THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION AND DESIGN REPORT
CHICKEN FARM LAKE CULVERT REPLACEMENT
TOWNSHIP OF LESLIE, THUNDER BAY DISTRICT, ONTARIO
SITE No. 48E-127/C
HIGHWAY 614

G.W.P. No. 6332-14-00, W.P. No. 6332-14-01

GEOCRES Number: 42F-39

Report

to

HATCH

Date: December 20, 2016
File: 13662

103, 2010 Winston Park Drive, Oakville, ON L6H 5R7 T: 905 829 8666 F: 905 829 1166
thurber.ca

THURBER

TABLE OF CONTENTS

PART 1: FACTUAL INFORMATION

1. INTRODUCTION 1
2. SITE DESCRIPTION 2
3. INVESTIGATION PROCEDURES 2
4. LABORATORY TESTING 4
5. DESCRIPTION OF SUBSURFACE CONDITIONS 4
   5.1 Asphalt 5
   5.2 Sand and Gravel (Embankment Fill) 5
   5.3 Peat and Organic Silt 6
   5.4 Silty Sand to Sand 6
   5.5 Sand and Silt to Sand Till 7
   5.6 Bedrock 8
   5.7 Groundwater Conditions 8
6. CORROSIVITY AND SULPHATE TEST RESULTS 9
7. MISCELLANEOUS 10

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL 11
9. CULVERT DESIGN 12
   9.1 Summary of Subsurface Conditions 13
   9.2 Foundation Design for Concrete Box Culvert 13
      9.2.1 Geotechnical Resistance and Reaction 13
      9.2.2 Bedding Material 14
      9.2.3 Frost Penetration 15
      9.2.4 Subgrade Preparation 15
      9.2.5 Settlement 16
   9.3 Construction Considerations 16
10. EXCAVATION AND GROUNDWATER CONTROL 17
11. STREAM DIVERSION PIPE 17
12. CULVERT BACKFILL AND LATERAL EARTH PRESSURES 18
13. SEISMIC CONSIDERATIONS 19
14. TEMPORARY PROTECTION SYSTEM 20
15. EMBANKMENT RESTORATION 21
16. SCOUR AND EROSION PROTECTION 21

17. CORROSION AND SULPHATE ATTACK POTENTIAL 22
18. CONSTRUCTION CONCERNS 22
19. CLOSURE 23

APPENDICES

Appendix A	Record of Borehole Sheets
Appendix B	Geotechnical and Analytical Laboratory Test Results
Appendix C	Selected Site Photographs
Appendix D	Borehole Locations and Soil Strata Drawing
Appendix E	Record of Borehole Sheets and Borehole Location and Soil Strata Drawing from Preliminary Foundation Investigation and Design Report prepared by Golder Associates Ltd, dated September 8, 2015, Geocres No 42F-33
Appendix F	List of Specifications and Suggested Wording for NSSP

THURBER

FOUNDATION INVESTIGATION AND DESIGN REPORT
CHICKEN FARM LAKE CULVERT REPLACEMENT
TOWNSHIP OF LESLIE, THUNDER BAY DISTRICT, ONTARIO
SITE No. 48E-127/C
HIGHWAY 614

G.W.P. No. 6332-14-00, W.P. No. 6332-14-01

GEOCRES Number: 42F-39

PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed replacement of the Chicken Farm Lake Culvert on Highway 614, located in the Township of Leslie, Thunder Bay District, Ontario.

The purpose of this investigation was to explore the subsurface conditions in the culvert area to supplement the existing information obtained during the preliminary design of the project and, based on the data obtained, to provide a borehole location plan, stratigraphic profile, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by Hatch to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Agreement Number 6015-E-0018-004.

A preliminary foundation investigation carried out at this site was documented in the report titled “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”, Geocres No. 42F-33, prepared by Golder Associates (Golder), dated September 8, 2015. Reference should be made to that report for a written description of the subsurface conditions, borehole location plan, stratigraphic profile, record of borehole sheets and laboratory test results obtained during the preliminary stage of the design. It should be noted that Golder is solely responsible for the subsurface information provided in the Preliminary Foundation Report. The Record of Borehole sheets and Borehole Locations and Soil Strata drawing from the Golder’s report have been enclosed in Appendix E of this report for reference, and the subsurface information presented in that report was incorporated in the current report, as appropriate.

2. SITE DESCRIPTION

The Chicken Farm Lake Culvert site is located on Highway 614, in the Township of Leslie approximately 2.1 km south of the end of Highway 614, and approximately 50 km north of the junction of Highway 17 and Highway 614, in the Thunder Bay District, Ontario. The key plan showing the general location of the culvert site is presented on the Borehole Location and Soil Strata drawing in Appendix D.

Highway 614 runs in the general north-south direction with the culvert perpendicular to the centreline of the highway. Chicken Farm Lake is situated on the east side of the highway and drains to the stream flowing to the west through the culvert.

The terrain in the culvert area is gently undulating and forested outside of the right-of-way. The right-of-way is well vegetated with tall grass and occasional shrubs. The existing culvert is a twin cell (1.3 m span each) timber box approximately 18 m in length constructed prior to 1965. The Structural Design Report (SDR) prepared in December 2015 by Hatch refers to the evidence of deterioration of the culvert including decayed and splitting timber, as well as fair to poor culvert conditions at the inlet and outlet. The existing culvert invert was indicated at approximate Elev. 329.7 at the inlet and Elev. 329.6 at the outlet. The stream water level was reported to be at Elev. 330.2 on November 8, 2014.

At the culvert location, the highway embankment grade is at approximately Elev. 331.7. The depth of cover over the existing culvert is approximately 0.8 m.

Photographs in Appendix C show the general nature of the site and the existing culvert.

Based on published geological information, the culvert lies within an area of glaciolacustrine plain deposits comprising of sands and silts and interlayered with areas of organic/peat deposits and bedrock knobs. The bedrock at the site consists of granitic gneiss.

3. INVESTIGATION PROCEDURES

The field investigation and testing program for this project was specified in the Terms of Reference. The field work was carried out between July 26 and 27, 2016, and consisted of drilling and sampling of four (4) boreholes, designated as Boreholes 16-11 to 16-14. Borehole 16-11 was located near a proposed stream diversion pipe, approximately 10 m to the north from the existing culvert centreline, and Boreholes 16-12 to 16-14 were located on the south side of the culvert and distributed at 10 m intervals to determine the existence and extent of any frost taper near the

culvert. All boreholes were advanced from the top of the highway embankment.

Utility clearances were obtained prior to the start of drilling. The coordinates and ground surface elevations for the boreholes were derived from topographic plans provided to Thurber by Hatch. The coordinate system MTM NAD 83, Zone 14 was used for the boreholes. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawing included in Appendix D.

A track-mounted CME 55 drill rig was used to advance Borehole 16-11 using hollow stem augers, and solid stem augers were used to advance Boreholes 16-12 to 16-14.

Borehole 16-11 was advanced to a depth of 14.3 m, and Boreholes 16-12 to 16-14 were terminated at depths ranging from 1.2 m to 1.7 m following refusal on probable bedrock. In the boreholes, soil samples were obtained at selected intervals with a 50 mm outside diameter split spoon sampler driven in conjunction with the Standard Penetration Test (SPT) procedures as per ASTM D1586. The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes throughout the drilling operations, and boreholes were backfilled on completion of drilling in general accordance with Ontario Regulation 903, as amended. Completion details of the boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Completion Details
16-11	14.3 / 317.4	Bentonite holeplug and cuttings to 14.2 m then asphalt cold patch to ground surface.
16-12	1.7 / 330.0	Cuttings to 1.6 m then asphalt cold patch to ground surface.
16-13	1.7 / 330.0	Cuttings to 1.6 m then asphalt cold patch to ground surface.
16-14	1.2 / 330.5	Cuttings to 1.6 m then asphalt cold patch to ground surface.

4. LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and/or hydrometer). The results of the laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and on the figures included in Appendix B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, a sample of the existing fill near the invert level, and a sample of the surface water from the creek upstream of the existing culvert were collected. The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the "Borehole Locations and Soil Strata" drawing included in Appendix D. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It must be recognized and expected that soil conditions may vary between and beyond the borehole locations.

The description of the subsurface conditions in the immediate vicinity of the existing culvert were documented in the Preliminary Foundation Investigation and Design Report prepared by Golder Associates, Geocres No 42F-33, and reference should be made to that report to obtain details of the subsurface conditions. The Record of Borehole sheets numbered CK-1 to CK-4 and Borehole Locations and Soil Strata drawing excerpted from that report are enclosed in Appendix E, for quick reference.

The descriptions provided below refer to boreholes drilled during current investigation as well as the previous/preliminary investigation, as appropriate.

In general, the subsurface conditions encountered in the boreholes from the current and previous

investigations consisted of embankment fill overlying native cohesionless deposit comprising various proportions of silt, sand and gravel. Peat and organic silt were encountered beneath embankment fill and outside of the embankment. Granitic gneiss bedrock was encountered at various depths underlying the overburden in three of the Golder boreholes. The bedrock surface appears to slope down to the northwest in the general area of the culvert.

Descriptions of the individual strata are presented below.

5.1 Asphalt

Boreholes 16-11 to 16-14 were drilled through the existing asphalt pavement on Highway 614. The asphalt thickness of 100 mm was measured in the current boreholes; however, the asphalt thickness of 65 mm and 75 mm was encountered in two boreholes drilled during preliminary investigation. The thickness of asphalt may vary along the highway.

5.2 Sand and Gravel (Embankment Fill)

Underlying the asphalt in all current boreholes was a layer of granular fill. The classification of fill ranged from sand and gravel to silty sand. The fill was 3.7 m thick in Borehole 16-11 located to the north of the culvert with the base of the fill at 3.8 m depth (Elev. 327.9). The relative density of the fill was loose to dense with the SPT-N values recorded between 7 and 30 blows per 0.3 m of penetration.

In Boreholes 16-12 to 16-14 located to the south of the culvert, for investigation of existing frost taper, the granular fill under the pavement ranged in thickness from 1.1 m to 1.6 m. These boreholes were terminated upon meeting refusal on probable bedrock at Elev. 330.0 to Elev. 330.5. In Borehole 16-12, a 200 mm layer of gravel and rock fragments was encountered beneath the granular fill.

The measured moisture content of the fill generally ranged from 2% to 10%. The results of grain size analyses conducted on samples of the fill are presented on the Record of Borehole sheets included in Appendix A, and on Figures B1 and B2 in Appendix B.

The results are summarized in the following table:

Soil Particle	Percentage (%)	
	Sand and Gravel	Sand/Silty Sand
Gravel	45 to 51	16 to 17
Sand	41 to 47	60 to 64
Silt and Clay	8	20 to 23

The fill encountered in the previously drilled boreholes located in the area of the existing culvert was classified as gravelly silty sand to gravelly sand and ranged generally in thickness from 0.4 m to 3.6 m. Cobbles were encountered in the fill during drilling. The base of fill from the top of the embankment in Boreholes CK-2 and CK-3 was measured at 3.7 m depth or Elev. 328.0. Boreholes CK-1 and CK-4 drilled on the east and west sides of the embankment encountered fill extending to 0.8 m and 1.4 m depth or to Elev. 329.8 and Elev. 329.0, respectively, overlying fibrous to amorphous peat. The fill was noted to be very loose to compact.

5.3 Peat and Organic Silt

A layer of fibrous to amorphous peat with trace sand and trace wood was encountered beneath the fill materials in the previously drilled boreholes located outside of the embankment. The peat thickness ranged from 1.6 m to 1.8 m in Boreholes CK-1 and CK-4, and extended to depths of 2.6 m (Elev. 328.0) and 3.0 m (Elev. 327.4), respectively. Moisture contents of 333% to 531% were measured in the peat.

A 400 mm layer of organic silt was encountered in Borehole CK-2 beneath the granular fill with the base at a depth of 4.1 m (Elev. 327.6).

5.4 Silty Sand to Sand

A deposit of grey silty sand was encountered underlying the fill in Borehole 16-11. The silty sand contained some gravel, and trace of organic matter (wood fragments). The silty sand graded to sand at 6.1 m depth. The base of the deposit was encountered at a depth of 6.4 m or at Elev. 325.3. The deposit was compact, as indicated by SPT ‘N’ values of 11 and 12 blows per 0.3 m of penetration. A moisture content of 18% and 22% were measured on samples of the sand and silty sand.

The results of grain size analysis conducted on a sample of sand are presented on the Record of Borehole sheet included in Appendix A and on Figure B3 in Appendix B.

The results are summarized in the following table:

Soil Particle	Percentage (%)
Gravel	2
Sand	93
Silt and Clay	5

The cohesionless deposit classified as sand and silt to sandy silt was identified in the previously drilled boreholes. The deposit was grey in colour, very loose to compact and varied in thickness from 0.4 m to 6.6 m. The base of the deposit was encountered between Elev. 327.2 and Elev. 320.8.

5.5 Sand and Silt to Sand Till

A deposit of till was encountered below the sand layer in Borehole 16-11. The upper 4.3 m of the deposit extending to 10.7 m depth (Elev. 321.0) was classified as sand and silt with trace gravel and some clay, and below that depth, the deposit became coarser and graded to becoming predominantly a sand till. The borehole was terminated in the sand till at a depth of 14.3 m (Elev. 317.4).

SPT 'N' values within the sand and silt till of 2 and 8 blows per 0.3 m penetration were recorded, indicating a very loose to loose relative density. The sand till was typically very dense with the SPT-N values generally above 85 blows per 0.3 m of penetration. The measured moisture content of the sand and silt till ranged from 18% to 22%, and moisture content in the sand till ranged from 2% to 12%.

The results of grain size distribution analyses conducted on a sample of the sand and silt till and sand till are presented on the Record of Borehole sheet included in Appendix A and on Figures B4 and B5 in Appendix B. The results are summarized in the following table:

Soil Particle	Percentage (%)	
	Sand and Silt Till	Sand Till
Gravel	0	1
Sand	43	89
Silt	44	-
Clay	13	-
Silt and Clay		10

The till deposit classified as sand and silt to gravelly sandy silt was encountered in the three boreholes drilled during the preliminary investigation. The deposit varied in thickness between 0.7 m and 2.9 m, extending to bedrock surface at Elev. 327.3 and Elev. 324.3 in Boreholes CK-1 and CK-2. Borehole CK-4 was terminated in the till deposit at 11.3 m depth (Elev. 319.1).

Cobbles and boulders should be expected in the till deposits.

5.6 Bedrock

Boreholes 16-12 to 16-14 encountered refusal to further auger penetration on probable bedrock.

Boreholes CK-1 to CK-3 drilled for preliminary investigation encountered bedrock, which was cored for 1.7 m to 2.9 m length. The bedrock was described as a black to white to pink, fine to coarse grained, granitic gneiss. The depth to bedrock surface and bedrock elevation are summarized in the table below; for more details including bedrock properties, reference should be made to Geocres Report 42F-33.

Table 5.1 Bedrock Surface Depths and Elevations at Borehole Locations

Borehole Number	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)
16-12*)	1.7	330.0
16-13*)	1.7	330.0
16-14*)	1.2	330.5
CK-1	3.3	327.3
CK-2	7.4	324.3
CK-3	5.2	326.5

Note: *) Probable bedrock as inferred from refusal to further auger penetration.

Based on the borehole information, the bedrock surface seems to slope down towards northwest in the general area of the culvert.

5.7 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. The groundwater level in the open Borehole 16-11 was measured at 1.2 m depth below the ground surface or at Elev. 330.5. Boreholes 16-12 to 16-14 were dry upon completion of drilling.

The groundwater level should be assumed to reflect the stream water level, and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant or prolonged precipitation.

The measurements of water level in the stream documented in various sources are summarized in Table 5.2, below.

Table 5.2 Water Level in the Stream

Date	Water Level Elevation (m)	Comments/Reference
March 18, 2015	330.4	Geocres No. 42F-33 Report
November 8, 2014	330.21	Preliminary General Arrangement drawing
	330.73	High water level - Preliminary General Arrangement drawing

6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the existing fill near the invert level from Borehole 16-11, and a sample of the surface water from the creek were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	Units (Water)	Test Results	
			16-11, SS#3, 7'6"-9'6" (Sand and Gravel Fill)	Chicken Farm Creek (Creek Water)
Sulphide	%	mg/L	<0.02	<0.006
Chloride	µg/g	mg/L	110	51
Sulphate	µg/g	mg/L	29	0.22
pH	No unit	No unit	7.84 to 8.91	7.47
Electrical Conductivity	µS/cm	µS/cm	358	371
Resistivity	Ohms.cm	Ohms.cm	2790	270
Redox Potential	mV	mV	217	280

THURBER

7. MISCELLANEOUS

Thurber obtained the borehole northing and easting coordinates and ground surface elevations from measurements taken in the field and relative to the topographic plans provided by Hatch.

RPM Drilling Inc. of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full time basis by Mr. George Azzopardi of Thurber. Overall supervision of the field program was provided by Mr. Mark Farrant, P.Eng. of Thurber.

Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory. Analytical laboratory testing was carried out by SGS Canada Inc. Interpretation of the field data and preparation of this report was carried out by Ms. Anna Piascik, P.Eng and Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Anna Piascik, P.Eng.
Senior Geotechnical Engineer

Mark Farrant, P.Eng.
Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

THURBER

FOUNDATION INVESTIGATION AND DESIGN REPORT
CHICKEN FARM LAKE CULVERT REPLACEMENT
TOWNSHIP OF LESLIE, THUNDER BAY DISTRICT, ONTARIO
SITE No. 48E-127/C
HIGHWAY 614

G.W.P. No. 6332-14-00, W.P. No. 6332-14-01

GEOCRES Number: 42F-39

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This report provides an interpretation of the geotechnical data in the factual report, and presents foundation design recommendations for the design of the proposed Chicken Farm Lake Culvert replacement on Highway 614, located in the Township of Leslie, Thunder Bay District, Ontario.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction contractor. The contractor must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects, which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

Information on the existing culvert site was obtained from the MTO Terms of Reference, and the Structural Design Report (SDR) for the preliminary design of the project, titled “Chicken Farm Lake Timber Culvert, Site No. 48E-127C, Highway 614”, prepared by Hatch Mott MacDonald, dated December 2015. The Structural Design Report provided discussion on the existing structure, discussion of alternatives for the proposed culvert replacement, and recommendations for the preferred alternative.

The existing structure is an 18 m long twin cell timber culvert with a total span of 2.6 m (1.3 m each span), constructed prior to 1965. The SDR indicates the culvert upstream invert at approximate Elevation 329.7 m, and the downstream invert at Elevation 329.6. The culvert soffit

(upstream) is listed at Elevation 330.9. The finished road grade is indicated at Elev. 331.7, which results in approximately 0.8 m of fill above the culvert.

In the process of the preliminary design the following options for the replacement structure were considered:

Option 1 – Single precast Concrete Closed Box
Option 2 – Twin Cell Precast Concrete Closed Box Culvert
Option 3 – Precast Open Footing Metal Box Culvert
Option 4 – Multiple Round Corrugated Steel Pipe Culvert.

As described in the SDR, the preferred structure alternative is Option 2, which was indicated as the only one to satisfy most of the design criteria and resulted in favorable aquatic environment while minimizing disruption to the existing channel. The proposed structure will consist of a 19.2 m long, 2.4 m by 1.5 m twin cell precast concrete box culvert. The culvert is proposed to be constructed utilizing a traffic staging, which would require installation of a temporary roadway protection and a 1.2 m diameter temporary stream diversion pipe (CSP).

The Preliminary General Arrangement drawing was included in the SDR showing the proposed culvert and the temporary diversion pipe arrangement. The invert and alignment of the replacement culvert will remain the same as for the existing culvert.

As indicated in the SDR, the profile of the highway will remain unchanged and no wingwalls/headwalls will be required at this culvert.

The discussions and recommendations presented in this report are based on information provided by Hatch and on the factual data obtained during the course of the current investigation. In addition, the existing subsurface information collected during the preliminary investigation and documented in the Geocres Report No. 42F-33 has been reviewed and incorporated in this report, where appropriate. The subsurface information, including the Record of Borehole sheets and the Borehole Locations and Soil Strata drawings, from both the current and preliminary investigations should be included in the contract documents.

9. CULVERT DESIGN

This section presents discussions and recommendations on the foundation aspects of design of the preferred culvert replacement option. The replacement structure will consist of a 19.2 m long, 2.4 m by 1.5 m twin cell precast concrete box culvert.

9.1 Summary of Subsurface Conditions

In general, the subsurface conditions encountered in the boreholes from the current and preliminary investigations consisted of embankment fill overlying native cohesionless deposits comprising various proportions of silt, sand and gravel. Peat and organic silt were encountered beneath embankment fill and outside of the embankment. Granitic gneiss bedrock underlies the site.

The water level in the stream was measured at Elev. 330.2 on November 8, 2014.

9.2 Foundation Design for Concrete Box Culvert

9.2.1 Geotechnical Resistance and Reaction

The invert of the proposed culvert will be at Elev. 329.63 on the west side and at Elev. 329.66 on the east side of the culvert, and the underside of the culvert will be located at approximate Elev. 329.0.

Peat and organic silt were encountered in the boreholes drilled for the preliminary investigation. Any organic soils or other unsuitable materials should be removed / subexcavated from the founding subgrade in accordance with OPSS PROV 422, and the subexcavated area should be backfilled with granular material meeting OPSS PROV 1010 Granular A or Granular B Type II requirements, compacted as per OPSS.PROV 501. The preliminary investigation indicates that peat may have to be removed down to Elev. 327.2 and replaced with Granular A or Granular B Type II fill.

The replacement culvert should be placed on a 300 mm layer of granular bedding material.

The factored geotechnical resistance at the Ultimate Limit State (ULS) and the geotechnical reaction at Serviceability Limit State (SLS) for a twin cell box culvert of a total width of 5.3 m founded on bedding placed on well compacted granular fill material as described above can be assumed as follows:

- Factored Geotechnical Resistance at ULS of 200 kPa
- Geotechnical Resistance at SLS (up to 25 mm settlement) of 150 kPa.

The consequence factor of 1 was utilized in this design adopting the typical consequence level. The geotechnical resistance factor of 0.5 for bearing, and 0.8 for settlement, both

adopted for typical degree of understanding, were used to obtain the above values, as per CHBDC 2014, Sec. 6.9.

The ULS resistance and settlement are dependent on the footing/culvert size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the culvert width or founding elevation differs significantly from that given above.

The geotechnical resistances are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance used in design should be reduced in accordance with the CHBDC 2014, Clause 6.10.3 and Clause 6.10.4.

The box culvert should be designed to resist external loadings, including lateral earth pressure, hydrostatic pressure, weight of embankment fill, traffic loadings and surcharge due to construction equipment and activities.

Resistance to lateral forces/sliding between concrete and the underlying bedding material should be evaluated in accordance with the CHBDC assuming an ultimate/unfactored coefficient of friction of 0.5.

Water control, including stream water, groundwater and/or surface water will be required for excavation and construction of box culvert replacement, as discussed further in the report.

9.2.2 Bedding Material

A bedding material should be placed on the approved subgrade under the base of the box culvert, as per OPSD 803.010, as soon as practicable following its inspection and approval. The bedding material should consist of OPSS PROV 1010 Granular B Type II. The subgrade preparation must be carried out in the dry. The surface prepared to support the box units should have a 75 mm minimum thickness top levelling course consisting of uncompacted Granular A as per OPSS 422. Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction.

Alternatively, in light of anticipated difficulties with controlling the inflow of water into excavation at this site, consideration could be given to using clear stone as the backfill and bedding materials, which would not require compaction. A separation layer consisting of a non-woven geotextile should be placed above and below the clear stone bedding material to prevent migration of fines from the underlying subgrade soils and the overlying culvert backfill material. The geotextile should meet the specifications for OPSS 1860 Class II, and

have a fabric opening size (FOS) not greater than 212 micro millimetres. The top of the clear stone backfill should be compacted with vibratory compaction to mitigate differential settlement during construction. To facilitate compaction of the clear stone, the groundwater level should be maintained a minimum of 0.7 m below the culvert invert. Suggesting wording for an NSSP in this regard is included in Appendix F.

9.2.3 Frost Penetration

The depth of frost penetration at this site is approximately 2.4 m. The box structure composed of pre-cast segments is, in general, tolerant of small magnitudes of movement related to freeze-thaw cycles; therefore, founding the box culvert below the standard depth for frost penetration is not necessary.

Reference should be made to OPSD 803.010 for consideration for the frost treatment/taper for a box culvert. The frost taper investigation in Boreholes 16-12 to 16-14 indicated the presence of 1.1 to 1.6 m of Granular A or Granular B fill directly overlying probable bedrock to at least 30 m south of the existing culvert. It is not known whether the granular fill material was intentionally placed as a frost taper, or as road embankment fill and base material above the bedrock surface. Borehole 16-11 also included Granular A to B material to a depth of 3.8 m, extending at least 8 m north of the existing culvert.

With the exception of the peat noted in the boreholes drilled near the inlet and outlet of the culvert, frost susceptible soils were not encountered within the depth of frost penetration. As described in Section 9.2.1, the peat must be removed prior to construction of the replacement culvert, and therefore frost susceptible soils should not be present within the frost penetration depth below the culvert foundation, and frost heave is not anticipated to be a concern.

9.2.4 Subgrade Preparation

Performance of the replacement culvert will depend on the preparation of the subgrade. After the excavation reaches the design subgrade elevation, the exposed surface should be inspected to confirm that the subgrade is suitable and uniformly competent. Any remaining fill, topsoil, peat, stream bed deposits, disturbed soils and any deleterious materials within the replacement culvert footprint should be removed and replaced with granular fill.

In the event that subexcavation of peat or any unsuitable materials encountered at the founding level is required, the width of the subexcavation should be defined by a line extending from 0.3 m beyond the outside edge of the proposed culvert, outward and downward at 1H:1V. The subexcavated area should then be backfilled with granular material meeting OPSS.PROV 1010 Granular A or Granular B Type II, compacted as per OPSS/PROV 501. Alternatively, in light of anticipated difficulties with controlling the inflow of water into excavation at this site, consideration could be given to using clear stone as the backfill material, which would only require compaction at the surface of the clear stone.

The work should be carried out in accordance with OPSS 902 and culvert construction and subgrade preparation must be carried out in the dry.

To minimize disturbance of the prepared subgrade, a 100 mm thick concrete working slab could be placed on the subgrade if the bedding material and culvert are not placed within 4 hours from preparation. The concrete should have a minimum 28 day compressive strength of 20 MPa.

9.2.5 Settlement

It is anticipated that the replacement culvert will have approximately the same alignment with no embankment grade raise. However, the new twin cell box culvert will be somewhat wider than the existing and this will result in net unloading of the foundation soils. If all peat and organic silts are subexcavated from the culvert footprint and replaced with granular fill, very little post-construction settlement is anticipated.

9.3 Construction Considerations

As indicated in the Structural Design Report, one lane of traffic will have to be maintained, which requires staged construction.

In summary, staged construction sequencing will likely require the following:

- Diversion of the stream for construction, in addition to a suitable dewatering plan to construct the culvert in the dry.
- Temporary roadway protection at all stages of construction, including excavation and removal of the existing culvert and the diversion pipe and, installation of the new culvert.
- Culvert subgrade preparation and foundation preparation must be carried out in the dry, unless clear stone is intended to be used as backfill and bedding materials; which can be

placed in wet conditions without the need for compaction, except at the surface of the clear stone.

10. EXCAVATION AND GROUNDWATER CONTROL

All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the embankment fill and native sand at this site are classified as Type 3 soils above the water level and Type 4 soils below the water level.

Excavation and backfilling for culvert construction should be carried out in accordance with OPSS PROV 902. Excavations for culvert replacement will be carried out through the existing embankment fill and extended below the water level in the stream. Diversion of the stream flow and implementation of the effective dewatering system will be required.

The underlying sand subgrade is relatively permeable, and seepage should be anticipated from the embankment fill and the foundation soils. Depending on the time of construction, a combination of cofferdam enclosures and creek diversion along with pumping from filtered sumps within an enclosure will be required to maintain dry excavations during the course of staged construction. The groundwater level should be maintained at a depth of at least 0.5 m below the proposed excavation depths to allow for dry construction to take place.

The design of a dewatering system that may be required is the responsibility of the Contractor and the Contract Documents should alert him to this responsibility and the need to engage a dewatering specialist. Dewatering should remain operational and effective until the culvert is installed and backfilled. Suggesting wording for an NSSP in this regard is included in Appendix F.

11. STREAM DIVERSION PIPE

The Preliminary General Arrangement drawing indicates a 1200 mm diameter CSP stream diversion pipe located approximately 8.0 m to the north of the centreline of the new culvert. The invert of the diversion pipe is indicated at approximately Elev. 329.5, which corresponds to a compact sand and gravel fill.

The CSP should be placed on a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A or Granular B Type II requirements as per OPSD 802.010. The bedding material should be placed on the prepared subgrade as soon as practical, following its inspection and approval. The subgrade preparation should be carried out in the dry. The prepared subgrade should be protected from disturbance during construction.

12. CULVERT BACKFILL AND LATERAL EARTH PRESSURES

Backfill to the culvert should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of OPSS PROV 1010. Reference should be made to the backfill arrangements stipulated in OPSD 803.010. Backfilling for the culvert should be in accordance with OPSS 902 for a box culvert. All fills should be placed in regular lifts and be compacted in accordance with OPSS PROV 501. The backfill should be placed and compacted in simultaneous lifts on both sides of the culvert, and the top of backfill elevation should not differ more than 500 mm on both sides of the culvert at all times. Heavy compaction equipment should not be used adjacent to the walls and on the roof of the culvert. Compaction equipment to be used adjacent to the culvert should be restricted in accordance with OPSS PROV 501.

Lateral earth pressures acting on the culvert walls may be assumed to be a triangular distribution. For a fully drained backfill, the pressures should be computed in accordance with the CHBDC 2014, but are generally given by the expression:

$$p_h = K(\gamma h + q)$$

where
- p_h = horizontal pressure on the wall at depth h (kPa)
- K = earth pressure coefficient (see table below)
- γ = bulk unit weight of retained soil (see table below)
- h = depth below top of fill where pressure is computed (m)
- q = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the culvert walls are dependent on the material used as backfill. Recommended unfactored values are shown in Table 12.1 below.

Table 12.1 – Lateral Earth Pressure Coefficients (K)

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35°$; $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I (modified) $\phi = 32°$; $\gamma = 21.2$ kN/m^3		Existing Fill $\phi = 30°$; $\gamma = 20$ kN/m^3	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.40	0.31	0.48	0.33	0.54
At-rest (Restrained Wall)	0.43	0.62	0.47	0.70	0.50	0.76
Passive	3.7	-	3.3	-	3.0	-

Note: Submerged unit weight should be used below the groundwater level/high stream level.

For rigid structures such as concrete box culverts, at-rest horizontal earth pressures should be used for design. Active pressures should be used for any unrestrained wall.

The use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the culvert.

In accordance with Clause 6.12.3 of the CHBDC 2014, a compaction surcharge should be added. The magnitude of the surcharge should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 1.7 m for Granular B Type I, or at a depth of 2.0 m for Granular A or B Type II.

13. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2014, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy, which consists of loose to compact cohesionless deposits overlying very dense silt and sand till and bedrock.

The seismic site classification for this is site is based on the N_{60} criteria. The harmonic mean of the typical N_{60} values provided above is 18 blows, which corresponds to a Seismic Site Class D in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2% in 50 year probability of exceedance at this site is 0.034 g as per the National Building Code of Canada (NBCC).

In accordance with Clause 4.6.5 of the CHBDC 2014, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of

earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 13.1 may be used:

Table 13.1 – Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)		
	OPSS Granular A or Granular B Type II $\phi = 35°, \gamma = 22.8$ kN/m^3	OPSS Granular B Type I (modified) $\phi = 32°, \gamma = 21.2$ kN/m^3	Existing Fill $\phi = 30°, \gamma = 20$ kN/m^3
Active (K_{AE})*	0.29	0.32	0.35
Passive (K_{PE})	3.6	3.2	2.9
At Rest (K_{OE})**	0.49	0.53	0.56

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.
** After Woods

Although the site is underlain by loose to compact cohesionless deposits, in view of the low potential for seismic activity in the area, liquefaction is not considered to be a concern at this site.

14. TEMPORARY PROTECTION SYSTEM

Temporary roadway protection system should be implemented in accordance with OPSS PROV 539 and designed for Performance Level 2.

Options for roadway protection are a soldier pile-lagging system or interlocking sheet piles. Sloping bedrock was encountered within the new culvert footprint. The bedrock surface was at depths of 5.2 m and 7.4 m in the boreholes located near the south and north boundaries of the culvert footprint.

The soil parameters in Table 14.1 may apply for design of the temporary roadway protection system with horizontal backfill.

Table 14.1 –Soil Parameters for Temporary Protection System Design

Soil Parameter	Existing Fill	Native Sand
γ	21 kN/m^3	21 kN/m^3
γ_w	10 kN/m^3	10 kN/m^3
K_a	0.33	0.33
K_p	3.0	3.0

Full hydrostatic pressure should be considered assuming a water level at least equal to the design stream water level.

The design of temporary protection system is the responsibility of the Contractor. The actual pressure distribution acting on the protection/shoring system is a function of the construction sequence and the relative flexibility of the wall, and these factors have to be considered when designing the shoring system. All protection systems should be designed by a Professional Engineer experienced in such designs, who will determine an appropriate support system.

15. EMBANKMENT RESTORATION

The existing Highway 614 embankment is approximately 3 m in height at the culvert location and the embankment slopes appear to be performing satisfactorily. Provided that the embankment is reconstructed at the same slope inclination as the existing embankment, but not steeper than 2H:1V, the restored embankment slope should remain stable.

It is anticipated that there will be no grade raise at this site for the culvert replacement, and therefore settlement of the embankment is not a concern. Presence of peat was noted in the boreholes located on both sides of the highway embankment, which may also be present under the existing embankment footprint. The peat, if present, must be subexcavated and replaced with Granular B Type II material. Provided all peat and soft soils are removed from the culvert footprint, any settlement due to changes in the culvert configuration is expected to be less than 25 mm. Any settlement in the granular foundation soils should be completed by the end of construction.

Embankment restoration after completion of the culvert replacement should be carried out in accordance with OPSS PROV 206 and OPSS PROV 209. The embankment material may consist of imported Granular A or B Type II material.

In general, surface vegetation, peat, topsoil, organic deposits, disturbed material or otherwise loose/soft soils should be stripped from the areas around the culvert inlets and outlets, and within the embankment footprints. Inspection and approval of the foundation surfaces by qualified geotechnical personnel should be conducted.

16. SCOUR AND EROSION PROTECTION

Erosion protection should be provided at the culvert inlet and outlet. Design of the erosion protection measures should consider hydrologic and hydraulic factors and should be carried out

by specialists experienced in this field and in accordance with OPSD 810.010, OPSS 511 and OPSS PROV 1004.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS PROV 804.

A vertical concrete cut-off wall should be used to minimize the potential for erosion or piping around the culvert. Alternatively, a clay seal or equivalent geosynthetic clay liner could be considered for this application. The clay seal or liner should extend to approximately 0.3 m above the high water level and laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The material requirements for the clay seal or liner should be in accordance with OPSS PROV 1205, and consist of a Bentofix Thermal Lock Geosynthetic Clay Liner or equivalent.

17. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the sand and gravel fill near the invert level and the creek water indicates the following conditions at the locations tested:

- The potential for corrosion or sulphate attack on concrete foundations from the soil or surface water is considered to be negligible due to the low concentration of sulphate and chloride in the samples tested.

- The potential for soil or surface water corrosion on metal is considered to be mild to moderate.

- Appropriate protection measures are recommended if metal structural elements are used.

18. CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

- A suitable dewatering / unwatering system must be employed to enable culvert construction in the dry and prevent base boiling, sloughing and instability of the excavation walls.

THURBER

- The water level in the stream may fluctuate and be at higher elevation at the time of construction than indicated in the report.
- Cobbles or other buried obstructions may be encountered during excavation in the existing embankment fill. Furthermore, probable bedrock was encountered at shallow depth on the south side of the culvert. The presence of obstructions or shallow bedrock may interfere with installation of the temporary roadway protection system. Suggested wording for an NSSP on obstructions is included in Appendix F.
- The Contractor's selection of construction equipment and methodology should include assessment of the capability of the existing embankment to support the proposed construction equipment and any temporary structures or fill (i.e., as a pad for crane support). Site conditions may limit the type of equipment suitable for use during construction. The design and safety of any temporary works is the responsibility of the Contractor.

19. CLOSURE

Engineering analysis and preparation of this report was carried out by Ms. Anna Piascik, P.Eng. and Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Anna Piascik, P.Eng.
Senior Geotechnical Engineer

Mark Farrant, P.Eng.
Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT[(1)] 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample		TP Thin Wall Piston Sample
	PH Sampler Advanced by Hydraulic Pressure		PM Sampler Advanced by Manual Pressure
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

EXPLANATION OF ROCK LOGGING TERMS

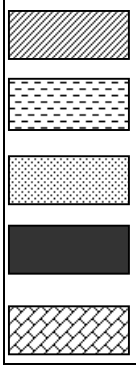
ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.

DISCONTINUITY SPACING

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

SYMBOLS



CLAYSTONE

SILTSTONE

SANDSTONE

COAL

BEDROCK

STRENGTH CLASSIFICATION

Rock Strength	**Approximate Uniaxial Compressive Strength (MPa)**	**(psi)**	**Field Estimation of Hardness***
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length
Solid Core Recovery:(SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run
Rock Quality Designation:(RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a % of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index:(FI)	Frequency of natural fractures per 0.3m of core run.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-11 1 OF 2 METRIC

W.P. 6332-14-01 LOCATION Chicken Farm Lake Culvert N 5 441 407.3 E 388 856.3 ORIGINATED BY OA

HWY 614 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.07.26 - 2016.07.27 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
331.7	GROUND SURFACE										
0.0	**ASPHALT:** (100mm)										
0.1	**SAND** and **GRAVEL**, trace silt Compact Grey to Brown Moist (FILL)		1	GS					○		
			1	SS	23	▽	331		○		
			2	SS	30		330		○		45 47 8 (SI+CL)
			3	SS	17		329		○		
			4	SS	7		328		○		
327.9											
3.8	Silty **SAND**, some gravel, trace organics (wood fragments) Compact Grey Wet		5	SS	11		327		○		
325.6							326				
6.1	**SAND**, trace gravel, trace silt Compact Grey Wet		6	SS	12		325		○ ○		2 93 5 (SI+CL)
325.3											
6.4	**SAND** and **SILT**, trace gravel, some clay Very Loose to Loose Grey Moist to Wet (TILL)		7	SS	2		324		○ ○		0 43 44 13
			8	SS	8		323		○		
							322				

Continued Next Page

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-11 2 OF 2 METRIC

W.P. 6332-14-01 LOCATION Chicken Farm Lake Culvert N 5 441 407.3 E 388 856.3 ORIGINATED BY OA

HWY 614 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.07.26 - 2016.07.27 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
321.0											
10.7	**SAND**, trace to some gravel, some silt Very Dense Grey Moist (TILL)		9	SS	85/ 0.225		321		○		1 89 10 (SI+CL)
			10	SS	85		320		○		
							319				
			11	SS	50/ 0.125		318		○		
317.4											
14.3	END OF BOREHOLE AT 14.3m. WATER LEVEL AT 1.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS, ASPHALT COLD PATCH AT SURFACE.										

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

$\overset{20}{15\oplus 5}$ $\underset{10}{}$ (%) STRAIN AT FAILURE

ONTMT4S 13662-MTO.GPJ 2015TEMPLATE(MTO).GDT 8/23/16

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-12 1 OF 1 METRIC

W.P. 6332-14-01 LOCATION Chicken Farm Lake Culvert N 5 441 386.0 E 388 850.8 ORIGINATED BY OA

HWY 614 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.07.26 - 2016.07.26 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
331.7	GROUND SURFACE										
0.0	**ASPHALT:** (100mm)										
0.1	**SAND**, some gravel, some silt Compact Grey Moist (FILL)		1	GS			331		○		16 64 20 (SI+CL)
330.2			2	GS					○		
330.0	Rock fragments, some gravel		1	SS	50/				○		
1.7	**(PROBABLY BEDROCK)** Grey Wet				0.125						
	END OF BOREHOLE AT 1.7m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH CUTTINGS, ASPHALT COLD PATCH AT SURFACE.										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-13 1 OF 1 METRIC

W.P. 6332-14-01 LOCATION Chicken Farm Lake Culvert N 5 441 376.3 E 388 848.3 ORIGINATED BY OA

HWY 614 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.07.26 - 2016.07.26 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
331.7	GROUND SURFACE										
0.0	**ASPHALT:** (100mm)										
0.1	**SAND** and **GRAVEL**, trace silt Compact to Very Dense Grey Moist (FILL)		1	GS			331		○		
			2	GS					○		51 41 8 (SI+CL)
330.0			1	SS	50/				○		
1.7	END OF BOREHOLE AT 1.7m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH CUTTINGS, ASPHALT COLD PATCH TO SURFACE.				0.150						

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

ONTMT4S 13662-MTO.GPJ 2015TEMPLATE(MTO).GDT 8/23/16

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-14 1 OF 1 METRIC

W.P. 6332-14-01 LOCATION Chicken Farm Lake Culvert N 5 441 366.6 E 388 845.8 ORIGINATED BY OA

HWY 614 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.07.26 - 2016.07.26 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100) ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
331.7	GROUND SURFACE										
0.0	**ASPHALT:** (100mm)										
0.1	**SAND** to Silty **SAND**, some gravel Grey Moist (FILL)		1	GS			331		○		17 60 23 (SI+CL)
330.5											
1.2	END OF BOREHOLE AT 1.2m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH CUTTINGS, ASPHALT COLD PATCH AT SURFACE.										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

Appendix B

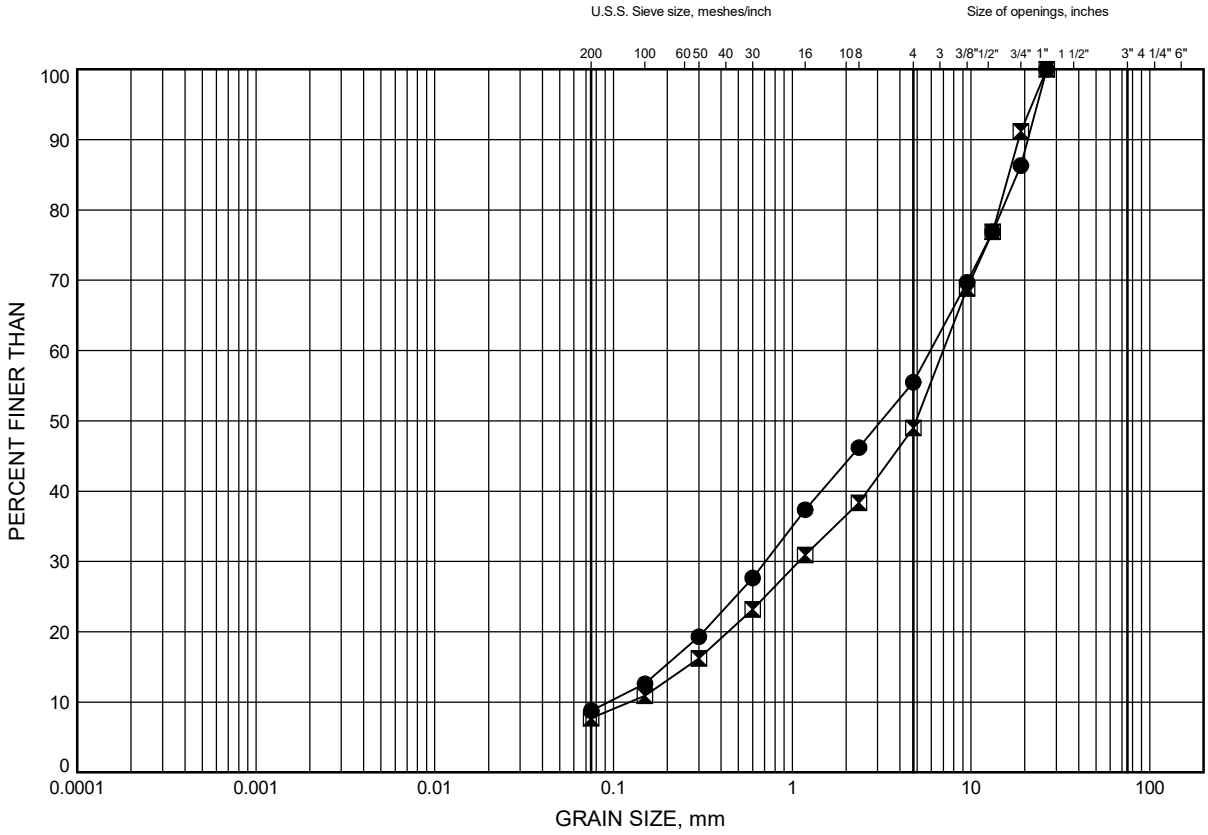
Geotechnical and Analytical Laboratory Test Results

MTO NW Region Retainer

GRAIN SIZE DISTRIBUTION

FIGURE B1

Sand and Gravel Fill



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-11	1.83	329.87
⊠	16-13	1.37	330.33

Date August 2016

W.P. 6332-14-01

THURBER

Prep'd MFA

Chkd. AMP

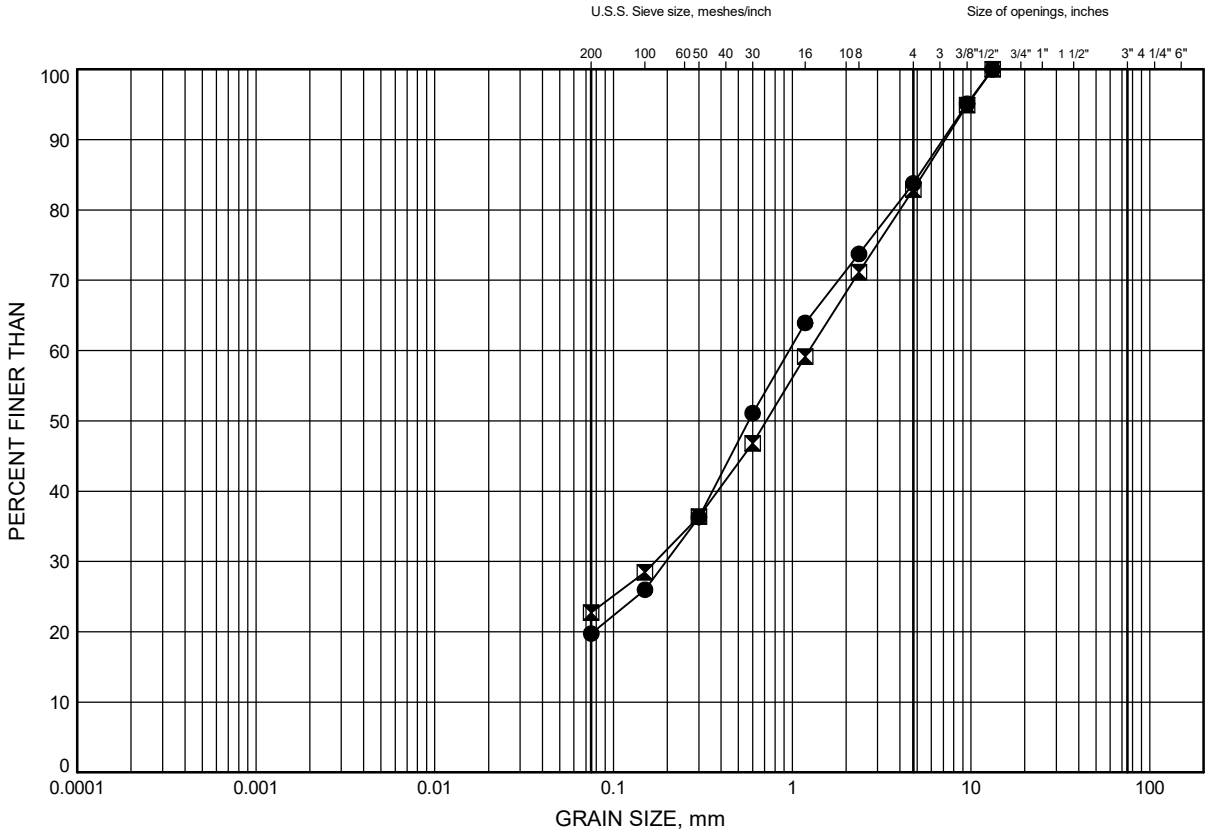
GRAIN SIZE DISTRIBUTION - THURBER 13662-MTO.GPJ 8/23/16

MTO NW Region Retainer

GRAIN SIZE DISTRIBUTION

FIGURE B2

Sand to Silty Sand Fill



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-12	0.61	331.09
⊠	16-14	0.53	331.17

Date August 2016

W.P. 6332-14-01

THURBER

Prep'd MFA

Chkd. AMP

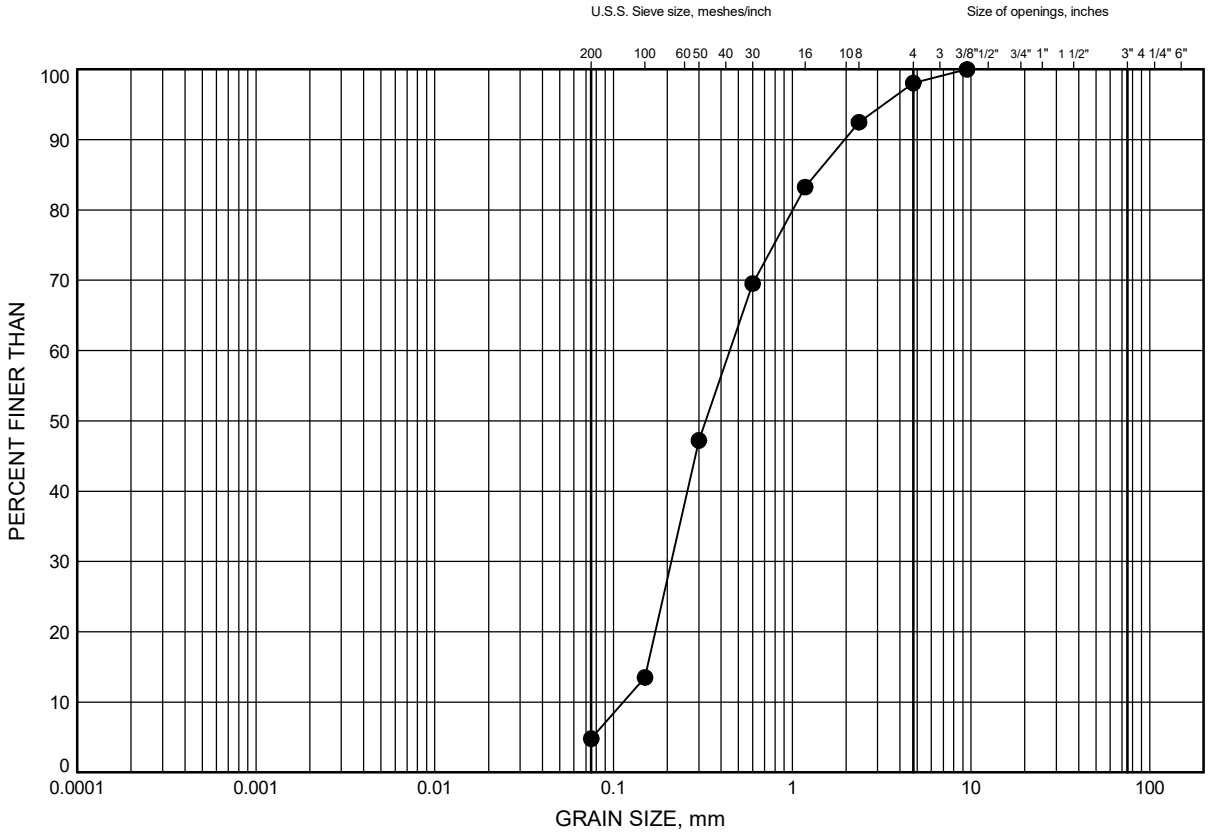
GRAIN SIZE DISTRIBUTION - THURBER 13662-MTO.GPJ 8/23/16

MTO NW Region Retainer

GRAIN SIZE DISTRIBUTION

FIGURE B3

Sand



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-11	6.25	325.45

Date August 2016

W.P. 6332-14-01

THURBER

Prep'd MFA

Chkd. AMP

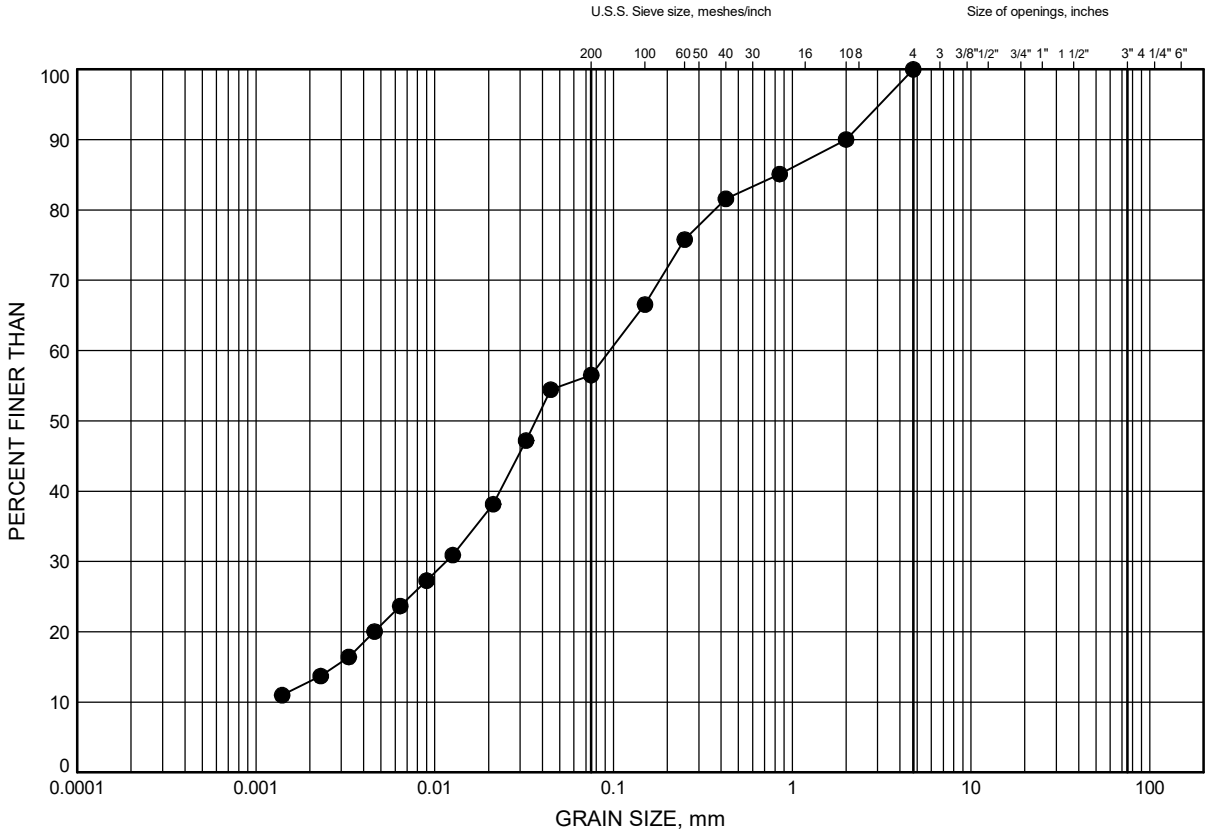
GRAIN SIZE DISTRIBUTION - THURBER 13662-MTO.GPJ 8/23/16

MTO NW Region Retainer

GRAIN SIZE DISTRIBUTION

FIGURE B4

Sand and Silt Till



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-11	8.08	323.62

Date August 2016

W.P. 6332-14-01

THURBER

Prep'd MFA

Chkd. AMP

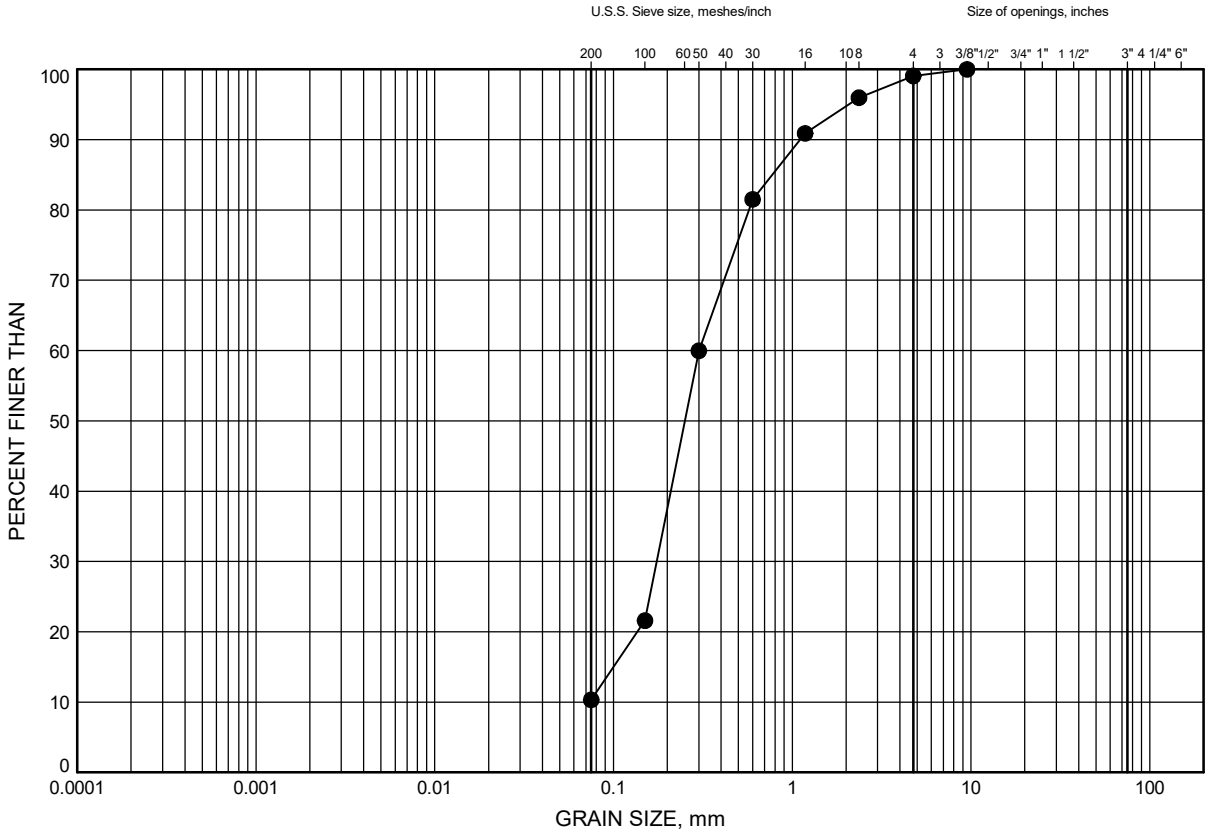
GRAIN SIZE DISTRIBUTION - THURBER 13662-MTO.GPJ 8/23/16

MTO NW Region Retainer

GRAIN SIZE DISTRIBUTION

FIGURE B5

Sand Till



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-11	10.97	320.73

Date August 2016

W.P. 6332-14-01

THURBER

Prep'd MFA

Chkd. AMP

GRAIN SIZE DISTRIBUTION - THURBER 13662-MTO.GPJ 8/23/16

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13662

09-August-2016

Thurber Engineering Ltd.
Attn : Mark Farrant

103, 2010 Winston Park Drive
Oakville, ON
L6H 5R7,

Phone: 905-829-8666 x 228
Fax:

Date Rec. : 03 August 2016
LR Report: **CA14112-AUG16**
Reference: 13662

Copy: #1

CERTIFICATE OF ANALYSIS
Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: BH16-11, SS3 7'6"-9'-6"
Sample Date & Time					26-Jul-16
Temperature Upon Receipt [°C]	---	---	---	---	24.2
Corrosivity Index [none]	09-Aug-16	13:29	09-Aug-16	14:28	2
pH [no unit]	08-Aug-16	11:40	09-Aug-16	09:32	7.84
Soil Redox Potential [mV]	08-Aug-16	18:47	09-Aug-16	08:27	217
Sulphide [%]	08-Aug-16	10:07	09-Aug-16	09:35	< 0.02
% Moisture (wet wt) [%]	05-Aug-16	07:02	05-Aug-16	09:08	7.2
pH [no unit]	04-Aug-16	09:56	04-Aug-16	15:49	8.91
Chloride [µg/g]	05-Aug-16	18:51	09-Aug-16	09:15	110
Sulphate [µg/g]	05-Aug-16	18:51	09-Aug-16	09:15	29
Conductivity [uS/cm]	04-Aug-16	09:56	04-Aug-16	15:49	358
Resistivity (calculated) [Ohms.cm]	09-Aug-16	12:55	09-Aug-16	14:28	2790

Deanna Edwards, B.Sc, C.Chem
Project Specialist
Environmental Services, Analytical

OnLine LIMS

0000751543

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13662

LR Report : **CA14112-AUG16**

Temperature of Samples upon receipt 24 degrees C
No cooling agent present
Custody Seal not present

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13662

LR Report : **CA14112-AUG16**

Method Descriptions

Parameter	SGS Method Code	Reference Method Code
Anions by IC	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
Carbon/Sulphur	ME-CA-[ENV]ARD-LAK-AN-020	ASTM E1918
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006	SM 2510
Metals Prep	ME-CA-[ENV]ARD-LAK-AN-013	
pH	ME-CA-[ENV]EWL-LAK-AN-001	SM 4500

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13662
LR Report : **CA14112-AUG16**

Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank		RPD	Acceptance Criteria	LCS / Spike Blank			Matrix Spike / Reference Material		
							Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
						%		Low	High		Low	High
Anions by IC - QCBatchID: DIO0053-AUG16												
Chloride	0.4	µg/g	<0.4		0	20	109	80	120	111	75	125
Sulphate	0.4	µg/g	<0.4		3	20	101	80	120	101	75	125
Carbon/Sulphur - QCBatchID: ECS0007-AUG16												
Sulphide	0.02	%	<0.02		NV	20	113	80	120			
Conductivity - QCBatchID: EWL0045-AUG16												
Conductivity	2	uS/cm	2		1	10	99	90	110	NA		
pH - QCBatchID: EWL0045-AUG16												
pH	0.05	no unit	NA		0		100			NA		

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13662

16-November-2016

Thurber Engineering Ltd.
Attn : Mark Farrant

103, 2010 Winston Park Drive
Oakville, ON
L6H 5R7,

Phone: 905-829-8666 x 228
Fax:

Date Rec. : 02 August 2016
LR Report: **CA13006-AUG16**
Reference: 13662

Copy: #1

CERTIFICATE OF ANALYSIS
Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: MDL	6: Chicken Farm Creek
Sample Date & Time						27-Aug-16 09:00
Temperature Upon Receipt [°C]	---	---	--	--	---	26.0
Corrosivity Index [none]	04-Aug-16	15:49	04-Aug-16	15:49		12
pH [no unit]	03-Aug-16	07:59	04-Aug-16	10:21	0.05	7.47
Conductivity [µS/cm]	03-Aug-16	07:59	04-Aug-16	10:21	2	371
Resistivity (calculated) [Ohms.cm]	03-Aug-16	07:59			---	270
Redox Potential [mV]	02-Aug-16	17:51	03-Aug-16	12:43	---	280
Chloride [mg/L]	03-Aug-16	08:25	04-Aug-16	09:21	0.04	51
Sulphate [mg/L]	03-Aug-16	08:25	04-Aug-16	09:21	0.04	0.22
Sulphide [mg/L]	03-Aug-16	08:00	03-Aug-16	12:20	0.006	< 0.006

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

Temperature of samples upon receipt 26 degrees C
Cooling Agent Present
Custody Seal not used to seal cooler

Deanna Edwards

Deanna Edwards, B.Sc, C.Chem
Project Specialist
Environmental Services, Analytical

OnLine LIMS

0000836330

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13662

LR Report : **CA13006-AUG16**

Method Descriptions

Parameter	SGS Method Code	Reference Method Code
Anions by IC	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006	SM 2510
pH	ME-CA-[ENV]EWL-LAK-AN-006	SM 4500
Redox Potential		SM 2580
Sulphide by SFA	ME-CA-[ENV]SFA-LAK-AN-008	SM 4500

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13662
LR Report : **CA13006-AUG16**

Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank		RPD	Acceptance Criteria	LCS / Spike Blank			Matrix Spike / Reference Material		
							Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
						%		Low	High		Low	High
Anions by IC - QCBatchID: DIO0016-AUG16												
Anions by IC - QCBatchID: DIO0024-AUG16												
Chloride	0.04	mg/L	<0.04		0	20	102	80	120	90	75	125
Sulphate	0.04	mg/L	<0.04		0	20	102	80	120	88	75	125
Conductivity - QCBatchID: EWL0020-AUG16												
Conductivity	2	µS/cm	< 2		0	10	101	90	110	NA		
pH - QCBatchID: EWL0020-AUG16												
pH	0.05	no unit	NA		0		100			NA		
Redox Potential - QCBatchID: EWL0019-AUG16												
Redox Potential	no	mV	NA		1	20	106	80	120	NA		
Sulphide by SFA - QCBatchID: SKA0010-AUG16												
Sulphide	0.006	mg/L	<0.006		ND	20	103	80	120	125	75	125

Appendix C

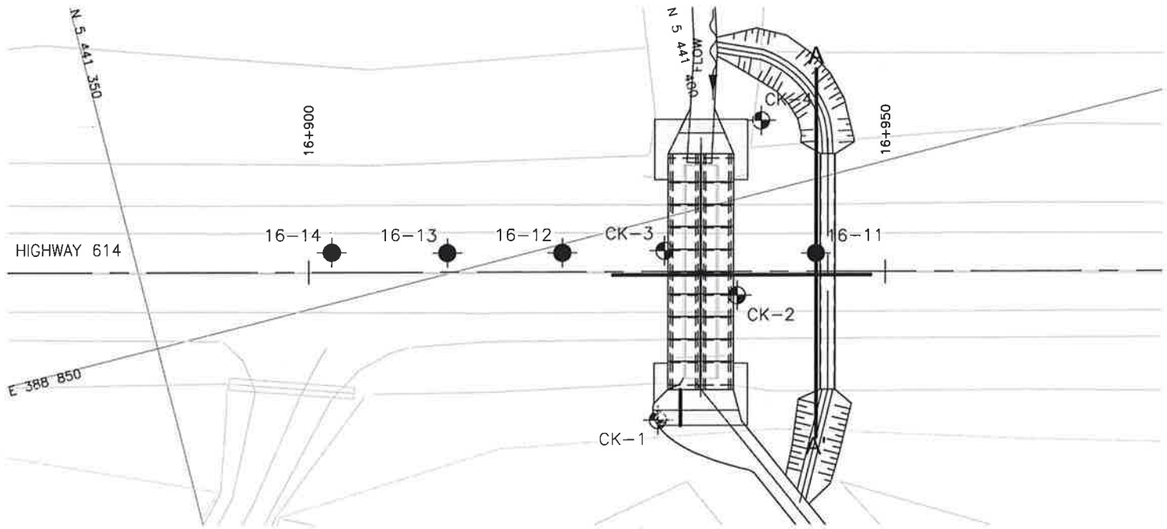
Selected Site Photographs

Photograph 1 – Chicken Farm Lake Culvert, East End (Outlet)

Photograph 2 – Chicken Farm Lake Culvert, West End (Inlet)

Appendix D

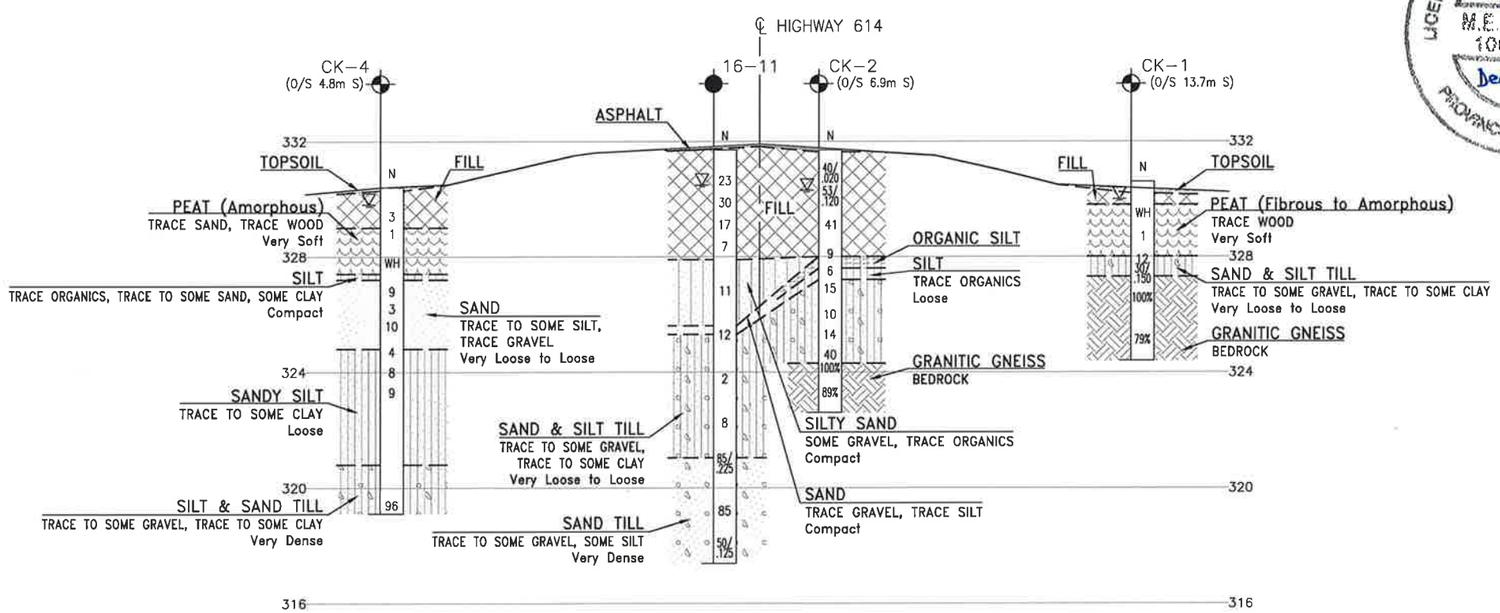
Borehole Locations and Soil Strata Drawing



PLAN

10 0 10 20m

SCALE 1:500



SECTION A–A'

4 0 4 8m

SCALE 1:200

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Dec 16/16
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
M.E. FARRANT
100053767
Dec. 16/16
PROVINCE OF ONTARIO

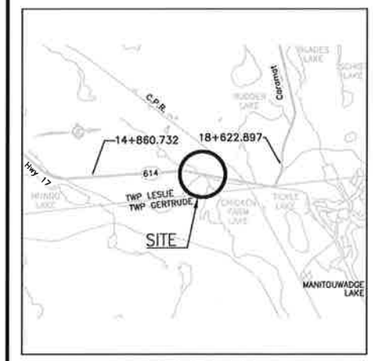
CONT No
WP No 6332–14–01

HIGHWAY 614
CHICKEN FARM LAKE
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

HATCH

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

⊕	Borehole (by Thurber)
⊕	Borehole (by Others)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Head Artesian Water
▏	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
16–11	331.7	5 441 407.3	388 856.3
16–12	331.7	5 441 386.0	388 850.8
16–13	331.7	5 441 376.3	388 848.3
16–14	331.7	5 441 366.6	388 845.8
CK–1	330.6	5 441 390.4	388 866.9
CK–2	331.7	5 441 399.7	388 858.1
CK–3	331.7	5 441 394.6	388 852.8
CK–4	330.4	5 441 405.5	388 843.9

-NOTES-

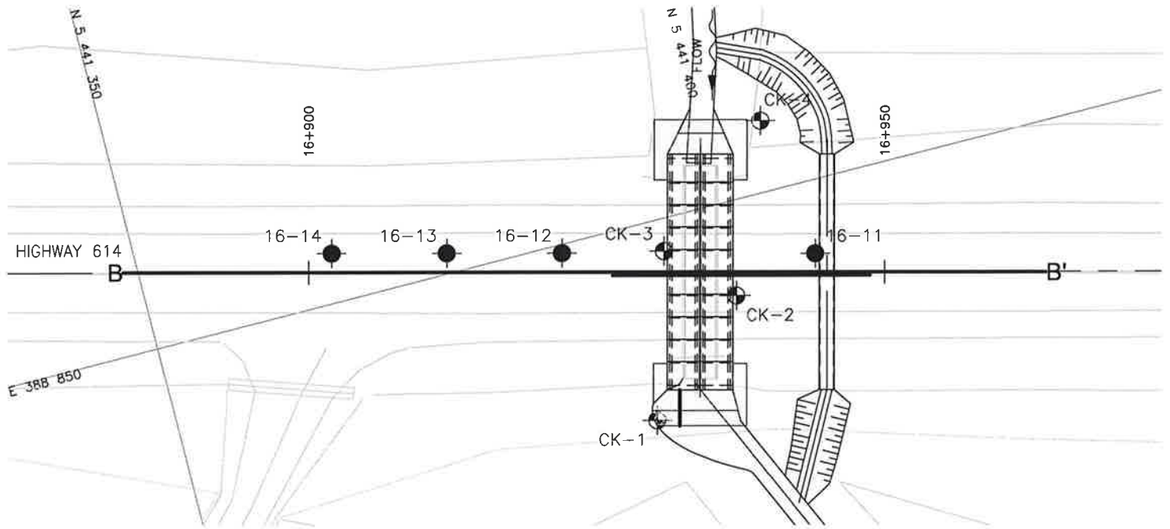
1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) MTM Zone 14 co–ordinate system used to obtain borehole Northings and Eastings.
4) Preliminary general arrangement drawing provided by Hatch in digital format.

GEOCRES No. 42F-39

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	MEF	CHK	PKC	CODE	LOAD	DATE	DEC 2016
DRAWN	MFA	CHK	MEF	SITE	STRUCT	DWG	1

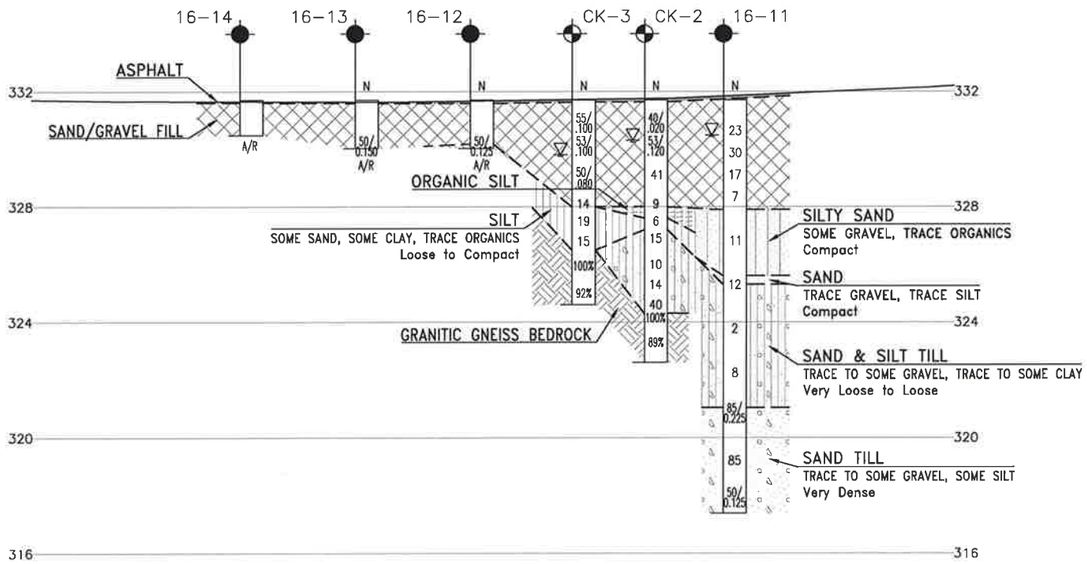
FILENAME: H:\Drafting\13000\13682\TED-13682-PLSC-CF.dwg
PLOTDATE: 12/16/2016 11:35 AM



PLAN

10 0 10 20m

SCALE 1:500



PROFILE B–B'

10 0 10 20m H 1:500

4 0 4 8m V 1:200

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

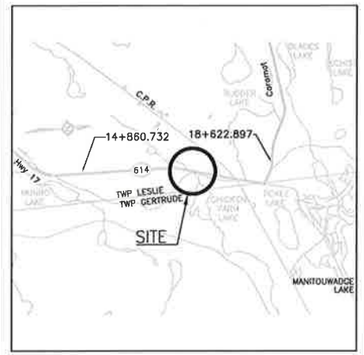
CONT No
WP No 6332-14-01

HIGHWAY 614
CHICKEN FARM LAKE
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

HATCH

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Borehole (by Thurber)
⊕	Borehole (by Others)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
16-11	331.7	5 441 407.3	388 856.3
16-12	331.7	5 441 386.0	388 850.8
16-13	331.7	5 441 376.3	388 848.3
16-14	331.7	5 441 366.6	388 845.8
CK-1	330.6	5 441 390.4	388 866.9
CK-2	331.7	5 441 399.7	388 858.1
CK-3	331.7	5 441 394.6	388 852.8
CK-4	330.4	5 441 405.5	388 843.9

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) MTM Zone 14 co-ordinate system used to obtain borehole Northings and Eastings.
4) Preliminary general arrangement drawing provided by Hatch in digital format.

GEOCRES No. 42F-39

REVISIONS		
DATE	BY	DESCRIPTION

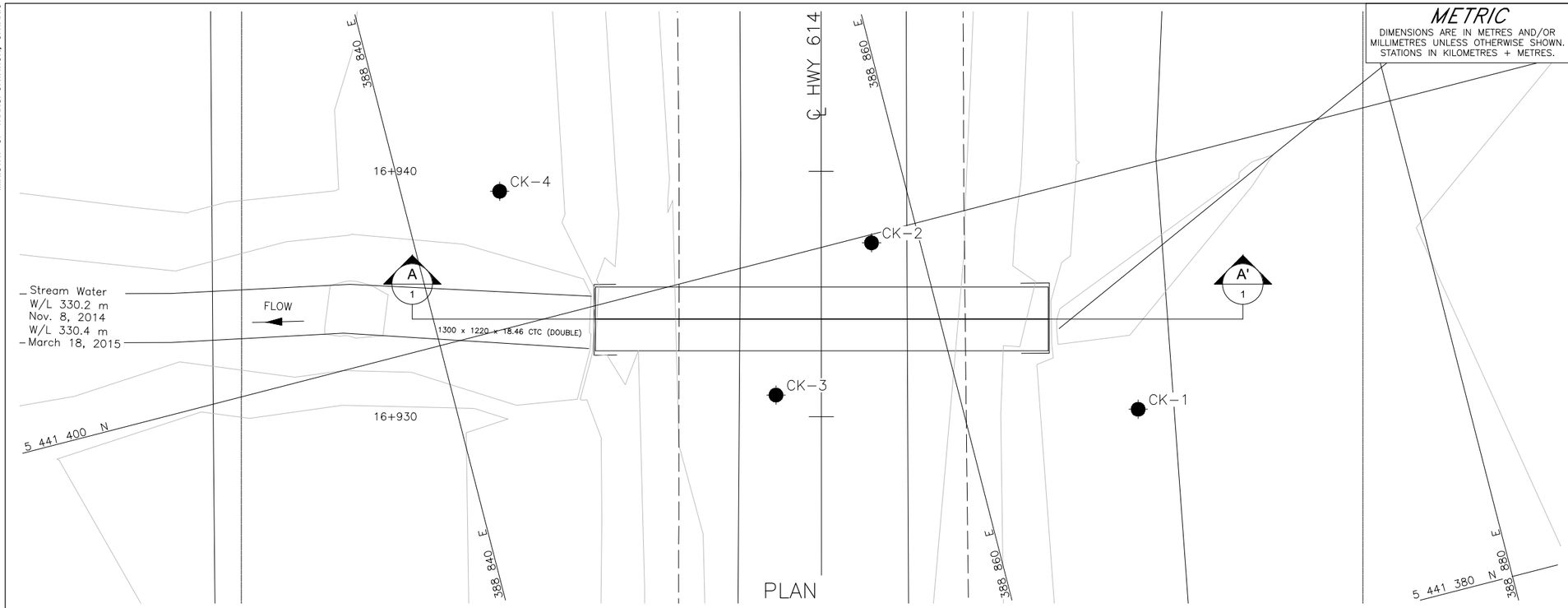
DESIGN	MEF	CHK	PKC	CODE		LOAD	
DRAWN	MFA	CHK	MEF	SITE		STRUCT	
						DATE	DEC 2016
						DWG	2

FILENAME: H:\Drafting\13000\13682\TED-13682-PLSC-GF.dwg
PLOTDATE: 12/16/2016 11:36 AM

Appendix E

Record of Borehole Sheets and Borehole Location and Soil Strata Drawing From Preliminary Foundation Investigation and Design Report prepared by Golder Associates, dated September 8, 2015, Geocres No. 42F-33

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

SCALE
2 0 2 4 m

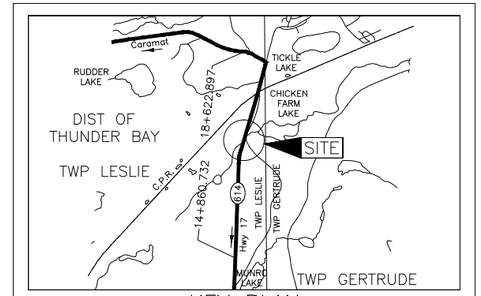
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 6332-14-00

SHEET

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

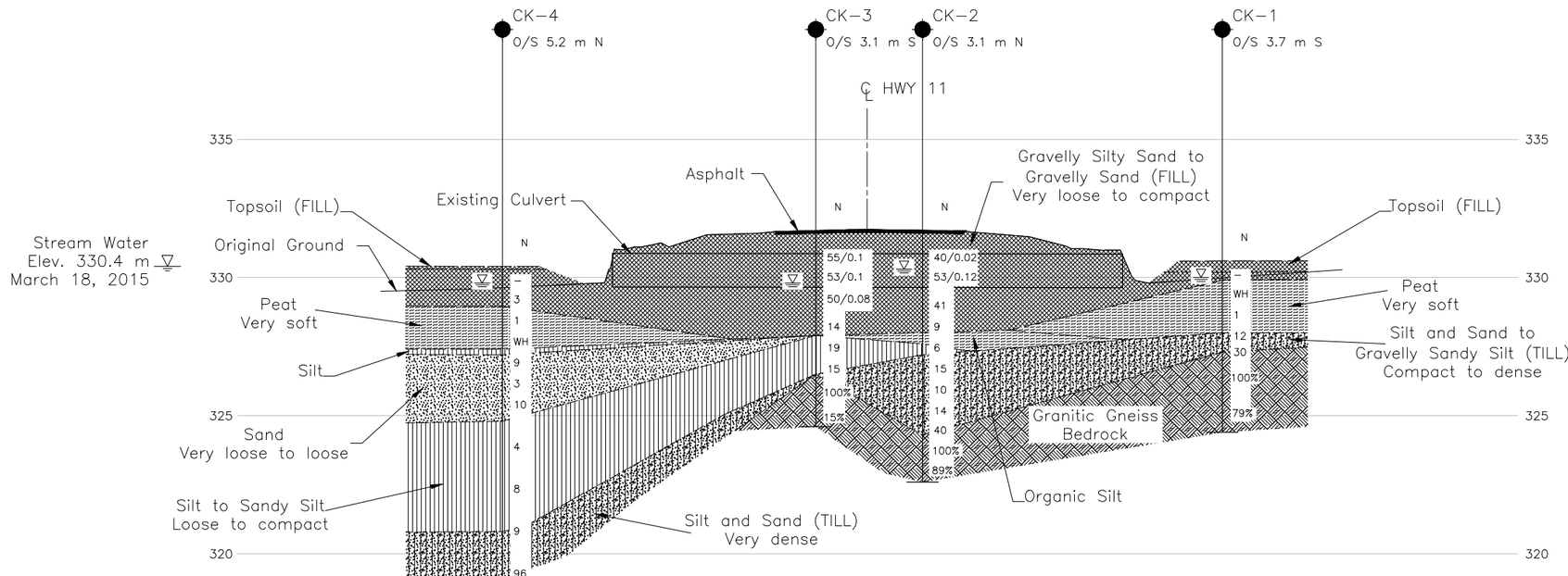
Golder Associates



KEY PLAN
1 0 1 2 km
1:50,000 m

LEGEND

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



A-A'
1
PROFILE
HORIZONTAL SCALE
2 0 2 4 m
2 0 2 4 m
VERTICAL SCALE

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.

LICENSED PROFESSIONAL ENGINEER S.E.M. POOT 90471921 SEP 08, 2015 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER J.M.A. COSTA SEP 08, 2015 PROVINCE OF ONTARIO

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

PLOT DATE: August 26, 2015
FILENAME: \\golder.gds\gal\Sudbury\CAD-GIS\CAD\Projects\2014\1411523 HAM 26 Culverts Thunder Bay\Civil_3D\1411523_Chicken Farm Lake.dwg

Golder Associates

RECORD OF BOREHOLE No CK-1

1 OF 1 **METRIC**

PROJECT 1411523 | 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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
330.6	GROUND SURFACE										
0.0 / 330.2	Topsoil (FILL) Black Frozen		1A	AS	-	▽	330				
329.8 / 0.8	Gravelly sand (FILL) Brown Frozen		1B	SS	WH						
	PEAT (Fibrous to Amorphous), trace wood Very soft Black Wet		2	SS	1		329		333.3 ⊙		
328.0 / 2.6	Gravelly Sandy SILT, trace clay (TILL) Compact Grey		3A 3B	SS	12		328	○			23 26 46 5
327.3 / 3.3	Wet		4	SS	30/0.15						
	GRANITIC GNEISS BEDROCK Bedrock cored from 3.3 m depth to 6.2 m depth. For coring details see Record of Drillhole CK-1.		1	RC	REC 100%		327				RQD = 100%
			2	RC	REC 100%		326				RQD = 79%
324.4 / 6.2	END OF BOREHOLE 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.						325				

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

PROJECT: 1411523

RECORD OF DRILLHOLE: CK-1

SHEET 1 OF 1

LOCATION: N 5441390.4 ;E 388866.9

DRILLING DATE: March 25, 2015

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

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

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR % RETURN / FLUSH	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		Refer to Previous Page		327.3																
4	CME 55 NW NQ	GRANITIC GNEISS Medium to coarse grained Black to white to pink Strong Fresh		3.3	1	GREY 100							JNPLRO							USC=77 MPa
5		Vertical joint from 5.0 m to 6.0 m depth, water recovery 25%.			2	GREY 25-100							JNPLRO JNPLRO							
6				324.4																
		END OF DRILLHOLE		6.2																
7																				
8																				
9																				
10																				
11																				
12																				
13																				

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: RI

CHECKED: SEMP

SUD-RCK 1411523.GPJ GAL-MISS.GDT 03/07/15 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No CK-2

1 OF 1 **METRIC**

PROJECT 1411523 | 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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
331.7	GROUND SURFACE										
0.0 / 0.1	ASPHALT (65 mm)										
	Gravelly sand, trace silt (FILL) Loose Brown Frozen* to wet		1	SS	40/ 0.02*		331				
	Augers grinding from 0.8 m to 2.7 m depth on inferred cobbles.		2	SS	53/ 0.12*	▽	330				
			3	SS	41*		329				
328.0			4	SS	9		328				
327.6	ORGANIC SILT Brown Wet		5A 5B	SS	6					NP	8 13 72 7
327.2 / 4.5	SILT, trace organics Loose Brown to dark grey Wet		6	SS	15		327				
	SILT and SAND, trace to some gravel, trace to some clay (TILL) Compact to dense Grey Wet		7	SS	10		326				8 34 47 11
			8	SS	14		325				
324.3			9	SS	40						
7.4	GRANITIC GNEISS BEDROCK Bedrock cored from 7.4 m depth to 9.1 m depth. For coring details see Record of Drillhole CK-2.		1	RC	REC 100%		324				RQD = 100%
322.6			2	RC	REC 100%		323				RQD = 89%
9.1	END OF BOREHOLE 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.										

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

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.

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

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR / % RETURN	FLUSH	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		Refer to Previous Page		324.3																	
8	CME 55 NQ Coring NW	GRANITIC GNEISS Medium to fine grained Black to pink to white Very strong Fresh		7.4	1	GREY 100															UCS=147 MPa
9				322.6	2	GREY 100								JNPLRO JNPLRO JNPLRO JNPLRO JNPLRO							
		END OF DRILLHOLE		9.1																	
10																					
11																					
12																					
13																					
14																					
15																					
16																					
17																					

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: RI

CHECKED: SEMP

SUD-RCK 1411523.GPJ GAL-MISS.GDT 03/07/15 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No CK-3

1 OF 1 **METRIC**

PROJECT 1411523 | G.W.P. 6332-14-00 | LOCATION N 5441394.6; E 388852.8 | 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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
331.7	GROUND SURFACE										
0.0	ASPHALT (75 mm)										
0.1	Gravelly sand, trace silt (FILL) Compact Brown Frozen* to wet Augers grinding from 0.8 m to 3.0 m depth on inferred cobbles.		1	SS	55/0.1*	▽	331				
			2	SS	53/0.1*		330		○		
			3	SS	50/0.08*						
			4	SS	14		329				
328.0											
3.7	SILT, some sand, some clay Compact Grey Wet		5	SS	19		328		○		0 14 71 15
			6	SS	15		327				
326.5											
5.2	GRANITIC GNEISS BEDROCK Bedrock cored from 5.2 m depth to 7.2 m depth. For coring details see Record of Drillhole CK-3.		1	RC	REC 100%		326				RQD = 100%
			2	RC	REC 100%		325				RQD = 92%
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.										

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

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.

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

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR / % RETURN	FLUSH	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		Refer to Previous Page		326.5																	
6	CME 55 NQ Coring NW	GRANITIC GNEISS Medium to fine grained Black to pink to white Very strong Fresh		5.2	1	GREY 100								JNPLRO JNPLRO							
7				324.6	2	GREY 100								JNCURO JNPLRO							UCS=128 MPa
		END OF DRILLHOLE		7.1																	
8																					
9																					
10																					
11																					
12																					
13																					
14																					
15																					

SUD-RCK 1411523.GPJ GAL-MISS.GDT 03/07/15 DATA INPUT:

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: RI

CHECKED: SEMP

Golder Associates

RECORD OF BOREHOLE No CK-4

1 OF 1 **METRIC**

PROJECT 1411523 | 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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
330.4	GROUND SURFACE										
0.0	Topsoil (FILL)										
0.1	Gravelly silty sand (FILL) Very loose Dark brown Frozen* to wet		1A	AS	-*	▽	330				
329.0			1B	SS	3						
1.4	PEAT (Amorphous), trace sand, trace wood Very soft Black Wet		2	SS	1		329				
327.4			3	SS	WH		328		531.4		
	SILT, trace organics, trace sand		4A	SS	9						
3.2	Brown Wet		4B				327			NP	
	SAND, trace to some silt, trace gravel Very loose to loose Grey Wet		5	SS	3						3 90 (7)
			6	SS	10		326				
324.8							325				
5.6	Sandy SILT, trace to some clay Loose Grey Wet		7	SS	4		324				0 19 73 8
			8	SS	8		323				
320.8			9A	SS	9		322				
9.6	SILT and SAND, trace to some gravel, trace to some clay (TILL) Very dense Grey Wet		9B				321				
319.1			10	SS	96		320				8 35 49 8
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.										

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

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

Appendix F

List of Specifications and Suggested Wording for NSSP

1. List of OPSS and OPSD Documents Relevant to this Project

- OPSS PROV 206
- OPSS PROV 209
- OPSS PROV 422
- OPSS PROV 501
- OPSS PROV 539
- OPSS PROV 804
- OPSS PROV 902
- OPSS PROV 1004
- OPSS PROV 1010
- OPSS PROV 1205
- OPSS 511
- OPSS 1860
- OPSD 802.010
- OPSD 803.010
- OPSD 810.010

2. Suggested Wording for NSSP

- Suggested Text for NSSP on “Obstructions”

“Excavations and installation of cofferdams and roadway protection systems could encounter obstructions such as cobbles and boulders embedded in the fill and native soils, or shallow bedrock. Such obstructions may impede excavation progress and/or sheetpile installation. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions to achieve the design depths.”

- Suggested Text for NSSP on “Groundwater and Dewatering”

"The Contractor is notified that the site has high groundwater levels and that these levels may be higher than the water levels shown in the Foundation Investigation Report prepared for this site. While reference should be made to that report for a description of the encountered

conditions, the Contractor must satisfy himself regarding the groundwater levels likely to prevail at the time of construction and be prepared to implement dewatering procedures.

The Contractor is further notified that failure to implement dewatering in advance of excavating below the groundwater table may result in sloughing and boiling of the soil in the excavation and a loss in stability and bearing resistance.

Design and provision of an effective dewatering system is the responsibility of the Contractor. Subgrade preparation, culvert construction and backfilling must be carried out in the dry.

- Suggested Text for NSSP on “Limited Depth Dewatering”

“If clear stone is used for subexcavation backfill and/or bedding in place of compacted Granular A or B, the groundwater level must be maintained at a minimum of 0.7 m below the culvert invert to facilitate vibratory compaction of the top of the clear stone backfill.”