FOUNDATION INVESTIGATION AND DESIGN REPORT
SLATE RIVER BRIDGE REPLACEMENT
HIGHWAY 608, DISTRICT OF THUNDER BAY, ONTARIO
W.P. 6083-09-01, SITE #48W-85

Geocres Number: 52A-190

Report to

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for the proposed replacement of the Slate River Bridge on Highway 608, located approximately 500 m west of Highway 61, in the Thunder Bay District, Ontario.

The purpose of the investigation was to explore the subsurface conditions at the site, and based on the data obtained, to provide a borehole location plan, record of borehole sheets, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions. 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 Hatch Mott MacDonald, under the Ministry of Transportation Ontario (MTO) Agreement Number 6010-E-0010.

A previous foundation investigation carried out at this site prior to construction of the existing bridge was documented in the report "Proposed Slate River Bridge on Hwy 608, 0.2 miles West of Hwy 61, District No. 19 (Thunder Bay) Site No. 48W-85, W.O. 73-11062, W.P. 20-72-02", dated October 3, 1973, Geocres No. 52A-32. The information presented in the above report was reviewed and incorporated in this report.

2 SITE DESCRIPTION

The bridge site is located on Highway 608 approximately 500 m west of Highway 61 and 26 km south of Thunder Bay. The Slate River flows meandering northerly into the Kaministiquia River. The existing bridge is a three span structure of a total length of 28.0 m and width of 9.8 m. The bridge abutments are supported on timber piles 15.8 m in length and the bents at the piers are approximately 20.7 m in length. The existing approach embankments are approximately 4.5 m in height.

The land surrounding the site is gently undulating and treed, with occasional clearings. Photographs of the bridge and surrounding area are presented in Appendix C.

The site lies within the physiographical region known as the Animikie Basin of the Southern Province, which is characterized by sedimentary rock of the Rove Formation. According to Ontario Geological Survey (OGS) data, the bedrock at this site generally consists of black shale, siltstone and greywacke. The bedrock is overlain by glaciolacustrine and quiet basin deposits of the Pleistocene age consisting of silts and clays with minor sands.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried between October 21 and 27, 2014. A total of six boreholes, denoted as SRB-01 to SRB-06, were advanced to depths ranging from 10.1 to 39.2 m below the existing highway embankment. Details of the borehole locations, drilling depths and completion details are summarized in Table 3.1 below.

Table 3.1 – Borehole Summary

Location	Boreholes	Drilling and Coring Depth/ Base of Hole Elevation(m)	Completion Details
West Approach	SRB-01	10.1 / 217.5	Borehole backfilled with bentonite holeplug and cuttings to 0.8 m concrete to 0.1 m then asphalt cold patch to surface.
West Abutment	SRB-02	30.9 / 196.0	Borehole backfilled with bentonite holeplug and cuttings to 0.8 m concrete to 0.1 m then asphalt cold patch to surface.
	SRB-03	33.2 / 193.6	Standpipe piezometer consisting of 19 mm diameter Schedule 40 PVC pipe with a 3 m slotted screen installed.
East Abutment	SRB-04	35.4 / 190.4	Standpipe piezometer consisting of 19 mm diameter Schedule 40 PVC pipe with a 3 m slotted screen installed.
	SRB-05	39.2 / 186.6	Borehole backfilled with bentonite holeplug and cuttings to 0.8 m concrete to 0.1 m then asphalt cold patch to surface.
East Approach	SRB-06	10.2 /215.2	Borehole backfilled with bentonite holeplug and cuttings to 0.6 m concrete to 0.1 m then asphalt cold patch to surface.

The locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing included in Appendix H.

All boreholes were advanced using a CME55 truck-mounted drill rig in combination with hollow stem augers and NW casing/tri-cone methods to advance the boreholes in the overburden. Samples of the overburden soils were obtained from the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

Core samples of the underlying bedrock were recovered from one borehole using NQ rock coring equipment. All rock cores were logged, and the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

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 and rock samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed during the drilling operations. Standpipe piezometers consisting of 19 mm PVC pipe with a slotted screen were installed in Boreholes SRB-03 and SRB-04. Following the final water level reading, the piezometers were decommissioned in general accordance with MOE Regulation 903.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets included in Appendix A. Selected samples were also subjected to gradation analysis and Atterberg Limits testing, and the results of this testing program are summarized on the Record of Borehole sheets in Appendix A and shown on the figures included in Appendix B.

Point load tests (PLT) were performed on selected intact rock core samples. Unconfined compressive strengths (UCS) of the rock cores correlated from the PLT results are shown on the Record of Borehole sheets in Appendix A and the results of the testing are enclosed in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered stratigraphy are presented in this appendix and on the "Borehole Locations and Soil Strata" drawings in Appendix H. Subsurface information obtained from the existing MTO report (Geocres No. 52A-32) was reviewed during preparation of this report. The subsurface conditions documented in the MTO report are, in general consistent with those observed during the present investigations. Two Record of Borehole sheets and the Borehole Locations and Soil Strata drawing from that report are enclosed in Appendix G, for information.

An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

The subsurface stratigraphy below the existing embankment fill encountered at the site generally consists of glaciolacustrine cohesive and cohesionless deposits underlain by a glacial till and bedrock. The cohesive deposit consists of clayey silts and silty clays/sand and silt extending to approximately 21 m depth. A cohesionless deposit ranging in composition from silt to sandy gravel extends to the clayey silt till encountered at depths varying from 28 m to 35 m. Bedrock was encountered at approximately 36 m depth in a borehole drilled at the east abutment. Descriptions of the individual strata are presented below.

5.1 Asphalt and Concrete

Asphalt pavement was encountered in all boreholes. The thickness of the asphalt ranged from 63 to 100 mm. Boreholes SRB-02 to SRB-05 were advanced through the approach slab of the bridge and encountered 300 mm of concrete.

5.2 Fill

Existing embankment fill was encountered below the asphalt or concrete slab in all boreholes. The thickness of the fill materials ranged from 3.0 m to 4.7 m, with the base of the fill between Elev. 221.1 m and Elev. 223.5 m.

The fill consists of primarily gravelly sand with varying content of fine fractions (silt and clay). Occasional cobbles were encountered in the fill.

In Boreholes SRB-01, SRB-04 and SRB-05, the lower 1.4 to 1.8 m of fill was classified as sand with some gravel, silt and clay.

SPT ‘N’ values recorded in the granular fill ranged from 5 to 60 blows per 0.3 m penetration, indicating a loose to very dense relative density. The SPT ‘N’ values in excess of 50 blows for 0.1 m penetration are probably indicative of the presence of cobbles.

Moisture contents of the granular fill ranged from 2 to 25% with typical values between 4 and 12%.

The results of grain size analyses conducted on fill samples are provided on the Record of Borehole sheets in Appendix A, and are illustrated in Figures B1 and B2 of Appendix B. The results are summarized as follows:

	Gravelly Sand	Sand
Gravel	28 to 35%	14 to 18%
Sand	51 to 59%	48 to 59%
Silt & Clay	13 to 17%	27 to 34%
Silt	-	18%
Clay	-	14%

5.3 Upper Clayey Silt to Clayey Sand and Silt

The fill on the east side of the river is underlain by a layer of grey clayey silt to clayey sand and silt. Trace organic matter (rootlets and wood fragments) were noted in the deposit. The thickness of this deposit ranged from 4.1 m to 5.2. The lower boundary of the layer was encountered between 8.2 m and 8.7 m depth (Elev 217.1 and 217.3).

SPT ‘N’ values recorded in the clayey silt/sand and silt ranged from 3 blows per 0.3 m penetration to 9 blows for 0.3 m penetration, indicating a soft to firm consistency. Measured natural moisture contents ranged from 25 to 30% in the clayey silt and 18 to 23% in the clayey sand and silt, with one value of 60%.

The results of grain size analyses conducted on a sample of the clayey sand and silt are provided on the Record of Borehole sheet in Appendix A and plotted in Figure B3 of Appendix B. The results are summarized as follows:

Gravel	0%
Sand	41%
Silt	37%
Clay	22%

5.4 Silty Clay

A layer of grey silty clay was encountered directly below the fill in Boreholes SRB-01 to SRB-03 located on the west side of the river, and below the clayey silt/sand and silt in Boreholes SRB-04 to SRB-06 on the east side of the river. Where fully penetrated, the thickness of the layer ranged from 7.3 m to 12.2 m, and the lower boundary of the layer between 16.3 m and 16.5 m (Elev. 209.5 and 210.4). Boreholes SBR-01 and SBR-06 were terminated in the silty clay deposit at 10.1 m and 10.2 m depth.

SPT ‘N’ values recorded in the silty clay varied between zero blows per 0.3 m penetration (Weight of Rod to Weight of Hammer) to 12 blows per 0.3 m of penetration. The values of 8 to 12 blows per 0.3 m of penetration indicate the presence of a crust in the clay deposit. Field vane shear tests (VST) measured undrained shear strengths ranging from 36 to 83 kPa. Based on the SPT and VST data, the consistency of the silty clay varied from very soft to stiff.

The sensitivity of the silty clay, calculated as a ratio of undisturbed strength to remoulded strength, ranged from 3 to 23, suggesting that the silty clay is low to highly sensitive.

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 illustrated in Figures B4a and B4b of Appendix B. The results are summarized as follows:

Gravel	0%
Sand	0% to 14%
Silt	24 to 59%
Clay	30 to 76%

The results of Atterberg Limits tests conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix A and illustrated in Figures B11a and B11b of Appendix B. The results indicate that the deposit has plastic limits ranging from 15 to 26% and liquid limits ranging from 33 to 63%, suggesting low to high plasticity. Plasticity indices, determined as the difference between the plastic limit and liquid limit, ranged from 15 to 38%. Natural moisture contents of the silty clay ranged from 18 to 63%.

5.5 Lower Clayey Silt

A layer of grey clayey silt was encountered below the silty clay in four deeper boreholes (SRB-02 to SRB-05). The thickness of the layer ranged from 3.0 m to 5.3 m, and the base of the clayey silt was encountered between 19.5 m and 21.6 m depth (Elev. 204.2 to 207.4).

Most SPT ‘N’ values recorded in the clayey silt were zero blows per 0.3 m penetration (Weight of Rod to Weight of Hammer). A blow count of 3 blows per 0.3 m of penetration was noted at Elev. 205.5 in Borehole SRB-04. Undrained shear strengths ranging from 25 to 41 kPa were measured by field vane shear tests (VST). Based on the SPT and VST data, the consistency of the clayey silt varied from very soft to firm.

The sensitivity of the clayey silt, calculated as a ratio of undisturbed strength to remoulded strength, ranged from 1 to 3, suggesting that the clayey silt is of low sensitivity.

The results of grain size analyses conducted on three samples of the clayey silt are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B5 of Appendix B. The results are summarized as follows:

Gravel	0%
Sand	0% to 1%
Silt	72% to 79%
Clay	21% to 27%.

5.6 Sand and Silt

In Boreholes SBR-02 to SBR-05, a cohesionless deposit consisting of various proportions of sand and silt was encountered underlying the clayey silt below 19.5 m to 21.6 m depth (Elev. 204.2 to 207.4). Where fully penetrated, the thickness of this deposit ranged from 8.8 m on the west side of the river to 11.7 m on the east side of the river, and the depth to the base varied from 28.3 m to 33.0 m (Elev. 198.6 to 192.8), respectively.

SPT 'N' values recorded in the sand and silt layer ranged from 0 to 35 blows per 0.3 m penetration, indicating a very loose to dense relative density. Natural moisture contents was measured to be between 10 and 22%.

The results of grain size analyses conducted on selected samples are provided on the Record of Borehole sheets in Appendix A, and plotted in Figures B6 to B9 of Appendix B. The results are summarized as follows:

Gravel	0%
Sand	11% to 79%
Silt	16% to 81%
Clay	5% to 8%

5.7 Sandy Gravel to Sand and Gravel

A layer of sandy gravel to sand and gravel was encountered in Boreholes SRB-04 and SRB-05. The sand and gravel contains occasional cobbles and boulders. The layer was 3.6 m and 1.7 m thick and extended to depths of 34.4 m and 34.7 m (Elev.191.4 and 191.1) in Boreholes SRB-04 and SRB-05, respectively.

SPT 'N' values recorded in the deposit were 17 and 28 blows per 0.3 m penetration, indicating a compact relative density. Measured natural moisture contents of 10% and 12% were obtained.

The results of grain size analyses conducted on samples of the gravelly deposit are provided on the Record of Borehole sheets in Appendix A and plotted in Figure B10 of Appendix B. The results are summarized as follows:

Gravel	42 to 64%
Sand	33 to 52%
Silt & Clay	3 to 6%

5.8 Clayey Silt Till

A layer of clayey silt till was encountered below the cohesionless deposits of sand, silt and gravel in Boreholes SRB-02 to SRB-05. The clayey silt till contains cobbles and boulders. The till layer fully penetrated in Borehole SRB-05 was 1.4 m thick. The remaining boreholes were advanced into the clayey silt till for 1.0 m to 2.9 m to depths from 30.9 m to 36.1 m (Elev. 189.7 and 196.0). The base of the layer fully penetrated in Borehole SRB-05 was at 36.1 m (Elev. 189.7).

SPT 'N' values recorded in the deposit were greater than 100 blows per 0.3 m penetration, indicating a hard/ very dense relative density. Measured natural moisture contents ranged from 5 to 15%.

5.9 Bedrock

Bedrock was encountered in Borehole SRB-05 at 36.1 m depth (Elev. 189.7 m).

The bedrock is described as dark grey shale, moderately weathered to fresh. Occasional zones of limestone were noted in the recovered core samples. Broken zones up to 225 mm in thickness were encountered throughout the cored depth. In the two recovered rock cores, the measured Total Core Recovery (TCR) were 93% and 98%, and the Rock Quality Designation (RQD) were 23% and 52%, indicating poor to fair rock quality.

Borehole SRB-05 was terminated in the bedrock at 39.2 m depth (Elev. 186.6 m).

The unconfined compressive strength (UCS) of the rock, estimated from the results of point load tests conducted on the rock core samples, ranges between 61 and 119 MPa, indicating a strong to very strong intact rock. The point load test results (average values for each core) are included on the borehole logs in Appendix A, and the point load test sheet with details of testing is enclosed in Appendix B.

5.10 Water Levels

The water levels in the boreholes were measured upon completion of drilling operations. Since the water was used during the wash-boring and coring operations, the measured water levels may not reflect prevailing groundwater levels at the site.

Standpipe piezometers were installed in Boreholes SRB-03 and SRB-04 to monitor groundwater levels after drilling. The water levels measured in the open boreholes upon completion of drilling and in the piezometers are summarized in Table 5.1.

Table 5.1 - Water Level Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
SRB-03	Nov. 1, 2014	3.6	223.2	In piezometer
	Nov. 2, 2014	3.6	223.2	
	Nov. 3, 2014	3.6	223.2	
SRB-04	Nov. 1, 2014	2.5	223.3	In piezometer
	Nov. 2, 2014	2.5	223.3	
	Nov. 3, 2014	2.5	223.3	
SRB-06	Oct. 24, 2014	4.3	221.1	Open borehole

The approximate water level in the river shown on the preliminary GA drawing is at Elev. 220.97 m on Nov. 8, 2013, which is consistent with the water level referenced in the previous foundation report (Geocres No. 52A-32) dated May 29, 1973. The water level in the river and groundwater levels are expected to fluctuate seasonally and are subject to precipitation patterns, and may vary from the levels presented above.

6 MISCELLANEOUS

Eastern Ontario Diamond Drilling Ltd. supplied the drill rig and conducted the drilling, sampling and in-situ testing operations. A truck-mounted CME 55 drill rig was used for the duration of the investigation.

The drilling and sampling operations were supervised in the field by Mr. Matthew Whalen of Thurber. Mr. Mark Farrant, P.Eng. directed the field operations.

The report was prepared by Ms. Anna Piascik, P.Eng., and reviewed by Mr. Murray Anderson, 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

7 GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides geotechnical recommendations to assist the design team in selecting and designing a suitable foundation system for the proposed replacement bridge.

At present, Highway 608 crosses the Slate River on a three span structure with a total length of 28.0 m and width of 9.8 m. The bridge is supported on timber piles, 15.8 m in length at the abutments and 20.7 m in length at the bents. The foundation units of the bridge are positioned on a skew of 20° to the centreline of the highway. The existing approach embankments are approximately 4.5 m in height. The existing road grade at the bridge is at approximate Elev. 225.8 m on the east side and 226.9 m on the west side.

The preliminary General Arrangement drawing indicates that the replacement bridge will be a single span structure with a total length of 29.1 m and a width of 11.8 m. The existing road grade will be raised by 860 mm at the east abutment and by 630 mm at the west abutment. Sheet pile walls are proposed at both abutments to retain the approach fill. The new abutments will be installed square to the roadway centreline and within the footprint of the existing abutment foundations.

The discussion and recommendations presented in this report are based on information provided by Hatch Mott MacDonald (HMM) and on the factual data obtained in the course of this investigation, in combination with the subsurface information presented in the Geocres 52A-32 report.

8 STRUCTURE FOUNDATIONS

In general, the site is underlain by glaciolacustrine cohesive and cohesionless deposits overlying relatively thin glacial till and bedrock. The cohesive deposit consisting of clayey silt/sand and silt and silty clay extends to as much as 21.6 m depth. The consistency of the deposit varies from very soft to stiff. The silty clay is underlain by a cohesionless deposit ranging in composition from silt to sandy gravel, which in turn overlies the clayey silt till encountered at 28 m to 35 m depth. Shale bedrock was encountered beneath the till at approximately 36 m depth in one borehole located in the area of the east abutment.

The river level was indicated on the General Arrangement drawing at Elev. 220.97 on November 8, 2013. The groundwater level measured on May 23, 1973 during the previous investigation by MTO was at Elev. 220.9. The groundwater levels in the piezometers installed in the boreholes were measured at Elev. 223.2 and 223.3 on the west and east side of the river, respectively.

Several foundation options were considered for this bridge, namely

- spread footings placed on native soil or engineered fill,
- driven steel H-piles, and
- augered caissons.

A comparison of the technical advantages and disadvantages of the alternative foundation schemes is presented in Appendix D.

Recommendations for design of the feasible foundation alternatives are presented in the following sections together with the corresponding geotechnical design parameters. A preferred foundation alternative from a geotechnical perspective is recommended.

8.1 Spread Footings on Native Soil or Engineered Fill

The use of spread footings to support the abutments is not recommended given the relatively low geotechnical resistance available in the native soils and the potential for large consolidation settlement in the cohesive deposits.

8.2 Driven H-Pile Foundations

8.2.1 Axial Resistance

The ground conditions at the site are considered to be suitable for the use of steel H-piles driven to practical refusal into hard clayey silt till.

H-piles founded in the above strata should be designed using the recommended geotechnical capacities presented in Table 8.1.

Table 8.1 – Recommended Geotechnical Resistance and Reaction for HP310x110

Foundation Element	Pile Tip Elevation (m)	Factored Geotechnical Resistance at ULS (kN) per pile	Geotechnical Reaction at SLS (kN) per pile
West Abutment	195	1600	1400
East Abutment	190	1600	1400

The above pile tip elevations were estimated for a pile tip penetrating into hard till, as encountered at the borehole locations. The actual founding elevation for each pile may vary during installation.

Oversize materials (e.g. greater than 75 mm nominal diameter) must not be used for any new fill through which the piles will be driven.

8.2.2 Pile Tips

Pile tip protection is recommended for driven H-piles to prevent pile damage when setting the piles in the very dense/hard deposit or if cobbles or boulders are encountered. The tips of all driven H-piles at the abutments must be fitted with pile tip protection from an approved manufacturer such as Skyline Steel, Titus Steel (Standard H-point) or similar.

8.2.3 Pile Installation

Pile installation should be in accordance with OPSS 903.

Pile driving must 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 2.0 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” must have a minimum value of twice the design load at ULS.

If the proposed bridge design requires that the deviation at the top of the pile be limited to tight tolerance, a driving template or other means may be required to achieve the specified maximum deviation.

8.2.4 Pile 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 of horizontal subgrade reaction (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 = $67\ S_u / D$ (kN/m^3)

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

Where S_u = undrained shear strength (kPa)

D = pile width or diameter in metres

The above equations and recommended parameters in Table 8.2 below may be used to analyze the interaction between a pile and the surrounding soil. The lateral pressures obtained from the analysis must not exceed the ultimate lateral resistance.

Table 8.2 – 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				
West Abutment						
Fill	GS	222.5	20	2,500	3.0	-
Silty Clay	222.5	210.3	17	-	-	40
Clayey Silt	210.3	205.3	17	-	-	25
Silt and Sand	205.3	197.3	19	3,500	3.3	-
Clayey Silt Till	197.3	193.6	22	6,000	3.5	-
East Abutment						
Fill	GS	221.3	20	3,000	3.0	-
Clayey Silt/Clayey Sand and Silt	221.3	217.2	17	-		40
Silty Clay	217.2	209.5	17	-	-	40
Lower Clayey Silt	209.5	204.5	17	-	-	25
Silt and Sand	204.5	191.0	19	3,500	3.3	-
Clayey Silt Till	191.0	189.7/Bedrock	22	6,000	3.5	-

Note: * Submerged unit weight should be used below the HWL.

** Pile tip elevations vary at pile locations.

For analysis, the spring constant, K_s, may be obtained from the expression:

$$K_s = k_s\ L\ D\ (kN/m),$$

where k_s = coefficient of horizontal subgrade reaction (kN/m^3),

D = pile width (m), and

L = 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.

According to CHBDC Clause 6.8.7.1, Table C 6.4, the lateral resistance of a HP310x110 pile driven in those soil conditions should be limited to 120 kN at ULS, and 35 KN at SLS.

The modulus of subgrade reaction 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 8.3. Intermediate values may be obtained by linear interpolation.

Table 8.3 – 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. Additional lateral resistance could also be provided by socketing the piles into bedrock. However, considering the depth to bedrock at this site, socketing of the piles is not expected to be an efficient means of developing lateral resistance.

8.3 Downdrag

The existing road grade will be raised by 860 mm at the east abutment and by 630 mm at the west abutment. Downdrag forces will develop along the length of abutment piles embedded in the cohesive deposits due to consolidation of these deposits under the weight of the new approach fill placed to raise the grade.

For design purposes, an unfactored downdrag load of 650 kN per pile should be used to evaluate the impact of downdrag load on the abutment piles.

This downdrag load should be multiplied by a load factor of 1.25 as per CHBDC Commentary Clause C6.8.4 to obtain a factored downdrag load. In accordance with Section 6.8.4 of the CHBDC and Clause C6.8.4 of the Commentary, in the structural design of a pile, the factored downdrag load should be added to the factored permanent loads to assess the effects of downdrag. The factored dead and downdrag load should not exceed the factored structural resistance of a pile.

In geotechnical analysis of downdrag, live load effects should not be considered.

The location of the neutral plane for a pile or group of piles should be determined by using unfactored loads and unfactored geotechnical parameters.

8.4 Caissons / Drilled Shafts

In view of the presence of relatively low strength compressible deposits and cohesionless soils under high groundwater conditions extending to significant depth, the use of caissons is not recommended and has not been developed herein.

8.5 Recommended Foundation

From a geotechnical perspective and based on the subsurface conditions, steel H-piles driven into the hard till is the preferred foundation option at this site.

8.6 Frost Cover

The depth of frost penetration at this site is approximately 2.2 m. The base of pile caps must be provided with a minimum of 2.2 m of earth cover as protection against frost action.

8.7 Impact of Construction of New Piles on Existing Foundations

The existing abutments are positioned on 20 degrees skew to the centreline of the bridge. Archive documents indicate that the timber piles supporting the existing bridge were driven approximately 16 m into firm to stiff cohesive deposits with tips at approximately Elev. 208. The timber piles are battered. The new abutments will be constructed at 90 degrees to the centreline of the bridge, which means that the new piles may be in conflict with the existing timber piles. Moreover, the proposed sheet pile to contain the abutment fills are likely to encounter timber piles at various depths. There is a possibility that some of the sheet piles will not reach the design tip elevations.

As per discussion with the Designer, for each stage of construction, the intention is to remove a section of the existing abutment and expose the existing timber piles. Where the locations of new piles are in conflict with the existing piles, the upper/obstructing part of the old piles will be cut-off and removed to allow for the installation of the new piles. In addition, pre-augering and/or coring of the obstructing piles is envisioned to allow for the new pile installation.

Due to nature of the soils (compressible and sensitive clays) within the pile length, pre-augering or coring through the timber piles may cause disturbance of the surrounding soil mass and structure deformation. The Contractor must not attempt to remove/pull-out the full pile length, as this could disturb the surrounding clays, and could induce significant deformations/settlements of the existing/operational part of the bridge.

The complexity of the new pile installation should be brought to the attention of the Contractor prior to Contract Award, so the appropriate equipment and related costs would be accounted for prior to commencement of the contract/ foundation construction.

It is recommended that a monitoring program (including establishment of adequate benchmarks outside the zone of potential influence and acquirement of baseline readings in advance of construction) be implemented for the duration of foundation construction to identify any movement of the existing structure. Appropriate monitoring points and tolerable levels of movement should be specified by the structural designer. If movements exceed tolerable levels, the Contractor must be prepared to jack and/or shim the bridge structure. Suggested wording for an NSSP for monitoring of the existing structure during pile driving has been included in Appendix E.

To avoid conflict with the existing abutment piles, consideration should be given to lengthening the bridge span or installing RRS structures as abutment walls in place of sheet piles.

9 EXCAVATION AND DEWATERING

Excavation for removal of the existing abutments and pile tops is expected to extend to approximately Elev. 221 and 222 and the east and west abutments, respectively (approximately 1.5 m below the underside of the pile cap). This excavation is expected to extend into the existing fill, and nominally into the native cohesive deposits. The base of excavation will be close to the water table, however, it is not expected to extend below the water level in the river, although perched groundwater may be present in the fill.

All excavations must be carried out in accordance with the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the existing fill above the water table may be classified as Type 3 soil. Flatter slopes may be required at locations where water seepage affects surficial stability.

The excavation and backfilling for foundations must be carried out in accordance with OPSS 902. The selection of the method of excavation and equipment is the responsibility of the Contractor. Provision must be made for handling of pavement materials, potential obstructions in the fill, and cobbles/boulders. Special equipment may be required for excavation of the existing abutments and cutting off of the piles that will be in conflict with the new piles.

Roadway protection will be required to facilitate staged construction at this site. The temporary excavation support system should be designed and constructed in accordance with OPSS 539. Sheet piles or soldier pile and lagging walls are considered appropriate for roadway protection. The Contractor should select the wall type and design taking into account the soil conditions encountered in the boreholes.

10 SHEET PILE WALLS

The current design indicates that steel sheet pile walls will be installed adjacent to the pile foundations in lieu of conventional abutment walls. The sheet piles will provide containment and resistance to lateral earth pressures from the approach fill. If possible, the alignment of the proposed sheet pile walls should be carefully selected to not intersect the existing timber piles and bents.

Lateral stability of the sheet pile walls should be checked by the wall designer using the parameters presented in Table 10.1. The coefficients of passive earth pressure (K_p) are provided for horizontal ground surface in front of the sheet pile wall. For sloping ground in front of the sheet pile wall, the recommended values for the coefficients of passive earth pressure (K_p) should be reduced.

Table 10.1 – Soil Parameters for Sheet Pile Analysis

Foundation Element	Soil Unit	Elevation (m)		γ′ (kN/m³)	K_a	K_p	K_o
		Top	Bottom				
West Abutment	Fill	GS	222.5	20	0.33	3.0	0.50
	Silty Clay	222.5	210.3	17	0.39	2.6	0.56
	Clayey Silt	210.3	205.3	17	0.42	2.4	0.59
	Sand and Silt	205.3	197.3	19	0.31	3.3	0.47
East Abutment	Fill	GS	221.3	20	0.33	3.0	0.50
	Clayey Silt/Clayey Sand and Silt	221.3	217.2	17	0.42	2.4	0.59
	Silty Clay	217.2	209.5	17	0.39	2.6	0.56
	Lower Clayey Silt	209.5	204.5	17	0.42	2.4	0.59
	Sand and Silt	204.5	191.0	19	0.31	3.3	0.47

Cobbles and boulders may be encountered during driving the sheet piles through the existing approach fill. Moreover, the existing erosion protection on both banks of the river consists of a large size rock fill. This rock fill material, as well as any visible obstructions along the sides of the embankment should be removed prior to driving the sheet piles. Tip protection is recommended for these sheet piles.

Design of the permanent sheet pile walls must consider environmental conditions such as road salts or fluctuating water levels that may cause corrosion and reduce the service life of the structure. The native soils in front of the sheet piles should be protected from river erosion so that the sheet piles do not lose lateral support.

Backfill to the sheet pile walls should be in accordance with OPSS 902 and should consist of Granular A, Granular B Type II or Granular B Type III material. All granular material should meet the specifications of OPSS.PROV 1010. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS 501.

11 RETAINED SOIL SYSTEM (RSS)

Consideration could be given to incorporating RSS walls at the abutments.

The borehole information indicates that the soil conditions at the abutments comprise in general, embankment fill underlain by native firm to stiff silty clay and clayey silt/sand and silt. The firm to stiff silty clay and clayey silt/sand and silt are considered suitable for support of the RSS wall, when properly prepared.

The performance of a RSS is dependent, among other factors on the characteristics of its foundation. Fill and any excessively soft/loose native material should be stripped from the footprint of the RSS, and an engineered fill pad approximately 500 mm thick should be placed under the RSS mass to achieve the design founding level. The fill should consist of OPSS Granular “A” compacted to 100% of its SPMDD at a moisture content within 2% of optimum. The engineered fill pad must extend at least 500 mm beyond the limits of the RSS mass and levelling strip.

The granular pad for the RSS foundation should be placed on native firm to stiff silty clay and clayey silt/sand and silt encountered between Elev. 222.1 and 222.6 at the west abutment and Elev. 221.2 and 221.4 at the east abutment, some 4.3 m to 4.7 m below the existing embankment grade. The following geotechnical capacities may be assumed for design of the RSS walls placed on the 500 mm granular pad:

Geotechnical Resistance at ULS (factored) – 230 kPa

Geotechnical Reaction at SLS – 150 kPa

The above values assume that the RSS wall reinforcement will extend a distance behind the wall face of approximately 70% of the wall height. The geotechnical reaction at SLS is based on a settlement of 25 mm of the foundation soils.

The geotechnical resistances provided above are for concentric, vertical loading. The effects of load inclination and eccentricity need to be taken into account according to the CHBDC 2006 Section 6.7.

The entire block of reinforced earth must be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall placed on engineered granular fill may be estimated using ultimate friction coefficients of 0.55. The internal stability of the RSS wall should be analysed by the supplier/designer of the proprietary product selected for this site.

The global stability should be reviewed by this office once further design details have been established.

The RSS walls included in the design, may be specified to be "Medium Performance" and "Medium Appearance". The RSS supplier/designer may specify more stringent criteria or other requirements related to the particular design.

Sufficient erosion protection should be provided for the RSS foundations and along any wall surface to the height corresponding to the high water level (HWL) in the Slate River. The HWL in the river should be determined by the bridge designer.

The contract drawings and documents must include information on the longitudinal alignment of the wall in plan, the top and base elevations of the wall in profile and cross-sectional space constraints. The Special Provision for RSS walls SP599S22, December 2014 should be included.

12 APPROACH EMBANKMENTS

Based on the latest GA drawing, the existing road grade will be raised by 860 mm at the east abutment and by 630 mm at the west abutment. In a distance of 20 m from the abutments, the grade raise will be 220 mm on the west side and 620 mm on the east side of the bridge.

The estimated primary consolidation settlements and immediate settlements during construction due to grade raise indicated above will be less than 25 mm within 20 m length of both approach embankments.

The new approach embankments will be retained by sheet pile walls to approximately 6 m behind the abutment walls. The foundation soils governing stability of the approach embankments consist of firm to stiff silty clay and clayey silt and sand.

Global stability analyses were carried out to assess the stability of the forward slopes with the proposed sheet pile wall configuration. The stability analyses were carried out using the commercially available slope stability program GEO-SLOPE, applying the Morgenstern-Price method. The geotechnical model and results of the analyses are shown on Figures 1 to 4 in Appendix F. The computed factors of safety are summarized in Table 12.1.

Table 12.1 - Estimated Factors of Safety for Approach Embankments

Abutment	Condition	Sheet Piles	Factor of Safety	Figure (Appendix F)
West	Total stress analysis - Short term	Yes	1.5	1
	Effective Stress Analysis - long term	Yes	1.5	2
East	Total stress analysis - Short term	Yes	1.6	3
	Effective Stress Analysis - long term	Yes	1.5	4

The estimated factors of safety generally meet or exceed the minimum values of 1.3 and 1.5 normally accepted for this type of analysis under short and long term conditions, respectively, provided the sheet piles are driven to the following tip elevations:

West Abutments	Elev. 215.0
East Abutment	Elev. 215.0

The above noted depth of penetration was derived based on the slope stability criteria. The depth of sheet pile penetration must be checked to ensure that requirements for the lateral stability are fulfilled.

Embankment construction should be in accordance with OPSS.PROV 206. All granular material should meet the specifications of OPSS.PROV 1010. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS 501. The backfill to the abutment walls should be in accordance with OPSS 902. Granular backfill should be placed to the extents shown in OPSD 3101.150.

13 SCOUR AND EROSION PROTECTION

Erosion protection should be provided along any soil surfaces that may be in contact with the river flow. In particular, erosion protection must be provided in front of the RSS walls or sheet pile walls to prevent undermining/scouring of the walls at the abutments.

A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion, in general accordance with OPSS 804.

14 LATERAL EARTH PRESSURES

Earth pressures acting on the structure may be assumed to be distributed triangularly and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$p_h = K(\gamma h + q)$$

where: p_h = horizontal pressure on the wall at depth h (kPa)

K = coefficient of lateral earth pressure (see Table 14.1)

γ = unit weight of retained soil (see Table 14.1)

h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are given in Table 14.1.

Table 14.1 – Coefficients of Lateral Earth Pressure (K)

Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or Granular B Type II $\phi = 35°, \gamma = 22.8$ kN/m^3		OPSS Granular B Type I or Type III $\phi = 32°, \gamma = 21.2$ kN/m^3	
	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.38*	0.31	0.46*
At-rest (Restrained Wall)	0.43	-	0.47	-
Passive	3.7	-	3.3	-

* For wing walls.

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

The factors in Table 14.1 are "ultimate" values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.16 in the Commentary to the Canadian Highway Bridge Design Code (CHBDC).

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I or III, or at a depth of 1.7 m for Granular A or Granular B Type II.

15 SEISMIC CONSIDERATIONS

The following seismic parameters should be used for design:

- Velocity Related Seismic Zone 0
- Zonal Velocity Ratio 0.00
- Acceleration Related Seismic Zone 0
- Zonal Acceleration Ratio 0.00
- Peak Ground Acceleration 0.02 g

The soil profile type at this site has been classified as Type III. Therefore, according to Table 4.4 of the CHBDC, a Site Coefficient S of 1.5 should be used in seismic design.

In accordance with Clause 4.6.4 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.

For the design of retaining walls under seismic loading, the coefficients of horizontal earth pressure in Table 15.1 may be used:

Table 15.1 – Earth Pressure Coefficient for Earthquake Loading

Loading Condition	Earth Pressure Coefficient (K) for Earthquake Loading			
	Granular A or Granular B Type II $\phi = 35°$; $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I or Type III $\phi = 32°$; $\gamma = 21.2$ kN/m^3	
	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)
Active (K_{AE})*	0.28	0.42	0.32	0.51
Passive (K_{PE})	3.6	-	3.2	-
At Rest (K_{OE})**	0.47	-	0.52	-

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.
** After Woods (1973).

Based on soil types and field test data, the foundation soils at the site are assessed as not being prone to liquefaction.

16 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not limited to:

- The new abutment H-piles and sheet piles are likely to be in conflict with the existing timber piles. The complexity of the new pile installation procedures should be brought to the attention of the Contractor prior to Contract Award, so the required equipment and associated costs to overcome the challenges during pile installation are accounted for prior to construction.
- The Contractor should be warned to not attempt to remove/pull-out the full length of timber piles, as this could disturb the surrounding clays, and could induce significant deformations/settlements of the existing/operational part of the bridge.

- Pile driving for the replacement bridge may potentially cause settlement of the existing bridge during staged construction. Monitoring of the settlement of the existing bridge will be required for the duration of pile driving. The Contactor should be prepared with appropriate equipment on site to maintain the grade of the existing bridge within acceptable tolerance.
- The sequence of H-pile and sheet pile installation should be carefully considered to avoid pile alignment implications.
- Installation of the sheet piles retaining approach embankments may encounter resistance in the fill due to the presence of cobble/boulders. The Contractor must allow for removal of any such obstructions.
- The Contractor's selection of construction equipment and methodology must include assessment of the capability of the clay subgrade to support the proposed construction equipment and any temporary structures or fill (i.e. as a pad for crane support). Site conditions may limit the type of equipment suitable for use. This is of particular importance due to the presence of the silty clay/clayey silt underlying directly the embankment fill. The design and safety of any temporary works is the responsibility of the Contractor. Recommended wording for an NSSP addressing this issue is provided in Appendix E.

17 CLOSURE

Engineering analysis and preparation of the foundation design report were carried out by Ms. Anna Piascik, P.Eng. The report was reviewed by Mr. Murray Anderson, P.Eng. and Dr. P. K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Appendix A

Record of Borehole Sheets

<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			

EXPLANATION OF ROCK LOGGING TERMS

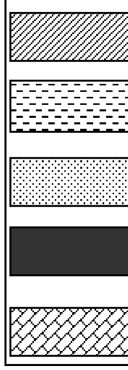
ROCK WEATHERING CLASSIFICATION

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**		**Field Estimation of Hardness***
	(MPa)	**(psi)**	
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.

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.

Ministry of Transportation
Ontario

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RECORD OF BOREHOLE No SRB-01

METRIC

WP# 6083-09-01	LOCATION Slate River Bridge N 5 346 841.4 E 342 672.2	ORIGINATED BY MW	
HWY 608	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY AN	
DATUM Geodetic	DATE 2014.10.21 - 2014.10.21	CHECKED BY AP	

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
227.6	GROUND SURFACE							
0.0 / 0.1	**ASPHALT:** (75mm)							
	Gravelly **SAND**, some fines, Compact to Dense, Dark Brown, Moist to Dry (FILL)	1	SS	46	227		○	35 52 13 (SI+CL)
		2	SS	24			○	
		3	SS	23	226		○	
225.3 / 2.3	**SAND**, some gravel, silt and clay, Loose to Compact, Brown to Dark Brown, Moist to Wet (FILL)	4	SS	12	225		○	
		5	SS	5	224		○	14 59 27 (SI+CL)
223.5 / 4.1	Silty **CLAY**, Stiff, Dark Brown, Moist				223			
		6	SS	7	222		○	
		7	SS	3	221		wP–w–wL	0 0 24 76
					220	+ 5.7		
		8	SS	1	219	+ 4.6	○	
		9	SS	2	218		○	

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

Legend: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE. Dynamic Cone Penetration Resistance Plot 20 40 60 80 100. Plastic Limit wP, Natural Moisture Content w, Liquid Limit wL. Unit Weight γ kN/m³.

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SRB-01

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 841.4 E 342 672.2	ORIGINATED BY	MW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.21 - 2014.10.21	CHECKED BY	AP

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										
217.5 / 10.1	END OF BOREHOLE AT 10.1m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.8m, CONCRETE TO 0.1m, THEN COLD PATCH TO SURFACE.							+ 4.9 (approx. 80)			

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/2/14

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No SRB-02

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 847.5 E 342 688.9	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers/Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.23 - 2014.10.23	CHECKED BY	AP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%) / OTHER	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
226.9	GROUND SURFACE						
0.0	**ASPHALT:** (100mm)						
0.1 / 226.5	**CONCRETE**						
0.4	Gravelly **SAND**, some fines Loose to Compact Brown Moist (FILL)						
		1	SS	9	226	○	
		2	SS	7	225	○	
		3	SS	9	224	○	
		4	SS	11		○	28 59 13 (SI+CL)
222.6 / 4.3	Silty **CLAY**, with lenses of sand and silt Stiff Brown Wet to Moist				223		
		5	SS	12	222	○	
		6	SS	10	221	○	
		7	SS	4	220 / 219	○	
						Field vane + 22.7	
		8	SS	5	218 / 217	○	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

UNIT WEIGHT γ kN/m³

Continued Next Page

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

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/2/14

RECORD OF BOREHOLE No SRB-02

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 847.5 E 342 688.9	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers/Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.23 - 2014.10.23	CHECKED BY	AP

Continued From Previous Page

Soil Profile

ELEV / DEPTH	DESCRIPTION
	Trace stratifications Soft
	Lenses of sand and silt
210.4 / 16.5	Clayey **SILT**, startified Very Soft Dark Grey/Brown Wet
207.4 / 19.5	**SILT**, some sand, trace clay Compact Dark Grey

Continued Next Page

Samples

NUMBER	TYPE	"N" VALUES	ELEVATION (approx.)	WATER CONTENT	GR	SA	SI	CL
9	SS	3	~215.9	w plotted (PL–w range plotted)	0	0	51	49
10	SS	3	~214.4	plotted				
11	TW	-	~212.9					
12	SS	6	~211.4	plotted				
13	SS	0	~209.8	plotted	0	1	72	27
14	SS	0	~208.3	plotted				

Field vane shear strength values plotted (kPa): 18.7, 10.7, 7.4, 6.2

Elevation scale: 216, 215, 214, 213, 212, 211, 210, 209, 208, 207

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

+ ³, × ³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No SRB-02

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 847.5 E 342 688.9	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers/Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.23 - 2014.10.23	CHECKED BY	AP

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	SILT, some sand, trace clay Compact Dark Grey Wet	15	SS	0		~32	0	0	87	13
					206					
					205					
					204					
		16	SS	18		~20				
	Some clay, trace gravel, occasional cobbles				203					
					202					
					201					
	Thinly stratified Dense	17	SS	35		~19	0	11	81	8
					200					
					199					
198.6 / 28.3	Clayey **SILT**, trace sand, trace gravel Very Stiff to Hard Dark Grey Moist (TILL)				198					
		18	SS	19		~15				
					197					

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SRB-02

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 847.5 E 342 688.9	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers/Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.23 - 2014.10.23	CHECKED BY	AP

ELEV / DEPTH	SOIL PROFILE: 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										
196.0 / 30.9	END OF BOREHOLE AT 30.9m. BOREHOLE BACKFILLED WITH HOLEPLUG AND CUTTINGS TO 0.8m, CONCRETE TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE.		19	SS	75/ 0.025				○		

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

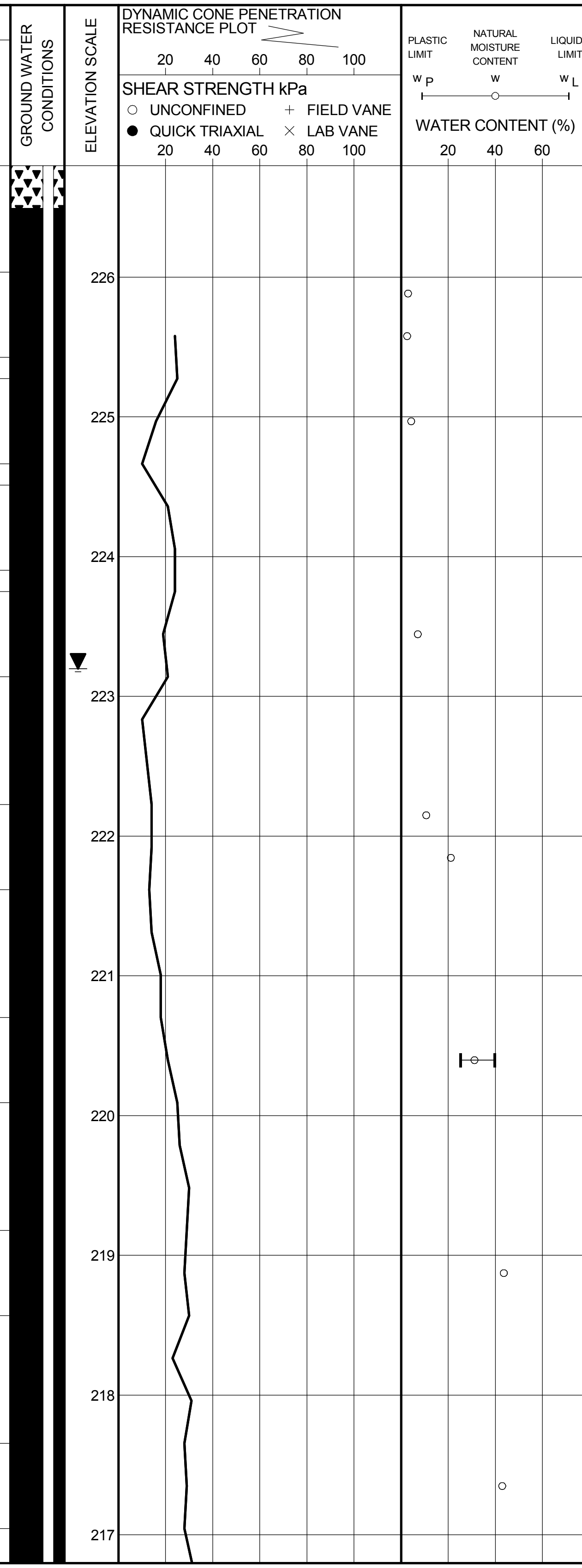
THURBER

RECORD OF BOREHOLE No SRB-03

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 843.5 E 342 690.3	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers/Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.21 - 2014.10.22	CHECKED BY	AP

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
226.8	GROUND SURFACE				
0.0	**ASPHALT:** (100mm)				
0.1 / 226.4	**CONCRETE**				
0.4	Gravelly **SAND**, some fines Compact Brown Dry to Moist (FILL)	1	SS	14	
		2	SS	23	
		3	SS	10	
		4	SS	13	30 55 15 (SI+CL)
222.1 / 4.7	Silty **CLAY**, some sand Very Soft to Stiff Dark Brown Moist	5	SS	13	
		6	SS	8	0 14 56 30
		7	SS	6	
	Wood fragments (possible timber pile) Some silt to silty Moist to Wet	8	SS	7	



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+3, ×3: Numbers refer to Sensitivity

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

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/2/14

RECORD OF BOREHOLE No SRB-03

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 843.5 E 342 690.3	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers/Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.21 - 2014.10.22	CHECKED BY	AP

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	FIELD VANE (kPa, sensitivity)	WATER CONTENT	REMARKS GR SA SI CL
					+ (5.6)		
	Very Soft	9	SS	WH			
					+ (2.8)		
	Very Soft	10	SS	WH		o	
					+ (6.8)		
		11	SS	2		o, o	
					+ (9.0)		
	Stratified and very soft below 15.2m depth	12	SS	2		o (with Wp–WL range)	0 0 27 73
					+ (7.2)		
210.3 / 16.5	Clayey **SILT**, stratified Very Soft Dark Brown/Grey Wet						
		13	SS	0		o	
					+		
		14	SS	0		o	

Elevation scale: 216, 215, 214, 213, 212, 211, 210, 209, 208, 207

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 SRB-03

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 843.5 E 342 690.3	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers/Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.21 - 2014.10.22	CHECKED BY	AP

SOIL PROFILE

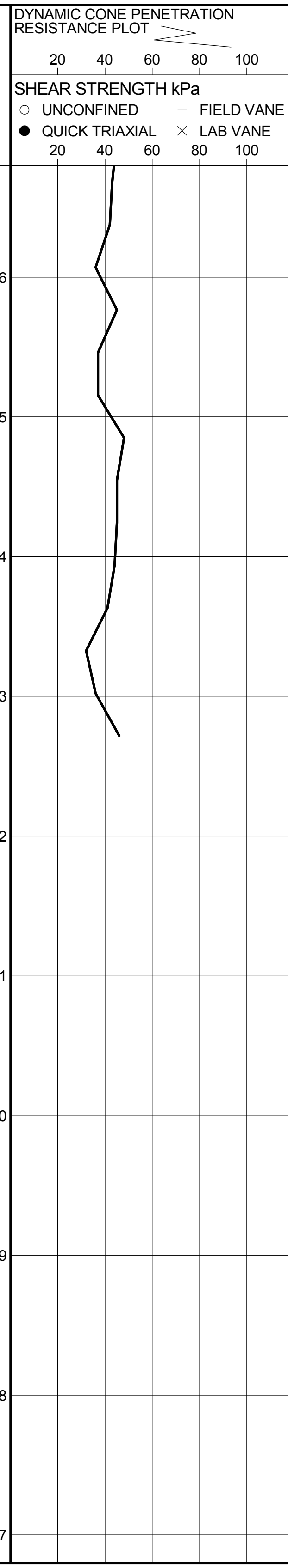
Continued From Previous Page

ELEV / DEPTH	DESCRIPTION
205.2 / 21.6	**SILT**, some sand Compact Dark Brown Wet Sandy below 25.0m depth
199.1 / 27.7	**SAND**, some silt, trace clay Compact Dark Brown/Grey Wet/Saturated

SAMPLES

NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
15	SS	0	~22	0	0	79	21
16	SS	19	~17				
17	SS	23	~21				
18	SS	26	~20	0	79	16	5

Elevation scale: 206, 205, 204, 203, 202, 201, 200, 199, 198, 197



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 SRB-03

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 843.5 E 342 690.3	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers/Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.21 - 2014.10.22	CHECKED BY	AP

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
	Continued From Previous Page				
196.5 / 30.3	Clayey **SILT**, some sand, some gravel, occasional cobbles Hard Dark Grey Moist (TILL)	19	SS	80/ 0.0	196
					195
		20	SS	75/ 0.050	194
193.6 / 33.2	END OF BOREHOLE AT 33.2m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.	21	SS	80/ 0.0	

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; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Nov 01/14	3.6	223.2
Nov 02/14	3.6	223.2
Nov 03/14	3.6	223.2

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SRB-04

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 847.0 E 342 723.6	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.26 - 2014.10.27	CHECKED BY	AP

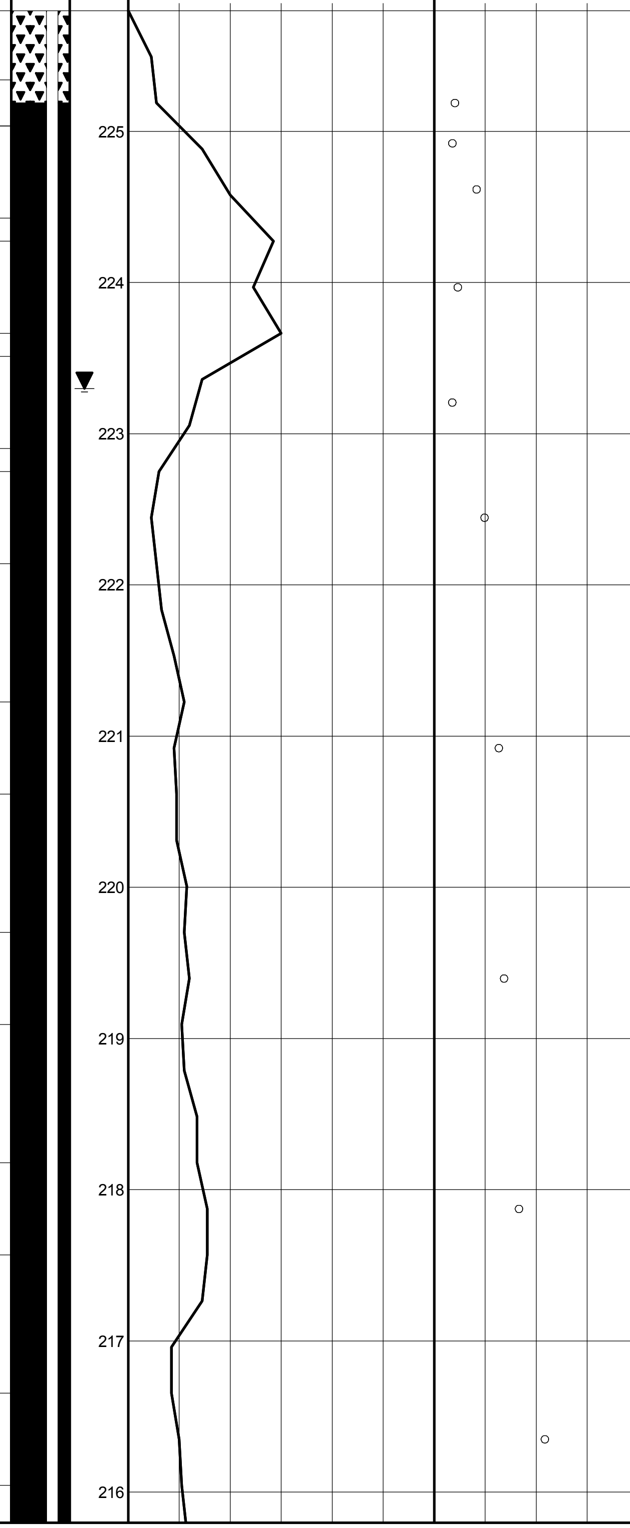
SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
225.8	GROUND SURFACE
0.0 / 0.1	**ASPHALT:** (100mm)
225.4	**CONCRETE**
0.4	Gravelly **SAND**, trace fines, occasional cobbles Compact to Very Dense Brown Moist (FILL)
222.7 / 3.0	**SAND**, some gravel, silt and clay, occasional cobbles Compact Brown Moist (FILL)
221.4 / 4.4	Clayey **SILT**, trace rootlets Firm Grey Moist
220.0 / 5.8	Clayey **SAND** and **SILT**, trace wood fragments Soft to Firm Dark Grey Wet
217.3 / 8.5	Silty **CLAY** Very Soft to Firm Brown Moist

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	24	
2	SS	20	
3	SS	56	34 51 15 (SI+CL)
4	SS	39	
5	SS	14	16 52 18 14
6	SS	8	
7	SS	3	
8	SS	7	
9	SS	8	

GROUND WATER CONDITIONS · ELEVATION SCALE · DYNAMIC CONE PENETRATION RESISTANCE PLOT · SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) · PLASTIC LIMIT w_P · NATURAL MOISTURE CONTENT w · LIQUID LIMIT w_L · WATER CONTENT (%) · UNIT WEIGHT γ kN/m³



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+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SRB-04

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 847.0 E 342 723.6	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.26 - 2014.10.27	CHECKED BY	AP

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

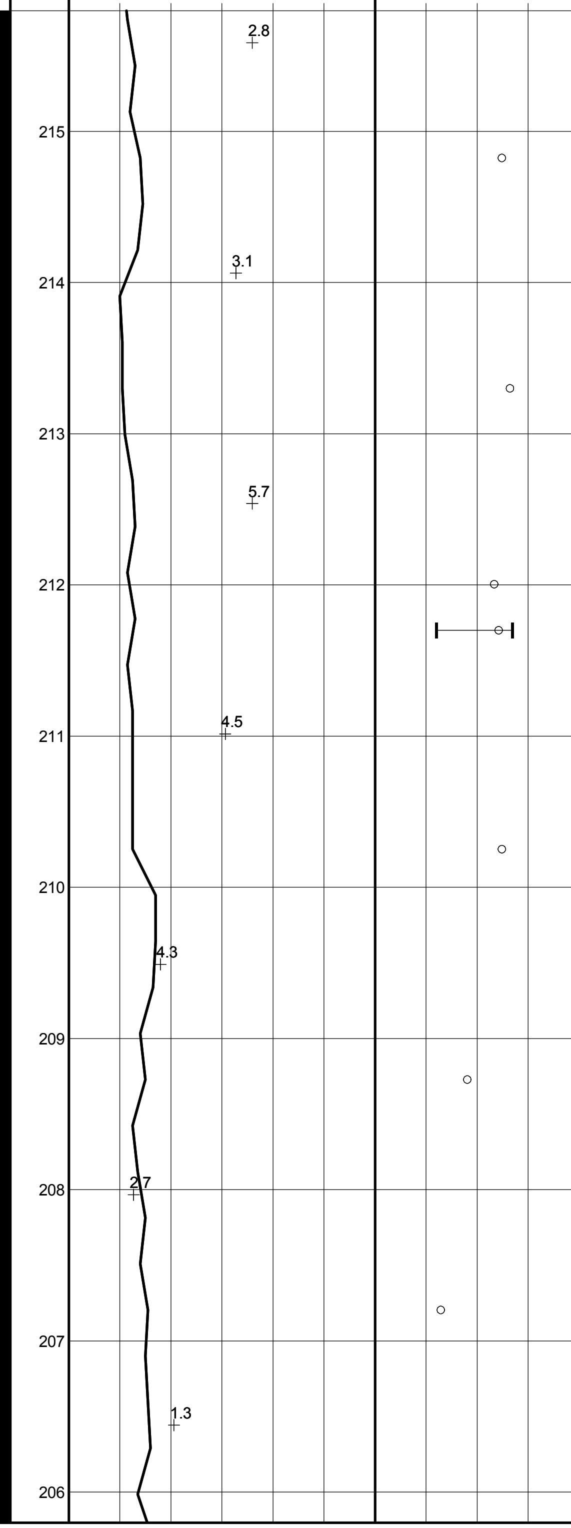
UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION
	Occasional lenses of silt, occasional dark brown mottles Moist
	trace gravel, trace stratifications, trace silt lenses
209.5 / 16.3	Clayey **SILT**, some sand. stratified Very Soft to Stiff Dark Grey Wet
	Soft

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
10	SS	2				
11	SS					
12	SS	1	0	0	25	75
13	SS	1				
14	SS	0				
15	SS	0				



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+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SRB-04

METRIC

WP# 6083-09-01	LOCATION Slate River Bridge N 5 346 847.0 E 342 723.6		ORIGINATED BY MNW
HWY 608	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY AN
DATUM Geodetic	DATE 2014.10.26 - 2014.10.27		CHECKED BY AP

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 From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH	GR	SA	SI	CL
	Wet	16	SS	3						
					205	+ 2.4				
204.2 / 21.6	Sandy **SILT**, trace clay Very Loose Dark Grey Wet				204					
					203					
		17	SS	1						
					202					
201.3 / 24.5	**SAND** and **SILT**, trace clay Compact Dark Grey Wet				201					
					200					
		18	SS	26						
					199					
	Trace stratifications				198					
					197					
		19	SS	21			0	38	54	8
					196					

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No SRB-04

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 847.0 E 342 723.6	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.26 - 2014.10.27	CHECKED BY	AP

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT (kN/m³)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
195.0 / 30.8	**SAND** and **GRAVEL**, trace silt Compact Dark Grey Wet				195			
					194			
		20	SS	28		○		42 52 6 (SI+CL)
					193			
					192			
191.4 / 34.4	Clayey **SILT**, some sand, some gravel, occasional cobbles and boulders Hard Dark Grey Wet (TILL)				191			
		21	SS	123		○		
190.4 / 35.4	END OF BOREHOLE AT 5.4m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.							

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Nov 01/14	2.5	223.3
Nov 02/14	2.5	223.3
Nov 03/14	2.5	223.3

Chart scales: 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; GROUND WATER CONDITIONS; STRAT PLOT; γ

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SRB-05

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 843.0 E 342 724.9	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers/Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.24 - 2014.10.25	CHECKED BY	AP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
225.8	GROUND SURFACE						
0.0	**ASPHALT:** (100mm)						
225.4 / 0.1	**CONCRETE**						
0.4	Gravelly **SAND**, trace fines, occasional cobbles, Compact to Very Dense, Brown, Moist (FILL)	1	SS	12	225	~8	
		2	SS	20		~8	
		3	SS	50	224	~8	32 51 17 (SI+CL)
		4	SS	52	223	~7	
222.6 / 3.2	**SAND**, some gravel, silt and clay, Compact, Dark Brown, Moist (FILL)	5	SS	13	222	~11; ~27	
221.2 / 4.6	Clayey **SILT**, trace rootlets, occasional grey mottling and dark brown stratifications, Firm, Moist	6	SS	6	221	~28	
219.7 / 6.1	Clayey **SAND** and **SILT**, trace rootlets, Soft to Stiff, Dark Grey, Wet	7	SS	5	220 / 219	~24	
		8	SS	3	218	~60	0 41 37 22
217.1 / 8.7	Silty **CLAY**, Very Soft to Stiff, Brown, Moist to Wet	9	SS	7	217 / 216	~48	

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+ 3, × 3: Numbers refer to Sensitivity

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

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/2/14

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SRB-05

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 843.0 E 342 724.9	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers/Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.24 - 2014.10.25	CHECKED BY	AP

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	FIELD VANE (kPa)	WATER CONTENT (%)	GR	SA	SI	CL
						5.8					
		1	ST		215		○				
					214	5.7					
	Very Soft	10	SS	1			⊢○	0	0	44	56
					213	5.8					
	Trace sand and gravel	11	SS	2	212		○ ○				
					211	10.0					
	Stratified Firm Wet	12	SS	6	210		○				
209.5 16.3	Clayey **SILT**, some sand, stratified Very Soft to Firm Dark Grey/Brown Moist to Wet										
		13	SS	0	209		○				
					208	+					
		14	SS	0	207		○				
	Some clay to clayey				206						

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 SRB-05

METRIC

WP# 6083-09-01 | LOCATION Slate River Bridge N 5 346 843.0 E 342 724.9 | ORIGINATED BY MNW

HWY 608 | BOREHOLE TYPE Hollow Stem Augers/Casing | COMPILED BY AN

DATUM Geodetic | DATE 2014.10.24 - 2014.10.25 | CHECKED BY AP

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
		15	SS	0		~21				
					205					
204.5 21.3	Sandy **SILT**, trace clay Very Loose Dark Brownish Grey Wet				204					
					203					
		16	SS	1		~19				
					202					
201.1 24.7	Silty **SAND**, trace clay, stratified Compact Dark Grey Saturated				201					
					200					
		17	SS	27		~19	0	74	20	6
					199					
					198					
					197					
		18	SS	23		~20				
					196					

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No SRB-05

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 843.0 E 342 724.9	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers/Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.24 - 2014.10.25	CHECKED BY	AP

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 From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
					195	
					194	
		19	SS	22		
192.8 / 33.0	Sandy **GRAVEL**, trace silt Compact Dark Grey Wet				193	
		20	SS	17	192	64 33 3 (SI+CL)
191.1 / 34.7	Clayey **SILT**, some sand and gravel, occasional cobbles Hard Dark Grey Wet (TILL)				191	
		21	SS	100/ 0.050	190	
189.7 / 36.1	**SHALE BEDROCK**, occasional interbeds of limestone, moderately weathered to fresh, dark grey Rubble zone at: 175mm at 36.1m 200mm at 36.9m 25mm at 37.3m 225mm at 37.4m	1	RUN		189	RUN #1 TCR=93% SCR=43% RQD=23% UCS=71MPa (Average)
	Rubble zone at: 25mm at 38.5m 50mm at 39.0m Clay seam (25mm) at 38.7m	2	RUN		188 187	RUN #2 TCR=98% SCR=78% RQD=52% UCS=82MPa (Average)
186.6 / 39.2	END OF BOREHOLE AT 39.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.8m, CONCRETE TO 0.1m THEN COLD PATCH ASPHALT					

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 SRB-05

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 843.0 E 342 724.9	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers/Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.24 - 2014.10.25	CHECKED BY	AP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	TO SURFACE.										

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SRB-06

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 849.1 E 342 741.7	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.24 - 2014.10.24	CHECKED BY	AP

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
225.4	GROUND SURFACE					
0.0 0.1	**ASPHALT:** (63.0mm)					
	Gravelly **SAND**, trace silt, Very Dense to Compact, Brown, Moist (FILL)	1	SS	55		
		2	SS	60		31 54 15 (SI+CL)
		3	SS	18		
		4	SS	23		18 48 34 (SI+CL)
222.3 3.0	Clayey **SILT**, trace to some sand, trace gravel, trace wood fragments, Firm, Grey, Moist	5	SS	9		
	Pockets of trace sand				∇ (approx. El. 221.2)	
		6	SS	7		
219.4 6.0	Clayey **SAND** and **SILT**, Stiff, Dark Grey, Wet	7	SS	4		
		8	SS	6		
217.2 8.2	Silty **CLAY**, Firm, Greyish Brown, Moist to Wet					
		9	SS	4		0 0 59 41

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

Field vane at approx. El. 218.3: 4.0

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

UNIT WEIGHT γ kN/m³

Elevation scale: 225, 224, 223, 222, 221, 220, 219, 218, 217, 216

Continued Next Page

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

RECORD OF BOREHOLE No SRB-06

METRIC

WP#	6083-09-01	LOCATION	Slate River Bridge N 5 346 849.1 E 342 741.7	ORIGINATED BY	MNW
HWY	608	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.10.24 - 2014.10.24	CHECKED BY	AP

ELEV / DEPTH	SOIL PROFILE: 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										
215.2								4.6			
10.2	END OF BOREHOLE AT 10.2m. BOREHOLE OPEN TO 5.8m AND WATER LEVEL AT 4.3m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.6m, CONCRETE TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE.										

+ 3, × 3: Numbers refer to Sensitivity

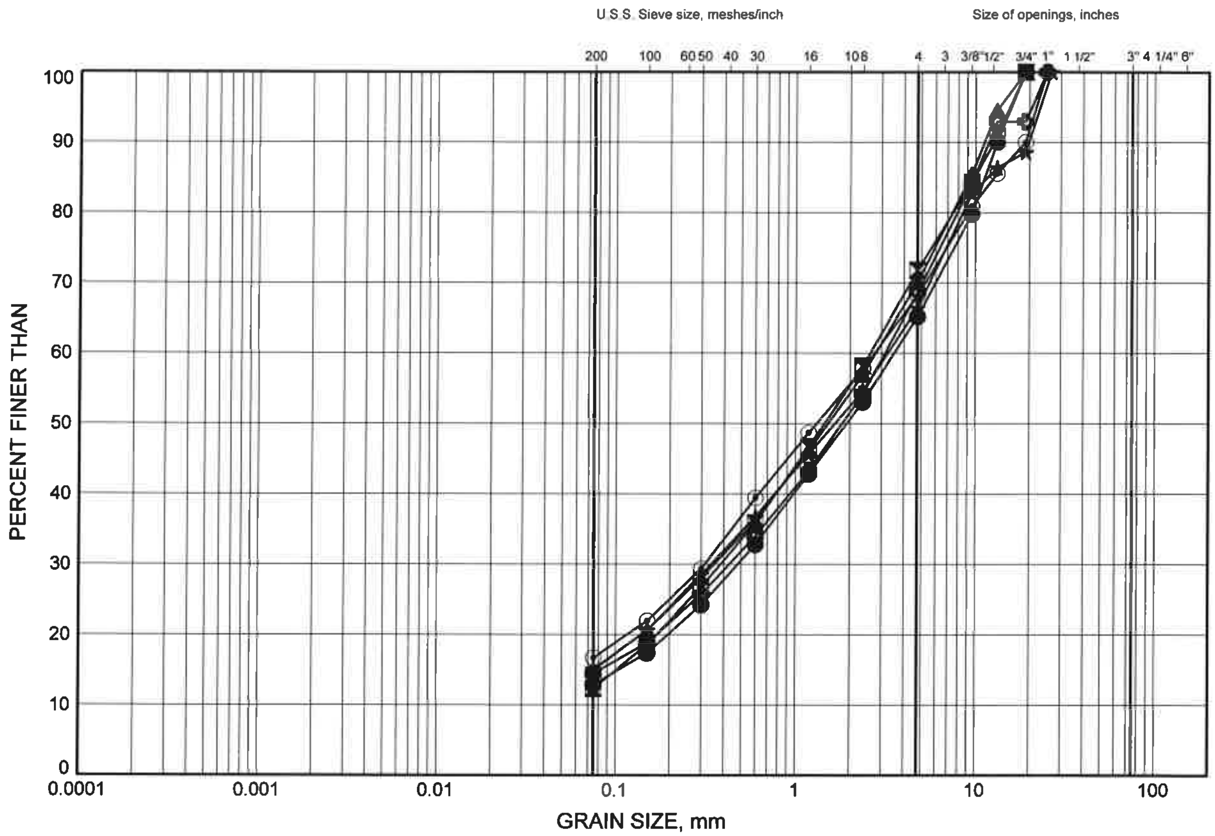
20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Appendix B

Laboratory Test Results

Slate River Bridge GRAIN SIZE DISTRIBUTION	FIGURE B1

GRAVELLY SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-01	0.38	227.22
⊠	SRB-02	3.35	223.54
▲	SRB-03	3.35	223.44
★	SRB-04	1.83	223.97
⊙	SRB-05	1.83	223.97
✪	SRB-06	1.07	224.33

Date November 2014
WP# 6083-09-01

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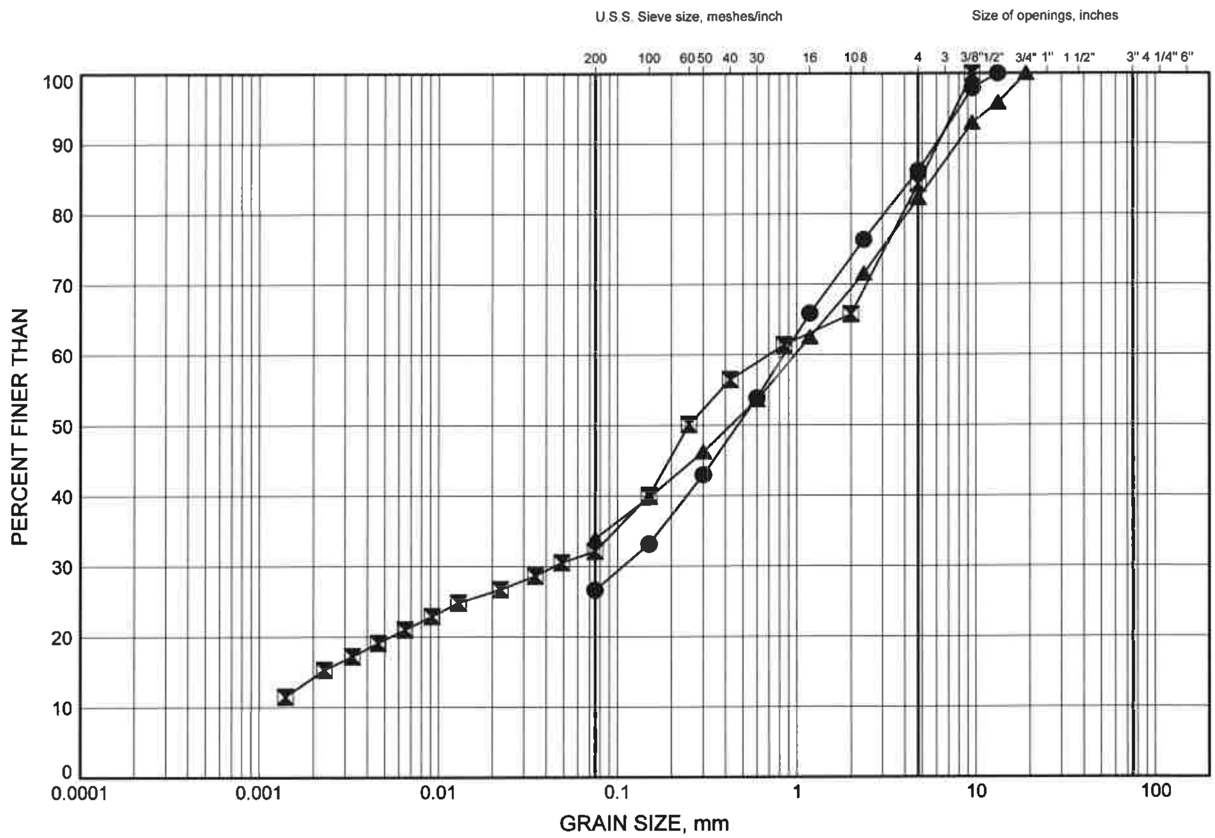
GRAIN SIZE DISTRIBUTION - THURBER 5121.GPJ 11/27/14

Slate River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B2

SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-01	3.35	224.24
⧗	SRB-04	3.35	222.44
▲	SRB-06	2.59	222.81

Date November 2014

WP# 6083-09-01

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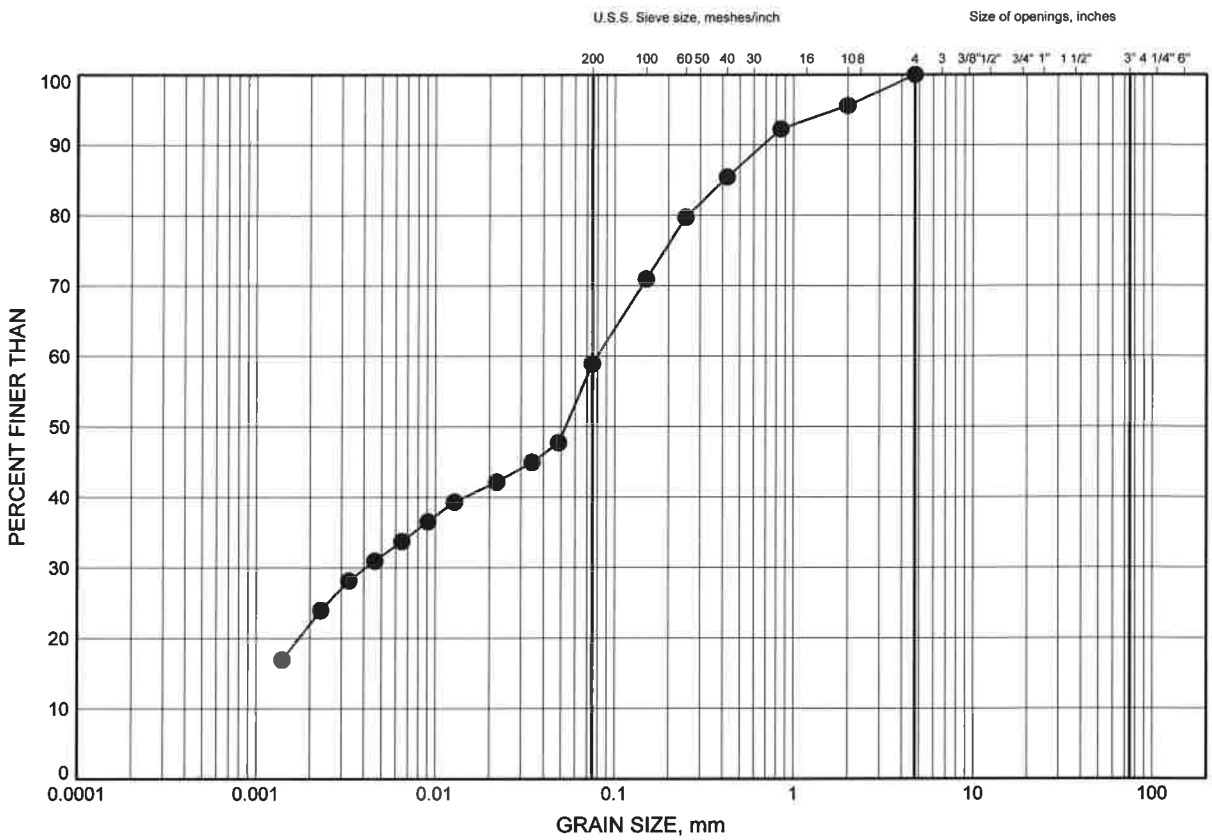
Slate River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B3

CLAYEY SAND & SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-05	7.92	217.87

GRAIN SIZE DISTRIBUTION - THURBER 5121.GPJ 11/28/14

Date November 2014

WP# 6083-09-01

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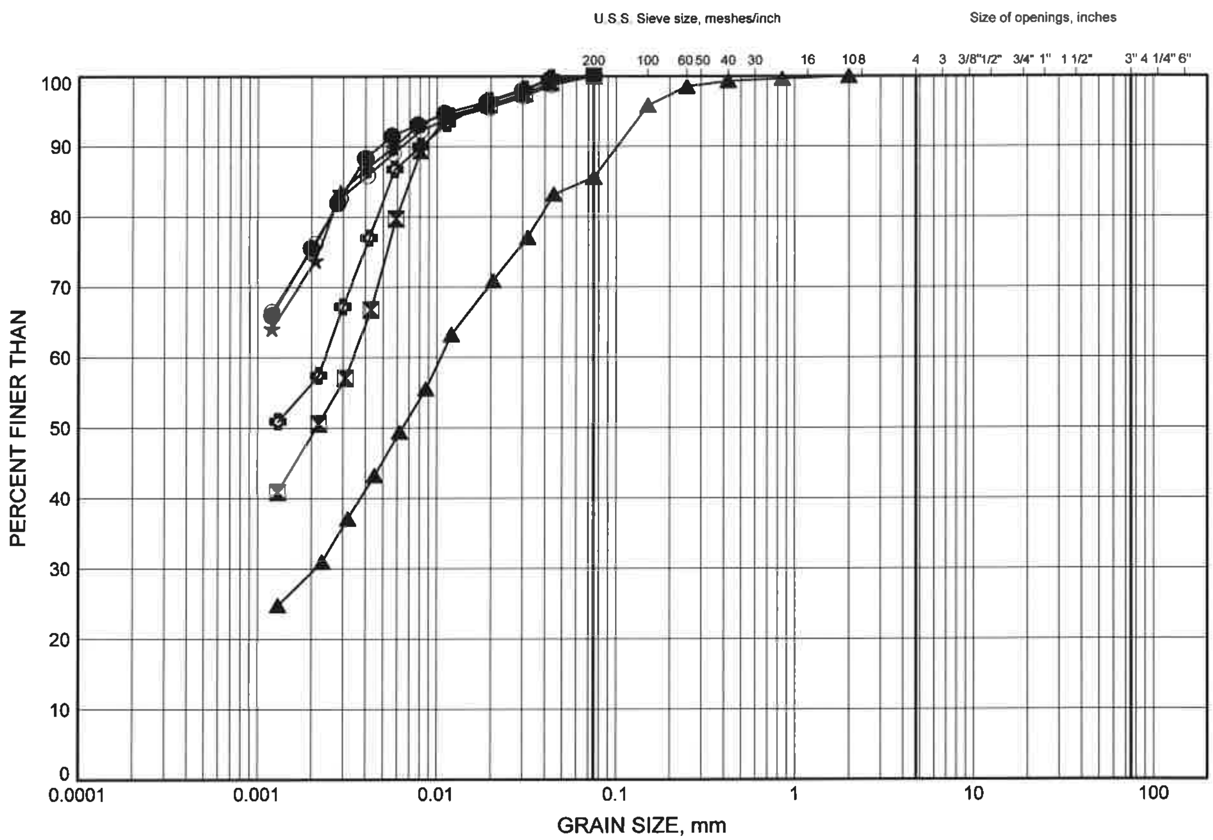
Slate River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B4a

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-01	6.40	221.20
⊠	SRB-02	10.97	215.92
▲	SRB-03	6.40	220.40
★	SRB-03	15.54	211.25
⊙	SRB-04	14.10	211.70
✪	SRB-05	12.50	213.30

Date November 2014

WP# 6083-09-01

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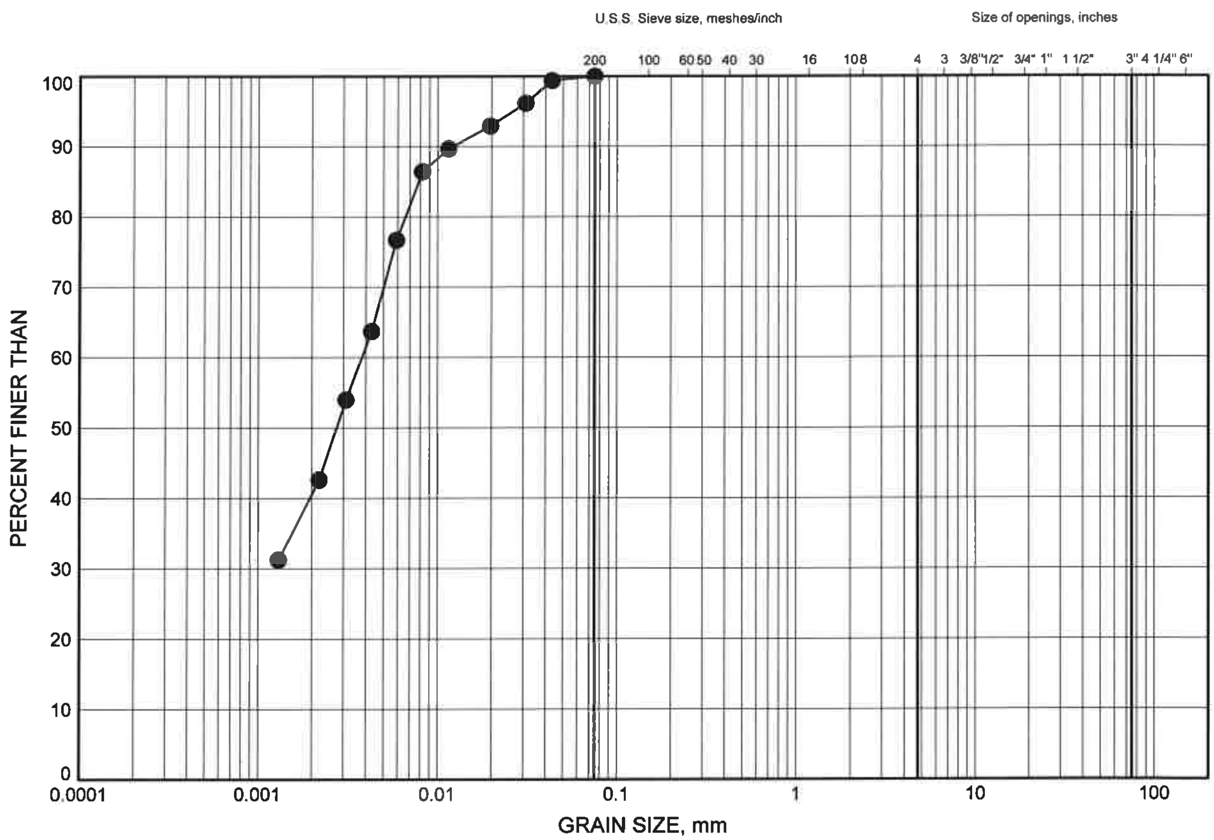
GRAIN SIZE DISTRIBUTION - THURBER 5121.GPJ 11/28/14

Slate River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B4b

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-06	9.45	215.95

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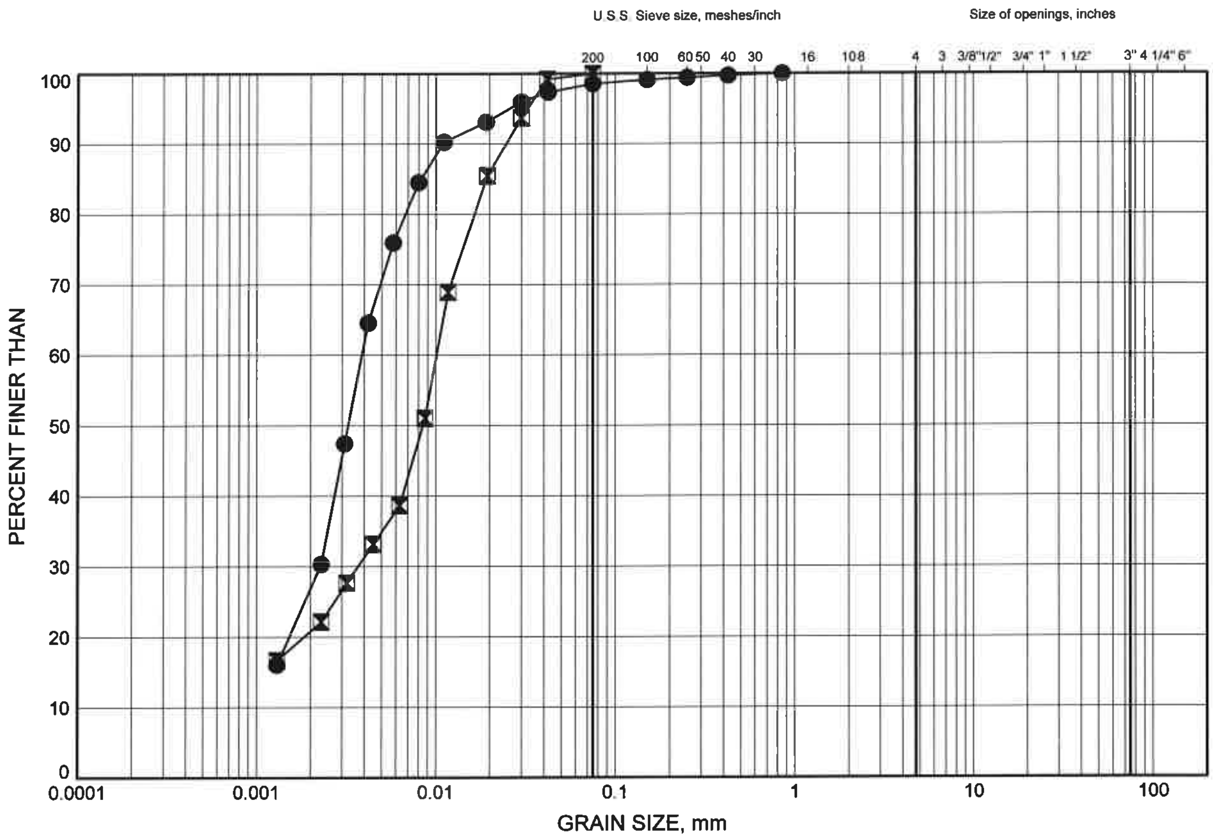
GRAIN SIZE DISTRIBUTION - THURBER 5121.GPJ 11/28/14

Slate River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B5

CLAYEY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-02	17.07	209.83
⊠	SRB-03	20.12	206.68

GRAIN SIZE DISTRIBUTION - THURBER 5121.GPJ 11/28/14

Date November 2014

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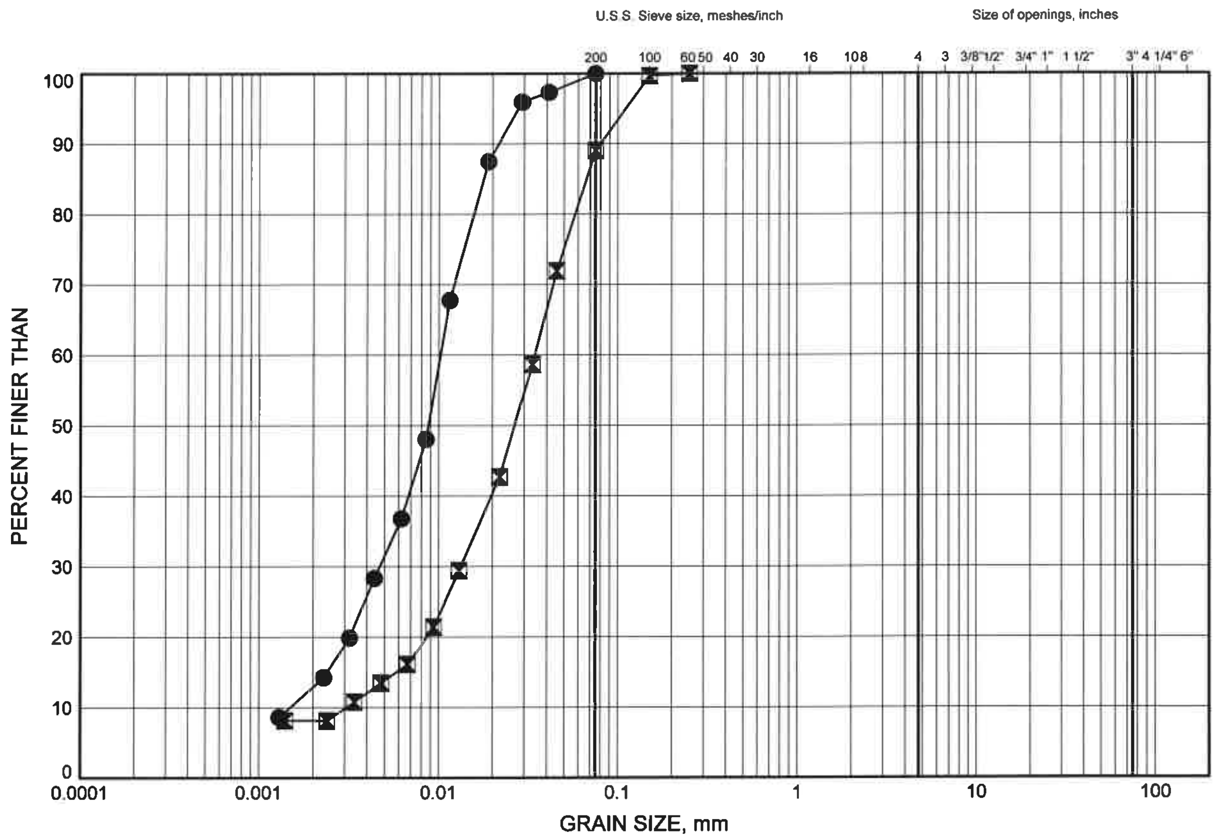
Slate River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B6

SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-02	20.12	206.78
⊠	SRB-02	26.21	200.68

Date November 2014

WP# 6083-09-01

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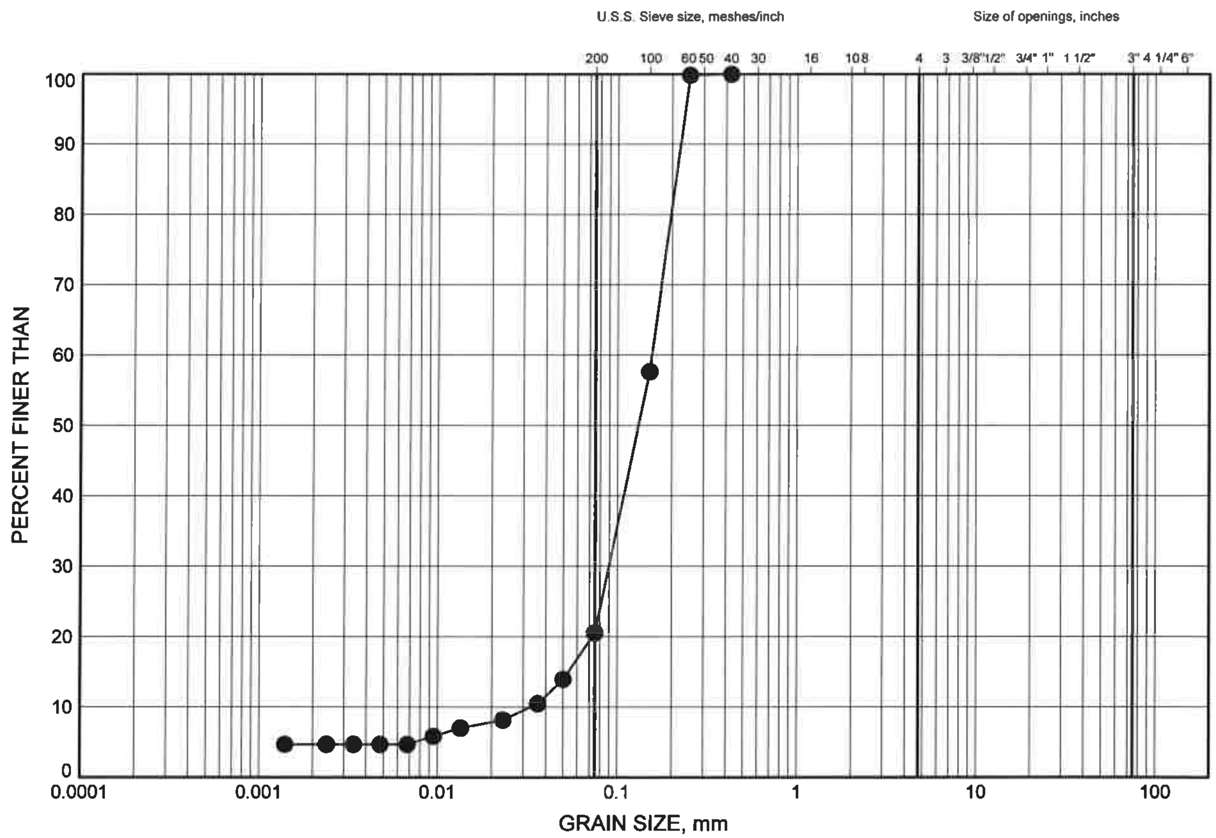
Slate River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B7

SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-03	29.26	197.54

GRAIN SIZE DISTRIBUTION - THURBER 5121.GPJ 11/27/14

Date November 2014

WP# 6083-09-01

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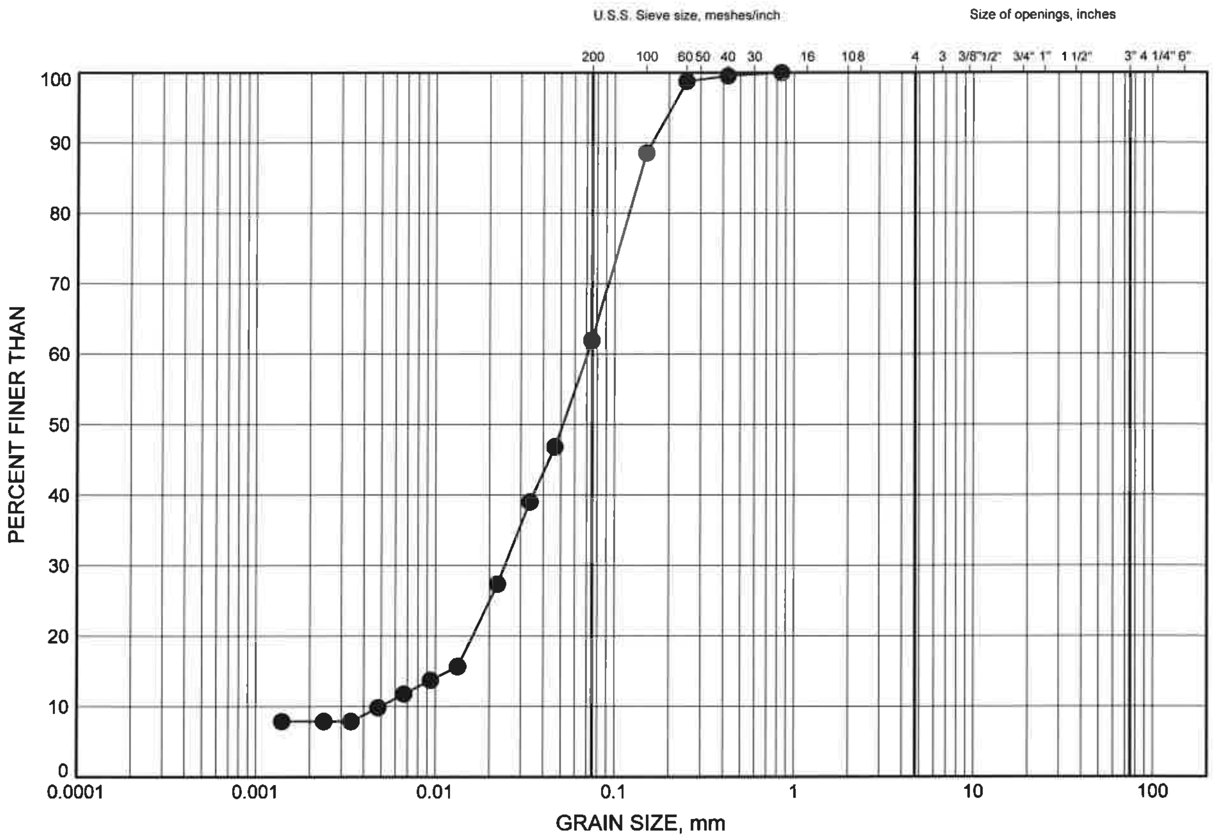
Slate River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B8

SAND & SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-04	29.26	196.54

GRAIN SIZE DISTRIBUTION - THURBER 5121.GPJ 11/27/14

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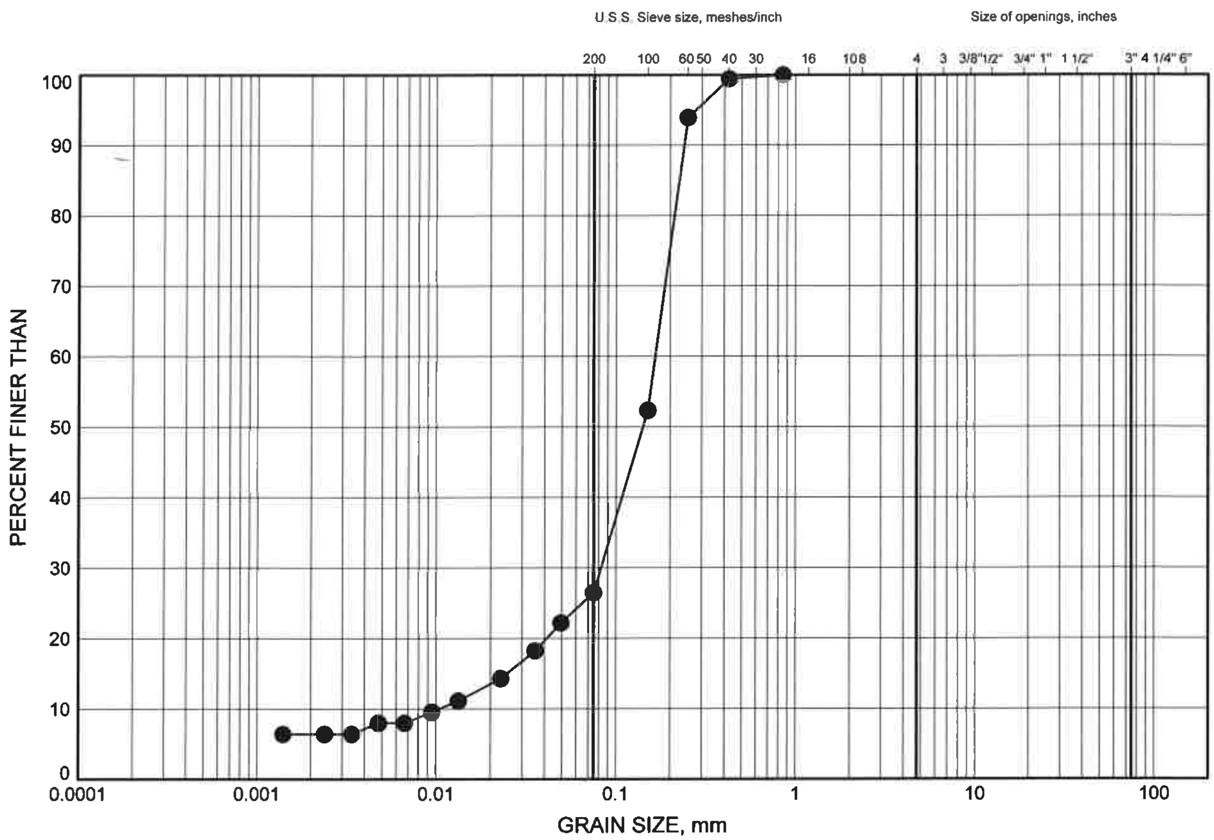
Slate River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B9

SILTY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-05	26.21	199.58

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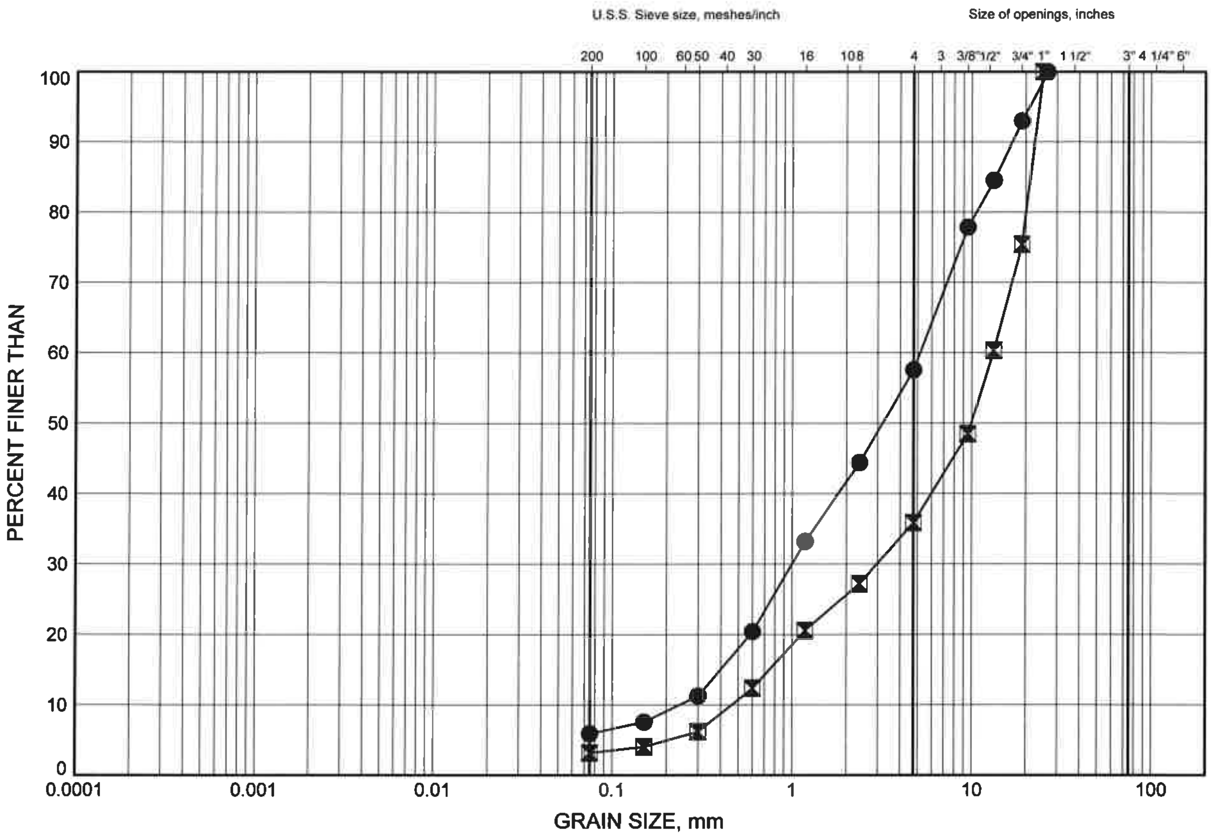
Slate River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B10

SANDY GRAVEL to SAND & GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-04	32.31	193.49
⊠	SRB-05	33.83	191.96

Date November 2014

WP# 6083-09-01

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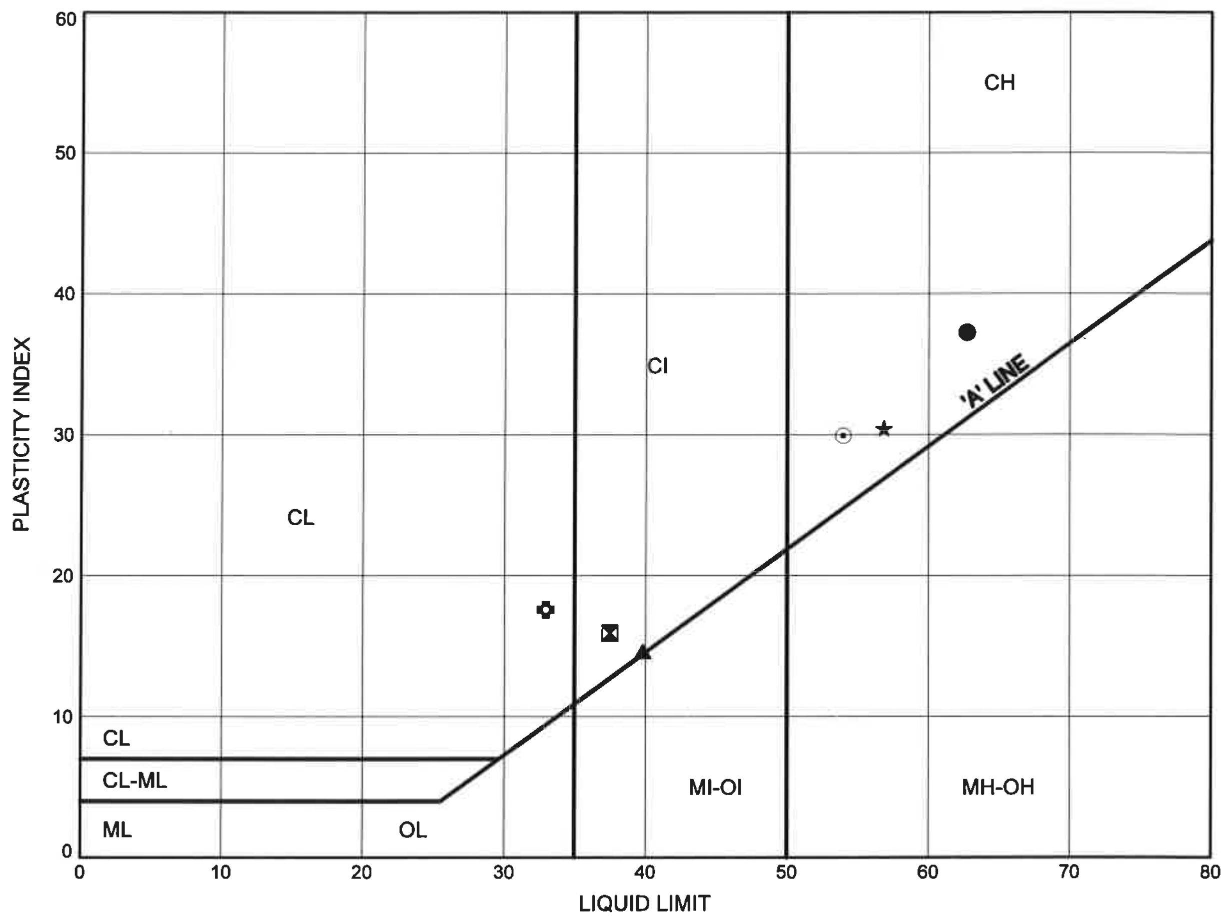
Slate River Bridge

ATTERBERG LIMITS TEST RESULTS

FIGURE B11a

SILTY CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-01	6.40	221.20
⊠	SRB-02	10.97	215.92
▲	SRB-03	6.40	220.40
★	SRB-03	15.54	211.25
⊙	SRB-04	14.10	211.70
✿	SRB-05	12.50	213.30

Date November 2014

WP# 6083-09-01

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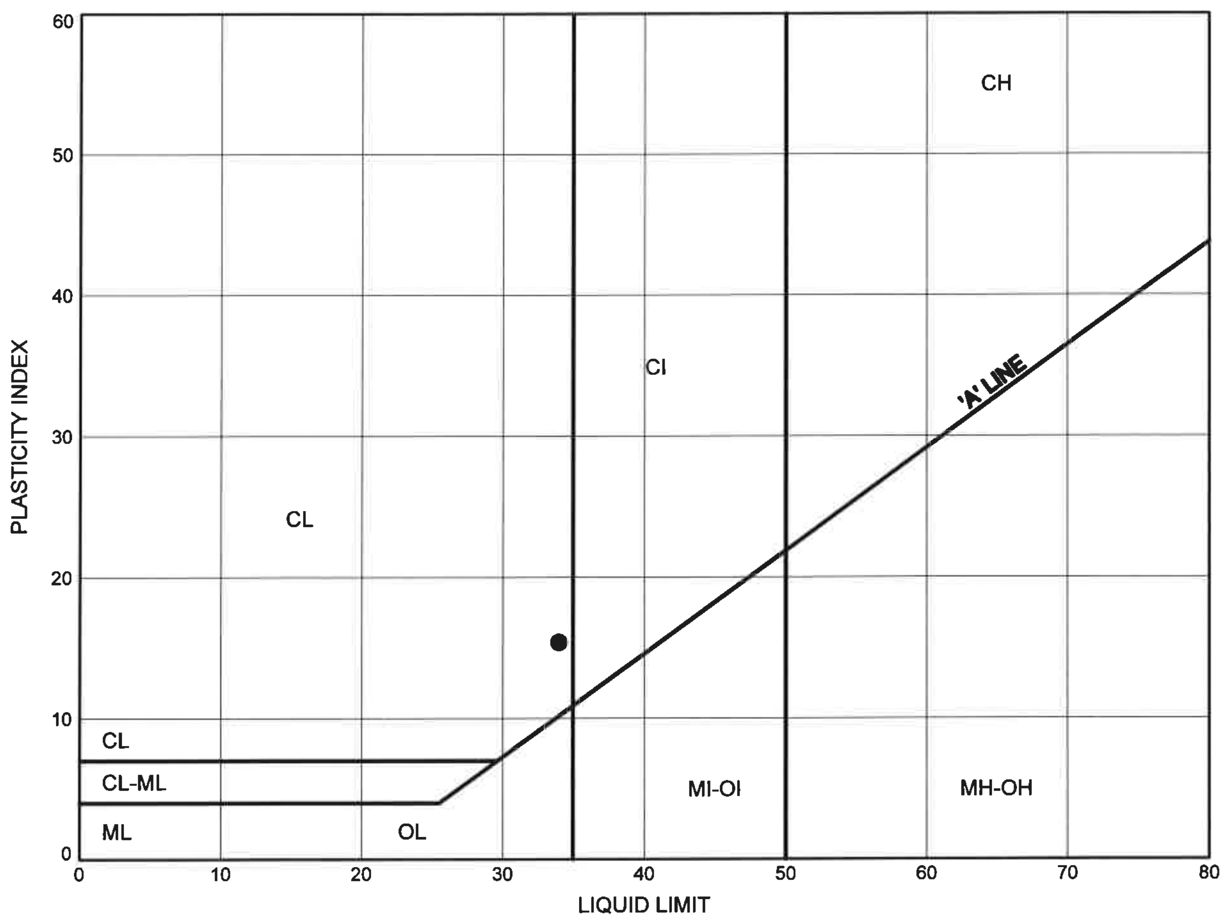
THURBALT 5121.GPJ 11/28/14

Slate River Bridge

ATTERBERG LIMITS TEST RESULTS

FIGURE B11b

SILTY CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-06	9.45	215.95

THURBALT 5121.GPJ 11/28/14

Date November 2014

WP# 6083-09-01

THURBER

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THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

POINT LOAD TEST SHEET

Job No : 19-1605-121 **Client :** HMM

Date Drilled : 10/14/2014

Project Name : Slate River Bridge **Date Tested :** 11/17/2014

Core Size : NQ **BH No :** SRB-05 **Tester :** ISP

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (kPa)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	1	36.4	ial or Diame	42800.0	47.0	97.9	74.8	Chert	Strong
2	1	37.1	ial or Diame	1540.0	44.5	72.7	66.6	Chert	Strong
3	2	37.8	D	17020.0	47.1	114.6	118.9	Limestone	Very Strong
4	2	37.9	ial or Diame	24880.0	47.1	114.6	69.9	Limestone	Strong
5	2	38.4	ial or Diame	2620.0	47.0	114.6	60.7	Chert	Strong
6	2	38.7	ial or Diame	3040.0	47.3	114.6	76.7	Chert	Strong
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
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21									
22									
23									
24									
25									
26									
27									
28									
29									
30									

* 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.

Appendix C

Site Photographs

Slate River Bridge Looking East

Looking Northwest at West Abutment

Looking Northeast at East Abutment

Looking Southeast from West Abutment

Appendix D

Comparison of Foundation Alternatives

COMPARISON OF FOUNDATION ALTERNATIVES

Footings on Native Soil	Footings on Engineered Fill	Driven Piles	Caissons
Advantages: i. Ease of construction. ii. Lower cost than deep foundations.	***Advantages:*** i. Generally less costly construction than deep foundation elements. ii. Allows use of perched abutments. iii. Higher geotechnical resistance than on native soil.	***Advantages:*** i. Piles will develop high geotechnical resistance on bedrock or very dense soils. ii. Installation of piles could continue in freezing weather. iii. Allows integral abutment design. iv. Requires less excavation than footings.	***Advantages:*** i. Higher resistances are available for caissons than for spread footings founded in native soils. ii. Construction of caissons could continue in freezing weather.
Disadvantages: i. Low geotechnical resistance available in native soils at abutments. ii. Potential for significant consolidation settlement in silty clay and clayey silt. iii. Dewatering may be required, depending on depth of excavation.	***Disadvantages:*** i. Cost of engineered fill placement. ii. Potential for consolidation settlement in silty clay and clayey silt. iii. Dewatering may be required, depending on depth of excavation.	***Disadvantages:*** i. Higher unit costs than for spread footings. ii. Possibility that cobbles and/or boulders may be encountered in the fill and native deposits.	***Disadvantages:*** i. Relatively low capacities in native soils in comparing to H-pile foundations. ii. High cost of construction, as caissons would need to be relatively deep; bedrock proved at 36 m depth. iii. Possibility of encountering cobbles and boulders during augering and liner installation. iv. Difficulty in cleaning and inspecting bases.
NOT RECOMMENDED	**NOT RECOMMENDED**	**RECOMMENDED**	**NOT RECOMMENDED**

Appendix E

List of Standard Specifications and Special Provisions

1) The following Standard Specifications and Special Provisions are referenced in this report:

OPSS 501
OPSS 539
OPSS 804
OPSS 902
OPSS 903

OPSS.PROV 1010
OPSS.PROV 206

OPSD 3101.150

SP599S22

2) Recommended wording for "NSSP – Use of Heavy Construction Equipment"

The use of heavy construction equipment and in particular heavy lift cranes may be required during removal of the existing and erection of the new bridge. The impact of the heavy equipment loads on the underlying sensitive soils, river banks and existing bridge foundations must be considered during selection of the methodology and equipment employed for construction.

Prior to commencement of construction, the Contractor shall retain a Geotechnical Consultant to assess the impact of the proposed equipment loads and methodology, and determine requirements and/or restrictions necessary to safely support the loads. All Foundation Engineering services required for this project shall be performed by consultant(s) listed as accepted under the MTO's RAQS for providing services under the specialty of Geotechnical (Structures and Embankments) – High Complexity.

The assessment shall include, but not be limited to, the following:

- Determining appropriate setbacks for heavy equipment from the river banks and existing foundations;
- Evaluating the need for preventing heavy equipment from travelling or operating on the areas adjacent to the river, possibly requiring restriction of heavy loads to the existing highway embankment platform;
- Determining the permissible ground pressure that may be applied to the foundation soils by the equipment; and
- Providing recommendations for crane pad design to distribute the crane loads without causing foundation failure.

The Contractor shall submit the findings of the geotechnical assessment and details of the proposed equipment and construction methodology to the Contract Administrator for information purposes a minimum of two weeks prior to the start of construction.

3) Recommended wording for "NSSP – Monitoring of Existing Structure"

The Contractor shall ensure the existing structure remains stable during removal.

It is recommended that the Contract Documents include a monitoring program for the existing structure. As a minimum, the monitoring program should require the Contractor to establish reference points over each abutment of the existing structure and to monitor movement of these points relative to known, fixed reference points on a regular basis. The suggested frequency is:

- Three readings on separate days prior to construction to establish a baseline;
- Twice daily while any foundation construction or other subsurface construction is in progress;
- Daily for one week after completion of foundation construction.

The vertical and horizontal accuracy of readings should be ± 2 mm. All readings must be reported to the Contract Administrator within 24 hours and immediately if any movement exceeds limits set by the structural designer.

The Contract Administrator must be advised of the importance of monitoring and be required to advise the Ministry immediately if the vertical and horizontal movements exceed the specified limits.

Appendix F

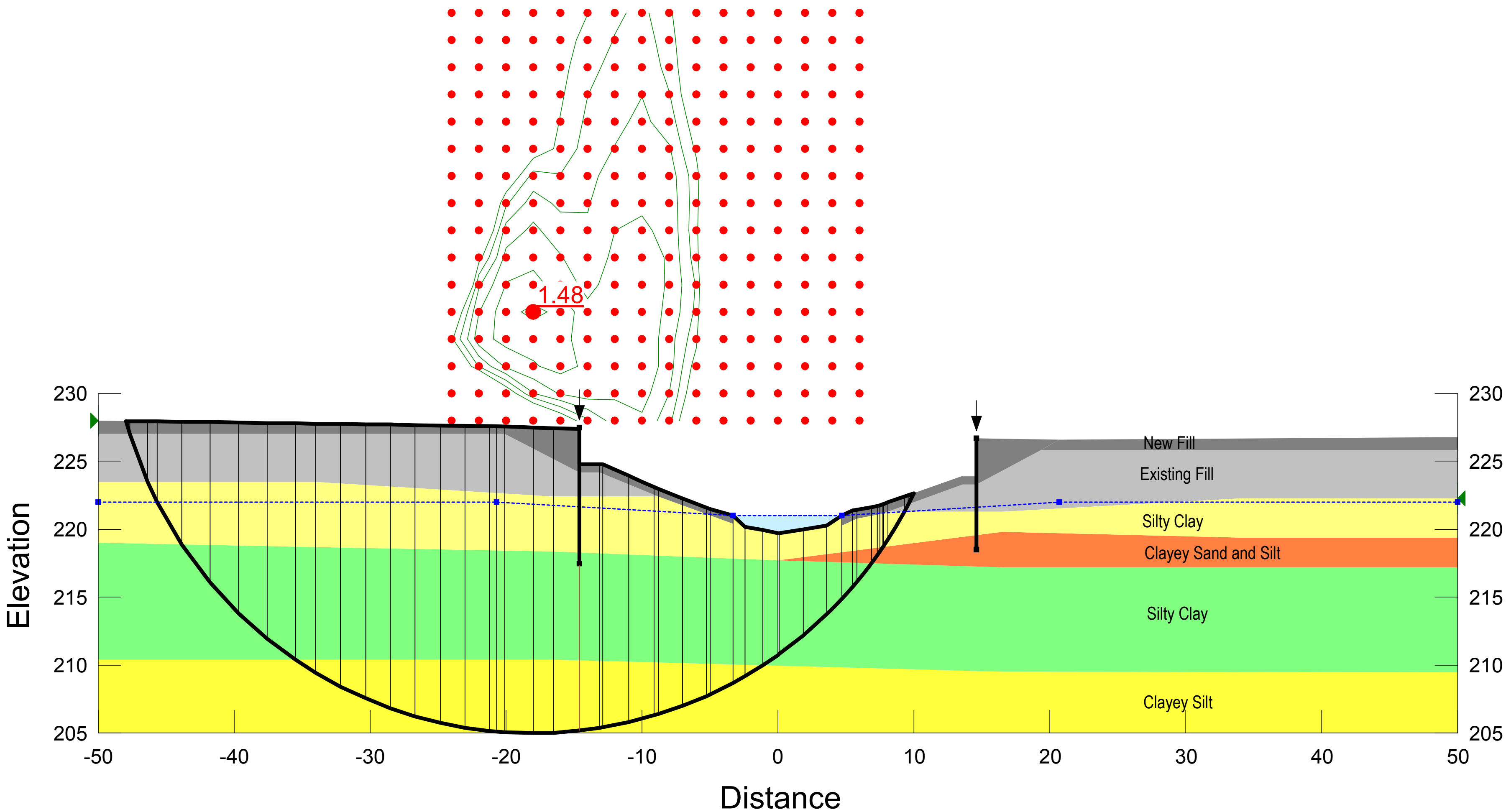
Slope Stability Analysis Results

Title: Highway 608, Slate River, Ontario
Comments: Stability Assessment
Name: West Abutment: TSA

New FILL	21 kN/m³	0 kPa	32 °	1
Existing FILL	20 kN/m³	0 kPa	30 °	1
Silty CLAY 1 (TSA)	17 kN/m³	30 kPa	0 °	1
Clayey SAND and SILT	17 kN/m³	0 kPa	30 °	1
Silty CLAY 2 (TSA)	17 kN/m³	50 kPa	0 °	1
Clayey SILT (TSA)	17 kN/m³	25 kPa	0 °	1

Method: GLE, Half-Sine
Minimum Slip Surface Depth: 1 m
Seismic: 0
Center: (-18, 236) m

West Abutment Sheet Pile: (-14.6, 217.5) m
East Abutment Sheet Pile: (14.6, 218.5) m



Reviewed By: ___________________
Last Edited By: Stephen Peters
Last Solved Date: 2014-11-28, 11:43:41 AM
Directory: H:\19\1605\121 Bridge & Culvert Rehabs NWR\Analysis\Slate River\SlateRiver_003.gsz

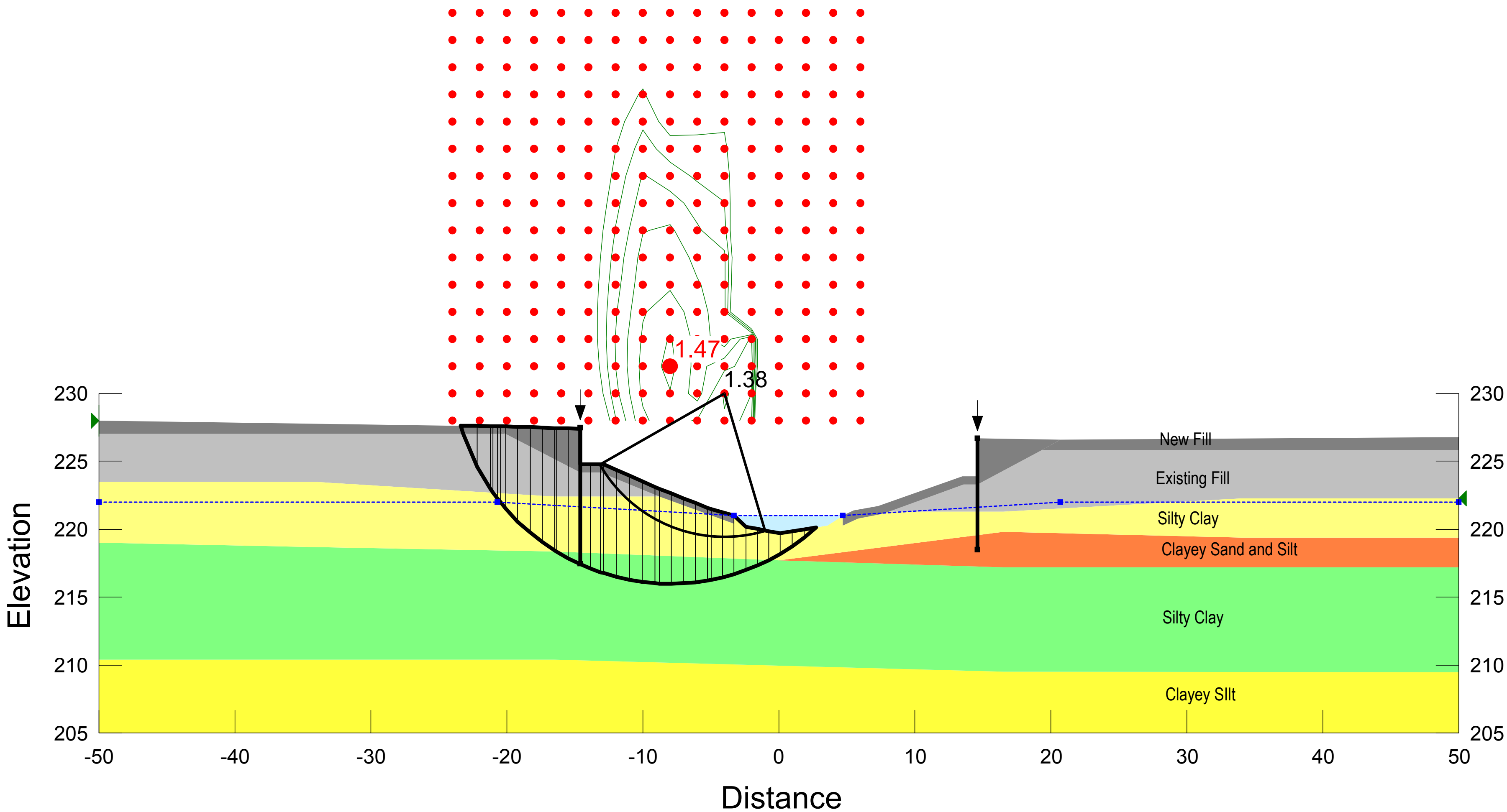
Figure 1

Title: Highway 608, Slate River, Ontario
Comments: Stability Assessment
Name: West Abutment: ESA

New FILL	21 kN/m³	0 kPa	32 °	1
Existing FILL	20 kN/m³	0 kPa	30 °	1
Silty CLAY 1 (ESA)	17 kN/m³	2 kPa	27 °	1
Clayey SAND and SILT	17 kN/m³	0 kPa	30 °	1
Silty CLAY 2 (ESA)	17 kN/m³	2 kPa	27 °	1
Clayey SILT (ESA)	17 kN/m³	2 kPa	24 °	1

Method: GLE, Half-Sine
Minimum Slip Surface Depth: 1 m
Seismic: 0
Center: (-8, 232) m

West Abutment Sheet Pile: (-14.6, 217.5) m
East Abutment Sheet Pile: (14.6, 218.5) m



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Last Edited By: Stephen Peters
Last Solved Date: 2014-11-28, 1:03:01 PM
Directory: H:\19\1605\121 Bridge & Culvert Rehabs NWR\Analysis\Slate River\SlateRiver_003.gsz

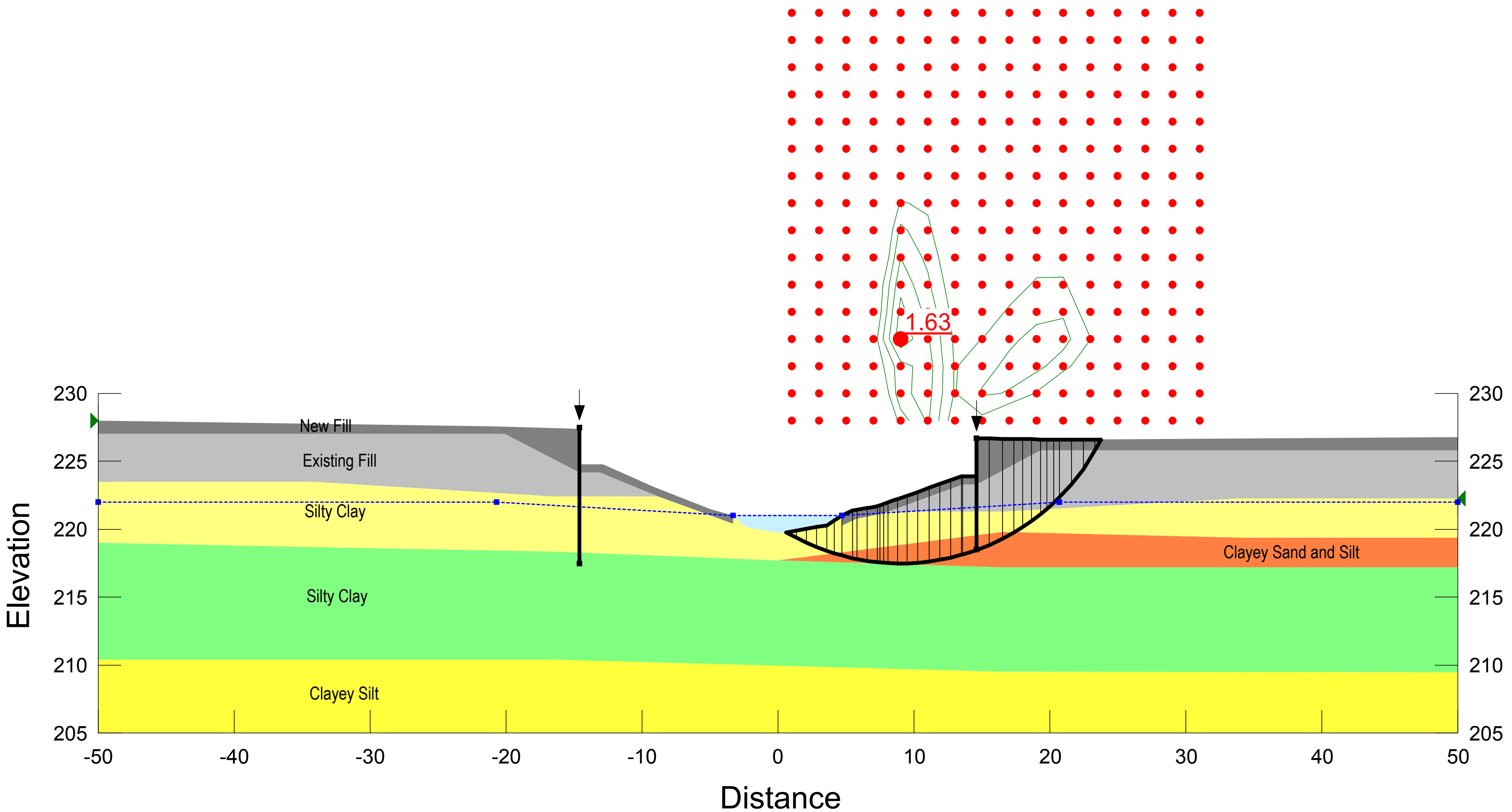
Figure 2

Title: Highway 608, Slate River, Ontario
Comments: Stability Assessment
Name: East Abutment: TSA

New FILL	21 kN/m³	0 kPa	32 °	1
Existing FILL	20 kN/m³	0 kPa	30 °	1
Silty CLAY 1 (TSA)	17 kN/m³	30 kPa	0 °	1
Clayey SAND and SILT	17 kN/m³	0 kPa	30 °	1
Silty CLAY 2 (TSA)	17 kN/m³	50 kPa	0 °	1
Clayey SILT (TSA)	17 kN/m³	25 kPa	0 °	1

Method: GLE, Half-Sine
Minimum Slip Surface Depth: 1 m
Seismic: 0
Center: (9, 234) m

West Abutment Sheet Pile: (-14.6, 217.5) m
East Abutment Sheet Pile: (14.6, 218.5) m



Reviewed By: ____________________
Last Edited By: Stephen Peters
Last Solved Date: 2014-11-28, 1:02:22 PM
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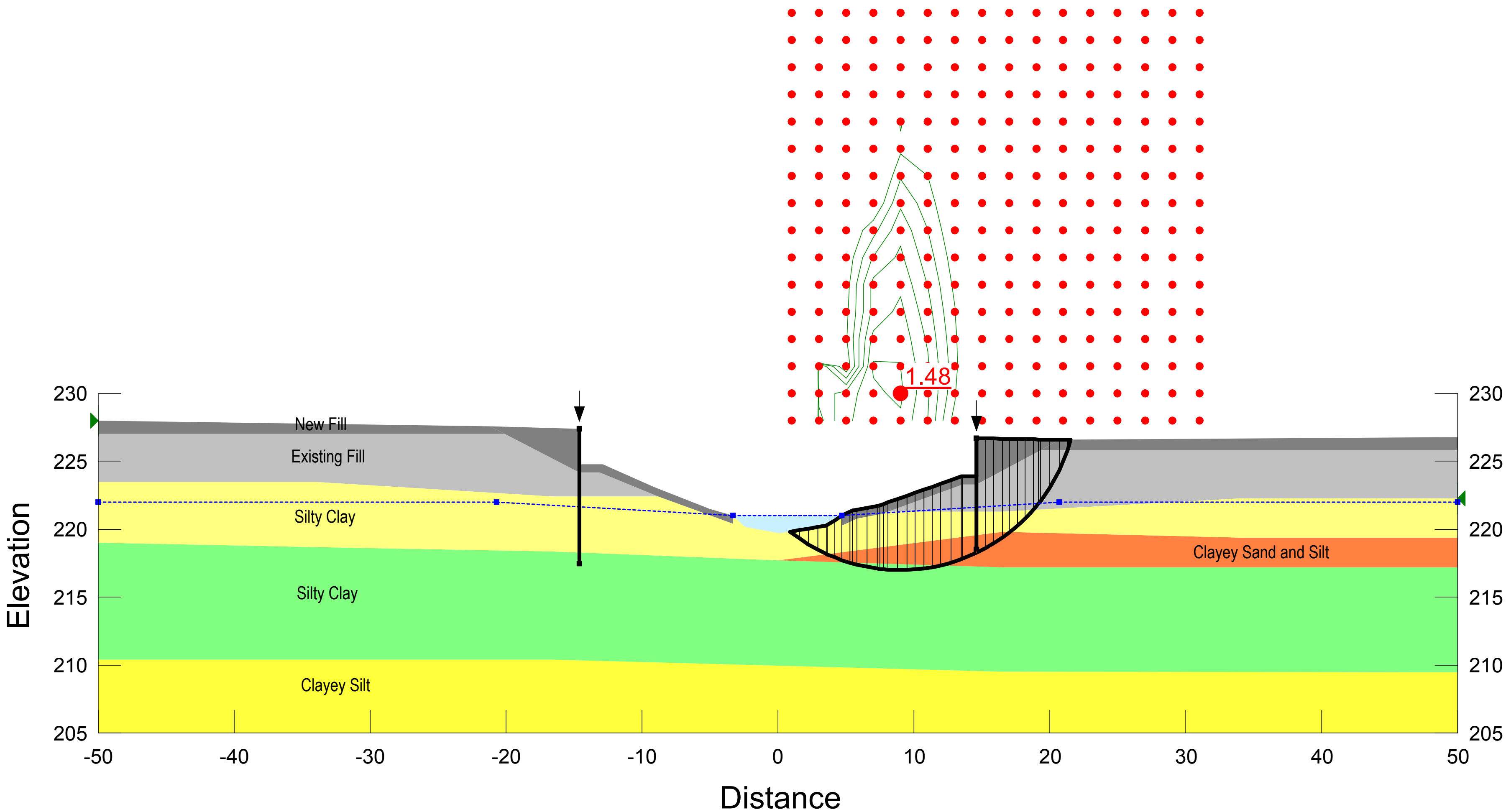
Figure 3

Title: Highway 608, Slate River, Ontario
Comments: Stability Assessment
Name: East Abutment: ESA

New FILL	21 kN/m³	0 kPa	32 °	1
Existing FILL	20 kN/m³	0 kPa	30 °	1
Silty CLAY 1 (ESA)	17 kN/m³	2 kPa	27 °	1
Clayey SAND and SILT	17 kN/m³	0 kPa	30 °	1
Silty CLAY 2 (ESA)	17 kN/m³	2 kPa	27 °	1
Clayey SILT (ESA)	17 kN/m³	2 kPa	24 °	1

Method: GLE, Half-Sine
Minimum Slip Surface Depth: 1 m
Seismic: 0
Center: (9, 230) m

West Abutment Sheet Pile: (-14.6, 217.5) m
East Abutment Sheet Pile: (14.6, 218.5) m

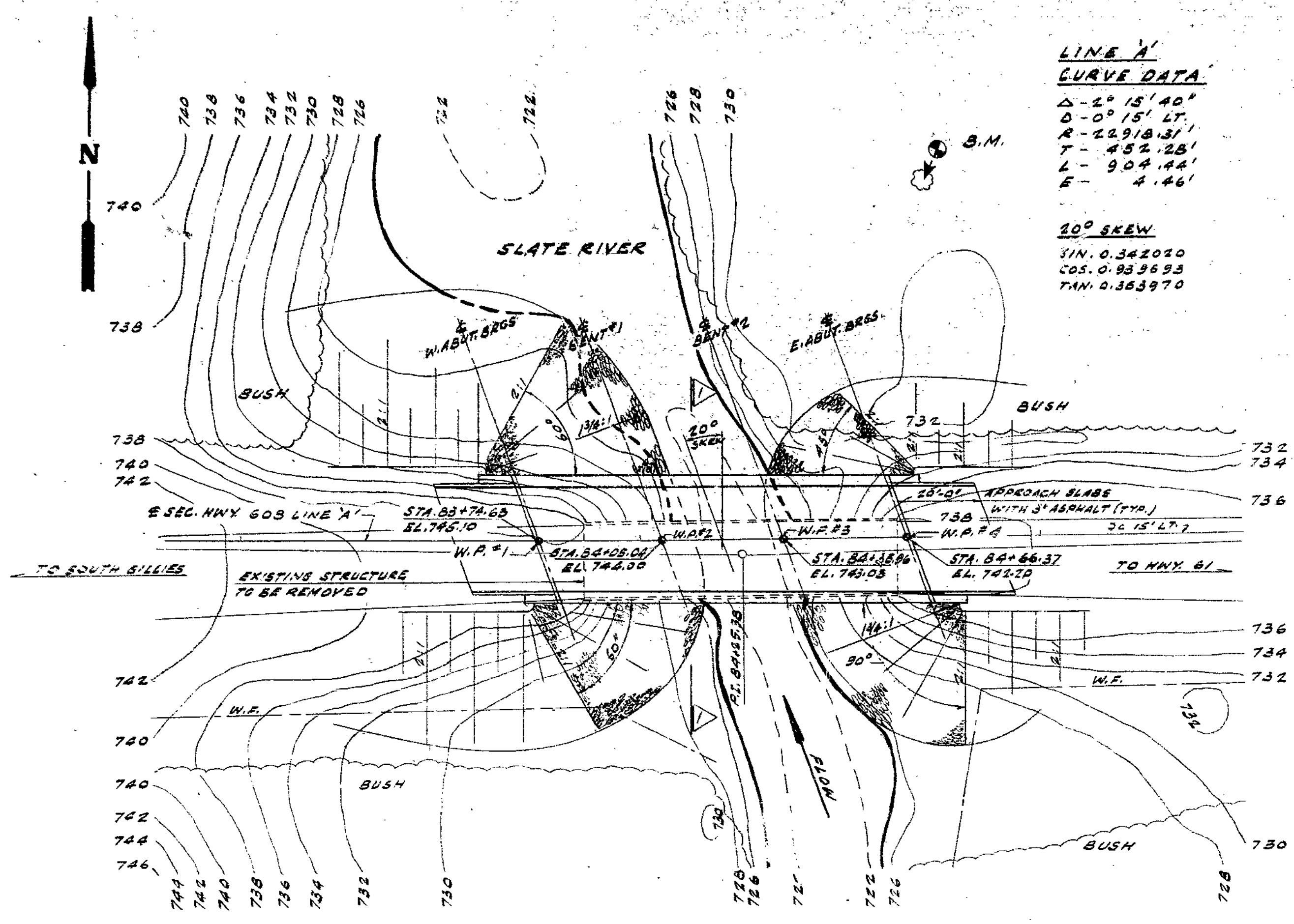


Reviewed By: ____________________
Last Edited By: Stephen Peters
Last Solved Date: 2014-11-28, 1:01:37 PM
Directory: H:\19\1605\121 Bridge & Culvert Rehabs NWR\Analysis\Slate River\SlateRiver_003.gsz

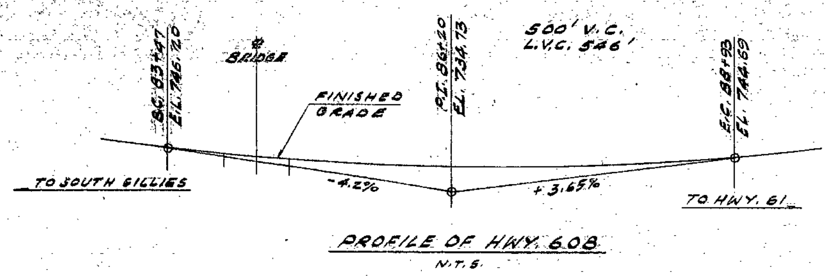
Figure 4

Appendix G

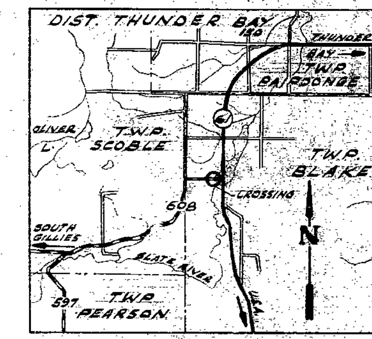
Borehole Locations and Record of Borehole Sheets
Geocres No. 52A-85



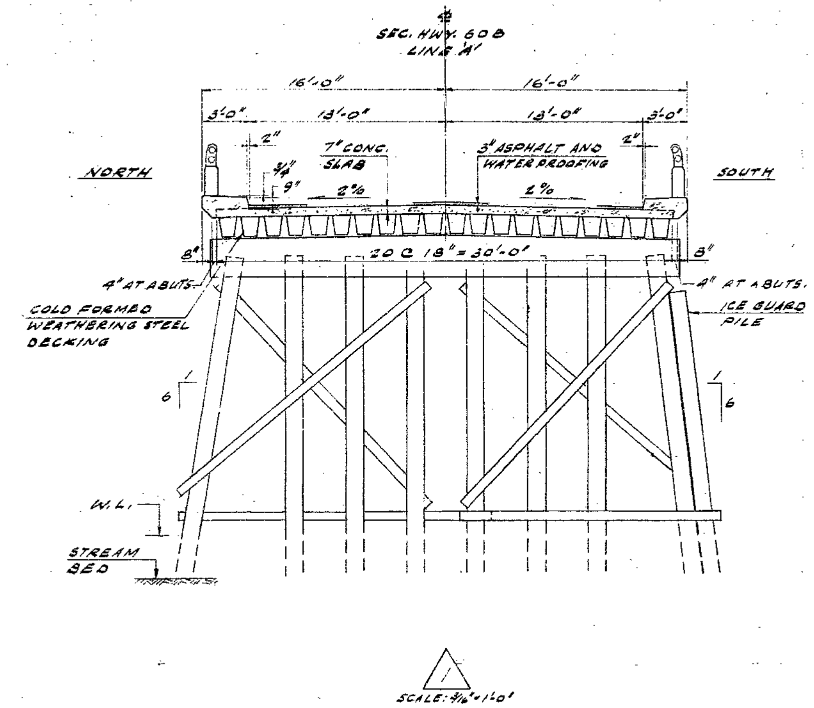
PLAN
SCALE: 1" = 20'-0"



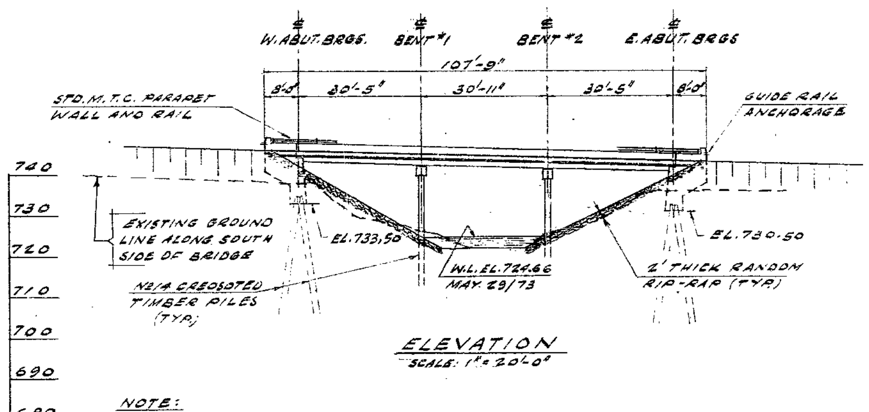
PROFILE OF HWY. 608
N.T.S.



KEY PLAN
SCALE: 1 IN. = 0.8 MI.



SCALE: 3/16" = 1'-0"



ELEVATION
SCALE: 1" = 20'-0"

NOTE:
PILES TO BE DRIVEN IN ACCORDANCE WITH STANDARD BD 82-7 USING DESIGN LOAD 26 TONS/PILE. SEE SHEET 14.

LIST OF DRAWINGS

SHEET 1 GENERAL LAYOUT
2 BORE HOLE LOCATIONS & SOIL STRATA
3 PILE LAYOUT
4 ABUTMENT LAYOUT
5 ABUTMENT REINFORCING
6 BENTS #1 & #2 & BILL OF MATERIAL
7 STEEL DECKING
8 STRUCTURAL STEEL - BILL OF MATERIAL
9 DECK DETAILS
10 PARAPET WALL DETAILS
11 STANDARD STEEL PARAPET RAIL
12 20 FOOT APPROACH SLAB
13 STANDARD DETAILS I
SHEET 14 STANDARD DETAILS II

NOTES:
1. CLASS OF CONCRETE DECK, CURBS OVER DECK & PARAPET WALLS 4000 P.S.I., REMINDER 3000 P.S.I. @ 28 DAYS.
2. CLEAR COVER ON REINFORCING STEEL
   - ABUTMENTS — 3"
   - PIER CAPS — 2"
   - DECK SLAB — 1½" TOP, — 1" BOTTOM
   - CURBS 2"

   AND/OR AS NOTED ON DRAWINGS.
3. THE CONTRACTOR IS RESPONSIBLE FOR FINISHING THE BEARING SEATS TO THE SPECIFIED ELEVATIONS AND SLOPES WITH A TOLERANCE OF ± 1/8".
4. NO CONCRETE SHALL BE PLACED ABOVE THE ABUTMENT BEARING SEATS UNTIL THE CONCRETE IN THE DECK HAS BEEN PLACED.

CONCRETE QUANTITIES:

CONCRETE IN PIER CAPS, ABUTS & WINGWALLS	91 C.Y.
CONCRETE IN DECK & DIAPHRAGMS	91 C.Y.
CONCRETE IN PARAPET WALLS	14 C.Y.
CONCRETE IN APPROACH SLABS	35 C.Y.

WEIGHT OF STEEL DECKING — 28 TONS

B.M. 731.68
GEODETIC DATUM
N&H IN ROOT 0.6' POP.
92' LT. 84+73

52A-32
GEOCRES No.

PRINT RECORD		
No.	FOR	DATE

REVISIONS		
DATE	BY	DESCRIPTION

FOR REDUCED PLAN
USE SCALE BELOW
0 1 2 3
3 INCHES ON ORIGINAL PLAN

CIVIL
KRYZEVICIUS

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS
ONTARIO

SLATE RIVER BRIDGE

SEC. HIGHWAY No. 608 LINE 'A' — DIST. No. 19
DIST. THUNDER BAY
TWP. BLAKE — SEC. 11 — CON. 2

GENERAL LAYOUT

APPROVED	STRUCTURAL ENGINEER		CONTRACT No.	
DESIGN S.K.	CHECK M.G.		W.P. No.	20-72-02
DRAWING R.V.	CHECK AK		SITE No. 48W-85	SHEET 1
DATE MAY '74	LOADING HS20-44			

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 1

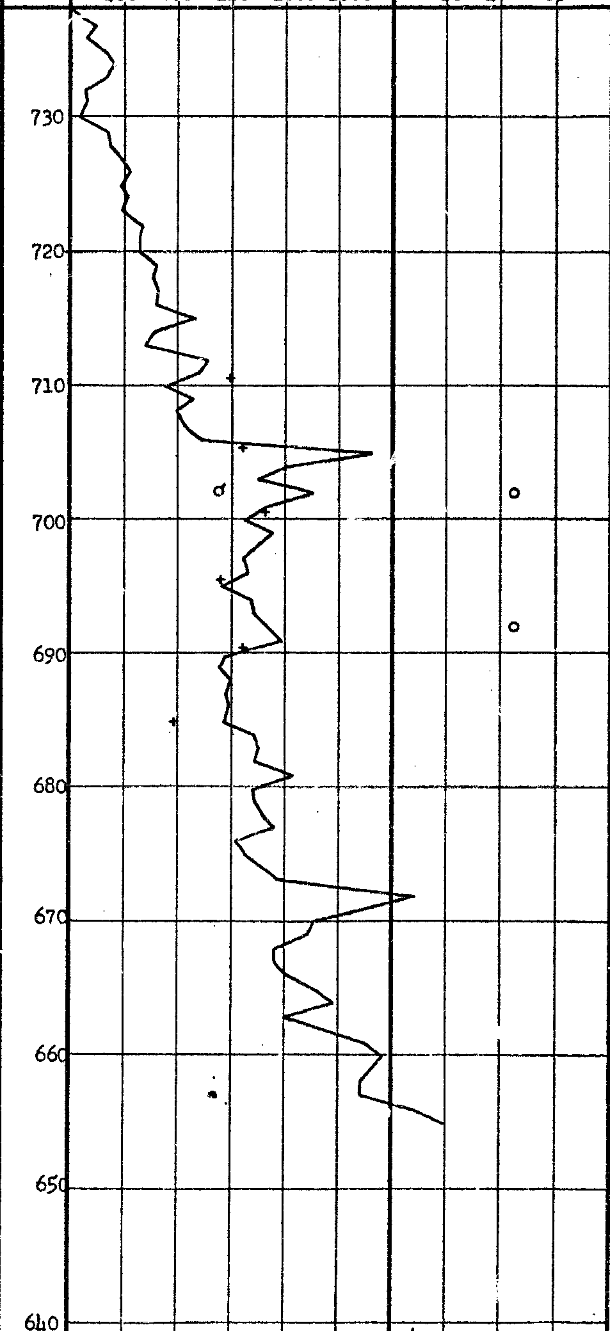
JOB 73-11062	LOCATION Sta. 84 + 78 14' Rt. of ℄		ORIGINATED BY EW
W.P. 20-72-02	BORING DATE August 23 - 31, 1973		COMPILED BY EW
DATUM Geodetic	BOREHOLE TYPE Washboring & Cone Test		CHECKED BY [signature]

Soil Profile

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT
737.8	Ground Level	
0.0	Fill material Sand, some gravel & silt. Compact	Fill (cross-hatched)
731.8 / 6.0	Fill material; clayey silt, some gravel. Firm	Fill (cross-hatched)
725.8 / 12.0	Silt, with to a trace of sand, trace to some clay, traces of organics. Very Loose to Compact	Silt
712.8 / 25.0	Silty clay. Firm to Stiff	Clay
682.8 / 55.0	Silt with to a trace of sand. Very Loose	Silt
656.8 / 81.0	Sand, traces of silt. Dense	Sand (dotted)
637.8 / 100.0		

Samples

NUMBER	TYPE	BLOWS/FOOT	BULK DENSITY γ P.C.F.
1	SS	10	
2	SS	20	
3	SS	27	
4	SS	8	
5	SS	2	
6	SS	3	
7	SS	5	
8	SS	15	
9	SS	5	
10	TW	PM	
11	TW	PM	108
12	TW	PM	
13	TW	PM	109
14	TW	PM	
15	TW	PM	
16	SS	2	
17	SS	1	
18	SS	35	
19	SS	46	



REMARKS GR.SA.SI.CL.

Continued

15 20 5 0 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

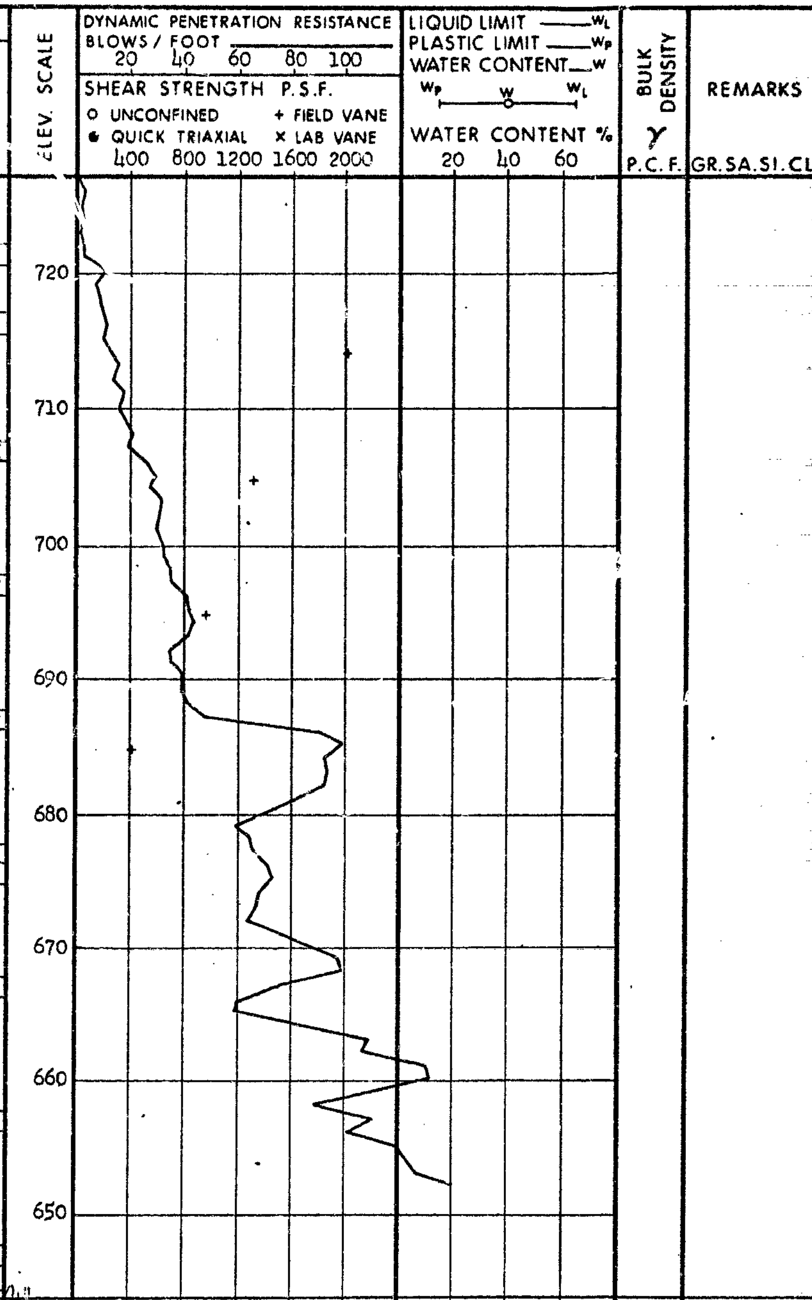
RECORD OF BOREHOLE Nº 2

JOB 73-11062 | LOCATION Sta. 83 + 76 31' Lt. of Ø | ORIGINATED BY EV
W.P. 20-72-02 | BORING DATE Sept. 10, 11, 12, 1973 | COMPILED BY EW
DATUM Geodetic | BOREHOLE TYPE Washboring & Cone Test | CHECKED BY [illegible]

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT
727.2	Ground Level				
0.0	Silt, some sand, traces of organics. Very Loose		1	SS	2
719.2 / 8.0	Silty clay. Firm to Stiff		2	SS	4
			3	TW	PM
			4	TW	PM
			5	TW	PM
682.2 / 45.0	Silt, trace to some sand, traces of clay. Loose to Compact		6	TW	PM
			7	SS	13
			8	SS	8
662.2 / 65.0	Sand, some silt, traces of gravel. Compact to Dense		9	SS	22
648.2 / 79.0	Het. mix. of clayey silt, sand & gravel. Very Dense		10	SS	129
			11	SS	100/4"
643.9 / 83.3	End of Borehole				

Note: Groundwater Level not established.

Note: Cone was driven to El. 687.2 on Sept. 11 & completed on Sept. 12.



20 / 15 – 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

RECORD OF BOREHOLE № 1 Continued

JOB 73-11062 | LOCATION Sta. 84 + 78 14' Rt. of ℄ | ORIGINATED BY EW

W.P. 20-72-02 | BORING DATE Aug. 23 - 31, 1973 | COMPILED BY EW

DATUM Geodetic | BOREHOLE TYPE Washboring & Cone Test | CHECKED BY

ELEV. / DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
636.8 101.0	Het.mix.of clayey silt, sand and gravel, occ.cobbles. Very Dense		20	SS	68					
628.8			21	RC	10%	630				
109.0	End of Borehole									
	Note: Groundwater Level not established.									
	Note: Cone was driven to El.705.8 on Aug.30 and completed on Aug. 31.									

20
15 -◇- 5 % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 1 Continued

JOB 73-11062
W.P. 20-72-02
DATUM Geodetic

LOCATION Sta. 84 + 78 14' Rt. of ⊘
BORING DATE Aug. 23 - 31, 1973
BOREHOLE TYPE Washboring & Cone Test

ORIGINATED BY EW
COMPILED BY EW
CHECKED BY

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
636.8 / 101.0	Het.mix.of clayey silt, sand and gravel, occ.cobbles.		20	SS	68					
628.8	Very Dense		21	RC	10%	630				
109.0	End of Borehole									
	Note: Groundwater Level not established.									
	Note: Cone was driven to El.705.8 on Aug.30 and completed on Aug. 31.									

20 / 15 ⌖ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT SOIL EXPLORATION

FD-9 (Rev. Jan. 73)

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

PENETRATION RESISTANCE

'N'- STANDARD PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

CONSISTENCY	c LB./SQ.FT.	DENSENESS	'N' BLOWS / FT.
VERY SOFT	0 - 250	VERY LOOSE	0 - 4
SOFT	250 - 500	LOOSE	4 - 10
FIRM	500 - 1000	COMPACT	10 - 30
STIFF	1000 - 2000	DENSE	30 - 50
VERY STIFF	2000 - 4000	VERY DENSE	> 50
HARD	> 4000		

TERMS TO BE USED IN DESCRIBING SOILS:-

TRACE < 10% , SOME 10–25% , WITH 25–40% , > 40% SILTY, SANDY, GRAVELLY, CLAYEY ETC.

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CIU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_P	PLASTIC LIMIT
I_P	PLASTICITY INDEX
w_S	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE $= \frac{-\Delta\epsilon}{(1+e)\Delta\sigma'}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX $= \frac{\Delta e}{\Delta \log_{10} \sigma'}$
T_v	TIME FACTOR $= \frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT } IN TERMS OF EFFECTIVE STRESS $\tau_f = c' + \sigma' \tan \phi'$
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION }
c_u	APPARENT COHESION } IN TERMS OF TOTAL STRESS $\tau_f = c_u + \sigma \tan \phi$
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION }
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	$= 3{\cdot}1416$
e	BASE OF NATURAL LOGARITHMS 2·7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNGS MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_o	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

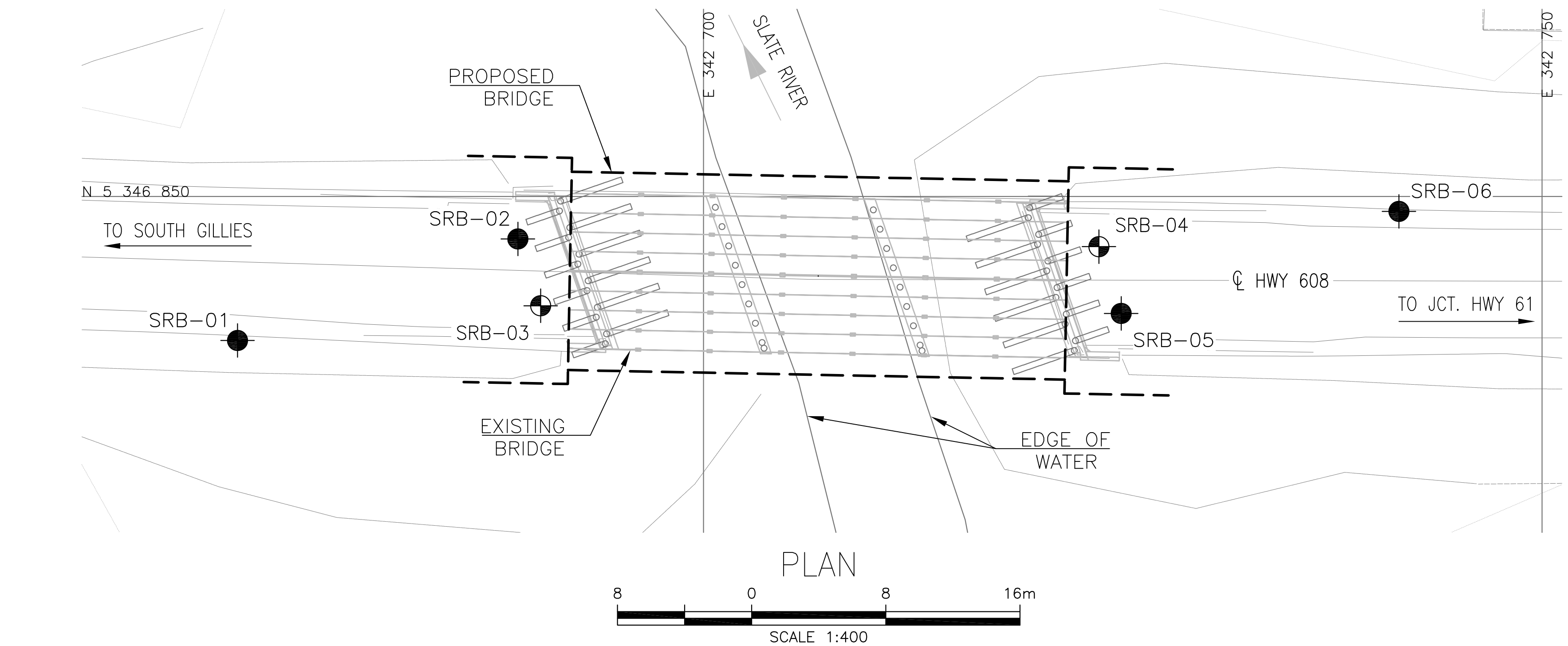
B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY. DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL

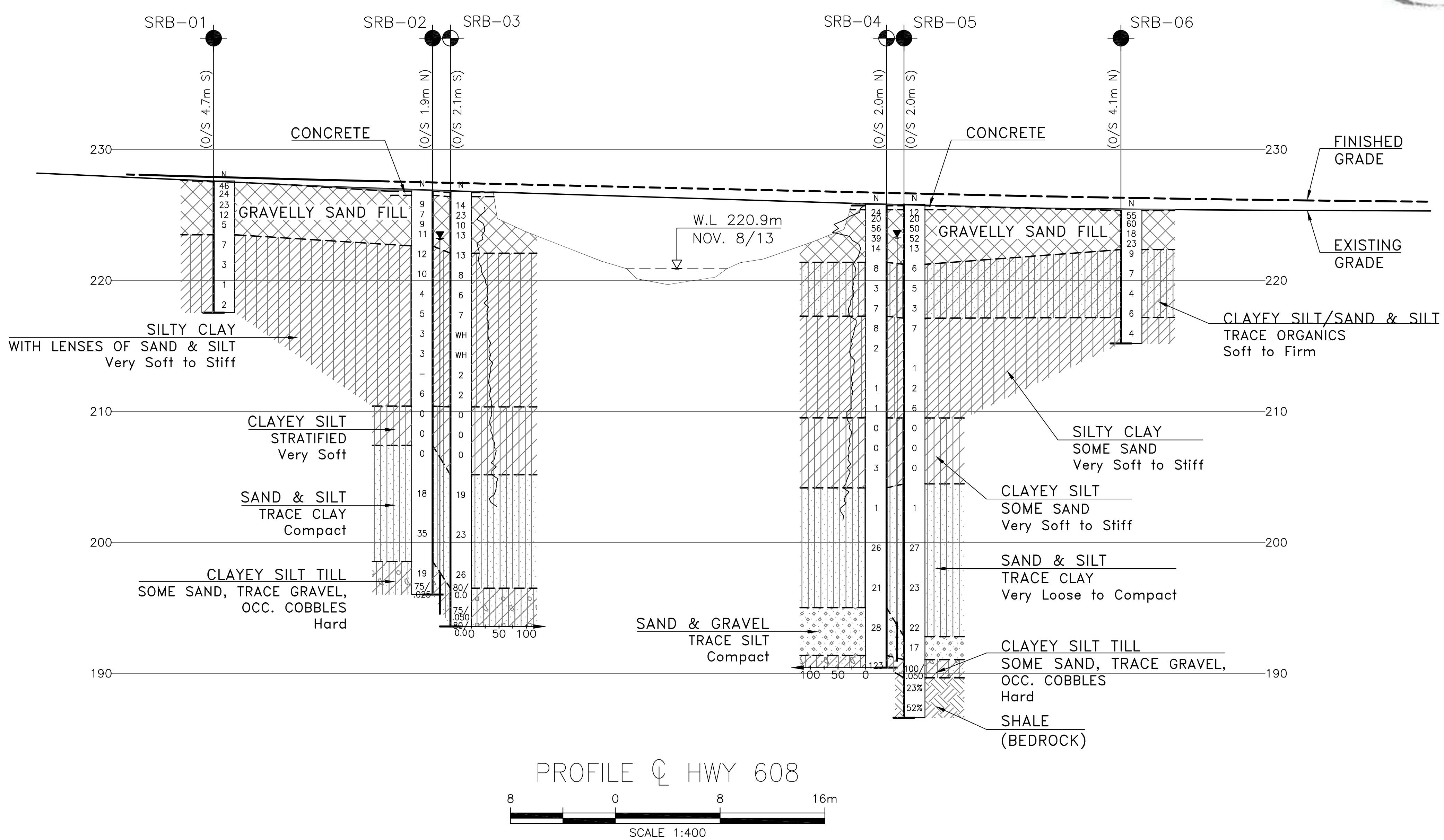
Appendix H

Borehole Locations and Soil Strata Drawing



METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



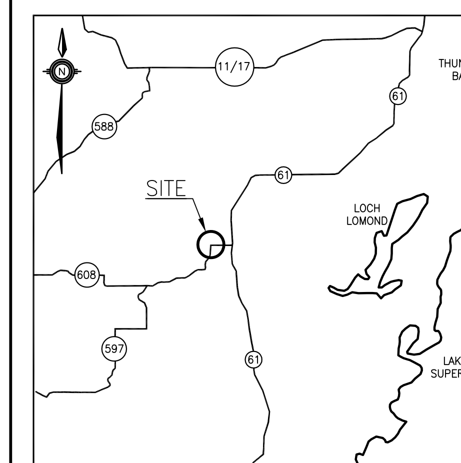
CONT No
WP No 6083-09-01

HIGHWAY 608
SLATE RIVER BRIDGE
STRUCTURAL REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
11

Hatch Mott MacDonald

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 During Drilling
▼	Water Level In Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
SRB-01	227.6	5 346 841.4	342 672.2
SRB-02	226.9	5 346 847.5	342 688.9
SRB-03	226.8	5 346 843.5	342 690.3
SRB-04	225.8	5 346 847.0	342 723.6
SRB-05	225.8	5 346 843.0	342 724.9
SRB-06	225.4	5 346 849.1	342 741.7

-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.

GEOCRES No. 52A-190

REVISIONS | DATE | BY | DESCRIPTION

DESIGN AP	CHK MRA	CODE CAN/CSA S6-06	LOAD CL-625-ONT	DATE	JAN 2015
DRAWN AN	CHK AP	SITE 48W-85	STRUCT	DWG 2	