THURBER ENGINEERING LTD.

**FINAL**

# FOUNDATION INVESTIGATION AND DESIGN REPORT
# HIGHWAY 17 TWINNING, RENFREW AREA
# PRIVATE DRIVE CULVERT (ANDERSON ROAD LOCHA CREEK)
# WP 4068-09-00 / ASSIGNMENT NO. 4018-E-0009

Geocres No.: 31F-212

Report to:

**Ministry of Transportation Ontario**

Latitude: 45.443700
Longitude: -76.534900

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Thurber File No.: 24726

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# PART 1. FACTUAL INFORMATION

## 1 INTRODUCTION

Thurber Engineering Ltd. (Thurber) has been engaged by the Ministry of Transportation Ontario (MTO) under Assignment No. 4018-E-0009 to carry out Foundation Investigations to support the design of the Highway 17 Twinning Project which extends from Scheel Drive westerly to 3 km west of Bruce Street in the Renfrew area.

This report addresses the replacement of a structural culvert and embankment modifications to a service road on the south side of Highway 17 approximately 150 m west of the current intersection with Anderson Road. The service road is currently known as Daisy Lane but will be realigned to become an extension to Anderson Road.

This section of the report presents the factual findings obtained from the foundation investigation completed for the replacement of the existing culvert under the extended Anderson Road, as well as for the high fill resulting from the alignment shift.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and construction was developed in the course of the current investigation.

Previous foundation investigation information from boreholes completed in 2017 and 2018 for the Highway 17 Locha Creek Culvert (Site No. 29-249/C1) was available under Geocres 31F-205.

## 2 SITE DESCRIPTION

### 2.1 General

The exisitng culvert is located on Daisy Lane, a private unpaved roadway that extends from Anderson Road and runs south of and parallel to the existing Highway 17 alignment for a short distance. The culvert facilitates the flow of Locha Creek under Daisy Lane, approximately 150 m west of where Anderson Road currently meets Highway 17. Creek flow is from the south to the north.

At the location of the culvert, Daisy Lane is a one-lane roadway with a rural cross-section and gravel surface. The road surface is at approximate elevation 135 m. The existing embankment side slopes did not show any visible signs of distress at the time of the investigation and were sloped at approximately 2H:1V to 3H:1V. During a site visit on April 27, 2020, the measured width of Locha Creek ranged from approximately 5 m to 7 m and had an average depth of approximately 1.0 m.

The existing Highway north of this consists of a two-lane undivided highway with gravel shoulders. The Locha Creek Culvert crossing Highway 17 (Site No. 29-249/C1) is present downstream (north) of the site.

The land adjacent to the site typically consists of forests and agricultural fields. The terrain is relatively flat except where bisected by the Locha Creek Valley. The existing culvert is a structural multi-plate corrugated steel pipe arch with a span of 4.8 m, a rise of 3.0 m and a length of 9.7 m. The creek bed and culvert invert is at approximate elevation of 131.4 m. The fill height above the culvert is approximately 0.7 m.

Photographs showing the existing conditions in the area of the culvert at the time of the field investigation are included in Appendix D for reference.

### 2.2 Site Geology

Based on published geological information in The Physiography of Southern Ontario by Chapman and Putnam (1984), the culvert site lies within the physiographic region known as the Ottawa Valley Clay Plains. This physiographic region is characterized primarily by clay plains interrupted by ridges of rock or sand.

Ontario Geological Survey Map P.3784 for Precambrian Geology for the Horton Area, Grenville Province, suggests the bedrock is comprised of calcitic carbonate metasedimentary bedrock including calcite marble.

## 3 SITE INVESTIGATION AND FIELD TESTING

The current site investigation and field testing program was carried out between July 22 and September 30, 2019. The field investigation consisted of advancing three main boreholes identified as AND19-1, AND19-2 and AND19-3 as well as one borehole for the Anderson Road high fill section, AND19-4. AND19-1 was divided into 4 parts: AND19-1 for soil sampling, AND19-1B for a well installation at 10.4 m below ground surface, AND19-1C for a well installation at 4.6 m below ground surface and AND19-1D for rock coring. AND19-2 was divided into two parts, with AND19-2A for the collection of thin-walled tube samples. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

Historical Borehole 18-103 which was drilled by Thurber in June 2018 for the replacement of the Locha Creek culvert under the existing Highway 17 is located near the outlet of the subject culvert. Data from Borehole 18-103 has been fully incorporated into this report.

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The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A, the individual Record of Borehole sheets in Appendix B, and in Table 3-1 below. The site is located within MTM Zone 9.

**Table 3-1: Borehole Summary**

| Borehole No. | Drilled Location | Northing (m) | Easting (m) | Ground Surface Elevation (m) | Termination Depth (m) | Comments |
|---|---|---|---|---|---|---|
| 18-103 | Outlet | 5 033 766.1 | 302 084.0 | 133.9 | 28.4 | - |
| AND19-1 | Inlet | 5 033 735.8 | 302 065.1 | 132.6 | 17.5 | - |
| AND19-1B | Inlet | 5 033 744.5 | 302 063.2 | 132.9 | 10.4 | Well Install only |
| AND19-1C | Inlet | 5 033 739.8 | 302 062.3 | 132.9 | 4.6 | Well Install only |
| AND19-1D | Inlet | 5 033 736.4 | 302 061.2 | 132.8 | 21.1 | Rock coring only |
| AND19-2 | On-Road | 5 033 754.1 | 302 078.4 | 134.8 | 28.7 | - |
| AND19-2A | On-Road | 5 033 753.9 | 302 079.4 | 134.8 | 7.5 | Tube samples |
| AND19-3 | Outlet | 5 033 769.5 | 302 062.6 | 133.7 | 21.3 | - |
| AND19-4 | 10+370 Toe of Slope | 5 033 740.3 | 302 088.1 | 132.6 | 10.7* 20.4** | - |

**Notes:** * - Termination of Sampled Borehole
** - DCPT refusal

The drilling was carried out using track-mounted CME 850 and CME 45 drill rigs equipped with hollow stem augers and rotary diamond drilling equipment.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Upon achieving casing refusal, Boreholes 19-1D, AND19-2 and 18-103 were drilled into bedrock while collecting NQ core.

50 mm diameter monitoring wells were installed in Boreholes AND19-1B and AND19-1C. A 19 mm diameter monitoring well was installed in Borehole AND19-4. The installation details are illustrated on the Record of Borehole sheets provided in Appendix B. The boreholes were backfilled in accordance with MOE requirements (O.Reg 903, as amended). The wells will be utilized as part of a hydrogeological study and subsequently decommissioned by Thurber.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's geotechnical staff. The drilling supervisor logged the boreholes and processed the recovered soil and bedrock samples for transport to Thurber's Ottawa geotechnical laboratory for further examination and testing.

# 4 LABORATORY TESTING

Laboratory testing was selected in accordance with the current MTO Guideline for Foundation Engineering Services, Section 5. Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. At least 25% of the recovered soil samples were subjected to grain size distribution analysis and Atterberg limits tests, where appropriate. The testing was carried out to MTO and ASTM standards. A one-dimensional consolidation test was carried out on a thin-walled tube sample from AND19-2A. All rock cores were photographed and their total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were measured. Chemical analysis for determination of pH, conductivity, resistivity, sulphide, sulphate and chloride concentrations was carried out on one soil sample from AND19-2.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory results are presented on the figures included in Appendix C.

# 5 GENERAL DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata Drawing included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following sections. However, the factual data presented on the Borehole Records takes precedence over the Soil Strata Drawing and the general description. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations. Soil classification is in accordance with ASTM D2487. Cohesive soils are described per current MTO protocols for the boreholes drilled in 2019; historic boreholes have based classification on ASTM D2487.

In general terms, the site was found to be underlain by sands, silts or embankment fill overlying a native deposit of clay, which is underlain by a sand till deposit with variable quantities of clay, gravel and cobbles. The overburden soils are underlain by marble bedrock.

## 5.1 Fill

A fill consisting of sand with silt to silty sand to silt with sand to sandy clay with silt, was encountered in Boreholes AND19-2, AND19-3, AND19-4 and 18-103. The underside of the fill was encountered at depths from 2.3 m to 3.0 m or elevations ranging from 130.3 to 131.8 m.

SPT tests conducted in this layer gave N-values ranging from Weight of Hammer to 8 in AND19-3, AND19-4 and 18-103, indicating a very loose to loose relative density. In AND19-2 which was advanced through the existing embankment gave SPT N-values ranging from 5 to 25, indicating a loose to compact relative density.

The moisture content of the samples tested ranged from 3 to 65%. The results of grain size analysis tests conducted on three samples of the fill material are summarized below in Table 5-1 and are illustrated on Figure C1 in Appendix C.

**Table 5-1: Summary of Grain Size Distribution Testing**

| Soil Particle | Percentage (%) |
|---|---|
| Gravel | 0 to 10 |
| Sand | 79 to 94 |
| Silt and Clay | 6 to 14 |

## 5.2 Sand with Silt (SP-SM)

A layer of sand with silt, trace to some roots was observed at ground surface in Borehole AND19-1. The sand with silt layer had a thickness of 0.6 m and a base elevation of 132.0 m.

SPT tests conducted in the layer gave an N-value of Weight of Hammer, indicating a relative density of very loose.

The moisture content of the sample tested was 37%.

## 5.3 Silty Sand (SM) to Silt with Sand (ML) to Sandy Clayey Silt (CL)

A soil with variable quantities of sand, silt, and clay was encountered below the fill in Boreholes AND19-2, AND19-4 and 18-103, below the sand with silt in AND19-1. This layer ranged in thickness from 0.9 m to 1.9 m, with base elevations from 128.9 m to 131.1 m.

SPT tests conducted in the layer gave N-values of Weight of Hammer to and 6, indicating a very loose to loose relative density.

The moisture content of the samples tested ranged from 29 to 137%. The results of grain size analysis tests conducted on four samples of this material are summarized below in Table 5-2 and are illustrated on Figure C2 in Appendix C.

**Table 5-2: Summary of Grain Size Distribution Testing**

| Soil Particle | Percentage (%) |
|---|---|
| Gravel | 0 – 19 |
| Sand | 16 – 45 |
| Silt | 24 – 44 |
| Clay | 16 – 40 |

The results of Atterberg Limits testing carried out on the fines of samples of this material are summarized in Table 5-3 below and are illustrated on Figure C7 in Appendix C and indicate the fines to be variable and range from non-plastic to medium plastic (MI-OI to CL).

**Table 5-3: Summary of Atterberg Limit Testing**

| Parameter | AND19-2 SS4 | AND19-4 SS4 | 18-103 SS5 | 18-103 SS6 |
|---|---|---|---|---|
| Liquid Limit | 46 | - | 34 | 30 |
| Plastic Limit | 31 | NP | 20 | 16 |
| Plasticity Index | 15 | - | 14 | 14 |
| Soil Symbol (fines) | MI to OI | ML | CL | CL |

## 5.4 Clayey Silt to Clay (CL to CH)

A cohesive native deposit of clayey silt to clay was encountered in all boreholes. The top of the deposit was encountered at elevations ranging from 128.9 m to and 131.1 m. The thickness of the deposit, where fully penetrated ranged from 11.9 m to 18.6 m with an underside elevation ranging from 110.7 m to 119.2 m.

SPT tests conducted in the layer gave N-values ranging from weight of hammer to 8. In-situ shear vane test results indicated undrained shear strengths ranging from 34 kPa to greater than 100 kPa; indicating a firm to very stiff consistency, but typically firm to stiff. The measured sensitivity ranged from 3 to 30; indicating a medium sensitivity to quick clay deposit, but typically of medium to high sensitivity.

The moisture content of the samples tested ranged from 28 to 54%. The results of grain size analysis tests conducted on samples of this deposit are summarized below in Table 5-4 and are illustrated on Figures C3, C4 and C5 in Appendix C.

**Table 5-4: Summary of Grain Size Distribution Testing**

| Soil Particle | Percentage (%) |
|---|---|
| Gravel | 0 – 7 |
| Sand | 0 –22 |
| Silt | 37 – 64 |
| Clay | 30 – 62 |

The results of Atterberg Limits testing carried out on samples of this material are summarized in Table 5-5 below and are illustrated on Figures C8, C9 and C10 in Appendix C and indicate the material is a clayey silt to clay ranging from low to high plasticity (CL to CH); but typically low to intermediate plasticity (CL to CI). It should be noted in accordance with the MTO Guideline for Foundation Engineering Services (May 2019) this cohesive deposit is described as a “clayey silt” where Atterberg limits tests indicate a CL material. The historic logs from Geocres 31F-205 referenced in and appended to this report do not follow this guideline and describe the CL material as “clay”. For the purposes of this report, they are considered the same material.

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**Table 5-5: Summary of Atterberg Limit Testing**

| Parameter | Value |
|---|---|
| Liquid Limit | 22 – 52 |
| Plastic Limit | 13 – 22 |
| Plasticity Index | 9 – 30 |

The results of one laboratory oedometer (one-dimensional consolidation) test carried on an undisturbed sample in the deposit is presented in Appendix C and summarized below in Table 5-6. Also presented in Table 5-6 are the test results from four consolidation tests reported in Geocres 31F-205 from the adjacent site.

**Table 5-6: Consolidation Test Results**

| Parameter | Results | | | | |
|---|---|---|---|---|---|
| Borehole | 19-2A | 17-2 | 17-3 | 18-101 | 18-101 |
| Sample | ST2 | ST9 | ST17 | ST5 | ST9 |
| Sample Depth, (m) | 7.2 | 10.2 | 15.6 | 4.9 | 11 |
| Sample Elevation, (m) | 127.6 | 121.7 | 123.3 | 127.7 | 121.5 |
| Approx. Existing Effective Stress, $P_0$, (kPa) | 94 | 83 | 193 | 37 | 85 |
| Moisture Content, (%) | 47 | 45 | 49 | 43 | 45 |
| Liquid Limit, % | 31 | - | - | - | - |
| Plastic Limit, % | 21 | - | - | - | - |
| Liquidity Index | 2.6 | - | - | - | - |
| Unit Weight, $\gamma$ (kN/m$^3$) | 17.1 | 17.5 | 16.8 | 17.5 | 17.6 |
| Specific Gravity, $G_s$ | 2.747 | 2.746 | 2.746 | 2.750 | 2.750 |
| Initial Void Ratio $e_o$ | 1.325 | 1.229 | 1.383 | 1.197 | 1.211 |
| Pre-consolidation Pressure, $P_c$', (kPa) | 320 | 210 | 200 | 285 | 185 |
| Over Consolidation Ratio, OCR | 3.4 | 2.5 | 1.0 | 7.7 | 2.2 |
| Compression Index, $C_c$ | 0.53 | 0.65 | 0.75 | 0.48 | 0.65 |
| Recompression Index, $C_r$ | 0.06 | 0.05 | 0.08 | 0.02 | 0.02 |
| Coefficient of consolidation, $c_v$ (mm$^2$/s) | 0.05 | 0.05 | 0.04 | 0.06 | 0.03 |
| Coefficient of re-consolidation, $c_{vr}$ (mm$^2$/s) | 0.4 | 0.3 | 0.5 | 1.3 | 0.7 |

## 5.5 Glacial Till

A glacial till deposit ranging from gravelly silty sand to clayey sand with gravel was encountered beneath the clay in Boreholes AND19-1, AND19-2, AND19-3 and 18-103. The top of this layer ranges from elevation 110.7 m to 119.2 m. The thickness of the layer ranges from 1.4 m to 4.1 m. Occasional cobbles and boulders were noted within the glacial till, particularly within the lower portion and coring techniques were required to penetrate the layer.

SPT tests conducted in this layer gave N-values ranging from 13 to greater than 100, indicating a compact to very dense relative density. The higher blow counts could be due to the presence of cobbles or a boulder within the deposit rather than the relative density of the soil matrix. On the other hand, artesian conditions were noted in this layer which may have decreased N-values.

The moisture content of two samples were 18% and 28%. The results of grain size analysis on two samples of the till are summarized in Table 5-7 below and are illustrated on Figure C6 in Appendix C.

**Table 5-7: Summary of Grain Size Distribution Testing**

| Soil Particle | Percentage (%) | |
|---|---|---|
| Gravel | 23 – 25 | |
| Sand | 30 – 59 | |
| Silt | 30 | 16 |
| Clay | 17 | |

The results of Atterberg Limits testing completed on the material with 47% fines indicated that the fines were of low plasticity (CL). Atterberg Limits analysis results are illustrated on Figure C11 in Appendix C.

## 5.6 Refusal and Bedrock

In Boreholes AND19-1 and AND19-3, boreholes were terminated at casing refusal at elevation 115.1 m and 112.4 m respectively. A dynamic cone penetration test (DCPT) for AND19-4 began at 10.7 m deep (elevation 121.9 m) and terminated at 20.4 m deep (elevation 112.2 m) at cone refusal.

Bedrock was proven by coring in boreholes AND19-1D, AND19-2 and 18-103. A summary of the bedrock surface information is provided in Table 5-8 below:

**Table 5-8: Summary of Bedrock Depth/Elevation**

| Borehole No. | Depth to Bedrock Surface (mbgs) | Bedrock Surface Elevation (m) |
|---|---|---|
| AND19-1 | 17.5* | 115.1* |
| AND19-1D | 17.1 | 115.7 |
| AND19-2 | 24.9 | 109.9 |
| AND19-3 | 21.3* | 112.4* |
| AND19-4 | 20.4** | 112.2** |
| 18-103 | 24.6 | 109.3 |

**Notes:** * – Inferred, Casing refusal
** – Inferred, DCPT refusal

The bedrock surface generally slopes downwards from south to north and from the east and west sides to the centerline of the culvert.

The bedrock encountered within boreholes AND19-1D, AND19-2 and 18-103 consisted of freshly weathered, very strong, grey to white marble with close joint spacing. The Total Core Recovery (TCR) measured on the recovered bedrock core ranged from 82 to 100%, the Solid Core Recovery (SCR) ranged from 30 to 100% and the Rock Quality Designation (RQD) ranged from 20 to 97%.

Unconfined compressive strength testing was carried out on one sample of the bedrock in Borehole 18-103; the result was 156 MPa.

Based on the measured RQD values, the bedrock is classified as poor to excellent quality. Based on the unconfined compressive strength testing the bedrock is very strong. Photographs of the bedrock core are provided in Appendix C.

## 5.7 Groundwater Conditions

The water level in Locha Creek was measured at an approximate elevation of 131.9 m on July 24th, 2019. The groundwater level in the area of the culvert is expected to reflect the creek level.

Artesian conditions were noted at the site during and upon completion of drilling in Boreholes AND19-1, AND19-1D, AND19-2, AND19-3 and 18-103 originating from the glacial till layer which is overlain clay in all boreholes. The non-stabilized artesian levels were measured from the base of the borehole and are presented in Table 5-9. The artesian flow was sealed at the source with bentonite pellets while decommissioning the boreholes.

**Table 5-9: Summary of Artesian Groundwater Conditions**

| Borehole | Approximate Depth (mbgs) | Groundwater Elevation (m) | Date of Measurement |
|---|---|---|---|
| AND19-1 | -3.5 | 136.1 | July 23, 2019 |
| AND19-1D | -3.5 | 136.3 | July 29, 2019 |
| AND19-2 | -1.5 | 136.3 | August 2, 2019 |
| AND19-3 | -2.3 | 136.0 | July 30, 2019 |
| 18-103 | -2.4 | 136.3 | June 15, 2018 |

**Note:** Negative depth indicates artesian conditions

Two 50 mm diameter monitoring wells (AND19-1B and AND19-1C) and one 19 mm piezometer (AND19-4) were installed at the site. Groundwater levels were recorded and are presented in Table 5-10 below:

**Table 5-10: Summary of Groundwater Levels**

| Borehole No. | Bottom of Screen Elevation (m) | Depth (mbgs) | Groundwater Elevation (m) | Date of Measurement |
|---|---|---|---|---|
| AND19-1B | 122.5 | 0.5 | 132.4 | August 23, 2019 |
| | | 0.4 | 132.5 | September 5, 2019 |
| | | -0.1 | 133.0 | November 26, 2019 |
| | | 0.3 | 132.6 | July 20, 2021 |
| AND19-1C | 128.3 | 0.5 | 132.4 | August 23, 2019 |
| | | 0.3 | 132.6 | September 5, 2019 |
| | | 0.2 | 132.7 | November 26, 2019 |
| | | 0.1 | 132.8 | July 20, 2021 |
| AND19-4 | 124.2 | -0.5 | 133.1 | August 23, 2019 |
| | | -0.3 | 132.9 | September 5, 2019 |
| | | -0.4 | 133.0 | November 26, 2019 |
| | | >-2.1 | >134.7 | July 20, 2021 |

**Note:** Negative depth indicates artesian conditions

These observations are considered short term and it should be noted that the groundwater level at the time of construction may be different and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation.

The General Arrangement Drawing for the Highway 17 Locha Creek Culvert shows a high water level elevation of 133.86 m for a 50 year return period.

### 5.8 Analytical Testing

Samples of the native soils were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate, sulphides, chloride concentrations, resistivity and electrical conductivity. The analysis results are summarized in Table 5-11. Copies of the test results are provided in Appendix C.

**Table 5-11: Results of Chemical Analysis**

| Sample | Depth (m) | pH | Resistivity (Ohm-cm) | Chloride (µg/g) | Sulphate (µg/g) | Sulphide (%) | Conductivity µS/cm |
|---|---|---|---|---|---|---|---|
| AND19-2 SS5 | 4.1 | 7.57 | 1740 | 227 | 116 | 0.2 | 576 |

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## 6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to existing site features and the existing culvert location. The as-drilled locations and ground surface elevation of the boreholes were surveyed by Thurber following completion of the field program. The elevation survey was carried out in reference to geodetic elevation benchmarks provided by the MTO.

Marathon Drilling of Greely, Ontario supplied and operated the drilling equipment and carried out the drilling, soil sampling, in-situ testing, standpipe installation and borehole decommissioning. The field investigation was supervised on a full-time basis by Mr. Michael Wong of Thurber. Overall supervision of the investigation program was provided by Mr. Justin Gray, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa, Ontario. Unconfined Compressive Strength Testing of the bedrock and oedometer testing was carried out by Stantec Consulting Ltd. in its MTO-approved laboratory in Ottawa.

Overall project management and direction of the field program was provided by Dr. Fred Griffiths, P.Eng. Interpretation of the factual data and preparation of this report were carried out by Mr. Justin Gray, P.Eng. and by Dr. Fred Griffiths, 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**

# 7 INTRODUCTION

This report presents the interpretation of the factual data obtained from a foundation investigation conducted by Thurber for the replacement of a structural culvert and embankment modifications to a service road on the south side of Highway 17 approximately 150 m west of the current intersection with Anderson Road in the Township of McNab/Braeside, within Renfrew County, Ontario. The service road is currently known as Daisy Lane but will be realigned to become an extension to Anderson Road.

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 or design-build contractor. Contractors 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.

The following sections provide geotechnical recommendations for the replacement of the existing Locha Creek Culvert and the modifications to the roadway embankment. The discussions and recommendations presented in this report are based on the information provided by the Ministry of Transportation of Ontario (MTO) and the factual data obtained during the investigation.

## 7.1 Existing Culvert

The existing culvert conveying Locha Creek from south to north beneath Anderson Road/Daisy Lane consists of a 9.7 m x 4.8 m x 3.0 m corrugated steel plate arch (CSPA). No wingwalls or headwalls are present. The creek bed and culvert invert are at approximate elevation 131.4 m. Photographs 1 and 4 in Appendix D show the existing condition of the culvert and road platform, respectively.

The top of the gravel driveway above the culvert is at approximate elevation 135.0 m. The existing embankment is approximately 2.7 m wide across the top, up to 2.6 m high and the embankment slopes are graded at 2H:1V to 3H:1V. No evidence of excessive settlement, erosion or

embankment instability was observed during the site investigation. During a site visit on April 27, 2020, the measured width of Locha Creek ranged from approximately 5 m to 7 m and the average depth was approximately 1.0 m.

### 7.2 Proposed Structure

The proposed work is a component of the Highway 17 Twinning project from Scheel Drive westerly to past Renfrew. Based on proposed alignments provided by MTO, the centreline of the Anderson Road extension will be approximately 5 m south of the existing Daisy Lane centreline. The proposed top of embankment is expected to be 8.5 m wide to allow for two 3.25 m wide lanes and 1.0 m wide gravel shoulders. It is understood that the extension will allow access to property to the west before terminating; an AADT of less than 100 is anticipated.

It is understood that the creek contains sensitive fish habitat and that a closed-bottom box culvert was deemed not permissible by the Ministry for the Highway 17 culvert immediately north of this site from a fisheries perspective.

Based on a preliminary General Arrangement drawing (GA) provided by MTO in July 2020, the new road surface is to be at elevation 135.75 m at the culvert location, copy provided in Appendix H. The proposed invert/creek bed elevation is at 131.75 m to 131.79 m. The proposed structure is a 24.6 m long pre-cast, concrete open bottom culvert supported on H-Piles with an internal span of 7.3 m and an approximate internal height of 3.2 m.

The north end of the culvert will be located 6.9 m south of a similar culvert recently constructed for the future and existing Highway 17 lanes (Site No. 29-249/C1 under Contract 2018-4018). A copy of the GA and Soil Information from Contract 2018-4018 for the replacement of the adjacent culvert under Highway 17 is provided in Appendix H.

### 7.3 Design Code Considerations

The geotechnical assessment presented below has been prepared based on the available data regarding the proposed foundations and existing ground conditions and in accordance with the Canadian Highway Bridge Design Code (CHBDC), version CSA S6:19.

In accordance with CHBDC, the analysis and design of the structure takes into consideration the importance of the structure and the consequence associated with exceeding limit states. The importance category and consequence classification are defined by the Regulatory Authority, which in this case is the Ministry of Transportation, Ontario (MTO).

It is understood that the replacement of the Anderson Road culvert is being designed to the “Other” importance category.

This project has been assigned Low Consequence Classification, in accordance with Section 6.5.1 of the CHBDC (pending confirmation by MTO). Accordingly, a consequence factor ($\Psi$) of 1.15, as per Table 6.1 of the CHBDC, has been used in assessing the factored geotechnical resistances.

### 7.4 Frost Penetration Depth

The frost penetration depth at this site is 1.9 m as per OPSD 3090.101.

## 8 SEISMIC CONSIDERATIONS

### 8.1 Spectral and Peak Acceleration Hazard Values

The seismic hazard data for the CHBDC is based on the fifth-generation seismic model developed by the Geological Survey of Canada (GSC). Seismic hazard data for this site has been obtained from the GSC's seismic hazard calculator. The data includes peak ground acceleration (PGA), peak ground velocity (PGV), and the 5% damped spectral response acceleration values (Sa(T)) for the reference ground condition (Site Class C) for a range of periods (T) and for a range of return periods including the 475-year, 975-year and 2475-year events. The GSC seismic hazard calculation data sheet for this site is presented in Appendix F.

The site coefficients used to determine the design spectral acceleration and displacement values are a function of the Site Class and the peak ground acceleration (PGA) for this location for a reference Site Class C with a 2% probability of exceedance in 50 years is 0.227g (1 in 2475 year). This value is to be scaled by the F(PGA) based on the site-specific Site Class as per Section 4.4.3.3 (Table 4.8) of the CHBDC (See Section 8.2). The reference Site Class C values for 5% and 10% probability of exceedance in 50 years are 0.126g and 0.076g, respectively (1 in 975 year and 1 in 475 year). These values are also to be scaled as discussed above.

### 8.2 CHBDC Seismic Site Classification

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

Based on the average undrained shear strengths measured below the anticipated culvert foundation elevation, the site is classified as a Seismic Site Class D in accordance with Table 4.1 of the CHBDC. As per Table 4.8 of the CHBDC for a 1 in 2475 year event, Site Class D with a $PGA_{ref}$ of 0.182 yields an F(PGA) of 1.135 for the site; these values yield a factored PGA of 0.258g. Similarly, the Site Class D factored PGA values for the 1 in 975 and 1 in 475 year events are 0.163g and 0.098g, respectively.

### 8.3 Seismic Liquefaction

The susceptibility of the cohesive soils at this site to experience liquefaction/cyclic softening was assessed following the Boulanger and Idriss (2007)[i] criteria using measured undrained shear strengths. Based on the results of both analyses, the cohesive material at this site is not classified as susceptible to cyclic mobility or cyclic softening.

A liquefaction triggering analysis for the non-cohesive soils at the site was completed using the Idriss and Boulanger (2014)[ii] simplified procedure outlined in Section C6.14.8 of the CHBDC Commentary. Based on the factored PGA (Section 8.2), the non-cohesive soils encountered at

shallow depth (base depths from 1.5 m to 4.6 m; elevations 131.1 m to 128.9 m) are considered susceptible to liquefaction during the 1 in 2,475 year and 1 in 975 year seismic events. The non-cohesive soils are not considered susceptible under a 1 in 475 year seismic event where fill height is greater than 3 m.

It is anticipated that these shallow liquefiable soils will be removed to facilitate the construction of the culvert foundations and are therefore not a concern for culvert design. However, in accordance with Section 6.14.9.1 of the CHBDC, liquefaction must be taken into consideration for the proposed embankment slopes.

*Alternatively, given the extremely low volume of traffic as reflected in the low consequence classification, it is recommended that the Ministry allow the following code exception:*

- *PGA values for probability of exceedance of 10% in 50 years (475 year event) shall be utilized in the assessment of liquefaction of the native soils for the Anderson Road embankment design.*

This approach has been adopted in this report. If the Ministry does not accept the code exemption, the liquefiable soils will need to be removed and replaced with engineered fill. Given, the high water level at the site, this will likely require an extensive dewatering system to compact the fill in the dry. Alternately, ground improvement options would need to be explored. The following sections of the report are based on the assumption that the code exemption is accepted.

## 9 GEOTECHNICAL ASSESSMENT/CONSIDERATIONS

In general terms, the site was found to be underlain by embankment fill sands or silts or overlying a native deposit of clay, which is underlain by a sand till deposit with variable quantities of clay, gravel and cobbles. Clay property summary curves are presented against elevation in Appendix G. The overburden soils are underlain by marble bedrock. An artesian groundwater condition was observed originating from the sand till layer.

Based on the results of the field and laboratory investigation and the information provided by MTO with regards to the proposed project requirements, the geotechnical foundation design considerations include the following:

Bearing Resistance

- The near surface overburden soils at this site will not provide sufficient geotechnical resistance for an open footed culvert supported on spread footings.
- The clay deposit at this site would provide sufficient bearing resistance to allow for the installation of a closed bottom box culvert, provided, other measures are taken to mitigate settlement associated with the proposed embankment (see below).
- Deep foundations could be used to support an open bottom culvert or short single span bridge. The deep foundations should extend to bedrock.

Settlement

The future realignment will result in a maximum fill height of about 4.0 m near the new centreline of the approach fills to the new culvert. It is anticipated that beneath the north shoulder a grade raise of only 0.75 m will be required over the existing embankment. Settlement and differential settlement of the roadway embankment needs to be considered not only in terms of pavement performance on the approaches but also in selection and design of the culvert foundations.

The clay deposit beyond the existing embankment is over-consolidated, based on the height of the proposed embankment, construction with conventional granular fill will not result in exceedance of the pre-consolidation pressure within the clay deposit.

An assessment of the time dependent settlement that would result from construction of the proposed embankment using conventional granular fill with 2H:1V side slopes was carried out using Rocscience's Settle3 modelling software with a Boussinesq stress distribution. The design pre-consolidation pressure profile has been derived from the oedometer test carried out on the native clay material, supplemented by correlations with undrained shear strength and index properties.

The following has been assumed for the embankment geometry:

- Height = 4.0 m
- Length = 100 m
- Platform Width = 8.5 m
- Side slopes = 2H:1V

The clay stratum was separated into upper and lower sub-layers. The geotechnical parameters used in the settlement analysis were based on soil thicknesses encountered in Boreholes AND19-2 and AND19-4 and the consolidation test results from Boreholes AND19-2A (Upper Clay) and 18-101 (Lower Clay).

Table 9-1 presents the properties used in the Settle3 analysis for the various sub-layers.

**Table 9-1: Settle3 Inputs**

| Layer | Elevation (m) | $c_{vr}$ ($mm^2$/sec) | $C_r$ | $P_c$' (kPa) | $e_o$ | Ca/Cc | $E_s$ (kPa) |
|---|---|---|---|---|---|---|---|
| Silty Sand | 132.5 to 129.5 | - | - | - | - | - | 10000 |
| Upper Clay | 129.5 to 122.5 | 0.4 | 0.06 | 320 – 185 | 1.325 | 0.045 | - |
| Lower Clay | 122.5 to 112.5 | 0.7 | 0.02 | 185 – 310 | 1.211 | 0.045 | - |
| Till | 112.5 to 110.5 | - | - | - | - | - | 50000 |

The results of the settlement analysis for the proposed embankment are summarized as follows:

- The magnitude of settlement beneath the new embankment centerline has been estimated to be about 70 to 100 mm. It is anticipated that it will take approximately 9 to 12 months to achieve substantial completion of the settlement at this location.
- It is noted that construction of the proposed 0.75 m grade raise at the existing centreline of the embankment would generate approximately 25 mm of settlement. Thus differnential settlement along the length of the culvert is anticipated.

MTO guidelines for settlement of surface treated and gravel roadways within structure transition zones over a period of 20 years after paving is outlined below:

- 25 mm within 20 m of the structure;
- 75 mm from 20 to 50 m from the structure;
- 150 mm from 50 to 75 m from the structure; and
- 300 mm greater than 75 m from the structure.

Based on these guidelines, the total embankment settlement of the widened embankment exceed these criteria within 50 m of the structure.

Therefore, deep foundations will need to be designed to account for downdrag loads, see Section 11.2 and future regrading of the road surface should be anticipated.

Alternatively it is recommended that a full height preload and a temporary CSP culvert be constructed and left in place for a duration of 1 year to ensure that post-construction settlement meets the above guidelines. The end of preload will need to be confirmed with a settlement monitoring program. The preload material would then be excavated to remove the temporary CSP and construct the permanent highway culvert.

Post seismic consolidation settlements for the 1 in 475 year earthquake are not expected to occur under the travelled lanes but could range from 20 to 200 mm where there is minimal confinement near the toes of the proposed embankment.

Construction

Excavations will extend below the water level in the creek. An adequate and effective dewatering plan including surface water management, cofferdams, creek diversion and excavation dewatering will be required to enable excavation to the required founding elevation and construction of the foundations in the dry (See Section 12.2).

The bedrock surface elevation increases approximately 6.4 m from north to south along the length of the culvert (elevation 109.3 m to 115.7 m). Suggested wording for a Notice to Contractor alerting the Contractor to the variable pile length is provided in Appendix I.

# 10 EVALUATION OF DESIGN OPTIONS

## 10.1 Culvert Type/Foundation Alternatives

It is understood that the creek contains sensitive fish habitat and that a closed-bottom box culvert was not permissible for the Highway 17 culverts immediately north of this site from a fisheries perspective. Regardless, a detailed assessment of culvert types and foundation options was carried out for the Daisy Lane/Anderson Road culvert replacement. The key findings and conclusion of the assessment are summarized as follows:

- An open-bottom concrete or steel plate arch culvert on spread footings was determined to be not feasible due to insufficient bearing resistance available from the underlying clay and the potential settlement in the foundation clay.
- An open-bottom concrete or steel plate arch culvert on deep foundations was determined to be feasible
- Although circular pipes installed with appropriate granular bedding over the clay subgrade were considered feasible, numerous circular pipes would be needed to provide the required hydraulic capacity and the fishery requirements would not be satisfied.
- A closed-bottom box culvert supported on the clay was determined to be feasible but not recommended without mitigation against damage from settlement. The base of the culvert could include perforations to partially mitigate fishery concerns.
- Precast concrete panels supported on sheet pile abutments were determined to be feasible.

An evaluation of the culvert/foundation alternatives including the advantages, disadvantages, risk/consequences and relative cost from a foundation perspective is provided in Appendix E.

## 10.2 Construction Staging Alternatives

Installation of a new culvert using open cut techniques and a full road closure would allow for an expedited construction schedule and could reduce costs associated with requiring roadway protection and traffic staging. Since the existing driveway is currently not in use this option is recommended.

## 10.3 Recommended Approach for the Culvert Replacement

Given the anticipated fisheries restriction against the use of a closed-bottom box culvert, replacing the existing culvert with an open-bottom box culvert supported on piles using full road closure is the preferred option. The preliminary General Arrangement (GA) drawing provided by MTO has been used in the development of design recommendations, a copy is provided in Appendix H. Given the anticipated duration of settlement at, this site, it is recommended that the culvert be designed to accommodate the anticipated down drag loads and settlement.

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## 11 FOUNDATION DESIGN RECOMMENDATIONS

The culvert may be supported on steel H-piles driven to bedrock or to practical refusal within the glacial till. Approximate key elevations are as follows:

- Proposed top of pavement, based on GA drawing 135.75 m
- Proposed cut-off of piles, based on GA drawing 131.4 m
- Underside of pile cap, based on GA drawing 130.8 m
- Stream bed elevation, based on GA drawing 131.75 m
- Locha Creek water level on July 24, 2019 131.9 m
- Glacial till surface (Boreholes AND19-1 to AND19-3 and 18-103) 110.7 to 119.2 m
- Bedrock surface (Boreholes AND19-1D, AND19-2 and 18-103) 109.3 to 115.7 m

The length of the piles is expected to range from approximately 16 m at the south end to 22 m at the north end. Suggested wording for a Notice to Contractor to alert the Contractor to the expected variation in pile length is provided in Appendix I.

### 11.1 Axial Compression

The factored geotechnical resistance of steel piles driven to bedrock at this site are as follows:

**Table 11-1: Factored Geotechnical Resistances at ULS and SLS**

| Pile Section | Factored Geotechnical Resistance at ULS (kN)* | Factored Geotechnical Resistance at SLS (kN) |
|---|---|---|
| HP 310x110 | 2,650 | N/A |
| HP 310x132 | 3,150 | N/A |

* The factored axial structural resistance of the piles driven to bedrock will likely govern the design.

The SLS condition will not govern for piles driven to bedrock.

It is anticipated that the factored geotechnical resistance at ULS exceeds the factored axial structural capacity of the pile (typically 2,000 kN for HP 310x110 and 2,400 kN for HP310x132). Therefore, the factored axial structural capacity at ULS shall be used for design.

The factored geotechnical resistances include the following factors as per Table 6.2 of the CHBDC:

- $\phi_{gu}$ = 0.4 (ULS; static analysis; typcial degree of understanding)
- $\phi_{gs}$ = 0.8 (SLS; static analysis; typical degree of understanding)
- $\psi$ = 1.15 (consequence factor)

## 11.2 Downdrag and Lateral Loading due to Clay Settlement

It is understood that a partial grade raise of 0.8 m is proposed for the segment of culvert beneath the existing embankment but that the grade to the south is to be raised by as much as 4 m. As noted in Section 9 above, settlement of 70 mm to 100 mm is predicted near the new embankment centreline. The settlement will induce downdrag loads on the pile foundations. The piles (HP310x110 or HP310x132) will be subject to an unfactored down drag load of approximately 700 kN/pile. The neutral plane will be near the top of the glacial till.

A load factor shall be added to the downdrag value provided as per Table 3.3 of the CHBDC to obtain the factored downdrag load. In accordance with Section C6.11.4.10 of the Commentary to the CHBDC for the structural design of a pile, the factored downdrag load shall be added to the factored permanent loads to assess the effects of downdrag. Also, in geotechnical analysis of downdrag, transient and live loads shall not be considered. The factored dead and downdrag loads shall not exceed the factored structural capacity of the piles.

In addition to vertical settlement of the clay deposit resulting in downdrag loads, lateral deformation of the clay is expected during the settlement process. The estimated lateral displacement profile is provided in tabular format in Appendix G. The resulting loading on the piles can be evaluated in a structural model using the p-y curves (see Section 11.3) for the static load case and imposing the displacement profile. The deep foundations will need to be designed to resist this loading.

If the HP 310x110 pile sections can not provide adequate resistance to the downdrag loads or lateral loads, a heavier pile section could be considered (e.g. HP 310x132).

If the embankments are pre-loaded prior to installing the piles, downdrag loads need not be considered. Pre-loading would likely require installation of a temporary culvert such as a CSP arch culvert.

## 11.3 Foundation Lateral Response

The lateral soil response of HP 310x110 and HP 310x132 piles was evaluated using the software program LPile 2018 published by Ensoft Inc. The lateral soil response for a single pile, for static and seismic conditions, is presented as p-y data in the tables provided in Appendix F for soils below the underside of the pile cap elevation assumed to be at elevation 130.8 m as indicated on the Preliminary GA Drawing. The values of P(kN/m) represent soil reaction per metre of pile length while the y(m) values represent soil/pile deflection.

The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters shall be factored using the geotechnical resistance factors ($\phi_{gu}$ and $\phi_{gs}$) provided in Table 6.2 of the CHBDC.

If lateral spacing between an adjacent pile or another structural element is less than four equivalent pile diameters, suitable reduction factors based on the center to center spacing shall

be applied as per Section C6.11.3 and Figures C6.22 C.6.23 and C6.24 of the Commentary to the CHBDC.

## 11.4 Pile Installation

Driven piles must be installed in accordance with OPSS.PROV 903 and Special Provision 109F57.

As the piles are to be driven through glacial till that contains cobbles and boulders, the pile tips of new piles driven at the site shall be protected from damage during driving with pile tip protection from an approved manufacturer such as Titus Steel (standard H-Point) or approved equivalent as per Section 6.11.4.8 of the CHBDC.

The appropriate pile driving note is "Piles to be driven to bedrock". OPSS 903.07.02.07.03.03 shall apply for all piles driven to bedrock. Care must be exercised if driving inclined piles or piles near sloping bedrock (see Section 5.6).

## 11.5 Frost Protection

The frost penetration depth at this site is 1.9 m as per OPSD 3090.101. Accordingly, a minimum of 1.9 m of earth cover, or equivalent insulation, must be provided above the base of the pile caps to serve as frost protection.

## 11.6 Wingwalls and Retaining Walls

Although the preliminary drawings don't indicate the use of wingwalls or retaining walls, consideration could be given to their inclusion to shorten the culvert length.

### 11.6.1 Deep Foundations

Foundations supported on driven piles for wingwalls or retaining walls should follow recommendations discussed in Sections 11.1 to 11.5. Refer to section 11.7 for recommendations on lateral earth pressures.

### 11.6.2 Shallow Foundations

Retaining walls founded on shallow foundations are not feasible at this site based on the low bearing capacity of the native soils and the anticipated settlements under the widened embankment.

### 11.6.3 RSS Walls

Retained soil system (RSS) walls are not considered feasible at this site due to the low bearing capacity of the native soil as well as the anticipated settlement. In addition, the site is located within a watercourse and could be affected by fluctuating water levels.

## 11.7 Lateral Earth Pressures and Culvert Backfill

Structural backfill material should consist of Granular A or Granular B Type II meeting the OPSS.PROV 1010 and SP110S06 specifications. Large scale direct shear box testing on samples of Granular A and Granular B Type II from numerous nearby aggregate sources was completed for this project. The results indicate that for design of structural backfill for this project, an internal angle of friction of 40 degrees can be used for Granular B Type II and quarry- sourced Granular A in this area provided the vertical pressure on the material is less than 150 kPa (Geocres Memorandum 31F-213). An Operational Constraint will be required in the contract restricting the source of Granular A to quarries. Throughout this report, the term “Granular A” is defined as “Quarry-Source Granular A” unless specifically described as “Pit-Source Granular A”.

The backfill must be in accordance with OPSS 902 and placed to the extents shown on OPSD 803.010 for the culvert and OPSD 3101.150 for retaining walls (if required). The backfill should be compacted and compaction equipment to be used adjacent to the structure must be restricted in accordance with OPSS.PROV 501. The design of the wingwalls/retaining walls, if required, must incorporate a subdrain as shown in OPSD 3101.150.

The lateral earth pressure parameters provided in Table 11-2 and Table 11-3 are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for buildup of hydrostatic pressures should be considered in the design.

### 11.7.1 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on structures shall be computed in accordance with the CHBDC but generally are given by the expression:

$$\sigma_h = K^*(\gamma h + q)$$

where:

- $\sigma_h$ = static lateral earth pressure on the wall at depth d (kPa)
- K = earth pressure coefficient
- $\gamma$ = unit weight of retained soil (kN/m$^3$); use submerged unit weight for soils below the groundwater level
- h = depth below top of fill where pressure is computed (m)
- q = value of any surcharge (kPa)

The recommended lateral earth pressure parameters for use in the design of vertical walls with a horizontal backslope are provided in Table 11-2.

If lateral movement is not permissible and/or the wall is retained from lateral yielding, it is recommended that the at-rest horizontal lateral earth pressures be used for design. Active

pressures shall be used for the design of unrestrained walls. For static analysis of permanent structures, passive earth resistance should be ignored, and therefore has not been provided.

**Table 11-2: Static Lateral Earth Pressure Coefficients**

| Parameter | Quarry Sourced OPSS Granular A and Granular B Type II $\phi = 40^o$, $\gamma = 22.8$ kN/m$^3$ | Pit Sourced OPSS Granular A $\phi = 35^o$, $\gamma = 22.8$ kN/m$^3$ |
|---|---|---|
| Coefficient of at Rest Earth Pressure, $K_o$ (Restrained Wall) | 0.36 | 0.43 |
| Coefficient of Active Earth Pressure, $K_A$ (Unrestrained Wall) | 0.22 | 0.27 |

A lateral pressure due to backfill compaction shall be added to the calculated lateral earth pressure in accordance with Section 6.12.3 of the CHBDC. A live load surcharge shall be considered as per Section 6.12.5 of the CHBDC.

The parameters in the table correspond to full mobilization of active earth pressures and require certain relative movements between the wall and adjacent soil to produce these conditions. The movement required can be assessed from Table C6.12 of the Commentary to the CHBDC. Active earth pressures should be used for any wingwalls or unrestrained walls. For rigid structures, at rest horizontal earth pressures would apply for design.

11.7.2 Combined Static and Seismic Lateral Earth Pressure Parameters

The following recommendations are per Section C6.14.7.2 of the Commentary of the CHBDC which states that seismically induced lateral soil pressures may be calculated using the Mononobe- Okabe Method with:

- $k_h$ = ½ F(PGA)•PGA for structures that allow 25 mm to 50 mm of movement, and
- $k_h$ = F(PGA)•PGA for non-yielding walls

The recommended combined static and seismic lateral earth pressure parameters for use in the design of vertical walls that are provided in Table 11-3 assume the following:

- Seismic Site Class of D,
- Site Coefficient F(PGA) of 1.135 as per Table 4.8 of the CHBDC, and
- Site adjusted PGA value with a 2% probability of exceedance in 50 years of 0.258g as outlined in Section 8.2.

**Table 11-3: Lateral Earth Pressure (Under Combined Static and Seismic Loads)**

| Parameter | Quarry Sourced OPSS Granular A and Granular B Type II<br>$\phi = 40^o$, $\gamma = 22.8$ kN/m$^3$ | Pit Sourced OPSS Granular A<br>$\phi = 35^o$, $\gamma = 22.8$ kN/m$^3$ |
|---|---|---|
| Coefficient of Active Earth Pressure, $K_{AE}$ (Restrained Wall) | 0.37 | 0.44 |
| Coefficient of Active Earth Pressure, $K_{AE}$ (Unrestrained Wall) | 0.28 | 0.35 |

The total pressure due to combined static and seismic loads acting at a specific depth below the top of the wall may be determined using the following equation that includes consideration of material properties and the soil profile:

$$\sigma_{hAE} = K\gamma d + (K_{AE} - K_A)\,\gamma\,(H - d)$$

where:

$\sigma_{hAE}$ = combined static and seismic active lateral earth pressure on the wall at depth d (kPa)
d = depth below the top of the wall (m)
K = static earth pressure coefficient ($K_o$ for non-yielding and $K_A$ for yielding walls)
$\gamma$ = unit weight of retained soil (kN/m$^3$); use submerged unit weight for soils below the groundwater level
$K_{AE}$ = combined static and seismic earth pressure coefficient
H = total height of the wall (m)

## 11.8 Embankment Design and Reinstatement

Emabnkments shall be constructed in accordance with OPSS.PROV 206.

### 11.8.1 Embankment for Extended Anderson Road

Construction of the new Anderson Road embankment is expected to result in approximately 70 to 100 mm of settlement; (see Section 9) at the new centreline, with substantial completion of the settlement occurring within 9 to 12 months. Consideration could be given to preloading the area prior to installation of the piles. Preloading would likely require installation of a temporary culvert such as a CSP arch culvert. With the preload scenario it is anticipated that that construction of the culvert would commence approximately 1 years after placement of the embankment fill.

Alternatively, it is recommended that the structural design of the culvert incorporate the additional design drag loads on the piles and the embankment surface could undergo grade corrections as needed. Given the limited traffic, this would be facilitated with a granular driving surface.

It is recommended that the culvert backfill and cover material consist of Granular A or Granular B Type II to minimize the lateral earth pressures on the structure. The embankment material between the bottom of the pavement subbase elevation and the top of the cover material could consist of either OPSS Select Subgrade, Granular A or Granular B Type I, II or III materials. All backfill, and embankment material shall be placed and compacted in accordance with the OPSS.PROV 501.

### 11.8.2 Embankment Stability

The global stability for the new embankment for the Anderson Road Extension constructed using conventional granular fill with 2H:1V side slopes was evaluated using GeoStudio 2020 Slope/W software for limit equilibrium analysis. Input parameters for the analysis are based on the in-situ shear vane measurements, SPT N values and the results of laboratory testing.

The following additional parameters were used in the analysis:

- The soil stratigraphy is based on the nearest boreholes.
- The maximum fill height away from the culvert is 3.3 m.
- Embankment slopes of 2H:1V.
- Seismic Site Class of D.
- For the 1 in 475 year event: Site Coefficient F(PGA) of 1.29 as per Table 4.8 of the CHBDC. Horizontal seismic coefficients of 0.049g equal to ½ of the site adjusted PGA values were used for seismic analysis, as discussed in Section 8.2.
- For the 1 in 2,475 year event: Site Coefficient F(PGA) of 1.13 as per Table 4.8 of the CHBDC. Horizontal seismic coefficients of 0.129g equal to ½ of the site adjusted PGA values were used for seismic analysis, as discussed in Section 8.2.
- A traffic surcharge of 17 kPa has been applied as a temporary load.

The global stability analysis results indicate the following factor of safety values:

**Table 11-4 Slope Stability Analysis Results for Rock Fill Embankments**

| Condition | Case | 2H:1V Slope |
|---|---|---|
| Temporary (traffic loading) | Short Term (Undrained) | 1.4 (Fig 1-1) |
| Permanent (no traffic loading) | Long Term (Drained) | 1.4 (Fig 1-2) |
| Temporary (includes seismic) | Pseudo-Static Seismic – 1 in 475 year (Undrained) | 1.2 (Fig 1-3) |
| | Pseudo-Static Seismic – 1 in 2475 year (Undrained) | 1.1 (Fig 1-4) |

Table 6.2 of the CHBDC for embankment fills with a typcial degree of understanding and a Ψ of 1.15 generates minimum Factors of Safety of 1.3 and 1.2 for permanent and temporary conditions respectively**.** The permanent and temporary results presented above exceed the target Factors of Safety.

Table 6.3 in Section 6.14.4.1 of the CHBDC indicates a minimum seismic resistance factor of 1.0 for force-based design and 1.0 for performance-based design. Based on these values and Ψ of 1.15, a target Factor of Safety of 1.0 for this temporary condition with a typical degree of understanding is appropriate for the pseudo-static seismic analysis. The pseudo-static result presented above, exceeds the target Factor of Safety for seismic design stability.

It is noted that some displacement of the embankment can occur where the pseudo-static Factor of Safety is less than 1.3 (Section C6.14.9.1 of the CHBDC). As per Section 6.14.2.1 of the CHBDC, “other” geotechnical systems in the structure-embankment interface zone shall not collapse under ground motions with a return period of 2475 years and shall have 50% of the lanes (not less than one) available for use following ground motions with a return period of 475 years. Both of these criteria have been satisfied.

The proposed embankment slopes satisfy all of the static and pseudo-static slope stability requirements.

The outputs from the global stability analyses are provided in Appendix F.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes, see Section 12.4.

### 11.9 Cement Type and Corrosion Potential

Chemical analysis for determination of pH, water soluble sulphate, sulphides, chloride concentrations, resistivity and electrical conductivity was carried out on samples of the native materials. The analysis results are summarized in Table 5-11 and a copy of the test results is provided in Appendix C.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The test results provided in Table 5-11 were compared with Table 3.2 of the MTO Gravity Pipe Design Guideline and generally indicate a severe corrosive environment. The test results provided in Table 5-11 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with the soil and groundwater at the site. The sulphate results in Table 5-3 were compared with Table 3 of Canadian Standards Association Standards A23.1-14 (CSA A23.1) and generally indicate a low degree of sulphate attack potential on concrete structures at this site.

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# 12 CONSTRUCTION CONSIDERATIONS

## 12.1 Excavations

It is anticipated that temporary excavations up to 4 m below the existing top of roadway will be required to allow the removal of the existing culvert and installation of the new foundations. As it is anticipated that the roadway will be closed during construction, the use of temporary roadway protection systems to support excavations is not anticipated.

Artesian conditions originating from the glacial till layer were noted at the site, with water pressures extending to at least 0.5 m to 3.5 m above the ground surface in boreholes extended into the till layer (AND19-1, AND19-2, AND19-3 and 18-103). Based on an assumed bottom of pile cap elevation of 130.0 m, the glacial till surface would be overlain by between 10.8 m (Borehole AND19-1) and 19.3 m (Borehole 18-103) of clay. As such basal instability issues due to the artesian condition encountered in the glacial till layer are not considered a design issue at this site.

Excavation for the installation of the culvert shall be carried out in accordance OPSS 902 and NSSP FOUN0003.

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The fills and native soils at the site shall be classified as Type 3 generally and Type 4 for the loose sands and silts in accordance with OHSA. If an excavation penetrates more than one soil type, the entire excavation must be completed in accordance with the more stringent requirements. Excavation must not destabilize existing or proposed foundations.

The management and disposal of excess material shall be in accordance with OPSS.PROV 180.

Selection of the equipment and methodology to excavate and prepare the founding surface is the responsibility of the Contractor. In addition, the Contractor must plan the work appropriately to ensure stable work platforms for equipment including pile driving cranes.

The base of excavation for removal of the existing culvert and construction of the new pile caps is expected to consist primarily of clay, with the possibility of some areas with saturated silt and sand. These subgrade materials will be easily disturbed by construction activities and should be protected with a concrete working slab or granular pad. Tremie concrete should be considered. The tender documents should include FOUN0001, requiring the provision of a concrete working slab for the construction of the new pile caps.

## 12.2 Dewatering

The depth of excavations required to replace the existing culvert will extend below the creek level observed at the time of the investigation. Furthermore, groundwater and surface runoff will tend to seep into and accumulate into the excavations. The Contractor must control groundwater and

creek/surface water flow at the site to permit the replacement of the culvert in a dry and stable excavation.

Excavation for construction of the culvert must be carried out with a properly designed dewatering system to control groundwater and creek/surface water and may include cofferdams, creek diversion, pumping, etc. The creek diversion should be placed outside the construction area. The dewatering system will be required to remain operational and effective until the temporary excavations are backfilled and then shall be decommissioned and removed.

Construction specifications for dewatering can be found in OPSS.PROV 517.

The design of dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with SP FOUN0003 which amends OPSS 902. A preconstruction survey is not recommended, thus Designer Fill-In ** in this SP should be “NA”.

The water level will fluctuate and the minimum groundwater elevation for the site at the time of the excavation should be taken as the expected high water level defined in SP517F01 and SP FOUN0003. Given the presence of significant artesian groundwater conditions it is recommended that the dewatering system design engineer requirement be invoked in SP517F01. Excavation base instability due to artesian conditions must be considered for the site. In addition, the potential for bottom heave due to the presence of cohesive soils needs to be assessed.

Recommended wording for an NSSP amending SP FOUN0003 to include the requirement that the design Engineer and design-checking Engineer of the dewatering system have a minimum of 5 years of experience in designing systems of similar nature and scope to the required work has been provided in Appendix I.

The groundwater level will fluctuate and the minimum groundwater elevation at the time of the proposed work shall be taken as the creek water level of the design storm return period defined by the contract documents for the temporary dewatering system.

Further assessment of the dewatering requirements and the need for a Permit to take Water (PTTW) should be carried out by specialists experienced in this field.

It is noted that a Hydrogeological Investigation and Design Report is under preparation for the Highway 17 Twinning Project. Please refer to that document for additional discussion on dewatering with respect to this assignment.

### 12.3 Temporary Protection System

It is anticipated that the water course diversion will be carried out with a cofferdam redirecting creek water through a pipe or series of pipes installed through the existing culvert. During periods of high creek levels, a watertight braced enclosure system shall be considered. Sheet pile cofferdams can be designed following the recommendations provided below.

The construction of the pile caps will include excavation to 1.9 m below the creek level of 131.9 m elevation observed on July 24, 2019. It is anticipated that the pile caps will be constructed within closed sheet pile enclosures. The base of the pile cap should be constructed with tremie concrete to minimize the risk of basal instability.

The sheet pile enclosures are temporary protection systems and shall be provided in accordance with OPSS.PROV 539 and SP 105S09 and designed for Performance Level 2. All protection systems shall be designed by a Professional Engineer experienced in such designs.

Typical lateral earth pressure coefficients are provided in Table 12-1 for the design of vertical temporary protection systems. The values provided are for a horizontal backslope behind, and a horizontal surface in front of the protection system. If the backslope behind or if the ground surface in front of the temporary protection systems are not horizontal, the lateral earth pressure parameters provided in Table 12-1 do not apply and recalculation of the earth pressure parameters for sloped backfill will be required.

**Table 12-1: Lateral Earth Pressure Coefficients for Temporary Protection System Design**

| Parameter | OPSS Granular B Type II | Existing Fill/SSM | Native Clay |
|---|---|---|---|
| Soil Unit Weight, kN/m$^3$, $\gamma$ | 22.8 | 21.0 | 17.3 |
| Angle of Internal Friction, $\phi$ | 40° | 30° | - |
| Coefficient of at Rest Earth Pressure, $K_o$ | 0.36 | 0.50 | - |
| Coefficient of Active Earth Pressure, $K_a$ | 0.22 | 0.33 | - |
| Coefficient of Passive Earth Pressure, $K_p$ | 4.6 | 3.0 | - |
| Undrained Shear Strength, kPa | - | - | 40 |

The design of protection systems is the responsibility of the Contractor. The designer of the temporary protection system must ensure the penetration depth is sufficient to cut off seepage as well as provide base fixity, incorporate traffic loading and surcharge loading due to construction equipment and their operations and shall consider the slope of temporary embankments above the top of the protection system and location of existing utilities and trenches.

When designing roadway protection systems, the Contractor should consider the potential for obstructions such as cobbles and boulders (inherent in glacial tills) as well as artesian conditions that were noted during groundwater measurements in the glacial till layer. Suggested wording for an NSSP for obstructions is included in Appendix I.

The use of sheet piles driven sufficiently deep into the underlying clay soil to provide lateral stability is considered feasible. In view of the high lateral earth pressures associated with the existing embankment slope (retained heights of up to 4 m), tie back anchors consisting of soil anchors installed within the clay may be required to maintain stability. The use of deadman anchor blocks or internal bracing could also be considered.

Installation of temporary protection systems using vibratory equipment should be prohibited for this site due to the risk of disturbing the soils under the new Anderson Road embankment as well as the adjacent Highway 17 embankment.

The temporary protection systems should be cut off and left in place.

### 12.4 Erosion and Scour Protection

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes. The Contractor shall provide silt fences and erosion control blankets, as required, throughout the duration of the construction to prevent silt/sediments from running off the site as per OPSS 805.

Particle size analysis on samples of the existing embankment materials and native silts indicate that the soils have a low and moderate potential for soil erodibility respectively (Wischmeier Nomograph factor, K of 0.03 and 0.54, respectively).

Scour protection shall be provided at the culvert inlet and outlet areas. Design of the erosion protection measures must consider hydrologic and hydraulic factors and shall 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. Treatment at the inlet and outlet shall be in accordance with OPSD 810.010. A vegetation cover shall be established on all other exposed earth surfaces as soon as practical to protect against surficial erosion in accordance with OPSS.PROV 804.

It is recommended that a clay seal be used to minimize the potential for erosion near the inlet and outlet areas. The clay seal shall extend a minimum of 0.3 m above the high-water level and laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The material requirements shall be in accordance with OPSS.PROV 1205. A geosynthetic clay liner may also be considered.

Liaison between the Foundations Consultant, Structural Engineer and Hydraulic/Drainage Engineer will be required in design to ensure that scour protections is adequately addressed.

## 13 CONSTRUCTION CONCERNS

The planned construction methodology includes an open cut excavation for the installation of a new culvert.

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

- Construction will extend below the water level in the creek. An adequate and effective surface water management and dewatering plan must be implemented to construct the replacement culvert foundations in the dry.

- The glacial till layer is relatively thin (1.4 to 4.1 m) but contains cobbles and may contain boulders. Although most piles will likely penetrate the till and reach refusal on the bedrock, some of the piles may reach refusal on boulders. The tips of the piles shall be protected.
- Artesian conditions were encountered in the glacial till layer beneath the thick clay unit. Due to the shallow excavation depths and thickness of the clay layer, base instability issues due to the artesian condition encountered are not consider a design issue at the site.
- Mitigation of the settlement induced by the construction of the new Anderson Road embankment will require a pre-load or a structure designed to accommodate the movements. If a preload approach is selected, an instrumentation and monitoring program will need to be implemented to assess the progress of the preload. Given the limited project length, the monitoring program would include approximately six settlement rods located on the new alignment with a nominal spacing of 25 m. The base plates should be installed prior to fill placement and the rods will require extension as fill is placed around them. The top of the settlement rods should be surveyed every week during preload construction and every two weeks for 3 months and every month thereafter until completion of the anticipated 1 year pre-load period. The installation of the monitoring equipment and surveying would typically be carried out by the Contractor, with the results evaluated by the Contract Administration team.

The successful performance of this structure will depend largely upon good workmanship and quality control during construction. Observation of the excavation and backfilling operations will be required as per OPSS.PROV 902 during construction to confirm that the foundation recommendations are correctly implemented, and material specifications are met.

## 14 CLOSURE

Engineering analysis and preparation of this report was carried out by Justin Gray, P.Eng. and by Dr. Fred Griffiths, 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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## REFERENCES

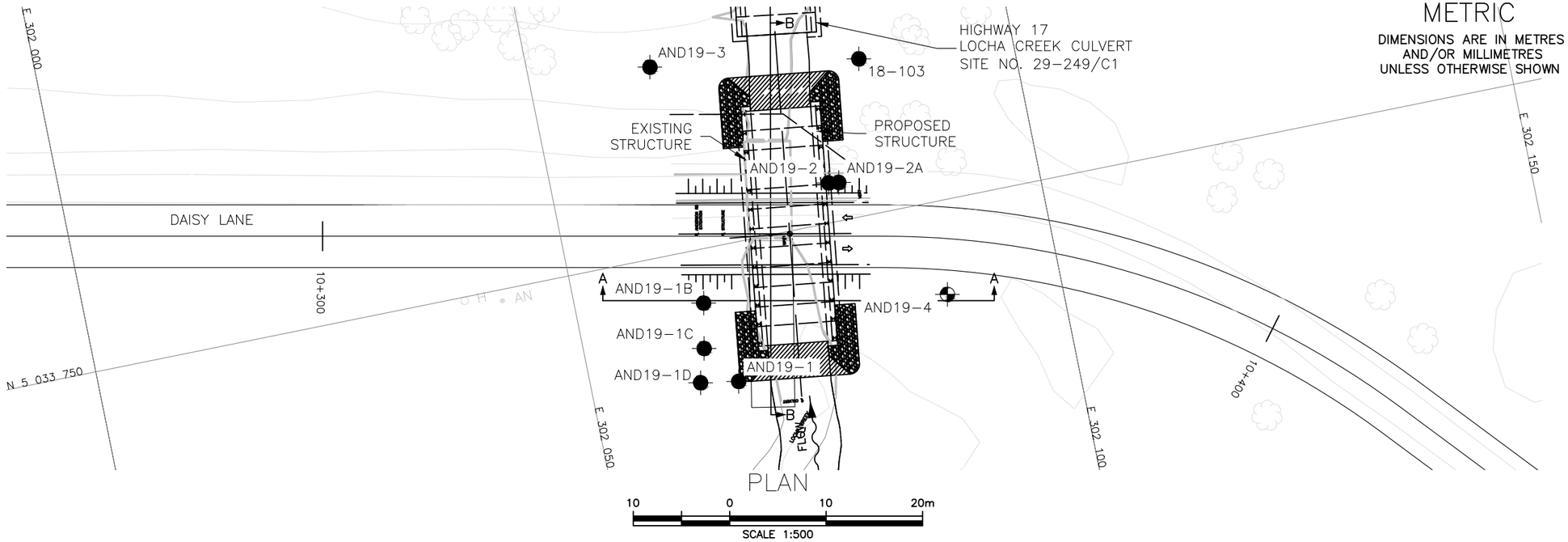

[i] Boulanger, R. W. and Idriss, I. M. (2007). Evaluation of cyclic softening in silts and clays, ASCE, Journal of Geotechnical and Geoenvironmental Engineering, 133(6), 641-652.

[ii] Boulanger, R. W., and Idriss, I. M. (2014). CPT and SPT based liquefaction triggering procedures, Report No. UCD/CGM-14/01, Center for Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, CA, 134 pp.

## Appendix A.

## Borehole Location Plan and Stratigraphic Drawings

MINISTRY OF TRANSPORTATION, ONTARIO

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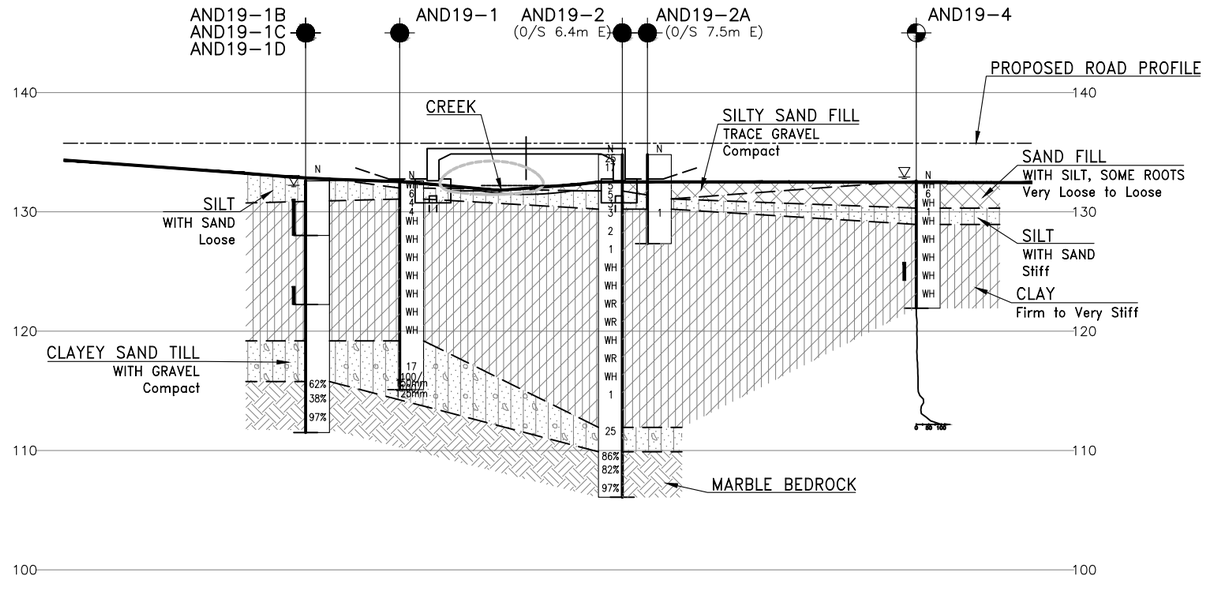



SECTION (A–A)

5 0 5 10m H 1:250

10 0 10 20m V 1:500

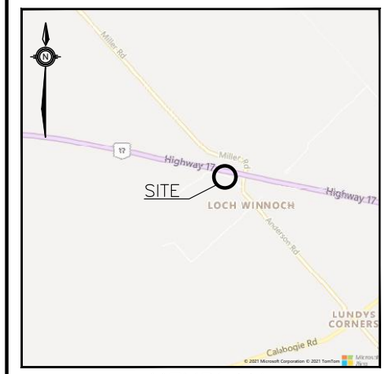
CONT No
WP No 4068–09–00

SHEET

HIGHWAY 17
ANDERSON ROAD EXTENSION
LOCHA CREEK CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

Ontario

THURBER ENGINEERING LTD.




KEYPLAN

LEGEND

| | |
|---|---|
| ● | Borehole |
| ⊕ | Borehole and Cone |
| 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 |
|---|---|---|---|
| AND19–1 | 132.6 | 5 033 735.8 | 302 065.1 |
| AND19–1B | 132.9 | 5 033 744.5 | 302 063.2 |
| AND19–1C | 132.9 | 5 033 739.8 | 302 062.3 |
| AND19–1D | 132.8 | 5 033 736.4 | 302 061.2 |
| AND19–2 | 134.8 | 5 033 754.1 | 302 078.4 |
| AND19–2A | 134.8 | 5 033 753.9 | 302 079.4 |
| AND19–3 | 133.7 | 5 033 769.5 | 302 062.6 |
| AND19–4 | 132.6 | 5 033 740.3 | 302 088.1 |
| 18–103 | 133.9 | 5 033 766.1 | 302 084.0 |

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Structural elements, surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83 Zone 9.

**GEOCRES No. 31F-212**

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F. J. GRIFFITHS
July 30, 2021
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
July 30, 2021
PROVINCE OF ONTARIO

| REVISIONS | | | |
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| DATE | BY | DESCRIPTION | |
| DESIGN JG | CHK FJ | CODE | LOAD |
| DRAWN BH | CHK JG | SITE | STRUCT |
| | | | DATE JUL 2021 |
| | | | DWG 1 |

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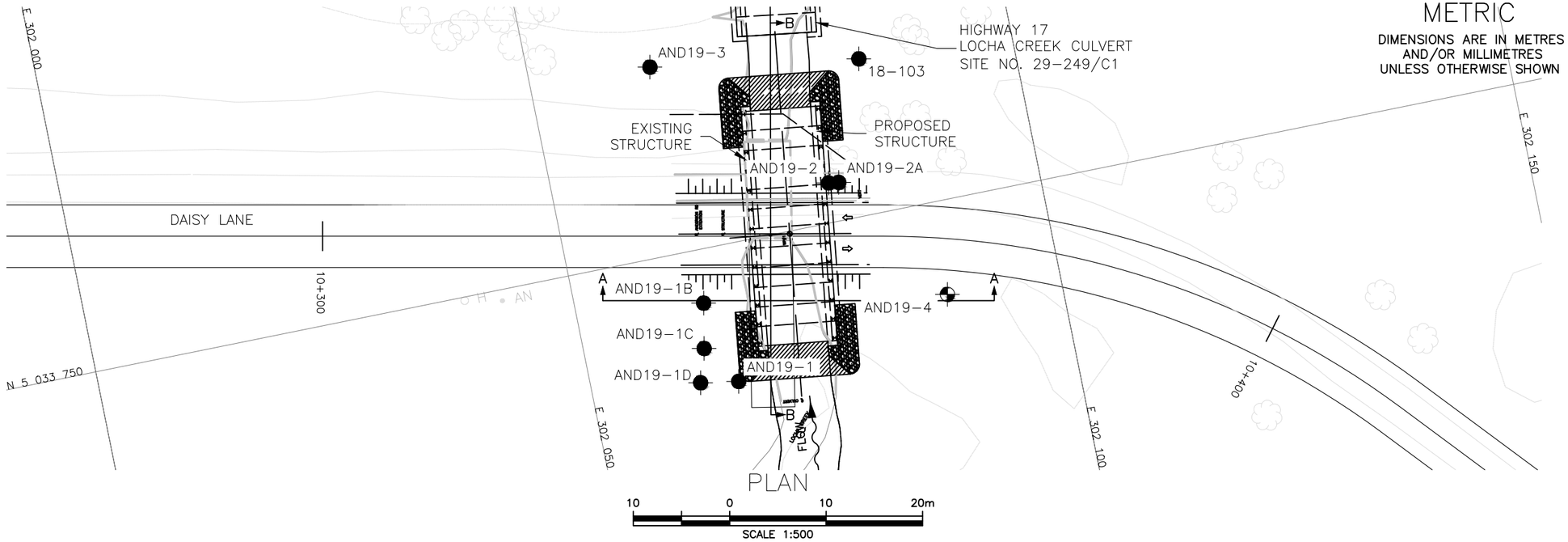
MINISTRY OF TRANSPORTATION, ONTARIO

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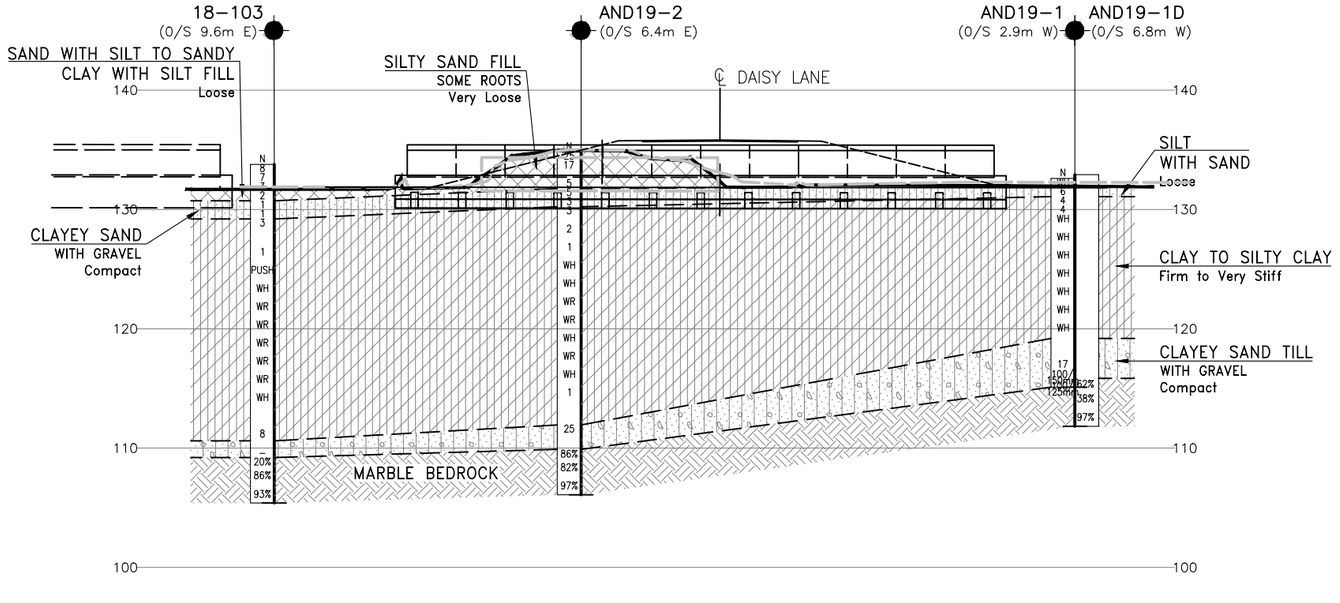
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN




SECTION (B-B)

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10 0 10 20m V 1:500

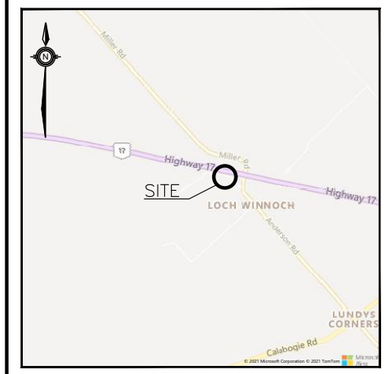
CONT No
WP No 4068-09-00

SHEET

HIGHWAY 17
ANDERSON ROAD EXTENSION
LOCHA CREEK CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

Ontario

THURBER ENGINEERING LTD.




KEYPLAN

## LEGEND

| | |
|---|---|
| ● | Borehole |
| ⊕ | Borehole and Cone |
| 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 |
|---|---|---|---|
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| REVISIONS | | | |
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## Appendix B.

## Record of Borehole Sheets

THURBER

# SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

**TERMINOLOGY DESCRIBING COMMON SOIL GENESIS**

| | |
|---|---|
| Topsoil | mixture of soil and humus capable of supporting vegetative growth |
| Peat | mixture of fragments of decayed organic matter |
| Till | unstratified glacial deposit which may include particles ranging in sizes from clay to boulder |
| Fill | material below the surface identified as placed by humans (excluding buried services) |

**TERMINOLOGY DESCRIBING SOIL STRUCTURE:**

| | |
|---|---|
| Desiccated | having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc. |
| Fissured | having cracks, and hence a blocky structure |
| Varved | composed of alternating layers of silt and clay |
| Stratified | composed of alternating successions of different soil types, e.g. silt and sand |
| Layer | > 75 mm in thickness |
| Seam | 2 mm to 75 mm in thickness |
| Parting | < 2 mm in thickness |

**RECOVERY:**

For soil samples, the recovery is recorded as the length of the soil sample recovered.

**N-VALUE:**

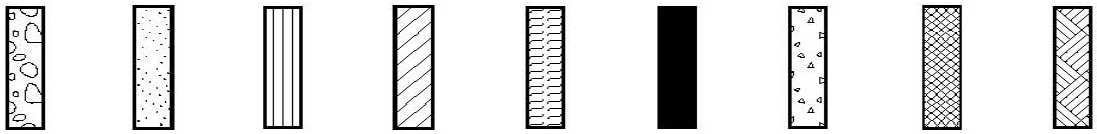
Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

**DYNAMIC CONE PENETRATION TEST (DCPT):**

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an “A” size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.

THURBER

**STRATA PLOT:**
Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



| Boulders Cobbles Gravel | Sand | Silt | Clay | Organics | Asphalt | Concrete | Fill | Bedrock |
|---|---|---|---|---|---|---|---|---|

**TEXTURING CLASSIFICATION OF SOILS**

| Classification | Particle Size |
|---|---|
| Boulders | Greater than 200 mm |
| Cobbles | 75 – 200 mm |
| Gravel | 4.75 – 75 mm |
| Sand | 0.075 – 4.75 mm |
| Silt | 0.002 – 0.075 mm |
| Clay | Less than 0.002 mm |

**SAMPLE TYPES**

| | |
|---|---|
| SS | Split spoon samples |
| ST | Shelby tube or thin wall tube |
| DP | Direct push sample |
| PS | Piston sample |
| BS | Bulk sample |
| WS | Wash sample |
| HQ, NQ, BQ etc. | Rock core sample obtained with the use of standard size diamond coring equipment |

**TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)**

| Descriptive Term | Undrained Shear Strength (kPa) |
|---|---|
| Very Soft | 12 or less |
| Soft | 12 – 25 |
| Firm | 25 – 50 |
| Stiff | 50 – 100 |
| Very Stiff | 100 – 200 |
| Hard | Greater than 200 |

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

**TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)**

| Descriptive Term | SPT "N" Value |
|---|---|
| Very Loose | Less than 4 |
| Loose | 4 – 10 |
| Compact | 10 – 30 |
| Dense | 30 – 50 |
| Very Dense | Greater than 50 |

THURBER

## MODIFIED UNIFIED SOIL CLASSIFICATION

| Major Divisions | | Group Symbol | Typical Description |
|---|---|---|---|
| **COARSE GRAINED SOIL** | 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** | SILT AND CLAY SOILS $W_L < 35\%$ | ML | Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity. |
| | | CL | Inorganic clayey silts of low plasticity, gravelly clays, sandy clays. |
| | | OL | Organic silts and organic silty-clays of low plasticity. |
| | SILT AND CLAY SOILS $35\% < W_L < 50\%$ | MI | Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts. |
| | | CI | Inorganic clays of medium plasticity, silty clays. |
| | | OI | Organic silty clays of medium plasticity. |
| | SILT AND CLAY SOILS $W_L > 50\%$ | MH | Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts. |
| | | CH | Inorganic clays of high plasticity, fat clays. |
| | | OH | Organic clays of high plasticity, organic silts. |
| **HIGHLY ORGANIC SOILS** | | Pt | Peat and other organic soils. |

Note - $W_L$= Liquid Limit

THURBER

# EXPLANATION OF ROCK LOGGING TERMS

## ROCK WEATHERING CLASSIFICATION

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

## TERMS

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

## DISCONTINUITY SPACING

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

## STRENGTH CLASSIFICATION

| Rock Strength | Approximate Uniaxial Compressive Strength (MPa) |
|---|---|
| Extremely Strong | Greater than 250 |
| Very Strong | 100 – 250 |
| Strong | 50 – 100 |
| Medium Strong | 25 – 50 |
| Weak | 5 – 25 |
| Very Weak | 1 – 5 |
| Extremely Weak | 0.25 – 1 |

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-1 1 OF 2 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 735.8 E 302 065.1 ORIGINATED BY MW

HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW

DATUM Geodetic DATE 2019.07.22 - 2019.07.23 CHECKED BY FG

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) (20 40 60) | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 132.6 | **Ground Surface** | | | | | | | | | | |
| 0.0 / 132.0 | **SAND** with silt, trace roots<br>Very Loose<br>Grey-Brown | | 1 | SS | WH | | | | | | |
| 0.6 / 131.1 | **SILT (ML)** with sand, some clay, trace roots<br>Loose<br>Grey-Brown | | 2 | SS | 6 | | | | | | |
| 1.5 | **CLAYEY SILT to CLAY (CL to Cl)**<br>Stiff<br>Grey | | 3 | SS | 4 | | | | | | |
| | | | 4 | SS | 4 | | | | | | 0 0 38 62 |
| | | | 5 | SS | WH | | | | | | |
| | | | 6 | SS | WH | | | | | | |
| | | | 7 | SS | WH | | | | | | 0 0 52 48 |
| | | | 8 | SS | WH | | | | | | |
| | | | 9 | SS | WH | | | | | | |

Elevation scale: 132, 131, 130, 129, 128, 127, 126, 125, 124, 123

Shear strength: UNCONFINED ○, FIELD VANE +, QUICK TRIAXIAL ●, LAB VANE ×

Dynamic cone penetration resistance plot: 12.0, 20.0, 4.0, 3.5, 9.7, 8.3, 5.2, 6.7

Continued Next Page

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

$\frac{20}{15 \cdot 10 \cdot 5}$ (%) STRAIN AT FAILURE

ONTMT4S 24726 ANDERSON ROAD.GPJ 2012TEMPLATE(MTO).GDT 21/7/21

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-1 2 OF 2 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 735.8 E 302 065.1 ORIGINATED BY MW

HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW

DATUM Geodetic DATE 2019.07.22 - 2019.07.23 CHECKED BY FG

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Continued From Previous Page | | | | | | | | | | |
| | **CLAYEY SILT to CLAY (CL to CI)**<br>Stiff<br>Grey | | | | | | | | | | |
| | | | 10 | SS | WH | | | | | | |
| | | | 11 | SS | WH | | | | | | 0 2 37 61 |
| 119.2 | | | | | | | | | | | |
| 13.4 | Clayey **SAND** with gravel<br>occasional cobbles<br>Compact<br>**(TILL)**<br>-Artesian conditions encountered at 13.7 m | | 12 | NQ | | | | | | | |
| | -Poor sample recovery | | 13 | SS | 17 | | | | | | |
| | - Frequent cobbles below 16.8 m<br>- Artesian pressure increase (Observed) | | 14 | SS | 100/150mm | | | | | | |
| 115.1 | Casing Refusal | | 15 | SS | 100/125mm | | | | | | |
| 17.5 | End of Borehole<br>-Borehole terminated at bedrock surface due to artesian conditions, See AND19-1D for bedrock coring<br>-Artesian head in casing at approx. 3.5 m above ground surface (elevation 136.1 m) upon completion | | | | | | | | | | |

ELEVATION SCALE: 122, 121, 120, 119, 118, 117, 116

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: 20 40 60 80 100

5.7
5.0
5.0
3.5
4.8

WATER CONTENT (%): 20 40 60

+ ³, × ³: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

ONTMT4S 24726 ANDERSON ROAD.GPJ 2012TEMPLATE(MTO).GDT 21/7/21

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-1B 1 OF 2 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 744.5 E 302 063.2 ORIGINATED BY MW

HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW

DATUM Geodetic DATE 2019.07.25 - 2019.07.25 CHECKED BY FG

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) 20 40 60 | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | GR SA SI CL |
| 132.9 | **Ground Surface** | | | | | | | | | | |
| 0.0 | No sampling<br>Cased to 10.4 m for well installation<br>See AND19-1 for stratigraphy | | | | | | 132<br>131<br>130<br>129<br>128<br>127<br>126<br>125<br>124<br>123 | | | | |

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-1B 2 OF 2 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 744.5 E 302 063.2 ORIGINATED BY MW

HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW

DATUM Geodetic DATE 2019.07.25 - 2019.07.25 CHECKED BY FG

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (20 40 60) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Continued From Previous Page | | | | | | | | | | |
| 122.5 | No sampling<br>Cased to 10.4 m for well installation<br>See AND19-1 for stratigraphy | | | | | | | | | | |
| 10.4 | End of Borehole<br><br>0.6 m Stickup on well<br><br>WATER LEVEL READINGS:<br>DATE DEPTH (m) ELEV. (m)<br>2019.08.23 0.5 132.4<br>2019.09.05 0.4 132.5<br>2019.11.25 0.1 above g.s. 133.0<br>2021.07.20 0.3 132.6 | | | | | | | | | | |

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

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

ONTMT4S 24726 ANDERSON ROAD.GPJ 2012TEMPLATE(MTO).GDT 21/7/21

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-1C 1 OF 1 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 739.8 E 302 062.3 ORIGINATED BY MW

HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW

DATUM Geodetic DATE 2019.07.25 - 2019.07.25 CHECKED BY FG

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 132.9 | **Ground Surface** | | | | | | | 20 40 60 80 100 | 20 40 60 | | |
| 0.0 | No sampling<br>Cased to 4.6 m for well installation<br>See AND19-1 for stratigraphy | | | | | | 132<br>131<br>130<br>129 | | | | |
| 128.3 | | | | | | | | | | | |
| 4.6 | End of Borehole<br><br>0.9 m stickup on well<br><br>WATER LEVEL READINGS:<br>DATE DEPTH (m) ELEV. (m)<br>2019.08.23 0.5 132.4<br>2019.09.05 0.3 132.6<br>2019.11.25 0.2 132.7<br>2021.07.20 0.1 132.8 | | | | | | | | | | |

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

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

ONTMT4S 24726 ANDERSON ROAD.GPJ 2012TEMPLATE(MTO).GDT 21/7/21

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-1D 1 OF 3 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 736.4 E 302 061.2 ORIGINATED BY MW

HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW

DATUM Geodetic DATE 2019.07.29 - 2019.07.29 CHECKED BY FG

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa 20 40 60 80 100 (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) 20 40 60 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | |
| 132.8 | **Ground Surface** | | | | | | | | | | |
| 0.0 | No sampling of overburden<br>Cased 17.1 m to bedrock surface<br>See AND19-1 for stratigraphy | | | | | | 132<br>131<br>130<br>129<br>128<br>127<br>126<br>125<br>124<br>123 | | | | |

Continued Next Page

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

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

ONTMT4S 24726 ANDERSON ROAD.GPJ 2012TEMPLATE(MTO).GDT 21/7/21

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-1D 2 OF 3 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 736.4 E 302 061.2 ORIGINATED BY MW

HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW

DATUM Geodetic DATE 2019.07.29 - 2019.07.29 CHECKED BY FG

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) (20 40 60) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Continued From Previous Page | | | | | | | | | | |
| | No sampling of overburden<br>Cased 17.1 m to bedrock surface<br>See AND19-1 for stratigraphy | | | | | | 122 | | | | |
| | | | | | | | 121 | | | | |
| | | | | | | | 120 | | | | |
| | -Artesian conditions encountered at 13.6 m | | | | | | 119 | | | | |
| | | | | | | | 118 | | | | |
| | | | | | | | 117 | | | | |
| 115.7 | | | | | | | 116 | | | | |
| 17.1 | **MARBLE**<br>Freshly weathered<br>Very Strong<br>Close joint spacing<br>Poor to excellent quality<br>Coarse grained<br>Grey to White | | 1 | Run | | | 115 | | | FI<br>3<br>1<br>>10 | RUN #1<br>TCR=97%<br>SCR=69%<br>RQD=62% |
| | -Occasional vertical fracture from 18 m to 19.5 m | | 2 | Run | | | 114 | | | 3<br>3<br>>10 | RUN #2<br>TCR=82%<br>SCR=30%<br>RQD=38% |
| | -Increased artesian flow after 19.5 m | | | | | | 113 | | | | |

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-1D 3 OF 3 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 736.4 E 302 061.2 ORIGINATED BY MW

HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW

DATUM Geodetic DATE 2019.07.29 - 2019.07.29 CHECKED BY FG

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa 20 40 60 80 100 (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) 20 40 60 | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | |
| | Continued From Previous Page | | | | | | | | | | |
| 111.7 | **MARBLE BEDROCK**<br>Freshly weathered<br>Very Strong<br>Close joint spacing<br>Poor to excellent quality<br>Coarse grained<br>White | | 3 | Run | | | 112 | | | 1<br>1 | RUN #3<br>TCR=98%<br>SCR=92%<br>RQD=97% |
| 21.1 | End of Borehole<br><br>-Artesian head in casing at approx. 3.5 m above ground surface (elevation 136.1 m) upon completion | | | | | | | | | | |

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

15 20 10 5 (%) STRAIN AT FAILURE

ONTMT4S 24726 ANDERSON ROAD.GPJ 2012TEMPLATE(MTO).GDT 21/7/21

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-2 1 OF 3 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 754.1 E 302 078.4 ORIGINATED BY MW

HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW

DATUM Geodetic DATE 2019.08.01 - 2019.08.02 CHECKED BY FG

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) 20 40 60 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 134.8 | **Ground Surface** | | | | | | | | | | |
| 0.0 | Silty SAND, trace gravel<br>Compact<br>Brown<br>**(FILL)** | | 1 | SS | 25 | | | | ○ | | 7 79 14 (SI+CL) |
| | | | 2 | SS | 17 | | 134 | | ○ | | |
| | | | | | | | 133 | | | | |
| | | | 3 | SS | 5 | | | | ○ | | |
| 131.8 | | | | | | | 132 | | | | |
| 3.0 | Silty **SAND (SM)** with gravel, some clay, trace roots<br>Very Loose to Loose<br>Grey-Brown | | 4 | SS | 5 | | | | ○ | | 19 37 28 16 |
| | | | 5 | SS | 3 | | 131 | | ○ | | |
| 130.2 | | | | | | | | | | | |
| 4.6 | **CLAYEY SILT to CLAY (CL to CI)**<br>Firm to Stiff<br>Grey | | 6 | SS | 3 | | 130 | 5.8<br>6.8 | ○ | | 0 6 57 37 |
| | | | 7 | SS | 2 | | 129 | | ○ | | |
| | | | | | | | 128 | 3.9<br>7.1 | | | |
| | | | 8 | SS | 1 | | 127 | 19.0 | ○ | | |
| | | | | | | | 126 | 3.4 | | | |
| | | | 9 | SS | WH | | | | ○ | | |
| | | | | | | | 125 | | | | |

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 24726 ANDERSON ROAD.GPJ 2012TEMPLATE(MTO).GDT 21/7/21

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-2 2 OF 3 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 754.1 E 302 078.4 ORIGINATED BY MW

HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW

DATUM Geodetic DATE 2019.08.01 - 2019.08.02 CHECKED BY FG

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | 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 | | | 20 40 60 80 100 | $w_P$ $w$ $w_L$ | $\gamma$ kN/m$^3$ | GR SA SI CL |
| | Continued From Previous Page | | | | | | | SHEAR STRENGTH kPa | WATER CONTENT (%) | | |
| | | | | | | | | ○ UNCONFINED + FIELD VANE | 20 40 60 | | |
| | | | | | | | | ● QUICK TRIAXIAL × LAB VANE | | | |
| | | | | | | | | 20 40 60 80 100 | | | |
| | **CLAYEY SILT to CLAY (CL to CI)** | | | | | | | | | | |
| | Firm to Stiff | | | | | | | | | | |
| | Grey | | | | | | | | | | |
| | | | 10 | SS | WH | | | | | | |
| | | | 11 | SS | WR | | | | | | 0 1 54 45 |
| | | | 12 | SS | WR | | | | | | |
| | | | 13 | SS | WH | | | | | | |
| | | | 14 | SS | WR | | | | | | |
| | | | 15 | SS | WH | | | | | | |

Continued Next Page

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

$\frac{20}{15 \cdot 10 \cdot 5}$ (%) STRAIN AT FAILURE

ONTMT4S 24726 ANDERSON ROAD.GPJ 2012TEMPLATE(MTO).GDT 21/7/21

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-2 3 OF 3 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 754.1 E 302 078.4 ORIGINATED BY MW

HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW

DATUM Geodetic DATE 2019.08.01 - 2019.08.02 CHECKED BY FG

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) 20 40 60 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Continued From Previous Page | | | | | | | | | | |
| | **CLAYEY SILT to CLAY (CL to CI)**<br>Firm to Stiff<br>Grey | | 16 | SS | 1 | | | | | | 0 0 49 51 |
| 111.9 | | | | | | | 114 | 6.9<br>4.8 | | | |
| 22.9 | Gravelly Silty **SAND**, occasional cobbles<br>Compact<br>Grey<br>**(TILL)** | | 17 | SS | 25 | | 113 | | | | 25 59 16 (SI+CL) |
| | - Frequent cobbles below 24.1 m | | 18 | NQ | | | 112 | | | | |
| 109.9 | | | | | | | 111 | | | | |
| 24.9 | **MARBLE BEDROCK**<br>Freshly weathered<br>Very Strong<br>Close joint spacing<br>Good to Excellent Quality<br>Coarse grained<br>White | | 1 | Run | | | 110 | | | FI<br>3 | RUN #1<br>TCR=100%<br>SCR=79%<br>RQD=86% |
| | | | 2 | Run | | | 109 | | | 3<br>3 | RUN #2<br>TCR=100%<br>SCR=67%<br>RQD=82% |
| | - 150 mm layer of quartzite at 27.8 m | | 3 | Run | | | 108 | | | 2<br>3 | RUN #3<br>TCR=100%<br>SCR=69%<br>RQD=97% |
| 106.1 | | | | | | | 107 | | | 0 | |
| 28.7 | End of Borehole<br><br>-Artesian head rose to 1.5 m above existing ground surface (elevation 136.3 m) upon completion | | | | | | | | | | |

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

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

ONTMT4S 24726 ANDERSON ROAD.GPJ 2012TEMPLATE(MTO).GDT 21/7/21

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-2A 1 OF 1 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 753.9 E 302 079.4 ORIGINATED BY MJJ

HWY 17 BOREHOLE TYPE CME 45 Trackmount, HSA COMPILED BY JP

DATUM Geodetic DATE 2019.09.30 - 2019.09.30 CHECKED BY FG

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) (20 40 60) | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 134.8 | **Ground Surface** | | | | | | | | | | |
| 0.0 | No sampling from 0 m to 4.6 m<br>See AND19-2 for stratigraphy | | | | | | 134<br>133<br>132<br>131<br>130<br>129<br>128 | | | | |
| 130.2 | | | | | | | | | | | |
| 4.6 | **CLAYEY SILT (CL)**, trace sand<br>Very Loose<br>Grey | | 1 | SS | 1 | | | | | | |
| | | | 1 | ST | | | | | | | |
| | | | 2 | ST | | | | | | $e_o$=1.325<br>$\gamma$=17.1<br>$P'_c$=320kPa | 0 0 41 59 |
| 127.3 | | | | | | | | | | | |
| 7.5 | End of Borehole | | | | | | | | | | |

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

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

ONTMT4S 24726 ANDERSON ROAD.GPJ 2012TEMPLATE(MTO).GDT 21/7/21

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-3 1 OF 3 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 769.5 E 302 062.6 ORIGINATED BY MW

HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW

DATUM Geodetic DATE 2019.07.30 - 2019.07.30 CHECKED BY FG

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (20 40 60) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 133.7 | **Ground Surface** | | | | | | | | | | |
| 0.0 | Silty SAND, some roots<br>Very loose<br>Brown<br>**(FILL)** | | 1 | SS | 2 | | | | | | |
| 132.6 | | | | | | | 133 | | | | |
| 1.1 | SILT (ML) with sand, some clay<br>Loose<br>Grey-Brown<br>**(FILL)** | | 2 | SS | 5 | | | | | | |
| | | | | | | | 132 | | | | |
| | | | 3 | SS | 8 | | | | | | |
| 130.7 | | | | | | | 131 | | | | |
| 3.0 | **CLAYEY SILT to CLAY (CL to CH)**<br>Firm to Very Stiff<br>Grey | | 4 | SS | 2 | | | | | | 0 1 42 57 |
| | | | | | | | 130 | | | | |
| | | | 5 | SS | 1 | | 129 | | | | |
| | | | | | | | 128 | 7.6<br>8.0 | | | |
| | | | 6 | SS | WH | | 127 | 2.9 | | | |
| | | | 7 | SS | WH | | 126 | 9.0 | | | |
| | | | | | | | 125 | 5.6 | | | |
| | | | 8 | SS | WH | | 124 | | | | |

Continued Next Page

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

$\frac{20}{15 \cdot 10 \cdot 5}$ (%) STRAIN AT FAILURE

ONTMT4S 24726 ANDERSON ROAD.GPJ 2012TEMPLATE(MTO).GDT 21/7/21

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-3 2 OF 3 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 769.5 E 302 062.6 ORIGINATED BY MW
HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW
DATUM Geodetic DATE 2019.07.30 - 2019.07.30 CHECKED BY FG

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Continued From Previous Page | | | | | | | | | | |
| | **CLAYEY SILT to CLAY (CL to CI)**<br>Firm to Very Stiff<br>Grey | | | | | | 123 | 10.7, 18.0 | | | |
| | | | 9 | SS | WH | | | | | | 0 0 64 36 |
| | | | | | | | 122 | 10.7, 4.4 | | | |
| | | | 10 | SS | WH | | 121 | | | | |
| | | | | | | | | 22.7, 7.4 | | | |
| | | | 11 | SS | WH | | 120 | | | | |
| | | | | | | | | 7.2 | | | |
| | | | | | | | 119 | 8.9 | | | |
| | | | 12 | SS | WH | | 118 | | | | |
| | | | | | | | | 3.5, 4.4 | | | |
| | | | 13 | SS | WH | | 117 | | | | |
| | | | | | | | | 6.7, 4.1 | | | |
| | | | 14 | SS | WH | | 116 | | | | 0 2 52 46 |
| | | | | | | | 115 | | | | |
| | | | | | | | | 4.8, 3.6 | | | |
| 113.9 | | | | | | | 114 | | | | |
| 19.8 | Clayey **SAND (SC)** with gravel | | | | | | | | | | |

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-3 3 OF 3 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 769.5 E 302 062.6 ORIGINATED BY MW

HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW

DATUM Geodetic DATE 2019.07.30 - 2019.07.30 CHECKED BY FG

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) 20 40 60 | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | GR | SA | SI | CL |
| | Continued From Previous Page | | | | | | | | | | | | | | |
| | Clayey **SAND (SC)** with gravel<br>Compact<br>Grey<br>**(TILL)** | | 15 | SS | 13 | | 113 | | | | 23 | 30 | 30 | 17 |
| 112.4 | Casing refusal | | | | | | | | | | | | | | |
| 21.3 | End of Borehole<br><br>-Artesian head in casing at approx. 2.3 m above ground surface (elevation 136.0 m) upon completion | | | | | | | | | | | | | | |

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

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

ONTMT4S 24726 ANDERSON ROAD.GPJ 2012TEMPLATE(MTO).GDT 21/7/21

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-4 1 OF 3 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 740.3 E 302 088.1 ORIGINATED BY MW

HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW

DATUM Geodetic DATE 2019.07.31 - 2019.07.31 CHECKED BY FG

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 132.6 | **Ground Surface** | | | | | | | | | | |
| 0.0 | SAND (SP-SM) with silt, some roots<br>Very Loose to Loose<br>Grey<br>**(FILL)** | | 1 | SS | WH | | 132 | | | | |
| | | | 2 | SS | 6 | | | | | | 0 94 6 (SI+CL) |
| | | | 3 | SS | WH | | 131 | | | | |
| 130.3 | | | | | | | | | | | |
| 2.3 | **SILT (ML)** with sand, some clay<br>Very Loose<br>Grey<br>-50 mm layer of roots at 2.5 m | | 4 | SS | 1 | | 130 | | 137 | | 0 16 44 40 Non-Plastic |
| | | | 5 | SS | WH | | | | | | |
| 128.9 | | | | | | | 129 | 9.1, 7.0 | | | |
| 3.7 | **CLAYEY SILT (CL)**<br>Firm to Stiff<br>Grey | | 6 | SS | WH | | 128 | | | | |
| | | | | | | | 127 | 15.2, 11.3 | | | |
| | | | 7 | SS | WH | | 126 | 11.0, 30.0 | | | 0 0 49 51 |
| | | | 8 | SS | WH | | 125 | | | | |
| | | | | | | | 124 | 4.5, 7.0 | | | |
| | | | 9 | SS | WH | | 123 | | | | |

Continued Next Page

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

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

ONTMT4S 24726 ANDERSON ROAD.GPJ 2012TEMPLATE(MTO).GDT 21/7/21

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-4 2 OF 3 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 740.3 E 302 088.1 ORIGINATED BY MW

HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW

DATUM Geodetic DATE 2019.07.31 - 2019.07.31 CHECKED BY FG

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) 20 40 60 | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | |
| | Continued From Previous Page | | | | | | | | | | |
| 121.9 | **CLAYEY SILT (CL)**<br>Firm to Stiff<br>Grey | | | | | | 122 | 10.5<br>8.3 | | | |
| 10.7 | End of Borehole<br><br>DCPT completed from 10.7 m to 20.4 m | | | | | | | | | | |

Continued Next Page

+ $^3$, × $^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No AND19-4 3 OF 3 METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 740.3 E 302 088.1 ORIGINATED BY MW

HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW

DATUM Geodetic DATE 2019.07.31 - 2019.07.31 CHECKED BY FG

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) 20 40 60 | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | |
| | Continued From Previous Page | | | | | | | | | | |
| | DCPT continued | | | | | | | | | | |
| 112.2 | DCPT Refusal | | | | | | | | | | |
| 20.4 | | | | | | | | | | | |
| | 0.9 m Stickup on piezometer | | | | | | | | | | |
| | WATER LEVEL READINGS:<br>DATE DEPTH (m) ELEV. (m)<br>2019.08.23 0.5 above g.s. 133.1<br>2019.09.05 0.3 above g.s. 132.9<br>2019.11.25 0.4 above g.s. 133.0<br>2021.07.20 >2.1 above g.s. >134.7 | | | | | | | | | | |

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

$\frac{20}{15}$ $\frac{5}{10}$ (%) STRAIN AT FAILURE

ONTMT4S 24726 ANDERSON ROAD.GPJ 2012TEMPLATE(MTO).GDT 21/7/21

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No 18-103 1 OF 3 METRIC

GWP# 4061-17-00 LOCATION Lat: 45.4438208°, Long: -76.5347193° MTO Zone 9: N 5 033 766.1 E 302 084.0 ORIGINATED BY CM

HWY 17 BOREHOLE TYPE HSA / NW / NQ COMPILED BY KP

DATUM Geodetic DATE 2018.06.14 - 2018.06.15 CHECKED BY PC

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 133.9 | | | | | | | | | | | |
| 0.0 / 0.1 | **50 mm ROOTMAT** | | | | | | | | | | |
| | Sand with silt<br>Loose<br>Brown<br>**FILL** | | 1 | SS | 8 | | | | | | 10 82 8 (SI+CL) |
| | | | 2 | SS | 7 | | 133 | | | | |
| 132.2 / 1.7 | Sandy clay with silt, trace to some wood pieces<br>Firm<br>Grey<br>**FILL** | | 3 | SS | 3 | | 132 | | | | |
| | | | 4 | SS | 2 | | 131 | | | | |
| 130.9 / 3.0 | **SANDY CLAY (CL)**<br>- occasional sand seams<br>Stiff<br>Grey | | 5 | SS | 1 | | | | | | 0 43 32 25 |
| | | | 6 | SS | 1 | | 130 | | | | 1 45 24 30 |
| 129.3 / 4.6 | **CLAY (CL)**<br>Stiff to firm<br>Grey<br>Wet | | 7 | SS | 3 | | 129 | + 14.0<br>+ 26.0 | | | |
| | | | 8 | SS | 1 | | 128 | | | | |
| | | | | | | | 127 | | | | |
| | | | | | | | 126 | + 15.0<br>+ 6.8 | | | |
| | | | 9 | ST | PUSH | | 125 | | | | |
| | - becomes firm below 9.5 m | | | | | | | + 10.5<br>+ 9.6 | | | |
| | | | | | | | 124 | | | | |

Continued Next Page

DOUBLE LINE LOCHA CREEK REPLACEMENT.GPJ 2012TEMPLATE(MTO).GDT 29/11/19

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 + 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No 18-103 2 OF 3 METRIC

GWP# 4061-17-00 LOCATION Lat: 45.4438208°, Long: -76.5347193° MTO Zone 9: N 5 033 766.1 E 302 084.0 ORIGINATED BY CM

HWY 17 BOREHOLE TYPE HSA / NW / NQ COMPILED BY KP

DATUM Geodetic DATE 2018.06.14 - 2018.06.15 CHECKED BY PC

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Continued From Previous Page | | | | | | | | | | |
| | **CLAY (CL)**<br>Firm to stiff | | 10 | SS | WH | | | | | | |
| | | | 11 | SS | WR | | 123 | 5.1<br>12.0 | | | |
| | | | 12 | SS | WR | | 122 | 13.0<br>7.7 | | | 1 3 57 39 |
| | - becomes stiff below 14 m | | 13 | SS | WR | | 121 | 5.2<br>10.0 | | | |
| | | | 14 | SS | WR | | 120 | 7.4<br>5.8 | | | |
| | | | 15 | SS | WR | | 119 | 6.0<br>4.0 | | | |
| | | | 16 | SS | WH | | 118 | 3.5<br>8.0 | | | |
| | | | | | | | 117 | | | | |
| | | | | | | | 116 | | | | |
| | | | | | | | 115 | | | | |
| | | | | | | | 114 | | | | |

Continued Next Page

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

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

DOUBLE LINE LOCHA CREEK REPLACEMENT.GPJ 2012TEMPLATE(MTO).GDT 29/11/19

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No 18-103 3 OF 3 METRIC

GWP# 4061-17-00 LOCATION Lat: 45.4438208°, Long: -76.5347193° MTO Zone 9: N 5 033 766.1 E 302 084.0 ORIGINATED BY CM

HWY 17 BOREHOLE TYPE HSA / NW / NQ COMPILED BY KP

DATUM Geodetic DATE 2018.06.14 - 2018.06.15 CHECKED BY PC

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Continued From Previous Page | | | | | | | | | | |
| | **CLAY (CL)**<br>Stiff | | | | | | | 4.8<br>3.8 | | | |
| | - fine sand seams below 22 m | | 17 | SS | 8 | | | | | | 7 22 41 30 |
| 110.7 | | | | | | | | | | | |
| 23.2 | **Silty Clayey SAND with Gravel TILL**<br>Grey<br>Wet | | | | | | | | | | |
| | - cored 160 mm cobble at 24 m | | 1 | RUN | - | | | | | | |
| 109.3 | | | | | | | | | | | |
| 24.6 | **MARBLE BEDROCK**<br>Freshly weathered<br>Very strong<br>Close joint spacing<br>Poor to excellent quality<br>Coarse grained<br>White | | 2 | RUN | | | | | | FI<br>4 | RUN #2<br>TCR=92%<br>SCR=65%<br>RQD=20% |
| | | | 3 | RUN | | | | | | >13<br>1<br>1<br>2<br>2<br>2 | RUN #3<br>TCR=94%<br>SCR=91%<br>RQD=86% |
| | | | 4 | RUN | | | | | | 0<br>1<br>1<br>1<br>2 | RUN #4<br>TCR=100%<br>SCR=100%<br>RQD=93%<br>UCS=156MPa |
| 105.5 | | | | | | | | | | | |
| 28.4 | End of Borehole<br>Groundwater rose to at least 2.4 m above existing grade (elev. 136.3 m) on 2018-06-15, just prior to decommissioning | | | | | | | | | | |

+ $^3$, × $^3$: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

DOUBLE LINE LOCHA CREEK REPLACEMENT.GPJ 2012TEMPLATE(MTO).GDT 29/11/19

# Appendix C.

# Laboratory Testing

**Appendix C.1**

**Particle Size Analysis Figures**

**Atterberg Limit Test Results**

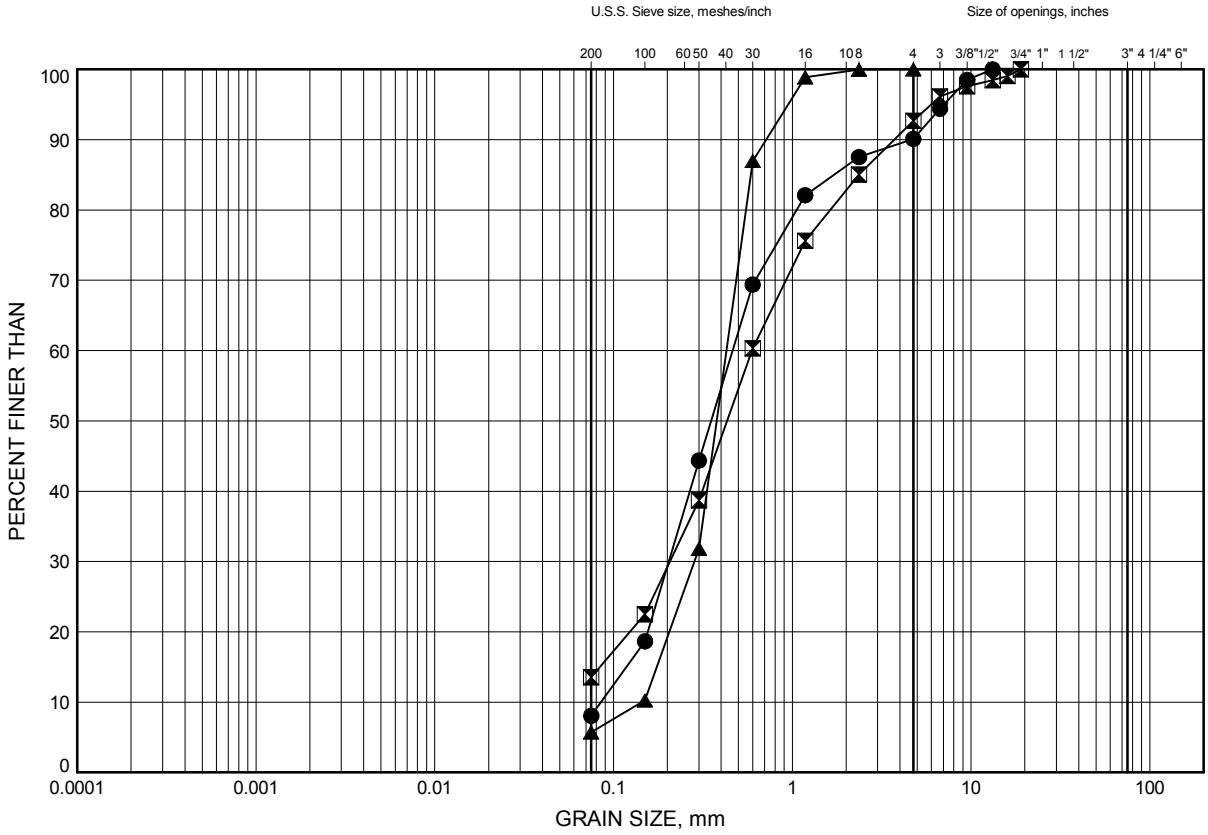
**One-Dimensional Consolidation Test Results**

Anderson Road Culvert

# GRAIN SIZE DISTRIBUTION

FIGURE C1

## FILL




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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | 18-103 | 0.3 | 133.6 |
| ⊠ | AND19-2 | 0.3 | 134.5 |
| ▲ | AND19-4 | 1.1 | 131.5 |

Date December 2019

WP# 4068-09-00

THURBER

Prep'd JG

Chkd. FG

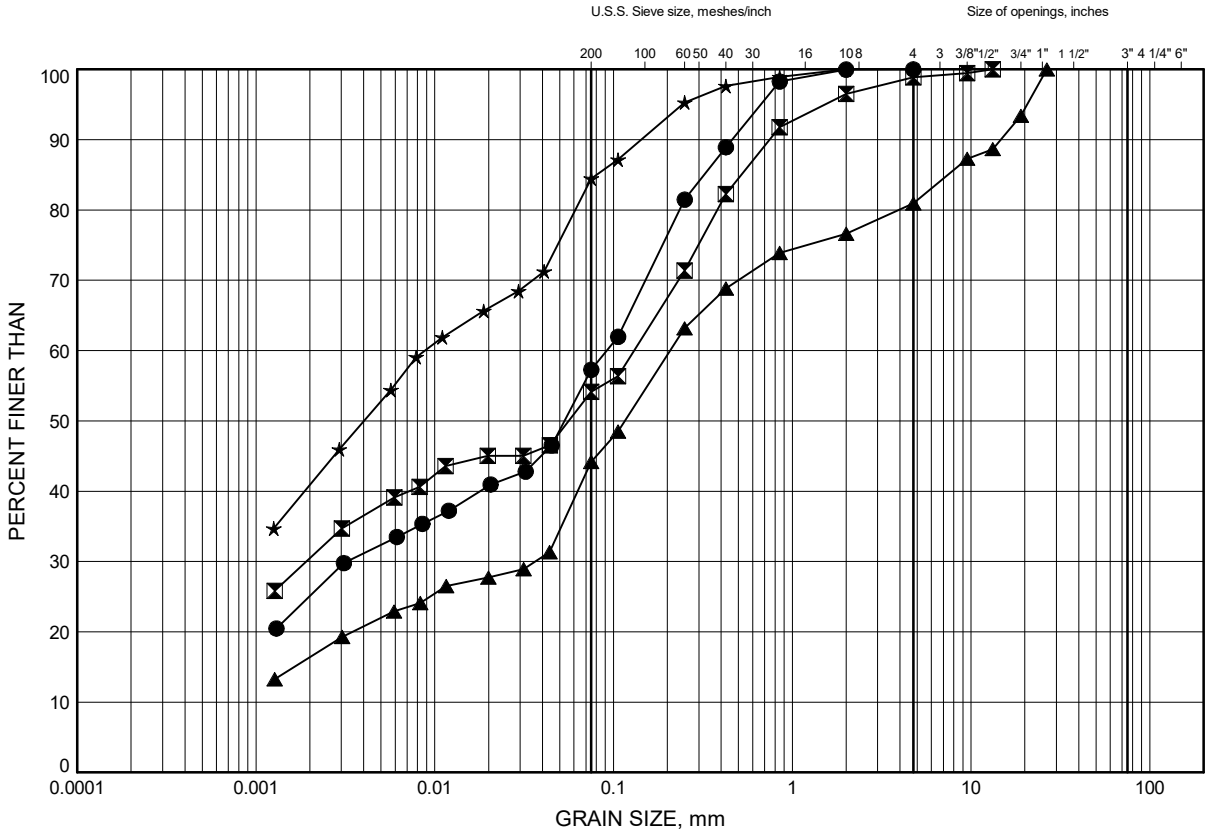
GRAIN SIZE DISTRIBUTION - THURBER 24726 ANDERSON ROAD.GPJ 12/12/19

Anderson Road Culvert

# GRAIN SIZE DISTRIBUTION

FIGURE C2

## Silty SAND (SM) to SILT with Sand (ML) to Sandy Clayey SILT (CL)




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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | 18-103 | 3.4 | 130.5 |
| ⊠ | 18-103 | 4.1 | 129.8 |
| ▲ | AND19-2 | 3.4 | 131.4 |
| ★ | AND19-4 | 2.6 | 130.0 |

Date March 2021

WP# 4068-09-00

THURBER

Prep'd JG

Chkd. FG

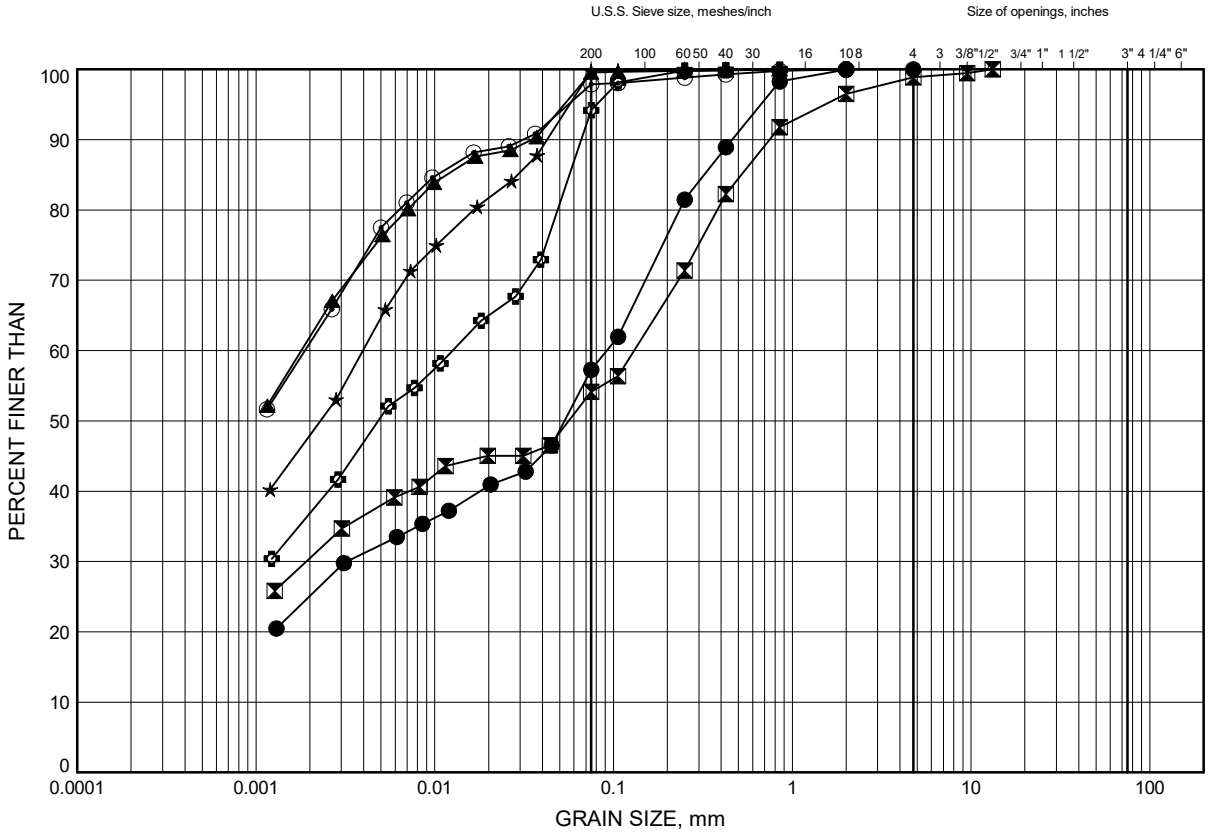
GRAIN SIZE DISTRIBUTION - THURBER 24726 ANDERSON ROAD.GPJ 4/3/21

Anderson Road Culvert

# GRAIN SIZE DISTRIBUTION

FIGURE C3

## Clayey SILT to CLAY (CL to CH)




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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | 18-103 | 3.4 | 130.5 |
| ⊠ | 18-103 | 4.1 | 129.8 |
| ▲ | AND19-1 | 2.6 | 130.0 |
| ★ | AND19-1 | 6.4 | 126.2 |
| ⊙ | AND19-1 | 12.5 | 120.1 |
| ✿ | AND19-2 | 4.9 | 129.9 |

Date July 2021

WP# 4068-09-00

THURBER

Prep'd JG

Chkd. FG

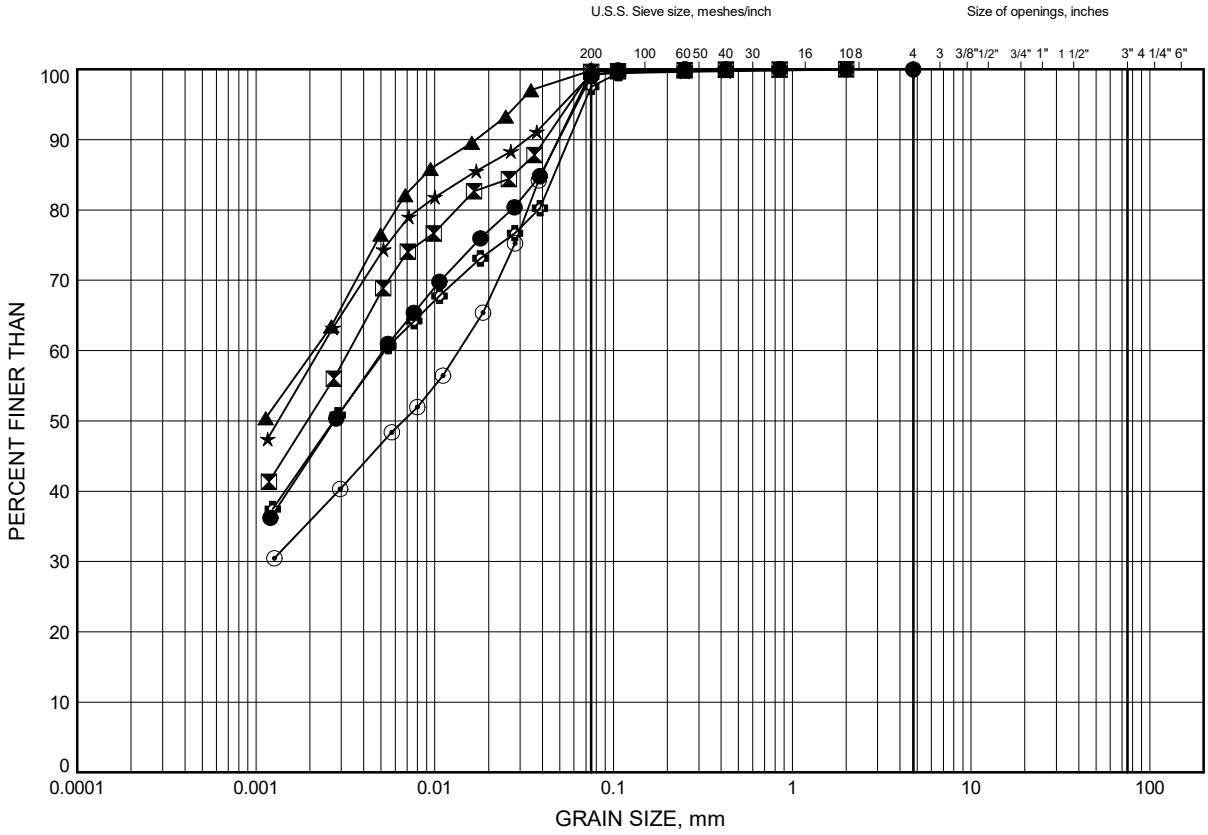
GRAIN SIZE DISTRIBUTION - THURBER 24726 ANDERSON ROAD.GPJ 21/7/21

Anderson Road Culvert

# GRAIN SIZE DISTRIBUTION

FIGURE C4

## Clayey SILT to CLAY (CL to CH)




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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | AND19-2 | 12.5 | 122.3 |
| ⊠ | AND19-2 | 20.1 | 114.7 |
| ▲ | AND19-2A | 7.2 | 127.6 |
| ★ | AND19-3 | 3.4 | 130.3 |
| ⊙ | AND19-3 | 11.0 | 122.7 |
| ✿ | AND19-3 | 18.6 | 115.1 |

Date July 2021

WP# 4068-09-00

THURBER

Prep'd JG

Chkd. FG

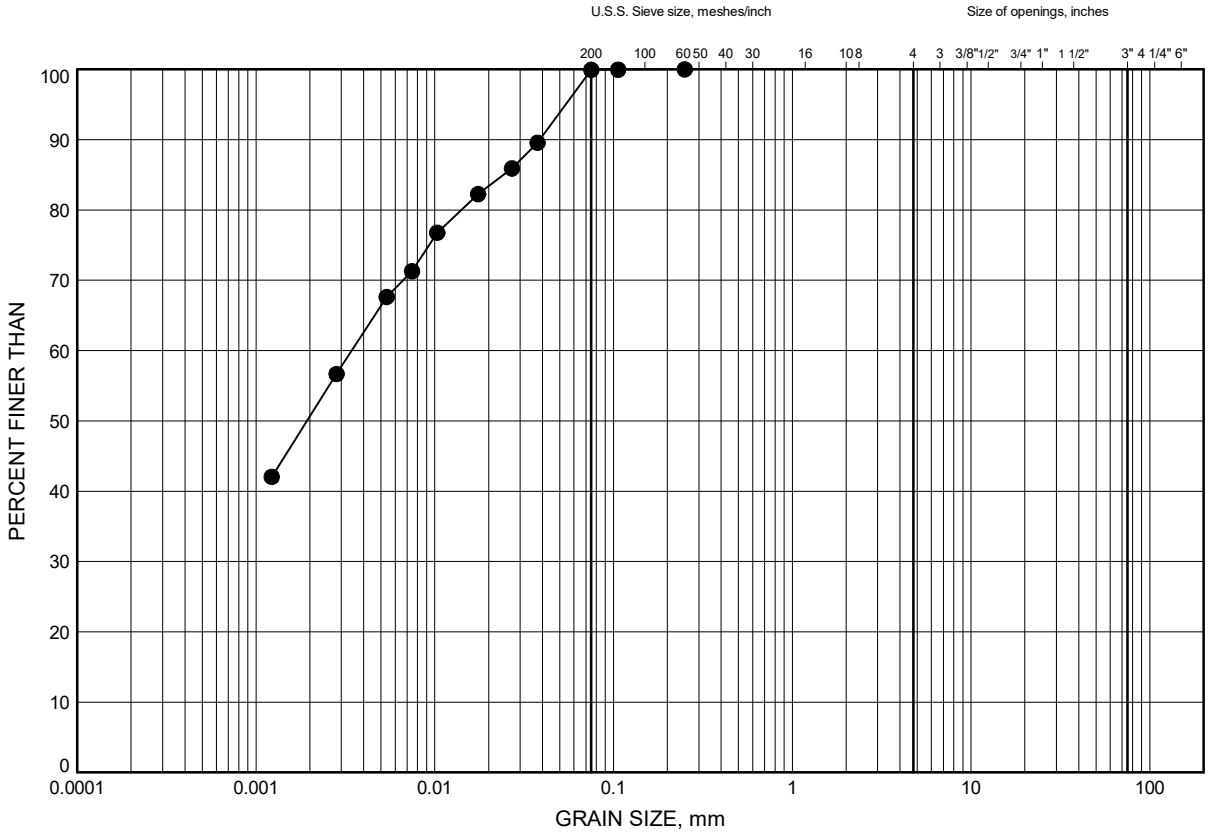
GRAIN SIZE DISTRIBUTION - THURBER 24726 ANDERSON ROAD.GPJ 21/7/21

Anderson Road Culvert

# GRAIN SIZE DISTRIBUTION

FIGURE C5

## Clayey SILT to CLAY (CL to CH)




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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | AND19-4 | 6.4 | 126.2 |

Date July 2021

WP# 4068-09-00

THURBER

Prep'd JG

Chkd. FG

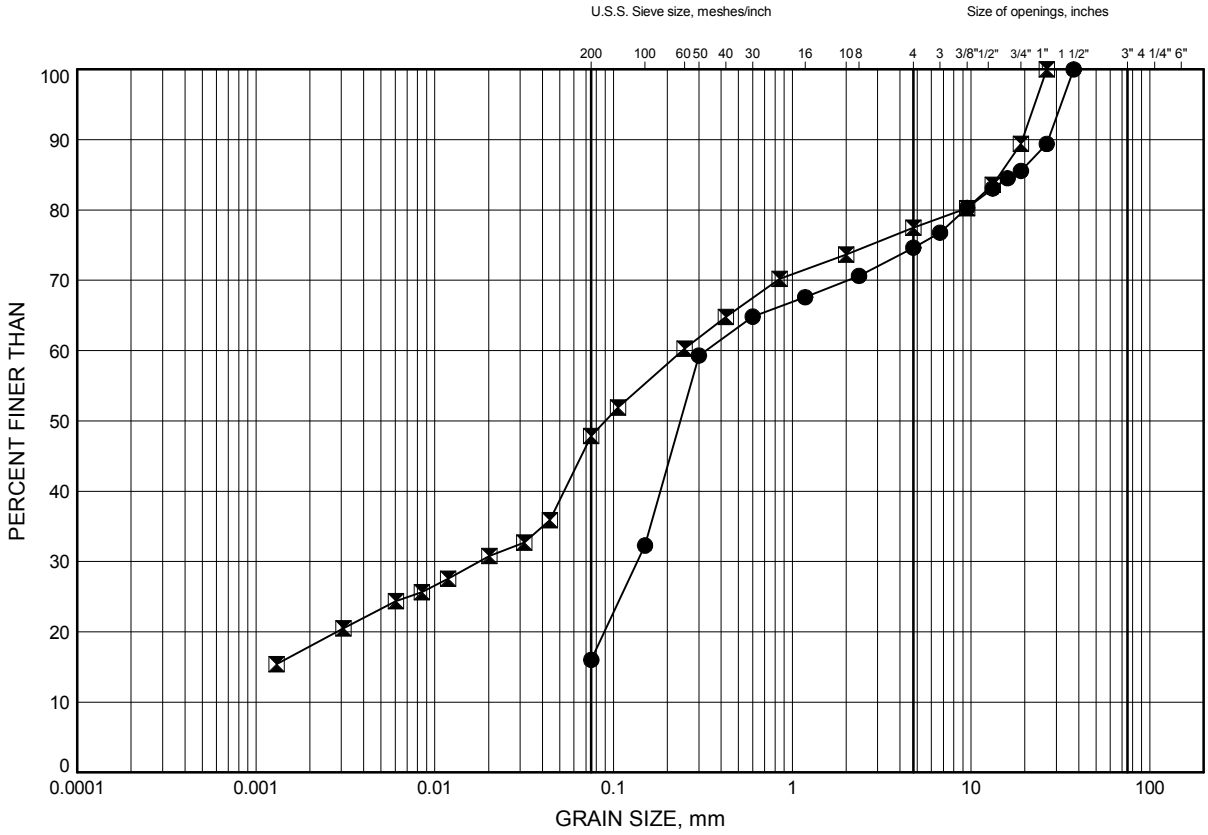
GRAIN SIZE DISTRIBUTION - THURBER 24726 ANDERSON ROAD.GPJ 21/7/21

Anderson Road Culvert

# GRAIN SIZE DISTRIBUTION

FIGURE C6

## Glacial TILL




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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | AND19-2 | 23.2 | 111.6 |
| ⊠ | AND19-3 | 20.1 | 113.6 |

Date December 2019

WP# 4068-09-00

THURBER

Prep'd JG

Chkd. FG

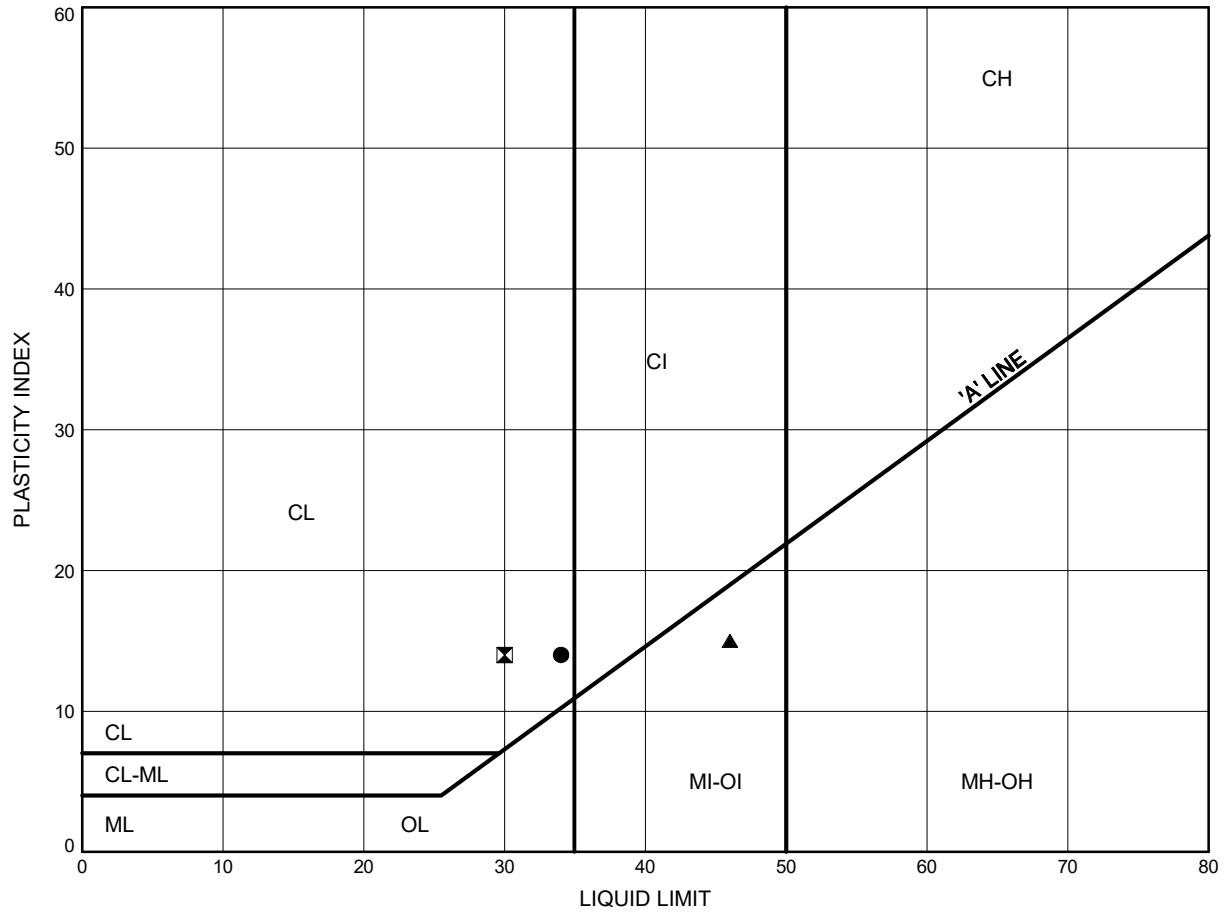
GRAIN SIZE DISTRIBUTION - THURBER 24726 ANDERSON ROAD.GPJ 12/12/19

Anderson Road Culvert

# ATTERBERG LIMITS TEST RESULTS

FIGURE C7

## Silty SAND (SM) to SILT with Sand (ML) to Sandy Clayey SILT (CL)




### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | 18-103 | 3.4 | 130.5 |
| ⊠ | 18-103 | 4.1 | 129.8 |
| ▲ | AND19-2 | 3.4 | 131.4 |

Date March 2021

WP# 4068-09-00

THURBER

Prep'd JG

Chkd. FG

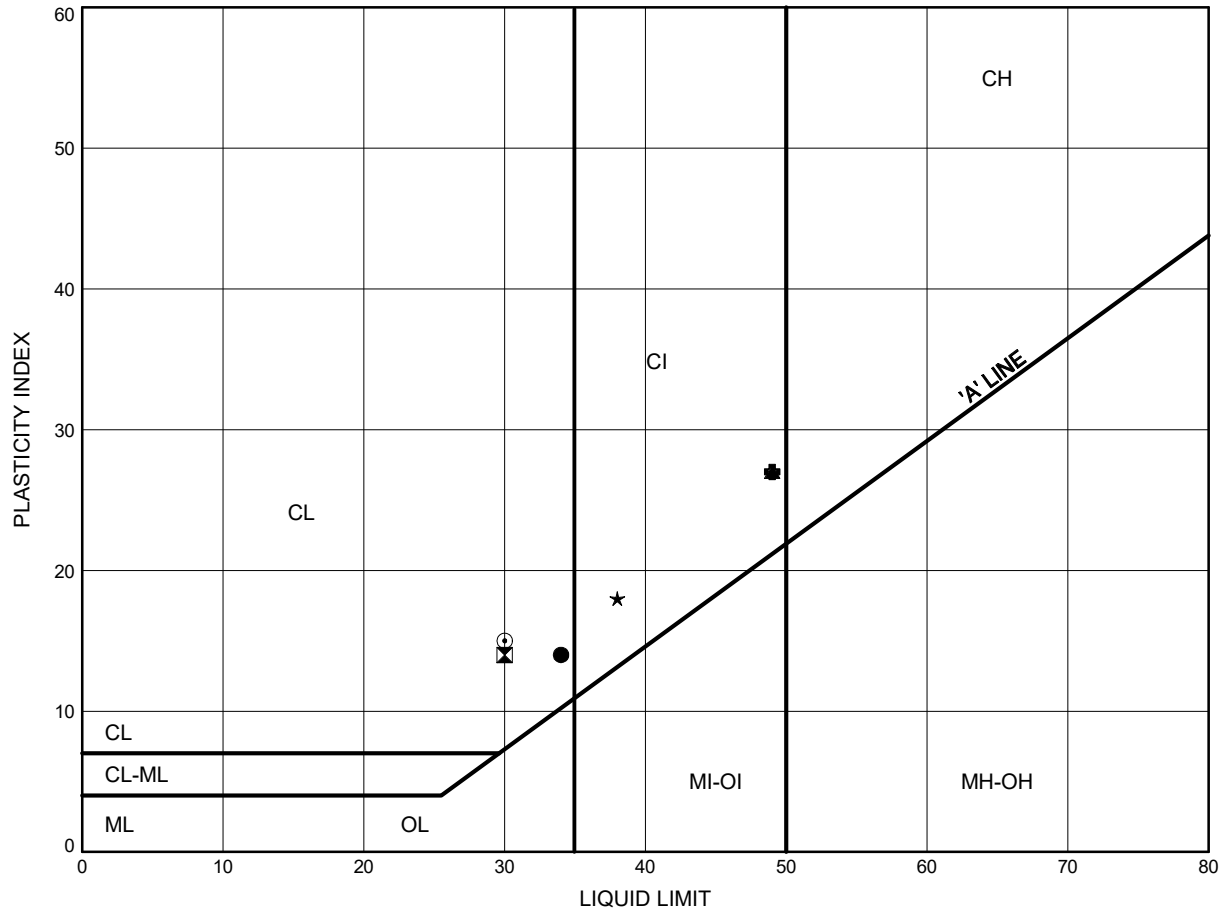
THURBALT 24726 ANDERSON ROAD.GPJ 4/3/21

Anderson Road Culvert

# ATTERBERG LIMITS TEST RESULTS

FIGURE C8

## Clayey SILT to CLAY (CL to CH)




### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | 18-103 | 3.4 | 130.5 |
| ⊠ | 18-103 | 4.1 | 129.8 |
| ▲ | AND19-1 | 2.6 | 130.0 |
| ★ | AND19-1 | 6.4 | 126.2 |
| ⊙ | AND19-1 | 12.5 | 120.1 |
| ✿ | AND19-2 | 4.9 | 129.9 |

Date July 2021

WP# 4068-09-00

THURBER

Prep'd JG

Chkd. FG

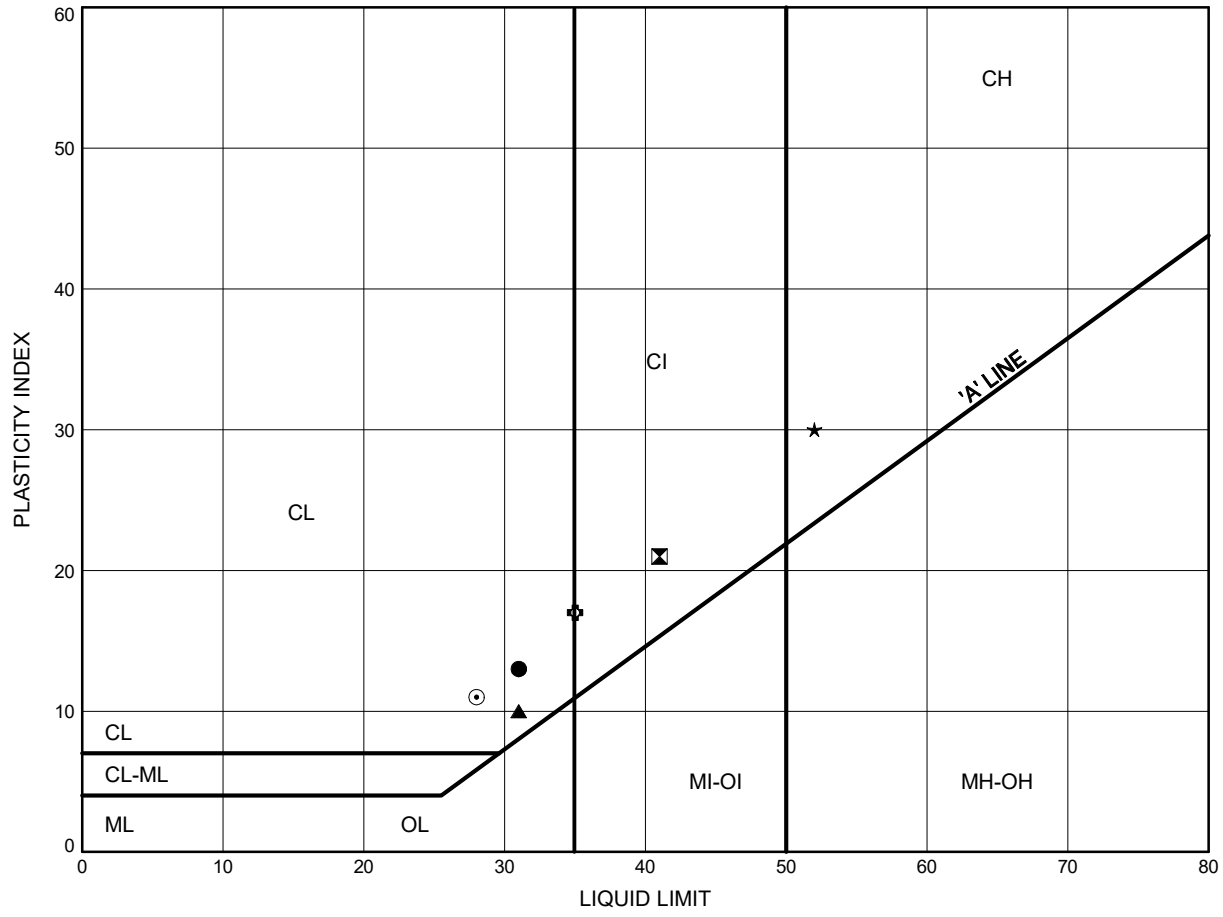
THURBALT 24726 ANDERSON ROAD.GPJ 21/7/21

Anderson Road Culvert

# ATTERBERG LIMITS TEST RESULTS

FIGURE C9

## Clayey SILT to CLAY (CL to CH)




### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | AND19-2 | 12.5 | 122.3 |
| ⊠ | AND19-2 | 20.1 | 114.7 |
| ▲ | AND19-2A | 7.2 | 127.6 |
| ★ | AND19-3 | 3.4 | 130.3 |
| ⊙ | AND19-3 | 11.0 | 122.7 |
| ✿ | AND19-3 | 18.6 | 115.1 |

Date July 2021

WP# 4068-09-00

THURBER

Prep'd JG

Chkd. FG

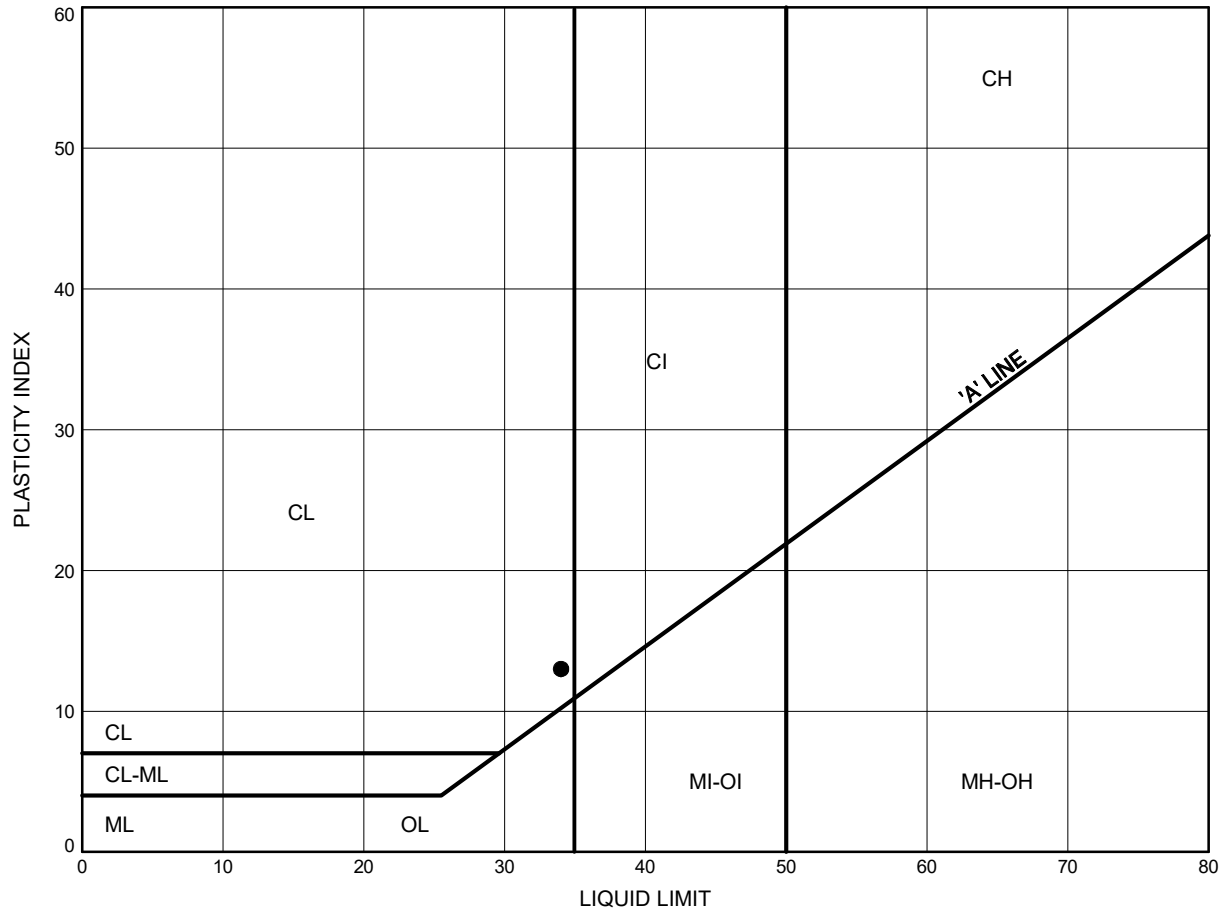
THURBALT 24726 ANDERSON ROAD.GPJ 21/7/21

Anderson Road Culvert

# ATTERBERG LIMITS TEST RESULTS

FIGURE C10

## Clayey SILT to CLAY (CL to CH)




### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | AND19-4 | 6.4 | 126.2 |

Date July 2021

WP# 4068-09-00

THURBER

Prep'd JG

Chkd. FG

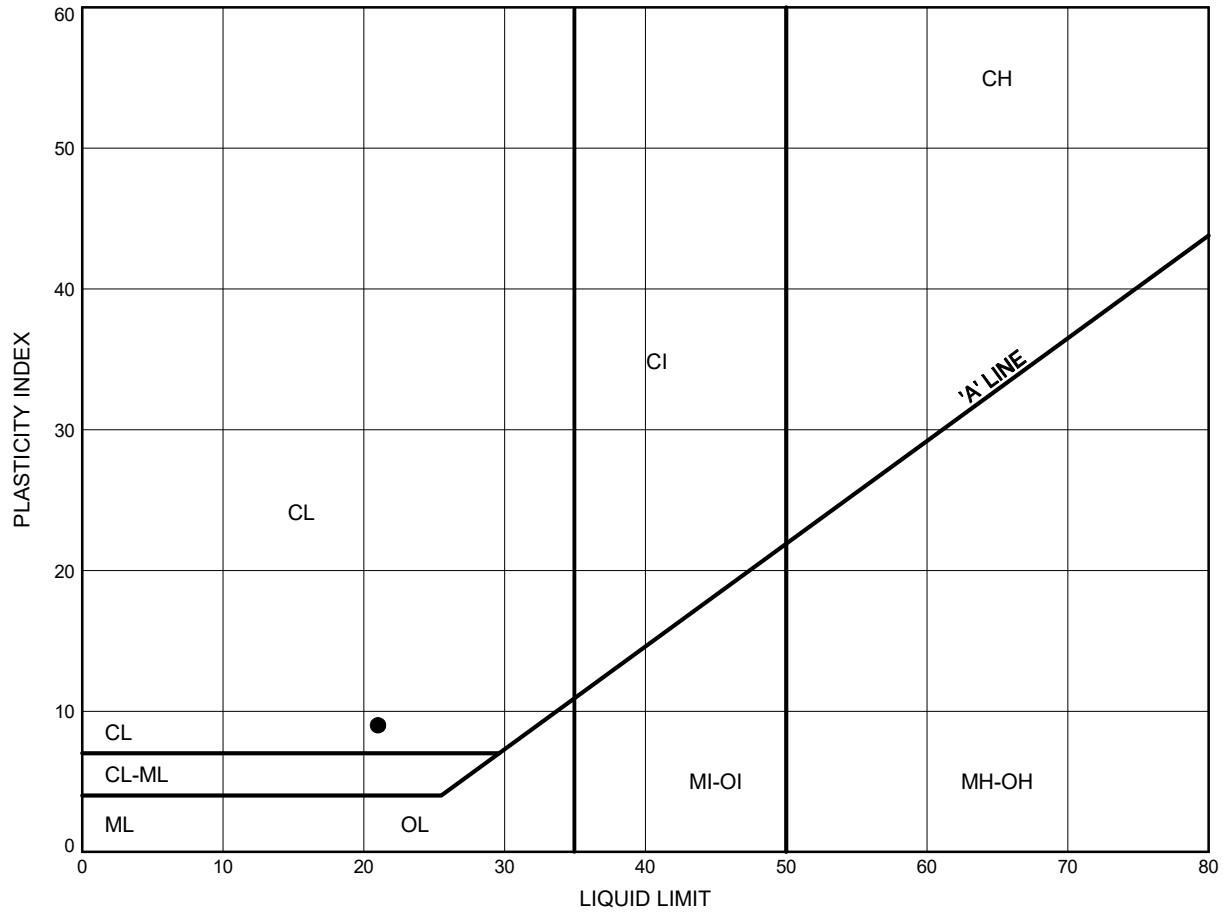
THURBALT 24726 ANDERSON ROAD.GPJ 21/7/21

Anderson Road Culvert

# ATTERBERG LIMITS TEST RESULTS

FIGURE C11

## Glacial TILL




LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | AND19-3 | 20.1 | 113.6 |

Date March 2021

WP# 4068-09-00

THURBER

Prep'd JG

Chkd. FG

THURBALT 24726 ANDERSON ROAD.GPJ 4/3/21

**Stantec Consulting Ltd.**
400 - 1331 Clyde Avenue, Ottawa ON K2C 3G4

November 1, 2017
File: 122410864

**Attention: Kenton Power**
Thurber Engineering Ltd.
104 – 2460 Lancaster Road
Ottawa, Ontario, Canada, K1B 4S5
Tel: 613-274-2121
E-mail: kpower@thurber.ca

Dear Mr. Power,

**Reference: Consolidation Test Results for Lochiel Project, Thurber Consulting Ltd., File #20482: BH 17-3, ST 17 & BH 17-2, ST 9, sampled on September 12 & 25, 2017**

This letter presents the results of one-dimensional consolidation tests carried out on the above referenced samples in accordance with ASTM D2435/D2435M - 11. The test results are provided in the attached tables and figures.

This letter provides test results only and does not constitute any interpretation or engineering recommendations with respect to material suitability or specification compliance.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Regards,

**STANTEC CONSULTING LTD.**

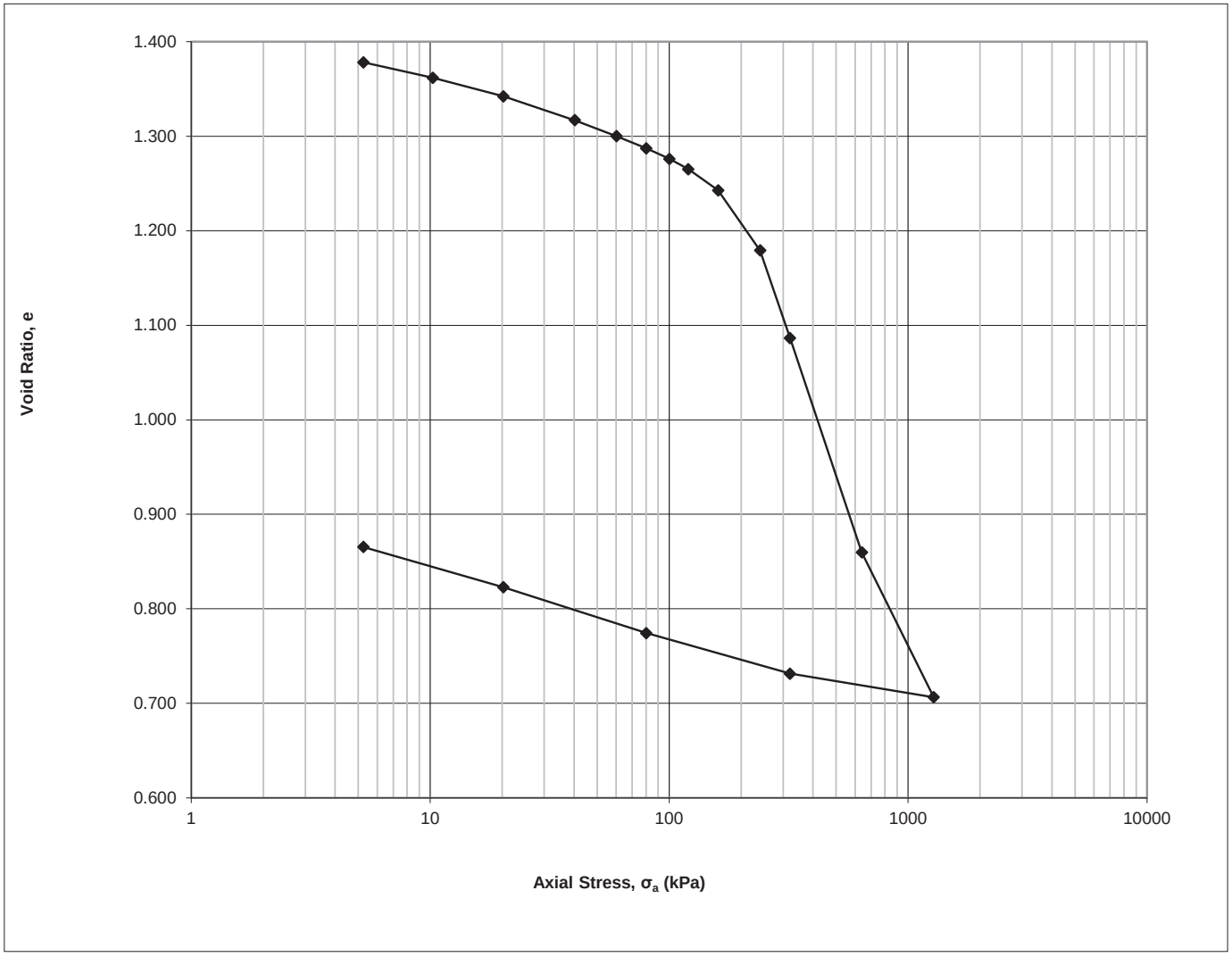
Ramy Saadeldin, Ph.D., P.Eng.
Geotechnical Engineering
Phone: (613) 738-6047
Fax: (613) 722-2799
Ramy.Saadeldin@stantec.com

Stantec

# One-Dimensional Consolidation Properties of Soils Using Incremental Loading

**ASTM D2435/D2435M - 11**

| | |
|---|---|
| **Project** | **Thurber Engineering, File# 20482** |
| **Project No.** | **122410864** |
| **Borehole No.** | **17-3** |
| **Sample No.** | **ST 17** |
| **Sample Depth** | **50-52 ft** |



Stantec

# Stantec Consulting Ltd.

1-Nov-17 Date: D. Boateng Checked by:

1-Nov-17 Date: R. Hache Approved by:

## One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

**Specimen Details**

| | |
|---|---|
| Project Name | Thurber Engineering, File# 20482 |
| Project Location | Lochiel, ON |
| Borehole | 17-3 |
| Sample No. | ST 17 |
| Depth | 50-52 ft |
| Sample Date | September 12, 2017 |
| Test Number | One |
| Technician Name | Daniel Boateng |

**Soil Description & Classification**

| | |
|---|---|
| Not Requested | |
| Specific Gravity of Solids | 2.746 |
| Average water content of trimmings % | 49 |
| **Additional Notes (information source, occurence and size of large isolated particles etc.)** | |
| | |

**Initial Specimen Conditions**

| | | |
|---|---|---|
| Height | mm | 20.00 |
| Diameter | mm | 50.00 |
| Area | $mm^2$ | 1963 |
| Volume | $mm^3$ | 39270 |
| Mass | g | 67.42 |
| Dry Mass | g | 45.26 |
| Density | $Mg/m^3$ | 1.717 |
| Dry Density | $Mg/m^3$ | 1.153 |
| Water Content | % | 48.96 |
| Degree of Saturation | % | 97.2 |
| Height of Solids | mm | 8.39 |
| Initial Void Ratio | | 1.383 |

**Final Specimen Conditions**

| | | |
|---|---|---|
| Water Content | % | 33.74 |
| Final Void Ratio | | 0.865 |

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# Stantec Consulting Ltd.

## One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Filename: V:\01216\active\laboratory_standing_offers\2017 Laboratory Standing Offers\1224
Date: 1-Nov-17
Checked by: D. Boateng
Approved by: R. Hache
Date: 1-Nov-17
Date: 1-Nov-17

**Specimen Details**

| | |
|---|---|
| Project Name | Thurber Engineering, File# 20482 |
| Project Location | Lochiel, ON |
| Borehole | 17-3 |
| Sample No. | ST 17 |
| Depth | 50-52 ft |
| Sample Date | September 12, 2017 |
| Test Number | One |
| Technician Name | Daniel Boateng |

**Test Procedure**

| | | |
|---|---|---|
| Date Started | | October 30, 2017 |
| Date Finished | | November 1, 2017 |
| Machine Number | | Frame C |
| Cell Number | | C |
| Ring Number | | C |
| Trimming Procedure | | Turntable |
| Moisture Condition | | Inundated |
| Axial Stress at Inundation | kPa | 5 |
| Water Used | | Distilled |
| Test Method | | B |
| Interpretation Procedure for $c_v$ | | 2 |

**All Departures from Outlined ASTM D2435/D2435M-11 Procedure**

**Calculations**

| Load Increment | Increment Duration | Axial Stress $\sigma_a$ | Corrected Deformation $\Delta H$ | Specimen Height H | Axial Strain $\varepsilon_a$ | Void Ratio e |
|---|---|---|---|---|---|---|
| | min | kPa | mm | mm | % | |
| Seating | 0.0 | 5 | 0.0000 | 20.0000 | 0.00 | 1.383 |
| 1 | 10.0 | 5 | 0.0372 | 19.9628 | 0.19 | 1.378 |
| 2 | 16.5 | 10 | 0.1754 | 19.8246 | 0.88 | 1.362 |
| 3 | 18.3 | 20 | 0.3391 | 19.6609 | 1.70 | 1.342 |
| 4 | 19.8 | 40 | 0.5514 | 19.4486 | 2.76 | 1.317 |
| 5 | 21.5 | 60 | 0.6935 | 19.3065 | 3.47 | 1.300 |
| 6 | 29.8 | 80 | 0.8005 | 19.1995 | 4.00 | 1.287 |
| 7 | 29.8 | 100 | 0.8948 | 19.1052 | 4.47 | 1.276 |
| 8 | 36.5 | 120 | 0.9858 | 19.0142 | 4.93 | 1.265 |
| 9 | 53.0 | 160 | 1.1741 | 18.8259 | 5.87 | 1.243 |
| 10 | 116.5 | 240 | 1.7085 | 18.2915 | 8.54 | 1.179 |
| 11 | 168.8 | 320 | 2.4859 | 17.5141 | 12.43 | 1.086 |
| 12 | 128.8 | 640 | 4.3883 | 15.6117 | 21.94 | 0.860 |
| 13 | 95.3 | 1280 | 5.6756 | 14.3244 | 28.38 | 0.706 |
| 14 | 18.3 | 320 | 5.4660 | 14.5340 | 27.33 | 0.731 |
| 15 | 36.8 | 80 | 5.1055 | 14.8945 | 25.53 | 0.774 |
| 16 | 63.5 | 20 | 4.6979 | 15.3021 | 23.49 | 0.823 |
| 17 | 103.8 | 5 | 4.3408 | 15.6592 | 21.70 | 0.865 |

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# Stantec Consulting Ltd.

## One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Date: 1-Nov-17 Date: 1-Nov-17

D. Boateng R. Hache

Checked by: Approved by:

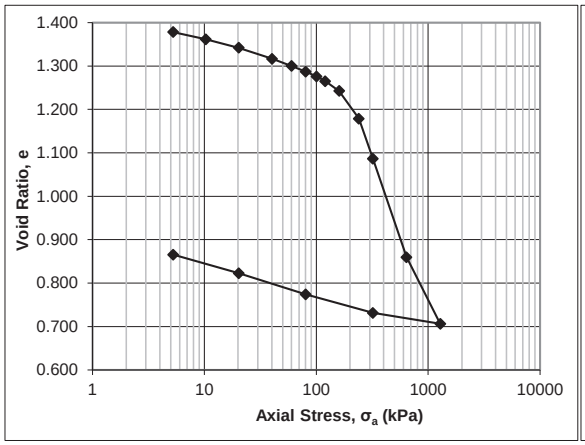
Filename: V:\01216\active\laboratory_standing_offers\2017 Laboratory Standing Offers\122 Date: 1-Nov-17

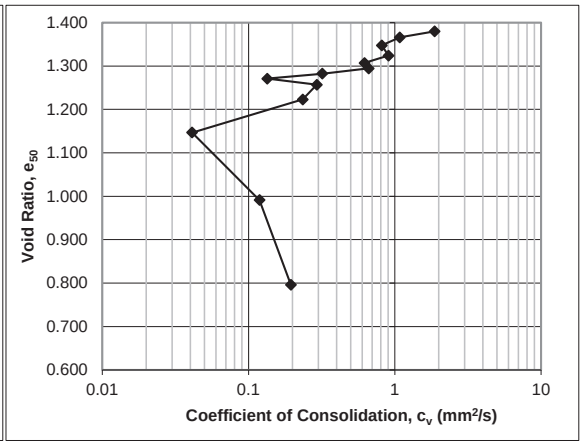
**Specimen Details**

| | |
|---|---|
| Project Name | Thurber Engineering, File# 20482 |
| Project Location | Lochiel, ON |
| Borehole | 17-3 |
| Sample No. | ST 17 |
| Depth | 50-52 ft |
| Sample Date | September 12, 2017 |
| Test Number | One |
| Technician Name | Daniel Boateng |

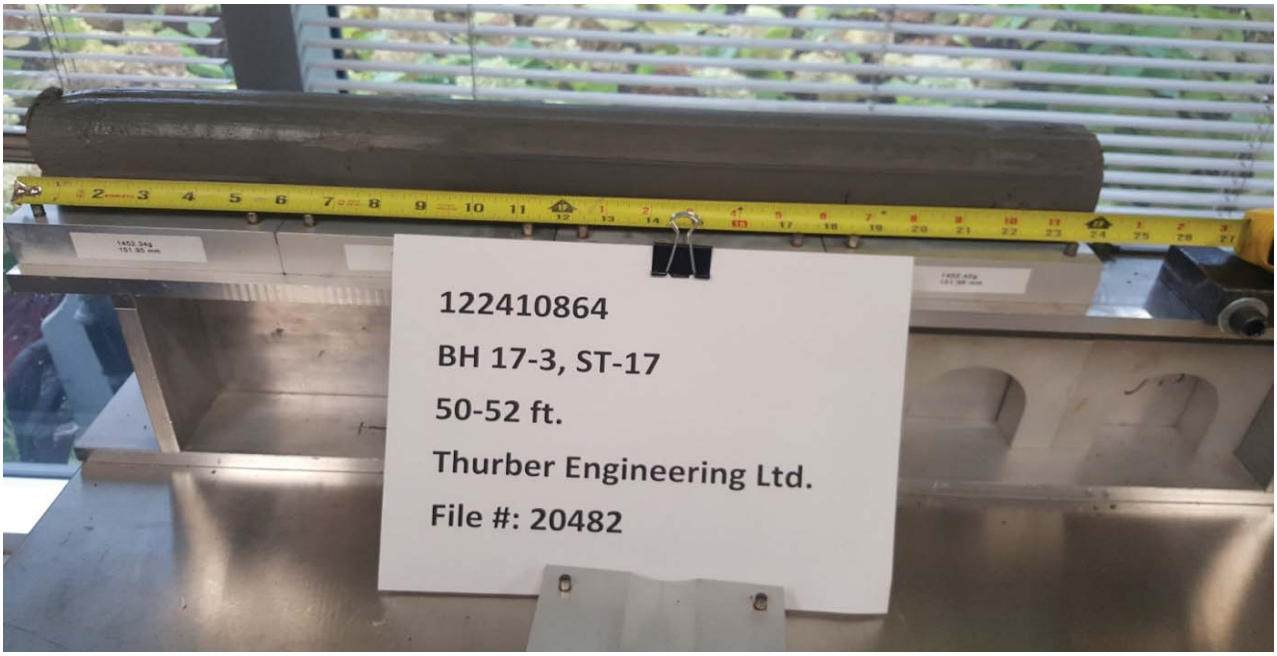
**Calculations**

| | | Calculated using Interpretation Procedure 2 | | | | Interpretation Procedure 1 | | Interpretation Procedure 2 | |
|---|---|---|---|---|---|---|---|---|---|
| Load Increment | Axial Stress $\sigma_{a,\ average}$ kPa | Corrected Deformation $\Delta H_{50}$ mm | Specimen Height $H_{50}$ mm | Axial Strain $\varepsilon_{a,50}$ % | Void Ratio $e_{50}$ | Time $t_{50}$ sec | Coeff. Consol. $c_v$ $mm^2/s$ | Time $t_{90}$ sec | Coeff. Consol. $c_v$ $mm^2/s$ |
| Seating | 3 | | | | | | | | |
| 1 | 5 | 0.0226 | 19.9774 | 0.11 | 1.380 | | | 45 | 1.87E+00 |
| 2 | 8 | 0.1394 | 19.8606 | 0.70 | 1.366 | | | 77 | 1.08E+00 |
| 3 | 15 | 0.2925 | 19.7075 | 1.46 | 1.348 | | | 101 | 8.13E-01 |
| 4 | 30 | 0.4904 | 19.5096 | 2.45 | 1.324 | | | 89 | 9.05E-01 |
| 5 | 50 | 0.6325 | 19.3675 | 3.16 | 1.307 | | | 128 | 6.20E-01 |
| 6 | 70 | 0.7391 | 19.2609 | 3.70 | 1.295 | | | 119 | 6.62E-01 |
| 7 | 90 | 0.8403 | 19.1597 | 4.20 | 1.282 | | | 244 | 3.19E-01 |
| 8 | 110 | 0.9366 | 19.0634 | 4.68 | 1.271 | | | 575 | 1.34E-01 |
| 9 | 140 | 1.0537 | 18.9463 | 5.27 | 1.257 | | | 260 | 2.93E-01 |
| 10 | 200 | 1.3376 | 18.6624 | 6.69 | 1.223 | | | 314 | 2.35E-01 |
| 11 | 280 | 1.9795 | 18.0205 | 9.90 | 1.147 | | | 1673 | 4.11E-02 |
| 12 | 480 | 3.2838 | 16.7162 | 16.42 | 0.991 | | | 497 | 1.19E-01 |
| 13 | 960 | 4.9221 | 15.0779 | 24.61 | 0.796 | | | 247 | 1.95E-01 |
| 14 | 800 | 5.5093 | 14.4907 | 27.55 | 0.726 | | | | |
| 15 | 200 | 5.2302 | 14.7698 | 26.15 | 0.760 | | | | |
| 16 | 50 | 4.8678 | 15.1322 | 24.34 | 0.803 | | | | |
| 17 | 13 | 4.6825 | 15.3175 | 23.41 | 0.825 | | | | |



| Stantec | Project No.: 122410864 | Photo Log |
|---|---|---|
| | Project Name: Thurber, File # 20482 | |




| Photo No.: 1 | Borehole: BH 17-3, ST 17 | Depth: 50-52 ft |
|---|---|---|


| Photo No.: 2 | Borehole: BH 17-3, ST 17 | Depth: 50-52 ft |
|---|---|---|

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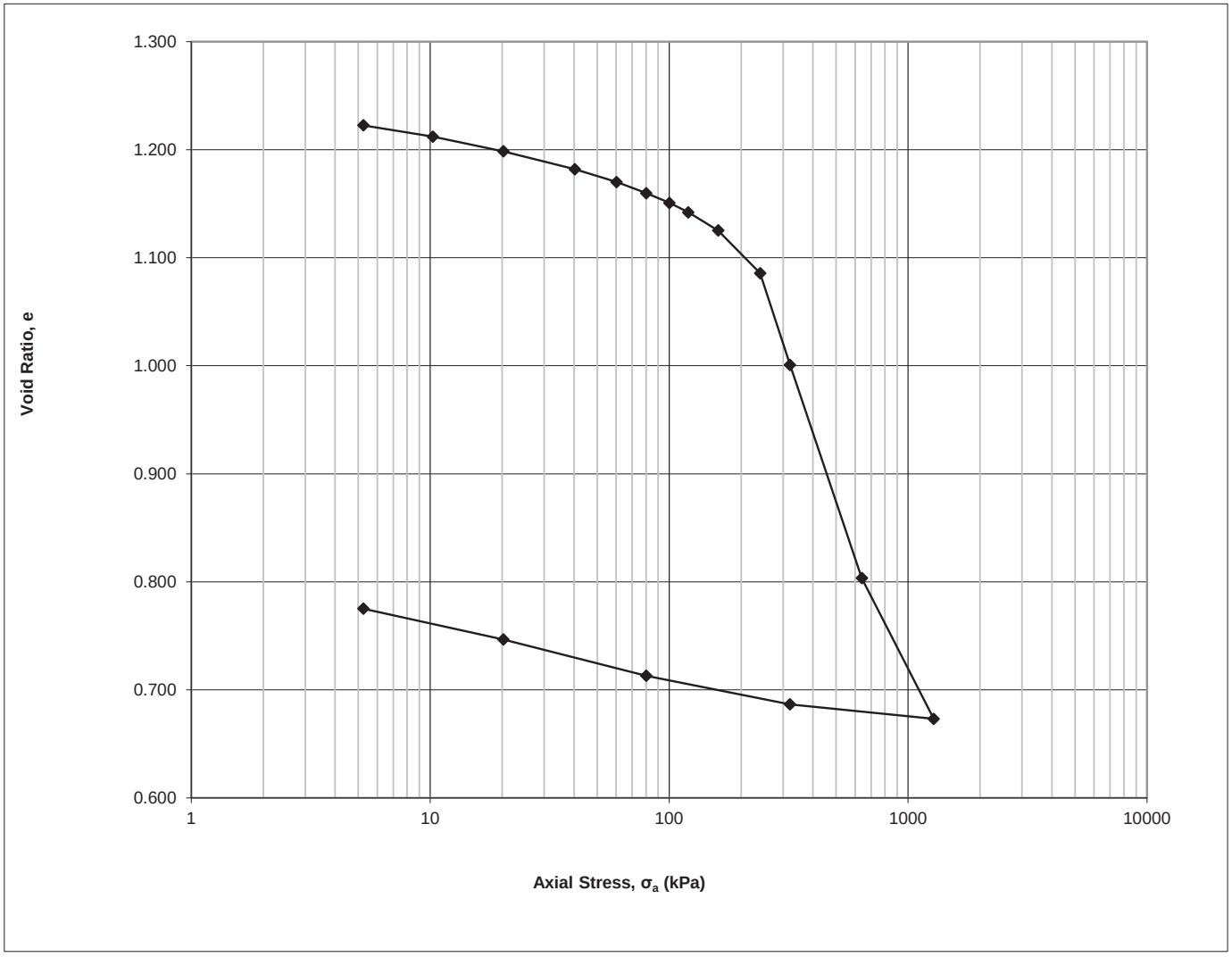
# One-Dimensional Consolidation Properties of Soils Using Incremental Loading

**ASTM D2435/D2435M - 11**

| | |
|---|---|
| **Project** | **Thurber Engineering, File# 20482** |
| **Project No.** | **122410864** |
| **Borehole No.** | **17-2** |
| **Sample No.** | **ST 9** |
| **Sample Depth** | **35-37 ft** |



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# Stantec Consulting Ltd.

## One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

1-Nov-17 Date: D. Boateng Checked by:

1-Nov-17 Date: R. Hache Approved by:

**Specimen Details**

| | |
|---|---|
| Project Name | Thurber Engineering, File# 20482 |
| Project Location | Lochiel, ON |
| Borehole | 17-2 |
| Sample No. | ST 9 |
| Depth | 35-37 ft |
| Sample Date | September 25, 2017 |
| Test Number | Two |
| Technician Name | Daniel Boateng |

**Soil Description & Classification**

| |
|---|
| Not Requested |

| | | |
|---|---|---|
| Specific Gravity of Solids | | 2.746 |
| Average water content of trimmings | % | 45 |
| **Additional Notes (information source, occurence and size of large isolated particles etc.)** | | |
| Specific Gravity of Solids Assumed | | |

**Initial Specimen Conditions**

| | | |
|---|---|---|
| Height | mm | 20.00 |
| Diameter | mm | 50.00 |
| Area | $mm^2$ | 1963 |
| Volume | $mm^3$ | 39270 |
| Mass | g | 69.92 |
| Dry Mass | g | 48.38 |
| Density | $Mg/m^3$ | 1.780 |
| Dry Density | $Mg/m^3$ | 1.232 |
| Water Content | % | 44.52 |
| Degree of Saturation | % | 99.5 |
| Height of Solids | mm | 8.97 |
| Initial Void Ratio | | 1.229 |

**Final Specimen Conditions**

| | | |
|---|---|---|
| Water Content | % | 30.07 |
| Final Void Ratio | | 0.775 |

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# Stantec Consulting Ltd.

## One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Filename: V:\01216\active\laboratory_standing_offers\2017 Laboratory Standing Offers\1224
Date: 1-Nov-17
Checked by: D. Boateng
Approved by: R. Hache
Date: 1-Nov-17
Date: 1-Nov-17

**Specimen Details**

| | |
|---|---|
| Project Name | Thurber Engineering, File# 20482 |
| Project Location | Lochiel, ON |
| Borehole | 17-2 |
| Sample No. | ST 9 |
| Depth | 35-37 ft |
| Sample Date | September 25, 2017 |
| Test Number | Two |
| Technician Name | Daniel Boateng |

**Test Procedure**

| | | |
|---|---|---|
| Date Started | | October 30, 2017 |
| Date Finished | | November 1, 2017 |
| Machine Number | | Frame D |
| Cell Number | | D |
| Ring Number | | D |
| Trimming Procedure | | Turntable |
| Moisture Condition | | Inundated |
| Axial Stress at Inundation | kPa | 5 |
| Water Used | | Distilled |
| Test Method | | B |
| Interpretation Procedure for $c_v$ | | 2 |

**All Departures from Outlined ASTM D2435/D2435M-11 Procedure**

**Calculations**

| Load Increment | Increment Duration | Axial Stress $\sigma_a$ | Corrected Deformation $\Delta H$ | Specimen Height H | Axial Strain $\varepsilon_a$ | Void Ratio e |
|---|---|---|---|---|---|---|
| | min | kPa | mm | mm | % | |
| Seating | 0.0 | 5 | 0.0000 | 20.0000 | 0.00 | 1.229 |
| 1 | 14.8 | 5 | 0.0576 | 19.9424 | 0.29 | 1.223 |
| 2 | 14.8 | 10 | 0.1507 | 19.8493 | 0.75 | 1.212 |
| 3 | 21.5 | 20 | 0.2735 | 19.7265 | 1.37 | 1.198 |
| 4 | 19.8 | 40 | 0.4214 | 19.5786 | 2.11 | 1.182 |
| 5 | 19.8 | 60 | 0.5284 | 19.4716 | 2.64 | 1.170 |
| 6 | 28.3 | 80 | 0.6203 | 19.3797 | 3.10 | 1.160 |
| 7 | 24.8 | 100 | 0.7016 | 19.2984 | 3.51 | 1.151 |
| 8 | 29.8 | 120 | 0.7803 | 19.2197 | 3.90 | 1.142 |
| 9 | 34.8 | 160 | 0.9306 | 19.0694 | 4.65 | 1.125 |
| 10 | 64.8 | 240 | 1.2849 | 18.7151 | 6.42 | 1.086 |
| 11 | 183.5 | 320 | 2.0464 | 17.9536 | 10.23 | 1.001 |
| 12 | 132.0 | 640 | 3.8172 | 16.1828 | 19.09 | 0.804 |
| 13 | 87.0 | 1280 | 4.9864 | 15.0136 | 24.93 | 0.673 |
| 14 | 15.0 | 320 | 4.8663 | 15.1337 | 24.33 | 0.687 |
| 15 | 28.3 | 80 | 4.6286 | 15.3714 | 23.14 | 0.713 |
| 16 | 53.3 | 20 | 4.3271 | 15.6729 | 21.64 | 0.747 |
| 17 | 68.5 | 5 | 4.0719 | 15.9281 | 20.36 | 0.775 |

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# Stantec Consulting Ltd.

## One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

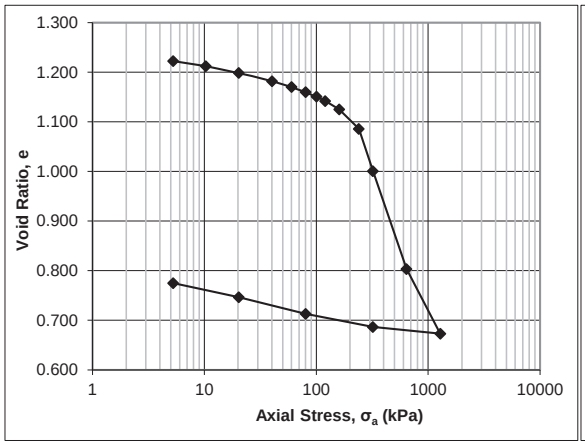
Filename: V:\01216\active\laboratory_standing_offers\2017 Laboratory Standing Offers\122 Date: 1-Nov-17
Checked by: D. Boateng Date: 1-Nov-17
Approved by: R. Hache Date:

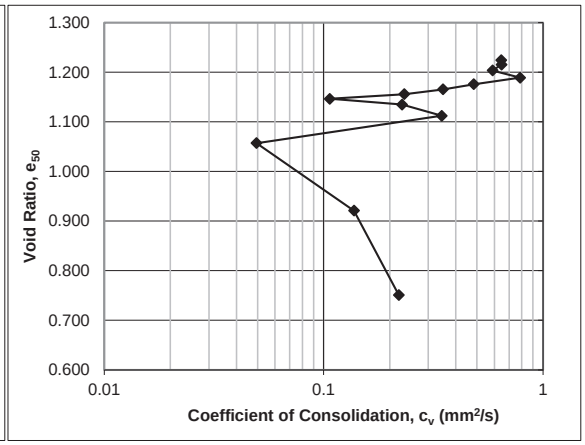
**Specimen Details**

| | | |
|---|---|---|
| Project Name | | Thurber Engineering, File# 20482 |
| Project Location | | Lochiel, ON |
| Borehole | | 17-2 |
| Sample No. | | ST 9 |
| Depth | m | 35-37 ft |
| Sample Date | | September 25, 2017 |
| Test Number | | Two |
| Technician Name | | Daniel Boateng |

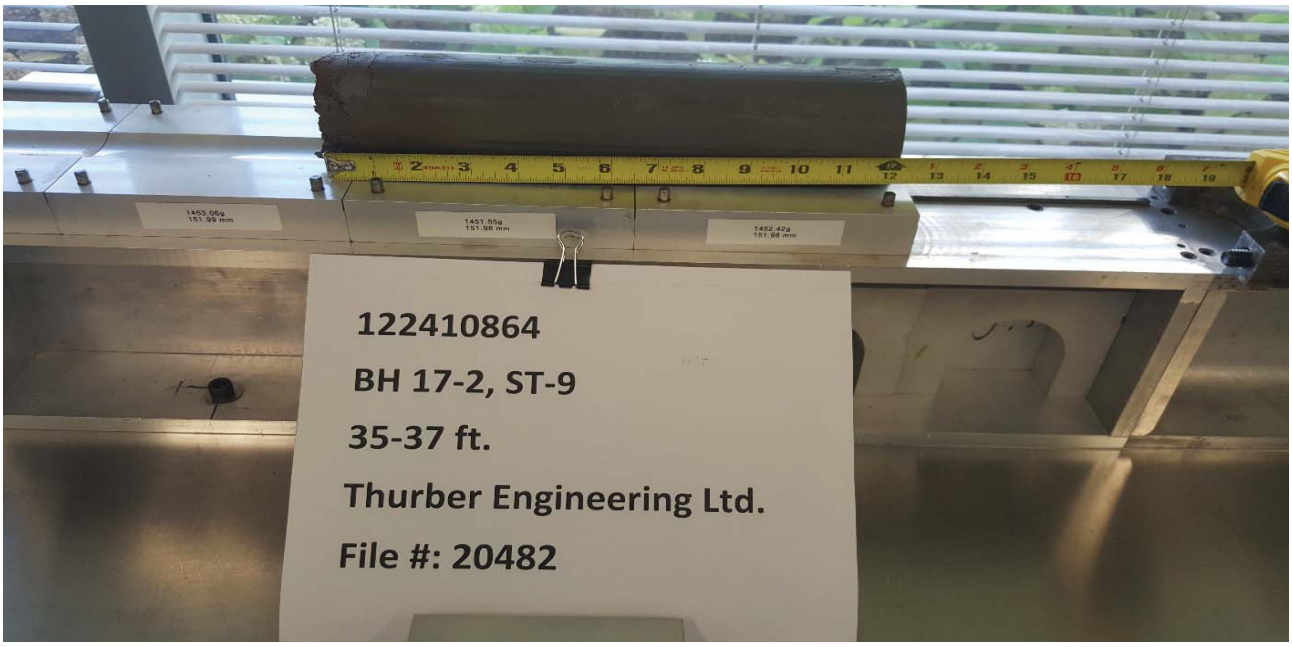
**Calculations**

| | | Calculated using Interpretation Procedure 2 | | | | Interpretation Procedure 1 | | Interpretation Procedure 2 | |
|---|---|---|---|---|---|---|---|---|---|
| Load Increment | Axial Stress $\sigma_{a,\ average}$ kPa | Corrected Deformation $\Delta H_{50}$ mm | Specimen Height $H_{50}$ mm | Axial Strain $\varepsilon_{a,50}$ % | Void Ratio $e_{50}$ | Time $t_{50}$ sec | Coeff. Consol. $c_v$ $mm^2/s$ | Time $t_{90}$ sec | Coeff. Consol. $c_v$ $mm^2/s$ |
| Seating | 3 | | | | | | | | |
| 1 | 5 | 0.0411 | 19.9589 | 0.21 | 1.224 | | | 131 | 6.44E-01 |
| 2 | 8 | 0.1198 | 19.8802 | 0.60 | 1.216 | | | 129 | 6.48E-01 |
| 3 | 15 | 0.2283 | 19.7717 | 1.14 | 1.203 | | | 141 | 5.89E-01 |
| 4 | 30 | 0.3571 | 19.6429 | 1.79 | 1.189 | | | 104 | 7.86E-01 |
| 5 | 50 | 0.4767 | 19.5233 | 2.38 | 1.176 | | | 167 | 4.83E-01 |
| 6 | 70 | 0.5692 | 19.4308 | 2.85 | 1.165 | | | 229 | 3.50E-01 |
| 7 | 90 | 0.6562 | 19.3438 | 3.28 | 1.156 | | | 341 | 2.33E-01 |
| 8 | 110 | 0.7406 | 19.2594 | 3.70 | 1.146 | | | 737 | 1.07E-01 |
| 9 | 140 | 0.8425 | 19.1575 | 4.21 | 1.135 | | | 342 | 2.28E-01 |
| 10 | 200 | 1.0466 | 18.9534 | 5.23 | 1.112 | | | 221 | 3.45E-01 |
| 11 | 280 | 1.5415 | 18.4585 | 7.71 | 1.057 | | | 1461 | 4.95E-02 |
| 12 | 480 | 2.7615 | 17.2385 | 13.81 | 0.921 | | | 458 | 1.38E-01 |
| 13 | 960 | 4.2882 | 15.7118 | 21.44 | 0.751 | | | 238 | 2.20E-01 |
| 14 | 800 | 4.8863 | 15.1137 | 24.43 | 0.684 | | | | |
| 15 | 200 | 4.7122 | 15.2878 | 23.56 | 0.704 | | | | |
| 16 | 50 | 4.4499 | 15.5501 | 22.25 | 0.733 | | | | |
| 17 | 13 | 4.3078 | 15.6922 | 21.54 | 0.749 | | | | |

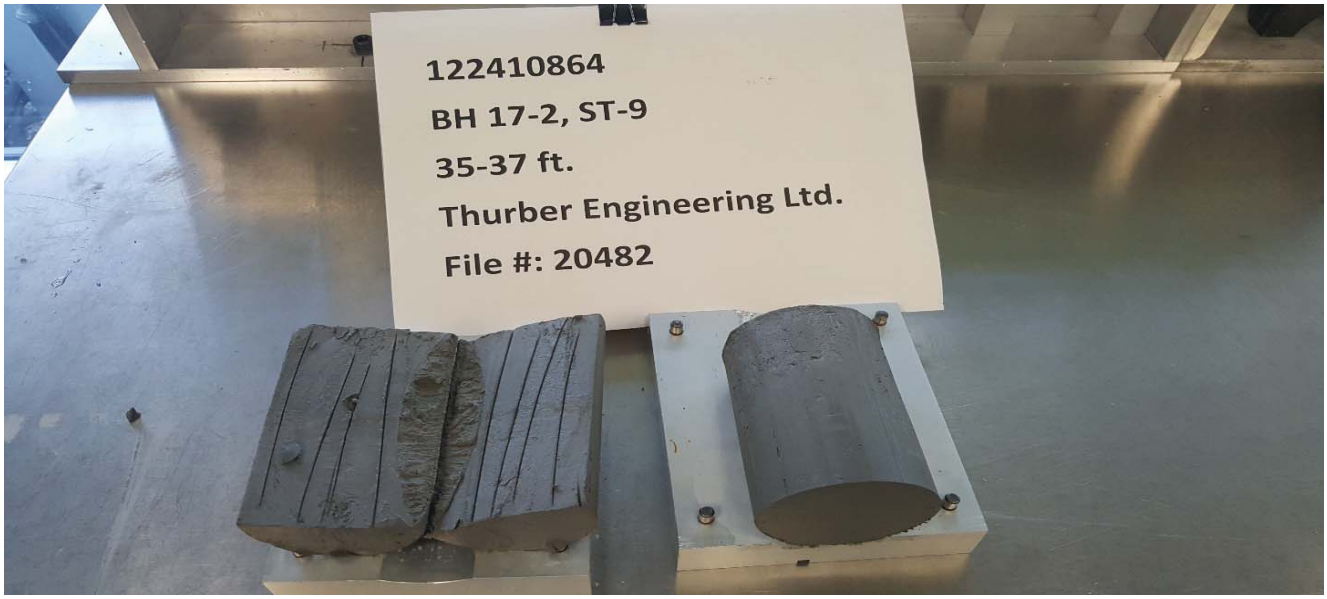


| Stantec | Project No.: 122410864 | Photo Log |
|---|---|---|
| | Project Name: Thurber, File# 20482 | |




| Photo No.: 1 | Borehole: BH 17-2, ST 9 | Depth: 35-37 ft |
|---|---|---|




| Photo No.: 2 | Borehole: BH 17-2, ST 9 | Depth: 35-37 ft |
|---|---|---|

**Stantec Consulting Ltd.**
400 - 1331 Clyde Avenue, Ottawa ON K2C 3G4

July 9, 2018
File: 122410864

**Attention: Kenton Power**
Thurber Engineering Ltd.
104 – 2460 Lancaster Road
Ottawa, Ontario, Canada, K1B 4S5
Tel: 613-274-2121
E-mail: kpower@thurber.ca

Dear Mr. Power,

**Reference: Consolidation Test Results for Locha Creek Culvert Project, Thurber Consulting Ltd., File #20482: BH 18-101, ST 5 & 9, sampled on June 11, 2018**

This letter presents the results of one-dimensional consolidation tests carried out on the above referenced samples in accordance with ASTM D2435/D2435M - 11. The test results are provided in the attached tables and figures.

This letter provides test results only and does not constitute any interpretation or engineering recommendations with respect to material suitability or specification compliance.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Regards,

**STANTEC CONSULTING LTD.**

Ramy Saadeldin, Ph.D., P.Eng.
Geotechnical Engineering
Phone: (613) 738-6047
Fax: (613) 722-2799
Ramy.Saadeldin@stantec.com

v:\01216\active\laboratory_standing_offers\2018 laboratory standing offers\122410864 thurber engineering ltd\june 11, two consolidation, one specific gravity\consolidation letter & results\122410864_let_consolidationresults_ bh 18-101 st 5 9.docx

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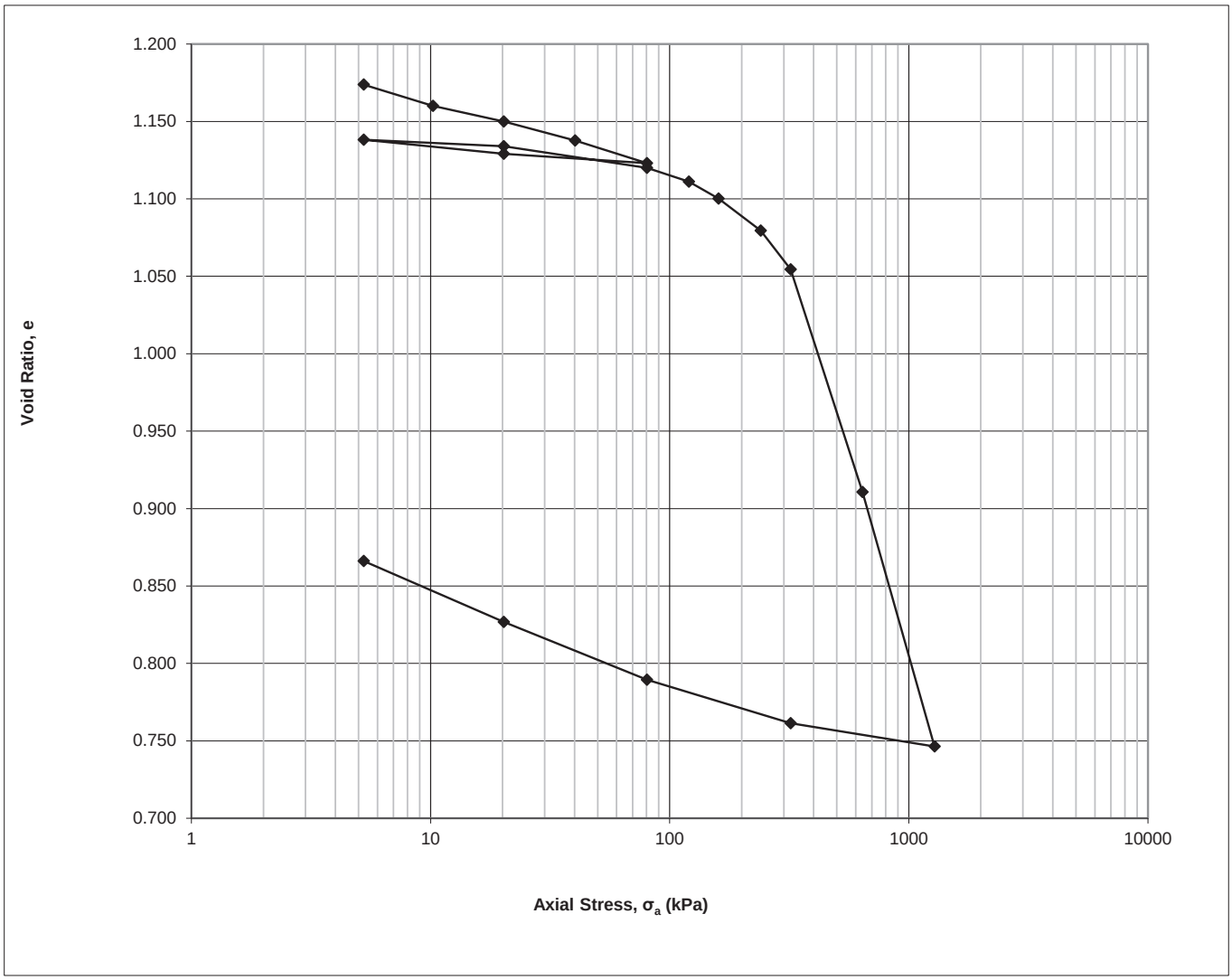
# One-Dimensional Consolidation Properties of Soils Using Incremental Loading

**ASTM D2435/D2435M - 11**

| | |
|---|---|
| **Project** | **Thurber Engineering, File# 20482** |
| **Project No.** | **122410864** |
| **Borehole No.** | **BH 18-101** |
| **Sample No.** | **ST 5** |
| **Sample Depth** | **15 - 17 ft.** |



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# Stantec Consulting Ltd.

## One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Date: 7-Jul-18 Date: 7-Jul-18

D. Boateng R. Hache

Checked by: Approved by:

**Specimen Details**

| | |
|---|---|
| Project Name | Thurber Engineering, File# 20482 |
| Project Location | HWY 17, Ontario |
| Borehole | BH 18-101 |
| Sample No. | ST 5 |
| Depth | 15 - 17 ft. |
| Sample Date | June 11, 2018 |
| Test Number | One |
| Technician Name | Daniel Boateng |

**Soil Description & Classification**

| | |
|---|---|
| Silty Clay, Brown/Grey, Fissured, Moist | |
| Specific Gravity of Solids | 2.750 |
| Average water content of trimmings % | 43 |
| **Additional Notes (information source, occurence and size of large isolated particles etc.)** | |
| | |

**Initial Specimen Conditions**

| | | |
|---|---|---|
| Height | mm | 20.00 |
| Diameter | mm | 50.00 |
| Area | $mm^2$ | 1963 |
| Volume | $mm^3$ | 39270 |
| Mass | g | 70.21 |
| Dry Mass | g | 49.16 |
| Density | $Mg/m^3$ | 1.788 |
| Dry Density | $Mg/m^3$ | 1.252 |
| Water Content | % | 42.82 |
| Degree of Saturation | % | 98.4 |
| Height of Solids | mm | 9.10 |
| Initial Void Ratio | | 1.197 |

**Final Specimen Conditions**

| | | |
|---|---|---|
| Water Content | % | 34.86 |
| Final Void Ratio | | 0.866 |

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# Stantec Consulting Ltd.

## One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Filename: V:\01216\active\laboratory_standing_offers\2018 Laboratory Standing Offers\122 Date: 7-Jul-18 | Checked by: D. Boateng Date: 7-Jul-18 | Approved by: R. Hache Date: 7-Jul-18

**Specimen Details**

| | |
|---|---|
| Project Name | Thurber Engineering, File# 20482 |
| Project Location | HWY 17, Ontario |
| Borehole | BH 18-101 |
| Sample No. | ST 5 |
| Depth | 15 - 17 ft. |
| Sample Date | June 11, 2018 |
| Test Number | One |
| Technician Name | Daniel Boateng |

**Test Procedure**

| | | |
|---|---|---|
| Date Started | | June 22, 2018 |
| Date Finished | | July 3, 2018 |
| Machine Number | | Frame C |
| Cell Number | | C |
| Ring Number | | C |
| Trimming Procedure | | Turntable |
| Moisture Condition | | Inundated |
| Axial Stress at Inundation | kPa | 5 |
| Water Used | | Distilled |
| Test Method | | A |
| Interpretation Procedure for $c_v$ | | 2 |

**All Departures from Outlined ASTM D2435/D2435M-11 Procedure**

**Calculations**

| Load Increment | Increment Duration | Axial Stress $\sigma_a$ | Corrected Deformation $\Delta H$ | Specimen Height H | Axial Strain $\varepsilon_a$ | Void Ratio e |
|---|---|---|---|---|---|---|
| | min | kPa | mm | mm | % | |
| Seating | 0.0 | 5 | 0.0000 | 20.0000 | 0.00 | 1.197 |
| 1 | 720.0 | 5 | 0.2093 | 19.7907 | 1.05 | 1.174 |
| 2 | 720.0 | 10 | 0.3335 | 19.6665 | 1.67 | 1.160 |
| 3 | 720.0 | 20 | 0.4253 | 19.5747 | 2.13 | 1.150 |
| 4 | 720.0 | 40 | 0.5376 | 19.4624 | 2.69 | 1.138 |
| 5 | 720.0 | 80 | 0.6706 | 19.3294 | 3.35 | 1.123 |
| 6 | 720.0 | 20 | 0.6159 | 19.3841 | 3.08 | 1.129 |
| 7 | 720.0 | 5 | 0.5332 | 19.4668 | 2.67 | 1.138 |
| 8 | 720.0 | 20 | 0.5716 | 19.4284 | 2.86 | 1.134 |
| 9 | 720.0 | 80 | 0.6981 | 19.3019 | 3.49 | 1.120 |
| 10 | 1440.0 | 120 | 0.7793 | 19.2207 | 3.90 | 1.111 |
| 11 | 1440.0 | 160 | 0.8794 | 19.1206 | 4.40 | 1.100 |
| 12 | 1440.0 | 240 | 1.0681 | 18.9319 | 5.34 | 1.079 |
| 13 | 720.0 | 320 | 1.2957 | 18.7043 | 6.48 | 1.054 |
| 14 | 720.0 | 640 | 2.6039 | 17.3961 | 13.02 | 0.911 |
| 15 | 720.0 | 1280 | 4.1005 | 15.8995 | 20.50 | 0.746 |
| 16 | 720.0 | 320 | 3.9638 | 16.0362 | 19.82 | 0.761 |
| 17 | 720.0 | 80 | 3.7079 | 16.2921 | 18.54 | 0.789 |
| 18 | 720.0 | 20 | 3.3679 | 16.6321 | 16.84 | 0.827 |
| 19 | 720.0 | 5 | 3.0108 | 16.9892 | 15.05 | 0.866 |

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# Stantec Consulting Ltd.

## One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

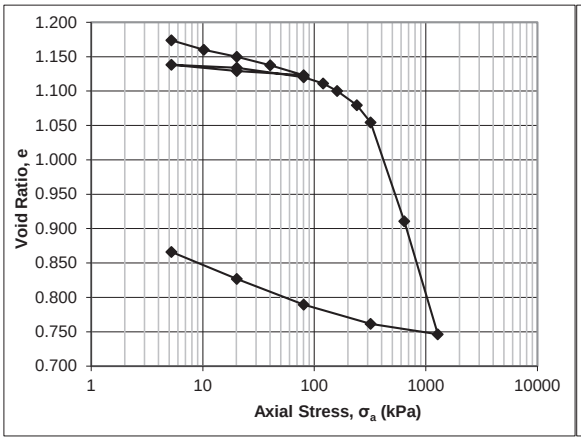
Filename: V:\01216\active\laboratory_standing_offers\2018 Laboratory Standing Offers\12: Date: 7-Jul-18
Checked by: D. Boateng Date: 7-Jul-18
Approved by: R. Hache Date:

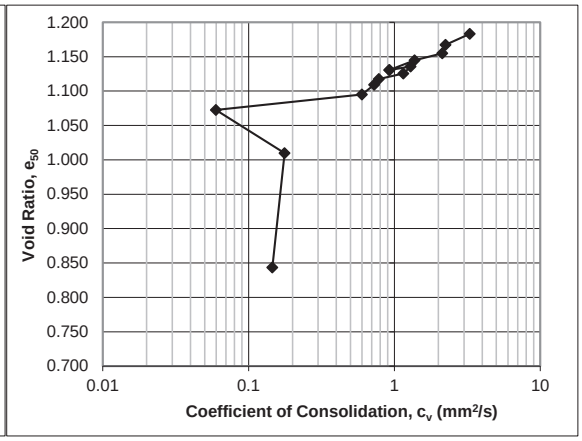
**Specimen Details**

| | |
|---|---|
| Project Name | Thurber Engineering, File# 20482 |
| Project Location | HWY 17, Ontario |
| Borehole | BH 18-101 |
| Sample No. | ST 5 |
| Depth | 15 - 17 ft. |
| Sample Date | June 11, 2018 |
| Test Number | One |
| Technician Name | Daniel Boateng |

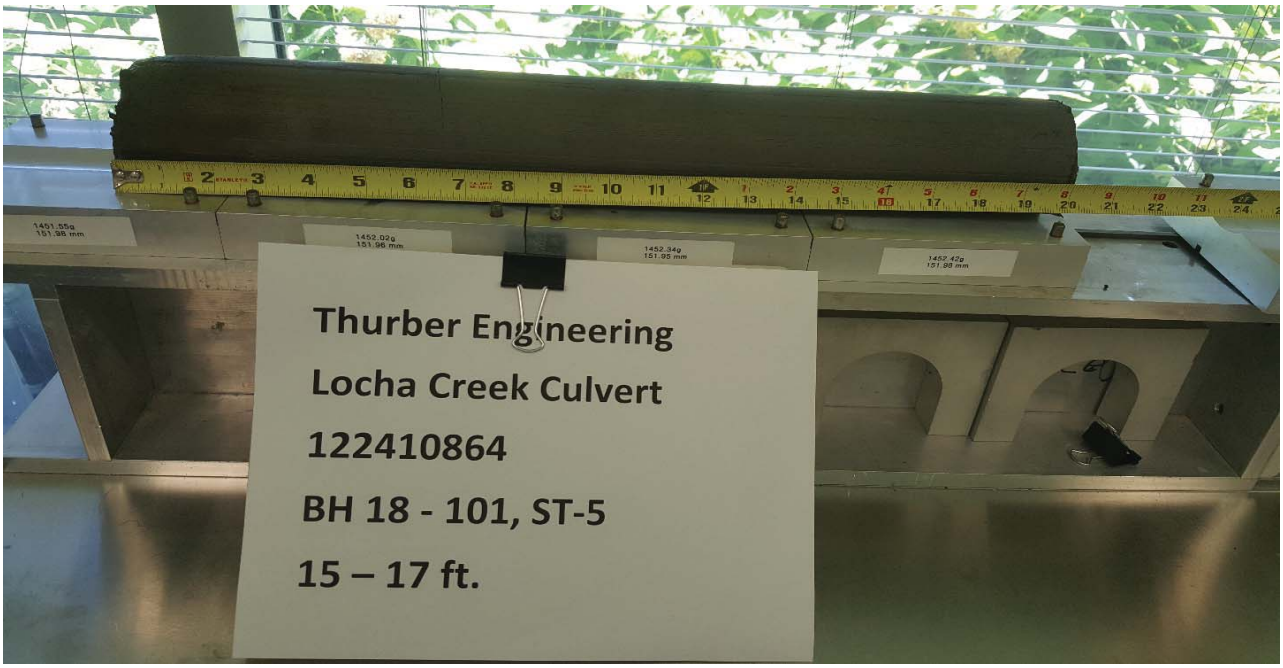
**Calculations**

| | | Calculated using Interpretation Procedure 2 | | | | Interpretation Procedure 1 | | Interpretation Procedure 2 | |
|---|---|---|---|---|---|---|---|---|---|
| Load Increment | Axial Stress $\sigma_{a,\ average}$ kPa | Corrected Deformation $\Delta H_{50}$ mm | Specimen Height $H_{50}$ mm | Axial Strain $\varepsilon_{a,50}$ % | Void Ratio $e_{50}$ | Time $t_{50}$ sec | Coeff. Consol. $c_v$ $mm^2/s$ | Time $t_{90}$ sec | Coeff. Consol. $c_v$ $mm^2/s$ |
| Seating | 3 | | | | | | | | |
| 1 | 5 | 0.1235 | 19.8765 | 0.62 | 1.183 | | | 25 | 3.29E+00 |
| 2 | 8 | 0.2685 | 19.7315 | 1.34 | 1.167 | | | 37 | 2.24E+00 |
| 3 | 15 | 0.3807 | 19.6193 | 1.90 | 1.155 | | | 38 | 2.13E+00 |
| 4 | 30 | 0.4727 | 19.5273 | 2.36 | 1.145 | | | 59 | 1.38E+00 |
| 5 | 60 | 0.6017 | 19.3983 | 3.01 | 1.131 | | | 86 | 9.26E-01 |
| 6 | 50 | 0.6319 | 19.3681 | 3.16 | 1.127 | | | | |
| 7 | 13 | 0.5718 | 19.4282 | 2.86 | 1.134 | | | | |
| 8 | 13 | 0.5570 | 19.4430 | 2.79 | 1.136 | | | 62 | 1.29E+00 |
| 9 | 50 | 0.6480 | 19.3520 | 3.24 | 1.126 | | | 69 | 1.15E+00 |
| 10 | 100 | 0.7217 | 19.2783 | 3.61 | 1.117 | | | 101 | 7.83E-01 |
| 11 | 140 | 0.7983 | 19.2017 | 3.99 | 1.109 | | | 108 | 7.26E-01 |
| 12 | 200 | 0.9248 | 19.0752 | 4.62 | 1.095 | | | 129 | 6.00E-01 |
| 13 | 280 | 1.1317 | 18.8683 | 5.66 | 1.072 | | | 1264 | 5.97E-02 |
| 14 | 480 | 1.7040 | 18.2960 | 8.52 | 1.010 | | | 401 | 1.77E-01 |
| 15 | 960 | 3.2145 | 16.7855 | 16.07 | 0.844 | | | 410 | 1.46E-01 |
| 16 | 800 | 4.0149 | 15.9851 | 20.07 | 0.756 | | | | |
| 17 | 200 | 3.8295 | 16.1705 | 19.15 | 0.776 | | | | |
| 18 | 50 | 3.5539 | 16.4461 | 17.77 | 0.806 | | | | |
| 19 | 13 | 3.2472 | 16.7528 | 16.24 | 0.840 | | | | |



| Stantec | Project No.: 122410864 | Photo Log |
|---|---|---|
| | Project Name: Thurber Engineering, File# 20482 | |




| Photo No.: 1 | Borehole: BH 18-101 ST 5 | Depth: 15 – 17 ft. |
|---|---|---|


| Photo No.: 2 | Borehole: BH 18-101 ST 5 | Depth: 15 – 17 ft. |
|---|---|---|

| Stantec | Project No.: 122410864 | Photo Log |
|---|---|---|
| | Project Name: Thurber Engineering, File# 20482 | |


| Photo No.: 3 | Borehole: BH 18-101 ST 5 | Depth: 15 – 17 ft. |
|---|---|---|


| Photo No.: 4 | Borehole: BH 18-101 ST 5 | Depth: 15 – 17 ft. |
|---|---|---|

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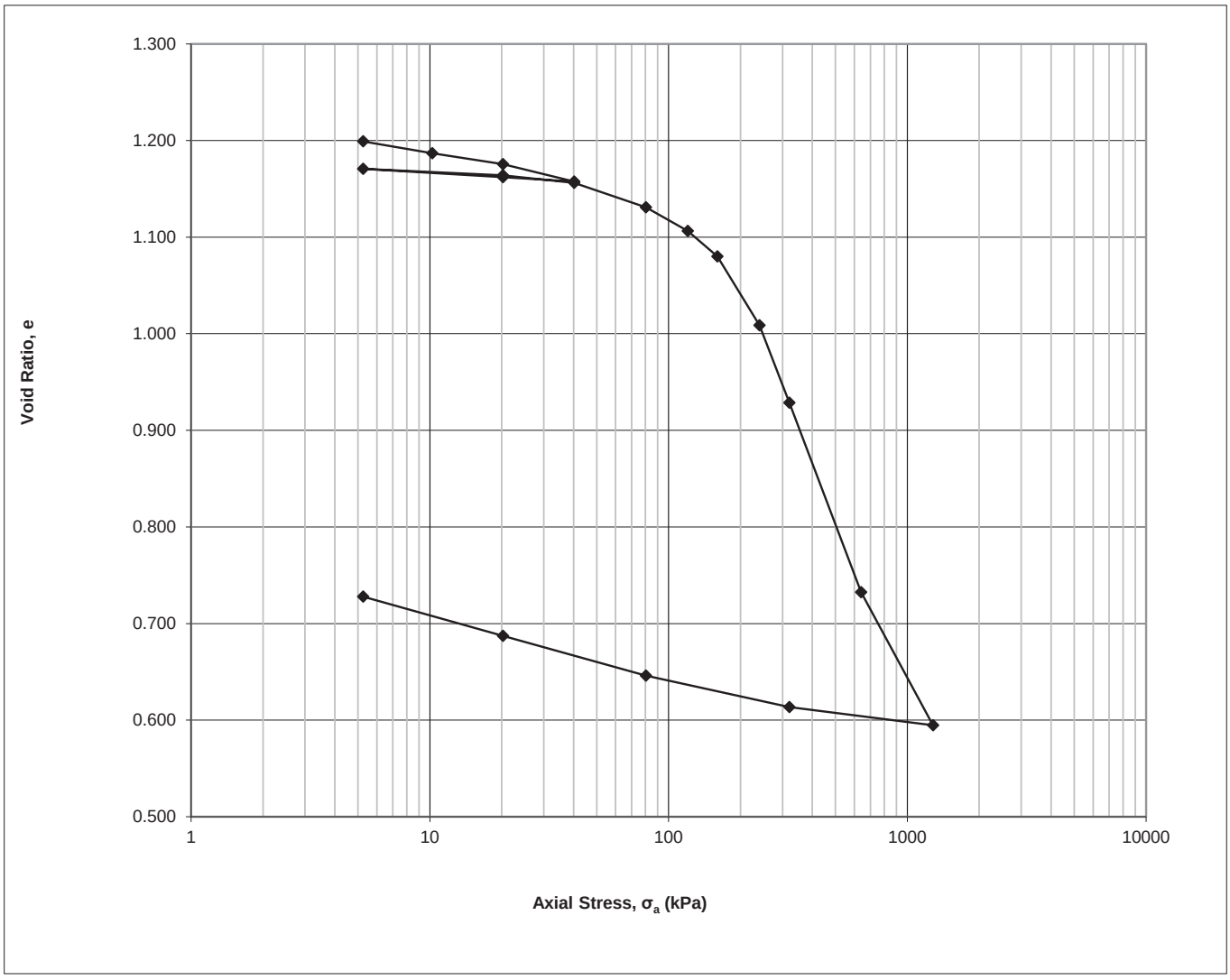
# One-Dimensional Consolidation Properties of Soils Using Incremental Loading

**ASTM D2435/D2435M - 11**

| | |
|---|---|
| **Project** | **Thurber Engineering, File# 20482** |
| **Project No.** | **122410864** |
| **Borehole No.** | **BH 18-101** |
| **Sample No.** | **ST 9** |
| **Sample Depth** | **35 - 37 ft.** |



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# Stantec Consulting Ltd.

## One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

7-Jul-18 Date: D. Boateng Checked by:

7-Jul-18 Date: R. Hache Approved by:

**Specimen Details**

| | |
|---|---|
| Project Name | Thurber Engineering, File# 20482 |
| Project Location | HWY 17, Ontario |
| Borehole | BH 18-101 |
| Sample No. | ST 9 |
| Depth | 35 - 37 ft. |
| Sample Date | June 11, 2018 |
| Test Number | Two |
| Technician Name | Daniel Boateng |

**Soil Description & Classification**

| | |
|---|---|
| Silty Clay, Grey, Wet | |
| Specific Gravity of Solids | 2.750 |
| Average water content of trimmings % | 45 |
| **Additional Notes (information source, occurence and size of large isolated particles etc.)** | |
| Specific Gravity of Solids Assumed | |

**Initial Specimen Conditions**

| | | |
|---|---|---|
| Height | mm | 20.00 |
| Diameter | mm | 50.00 |
| Area | $mm^2$ | 1963 |
| Volume | $mm^3$ | 39270 |
| Mass | g | 70.81 |
| Dry Mass | g | 48.84 |
| Density | $Mg/m^3$ | 1.803 |
| Dry Density | $Mg/m^3$ | 1.244 |
| Water Content | % | 44.98 |
| Degree of Saturation | % | 100.0 |
| Height of Solids | mm | 9.05 |
| Initial Void Ratio | | 1.211 |

**Final Specimen Conditions**

| | | |
|---|---|---|
| Water Content | % | 33.27 |
| Final Void Ratio | | 0.728 |

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# Stantec Consulting Ltd.

## One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Filename: V:\01216\active\laboratory_standing_offers\2018 Laboratory Standing Offers\122 Date: 7-Jul-18 | Checked by: D. Boateng Date: 7-Jul-18 | Approved by: R. Hache Date: 7-Jul-18

**Specimen Details**

| | |
|---|---|
| Project Name | Thurber Engineering, File# 20482 |
| Project Location | HWY 17, Ontario |
| Borehole | BH 18-101 |
| Sample No. | ST 9 |
| Depth | 35 - 37 ft. |
| Sample Date | June 11, 2018 |
| Test Number | Two |
| Technician Name | Daniel Boateng |

**Test Procedure**

| | | |
|---|---|---|
| Date Started | | June 22, 2018 |
| Date Finished | | July 3, 2018 |
| Machine Number | | Frame D |
| Cell Number | | D |
| Ring Number | | D |
| Trimming Procedure | | Turntable |
| Moisture Condition | | Inundated |
| Axial Stress at Inundation | kPa | 5 |
| Water Used | | Distilled |
| Test Method | | A |
| Interpretation Procedure for $c_v$ | | 2 |

**All Departures from Outlined ASTM D2435/D2435M-11 Procedure**

**Calculations**

| Load Increment | Increment Duration | Axial Stress $\sigma_a$ | Corrected Deformation $\Delta H$ | Specimen Height H | Axial Strain $\varepsilon_a$ | Void Ratio e |
|---|---|---|---|---|---|---|
| | min | kPa | mm | mm | % | |
| Seating | 0.0 | 5 | 0.0000 | 20.0000 | 0.00 | 1.211 |
| 1 | 720.0 | 5 | 0.1089 | 19.8911 | 0.54 | 1.199 |
| 2 | 720.0 | 10 | 0.2195 | 19.7805 | 1.10 | 1.187 |
| 3 | 720.0 | 20 | 0.3210 | 19.6790 | 1.61 | 1.176 |
| 4 | 720.0 | 40 | 0.4844 | 19.5156 | 2.42 | 1.158 |
| 5 | 720.0 | 20 | 0.4446 | 19.5554 | 2.22 | 1.162 |
| 6 | 720.0 | 5 | 0.3650 | 19.6350 | 1.83 | 1.171 |
| 7 | 720.0 | 20 | 0.4256 | 19.5744 | 2.13 | 1.164 |
| 8 | 720.0 | 40 | 0.4975 | 19.5025 | 2.49 | 1.156 |
| 9 | 1440.0 | 80 | 0.7250 | 19.2750 | 3.63 | 1.131 |
| 10 | 1440.0 | 120 | 0.9479 | 19.0521 | 4.74 | 1.106 |
| 11 | 1440.0 | 160 | 1.1869 | 18.8131 | 5.93 | 1.080 |
| 12 | 720.0 | 240 | 1.8311 | 18.1689 | 9.16 | 1.009 |
| 13 | 720.0 | 320 | 2.5549 | 17.4451 | 12.77 | 0.929 |
| 14 | 720.0 | 640 | 4.3293 | 15.6707 | 21.65 | 0.733 |
| 15 | 720.0 | 1280 | 5.5757 | 14.4243 | 27.88 | 0.595 |
| 16 | 720.0 | 320 | 5.4056 | 14.5944 | 27.03 | 0.614 |
| 17 | 720.0 | 80 | 5.1101 | 14.8899 | 25.55 | 0.646 |
| 18 | 720.0 | 20 | 4.7390 | 15.2610 | 23.70 | 0.687 |
| 19 | 720.0 | 5 | 4.3705 | 15.6295 | 21.85 | 0.728 |

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# Stantec Consulting Ltd.

## One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

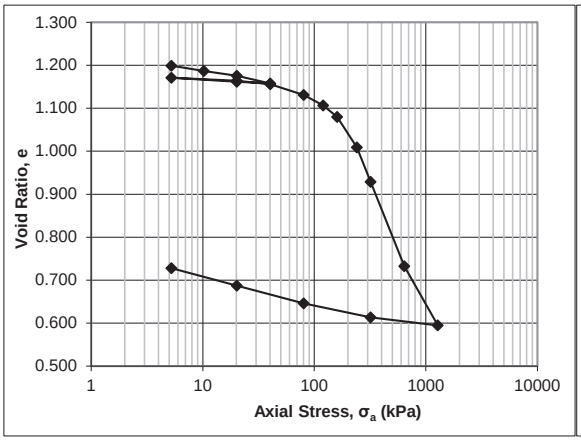
Filename: V:\01216\active\laboratory_standing_offers\2018 Laboratory Standing Offers\12: Date: 7-Jul-18
Checked by: D. Boateng Date: 7-Jul-18
Approved by: R. Hache Date:

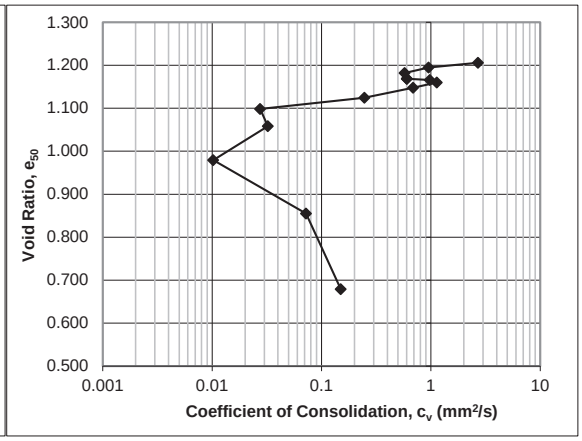
**Specimen Details**

| | |
|---|---|
| Project Name | Thurber Engineering, File# 20482 |
| Project Location | HWY 17, Ontario |
| Borehole | BH 18-101 |
| Sample No. | ST 9 |
| Depth | 35 - 37 ft. |
| Sample Date | June 11, 2018 |
| Test Number | Two |
| Technician Name | Daniel Boateng |

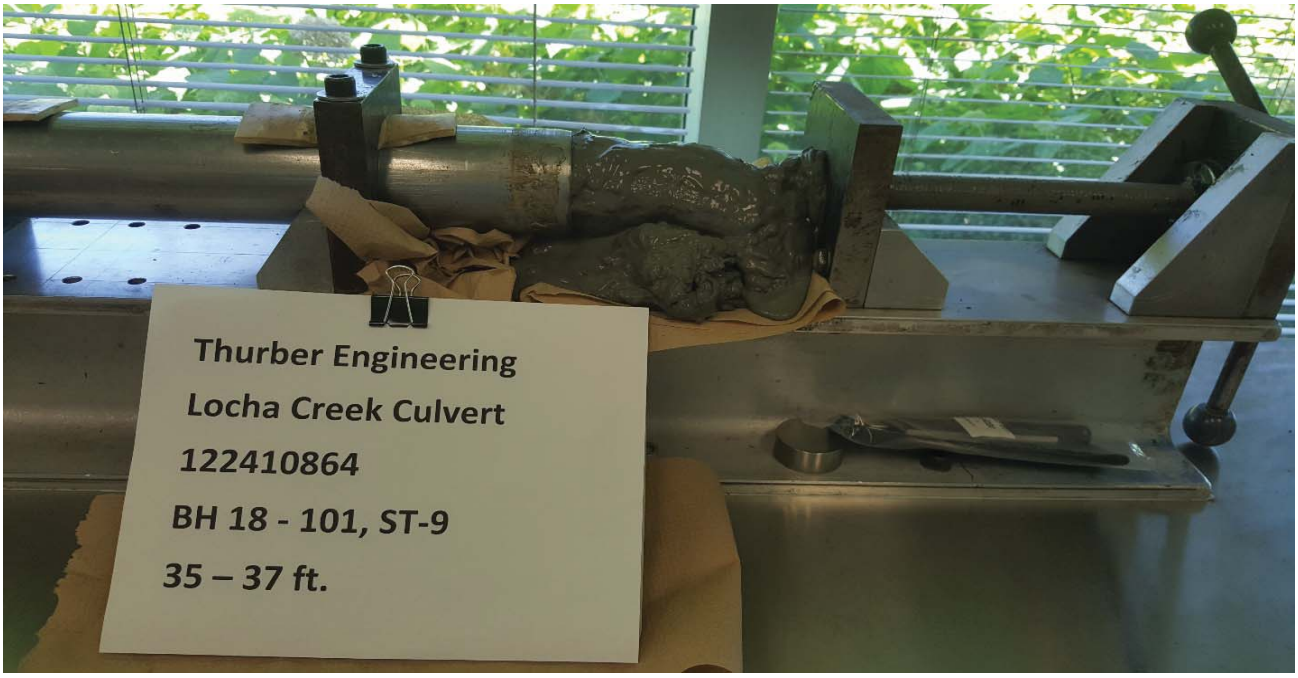
**Calculations**

| | | Calculated using Interpretation Procedure 2 | | | | Interpretation Procedure 1 | | Interpretation Procedure 2 | |
|---|---|---|---|---|---|---|---|---|---|
| Load Increment | Axial Stress $\sigma_{a,\ average}$ kPa | Corrected Deformation $\Delta H_{50}$ mm | Specimen Height $H_{50}$ mm | Axial Strain $\varepsilon_{a,50}$ % | Void Ratio $e_{50}$ | Time $t_{50}$ sec | Coeff. Consol. $c_v$ $mm^2/s$ | Time $t_{90}$ sec | Coeff. Consol. $c_v$ $mm^2/s$ |
| Seating | 3 | | | | | | | | |
| 1 | 5 | 0.0473 | 19.9527 | 0.24 | 1.206 | | | 31 | 2.70E+00 |
| 2 | 8 | 0.1455 | 19.8545 | 0.73 | 1.195 | | | 88 | 9.55E-01 |
| 3 | 15 | 0.2642 | 19.7358 | 1.32 | 1.182 | | | 143 | 5.76E-01 |
| 4 | 30 | 0.3842 | 19.6158 | 1.92 | 1.169 | | | 135 | 6.05E-01 |
| 5 | 30 | 0.4595 | 19.5405 | 2.30 | 1.160 | | | | |
| 6 | 13 | 0.3947 | 19.6053 | 1.97 | 1.168 | | | | |
| 7 | 13 | 0.4081 | 19.5919 | 2.04 | 1.166 | | | 83 | 9.77E-01 |
| 8 | 30 | 0.4614 | 19.5386 | 2.31 | 1.160 | | | 71 | 1.13E+00 |
| 9 | 60 | 0.5709 | 19.4291 | 2.85 | 1.148 | | | 116 | 6.90E-01 |
| 10 | 100 | 0.7809 | 19.2191 | 3.90 | 1.125 | | | 317 | 2.47E-01 |
| 11 | 140 | 1.0188 | 18.9812 | 5.09 | 1.099 | | | 2775 | 2.75E-02 |
| 12 | 200 | 1.3809 | 18.6191 | 6.90 | 1.058 | | | 2277 | 3.23E-02 |
| 13 | 280 | 2.0988 | 17.9012 | 10.49 | 0.979 | | | 6626 | 1.03E-02 |
| 14 | 480 | 3.2219 | 16.7781 | 16.11 | 0.855 | | | 825 | 7.23E-02 |
| 15 | 960 | 4.8114 | 15.1886 | 24.06 | 0.679 | | | 326 | 1.50E-01 |
| 16 | 800 | 5.4659 | 14.5341 | 27.33 | 0.607 | | | | |
| 17 | 200 | 5.2376 | 14.7624 | 26.19 | 0.632 | | | | |
| 18 | 50 | 4.9354 | 15.0646 | 24.68 | 0.665 | | | | |
| 19 | 13 | 4.5921 | 15.4079 | 22.96 | 0.703 | | | | |

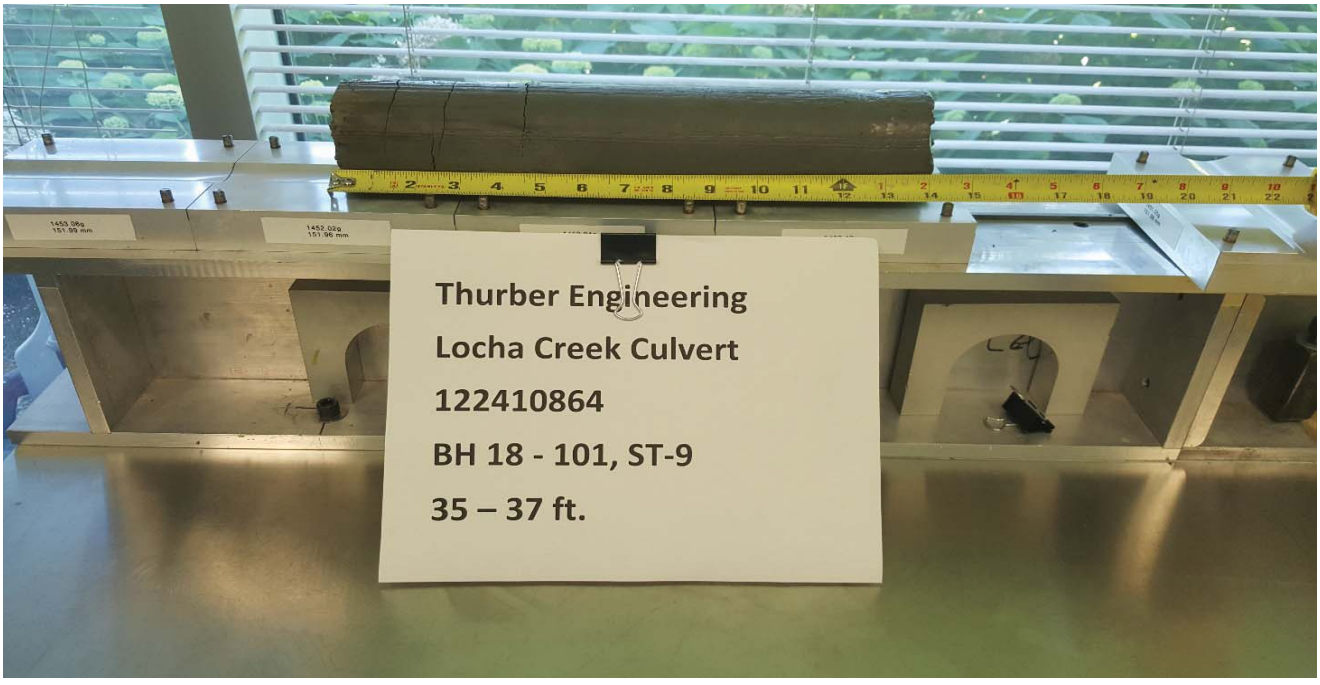


| Stantec | Project No.: 122410864 | Photo Log |
|---|---|---|
| | Project Name: Thurber Engineering, File# 20482 | |



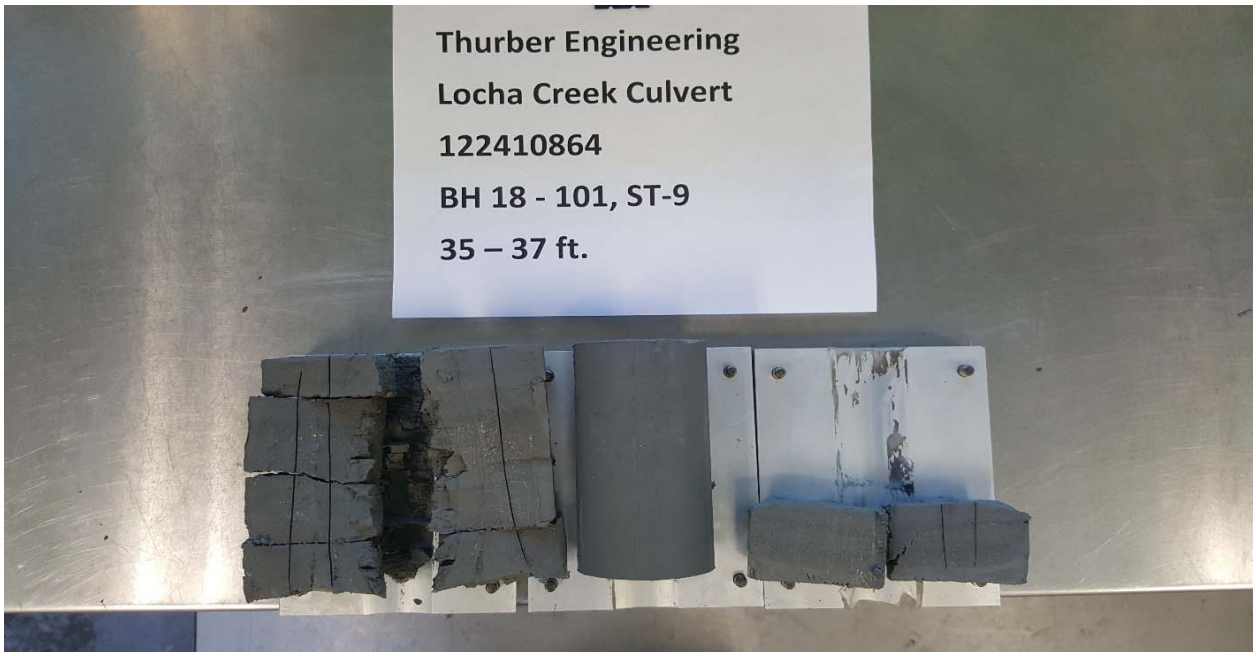

| Photo No.: 1 | Borehole: BH 18-101 ST 9 | Depth: 35 – 37 ft. |
|---|---|---|




| Photo No.: 2 | Borehole: BH 18-101 ST 9 | Depth: 35 – 37 ft. |
|---|---|---|

| Stantec | Project No.: 122410864 | Photo Log |
|---|---|---|
| | Project Name: Thurber Engineering, File# 20482 | |


| Photo No.: 3 | Borehole: BH 18-101 ST 9 | Depth: 35 – 37 ft. |
|---|---|---|




| Photo No.: 4 | Borehole: BH 18-101 ST 9 | Depth: 35 – 37 ft. |
|---|---|---|

**Stantec Consulting Ltd.**
400 - 1331 Clyde Avenue, Ottawa ON K2C 3G4

October 21, 2019
File: 122410864

**Attention: Justin Gray, P.Eng.**
Thurber Engineering Ltd.
104 – 2460 Lancaster Road
Ottawa, Ontario, Canada, K1B 4S5
Tel: 343-700-1316
E-mail: jgray@thurber.ca

Dear Mr. Gray,

**Reference: Consolidation Test Results for HWY 17, Anderson Road Project, Thurber Consulting Ltd., File #24726: BH AND19-2A, ST 2, sampled on September 30, 2019**

This letter presents the results of one-dimensional consolidation tests carried out on the above referenced sample in accordance with ASTM D2435/D2435M - 11. The test results are provided in the attached tables and figures.

This letter provides test results only and does not constitute any interpretation or engineering recommendations with respect to material suitability or specification compliance.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Regards,

**STANTEC CONSULTING LTD.**

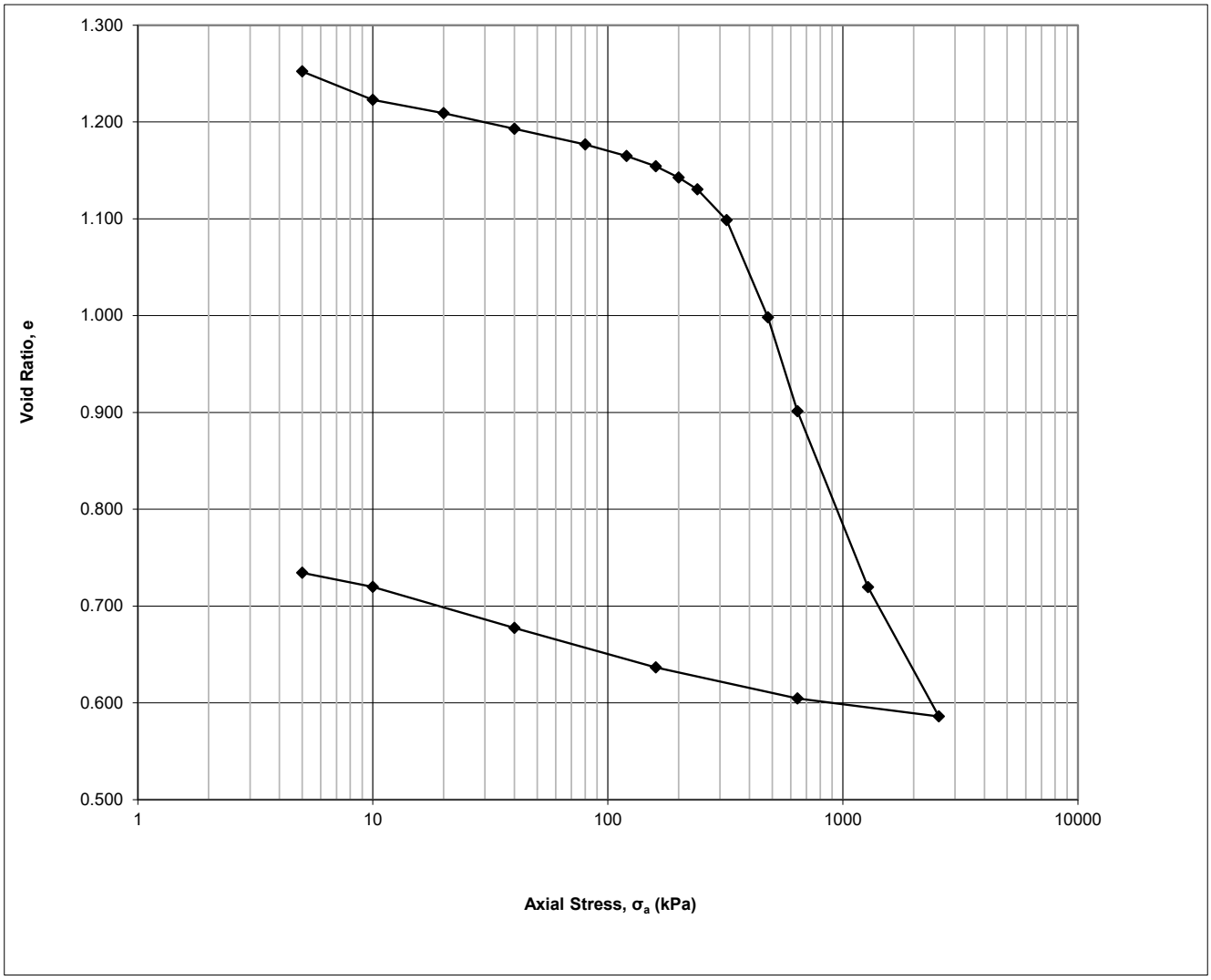
Bridgit Bocage, M.Eng., P.Eng.
Geotechnical Engineering
Phone: (613) 738-6045
Fax: (613) 722-2799
Bridgit.Bocage@stantec.com

Stantec

# One-Dimensional Consolidation Properties of Soils Using Incremental Loading

**ASTM D2435/D2435M - 11**

| | |
|---|---|
| **Project** | **Thurber Engineering, File# 24726** |
| **Project No.** | **122410864** |
| **Borehole No.** | **BH AND 19-2A** |
| **Sample No.** | **ST 2** |
| **Sample Depth** | **22½ - 24½ ft.** |



Filename: C:\Users\bbocage\Documents\[19-2A Anderson oc
Date: October 21, 2019

Checked by: D. Boateng
Date: October 21, 2019

Approved by: B. Bocage
Date:

# Stantec Consulting Ltd.

## One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

**Specimen Details**

| | |
|---|---|
| Project Name | Thurber Engineering, File# 24726 |
| Project Location | Anderson Road, Ottawa, ON |
| Borehole | BH AND 19-2A |
| Sample No. | ST 2 |
| Depth | 22½ - 24½ ft. |
| Sample Date | September 30, 2019 |
| Test Number | One |
| Technician Name | Daniel Boateng |

**Soil Description & Classification**

Clay and silt, dark grey, friable, moist - CI

| | | |
|---|---|---|
| Specific Gravity of Solids | | 2.747 |
| Liquid Limit | % | 31 |
| Plastic Limit | % | 21 |
| Plasticity Index | % | 10 |
| Average water content of trimmings | % | 47 |

**Additional Notes (information source, occurence and size of large isolated particles etc.)**

**Initial Specimen Conditions**

| | | |
|---|---|---|
| Height | mm | 20.00 |
| Diameter | mm | 50.00 |
| Area | $mm^2$ | 1963 |
| Volume | $mm^3$ | 39270 |
| Mass | g | 68.36 |
| Dry Mass | g | 46.39 |
| Density | $Mg/m^3$ | 1.741 |
| Dry Density | $Mg/m^3$ | 1.181 |
| Water Content | % | 47.36 |
| Degree of Saturation | % | 98.2 |
| Height of Solids | mm | 8.60 |
| Initial Void Ratio | | 1.325 |

**Final Specimen Conditions**

| | | |
|---|---|---|
| Water Content | % | 32.49 |
| Final Void Ratio | | 0.734 |
| Differential Height | mm | 14.92 |

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# Stantec Consulting Ltd.

Filename: C:\Users\bbocage\Documents\[19-2A Anderson consol report.xlsx]Report
Date: October 21, 2019
Checked by: D. Boateng Date: October 21, 2019
Approved by: B. Bocage Date: October 21, 2019

## One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

**Specimen Details**

| | |
|---|---|
| Project Name | Thurber Engineering, File# 24726 |
| Project Location | Anderson Road, Ottawa, ON |
| Borehole | BH AND 19-2A |
| Sample No. | ST 2 |
| Depth | 22½ - 24½ ft. |
| Sample Date | September 30, 2019 |
| Test Number | One |
| Technician Name | Daniel Boateng |

**Test Procedure**

| | | |
|---|---|---|
| Date Started | | October 7, 2019 |
| Date Finished | | October 9, 2019 |
| Machine Number | | Frame C |
| Cell Number | | C |
| Ring Number | | C |
| Trimming Procedure | | Turntable/Cutting ring |
| Moisture Condition | | Inundated |
| Axial Stress at Inundation | kPa | 5 |
| Water Used | | Deaired tap water |
| Test Method | | B |
| Interpretation Procedure for $c_v$ | | 2 |

**All Departures from Outlined ASTM D2435/D2435M-11 Procedure**

**Calculations**

| Load Increment | Increment Duration | Axial Stress $\sigma_a$ | Corrected Deformation $\Delta H$ | Specimen Height H | Axial Strain $\varepsilon_a$ | Void Ratio e |
|---|---|---|---|---|---|---|
| | min | kPa | mm | mm | % | |
| Seating | 0.0 | 0 | 0.0000 | 20.0000 | 0.00 | 1.325 |
| 1 | 25.1 | 5 | 0.6905 | 19.3095 | 3.15 | 1.252 |
| 2 | 25.1 | 10 | 0.8738 | 19.1262 | 4.40 | 1.223 |
| 3 | 25.1 | 20 | 0.9947 | 19.0053 | 5.00 | 1.209 |
| 4 | 25.1 | 40 | 1.1292 | 18.8708 | 5.69 | 1.193 |
| 5 | 25.1 | 80 | 1.2611 | 18.7389 | 6.39 | 1.177 |
| 6 | 29.9 | 120 | 1.3581 | 18.6419 | 6.90 | 1.165 |
| 7 | 31.6 | 160 | 1.4472 | 18.5528 | 7.36 | 1.154 |
| 8 | 43.2 | 200 | 1.5328 | 18.4672 | 7.86 | 1.143 |
| 9 | 44.9 | 240 | 1.6463 | 18.3537 | 8.38 | 1.131 |
| 10 | 71.4 | 320 | 1.8369 | 18.1631 | 9.75 | 1.099 |
| 11 | 177.4 | 480 | 2.3463 | 17.6537 | 14.06 | 0.998 |
| 12 | 194.0 | 640 | 3.3727 | 16.6273 | 18.24 | 0.901 |
| 13 | 131.0 | 1280 | 4.8847 | 15.1153 | 26.05 | 0.720 |
| 14 | 87.9 | 2560 | 6.1275 | 13.8725 | 31.80 | 0.586 |
| 15 | 25.1 | 640 | 6.1975 | 13.8025 | 31.00 | 0.605 |
| 16 | 34.9 | 160 | 5.9154 | 14.0846 | 29.61 | 0.637 |
| 17 | 69.7 | 40 | 5.5760 | 14.4240 | 27.86 | 0.678 |
| 18 | 114.4 | 10 | 5.2123 | 14.7877 | 26.04 | 0.720 |
| 19 | 74.7 | 5 | 5.2016 | 14.7984 | 25.41 | 0.734 |

Stantec

# Stantec Consulting Ltd.

Filename: C:\Users\bbocage\Documents\[19-2A Anderson consol report.xlsx]Report
Date: October 21, 2019
Checked by: D. Boateng Date: October 21, 2019
Approved by: B. Bocage Date: October 21, 2019

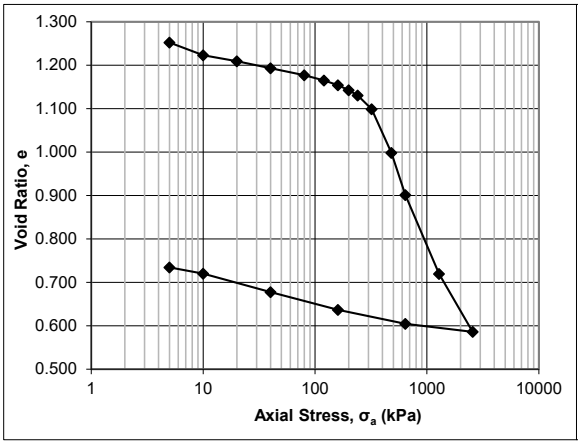
## One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

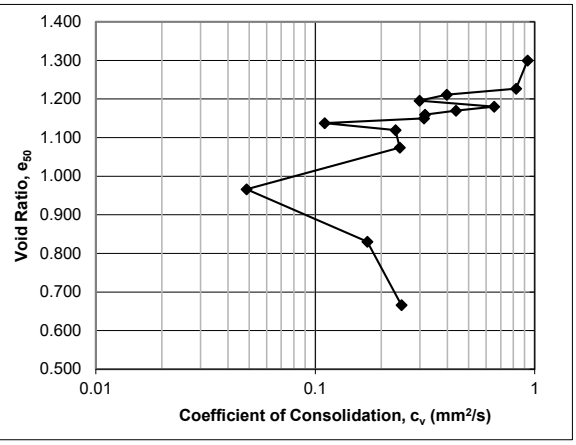
**Specimen Details**

| | |
|---|---|
| Job Ref. | Thurber Engineering, File# 24726 |
| Job Location | Anderson Road, Ottawa, ON |
| Borehole | BH AND 19-2A |
| Sample No. | ST 2 |
| Depth | 22½ - 24½ ft. |
| Sample Date | September 30, 2019 |
| Test Number | One |
| Technician Name | Daniel Boateng |

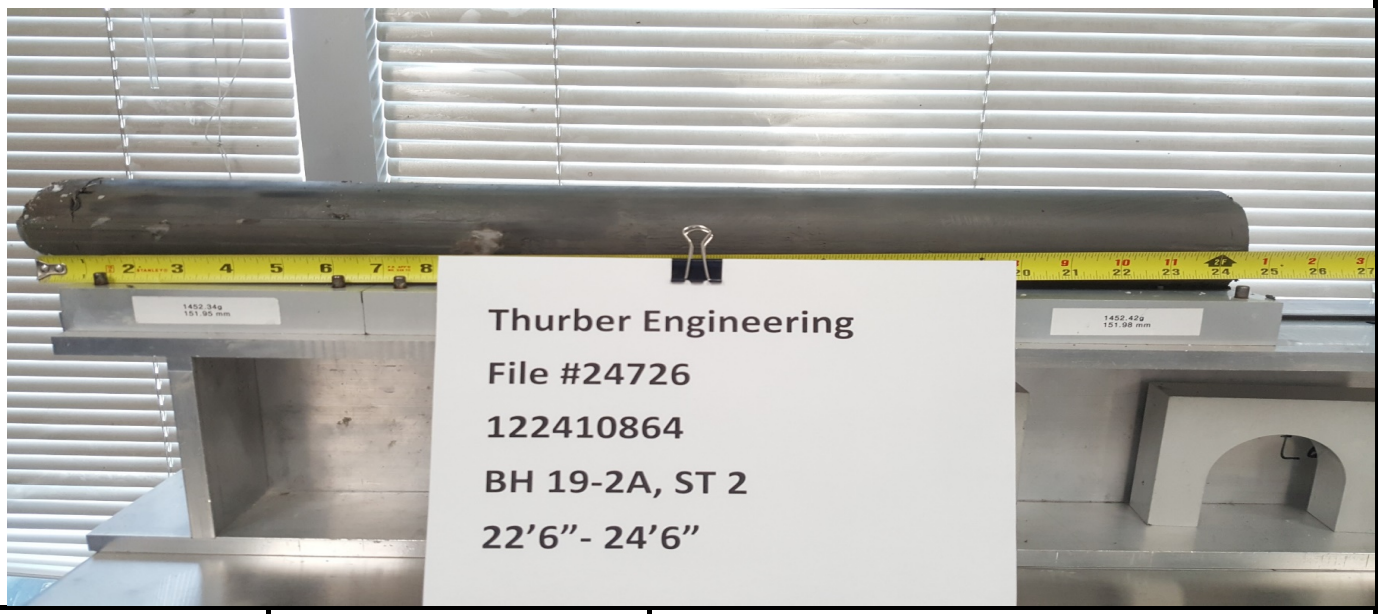
**Calculations**

| | | Calculated using Interpretation Procedure 2 | | | | Interpretation Procedure 1 | | Interpretation Procedure 2 | |
|---|---|---|---|---|---|---|---|---|---|
| Load Increment | Axial Stress $\sigma_{a,\ average}$ kPa | Corrected Deformation $\Delta H_{50}$ mm | Specimen Height $H_{50}$ mm | Axial Strain $\varepsilon_{a,50}$ % | Void Ratio $e_{50}$ | Time $t_{50}$ sec | Coeff. Consol. $c_v$ $mm^2/s$ | Time $t_{90}$ sec | Coeff. Consol. $c_v$ $mm^2/s$ |
| Seating | 0 | | | | | | | | |
| 1 | 3 | 0.2228 | 19.7772 | 1.11 | 1.299 | | | 89 | 9.28E-01 |
| 2 | 8 | 0.8503 | 19.1497 | 4.25 | 1.227 | | | 95 | 8.22E-01 |
| 3 | 15 | 0.9841 | 19.0159 | 4.92 | 1.211 | | | 193 | 3.97E-01 |
| 4 | 30 | 1.1178 | 18.8822 | 5.59 | 1.195 | | | 253 | 2.99E-01 |
| 5 | 60 | 1.2466 | 18.7534 | 6.23 | 1.180 | | | 114 | 6.53E-01 |
| 6 | 100 | 1.3394 | 18.6606 | 6.70 | 1.170 | | | 169 | 4.38E-01 |
| 7 | 140 | 1.4268 | 18.5732 | 7.13 | 1.159 | | | 231 | 3.16E-01 |
| 8 | 180 | 1.5107 | 18.4893 | 7.55 | 1.150 | | | 231 | 3.13E-01 |
| 9 | 220 | 1.6164 | 18.3836 | 8.08 | 1.137 | | | 649 | 1.10E-01 |
| 10 | 280 | 1.7726 | 18.2274 | 8.86 | 1.119 | | | 304 | 2.32E-01 |
| 11 | 400 | 2.1592 | 17.8408 | 10.80 | 1.074 | | | 278 | 2.43E-01 |
| 12 | 560 | 3.0898 | 16.9102 | 15.45 | 0.966 | | | 1246 | 4.86E-02 |
| 13 | 960 | 4.2588 | 15.7412 | 21.29 | 0.830 | | | 305 | 1.72E-01 |
| 14 | 1920 | 5.6727 | 14.3273 | 28.36 | 0.666 | | | 176 | 2.47E-01 |
| 15 | 1600 | 6.2322 | 13.7678 | 31.16 | 0.601 | | | | |
| 16 | 400 | 6.0346 | 13.9654 | 30.17 | 0.624 | | | | |
| 17 | 100 | 5.7471 | 14.2529 | 28.74 | 0.657 | | | | |
| 18 | 25 | 5.3902 | 14.6098 | 26.95 | 0.699 | | | | |
| 19 | 8 | 5.2040 | 14.7960 | 26.02 | 0.720 | | | | |



| Stantec | Project No.: 122410864<br>Project Name: Thurber Engineering, File# 24726 | Photo Log |
|---|---|---|




| Photo No.: 1 | Borehole: BH AND19-2A ST-2 | Depth: 22½ – 24½ ft |
|---|---|---|


| Photo No.: 2 | Borehole: BH AND19-2A ST-2 | Depth: 22½ – 24½ ft |
|---|---|---|

| Stantec | Project No.: 122410864<br>Project Name: Thurber Engineering, File# 24726 | Photo Log |
|---|---|---|


| Photo No.: 3 | Borehole: BH AND19-2A ST-2 | Depth: 22½ – 24½ ft |
|---|---|---|


| Photo No.: 4 | Borehole: BH AND19-2A ST-2 | Depth: 22½ – 24½ ft |
|---|---|---|

# Appendix C.2

# Analytical Testing Results

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# Certificate of Analysis

**Thurber Engineering Ltd.**

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B 4S5
Attn: Justin Gray

Client PO: 24726 Task 200a.201
Project: Anderson Rd. Culvert
Custody: 40231

Report Date: 16-Aug-2019
Order Date: 8-Aug-2019

**Order #: 1932412**

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

| Paracel ID | Client ID |
|---|---|
| 1932412-01 | And19-2,SS5 (12'6"-14'6") |

Approved By: Mark Foto

Mark Foto, M.Sc.
Lab Supervisor

Certificate of Analysis
**Client: Thurber Engineering Ltd.**
**Client PO: 24726 Task 200a.201**

Report Date: 16-Aug-2019
Order Date: 8-Aug-2019
**Project Description: Anderson Rd. Culvert**

## Analysis Summary Table

| Analysis | Method Reference/Description | Extraction Date | Analysis Date |
|---|---|---|---|
| Anions | EPA 300.1 - IC, water extraction | 13-Aug-19 | 14-Aug-19 |
| Conductivity | MOE E3138 - probe @25 °C, water ext | 14-Aug-19 | 14-Aug-19 |
| pH, soil | EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext. | 13-Aug-19 | 14-Aug-19 |
| Resistivity | EPA 120.1 - probe, water extraction | 14-Aug-19 | 14-Aug-19 |
| Solids, % | Gravimetric, calculation | 13-Aug-19 | 13-Aug-19 |

Certificate of Analysis

**Client: Thurber Engineering Ltd.**

**Client PO: 24726 Task 200a.201**

Report Date: 16-Aug-2019

Order Date: 8-Aug-2019

**Project Description: Anderson Rd. Culvert**

| | | | | | |
|---|---|---|---|---|---|
| | **Client ID:** | And19-2,SS5 (12'6"-14'6") | - | - | - |
| | **Sample Date:** | 01-Aug-19 12:00 | - | - | - |
| | **Sample ID:** | 1932412-01 | - | - | - |
| | **MDL/Units** | Soil | - | - | - |
| **Physical Characteristics** | | | | | |
| % Solids | 0.1 % by Wt. | 78.6 | - | - | - |
| **General Inorganics** | | | | | |
| Conductivity | 5 uS/cm | 576 | - | - | - |
| pH | 0.05 pH Units | 7.57 | - | - | - |
| Resistivity | 0.10 Ohm.m | 17.4 | - | - | - |
| **Anions** | | | | | |
| Chloride | 5 ug/g dry | 227 | - | - | - |
| Sulphate | 5 ug/g dry | 116 | - | - | - |

Certificate of Analysis
**Client: Thurber Engineering Ltd.**
**Client PO: 24726 Task 200a.201**

Report Date: 16-Aug-2019
Order Date: 8-Aug-2019
**Project Description: Anderson Rd. Culvert**

## *Method Quality Control: Blank*

| Analyte | Result | Reporting Limit | Units | Source Result | %REC | %REC Limit | RPD | RPD Limit | Notes |
|---|---|---|---|---|---|---|---|---|---|
| **Anions** | | | | | | | | | |
| Chloride | ND | 5 | ug/g | | | | | | |
| Sulphate | ND | 5 | ug/g | | | | | | |
| **General Inorganics** | | | | | | | | | |
| Conductivity | ND | 5 | uS/cm | | | | | | |
| Resistivity | ND | 0.10 | Ohm.m | | | | | | |

## *Method Quality Control: Duplicate*

| Analyte | Result | Reporting Limit | Units | Source Result | %REC | %REC Limit | RPD | RPD Limit | Notes |
|---|---|---|---|---|---|---|---|---|---|
| **Anions** | | | | | | | | | |
| Chloride | 219 | 5 | ug/g dry | 227 | | | 3.5 | 20 | |
| Sulphate | 116 | 5 | ug/g dry | 116 | | | 0.3 | 20 | |
| **General Inorganics** | | | | | | | | | |
| Conductivity | 1900 | 5 | uS/cm | 1940 | | | 2.2 | 5 | |
| pH | 10.49 | 0.05 | pH Units | 10.51 | | | 0.2 | 2.3 | |
| Resistivity | 5.27 | 0.10 | Ohm.m | 5.15 | | | 2.2 | 20 | |
| **Physical Characteristics** | | | | | | | | | |
| % Solids | 94.0 | 0.1 | % by Wt. | 93.7 | | | 0.2 | 25 | |

## *Method Quality Control: Spike*

| Analyte | Result | Reporting Limit | Units | Source Result | %REC | %REC Limit | RPD | RPD Limit | Notes |
|---|---|---|---|---|---|---|---|---|---|
| **Anions** | | | | | | | | | |
| Chloride | 320 | 5 | ug/g | 227 | 93.0 | 82-118 | | | |
| Sulphate | 219 | 5 | ug/g | 116 | 103 | 80-120 | | | |

## Qualifier Notes:

***Login Qualifiers :***

Received at temperature > 25C
*Applies to samples: And19-2,SS5 (12'6''-14'6'')*

## Sample Data Revisions

None

## Work Order Revisions / Comments:

None

## Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

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# Subcontracted Analysis

**Thurber Engineering Ltd.**
2460 Lancaster Rd, Suite 104
Ottawa, ON K1B 4S5
Attn: Justin Gray

Tel: (613) 408-6795
Fax: (613) 247-2185

| | |
|---|---|
| Paracel Report No | **1932412** |
| Client Project(s): | **Anderson Rd. Culvert** |
| Client PO: | **24726 Task 200a.201** |
| Reference: | **Standing Offer** |
| CoC Number: | **40231** |

| | |
|---|---|
| Order Date: | 08-Aug-19 |
| Report Date: | 16-Aug-19 |

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

| Paracel ID | Client ID | Analysis |
|---|---|---|
| 1932412-01 | And19-2,SS5 (12'6"-14'6") | Sulphide, solid |

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

19-August-2019

**Paracel Laboratories**
Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6, Canada

Phone: 613-731-9577
Fax:613-731-9064

**Date Rec. :** 13 August 2019
**LR Report:** **CA12524-AUG19**
**Reference:** Project#: 1932412

**Copy:** #1

# CERTIFICATE OF ANALYSIS
## Final Report

| Sample ID | Sample Date & Time | Sulphide % |
|---|---|---|
| 1: Analysis Start Date | | 16-Aug-19 |
| 2: Analysis Start Time | | 14:26 |
| 3: Analysis Completed Date | | 16-Aug-19 |
| 4: Analysis Completed Time | | 15:50 |
| 5: QC - Blank | | < 0.02 |
| 6: QC - STD % Recovery | | 110% |
| 7: QC - DUP % RPD | | ND |
| 8: RL | | 0.02 |
| 9: AND19-2, SS5 (12'6"-14'6") | 01-Aug-19 12:00 | 0.20 |

RL - SGS Reporting Limit

*Carrie Greenlaw*
*Project Specialist,*
*Environment, Health & Safety*

OnLine LIMS

0001861250

# Appendix C.3

# Bedrock Core Photographs

# Borehole AND19-1D

## Run 1 to 3 (of 3)

## Elevation 115.7 m to 111.7 m


THURBER ENGINEERING LTD.

**Geotechnical Investigation**
**HWY 17 Twinning (Anderson Road)**
**Renfrew, Ontario**

**WP: 4068-09-00**

**Project No.: 24726**

# Borehole AND19-2

## Run 1 to 3 (of 3)

## Elevation 109.9 m to 106.1 m


THURBER ENGINEERING LTD.

**Geotechnical Investigation**
**HWY 17 Twinning (Anderson Road)**
**Renfrew, Ontario**

**WP: 4068-09-00**

**Project No.: 24726**

# Borehole 18-103

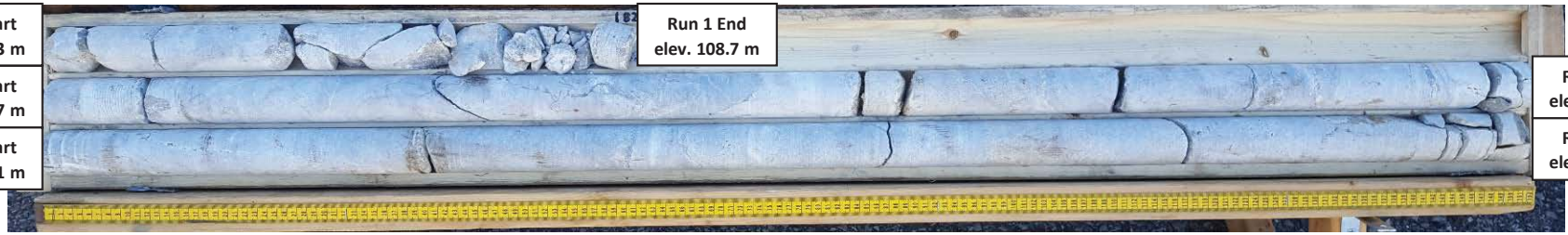
## Run 1 to 3 (of 3)

## Elevation 109.3 m to 105.5 m

Run 1 Start elev. 109.3 m

Run 2 Start elev. 108.7 m

Run 3 Start elev. 107.1 m



Run 1 End elev. 108.7 m

Run 2 End elev. 107.1 m

Run 3 End elev. 105.5 m

THURBER ENGINEERING LTD.

**Geotechnical Investigation**
**HWY 17 Twinning (Anderson Road)**
**Renfrew, Ontario**

**WP: 4068-09-00**

**Project No.: 24726**

# Appendix D.

# Site Photographs

**Photo 1. Looking North towards culvert inlet (2019/09/20)**

**Photo 2. Looking South towards AND19-1, AND19-1B, AND19-1C and AND19-1D (2019/09/20)**

**Photo 3. Looking South-east towards AND19-3 and culvert outlet (2019/08/08)**

**Photo 4. Looking East along existing roadway towards high fill area (2019/06/24)**

**Photo 5. Google Earth imagery showing the location of the Anderson Road Culvert. The construction for the replacement of the Highway 17 Locha Creek Culvert is visible to the north.**
**(Imagery Date 2019/10/10)**

# Appendix E.

# Foundation Comparison

## COMPARISON OF CULVERT ALTERNATIVES

| | Circular Pipes | Open Footing Culvert | Closed-Bottom Box Culvert | Open Box Culvert<br>Deep Foundation |
|---|---|---|---|---|
| **Advantages** | • Readily available materials and simple installation methods | • More flexibility for installation of temporary flow passage system<br>• Satisfies fisheries requirements | • Limits disturbance to streambed.<br>• Relatively expedient installation if precast units are used | • Less prone to effects of scour and erosion<br>• Similar culvert/construction to the new culvert under the twinned Highway 17 lanes<br>• Satisfies fisheries requirements |
| **Disadvantages** | • Numerous parallel pipes required to provide hydraulic opening equivalent to existing culvert<br>• May not be suitable from an ecological standpoint | • Founding elevation is deeper than with closed box, requiring deeper excavation<br>• Existing clay subgrade is not suitable for the use of open footed culverted supported on shallow foundations | • May not be suitable from an ecological standpoint | • Settlement will induce Downdrag loads on piles |
| **Risks/ Constructability** | • Potential for base disturbance if groundwater not controlled / added cost and schedule delays | • Potential for base disturbance if groundwater not controlled / added cost and schedule delays<br>• Potential for damage due to settlement | • Potential for damage due to settlement | • Potential for base disturbance if groundwater not controlled / added cost and schedule delays<br>• Piles may hit refusal in the glacial deposit / reduced bearing resistance |
| **Relative Cost** | Moderate | Moderate | Moderate | High |
| **Recommendation** | **NOT RECOMMENDED** | **NOT FEASIBLE** | **NOT RECOMMENDED** | **RECOMMENDED** |

# Appendix F.

## GSC Seismic Hazard Calculation
## Slope Stability Analysis Results

# 2015 National Building Code Seismic Hazard Calculation

**INFORMATION:** Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

**Site:** 45.444N 76.535W **User File Reference:** Anderson Road Culvert 2019-11-19 21:52 UT

| Probability of exceedance per annum | 0.000404 | 0.001 | 0.0021 | 0.01 |
|---|---|---|---|---|
| Probability of exceedance in 50 years | 2 % | 5 % | 10 % | 40 % |
| Sa (0.05) | 0.356 | 0.184 | 0.106 | 0.032 |
| Sa (0.1) | 0.423 | 0.229 | 0.139 | 0.046 |
| Sa (0.2) | 0.354 | 0.199 | 0.124 | 0.044 |
| Sa (0.3) | 0.270 | 0.155 | 0.099 | 0.036 |
| Sa (0.5) | 0.193 | 0.113 | 0.073 | 0.026 |
| Sa (1.0) | 0.099 | 0.059 | 0.038 | 0.013 |
| Sa (2.0) | 0.048 | 0.028 | 0.018 | 0.005 |
| Sa (5.0) | 0.013 | 0.007 | 0.004 | 0.001 |
| Sa (10.0) | 0.005 | 0.003 | 0.002 | 0.001 |
| PGA (g) | 0.227 | 0.126 | 0.076 | 0.025 |
| PGV (m/s) | 0.161 | 0.091 | 0.056 | 0.018 |

**Notes:** Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 $m/s^2$). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

## References

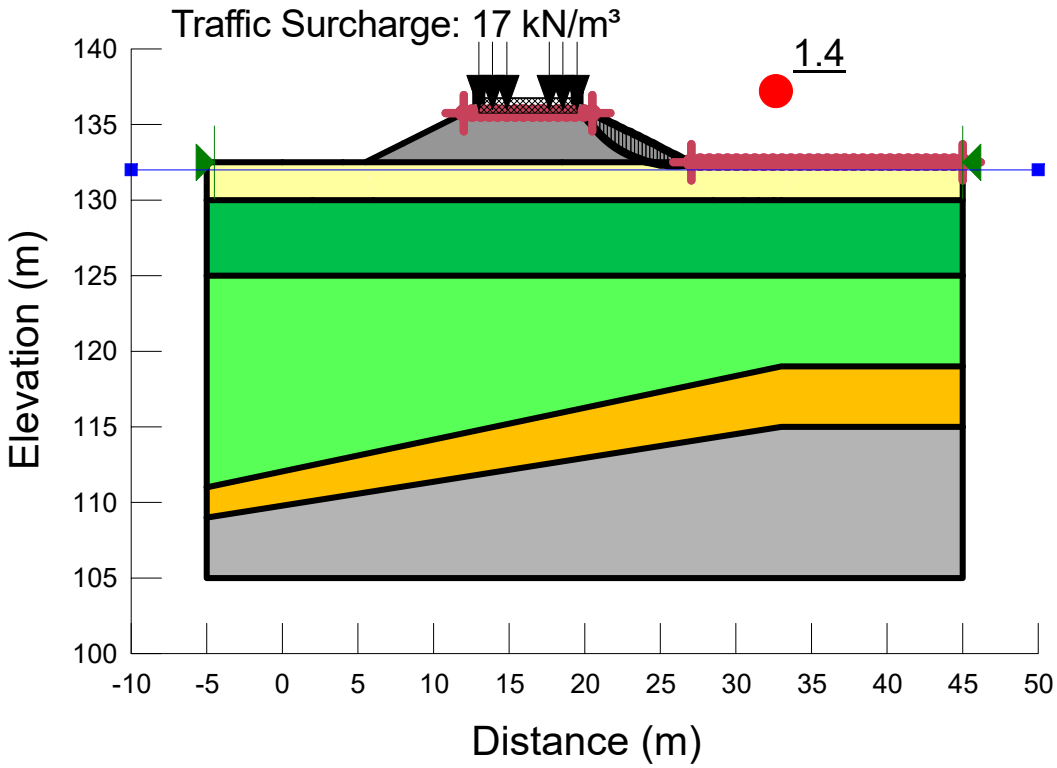
**National Building Code of Canada 2015 NRCC no. 56190;** Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

**Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)**
**Commentary J**: Design for Seismic Effects

**Geological Survey of Canada Open File 7893** Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information

| Color | Name | Model | Unit Weight (kN/m³) | C-Top of Layer (kPa) | C-Rate of Change ((kN/m²)/m) | C-Maximum (kPa) | Cohesion' (kPa) | Phi' (°) |
|---|---|---|---|---|---|---|---|---|
| | 1 Embankment Fill | Mohr-Coulomb | 21 | | | | 0 | 30 |
| | 2 Silty Sand | Mohr-Coulomb | 18 | | | | 0 | 28 |
| | 3 Upper Clay (TSA) | S=f(depth) | 17.1 | 80 | -8 | 40 | | |
| | 4 Lower Clay (TSA) | S=f(depth) | 17.6 | 40 | 1.18 | 60 | | |
| | 5 Till | Mohr-Coulomb | 21 | | | | 0 | 35 |
| | 6 Bedrock | Bedrock (Impenetrable) | | | | | | |




THURBER

Project
Anderson Road Extension

Analysis
1. Short Term (TSA) - Static

Seismic Coefficient
H: 0g, V: 0g

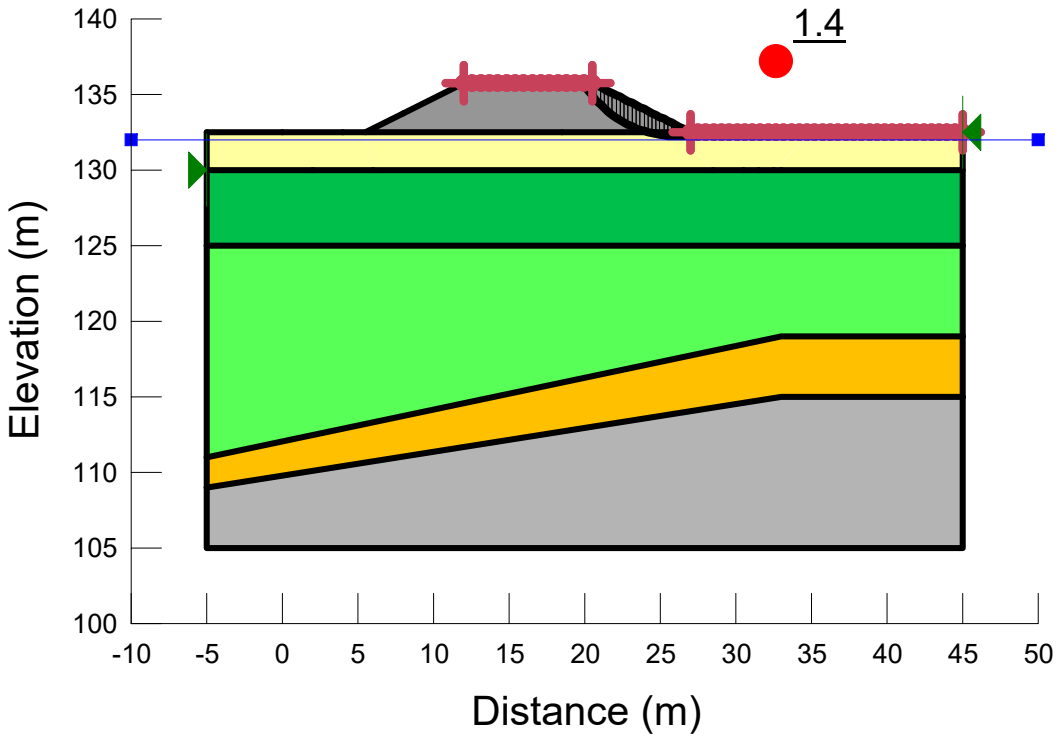
Last Run
07/26/2021, 05:07:47 PM

Scale
1:500

Additional Details
Name: Default Geometry
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (19.933333, 135.75) m, Exit: (27.654574, 132.5) m
Center: (25.971254, 139.29776) m, Radius: 7.0030762 m

**Figure 1.1**

| Color | Name | Model | Unit Weight (kN/m³) | Cohesion' (kPa) | Phi' (°) |
|---|---|---|---|---|---|
| | 1 Embankment Fill | Mohr-Coulomb | 21 | 0 | 30 |
| | 2 Silty Sand | Mohr-Coulomb | 18 | 0 | 28 |
| | 3 Upper Clay (ESA) | Mohr-Coulomb | 17.1 | 0 | 28 |
| | 4 Lower Clay (ESA) | Mohr-Coulomb | 17.6 | 0 | 28 |
| | 5 Till | Mohr-Coulomb | 21 | 0 | 35 |
| | 6 Bedrock | Bedrock (Impenetrable) | | | |




THURBER

Project
Anderson Road Extension

Analysis
2. Long Term (ESA) - Static

Seismic Coefficient
H: 0g, V: 0g

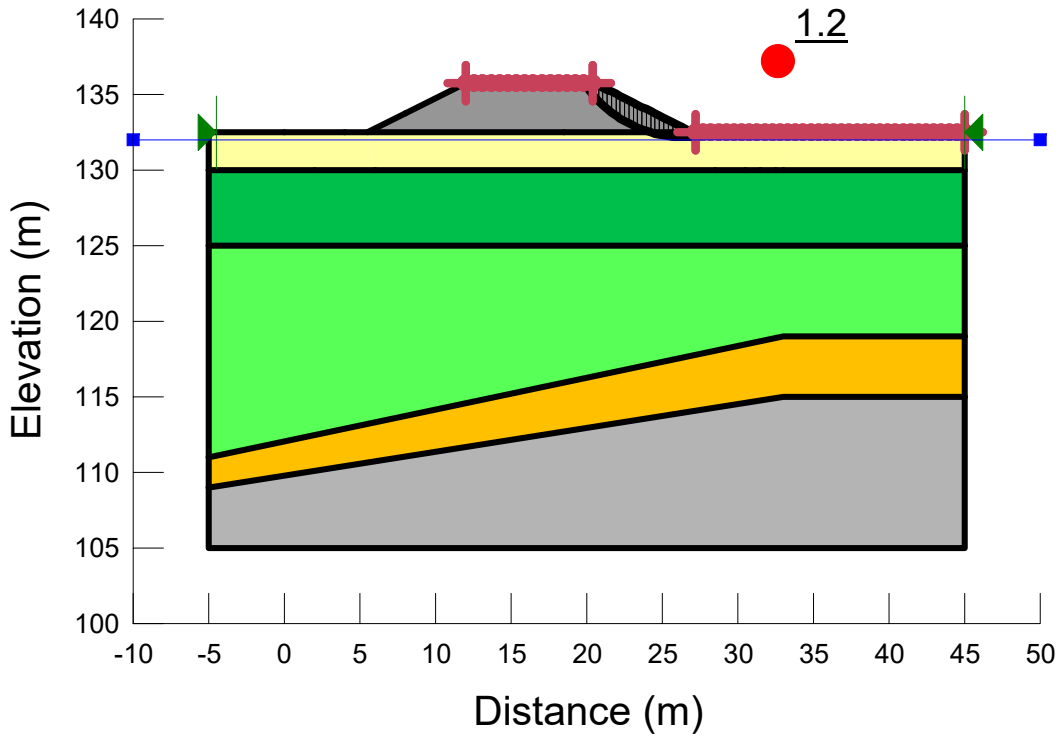
Last Run
07/26/2021, 05:07:54 PM

Scale
1:500

Additional Details
Name: Default Geometry
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (19.933333, 135.75) m, Exit: (28.020245, 132.5) m
Center: (26.106604, 139.42458) m, Radius: 7.1841351 m

**Figure 1.2**

| Color | Name | Model | Unit Weight (kN/m³) | C-Top of Layer (kPa) | C-Rate of Change ((kN/m²)/m) | C-Maximum (kPa) | Cohesion' (kPa) | Phi' (°) |
|---|---|---|---|---|---|---|---|---|
| | 1 Embankment Fill | Mohr-Coulomb | 21 | | | | 0 | 30 |
| | 2 Silty Sand | Mohr-Coulomb | 18 | | | | 0 | 28 |
| | 3 Upper Clay (TSA) | S=f(depth) | 17.1 | 80 | -8 | 40 | | |
| | 4 Lower Clay (TSA) | S=f(depth) | 17.6 | 40 | 1.18 | 60 | | |
| | 5 Till | Mohr-Coulomb | 21 | | | | 0 | 35 |
| | 6 Bedrock | Bedrock (Impenetrable) | | | | | | |




THURBER

Project
Anderson Road Extension

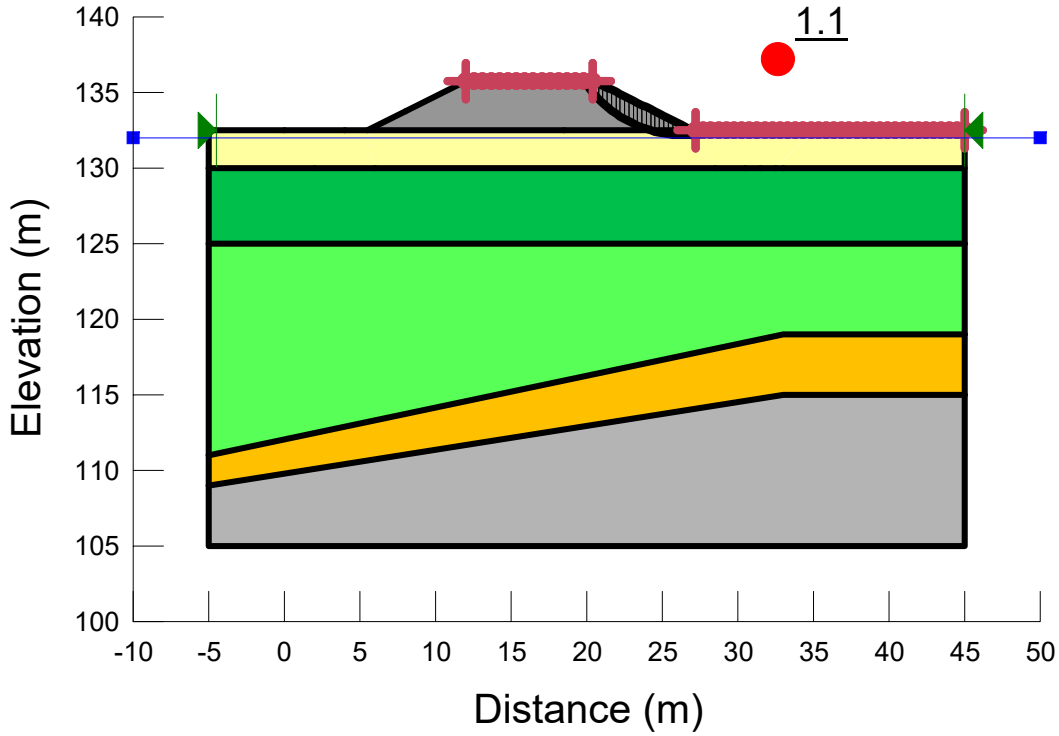
Analysis
3. (TSA) - Seismic - Pseudo Static - 475

| Seismic Coefficient | Last Run | Scale |
|---|---|---|
| H: 0.049g, V: 0g | 07/26/2021, 05:08:02 PM | 1:500 |

Additional Details
Name: Default Geometry
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (19.82077, 135.75) m, Exit: (28.725714, 132.5) m
Center: (26.477283, 140.16404) m, Radius: 7.9870452 m

**Figure 1.3**

| Color | Name | Model | Unit Weight (kN/m³) | C-Top of Layer (kPa) | C-Rate of Change ((kN/m²)/m) | C-Maximum (kPa) | Cohesion' (kPa) | Phi' (°) |
|---|---|---|---|---|---|---|---|---|
| | 1 Embankment Fill | Mohr-Coulomb | 21 | | | | 0 | 30 |
| | 2 Silty Sand | Mohr-Coulomb | 18 | | | | 0 | 28 |
| | 3 Upper Clay (TSA) | S=f(depth) | 17.1 | 80 | -8 | 40 | | |
| | 4 Lower Clay (TSA) | S=f(depth) | 17.6 | 40 | 1.18 | 60 | | |
| | 5 Till | Mohr-Coulomb | 21 | | | | 0 | 35 |
| | 6 Bedrock | Bedrock (Impenetrable) | | | | | | |




THURBER

Project
Anderson Road Extension

Analysis
4. (TSA) - Seismic - Pseudo Static - 2475

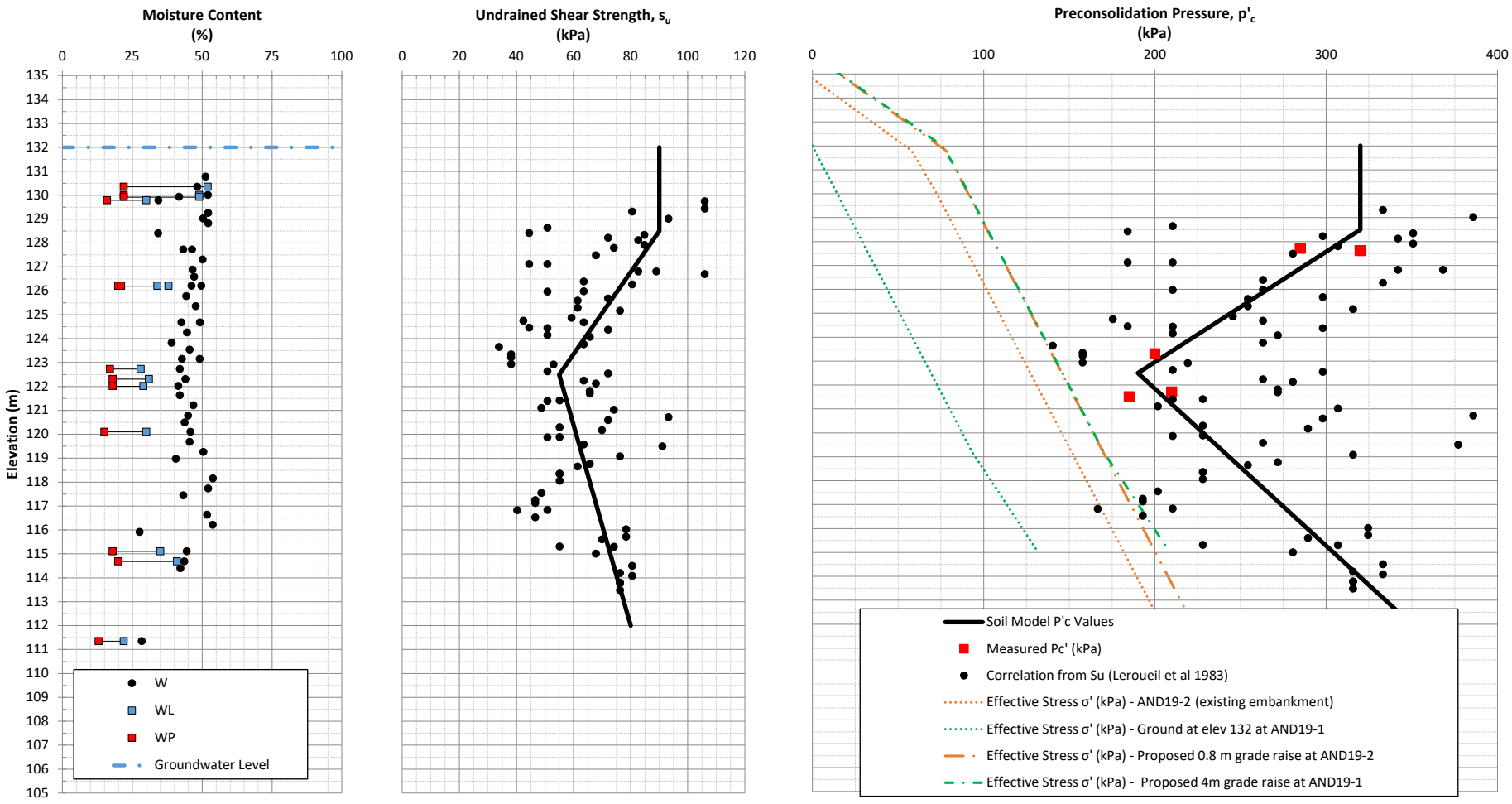
| Seismic Coefficient | Last Run | Scale |
|---|---|---|
| H: 0.129g, V: 0g | 07/26/2021, 05:08:09 PM | 1:500 |

Additional Details
Name: Default Geometry
Comments:
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (19.82077, 135.75) m, Exit: (28.725714, 132.5) m
Center: (26.477283, 140.16404) m, Radius: 7.9870452 m

**Figure 1.4**

**Appendix G.**

**Clay Property Summary Figures**
**Pile Analysis P-Y Data Output**




THURBER

# Clay Properties

Locha Creek Culvert Replacement
Anderson Road Extension
Renfrew County

**W.P. 4068-09-00**
**Project No.: 24726**

THURBER

# TABLE 1 (310x110)
## LPILE Results for P-Y Curves
## Anderson Road Extension (Locha Creek) Culvert Replacement

**GENERAL NOTES**

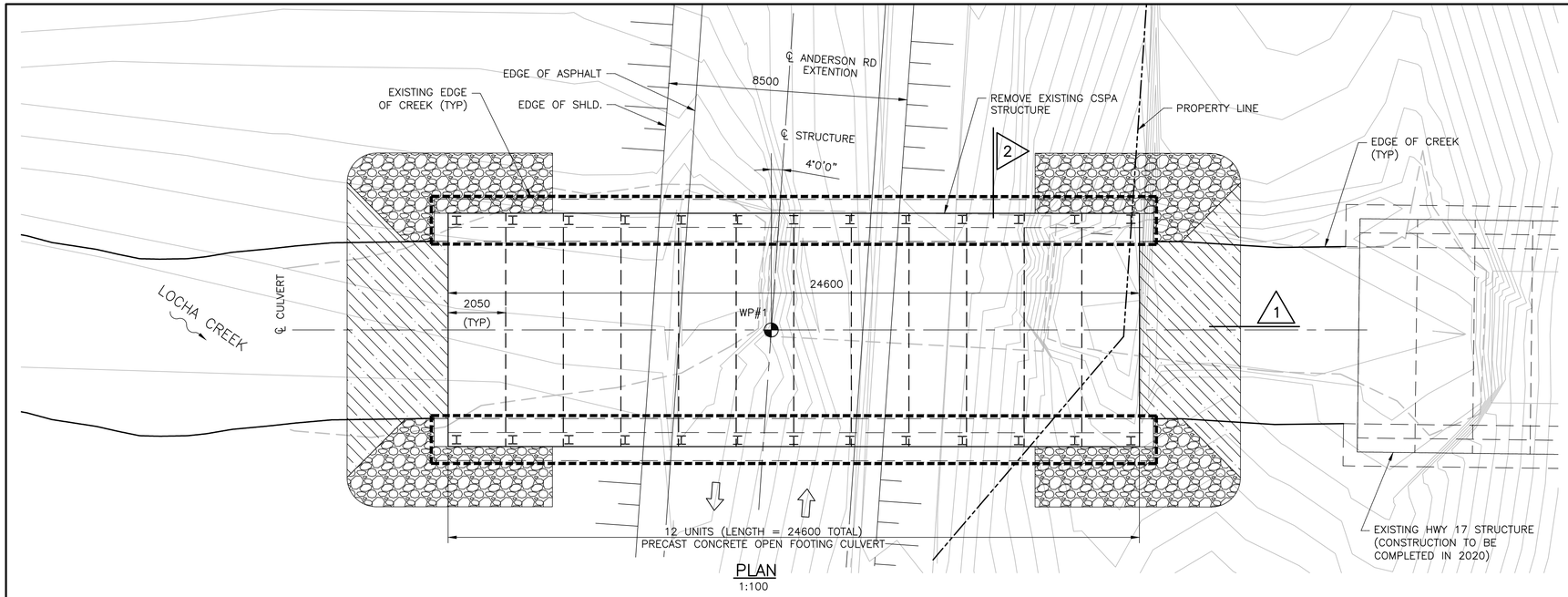
**- The values P(kN/m) represent soil reaction per metre of pile length**
**- The values y(m) represent soil/pile deflection**
**- The base of the footing is at Elev. 130.8 m (as per Preliminary General Arrangement Drawing, dated Feb, 2020)**
**- The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors ($\phi_{qu}$ and $\phi_{qs}$) provided in Table 6.2 of the CHBDC (S6:19)**
**- If lateral spacing between an adjacent pile or another structural element is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on tables C6.11.3(r), C.6.11.3(s) and C6.11.3(t) of the CHBDC (S6:19)**

| Soil Type | Stiff Clay (Below WT) | | Stiff Clay (Below WT) | | Stiff Clay (Below WT) | | Stiff Clay (Below WT) | | Stiff Clay (Below WT) | | Stiff Clay (Below WT) | | Stiff Clay (Below WT) | | Stiff Clay (Below WT) | | Stiff Clay (Below WT) | | Stiff Clay (Below WT) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | **1** | | **2** | | **3** | | **4** | | **5** | | **6** | | **7** | | **8** | | **9** | | **10** | |
| Elev. (m) | **129.8** | | **128.8** | | **127.8** | | **126.8** | | **125.8** | | **124.8** | | **123.8** | | **122.8** | | **121.8** | | **120.8** | |
| | y (m) | P (kN/m) | y (m) | P (kN/m) | y (m) | P (kN/m) | y (m) | P (kN/m) | y (m) | P (kN/m) | y (m) | P (kN/m) | y (m) | P (kN/m) | y (m) | P (kN/m) | y (m) | P (kN/m) | y (m) | P (kN/m) |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0.0007 | 79.8 | 0.0007 | 75.0 | 0.0007 | 70.3 | 0.0007 | 65.6 | 0.0007 | 60.8 | 0.0007 | 56.1 | 0.0007 | 51.4 | 0.0007 | 53.5 | 0.0007 | 55.6 | 0.0007 | 57.7 |
| | 0.0013 | 112.8 | 0.0013 | 106.1 | 0.0013 | 99.4 | 0.0013 | 92.7 | 0.0013 | 86.0 | 0.0013 | 79.3 | 0.0013 | 72.6 | 0.0013 | 75.6 | 0.0013 | 78.6 | 0.0013 | 81.6 |
| | 0.0020 | 131.5 | 0.0020 | 123.6 | 0.0020 | 115.8 | 0.0020 | 108.0 | 0.0020 | 100.2 | 0.0020 | 92.4 | 0.0020 | 84.6 | 0.0020 | 88.1 | 0.0020 | 91.6 | 0.0020 | 95.1 |
| | 0.0026 | 143.5 | 0.0026 | 135.0 | 0.0026 | 126.5 | 0.0026 | 118.0 | 0.0026 | 109.5 | 0.0026 | 100.9 | 0.0026 | 92.4 | 0.0026 | 96.2 | 0.0026 | 100.0 | 0.0026 | 103.9 |
| S | 0.0033 | 151.8 | 0.0033 | 142.8 | 0.0033 | 133.8 | 0.0033 | 124.8 | 0.0033 | 115.8 | 0.0033 | 106.7 | 0.0033 | 97.7 | 0.0033 | 101.8 | 0.0033 | 105.8 | 0.0033 | 109.8 |
| T | 0.0039 | 157.3 | 0.0039 | 148.0 | 0.0039 | 138.6 | 0.0039 | 129.3 | 0.0039 | 120.0 | 0.0039 | 110.6 | 0.0039 | 101.3 | 0.0039 | 105.5 | 0.0039 | 109.6 | 0.0039 | 113.8 |
| A | 0.0046 | 160.7 | 0.0046 | 151.2 | 0.0046 | 141.6 | 0.0046 | 132.1 | 0.0046 | 122.6 | 0.0046 | 113.0 | 0.0046 | 103.5 | 0.0046 | 107.7 | 0.0046 | 112.0 | 0.0046 | 116.3 |
| T | 0.0052 | 162.4 | 0.0052 | 152.8 | 0.0052 | 143.1 | 0.0052 | 133.5 | 0.0052 | 123.8 | 0.0052 | 114.2 | 0.0052 | 104.5 | 0.0052 | 108.9 | 0.0052 | 113.2 | 0.0052 | 117.5 |
| I | 0.0059 | 162.6 | 0.0059 | 153.0 | 0.0059 | 143.3 | 0.0059 | 133.7 | 0.0059 | 124.0 | 0.0059 | 114.4 | 0.0059 | 104.7 | 0.0059 | 109.0 | 0.0059 | 113.4 | 0.0059 | 117.7 |
| C | 0.0065 | 161.7 | 0.0065 | 152.1 | 0.0065 | 142.5 | 0.0065 | 132.9 | 0.0065 | 123.3 | 0.0065 | 113.7 | 0.0065 | 104.1 | 0.0065 | 108.4 | 0.0065 | 112.7 | 0.0065 | 117.0 |
| | 0.0072 | 159.6 | 0.0072 | 150.1 | 0.0072 | 140.6 | 0.0072 | 131.2 | 0.0072 | 121.7 | 0.0072 | 112.2 | 0.0072 | 102.7 | 0.0072 | 107.0 | 0.0072 | 111.2 | 0.0072 | 115.5 |
| | 0.0078 | 156.6 | 0.0078 | 147.3 | 0.0078 | 138.0 | 0.0078 | 128.7 | 0.0078 | 119.4 | 0.0078 | 110.1 | 0.0078 | 100.8 | 0.0078 | 105.0 | 0.0078 | 109.1 | 0.0078 | 113.3 |
| | 0.0130 | 112.9 | 0.0130 | 106.2 | 0.0130 | 99.5 | 0.0130 | 92.8 | 0.0130 | 86.1 | 0.0130 | 79.4 | 0.0130 | 72.7 | 0.0130 | 75.7 | 0.0130 | 78.7 | 0.0130 | 81.7 |
| | 0.0182 | 69.2 | 0.0182 | 65.1 | 0.0182 | 61.0 | 0.0182 | 56.9 | 0.0182 | 52.8 | 0.0182 | 48.7 | 0.0182 | 44.6 | 0.0182 | 46.4 | 0.0182 | 48.3 | 0.0182 | 50.1 |
| | 0.0234 | 25.5 | 0.0234 | 24.0 | 0.0234 | 22.5 | 0.0234 | 21.0 | 0.0234 | 19.5 | 0.0234 | 18.0 | 0.0234 | 16.4 | 0.0234 | 17.1 | 0.0234 | 17.8 | 0.0234 | 18.5 |
| | 0.0247 | 25.5 | 0.0247 | 24.0 | 0.0247 | 22.5 | 0.0247 | 21.0 | 0.0247 | 19.5 | 0.0247 | 18.0 | 0.0247 | 16.4 | 0.0247 | 17.1 | 0.0247 | 17.8 | 0.0247 | 18.5 |

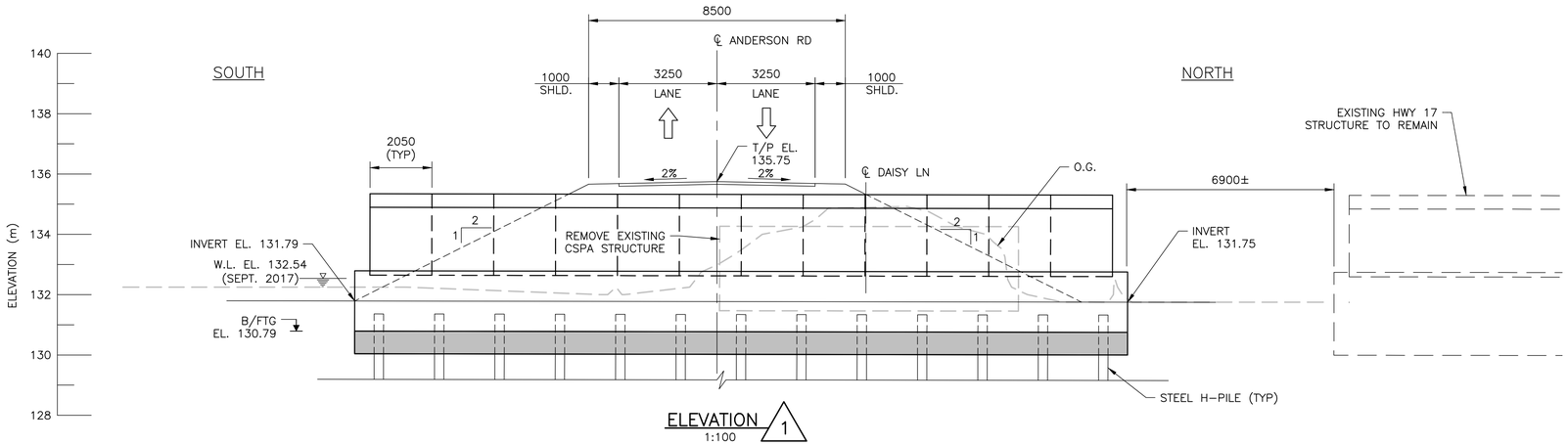
| Soil Type | Stiff Clay (Below WT) | | Stiff Clay (Below WT) | | Stiff Clay (Below WT) | | Stiff Clay (Below WT) | | Stiff Clay (Below WT) | | Stiff Clay (Below WT) | | Stiff Clay (Below WT) | | Stiff Clay (Below WT) | | Compact to Dense Till (Below WT) | | Compact to Dense Till (Below WT) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | **11** | | **12** | | **13** | | **14** | | **15** | | **16** | | **17** | | **18** | | **19** | | **20** | |
| Elev. (m) | **119.8** | | **118.8** | | **117.8** | | **116.8** | | **115.8** | | **114.8** | | **113.8** | | **112.8** | | **111.8** | | **110.8** | |
| | y (m) | P (kN/m) | y (m) | P (kN/m) | y (m) | P (kN/m) | y (m) | P (kN/m) | y (m) | P (kN/m) | y (m) | P (kN/m) | y (m) | P (kN/m) | y (m) | P (kN/m) | y (m) | P (kN/m) | y (m) | P (kN/m) |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0.0007 | 59.9 | 0.0007 | 62.0 | 0.0007 | 64.1 | 0.0007 | 66.2 | 0.0007 | 68.3 | 0.0007 | 70.5 | 0.0007 | 72.6 | 0.0008 | 389.7 | 0.0010 | 530.0 | 0.0013 | 692.0 |
| | 0.0013 | 84.6 | 0.0013 | 87.6 | 0.0013 | 90.6 | 0.0013 | 93.6 | 0.0013 | 96.7 | 0.0013 | 99.7 | 0.0013 | 102.7 | 0.0015 | 684.0 | 0.0020 | 930.1 | 0.0025 | 1214.5 |
| S | 0.0020 | 98.6 | 0.0020 | 102.1 | 0.0020 | 105.6 | 0.0020 | 109.1 | 0.0020 | 112.6 | 0.0020 | 116.1 | 0.0020 | 119.6 | 0.0023 | 862.4 | 0.0030 | 1172.7 | 0.0038 | 1531.3 |
| T | 0.0026 | 107.7 | 0.0026 | 111.5 | 0.0026 | 115.3 | 0.0026 | 119.1 | 0.0026 | 123.0 | 0.0026 | 126.8 | 0.0026 | 130.6 | 0.0031 | 956.5 | 0.0040 | 1300.8 | 0.0050 | 1698.5 |
| A | 0.0033 | 113.9 | 0.0033 | 117.9 | 0.0033 | 122.0 | 0.0033 | 126.0 | 0.0033 | 130.0 | 0.0033 | 134.1 | 0.0033 | 138.1 | 0.0038 | 1002.6 | 0.0050 | 1363.5 | 0.0063 | 1780.4 |
| T | 0.0039 | 118.0 | 0.0039 | 122.2 | 0.0039 | 126.4 | 0.0039 | 130.6 | 0.0039 | 134.8 | 0.0039 | 138.9 | 0.0039 | 143.1 | 0.0046 | 1024.4 | 0.0060 | 1393.1 | 0.0075 | 1819.0 |
| I | 0.0046 | 120.6 | 0.0046 | 124.8 | 0.0046 | 129.1 | 0.0046 | 133.4 | 0.0046 | 137.7 | 0.0046 | 141.9 | 0.0046 | 146.2 | 0.0054 | 1034.4 | 0.0070 | 1406.7 | 0.0088 | 1836.9 |
| C | 0.0052 | 121.8 | 0.0052 | 126.1 | 0.0052 | 130.5 | 0.0052 | 134.8 | 0.0052 | 139.1 | 0.0052 | 143.4 | 0.0052 | 147.8 | 0.0061 | 1039.1 | 0.0080 | 1413.0 | 0.0100 | 1845.1 |
| | 0.0059 | 122.0 | 0.0059 | 126.3 | 0.0059 | 130.7 | 0.0059 | 135.0 | 0.0059 | 139.3 | 0.0059 | 143.6 | 0.0059 | 148.0 | 0.0069 | 1041.2 | 0.0090 | 1415.9 | 0.0113 | 1848.8 |
| C | 0.0065 | 121.3 | 0.0065 | 125.6 | 0.0065 | 129.9 | 0.0065 | 134.2 | 0.0065 | 138.5 | 0.0065 | 142.8 | 0.0065 | 147.1 | 0.0077 | 1042.1 | 0.0100 | 1417.2 | 0.0125 | 1850.5 |
| t | 0.0072 | 119.7 | 0.0072 | 124.0 | 0.0072 | 128.2 | 0.0072 | 132.5 | 0.0072 | 136.7 | 0.0072 | 141.0 | 0.0072 | 145.2 | 0.0084 | 1042.6 | 0.0110 | 1417.8 | 0.0138 | 1851.3 |
| d | 0.0078 | 117.5 | 0.0078 | 121.6 | 0.0078 | 125.8 | 0.0078 | 130.0 | 0.0078 | 134.1 | 0.0078 | 138.3 | 0.0078 | 142.5 | 0.0092 | 1042.8 | 0.0120 | 1418.1 | 0.0150 | 1851.7 |
| . | 0.0130 | 84.7 | 0.0130 | 87.7 | 0.0130 | 90.7 | 0.0130 | 93.7 | 0.0130 | 96.7 | 0.0130 | 99.8 | 0.0130 | 102.8 | 0.0100 | 1042.9 | 0.0130 | 1418.2 | 0.0163 | 1851.8 |
| | 0.0182 | 51.9 | 0.0182 | 53.8 | 0.0182 | 55.6 | 0.0182 | 57.5 | 0.0182 | 59.3 | 0.0182 | 61.2 | 0.0182 | 63.0 | 0.0107 | 1042.9 | 0.0140 | 1418.3 | 0.0175 | 1851.9 |
| | 0.0234 | 19.2 | 0.0234 | 19.8 | 0.0234 | 20.5 | 0.0234 | 21.2 | 0.0234 | 21.9 | 0.0234 | 22.6 | 0.0234 | 23.2 | 0.0115 | 1042.9 | 0.0150 | 1418.3 | 0.0188 | 1851.9 |
| | 0.0247 | 19.2 | 0.0247 | 19.8 | 0.0247 | 20.5 | 0.0247 | 21.2 | 0.0247 | 21.9 | 0.0247 | 22.6 | 0.0247 | 23.2 | 0.0123 | 1042.9 | 0.0160 | 1418.3 | 0.0200 | 1851.9 |

**Appendix H.**

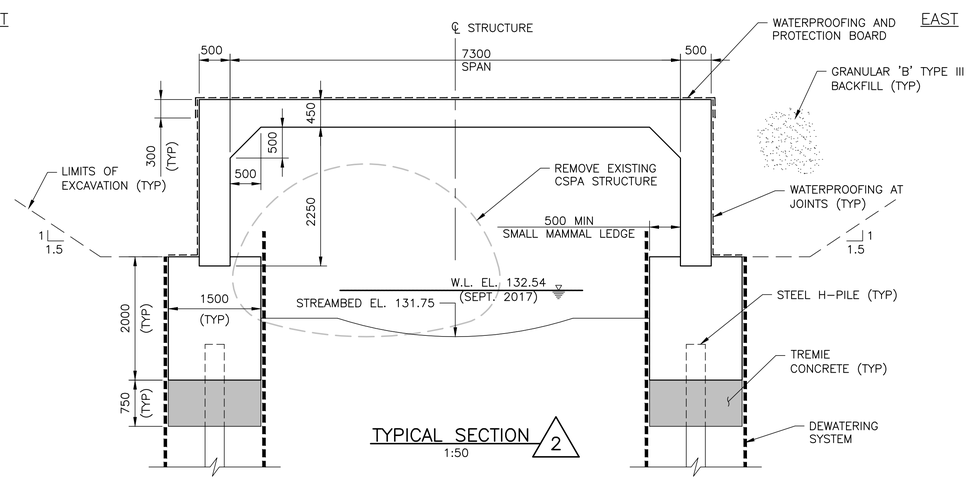
**Preliminary General Arrangement Drawing**
**Contract Documents 2018-4018 (Highway 17 Locha Creek Culvert)**



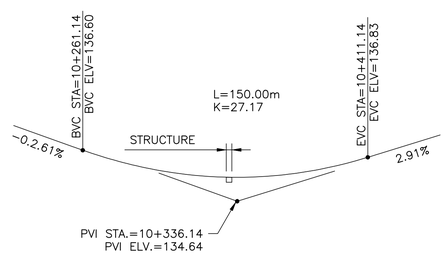

PLAN
1:100




ELEVATION 1
1:100




TYPICAL SECTION 2
1:50




PROFILE OF ANDERSON RD EXTENSION
N.T.S.

| WORKING POINT COORDINATES | | | | |
|---|---|---|---|---|
| WP # | STATION | ELEVATION | NORTHING | EASTING |
| 1 | 10+348.340 | 135.75 | 5033749.728 | 302073.362 |

# METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

ABBREVIATIONS:

| | | |
|---|---|---|
| B | – | BOTTOM |
| ℄ | – | CENTERLINE |
| C.J. | – | CONSTRUCTION JOINT |
| CSPA | – | CORRUGATED STEEL PIPE ARCH |
| EB | – | EAST BOUND |
| EBL | – | EAST BOUND LANE |
| EL. | – | ELEVATION |
| EQ. | – | EQUAL |
| FTG | – | FOOTING |
| HWL | – | HIGH WATER LEVEL |
| HWY | – | HIGHWAY |
| LOC. | – | LOCATION |
| NB | – | NORTH BOUND |
| NBL | – | NORTH BOUND LANE |
| N.T.S. | – | NOT TO SCALE |
| O.G. | – | ORIGINAL GROUND |
| QMB | – | QUICK MOVABLE BARRIER |
| RD. | – | ROAD |
| SB | – | SOUTH BOUND |
| SBGR | – | STEEL BEAM GUIDE RAIL |
| SBL | – | SOUTH BOUND LANE |
| SHLD. | – | SHOULDER |
| S.S. | – | STAINLESS STEEL |
| STA. | – | STATION |
| T | – | TOP |
| TYP | – | TYPICAL |
| T/C | – | TOP OF CONCRETE |
| T/F | – | TOP OF FOOTING |
| T/P | – | TOP OF PAVEMENT |
| U.N.O. | – | UNLESS NOTED OTHERWISE |
| WB | – | WEST BOUND |
| WBL | – | WEST BOUND LANE |
| WL | – | WATER LEVEL |
| WP | – | WORKING POINT |

GENERAL NOTES:

1. CLASS OF CONCRETE:
   PRECAST CONCRETE ———— 40 MPa
   CAST–IN–PLACE CONCRETE ——— 30 MPa
   TREMIE CONCRETE ———— 30 MPa
   REMAINDER ———— 30 MPa
   UNLESS OTHERWISE NOTED
2. CLEAR COVER TO REINFORCING STEEL:
   PRECAST ———— 50 ± 10
   FOOTING ———— 70 ± 25
   REMAINDER ———— 70 ± 20
   UNLESS NOTED OTHERWISE.
3. REINFORCING STEEL:
   - REINFORCING STEEL SHALL BE GRADE 400W UNLESS SHOWN OTHERWISE.
   - STAINLESS REINFORCING STEEL SHALL BE TYPE 316LN OR DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500 MPa UNLESS OTHERWISE SPECIFIED.
   - BAR MARKS WITH PREFIX 'S' DENOTE STAINLESS STEEL BARS.
   - UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL BAR SHALL BE CLASS B.
   - BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWINGS SS12–1, UNLESS INDICATED OTHERWISE.

CONSTRUCTION NOTES:

1. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS, DETAILS AND ELEVATIONS OF THE EXISTING STRUCTURE THAT ARE RELEVANT TO THE WORK SHOWN ON THE DRAWINGS PRIOR TO COMMENCEMENT OF THE WORK. ANY DISCREPANCIES SHALL BE REPORTED TO THE CONTRACT ADMINISTRATOR.
2. THE CONTRACTOR SHALL CHECK AND IDENTIFY ALL EXISTING UTILITIES WITHIN THE WORK AREA. PRIOR TO THE CONSTRUCTION WORK, THE CONTRACTOR SHALL CARRY OUT ALL NECESSARY PROTECTION AND PRECAUTIONARY MEASURES FOR OR ARRANGE TO DIVERT EXISTING UTILITIES AS MAY BE REQUIRED BY RELEVANT AUTHORITIES.
3. THE APPROACH SLABS ARE NOT PART OF THIS CONTRACT.

LEGEND:

GRANULAR MATERIAL

ROCK PROTECTION

STREAM BED MATERIAL

APPLICABLE STANDARD DRAWINGS:

OPSD–3370.100 – DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE WITH PROTECTION BOARD

MTOD–3941.210 – FIGURES IN CONCRETE SITE NUMBER AND DATE LAYOUT

PRELIMINARY

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

DIST. No.
CONT. No.XXXX–XXXX
WP. No.XXX–XXX–XX

ANDERSON RD EXTENSION
LOCHA CREEK MULTI–SPECIES CROSSING
GENERAL ARRANGEMENT

SHEET 01

MORRISON HERSHFIELD

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

| | | | | | |
|---|---|---|---|---|---|
| DESIGN | PMA | CHK. XXX | CODE CHBDC 2014 | LOAD CL–625–ONT | DATE FEB. 2020 |
| DRAWN | CTB | CHK. PMA | SITE XX–XXX | | DWG. 1 |

DRAWING PATH AND NAME: \\mh.local\data\Offices\Ottawa\proj\216061729 – Highway 17 Twinning Schnell to Miller\10 Design\Structures\SITES\Daisy Lane\01 – General Arrangement – Daisy Lane_ New Lower Road Profile.dwg
DRAWING LAYOUT: Layout1
LAST UPDATED: Jun 3, 2020–16:05
PRINTED: Jun 4, 2020–10:35

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

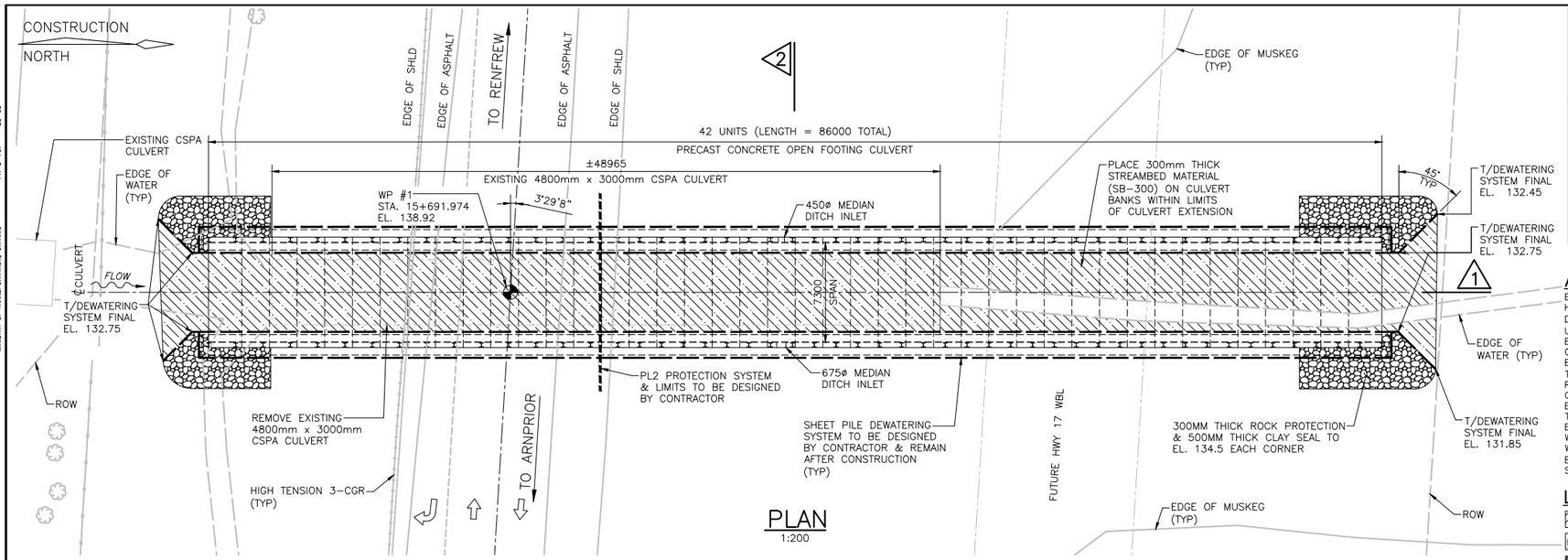
HIGHWAY 17
CONT. No. 2018-4018
WP No. 4300-13-01

LOCHA CREEK
CULVERT REPLACEMENT

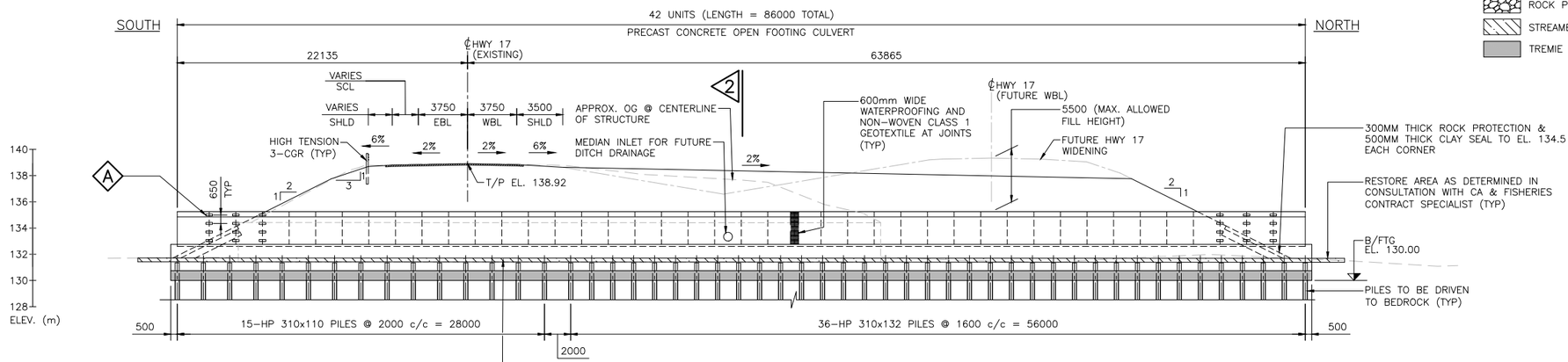
SHEET 48

GENERAL ARRANGEMENT

McINTOSH PERRY




## PLAN
1:200

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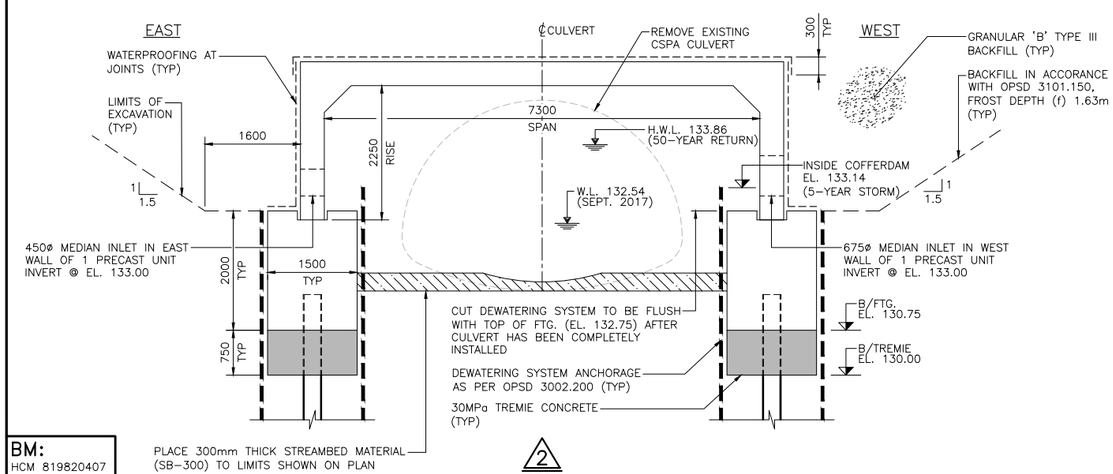
1:200

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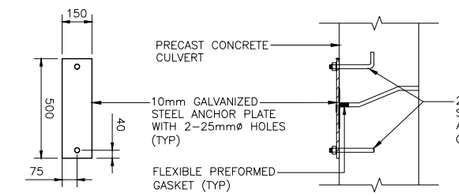
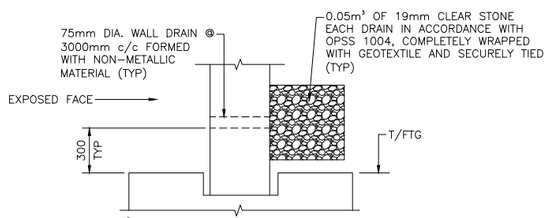
1:50




## A ANCHOR PLATE DETAIL
N.T.S.




## B WALL DRAIN DETAIL
N.T.S.

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

## ABBREVIATIONS:

| | |
|---|---|
| EL | ELEVATION (METERS) |
| HWL | HIGH WATER LEVEL |
| D/S | DOWNSTREAM |
| U/S | UPSTREAM |
| EX | EXISTING |
| OG | ORIGINAL GROUND |
| BD | BOTTOM OF DITCH |
| T/CLVT | TOP OF CULVERT |
| ROW | RIGHT OF WAY |
| CA | CONTRACT ADMINISTRATOR |
| EP | EDGE OF PAVEMENT |
| TYP | TYPICAL |
| EBL | EASTBOUND LANE |
| WBL | WESTBOUND LANE |
| W.L. | WATER LEVEL |
| B/FTG | BOTTOM OF FOOTING |
| SCL | SPEED CHANGE LANE |

## LEGEND:
- ASPHALT
- GRANULAR 'B' TYPE III
- ROCK PROTECTION
- STREAMBED MATERIAL (SB 300)
- TREMIE CONCRETE

## GENERAL NOTES:

### CLASS OF CONCRETE:

| | |
|---|---|
| PRECAST CONCRETE | 40 MPa |
| CAST-IN-PLACE CONCRETE | 30 MPa |
| TREMIE CONCRETE | 30 MPa |
| REMAINDER (UNLESS OTHERWISE NOTED) | 30 MPa |

### CLEAR COVER TO REINFORCING STEEL:

| | |
|---|---|
| PRECAST | 50 ± 10mm |
| FOOTINGS | 70 ± 25mm |
| REMAINDER (UNLESS OTHERWISE NOTED) | 70 ± 20mm |

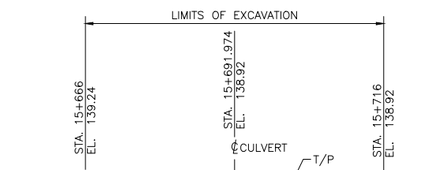
### REINFORCING NOTES:
- REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.
- UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES SHALL BE CLASS B.
- BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUP AND TIES SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1 UNLESS INDICATED OTHERWISE.

### CONSTRUCTION NOTES:
- BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH CULVERT WALLS KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN THE ELEVATION BE GREATER THAN 500MM.
- THE TEMPORARY FLOW CONTROL SHALL BE DESIGNED FOR A FIVE (5) YEAR DESIGN STORM RETURN PERIOD OF 5.50 m³/s.
- THE CONTRACTOR SHALL CHECK AND VERIFY ALL DIMENSIONS AND SITE CONDITIONS BEFORE PROCEEDING WITH WORK AND REPORT ANY DISCREPANCIES TO THE CONTRACT ADMINISTRATOR BEFORE COMMENCING THE WORK.
- ALL WORKS TO BE COMPLETED IN ACCORDANCE WITH THE TIMING RESTRICTIONS STIPULATED IN THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL ADJUST ALL NECESSARY DIMENSIONS TO ACCOMMODATE ANY CHANGES TO THE DIMENSIONS OF THE PRECAST UNITS, AT NO COST TO THE OWNER.
- THE CONTRACTOR SHALL DESIGN AND SUPPLY ANY TEMPORARY SUPPORT REQUIRED FOR THE REMOVAL OF THE EXISTING STRUCTURE IN ACCORDANCE WITH OPSS 919.
- BURIED BELL LINE 80m WEST OF CULVERT AND BURIED ENBRIDGE GAS LINE EAST OF THE CULVERT.
- MEDIAN INLET ADDITIONAL REINFORCING AND TEMPORARY SEAL PLATE TO BE DESIGNED BY PRECAST MANUFACTURE.
- FISHERIES CONTRACT SPECIALIST TO OVERSEE PLACEMENT OF ALL STREAMBED MATERIAL, PLACEMENT OF ROCK PROTECTION, PLANTING OF LIVE STAKES/ SEEDING AND ALL OTHER IN-WATER WORK AND WORKS.
- VOIDS IN STREAMBED MATERIAL PLACED WITHIN EXISTING CULVERT TO BE FILLED WITH SB-13.2 MATERIAL AS PER OPSS 1005.

## LIST OF DRAWINGS:
1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS AND SOIL STRATA
3. CONSTRUCTION STAGING
4. FOOTING DETAILS AND PILE LAYOUT
5. MISCELLANEOUS AND STANDARD DETAILS

## APPLICABLE STANDARD DRAWINGS:

| | |
|---|---|
| OPSD 3002.200 | – FOUNDATION PILES STEEL SHEET PILES, ANCHORAGE |
| MTOD 3941.210 | – FIGURES IN CONCRETE SITE NUMBER AND LAYOUT |
| OPSD 3101.150 | – WALL ABUTMENT, BACKFILL, MINIMUM GRANULAR REQUIRMENTS |




## ROADWAY PROFILE
N.T.S.

**BM:**
HCM 819820407
EL. 138.473
STA. 15+786.774

REVISIONS

| DATE | BY | REV | DESCRIPTION |
|---|---|---|---|

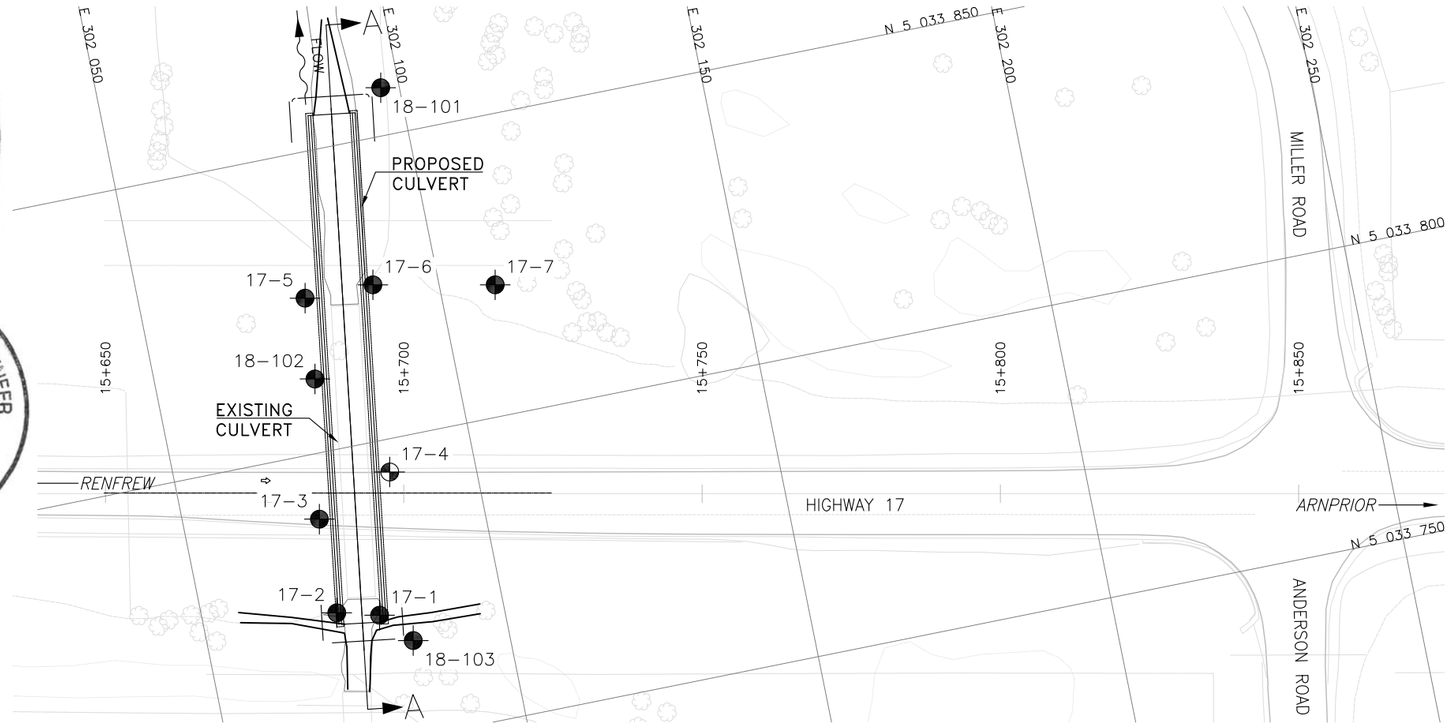
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| DESIGN YFO | CHK LD | CODE CAN/CSA S6-14 | LOAD CL-625-ONT | DATE APR/19 |
| DRAWN KM | CHK YFO | SITE 29X-0249/C0 | STRUCT | SCHEME | DWG 1 |

CAD FILE LOCATION AND NAME: \\10.16.10.4\Shares\Data\01 Project – Proposals\2016 Jobs\OKM-16-7122 – MTO ER Mega Rct 3 Areas\16-7122-07 – 2 Structural Culvert Replacements\12 CAD\8 Contract Drawings\CV02-Locha Creek Culvert\OKM-16-7122-07_CV02_001GEN.dwg
MODIFIED: 4/2/2019 4:22:56 PM BY: K.MARTIN
DATE PLOTTED: 4/2/2019 4:28:45 PM BY: KYLE MARTIN
PR-D-707 88-05
MINISTRY OF TRANSPORTATION, ONTARIO

MINISTRY OF TRANSPORTATION, ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
March 28/19
PROVINCE OF ONTARIO

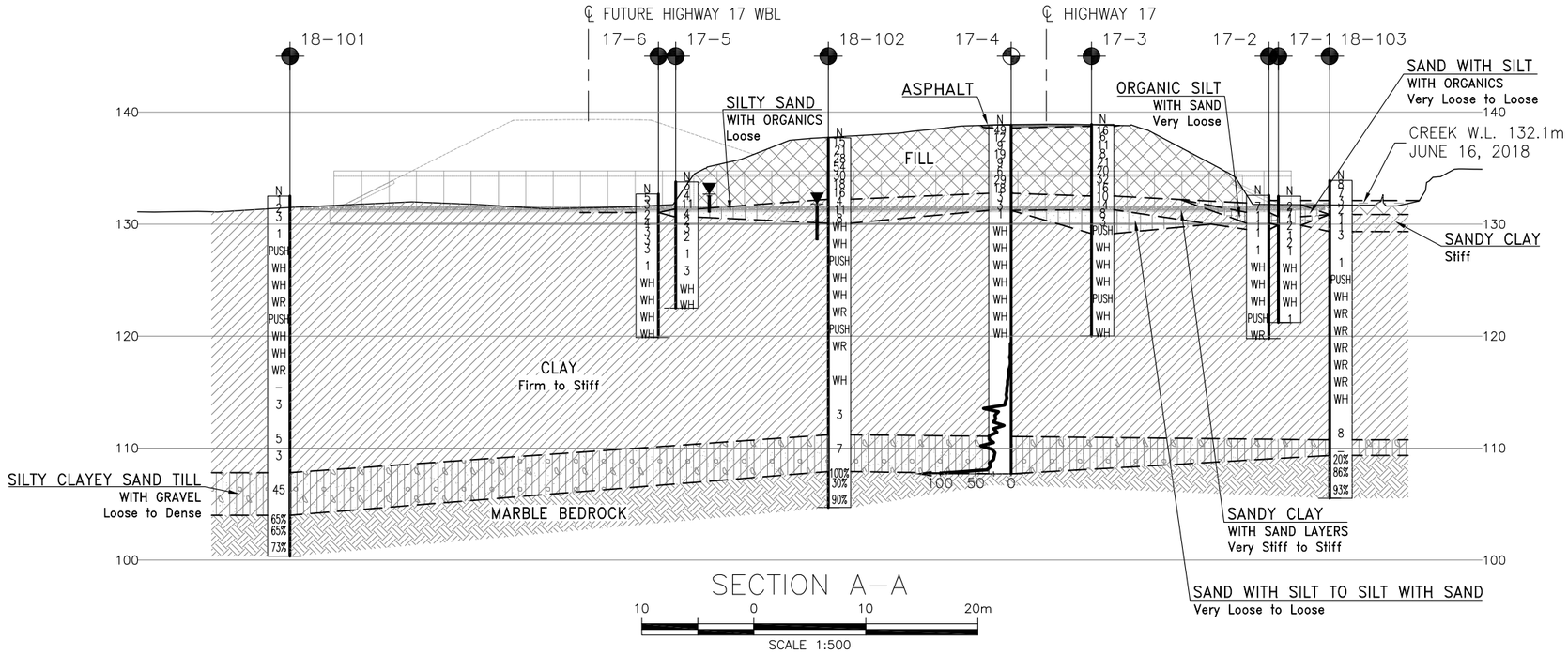
LICENSED PROFESSIONAL ENGINEER
P. CARNAFFAN
90416975
Mar 29/19
PROVINCE OF ONTARIO




PLAN

20 0 20 40m

SCALE 1:1000




SECTION A–A

10 0 10 20m

SCALE 1:500

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

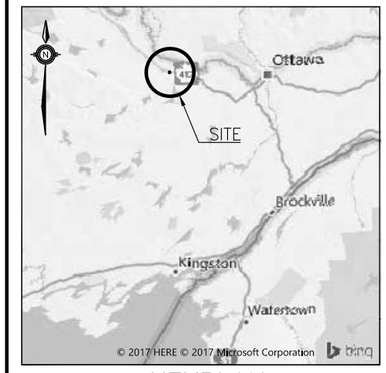
CONT No 2018–4018
WP No 4300–13–01

HIGHWAY 17
LOCHA CREEK CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 49

McINTOSH PERRY

THURBER ENGINEERING LTD.




KEYPLAN

LEGEND

| | |
|---|---|
| ⊕ | Borehole |
| ⊕ | Borehole and Cone |
| 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 |
|---|---|---|---|
| 17–1 | 132.5 | 5 033 771.3 | 302 079.3 |
| 17–2 | 132.6 | 5 033 773.2 | 302 072.3 |
| 17–3 | 138.9 | 5 033 789.1 | 302 072.6 |
| 17–4 | 138.8 | 5 033 794.5 | 302 085.7 |
| 17–5 | 133.8 | 5 033 825.9 | 302 077.5 |
| 17–6 | 132.7 | 5 033 825.8 | 302 089.1 |
| 17–7 | 134.3 | 5 033 821.8 | 302 109.2 |
| 18–101 | 132.5 | 5 033 858.0 | 302 096.9 |
| 18–102 | 137.7 | 5 033 812.3 | 302 076.5 |
| 18–103 | 133.9 | 5 033 766.1 | 302 084.0 |

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Borehole locations are shown in MTM Zone 9 coordinates.

**GEOCRES No. 31F-205**

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

| | | | | | |
|---|---|---|---|---|---|
| DESIGN | KP | CHK – | CODE | LOAD | DATE MAR 2019 |
| DRAWN | MFA | CHK KP | SITE | STRUCT | DWG 1 |

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PLOTDATE: 3/28/2019 4:48 PM

## Appendix I.

## List of Special Provisions and OPSS Documents Referenced in this Report Non-Standard Special Provisions

1. The following Special Provisions and OPSS Documents are referenced in this report:

| | |
|---|---|
| OPSD 810.010 | General Rip-Rap Layout for Sewer and Culvert Outlets |
| OPSD 3090.10 | Foundation Frost Depths for Southern Ontario |
| OPSD 3101.150 | Abutment Backfill Minimum Granular Requirement |
| OPSS.PROV 180 | Construction Specification for the Management of Excess Materials |
| OPSS.PROV 501 | Construction Specification for Compacting |
| OPSS.PROV 539 | Construction Specification for Temporary Protection Systems |
| OPSS.PROV 804 | Construction Specification for Seed and Cover |
| OPSS 805 | Construction Specification for Temporary Erosion and Sediment Control Measures |
| OPSS 902 | Construction Specification for Excavating and Backfilling Structures |
| OPSS.PROV 903 | Construction Specification for Deep Foundations |
| OPSS.PROV 1010 | Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material |
| OPSS.PROV 1205 | Material Specification for Clay Seal |
| SP 105S09 | Amendment to OPSS 539 |
| SP 109S12 | Amendment to OPSS 902 - QVE, Backfilling Compaction, and Certificate of Conformance |
| SP FOUN0001 | Requirements for Supply and Placement of a Concrete Working Slab Under Structure Foundations |
| SP FOUN0003 | Amendment to OPSS 902 – Dewatering Structure Excavations |

2. Non-Standard Special Provisions and Notices to Contractor

**“Recommended Wording for NSSP – Special Provision FOUND0003 – Dewatering Structure Excavations”**

Subsection 902.04.01 Design Requirements of SP FOUN0003 is amended by the addition of the following:

The design Engineer and design-checking Engineer of the dewatering system shall have a minimum of 5 years of experience in designing systems of similar nature and scope to the required work.

**“Recemmended Eording for Notice to Contractor – Pile Length”**

The bedrock surface elevation was observed to vary by approximately 6.4 m in the boreholes at this site. The pile length is expected to vary based on the variation in the bedrock surface elevation.

**“Recommended Wording for NSSP – Structural Backfill”**

Structural backfill for the culvert and retaining walls shall consist of OPSS Granular B Type II or Quarry Sourced OPSS Granular A material.

**“Recemmended Wording for Notice to Contractor – Obstructions”**

The Contractor is hereby notified that the native discontinuous tills at the site should be expected to contain cobbles and boulders. Considerations of these obstructions must be made in the selection of appropriate equipment and procedures for excavations, installations of deep foundations and temporary protection systems.