

**FOUNDATION INVESTIGATION AND DESIGN REPORT
MAKAMI RIVER BRIDGE WIDENING**

**Highway 144, Site No.: 46N-228
G.W.P. 123-88-00, W.P. 123-88-02
District 53, New Liskeard**

Geocres Number: 41P-45

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 site of a proposed bridge widening north west of Gogama, Ontario. The existing structure carries Highway 144 over the Makami River.

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, records of boreholes, 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 McCormick Rankin Corporation, under the Ministry of Transportation Ontario (MTO) Agreement Number 5007-E-0066.

2. SITE DESCRIPTION

The site of the investigation is the crossing of Highway 144 over the Makami River, approximately 3 km north west of Gogama, Ontario and 0.5 km west of Highway 661. At present, the highway crosses the Makami River on a three- span structure with two piers supported on piles.

At the site, the river channel is approximately 30 m wide. The surrounding area is relatively flat and heavily treed, as illustrated in Photo 1 in Appendix E, and there is no development in the immediate vicinity of the bridge. Photo 2 in Appendix E shows the existing bridge viewed from the upstream, east side.

Physiographically, the site lies within the Canadian Shield, characterized by Pre-Cambrian igneous and metamorphic bedrock. Locally, however, the bedrock is mantled by deposits of sand and gravel.

3. SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project was carried out between March 23 and March 27, 2010. A total of seven boreholes numbered 10-01, 10-01A, 10-02, 10-02A, 10-03, 10-03A and 10-04, were advanced to depths ranging from 10.2 m to 13.8 m below the existing highway grade.

Boreholes 10-01, 10-01A and 10-04 were drilled behind the existing west and east abutments, respectively. Boreholes 10-02, 10-02A, 10-03 and 10-03A were drilled at the piers in order to investigate the foundation soils underlying the proposed deck widening to the north. The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

The drilling was carried out from the highway using a CME75 truck-mounted drill rig with hollow stem augers and HW casing/NQ coring equipment. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the overburden soils.

Boreholes 10-01, 10-01A and 10-04 were drilled through the embankment fill and the native soils to a depth between 7.3 m and 10.7 m where granitic bedrock was encountered.

Boreholes 10-02, 10-02A, 10-03 and 10-03A were drilled through the bridge deck and into the native soils to a depth between 8.9 m and 10.1 m below the bridge deck where granitic bedrock was encountered.

All seven boreholes were advanced approximately 3 m into bedrock by NQ size diamond coring techniques.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Standpipe piezometers consisting of 19 mm PVC pipe with a slotted screen were installed in boreholes 10-01 and 10-04. The locations and completion details of the piezometers are shown in Table 3.1. The boreholes in which no piezometers were installed were grouted with bentonite. Grouting was carried out in general accordance with the requirements of MOE Reg. 903 (as amended by Reg. 372/07). The borehole completion details are shown in Table 3.1.

Table 3.1 – Borehole Completion Details

Location	Details	
	Piezometer Tip Depth/ Elevation (m)	Completion Details
10-01	7.6/345.5	Bentonite seal from 10.7 m to 7.6 m, Piezometer with 1.5 m slotted screen installed with sand filter to 5.7 m, bentonite seal from 5.7 m to 0.1 m. Flushmount cover installed.
10-01A	None installed	Backfilled with bentonite to 0.2 m. Asphalt from 0.2 m to surface.
10-02	None installed	Backfilled with bentonite to 5.8 m. Bridge deck filled with 0.3 m of concrete.
10-02A	None installed	Backfilled with bentonite to 5.5 m. Bridge deck filled with 0.3 m of concrete.
10-03	None installed	Backfilled with bentonite to 5.2 m. Bridge deck filled with 0.3 m of concrete.
10-03A	None installed	Backfilled with bentonite to 5.8 m. Bridge deck filled with 0.3 m of concrete.
10-04	10.7/342.3	Bentonite seal from 13.6 m to 10.7 m, Piezometer with 1.5 m slotted screen installed with sand filter to 8.7 m, bentonite seal from 8.7 m to 0.1 m. Asphalt from 0.1 m to surface. Flushmount cover installed.

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.

All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

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 in Appendix A. Selected samples were also subjected to gradation analysis and the results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the figures contained in Appendix B. Point load testing was conducted on selected portions of the rock cores. Uniaxial compressive strength (UCS) of the cores was assessed from the point load test results. The assessed UCS values are shown on the borehole logs and in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil and rock stratigraphy are presented in this Appendix and on the "Borehole Locations and Soil Strata" drawing in Appendix D. Soil stratigraphy along the existing bridge alignment from the boreholes drilled in 1964 is presented in Appendix F. 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 stratigraphy encountered in the three boreholes drilled through the highway consisted of pavement over gravelly sand fill, overlying native gravelly sand and sandy gravel. The overburden soils are underlain by granite bedrock.

The stratigraphy encountered in the boreholes drilled through the bridge deck consisted of native gravelly sand and sandy gravel overlying granitic bedrock.

5.1 Asphalt

At boreholes 10-01, 10-01A and 10-04, 100 mm of asphalt was encountered at the surface. The asphalt thickness may vary in other areas of the site.

5.2 Fill

In boreholes 10-01, 10-01A and 10-04, the asphalt is underlain by 3.6 m to 5.4 m of sand fill. The fill has SPT values generally ranging from 12 to 29 blows for 0.3 m penetration, indicating compact conditions. Occasional values of 8 and 32 blows for 0.3 m penetration indicate loose or dense layers, respectively. The fill is described as sand, trace gravel to gravelly, trace silt and clay, brown and dry to moist, with moisture contents ranging from 1% to 9%.

The underside of the fill lies at a depth of 3.7 m (Elevation 349.3) near the east abutment and 4.6 m to 5.5 m (Elevation 348.5 to 347.6) near the west abutment.

The gradations of the fill in the embankment are shown in Appendix B. The results of laboratory tests carried out are summarized below:

Soil Particles	(%)
Gravel	17 to 27
Sand	67 to 74
Silt & Clay	5 to 9

5.3 Gravelly Sand

A layer of gravelly sand with cobbles and boulders was encountered below the riverbed in boreholes 10-02, 10-02A, 10-03, 10-03A and below the fill in borehole 10-04. The sand is described as gravelly, trace silt, occasional cobbles and boulders, brown and wet and with moisture contents ranging from 9% to 19%.

The SPT values recorded range from 4 to 86 blows for 0.3 m penetration, indicating loose to very dense conditions.

The underside of the gravelly sand layer lies at a depth of 0.8 m to 2.9 m below the riverbed (Elevation 344.7 to 346.4) and 7.2 m below the highway grade (Elevation 345.8).

The gradations of the fill in the embankment are shown in Appendix B. The results of laboratory tests carried out are summarized below:

Soil Particles	(%)
Gravel	3 to 40
Sand	56 to 95
Silt & Clay	1 to 7

5.4 Sandy Gravel

Underlying the highway embankment fill and the gravelly sand layer, a layer of sandy gravel was encountered in all boreholes. This layer is present just above the bedrock. The thickness of the layer ranges from 1.0 m to 3.5 m with underside elevations ranging from 342.3 to 345.8. The sandy gravel contains trace silt and some cobbles and boulders and is brown and wet, with measured moisture content between 2% to 18%.

SPT values recorded in the sand and gravel deposit ranged from 74 to greater than 50 blows for 0.03 m penetration, indicating very dense conditions.

The gradations of the sandy gravel deposit are shown in Appendix B. The results of laboratory tests carried out are summarized below:

Soil Particles	(%)
Gravel	46 to 60
Sand	34 to 48
Silt & Clay	6 to 7

5.5 Bedrock

The overburden soils described above are underlain by granitic bedrock which was proved by coring at all boreholes. Table 5.1 summarizes the bedrock depth and the elevations to the top of bedrock.

Table 5.1 – Depth to Bedrock at Borehole Locations

Location	Depth to Bedrock (m)	Top of Bedrock Elevation
BH 10-01	7.6	345.5
BH 10-01A	7.3	345.8
BH 10-02	9.6	343.5
BH 10-02A	9.4	343.6
BH 10-03	10.1	342.9
BH 10-03A	8.9	344.1
BH 10-04	10.7	342.3

Total core recovery in the bedrock was 90 to 100% in all boreholes except for borehole 10-02 RUN #1 where a total core recovery of 47% was observed. Solid core recovery was 58 to 100% except for borehole 10-02 RUN #1 where a solid core recovery of 23% was noted. The RQD was 58 to 100% indicating fair to excellent rock quality except for borehole 10-02 RUN #1 where an RQD of 0% was observed. Point load tests are summarized in Appendix B. The UCS values assessed from the point load tests range from 128 to 264 MPa indicating a very strong rock.

5.6 Water Levels

Standpipe piezometers were installed in boreholes 10-01 and 10-04. Water levels were measured for the duration of the site work. The water level readings from the piezometers are presented in Table 5.2.

Based on these observations, local groundwater levels exist at Elevations 348.0 to 348.2, which is in good agreement with the river elevation of 348.1 at the time of the investigation. All groundwater observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events and will be strongly influenced by the river level.

Table 5.2: Water Level Measurements

Date	BH 10-01 West Abutment	BH 10-04 East Abutment
	Depth/ Elev. (m)	Depth/ Elev. (m)
March 24, 2010	4.9/348.2	-
March 25, 2010	4.9/348.2	-
March 26, 2010	5.0/348.1	4.9/348.0
March 27, 2010	5.0/348.1	4.9/348.0

6. MISCELLANEOUS

Eastern Ontario Diamond Drilling Limited of Hawkesbury, Ontario supplied the drill rig and conducted the drilling, sampling and in-situ testing operations. A truck-mounted CME #75 drill rig was used for the duration of the investigation.

The drilling and sampling operations in the field were supervised on a full time basis by Mr. George Azzopardi of Thurber.

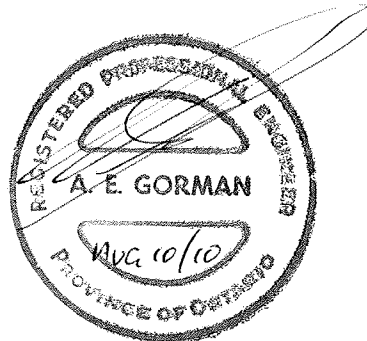
Mr. Alastair E. Gorman, P.Eng. directed the field operations and Mr. Lukasz Gilarski, Project Manager, prepared the report.

Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects, reviewed the report.

THURBER ENGINEERING LTD.



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Project Manager



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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 presents geotechnical design recommendations to assist the design team to select and design a suitable foundation system for the proposed structure widening.

At present, Highway 144 crosses the Makami River on a 38 m long three-span structure, supported on abutments and 2 piers. The preliminary GA drawing from MMM Group Limited shows that this structure will be widened 2.4 m to the north.

The grade of Highway 144 is at approximately Elevation 353.2 m and no grade raise is anticipated in the final design. The river level lies at approximately Elevation 348.1 m (March, 2010). The existing approach fills are 3.7 m high at the east abutment and up to 5.5 m high at the west abutment.

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

8. STRUCTURE FOUNDATIONS

The stratigraphy encountered in the four boreholes drilled at the existing bridge consists of a pavement structure overlying a 3.7 to 5.5 m high sand fill approach embankment that, in turn, overlies dense native sand and gravel deposits. Granitic bedrock was encountered at depths ranging between 7.3 and 10.7 m sloping towards the east.

In view of the fact that a structure widening is contemplated and the existing structure is supported on piles, consideration for the widening of the existing foundation was limited to driven H-piles.

8.1 Driven Steel Piles

The ground conditions at the site are considered to be suitable for the support of foundations on steel H-piles driven to refusal in the bedrock.

The anticipated pile lengths and tip elevations are shown in Table 8.1. HP 310 X 110 piles have been assumed, to match the existing.

Table 8.1 – Estimated Pile Lengths for Driven Piles

Location	Borehole No.	Estimated Pile Tip Elevation	Estimated Length of Pile (m)
West Abutment	10-01A	345.8	4.2
West Pier	10-02A	343.6	7.4
East Pier	10-03A	344.1	6.9
East Abutment	10-04	342.3	7.6

Piles lengths are approximate and taken from the pier cap.

8.1.1 Axial Geotechnical Resistance

Foundations supported on HP 310 X 110 steel piles driven to bedrock may be designed on the basis of the permitted structural resistance of $ULS_f = 2,000$ kN.

The SLS condition will not govern for piles founded on bedrock.

The structural resistance of the pile must be checked by the structural designer.

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

8.1.2 Downdrag

Downdrag on the piles is not considered to be an issue at this site.

8.1.3 Pile Tips

The tips of all driven piles must be fitted with cast steel, H-section rock points from an approved manufacturer such as Titus Steel (Standard H-point) or APF Hard Bite or approved equivalent.

8.1.4 Pile Installation

Pile installation must be in accordance with OPSS 903, November 2009.

8.1.5 Pile Driving

The piles at this site must be founded on bedrock.

The appropriate pile driving note is “Piles to be driven to bedrock”.

8.2 Impact on Existing Foundations

The existing piles are assumed to be driven to bedrock, or at least into very dense, cohesionless overburden.

The risk to the existing structure from driving the new piles is considered to be low. However, it is recommended that the structural designer select appropriate points on the existing structure and specify a monitoring program to continue at least for the duration of pile driving.

8.3 Pile Lateral Resistance

Since the existing structure is supported on battered piles, it is recommended that the widening incorporate battered piles to resist the horizontal loads in the structure.

8.4 Recommended Foundation

From a geotechnical perspective, the recommended foundation system for this structure is steel H-piles driven to bedrock.

8.5 Abutment Considerations

On the basis of the geotechnical conditions at the site, an integral, semi-integral or conventional abutment could be designed.

However, the preliminary GA indicates that the structure will be converted from conventional to semi-integral abutments.

8.6 Frost Cover

The design depth of frost penetration at this site is 2.3 m.

It would normally be recommended that pile caps be provided with a minimum of 2.3 m of earth cover above the base of the concrete. In this instance, it is recommended that the widening be designed to match the existing conditions.

New fill placed for the widening must be free-draining, granular material.

9. EXCAVATION AND BACKFILL

9.1 General

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA) and in accordance with OPSS 902, November 2009. For the purposes of the OHSA, the native soils and the fill in the existing approach embankments at this site may be classified as Type 3 soils. Excavation below the groundwater level is not recommended without prior dewatering. Provided dewatering is carried out as described below, temporary excavations may be sloped at 1H:1V.

9.2 Foundations

The excavation and backfilling for foundations must be carried out in accordance with OPSS 902, November 2009.

9.3 Abutments

Backfill to the abutment must be granular material placed to the extents shown in OPSD 3101.150.

The backfill to the abutment walls must be in accordance with OPSS 902, November 2009. All granular material should meet the requirements of SP 110S13 Amendment to OPSS 1010, April 2004.

Compaction equipment to be used adjacent to the abutment walls must be restricted in accordance with SSP 105S10.

The design of the abutment must incorporate a subdrain as shown in OPSD 3101.150 or OPSD 3101.200, as applicable.

10. GROUNDWATER AND SURFACE WATER CONTROL

Based on the preliminary GA, it will not be necessary for any excavation to be carried out below the groundwater level, or in the river.

On that basis, no groundwater control will be required, but steps should be taken to divert surface runoff away from the excavations.

Similarly, it is not anticipated that there will be any requirement for the Permit to Take Water.

11. STRUCTURE APPROACHES

The existing approach embankments will be widened to the north by approximately 2.4 m. The GA Drawing indicates that there will not be any grade raise at the bridge approaches. Accordingly, work on the structure approaches will be limited to a 2.4 m widening to the north.

The existing embankment consists of gravelly sand and the material used for the widening must be of similar composition.

A maximum settlement in the order of 25 mm is anticipated in the foundation soils under the embankment widening. This settlement will be essentially completed by the end of construction of the embankment widening.

The north side of the existing embankment must be benched in accordance with OPSD 208.010 prior to placement of the new fill.

Disturbed or regraded earth slopes must be provided with erosion protection in accordance with OPSS 572, November 2003.

12. ROADWAY PROTECTION

Roadway protection will be required to facilitate staging of removals and new construction at this site. Sheet-piles or soldier pile & lagging walls are considered appropriate for roadway protection at this site. The contract should select the wall type and design taking into account the earth pressure parameters given in Section 13 of this report.

The temporary excavation support system should be designed and constructed in accordance with OPSS 539, November 2009. In general, the lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS 539, November 2009.

13. EARTH PRESSURE

For cases where backfill to the abutment is placed in accordance with OPSD 3101.150 or OPSD 3101.200, as recommended, the lateral earth pressure will be governed by the properties of the material within the backfill limits shown in the respective OPSD, i.e. a line projected up at 1.5H:1V for granular backfill and 1.25H:1V for rock backfill.

If the support system allows lateral yielding of the wall (unrestrained system), active horizontal earth pressure may be used in the geotechnical design of the structure. If the support system does not allow lateral yielding (restrained system), at-rest horizontal earth pressures should be used.

Earth pressure acting on the structure may be assumed to be triangular and to be governed by the characteristics of the abutment backfill.

For fully drained conditions, earth pressures acting on the structure should be computed in accordance with Clause 6.9 of the CHBDC but generally are given by the expression:

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

P_h = horizontal pressure on the wall at depth h (kPa)

K = earth pressure coefficient (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)

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 at a depth of 1.7 m for Granular A or Granular B Type II.

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.

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) would result in lower earth pressures acting on the wall. In the case of integral or semi-integral abutments, material with a lower passive pressure

coefficient (e.g. Granular B Type I) would result in lower forces acting on the ballast wall as the wall moves toward the soil mass. However, the use of Granular “B” Type I may be restricted if the approach embankment consists of rock fill.

The coefficients in the Table 13.1 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 C6.9.1 (a) in the Commentary to the CHBDC, 2006.

Table 13.1 – Earth Pressure Coefficients

Wall Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ$; $\gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ$; $\gamma = 21.2 \text{ kN/m}^3$		Rock Fill $\phi = 42^\circ$; $\gamma = 19.0 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (Unrestrained Wall)	0.27	0.40*	0.31	0.48*	0.20	0.28*
At rest (Restrained Wall)	0.43	-	0.47	-	0.33	-
Passive (Movement Towards Soil Mass)	3.70	-	3.30	-	5.0	-

* For wing walls.

14. SEISMIC CONSIDERATIONS

14.1 Seismic Design Parameters

The bridge is located in an area where the overburden is underlain by Pre-Cambrian rocks of very low activity.

Therefore the following seismic parameters apply to this site:

- Velocity Related Seismic Zone 0
- Zonal Velocity Ratio 0.05
- Acceleration Related Seismic Zone 1.0
- Zonal Acceleration Ratio 0.05

14.2 Liquefaction Potential

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.

As the structure is supported on steel piles, the foundation loads will be transferred by the steel piles to bedrock. It is not considered likely that the vertical geotechnical resistance of the piles will be compromised due to seismic loading.

The embankments themselves will be constructed above the groundwater level and are not considered to be in danger of undergoing liquefaction.

14.3 Retaining Wall Dynamic Earth Pressures

In accordance with Clause 4.6.4 of the CHBDC, retaining structures should be designed using active (KAE) and passive (KPE) earth pressure coefficients that incorporate the effects of earthquake loading.

For the design of retaining walls, the coefficient of horizontal earth pressure in Table 14.1 may be used.

Table 14.1 – Earth Pressure Coefficient (K) for the Earthquake Loading

Wall Condition	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ; \gamma = 22.8$ kN/m ³		OPSS Granular B Type I $\phi = 32^\circ; \gamma = 21.2$ kN/m ³	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (Unrestrained Wall)	0.28	0.42*	0.32	0.5*
At rest (Restrained Wall)	0.43	-	0.47	-
Passive (Movement Towards Soil Mass)	3.54	-	3.12	-

* For wing walls.

15. CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to the issues discussed below.

Installation of Foundation Piles

Due to the presence of cobbles and boulders in the soils at this site, it is possible that there may be some difficulty in driving the piles to bedrock. It is important that the founding elevations of the piles be monitored closely and any significant deviation from the predicted elevation must be reported to the design team for comment. "Significant" in this instance can be taken as 0.5 m.

Installation of Sheet Piles

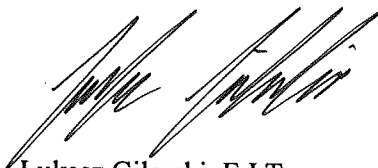
If sheet piling is used for roadway protection, installation into the very dense native soil below the embankment fill may be difficult due to the presence of occasional cobbles and boulders. Fills may also contain other obstructions that may impact sheet pile installation. Under these circumstances, contractors must allow for the possibility of pre-drilling in some locations.

16. CLOSURE

Engineering analysis and preparation of the report were carried out by Mr. Lukasz Gilarski, E.I.T., Project Manager and Mr. Alastair E. Gorman, P.Eng.

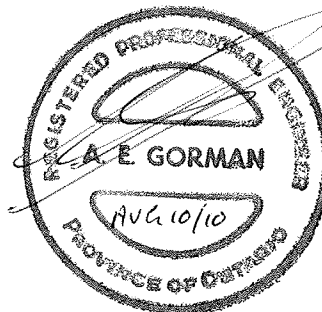
The report was reviewed by Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundations Projects.

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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

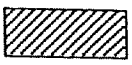




C_{pen} Shear Strength Determination by Pocket Penetrometer

- (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.

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			

EXPLANATION OF ROCK LOGGING TERMS

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

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	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

<u>TERMS</u>	
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 percentage 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.

RECORD OF BOREHOLE No 10-01

1 OF 2

METRIC

G.W.P. 123-88-00 LOCATION N 5 285 258.4 E 249 407.9 ORIGINATED BY GA
 HWY 144 - Bridge at Makami River BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM GEODETIC DATE 2010-03-23 - 2010-03-23 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						WATER CONTENT (%) PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _p w w _L			
353.1								20	40	60	80	100					
0.0	ASPHALT																
0.1	SAND, gravelly, occasional cobbles Loose to Dense Brown Dry (FILL)		1	SS	22												
			2	SS	24												
			3	SS	32												
			4	SS	8												
			5	SS	29												
			6	SS	12												
347.6																	
5.5	Sandy GRAVEL, some cobbles and boulders, trace silt Very Dense Brown Wet		7	SS	74												
345.5																	
7.6	GRANITE, slightly weathered to fresh, coarse grained, very strong, occasional mechanical breaks Start coring at 7.6m Highly broken zone at 7.8m		1	RUN													
			2	RUN													

Continued Next Page

+ 3 . X 3 : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

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RUN 1#
TCR=100%,
SCR=95%,
RQD=83%,
UCS=232MPa

RUN 2#

RECORD OF BOREHOLE No 10-01

2 OF 2

METRIC

G.W.P. 123-88-00 LOCATION N 5 285 258.4 E 249 407.9 ORIGINATED BY GA
 HWY 144 - Bridge at Makami River BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM GEODETIC DATE 2010-03-23 - 2010-03-23 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page							20	40	60	80	100					GR SA SI CL
	125mm sub-vertical joints at 10.0m						343										TCR=90%, SCR=90%, RQD=90%, UCS=214MPa
342.5																	
10.7	END OF BOREHOLE AT 10.7m. BOREHOLE OPEN TO 10.7m AND WATER LEVEL AT 5.2m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 24/03/2010 4.9 348.2 25/03/2010 4.9 348.2 26/03/2010 5.0 348.1 27/03/2010 5.0 348.1																

ONTMT4S 1154.GPJ 10/5/27

RECORD OF BOREHOLE No 10-01A

1 OF 2

METRIC

G.W.P. 123-88-00 LOCATION N 5 285 257.9 E 249 414.2 ORIGINATED BY GA
 HWY 144 - Bridge at Makami River BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
 DATUM GEODETIC DATE 2010-03-26 - 2010-03-26 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
353.1								20 40 60 80 100						
0.0	ASPHALT							20 40 60 80 100						
0.1	SAND, some gravel, trace silt and clay Compact Brown Dry (FILL)		1	SS	29		353							
			2	SS	22		352							
			3	SS	14		351							17 74 9 (SI+CL)
			4	SS	17		350							
			5	SS	29		349							
348.5							348							
4.6	Sandy GRAVEL, some cobbles and boulders, trace silt Very Dense Brown Wet		6	SS	50/ 0.150		347							46 48 6 (SI+CL)
			7	SS	50/ 0.150		346							
345.8							345							
7.3	GRANITE, slightly weathered to fresh, coarse grained, very strong Start coring at 7.3m 125mm highly broken zone at 7.8m		1	RUN			344							
			2	RUN										

Continued Next Page

+³ ×³: Numbers refer to Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RUN 1#
TCR=100%,
SCR=76%,
RQD=72%,
UCS=137MPa

 RUN 2#
TCR=100%,
SCR=100%,
RQD=100%,
UCS=183MPa

RECORD OF BOREHOLE No 10-01A

2 OF 2

METRIC

G.W.P. 123-88-00 LOCATION N 5 285 257.9 E 249 414.2 ORIGINATED BY GA
 HWY 144 - Bridge at Makami River BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
 DATUM GEODETIC DATE 2010-03-26 - 2010-03-26 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE									
	Continued From Previous Page							20	40	60	80	100					
342.9							343										
10.2	END OF BOREHOLE AT 10.2m. BOREHOLE OPEN TO 10.2m AND WATER LEVEL AT 4.7m. BOREHOLE BACKFILLED WITH HOLEPLUG TO 0.2m, THEN ASPHALT TO SURFACE.																

ONTMT4S 1154.GPJ 10/5/27

+ 3 . X 3 : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10-02

1 OF 2

METRIC

G.W.P. 123-88-00 LOCATION N 5 285 242.1 E 249 417.9 ORIGINATED BY GA
 HWY 144 - Bridge at Makami River BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
 DATUM GEODETTIC DATE 2010-03-24 - 2010-03-24 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)			
353.1							20 40 60 80 100	○ UNCONFINED + FIELD VANE	W _P W W _L				GR SA SI CL
0.0 352.8	CONCRETE (Bridge Deck)						20 40 60 80 100	● QUICK TRIAXIAL x LAB VANE					
0.3	AIR												
348.3													
4.8	WATER												
347.3													
5.8	Gravelly SAND, trace silt, occasional cobbles and boulders Very Dense Brown Wet		1	SS	66					○			34 61 5 (SI+CL)
346.4													
6.6	Sandy GRAVEL, some cobbles and boulders, trace silt Very Dense Brown Wet		2	SS	50/ 0.025								
			3	SS	50/ 0.00								
343.5			4	SS	50/ 0.100					○			
9.6	GRANITE, fresh, coarse grained, very strong, occasional mechanical breaks											FI 4	

Continued Next Page

+ 3 x 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10-02

2 OF 2

METRIC

G.W.P. 123-88-00 LOCATION N 5 285 242.1 E 249 417.9 ORIGINATED BY GA
 HWY 144 - Bridge at Makami River BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
 DATUM GEODETIC DATE 2010-03-24 - 2010-03-24 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								20 40 60 80 100										20 40 60		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE												
	Continued From Previous Page		1	RUN			343								2	RUN 1# TCR=47%, SCR=23%, RQD=0%, UCS=145MPa				
	Start coring at 9.6m		2	RUN			342								0					
			3	RUN			341								0					
339.8							340								0	RUN 2# TCR=100%, SCR=100%, RQD=100%, UCS=187MPa				
13.3	END OF BOREHOLE AT 13.3m. BOREHOLE OPEN TO 13.3m AND WATER LEVEL AT 4.8m. BOREHOLE BACKFILLED WITH GROUT TO 5.8m, THEN 0.3m OF CONCRETE FOR BRIDGE DECK.														0	RUN 3# TCR=100%, SCR=100%, RQD=100%, UCS=256MPa				

+ 3. × 3. Numbers refer to
Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10-02A

2 OF 2

METRIC

G.W.P. 123-88-00 LOCATION N 5 285 241.4 E 249 423.3 ORIGINATED BY GA
 HWY 144 - Bridge at Makami River BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
 DATUM GEODETIC DATE 2010-03-26 - 2010-03-26 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
	Continued From Previous Page							20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
			1	RUN			343							0	RUN 1# TCR=100%, SCR=58%, RQD=58%, UCS=255MPa
			2	RUN			342							0	RUN 2# TCR=100%, SCR=100%, RQD=100%, UCS=247MPa
340.9							341							0	
12.2	END OF BOREHOLE AT 12.2m. BOREHOLE OPEN TO 12.2m AND WATER LEVEL AT 4.8m. BOREHOLE BACKFILLED WITH GROUT TO 4.8m, THEN 0.3m OF CONCRETE FOR BRIDGE DECK.														

ONTMT4S 1154.GPJ 10/5/27

METRIC

DATUM GEODETIC DATE 2010-03-24 - 2010-03-24 CHECKED BY LPG

Continued Next Page

(%) STRAIN AT FAILURE


ONTMT4S 1154.GPJ 10/5/27

RECORD OF BOREHOLE No 10-03

2 OF 2

METRIC

G.W.P. 123-88-00 LOCATION N 5 285 228.8 E 249 425.3 ORIGINATED BY GA
 HWY 144 - Bridge at Makami River BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
 DATUM GEODETIC DATE 2010-03-24 - 2010-03-24 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								20 40 60 80 100								
Continued From Previous Page							20 40 60 80 100				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _P W W _L WATER CONTENT (%)					
342.9																
10.1	GRANITE, fresh, coarse grained, very strong, occasional mechanical breaks Start coring at 10.1m Highly broken zone at 10.1m (150mm)		1	RUN			343							5	RUN 1# TCR=100%, SCR=90%, RQD=90%, UCS=222MPa	
								342								0
																0
					2	RUN			341							0
																0
									340							0
339.2			3	RUN										0	RUN 2# TCR=100%, SCR=100%, RQD=100%, UCS=261MPa	
13.8	END OF BOREHOLE AT 13.8m. BOREHOLE OPEN TO 13.8m AND WATER LEVEL AT 4.9m. BOREHOLE BACKFILLED WITH GROUT TO 5.2m, THEN 0.3m OF CONCRETE FOR BRIDGE DECK.													0	RUN 3# TCR=100%, SCR=100%, RQD=100%, UCS=264MPa	

RECORD OF BOREHOLE No 10-03A

2 OF 2

METRIC

G.W.P. 123-88-00 LOCATION N 5 285 231.9 E 249 428.7 ORIGINATED BY GA
 HWY 144 - Bridge at Makami River BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
 DATUM GEODETIC DATE 2010-03-27 - 2010-03-27 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page							20	40	60	80	100					
	50mm highly broken zone at 10.0m						343										GR SA SI CL
																	UCS=229MPa
			2	RUN			342										RUN 2#
																	TCR=100%,
																	SCR=100%,
																	RQD=100%,
																	UCS=215MPa
341.1																	
11.9	END OF BOREHOLE AT 11.9m. BOREHOLE OPEN TO 11.9m AND WATER LEVEL AT 4.9m. BOREHOLE BACKFILLED WITH GROUT TO 5.8m, THEN 0.3m OF CONCRETE FOR BRIDGE DECK.																

+³. X³: Numbers refer to
Sensitivity




20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10-04

1 OF 2

METRIC

G.W.P. 123-88-00 LOCATION N 5 285 215.9 E 249 437.6 ORIGINATED BY GA
 HWY 144 - Bridge at Makami River BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM GEODETIC DATE 2010-03-25 - 2010-03-25 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	W _P W W _L	20 40 60	GR SA SI CL			
352.9 0.0 0.1	ASPHALT Gravelly SAND, trace silt and clay Compact Brown Dry to Moist (FILL)		1	SS	26									
			2	SS	29									23 72 5 (SI+CL)
			3	SS	28									
			4	SS	16									
			5	SS	19									24 69 7 (SI+CL)
349.3 3.7	Gravelly SAND, trace silt, occasional cobbles and boulders Compact to Very Dense Brown Wet		6	SS	24									
			7	SS	74									
345.8 7.2	Sandy GRAVEL, some cobbles and boulders, trace silt Very Dense Grey Wet		8	SS	50/ 0.00									
			9	SS	50/ 0.075									

Continued Next Page

+ 3, X 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10-04

2 OF 2

METRIC

G.W.P. 123-88-00 LOCATION N 5 285 215.9 E 249 437.6 ORIGINATED BY GA
 HWY 144 - Bridge at Makami River BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM GEODETIC DATE 2010-03-25 - 2010-03-25 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
Continued From Previous Page							20 40 60 80 100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) 20 40 60				
342.3	GRANITE, slightly weathered to fresh, coarse grained, very strong Start coring at 10.7m		1	RUN			343								FI	RUN 1# TCR=100%, SCR=100%, RQD=100%, UCS=128MPa
342																
341																
340																
339.4	END OF BOREHOLE AT 13.6m. BOREHOLE OPEN TO 13.5m AND WATER LEVEL AT 4.9m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 26/03/2010 4.9 348.0 27/03/2010 4.9 348.0															
13.6																

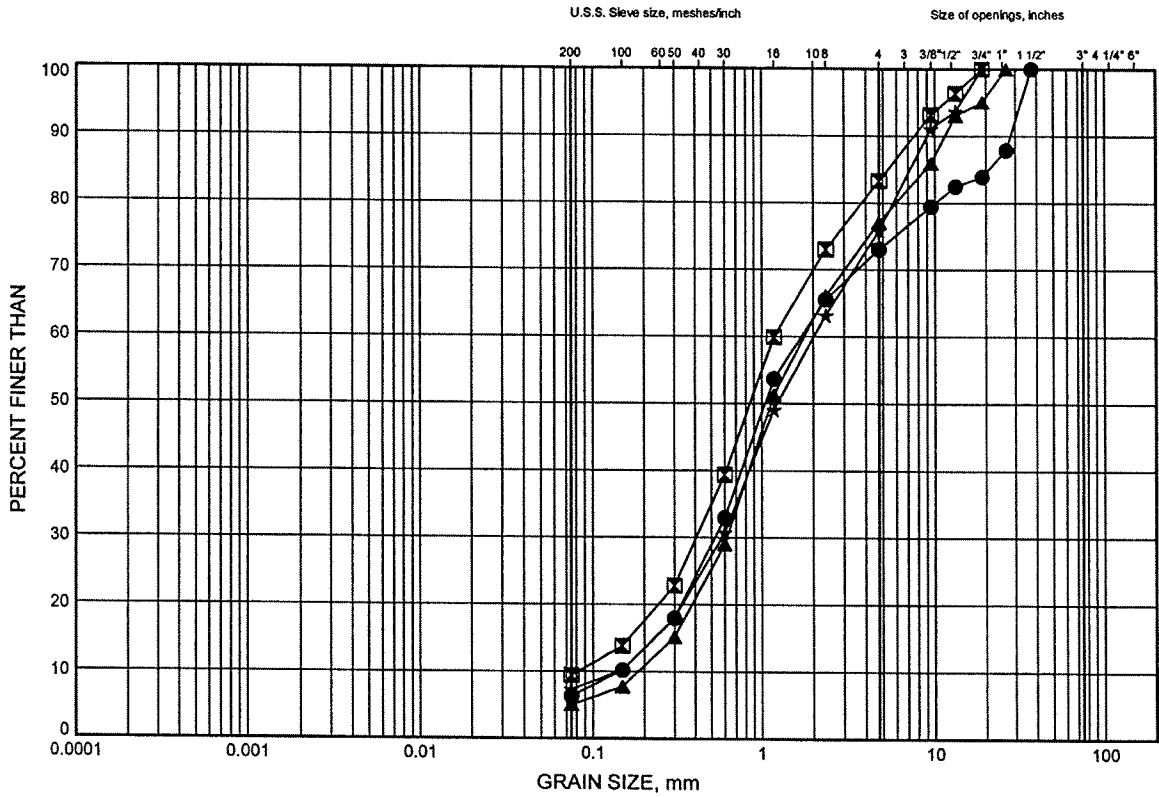
Appendix B

Laboratory Test Results

Hwy 144 Bridge at Makami River
GRAIN SIZE DISTRIBUTION

FIGURE 1

SAND, Some Gravel to Gravelly FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	10-01	3.35	349.77
⊠	10-01A	1.83	351.29
▲	10-04	1.07	351.85
★	10-04	3.35	349.57

GRAIN SIZE DISTRIBUTION - THURBER 1154.GPJ 5/31/10

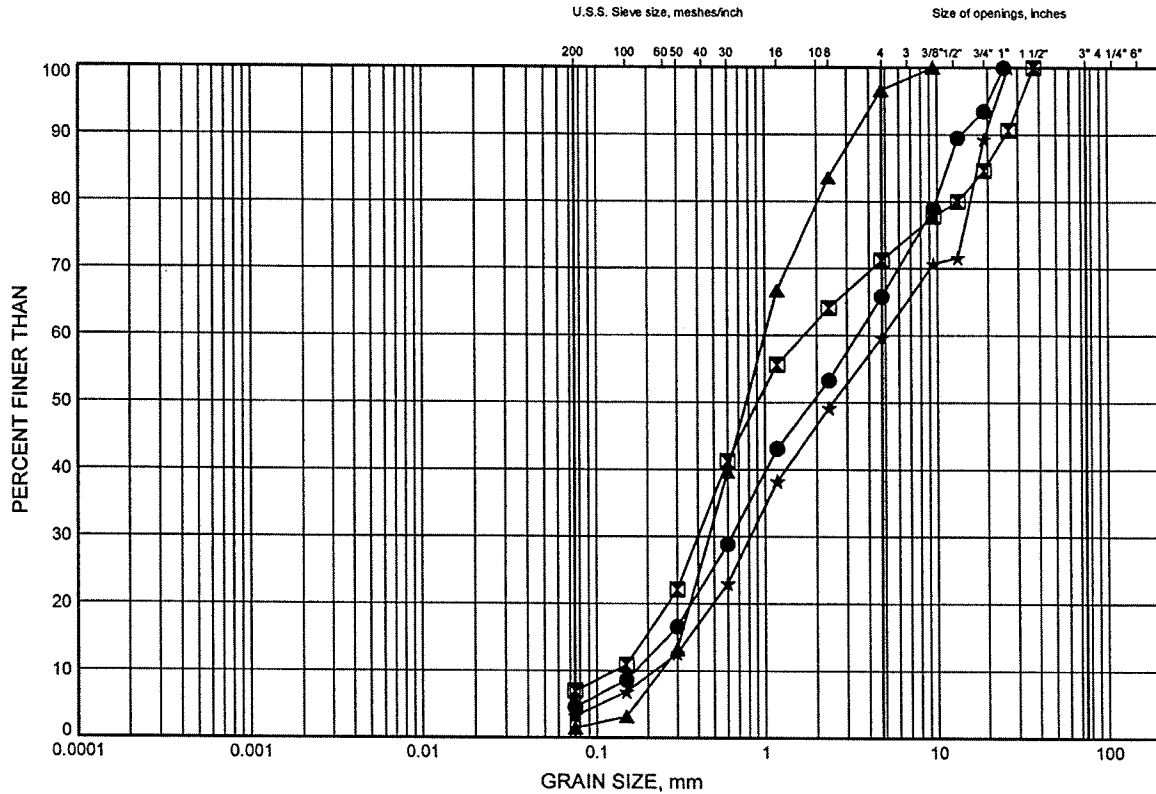
W.P.# 123-88-00
 Prepared By AN
 Checked By LPG



Hwy 144 Bridge at Makami River GRAIN SIZE DISTRIBUTION

FIGURE 2

Gravelly SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	10-02	6.10	346.97
⊠	10-02A	5.79	347.26
▲	10-02A	7.92	345.13
★	10-03	5.49	347.50



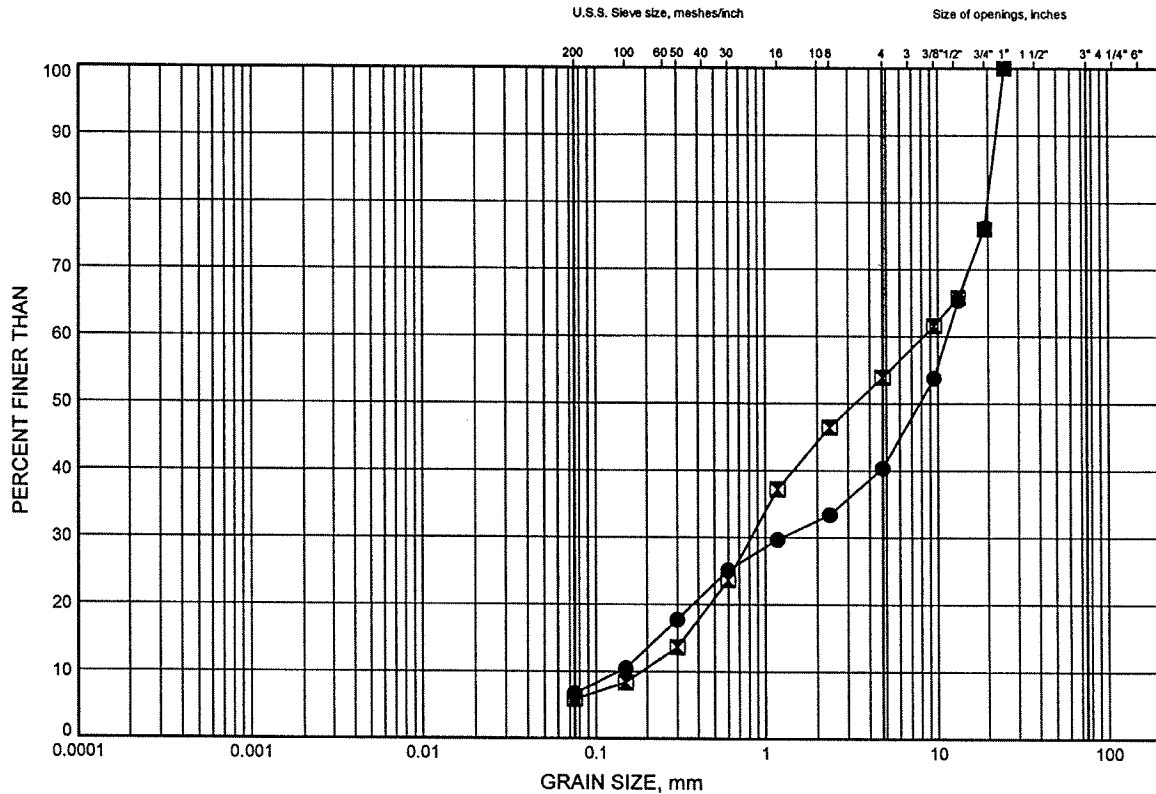
W.P.# 123-88-00
Prepared By AN
Checked By LPG

Hwy 144 Bridge at Makami River

GRAIN SIZE DISTRIBUTION

FIGURE 3

Sandy GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	10-01	6.40	346.72
■	10-01A	4.88	348.24

GRAIN SIZE DISTRIBUTION - THURBER 1154.GPJ 5/31/10

W.P.# 123-88-00
 Prepared By AN
 Checked By LPG





POINT LOAD TEST SHEET

Client :	MRC
Date Drilled :	23/03/2010
Date Tested :	29/3/2010
Tester :	JM

[illegible]

* 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 $0.7 \times D$ on either side of test point.



POINT LOAD TEST SHEET

Client :	MRC
Date Drilled :	26/3/2010
Date Tested :	29/3/2010
Tester :	WC

[illegible]

* 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 $0.7 \times D$ on either side of test point.



POINT LOAD TEST SHEET

Client :	MRC
Date Drilled :	24/03/2010
Date Tested :	29/3/2010
Tester :	WC

[illegible]

- * 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 $0.7 \times D$ on either side of test point.



POINT LOAD TEST SHEET

Client :	MRC
Date Drilled :	26/3/2010
Date Tested :	29/3/2010
Tester :	JM

[illegible]

- * 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 $0.7 \times D$ on either side of test point.



POINT LOAD TEST SHEET

Client :	MRC
Date Drilled :	24/03/2010
Date Tested :	29/3/2010
Tester :	JM

[illegible]

* 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 $0.7 \times D$ on either side of test point.



POINT LOAD TEST SHEET

Client :	MRC
Date Drilled :	27/3/2010
Date Tested :	29/3/2010
Tester :	WC

[illegible]

* 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 $0.7 \times D$ on either side of test point.



POINT LOAD TEST SHEET

Client :	MRC
Date Drilled :	25/3/2010
Date Tested :	29/3/2010
Tester :	WC

[illegible]

* 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 $0.7 \times D$ on either side of test point.

Appendix C

LIST OF SP's and OPSS

Highway 144 and Makami River
Bridge Rehabilitation

The following Special Provisions documents are referenced in this report:

SP 105S10

SP 110S13 amendment to OPSS, April 2004

The following OPSS and OPSD documents are referenced in this report:

OPSS 572, November 2003

OPSS 902, November 2009

OPSS 903, November 2009

OPSS 1010, April 2004

OPSD 208.010

OPSD 3101.150

OPSD 3101.200

OPSD 203.030

Appendix D

Drawing “Borehole Locations and Soil Strata”

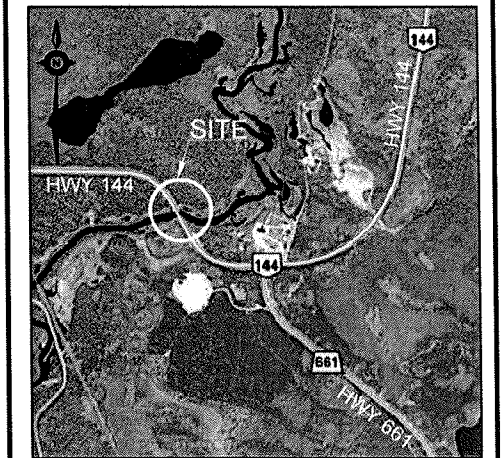
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No.
WP No 123-88-02

MAKAMI RIVER BRIDGE
REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

MMM GROUP

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



KEYPLAN

LEGEND

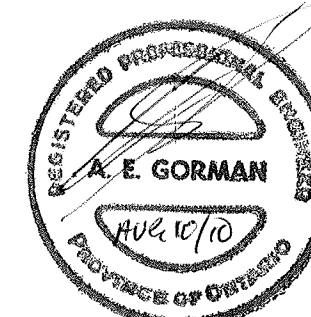
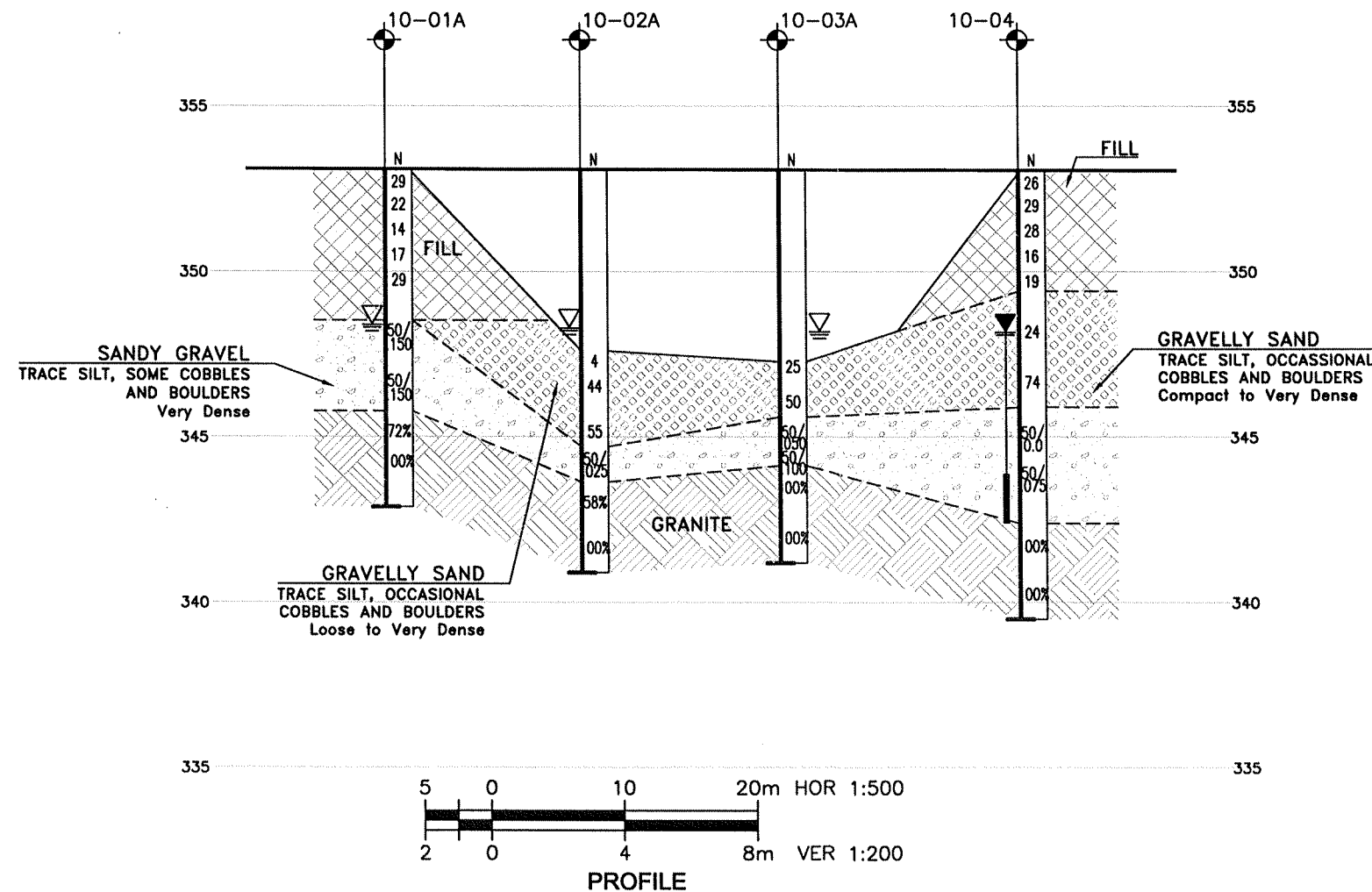
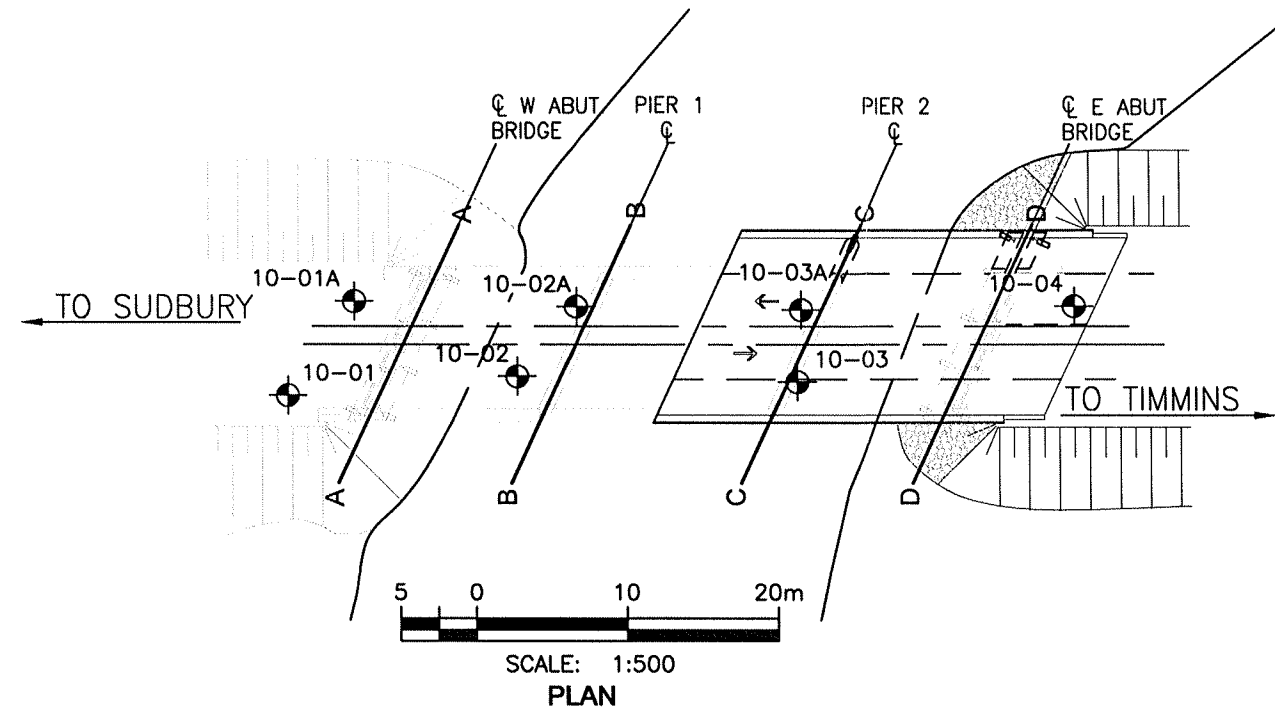
- ◆ Borehole
- ◆ Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level
- W Head Artesian Water
- P Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
10-01	353.1	5 285 258.4	294 407.9
10-01A	353.1	5 285 257.9	294 414.0
10-02	353.1	5 285 242.1	294 417.9
10-02A	353.1	5 285 241.4	294 423.3
10-03	353.0	5 285 228.8	294 425.3
10-03A	353.0	5 285 231.9	294 428.7
10-04	352.9	5 285 215.9	294 437.6

NOTES

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 41P - 45



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	LPG	CHK	PKC
DRAWN	AN	CHK	AEG

MINISTRY OF TRANSPORTATION, ONTARIO

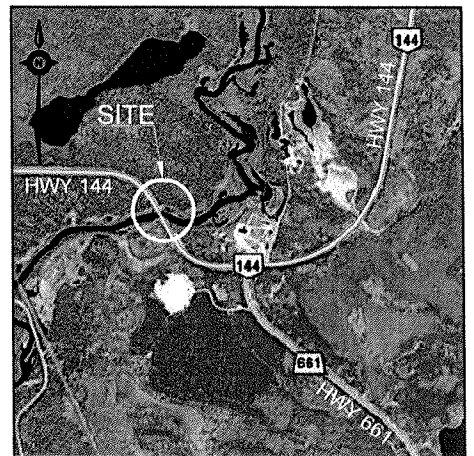
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No.
WP No 123-88-02

MAKAMI RIVER BRIDGE
REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



KEYPLAN

LEGEND

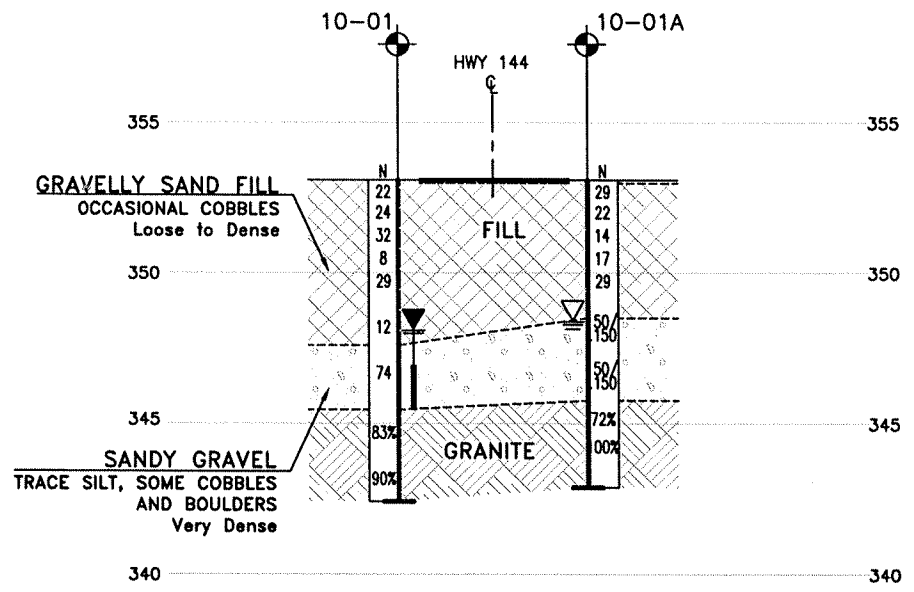
- Borehole
- Borehole and Cone
- N
Blows /0.3m (Std Pen Test, 475J/blow)
- CONE
Blows /0.3m (60° Cone, 475J/blow)
- PH
Pressure, Hydraulic
- W
Water Level
- W
Head Artesian Water
- P
Piezometer
- 90%
Rock Quality Designation (RQD)
- A/R
Auger Refusal

NO	ELEVATION	NORTHING	EASTING
10-01	353.1	5 285 258.4	294 407.9
10-01A	353.1	5 285 257.9	294 414.0
10-02	353.1	5 285 242.1	294 417.9
10-02A	353.1	5 285 241.4	294 423.3
10-03	353.0	5 285 228.8	294 425.3
10-03A	353.0	5 285 231.9	294 428.7
10-04	352.9	5 285 215.9	294 437.6

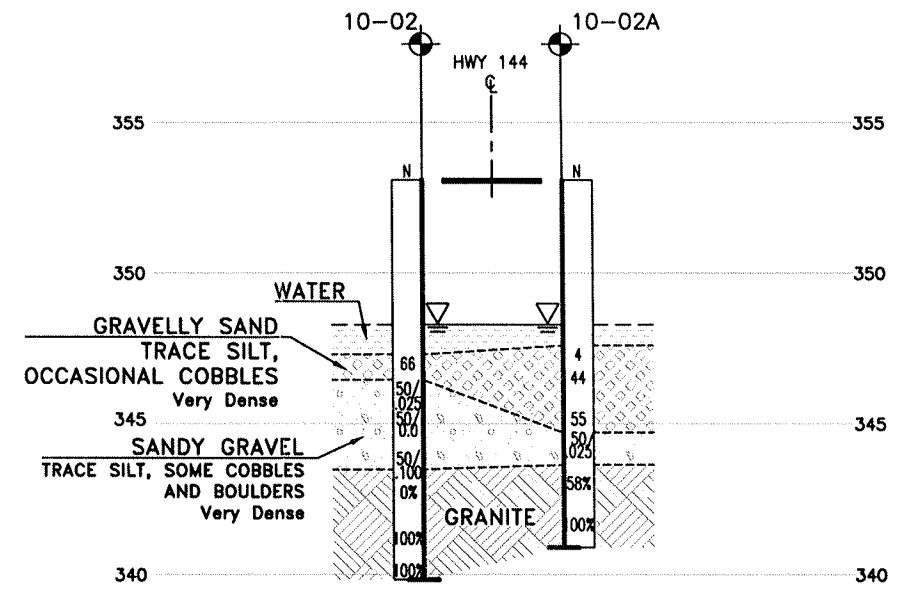
-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

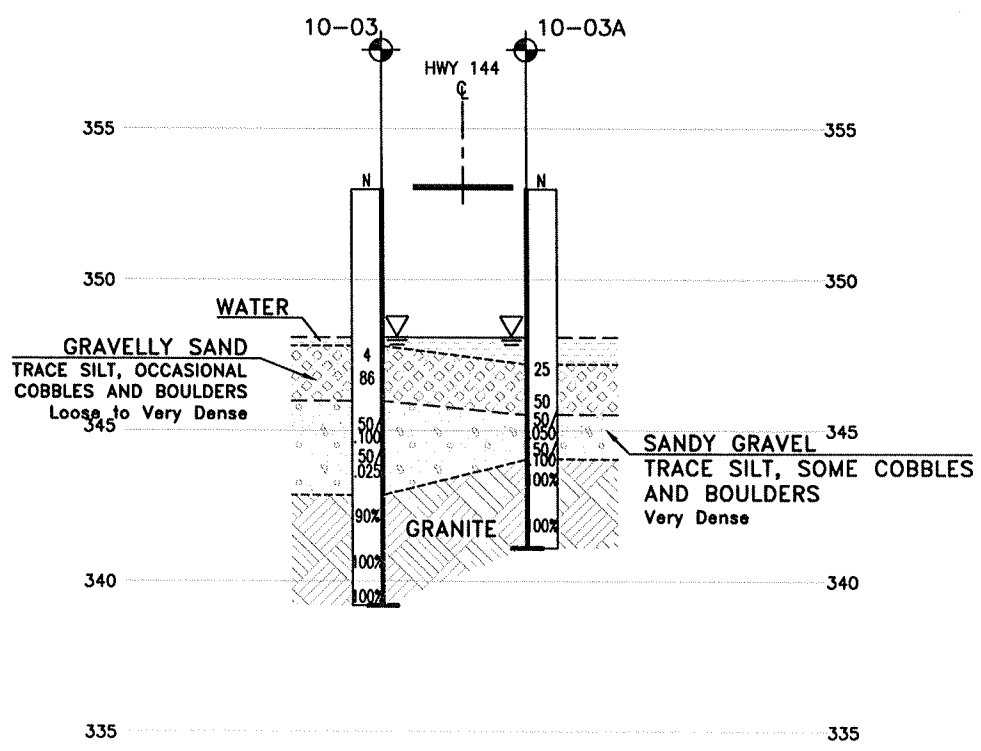
GEOCRES No. 41P - 45



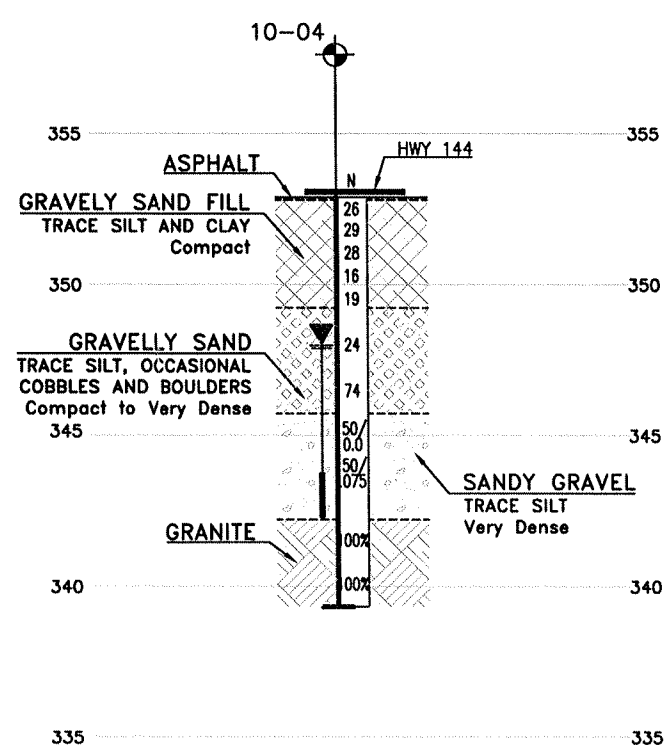
SECTION A-A



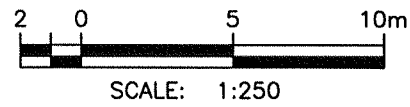
SECTION B-B



SECTION C-C



SECTION D-D



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	LPG	CHK PKC	CODE CHBDC 2006[LOW CL-625-ONT]DATE AUG. 2010
DRAWN	AN	CHK AEG	SITE 46-228 STRUCT DWG 3

PLANNING
PLOT/DATE

Appendix E

Site Photographs

Highway 144 and Makami River
Bridge Rehabilitation



Photo 1. General view of bridge site. (East Side Looking South)



Photo 2. North East Side of Bridge where widening will take place.

Appendix F

Soil Stratigraphy Along Existing Bridge Alignment

