVERT STA 16+934					
TITLE					
GRAIN SIZE DISTRIBUTION SILT					
PROJECT No. 1411523			FILE No. 1411523.GPJ		
DRAWN	TB	Jun 2015	SCALE	N/A	REV.
CHECK	DAM	Jun 2015			
APPR	JMAC	Jun 2015			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B1</b>		



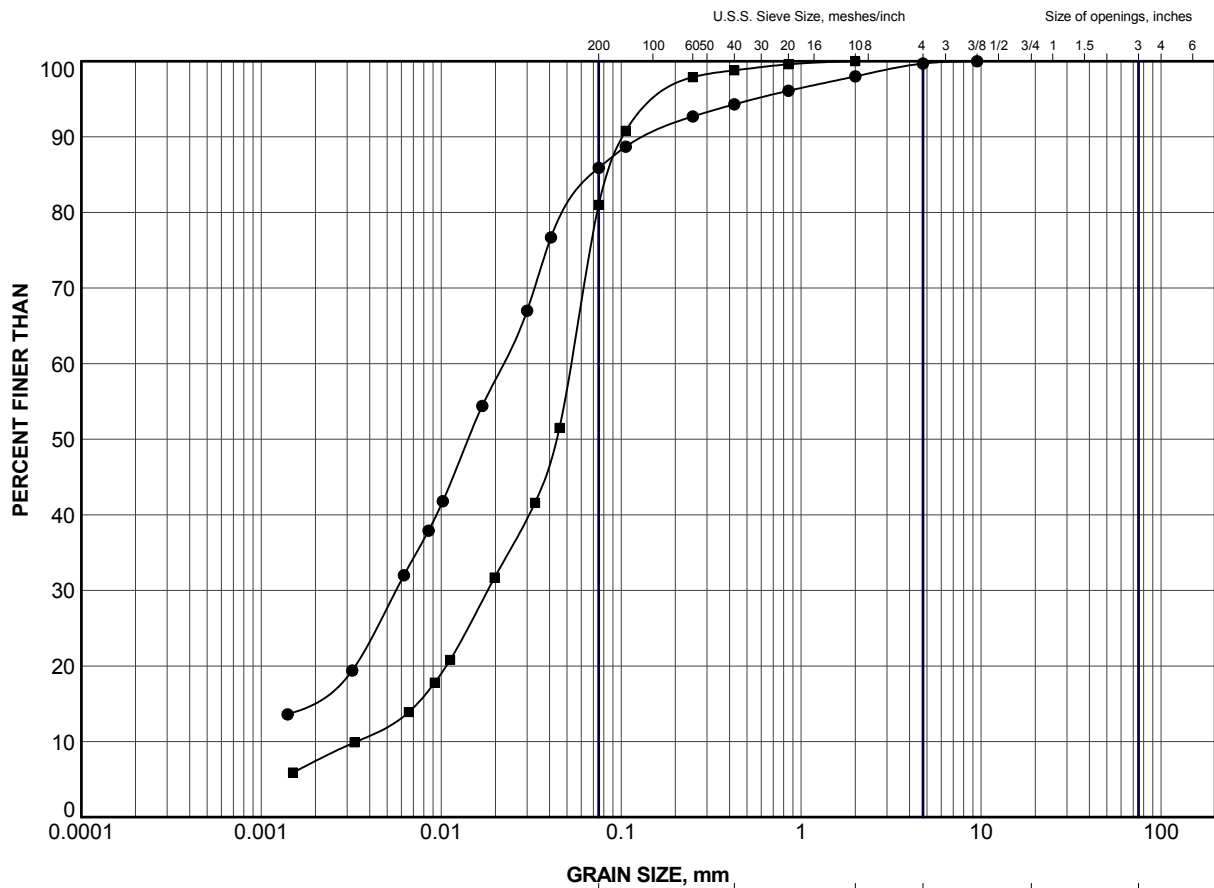
GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	CK-4	5	326.3

PROJECT					
HIGHWAY 614 CHICKEN FARM LAKE CULVERT STA 16+934					
TITLE					
GRAIN SIZE DISTRIBUTION SAND					
PROJECT No.		1411523		FILE No. 1411523.GPJ	
DRAWN	TB	Jun 2015	SCALE	N/A	REV.
CHECK	DAM	Jun 2015	<b>FIGURE B2</b>		
APPR	JMAC	Jun 2015			




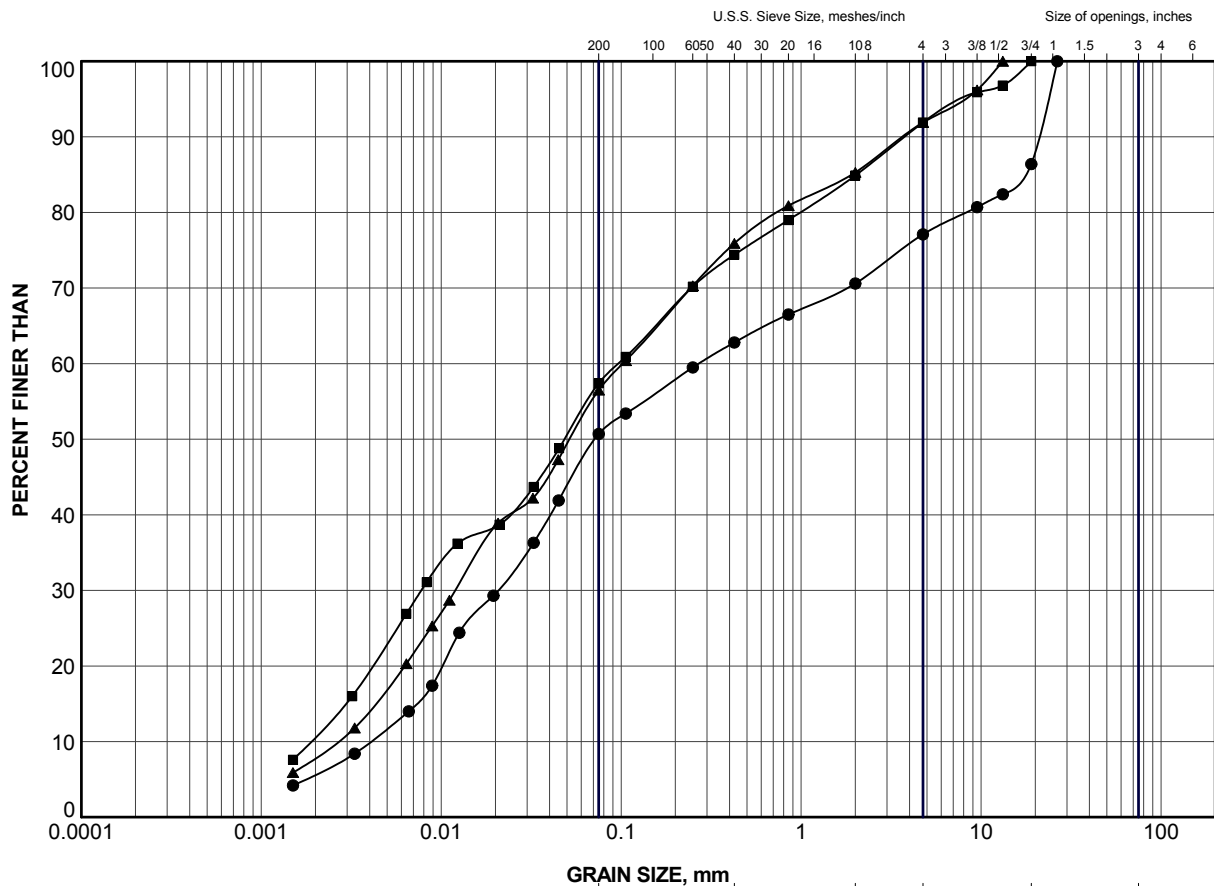


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	CK-3	5	327.6
■	CK-4	7	324.0


PROJECT					
HIGHWAY 614 CHICKEN FARM LAKE CULVERT STA 16+934					
TITLE					
GRAIN SIZE DISTRIBUTION SILT to SANDY SILT					
PROJECT No. 1411523			FILE No. 1411523.GPJ		
DRAWN	TB	Jun 2015	SCALE	N/A	REV.
CHECK	DAM	Jun 2015			
APPR	JMAC	Jun 2015			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B3</b>		



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

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	CK-1	3B	327.8
■	CK-2	7	326.1
▲	CK-4	10	319.4

PROJECT					
HIGHWAY 614 CHICKEN FARM LAKE CULVERT STA 16+934					
TITLE					
GRAIN SIZE DISTRIBUTION SILT and SAND to GRAVELLY SANDY SILT (TILL)					
PROJECT No.		1411523		FILE No. 1411523.GPJ	
DRAWN	TB	Jun 2015	SCALE	N/A	REV.
CHECK	DAM	Jun 2015			
APPR	JMAC	Jun 2015			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B4</b>		



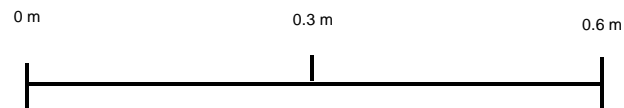
Borehole CK-1  
Elevation 327.3 m to 324.4 m




Borehole CK-2  
Elevation 324.3 m to 322.6 m



Borehole CK-3  
Elevation 326.5 m to 324.6 m



PROJECT		HIGHWAY 614 CHICKEN FARM LAKE CULVERT STA 16+934				
TITLE		BEDROCK CORE PHOTOGRAPHS				
	PROJECT No.		1411523		FILE No.	----
	DESIGN	AC	June, 2015		SCALE	AS SHOWN   REV.
	CADD	--			FIGURE B5	
	CHECK	DAM	June, 2015			
	REVIEW	JMAC	June, 2015			

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For more information, visit [golder.com](http://golder.com)

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.**  
**33 Mackenzie Street, Suite 100**  
**Sudbury, Ontario, P3C 4Y1**  
**Canada**  
**T: +1 (705) 524 6861**

