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FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 62 EMBANKMENT INVESTIGATION
TOWNSHIP OF HUNTINGDON
SITE 11-134, G.W.P. 4044-10-00
AGREEMENT NUMBER: 4015-E-0015

GEOCRES NUMBER: 31C-261

SUBMITTED TO
McINTOSH PERRY CONSULTING ENGINEERS LTD. / LEA CONSULTING LTD.
JOINT VENTURE

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for the construction of a new embankment as part of the re-alignment of Highway 62 associated with the replacement of the Highway 62 Rawdon Creek Bridge, located within the Township of Huntingdon, Ontario. Thurber carried out the investigation as a subconsultant to McIntosh Perry Consulting Engineers – LEA Engineering Joint Venture (MPCE-LEA), under Assignment 12 of Agreement No. 4015-E-0015.

Base plan mapping was provided by the Ministry of Transportation (MTO) Eastern Region Structural Office for the preparation of this report.

Highway 62 in the vicinity of the Rawdon Creek Bridge is being reconstructed on a permanent new alignment to the west of the existing highway alignment as part of the Rawdon Creek Bridge replacement. The north embankment for the Rawdon Creek crossing is to be located in an existing agricultural field and will range in height from 2.5 m to 3.6 m. During Thurber's 2016 pavement investigation for the realignment, a buried organic layer was identified in two boreholes advanced within the agricultural field in the vicinity of Station 12+575.

A supplemental foundation field investigation was carried out to assess the extent of the buried organic material and potential impact on the new highway embankment. It should be noted that the buried organic material was not encountered during the foundation investigation for the proposed Rawdon Creek bridge replacement, so the investigation was limited to within the footprint of the proposed north embankment.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on this data, provide a borehole location plan, record of boreholes, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions.

2 SITE DESCRIPTION

The location of the new Highway 62 north embankment extends from approximately Station 12+500 to Station 12+600. The site location is shown on the inset Key Plan on Drawing No. 1 in Appendix A.

While preparing the investigation plan, a swampy area was identified on the base plans within the proposed highway alignment between approximate Station 12+525 and 12+565. The swampy area is not currently evident on site; and appears to have been filled in for use as an agricultural field. The area is generally flat and grass covered. There is a difference in height between the proposed top of pavement and existing ground surface along the proposed embankment alignment of approximately 2.5 m to 3.6 m. Site photographs showing the general conditions at the site are presented in Appendix D.

The site is located near the boundary of three physiographic regions: the Dummer Morraine, the Peterborough Drumlin Field and the Iroquois Plain though the soil conditions on site most closely resemble those of the Iroquois Plain region. The Iroquois Plain region is characterized by the flat to undulating lake bed and beaches of the former glacial Lake Iroquois that existed during the last glacial recession. The overburden soils are comprised of glaciolacustrine sand, silt and clay deposits (though deposits of sand and gravel are also known to be present) all underlain by limestone bedrock (Chapman and Putnam, 1984).

The lands surrounding the project limits are typically agricultural with some residential properties. Storm water drainage in the area is to existing ditches and culverts.

3 SITE INVESTIGATION

3.1 Previous Investigations

Preliminary Investigation

A Preliminary Foundation Investigation for the bridge replacement was carried out in 2012 (Golder Associates Report No. 12-1111-0021-1). The investigation consisted of advancing one borehole at each proposed abutment (Boreholes RC-1 and RC-2).

The stratigraphy in the area of the bridge is generally described as surficial deposits of firm to stiff silty clay (on the south side of the creek) or loose to compact sand and gravel (on the north side of the creek), overlying a deposit of loose to compact silty sand to sandy silt, underlain by a deposit of compact to very dense sand and gravel, which contains cobbles and boulders, all overlying limestone bedrock. The bedrock surface was encountered at approximately elevation 123.2 m and 122.3 m at the north and south abutments, respectively.

Pavement Investigation

A pavement investigation in support of the detailed design for the realignment of Highway 62 was carried out by Thurber in 2016. Within the limits of the proposed north embankment the investigation consisted of advancing six auger probe style boreholes to depths of 1.5 m to 3.0 m. Bulk soil samples of the soil encountered were taken from the augers. Asphalt cores were advanced with a 150 mm diameter core barrel to determine total asphalt thickness at various locations along the exiting alignment.

In general, the stratigraphy encountered in the pavement boreholes is described as surficial material (asphalt or topsoil) overlying embankment fill (for boreholes through the existing roadway), overlying sandy silt and silty sand. Organic material was encountered at depths of 0.75 m and 2.0 m below existing ground surface in boreholes advanced near the proposed toe of slope and near the new centreline alignment of Highway 62 at Stations 12+573 and 12+572.

Foundation Investigation

A foundation investigation was carried out as part of the detailed design assignment to supplement the data from the preliminary foundation investigation. Within the limits of the proposed north embankment the investigation included advancing a total of two boreholes

(Boreholes 16-3 and 16-4) one drilled at the north abutment and the other in the approach embankment. A copy of Record of Boreholes from the foundation investigation is provided in Appendix B. The location of the foundation boreholes is also illustrated on Drawing No. 1 in Appendix A.

In general, the stratigraphy in the boreholes is characterized by a silty sand with gravel overlying sandy silt to silty sand, overlying silty sand with gravel till, underlain by limestone bedrock. This stratigraphy is generally consistent with the stratigraphy encountered in the preliminary investigation. A buried organic layer was not encountered.

3.2 Field Investigation

The field investigation plan for the north embankment investigation was finalized after discussion with the MTO Foundations Section. The field investigation for this site included advancing eight boreholes between April 3rd and April 10th, 2017. Two additional probe holes were advanced to confirm the soil stratigraphy at the existing toe of slope. The approximate locations and elevations of the boreholes/probe holes are shown on Drawing No. 1 provided in Appendix A and are summarized in Table 3-1.

Table 3-1: Borehole Summary

Borehole	Location	Northings (m)	Eastings (m)	Ground Surface Elevation (m)	Depth (m)
101	Existing Embankment	4911417.0	226832.9	133.6	10.0
102	Existing Embankment	4911438.4	226820.1	133.7	10.8
103	Existing Embankment	4911459.9	226807.3	134.1	11.5
104	Existing Embankment	4911474.7	226799.0	135.0	9.8
105	Toe of proposed slope	4911468.4	226788.1	132.4	5.2
106	Toe of proposed slope	4911450.9	226791.9	131.2	5.2
107	Toe of proposed slope	4911428.4	226803.2	130.8	5.2
108	Toe of proposed slope	4911405.3	226812.6	130.7	5.2
109[1]	Toe of existing slope	4911422.6	226818.8	130.9	1.7
110[1]	Toe of existing slope	4911443.8	226803.5	131.1	1.7

Note 1: Auger Probe Style boreholes

As a component of our standard procedures and due diligence, Thurber contacted Ontario One Call, to obtain utility locates/clearances for the intended borehole locations. In addition, MTO traffic operations was contacted to obtain ATMS Fibre utility locates and Carillion Canada / RW Electric were contacted to obtain MTO electric locates for the project limits.

The boreholes were advanced with a CME 55 track mount drill rig equipped with both hollow stem and solid stem augers. The subsurface stratigraphy encountered in the boreholes was recorded in the field by Thurber personnel. Split spoon samples were collected at regular depth intervals in the boreholes during the completion of Standard Penetration Tests (SPT), following the methods described in ASTM Standard D1586-11. Bulk soil sampling of the various soil stratigraphy were taken from the augers for probe holes 109 and 110. Thin-walled tube samples of the buried organic deposit were collected from Boreholes 106 to 108. All other soil samples recovered from the boreholes were placed in moisture-proof containers and transported to Thurber’s Ottawa geotechnical laboratory for further examination and testing.

A 19 mm inside diameter PVC piezometer was installed in Borehole 106 to allow for the measurement of the groundwater level at the site. The piezometer construction details are illustrated on the Record of Borehole sheet for Borehole 106, provided in Appendix B.

The boreholes without a piezometer installation were backfilled with a low-permeability combination of auger cuttings, and bentonite pellets in general accordance with the intent of Ontario MOE Regulation 903. Boreholes advanced through the existing roadway platform over capped with 150 mm of cold patch asphalt.

The as-drilled locations of the boreholes and ground surface elevations at the borehole locations were surveyed by Thurber on April 5th, 2017. The vertical datum used was the benchmark (GBM) 8321 identified on the plans provided by MTO, which is located on the southeast abutment of the existing Rawdon Creek bridge. The GBM has a geodetic elevation of 134.476 m.

3.3 Laboratory Testing

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all soil samples in accordance with the current MTO standards. Grain size distribution analyses, Atterberg Limits, consolidation and organic content testing were also carried out on selected samples to MTO and ASTM standards.

The laboratory test results are presented on the Record of Borehole sheets in Appendix B and are illustrated on the figures in Appendix D.

4 DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 Overview / General

Reference is made to the Record of Borehole sheets in Appendix B for details of the soil stratigraphy encountered in the boreholes. Stratigraphic profiles for the site are presented on Drawing Nos. 1 and 2 in Appendix A for illustrative purposes. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the Record of Boreholes governs any interpretation of the site conditions.

In general, the stratigraphy in the area of the boreholes is characterized by asphalt surface cover overlying embankment fill consisting of silty sand with gravel overlying a sandy clay (embankment boreholes), or rootmat/topsoil surface cover overlying fill material (agricultural field boreholes), overlying sandy organic silt / silty sand with organics overlying a native silty sand, overlying gravelly sand till, all underlain by inferred bedrock. A layer of clay was encountered beneath the silty sand layer in Borehole 106. It should be noted that the organic layer was encountered in the existing embankment Boreholes 101 and 102.

More detailed descriptions of the individual strata are presented below.

4.2 Surface Cover

Four boreholes (Boreholes 101 to 104) were advanced through the existing Highway 62 pavement structure. The thickness of the asphalt was 150 mm.

A rootmat/topsoil layer was enountered at the surface of all non-embankment boreholes. The thickness of the layer ranged from 50 mm to 100 mm.

4.3 Embankment Fill

Fill: Silty Sand with Gravel

A silty sand layer with varying amounts of gravel was encountered below the asphalt layer in all four embankment boreholes. The top of this layer ranges from elevation 133.4 m to 134.8 m. The thickness of this layer ranged from 2.1 m to 2.6 m. The SPT 'N' values ranged from 2 to 61 indicating a very loose to very dense condition; but typically compact to dense. Frequent cobbles were noted from 1.8 m to 2.4 m depth in Borehole 101. Organics were noted at 2.1 m depth in Boreholes 104.

The moisture content of the samples tested ranged from 3% to 17%. The results of grain size analysis testing completed on a sample of this material indicated a gravel content of 16%, a sand content of 52%, a fines content (combined silt and clay size particles) of 32%. The results of the grain size analysis are illustrated on Figure 1 in Appendix C.

Fill: Sandy Clay to Sandy Silt

A clay fill deposit was encountered beneath the silty sand fill in the four embankment boreholes as well as Boreholes 105, 109 and 110. The top of this layer ranges from elevation 130.8 m and 132.6 m. The thickness of the layer was 300 mm in Boreholes 109 and 110 and ranged from 1.0 m to 2.1 m in the embankment boreholes.

The moisture content of the samples tested ranged from 11% to 72%. The results of grain size analysis testing completed on samples of this material indicated a gravel content ranging from 0% to 5%, a sand content ranging from 6% to 35%, a silt content ranging from 43% to 53%, and a clay content ranging from 16% to 51%. The results of the grain size analysis are illustrated on Figure 2 in Appendix C.

The results of Atterberg Limits testing completed on samples of this material indicated a plastic limit ranging from 17 to 31, a liquid limit ranging from 32 to 49, and a plasticity index ranging from 10 to 22; indicating a clay and silt of intermediate plasticity. Atterberg Limits analysis results are illustrated on Figure 3 in Appendix C.

4.4 Sandy Organic Silt (OH) to Silty Sand (SM) with Organics

A silt and sand layer containing organics was encountered beneath the fill materials in Boreholes 101, 102, and 106 to 110. The top of this layer ranges from elevation 129.8 m to 130.8 m. The thickness of the layer ranged from 0.3 m to 1.2 m. Table 4-1 outlines the thickness of this layer encountered in the boreholes.

Table 4-1: Thickness of Organic Layer by Borehole Location

Borehole	Thickness of Organic Layer (m)	Borehole	Thickness of Organic Layer (m)
101	0.3	108	0.7
102	0.9	109	0.6
106	0.9	110	1.2
107	0.7		

The moisture content of the samples tested ranged from 10% to 197%. The results of grain size analyses completed on samples of this material indicated a gravel content ranging from 0% to 2%, a sand content ranging from 14% to 74%, a silt content ranging from 21% to 75%, and a clay content ranging from 0% to 18%. The results of the grain size analysis are illustrated on Figure 4 for the organic silt material and Figure 6 for the silty sand with organics material provided in Appendix C.

The results of Atterberg Limits testing completed on samples of this material indicated a plastic limit ranging from 0 to 66, a liquid limit ranging from 0 to 68, and a plasticity index ranging from 0 to 2, indicating a highly plastic to a non-plastic silt. Atterberg Limits analysis results are illustrated on Figure 5 in Appendix D. Test results carried on samples of this material indicated an organic content ranging from 14% to 35%.

The results of oedometer (one-dimensional consolidation) tests carried out on two undisturbed samples of this material are summarized in Table 4-2. Copies of the oedometer test results are provided in Appendix C. The results of the tests indicate that the material is slightly over-consolidated.

Table 4-2: Consolidation Test Results

Parameter	**Sample**	
Borehole	**106**	**108**
Sample	**ST-2**	**ST-2**
Depth / Elevation (m) (top of sample)	0.8 / 130.4	0.8 / 129.9
Moisture Content, (%)	151	87
Unit Weight, (γ) (kN/m^3)	11.8	13.3
Specific Gravity (G_s)	2.1	2.4
Initial Void Ratio (e_o)	4.391	2.549
Pre-consolidation Pressure, (kPa)	50	90
Compression Index (C_c)	1.809	1.506
Recompression Index (C_r)	0.350	0.133

4.5 Sandy Gravel (GP)

A sandy gravel layer with varying amounts of silt was encountered below the silty sand with organics layer in Boreholes 101 and 107. The top of this layer ranges from elevation 129.5 m to 129.5 m. The thickness of this layer ranged from 0.5 m to 0.6 m. The SPT ‘N’ value measured was 11 indicating a compact condition.

The moisture content of the samples tested was 9% and 18%. The results of grain size analysis testing completed on a sample of this material indicated a gravel content of 56%, a sand content of 39%, a fines content of 5%. The results of the grain size analysis are illustrated on Figure 7 in Appendix C.

4.6 Silty Sand (SM) to Sandy Silt (ML)

A native sand and silt deposit was encountered below a sandy gravel in Boreholes 101 and 107, below the organic layer in Boreholes 102, 106, and 108 to 110; and below the fill materials in the remaining boreholes.

The top of this layer ranges from elevation 128.6 m to 131.3 m. The thickness of this layer ranged from 2.9 m to 6.9 m. Boreholes 105 and 106 to 110 were terminated in this stratum. The SPT 'N' values ranged from 7 to 39 indicating a loose to dense condition; but typically compact.

The moisture content of the samples tested ranged from 11% to 34%. The results of a grain size analysis completed on samples of this material indicated a gravel content ranging from 0% to 1%, a sand content ranging from 35% to 78%, a fines content ranging from 14% to 65%. The results of the grain size analysis are illustrated on Figure 8 in Appendix C.

4.7 Clay (CH)

A clay layer was encountered below the silty sand to sandy silt layer in Borehole 106. The top of this layer had an elevation of 126.6 m. Borehole 106 was terminated in this layer.

The moisture content of the sample tested was 32%. The results of grain size analysis testing completed on samples of this material indicated a gravel content of 0%, a sand content of 2%, a silt content of 37%, and a clay content of 61%. The results of the grain size analysis are illustrated on Figure 9 in Appendix C.

The results of Atterberg Limits testing completed on a sample of this material indicated a plastic limit of 26, a liquid limit of 51, and a plasticity index of 25; indicating a clay high plasticity. Atterberg Limits analysis results are illustrated on Figure 10 in Appendix C.

4.8 Glacial Till

A silt and gravel glacial till material with varying amounts of silt was encountered below silty sand stratum in Boreholes 101 to 104.

The top of this layer ranges from elevation 123.5 m to 125.6 m. The thickness of this layer was 0.8 m. Boreholes 101 to 104 were terminated in this stratum. The SPT 'N' values were all greater than 100 indicating a very dense condition.

The moisture content of the samples tested was 5% and 10%. The results of grain size analyses completed on samples of this material indicated a gravel content of 3% and 21%, a sand content of 57% and 72%, and a fines content of 22% and 25%. The results of the grain size analysis are illustrated on Figure 11 in Appendix D.

4.9 Groundwater

The groundwater level in the piezometer installed in Borehole 106 was recorded on April 10th, 2017, at a depth of 0.2 m below existing grade; corresponding to elevation 131.0 m.

It should be noted that Rawdon Creek overtopped its banks and flooded the southern portion of the investigation area.

These observations are considered short-term readings and seasonal fluctuations of the groundwater level are to be expected. The groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

5 MISCELLANEOUS

Thurber staked and/or marked the test hole locations in the field and obtained utility clearances prior to drilling. Thurber surveyed the borehole locations, and determined the ground surface elevations based on contract drawings provided by MTO. Pontil Drilling of Mount Albert, Ontario supplied and operated the drilling equipment to carry out the drilling, sampling, and in-situ testing. The drilling, and sampling operations in the field were supervised on a full-time basis by Mr. Jeff Morrison of Thurber. Laboratory testing was carried out by Thurber in its MTO-approved laboratory in Ottawa. Consolidation testing was carried out by Golder Associates Ltd. MTO-approved laboratory in Mississauga, Ontario. Organic content testing was carried out by Stantec in its MTO approved laboratory in Ottawa.

Overall project management and direction of the field program was provided by Kenton Power, P.Eng. Interpretation of the field data and preparation of this report was completed by Kenton Power, P.Eng. The report was reviewed by Paul Carnaffan, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundations Projects.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

6 GENERAL

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for the construction of a new embankment as part of the re-alignment of Highway 62 associated with replacement of the Highway 62 Bridge over Rawdon Creek, located within the Township of Huntingdon, Ontario. Foundation recommendations are provided to assist the design team in designing a suitable embankment for the proposed bridge replacement.

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 address geotechnical recommendations for the construction of the proposed north embankment on a new alignment in conjunction with the Rawdon Creek bridge replacement project. The discussions and recommendations presented in this report are based on the information provided by MPCE-LEA and MTO and on the factual data obtained during the course of this investigation.

6.1 Proposed Approach Embankment

It is understood that the preferred alternative identified during the preliminary design study consisted of a new single span integral abutment bridge on a permanent new alignment approximately 10 m to the west of the existing bridge.

Based on the proposed top of deck elevation shown on the structural General Arrangement drawing and the existing ground surface elevations measured during Thurber's field investigation, the approach fills for the new alignment will have a maximum height of 3.6 m north of the north abutment. The existing elevations, grade raise and proposed elevations after constructing the proposed embankment are outlined in Table 6-1.

Table 6-1: Proposed Profile Grades

Location	Existing Ground Surface (m)	Approximate Height of Approach Fill (m)	Proposed Top of Pavement (m)
North embankment	130.7 to 132.4	1.6 to 3.6	134.0 to 135.0

6.2 Applicable Codes and Design Considerations

The geotechnical assessment presented below has been prepared based on the available data regarding the proposed works and existing ground conditions and in accordance with the Canadian Highway Bridge Design Code, version CSA S6-14 (CHBDC).

In accordance with CHBDC, the analysis and design of structures 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 MTO has designated the Rawdon Creek Bridge as follows:

Table 6-2: Bridge Structure Classification

Criteria	Classification	CHBDC Section
Importance Category	Major Route Bridge	4.4.2
Consequence Classification	Typical Consequence	6.5.1

Accordingly, a consequence factor (Ψ) of 1.0, as per Table 6.1 of the CHBDC, has been used in assessing factored geotechnical resistances. If the consequence classification changes, the geotechnical assessment will need to be reviewed and revised.

The frost penetration depth at this site is 1.5 m as per OPSD 3090.101.

6.3 Geotechnical Assessment

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

- A buried organic layer was identified in the boreholes beneath the proposed Highway 62 embankment at Boreholes 106 to 110. The thickness of the buried organic layer in this area ranged from 0.6 m to 1.2 m.
- A buried organic layer was identified beneath the existing Highway 62 embankment at Boreholes 101 and 102. The thickness of the buried organic layer in these boreholes ranged from 0.3 m to 0.9 m.
- The composition of the material ranged from silty sand with organic matter to sandy organic silt.
- A buried organic layer was not identified in the boreholes drilled through the existing Highway 62 embankment Boreholes 103 and 104.
- A buried organic layer was not identified in the north abutment Boreholes RC-1 and 16-3 or the approach Borehole 16-4 drilled approximately 20 m north of the abutment.
- A buried organic layer was not identified in the borehole beneath the proposed Highway 62 embankment at 12+590 (Borehole 105)
- The loose to compact silty sand deposits will be easily disturbed when saturated or if water is permitted to seep through it. If excavations are extended below the water level or creek level, appropriate dewatering methods will be required to ensure that the base of the excavation is stable.

7 SEISMIC CONSIDERATIONS

7.1 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).

7.2 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 soil and bedrock conditions encountered below the anticipated embankment footprint, the site is classified as a Seismic Site Class D in accordance with Table 4.1 of the CHBDC.

7.3 Seismic Liquefaction

The soils beneath the embankment footprint include loose to compact sandy silt to silty sand overlying a dense to very dense glacial till deposit underlain by limestone bedrock. These deposits are not considered susceptible to liquefaction under earthquake loading using the site-specific PGA value of 0.091g.

8 APPROACH EMBANKMENT

8.1 Assessment of Settlement

An assessment of the time dependent settlement that would result from construction of the proposed grade raise using conventional granular fill with 2H:1V (horizontal:vertical) side slopes was carried out using Rocscience's Settle^{3D} modelling software. The design pre-consolidation pressure profile has been derived from the oedometer tests carried out on the organic material. Compression characteristics have been modelled using C_c, C_r, C_v and C_{vr} for the organic material and Young's Modulus for the granular materials.

The following design geotechnical parameters have been used in the analysis:

Table 8-1: Geotechnical Design Parameters

Property	Sandy Organic Silt	Silty Sand with Organics	Silty Sand / Sandy Silt	Till
Unit Weight, kN/m^3	11.8	13.3	18	21
Initial Void Ratio, e_0	4.40	2.55	–	–
Compression Index, C_c	1.81	1.50	–	–
Recompression Index, C_r	0.35	0.13	–	–

Property	Sandy Organic Silt	Silty Sand with Organics	Silty Sand / Sandy Silt	Till
Coefficient of Consolidation, C_v, m^2/s	$8.4x10^{-8}$	$3.6x10^{-7}$	–	–
Coefficient, C_{vr}, m^2/s	$1.5x10^{-6}$	$2.5x10^{-6}$	–	–
Secondary Compression, C_α/C_c	0.05	0.05	–	–
Young's Modulus, E_s, kPa	–	–	30,000	75,000

Settlement Analysis Results

- The predicted settlement values reflect both the maximum embankment height after the grade raise as well as the aerial distribution of fill and fill height.
- The magnitude of total settlement beneath the proposed Highway 62 embankment has been estimated to range from approximately 100 mm to 180 mm with about 60 mm to 140 mm of primary consolidation and an additional 25 mm to 40 mm of secondary consolidation over a 20 year time period.
- The primary consolidation is expected to be substantially complete within approximately 2 months of completion of fill placement. The timeframe is relatively quick due in part to the relatively thin layer of organic material.

The magnitude of total settlement will depend on several variables including the thickness of the buried organic layer, the height of fill to be placed and the properties of the organic layer. As these parameters are variable throughout the footprint of the proposed highway embankment, the magnitude of the total settlement will also be variable, resulting in differential settlement.

Since there was no organic material encountered within the abutment and approach Boreholes 16-3 and 16-4, the predicted settlement within 20 m of the abutment is less than 25 mm and is within the MTO Guidelines for post construction settlement. The estimated settlement of the approach embankment beyond 20 m from the bridge abutment is in excess of the MTO Guidelines for post construction settlement over a period of 20 years after paving as outlined below:

- 25 mm within 20 m behind bridge abutment
- 50 mm from 20 to 50 m from the bridge abutment
- 100 mm for greater than 50 m from the bridge abutment

8.2 Assessment of Global Stability

The global stability for the proposed grade raise constructed using conventional granular fill with 2H:1V side slopes was evaluated using GeoStudio 2012 Slope/W software for limit equilibrium analysis. Input parameters for the analysis are based on the in-situ SPT 'N' values and the results of laboratory testing. The results of the global stability analysis are outlined in Table 8.2.

The following additional parameters were used in the analysis:

- A traffic surcharge load as per Section 6.12.5 of the CHBDC
- In accordance with Section 4.4.3.3 of the CHBDC, a seismic horizontal loading of 0.047, equal to ½ of the site adjusted PGA value (0.094g) was used for seismic analysis

Table 8-2: Global Stability Analysis Results – Embankment Constructed with Granular Fill

Location	Factory of Safety	
	Static Conditions	Seismic Conditions
North Abutment	1.4	1.2

The factor of safety does meet the target value of 1.3 under static conditions and 1.1 under seismic conditions.

8.3 Embankment Design Alternatives - Settlement Mitigation

Design/Construction Options

The estimated total settlement would result in unacceptable performance of the pavement surface. Several options for addressing the settlement issue were identifies and evaluated.

These options are discussed below and are outlined in the table provided in Appendix E.

1. Removal of Buried Organic Deposit

   Removal of the buried organic material is the best option for ensuring that post construction settlement meets the MTO Guidelines. Given the limited depth and thickness of the layer, removal of the buried organic deposit from within the new alignment outside of the existing highway embankment is feasible and relatively straight forward. The base of the buried organic layer beneath the existing highway embankment ranged from elevation 129.3 to 129.5 m, which is up to 5.0 m below the current top of pavement. Therefore, where there is overlap between the embankments for the existing and proposed alignments, traffic staging and the potential need for temporary protection systems would need to be considered for removal of the buried organic layer from beneath the existing embankment. It is noted that the buried organic layer beneath the existing embankment (including side slopes) has already been subjected to long term loading and post construction settlement will be less in these areas when new fill is placed than in areas beyond the current embankment.

   The base of the excavation for removal of the buried organic layer would extend below the groundwater level and the exposed subgrade would consist of saturated sandy silt to silty sand. Both dewatering and the use of temporary protection systems would be required to excavate down to remove the organic materials. Excavations should be carried out in short sections and the contractor would need to plan their work to limit the area exposed at any given time and to ensure that it is covered with backfill suitable to support construction equipment before moving on to adjacent sections. Erosion control will also need to be considered.

   Considering the above factors (i.e. requiring dewatering, temporary protection and limited excavations sections) removal of the buried organic material is feasible but not likely cost effective and therefore is not recommended.

2. Constructing the Embankment with Lightweight Fill

The magnitude of settlement could be significantly reduced by using lightweight fill within the embankment. Since lightweight fill would be restricted to below the pavement subgrade level, the embankment loads can only be partially offset unless subexcavation is first carried out. Subexcavation would include partial removal of the buried organic layer in which case the advantage of lightweight fill over removal of the buried organic layer (Option 1) is greatly diminished. Also, flooding of Rawdon Creek was noted therefore the potential for buoyancy of the lightweight fill such as expanded polystyrene would also need to be considered.

Considering the above factors the use of lightweight fill would likely not be cost effective and is therefore not recommended for this project.

3. Ground Improvement

Future settlements could be limited by carrying out ground improvement before construction of the embankment, however, many ground improvement techniques (e.g. rapid impact compaction, dynamic compaction, etc.) are not compatible with fine grained soil and organic deposits. The feasible options would likely include rigid inclusions like rammed aggregate piers.

Due to the limited depth and thickness of the organic deposit, ground improvement is expected to be costlier than removal. Ground improvement is feasible but not recommended for this project.

4. Embankment Preloading

Leaving the organic layer in place and preloading the embankment by placing embankment fill to the full design height (top of pavement) and allowing it to settle for a minimum of 2 months prior to placement of the pavement structure would allow for substantial completion of the primary consolidation. The remaining settlement over the ensuing 20 years is estimated to be approximately 40 mm which is within the acceptable post-construction settlement criteria (maximum of 50 mm for non-freeways at a distance of 20 to 50 m from a transition point). A settlement monitoring plan would need to be established and settlement monitoring would be required during construction.

Option 4 also avoids potential issues with deep excavation within the existing highway embankment.

The embankment will need to be overbuilt to account for the predicted settlement.

It should be noted that placement of the new embankment fill will result in some settlement beneath the adjacent side of the existing embankment and pavement structure; some maintenance of the existing pavement structure may be required during the preload period. As noted in Section 8.1 above the magnitude of the settlement will depend on several variables including the thickness of the buried organic layer, the height of fill to be placed and the properties of the organic layer. As these parameters are variable throughout the footprint of the proposed highway embankment, the magnitude of the differential settlement will also be variable. Generally, the greatest load will be placed on the existing sideslopes and the material beneath the existing sideslopes has been subjected to less load in the past. Therefore, the greatest settlement will be beneath the sideslopes. Differential settlement within the existing highway platform in the longitudinal direction is expected to be no more than 25 mm. The estimated settlement of the existing embankment is within the MTO Guidelines for post construction as settlement over a period of 20 years. In addition, it is noted that the adjacent pavement will be removed once the new bridge is open.

Embankment preloading is the recommended approach for this project from a foundations perspective.

8.4 Recommended Embankment Construction Alternative

Based on the proposed structure geometry and evaluation of embankment alternatives presented above, the recommended foundation approach from a geotechnical perspective is Option 4 to construct the embankment with pre-loading. The embankment should be constructed to the full design height (top of pavement) and allowed to settle.

It is anticipated that 90% of the settlement due to the grade raise to construct the embankment will be complete within approximately two months following construction of the embankment.

Geotechnical instrumentation monitoring will be required at this site to confirm the waiting period after fill placement and the magnitude and time-rate of settlement. The actual preloading time will be governed by results from the instrumentation monitoring program and may be longer than provided herein. An NSSP addressing this issue is provided in Appendix F.

9 CONSTRUCTION CONSIDERATIONS

9.1 Embankment Construction

The embankment construction should be carried out in accordance with OPSS.PROV 206. Embankment fill should consist of Select Subgrade (SSM) material or better in compliance with OPSS.PROV 1010. Excavated granular fill may also be reused as embankment fill provided it is unfrozen and there is no organic material in the excavated fill and there is sufficient space to stockpile on site and control the moisture content within acceptable limits for compaction.

The embankment constructed with side slopes at 2H:1V or flatter are considered stable.

The embankment will need to be overbuilt to account for the predicted settlement.

The fill material should be placed and compacted in accordance with OPSS.PROV 501. Where new embankment fill is placed against existing embankment slopes or fill slope must be benched in accordance with OPSD 208.010.

9.2 Excavations

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The fills and silts and sands at the site should be classified in accordance with OHSA as Type 3 above the groundwater and Type 4 below the water table unless dewatering is carried out to prevent seepage.

9.3 Erosion Protection

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes. The contractor should 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. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

9.4 Construction Concerns

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

- Confirmation that the granular backfill is adequately placed and compacted to specifications.
- Sufficient time is available to allow for settlement mitigation to occur
- A settlement monitoring program is properly carried out to monitor the preload settlement prior to the construction of the north abutment. An NSSP addressing this issue is provided in Appendix F.
- Construction should be kept above the existing creek level at the time construction.
- Seasonal fluctuations of the groundwater and river level are to be expected. In particular, the water level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall, which may impact the construction.

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

10 CLOSURE

Overall project management and direction of the field program was provided by Paul Carnaffan, P.Eng. Interpretation of the field data and preparation of this report was completed by Kenton Power, P.Eng. The report was reviewed by Paul Carnaffan, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundations Projects.

Kenton C. Power, P.Eng.
Geotechnical Engineer

Paul Carnaffan, P.Eng.
Principal, Senior Geotechnical Engineer

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

APPENDIX A

BOREHOLE LOCATIONS AND SOIL STRATA DRAWINGS

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

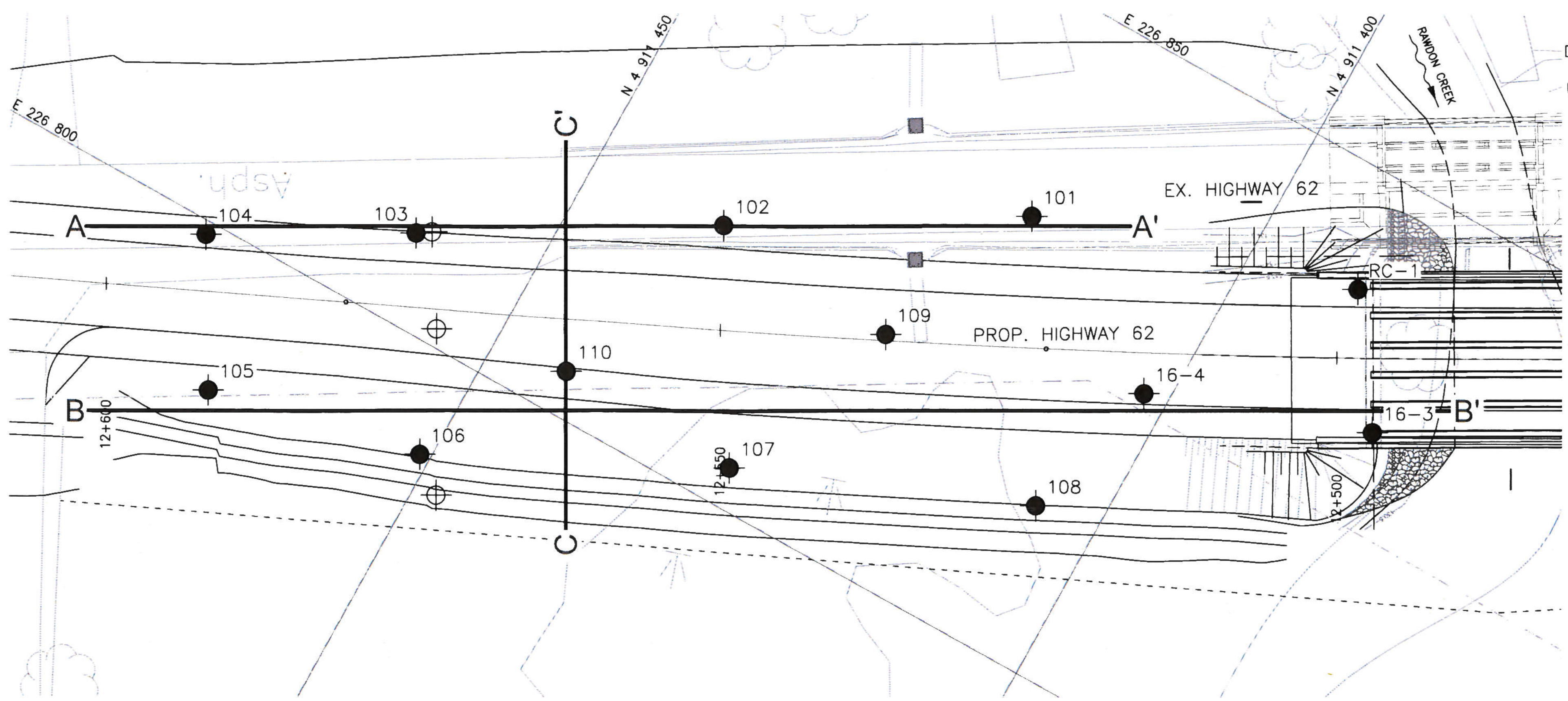
CONT No 2017-4001
GWP No 4044-10-00

HIGHWAY 62
RAWDON CREEK
BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

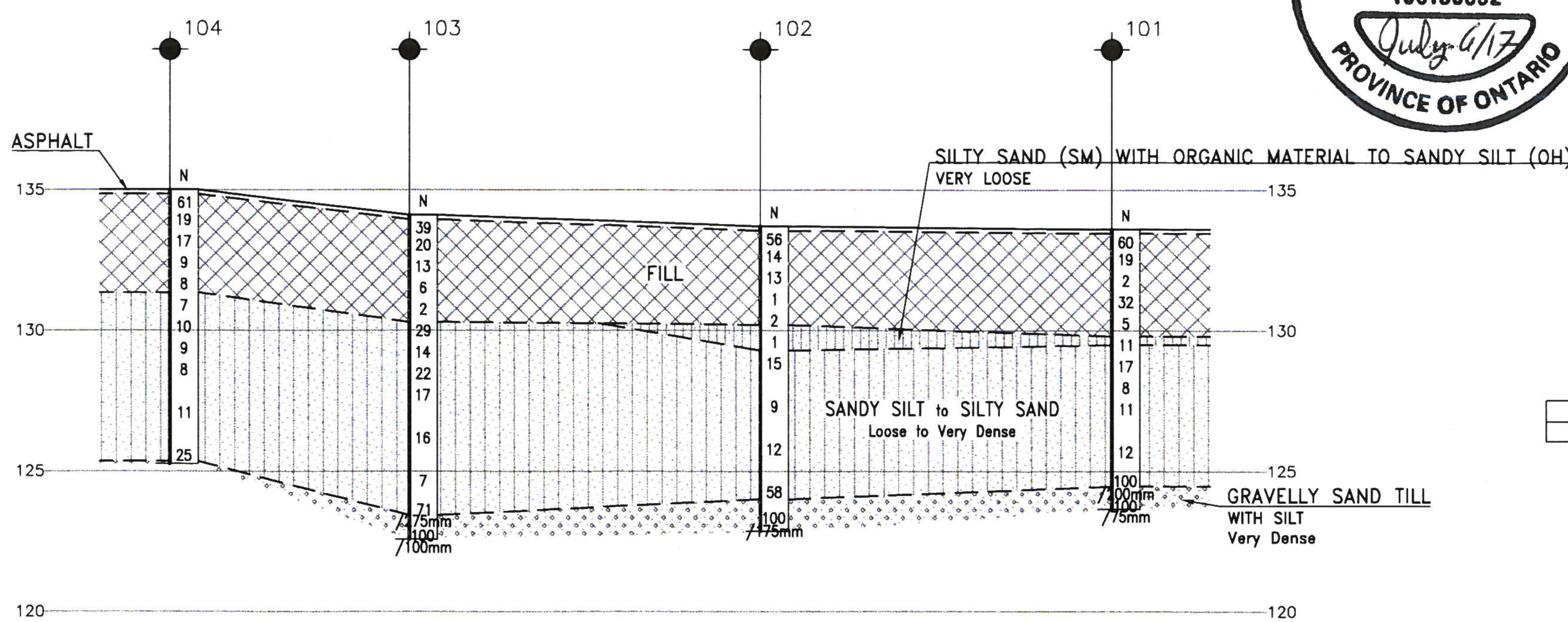
LEA / McINTOSH PERRY Joint Venture

THURBER ENGINEERING LTD.



PLAN

SCALE 1:500



SECTION A–A'

H 1:500

V 1:250

LICENSED PROFESSIONAL ENGINEER
K. T. C. POWER
100130652
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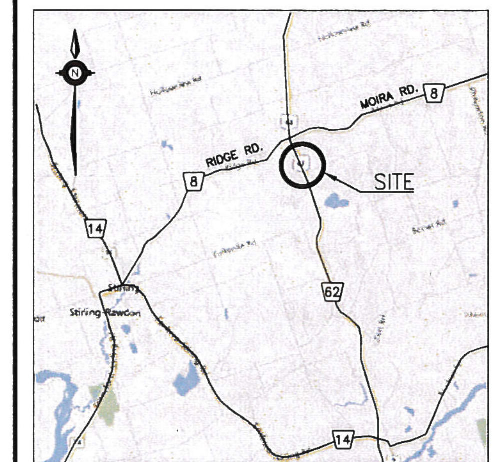
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
July 6/17
PROVINCE OF ONTARIO



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
	Borehole (Thurber Pavement 2016)
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
101	133.6	4 911 417.0	226 832.9
102	133.7	4 911 438.4	226 820.1
103	134.1	4 911 459.9	226 807.3
104	134.9	4 911 474.7	226 799.0
105	132.4	4 911 468.4	226 788.1
106	131.2	4 911 450.9	226 791.9
107	130.8	4 911 428.4	226 803.2
108	130.7	4 911 405.3	226 812.6
109	130.9	4 911 422.6	226 818.8
110	131.1	4 911 443.8	226 803.5
16-3	131.4	4 911 384.3	226 831.1
16-4	131.4	4 911 402.0	226 824.8

-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. 31C-261

REVISIONS	DATE	BY	DESCRIPTION			
DESIGN KP	CHK –	CODE	LOAD		DATE JUL 2017	
DRAWN AN	CHK KP	SITE 11-134	STRUCT	DWG 1		

FILENAME: H:\Drafting\18000\18115\TED-18115-BHPP-RC.dwg
PLOTDATE: 7/6/2017 11:41 AM

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

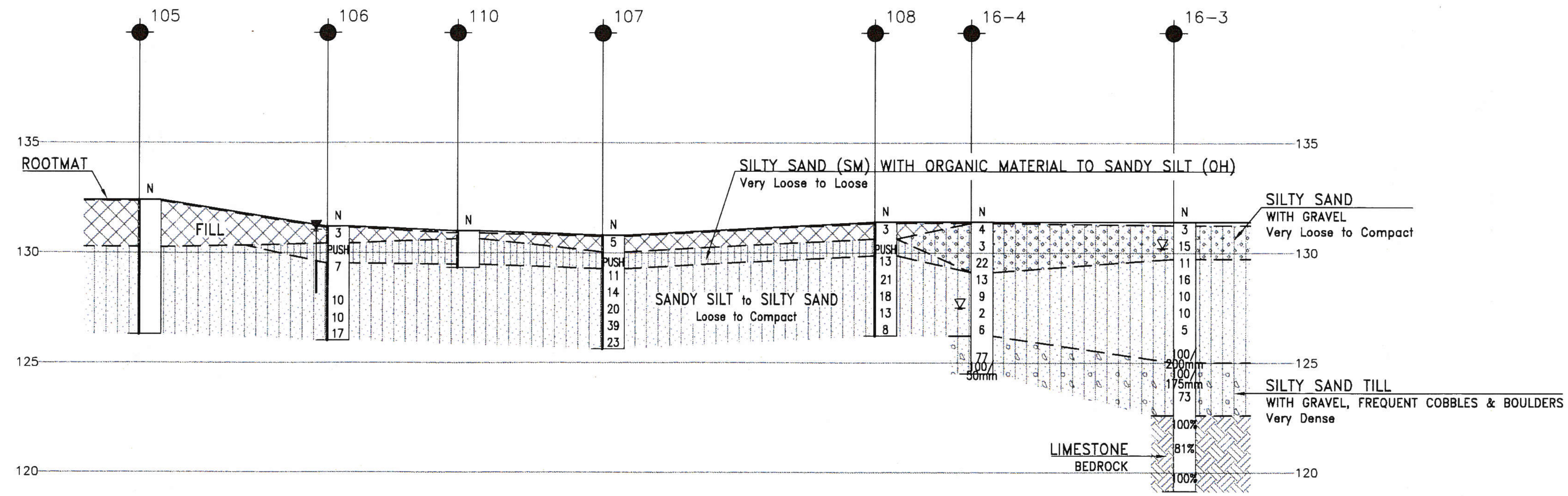
CONT No 2017-4001
GWP No 4044-10-00

HIGHWAY 62
RAWDON CREEK
BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

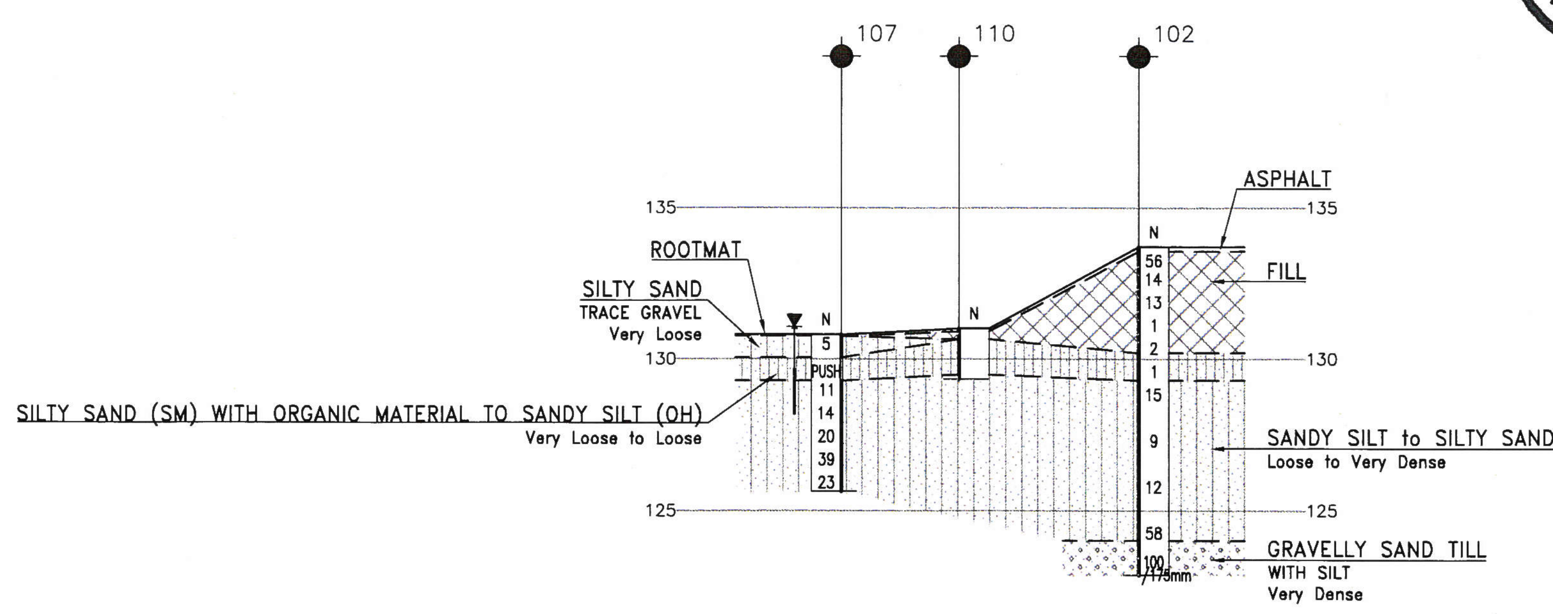
LEA McINTOSH PERRY Joint Venture

THURBER ENGINEERING LTD.



SECTION B-B'

H 1:500
V 1:250



SECTION C-C'

H 1:500
V 1:250

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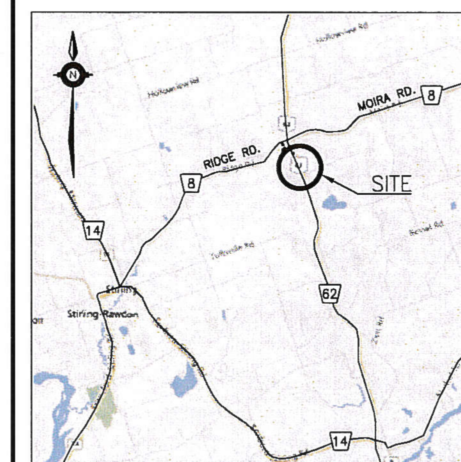
P. K. CHATTERJI
PROVINCE OF ONTARIO



KEYPLAN

LEGEND

Symbol	Description
●	Borehole
⊕	Borehole and Cone
⊕	Borehole (Thurber Pavement 2016)
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
101	133.6	4 911 417.0	226 832.9
102	133.7	4 911 438.4	226 820.1
103	134.1	4 911 459.9	226 807.3
104	134.9	4 911 474.7	226 799.0
105	132.4	4 911 468.4	226 788.1
106	131.2	4 911 450.9	226 791.9
107	130.8	4 911 428.4	226 803.2
108	130.7	4 911 405.3	226 812.6
109	130.9	4 911 422.6	226 818.8
110	131.1	4 911 443.8	226 803.5
16-3	131.4	4 911 384.3	226 831.1
16-4	131.4	4 911 402.0	226 824.8

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3) Borehole locations are shown in MTM Zone 9 coordinates.

GEOCRES No. 31C-261

REVISIONS	DATE	BY	DESCRIPTION

DESIGN KP	CHK -	CODE	LOAD	DATE JUL 2017
DRAWN AN	CHK KP	SITE 11-134	STRUCT	DWG 2

FILENAME: H:\Drafting\18000\18115\TED-18115-BHPP-RC.dwg
PLOTDATE: 7/6/2017 11:41 AM

APPENDIX B

RECORD OF BOREHOLE SHEETS – EMBANKMENT INVESTIGATION
RECORD OF BOREHOLE SHEETS – RAWDON CREEK BRIDGE INVESTIGATION

THURBER

60 YEARS

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:

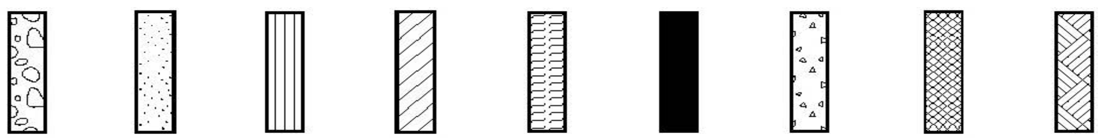
Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented,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

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

MODIFIED UNIFIED SOIL CLASSIFICATION

<table>
<tr><th colspan="2">Major Divisions</th><th>Group Symbol</th><th>Typical Description</th></tr>
<tr><td rowspan="8">COARSE GRAINED SOIL</td><td rowspan="4">GRAVEL AND GRAVELLY SOILS</td><td>GW</td><td>Well-graded gravels or gravel-sand mixtures, little or no fines.</td></tr>
<tr><td>GP</td><td>Poorly-graded gravels or gravel-sand mixtures, little or no fines.</td></tr>
<tr><td>GM</td><td>Silty gravels, gravel-sand-silt mixtures.</td></tr>
<tr><td>GC</td><td>Clayey gravels, gravel-sand-clay mixtures.</td></tr>
<tr><td rowspan="4">SAND AND SANDY SOILS</td><td>SW</td><td>Well-graded sands or gravelly sands, little or no fines.</td></tr>
<tr><td>SP</td><td>Poorly-graded sands or gravelly sands, little or no fines.</td></tr>
<tr><td>SM</td><td>Silty sands, sand-silt mixtures.</td></tr>
<tr><td>SC</td><td>Clayey sands, sand-clay mixtures.</td></tr>
<tr><td rowspan="9">FINE GRAINED SOILS</td><td rowspan="3">SILT AND CLAY SOILS $W_L < 35\%$</td><td>ML</td><td>Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.</td></tr>
<tr><td>CL</td><td>Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.</td></tr>
<tr><td>OL</td><td>Organic silts and organic silty-clays of low plasticity.</td></tr>
<tr><td rowspan="3">SILT AND CLAY SOILS $35\% < W_L < 50\%$</td><td>MI</td><td>Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.</td></tr>
<tr><td>CI</td><td>Inorganic clays of medium plasticity, silty clays.</td></tr>
<tr><td>OI</td><td>Organic silty clays of medium plasticity.</td></tr>
<tr><td rowspan="3">SILT AND CLAY SOILS $W_L > 50\%$</td><td>MH</td><td>Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.</td></tr>
<tr><td>CH</td><td>Inorganic clays of high plasticity, fat clays.</td></tr>
<tr><td>OH</td><td>Organic clays of high plasticity, organic silts.</td></tr>
<tr><td colspan="2">HIGHLY ORGANIC SOILS</td><td>Pt</td><td>Peat and other organic soils.</td></tr>
</table>

Note - W_L= Liquid Limit

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 101

METRIC

W.P.	4015-E-0015	LOCATION	Hwy 62 STN 12+525 2.1 LT CL N 4 911 417.0 E 226 832.9	ORIGINATED BY	JM
HWY	62	BOREHOLE TYPE	Hollow Stem Auger	COMPILED BY	KCP
DATUM	Geodetic	DATE	2017.04.10 - 2017.04.10	CHECKED BY	KCP

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
133.6						
0.0	**150 mm ASPHALT**					
0.2	Silty sand with gravel Very dense to very loose Brown **FILL**	1	SS	60	133	
		2	SS	19		16 52 32 (SI+CL)
		3	SS	2	132	
	- Frequent cobbles from 1.8 m to 2.4 m					
131.0 / 2.6	Sandy clay Firm Brown **FILL**	4	SS	32	131	
		5	SS	5		4 35 45 16
129.8 / 3.8	**Silty SAND (SM) with organics** Loose Dark brown to black	6	SS	11	130	16.0% organic content
129.5 / 4.1	**Sandy GRAVEL (GP)** Compact Brown					
129.1 / 4.6	**Silty SAND (SM) to Sandy Silt (ML)** trace gravel Loose to compact Brown	7	SS	17	129	3 46 51 (SI+CL)
		8	SS	8	128	
		9	SS	11	127	
		10	SS	12	126	0 50 50 (SI+CL)
					125	
124.5 / 9.1	**Gravelly SAND (SM)** with silt **TILL** Very dense Grey	11	SS	100 /200mm	124	21 57 22 (SI+CL)
123.7		12	SS	100		

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

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

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

ONTMT4S 18115 RAWDON CREEK 2017-04-06.GPJ 2012TEMPLATE(MTO).GDT 7/6/17

RECORD OF BOREHOLE No 101

METRIC

W.P.	4015-E-0015	LOCATION	Hwy 62 STN 12+525 2.1 LT CL N 4 911 417.0 E 226 832.9	ORIGINATED BY	JM
HWY	62	BOREHOLE TYPE	Hollow Stem Auger	COMPILED BY	KCP
DATUM	Geodetic	DATE	2017.04.10 - 2017.04.10	CHECKED BY	KCP

ELEV / DEPTH	SOIL PROFILE – 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										
10.0	End of Borehole Auger refusal on inferred bedrock				/75mm						

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 102

METRIC

W.P.	4015-E-0015	LOCATION	Hwy 62 STN 12+550 2.4 LT CL N 4 911 438.4 E 226 820.1	ORIGINATED BY	JM
HWY	62	BOREHOLE TYPE	Hollow Stem Auger	COMPILED BY	KCP
DATUM	Geodetic	DATE	2017.04.05 - 2017.04.05	CHECKED BY	KCP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
133.7								
0.0	**150 mm ASPHALT**							
0.2	Gravelly sand with silt, Very dense, Brown, **FILL**	1	SS	56				
132.9 / 0.8	Silty sand with gravel and occassional cobbles, Compact, Brown, **FILL**	2	SS	14				
		3	SS	13				
131.4 / 2.3	Silt with sand, Very loose, Brown to grey, **FILL**	4	SS	1				
		5	SS	2	5	20	53	22
130.2 / 3.5	**Sandy Organic SILT (OH)**, Very loose, Dark brown to black	6	SS	1	2	32	48	18
129.3 / 4.4	**Silty SAND (SM)** trace gravel, Loose to compact, Brown	7	SS	15				
		8	SS	9				
		9	SS	12	1	78	21 (SI+CL)	
		10	SS	58				
123.7								

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (133, 132, 131, 130, 129, 128, 127, 126, 125, 124); 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 Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

ONTMT4S 18115 RAWDON CREEK 2017-04-06.GPJ 2012TEMPLATE(MTO).GDT 7/6/17

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 102

METRIC

W.P. 4015-E-0015 | LOCATION Hwy 62 STN 12+550 2.4 LT CL N 4 911 438.4 E 226 820.1 | ORIGINATED BY JM

HWY 62 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY KCP

DATUM Geodetic | DATE 2017.04.05 - 2017.04.05 | CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"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										
10.0	**Gravelly SAND (SM)** with silt **TILL** Very dense Grey										
122.9			11	SS	100		123		○		
10.8	End of Borehole Auger refusal on inferred bedrock				/175mm						

+ 3, × 3: Numbers refer to Sensitivity

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

ONTMT4S 18115 RAWDON CREEK 2017-04-06.GPJ 2012TEMPLATE(MTO).GDT 7/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 103

METRIC

W.P. 4015-E-0015 LOCATION Hwy 62 STN 12+575 2.6 LT CL N 4 911 459.9 E 226 807.3 ORIGINATED BY JM

HWY 62 BOREHOLE TYPE Hollow Stem Auger COMPILED BY KCP

DATUM Geodetic DATE 2017.04.05 - 2017.04.05 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
134.1					
0.0	**150 mm ASPHALT**				
0.2	Silty sand with gravel Dense Brown **FILL**	1	SS	39	
		2	SS	20	
		3	SS	13	
		4	SS	6	
131.3 / 2.8	Sandy clay Soft Brown to grey **FILL**	5	SS	2	0 35 47 18
130.3 / 3.8	**Silty SAND (SM)** Loose to compact Brown	6	SS	29	1 60 39 (SI+CL)
		7	SS	14	
		8	SS	22	
		9	SS	17	
		10	SS	16	
		11	SS	7	0 74 26 (SI+CL)

Elevation scale: 134, 133, 132, 131, 130, 129, 128, 127, 126, 125

Column headings: 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 γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity   20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 103

METRIC

W.P. 4015-E-0015 | LOCATION Hwy 62 STN 12+575 2.6 LT CL N 4 911 459.9 E 226 807.3 | ORIGINATED BY JM

HWY 62 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY KCP

DATUM Geodetic | DATE 2017.04.05 - 2017.04.05 | CHECKED BY KCP

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty SAND (SM) Loose to compact						124				
123.5 / 10.7	**Gravelly SAND (SM)** with silt **TILL** Very dense grey		12	SS	71 /275mm		123		o		
122.6 / 11.5			13	SS	100 /100mm				o		
	End of Borehole Splitspoon refusal on inferred bedrock										

Legend: DCPT 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.

+ 3, × 3: Numbers refer to Sensitivity

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

ONTMT4S 18115 RAWDON CREEK 2017-04-06.GPJ 2012TEMPLATE(MTO).GDT 7/6/17

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 104

METRIC

W.P.	4015-E-0015	LOCATION	Hwy 62 STN 12+600 2.4 LT CL N 4 911 474.7 E 226 799.0	ORIGINATED BY	JM
HWY	62	BOREHOLE TYPE	Hollow Stem Auger	COMPILED BY	KCP
DATUM	Geodetic	DATE	2017.04.05 - 2017.04.05	CHECKED BY	KCP

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT
135.0		
0.0	**150 mm ASPHALT**	
0.2	Silty sand with gravel Very dense Brown **FILL**	
132.6	- organics 2.1 m to 2.15 m	
2.3	Sandy clay Firm to stiff Brown to grey **FILL**	
131.3 / 3.7	**Silty SAND (SM)** Loose to compact Brown	
125.6 / 9.4	**Gravelly SAND (SM)** with silt **TILL** Very dense Brown	
125.2 / 9.8	End of Borehole	

SAMPLES, WATER CONTENT AND REMARKS

NUMBER	TYPE	"N" VALUES	Elevation scale (approx.)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	61		
2	SS	19	134	
3	SS	17	133	
4	SS	9		
5	SS	8	132	
6	SS	7	131	
7	SS	10	130	3 57 40 (SI+CL)
8	SS	9	129	
9	SS	8	128	0 62 38 (SI+CL)
10	SS	11	127	
			126	
11	SS	25		3 72 25 (SI+CL)

Column headings: 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

+3, ×3: Numbers refer to Sensitivity

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

ONTMT4S 18115 RAWDON CREEK 2017-04-06.GPJ 2012TEMPLATE(MTO).GDT 7/6/17

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 105

METRIC

W.P. 4015-E-0015 | LOCATION Hwy 62 STN 12+592 15 LT CL N 4 911 468.4 E 226 788.1 | ORIGINATED BY JM

HWY 62 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY KCP

DATUM Geodetic | DATE 2017.04.03 - 2017.04.03 | CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
132.4							
0.0 / 0.1	**Rootmat**						
	Sandy clay Firm to stiff Brown to grey **FILL**	1	SS	4		132	
		2	SS	9			
		3	SS	10		131	0 6 43 51
130.3 / 2.1	**Silty SAND (SM)** Loose to compact Brown	4	SS	11		130	
		5	SS	8		129	3 54 43 (SI+CL)
		6	SS	10		128	
		1.5	SS	7			
127.3 / 5.2	End of Borehole						

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

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 106

METRIC

W.P.	4015-E-0015	LOCATION	Hwy 62 STN 12+575 20.5 LT CL N 4 911 450.9 E 226 791.9	ORIGINATED BY	JM
HWY	62	BOREHOLE TYPE	Hollow Stem Auger	COMPILED BY	KCP
DATUM	Geodetic	DATE	2017.04.03 - 2017.04.03	CHECKED BY	KCP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
131.2 / 0.0	**Rootmat**					
0.1	Silty sand trace gravel, Loose, Brown, **FILL**	1	SS	3		
130.4 / 0.8	**Sandy Organic SILT (OH)**, Black	2	ST	PUSH	197, 151, 172	35.2% organic content; 33.7% organic content
129.5 / 1.7	**Silty SAND (SM) to Sandy SILT (ML)**, Loose to compact, Brown	3	SS	7		
		4	SS	10		
		5	SS	10		
126.6 / 4.6	**CLAY (CH)**, Very stiff, Brown	6	SS	17		0 2 37 61
126.0 / 5.2	End of Borehole. Groundwater level was measured in piezometer at 0.16 BGS (elev. 131.0 m) on 2017-04-10					

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (131, 130, 129, 128, 127, 126); 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.

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 107

METRIC

W.P. 4015-E-0015 LOCATION Hwy 62 STN 12+550 22 LT CL N 4 911 428.4 E 226 803.2 ORIGINATED BY JM

HWY 62 BOREHOLE TYPE Hollow Stem Auger COMPILED BY KCP

DATUM Geodetic DATE 2017.04.03 - 2017.04.03 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	NATURAL MOISTURE CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
130.8						
0.0	**Rootmat**					
0.1	Silty sand trace gravel, Loose, Grey, **FILL**	1	SS	5		
130.0 / 0.8	**Silty SAND (SM) with organics**, Black	2	ST	PUSH		0 51 49 0; 13.8% organic content
129.2 / 1.5	**Sandy GRAVEL (GP)**, Compact, Brown	3	SS	11		56 39 5 (SI+CL)
128.6 / 2.1	**Silty SAND (SM)**, Compact to dense, Brown	4	SS	14		
		5	SS	20		
		6	SS	39		
		7	SS	23		1 85 14 (SI+CL)
125.6 / 5.2	End of Borehole					

Elevation scale: 130, 129, 128, 127, 126

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m^3

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 108

METRIC

W.P. 4015-E-0015	LOCATION Hwy 62 STN 12+525 25.5 LT CL N 4 911 405.3 E 226 812.6		ORIGINATED BY JM
HWY 62	BOREHOLE TYPE Hollow Stem Auger		COMPILED BY KCP
DATUM Geodetic	DATE 2017.04.03 - 2017.04.03		CHECKED BY KCP

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
130.7							
0.0 / 0.1	**Rootmat**						
	Silty sand trace gravel, Very loose, Grey, **FILL**	1	SS	3		o	0 67 33 (SI+CL)
129.9 / 0.8	**Silty SAND (SM) with organics**, Black				130		
		2	ST	PUSH		87	0 66 34 0; 16.2% organic content
129.2 / 1.5	**Silty SAND (SM) to Sandy SILT (ML)**, Loose to compact, Brown	3	SS	13	129	o	
		4	SS	21	128	o	
		5	SS	18	127	o	
		6	SS	13		o	0 35 65 (SI+CL)
		7	SS	8	126	o	
125.5 / 5.2	End of Borehole						

Column headings: SOIL PROFILE; STRAT PLOT; 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 γ kN/m^3

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 109

METRIC

W.P.	4015-E-0015	LOCATION	Hwy 62 STN 12+537 11.5 LT CL N 4 911 425.9 E 226 824.6	ORIGINATED BY	JM
HWY	62	BOREHOLE TYPE	Solid Stem Auger	COMPILED BY	KCP
DATUM	Geodetic	DATE	2017.04.03 - 2017.04.03	CHECKED BY	KCP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	SAMPLE TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
130.9												
0.0 / 0.1	**Rootmat**											
130.5 / 0.4	Sandy clay, Brown, **FILL**	1	AS									
	Silty SAND (SM) with organics, Black	2	AS			130			0	74	21	5
129.8 / 1.0	**Silty SAND (SM)**, Grey											
129.2 / 1.7	End of Borehole											

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; 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); REMARKS & GRAIN SIZE DISTRIBUTION (%).

+³, ×³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 110

METRIC

W.P. 4015-E-0015	LOCATION Hwy 62 STN 12+537 11.5 LT CL N 4 911 443.8 E 226 803.5	ORIGINATED BY JM
HWY 62	BOREHOLE TYPE Solid Stem Auger	COMPILED BY KCP
DATUM Geodetic	DATE 2017.04.03 - 2017.04.03	CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
131.1										
0.0 / 0.1	**Rootmat**					131				
130.8 / 0.4	Sandy clay, Brown, **FILL**									
129.6 / 1.5	**Sandy Organic SILT (OH)**, Black	1	AS			130		172		0 14 75 11; 27.9% organic content
129.5 / 1.7	**Silty SAND (SM)**, Grey									
	End of Borehole									

Legend: SHEAR STRENGTH kPa — ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE. Plastic limit w_P, natural moisture content w, liquid limit w_L.

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-3

METRIC

GWP# 4044-10-00 | LOCATION Highway 62 Rawdon Creek Bridge, MTM Zone 9: N 4 911 384.3 E 226 831.1 | ORIGINATED BY CAM

HWY 62 | BOREHOLE TYPE Hollow Stem Auger / HQ Coring | COMPILED BY CAM

DATUM Geodetic | DATE 2016.10.03 - 2016.10.03 | CHECKED BY KCP

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
131.4					
0.0	**150 mm ROOTMAT**				
0.2	**Silty SAND (SM)** with gravel Very loose to compact Brown	1	SS	3	
		2	SS	15	
129.7 1.7	**Sandy SILT (ML)** to **Silty SAND (SM)** Loose to compact Brown	3	SS	11	
		4	SS	16	
		5	SS	10	0 28 69 3
		6	SS	10	0 43 57 (SI+CL)
		7	SS	5	
		8	SS	100/ 200mm	
125.0 6.4	**Silty SAND (SM)** with gravel, **TILL** - frequent cobbles and occasional boulders Very dense Brown	9	SS	100/ 175mm	
	- Boulder at 7.7 m to 8.0 m	10	SS	73	22 59 19 (SI+CL)
122.6 8.8	**BEDROCK** Limestone Slightly weathered Thinly to moderate bedding Excellent quality Grey	1	HQ		RUN #1 TCR=100% SCR=100% RQD=100%

Elevation scale: 131, 130, 129, 128, 127, 126, 125, 124, 123, 122

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

Continued Next Page

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

RECORD OF BOREHOLE No 16-3

METRIC

GWP# 4044-10-00 LOCATION Highway 62 Rawdon Creek Bridge, MTM Zone 9: N 4 911 384.3 E 226 831.1 ORIGINATED BY CAM

HWY 62 BOREHOLE TYPE Hollow Stem Auger / HQ Coring COMPILED BY CAM

DATUM Geodetic DATE 2016.10.03 - 2016.10.03 CHECKED BY KCP

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"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										
	BEDROCK Limestone Slightly weathered Moderate bedding Strong to very strong strength Good to excellent quality Grey		2	HQ			121				RUN #2 TCR=98% SCR=98% RQD=81%
			3	HQ			120				RUN #3 TCR=100% SCR=100% RQD=100%
119.1 12.3	End of Borehole Groundwater level measured in the monitoring well at 0.95 m BGS (elev. 130.5 m) on 2016-10-24										
	Strong to very strong strength										

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-4

METRIC

GWP# 4044-10-00	LOCATION Highway 62 Rawdon Creek Bridge, MTM Zone 9: N 4 911 402.0 E 226 824.8		ORIGINATED BY CAM
HWY 62	BOREHOLE TYPE Hollow Stem Auger		COMPILED BY CAM
DATUM Geodetic	DATE 2016.10.04 - 2016.10.04		CHECKED BY KCP

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
131.4	
131.4 / 0.0 – 0.1	**50 mm ROOTMAT**
0.1	**Silty SAND (SM)** with gravel Very loose to compact Brown to grey **- slight hydro-carbon odour in sample SS3**
129.1 / 2.3	**Sandy SILT (ML)** to **Silty SAND (SM)** Loose to compact Brown
126.2 / 5.2	**Silty SAND (SM)** with gravel, **TILL** - frequent cobbles and occasional boulders Very dense Brown
124.5 / 6.9	End of Borehole Split Spoon refusal on inferred boulder Groundwater level was measured in the open borehole at 3.9 m BGS (elev. 127.5 m)

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	4				
2	SS	3				
3	SS	22				
4	SS	13	6	46	48 (SI+CL)	
5	SS	9				
6	SS	2				
7	SS	6				
8	SS	77	29	50	21 (SI+CL)	
9	SS	100/ 50mm				

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (131, 130, 129, 128, 127, 126, 125); 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.

+ 3, × 3: Numbers refer to Sensitivity

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

APPENDIX C

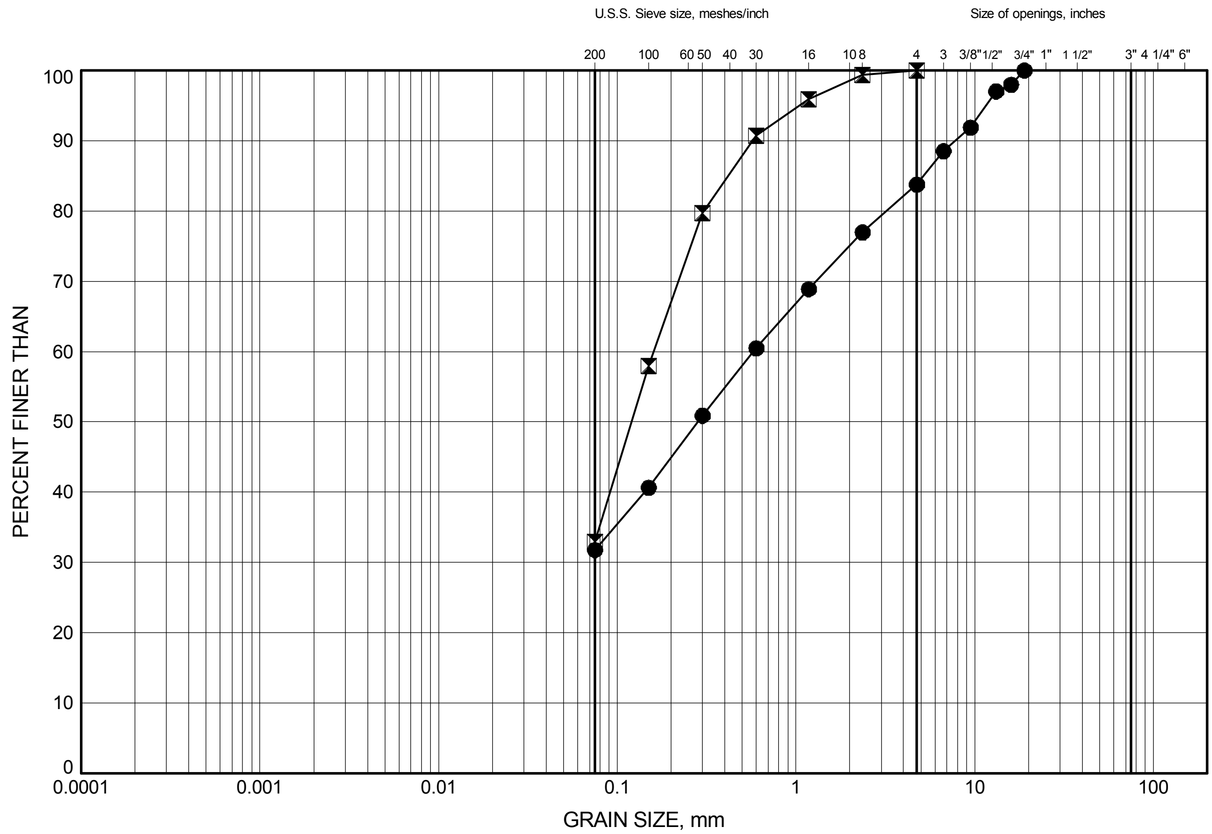
LABORATORY TEST RESULTS

Rawdon Creek

GRAIN SIZE DISTRIBUTION

FIGURE 1

Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	101	1.07	132.57
⧗	108	0.30	130.39

Date May 2017

W.P. 4015-E-0015

THURBER

Prep'd KCP

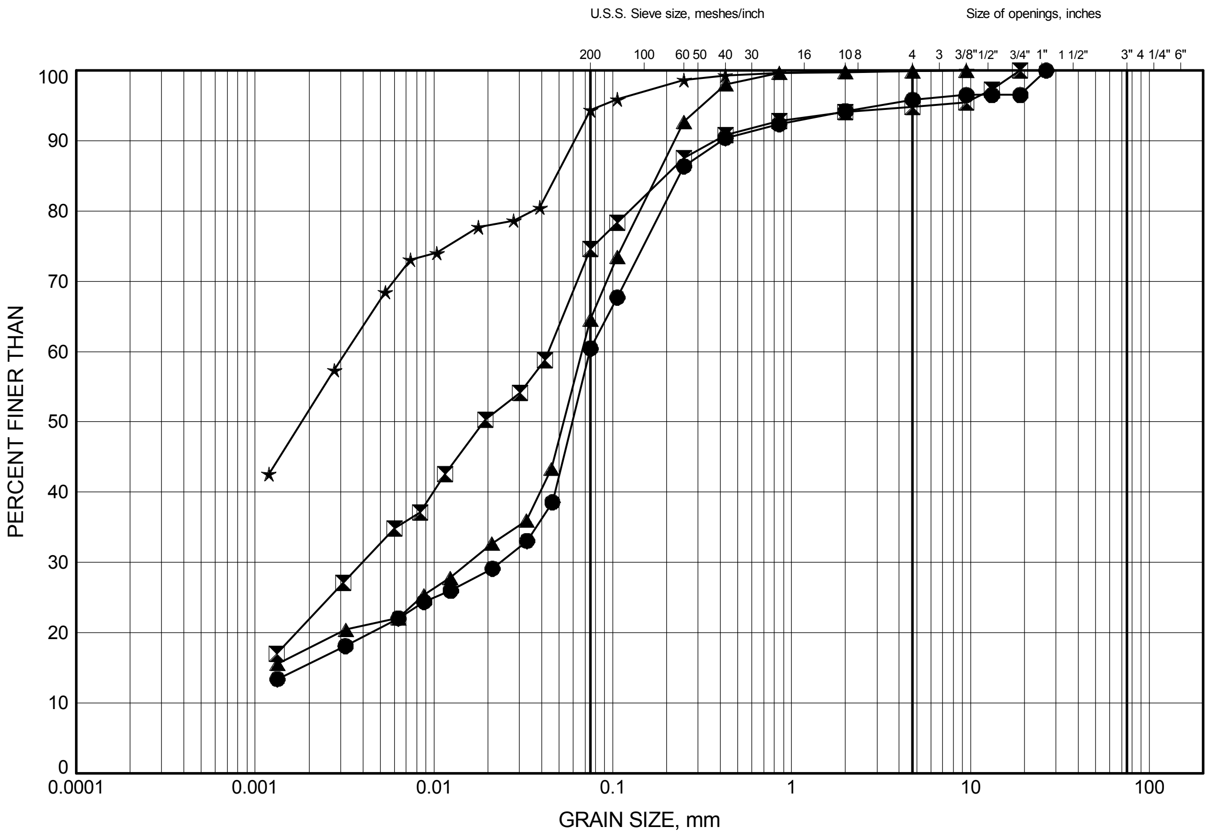
Chkd. PC

Rawdon Creek Highway 62 Embankment

GRAIN SIZE DISTRIBUTION

FIGURE 2

Fill: Sandy Clay to Silt with Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	101	3.35	130.29
⧗	102	3.28	130.43
▲	103	3.35	130.78
★	105	1.83	130.61

Date June 2017

W.P. 4015-E-0015

THURBER

Prep'd KCP

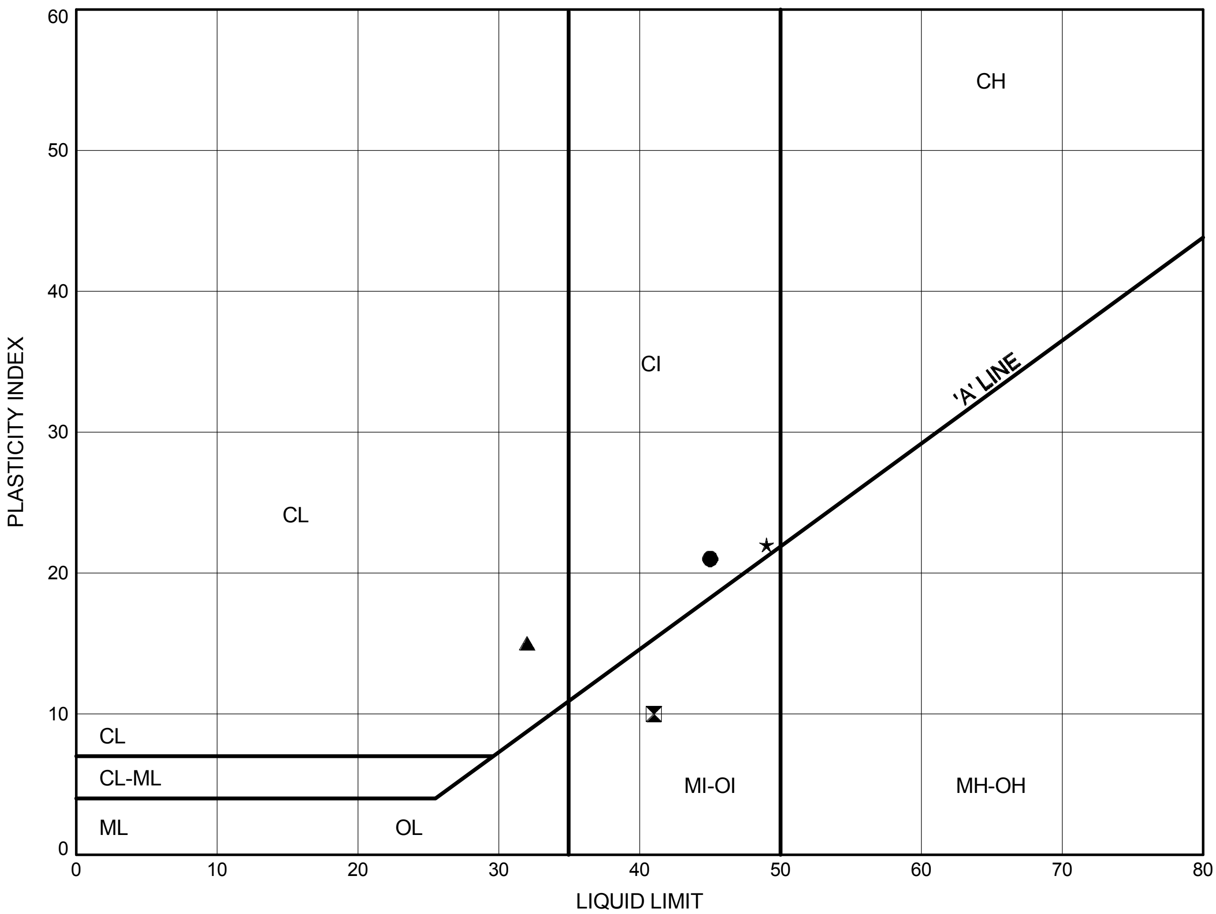
Chkd. PC

Rawdon Creek Highway 62 Embankment

ATTERBERG LIMITS TEST RESULTS

FIGURE 3

FILL: Sandy Clay to Silt with Sand



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	101	3.35	130.29
⧗	102	3.28	130.43
▲	103	3.35	130.78
★	105	1.83	130.61

Date June 2017

W.P. 4015-E-0015

THURBER

Prep'd KCP

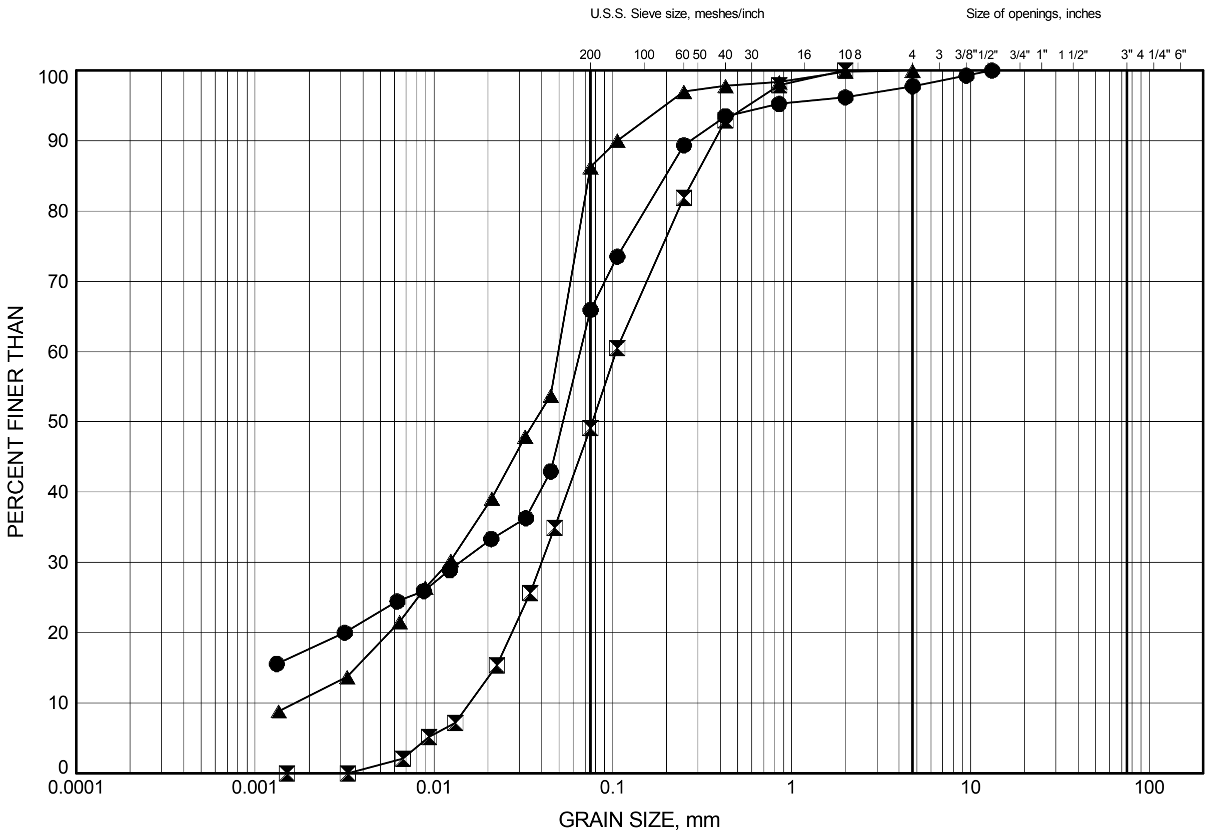
Chkd. PC

Rawdon Creek Highway 62 Embankment

GRAIN SIZE DISTRIBUTION

FIGURE 4

Sandy Organic Silt (OH)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	102	4.04	129.66
⧗	107	1.07	129.69
▲	110	1.22	129.91

Date May 2017

W.P. 4015-E-0015

THURBER

Prep'd KCP

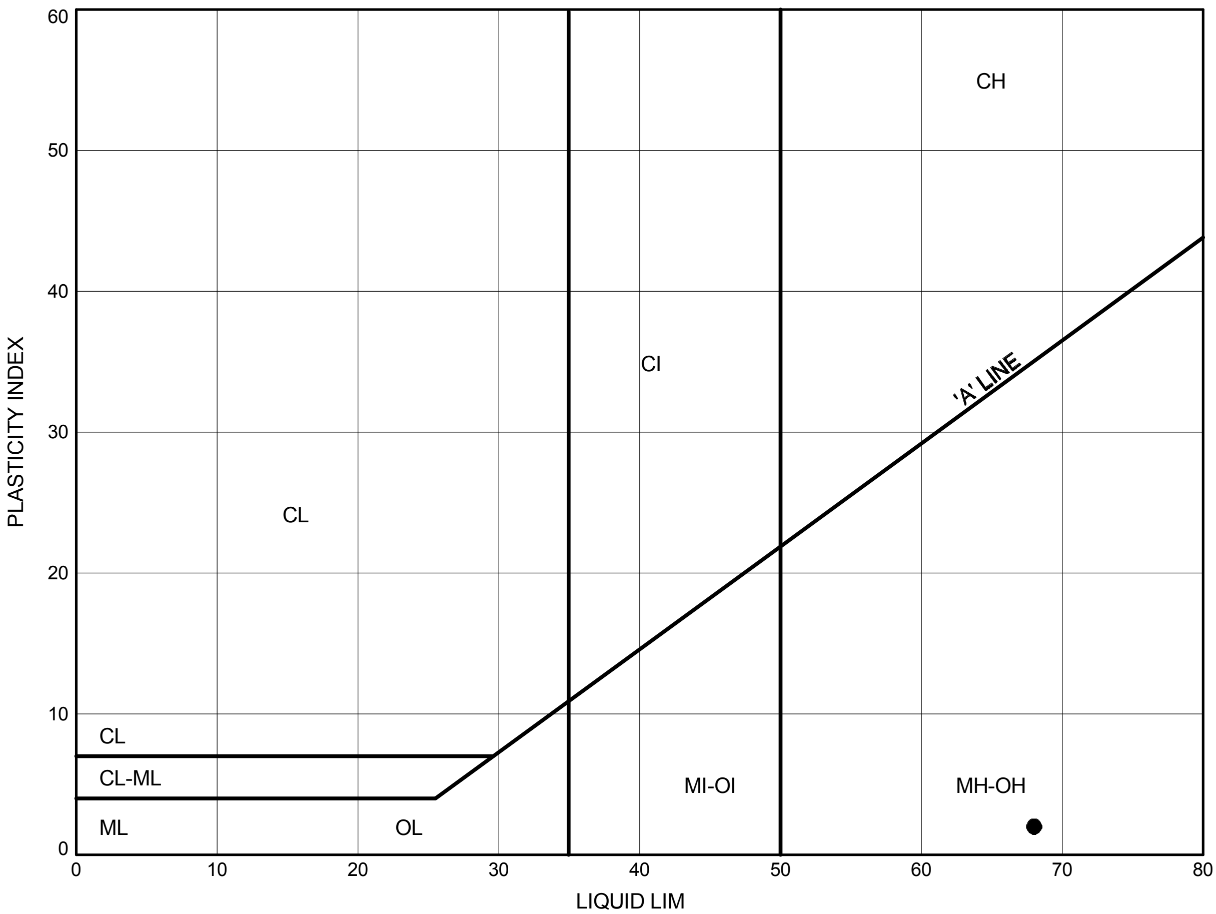
Chkd. PC

Rawdon Creek Highway 62 Embankment

ATTERBERG LIMITS TEST RESULTS

FIGURE 5

Sandy Organic Silt (OH)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	106	1.07	130.09

THURBALT 18115 RAWDON CREEK 2017-04-06.GPJ 29/5/17

Date May 2017

W.P. 4015-E-0015

THURBER

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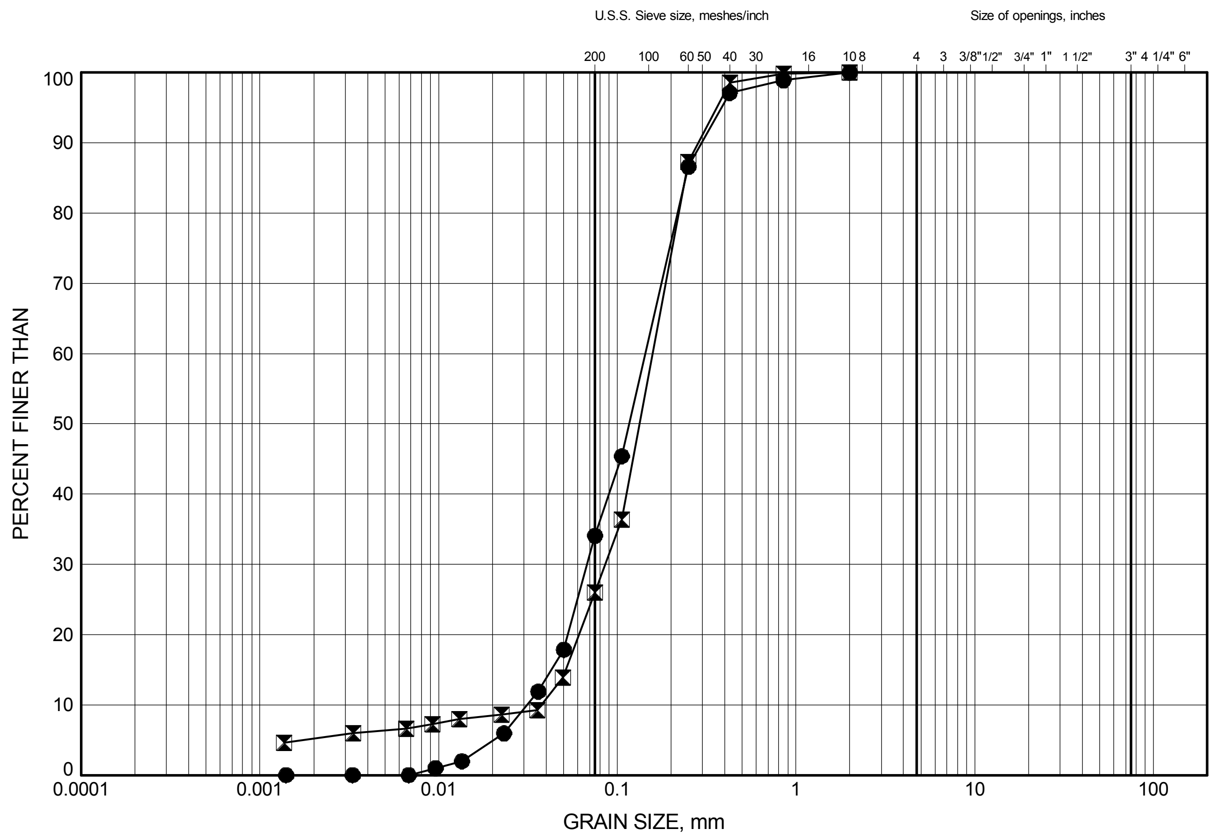
Chkd. PC

Rawdon Creek Highway 62 Embankment

GRAIN SIZE DISTRIBUTION

FIGURE 6

Silty Sand (SM) with organics



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	108	1.07	129.63
⧗	109	0.67	130.18

Date May 2017

W.P. 4015-E-0015

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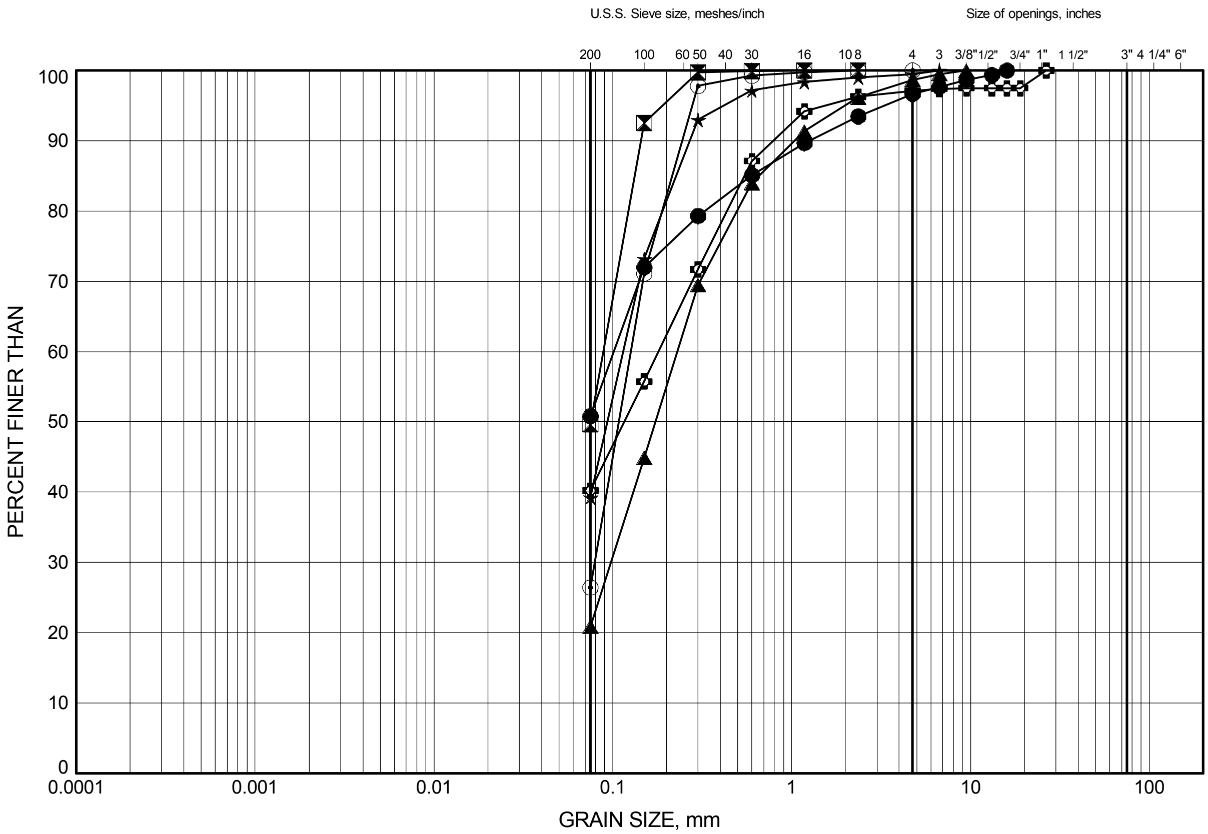
Rawdon Creek Highway 62 Embankment **GRAIN SIZE DISTRIBUTION**	FIGURE 7

Sitly Sand (SM) to Sandy Silt (ML)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	101	4.88	128.76
⧗	101	7.92	125.71
▲	102	7.92	125.78
★	103	4.04	130.09
⊙	103	9.45	124.68
✪	104	4.88	130.08

Date May 2017

W.P. 4015-E-0015

THURBER

Prep'd KCP

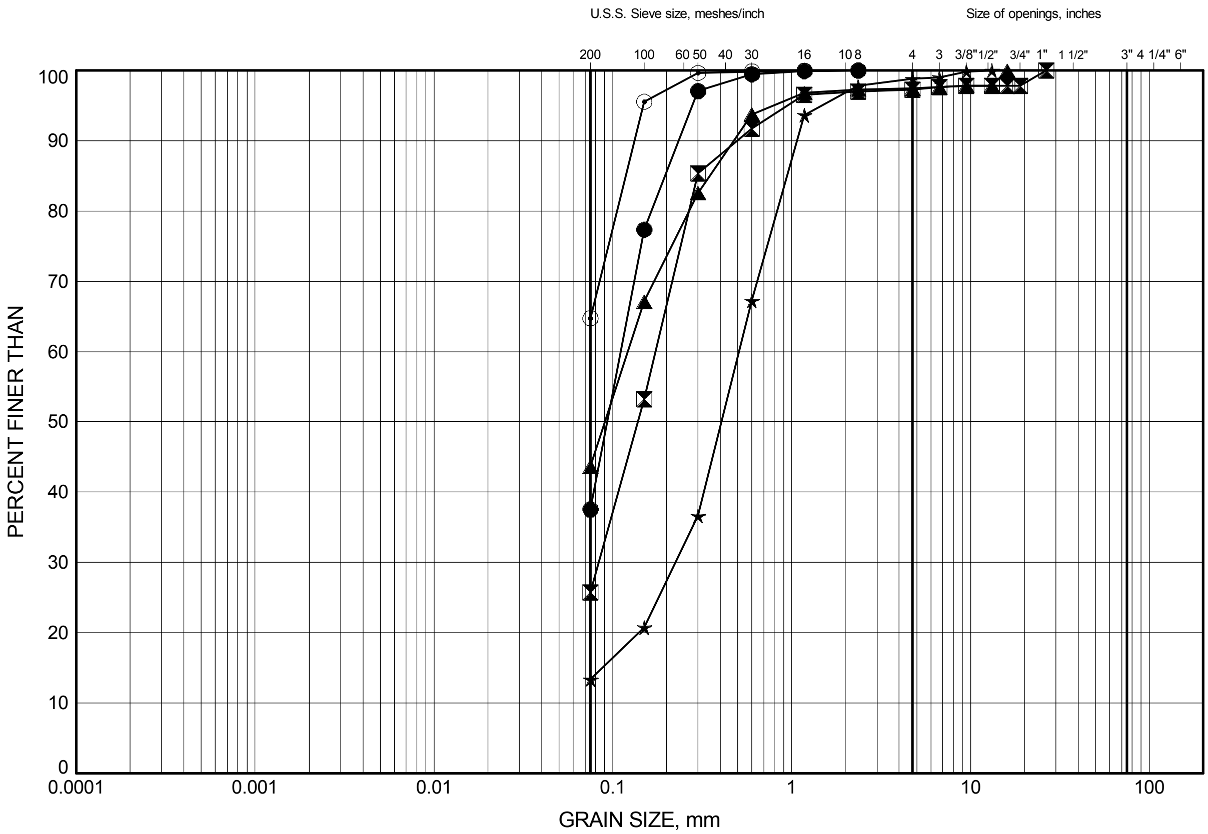
Chkd. PC

Rawdon Creek Highway 62 Embankment

GRAIN SIZE DISTRIBUTION

FIGURE 8

Sitly Sand (SM) to Sandy Silt (ML)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	104	6.40	128.55
⧗	104	9.39	125.57
▲	105	3.35	129.09
★	107	4.88	125.88
⊙	108	4.11	126.58

Date May 2017

W.P. 4015-E-0015

THURBER

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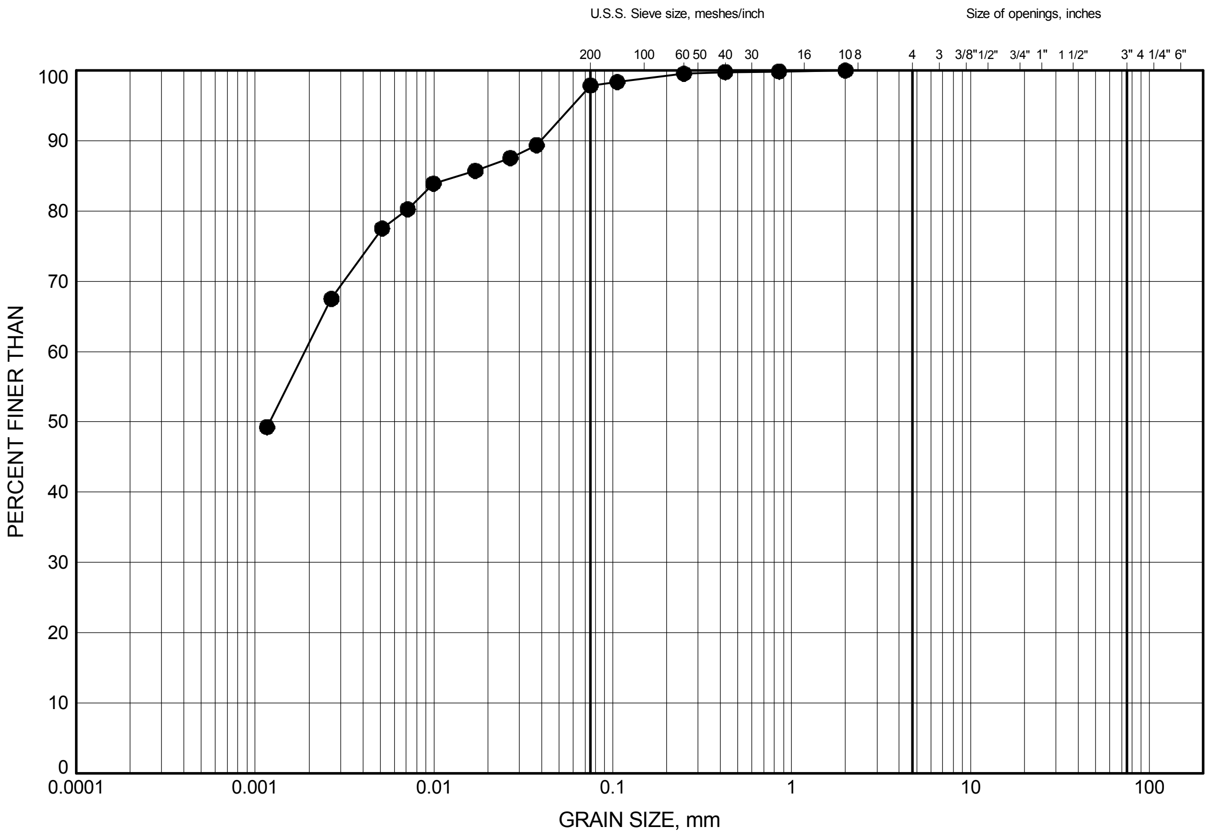
Chkd. PC

Rawdon Creek Highway 62 Embankment

GRAIN SIZE DISTRIBUTION

FIGURE 9

Clay (CH)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	106	4.88	126.28

Date May 2017

W.P. 4015-E-0015

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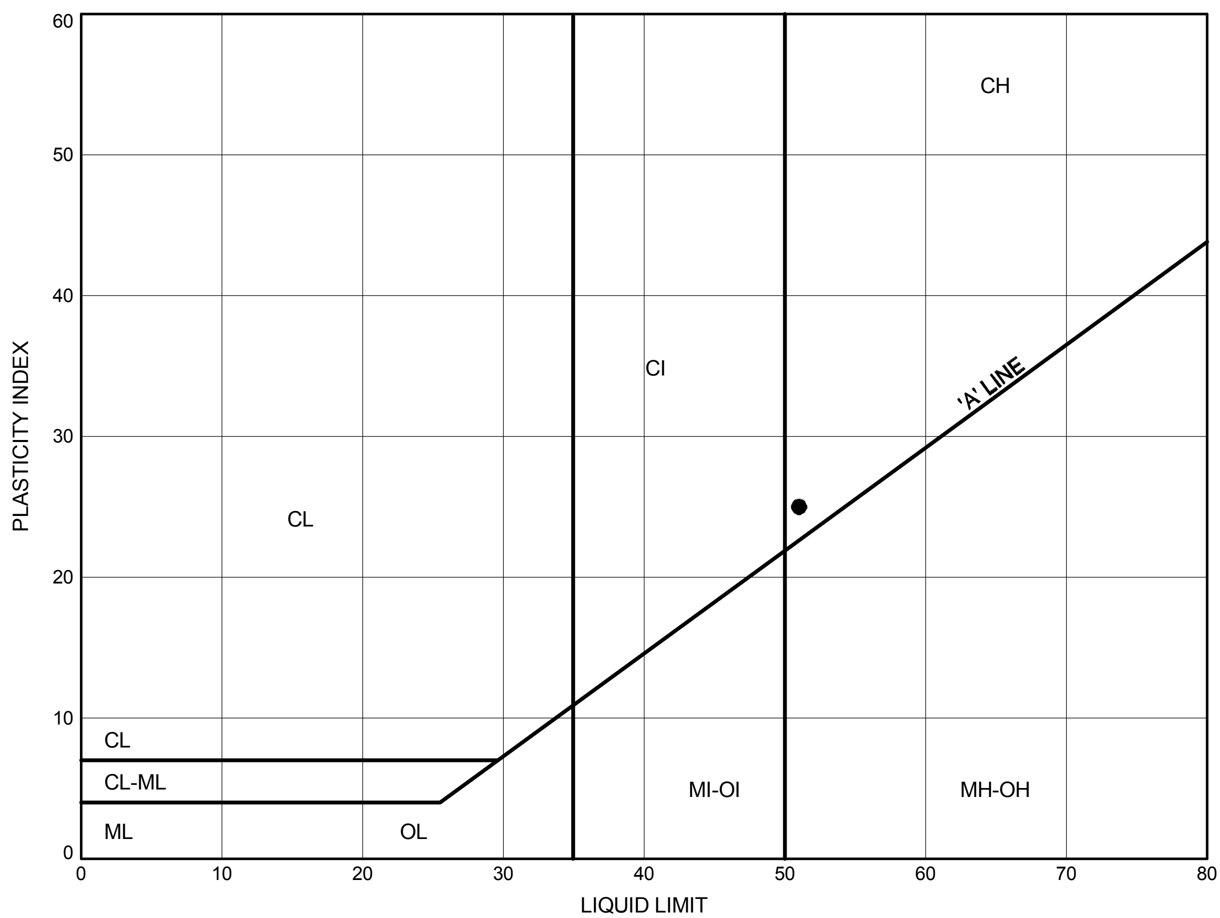
GRAIN SIZE DISTRIBUTION - THURBER 18115 RAWDON CREEK 2017-04-06.GPJ 30/5/17

Rawdon Creek Highway 62 Embankment

ATTERBERG LIMITS TEST RESULTS

FIGURE 10

Clay (CH)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	106	4.88	126.28

Date May 2017

W.P. 4015-E-0015

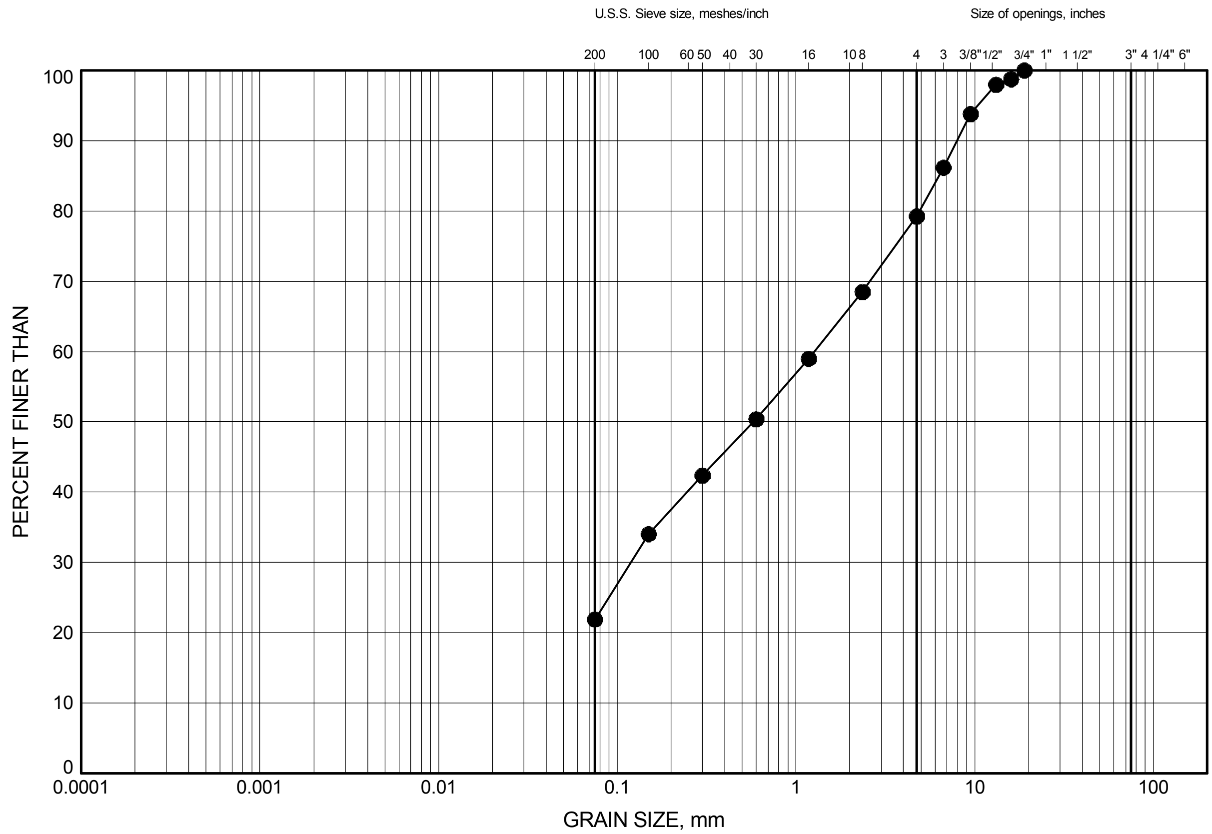
THURBER

Prep'd KCP

Chkd. PC

GRAIN SIZE DISTRIBUTION

Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	101	9.30	124.34

Date May 2017

W.P. 4015-E-0015

THURBER

Prep'd KCP

Chkd. PC

CONSOLIDATION TEST SUMMARY

FIGURE

ASTM D2435/D2435M

SAMPLE IDENTIFICATION

Project Number	1778186(2000)	Sample Number	TW2
Borehole Number	106	Sample Depth, m	0.8 - 1.7

TEST CONDITIONS

Test Type	Laboratory Standard	Load Duration, hr	24
Oedometer Number	9		
Date Started	04/17/2017		
Date Completed	05/01/2017		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.92	Unit Weight, kN/m^3	11.77
Sample Diameter, cm	4.43	Dry Unit Weight, kN/m^3	3.77
Area, cm^2	15.44	Specific Gravity, measured	2.07
Volume, cm^3	29.59	Solids Height, cm	0.355
Water Content, %	212.68	Volume of Solids, cm^3	5.49
Wet Mass, g	35.52	Volume of Voids, cm^3	24.10
Dry Mass, g	11.36	Degree of Saturation, %	100.3

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	1.916	4.391	1.916				
6.14	1.914	4.385	1.915				
11.15	1.891	4.320	1.902	60	1.28E-02	2.40E-03	3.00E-06
21.14	1.853	4.215	1.872	66	1.13E-02	1.96E-03	2.16E-06
41.04	1.776	3.998	1.815	34	2.05E-02	2.02E-03	4.07E-06
81.34	1.648	3.637	1.712	60	1.04E-02	1.66E-03	1.68E-06
161.03	1.481	3.166	1.564	54	9.61E-03	1.10E-03	1.03E-06
318.36	1.289	2.626	1.385	101	4.02E-03	6.37E-04	2.51E-07
641.27	1.095	2.082	1.192	173	1.74E-03	3.13E-04	5.34E-08
1275.38	0.931	1.618	1.013	375	5.80E-04	1.36E-04	7.71E-09
2543.27	0.793	1.230	0.862	778	2.02E-04	5.67E-05	1.12E-09
641.20	0.845	1.379	0.819				
161.12	0.917	1.581	0.881				
40.90	0.994	1.797	0.956				
11.06	1.066	2.000	1.030				

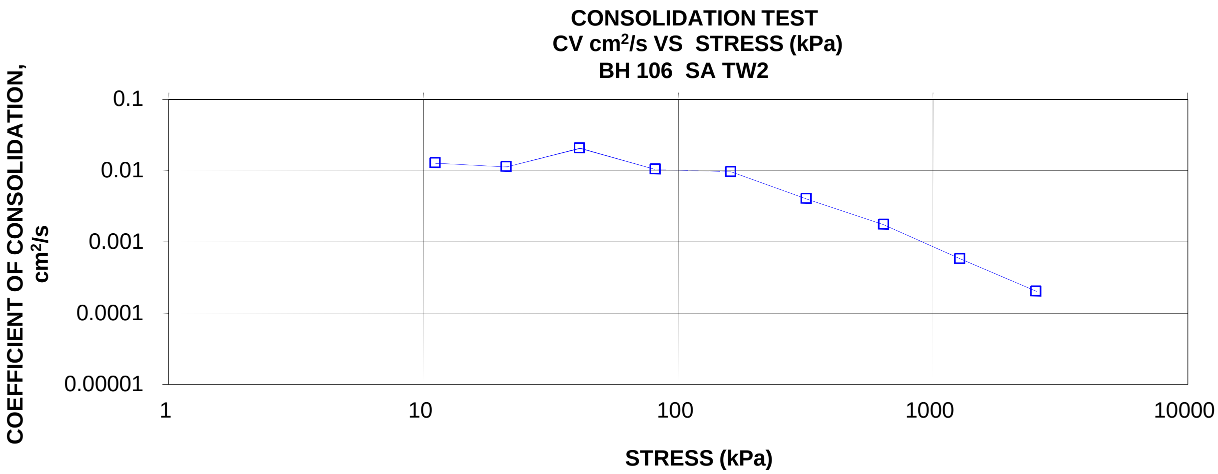
Note:
Consolidation loading and unloading schedule assigned by the client.
cv and k are approximate only based on t90 estimated from Square Root of Time Method (ASTMD2435/2435M)
Specimen taken 9.5-14.5cm from top of the tube.
Specimen swelled under 6.14 kPa.

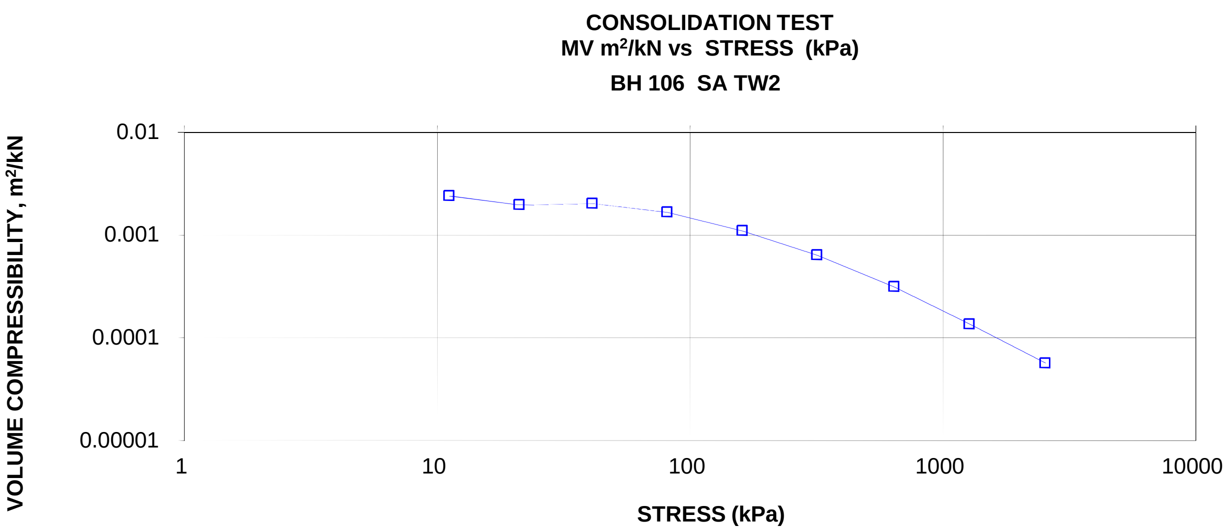
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

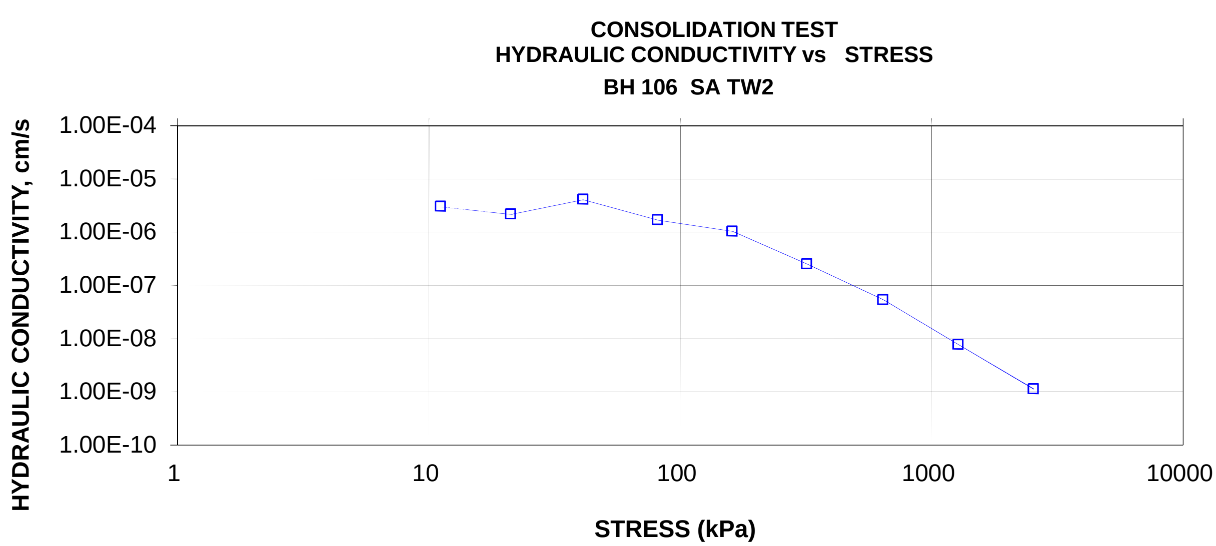
Sample Height, cm	1.07	Unit Weight, kN/m^3	13.62
Sample Diameter, cm	4.43	Dry Unit Weight, kN/m^3	6.77
Area, cm^2	15.44	Specific Gravity, measured	2.07
Volume, cm^3	16.46	Solids Height, cm	0.355
Water Content, %	101.32	Volume of Solids, cm ^{3}	5.49
Wet Mass, g	22.87	Volume of Voids, cm ^{3}	10.98
Dry Mass, g	11.36		

Prepared By: LH **Golder Associates** Checked By: MM

CONSOLIDATION TEST SUMMARY	FIGURE







Project No. 1778186(2000)

Prepared By: LH

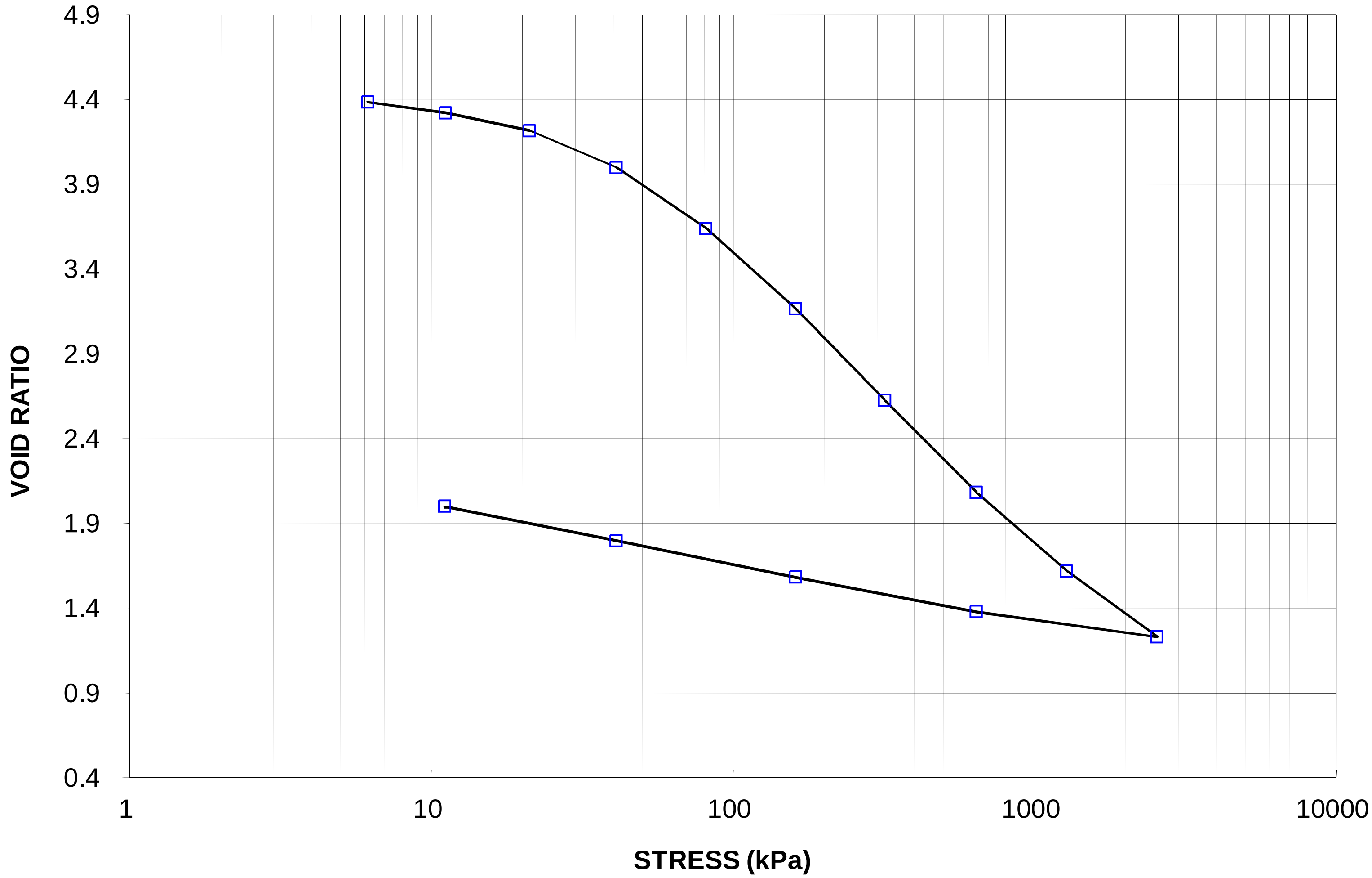
Golder Associates

Checked By: MM

Project No. 1778186(2000)

Prepared By: LH

CONSOLIDATION TEST
VOID RATIO vs STRESS
BH 106 SA TW2



Golder Associates

Checked By: MM

CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE

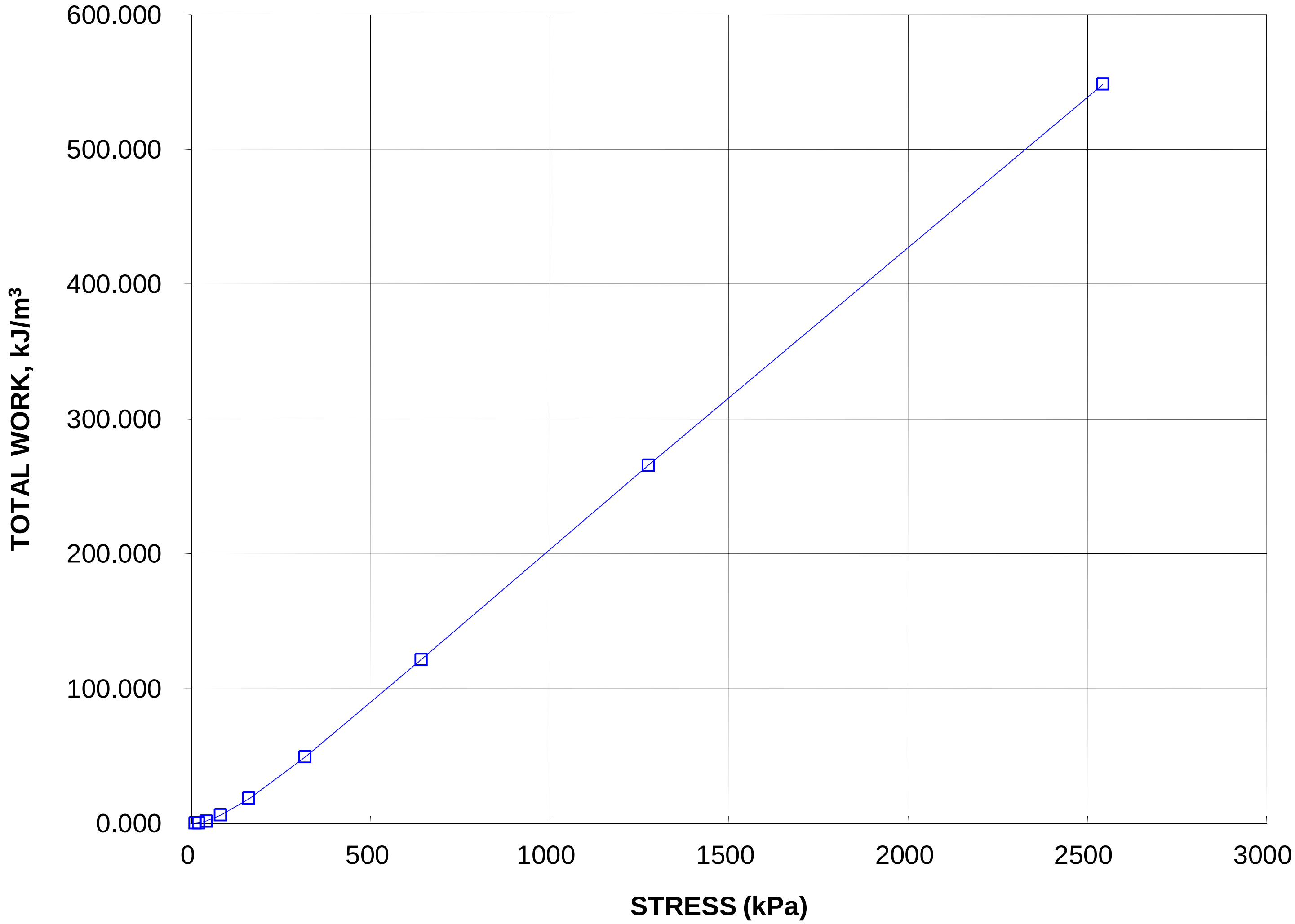
Project No. 1778186(2000)

Prepared By: LH

Golder Associates

Checked By: MM

CONSOLIDATION TEST
TOTAL WORK, kJ/m³ vs STRESS
BH 106 SA TW2



CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE

CONSOLIDATION TEST SUMMARY

FIGURE

ASTM D2435/D2435M

SAMPLE IDENTIFICATION

Project Number	1778186(2000)	Sample Number	TW2
Borehole Number	108	Sample Depth, m	0.8 - 1.5

TEST CONDITIONS

Test Type	Laboratory Standard	Load Duration, hr	24
Oedometer Number	8		
Date Started	04/17/2017		
Date Completed	05/01/2017		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.89	Unit Weight, kN/m^3	13.25
Sample Diameter, cm	4.84	Dry Unit Weight, kN/m^3	6.55
Area, cm^2	18.38	Specific Gravity, measured	2.37
Volume, cm^3	34.67	Solids Height, cm	0.531
Water Content, %	102.33	Volume of Solids, cm^3	9.77
Wet Mass, g	46.84	Volume of Voids, cm^3	24.90
Dry Mass, g	23.15	Degree of Saturation, %	95.1

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	1.886	2.549	1.886				
5.91	1.883	2.543	1.884				
10.90	1.861	2.502	1.872	29	2.56E-02	2.33E-03	5.85E-06
20.94	1.822	2.429	1.841	25	2.88E-02	2.06E-03	5.80E-06
40.89	1.787	2.363	1.804	34	2.03E-02	9.22E-04	1.83E-06
80.83	1.714	2.225	1.750	83	7.83E-03	9.76E-04	7.48E-07
160.99	1.567	1.948	1.640	66	8.64E-03	9.73E-04	8.24E-07
321.01	1.272	1.393	1.419	97	4.40E-03	9.77E-04	4.22E-07
640.89	1.087	1.046	1.179	73	4.04E-03	3.06E-04	1.21E-07
1281.07	0.975	0.836	1.031	94	2.40E-03	9.26E-05	2.18E-08
2560.76	0.885	0.666	0.930	208	8.82E-04	3.72E-05	3.22E-09
640.81	0.915	0.721	0.900				
161.14	0.954	0.795	0.934				
40.98	0.999	0.880	0.977				
10.91	1.048	0.971	1.023				

Note:

Consolidation loading and unloading schedule assigned by the client.

cv and k are approximate only based on t90 estimated from Square Root of Time Method (ASTMD2435/2435M)

Specimen taken 1.5-5.5cm from top of the tube.

Specimen swelled under 5.91 kPa.

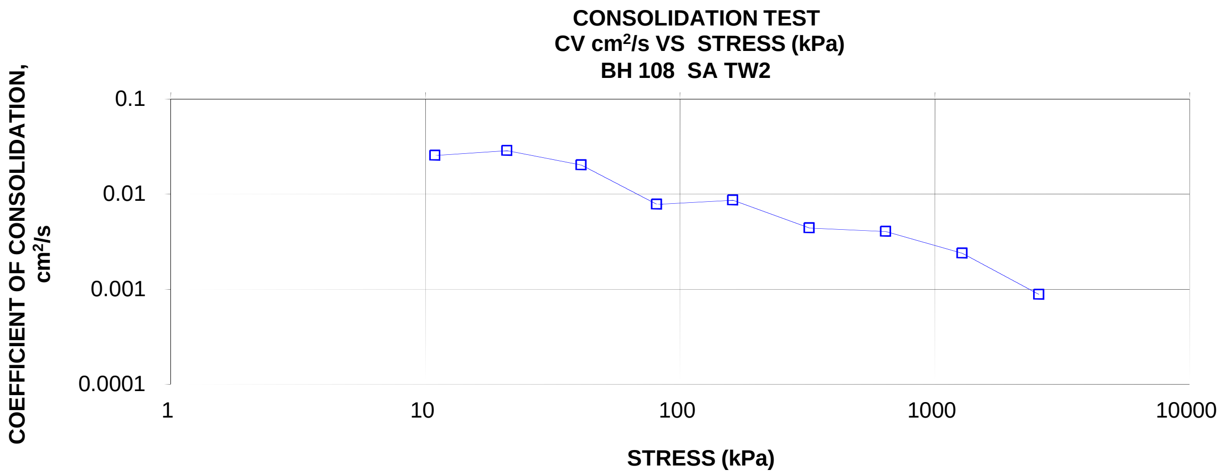
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

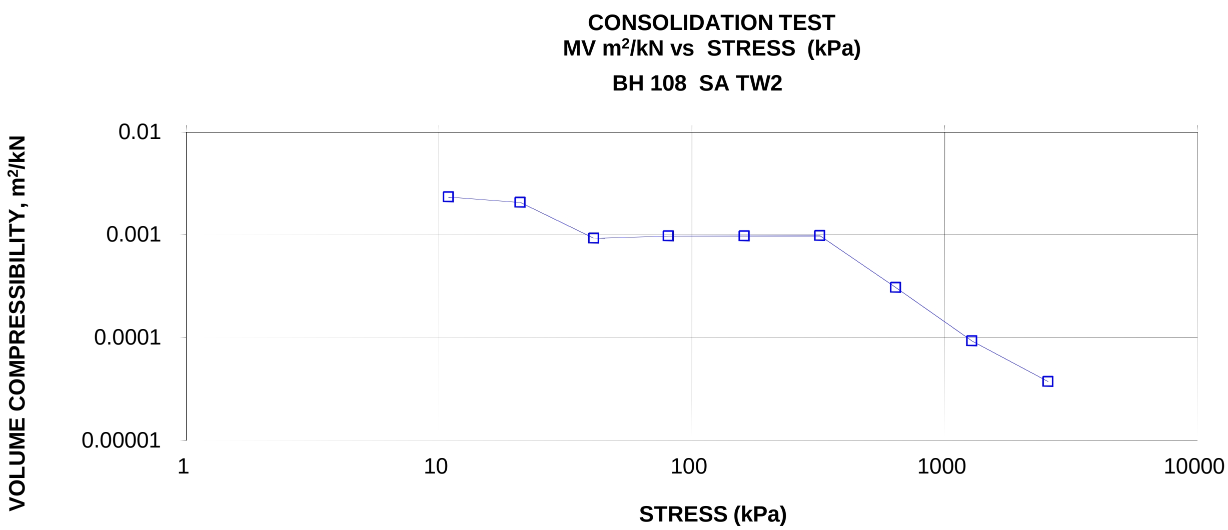
Sample Height, cm	1.05	Unit Weight, kN/m^3	16.70
Sample Diameter, cm	4.84	Dry Unit Weight, kN/m^3	11.79
Area, cm^2	18.38	Specific Gravity, measured	2.37
Volume, cm^3	19.26	Solids Height, cm	0.531
Water Content, %	41.68	Volume of Solids, cm ^{3}	9.77
Wet Mass, g	32.80	Volume of Voids, cm ^{3}	9.49
Dry Mass, g	23.15		

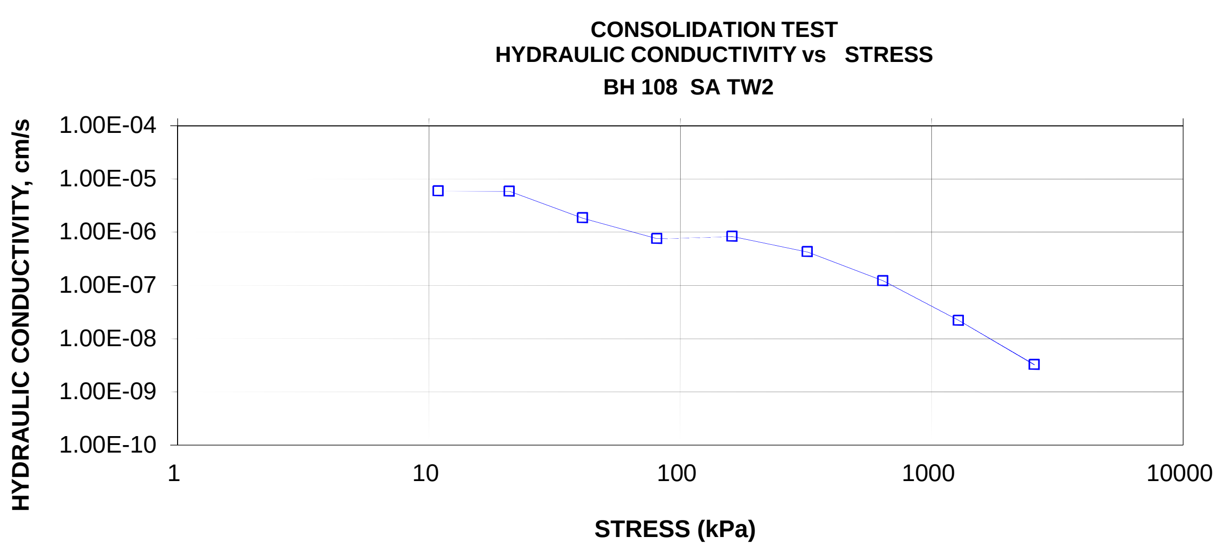
Prepared By: LH **Golder Associates** Checked By: MM

CONSOLIDATION TEST SUMMARY

FIGURE







Project No. 1778186(2000)

Prepared By: LH

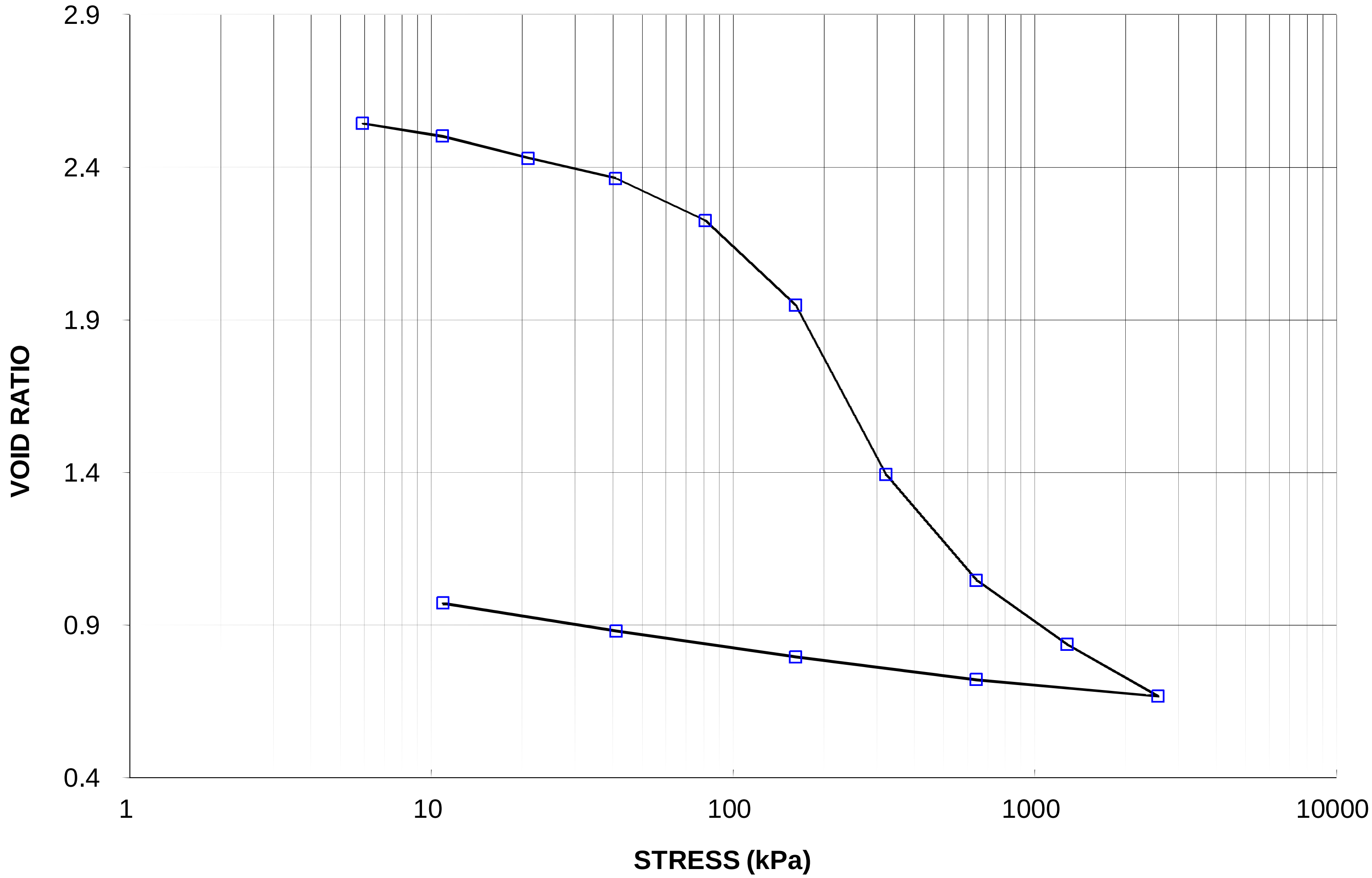
Golder Associates

Checked By: MM

Project No. 1778186(2000)

Prepared By: LH

CONSOLIDATION TEST
VOID RATIO vs STRESS
BH 108 SA TW2



Golder Associates

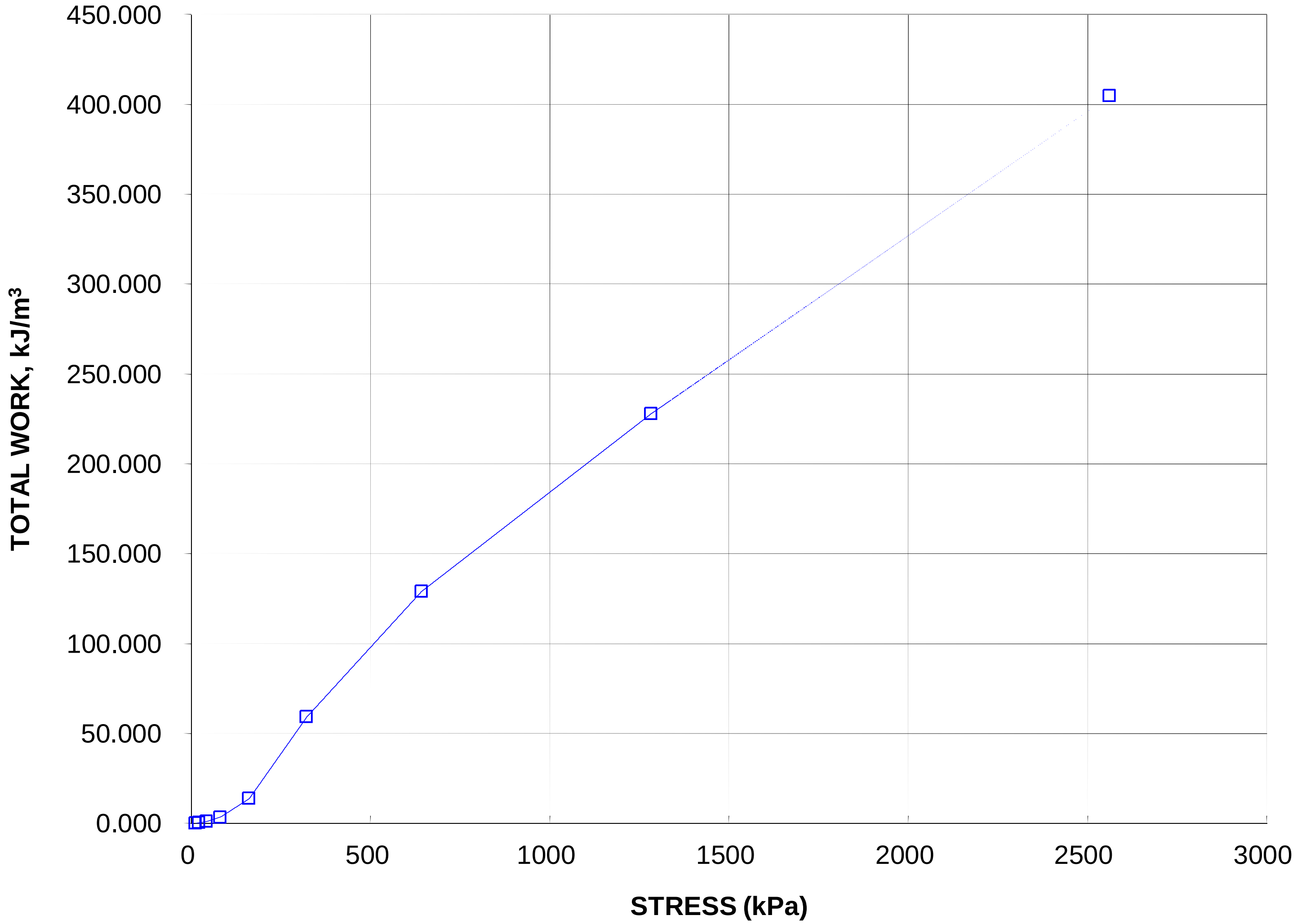
Checked By: MM

CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE

Project No. 17781186(2000)
Prepared By: LH

CONSOLIDATION TEST
TOTAL WORK, kJ/m³ vs STRESS
BH 108 SA TW2



Golder Associates

Checked By: MM

CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE

APPENDIX D

SITE PHOTOGRAPHS

Figure 1: Looking south toward Rawdon Creek along the new alignment for Highway 62 from Borehole 105

Figure 2: Looking north along existing roadway platform of Highway 62 from Borehole 101

Figure 3: Looking northeast from Borehole 106 towards existing embankment

Figure 4: Looking southeast from Borehole 106 towards existing embankment and Rawdon Creek Bridge

APPENDIX E

EVALUATION OF EMBANKMENT CONSTRUCTION DESIGN OPTIONS

THURBER

Option	Description	Advantages	Disadvantages	Risks / Consequences	Relative Cost	Comments
1	**Removal of Organic Deposit** The base of the buried organic layer beneath the existing highway embankment ranged from elevation 129.3 to 129.5 m Excavation to depths 5.5 m below current top of pavement The thickness of the layer ranged from 0.3 m to 1.2 m	Organic material is no longer beneath the embankment footprint Removal ensures that post construction settlement is not a problem	Organic material was encountered beneath the roadway therefore traffic staging and temporary protection system would be required for excavation Dewatering of excavation to place backfill in the dry, base instability is possible Larger quantity of backfill material will be required	A high groundwater level was recorded and flooding was noted in the area potential for base disturbance if groundwater and seepage is not controlled / added cost and schedule delays	Medium	**Not Recommended**
2	**Constructing Embankment with Lightweight Fill** Construction of embankment using lightweight fill beneath the pavement subgrade level to limit the stress increase. Lightweight fill options include slag based aggregate, tire derived aggregate, expanded polystyrene and cellular concrete.	Addresses settlement concerns Settlement could be significantly reduced vs. conventional granular fill No preload time is required prior to final paving Avoids need for installation of temporary protection a system	Requires specialty contactors / equipment to construct embankment Organic material would remain within the footprint of the embankment Increased engineering and design costs for using lightweight fill over granular fill	A high groundwater level was recorded and flooding was noted in the area therefore the potential for buoyancy of lightweight fill / Embankment instability	High	**Not Recommended**

THURBER

Option	Description	Advantages	Disadvantages	Risks / Consequences	Relative Cost	Comments
3	**Ground Improvement** Treatment of the ground to make it less compressible through methods such as rigid inclusions	Addresses settlement concerns	More expensive than removal option Layer thickness and material type limit the type of ground improvement options		High	**Not Recommended**
4	**Leaving Organic Material in Place and Constructing Embankment with Granular Material** Construction of 3.6 m high embankment at 2H:1V using conventional construction techniques. Preload embankment area to the final top of pavement elevation and allow embankment settlement prior to paving	Conventional construction techniques Removal of organic material is not required Avoids need for installation of protection system Ease of benching new embankment granular material into existing embankment Relatively fast construction	Preload time is required prior to final paving Settlement monitoring program will be required	Settlement is slower than expected and surcharge period needs to be extended / delays to project schedule	Low	**Recommended**

APPENDIX F
GSC SEISMIC HAZARD CALCULATION
SLOPE STABILITY ANALYSIS RESULTS
LIST OF REFERENCED SPECIFICATIONS

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

November 16, 2016

Site: 44.3379 N, 77.4774 W   User File Reference: Rawdon Creek

Requested by: , Thurber Engineering LTD.

National Building Code ground motions: 2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.05)	Sa(0.1)	**Sa(0.2)**	Sa(0.3)	**Sa(0.5)**	**Sa(1.0)**	**Sa(2.0)**	**Sa(5.0)**	**Sa(10.0)**	**PGA (g)**	**PGV (m/s)**
0.121	0.160	**0.150**	0.125	**0.101**	**0.060**	**0.031**	**0.0082**	**0.0034**	**0.091**	**0.086**

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" (NBCC 2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are specified in **bold** font. 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.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.05)	0.016	0.046	0.071
Sa(0.1)	0.025	0.066	0.099
Sa(0.2)	0.026	0.067	0.097
Sa(0.3)	0.023	0.058	0.083
Sa(0.5)	0.018	0.047	0.068
Sa(1.0)	0.0092	0.027	0.040
Sa(2.0)	0.0038	0.013	0.020
Sa(5.0)	0.0008	0.0031	0.0048
Sa(10.0)	0.0005	0.0013	0.0021
PGA	0.014	0.037	0.057
PGV	0.011	0.035	0.054

References

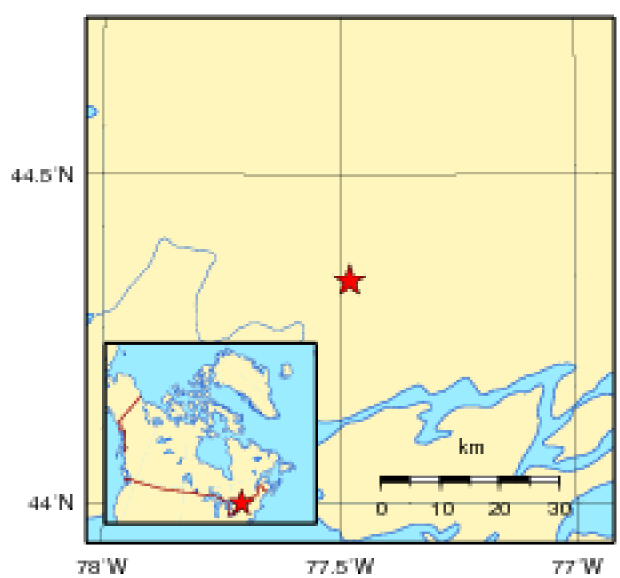
National Building Code of Canada 2015 NRCC no. 56190;
Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

User's Guide - NBC 2015, Structural Commentaries NRCC no. xxxxxx (in preparation)
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

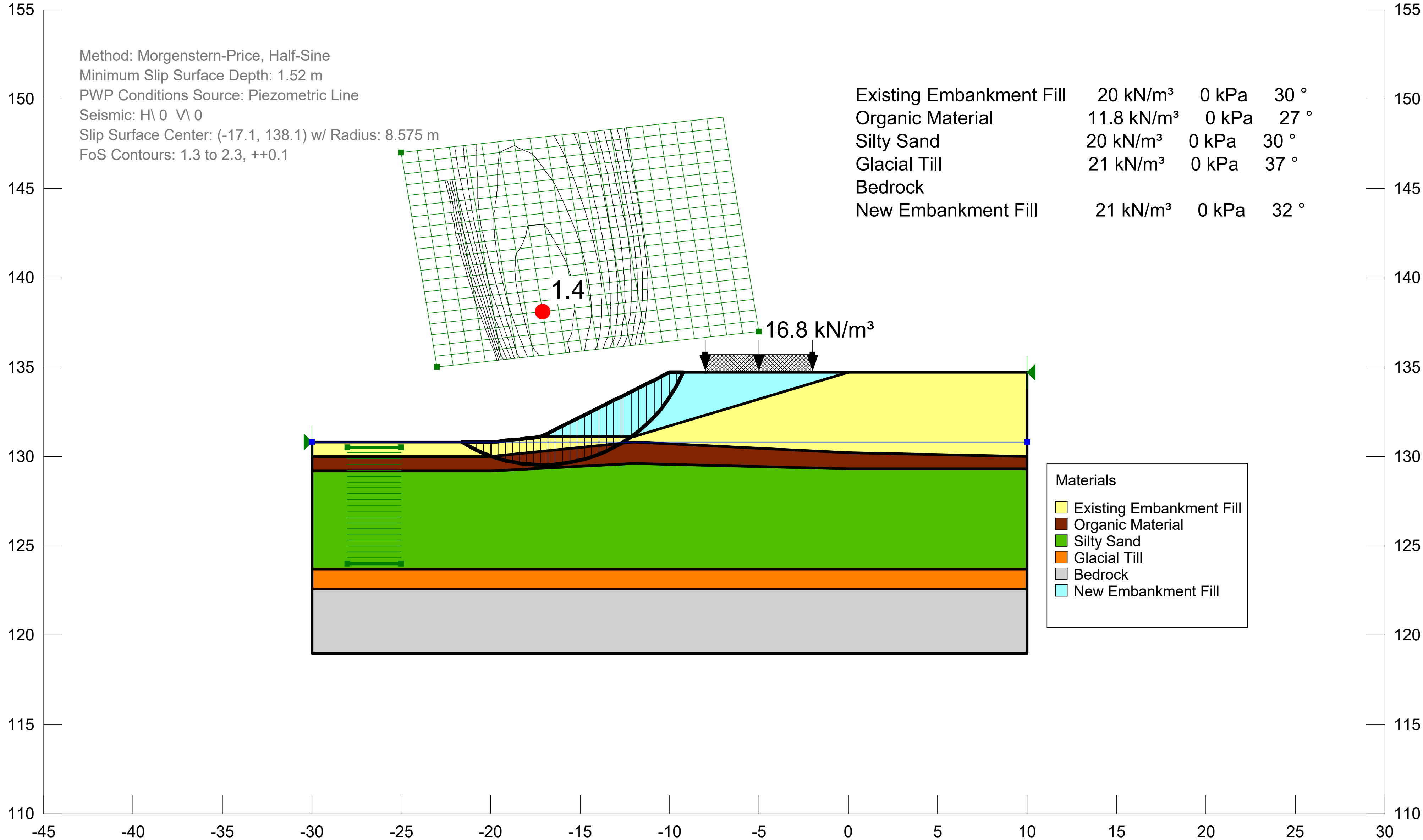
Aussi disponible en français



Natural Resources Canada   Ressources naturelles Canada

Canada

Title: Highway 62 at Rawdon Creek North Embankment
Comments: Embankment Stability Assessment
Name: Proposed Embankment Static



Reviewed By: ________________
Tool Version: 8.15.5.11777
Last Solved Date: 7/13/2017, 3:21:00 PM
Directory: H:\Projects\10000 to 20000\18115 - Hwy 62 Rawdon Creek Assignment 12\Analysis\SlopeW\Rawdow Creek Embankment.gsz

Figure 1

Title: Highway 62 at Rawdon Creek North Embankment
Comments: Embankment Stability Assessment
Name: Proposed Embankment Seismic

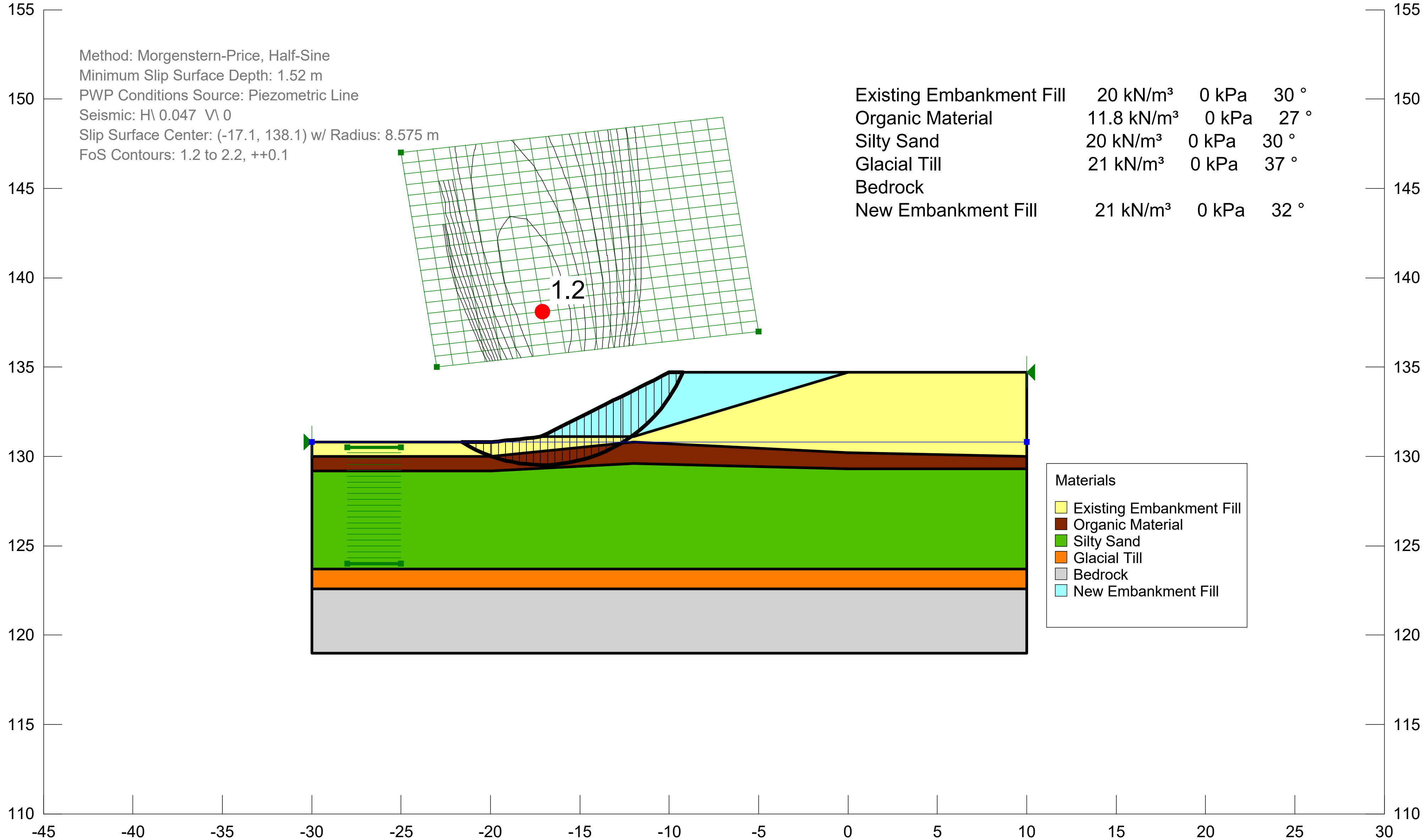


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Figure 2

LIST OF REFERENCED SPECIFICATIONS

OPSD 208.010	Benching of Earth Slopes
OPSD 3090.101	Foundation, Frost Penetration Depths for Southern Ontario
OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS 805	Construction Specification for Temporary Erosion and Sediment Control Measures
OPSS.PROV 1010	Material Specification for Aggregates - Base, Subbase, Select Subgrade, and Backfill Material

APPENDIX G
NON-STANDARD SPECIAL PROVISION – EMBANKMENT MONITORING – SUPPLY AND INSTALLATION OF SETTLEMENT MONITORING PINS

EMBANKMENT MONITORING – SUPPLY AND INSTALLATION OF SETTLEMENT MONITORING PINS - Item No. XX

Special Provision

1.0 GENERAL

1.1 Scope

1.1.1 As part of the work under the above tender item, the Contractor shall:

a) supply and install settlement pins for monitoring the settlement of the new Highway 62 north approach embankment at Rawdon Creek Bridge.

b) provide a minimum of two (2) stable, non-yielding and non-moving, deep seated survey benchmark and establish the geodetic elevation and position of each such benchmark.

1.1.2 The Contractor shall retain a registered surveyor with appropriate equipment and experience to establish the benchmarks and install the settlement pins.

1.2 Location of Settlement Pins

Reference shall be made to the Settlement Pin Location Plan provided elsewhere in the contract package

A total of six (6) settlement pins shall be provided. The settlement pins shall be installed as illustrated on the attached plan and outlined in Table 1. The location provided are based on the proposed Highway 62 centreline stationing. The proposed locations of the settlement pins shall be subject to the approval of the Contract Administrator.

Table 1

No.	Northing	Easting
SP01	4911403.1	226828.0
SP02	4911424.7	226820.0
SP03	4911422.6	226815.5
SP04	4911444.6	226810.6
SP05	4911442.5	226806.0
SP06	4911466.2	226797.8

2.0 MATERIALS

2.1 The Contractor shall supply all materials and equipment required for the installation of the settlement pins and benchmarks.

2.2 All settlement pin and benchmark materials shall be capable of withstanding the range of temperatures possible for their location.

2.3 The Settlement Pins shall be steel bolts with a rounded head. The bolt shall have a diameter of at least 25.4 mm and a minimum length of 350 mm.

2.4 The top of the bolt shall be rounded or angled in such a way that a single survey point can be clearly identified and repeated.

3.0 INSTALLATION

3.1 General

3.1.1 All settlement pins and benchmarks shall be installed immediately after the embankment has been constructed to the preload grade.

3.1.2 The Contractor shall submit details of proposed installation methods including locations and types of survey benchmark together with an installation schedule to the Contract Administrator at least 15 working days before the start of benchmark and settlement pin installation.

3.1.3 The location of any above ground monitoring fixture shall be made clearly visible to nearby traffic. Marking shall be of sufficient size to be visible from a reversing vehicle and following snow removal.

3.2 Settlement Pin Installation Details

3.2.1 Prior to the installation of the settlement pins, the Contractor shall accurately survey and stake/mark the location of each settlement pin and obtain a ground elevation at each settlement pin location.

3.2.2 The points (steel bolts / pins) shall be cast / grouted into cement at the locations shown on the Settlement Pin Location Plan approved by the Contract Administrator.

3.2.3 The cement grout shall be cast in situ in a hole dug into the top of the new embankment as per the Settlement Pin Location Plan provided elsewhere in the contract package.

3.2.4 The settlement pins shall be clearly labelled in the field. Each settlement pin shall have a unique identifier. The labelling shall remain legible for the entire period of monitoring.

3.3 Survey Benchmark

3.3.1 The number and locations of benchmark shall be such that direct sighting is possible from all settlement pins to at least one benchmark.

3.3.2 The elevation, northing, and easting of the top of the settlement pins shall be surveyed by an experienced, registered surveyor, retained by the Contractor, to provide the initial locations and elevations after installation and after the cement grout has set and the pins are firmly secured in the cement grout. The surveyor shall provide suitable equipment capable of surveying settlement pin elevations to an accuracy of ± 2 mm or better and position (i.e. northing, easting) to an accuracy of ± 4 mm or better.

3.3.3 Elevations of the benchmark and all other elevations to be determined by the Contractor shall be surveyed to an accuracy of ± 2 mm or better.

4.0 PROTECTION OF SETTLEMENT PINS

The Contractor shall adequately protect all settlement pins and benchmarks such that they are not damaged by other construction work or by vandalism. Any settlement pins or benchmark damaged by the Contractor’s work shall be replaced by the Contractor within one business day at the Contractor’s cost.

5.0 UNDERGROUND UTILITIES

The Contractor shall be responsible for locating and protecting all underground utilities prior to drilling boreholes for installing settlement pins or benchmarks. Any damage to underground utilities caused by the Contractor's work shall be repaired by the Contractor at no cost to the Contract Administrator.

6.0 SETTLEMENT MONITORING

Monitoring of the settlement pins will be carried out by the Contract Administrator at the frequency indicated elsewhere in the contract. The results of the settlement monitoring will be provided to the Contractor within 24 hours of each reading.

7.0 REPORTING AND MEETINGS

The Contractor shall meet with the Contract Administrator as follows:

- One (1) meeting prior to constructing the embankment
- One (1) meeting after completion of benchmark and settlement pin installation

At the second meeting, the Contractor shall hand over to the Contract Administrator all records pertaining to the installation of the settlement pins and benchmark including as a minimum:

- Easting, northing and elevation of each benchmark and settlement pin;
- Dates of installation;
- Installation notes/sketches; and
- Description of the materials used in the installation of the settlement pins and benchmark

8.0 DECOMMISSIONING OF INSTRUMENTS

- The instrumentation shall not be decommissioned unless instructed by the Contract Administrator after discussion with and concurrence from MTO.
- The Contractor shall decommission the settlement pins as directed by the Contract Administrator.

9.0 PAYMENT

9.1 Measurement for Payment

Measurement of this tender item including settlement pin installation and establishing benchmarks shall be lump sum.

9.2 Basis of Payment

Payment at the contract price for the above tender item shall include full compensation for all labour, equipment and material to do the work, including the installation of the settlement pins, establishment of the required benchmarks, and the required reporting.

MINISTRY OF TRANSPORTATION, ONTARIO

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

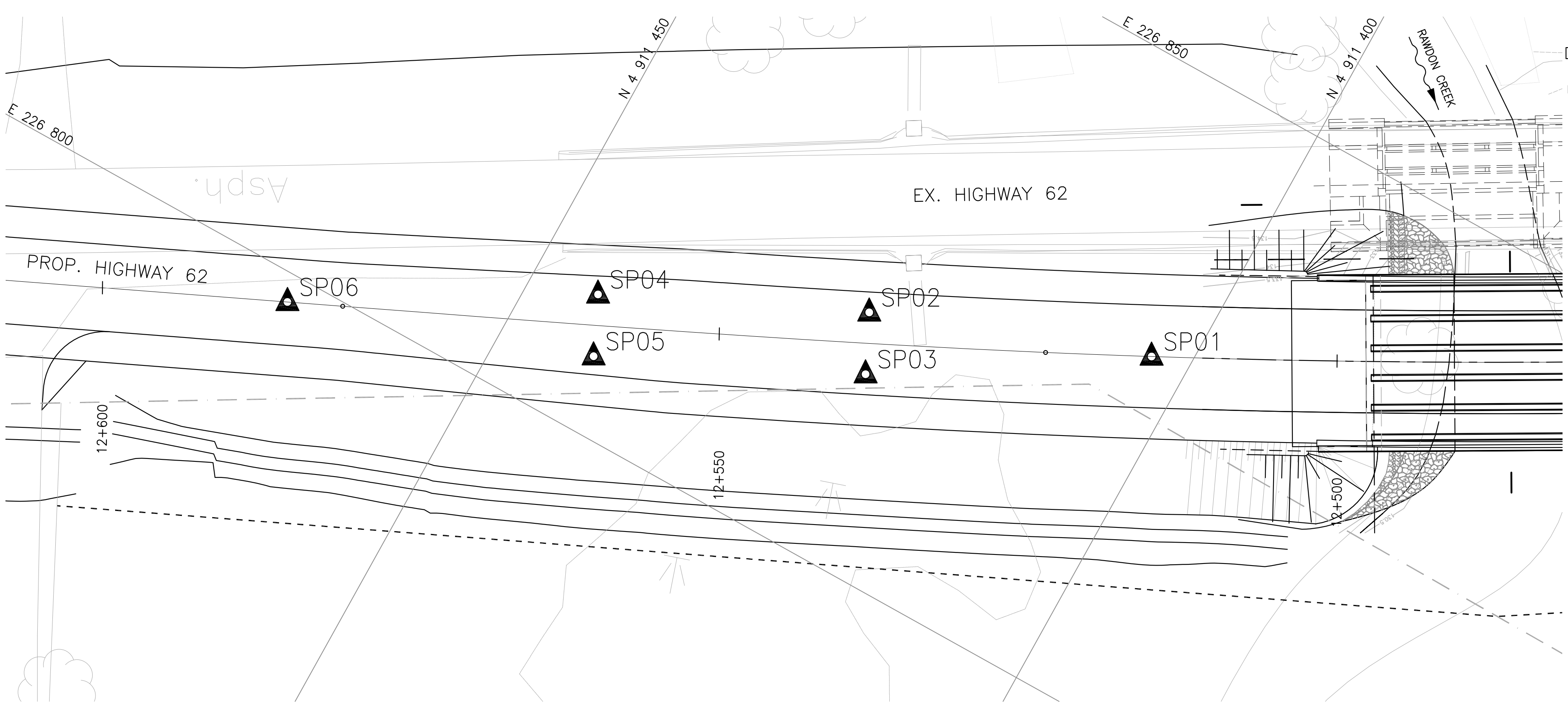
CONT No 2017–4001
GWP No 4044–10–00

SHEET

HIGHWAY 62
RAWDON CREEK EMBANKMENT
SETTLEMENT PIN LOCATION PLAN

LEA McINTOSH PERRY Joint Venture

THURBER ENGINEERING LTD.



PLAN

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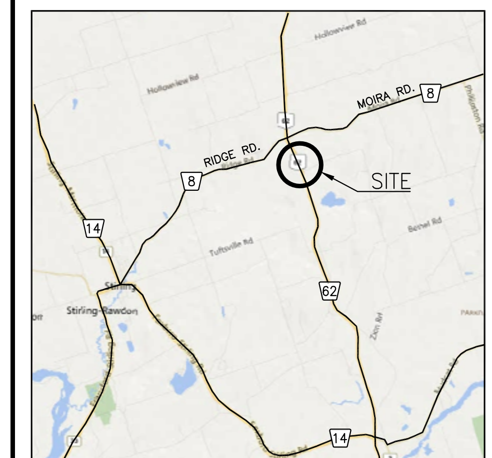


KEYPLAN

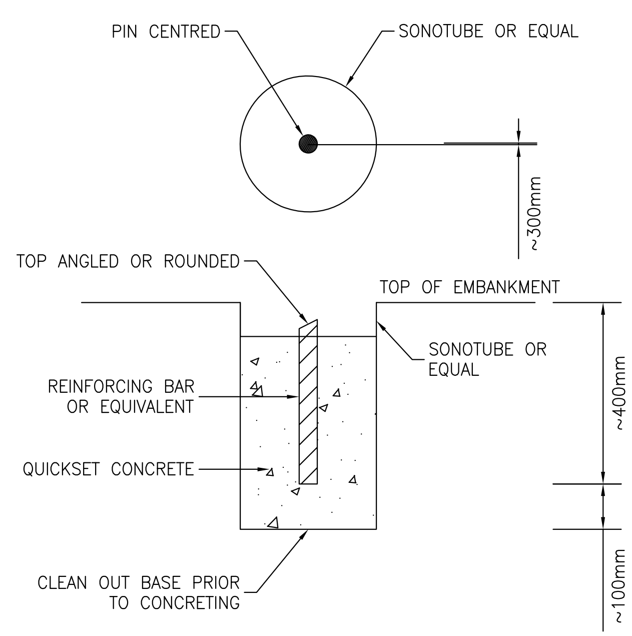
LEGEND

△ Settlement Pin

NO	NORTHING	EASTING
SP01	4 911 403.1	226 828.0
SP02	4 911 424.7	226 820.0
SP03	4 911 422.6	226 815.5
SP04	4 911 444.6	226 810.6
SP05	4 911 442.5	226 806.0
SP06	4 911 466.2	226 797.8

-NOTE-

Settlement Pin locations are shown in MTM Zone 9 coordinates.



SETTLEMENT PIN (SP) DETAIL
N.T.S.

LICENSED PROFESSIONAL ENGINEER K. T. C. POWER 100130652 2017/08/08 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER P. K. CHATTERJI Aug 8/17 PROVINCE OF ONTARIO

REVISIONS	DATE	BY	DESCRIPTION			
DESIGN KP	CHK –	CODE		LOAD		DATE AUG 2017
DRAWN MFA	CHK KP	SITE 38S–154		STRUCT		DWG 1

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