



THURBER ENGINEERING LTD.



**FOUNDATION INVESTIGATION AND DESIGN REPORT
FLYNNE CREEK EAST CULVERT REPLACEMENT
HIGHWAY 11, SITE No. 48E-125/C
DISTRICT OF THUNDER BAY, ONTARIO
G.W.P. No. 6310-14-00, W.P. No. 6310-14-01**

GEOCRES Number: 42F-40

Report

to

HATCH

Date: February 6, 2017
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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 Flynne Creek East Culvert on Highway 11, located east of Longlac, in unsurveyed territory in the District of Thunder Bay, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the culvert location 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 Ltd. (Hatch) to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Agreement Number 6015-E-0018-04.

A preliminary foundation investigation carried out at this site was documented in the report titled "Preliminary Foundation Investigation and Design Report, Flynne Creek East Culvert-Site No. 48E-125/C, Highway 11, District of Thunder Bay, Unsurveyed Territory, Ministry of Transportation, Ontario, G.W.P 6310-14-00" Geocres No. 42F-34, prepared by Golder Associates, dated September 8, 2015. Reference should be made to the Golder 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 Investigation and Design Report (FIDR). The Record of Borehole sheets and Borehole Locations and Soil Strata drawing from the preliminary FIDR 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. The subsurface information, including the

Record of Borehole sheets and the Borehole Locations and Soil Strata drawings, from both the current investigation and the Golder preliminary FIDR should be included in the contract documents.

2. SITE DESCRIPTION

The Flynne Creek Culvert site is located on Highway 11, approximately 43.6 km east of the intersection of Highway 625 and Highway 11 in unsurveyed territory in the District of Thunder Bay, 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 11 runs in a general east-west direction with the culvert perpendicular to the centreline of the highway. Flynne Lake is situated on the south side of the highway and Flynne Creek drains into the lake flowing from the north through the culvert.

The Structural Design Report (SDR) for the culvert replacement, which was dated December 2015 and provided to Thurber by Hatch, indicates that the existing structure is a 27 m long, two cell (each 1.4 m wide) timber culvert with an unknown construction date. The highway embankment is approximately 2.5 m high, and there is approximately 1.4 m of fill above the culvert. A Biennial Inspection on July 23, 2014 indicates that the structure generally is in poor condition. The grade level of Highway 11 at the existing culvert is at an approximate Elevation of 271.6 m. The culvert invert is at approximate Elevation 268.8 m at the inlet (north end) and 268.7 m at the outlet (south end). The creek water level was measured at Elevation 270.1 m and Elevation 269.9 by others on October 20, 2014 and March 17, 2015, respectively.

The lands surrounding Flynne Creek East and the culvert at the site predominantly consist of heavily forested areas with occasional marsh lands and lakes. Local topography is generally of low relief with bedrock outcrops visible along Highway 11 approximately 1.0 km east of the site. Photographs of the culvert and surrounding area are presented in Appendix C.

Based on published geological information, the subsurface soils at the site generally consist of organic terrain deposits of mainly peat/muck bordering with areas of undulating to rolling bedrock knobs. Bedrock in the area has been identified as mafic to intermediate metavolcanic bedrock of Archean era, comprised of massive granodiorite to granite rocks.

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 on August 12, 2016, and consisted of drilling and sampling four (4) boreholes, designated as Boreholes 16-21 to 16-24. All boreholes were located in the paved section of Highway 11 in the eastbound lane. Borehole 16-21 was located approximately 13 m east of the centreline of the existing culvert near the alignment of the proposed stream diversion pipe, and Boreholes 16-22 to 16-24 were located west of the existing culvert structure and distributed at 10 m intervals to assess 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 ground surface elevations for the boreholes were derived from cross sections and topographic drawings 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 rubber track mounted CME 55 drill rig was used to advance the boreholes using hollow stem and solid stem augers. Borehole 16-21 was advanced to a depth of approximately 14.3 m (Elev. 257.3 m) below the existing road surface and Boreholes 16-22 to 16-24 were each advanced to approximately 3.7 m depth (Elev. 267.9 m) below existing road surface. Samples of the overburden soils were obtained from the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (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 upon completion of drilling. The boreholes were backfilled in general accordance with Ontario Regulation 903.

Completion details of the borehole are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Completion Details
16-21	14.3 / 257.3	Borehole backfilled with bentonite holeplug and cuttings and surface reinstated with asphalt.

Borehole Number	Borehole Depth / Base Elevation (m)	Completion Details
16-22	3.7 / 267.9	Borehole backfilled with bentonite holeplug and cuttings and surface reinstated with asphalt.
16-23	3.7 / 267.9	Borehole backfilled with bentonite holeplug and cuttings and surface reinstated with asphalt.
16-24	3.7 / 269.7	Borehole backfilled with bentonite holeplug and cuttings and surface reinstated with asphalt.

The preliminary investigation conducted by Golder included four (4) boreholes, numbered FE-1 to FE-4. Boreholes FE-1 and FE-4 were advanced at the toe of the embankment near the culvert outlet and inlet to depths of 5.8 to 5.9 m (Elev. 264.5 to 264.6 m), and Boreholes FE-2 and FE-3 were advanced from the existing highway platform to depths of approximately 11.0 and 10.7 m respectively (Elev. 260.5 and 260.8 m). The approximate locations of the Golder boreholes are shown on the Borehole Locations and Soil Strata Drawing included in Appendix D, and on the 2015 Golder report's Borehole Location and Soil Strata Drawing included in Appendix E.

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) and plasticity testing (Atterberg Limits) where appropriate. The results of this 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 native soil, 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 Appendices A and E. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the

“Borehole Locations and Soil Strata” drawings included in Appendices D and E. 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 should 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 borehole logs from the previous Golder investigation are presented in Appendix E and are generally consistent with the results of the current investigation.

In general, the subsurface conditions encountered in the boreholes from the current and previous investigations consisted of embankment fill comprising sand to silty sand, underlain by a layer of silt with organic seams, followed by layers of silt and sand. Peat was encountered at the surface in Boreholes FE-1 and FE-4 at the inlet and outlet. Descriptions of the individual strata are presented below.

5.1 Asphalt

Boreholes 16-21 to 16-24, FE-2 and FE-3 were drilled in the paved section of Highway 11 and the pavement surface consisted of 130 mm to 250 mm of asphalt.

5.2 Fill

Underlying the asphalt in Boreholes 16-21 to 16-24, FE-2 and FE-3 was a layer of granular fill, which generally ranged in composition from sand to silty sand, and contained trace to some gravel. The fill was approximately 1.8 m to 3.3 m thick with the base of the fill ranging between approximately 2.1 m and 3.4 m below existing road surface elevation (Elev. 268.1 to Elev. 269.5 m). The relative density of the fill ranged from very loose to compact with the SPT ‘N’ values recorded between 1 and 29 blows per 0.3 m of penetration. Higher SPT ‘N’ values ranging from 17 to greater than 50 blows per 0.05 m of penetration were noted in frozen fill in Boreholes FE-2 and FE-3. Wood fragments were encountered within the fill in FE-2.

The measured moisture content of the fill generally ranged from 3% to 50%. The results of grain size distribution analyses conducted on samples of the fill are presented on the Record of Borehole sheets included in Appendices A and E and are summarized in the following table. The results from the Thurber boreholes are also presented on Figures B1 and B2 in Appendix B.

Soil Particle	Percentage (%)	
	Sand Fill	Silty Sand Fill
Gravel	5 to 21	4 to 10
Sand	62 to 86	65 to 67
Silt and Clay	9 to 21	25 to 29

5.3 Peat

A layer of amorphous peat to silty peat with some rootlets and trace gravel was encountered at the ground surface in Boreholes FE-1 and FE-4 of the previous investigation, which were drilled near the inlet and outlet of the existing culvert. The peat extended to depths of 0.6 to 1.4 m (Elev. 269.0 to 269.8 m). SPT 'N' values recorded in the peat, while frozen, ranged from 2 to 4 blows per 0.3 m penetration. Measured moisture contents in the peat varied from 108% to 250%.

5.4 Upper Silt

An upper native deposit of silt was encountered in all of the boreholes beneath the fill or peat. The silt generally contained trace to some clay, trace to some sand, trace gravel, and was grey in colour. Occasional peat lenses were encountered in Boreholes 16-21 and FE-3 interbedded within the silt layer.

Where fully penetrated, the upper silt layer extended to depths of 2.8 to 6.1 m (Elev. 265.5 to 267.6 m), and ranged in thickness from 1.2 to 3.0 m. Boreholes 16-22 to 16-24 were terminated in the upper silt at depths of 3.7 m (Elev. 267.9 m).

The upper silt was generally very loose to compact, with recorded SPT 'N' values of 2 to 24 blows per 0.3 m penetration. The measured moisture content of the upper silt ranged from 18% to 25%.

The results of grain size analyses conducted on samples of the upper silt are provided on the Record of Borehole sheets in Appendices A and E and are summarized in the following table. The results from the Thurber boreholes are also presented on Figure B3 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 1
Sand	3 to 17
Silt	70 to 91
Clay	5 to 13

5.5 Sand

Sand was encountered beneath the silt deposit in Boreholes 16-21 and FE-1 to FE-4. The sand contained trace to some silt, trace clay, trace gravel, and is grey in colour. Where fully penetrated in Boreholes 16-21 and FE-3, the sand ranged in thickness from 4.6 to 6.4 m and extended to depths from 8.7 to 12.5 m (Elev. 259.1 to 262.8 m). Boreholes FE-1, FE-2 and FE-4 were terminated in the sand at depths from 5.3 to 9.8 m (Elev. 261.7 to 265.1 m). Sand and Silt was encountered near the base of the stratum in Borehole FE-3.

The sand was typically very loose to compact with SPT 'N' values of 0 to 11 blows per 0.3 m penetration. Measured moisture contents in the sand ranged from 14% to 25%.

The results of grain size analyses conducted on samples of the sand are provided on the Record of Borehole sheets in Appendices A and E and are summarized in the following table. The results from Borehole 16-21 are presented on Figure B4 of Appendix B.

Soil Particle	Percentage (%)	
	Sand	Sand and Silt
Gravel %	0 to 2	0
Sand %	87 to 96	52
Silt and Clay %	4 to 13	48

5.6 Lower Silt

A lower deposit of silt to sandy silt with trace clay was encountered below the sand in Boreholes 16-21 and FE-3. The boreholes were terminated in the lower silt at depths from 10.7 to 14.3 m (Elev. 257.3 to 260.8 m).

The lower silt was generally very loose to dense with SPT 'N' values of 0 (weight of hammer) to 39 blows per 0.3 m penetration. The measured moisture content in the lower silt ranged from 18% to 23%.

The results of a grain size analysis conducted on a sample of the lower silt are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B5 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	7
Silt	89
Clay	4

5.7 Groundwater Conditions

Groundwater conditions were observed during drilling operations and upon completion of drilling. The groundwater levels measured in the open boreholes during the preliminary and current investigations are summarized in Table 5.1, below.

Table 5.1 – Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
16-21	August 12, 2016	1.5	270.1	Open borehole
16-22	August 12, 2016	1.8	269.8	Open borehole
16-23	August 12, 2016	1.5	270.1	Open borehole
16-24	August 12, 2016	2.1	269.5	Open borehole
FE-1	February 23, 2015	1.2	269.2	Open borehole
FE-2	March 17, 2015	1.4	270.1	Open borehole
FE-3	March 17, 2015	1.8	269.7	Open borehole
FE-4	February 23, 2015	1.5	268.9	Open borehole

A water level near the inlet was shown at Elevation 270.1 m on October 20, 2014 on Hatch's Preliminary General Arrangement drawings and Elevation 269.9 m on March 17, 2015 on Golder's Soil Strata drawing. The groundwater level should be assumed to reflect the local creek water level. The measurements in the table above are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the native sand from Borehole 16-21, 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	
			16-21, SS#7, 4.6 m – 5.2 m	Flynn Creek East
			(Sand)	(Creek Water)
Sulphide	%	mg/L	<0.02	<0.006
Chloride	µg/g	mg/L	100	64
Sulphate	µg/g	mg/L	13	0.15
pH	No unit	No unit	7.62 to 8.69	7.70
Electrical Conductivity	µS/cm	µS/cm	156	424
Resistivity	Ohms.cm	Ohms.cm	6400	2360
Redox Potential	mV	mV	115	198

7. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. Thurber obtained the northing and easting coordinates and ground surface elevations from measurements taken in the field 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. Tim Sivak 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 Mr. Cory Zanatta, EIT, 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.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This report provides an interpretation of the geotechnical data in the factual report, and presents foundation recommendations for detailed design of the proposed Flynne Creek East Culvert replacement on Highway 11, located east of Longlac, in the District of Thunder Bay, Unsurveyed Territory.

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 Structural Design Report (SDR) titled "Flynn Creek East Timber Culvert, Site No. 48E-125C, Highway 11", prepared by Hatch, dated December 2015. The SDR provided discussion on the existing structure, discussion of alternatives for the proposed culvert replacement, and recommendations for the preferred alternative.

As indicated in SDR, the existing timber culvert is 27 m long and has two cells; each cell 1.4 m span and 1.6 m in height. The construction date of the culvert is unknown. A Biennial Inspection at the culvert site conducted on July 23, 2014 indicated that the structure was generally in poor condition. The Preliminary General Arrangement (GA) drawing indicates the grade of Highway 11

at the existing culvert at Elevation 271.6 m. The top of obvert is at approximate Elevation 270.2 m, which results in approximately 1.4 m of fill above the culvert. The height of the embankment is approximately 2.5 m.

9. CULVERT DESIGN

9.1 Culvert Replacement Options

The following options for the replacement culvert were presented and evaluated in the Structural Design Report (SDR):

- Option 1 – Precast Concrete Closed Box Culvert
- Option 2 – Precast Open Footing Metal Box Culvert
- Option 3 – Multiple Round Corrugated Steel Pipe (CSP) Culvert.

As described in the SDR, Option 3 was selected for detail design as the preferred structure alternative based on the evaluation that it would most effectively satisfy all of the design criteria and would result in favorable aquatic environment while minimizing disruption to the existing channel. For Option 3, the proposed structure would consist of two 27 m long and 2.7 m diameter round aluminized or polymer laminated corrugated steel pipes. The invert will be located at Elev. 268.1 m on the upstream (north) and Elev. 268.0 m on the downstream (south) side.

The SDR identified also Option 1 (concrete closed box) as a viable culvert replacement alternative with some advantages over Option 3, however it is more expensive. The required opening size of 4.8 m by 2.1 m was determined for a box culvert. The invert of the concrete box culvert would be located at Elev. 268.8 m on the upstream (north) side and at Elev. 268.7 m on the downstream (south) side, which would be approximately 700 mm higher than for Option 3.

Preliminary General Arrangement (GA) drawings for both the CSP and concrete closed box options were included in the SDR, illustrating the proposed replacement culvert and the temporary diversion pipe arrangement. The alignment of the replacement culvert will remain unchanged for the CSP option, but would be shifted by approximately 3 m to the east for the box culvert option. The finished road grade level will remain unchanged for both options. Construction staging, installation of a temporary roadway protection and a temporary stream diversion pipe (CSP) would be required to accommodate construction. As indicated in the SDR, no wingwalls/headwalls will be required at this culvert.

Both CSP and concrete closed box options, as well as other potential replacement alternatives are discussed in this report. The discussions and recommendations are based on information

provided by Hatch and on the factual data obtained during the course of the current and preliminary investigations. The subsurface information, including Record of Borehole sheets and the Borehole Locations and Soil Strata drawings from both current and preliminary investigations should be included in the contract documents.

9.2 Summary of Subsurface Conditions

In general, the subsurface conditions encountered in the boreholes advanced during the preliminary and current investigations consisted of 1.8 m to 3.3 m of sand to silty sand embankment fill overlying native cohesionless deposits comprising various proportions of silt and sand. All boreholes were terminated in the native silt or sand deposits between 3.7 m and 14.3 m depth (between Elev. 267.9 and Elev. 257.3). The boreholes located outside of the embankment encountered a layer of peat as much as 1.4 m thick overlying the native deposit of silt. The base of the peat in Borehole FE-1 at the north end of the culvert was noted at Elev. 269.8 and in Borehole FE-4, at Elev. 269.0.

The water level in Flynn Creek was measured at Elevation 270.1 m and Elevation 269.9 m on October 20, 2014 and March 17, 2015, respectively.

9.3 Foundation Design

9.3.1 Corrugated Steel Pipe Culvert

Replacement of the culvert with multiple CSPs on the same alignment as the existing culvert is identified in the SDR as the preferred option for this site. The multiple pipes are required to accommodate the hydraulic requirements. The proposed invert level of the culverts will be at approximate Elevation 268.1 m at the inlet (north end) and 268.0 m at the outlet (south end). The invert of the proposed culvert will be located either near the base of the embankment fill and/or in the native silt deposit underlying the fill, as indicated by Boreholes FE-2 and FE-3.

If this alternative is selected, the CSPs should be placed on a minimum 300 mm thick layer of bedding material, as outlined in Section 12. The underside of the bedding layer is anticipated to be located in the native loose to compact silt. Culvert subgrade preparation and placement and compaction of the bedding must be carried out in the dry.

Culvert must not be placed on the peat noted at the inlet and outlet. Any peat encountered at the culvert subgrade must be removed and replaced with compacted granular fill.

9.3.2 Concrete Box Culvert

A concrete box replacement culvert with an opening 4.8 m by 2.1 m was presented in the SDR as a viable alternative for this site. The proposed culvert invert would be at approximate Elev. 268.8 m at the inlet (north end) and Elev. 268.7 m at the outlet (south end) as shown in the SDR. The subgrade at this level will encounter embankment fill consisting of a compact sand and/or loose to compact native silt subgrade. The foundation subgrade should be prepared in the dry and the culvert should be placed on a 300 mm thick layer of bedding material and levelling course, as discussed in Sections 12.1 and 12.2 of this report.

Culvert must not be placed on the peat noted at the inlet and outlet. Any peat encountered at the culvert subgrade must be removed and replaced with compacted granular fill.

The following geotechnical capacities can be used for design of a box culvert founded at or below Elev. 268.8 m on the compact sand fill or loose to compact native silt subgrade:

- Factored Geotechnical Resistance at ULS of 150 kPa
- Geotechnical Resistance at SLS (less than 25 mm settlement) of 100 kPa.

The above values of the geotechnical resistance and reaction were based on the box culvert width of 5.2 m.

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/invert 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.

Resistance to lateral forces / sliding resistance between the concrete and the underlying Granular A or B Type II bedding material should be calculated assuming an ultimate coefficient of friction of 0.45.

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

9.4 Settlement and Stability

Embankment grade raise or widening was not indicated in the SDR as part of the culvert replacement. Therefore, changes in the loading conditions on the foundation soils consisting of compact sand fill and/or native silt are expected to be insignificant. The post construction settlements after culvert construction and embankment reconstruction at this site are estimated to be less than 25 mm.

Considering the subsurface conditions and the embankment height up to 3.6 m above the culvert invert, the granular fill embankment will be stable at side slopes inclined at 2 horizontal to 1 vertical, or flatter.

9.5 Frost Cover

The depth of frost penetration at this site is approximately 2.5 m. The pipe and box culvert options do not require frost cover/protection.

The frost taper investigation in Boreholes 16-22 to 16-24 indicated the presence of 1.8 to 2.2 m of granular fill overlying native silt to at least 30 m west of the centreline of the existing culvert. Borehole 16-21 also included granular fill to a depth of 3.1 m, extending at least 13 m east of the centreline 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 native silt.

The native silt underlying the fill is frost susceptible, and extends below the depth of frost penetration in all of the boreholes. As the top of the CSP or box culvert will be above the depth of frost penetration, frost treatment or a frost taper will be required as per OPSD 803.031 for a CSP culvert or OPSD 803.010 for a box culvert.

10. LATERAL EARTH PRESSURES

A triangular distribution of lateral earth pressures acting on the culvert walls may be assumed for design. 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	=	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 10.1 below.

Table 10.1 – Lateral Earth Pressure Coefficients (K)

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ$; $\gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I (modified) $\phi = 32^\circ$; $\gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.40	0.31	0.48
At-rest (Restrained Wall)	0.43	0.62	0.47	0.70
Passive	3.7	-	3.3	-

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

11. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2014, the selection of the seismic site classification is based on the average soil conditions encountered in the upper 30 m of the stratigraphy. The stratigraphy of

the site includes very loose to compact silts and sands. The harmonic mean of the typical N_{60} values is less than 15 blows, which corresponds to a Seismic Site Class E 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 11.1 may be used:

Table 11.1 – Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)	
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I (modified) $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$
Active (K_{AE})*	0.29	0.33
Passive (K_{PE})	3.6	3.2
At Rest (K_{OE})**	0.51	0.55

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

** After Woods

The saturated silts and sands should be considered as prone to liquefaction; however, in view of the low potential for seismic activity in the area, liquefaction is not considered to be a major concern at this site.

12. CULVERT CONSTRUCTION CONSIDERATIONS

12.1 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, organic creek bed deposits, disturbed soils and any deleterious materials within the footprint of the replacement culvert should be removed and replaced with granular material compacted as per OPSS.PROV 501. The peat noted in the boreholes drilled immediately outside of the embankment toes (Boreholes FE-1 and FE-4), if encountered, should be removed from the footprint of the culvert excavation to expose the underlying native silt. In the event that subgrade

subexcavation is required, the width of the subexcavation should be defined by a line extending from 0.5 m beyond the outside edge of the proposed culvert, outward and downward at 1H:1V. The subexcavated area should be backfilled with granular material meeting the requirements of OPSS.PROV 1010 for Granular A or Granular B Type II placed in accordance with OPSS.PROV.206, and compacted as per OPSS.PROV 501.

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

12.2 Bedding and Backfilling

The bedding material should be placed on the prepared subgrade as soon as practical following inspection and approval. The subgrade preparation to receive the bedding material should be carried out in the dry.

Considering high permeability of the embankment and fine grained underlying native soils at this site, there is a potential for groundwater seepage and surface water flow at the subgrade and bedding level. In order to provide a uniform foundation subgrade, a 300 mm thick layer of bedding material conforming to OPSS PROV 1010 Granular A or Granular B Type II requirements should be provided under the base of the proposed CSPs or box culvert.

Bedding requirements should follow OPSD 802.014 (Flexible Pipe Embedment in Embankments) for CSP pipe culvert, and OPSD 803.010 (Backfill and Cover for Concrete Box Culverts) for box culvert. In addition, 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.

The bedding should be placed in maximum 150 mm loose lifts and compacted to at least 95 per cent of the SPMDD of the material as specified in OPSS.PROV 501 (Compaction).

A separation layer consisting of a non-woven geotextile should be placed between the subgrade soil and the underside of the bedding 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.

Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which has to be protected from disturbance during construction.

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 802.014 or 803.010, as appropriate. Backfilling for the culvert should be in accordance with OPSS PROV 421 for a CSP and OPSS 422 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.

12.3 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 silt at this site are classified as Type 3 soils above the water level and Type 4 soils below the water level. Surficial alluvial deposits and peat that are anticipated in the inlet and outlet areas should be classified as Type 4 soils.

Excavation and backfilling for culvert construction should be carried out in accordance with OPSS 902.

Excavations for culvert replacement will be carried out through the existing embankment fill and will extend into the native silt deposit. Peat deposit as much as 1.4 m thick could be present at the north and south ends of the culvert footprint. Moreover, excavations for culvert replacement will be carried out below the creek water level, and diversion of the creek flow will be required. Given the relatively high permeability of the embankment fill materials and native silt, seepage should be anticipated from the embankment fill and the native silt adjacent to the creek. 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 design of an effective dewatering system that may be required is the responsibility of the Contractor and the Contract Documents must alert him to this responsibility and the need to engage a dewatering specialist. Dewatering must remain operational and effective until the culvert is installed and backfilled. Suggesting wording for an NSSP in this regard is included in Appendix F.

13. STREAM DIVERSION PIPE

The Preliminary General Arrangement drawing indicates a CSP stream diversion pipe located approximately 11 m to the east of the centreline of the new culvert. The invert of the diversion pipe is indicated at approximate Elev. 268.0 or approximately 3.6 m below the road grade. A very loose native silt will be encountered at the diversion pipe invert.

The temporary CSP should be placed on a minimum 150 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.

The stream diversion pipe could be installed within the temporary open cut excavations, or alternatively temporary roadway protection system could be utilized. The installation of the diversion pipe in open cut should follow OPSD 802.014 (Flexible Pipe Embedment in Embankment) and OPSS 421 (Pipe Culvert Installation in Open Cut). .

14. TEMPORARY PROTECTION SYSTEM

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

Interlocking sheet piles could be considered at this site. 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	Native Silt
Bulk Unit Weight (γ)	21 kN/m ³	20 kN/m ³	20 kN/m ³
Submerged Unit Weight (γ_w)	11 kN/m ³	10 kN/m ³	10 kN/m ³
Coefficient of Active Earth Pressure (K_a)	0.33	0.33	0.35
Coefficient of Passive Earth Pressure (K_p)	3.0	3.0	2.9

Full hydrostatic pressure should be considered assuming a water level equal to the design high water level in the creek.

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

Provided that the embankment is reconstructed with side slopes inclined at not steeper than 2H:1V, the restored embankment slope should remain stable. As discussed in Section 9.4, settlement of the embankment in the order of 25 should be expected under the existing culvert footprint.

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, Granular B Type II, or Granular B Type III material. Alternatively the existing embankment fill may be reused above the culvert cover and below the roadbase granular fill, provided it is free of organics, and at a moisture content that it is suitable for compaction.

Fill placement along the culvert should follow the requirements of OPSD

208.010 (Benching of Earth Slopes) to integrate the existing and new embankment fill.

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.

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 concrete cut-off wall or clay seal should be used to minimize the potential for erosion or piping around the culvert. The clay seal should extend laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The material requirements should be in accordance with OPSS PROV 1205. A geosynthetic clay liner may be used in place of a compacted clay seal.

17. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the native soil and creek water from the current and preliminary investigations indicates the following conditions at the locations tested:

- The potential for corrosion or sulphate attack on concrete foundations from the surrounding native 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.
- Appropriate protection measures commensurate with the above 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 should be employed to enable culvert construction in the dry and prevent base boiling, sloughing and instability of the excavation walls.
- The water level in the creek 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 and 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.

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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
 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.

UNIFIED SOILS CLASSIFICATION




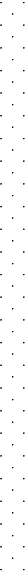
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, 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			

RECORD OF BOREHOLE No 16-21

1 OF 2

METRIC

W.P. 6310-14-01 LOCATION Flynne Creek East Culvert N 5 518 900.3 E 397 023.9 ORIGINATED BY TS
 HWY 11 BOREHOLE TYPE Solid Stem Augers/Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.08.12 - 2016.08.12 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
271.6	GROUND SURFACE						<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					<div><div>PLASTIC LIMITNATURAL MOISTURE CONTENTLIQUID LIMIT</div><div>W_PW_L</div><div>WATER CONTENT (%)</div><div>204060</div></div>						GRSA SILCL	
0.0	ASPHALT: (225mm)																		
0.2	SAND, trace to some gravel, trace to some silt, trace clay Very Loose to Compact Brown Moist (FILL)		1	GS			271									176221 (SI+CL)			
			2	SS	29														
			3	SS	7														5869 (SI+CL)
			4	SS	1														
268.5																			
3.1	SILT, some clay, trace sand, occasional peat lenses Very Loose to Loose Grey Moist to Wet		5	SS	2		268												038512
			6	SS	5		267												
266																			
265.5																			
6.1	SAND, trace silt, trace clay, trace gravel Very Loose to Loose Grey Wet		7	SS	1	265													
			8	SS	7	264											09631		
			9	SS	0	263													
262																			

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-21

2 OF 2

METRIC

W.P. 6310-14-01 LOCATION Flynne Creek East Culvert N 5 518 900.3 E 397 023.9 ORIGINATED BY TS
 HWY 11 BOREHOLE TYPE Solid Stem Augers/Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.08.12 - 2016.08.12 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE																	
	Continued From Previous Page						20	40	60	80	100						
			10	SS	9												
259.1			11	SS	39												
12.5	SILT, trace sand, trace clay Compact Grey Moist																
			12	SS	22												
257.3																	
14.3	END OF BOREHOLE AT 14.3m. WATER LEVEL AT 1.5m BELOW SURFACE AFTER DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS AND PATCHED WITH ASPHALT AT SURFACE.																

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-22

1 OF 1

METRIC

W.P. 6310-14-01 LOCATION Flynne Creek East Culvert N 5 518 896.5 E 397 998.3 ORIGINATED BY TS
 HWY 11 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.08.12 - 2016.08.12 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
271.6	GROUND SURFACE							20 40 60 80 100						
0.0	ASPHALT: (213mm)							20 40 60 80 100						
0.2	Silty SAND, trace to some gravel, trace clay Compact Brown Moist (FILL)		1	GS		▽	271						○	4 67 29 (SI+CL)
			2	GS			270						○	
269.8														
1.8	SAND, some gravel, trace silt Compact Grey Moist (FILL)		3	GS									○	18 73 9 (SI+CL)
269.2														
2.4	SILT, trace sand, some clay, trace rootlets Loose Grey Moist		4	GS		269						○		
			5	SS	7							○		0 7 80 13
267.9							268							
3.7	END OF BOREHOLE AT 3.7m. WATER LEVEL AT 1.8m BELOW SURFACE AFTER DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS AND PATCHED WITH ASPHALT AT SURFACE.													

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-23

1 OF 1

METRIC

W.P. 6310-14-01 LOCATION Flynne Creek East Culvert N 5 518 896.4 E 397 988.3 ORIGINATED BY TS
 HWY 11 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.08.12 - 2016.08.12 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
271.6	GROUND SURFACE													
0.0	ASPHALT: (200mm)													
0.2	Silty SAND, some gravel, trace clay Compact Brown Moist (FILL)		1	GS									10 65 25 (SI+CL)	
270.5														
1.1	SAND, some gravel, trace silt Compact Brown Moist to Wet (FILL)		2	GS										
			3	GS										
269.2														
2.4	SILT, some sand, trace clay, trace gravel Loose Grey Moist		4	GS									0 16 79 5	
			5	SS	5									
267.9														
3.7	END OF BOREHOLE AT 3.7m. WATER LEVEL AT 1.5m BELOW SURFACE AFTER DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS AND PATCHED WITH ASPHALT AT SURFACE.													

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-24

1 OF 1

METRIC

W.P. 6310-14-01 LOCATION Flynne Creek East Culvert N 5 518 896.3 E 397 978.3 ORIGINATED BY TS
 HWY 11 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.08.12 - 2016.08.12 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
271.6	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT: (250mm)																
271.3																	
0.3	Silty SAND, some gravel Compact Brown Moist (FILL)		1	GS			271										
270.5																	
1.1	SAND, some gravel, some silt Compact Brown Moist (FILL)		2	GS			270										14 68 18 (SI+CL)
269.5			3	GS													
2.1	SILT, some sand, some clay, trace gravel Loose Grey Wet						269										1 17 70 12
			4	GS													
			5	SS	4												
267.9							268										
3.7	END OF BOREHOLE AT 3.7m. WATER LEVEL AT 2.1m BELOW SURFACE AFTER DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS AND PATCHED WITH ASPHALT AT SURFACE.																

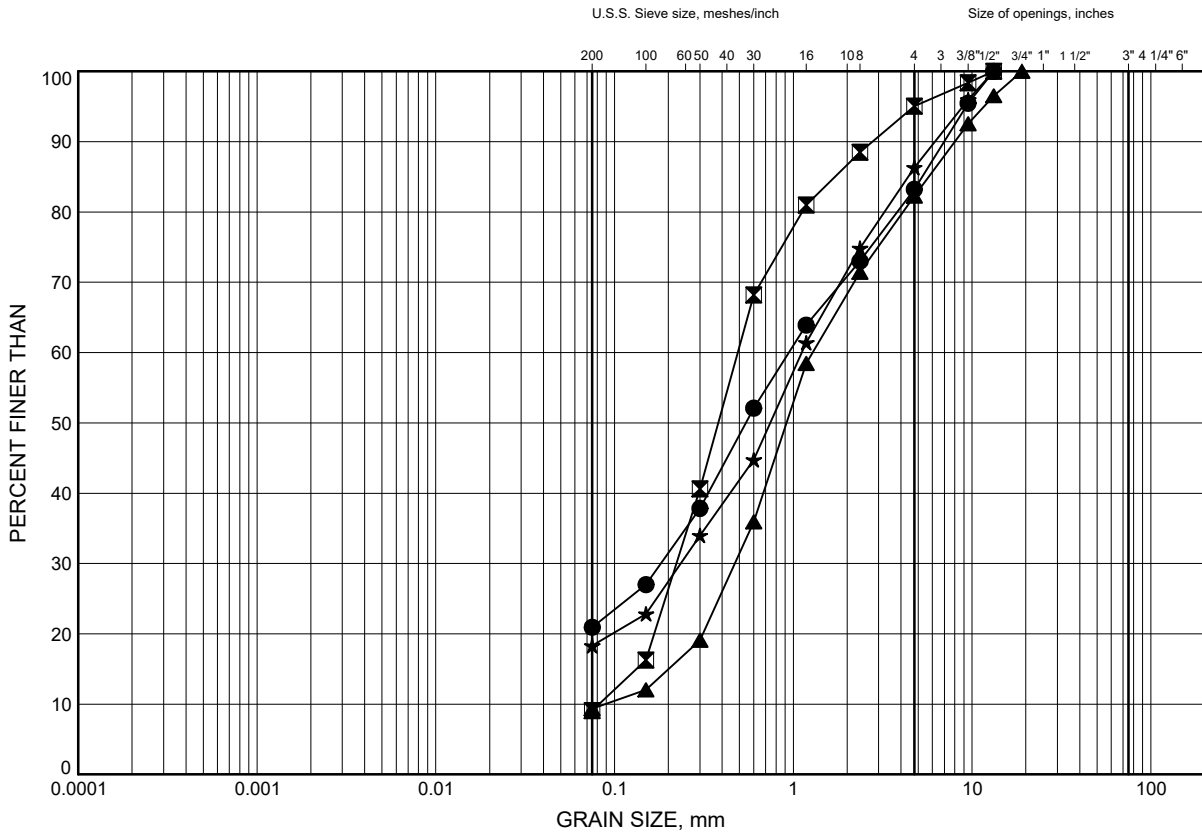
Appendix B

Geotechnical and Analytical Laboratory Test Results

Flynn Creek East Culvert GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-21	0.42	271.18
⊠	16-21	1.83	269.77
▲	16-22	2.13	269.47
★	16-24	1.37	270.23

Date February 2017
W.P. 6310-14-01



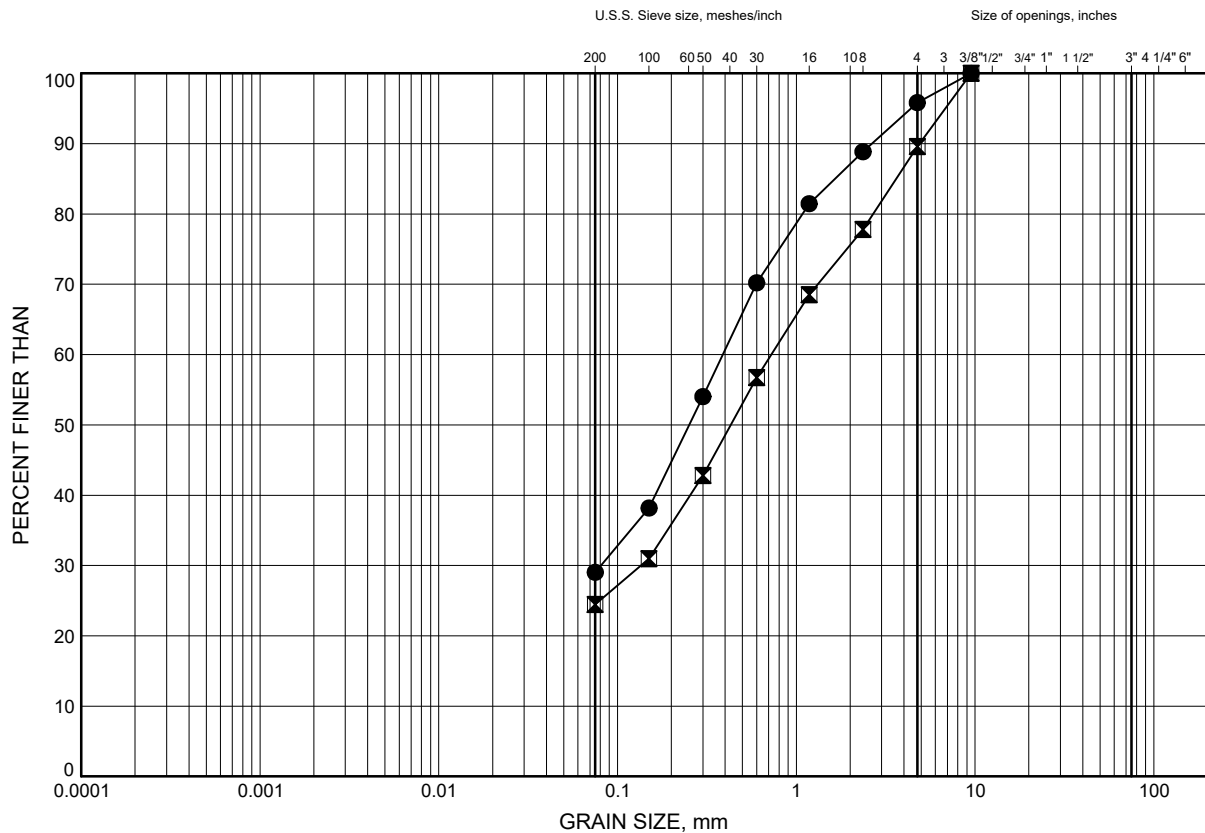
Prep'd AN
Chkd. AMP

Flynn Creek East Culvert

GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-22	0.53	271.07
⊠	16-23	0.53	271.07

Date February 2017
W.P. 6310-14-01

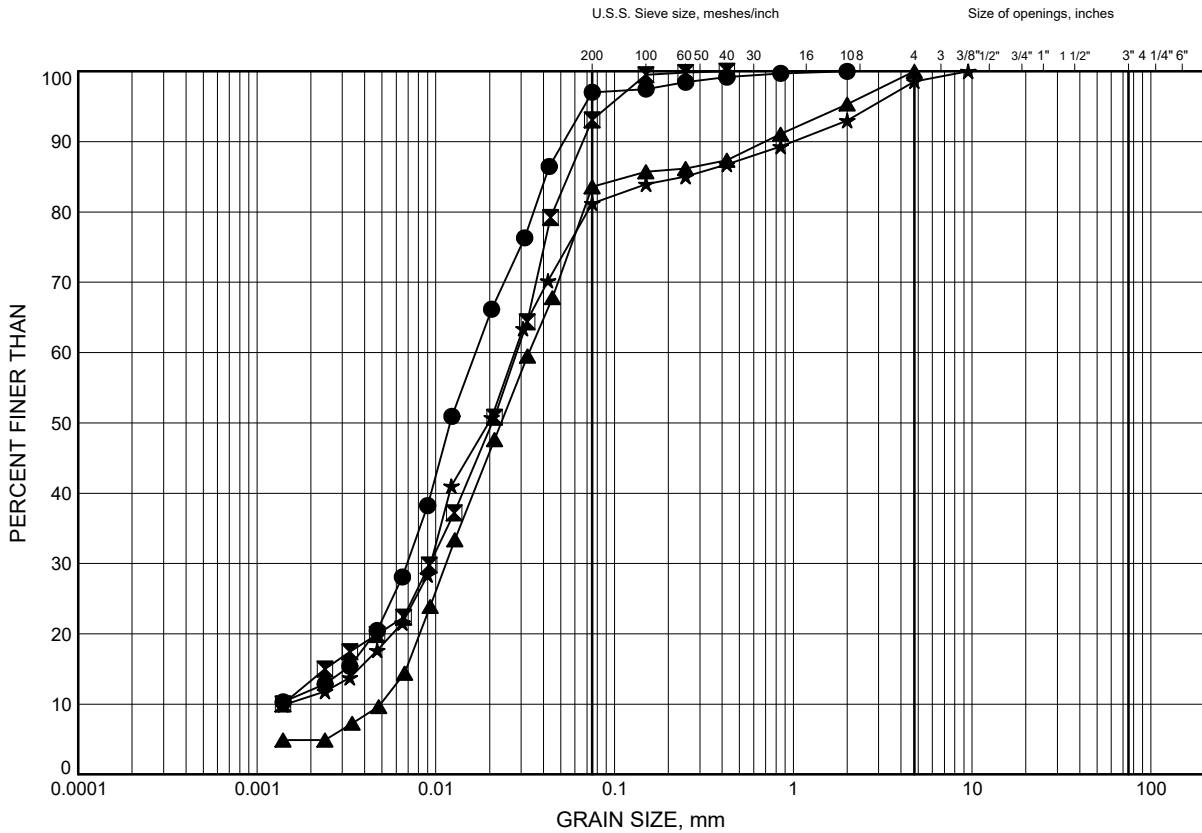


Prep'd AN
Chkd. AMP

Flynn Creek East Culvert GRAIN SIZE DISTRIBUTION

FIGURE B3

Upper SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-21	3.46	268.14
⊠	16-22	3.35	268.25
▲	16-23	2.74	268.86
★	16-24	2.90	268.70

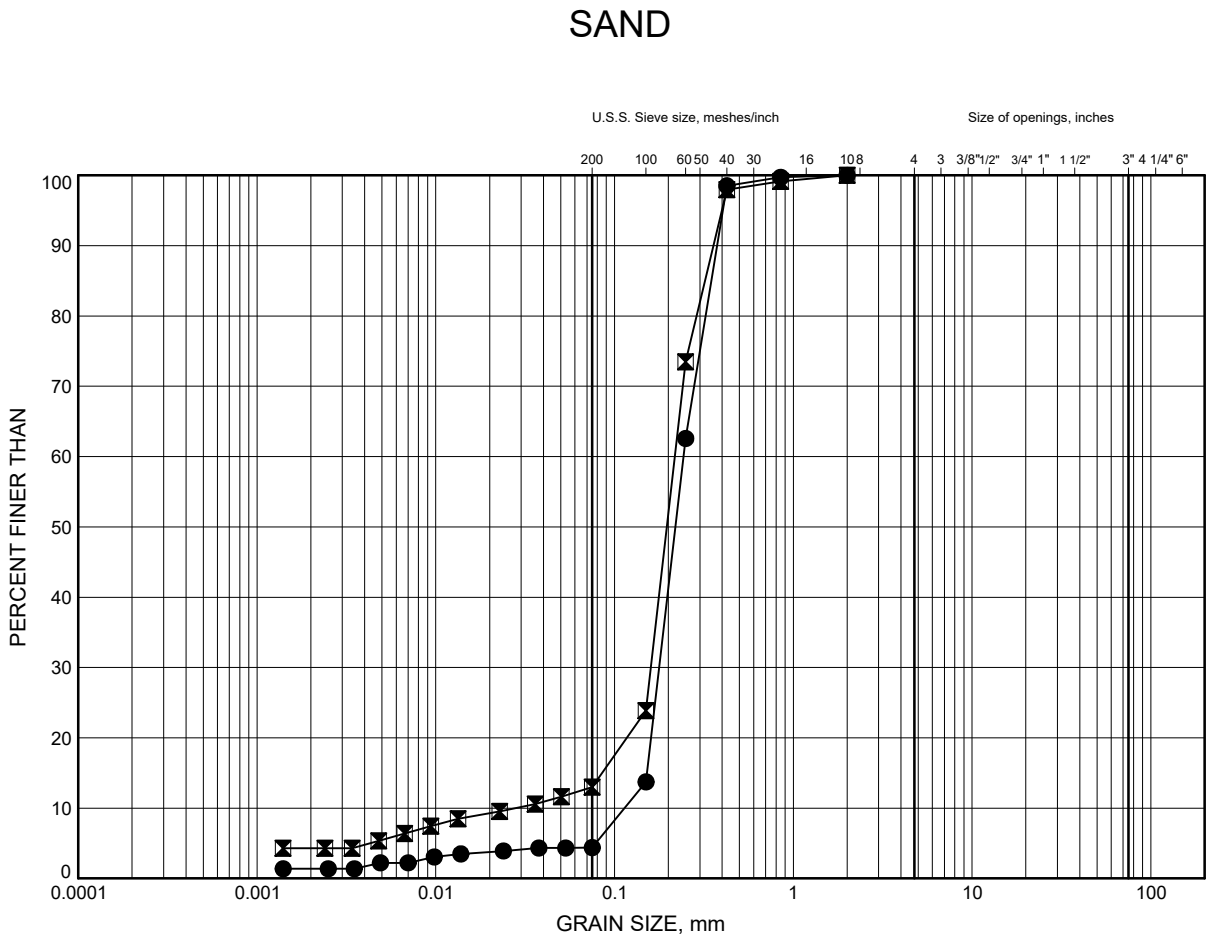
Date February 2017
W.P. 6310-14-01



Prep'd AN
Chkd. AMP

Flynn Creek East Culvert GRAIN SIZE DISTRIBUTION

FIGURE B4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-21	7.92	263.68
⊠	16-21	10.82	260.78

Date February 2017
W.P. 6310-14-01

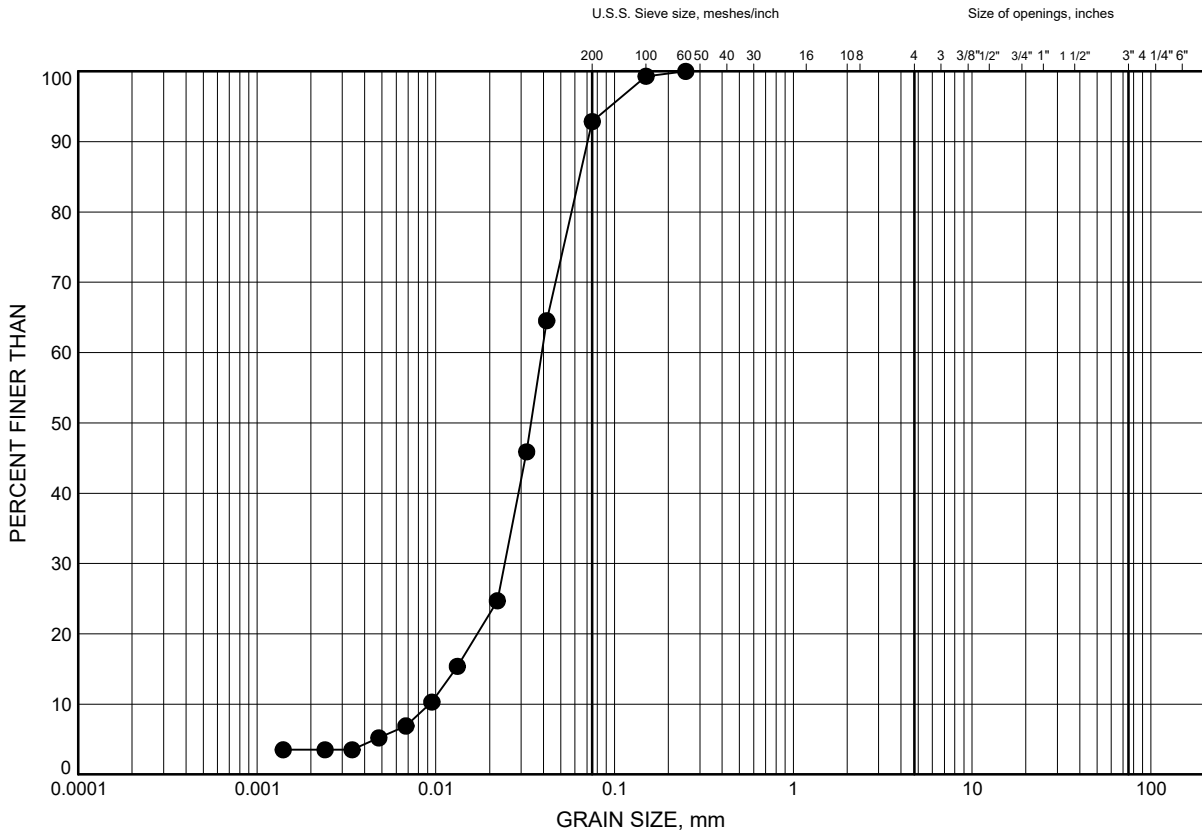


Prep'd AN
Chkd. AMP

Flynn Creek East Culvert GRAIN SIZE DISTRIBUTION

FIGURE B5

Lower SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-21	14.02	257.58

Date February 2017
W.P. 6310-14-01



Prep'd AN
Chkd. AMP

SGS Canada Inc.

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13662
29-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. : 25 August 2016
LR Report: CA15493-AUG16
Reference: 13662 Mark Farrant

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	6: BH-21, SS#7, 15'-17'
Sample Date & Time					24-Aug-16
Temperature Upon Receipt [°C]	---	---	---	---	16.0
Corrosivity Index [none]	---	---	29-Aug-16	15:32	1
pH [no unit]	27-Aug-16	10:28	29-Aug-16	15:29	7.62
Soil Redox Potential [mV]	26-Aug-16	13:46	29-Aug-16	11:43	115
Sulphide [%]	26-Aug-16	14:07	26-Aug-16	14:13	< 0.02
% Moisture (wet wt) [%]	25-Aug-16	15:23	25-Aug-16	15:23	17.1
pH [no unit]	26-Aug-16	08:44	29-Aug-16	11:36	8.69
Chloride [µg/g]	25-Aug-16	19:10	29-Aug-16	13:38	100
Sulphate [µg/g]	25-Aug-16	19:10	29-Aug-16	13:38	13
Conductivity [µS/cm]	26-Aug-16	08:44	29-Aug-16	12:11	156
Resistivity (calculated) [Ohms.cm]	---	---	29-Aug-16	14:39	6400

Temperature of Samples upon receipt 28.3 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.



Brian Graham B.Sc.
Project Specialist
Environmental Services, Analytical

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13662**Thurber Engineering Ltd.****Attn : Mark Farrant**

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

Phone: 905-829-8666 x 228
Fax:

17-November-2016

Date Rec. : 16 August 2016
LR Report: CA15286-AUG16
Reference: 13662 Mark Farrant

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: Flynn Creek
Sample Date & Time						12-Aug-16
Temperature Upon Receipt [°C]	---	---	--	--	---	4.0
Corrosivity Index [none]	23-Aug-16	16:05	23-Aug-16	16:05		4
pH [no unit]	16-Aug-16	11:00	16-Aug-16	14:58	0.05	7.70
Conductivity [µS/cm]	16-Aug-16	11:00	16-Aug-16	14:58	2	424
Resistivity (calculated) [Ohms.cm]	16-Aug-16	11:00	24-Aug-16	09:08	---	2360
Redox Potential [mV]	16-Aug-16	14:10	17-Aug-16	11:15	---	198
Chloride [mg/L]	16-Aug-16	13:23	19-Aug-16	16:55	0.04	64
Sulphate [mg/L]	16-Aug-16	13:23	19-Aug-16	16:55	0.04	0.15
Sulphide [mg/L]	17-Aug-16	13:02	18-Aug-16	15:07	0.006	< 0.006

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


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



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 : CA15286-AUG16

Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank				LCS / Spike Blank			Matrix Spike / Reference Material		
					RPD	Acceptance Criteria	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
						%		Low	High		Low	High
Anions by IC - QCBatchID: DIO0220-AUG16												
Chloride	0.04	mg/L	<0.04		NV	20	101	80	120	NV	75	125
Sulphate	0.04	mg/L	<0.04		3	20	100	80	120	97	75	125
Conductivity - QCBatchID: EWL0226-AUG16												
Conductivity	2	µS/cm	4.44		6	10	99	90	110	NA		
pH - QCBatchID: EWL0226-AUG16												
pH	0.05	no unit	NA		1		101			NA		
Redox Potential - QCBatchID: EWL0230-AUG16												
Redox Potential	no	mV	NA		3	20	106	80	120	NA		
Sulphide by SFA - QCBatchID: SKA0139-AUG16												
Sulphide	0.006	mg/L	<0.006		100	20	101	80	120	104	75	125

Appendix C

Selected Site Photographs



Photo 1: Flynn Creek Culvert, looking north



Photo 2: Flynn Creek Culvert, looking south



Photo 3: Flynne Creek Culvert, looking east



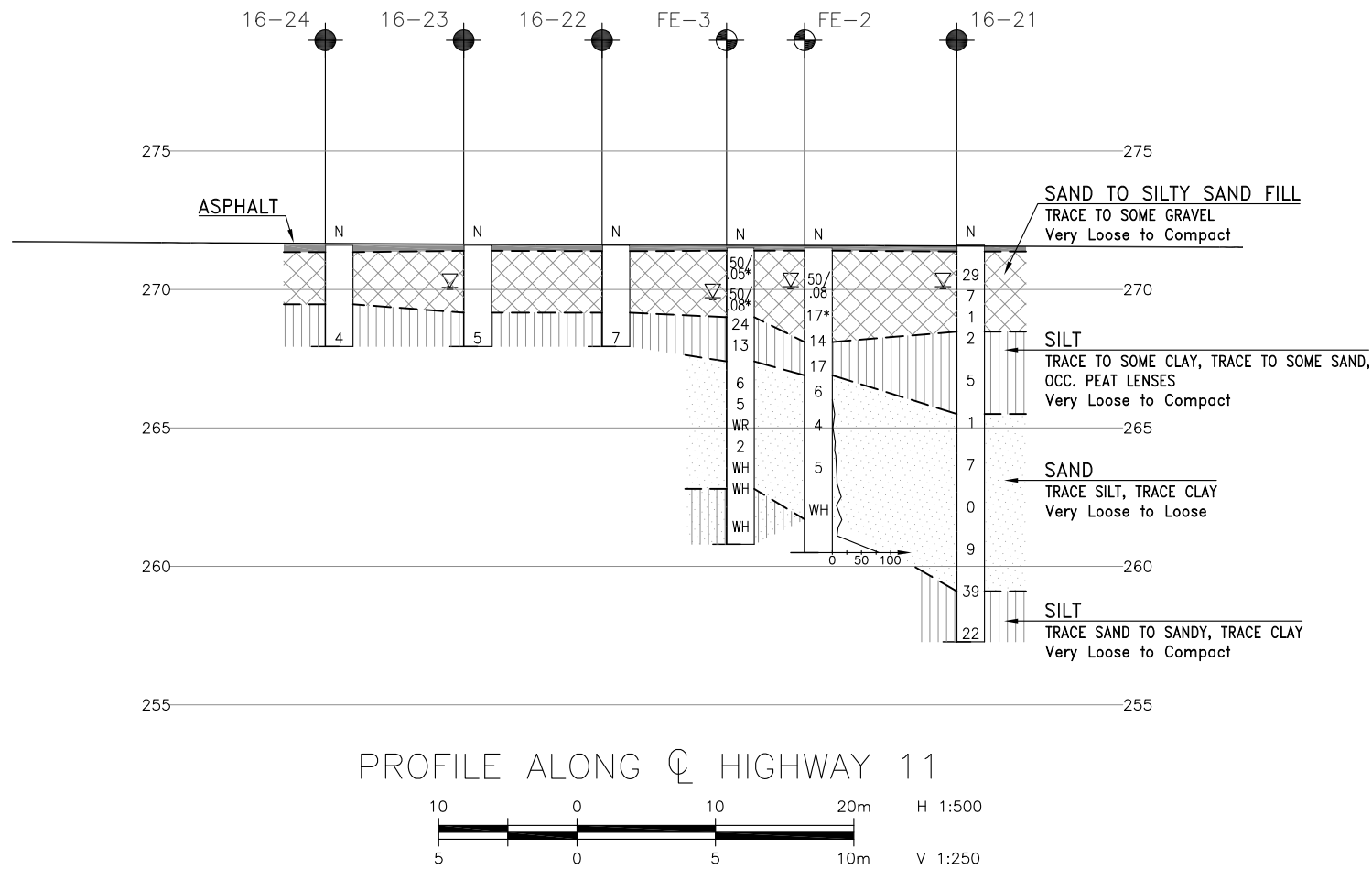
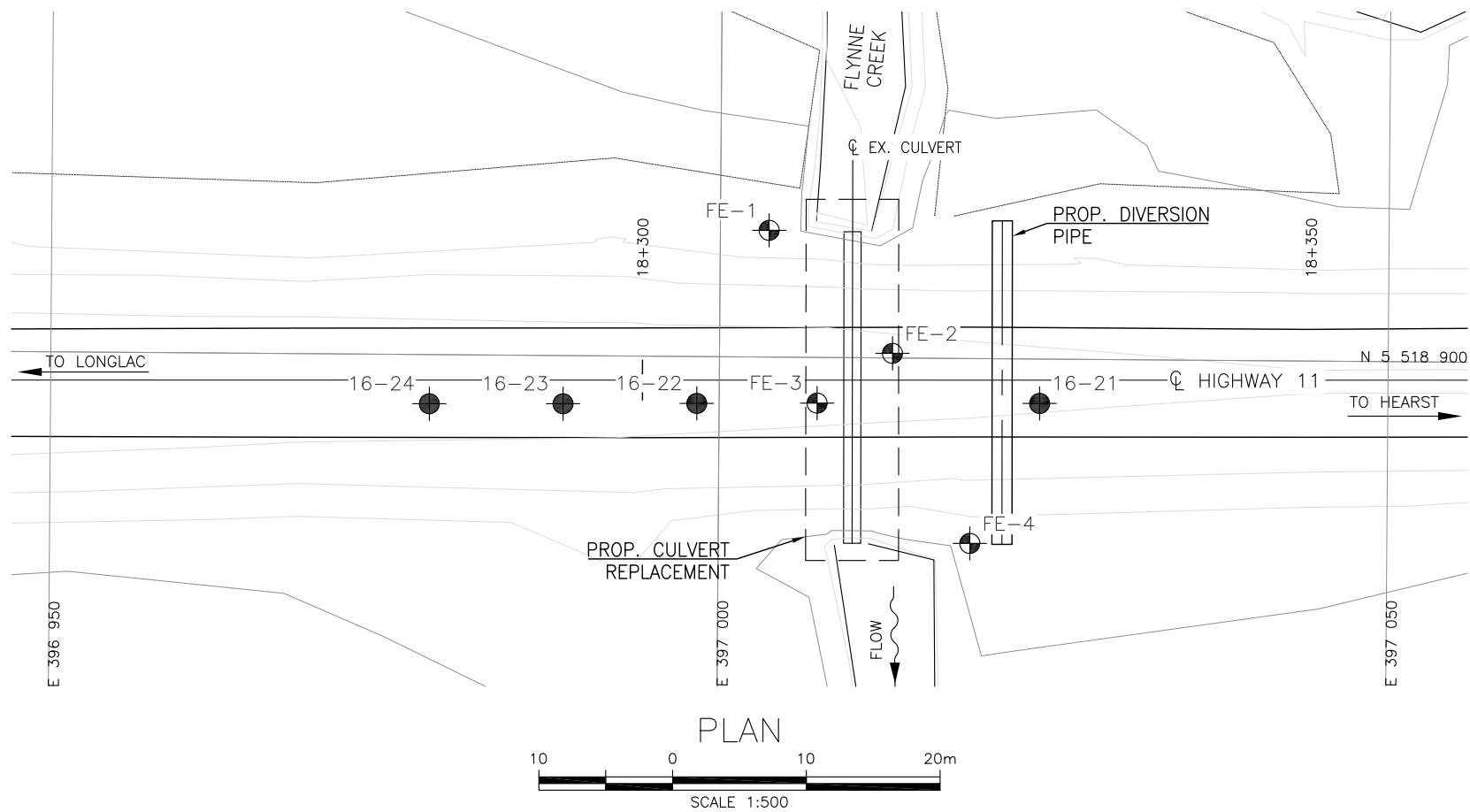
Photo 4: Flynne Creek Culvert, inlet (north side)



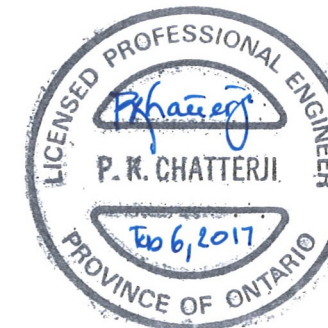
Photo 5: Flynne Creek Culvert, outlet (south side)

Appendix D

Borehole Locations and Soil Strata Drawing



METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



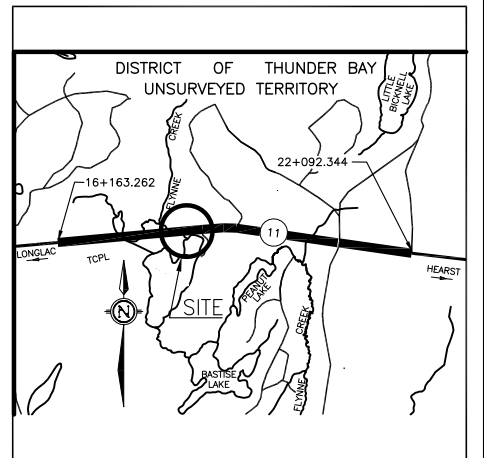
CONT No 2017-6001
WP No 6310-14-01

HIGHWAY 11
FLYNNE CREEK EAST
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET
22

HATCH



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
16-21	271.6	5 518 896.7	397 024.0
16-22	271.6	5 518 896.5	396 998.3
16-23	271.6	5 518 896.4	396 988.3
16-24	271.6	5 518 896.3	396 978.3
FE-1	270.4	5 518 909.5	397 003.6
FE-2	271.5	5 518 900.3	397 012.9
FE-3	271.5	5 518 896.6	397 007.3
FE-4	270.4	5 518 886.2	397 018.8

-NOTES-

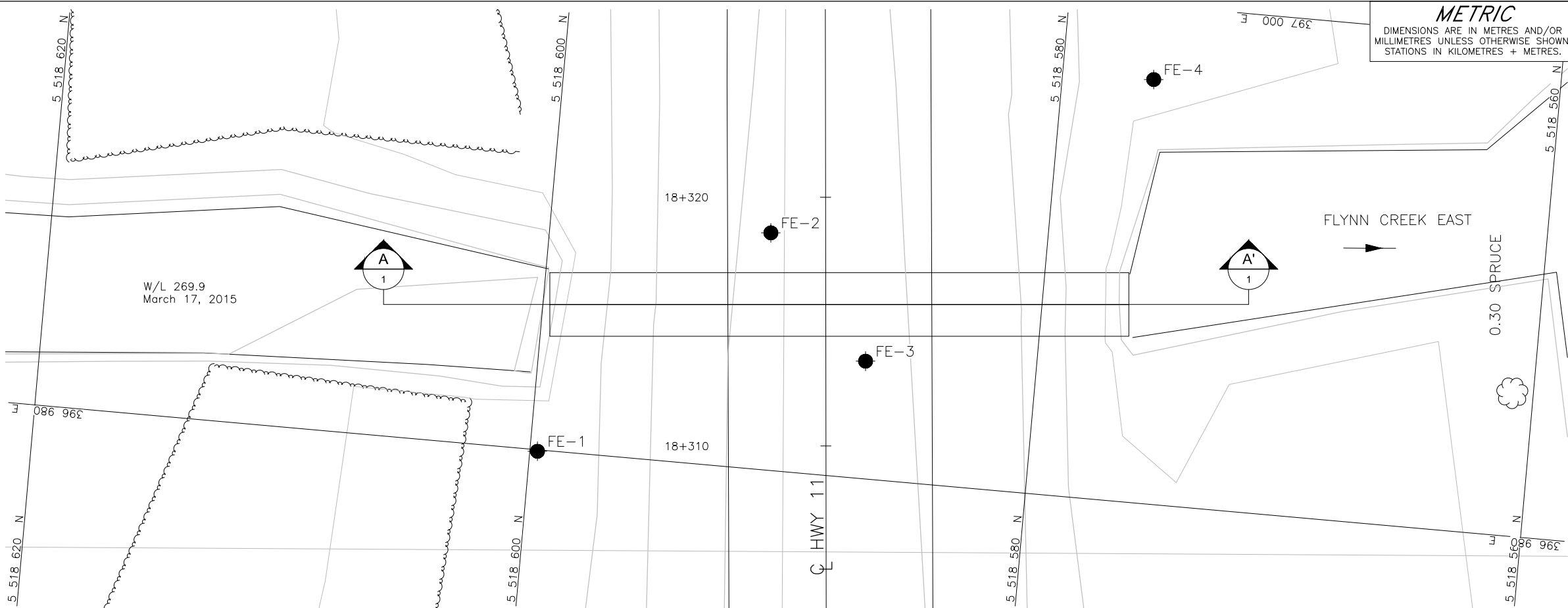
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- MTM Zone 14 co-ordinate system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

GEOCRES No. 42F-40

REVISIONS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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Appendix E

**Record of Borehole Sheets and Borehole Location and Soil Strata Drawing
Geocres No 42F-34**

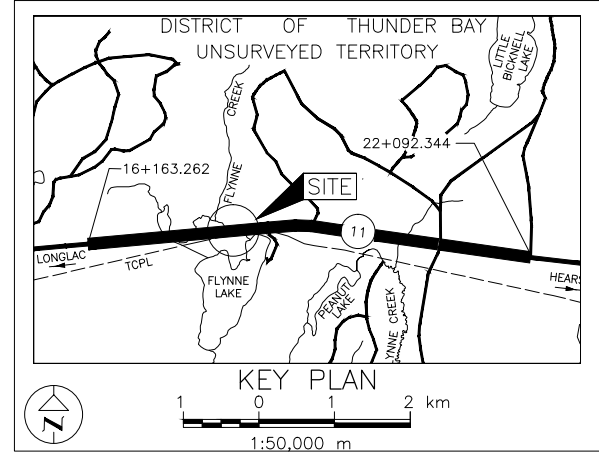


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No. GWP No. 6310-14-00

HIGHWAY 11
FLYNN CREEK EAST CULVERT STA 18+316
BOREHOLE LOCATION PLAN AND
SOIL STRATA

SHEET



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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
FE-1	270.4	5518599.7	396979.9
FE-2	271.5	5518591.1	396989.5
FE-3	271.5	5518586.9	396984.7
FE-4	270.4	5518576.3	396997.0

NOTES

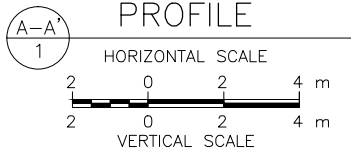
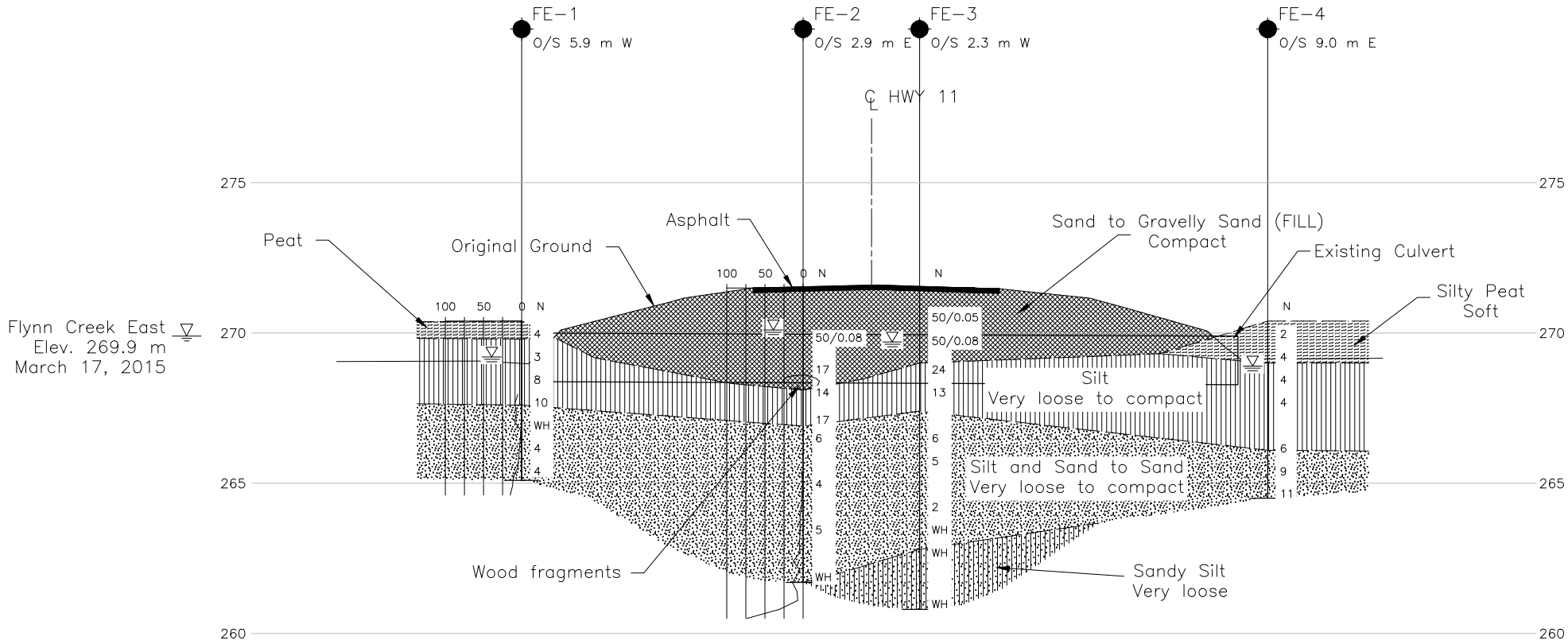
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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. BC494854114, dated NOV 2008, received FEB 20 2015.



NO.	DATE	BY	REVISION
Geocres No. 42F-34			
HWY. 11	PROJECT NO. 1411523		DIST. .
SUBM'D. AC	CHKD. .	DATE: 9/3/2015	SITE: 48E-125/C
DRAWN: TB	CHKD. SEMP	APPD. JMAC	DWG. 1




PROJECT		1411523		RECORD OF BOREHOLE No FE-1		1 OF 1 METRIC											
G.W.P.		6310-14-00		LOCATION		N 5518599.7; E 396979.9											
DIST		HWY 11		BOREHOLE TYPE		108 mm I. D. Hollow Stem Augers											
DATUM		GEODETIC		DATE		February 23, 2015											
				ORIGINATED BY		SC											
				COMPILED BY		TB											
				CHECKED BY		SEMP											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
270.4	GROUND SURFACE																
0.0	PEAT (Amorphous), some rootlets, trace gravel Black Frozen		1	SS	4	▽	270										
269.8							269										
0.6	SILT, trace to some clay, trace sand, trace gravel Very loose to compact Grey Moist		2	SS	3		268										
			3	SS	8												
			4	SS	10												
267.6							267										
2.8	SAND, trace to some silt, trace gravel Very loose Grey Wet		5	SS	WR												
			6	SS	4												
			7	SS	4												
265.1	Approximately 0.7 m of heave encountered at 5.3 m depth.						266										
5.3	END OF BOREHOLE						265										
264.6																	
5.8	END OF DCPT																
	Note: 1. Water level at a depth of 1.2 m below ground surface (Elev. 269.2 m) upon completion of drilling. 2. Advanced DCPT 0.5 m west of Borehole FE-1. Advanced hollow stem augers to 2.3 m depth and started DCPT.																

PROJECT 1411523		RECORD OF BOREHOLE No FE-2				1 OF 1 METRIC							
G.W.P. 6310-14-00		LOCATION N 5518591.1; E 396989.5				ORIGINATED BY NJ							
DIST _____ HWY 11		BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers				COMPILED BY TB							
DATUM GEODETIC		DATE March 17, 2015				CHECKED BY SEMP							
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa		WATER CONTENT (%)		γ kN/m ³	GR SA SI CL
							20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED	W _p W W _L			
271.5	GROUND SURFACE												
0.0	ASPHALT (130 mm)												
0.1	Sand, some gravel (FILL) Compact Grey to brown Frozen* to moist		1	AS	-		271						
	Trace wood encountered in Samples 3 and 4A.		2	SS	50/0.08		270						
			3	SS	17*		269						
268.1			A										
3.4	SILT, trace to some clay, trace sand Compact Grey Wet		4	SS	14		268					NP	0 4 89 7
			B										
266.9			5	SS	17		267						
4.6	SAND, trace to some silt, trace gravel Very loose to loose Grey Wet		6	SS	6		266						
	Approximately 0.3 m of heave encountered in augers at 4.6 m depth.						265						
			7	SS	4		264						
			8	SS	5		263						
							262						
261.7			9	SS	WH		261						
9.8	END OF BOREHOLE												
260.5	END OF DCPT												
11.0	Note: 1. Water level at a depth of 1.4 m below ground surface (Elev. 270.1 m) upon completion of drilling. 2. Advanced DCPT 1.0 m north of Borehole FE-2. Advanced hollow stem augers to 4.6 m depth and started DCPT.												

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 28/05/15 DATA INPUT:

PROJECT 1411523			RECORD OF BOREHOLE No FE-3			1 OF 1 METRIC														
G.W.P. 6310-14-00			LOCATION N 5518586.9; E 396984.7			ORIGINATED BY NJ														
DIST _____ HWY 11			BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers			COMPILED BY TB														
DATUM GEODETIC			DATE March 17, 2015			CHECKED BY SEMP														
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%) W _p W W _L			γ	GR	SA	SI	CL
271.5	GROUND SURFACE							20 40 60 80 100												
0.0	ASPHALT (140 mm)																			
0.1	Sand to gravelly sand, trace to some silt (FILL) Brown Frozen* to wet		1	AS	-		271													
			2	SS	50/ 0.05*															
			3	SS	50/ 0.08*		270													
269.0	SILT, trace to some clay, trace sand Compact Grey Wet		A 4	SS	24		269											21	70	(9)
2.5	A 75 mm thick layer of black organics encountered at 2.5 m depth.		B																	
			5	SS	13		268											0	4	89 7
267.4	SILT and SAND to SAND Very loose to loose Grey Wet																			
4.1			6	SS	6		267													
			7	SS	5		266													
			8	SS	WR		265													
			9	SS	2		264													
			10	SS	WH													0	52	41 7
262.8	Sandy SILT, trace clay Very loose Grey Wet		A 11	SS	WH		263													
8.7			B				262													
			12	SS	WH		261													
260.8	END OF BOREHOLE																			
10.7	Note: 1. Water level at a depth of 1.8 m below ground surface (Elev. 269.7 m) upon completion of drilling.																			

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 28/05/15 DATA INPUT:

PROJECT 1411523		RECORD OF BOREHOLE No FE-4				1 OF 1 METRIC											
G.W.P. 6310-14-00		LOCATION N 5518576.3; E 396997.0				ORIGINATED BY SC											
DIST _____ HWY 11		BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers				COMPILED BY TB											
DATUM GEODETIC		DATE February 21, 2015				CHECKED BY SEMP											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
270.4	GROUND SURFACE							20	40	60	80	100					
0.0	Silty PEAT (Amorphous) Soft Black to brown Frozen* to moist		1	SS	2*	▽	270										
			2	SS	4		269										
269.0	SILT, trace to some sand, trace clay Loose Grey Wet		3	SS	4		268										
1.4			4	SS	4		267										
			A 5 B	SS	6		266										
266.1	SAND, trace to some silt Loose to compact Grey Wet		6	SS	9		265										
4.3			7	SS	11												
264.5	END OF BOREHOLE																
5.9	Note: 1. Water level at a depth of 1.5 m below ground surface (Elev. 268.9 m) upon completion of drilling.																

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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 421
- OPSS PROV 422
- OPSS PROV 501
- OPSS.PROV 517
- OPSS PROV 539
- OPSS PROV 804
- OPSS PROV 902
- OPSS PROV 1010
- OPSS PROV 1205
- OPSS 1860
- OPSD 208.010
- OPSD 802.010
- OPSD 802.014
- OPSD 803.010
- OPSD 803.031
- OPSD 3090.100

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. The dewatering system must be effective to maintain the water level at a minimum depth of 0.5 m below the final subgrade level throughout construction. The dewatering system must remain operational and effective until the culvert is installed and backfilled.

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."