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FOUNDATION INVESTIGATION AND DESIGN REPORT
PIKE RIVER BRIDGE REPLACEMENT
HIGHWAY 572
NEW LISKEARD DISTRICT, ONTARIO
G.W.P 5196-13-00, W.P. 417-91-01, SITE NO. 39-152

GEOCRES No. 42A-116

Report

to

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the existing Pike River Bridge along Highway 572, in the District of New Liskeard, Ontario. The investigation was carried out for three alignment alternatives for a replacement structure, namely, for the structure to be located along the existing bridge alignment (Alternative 1), a minor shift of 9 to 14 m to the east (Alternative 2) and a major shift of 70 to 80 m to the east (Alternative 3).

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

Thurber carried out the investigation as a sub-consultant to MMM Group Limited, under the Ministry of Transportation Ontario (MTO) Agreement Number 5014-E-0019.

2. SITE DESCRIPTION

The existing Pike River Bridge is located on Highway 572, approximately 4.5 km south of Highway 101, in the Township of Guibord, New Liskeard District. Pike River flows from northwest to southeast in the general area and approaches a north-south flow direction at the bridge site. In the vicinity of the existing bridge, the river valley is relatively steep on the south side, and the land on the north side is relatively flat within approximately 140 m distance from the bridge. The river valley is densely vegetated with trees, shrubs and grass.

Highway 572 is carried over the Pike River by a single-span bailey bridge with a grated steel deck. The structure was constructed in 1975 and upgraded in 2008. The bridge has a span of approximately 37 m and a width of 3.4 m, and is supported on timber crib abutments. Deterioration of the timber forming the cribs and adjacent gabion baskets are evident, especially at the north abutment. Erosion of the river banks at the bridge location, including steepening of the river valley slopes in front of the abutments and erosion/scour below the timber cribs can be observed on the photographs enclosed in Appendix C.

Based on the published geological information, the general area of the project is covered by glaciolacustrine sediments of clays and silts deposited during the Pleistocene period. These deposits are mostly varved clays, but massive clays are also present in some areas. Underlying the clays are glacial outwash deposits of silts, sands and gravels extending to Precambrian mafic to intermediate meta-volcanic bedrock.

3. INVESTIGATION PROCEDURES

The field investigation program for this project was conducted in two phases. The first phase of the investigation was carried out between March 5 and March 8, 2016 and consisted of drilling and sampling four boreholes, identified as Boreholes PR-01 to PR-04, for the two proposed bridge alignments referred to as Alternatives 2 and 3. Boreholes PR-01 and PR-02 were advanced at the respective south and north abutments of the Alternative 2 alignment, and Boreholes PR-03 and PR-04 were advanced at the respective south and north abutments of the Alternative 3 alignment. Dynamic Cone Penetration Tests (DCPTs) were conducted from the ground surface adjacent to each of the four sampled boreholes. The boreholes extended to depths ranging from 10.8 to 14.0 m and the DCPTs were conducted to depths ranging from 5.5 to 8.8 m.

The second phase of the investigation was conducted on July 13 and July 14, 2016, following selection of the alignment of the replacement bridge. The field investigation program consisted of drilling and sampling of two boreholes designated as Boreholes PR-05 and PR-06 to depths of 18.3 and 16.8 m, respectively, along the existing Highway 572 alignment (referred to as Alternative 1), and near the south and north abutments of the existing bridge.

The approximate locations of all completed boreholes are shown on the attached Borehole Locations and Soil Strata Drawing enclosed in Appendix D.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling operations. The coordinates and ground surface elevations for the boreholes were derived from topographic plans provided to Thurber by MMM Group Limited.

Track-mounted CME-45 and CME-55 drill rigs were used to advance the boreholes during the first phase and second phase of the investigation, respectively. The first-phase boreholes were advanced using NW casing and wash boring techniques. The second-phase boreholes were advanced using hollow stem augers. NQ coring equipment was used to penetrate through cobble and boulder layers and to obtain core samples of the bedrock in Boreholes PR-05 and PR-06. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) procedures, as per ASTM D-1586-99.

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

Groundwater conditions in the open boreholes were observed throughout the drilling operations and in open boreholes after completion of drilling. These groundwater level observations may not be representative of the site conditions as water was used during wash boring operations. Standpipe piezometers were installed in Boreholes PR-02, PR-04, PR-05 and PR-06 to monitor the groundwater level after drilling. The piezometers were subsequently decommissioned following the final water level readings. The boreholes were backfilled in general accordance with MOE Regulation 903 (amended by Ontario Reg. 331). Completion details of the piezometers and boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Foundation Unit	Borehole	Borehole Depth/Elev. (m)	Piezometer Installations		Completion Details
			Sand Screen Depth (m)	Sand Screen Elev. (m)	
Alternative 1					
South Abutment	PR-05	18.3/264.5	12.8 - 15.2	270.0 - 267.6	Sand from 12.8 m to 15.2 m and bentonite holeplug to surface.
North Abutment	PR-06	16.8/267.3	11.7 - 13.9	272.4 - 270.2	Sand from 11.7 m to 13.9 m and bentonite holeplug to surface.
Alternative 2					
South Abutment	PR-01	10.8/270.7	None Installed		Bentonite holeplug from 10.8 m to surface.
North Abutment	PR-02	14.0/268.6	12.2 - 14.0	270.4 - 268.6	Sand from 12.2 m to 14.0 m and bentonite holeplug to surface.
Alternative 3					
South Abutment	PR-03	12.3/267.5	None Installed		Bentonite holeplug from 12.3 m to surface.

Foundation Unit	Borehole	Borehole Depth/Elev. (m)	Piezometer Installations		Completion Details
			Sand Screen Depth (m)	Sand Screen Elev. (m)	
North Abutment	PR-04	13.9/266.5	11.9 - 13.9	268.5 - 266.5	Sand from 11.9 m to 13.9 m and bentonite holeplug to surface

4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification (VI) and natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and hydrometer) and plasticity testing (Atterberg Limits). The results of the geotechnical laboratory program are summarized on the Record of Borehole sheets included in Appendix A and on figures presented in Appendix B.

Point load tests (PLT) were performed on selected intact rock core samples. The test results are included in Appendix B. Average unconfined compressive strengths (UCS) of the rock cores correlated from the PLT results for each run are shown on the Record of Borehole sheets in Appendix A.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, a sample of the native silty clay to clayey silt, and a sample of surface water from the creek upstream of the bridge were collected. The samples were submitted to AGAT Laboratories in Mississauga, Ontario for analytical testing of corrosivity parameters and sulphate contents. The results of the analytical testing are summarized in this report and are enclosed in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix A and on the Borehole Locations and Soil Strata drawing included in Appendix D.

A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. The factual data presented on the Record of Borehole sheets take precedence over this general description and should be used for interpretation of the site conditions. It should be recognized and expected that soil conditions may vary between and beyond borehole locations.

As noted above, the replacement bridge is proposed to be located on the existing Highway 572 alignment or Alternative 1. Given the distance of Boreholes PR-03 and PR-04 from the existing Highway 572, the two boreholes were not considered in the descriptions of individual soil strata. However, the Record of Borehole sheets of the completed boreholes are enclosed in Appendix A for reference.

The subsurface information in the area of Pike River Bridge was also available in the MTO Foundation Investigation and Design Report dated September 30, 1983 (Geocres No. 42A-36), which was prepared for the-then proposed replacement of the Pike River Bridge on Line "B". The locations of the boreholes and the Line "B" from the 1983 report cannot be determined with sufficient accuracy for reference in the subsurface stratigraphy described in this report. The Record of Borehole sheets and the Foundation Drawing from the 1983 Report are enclosed in Appendix E for information.

In general, the soil stratigraphy beneath the existing embankment fill comprises a silty clay layer underlain by a silty sand to sand till with trace to some clay and gravel and occasional cobbles and boulders. The silty sand to sand till was underlain by basaltic bedrock as encountered in Boreholes PR-05 and PR-06. Descriptions of the individual strata are presented below.

5.1 Embankment Fill

Embankment fill was encountered at the ground surface in Boreholes PR-05 and PR-06. The embankment fill comprised a layer of sand with some gravel, some silt and trace clay overlain by a silty clay with trace sand, trace gravel and occasional wood fragments and organics. The thickness of the cohesionless fill ranged from 0.2 to 0.3 m. The cohesive fill extended to depths ranging from 0.8 to 0.9 m below the ground surface (Elev. 281.9 to 283.3).

The results of a grain size analysis conducted on a sample of the sand fill is provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B1 of Appendix B. The results indicate that the fill contains 14% gravel, 68% sand, 12% silt and 6% clay.

5.2 Silty Clay

A silty clay deposit was encountered below the silty clay fill in Boreholes PR-05 and PR-06 and at the ground surface in Boreholes PR-01 and PR-02. The deposit was brown to grey in colour and contained occasional rootlets and wood fibres near the ground surface. The thickness of the deposit ranged from 1.4 to 5.3 m with the bottom at depth between 1.4 m and 6.1 m (Elevation 280.4 to 278.0). The silty clay was also encountered in Boreholes PR-03 and PR-04 at surface drilled for an alternative alignment during preliminary design phase. However, the soil conditions encountered in these two boreholes are not included in the current description as they were located approximately 150 m away from the proposed final alignment.

SPT N values measured in the deposit ranged between 4 and 21 blows per 0.3 m penetration, with most values between 4 and 12 blows, indicating firm to stiff consistency. The measured water contents ranged from 21% to 64% with typical values between 21% and 44%.

The results of grain size analyses conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix A, and are illustrated in Figure B2 of Appendix B. The results are summarized in the following table.

Soil Particle	Percentage (%)
Gravel	0
Sand	0
Silt	21 to 70
Clay	30 to 79

The results of the Atterberg Limits tests conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B4 of Appendix B. The test results are summarized below.

Atterberg Limits	Percentage (%)
Liquid Limit	24 to 62
Plasticity Index	7 to 40

The results of the Atterberg Limits tests indicate that the silty clay varies from low plasticity (CL) to high plasticity (CH). The high plastic zone was encountered in the upper 2 m of the deposit in Borehole PR-06.

5.3 Sand to Silty Sand Till

A layer of sand to silty sand till was encountered underlying the silty clay in all boreholes. The brown to grey till contained trace to some clay and gravel, and occasional cobbles and boulders. The thickness of the till, where fully penetrated in Boreholes PR-05 and PR-06, varied between 7.8 m and 12.8 m with the bottom at Elevation 267.6 and 270.2, respectively. Boreholes PR-01 and PR-02 were terminated in the till at depths of 10.8 m and 14.0 m (Elevation 270.7 and 268.6).

SPT N values measured in the till ranged from 3 blows per 0.3 m penetration to greater than 100 blows per 0.15 m penetration, indicating a very loose to very dense relative density. Low SPT N values of 3 and 6 blows per 0.3 m penetration were obtained at 3.6 m and 12.2 m depth in Borehole PR-05. The measured water contents of till samples ranged from 7% to 19%.

The results of grain size analyses conducted on selected till samples are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B3 of Appendix B. The results are summarized in the following table.

Soil Particle	Percentage (%)
Gravel	0 to 13
Sand	40 to 63
Silt	18 to 33
Clay	5 to 21

Glacial till inherently contains cobbles and boulders.

5.4 Bedrock

Basaltic meta-volcanic bedrock was encountered in Boreholes PR-05 and PR-06 below the sand to silty sand till. Table 5.1 summarizes the depth to bedrock and the bedrock surface elevations determined by coring in the boreholes.

Table 5.1: Depth to Bedrock at Borehole Locations

Location	Borehole	Depth to Bedrock (m)	Bedrock Surface Elevation (m)	Comment
South Abutment	PR-05	15.2	267.6	Cored 3 m
North Abutment	PR-06	13.9	270.2	Cored 3 m

The bedrock is generally described as slightly weathered to fresh, dark grey in colour with occasional pink and white veins ranging between 1 mm and 10 mm in width. Total Core Recovery (TCR) in the bedrock was 100% with solid core recovery (SCR) ranging from 67% to 89%. The Rock Quality Designation (RQD) determined from the recovered cores ranged from 48% to 82%, indicating poor to good rock quality. The Fracture Index (FI) of the rock, expressed as number of fractures per 0.3 m of core, varied from 0 to 6.

The unconfined compressive strength (UCS) of the rock interpreted from point load tests conducted on core samples ranged from 60 to 275 MPa, indicating a strong to extremely strong rock. The UCS values of individual tested cores interpreted from point load tests are presented on the Point Load Test Sheet enclosed in Appendix B.

5.5 Groundwater Conditions

Where possible, water levels were monitored in the open boreholes during drilling operation. Wash boring and/or coring methods were used to advance all boreholes and therefore water levels recorded during or upon completion of drilling may not reflect natural groundwater levels.

The water levels measured in the piezometers installed in Boreholes PR-02, PR-05 and PR-06 and upon completion of drilling are summarized in Table 5.2.

Table 5.2 – Water Level Measurements

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
PR-01	March 5, 2016	1.4	280.1	Open Borehole
PR-02	March 8, 2016	3.1	279.5	Open Borehole
	March 9, 2016	2.5	280.1	Piezometer
	June 20, 2016	2.7	279.9	Piezometer
PR-05	July 17, 2016	3.7	279.1	Piezometer
PR-06	July 14, 2016	3.5	280.6	Piezometer
	July 17, 2016	3.6	280.5	Piezometer

The recorded levels are short-term readings and 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.

The water level in Pike River was shown on the archive drawing (Geocres No. 42A-36) at Elevation 279.5 on November 17, 1982. The Preliminary General Arrangement drawing prepared by MMM Group also indicated the water level in Pike River at Elev. 279.54 in June 2015 and a 2-year high water level at Elev. 280.23.

6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the native silty clay and a sample of surface water from the Pike River were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are summarized in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	Units (Water)	Test Results	
			PR-02 SS#4, 7.5' – 9.5' (Soil 2.3 – 2.9 m)	Pike River Water (Creek Water)
Sulphide	%	mg/L	0.1	< 0.05
Chloride	µg/g	mg/L	2	2.6
Sulphate	µg/g	mg/L	70	4.64
pH	pH Units	pH Units	8.07	7.62
Electrical Conductivity	mS/cm	µS/cm	0.159	158
Resistivity	ohm.cm	ohm.cm	6290	6330
Redox Potential	mV	mV	348	368

7. MISCELLANEOUS

Borehole locations were selected and established in the field by Thurber Engineering Ltd. The coordinates and the ground surface elevations for the boreholes were established based on topographic survey information provided by MMM Group Limited.

Thurber obtained utility clearances for the borehole locations prior to drilling. Overall supervision of the field program was carried out by Mr. Stephane Loranger, CET.

The drilling operations carried out in March 2016 were supervised by Mr. George Azzopardi of Thurber. Eastern Ontario Diamond Drilling of Hawkesbury, Ontario, supplied a track-mounted CME-55 drill rig and conducted the drilling, sampling and in-situ testing operations. The drilling operations conducted in July 2016 were supervised by Mr. Zane Bourk of Thurber, and Eastern Ontario Diamond Drilling of Hawkesbury, Ontario, supplied a track-mounted CME-55 drill rig and conducted the drilling, sampling and in-situ testing operations.

Routine laboratory testing was carried out at Thurber's geotechnical laboratory.

Interpretation of the field data and preparation of this report were carried out by Ms. Anna Piascik, P.Eng. and Mr. Keli Shi, P.Eng. The report was reviewed by Mr. Alastair Gorman, M.Sc., P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides geotechnical recommendations for the proposed replacement of the existing Pike River Bridge located on Highway 572, in the District of New Liskeard, Ontario.

This foundation investigation and design report with the interpretations and recommendations is 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 contractors. Design-build contractors must make their own interpretations 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.

Highway 572 is carried over the Pike River by a single-span bailey bridge with a grated steel deck. The bridge, constructed in 1975 and rehabilitated in 2008, has a span of approximately 37 m and a width of 3.4 m and is supported on timber crib abutments. The intent of the bridge replacement was documented in the MTO Foundation Investigation and Design Report dated September 30, 1983 (Geocres No. 42A-36). The report discusses the-then proposed replacement of the Pike River Bridge on Line “B”. The locations of the boreholes and the proposed alignment (Line “B”) from the 1983 report cannot be determined with sufficient accuracy to be utilized in this report.

At the preliminary stage of the project, three alignment alternatives for the Pike River Bridge replacement were considered. The design alternatives, as shown on the preliminary drawings provided by MMM Group, are summarized as follows:

- Alternative 1 – replacement of the bridge on the existing alignment adopting a slightly longer structure span.

- Alternative 2 – the horizontal alignment to be shifted to the east by approximately 9 to 14 m at the abutment locations, which would result in a bridge span of approximately 60 m, and the approach embankments up to 5.5 m in height.

- Alternative 3 – the horizontal alignment to be shifted to the southeast (along the river) by as much as 70 to 80 m, which would result in the span of the replacement bridge of approximately 40 m and approach embankments up to 6.5 m in height. The Alternative 3 alignment would require significant length of high embankments, as well as some cuts.

The preliminary field foundation investigation was carried out at the proposed structure locations for Alternatives 2 and 3. Preliminary geotechnical recommendations on the foundation aspects of the design for all three alternatives were provided in the Thurber's Technical Memorandum dated April 14, 2016 (Geocres No. 42A-106).

Following selection of Alternative 1 alignment for detailed design, an additional round of field investigation (Phase 2) was conducted for the proposed bridge replacement.

As shown on the Preliminary General Arrangement (GA) drawing prepared by MMM Group dated May 2016, the replacement bridge will be a 39.6 m long single-span modular structure with fully reinforced panels (DSR) and steel deck with asphalt surface. The superstructure will be supported on shallow spread footings founded on engineered granular fill pads. The existing approach embankment immediately behind the bridge abutments will be raised by approximately 0.5 m on the south side and by 1.0 m on the north side.

The discussions and recommendations for Alternative 1 presented in this report are based on information shown in the Preliminary GA drawing and on the factual data obtained during the course of this investigation.

9. STRUCTURE FOUNDATIONS

In general, the soil stratigraphy below the existing approach embankment fill consists of a layer of firm to stiff silty clay overlying a sand to silty sand till deposit over the basaltic bedrock. Bedrock was encountered at depths of 15.2 and 13.9 m (Elev. 267.6 and 270.2) near the proposed south and north abutments, respectively.

The river level in the Preliminary GA was shown at Elev. 279.54 in June 2015. The 2-year high water level is reported to be at Elev. 280.23. Groundwater level measured in the piezometers installed during current investigation was at Elev. 279.1 on the south side and at Elev. 280.5 on the north side of the river. The water levels in the piezometers reflect the groundwater level in the underlying cohesionless till. It is anticipated that the groundwater level will be influenced by the water level in the river.

The following foundation options were considered for the support of this bridge:

- spread footings placed on native soils,
- spread footings placed on engineered rock fill, and
- driven steel H-piles.

Spread footings founded on engineered granular pad are not recommended at this site since the pads will be constructed close to the river banks and during a high water level event, there is a risk that the sand fractions and finer sizes may get washed out through the rock protections. Accordingly, a footing on engineered rock fill is recommended which will minimize this concern.

Recommendations for design of the feasible foundation options are presented in the following sections along with the corresponding geotechnical design parameters, where applicable. A preferred foundation option is indicated from a geotechnical perspective.

9.1 Spread Footings on Native Soils

Underlying the embankment fill is silty clay of firm to stiff consistency, which vary in thickness from 1.5 m at the south abutment to 5.3 m at the north abutment. Given the relatively low strength and high compressibility of the native silty clay and variable thickness of the silty clay deposit, spread footings placed directly on the native silty clay are not recommended.

Placement of spread footings on sand to silty sand till underlying the silty clay would require 2.4 to 6.1 m deep excavations that will extend below the groundwater and river water levels. Dewatering and temporary protection system would be required to construct the foundations in the dry. Although technically feasible, this option is not considered to be cost effective, and therefore, not recommended.

9.2 Spread Footings on Engineered Rock Fill Pads

9.2.1 Founding Levels

A modular bridge supported on concrete spread footings placed on minimum 2 m thick rock fill pad can be considered at this site. The preliminary GA drawing indicates the finished road grade at approximate Elev. 282.8 at the south abutment, and Elev. 283.4 at the north abutment. It also shows the base of the engineered rock fill pad located at approximate Elev. 279. At that elevation, the engineered rock fill pad will be constructed on the sand to silty sand till at the south abutment and on the firm to stiff silty clay at the north abutment.

9.2.2 Engineered Rock Fill Construction

The engineered rock fill pads should consist of well graded and freshly produced rock fill having a maximum size of 250 mm. A sketch of the abutment footing placed on rock fill pad is presented on Figure 1 enclosed in Appendix G.

Excavations for the engineered rock fill pad construction will most likely require the existing timber cribs and gabion baskets to be removed or partially removed. Suggested wording for an NSSP on the construction of the engineered rock fill pad is included in Appendix F. The following construction sequence may be considered:

1. Excavate to remove all timber and other deleterious material from the footprint of the new foundation;
2. The minimum depth of excavation must accommodate the concrete foundation slab and the thickness of engineered rock fill pad below the slab;
3. The subgrade for the engineered rock fill pad should be inspected and all organics, soft/loose soils, and any deleterious materials should be removed from the footprint of the excavation. Dewatering measures should be provided, as required, to place the engineered rock fill in the dry;
4. The dimensions of the base of the excavation should be determined by assuming a pad 1.0 m wider than the footing at the level of the footing base and projecting outward and downward no steeper than 1.5H: 1V.

The preliminary GA drawing indicates that the new abutments will be located some distance behind the existing abutments. However, due to geometry requirements and the configuration of the river valley slopes, the underside of the engineered rock fill pads will likely be located close to or below the river level.

9.2.3 Factored Geotechnical Resistance and Geotechnical Reaction

The following values of factored Geotechnical Resistance at ULS and Geotechnical Reaction at SLS may be used for design of a minimum 2 m wide spread footing placed on the above prepared engineered rock fill pad, with the base of the rock fill pad at Elev. 279:

Factored Geotechnical Resistance at ULS (kPa)	-	300 kPa
Geotechnical Reaction at SLS (kPa)	-	200 kPa

The value of the Geotechnical Reaction at SLS given above is for up to 25 mm of settlement.

The value of a Factored Geotechnical Resistance at ULS was assessed assuming a Consequence Factor of 1.0 (Typical), and a Resistance Factor of 0.5 (Typical), as per CHBDC

2014. The Geotechnical Reaction at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.

The geotechnical resistance provided above is for concentric, vertical loading conditions only. In the case of eccentric or inclined loading, the geotechnical resistance should be calculated as indicated in the CHBDC 2014 Clause 6.10.3 and Clause 6.10.4.

The lateral resistance of the footings founded on engineered rock fill pad may be computed using an unfactored friction coefficient of 0.45.

9.3 Driven H-Pile Foundations

The ground conditions at the site are considered to be suitable for the use of driven steel H-pile foundations to support the bridge abutments. The piles may be driven into the very dense cohesionless till or to bedrock, depending on the resistance required.

9.3.1 Axial Geotechnical Resistances

9.3.1.1 Piles Driven into Till

The axial geotechnical resistances at Ultimate Limit States (ULS) and geotechnical reaction at Serviceability Limit States (SLS) for a steel HP 310x110 piles are provided in the table below. It was assumed that the underside of the pile caps will be located at approximately Elev. 281.0 and above the water level in the river.

Table 9.1 – Axial Geotechnical Resistances for HP310x110 Driven into Till

Abutment Location / Reference Borehole	Estimated Pile Tip Elevation (m)	Approximate Pile Length (m)	Factored Geotechnical Resistance at ULS	Geotechnical Reaction at SLS
South / PR-05	273.0	8.0	1,000 kN	800 kN (for up to 25 mm Settlement)
North / PR-06				

9.3.1.2 Piles Driven to Bedrock

The subsurface conditions at this site are considered to be suitable for use of steel H-piles driven to refusal on bedrock.

A factored geotechnical resistance and reaction as well as estimated tip elevations for HP 310x110 piles driven to the bedrock surface are presented in Table 9.2.

Table 9.2 – Axial Geotechnical Resistances for HP310x110 Piles Driven to Bedrock

Abutment Location / Reference Borehole	Estimated Pile Tip Elevation / Bedrock Surface (m)	Approximate Pile Length (m)	Factored Geotechnical Resistance at ULS	Geotechnical Reaction at SLS
South / PR-05	267.6	13.4	2,000 kN	Does not govern.
North / PR-06	270.2	10.8		

9.3.2 Pile Installation

Pile installation should be in accordance with OPSS.PROV 903.

The pile tip elevations listed in Table 9.1 assume that piles are driven to effective refusal and penetrate a minimum 2 m into the very dense cohesionless till. Cobbles and boulders were encountered in the till deposit and should be expected during pile installation. For piles driven in soils, pile installation should be controlled in accordance with Standard Drawing SS103-11 (Hiley Formula) and an ultimate pile resistance should be specified by the designer. The Hiley formula need not be used until the piles are within 1.0 m of the design pile tip elevation. The appropriate pile driving note is "Piles to be driven in accordance with Standard SS 103-11 using an ultimate resistance of "R" kN per pile. "R" should have a minimum value of twice the design load at ULS as calculated by the Structural Engineer.

For piles driven to bedrock, as listed in Table 9-2, the requirement in OPSS.PROV 903 to seat pile properly on bedrock should be noted. The appropriate pile driving note in the contract is "Piles to be driven to bedrock".

Cobbles and boulders and/or rock fill may be encountered when driving piles through the existing fill and till deposit. The Contract Documents should contain an NSSP alerting bidders to the presence of the cobbles and boulders in the foundation soil and/or rock fill within the existing embankment. Suggested wording for an NSSP addressing presence of obstructions is included in Appendix F.

9.3.3 Pile Tips

To prevent pile damage when setting the piles on bedrock or in the very dense till, which contains cobbles or boulders, piles should be equipped with tip protections.

The pile tip protection supplied by an approved manufacturer such as Titus Steel (Standard H-point), Skyline Steel or approved equivalent could be used at this site.

9.3.4 Downdrag Load

Driven H-piles could encounter practical refusal in the very dense till deposit or on bedrock. The weight of the new approach embankment fill to be placed for the realignment of Highway 572 will induce consolidation settlements of the underlying silty clay layer. As a result, downdrag loads will develop along the length of abutment piles embedded in this deposit.

For design purposes, an unfactored downdrag load of 100 kN per pile should be used to evaluate the impact of downdrag load on the abutment piles, as per CHBDC Commentary Clause C6.11.

9.4 Lateral Resistance

The geotechnical lateral resistance acting on a pile in cohesionless soils may be calculated using a value for the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

$$k_s = n_h z / D \quad (kN/m^3)$$

$$p_{ult} = 3 \gamma' z K_p \quad (kPa)$$

Where
- z = depth of embedment of pile (m)
- D = pile width or diameter (m)
- n_h = coefficient related to soil relative density (kN/m^3)
- γ' = effective unit weight (kN/m^3)
- K_p = passive earth pressure coefficient

The geotechnical lateral resistance acting on a pile in cohesive soils may be calculated using a value for the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

$$k_s = 67 S_u / D \quad (kN/m^3)$$

$$p_{ult} = 9 S_u \quad (kPa)$$

Where
- S_u = undrained shear strength (kPa)
- D = pile width or diameter (m)

The above equations and recommended parameters in Table 9.3 below may be used to analyse the interaction between a pile and the surrounding soil. The lateral pressures obtained from the analysis must not exceed the ultimate lateral resistance.

Table 9.3 – Soil Parameters for Lateral Pile Resistance

Soil Unit	Elevation (m)		γ' (kN/m^3)	n_h (kN/m^3)	K_p	S_u (kPa)
	Top	Bottom				
South Abutment (PR-05)						
Silty Clay	281.0*	280.4	19	-	-	30
Sand to Silty Sand Till (Loose to Compact)	280.4	276.0	10	2,500	3.0	-
Sand to Silty Sand Till (Dense to Very Dense)	276.0	267.6 (Bedrock)	11	10,000	3.5	-
North Abutment (PR-06)						
Silty Clay	281.0*	280.5	19	-	-	60
Silty Clay (below water level)	280.5	278.0	9	-	-	30
Silty Sand Till (Compact)	278.0	276.0	10	3,000	3.1	-
Silty Sand Till (Dense to Very Dense)	276.0	270.2 (Bedrock)	11	10,000	3.5	-

Note: * Assumed underside of pile cap at abutments.

The spring constant, K_s, for analysis may be obtained by the expression, $K_s = k_s\ L\ D$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m^3), D is the pile width (m) and L is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance, P_{ult}, may be obtained from the expression, $P_{ult} = p_{ult}\ L\ D$. This represents the ultimate load at which the pile fails and will not support any additional load at greater displacements.

The modulus of subgrade reaction and ultimate lateral resistance may have to be reduced, based on the pile spacing. The reduction factors to be used for a pile group oriented perpendicular or parallel to the direction of loading are provided in Table 9.4. Intermediate values may be obtained by linear interpolation.

Table 9.4 – Subgrade Reaction Reduction Factors for Pile Spacing

Condition	Pile Spacing (Centre to Centre)	Reduction Factor
Pile group oriented ***perpendicular*** to direction of loading	4D	1.0
	1D	0.5
Pile group oriented ***parallel*** to direction of loading	8D	1.0
	6D	0.7
	4D	0.4
	3D	0.25

In the case of conventional abutments, i.e. not integral type, horizontal loads may be resisted by means of battered piles.

9.5 Frost Cover

The depth of frost penetration at this site is approximately 2.4 m.

If steel H-piles are adopted, the base of pile caps should be provided with a minimum of 2.4 m of earth cover as protection against frost action. If it is not practical to provide 2.4 m of earth cover, consideration can be given to use of expanded polystyrene insulation (EPS). Typically, 25 mm of EPS can be considered as an equivalent to 600 mm of earth cover. If EPS is used, it should be provided with long term protection against erosion, environmental degradation and spills.

Concrete bearing slab foundations for modular bridge founded on a non frost susceptible, free draining engineered fill pad should be provided with a minimum embedment of 0.5 m.

9.6 Recommended Foundation

From a geotechnical perspective and based on the subsurface conditions, spread footings placed on engineered fill pads are considered the preferred foundation option at this site.

10. SCOUR AND EROSION CONTROL

The existing forward slopes appear to be experiencing erosion, as shown on the site photographs enclosed in Appendix C. Adequate scour and erosion protection should be established for the forward slopes at the bridge and the river bank slopes on both sides of the bridge. Design of the scour and erosion protection works should be undertaken by a specialist in this field.

Protection of the river banks is important to avoid undermining of the bridge foundations. A vegetation cover should be established on all exposed earth surfaces to protect against surficial erosion, in general accordance with OPSS.PROV 804.

11. EXCAVATION AND GROUNDWATER CONTROL

Excavation for works associated with the construction of the new abutments will extend through the existing fill and into the native silty clay at the north abutment and sand/silty sand till at the south abutment. The base of excavation will be located near the river level. Removal of the existing timber cribs and gabion baskets will be required for construction of engineered fill pad.

All excavations should be carried out in accordance with OPSS 902 and the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the approach embankment fill within the depth of excavation may be classed as Type 3 soil above the water table and Type 4 below the water level. The native silty clay may be classed as Type 3 soil.

Open cut excavation may be carried out at inclinations no steeper than 1H:1V. Where space permits and where required, flatter slopes may be warranted to maintain stability.

The selection of the method of excavation is the responsibility of the Contractor and should be based on the Contractor's experience, equipment and interpretation of the site conditions. The existing timber cribs contain rock fill material. It is anticipated that a hydraulic excavator will be suitable for use at this site. Provision should be made for handling of potential obstructions in the fill and native soils such as cobbles and boulders.

The groundwater level is expected to be largely governed by the water level in the river. Excavation for the engineered fill pad construction will extend close to or slightly below the water level in the river.

Seepage into the excavation may be handled by pumping from filtered sumps. The use of sandbagged cofferdams may be considered where required. The design of groundwater control system is the responsibility of the Contractor.

12. LATERAL EARTH PRESSURE

The lateral earth pressures acting on the retaining structures may be assumed to be triangularly distributed and governed by the characteristics of the backfill and existing fill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC 2014 but generally are given by the following equation and in the table below:

$$p_h = K(\gamma h + q) \quad (kN/m^3)$$

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

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

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

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

13. SEISMIC CONSIDERATIONS

In accordance with the CHBDC, the selection of the seismic site class is based on the soil conditions encountered in the upper 30 m of the stratigraphy. The stratigraphy at this site corresponds to a Seismic Site Class D in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2,475-year return period seismic event at this site is 0.097 g as per the National Building Code of Canada (NBCC).

In accordance with Clause 4.6.5 of the CHBDC, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in the table below may be used:

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35°$, $\gamma = 22.8$ kN/m^3	OPSS Granular B Type I (modified) $\phi = 32°$, $\gamma = 21.2$ kN/m^3	Existing Fill $\phi = 30°$, $\gamma = 20$ kN/m^3
Active (K_{AE})*	0.32	0.36	0.39
Passive (K_{PE})	3.5	3.1	2.8
At Rest (K_{OE})**	0.59	0.64	0.67

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

Given the firm to very stiff silty clay and compact to very dense sand till underlying this site, seismic liquefaction is not considered to be a concern.

14. ROADWAY PROTECTION SYSTEM

Temporary roadway protection systems, if required, should be implemented in accordance with OPSS.PROV 539 and designed for Performance Level 2.

Options for roadway protection are soldier pile and lagging or interlocking sheet piles.

The soil parameters in the table below may be used for design of the temporary roadway protection system with horizontal backfill.

Soil Parameter	Existing Fill	Silty Clay	Sand/Silty Sand Till
γ (total unit weight)	20 kN/m^3	19 kN/m^3	21 kN/m^3
γ' (effective unit weight)	10 kN/m^3	9 kN/m^3	11 kN/m^3
K_a	0.33	0.38	0.32
K_p	3.0	2.7	3.1

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

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

15. APPROACH EMBANKMENTS

No evidence of instability of the existing approach embankments were noted during the time of the foundation investigation, although settlements at the abutments were evident. These settlements could be related to the river bank erosion leading to the undermining of the timber cribs and loss/washout of the abutment fill.

Based on the preliminary General Arrangement drawing, the road grade of the existing approach embankments will be raised by approximately 0.5 to 1.0 m at the new abutments. The proposed grade raises of 0.5 m at the south abutment and 1.0 m at the north abutment are expected to induce ground settlements up to 25 mm. The majority of the estimated settlement will occur in the first three months following the fill placement. In light of the fact that this is a surface treated secondary highway, it is anticipated that this ground settlement will be tolerable. Periodic maintenance of the road may be carried out as required.

In view of the soil conditions at this site, stability issues are not anticipated for the approach embankments constructed to slopes no steeper than 2H:1V.

16. CORROSION & SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the embankment fill soil and the river water indicate the following:

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

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

- Appropriate protection measures are recommended to address the mild potential for corrosion on metal structure elements in contact with the soil or the river water.

17. CONSTRUCTION CONCERNS

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

- Seasonal fluctuations of the groundwater and river water levels are to be expected. In particular, the water level may be at a higher elevation after periods of heavy rainfall, which may impact the construction.

- Rock fill may be present as fill in the existing timber cribs, and occasional cobbles and boulders were encountered in the sand/silty sand till. Cobbles and boulders may interfere with excavations or installation of temporary protection system should it be required.

- If deep foundations are selected to support the bridge abutments, variability of pile lengths should be anticipated given the highly variable subsurface conditions at this site.

THURBER

18. CLOSURE

Engineering analysis and preparation of this report were carried out by Mr. Keli Shi, P.Eng. The report was reviewed by Mr. Alastair Gorman, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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THURBER

60 YEARS

Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

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

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

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

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

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

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

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

DISCONTINUITY SPACING

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

SYMBOLS

- CLAYSTONE
- SILTSTONE
- SANDSTONE
- COAL
- BEDROCK

STRENGTH CLASSIFICATION

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

TERMS

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

<u>UNIFIED SOILS CLASSIFICATION</u>

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

RECORD OF BOREHOLE No PR-01

METRIC

GWP# 5196-13-00	LOCATION Pike River Bridge N 5 373 529.9 E 358 355.2		ORIGINATED BY GA
HWY 572	BOREHOLE TYPE NW Casing/NQ Coring/Dynamic Cone Penetration Test		COMPILED BY AN
DATUM Geodetic	DATE 2016.03.05 - 2016.03.05		CHECKED BY AMP

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
281.5	GROUND SURFACE
0.0	Silty **CLAY**, occasional rootlets Stiff Brown Moist to Wet
280.1 1.4	Silty **SAND**, trace to some clay, trace gravel, occasional cobbles and boulders Compact to Very Dense Brown to Grey Moist (TILL) 150mm boulder at 4.3m

SAMPLES

NUMBER	TYPE	"N" VALUES	WATER CONTENT (%) (approx.)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	12		
2	SS	11		0 0 53 47
3	SS	16		
4	SS	18		
5	SS	21		2 56 32 10
6	SS	112/0.150		
7	SS	109/0.150		
8	SS	106/0.150		0 51 33 16
9	SS	102/0.150		

GROUND WATER CONDITIONS: water level symbol at elev. approx. 280.1

ELEVATION SCALE: 281, 280, 279, 278, 277, 276, 275, 274, 273, 272

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No PR-01

METRIC

GWP# 5196-13-00 | LOCATION Pike River Bridge N 5 373 529.9 E 358 355.2 | ORIGINATED BY GA

HWY 572 | BOREHOLE TYPE NW Casing/NQ Coring/Dynamic Cone Penetration Test | COMPILED BY AN

DATUM Geodetic | DATE 2016.03.05 - 2016.03.05 | CHECKED BY AMP

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	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										
							271				
270.7			10	SS	116/				○		
10.8	END OF BOREHOLE AT 10.8m. BOREHOLE OPEN TO 10.8m AND WATER LEVEL AT 1.4m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.				0.150						

+ 3, × 3: Numbers refer to Sensitivity

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

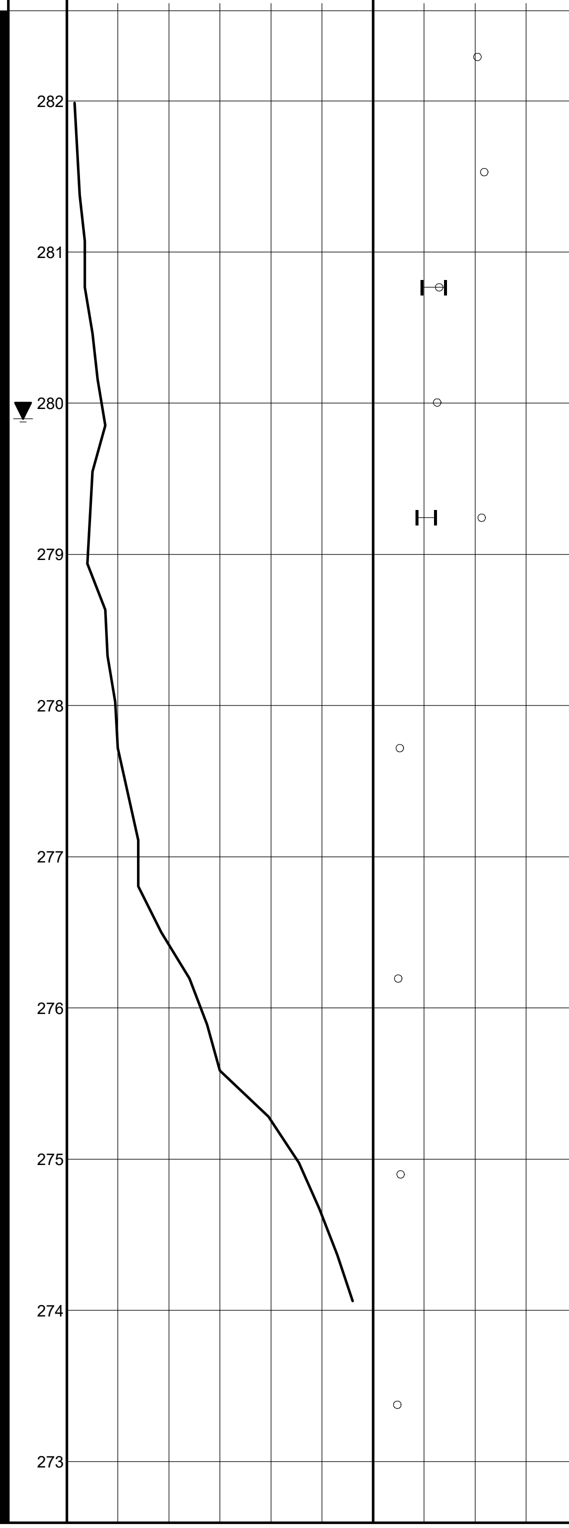
RECORD OF BOREHOLE No PR-02

METRIC

GWP#	5196-13-00	LOCATION	Pike River Bridge N 5 373 589.3 E 358 371.8	ORIGINATED BY	GA
HWY	572	BOREHOLE TYPE	NW Casing/NQ Coring/Dynamic Cone Penetration Test	COMPILED BY	AN
DATUM	Geodetic	DATE	2016.03.08 - 2016.03.08	CHECKED BY	AMP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
282.6	GROUND SURFACE							
0.0	Silty **CLAY**, occasional rootlets Firm to Very Stiff Brown Wet	1	SS	21				
		2	SS	7				
		3	SS	12	0	0	70	30
		4	SS	16				
	Becoming Grey	5	SS	6				
278.5 / 4.1	Silty **SAND**, trace to some clay, trace gravel, occasional cobbles and boulders Compact to Very Dense Grey Moist (TILL)	6	SS	13	3	59	33	5
	Cobbles from 5.5m to 6.1m							
		7	SS	24				
		8	SS	100/ 0.150				
		9	SS	111/ 0.150				

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + 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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No PR-02

METRIC

GWP# 5196-13-00 | LOCATION Pike River Bridge N 5 373 589.3 E 358 371.8 | ORIGINATED BY GA

HWY 572 | BOREHOLE TYPE NW Casing/NQ Coring/Dynamic Cone Penetration Test | COMPILED BY AN

DATUM Geodetic | DATE 2016.03.08 - 2016.03.08 | CHECKED BY AMP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Continued From Previous Page									
					272					
		10	SS	102/ 0.150		○				
	225mm boulder at 11.0m									
					271					
		11	SS	119/ 0.150		○				
					270					
					269					
268.6		12	SS	138		○	7	40	32	21
14.0	END OF BOREHOLE AT 14.0m. BOREHOLE OPEN TO 14.0m AND WATER LEVEL AT 3.1m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.									

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2016.03.09	2.5	280.1
2016.06.20	2.7	279.9

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; 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 (%).

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

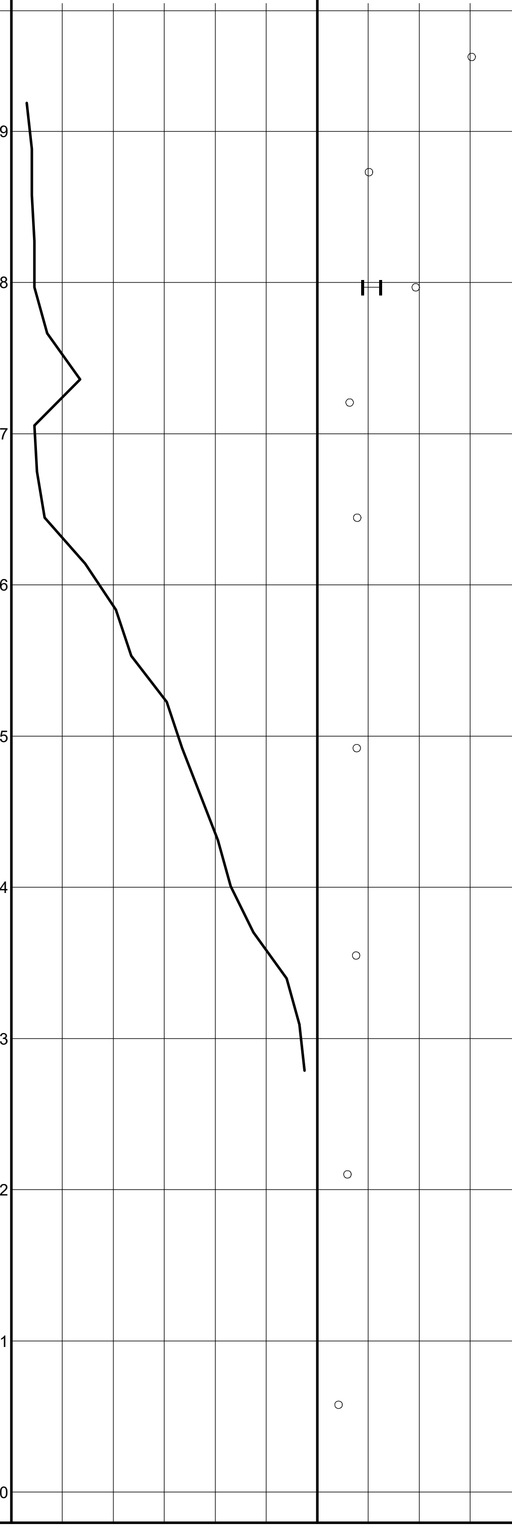
RECORD OF BOREHOLE No PR-03

METRIC

GWP#	5196-13-00	LOCATION	Pike River Bridge N 5 373 427.0 E 358 409.2	ORIGINATED BY	GA
HWY	572	BOREHOLE TYPE	NW Casing/NQ Coring/Dynamic Cone Penetration Test	COMPILED BY	AN
DATUM	Geodetic	DATE	2016.03.06 - 2016.03.06	CHECKED BY	AMP

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
279.8	GROUND SURFACE								
0.0	Silty **CLAY** to Clayey **SILT**, trace sand, occasional wood fibres Very Stiff to Stiff Grey Wet to Moist	1	SS	18					
		2	SS	9	279				
		3	SS	10	278	0	6	63	31
277.6 / 2.2	Silty **SAND**, trace to some clay, trace to some gravel, occasional cobbles Loose to Very Dense Grey Moist (TILL) 100mm cobble at 2.4m	4	SS	50/ 0.150	277				
		5	SS	7	276				
		6	SS	41	275	1	75	24 (SI+CL)	
	Cobbles from 5.5m to 6.1m				274				
		7	SS	107	273				
		8	SS	103/ 0.150	272				
					271				
		9	SS	112/ 0.150	270				

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; 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 PR-03

METRIC

GWP# 5196-13-00	LOCATION Pike River Bridge N 5 373 427.0 E 358 409.2	ORIGINATED BY GA
HWY 572	BOREHOLE TYPE NW Casing/NQ Coring/Dynamic Cone Penetration Test	COMPILED BY AN
DATUM Geodetic	DATE 2016.03.06 - 2016.03.06	CHECKED BY AMP

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										
	300mm boulder at 10.4m										
			10	SS	111/ 0.150		269		○ (≈5)		0 52 34 14
							268				
267.5			11	SS	119/				○ (≈4)		
12.3	END OF BOREHOLE AT 12.3m BOREHOLE OPEN TO 12.3m AND ARTESIAN PRESSURE AT 1.0m ABOVE GROUND SURFACE IN NW CASING UPON COMPLETION OF BOREHOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.				0.150						

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No PR-04

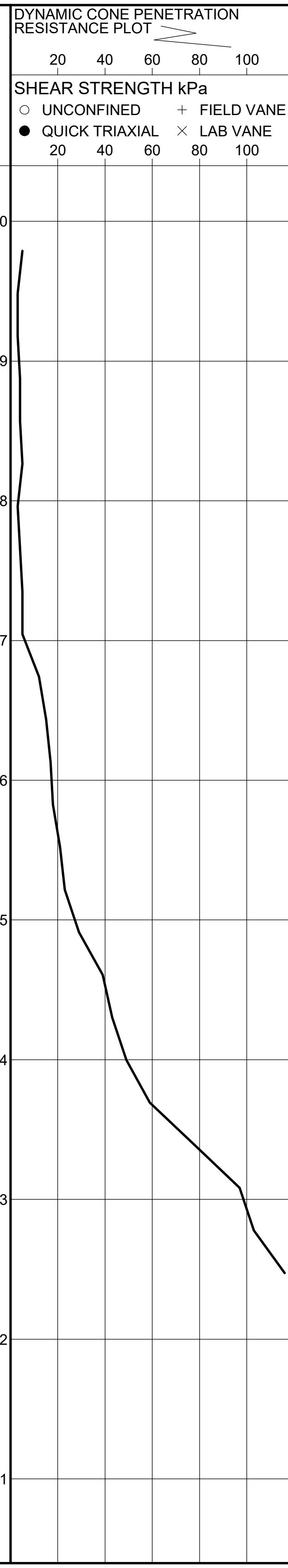
METRIC

GWP# 5196-13-00 | LOCATION Pike River Bridge N 5 373 461.4 E 358 415.3 | ORIGINATED BY GA

HWY 572 | BOREHOLE TYPE NW Casing/NQ Coring/Dynamic Cone Penetration Test | COMPILED BY AN

DATUM Geodetic | DATE 2016.03.07 - 2016.03.07 | CHECKED BY AMP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
280.4	GROUND SURFACE						
0.0	**TOPSOIL:** (150mm)						
0.2	Silty **CLAY**, some sand, trace gravel in upper zone, occasional rootlets and wood fibres Stiff to Soft Grey Moist	1	SS	14	280	○	
		2	SS	6		○	
		3	SS	4	279	├─┤ ○	0 18 38 44
		4	SS	3	278	○	
277.4 3.0	**PEAT**, fibrous, trace to some silt, trace sand, trace clay Loose Dark Brown Wet	5	SS	4	277	189 ○	
276.6 3.8	Silty **SAND**, trace gravel, trace to some clay, occasional cobbles and boulders Compact to Very Dense Grey Moist (TILL) 125mm cobbles at 5.3m				276		
		6	SS	20	275	○	
		7	SS	20	274	○	5 62 28 5
		8	SS	103	273	○	
		9	SS	105/ 0.150	272 271	○	



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 PR-04

METRIC

GWP# 5196-13-00	LOCATION Pike River Bridge N 5 373 461.4 E 358 415.3		ORIGINATED BY GA
HWY 572	BOREHOLE TYPE NW Casing/NQ Coring/Dynamic Cone Penetration Test		COMPILED BY AN
DATUM Geodetic	DATE 2016.03.07 - 2016.03.07		CHECKED BY AMP

SOIL PROFILE: ELEV / DEPTH; DESCRIPTION; STRAT PLOT. SAMPLES: NUMBER; TYPE; "N" VALUES. GROUND WATER CONDITIONS. ELEVATION SCALE. DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100). SHEAR STRENGTH kPa: ○ UNCONFINED, + 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

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT	GR	SA	SI	CL
					270					
		10	SS	111/ 0.150		○	3	42	39	16
					269					
		11	SS	106/ 0.150	268	○				
					267					
266.5 / 13.9	END OF BOREHOLE AT 13.9m. BOREHOLE OPEN TO 13.9m AND WATER LEVEL AT 1.5m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.	12	SS	116/ 0.150		○				

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2016.03.08	0.9	279.5
2016.03.09	0.8	279.6

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

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

RECORD OF BOREHOLE No PR-05

METRIC

GWP# 5196-13-00	LOCATION Pike River Bridge N 5 373 546.7 E 358 341.8	ORIGINATED BY ZRB	
HWY 572	BOREHOLE TYPE Hollow Stem Augers/NQ Coring	COMPILED BY AN	
DATUM Geodetic	DATE 2016.07.14 - 2016.07.14	CHECKED BY AMP	

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
282.8	GROUND SURFACE
0.0 / 0.2	**SAND**, some gravel, some silt, trace clay Brown Moist (FILL)
281.9 / 0.9	Silty **CLAY**, occasional rootlets and wood fragments Firm Brown Moist (FILL)
	Silty **CLAY** Firm Grey Moist
280.4 / 2.4	**SAND** to Silty **SAND**, trace to some clay, trace to some gravel, occasional cobbles and boulders Very Loose to Very Dense Brown to Grey Moist (TILL) Occasional cobbles and boulders from 4.9m to 12.2m

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	GS		14 68 12 6
1	SS	7	0 0 62 38
2	SS	4	
3	SS	8	13 63 18 6
4	SS	13	
5	SS	3	
6	SS	18	
7	SS	43	
8	SS	108/ 0.150	
			8 49 30 13

ELEVATION SCALE: 282, 281, 280, 279, 278, 277, 276, 275, 274, 273

GROUND WATER CONDITIONS: water level symbol shown at approx. elevation 279.1

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 PR-05

 METRIC

GWP# 5196-13-00 | LOCATION Pike River Bridge N 5 373 546.7 E 358 341.8 | ORIGINATED BY ZRB

HWY 572 | BOREHOLE TYPE Hollow Stem Augers/NQ Coring | COMPILED BY AN

DATUM Geodetic | DATE 2016.07.14 - 2016.07.14 | CHECKED BY AMP

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page						
	Occasional cobbles and boulders from 10.5m to 12.2m	9	SS	130	272		
					271		
		10	SS	6	270		
		11	SS	36	269		
267.6					268	FI	
15.2	**BASALTIC METAVOLCANIC BEDROCK**, slightly weathered to fresh, dark grey, joints dipping 40' to 160' to vertical, occasional white and pink veins 2.0 to 10.0mm thick	1	RUN		267	4, 4, 4, 1	RUN #1 TCR=100% SCR=71% RQD=48% UCS=132MPa (Average)
		2	RUN		266, 265	2, 5, 6, 1, 3, 2	RUN #2 TCR=100% SCR=83% RQD=58% UCS=218MPa (Average)
264.5 18.3	END OF BOREHOLE AT 18.3m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.						

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2016.07.17	3.7	279.1

Chart headings: 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); STRAT PLOT; GROUND WATER CONDITIONS.

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No PR-06

METRIC

GWP# 5196-13-00 | LOCATION Pike River Bridge N 5 373 609.7 E 358 364.4 | ORIGINATED BY ZRB

HWY 572 | BOREHOLE TYPE Hollow Stem Augers/NQ Coring | COMPILED BY AN

DATUM Geodetic | DATE 2016.07.13 - 2016.07.13 | CHECKED BY AMP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%) (wP – w – wL)	GR	SA	SI	CL
284.1	GROUND SURFACE									
0.0 / 283.8 / 0.3	**SAND**, some gravel, some silt, trace clay, Brown, Moist (FILL)	1	GS		284					
		2	GS							
283.3 / 0.8	Silty **CLAY**, occasional wood fragments and rootlets, Firm, Dark Grey, Moist (FILL)	1	SS	11	283		0	0	31	69
	Silty **CLAY**, Firm to Stiff, Grey, Moist	2	SS	10	282		0	0	21	79
		3	SS	4	281					
		4	SS	5	280		0	0	59	41
		5	SS	5	279					
278.0 / 6.1	Silty **SAND**, trace to some gravel, trace clay, occasional cobbles and boulders, Compact to Very Dense, Grey, Moist (TILL)	6	SS	13	278, 277					
		7	SS	30	276, 275					
	Occasional cobbles and boulders present	8	SS	108						

Groundwater level symbol shown at approx. elev. 280.6.

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

UNIT WEIGHT γ kN/m3

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No PR-06

METRIC

GWP# 5196-13-00 | LOCATION Pike River Bridge N 5 373 609.7 E 358 364.4 | ORIGINATED BY ZRB

HWY 572 | BOREHOLE TYPE Hollow Stem Augers/NQ Coring | COMPILED BY AN

DATUM Geodetic | DATE 2016.07.13 - 2016.07.13 | CHECKED BY AMP

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	UNIT WEIGHT (FI)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		9	SS	112/ 0.150		
		10	SS	108/ 0.150		
270.2	Zone of rock fragments from 13.7m to 13.9m				FI	
13.9	**BASALTIC METAVOLCANIC BEDROCK**, slightly weathered to fresh, dark grey, joints dipping 45' to 160' to vertical, occasional white and pink veins 1.0 to 4.0mm thick	1	RUN		2, 3, 2, 1, 3	RUN #1 TCR=100% SCR=67% RQD=48% UCS=153MPa (Average)
		2	RUN		1, 1, 2, 1, 1, 0	RUN #2 TCR=100% SCR=89% RQD=82% UCS=145MPa (Average)
267.3 / 16.8	END OF BOREHOLE AT 16.8m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.					

Elevation scale: 274, 273, 272, 271, 270, 269, 268

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2016.07.14	3.5	280.6
2016.07.17	3.6	280.5

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/m³

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

THURBER

60 YEARS

Appendix B

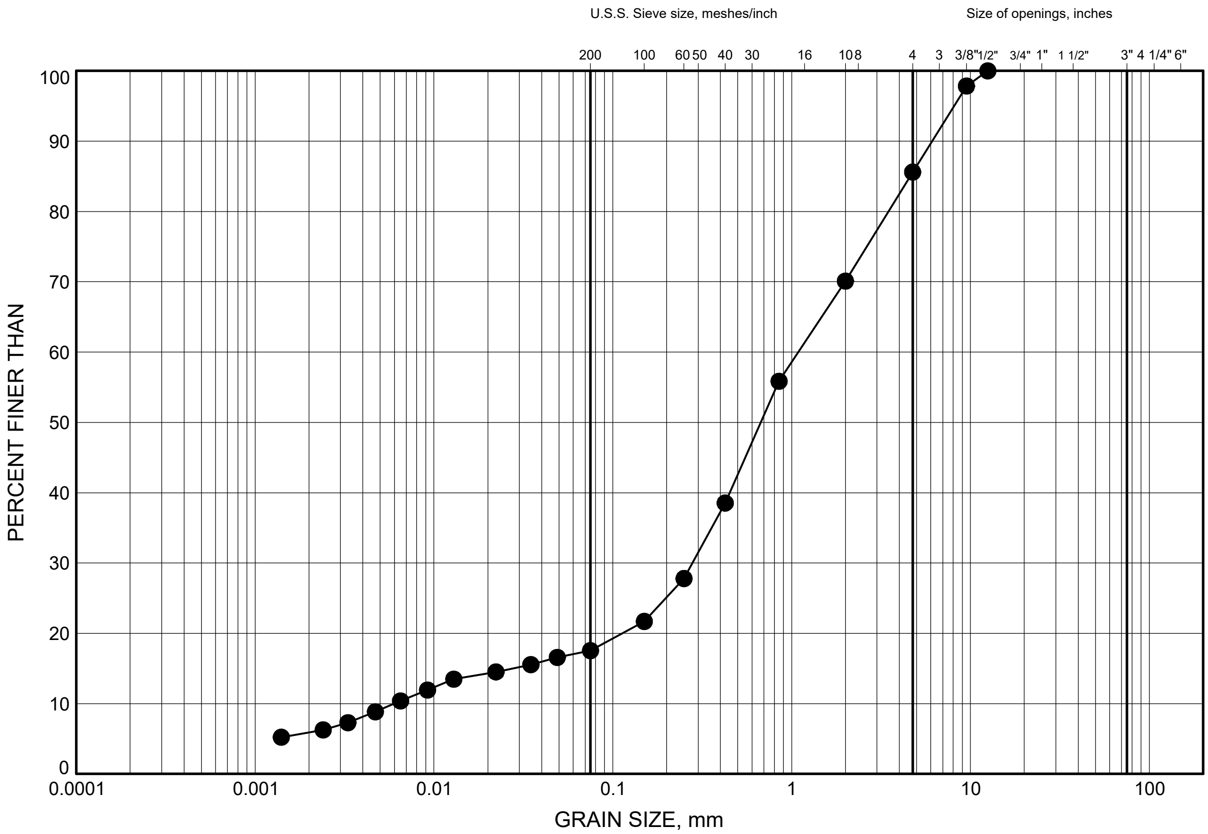
Geotechnical and Analytical Laboratory Test Results

Pike River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PR-05	0.08	282.72

GRAIN SIZE DISTRIBUTION - THURBER 19-5161-251.GPJ 9/26/16

Date September 2016

GWP# 5196-13-00

THURBER

Prep'd AN

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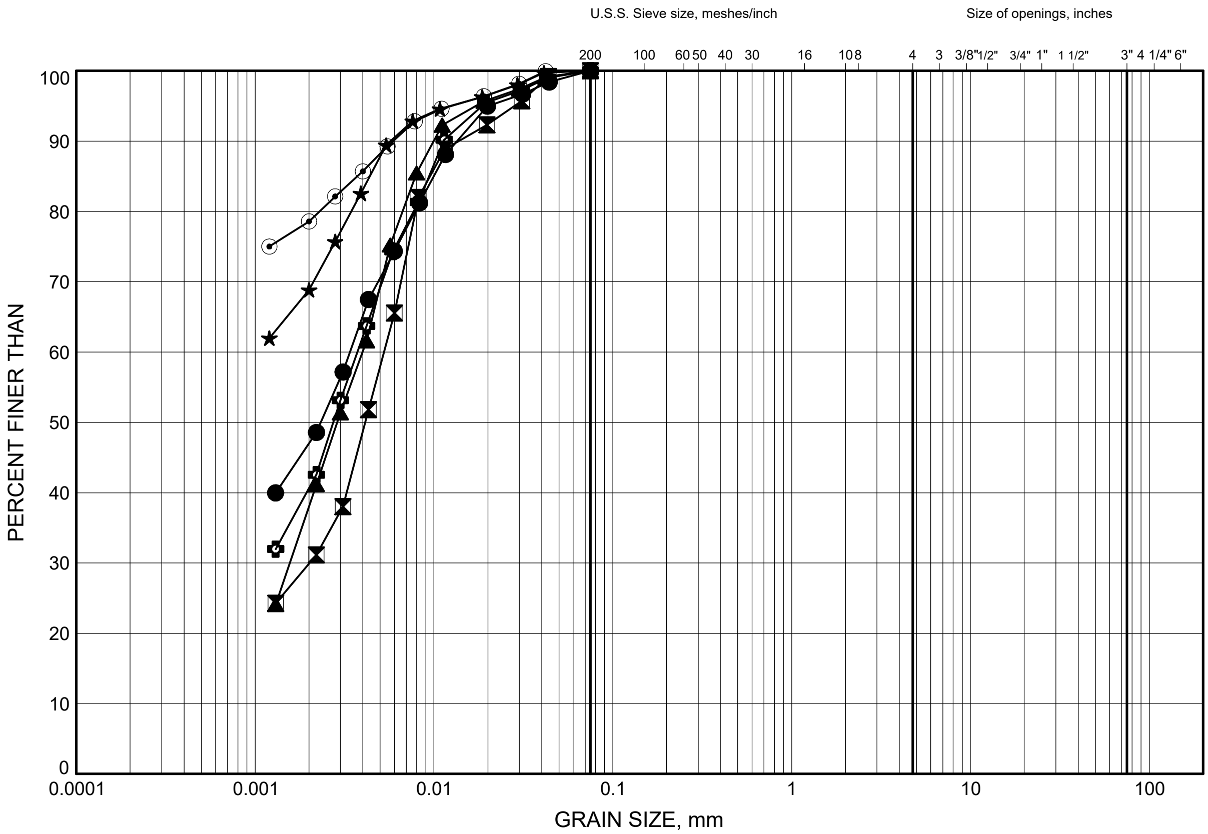
Pike River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PR-01	1.07	280.43
⧗	PR-02	1.83	280.77
▲	PR-05	1.14	281.66
★	PR-06	1.07	283.03
⊙	PR-06	1.83	282.27
✿	PR-06	3.35	280.75

Date October 2016

GWP# 5196-13-00

THURBER

Prep'd AN

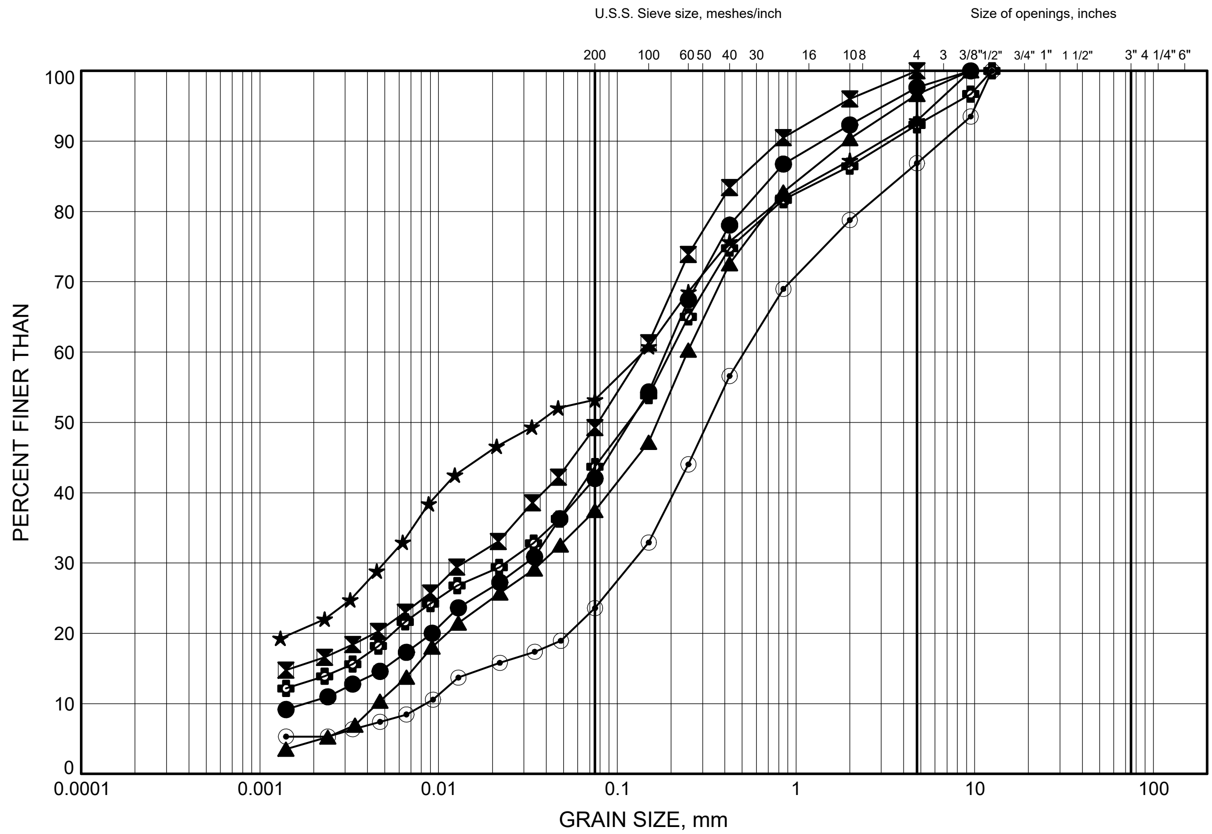
Chkd. AMP

Pike River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty SAND TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PR-01	3.35	278.15
⧗	PR-01	7.70	273.80
▲	PR-02	4.88	277.72
★	PR-02	13.87	268.73
⊙	PR-05	2.67	280.13
✪	PR-05	9.75	273.05

Date September 2016

GWP# 5196-13-00

Prep'd AN

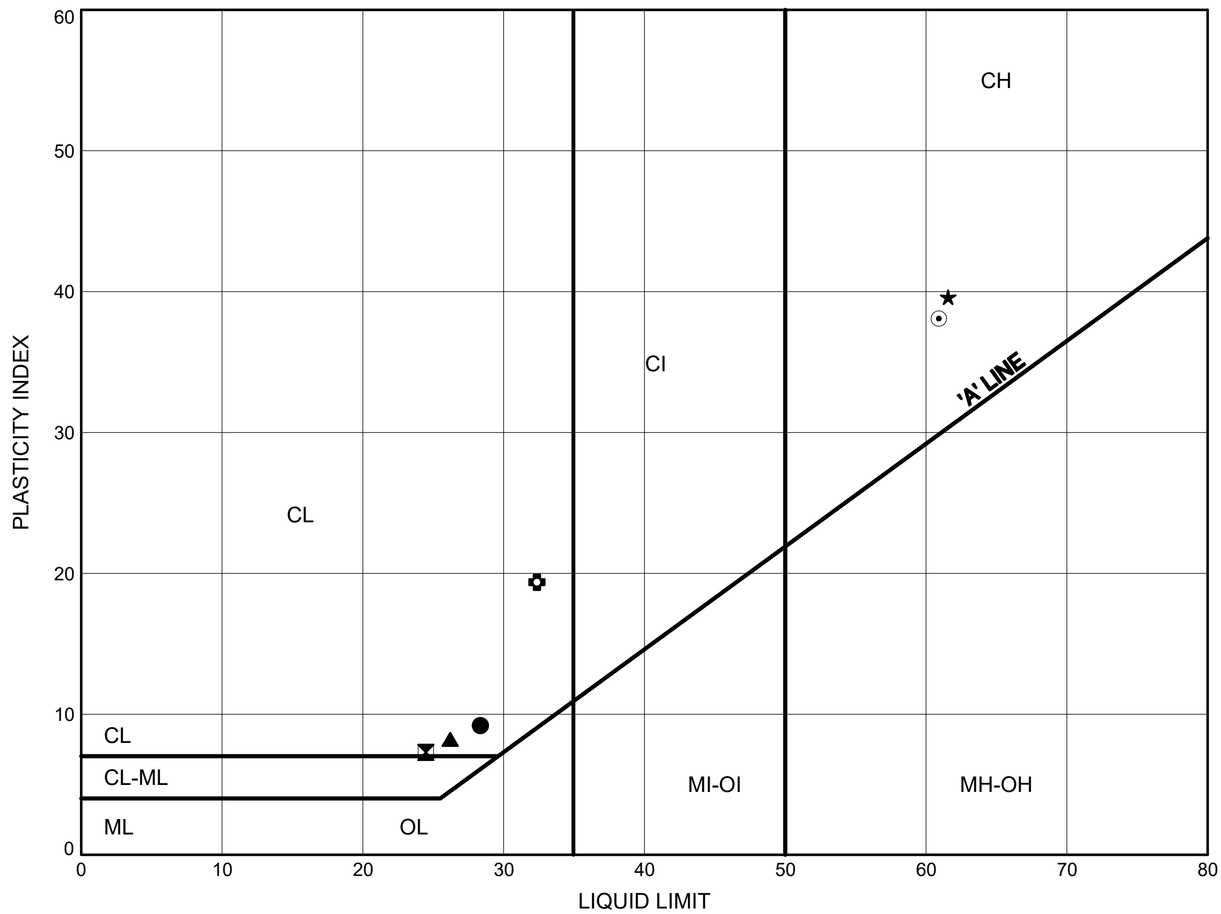
Chkd. AMP

Pike River Bridge

ATTERBERG LIMITS TEST RESULTS

FIGURE B4

Silty CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PR-02	1.83	280.77
⧗	PR-02	3.35	279.24
▲	PR-05	1.14	281.66
★	PR-06	1.07	283.03
⊙	PR-06	1.83	282.27
✿	PR-06	3.35	280.75

Date October 2016

GWP# 5196-13-00

THURBER

Prep'd AN

Chkd. AMP

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

Job No :	19-5161-251	**Client :**	MMM
		Date Drilled :	Jul-16
Project Name :	Pike River Bridge	**Date Tested :**	22-Aug-16
Core Size :	NQ **BH No :** PR-05	**Tester :**	RMT

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	1	15.6	D	7.3	47.5	117.8	60.1	Metamorphic	Strong
2	1	16.1	D	20.4	47.5	82.9	167.2	Metamorphic	Very Strong
3	1	16.4	D	10.3	47.5	150.0	84.7	Metamorphic	Strong
4	1	16.6	D	25.0	47.5	150.0	205.6	Metamorphic	Very Strong
5	1	16.7	D	17.1	47.5	150.0	140.6	Metamorphic	Very Strong
6	2	16.9	D	22.1	47.5	77.3	181.6	Metamorphic	Very Strong
7	2	17.4	D	23.4	47.5	88.4	192.0	Metamorphic	Very Strong
8	2	17.7	D	27.2	47.5	150.0	223.5	Metamorphic	Very Strong
9	2	18.1	D	33.6	47.5	150.0	275.9	Metamorphic	Extremely Strong
10									
11									
12									
13									
14									
15									
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35									

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

Last Modified: August 15, 2013

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

Job No :	19-5161-251	**Client :**	MMM
		Date Drilled :	Jul-16
Project Name :	Pike River Bridge	**Date Tested :**	22-Aug-16
Core Size :	NQ **BH No :** PR-06	**Tester :**	RMT

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	1	13.9	D	16.4	47.5	150.0	135.0	Metamorphic	Very Strong
2	1	14.2	D	20.0	47.5	150.0	164.2	Metamorphic	Very Strong
3	1	14.5	D	22.0	47.5	118.2	180.7	Metamorphic	Very Strong
4	1	14.8	D	23.9	47.5	150.0	195.9	Metamorphic	Very Strong
5	1	15.1	D	16.7	47.5	150.0	137.1	Metamorphic	Very Strong
6	1	15.3	D	13.1	47.5	150.0	107.6	Metamorphic	Very Strong
7	2	15.5	D	13.2	47.5	150.0	108.6	Metamorphic	Very Strong
8	2	15.7	D	13.0	47.5	150.0	106.9	Metamorphic	Very Strong
9	2	16.1	D	22.0	47.5	150.0	180.7	Metamorphic	Very Strong
10	2	16.4	D	17.2	47.5	150.0	141.2	Metamorphic	Very Strong
11	2	16.7	D	22.9	47.5	150.0	188.2	Metamorphic	Very Strong
12									
13									
14									
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31									
32									
33									
34									
35									

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

Last Modified: August 15, 2013

Certificate of Analysis

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FAX (905)712-5122
http://www.agatlabs.com

AGAT WORK ORDER: 16T078548

PROJECT: 19-5161-251

CLIENT NAME: THURBER ENGINEERING LTD

SAMPLING SITE:Temiskaming Structures

ATTENTION TO: Deanna Pizycki

SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2016-03-18

DATE REPORTED: 2016-03-30

Parameter	Unit	G / S	RDL	7450204
			SAMPLE DESCRIPTION:	PR-02 SS4 7.5'-9.5'
			SAMPLE TYPE:	Soil
			DATE SAMPLED:	3/8/2016
Sulphide*	%		0.05	0.10
Chloride (2:1)	µg/g		2	2
Sulphate (2:1)	µg/g		2	70
pH (2:1)	pH Units		NA	8.07
Electrical Conductivity (2:1)	mS/cm		0.005	0.159
Resistivity (2:1)	ohm.cm		1	6290
Redox Potential (2:1)	mV		5	348

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

7450204 EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil).

Certified By: Amanjot Bhela

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Quality Assurance

CLIENT NAME: THURBER ENGINEERING LTD
PROJECT: 19-5161-251
SAMPLING SITE:Temiskaming Structures

AGAT WORK ORDER: 16T078548
ATTENTION TO: Deanna Pizycki
SAMPLED BY:

Soil Analysis

RPT Date: Mar 30, 2016			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Corrosivity Package															
Sulphide*	7444756		< 0.05	< 0.05	NA	< 0.05	95%	80%	120%	NA			NA		
Chloride (2:1)	7443948		70	69	1.4%	< 2	98%	80%	120%	100%	80%	120%	95%	70%	130%
Sulphate (2:1)	7443948		337	336	0.3%	< 2	97%	80%	120%	102%	80%	120%	96%	70%	130%
pH (2:1)	7449192		7.50	7.62	1.6%	NA	102%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	7443948		0.531	0.536	0.9%	< 0.005	97%	90%	110%	NA			NA		
Redox Potential (2:1)	7449192		381	380	0.3%	< 5	109%	70%	130%	NA			NA		

Comments: NA signifies Not Applicable.
Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Certified By: Amanjot Bhela

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Method Summary

CLIENT NAME: THURBER ENGINEERING LTD
AGAT WORK ORDER: 16T078548
PROJECT: 19-5161-251
ATTENTION TO: Deanna Pizycki
SAMPLING SITE:Temiskaming Structures
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Sulphide*	MIN-200-12025	ASTM E1915-09	GRAVIMETRIC
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential (2:1)		McKeague 4.12 & SM 2510 B	REDOX POTENTIAL ELECTRODE

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 16T076149

PROJECT:

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Deanna Pizycki

SAMPLING SITE:

SAMPLED BY:GA

Corrosivity Package (Water)

DATE RECEIVED: 2016-03-11

DATE REPORTED: 2016-03-18

			SAMPLE DESCRIPTION:	Pike River
			SAMPLE TYPE:	Water
			DATE SAMPLED:	3/9/2016
Parameter	**Unit**	**G / S**	**RDL**	**7435575**
Sulphide	mg/L		0.05	<0.05
Chloride	mg/L		0.10	2.60
Sulphate	mg/L		0.10	4.64
Electrical Conductivity	uS/cm		2	158
pH	pH Units		NA	7.62
Redox Potential	mV		5	368
Resistivity	ohms.cm			6330

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Certified By: Amanjot Bhela

Results relate only to the items tested and to all the items tested

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Quality Assurance

CLIENT NAME: THURBER ENGINEERING LTD

PROJECT:

SAMPLING SITE:

AGAT WORK ORDER: 16T076149

ATTENTION TO: Deanna Pizycki

SAMPLED BY:GA

Water Analysis

RPT Date: Mar 18, 2016			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Corrosivity Package (Water)															
Sulphide	7430656		<0.05	<0.05	NA	< 0.05	100%	80%	120%	102%	85%	115%	102%	70%	130%
Chloride	7435391		149	148	0.7%	< 0.10	108%	90%	110%	110%	90%	110%	114%	80%	120%
Sulphate	7435391		10.0	10.0	0.0%	< 0.10	107%	90%	110%	109%	90%	110%	108%	80%	120%
Electrical Conductivity	7436969		2740	2750	0.4%	< 2	104%	80%	120%	NA			NA		
pH	7436969		8.07	8.03	0.5%	NA	99%	90%	110%	NA			NA		
Redox Potential	7435580	7435580	395	395	0.0%	< 5	109%	70%	130%	NA			NA		

Comments: NA signifies Not Applicable.
Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Certified By:

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Method Summary

CLIENT NAME: THURBER ENGINEERING LTD
PROJECT:
SAMPLING SITE:

AGAT WORK ORDER: 16T076149
ATTENTION TO: Deanna Pizycki
SAMPLED BY:GA

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Water Analysis			
Sulphide	INOR-93-6054	SM 4500 S2- D	SPECTROPHOTOMETER
Chloride	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Sulphate	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Electrical Conductivity	INOR-93-6000	SM 2510 B	PC TITRATE
pH	INOR-93-6000	SM 4500-H+ B	PC TITRATE
Redox Potential		SM 2510 B	REDOX POTENTIAL ELECTRODE
Resistivity		SM 2510 B	EC METER

Appendix C

Site Photographs

Photo 1 – South Approach Looking North

Photo 2 – North Approach Looking South

Photo 3 – South Abutment

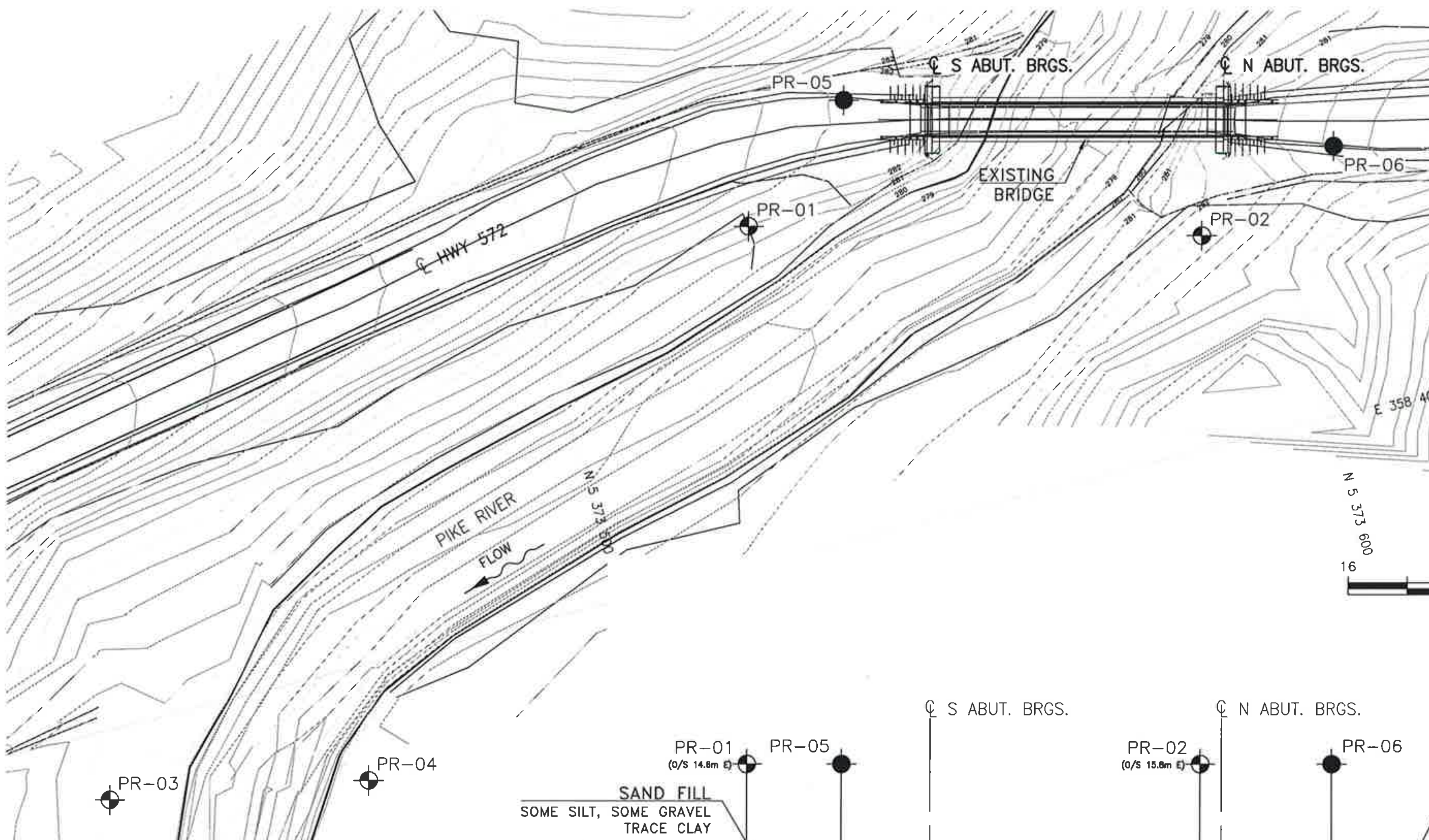
Photo 4 – North Abutment

Photo 5 – East Elevation Looking South

Photo 6 – West Elevation Looking North

Appendix D

Borehole Locations and Soil Strata Drawings



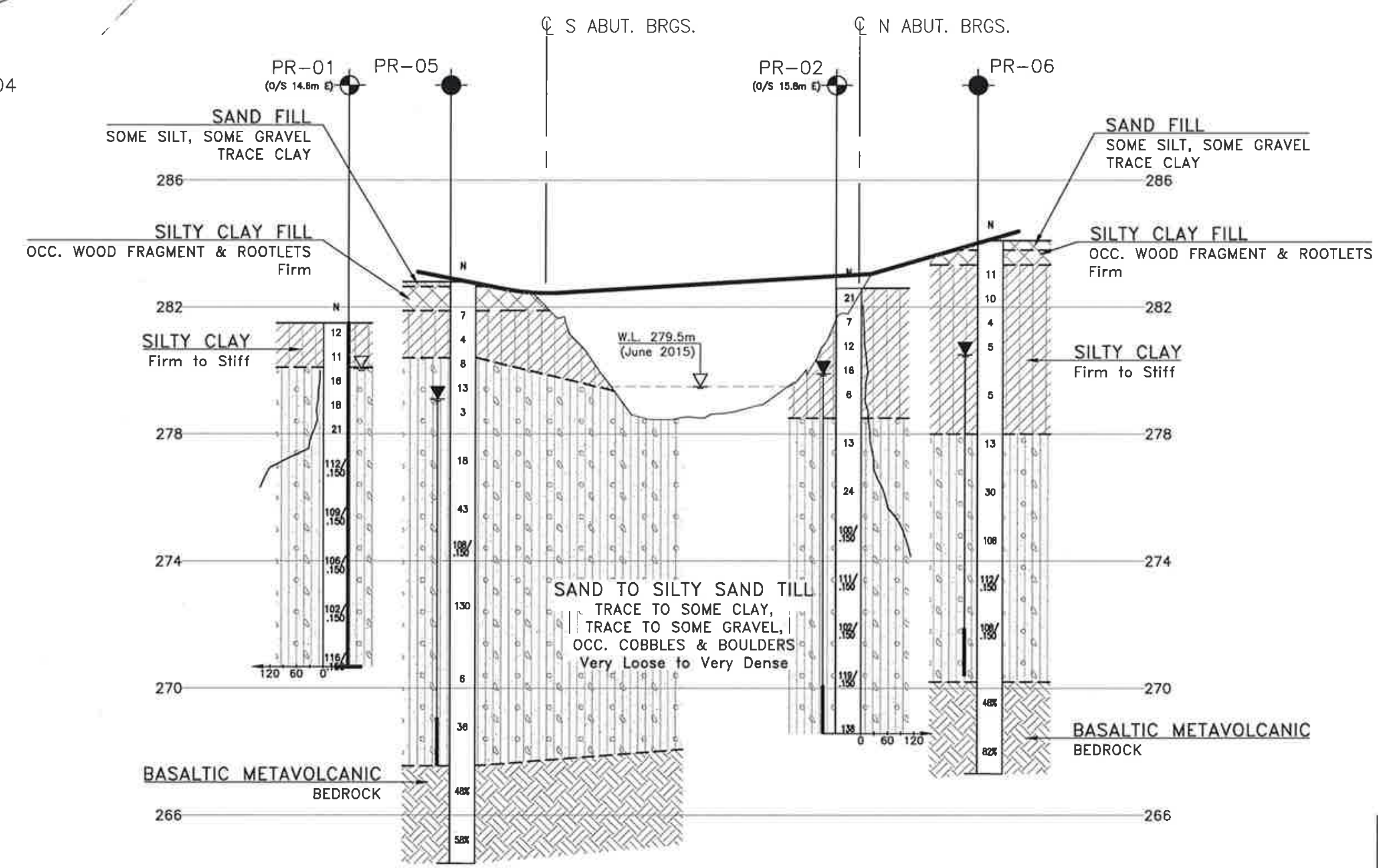
PLAN

16 0 16 32m

SCALE 1:800

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



PROFILE ALONG ℄ HWY 572

16 0 16 32m H 1:800

4 0 4 8m V 1:200

CONT No

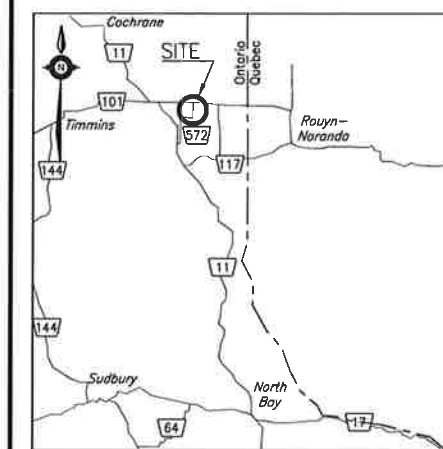
GWP No 5196-13-00

HIGHWAY 572
PIKE RIVER BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

⯁	Borehole
⯁	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Water Level in Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING (MTM)	EASTING (MTM)
PR-01	281.5	5 373 529.9	358 355.2
PR-02	282.6	5 373 589.3	358 371.8
PR-03	279.8	5 373 427.0	358 409.2
PR-04	280.4	5 373 461.4	358 415.3
PR-05	282.8	5 373 546.7	358 341.8
PR-06	284.1	5 373 609.7	358 364.4

-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) Survey data provided by MMM.
4) MTM 83, Zone 12 coordinate system was used to obtain boreholes Northings and Eastings.

GEOCRES No. 42A-116

REVISIONS	DATE	BY	DESCRIPTION		
DESIGN DJP	CHK DJP	CODE	LOAD		DATE JUN 2017
DRAWN AN	CHK AMP	SITE	STRUCT	DWG 1	

FILENAME: H:\Drafting\19\5161\251\ted1251-Plan&Profile(Pike Culvert)_REVISE.dwg
PLOTDATE: 6/8/2017 5:40 PM

THURBER

60 YEARS

Appendix E

Subsurface Information from 1983 Foundation Report, Geocres No 42A-36

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO PH-D-207 82 04

METRIC

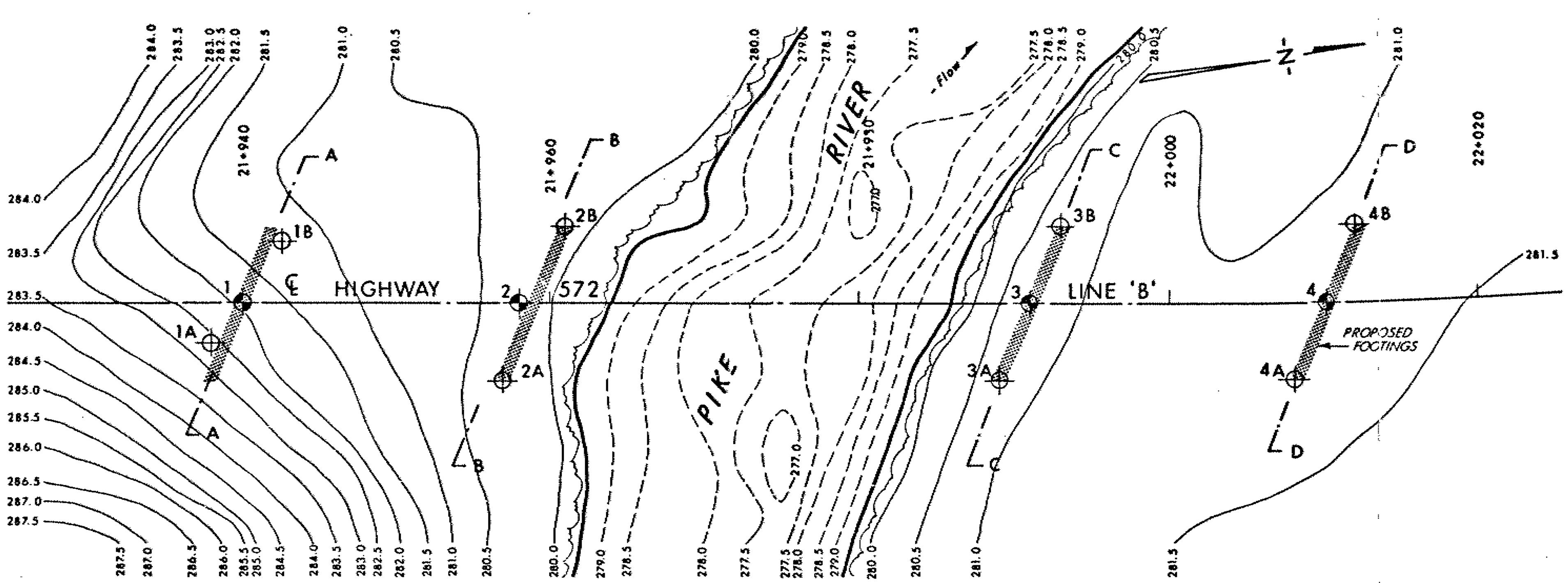
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES

CONT No
WP No 1-81-02

PIKE RIVER

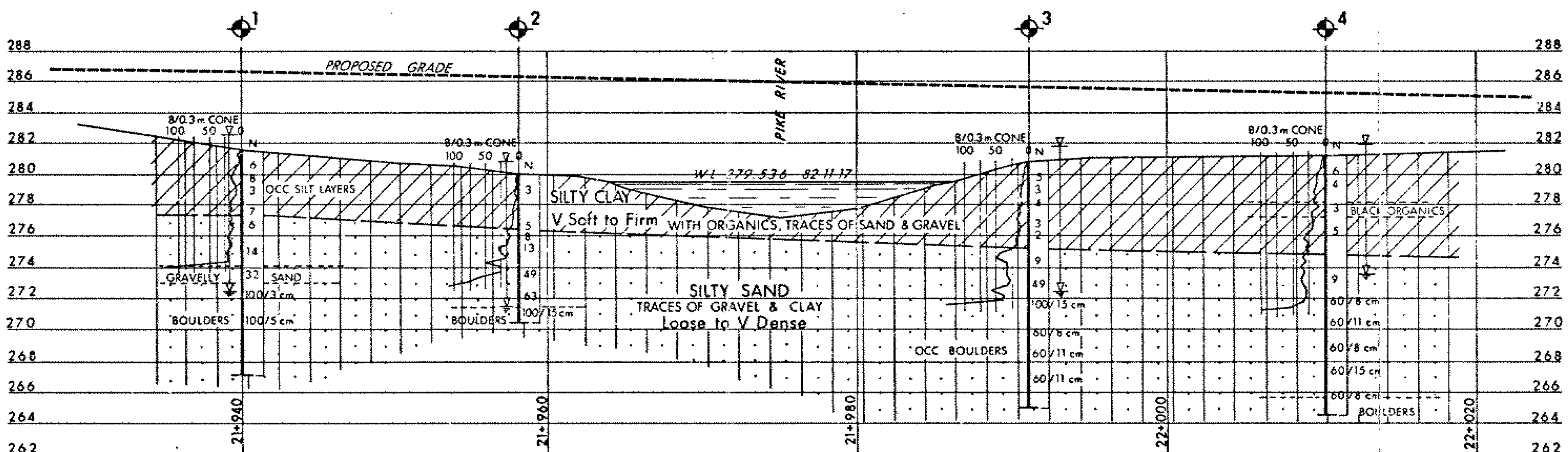
BORE HOLE LOCATIONS & SOIL STRATA

SHEET



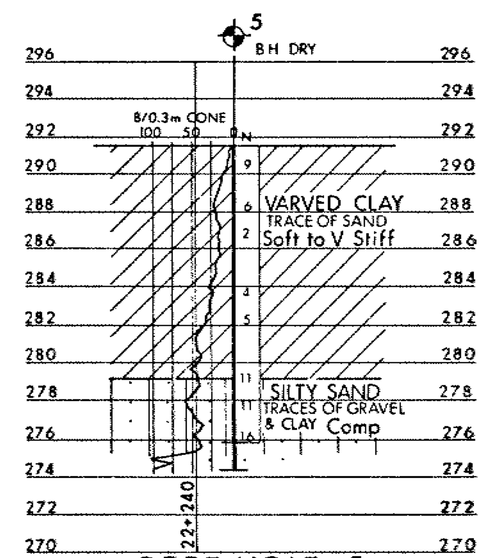
PLAN

SCALE 4m 2 0 4m



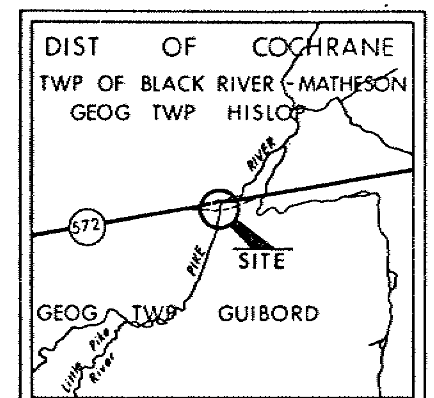
℄ PROFILE HWY 572 LINE 'B'

SCALE 4m 2 0 4m



BORE HOLE 5

SCALE 4m 2 0 4m



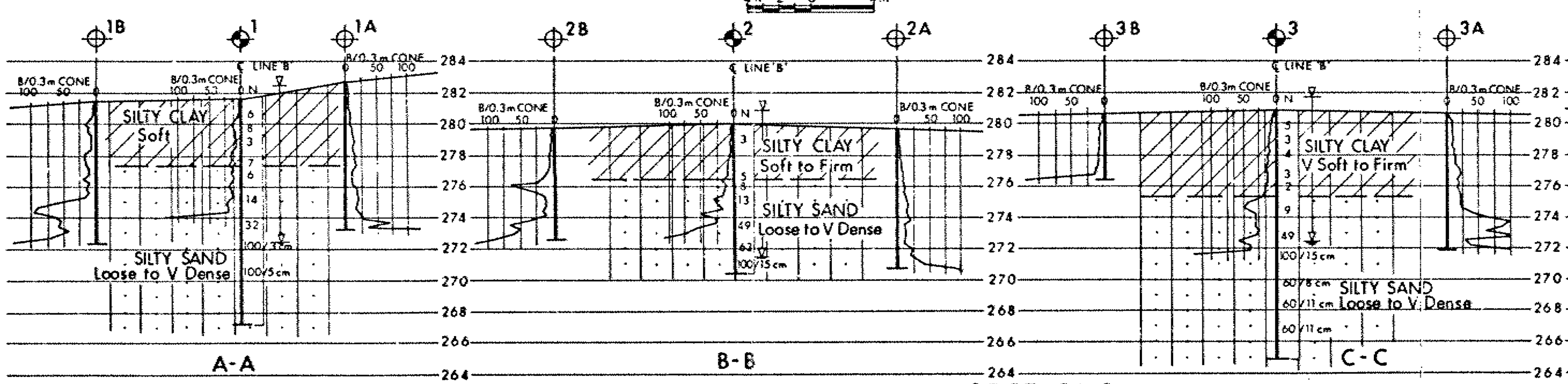
KEY PLAN

SCALE 1km 0.5 0 1km

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N — Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE — Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation 83 06
- Head / ARTESIAN WATER / Encountered

No	ELEVATION	STATION	OFFSET
1	281.6	21+940	℄
1A	282.7	21+938	2.5 m RT
1B	281.4	21+942.5	4.0 m LT
2	280.0	21+958	℄
2A	279.7	21+957	5.0 m RT
2B	279.8	21+961	5.0 m LT
3	280.9	21+991	℄
3A	230.6	21+989	5.0 m RT
3B	280.7	21+993	5.0 m LT
4	281.2	22+010	℄
4A	281.0	22+008	5.0 m RT
4B	281.0	22+012	5.0 m LT
5	291.6	22+242	17.0 m RT



SECTIONS

SCALE 4m 2 0 4m Ver; 2m 1 0 2m Hor

REF NO E-9016-1 83 02

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100

REV	DATE	BY	DESCRIPTION

Geocres No 42A-36

HWY No 572 LINE 'B'			DIST 14
SUBM'D PP	CHECKED	DATE 83 09 14	SITE 39E-152
DRAWN SO	CHECKED	APPROVED	DWG 18102-A

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 1

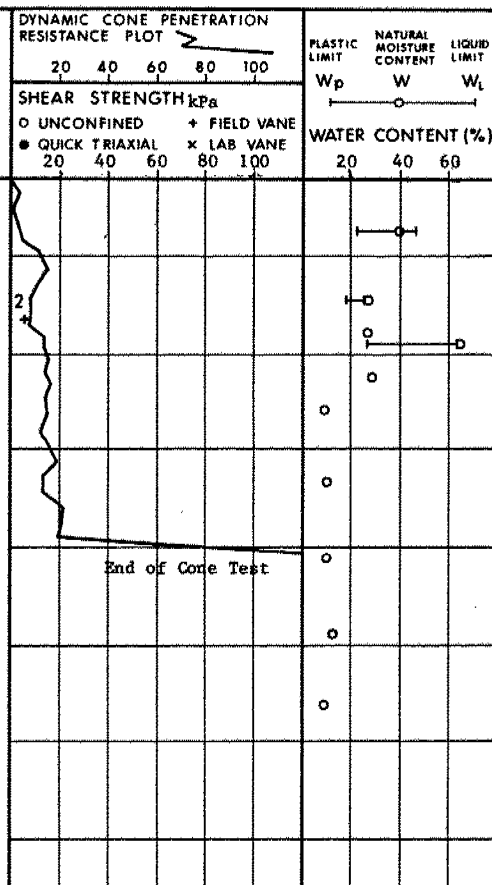
METRIC

W P 1-81-02 LOCATION Sta: 21+940; o/s ℄, Line 'B' ORIGINATED BY CM

DIST 14 HWY 572 BOREHOLE TYPE Cont. Flight Auger COMPILED BY PP

DATUM Geodetic DATE 83 06 24-27 CHECKED BY [signature]

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
281.6	Ground Level							
0.0	Silty Clay, Traces of Sand and Organics, Occ. Silt Sand, Soft		1	SS	6			0 2 45 53
			2	SS	8		280	
			3	SS	3			
			4	TW	PM		278	0 1 83 16
277.4 / 4.2	Silty Sand, Traces of Gravel and Clay, Loose to Very Dense		5	SS	7			0 12 66 21
			6	SS	6			3 62 31 4
							276	
			7	SS	14			
	Gravelly Sand		8	SS	32		274	31 54 11 4
			9	SS	100 / 3cm	▽	272	
	Boulders		10	SS	100 / 5cm			8 83 7 2
							270	
							268	
267.1 / 14.5	End of Borehole							



+[3], ×[5] : Numbers refer to Sensitivity

15 ✧ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 1A

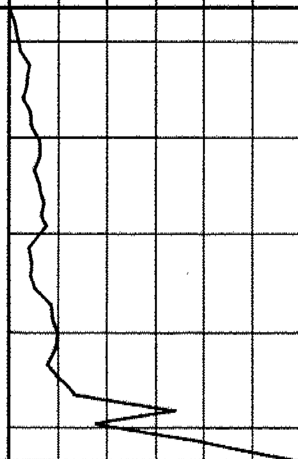
METRIC

W P 1-81-02 LOCATION Sta: 21+938; 2.5 m RT, Line 'B' ORIGINATED BY CM

DIST 14 HWY 572 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY JB

DATUM Geodetic DATE 83 06 24 CHECKED BY [signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT W_p, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
282.7	Ground Level										
0.0							282, 280, 278, 276, 274				
273.3 / 9.4	End of Cone Test										



$+^3, \times^5$: Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 1B

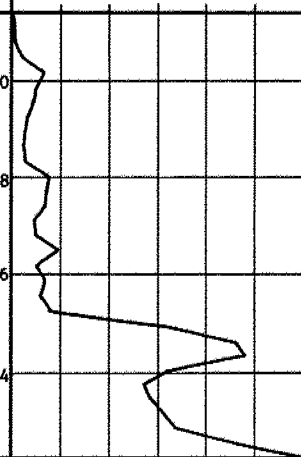
METRIC

W P 1-81-02 | LOCATION Sta: 21 + 942.5; o/s 4 m Lt. Line 'B' | ORIGINATED BY CM

DIST 14 HWY 572 | BOREHOLE TYPE Dynamic Cone Penetration Test | COMPILED BY JB

DATUM Geodetic | DATE 83 06 27 | CHECKED BY [signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	PLASTIC LIMIT W_p — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L / WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
281.4	Ground Level										
0.0							280				
							278				
							276				
							274				
272.3 / 9.1	End of Cone Test										



$+^3$, $\times^5$: Numbers refer to Sensitivity

15 -◇- 5 (20 above, 10 below) (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 2

METRIC

W P 1-81-02 LOCATION Sta: 21 + 958; o/s ℄ , Line 'B' ORIGINATED BY CM

DIST 14 HWY 572 BOREHOLE TYPE Cont. Flight Auger and Washbore COMPILED BY PP

DATUM Geodetic DATE 83 06 21-23 CHECKED BY [signature]

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ KN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
280.0	Ground Level							
0.0	Silty Clay with organics trace of sand Soft to Firm	1	SS	3			om 6.1%	
		2	TW	PH		278	16.5	0 10 41 49
		3	SS	5				4 10 64 22
276.4 / 3.6	Silty Sand traces of gravel and clay Loose to Very Dense	4	SS	8		276		8 62 27 3
		5	SS	13				
		6	SS	49		274		4 93 (3)
		7	SS	63		272		
	Boulders	8	SS	100/15 cm	▽			14 84 (2)
270.4 / 9.6								

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 Wp, NATURAL MOISTURE CONTENT W, LIQUID LIMIT WL; WATER CONTENT (%): 20 40 60

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 -○- 5 (%) STRAIN AT FAILURE (20 above, 10 below)

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 2A

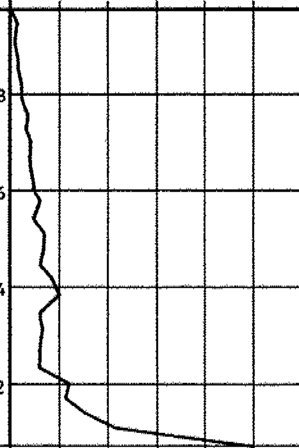
METRIC

W P 1-81-02 LOCATION Sta: 21 + 957; o/s 5 m Rt.; Line 'B' ORIGINATED BY CM

DIST 14 HWY 572 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY JB

DATUM Geodetic DATE 83 06 23 CHECKED BY [signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT W_p NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L / WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
279.7	Ground Level										
0.0							278				
							276				
							274				
							272				
270.7 / 9.0	End of Cone Test										



$+^3, \times^5$: Numbers refer to Sensitivity

15 ⌖ 5 (%) STRAIN AT FAILURE (20 above, 10 below)

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 2 B

METRIC

W P 1-81-02 LOCATION Sta: 21 + 961; o/s 5 m Lt. Line 'B' ORIGINATED BY CM

DIST 14 HWY 572 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY JB

DATUM Geodetic DATE 83 06 23 CHECKED BY [signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH: o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L / WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
279.8	Ground Level										
0.0							278				
							276				
							274				
272.6 / 7.2	End of Cone Test							120/25cm			

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 3

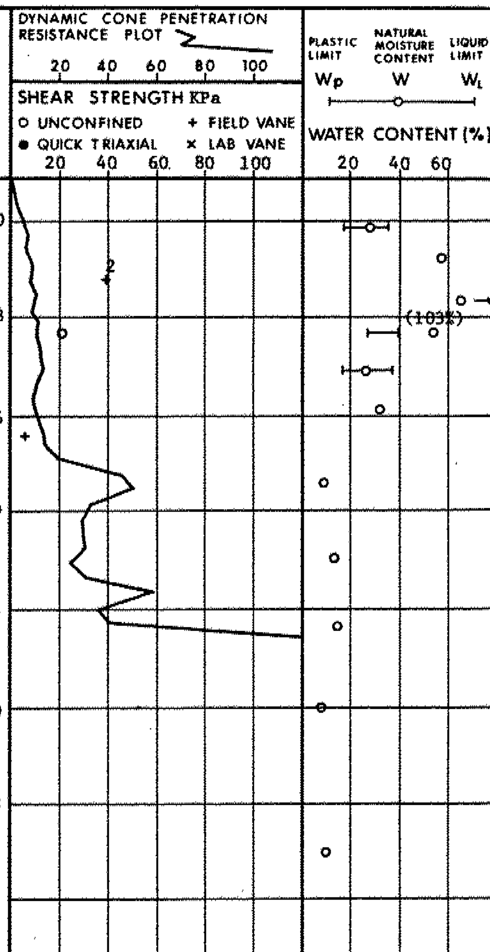
METRIC

W P 1-81-02 LOCATION Sta: 21 + 991; o/s , Line "B" ORIGINATED BY CM

DIST 14 HWY 572 BOREHOLE TYPE Cont. Flight Auger and Washboring COMPILED BY PP

DATUM Geodetic DATE 83 06 28-29 CHECKED BY

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	ELEVATION SCALE	UNIT WEIGHT γ (KN/m³)	GR	SA	SI	CL
280.9	Ground Level									
0.0	Silty Clay with organics some sand trace of gravel Very Soft to Firm	1	SS	5	280					
		2	SS	3		om 9.6%				
		3	SS	4	278	om 10.8%				
		4	TW	PM		15.5	0	14	58	28
		5	SS	3			3	33	26	38
		6	SS	2	276					
275.3 / 5.6	Silty Sand some gravel trace of clay Occ. Boulders Loose to Very Dense	7	SS	9	274		7	78	14	1
		8	SS	49						
		9	SS	100 / 15 cm	272		18	73	8	1
		10	SS	60 / 8 cm	270					
		11	SS	60 / 11 cm	268					
		12	SS	60 / 11 cm			21	38	33	8
					266					
264.9 / 16.0	End of Borehole									



GROUND WATER CONDITIONS

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 -◊- 5 (%) STRAIN AT FAILURE (20 above, 10 below)

OFFICE REPORT ON SOIL EXPLORATION

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RECORD OF BOREHOLE No 3 A

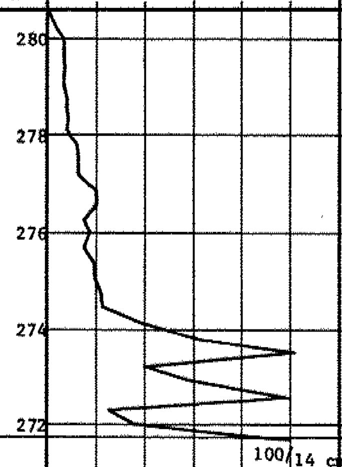
METRIC

W P 1-81-02 LOCATION Sta: 21 + 989; o/s 5 m RT ORIGINATED BY CM

DIST 14 HWY 572 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY PP

DATUM Geodetic DATE 83 06 29 CHECKED BY

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT W_p NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L / WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
280.6 / 0.0	Ground Level						280, 278, 276, 274, 272				
271.9 / 8.7	End of Cone Test							100/14 cm			



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+3, ×5 : Numbers refer to Sensitivity

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

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Ontario

RECORD OF BOREHOLE No 3B

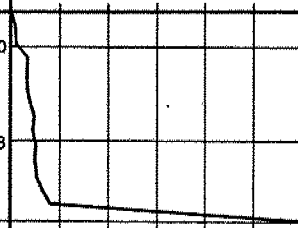
METRIC

W P 1-81-02 LOCATION Sta: 21 + 993; 5 m Lt. LINE 'B' ORIGINATED BY CM

DIST 14 HWY 572 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY PP

DATUM Geodetic DATE 83 06 29 CHECKED BY SO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	PLASTIC LIMIT W_p — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L / WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
280.7	Ground Level										
0.0							280				
							278				
276.4 / 4.3	End of Cone Test										



+3, x5 : Numbers refer to Sensitivity

15 ⌖ 5 (%) STRAIN AT FAILURE (20 above, 10 below)

OFFICE REPORT ON SOIL EXPLORATION

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RECORD OF BOREHOLE No 4

METRIC

W P 1-81-02 LOCATION Sta: 22 + 010; o/s ℄, Line 'B' ORIGINATED BY CM

DIST 14 HWY 572 BOREHOLE TYPE Cont. Flight Auger and Washbore COMPILED BY PP

DATUM Geodetic DATE 83 06 29 to 83 07 01 CHECKED BY [signature]

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
281.2	Ground Level				
0.0	Silty Clay some sand traces of organics	1	SS	6	
		2	SS	4	0 16 61 23
		3	TW	PH	
	Black Organics	4	SS	3	
	Soft to Firm	5	SS	5	
274.8		6	TW	PH	0 1 64 35
6.4	Silty Sand some gravel and clay Loose to Very Dense	7	SS	9	16 61 21 2
		8	SS	60/8 cm	
		9	SS	60/11 cm	2 46 36 16
		10	SS	60/8 cm	
		11	SS	60/15 cm	
		12	SS	60/8 cm	8 15 65 12
	Boulders				
264.4					
16.8	End of Borehole				

Elevation scale: 280, 278, 276, 274, 272, 270, 268, 266

Dynamic Cone Penetration Resistance Plot: 20 40 60 80 100; 100/9 cm

Shear Strength (KPa): ○ Unconfined, ● Quick Triaxial, + Field Vane, × Lab Vane — 20 40 60 80 100; field vane values: +10, +6, +6

Plastic Limit W_p — Natural Moisture Content W — Liquid Limit W_L; Water Content (%) 20 40 60

Unit Weight γ KN/m3

+3, ×5 : Numbers refer to Sensitivity

15 ⌖ 5 (%) STRAIN AT FAILURE (20 above, 10 below)

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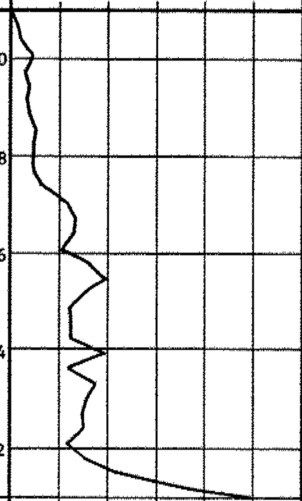
RECORD OF BOREHOLE No 4A

METRIC

W P 1-81-02 LOCATION Sta: 22 + 008; o/s 5 m Rt LINE 'B' ORIGINATED BY CM

DIST 14 HWY 572 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY PP

DATUM Geodetic DATE 83 07 01 CHECKED BY [signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
281.0	Ground Level										
0.0							280 278 276 274 272				
271.1 9.9	End of Cone Test							100/18 cm			

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 ◊ 5 (%) STRAIN AT FAILURE (20 above, 10 below)

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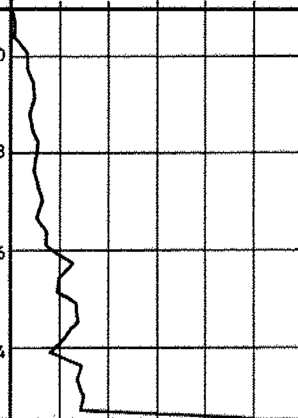
RECORD OF BOREHOLE No 4B

METRIC

W P 1-81-02 LOCATION Sta: 22 + 012; o/s 5 m Lt. Line 'B' ORIGINATED BY CM

DIST 14 HWY 572 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY PP

DATUM Geodetic DATE 83 07 01 CHECKED BY [signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	PLASTIC LIMIT W_p / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
281.0 / 0.0	Ground Level						280, 278, 276, 274				
272.6 / 8.4	End of Cone Test							100/21 cm			

$+^3, \times^5$: Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No 5

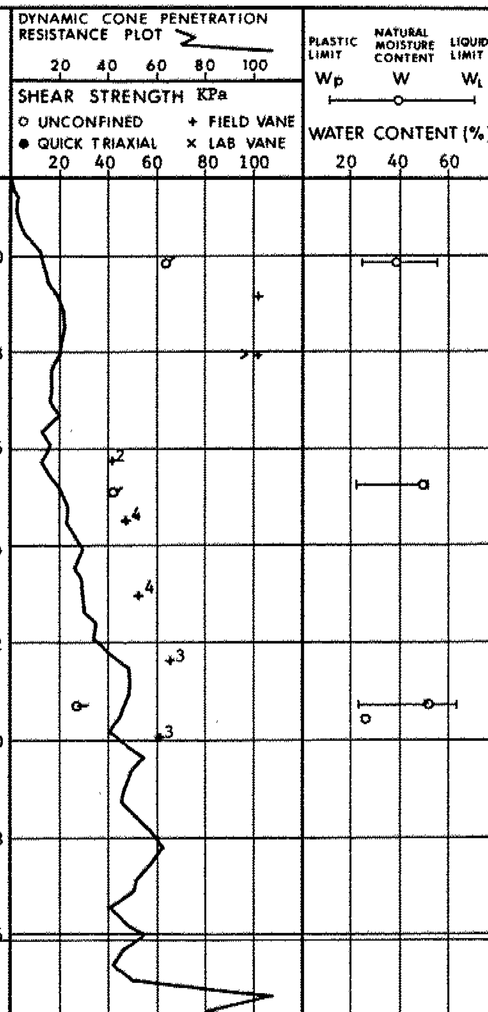
METRIC

W P 1-81-02 LOCATION Sta: 22 + 242;o/s 17 m Rt. LINE 'B' ORIGINATED BY CM

DIST 14 HWY 572 BOREHOLE TYPE Cont. Flight Auger (H.S.) COMPILED BY PP

DATUM Geodetic DATE 83 07 01-02 CHECKED BY [signature]

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ KN/m³	GR SA SI CL
291.6	Ground Level							
0.0		1	SS	9				
		2	TW	PH		290	17.9	0 1 27 72
	Varved Clay trace of sand	3	SS	6		288		
		4	SS	2		286		
		5	TW	PH	Dry		17.0	0 0 16 84
	Soft	6	SS	4		284		
	to							
	Very Stiff	7	SS	5		282		
		8	TW	PH		280	18.1	
279.1 / 12.5	Silty Sand traces of gravel and clay Compact	9	SS	11		278		
		10	SS	11				
275.9		11	SS	16		276		6 80 12 2
15.7	End of Borehole							
274.3 / 17.3	End of Cone Test							



+³, ×⁵ : Numbers refer to Sensitivity   15 -◇- 5 (20 above, 10 below) (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Appendix F

List of OPSS and Suggested Text for Selected NSSP

1. List of OPSS Documents Referenced in this Report

- OPSS.PROV 206
- OPSS.PROV 501
- OPSS.PROV 539
- OPSS 804
- OPSS PROV 902
- OPSS. PROV 903
- OPSS.PROV 1010

2. Suggested text for NSSP on "Obstructions"

Cobbles and boulders and rock fill are present within the existing embankment and underlying native soils at this site. These cobbles and boulders and rock fill may impede excavations, installation of piles and/or temporary support system. At some locations, the installation may not be able to penetrate the obstructions and reach the design elevations. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions to achieve the design depths.

3. Suggested text for NSSP on "Compacted Rock Fill Pads below Footings"

For rock fill pads below abutment footings, the rock fill shall be well graded, freshly produced in a quarry, and have a maximum size of 250 mm.

Rock fill pad construction must be carried out in the dry. The rock fill layers shall not exceed 500 mm in thickness prior to compaction. Material in each layer shall be fully compacted before the succeeding layer is placed. Each rock fill layer shall be compacted with a tractor bulldozer, crawler type as specified in the Tractor Bulldozer – Crawler Type for Rock Embankment Construction subsection of OPSS.PROV 206. The minimum number of complete passes shall be six and the maximum number of passes shall be eight. A complete pass shall be defined as 100% coverage of the layer surface.

For the rock fill pads, materials shall be placed in their final position by blading. End dumping or depositing of rock over the end of any layer by hauling equipment is not permitted. Each layer shall be levelled in place and compacted to minimize voids and bridging of large rock fragments within the rock fill pad.

The top surface of the rock fill pad shall be chinked with rock fragments and spalls to form the subgrade prior to the placement of the levelling pad in order to minimize voids and prevent migration of levelling pad material into the rock fill.

Care shall be taken to avoid large boulders and rock fragments protruding above the rock fill pad surface.

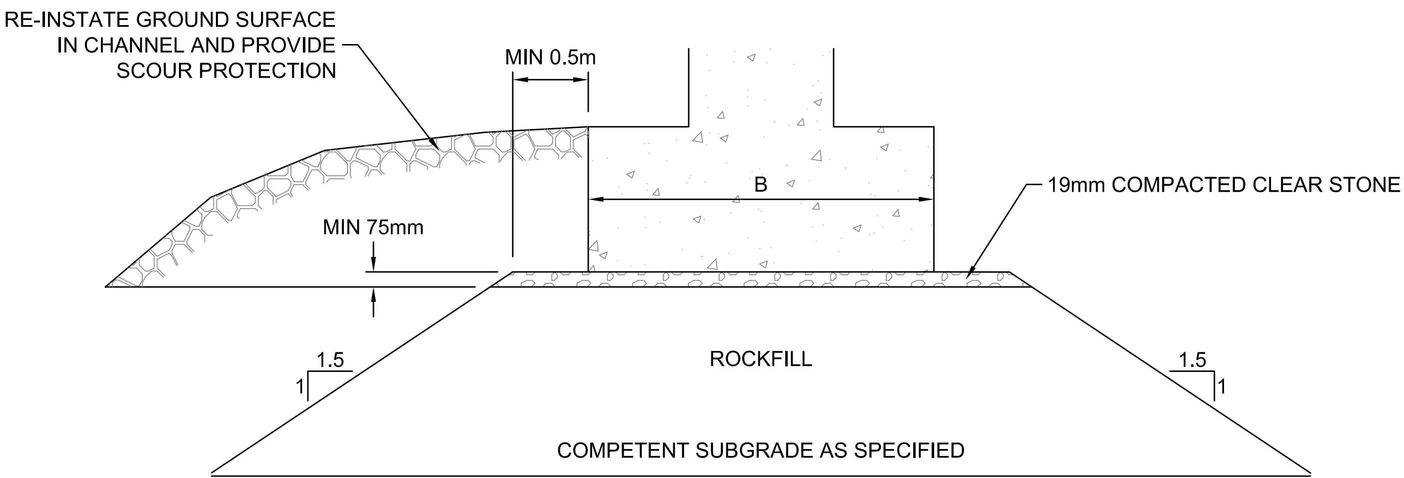
A minimum 75 mm thick layer of compacted 19 mm clear stone should be placed above the rock fill to provide an even founding surface for placement of the footings. Details of footing construction on rock fill are presented in Figure 1 of Appendix G.

THURBER

60 YEARS

Appendix G

Figure 1 – Abutment on Compacted Rock Fill



CROSS-SECTION

FOOTING ON ROCKFILL CORE

THURBER ENGINEERING LTD.

ENGINEER :	DRAWN :	APPROVED :
KS	MFA	PKC
DATE : APRIL 2017	SCALE : N.T.S.	DRAWING No. FIGURE 1

H:\Drafting\19\5161\252\FootingonRockfill-2.dwg - 4/4/2017 4:50 PM