FOUNDATION INVESTIGATION AND DESIGN REPORT
STRAWBERRY CREEK BRIDGE 1 REHABILITATION
HIGHWAY 102
THUNDER BAY DISTRICT, ONTARIO

G.W.P. 6073-09-00, SITE NO. 48W-1

Geocres Number: 52A-185

Report to:

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the existing Strawberry Creek Bridge 1 along Highway 102, in the District of Thunder Bay, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile and cross-sections, 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 MMM Group Limited, under the Ministry of Transportation Ontario (MTO) Agreement Number 6010-E-0011.

2 SITE DESCRIPTION

The existing Strawberry Creek Bridge 1 is located on Highway 102 in the community of Kaministiquia, approximately 7 km east of the intersection of Highways 102 and 11/17, and 25 km northwest of Thurber Bay. The existing bridge is a single-span structure with a concrete deck and steel girders supported on reinforced concrete abutments. The bridge spans a length of approximately 27.4 m and is 11 m wide.

Strawberry Creek flows from northeast to southwest and crosses Highway 102 at three locations before draining into the Kaministiquia River. The creek channel is approximately 9 m wide and 1 m deep at the site. The surrounding lands are heavily wooded. Gravel quarrying has been carried out along the northwest side of the Creek, and a gravel pit and access road are located approximately 100 m west of the site.

Photographs in Appendix C show the general nature of the site and the existing bridge.

The site lies within the physiographic region known as the Wawa Subprovince of the Superior Province of the Canadian Shield. The soil deposits in the area comprise glaciofluvial outwash gravel. Bedrock at depth is formed of intermediate mafic to felsic metavolcanic rocks.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out on July 10 and 11, 2013 and consisted of drilling and sampling four boreholes, identified as Boreholes SBC1-01 to SBC1-04, through the highway embankment in the area of the existing west and east abutments and approaches. Boreholes SBC1-02 and SBC1-03 were drilled near the abutments and Boreholes SCB1-01 and SBC1-04 were drilled through the approach embankments. The boreholes were terminated at depths of 9.2 to 13.7 m, including coring 3.2 to 3.3 m into bedrock in Boreholes SBC1-02 and SBC1-03.

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

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

A truck-mounted CME 75 drill rig was used to advance the boreholes using a combination of NW casing/wash boring techniques, and NQ coring. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Dynamic Cone Penetration Tests (DCPTs) were conducted adjacent to Boreholes SBC1-02 and SBC1-03 on completion of drilling.

NQ coring techniques were used to recover 3.2 to 3.3 m long core samples of the bedrock in Boreholes SBC1-02 and SBC1-03. All rock cores were logged and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and 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 transporting to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Groundwater conditions observed after completion of drilling were not representative of site conditions as water was used during wash boring and coring operations. Standpipe piezometers were installed in two boreholes to monitor the groundwater level after drilling. The piezometers were subsequently decommissioned and the boreholes without piezometers were backfilled in general accordance with MOE Regulation 903. Completion details of the piezometers and boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Foundation Unit	Boreholes	Piezometer Tip Depth/ Elevation (m)	Completion Details
West Approach	SBC1-01	None installed	Borehole backfilled with bentonite holeplug from 9.2 m to 0.15 m, then asphalt to surface.
West Abutment	SBC1-02	13.7/ 311.2	Sand from 13.7 m to 10.2 m, bentonite holeplug from 10.2 m to 0.15 m, then asphalt to surface.
East Abutment	SBC1-03	13.2/ 313.2	Sand from 13.2 m to 9.4 m, bentonite holeplug from 9.4 m to 0.15 m, then asphalt to surface.
East Approach	SBC1-04	None installed	Borehole backfilled with bentonite holeplug from 9.7 m to 0.15 m, then asphalt to surface.

4 LABORATORY TESTING

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

Bedrock core samples were subjected to geological logging. Point load tests were carried out on selected samples of intact rock in the laboratory to evaluate the unconfined compressive strength (UCS) of the bedrock. The average UCS values of the intact rock assessed from the point load test data are reported on the borehole logs in Appendix A.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the "Borehole Locations and Soil Strata" drawing included in Appendix E. 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. It must be recognized that soil conditions may vary between and beyond the borehole locations.

The soil stratigraphy typically comprises a sand and gravel embankment fill, underlain by native sand and gravel over metavolcanic bedrock. More detailed descriptions of the individual strata are presented below.

5.1 Asphalt and Concrete

Asphalt was encountered in all the boreholes, which were drilled from the existing Highway 102 roadway. The asphalt layer was 125 mm thick at the four borehole locations. A 225 mm thick concrete slab was encountered below the asphalt in Borehole SBC1-02.

5.2 Sand and Gravel Fill

The existing highway embankment fill beneath the asphalt typically comprised a brown sand and gravel with trace to some silt and occasional cobbles. The lower portion of the embankment fill typically varied to gravelly sand with some silt and clay. A layer of concrete (180 mm thick) was encountered at the base of the fill in Borehole SBC1-02 at a depth of 8.2 m. The embankment fill has a total thickness of 4.5 to 8.0 m with a lower boundary at depths of 4.6 to 8.4 m (Elev. 322.1 to 316.5).

SPT 'N' values recorded in the fill typically ranged from 11 to 59 blows per 0.3 m penetration, indicating a compact to very dense relative density. An 'N' value of 4 blows per 0.3 m penetration (loose) was obtained at the base of the fill in Borehole SBC1-02. Measured moisture contents of the fill ranged from 3% to 21%.

The results of grain size analysis tests conducted on the embankment fill are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are shown on Figures B1 and B2 of Appendix B.

	Sand & Gravel	Lower Gravelly Sand
Gravel %	49 to 55	13 to 28
Sand %	43 to 45	46 to 49
Silt %	2 to 6	11 to 17
Clay %	-	12 to 24

5.3 Sand and Gravel

A native deposit of brown sand and gravel containing trace to some silt and occasional cobbles and boulders was encountered below the embankment fill in all of the boreholes. In Boreholes SBC1-02 and SBC1-03, where fully penetrated, the sand and gravel deposit had a thickness of 2.0 and 3.9 m, with a lower boundary at depths of 10.4 and 10.0 m (Elev. 314.5 and 316.4). Boreholes SBC1-01 and SBC1-04 were terminated within the sand and gravel deposit at depths of 9.2 and 9.7 m respectively (Elevation 315.4 and 317.0).

SPT 'N' values obtained in the sand and gravel ranged from 11 blows for 0.3 m penetration to 50 blows for 0.025 m penetration, indicating a compact to very dense relative density. Measured moisture contents ranged from 2% to 12%.

Selected samples of sand and gravel underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are shown on Figure B3 of Appendix B.

Gravel %	34 to 43
Sand %	44 to 55
Silt & Clay %	6 to 22

5.4 Bedrock

Bedrock was encountered below the sand and gravel deposit in Boreholes SBC1-02 and SBC1-03 at depths of 10.4 and 10.0 m respectively (Elevation 314.5 and 316.4). Bedrock was proven by recovery of 3.2 m to 3.3 m long rock core samples in the boreholes.

The recovered bedrock core samples were described as grey tuff with quartz veins. Total Core Recovery (TCR) in the bedrock was 97% to 100%, and the Rock Quality Designation (RQD) was between 79% and 97%, indicating good to excellent rock quality. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m core, was typically less than 3.

The unconfined compressive strength of the intact rock interpreted from point load tests conducted on selected cores ranged from 44 MPa to 165 MPa (average per core run), indicating a medium to very strong rock classification.

5.5 Water Levels

Where possible, water levels were monitored in the open boreholes during drilling operations. Wash boring and rock coring methods were used to advance the boreholes and therefore water levels recorded during or upon completion of drilling may not reflect natural groundwater levels. Standpipe piezometers were installed in two boreholes to monitor the groundwater level after completion. The water levels observed in the open boreholes upon completion and measured in the piezometers are summarized in Table 5.1.

Table 5.1 – Water Level Measurements

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
SBC1-02	July 10, 2013	3.9	321.0	Open borehole
	August 1, 2013	5.2	319.7	In piezometer
	May 2, 2014	5.3	319.6	In piezometer
SBC1-03	July 11, 2013	4.2	322.2	Open borehole
	August 1, 2013	5.7	320.7	In piezometer
	May 2, 2014	5.3	321.1	In piezometer
SBC1-04	July 10, 2013	5.1	321.6	Open borehole

The preliminary GA drawings provided by MMM Group Limited indicates a water level at Elev. 319.7 in Strawberry Creek in March 2011. In general, the groundwater level is expected to be at or slightly above the water level in the creek.

The above values are short-term readings and seasonal fluctuations of the groundwater and creek level are to be expected. In particular, the water levels may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

6 MISCELLANEOUS

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

Thurber obtained utility clearances for the borehole locations prior to drilling.

Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied a truck-mounted CME-75 drill rig and conducted the drilling, sampling and in-situ testing operations for the boreholes. The drilling operations were supervised by Ms. Eckie Siu of Thurber.

Overall supervision of the field program, interpretation of the data, and preparation of the report were carried out by Mr. Mark Farrant 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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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides geotechnical recommendations for the proposed rehabilitation of the existing Strawberry Creek Bridge 1 on Highway 102, in the District of Thunder Bay, Ontario.

At present, the bridge carries Highway 102 over Strawberry Creek on a single-span structure with a span of 27.4 m and a deck width of 11 m. Archive drawings dated June 1973 indicate that the existing bridge abutments are supported on concrete spread footings constructed on tremie concrete placed on bedrock. The design depths from the finished road grade to concrete base are approximately 10.5 m and 10.2 m at the west and east abutment, respectively. The existing approach fill heights above the surrounding ground are approximately 5 m at both abutments.

Based on the GA drawing dated September 2014, rehabilitation of the bridge will consist of replacement of the existing deck slab with a new precast concrete deck. The rehabilitation will include modification of the tops of the abutments and wingwalls. There will be a 120 mm grade raise at both approaches. Widening of the bridge deck is not proposed.

The discussion and recommendations presented in this report are based on the information provided by MMM Group Limited and on the factual data obtained in the course of the investigation.

8 ASSESSMENT OF EXISTING ABUTMENT FOUNDATIONS

The subsurface stratigraphy encountered at this site generally consists of sand and gravel fill underlain by a layer of compact to very dense native sand and gravel overlying bedrock. Medium strong to strong bedrock was encountered at depths of 10.4 m and 10.0 m (elevations 314.5 and 316.4).

The archive drawings for the existing bridge indicate that the footings supporting the existing abutments were constructed on tremie concrete placed on bedrock. The design base level of the tremie

concrete was at elevations 315.0 m and 316.4 m at the west abutment and east abutment, respectively. Rock excavation was specified at the west abutment to provide a level bedrock surface.

For footings and tremie concrete on bedrock, a factored geotechnical resistance at Ultimate Limit State (ULS) of 2,000 kPa is recommended to assess the capability of the existing foundations to support the revised bridge loads. The SLS condition will not govern for footings founded on the bedrock.

It is understood from MMM that the loads on the foundations may be increased slightly (less than 10% of the existing load) due to the deck replacement. Supporting the new deck on the existing spread footings is therefore considered to be acceptable from a geotechnical viewpoint. The Structural Designer must verify that the strength and integrity of the existing foundations and tremie concrete is adequate to carry the foundation loads.

The lateral resistance of the footings may be computed using an unfactored friction coefficient of 0.70 for concrete on bedrock.

The design depth of frost penetration at this site is 2.2 m. Footings on bedrock at this site do not require frost protection.

9 ABUTMENT BACKFILL AND LATERAL EARTH PRESSURES

Any new backfill behind the modified abutment and wing walls should be placed in accordance with OPSS 902. All backfill material should consist of Granular A, Granular B Type II or Granular B Type III material meeting the specifications of OPSS.PROV 1010. Compaction equipment to be used adjacent to the walls should be restricted in accordance with OPSS 501.

Lateral earth pressures acting on the abutment walls may be assumed to be distributed triangularly and to be governed by the characteristics of the wall 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 = earth pressure coefficient (see Table 9.1)

γ = unit weight of retained soil (see Table 9.1)

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 and the existing material adjacent to the wall. Typical values are given in Table 9.1.

Table 9.1 – Earth Pressure Coefficients (K)

Condition	OPSS Granular A or Granular B Type II $\phi = 35°, \gamma = 22.8$ kN/m^3		OPSS Granular B Type I, Granular B Type III or Existing Granular Fill $\phi = 32°, \gamma = 21.2$ 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 (Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the wall.

The earth pressure coefficients in Table 9.1 are "ultimate" values and require certain movements for the respective conditions to be mobilized. The values to use in design may be estimated from Figure C6.16 in the Commentary to the Canadian Highway Bridge Design Code.

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.

10 SEISMIC CONSIDERATIONS

The following seismic parameters should be used for design:

- Velocity Related Seismic Zone 0
- Zonal Velocity Ratio 0.0
- Acceleration Related Seismic Zone 0
- Zonal Acceleration Ratio 0.0
- Peak Horizontal Acceleration 0.036

The soil profile type at this site has been classified as Type I. Therefore, according to Table 4.4 of the CHBDC, a Site Coefficient "S" (ground motion amplification factor) of 1.0 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. The coefficients of horizontal earth pressure for seismic loading presented in Table 10.1 may be used.

Based on review of the SPT data, the foundation soils at this site are assessed as not being prone to liquefaction.

Table 10.1 – Earth Pressure Coefficients for Earthquake Loading (K_E)

Conditions	OPSS Granular A or Granular B Type II $\phi = 35°$; $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I or Existing Granular Fill $\phi = 32°$, $\gamma = 21.2$ 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

11 SCOUR AND EROSION CONTROL

Erosion protection must be provided along any soil surfaces that may be in contact with the river flow. In particular, erosion should be provided along the toe of the embankment slopes where not protected by wingwalls.

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

12 EXCAVATION AND GROUNDWATER CONTROL

Excavation to carry out modifications to the existing abutments is expected to be limited to the existing granular embankment fill above the river and groundwater levels. Based on the preliminary General Arrangement drawing provided by MMM, the depth of excavation at the abutments is anticipated to be less than 1.5 m below the existing grade.

All excavations must be carried out in accordance with OPSS 902 and the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the approach fill within the depth of excavation may be classed as Type 3 soil above the water table.

The selection of the method of excavation is the responsibility of the Contractor and must be based on his equipment, experience and interpretation of the site conditions. It is anticipated that a hydraulic excavator will be suitable. Provision must be made for the handling of pavement materials, potential obstructions in the fill, and cobbles and boulders.

Bridge rehabilitation will be carried out in stages to maintain one traffic lane operational at all times. Roadway protection will be required to facilitate staging. Roadway protection should be provided in accordance with OPSS 539 and designed for Performance Level 2.

Conventional steel soldier pile and timber lagging walls or continuous sheet pile walls are two options to provide temporary support to the roadway during excavation. However, the existing embankment fill and underlying native soils contain occasional cobbles and possible boulders which may interfere with installation of soldier piles or sheet piles. The Contractor should be advised of potential

obstructions in the fill during installation. Suggested text for an NSSP on "Installation of Roadway Protection System" is included in Appendix D.

Design of any road protection or dewatering system that may be required is the responsibility of the Contractor. All shoring systems should be designed by a Professional Engineer experienced in such designs.

13 APPROACH EMBANKMENTS

A grade raise of 120 mm is planned at both approaches. In view of the soil conditions at this site, settlement or stability issues are not anticipated.

14 CONSTRUCTION CONCERNS

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

- The existing embankment fill contains occasional cobbles which may interfere with excavation or installation of temporary roadway protection systems.
- Water levels in the creek may fluctuate during construction.

15 CLOSURE

Engineering analysis and preparation of the report were carried out by Mr. Keli Shi, 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

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

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

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

∇ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

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

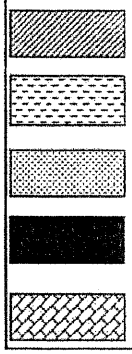
(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of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

EXPLANATION OF ROCK LOGGING TERMS

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

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

SYMBOLS



CLAYSTONE

SILTSTONE

SANDSTONE

COAL

BEDROCK

STRENGTH CLASSIFICATION			
Rock Strength	**Approximate Uniaxial Compressive Strength**		**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.

UNIFIED SOILS CLASSIFICATION

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SBC1-01 1 OF 1 METRIC

WP# 6073-09-00 LOCATION Strawberry Creek Bridge 1 N 5 377 568.3 E 337 376.5 ORIGINATED BY ES

HWY 102 BOREHOLE TYPE NW Casing COMPILED BY AN

DATUM Geodetic DATE 2013.07.11 - 2013.07.11 CHECKED BY MC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
324.6	GROUND SURFACE										
0.0	**ASPHALT:** (125mm)										
0.1	**SAND** and **GRAVEL**, trace to some silt, occasional cobbles Very dense to Compact Brown (FILL)		1	SS	51		324		○		52 45 3 (SI+CL)
			2	SS	15		323		○		
			3	SS	11		322		○		
	Some clay		4	SS	27		321		○		28 49 11 12
320.0											
4.6	**SAND** and **GRAVEL**, trace to some silt, occasional cobbles Compact to Very Dense Brown Wet		5	SS	15		320				
			6	SS	50/ 0.075		319				
	Boulder from 6.3m to 7.3m						318				
			7	SS	50/ 0.125		317		○		34 44 22 (SI+CL)
315.4			8	SS	50/ 0.025		316				
9.2	END OF BOREHOLE AT 9.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.15m AND ASPHALT TO SURFACE.										

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SBC1-02 1 OF 2 METRIC

WP# 6073-09-00 LOCATION Strawberry Creek Bridge 1 N 5 377 560.8 E 337 382.5 ORIGINATED BY ES

HWY 102 BOREHOLE TYPE NW Casing/Dynamic Cone Penetration Test COMPILED BY AN

DATUM Geodetic DATE 2013.07.10 - 2013.07.10 CHECKED BY MC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
324.9	GROUND SURFACE										
0.0	**ASPHALT:** (125mm)										
0.1 / 324.5	**CONCRETE SLAB:** (225mm)										
0.4	**SAND** and **GRAVEL**, trace silt Compact Brown (FILL)		1	SS	21		324				
	Occasional cobbles		2	SS	24		323				
			3	SS	21						55 43 2 (SI+CL)
			4	SS	13		322				
			5	SS	17		321				
							320				
			6	SS	11		319				
	Occasional cobbles						318				
317.3											
7.6	Gravelly **SAND**, some silt and clay Loose Brown Moist		7	SS	4		317				24 48 12 16
316.7 / 316.5	(FILL)										
8.4	**CONCRETE:** (180mm)						316				
	SAND and **GRAVEL** Compact Brown Wet		8	SS	14						
							315				

Continued Next Page

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SBC1-02 2 OF 2 METRIC

WP# 6073-09-00 LOCATION Strawberry Creek Bridge 1 N 5 377 560.8 E 337 382.5 ORIGINATED BY ES

HWY 102 BOREHOLE TYPE NW Casing/Dynamic Cone Penetration Test COMPILED BY AN

DATUM Geodetic DATE 2013.07.10 - 2013.07.10 CHECKED BY MC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Cobbles									FI	
314.5											
10.4	**BEDROCK:** TUFF, grey, with quartz veins Rubble zone from 10.2m to 10.4m Sub-vertical fractures at 10.42m to 10.50m 10.84m to 11.56m		1	RUN			314			>5 1 0 0 0	RUN #1 TCR=100% SCR=88% RQD=79% UCS=86MPa (Average)
	Sub-vertical fractures from 11.73m to 11.86m 11.86m to 12.01m 12.27m to 12.42m		2	RUN			313 312			1 0 0 0	RUN #2 TCR=97% SCR=97% RQD=97% UCS=165MPa (Average)
311.2	Sub-vertical fractures at 13.26m to 13.70m		3	RUN						0 0	RUN #3 TCR=100%
13.7	END OF BOREHOLE AT 13.7m. WATER LEVEL AT 3.9m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Aug 01/13 5.2 319.7 May 02/14 5.3 319.6										SCR=100% RQD=100%

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SBC1-03 1 OF 2 METRIC

WP# 6073-09-00 LOCATION Strawberry Creek Bridge 1 N 5 377 551.8 E 337 418.7 ORIGINATED BY ES

HWY 102 BOREHOLE TYPE NW Casing/Dynamic Cone Penetration Test COMPILED BY AN

DATUM Geodetic DATE 2013.07.11 - 2013.07.11 CHECKED BY MC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
326.4	GROUND SURFACE										
0.0	**ASPHALT:** (125mm)										
0.0	**SAND** and **GRAVEL**, trace silt, occasional cobbles Compact to dense Brown (FILL)		1	SS	28		326				
			2	SS	28		325				51 44 5 (SI+CL)
			3	SS	40		324				
			4	SS	26		323				
	No recovery		5	SS	12	▼	322				
320.3							321				
6.1	**SAND** and **GRAVEL**, trace to some silt Compact to Very Dense Brown Wet		6	SS	11		320				
			7	SS	25		319				
			8	SS	112/ 0.250		318				
316.4							317				34 55 11 (SI+CL)

FI

Continued Next Page

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SBC1-03 2 OF 2 METRIC

WP# 6073-09-00 LOCATION Strawberry Creek Bridge 1 N 5 377 551.8 E 337 418.7 ORIGINATED BY ES

HWY 102 BOREHOLE TYPE NW Casing/Dynamic Cone Penetration Test COMPILED BY AN

DATUM Geodetic DATE 2013.07.11 - 2013.07.11 CHECKED BY MC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
10.0	**BEDROCK:** TUFF, grey, with quartz veins Sub-vertical fractures at 10.13m to 10.57m Vertical fractures from 10.74m to 10.87m		1	RUN			316			3 1 1 0	RUN #1 TCR=100% SCR=97% RQD=93% UCS=44MPa (Average)
							315			0 3	
	Sub-vertical fractures at 12.62m to 12.67m Vertical fractures at 11.53m to 11.66m, and 12.62m to 12.73m		2	RUN			314			0 0 1	RUN #2 TCR=100% SCR=100% RQD=94% UCS=61MPa (Average)
313.2			3	RUN						0	RUN #3 ~~TCR=100%~~ SCR=100% RQD=100%
13.2	END OF BOREHOLE AT 13.2m. WATER LEVEL AT 4.2m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Aug. 01/13 5.7 320.7 May 02/14 5.3 321.1										

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SBC1-04 1 OF 2 METRIC

WP# 6073-09-00 LOCATION Strawberry Creek Bridge 1 N 5 377 543.6 E 337 424.6 ORIGINATED BY ES
HWY 102 BOREHOLE TYPE NW Casing COMPILED BY AN
DATUM Geodetic DATE 2013.07.10 - 2013.07.10 CHECKED BY MC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
326.7	GROUND SURFACE										
0.0	**ASPHALT:** (125mm)										
0.1	**SAND** and **GRAVEL**, trace to some silt, occasional cobbles Very dense Brown (FILL)		1	SS	52		326		○		
			2	SS	59		325		○		
			3	SS	48		324		○		49 45 6 (SI+CL)
323.1			4	SS	14				○		
3.6	Clayey **SAND**, some gravel and silt Compact Brown (FILL)						323				13 46 17 24
322.1											
4.6	**SAND** and **GRAVEL**, trace silt, occasional cobbles Compact to Very Dense Brown Wet		5	SS	19	▽	322		○		
	No recovery		6	SS	22		321				
			7	SS	24		320				
			8	SS	65		319		○		43 51 6 (SI+CL)
317.0							318				
9.7	END OF BOREHOLE AT 9.7m. WATER LEVEL AT 5.1m UPON						317				

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SBC1-04 2 OF 2 METRIC

WP# 6073-09-00 LOCATION Strawberry Creek Bridge 1 N 5 377 543.6 E 337 424.6 ORIGINATED BY ES

HWY 102 BOREHOLE TYPE NW Casing COMPILED BY AN

DATUM Geodetic DATE 2013.07.10 - 2013.07.10 CHECKED BY MC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.15m THEN ASPHALT TO SURFACE										

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

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

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Appendix B

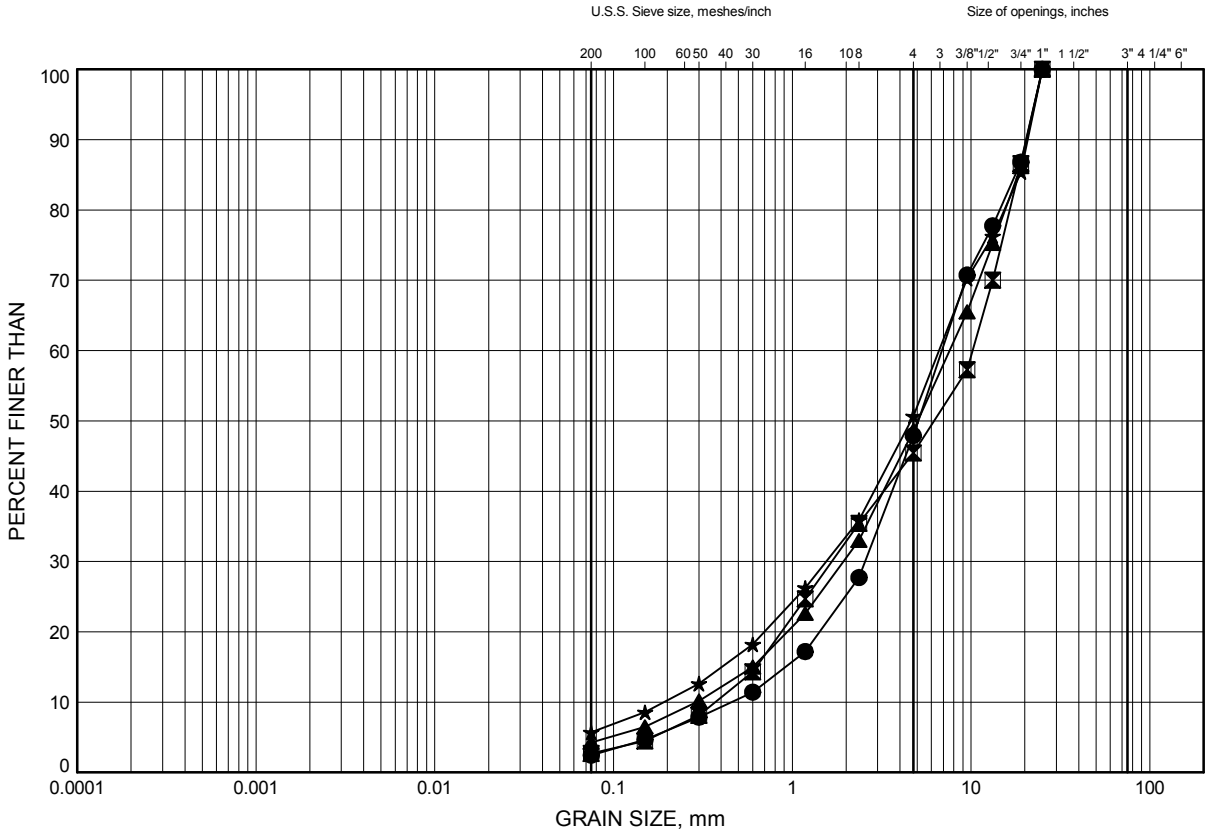
Laboratory Test Results

Strawberry Creek Bridge 1

GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND & GRAVEL FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SBC1-01	1.07	323.53
⊠	SBC1-02	2.59	322.31
▲	SBC1-03	1.83	324.57
★	SBC1-04	2.59	324.11

Date September 2014

WP# 6073-09-00

THURBER

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Chkd. MEF

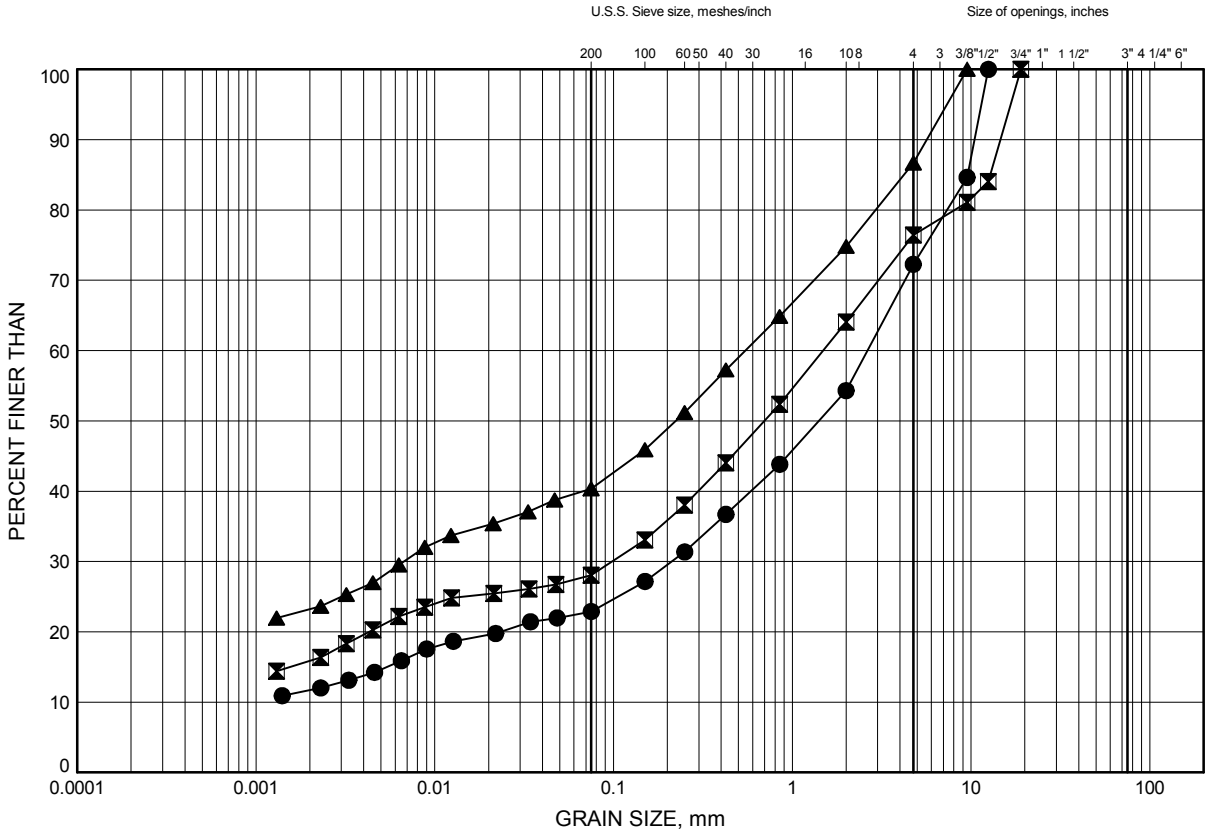
GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 9/25/14

Strawberry Creek Bridge 1

GRAIN SIZE DISTRIBUTION

FIGURE B2

GRAVELLY SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SBC1-01	3.35	321.25
⊠	SBC1-02	7.92	316.98
▲	SBC1-04	3.60	323.10

Date September 2014

WP# 6073-09-00

THURBER

Prep'd AN

Chkd. MEF

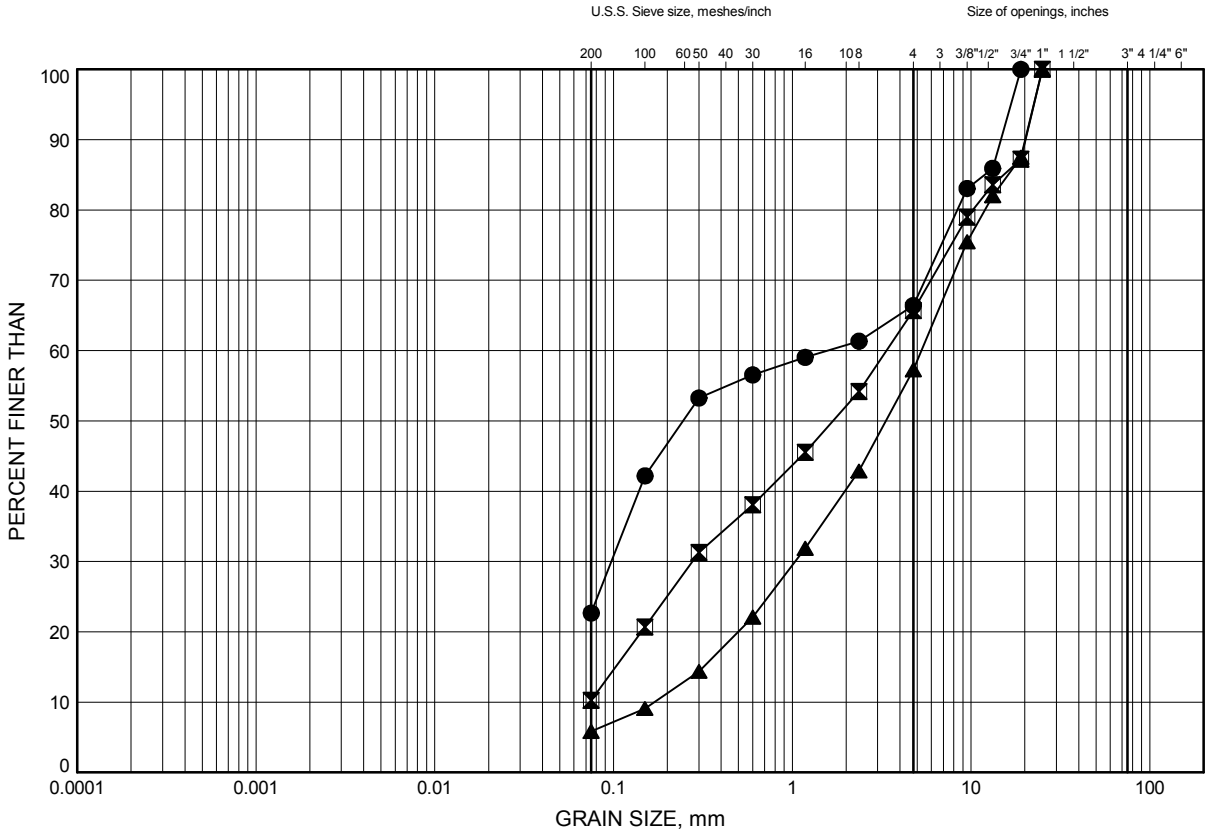
GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 9/25/14

Strawberry Creek Bridge 1

GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND & GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SBC1-01	7.70	316.90
⊠	SBC1-03	9.35	317.05
▲	SBC1-04	7.92	318.78

Date September 2014

WP# 6073-09-00

THURBER

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Chkd. MEF

GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 9/25/14

Appendix C

Site Photographs

Photograph 1 – East approach, looking west

Photograph 2 – East end of bridge, looking north

Photograph 3 – East Abutment

Photograph 4 – North Elevation, looking west

Appendix D

List of SPs and OPSS, and Suggested Text for Selected NSSP

1. List of Special Provisions and OPSS Documents Referenced in this Report

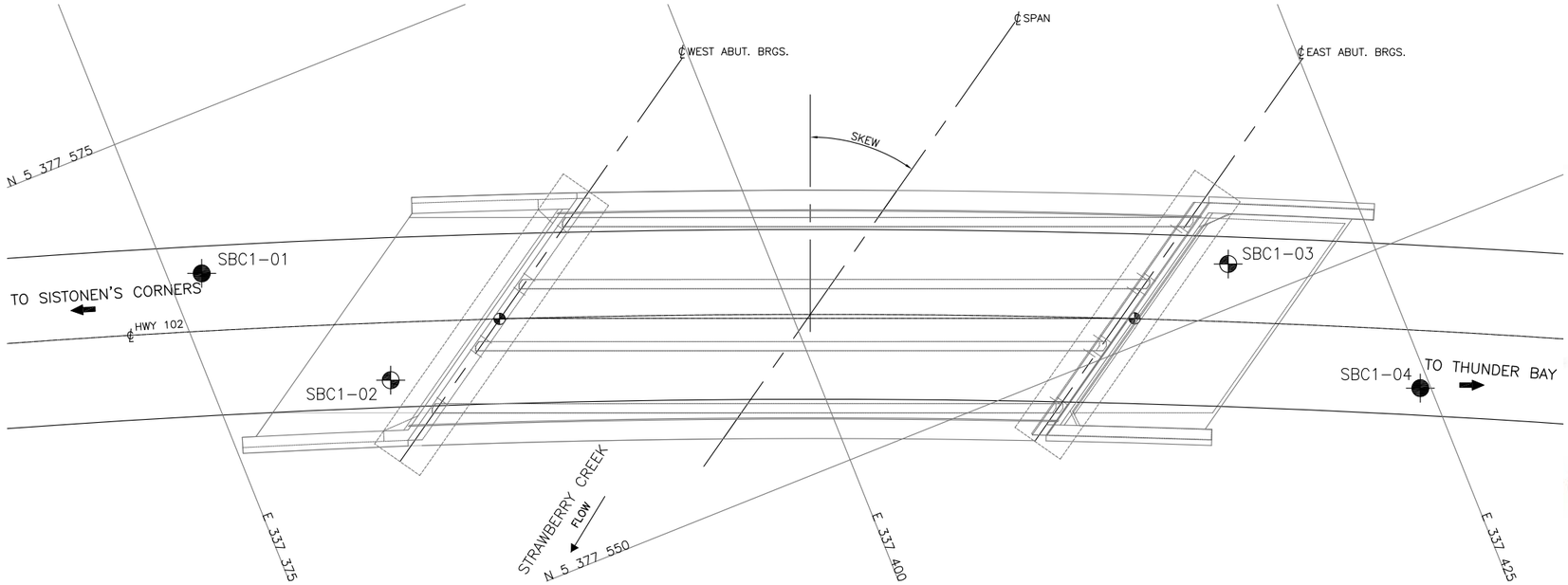
- OPSS 501
- OPSS 539
- OPSS 804
- OPSS 902
- OPSS.PROV 1010

2. Suggested text for NSSP on "Installation of Roadway Protection System"

Cobbles and possible boulders are present within the existing embankment fill and underlying native soils at this site. These cobbles and boulders may impede the installation of the roadway protection system. At some locations, the installation may not be able to penetrate the obstructions and reach the design depth. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions and extend the protection system to the design depth.

Appendix E

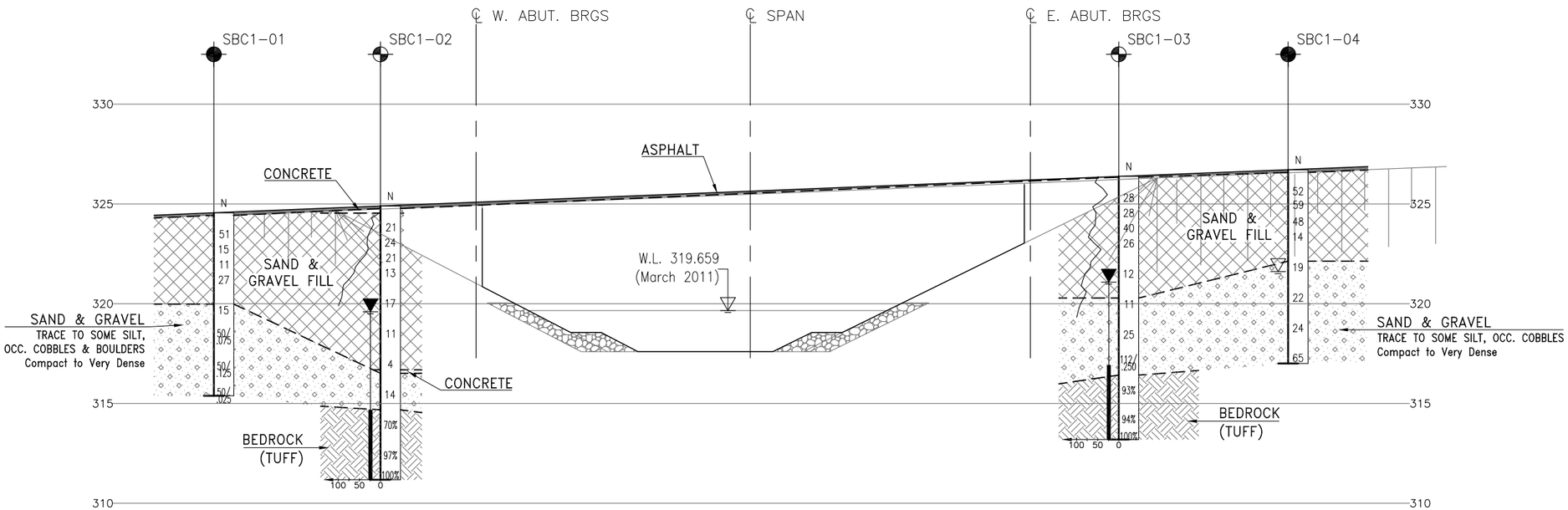
Borehole Locations and Soil Strata Drawing



PLAN

5 0 5 10m

SCALE 1:250



PROFILE ALONG ℄ HWY. 102

5 0 5 10m

SCALE 1:250

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
M. R. ANDERSON
Oct 22/14
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Oct 22/14
PROVINCE OF ONTARIO

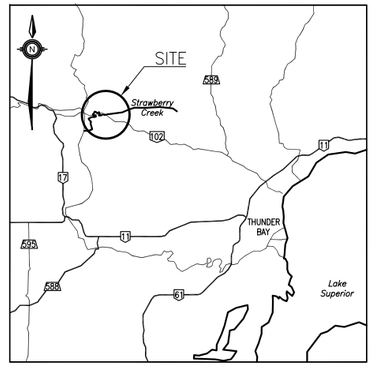
CONT No
WP No 6073-09-00

HIGHWAY 102
STRAWBERRY CREEK BRIDGE 1 REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 66

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
SBC1-01	324.6	5 377 568.3	337 376.5
SBC1-02	324.9	5 377 560.8	337 382.5
SBC1-03	326.4	5 377 551.8	337 418.7
SBC1-04	326.7	5 377 543.6	337 424.6

-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-185

REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN MEF	CHK PKC	CODE	LOAD DATE OCT 2014
DRAWN MFA	CHK MEF	SITE 48W-1	STRUCT DWG 1

FILENAME: H:\Drafting\19\135\197\Strawberry Creek\ted197-StrawberryCreek1.dwg
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