



THURBER ENGINEERING LTD.



**FOUNDATION INVESTIGATION 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

File: 13662

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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

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E file: H:\13000-13999\13662 MTO NWR Retainer Assignment 4 - Chicken Farm, Chowder, Flynne, Sawmill Culverts\Reports & Memos\Flyyne Creek East Culvert\FINAL\Flyyne Creek East Culvert - FIR FINAL.docx

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.



Thurber Engineering Ltd.

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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.

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 Flynn 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 | | | | | | |
| | | | | | | 20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE WATER CONTENT (%) 20 40 60 | | | | | | | | |
| 271.6 | GROUND SURFACE | | | | | | | | | | | | | |
| 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 | | | | | | | | | 17 62 21 (SI+CL) | |
| | | | 2 | SS | 29 | | | | | | | | | |
| | | | 3 | SS | 7 | | | | | | | | | 5 86 9 (SI+CL) |
| | | | 4 | SS | 1 | | | | | | | | | |
| 268.5 | SILT, some clay, trace sand, occasional peat lenses Very Loose to Loose Grey Moist to Wet | | 5 | SS | 2 | | | | | | | | 0 3 85 12 | |
| | | | 6 | SS | 5 | | | | | | | | | |
| | | | 7 | SS | 1 | | | | | | | | | |
| 265.5 | SAND, trace silt, trace clay, trace gravel Very Loose to Loose Grey Wet | | 8 | SS | 7 | | | | | | | | 0 96 3 1 | |
| | | | 9 | SS | 0 | | | | | | | | | |
| | | | | | | | | | | | | | | |

ONTMT4S_13662-MTO.GPJ_2015TEMPLATE(MTO).GDT_2/7/17

Continued Next Page

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

RECORD OF BOREHOLE No 16-21

2 OF 2

METRIC

W.P. 6310-14-01 LOCATION Flynn 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 | | | | | | | | | |
| | Continued From Previous Page | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | | |
| 259.1 | | | 10 | SS | 9 | | | | | | | | | | | 0 87 9 4 | |
| 12.5 | SILT , trace sand, trace clay Compact Grey Moist | | 11 | SS | 39 | | | | | | | | | | | | |
| 257.3 | | | 12 | SS | 22 | | | | | | | | | | | 0 7 89 4 | |
| 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. | | | | | | | | | | | | | | | | |

ONTMT4S_13662-MTO.GPJ_2015TEMPLATE(MTO).GDT_2/7/17

+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 Flynn 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 (%) | |
|---------------|--|------------|---------|------|------------|----------------------------|--|---|----|----|-----|------------------------------------|---|---|--------------------|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | |
| | | | | | | | 20 | 40 | 60 | 80 | 100 | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | |
| | | | | | | | ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | WATER CONTENT (%) | | | |
| | | | | | | | 20 | 40 | 60 | 80 | 100 | 20 | 40 | 60 | |
| 271.6 | GROUND SURFACE | | | | | | | | | | | | | | |
| 0.0 | ASPHALT: (213mm) | | | | | | | | | | | | | | |
| 0.2 | Silty SAND, trace to some gravel, trace clay Compact Brown Moist (FILL) | | 1 | GS | | | | | | | | ○ | | | 4 67 29 (SI+CL) |
| | | | 2 | GS | | | | | | | | ○ | | | |
| 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 | | | | | | | | ○ | | | |
| | | | 5 | SS | 7 | | | | | | | ○ | | | 0 7 80 13 |
| 267.9 | | | | | | | | | | | | | | | |
| 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. | | | | | | | | | | | | | | |

ONTMT4S_13662-MTO.GPJ_2015TEMPLATE(MTO).GDT_2/7/17

+³, ×³: Numbers refer to Sensitivity $\frac{20}{15} \pm 5$ 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-23

1 OF 1

METRIC

W.P. 6310-14-01 LOCATION Flynn 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 (%) |
|--------------|--|------------|---------|------|------------|--|-----------------|--|--|--|--|--|--|---------------------------------------|
| ELEV. DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | |
| | | | | | | 20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE WATER CONTENT (%) 20 40 60 | | | | | | | | |
| 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. | | | | | | | | | | | | | |

ONTMT4S_13662-MTO.GPJ_2015TEMPLATE(MTO).GDT_2/7/17

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

RECORD OF BOREHOLE No 16-24

1 OF 1

METRIC

W.P. 6310-14-01 LOCATION Flynn 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 | | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--------------|--|------------|---------|------|------------|--|-----------------|--|--|--|--|--|--|---------------------------------------|
| ELEV. DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | |
| | | | | | | 20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 | | | | | | | | |
| | | | | | | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L WATER CONTENT (%) 20 40 60 | | | | | | | | |
| 271.6 | GROUND SURFACE | | | | | | | | | | | | | |
| 0.0 | ASPHALT: (250mm) | | | | | | | | | | | | | |
| 271.3 | | | | | | | | | | | | | | |
| 0.3 | Silty SAND , some gravel Compact Brown Moist (FILL) | | 1 | GS | | | | | | | | | | |
| 270.5 | | | | | | | | | | | | | | |
| 1.1 | SAND , some gravel, some silt Compact Brown Moist (FILL) | | 2 | GS | | | | | | | | | 14 68 18 (SI+CL) | |
| 270.5 | | | | | | | | | | | | | | |
| 269.5 | | | 3 | GS | | | | | | | | | | |
| 2.1 | SILT , some sand, some clay, trace gravel Loose Grey Wet | | | | | | | | | | | | | |
| 269.5 | | | 4 | GS | | | | | | | | | 1 17 70 12 | |
| 269.5 | | | 5 | SS | 4 | | | | | | | | | |
| 267.9 | | | | | | | | | | | | | | |
| 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. | | | | | | | | | | | | | |

ONT/MT/4S_13662-MTO.GPJ_2015TEMPLATE(MTO).GDT_2/7/17

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

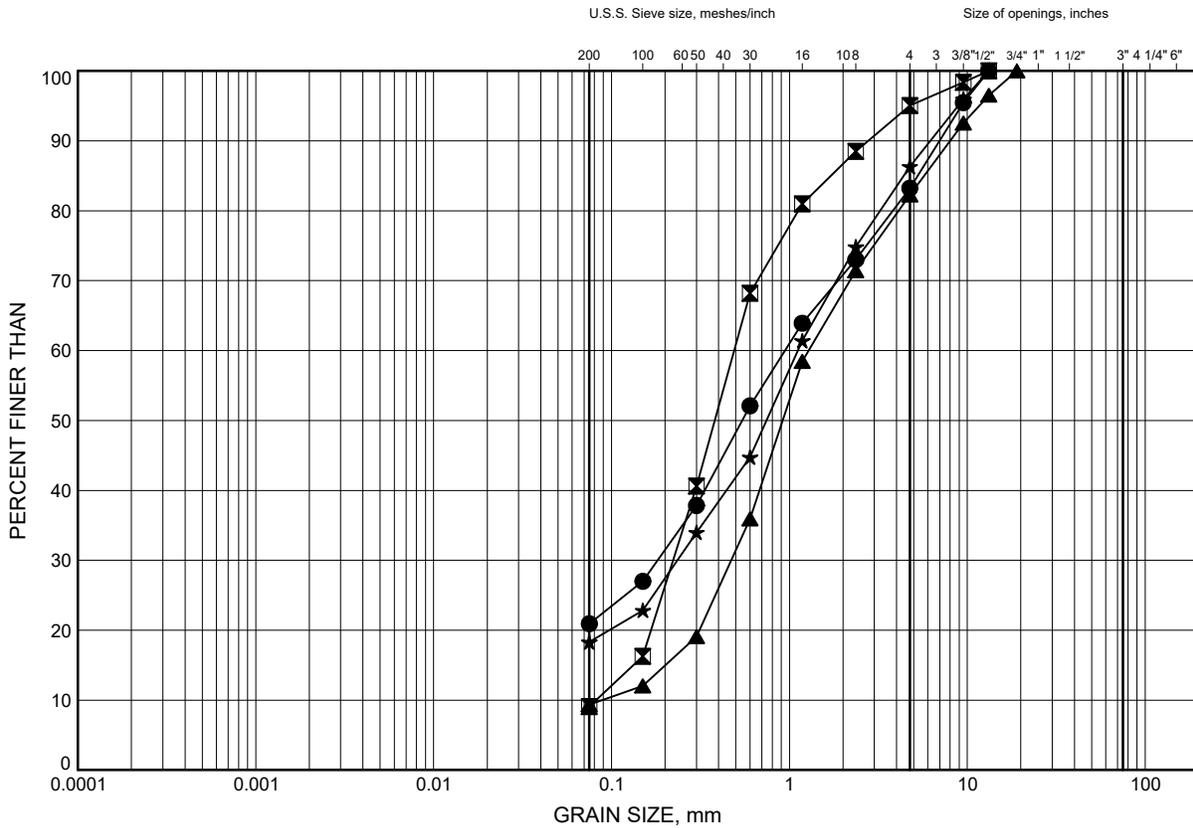
Appendix B

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 |

GRAIN SIZE DISTRIBUTION - THURBER 13662-MTO.GPJ 9/27/16

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

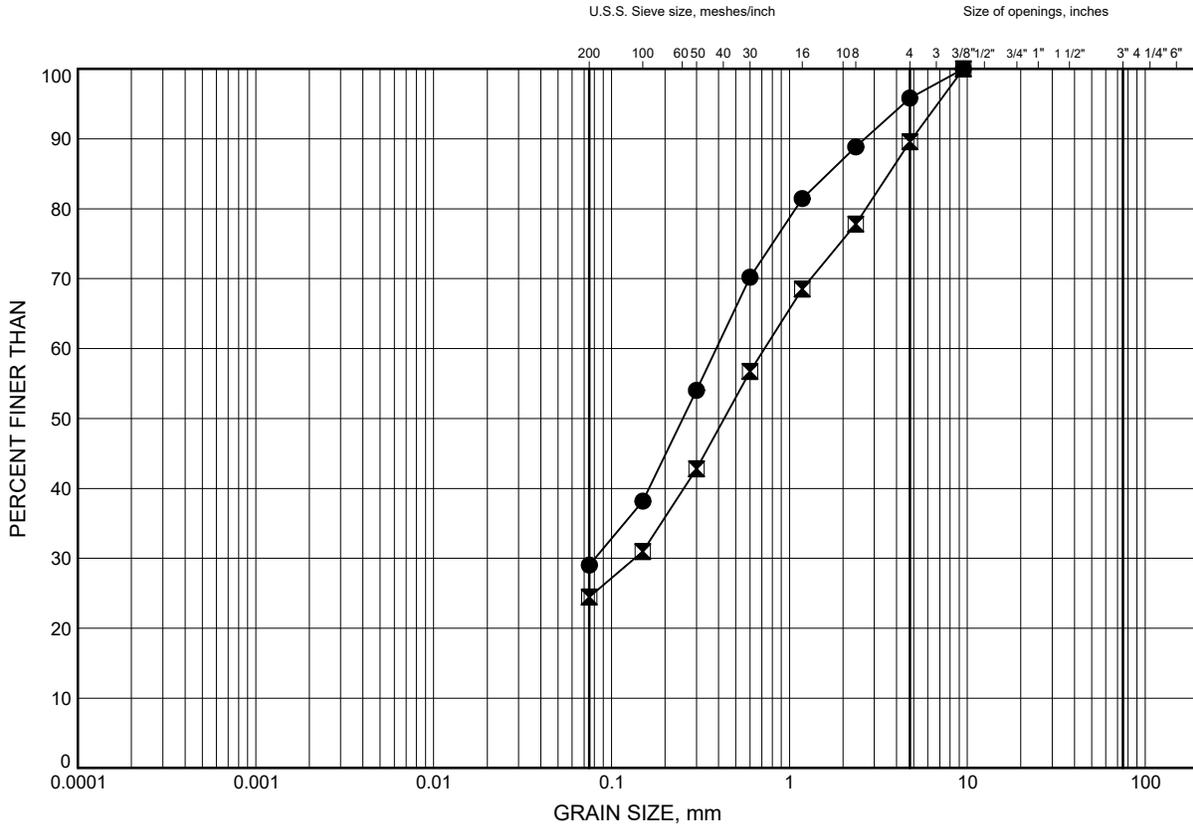


Prep'd AN
 Chkd. AMP

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 |

GRAIN SIZE DISTRIBUTION - THURBER 13662-MTO.GPJ 9/27/16

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

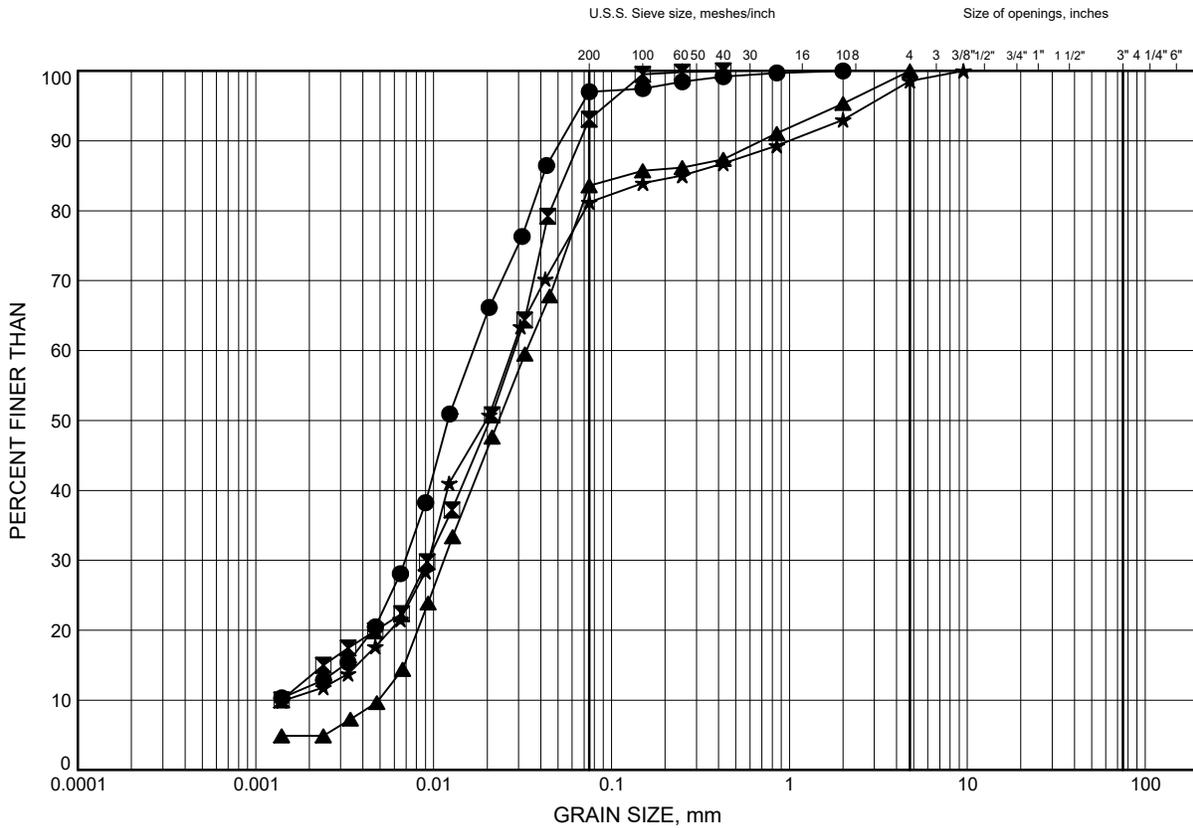


Prep'd AN
 Chkd. AMP

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 |

GRAIN SIZE DISTRIBUTION - THURBER 13662-MTO.GPJ 10/24/16

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

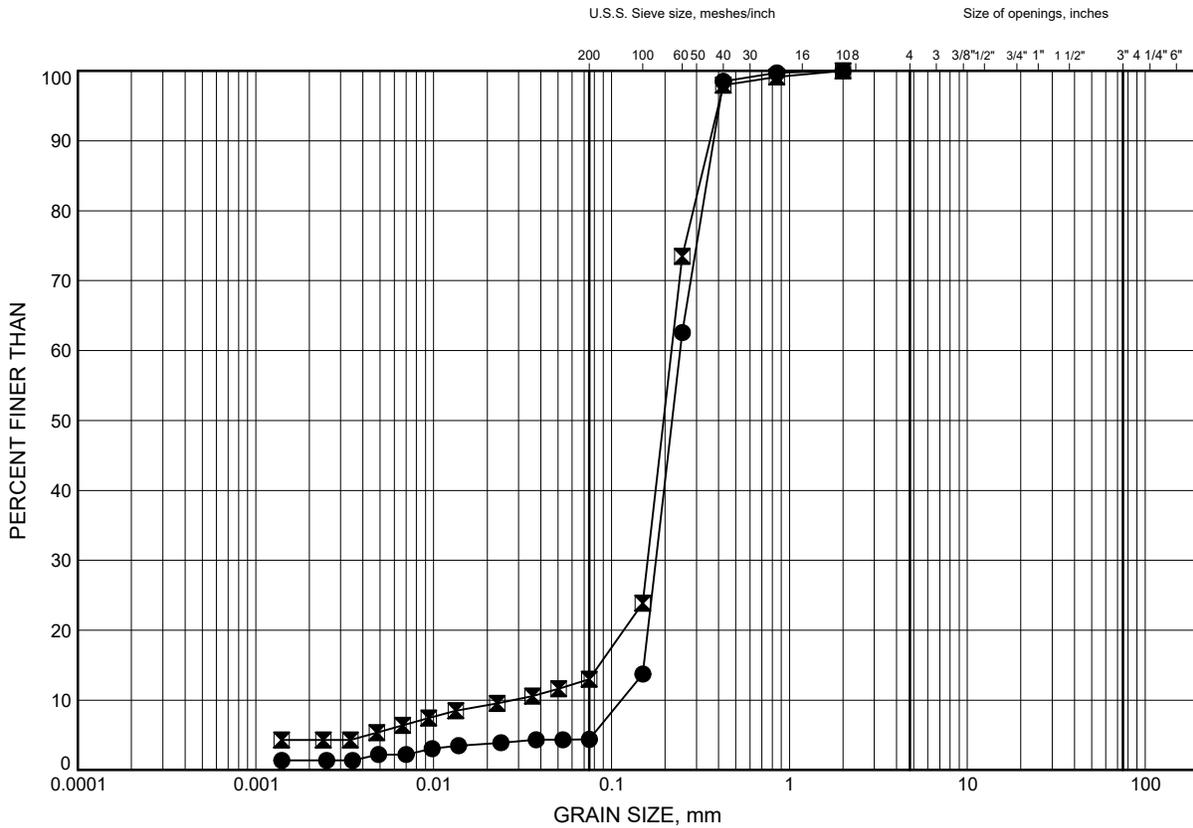


Prep'd AN
Chkd. AMP

Flynn Creek East Culvert GRAIN SIZE DISTRIBUTION

FIGURE B4

SAND



| | | | | | | |
|---------------|------|--------|--------|--------|--------|-------------|
| 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 |

GRAIN SIZE DISTRIBUTION - THURBER 13662-MTO.GPJ 9/27/16

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

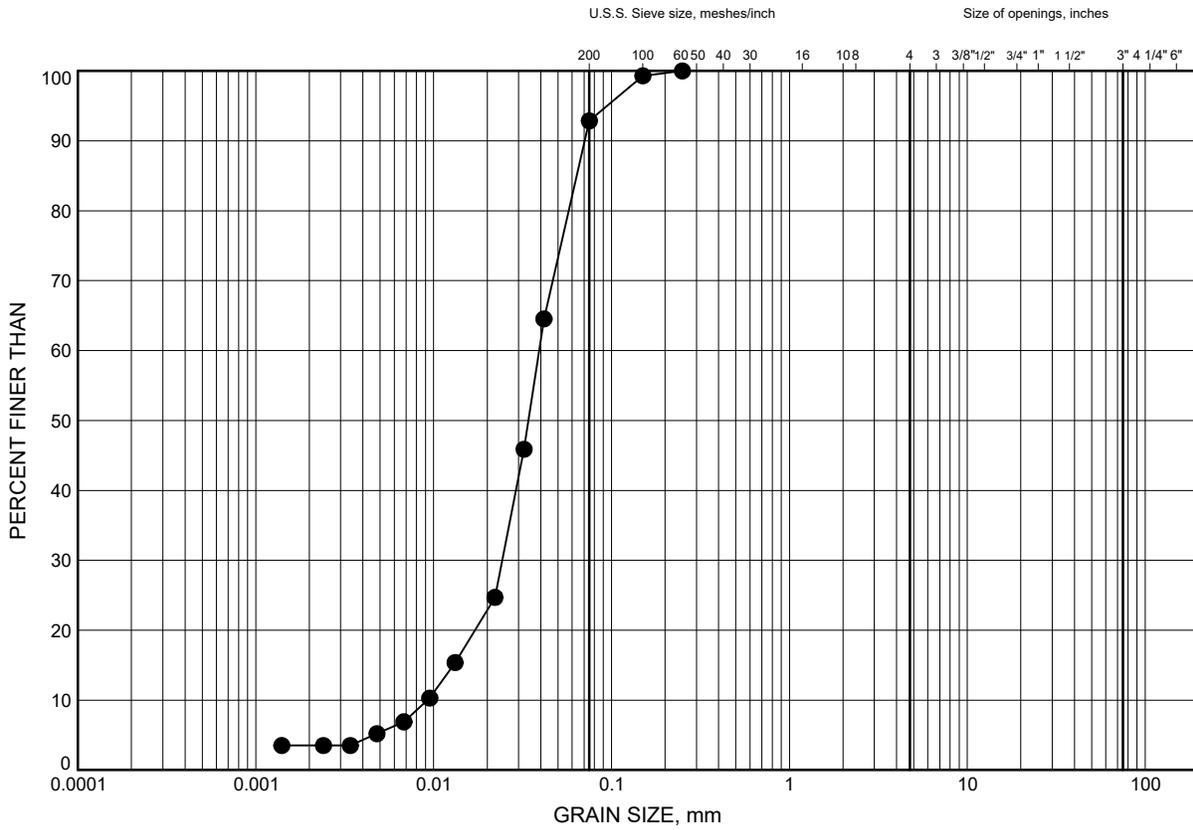


Prep'd AN
Chkd. AMP

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 |

GRAIN SIZE DISTRIBUTION - THURBER 13662-MTO.GPJ 10/25/16

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 - KOL 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 - KOL 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13662

17-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. : 16 August 2016
LR Report: CA15286-AUG16
Reference: 13662 Mark Farrant

Copy: #1

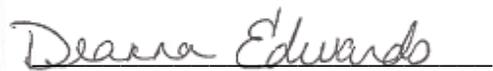
CERTIFICATE OF ANALYSIS

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 - K0L 2H0
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 | |
| <i>Anions by IC - QCBatchID: DIO0220-AUG16</i> | | | | | | | | | | | | |
| 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 |
| <i>Conductivity - QCBatchID: EWL0226-AUG16</i> | | | | | | | | | | | | |
| Conductivity | 2 | µS/cm | 4.44 | | 6 | 10 | 99 | 90 | 110 | NA | | |
| <i>pH - QCBatchID: EWL0226-AUG16</i> | | | | | | | | | | | | |
| pH | 0.05 | no unit | NA | | 1 | | 101 | | | NA | | |
| <i>Redox Potential - QCBatchID: EWL0230-AUG16</i> | | | | | | | | | | | | |
| Redox Potential | no | mV | NA | | 3 | 20 | 106 | 80 | 120 | NA | | |
| <i>Sulphide by SFA - QCBatchID: SKA0139-AUG16</i> | | | | | | | | | | | | |
| 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)

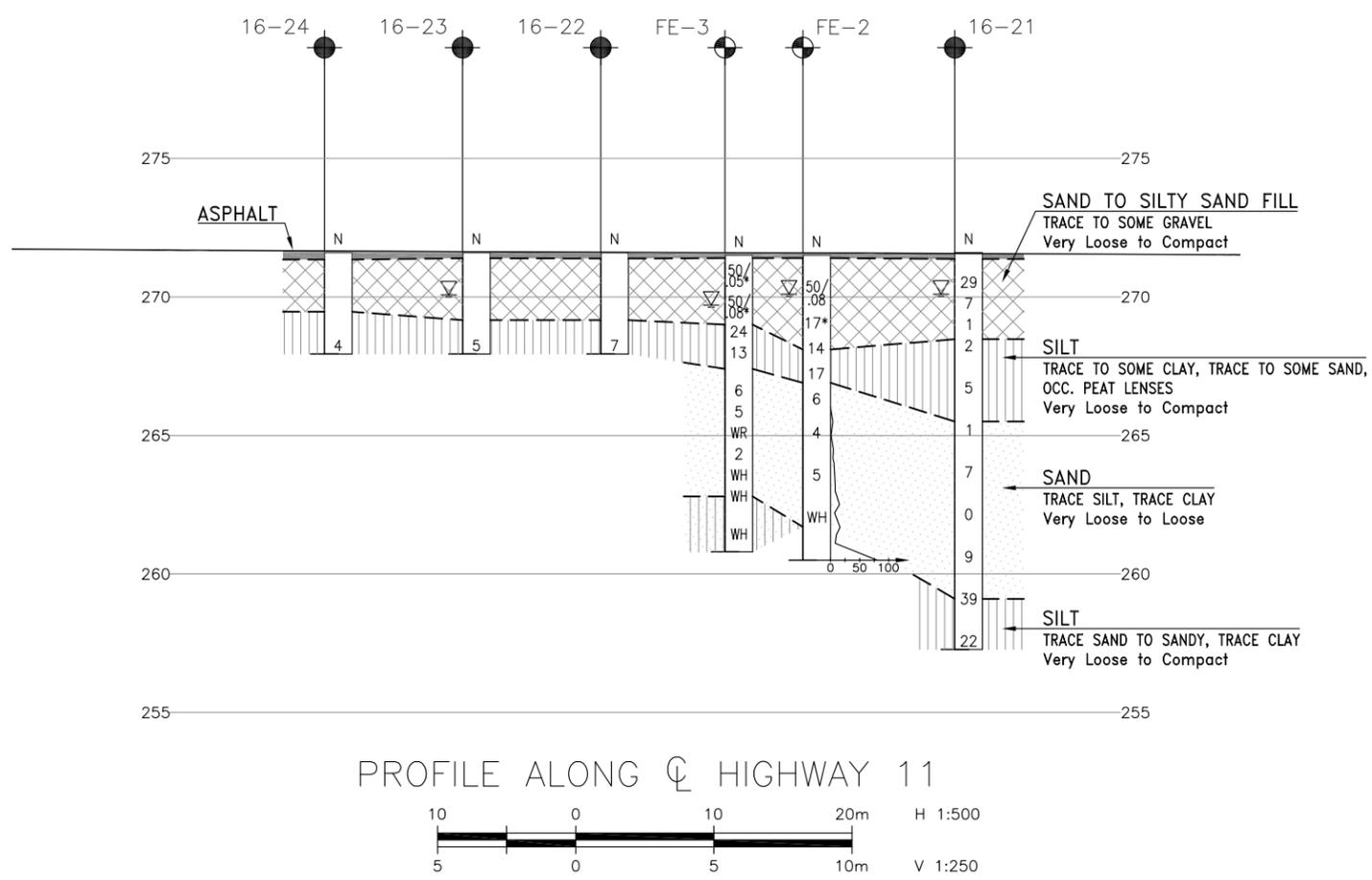
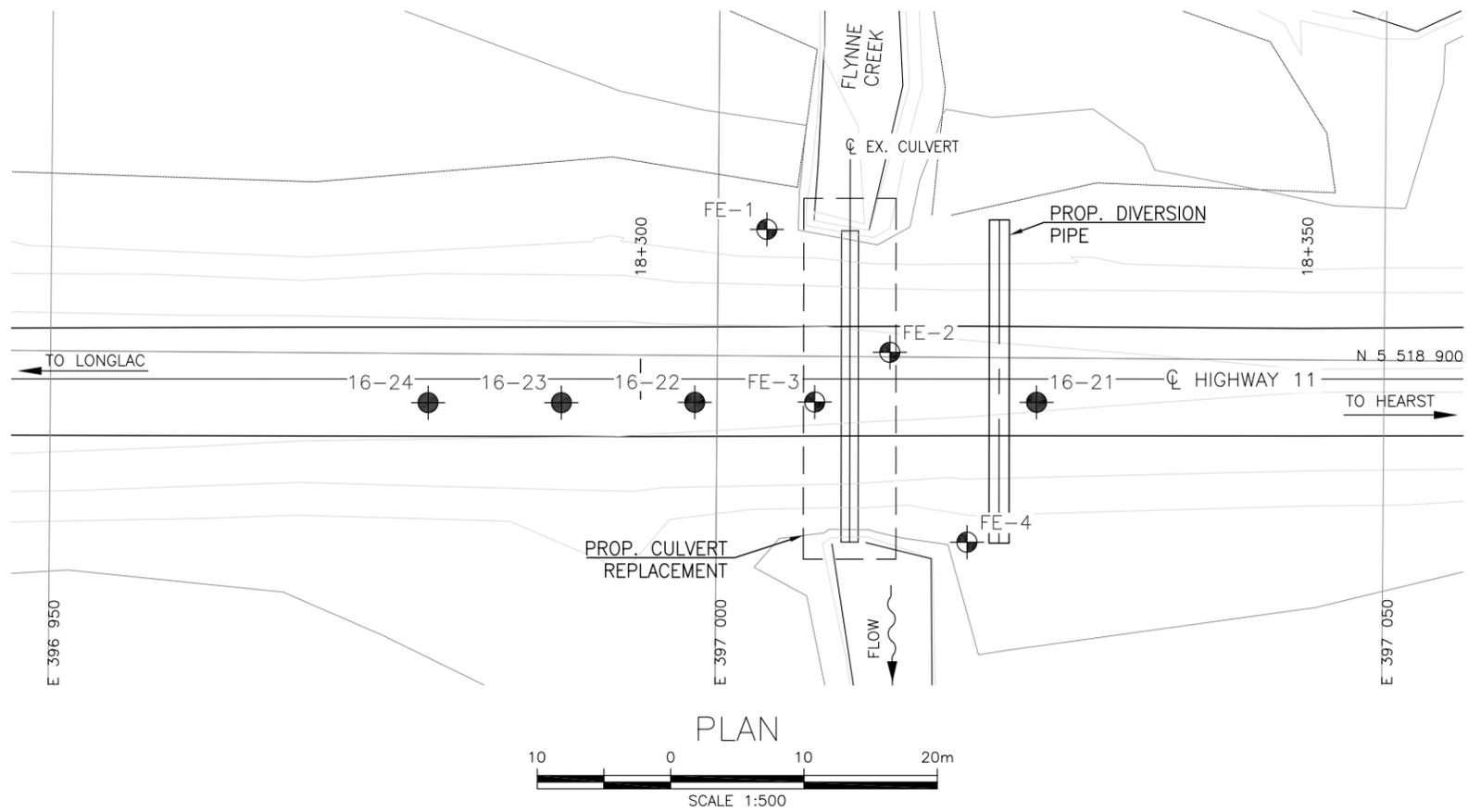


Photo 5: Flynn Creek Culvert, outlet (south side)

Appendix D

Borehole Locations and Soil Strata Drawing

MINISTRY OF TRANSPORTATION, ONTARIO



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



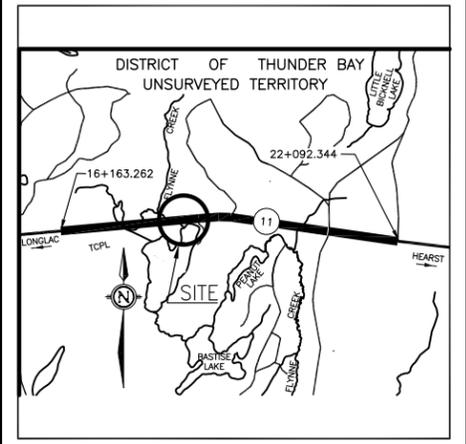
CONT No 2017-6001
WP No 6310-14-01



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.

GEORES No. 42F-40

| REVISIONS | DATE | BY | DESCRIPTION |
|-----------|------|----|-------------|
| | | | |
| | | | |

| | | | | | | | |
|--------|-----|-----|-----|------|--------|------|----------|
| DESIGN | AMP | CHK | PKC | CODE | LOAD | DATE | JAN 2017 |
| DRAWN | AN | CHK | AMP | SITE | STRUCT | DWG | 2 |

FILENAME: H:\Drafting\13000\13062\13062\13062-13662-PLSC-FG.dwg PLOTDATE: 1/27/2017 2:38 PM

Appendix E

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

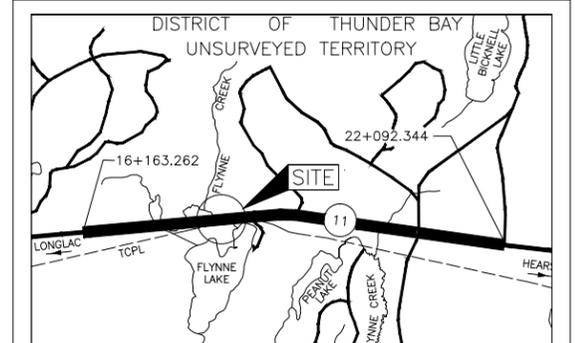
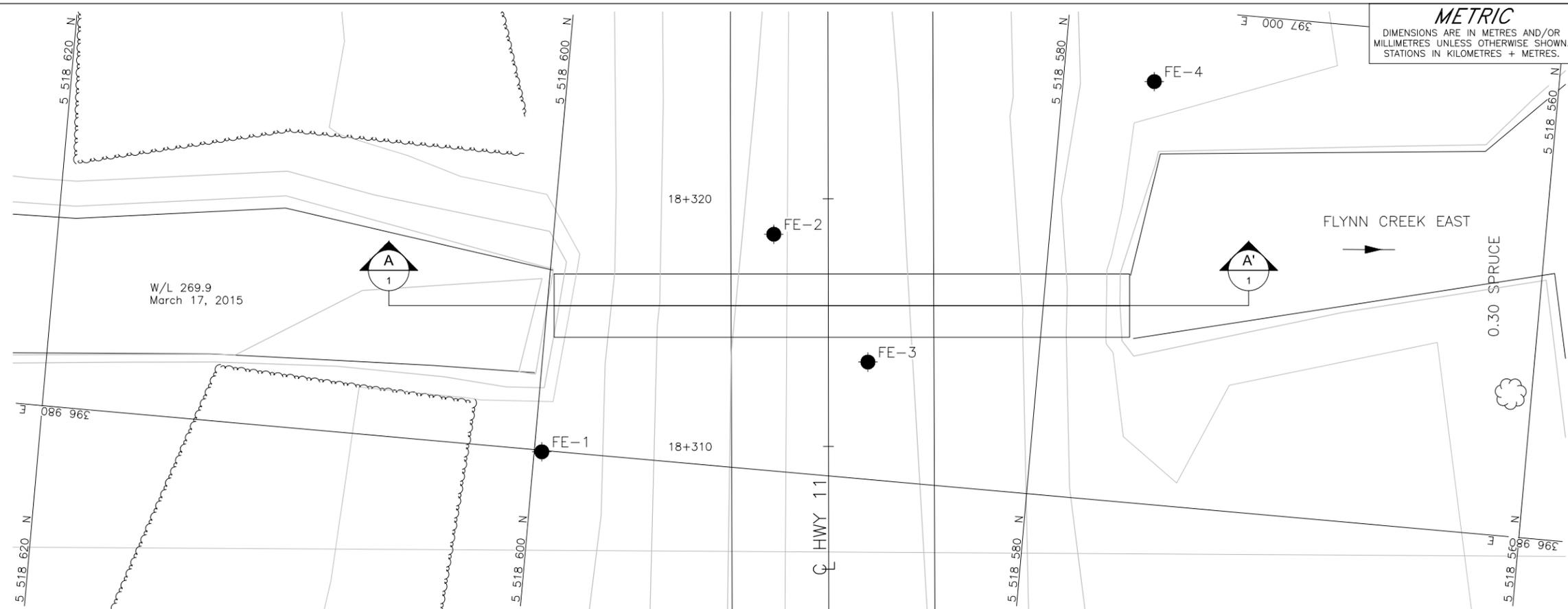
METRIC
 DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. GWP No. 6310-14-00



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

SHEET



KEY PLAN
 1:50,000 m

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

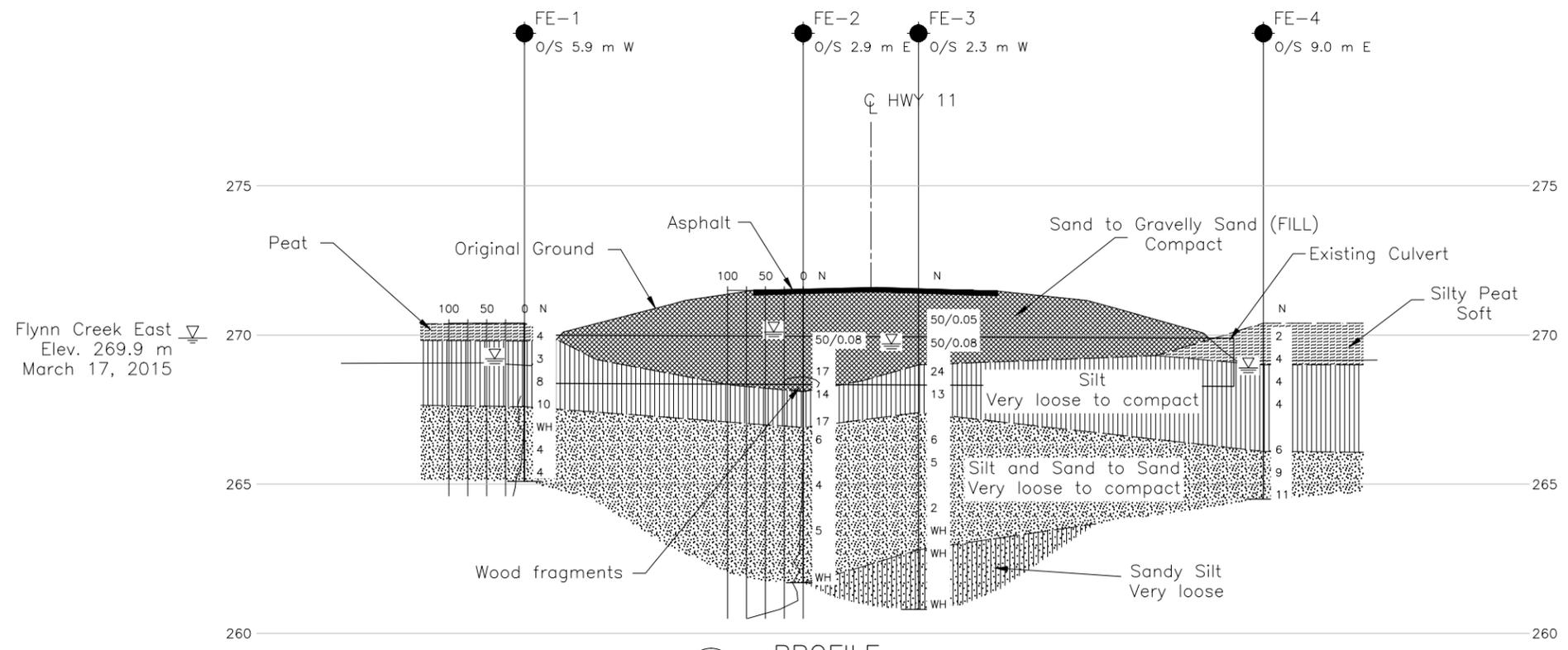
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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.



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



| NO. | DATE | BY | REVISION |
|-----|------|----|----------|
| | | | |

Geocres No. 42F-34

| | | |
|------------|---------------------|-----------------|
| HWY. 11 | PROJECT NO. 1411523 | DIST. . |
| SUBM'D. AC | CHKD. . | DATE: 9/3/2015 |
| DRAWN: TB | CHKD. SEMP | APPD. JMAC |
| | | SITE: 48E-125/C |
| | | DWG. 1 |

| | | |
|--|--|-------------------------|
| PROJECT <u>1411523</u> | RECORD OF BOREHOLE No FE-1 | 1 OF 1 METRIC |
| G.W.P. <u>6310-14-00</u> | LOCATION <u>N 5518599.7; E 396979.9</u> | ORIGINATED BY <u>SC</u> |
| DIST <u> </u> HWY <u>11</u> | BOREHOLE TYPE <u>108 mm I. D. Hollow Stem Augers</u> | COMPILED BY <u>TB</u> |
| DATUM <u>GEODETIC</u> | DATE <u>February 23, 2015</u> | CHECKED BY <u>SEMP</u> |

| 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 | | | | | | | | |
| | | | | | | 20 | 40 | 60 | 80 | 100 | 20 | 40 | 60 | | GR SA SI CL | |
| 270.4 | GROUND SURFACE | | | | | | | | | | | | | | | |
| 0.0 | PEAT (Amorphous), some rootlets, trace gravel Black Frozen | | 1 | SS | 4 | | | | | | | | | | | |
| 269.8 | | | | | | | | | | | | | | | | |
| 0.6 | SILT, trace to some clay, trace sand, trace gravel Very loose to compact Grey Moist | | 2 | SS | 3 | | | | | | | | | | 1 4 90 5 | |
| | | | 3 | SS | 8 | | | | | | | | | | | |
| | | | 4 | SS | 10 | | | | | | | | | | | |
| 267.6 | | | | | | | | | | | | | | | | |
| 2.8 | SAND, trace to some silt, trace gravel Very loose Grey Wet | | 5 | SS | WR | | | | | | | | | | 1 89 (10) | |
| | | | 6 | SS | 4 | | | | | | | | | | | |
| | | | 7 | SS | 4 | | | | | | | | | | | |
| 265.1 | Approximately 0.7 m of heave encountered at 5.3 m depth. | | | | | | | | | | | | | | | |
| 5.3 | END OF BOREHOLE | | | | | | | | | | | | | | | |
| 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. | | | | | | | | | | | | | | | |

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

| | | |
|--|--|-------------------------|
| PROJECT <u>1411523</u> | RECORD OF BOREHOLE No FE-2 | 1 OF 1 METRIC |
| G.W.P. <u>6310-14-00</u> | LOCATION <u>N 5518591.1; E 396989.5</u> | ORIGINATED BY <u>NJ</u> |
| DIST <u> </u> HWY <u>11</u> | BOREHOLE TYPE <u>108 mm I. D. Hollow Stem Augers</u> | COMPILED BY <u>TB</u> |
| DATUM <u>GEODETIC</u> | DATE <u>March 17, 2015</u> | CHECKED BY <u>SEMP</u> |

| ELEV. DEPTH | SOIL PROFILE DESCRIPTION | STRAT PLOT | 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 (%) |
|-------------|--|------------|---------|------|------------|-------------------------|-----------------|--|----|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| | | | NUMBER | TYPE | "N" VALUES | | | 20 | 40 | | | | | |
| 271.5 | GROUND SURFACE | | | | | | | | | | | | | |
| 0.0 | ASPHALT (130 mm) | | | | | | | | | | | | | |
| 0.1 | Sand, some gravel (FILL) Compact Grey to brown Frozen* to moist | | 1 | AS | - | | | | | | | | | |
| | Trace wood encountered in Samples 3 and 4A. | | 2 | SS | 50/0.08 | ▽ | | | | | | | | |
| | | | 3 | SS | 17* | | | | | | | | | |
| 268.1 | | | A | | | | | | | | | | | |
| 3.4 | SILT, trace to some clay, trace sand Compact Grey Wet | | 4 | SS | 14 | | | | | | | | NP | 0 4 89 7 |
| | | | B | | | | | | | | | | | |
| 266.9 | | | 5 | SS | 17 | | | | | | | | | |
| 4.6 | SAND, trace to some silt, trace gravel Very loose to loose Grey Wet | | 6 | SS | 6 | | | | | | | | | |
| | Approximately 0.3 m of heave encountered in augers at 4.6 m depth. | | | | | | | | | | | | | |
| | | | 7 | SS | 4 | | | | | | | | | 2 88 (10) |
| | | | 8 | SS | 5 | | | | | | | | | |
| | | | 9 | SS | WH | | | | | | | | | |
| 261.7 | END OF BOREHOLE | | | | | | | | | | | | | |
| 9.8 | | | | | | | | | | | | | | |
| 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 <u>1411523</u> | RECORD OF BOREHOLE No FE-3 | 1 OF 1 METRIC |
| G.W.P. <u>6310-14-00</u> | LOCATION <u>N 5518586.9; E 396984.7</u> | ORIGINATED BY <u>NJ</u> |
| DIST <u> </u> HWY <u>11</u> | BOREHOLE TYPE <u>108 mm I. D. Hollow Stem Augers</u> | COMPILED BY <u>TB</u> |
| DATUM <u>GEODETIC</u> | DATE <u>March 17, 2015</u> | CHECKED BY <u>SEMP</u> |

| ELEV DEPTH | SOIL PROFILE DESCRIPTION | STRAT PLOT | 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 (%) |
|---------------|---|------------|--------------|------|--------------|----------------------------|-----------------|---|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|---------------------|---|
| | | | NUMBER | TYPE | "N" VALUES | | | 20 | 40 | 60 | 80 | 100 | | | | | |
| 271.5 | GROUND SURFACE | | | | | | | | | | | | | | | | |
| 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 B | SS | 24 | | 269 | | | | | | | | | | 21 70 (9) |
| 2.5 | A 75 mm thick layer of black organics encountered at 2.5 m depth. | | 5 | SS | 13 | | 268 | | | | | | | | | | 0 4 89 7 |
| 267.4 | SILT and SAND to SAND Very loose to loose Grey Wet | | 6 | SS | 6 | | 267 | | | | | | | | | | |
| 4.1 | | | 7 | SS | 5 | | 266 | | | | | | | | | | |
| | | | 8 | SS | WR | | 265 | | | | | | | | | | |
| | | | 9 | SS | 2 | | 264 | | | | | | | | | | |
| | | | 10 | SS | WH | | 263 | | | | | | | | | | 0 52 41 7 |
| 262.8 | Sandy SILT, trace clay Very loose Grey Wet | | A 11 B | SS | WH | | 263 | | | | | | | | | | |
| 8.7 | | | | | | | 262 | | | | | | | | | | |
| | | | 12 | SS | WH | | 261 | | | | | | | | | | NP |
| 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 <u>1411523</u> | RECORD OF BOREHOLE No FE-4 | 1 OF 1 METRIC |
| G.W.P. <u>6310-14-00</u> | LOCATION <u>N 5518576.3; E 396997.0</u> | ORIGINATED BY <u>SC</u> |
| DIST <u> </u> HWY <u>11</u> | BOREHOLE TYPE <u>108 mm I. D. Hollow Stem Augers</u> | COMPILED BY <u>TB</u> |
| DATUM <u>GEODETIC</u> | DATE <u>February 21, 2015</u> | CHECKED BY <u>SEMP</u> |

| 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 | | | | | | | | |
| | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | | |
| 270.4 | GROUND SURFACE | | | | | | | | | | | | | | | |
| 0.0 | Silty PEAT (Amorphous) Soft Black to brown Frozen* to moist | | 1 | SS | 2* | | | | | | | | | | | |
| | | | 2 | SS | 4 | | | | | | | | | | | |
| 269.0 | | | | | | | | | | | | | | | | |
| 1.4 | SILT, trace to some sand, trace clay Loose Grey Wet | | 3 | SS | 4 | | | | | | | ○ | | NP | 0 4 91 5 | |
| | | | 4 | SS | 4 | | | | | | | ○ | | NP | 0 11 84 5 | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| 266.1 | | | A 5 | SS | 6 | | | | | | | | | | | |
| 4.3 | SAND, trace to some silt Loose to compact Grey Wet | | 6 | SS | 9 | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| 264.5 | | | 7 | SS | 11 | | | | | | | ○ | | | 0 88 (12) | |
| 5.9 | END OF BOREHOLE Note: 1. Water level at a depth of 1.5 m below ground surface (Elev. 268.9 m) upon completion of drilling. | | | | | | | | | | | | | | | |

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