PRELIMINARY
FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 7 EBL AND WBL OVER HOPEWELL CREEK
HIGHWAY 7-NEW, KITCHENER TO GUELPH
G.W.P. 408-88-00

Geocres Number: 40P8-153

Report to

Ministry of Transportation Ontario
West Region

Thurber Engineering Ltd.
2010 Winston Park Drive, Suite 103
Oakville, Ontario
L6H 5R7
Phone: (905) 829 8666
Fax: (905) 829 1166

November 10, 2009
File: 15-64-17

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a preliminary foundation investigation conducted at the site of the proposed bridge structures to carry Highway 7-New Eastbound lanes (EBL) and Westbound lanes (WBL) over Hopewell Creek in the Regional Municipality of Waterloo, Ontario.

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

The information collected in the course of the investigation and presented in this report is intended for preliminary design purposes only. Additional site investigation, field testing and engineering analysis will be required at the detail design stage. The extent of the additional investigation will depend, in part, on the final location and General Arrangement of the structure.

Thurber carried out the investigation for the Ministry of Transportation Ontario, Southwestern Region (MTO) under Purchase Order Number 3006-E-0123.

2 SITE DESCRIPTION

At the site, the Highway 7-New alignment runs approximately parallel to the existing Highway 7 alignment and 150 m to the north. The site lies approximately 5.0 km to the northeast of a developed area of the City of Kitchener.

Based on the Ontario Geological Survey Special Volume 2, The Physiography of Southern Ontario, Third Edition by Chapman and Putnam, the site lies within an area referred to as the Guelph Drumlin Field, an area of drumlinized till plain, also mapped as containing eskers. The till is described as stony and the occurrence of surface boulders is noted. Chapman and Putnam give a

typical gradation of the till as being 50% sand, 35% silt and 15% clay. Swampy valleys are reported to occur between the drumlins and associated gravel terraces.

The site lies within an area of farms and agricultural lands. There are farmsteads to the east and west sides of Hopewell Creek, and to the north of the existing Highway 7 alignment.

Hopewell Creek runs north to south and crosses the proposed Highway 7 alignment near station 25+840. The creek is approximately 9.0 m wide.

Photographs of the site included in Appendix E show the general nature of the surrounding lands.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing at this site was carried out on May 26, July 31, August 1 and August 5 to 8, 2008. Four boreholes numbered 08-130 to 08-133 were drilled for the proposed Highway 7 EBL and WBL bridges. Boreholes 08-130 and 08-131 were drilled for the WBL bridge and Boreholes 08-132 and 08-133 were drilled for the EBL bridge. One borehole was drilled at each bridge abutment of possible one-span structure arrangements. The depths of the boreholes ranged from 12.2 m to 13.9 and at 26.0 m depth in Borehole 08-132. The Record of Borehole sheets for the boreholes are included in Appendix A. The approximate locations of the four boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix F.

Prior to commencing the site investigation, clearance was obtained from utility companies having plant in the area.

The boreholes were drilled using hollow stem auger equipment mounted on a CME-75 truck-mounted drill rig. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the overburden soils.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Two standpipe piezometers were installed in Boreholes 08-130 and 08-133. The piezometers consisted of 25 mm diameter PVC pipe with a slotted screen, installed and enclosed in filter sand to permit longer term groundwater level monitoring. The locations and completion details of the piezometers are shown in Table 3.1. Boreholes without piezometer installations were grouted with bentonite grout upon completion. The borehole completion details are also shown in Table 3.1.

The completion of the boreholes and the standpipe piezometers were carried out in accordance with the requirements of O. Reg. 903 (as amended by O. Reg. 372/07).

Table 3.1 – Borehole Completion Details

Foundation Unit		Borehole Location	Piezometer Tip Depth/ Elevation (m)	Completion Details
WBL	West Abutment	08-130	13.4/302.6	Piezometer with 1.5 m slotted screen installed with sand filter to 11.6 m, holeplug from 11.6 m to 11.3 m, grout from 11.3 m to 0.2 m, then holeplug to ground surface.
	East Abutment	08-131	No installation	Bentonite benseal to 0.3 m, then holeplug to ground surface.
EBL	West Abutment	08-132	No installation	Grout to 0.6 m, then holeplug to ground surface.
	East Abutment	08-133	13.9/302.1	Piezometer with 1.5 m slotted screen installed with sand filter to 11.6 m, holeplug from 11.6 m to 11.3 m, bentonite seal from 11.3 m to 0.3 m, then holeplug to ground surface.

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

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 (sieve and hydrometer) and Atterberg Limits testing where appropriate. 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.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil stratigraphy along the proposed alignment are presented in this appendix and on the "Borehole Locations and Soil Strata" drawings 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.

In general, the site is underlain by topsoil and recent alluvium overlying native layers of sand and gravel, sandy silt and sand. Two distinct glacial till deposits, sandy silt till and silty clay till were encountered within the depth of exploration.

5.1 Topsoil

Topsoil was identified at ground surface in Boreholes 08-131 and 08-133, drilled near the east abutments. The topsoil thickness was 0.3 m.

The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

5.2 Recent alluvium

Dark brown to brown recent alluvium containing some silt, trace clay, trace sand and occasional organics was encountered surficially in Boreholes 08-130 and 08-132, drilled at the west abutments. The alluvium thickness was 1.3 m and 1.5 m.

The alluvium is loose in density, based on SPT 'N' values of 5 blows per 0.3 m of penetration. Moisture content ranged from 19% to 39%.

5.3 Sandy Silt

A 1.2-m thick layer of native brown sandy silt containing trace gravel and occasional cobbles was encountered below the topsoil in Borehole 08-131. The depth to the base of the sandy silt was 1.5 m (Elevation 313.6).

The sandy silt is described as compact, based on an SPT 'N' value of 11 blows per 0.3 m of penetration. The moisture content of this layer was in the order of 10%.

5.4 Sand and Gravel

A native brown sand and gravel layer containing trace to some silt, trace clay and occasional cobbles was contacted below the topsoil and alluvium in Boreholes 08-130, 08-132 and 08-133. In Borehole 08-131, the sand and gravel layer was contacted below the sandy silt at 1.5 m depth (Elevation 313.6).

Thickness of the sand and gravel layer ranged from 1.2 m to 3.4 m. The depth to the base of the sand and gravel varies from 2.5 m to 4.3 m (Elevations 311.1 and 313.5).

A lower layer of sand and gravel was contacted in Borehole 08-132 at 15.7 m depth (Elevation 301.5). Thickness of this layer was 2.1 m.

SPT 'N" values in the sand and gravel layer generally ranged from 20 to 100 blows per 0.3 m of penetration indicating a compact to very dense relative density. SPT 'N' values measured in the lower sand and gravel layer were 70 blows per 0.3 m of penetration and 100 blows per 0.225 m of penetration, indicating a very dense relative density. Moisture content ranged from 8% to 18%.

Grain size distribution curves for four sand and gravel samples are presented on the Record of Borehole sheets and on Figure B1 of Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	(%)
Gravel	34 to 57
Sand	28 to 42
Silt & Clay	13 to 24

5.5 Upper Sandy Silt Till

Native brown to grey sandy silt till containing trace gravel and trace silt and was contacted below the sand and gravel in Boreholes 08-130 to 08-132 at depths and elevations indicated in Table 5.1.

Table 5.1 – Depths and Elevations of Native Sandy Silt Till

Foundation Unit		Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
WBL	West Abutment	08-130	2.5 to 6.1	313.5 to 309.9	3.6
	East Abutment	08-131	4.0 to 12.2 (borehole termination depth)	311.1 to 302.9	8.2+
EBL	West Abutment	08-132	4.3 to 7.0	312.9 to 310.2	2.7

SPT 'N" values in the upper sandy silt till layer, generally ranged from 32 blows per 0.3 m of penetration to higher than 100 blows per 0.025 m of penetration indicating a dense to very dense relative density. The moisture content varies from 10% to 20%.

Grain size distribution curves for four sandy silt till samples are presented on the Record of Borehole sheets and on Figure B4 of Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	(%)
Gravel	0 to 4
Sand	18 to 42
Silt	39 to 55
Clay	7 to 27

Although not encountered in the boreholes, this glacial till layer may contain cobbles and boulders which may account for some high blow counts and resistance to augering.

5.6 Sand

Brown sand containing trace to some silt, trace gravel and trace clay was encountered at 6.1 m and 3.7 m depth (Elevations 309.9 and 312.2) in Boreholes 08-130 and 08-133, respectively.

Thickness of the layer was 1.5 m and 1.9 m. The depth to the base of the sand was 7.6 m and 5.6 m (Elevations 308.4 and 310.3) in Boreholes 08-130 and 08-133, respectively.

SPT 'N" values in the sand were 49 and 52 blows per 0.3 m of penetration indicating a dense to very dense relative density. Moisture content ranged from 18% to 20%.

Grain size distribution curves for two sand samples are presented on the Record of Borehole sheets and on Figure B2 of Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	(%)
Gravel	0 to 1
Sand	76 to 90
Silt	21
Clay	2
Silt & Clay	10

5.7 Silty Clay Till

Native layers of grey silty clay till containing trace to some sand and trace gravel were encountered at 7.6 m, 7.0 m and 5.6 m (Elevations308.4, 310.2 and 310.3) in Boreholes 08-130, 08-132 and 08-133, respectively.

Borehole 08-130 was terminated within the silty clay till at 13.8 m (Elevation 302.2).

Thickness of the silty clay till ranged from 1.7 m to 8.7 m. The depth to the base of the silty clay till was 13.8 m, 15.7 m and 7.3 m (Elevations 302.2, 301.5 and 308.7) in Boreholes 08-130, 08-132 and 08-133, respectively.

SPT 'N" values in silty clay till generally ranged from 11 blows per 0.3 m of penetration to higher than 100 blows per 0.125 m of penetration, indicating a stiff to hard consistency. The natural moisture contents generally lay in the range of 9% to 18%.

Grain size distribution curves for two silty clay till samples are presented on the Record of Borehole sheets and on Figure B3 of Appendix B. Atterberg Limits test result is presented on Figure B5 of Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	(%)
Gravel	0 to 1
Sand	10
Silt	45 to 48
Clay	41 to 45

Liquid Limit	38
Plastic Limit	16

The above results show that the silty clay till is of medium plasticity with a group symbol of CI.

It should be noted that glacial tills are known to contain cobbles and boulders.

5.8 Lower Sandy Silt Till

Lower layers of grey sandy silt till containing some clay, trace gravel, trace silt and occasional cobbles and boulders were contacted at 17.8 m and 7.3 m depths (Elevations 299.4 and 308.7) in Boreholes 08-132 and 08-133, respectively.

Both boreholes were terminated within the lower sandy silt till layer at 26.0 m and 13.9 m depths (Elevations 291.2 and 302.0).

SPT 'N" values in the lower sandy silt till generally ranged from 51 blows per 0.3 m of penetration to higher than 100 blows per 0.1 m of penetration indicating a very dense relative density. The moisture content varies from 10% to 19%.

Grain size distribution curves for two lower sandy silt till samples are presented on the Record of Borehole sheets and on Figure B4 of Appendix B. Atterberg Limits test results are presented on Figure B6 of Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	(%)
Gravel	2 to 9
Sand	42 to 43
Silt	39 to 41
Clay	9 to 15

Liquid Limit	18
Plastic Limit	10

The above results show that the lower sandy silt till is of low plasticity with group symbols of CL-ML.

This glacial till layer contains cobbles and boulders which may account for some high blow counts and resistance to augering.

5.9 Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. Two standpipe piezometers were installed in Borehole 08-130 (WBL west abutment) and Borehole 08-133 (EBL east abutment) to monitor water levels after completion of drilling. The water levels measured in the piezometers are summarized in Table 5.2, along with the measurements in the boreholes upon completion of drilling.

Table 5.2 – Water Level Measurements

Foundation Unit		Borehole	Date (2008)	Water Level (m)		Comment
				Depth	Elevation	
WBL	West Abutment	08-130	August 22	0.4*	316.4*	In piezometer
	East Abutment	08-131	May 26	1.1	314.0	Open borehole
EBL	West Abutment	08-132	July 31	Dry	-	Open borehole
	East Abutment	08-133	July 15 August 22	0.7* 0.9*	316.7* 316.9*	In piezometer

* Above ground surface (artesian conditions)

Piezometric readings indicate the presence of artesian conditions on the site. Groundwater levels were 0.4 m to 0.9 m above ground surface (Elevations 316.4 to 316.9) in Boreholes 08-130 and 08-133.

Decommission of standpipe piezometers was carried out in accordance with the requirements of O. Reg. 903 (as amended by O. Reg. 372/07).

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

6 MISCELLANEOUS

All-Terrain Drilling of Waterloo, Ontario supplied a CME75 track-mounted drill rig and conducted the drilling, sampling and in-situ testing operations.

The drilling and sampling operations in the field were supervised on a full time basis by Mr. Stephane Loranger, C.E.T., Ms. Eckie Siu and Mr William Ball of Thurber, under the direction of Mr. Alastair E. Gorman, P.Eng. And Mr. M. Farrant, P. Eng.

The coordinates for the boreholes and the ground surface elevations were obtained by Thurber Engineering Ltd. using GPS equipment.

Overall supervision of the field program was conducted by Mr. Alastair E. Gorman, P.Eng. and Mr. M. Farrant, P. Eng. Interpretation of the data and preparation of the report were carried out by Mr. Alastair E. Gorman, P.Eng. and Ms. R. Palomeque Reyna, P.Eng.

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

Thurber Engineering Ltd.

Rocío Palomeque Reyna, P.Eng.
Geotechnical Engineer

Alastair E. Gorman, P.Eng.,
Senior Foundations Engineer

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

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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 preliminary geotechnical design recommendations to assist the design team to select and design a suitable foundation system for the two new bridge structures to carry the proposed Highway 7-New EBL and WBL over Hopewell Creek.

Based on the Plate 9 of the E.A:

- Existing ground surface near Elevations 315.0 to 317.0
- The mainline will be in at Elevation 320.2, with approach embankments 3.0 m to 5.0 m high.

The discussion and recommendations presented in this report are based on our understanding of the project and on the factual data obtained in the course of this investigation.

It is anticipated that two single-span structures will be constructed.

8 STRUCTURE FOUNDATIONS

The stratigraphy identified in the preliminary investigation consisted of a surficial topsoil and recent alluvium overlying layers of native compact to very dense sand and gravel, sandy silt and sand. Two layers of glacial till, hard silty clay till and compact to very dense sandy silt till, were observed in all the drilled locations. The groundwater levels measured in the piezometers installed in Boreholes 08-130 and 08-133 were 0.4 m to 0.9 m above ground surface (Elevations 316.4 to 316.9), indicating artesian conditions.

In the preparation of the preliminary geotechnical design recommendations, consideration was given to the following foundation types:

- Spread footings bearing on native soil
- Spread footings on engineered fill
- Steel H-piles driven into the very dense or hard soil

A comparison of the foundation alternatives based on advantages and disadvantages of each is included in Appendix C.

8.1 Spread Footings on Native Soil

Spread footings bearing on native soil generally are the least expensive form of construction.

The design of spread footings bearing on native compact to very dense sand and gravel or sandy silt till must be in accordance with the elevations and bearing resistances given in Table 8.1.

Table 8.1 – Bearing Resistances for Spread Footings

Foundation Unit		Borehole	Depth (m)	Elev.	ULS_f (kPa)	SLS (kPa)
WBL	West Abutment	08-130	1.5	314.5	600	400
	East Abutment	08-131	1.6	313.5	600	400
EBL	West Abutment	08-132	2.2	315.0	450	300
			4.3	312.9	600	400
	East Abutment	08-133	0.8	315.2	450	300
			2.0	314.0	600	400

The bearing resistances in Table 8.1 are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be adjusted as shown in the CHBDC (2006) Clause 6.7.3 and Clause 6.7.4.

The geotechnical SLS resistance values given above are based on an estimated total settlement not exceeding 25 mm. This settlement is expected to be substantially complete by the end of construction. Differential settlement is not expected to exceed 20 mm across the width of the structure or between foundation elements.

At this structure, footings must be protected from scour.

Artesian conditions were observed at this site and consequently, founding elevations presented in Table 8.1 are generally 1.7 m to 4.0 m below the groundwater level. Groundwater control will be required prior to excavation to construct the footings in the

dry, to prevent sloughing of the sides and to prevent disturbance of the footing bases due to the inflow of groundwater.

8.2 Spread Footings on Engineered Fill

Spread footings can also be founded on Granular "A" engineered fill pads. These would most typically be used in the case of perched abutments on footings. In this case, particular attention must be paid to scour and erosion of the forward slope.

If an engineered fill pad is used, all topsoil, alluvium, organics or other deleterious materials must be stripped from the footprint of the foundation to expose competent native subgrade material consisting of dense to very dense sand and gravel or compact sandy silt and the highest permitted founding elevations at which engineered fill pads may be founded, are given in Table 8.2.

Table 8.2 – Founding Elevations for Engineered Fill Pads

Foundation Unit		Borehole	Founding Elevations
WBL	West Abutment	08-130	314.6
	East Abutment	08-131	313.8
EBL	West Abutment	08-132	315.0
	East Abutment	08-133	315.7

Typically, spread footings on pads of engineered granular fill at least 2 m thick may be designed for the following geotechnical resistances:

- Factored ULS 900 kPa
- SLS 350 kPa

These resistance values are for concentric, vertical loads only. In the case of eccentric or inclined loading, the geotechnical resistance must be calculated as illustrated in the CHBDC Clause 6.7.3 and Clause 6.7.4.

For footings designed on the basis of the geotechnical resistance values given above, total settlement under a footing is expected to not exceed 25 mm. Differential settlements are not expected to exceed 20 mm across the width of the structure or between foundation elements.

The Granular A pad must be compacted to 100% of Standard proctor maximum dry density (SPMDD) at optimum moisture content ±2%. The geometry of the fill pad must conform to the general requirements shown in Figure 1 in Appendix D.

8.3 Steel H-Piles

The soil stratigraphy encountered at this site is considered to be suitable for the support of foundations on driven steel piles.

It is recommended that the H-piles be driven to achieve resistance in the very dense sandy silt till or hard silty clay till glacial soils encountered at this site.

The elevations at which the H-piles are expected to develop the required resistance are given in Table 8.3.

Table 8.3 – Estimated Pile Tip Elevation

Foundation Unit		Borehole	Anticipated Pile length below original ground (m)	Highest Pile Tip Elevation
WBL	West Abutment	08-130	10.0	306.0
	East Abutment	08-131	10.6	304.5
EBL	West Abutment	08-132	15.7	301.5
	East Abutment	08-133	11.5	304.5

8.3.1 Axial Resistance

For preliminary design, the vertical, axial, factored geotechnical resistance at Ultimate Limit States (ULS) and geotechnical resistance at Serviceability Limit States (SLS) for a pile section when driven into the very dense/hard soil are presented in Tables 8.4 .

Table 8.4 – Axial Resistance of Two Pile Sections Founded on Very Dense/Hard Soils

Pile Section	Geotechnical Resistance (kN)	
	Factored ULS	SLS
HP 310 X 110	1,600	1,400
HP 360 X 132	1,800	1,600

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

Installation of the piles must be in accordance with SP 903S01 and must be controlled using the Hiley Formula and an ultimate resistance of 3,200 kN for an HP 310 X 110 pile and 3,600 kN for the HP 360 X 132 pile.

These are preliminary recommendations and may change during detail design based on the final alignment, final bridge arrangement and the results of the site investigation and field testing to be completed at that time.

8.3.2 Downdrag

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

8.3.3 Artesian Water Pressure

The artesian groundwater levels noted at this site have the potential to cause flow up the side of piles, with an attendant loss of fines and potential loss of geotechnical resistance. However, the preliminary design indicates that fill will be placed on the site to an elevation above the artesian groundwater level. In that situation, groundwater flow is not likely to occur. However, this condition should be investigated during detail design, when the final grades are known and, if necessary, appropriate designs such as sand filters can be developed at that time.

8.4 Abutment Design Considerations

From a geotechnical perspective, the conditions at this site are considered to be suitable for the design of conventional, semi-integral or integral abutments.

8.5 Frost Cover

The design depth of frost penetration for this site is 1.4 m. All footing bases and undersides of pile caps/abutment stems must be provided with at least 1.4 m of soil cover.

8.6 Recommended Foundation

From a geotechnical perspective, and based on current information, the recommended abutment foundation consists of steel H-piles driven into the very dense sandy silt till or hard silty clay till native soils. Despite the higher cost noted in Appendix C, driven piles are the technically preferred option and are less susceptible to the effects of scour.

9 BRIDGE APPROACHES AND EMBANKMENTS

Based on the four boreholes drilled at the site, the approach embankments will be constructed over compact to very dense sand and gravel and sandy silt soils. Overlain by recent alluvium.

It is recommended that recent alluvium be stripped within 20 m of the abutment prior to placing fill.

No long term settlement or global stability issues are anticipated for approach embankments built at this site. The 3.0 m to 5.0 m high embankments likely to be constructed will be stable at side slopes of 2H:1V if constructed using SSM or granular fill.

The proposed Highway 7 grade shown on EA Plate 9 will be approximately 3.3 m above the artesian groundwater table. During detail design, when the grade has been finalized, permanent drainage (if necessary) and slope protection requirements must be addressed.

The global, internal and surficial stability of the approach embankment fills should be further evaluated during the detail design phase.

10 CONSTRUCTION CONCERNS

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

1. Pile refusal at higher elevation.

   Although there was little direct evidence of their presence during drilling, glacial till deposits inherently contain boulders. It is possible that a pile will achieve refusal at a higher elevation than anticipated due to encountering a boulder. If it is suspected that this is happening, the QVE must immediately bring it to the attention of the CA. If the CA cannot resolve the issue, it must be referred to the design team for resolution.

2. Pile fails to develop specified resistance.

   If a pile has not developed the specified resistance after being driven 3 m beyond the anticipated pile tip elevation, stop driving and check the Hiley calculation and all input values. If the calculation still shows that the pile has not reached the specified resistance, the following procedure should be implemented:

   a) Stop driving in that pile group for 48 hours (minimum)
   b) After 48 hours, warm up the hammer on another pile then commence redriving the subject pile and measure the resistance.
   c) If the pile still does not reach the specified resistance, the QVE must immediately advise the CA who, in turn, should refer the issue to the design team.

3. Artesian water flow during pile driving.

   Although groundwater levels were encountered that were above the existing ground level, they are below the design highway grade. Thus it is not anticipated that artesian groundwater flow will occur.

   However, the contractor must review the site conditions and if contractor's working methods may permit artesian flow, then the contractor must implement measures to control the flow.

   If, despite the contractor's control measures, artesian groundwater flow is observed during pile driving, or any other construction activities, the contractor or QVE must immediately advise the CA. If the CA agrees there are concerns regarding the artesian flow, the issue should be referred to the design team.

   The issue of the risk of artesian water flowing upward around the piles should be further assessed during detailed design and measures to control this flow implemented if necessary.

4. Destabilization of excavations

   If excavation is carried out in cohesionless soil without prior implementation of adequate measures to control groundwater and surface water, there is a risk that the sides and or base of the excavation will be destabilized. This could lead to a risk to personnel working on site, or to a loss of bearing resistance in the soil.

   Accordingly, it must be emphasized to the contractor that proper groundwater and surface water control measures must be in place prior to commencing excavation.

11 INVESTIGATION FOR DETAIL DESIGN

During the detail design phase of the project, additional site investigation and field testing will be required. The following minimum program is recommended:

1. Boreholes for structure foundations.

   Additional boreholes will be required for the structure foundations. Particular attention should be paid to groundwater levels and water pressure.

2. Boreholes for approaches.

   A minimum of one borehole is recommended in each approach fill on proposed Highway 7 alignment.

3. Artesian conditions

   Further investigation of the artesian groundwater conditions must be carried out during the detail design phase, including identification of the artesian aquifer and overlying aquetards. This will include installing and monitoring piezometers. Depending on the findings, design details may have to be developed to control artesian flow and loss of fines from the soil.

12 CLOSURE

Engineering analysis and preparation of the report were carried out by Mr. Alastair E. Gorman, P.Eng and Ms. R. Palomeque Reyna, P.Eng.

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

Thurber Engineering Ltd.

Rocío Palomeque Reyna, P.Eng., M.Eng.
Geotechnical Engineer

Alastair E. Gorman, P.Eng.,
Senior Foundations Engineer

P. K. Chatterji, P.Eng.,
Review Principal

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

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

$\overline{\blacktriangledown}$ 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			

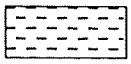
EXPLANATION OF ROCK LOGGING TERMS

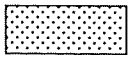
ROCK WEATHERING CLASSIFICATION

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.

SYMBOLS


CLAYSTONE


SILTSTONE


SANDSTONE


COAL


Bedrock (general)

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

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 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.

STRENGTH CLASSIFICATION

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

THURBER

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-130 1 OF 2 METRIC

G.W.P. 408-88-00 LOCATION N 4 817 526.71 E 231 156.52 ORIGINATED BY ES
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA
DATUM Geodetic DATE 2008.08.07 - 2008.08.08 CHECKED BY RPR

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
316.0							316				
0.0	**RECENT ALLUVIUM**, trace gravel, some silt, trace clay, trace sand, occasional organics Loose Dark Brown Damp		1	SS	5				○		
314.7							315				
1.3	**SAND** and **GRAVEL**, some silt Very Dense Brown Moist to Wet		2	SS	80				○ ○		
313.5							314				
2.5	Sandy **SILT**, some clay, trace gravel Very Dense Brown Moist (TILL)		3	SS	50				○		
			4	SS	45		313		○		0 18 55 27
	occasional cobbles		5	SS	99		312		○		
309.9	Clayey						311				
6.1	**SAND**, fine grained, trace silt, trace clay Dense Brown Moist		6	SS	49		310		○		0 90 10 (SI+CL)
308.4	Spoon bouncing at 7.6m						309				
7.6	Silty **CLAY**, trace sand, trace gravel Hard Grey (TILL)		7	SS	50/.125		308		○		
			8	SS	79		307		○		1 10 48 41

Continued Next Page

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

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

ONTMT4S 6417R.GPJ 9/18/08

Ministry of Transportation
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THURBER

RECORD OF BOREHOLE No 08-130 2 OF 2 METRIC

G.W.P. 408-88-00 LOCATION N 4 817 526.71 E 231 156.52 ORIGINATED BY ES
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA
DATUM Geodetic DATE 2008.08.07 - 2008.08.08 CHECKED BY RPR

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty **CLAY**, trace sand, trace gravel Hard Grey (TILL)						306				
			9	SS	105		305		○		
	some sand		10	SS	100/ .125		304		○		
302.2							303				
			11	SS	100/ .125				○		
13.8	END OF BOREHOLE AT 13.8m. Piezometer installation consists of 25mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2008.08.22 0.4* 316.4 *Above ground level										

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

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

ONTMT4S 6417R.GPJ 9/18/08

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-131 1 OF 2 METRIC

G.W.P. 408-88-00 LOCATION N 4 817 555.39 E 231 188.29 ORIGINATED BY SLL

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM

DATUM Geodetic DATE 2008.05.26 - 2008.05.26 CHECKED BY RPR

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: O 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
315.1											
0.0 / 314.8	**TOPSOIL:** (300mm) Black						315				
0.3	Sandy **SILT**, trace gravel, occasional cobbles Compact Brown Wet		1	SS	11	▼			o		
313.6							314				
1.5	**SAND and GRAVEL**, trace to some silt, trace clay, occasional cobbles Very Dense Brown Wet		2	SS	91				o		
			3	SS	76		313		o		55 32 13 (SI+CL)
			4	SS	75		312		o		
311.1											
4.0	Sandy **SILT**, some clay, trace gravel Dense to Very Dense Grey (TILL)		5	SS	32		311				
			6	SS	40		310				
	sand seams		7	SS	70		309				3 42 39 16
			8	SS	100/275		308				
	Auger grinding at 9.8m						307				
							306		o		

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Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-131 2 OF 2 METRIC

G.W.P. 408-88-00 LOCATION N 4 817 555.39 E 231 188.29 ORIGINATED BY SLL

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM

DATUM Geodetic DATE 2008.05.26 - 2008.05.26 CHECKED BY RPR

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										
	Sandy **SILT**, trace clay, trace gravel Very Dense Grey Moist (TILL)						305				
			9	SS	100/ .175				○		4 42 47 7
							304				
302.9											
			10	SS	100/ .025		303				
12.2	END OF BOREHOLE AT 12.2m. BOREHOLE OPEN TO 11.7m AND WATER LEVEL AT 1.1m ON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE BENSEAL TO 0.3m, THEN HOLEPLUG 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 08-132 1 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 817 498.75 E 231 169.61 ORIGINATED BY WB/ES
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA
DATUM Geodetic DATE 2008.07.31 - 2008.08.06 CHECKED BY RPR

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
317.2											
0.0	**RECENT ALLUVIUM**, some silt, trace clay, trace sand, occasional organics Dark Brown to Brown Damp		1	AS			317		○		
	Loose		1	SS	5		316		○		
315.7											
1.5	**SAND** and **GRAVEL**, trace to some silt, trace clay Compact to Dense Brown Damp Auger grinding at 2.1m		2	SS	20		315		○		34 42 24 (SI+CL)
			3	SS	44		314		○		
			4	SS	28		313		○		
312.9											
4.3	Sandy **SILT**, trace to some clay, trace gravel Very Dense Brown Moist (TILL)		5	SS	100/ ~~200~~		312		○		1 29 53 17
	Wet		6	SS	73		311		○		
310.2											
7.0	Silty **CLAY**, trace sand, trace gravel Hard Grey (TILL)		7	SS	32		310		○		
			8	SS	25		309		⊕		0 10 45 45
							308				

Continued Next Page

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

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

ONTMT4S 6417R.GPJ 9/18/08

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-132 2 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 817 498.75 E 231 169.61 ORIGINATED BY WB/ES

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA

DATUM Geodetic DATE 2008.07.31 - 2008.08.06 CHECKED BY RPR

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
	Continued From Previous Page										
	Silty **CLAY**, trace sand, trace gravel Hard Grey (TILL)						307				
			9	SS	11				○		
							306				
			10	SS	40				○		
							305				
			11	SS	51				○		
							304				
			12	SS	100/ .200				○		
301.5	Auger grinding at 15.5m						303				
15.7	**SAND** and **GRAVEL**, trace to some silt, trace clay Very Dense Grey Wet						302				
			13	SS	100/ .225				○		46 31 23 (SI+CL)
							301				
299.4							300		○		
17.8	Sandy **SILT**, trace gravel, trace clay, cobbles and boulders Very Dense Grey Moist (TILL) Auger grinding at 18.6m		14	SS	70				○		
							299				
							298				

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

ONTMT4S 6417R.GPJ 9/18/08

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-132 3 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 817 498.75 E 231 169.61 ORIGINATED BY WB/ES

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA

DATUM Geodetic DATE 2008.07.31 - 2008.08.06 CHECKED BY RPR

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
	Continued From Previous Page										
	Sandy **SILT**, trace gravel, trace clay, presence of cobbles and boulders Very Dense Grey Moist (TILL)						297				
							296				
			15	SS	51						
							295				
			16	SS	100/ .075				○		
							294				
			17	SS	100/ .150		293		○		
291.2							292				
			18	SS	100/ .125				○		
26.0	END OF BOREHOLE AT 26.0m. BOREHOLE OPEN AND DRY TO BOTTOM UPON COMPLETION. BOREHOLE BACKFILLED WITH GROUT TO 0.6m THEN HOLEPLUG TO SURFACE.										

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

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

ONTMT4S 6417R.GPJ 9/18/08

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THURBER

RECORD OF BOREHOLE No 08-133 1 OF 2 METRIC

G.W.P. 408-88-00 LOCATION N 4 817 528.39 E 231 194.99 ORIGINATED BY SLL

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM

DATUM Geodetic DATE 2008.05.26 - 2008.05.26 CHECKED BY RPR

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
316.0							316				
0.0 / 315.7	**TOPSOIL:** (275mm) Black										
0.3	**SAND** and **GRAVEL**, trace to some silt, trace clay, occasional cobbles Dense to Very Dense Brown Moist		1	SS	35		315		○		
			2	SS	45		314		○		
			3	SS	90				○		57 28 15 (SI+CL)
312.2			4	SS	100		313		○		
3.7	**SAND**, some silt, trace gravel, trace clay Very Dense Brown Wet		5	SS	52		312		○		1 76 21 2
310.3							311				
5.6	Silty **CLAY**, some sand, trace gravel Hard Grey (TILL)		6	SS	48		310		○		
308.7							309				
7.3	Sandy **SILT**, some clay, trace gravel Very Dense Grey (TILL)		7	SS	100/.200		308		○		
			8	SS	69		307		⊕		2 42 41 15

Continued Next Page

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

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

ONTMT4S 6417R.GPJ 9/18/08

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-133 2 OF 2 METRIC

G.W.P. 408-88-00 LOCATION N 4 817 528.39 E 231 194.99 ORIGINATED BY SLL

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM

DATUM Geodetic DATE 2008.05.26 - 2008.05.26 CHECKED BY RPR

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 + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	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										
	Sandy **SILT**, some clay, trace gravel Very Dense Grey (TILL)						306				
			9	SS	100/ .175		305		○		
							304				
			10	SS	100/ .100				○		9 43 39 9
							303				
302.0			11	SS	100/ .100				○		
13.9	END OF BOREHOLE AT 13.9m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2008.07.15 0.7* 316.7 2008.08.22 0.9* 316.9 *Above ground level										

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

$\begin{matrix}20\\15\oplus 5\\10\end{matrix}$ (%) STRAIN AT FAILURE

ONTMT4S 6417R.GPJ 9/18/08

Appendix B

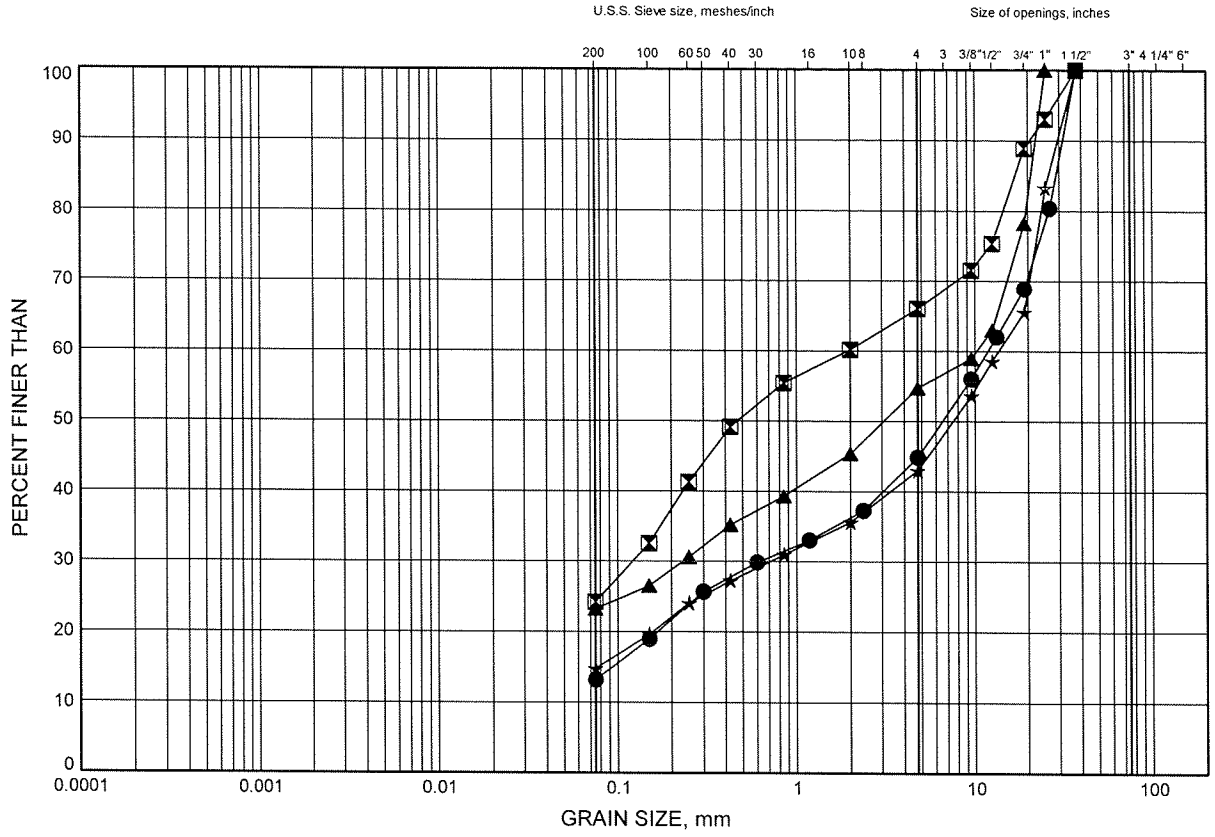
Laboratory Test Results

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B1

Sand and Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-131	2.59	312.50
⊠	08-132	1.83	315.39
▲	08-132	16.19	301.03
☆	08-133	2.59	313.38

W.P.# 408-88-00
Prepared By MFA
Checked By RPR

THURBER

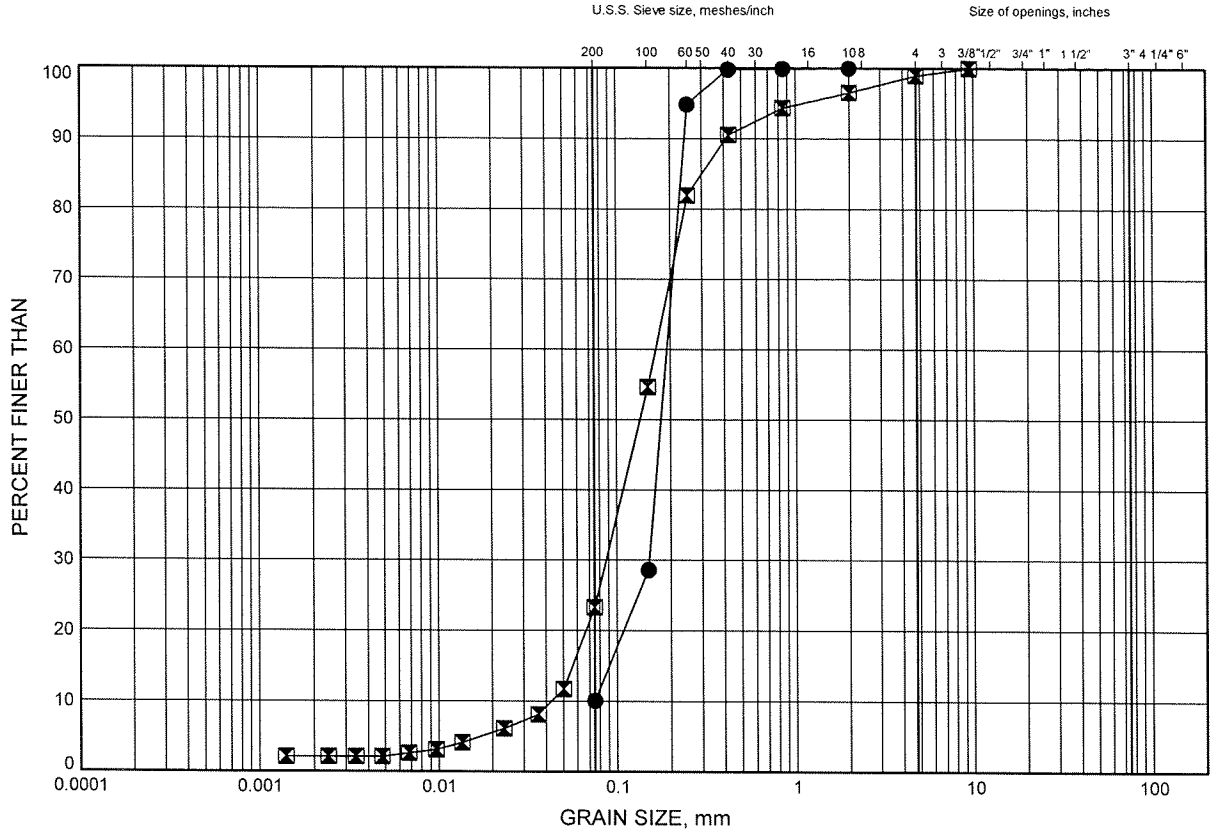
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 9/15/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B2

Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-130	6.40	309.61
⊠	08-133	4.88	311.09

W.P.# 408-88-00
Prepared By MFA
Checked By RPR

THURBER

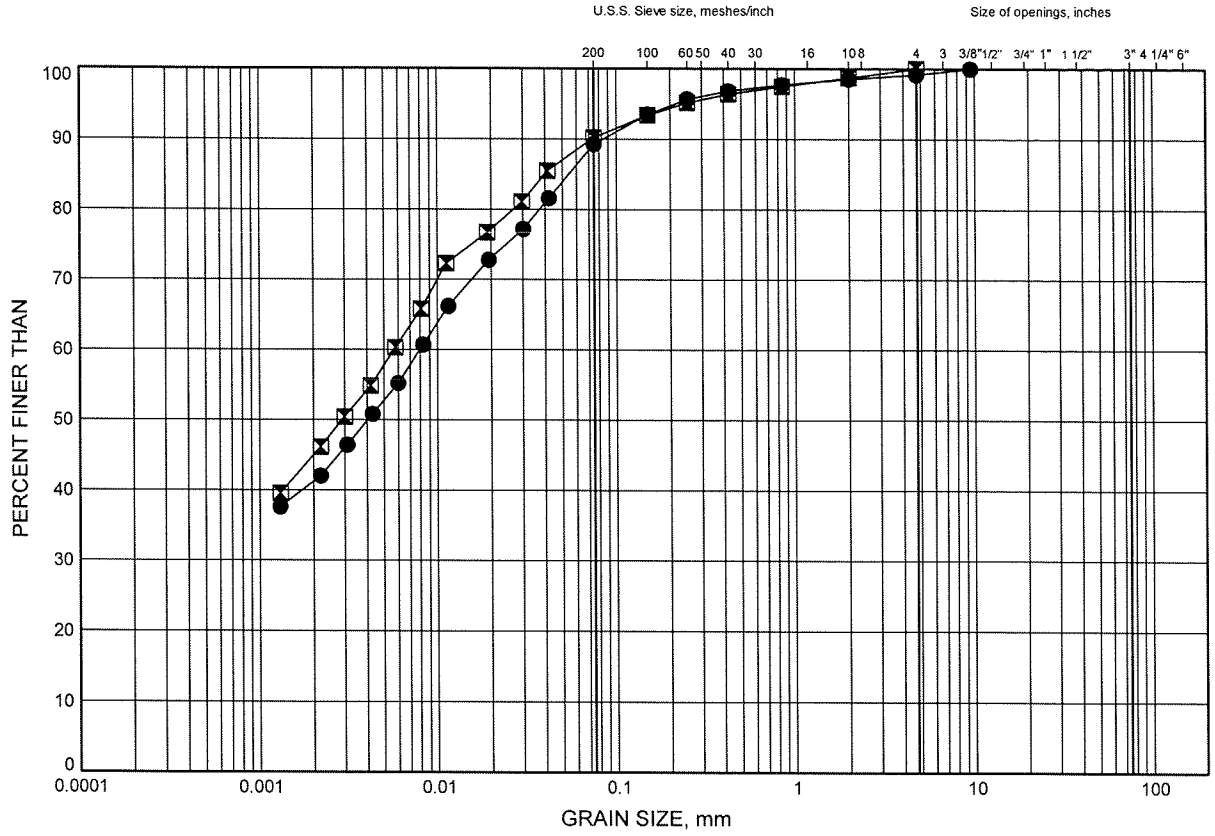
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 9/15/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty Clay Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-130	9.45	306.56
⊠	08-132	9.45	307.77

W.P.# 408-88-00
Prepared By MFA
Checked By RPR

THURBER

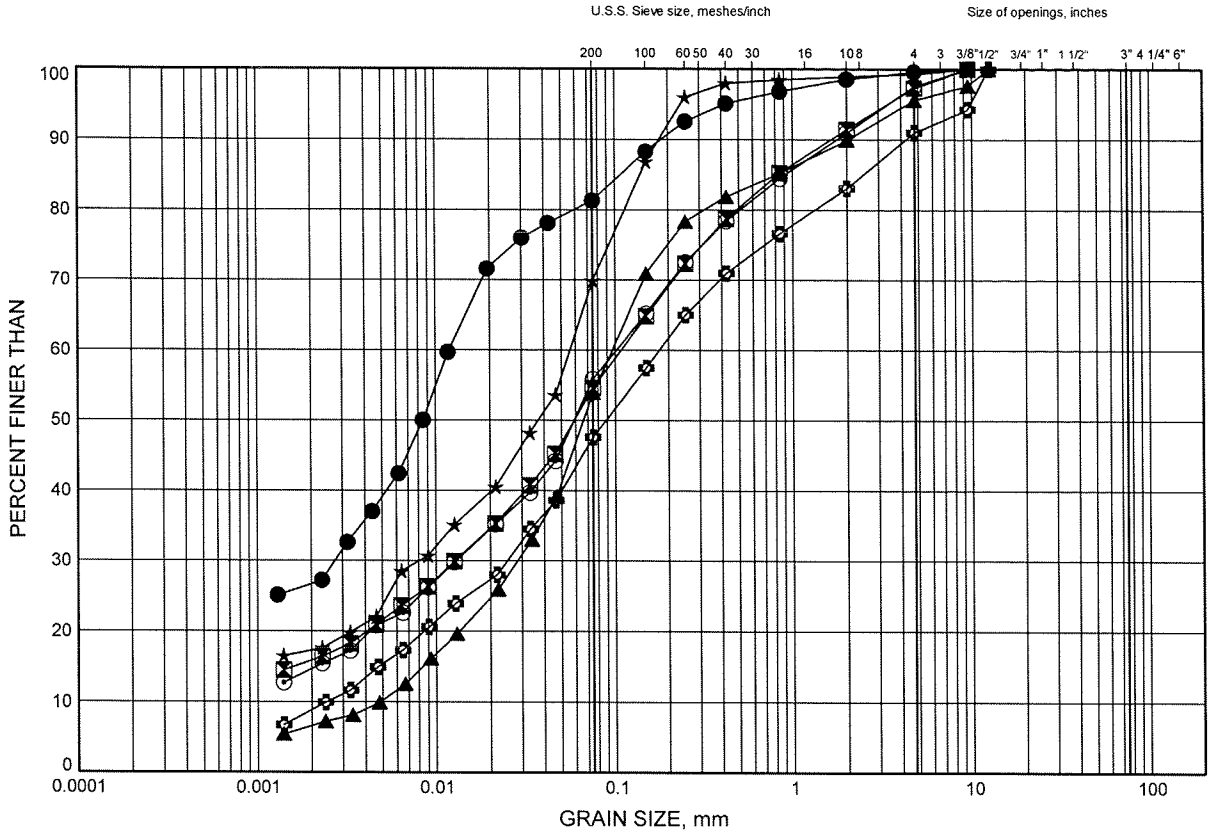
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 9/18/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B4

Sandy Silt Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-130	3.35	312.66
⊠	08-131	7.92	307.17
▲	08-131	10.83	304.26
☆	08-132	4.75	312.47
⊙	08-133	9.45	306.52
✿	08-133	12.32	303.65

W.P.# 408-88-00
Prepared By MFA
Checked By RPR

THURBER

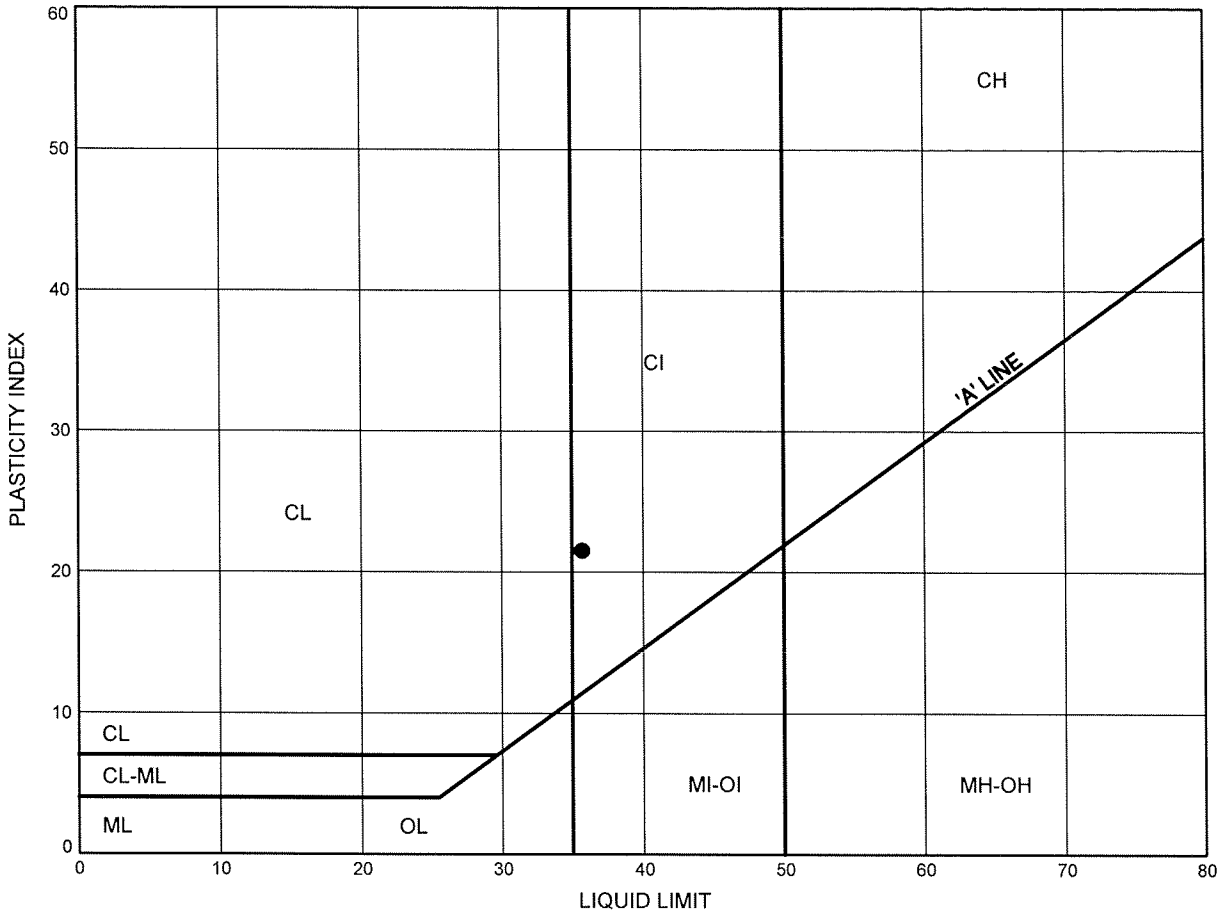
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 9/18/08

Highway 7 - New

ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty Clay Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-132	9.45	307.77

Date September 2008

Project 408-88-00

THURBER

Prep'd MFA

Chkd. RPR

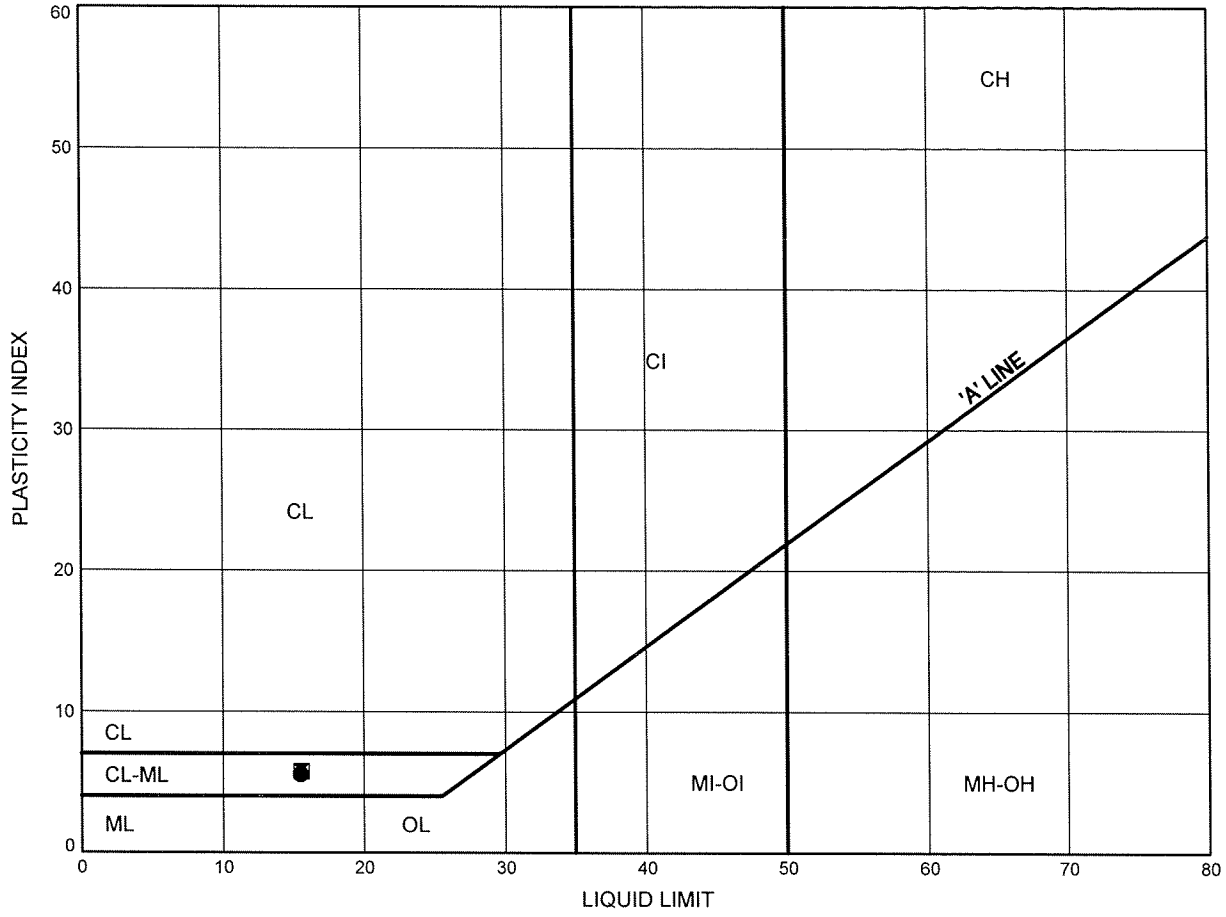
THURBALT 6417R.GPJ 9/18/08

Highway 7 - New

ATTERBERG LIMITS TEST RESULTS

FIGURE B6

Sandy Silt Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-131	7.92	307.17
⊠	08-133	9.45	306.52

Date September 2008

Project 408-88-00

THURBER

Prep'd MFA

Chkd. RPR

THURBALT 6417R.GPJ 9/4/08

Appendix C

Foundation Comparison

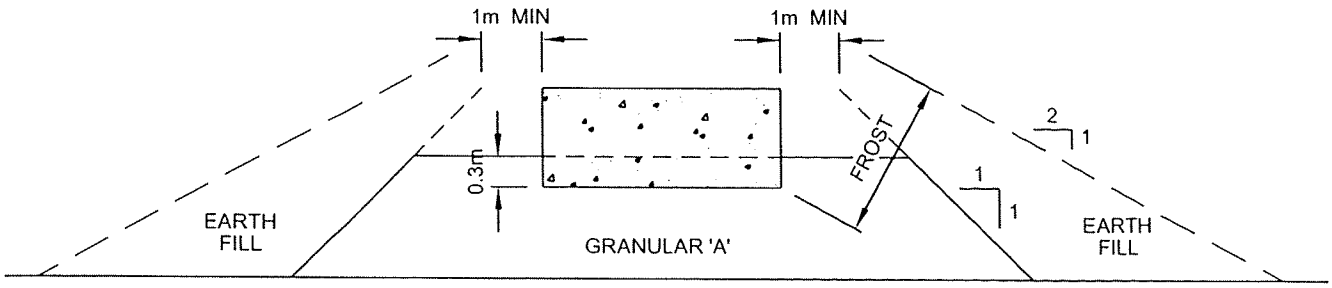
COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Foundation Element	Spread Footings	Spread Footings on Engineered Fill	Driven Piles
Abutments	***Advantages:*** i. Generally less costly construction than deep foundation elements. ***Disadvantages:*** i. Lower geotechnical resistance available due to founding on compact soils near the surface. ii. Dewatering may be required, depending on depth of excavation. iii. Foundations close to water would be at risk due to scour, erosion and undermining problems. **NOT RECOMMENDED**	***Advantages:*** i. Generally less costly construction than deep foundation elements. ***Disadvantages:*** i. Better geotechnical resistance than spread footings on native, but still influenced by the compact soils at the surface. ii. Dewatering may be required, depending on depth of excavation. iii. Foundations close to water would be at risk due to scour, erosion and undermining problems. **NOT RECOMMENDED**	***Advantages:*** i. High geotechnical resistance may be developed by driving the piles into very dense/hard soils. ii. Comparatively short abutment stem possible iii. Permits integral abutment design ***Disadvantages:*** i. Higher unit cost compared to footings. ii. Very dense/hard soils at shallow depth will limit length of pile and geotechnical resistance that can be developed. **RECOMMENDED**

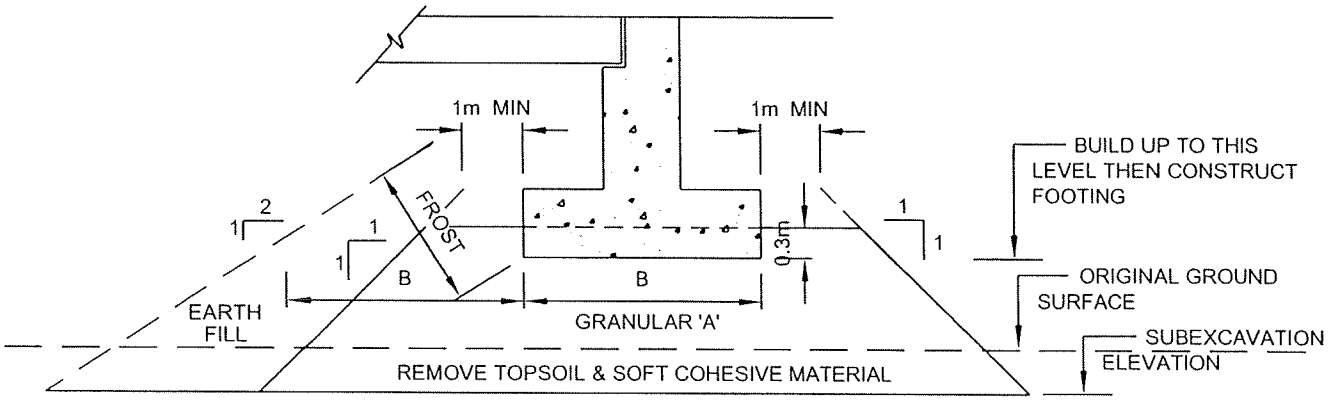
Appendix D

Figure

March , 2004



CROSS-SECTION



LONGITUDINAL SECTION

NOT TO SCALE

NOTES:

1. REMOVE TOPSOIL AND SOFT SILTY CLAY SUBSOIL UNDER FOOTPRINT OF COMPACTED GRANULAR 'A'.
2. PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO O.P.S.S. 501.
3. CONSTRUCT CONCRETE FOOTING.
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED.
5. SOURCE M.T.C. 1982.

ENGINEER AEG		
DRAWN SS	ABUTMENT ON COMPACTED FILL SHOWING GRANULAR A CORE	THURBER
DATE April , 2004		DWG. NO. FIGURE 1
APPROVED PKC		
SCALE NTS		

TED35146 .DWG

Appendix E

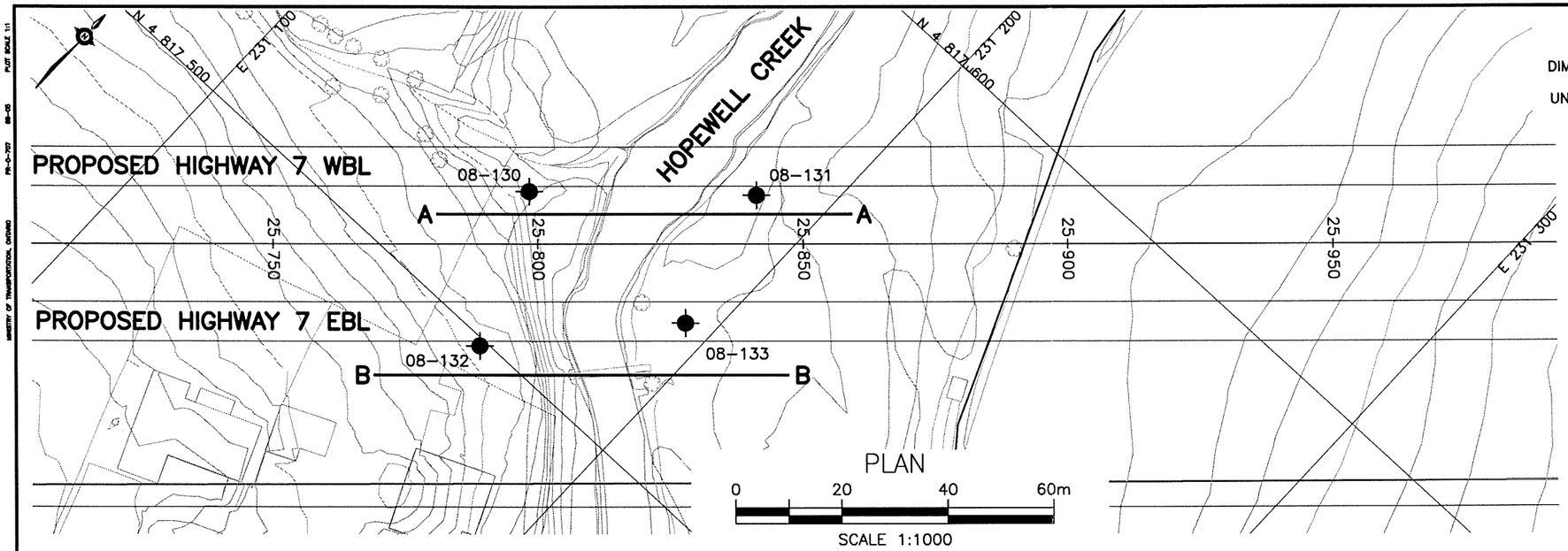
Site Photographs

Photo 1. Looking to the west side of the site

Photo 2. Looking to the south side of the site

Appendix F

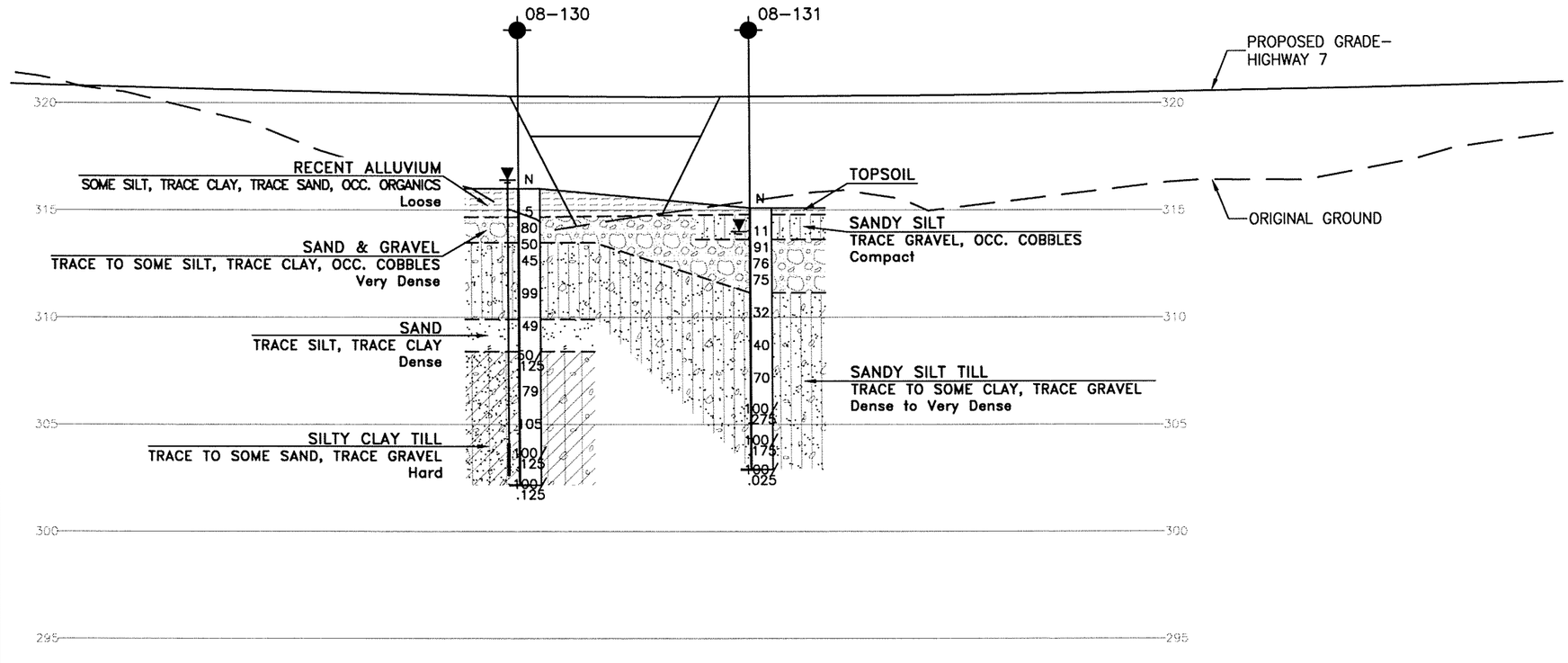
Drawing titled "Borehole Locations and Soil Strata"



PLAN

0 20 40 60m

SCALE 1:1000



PROFILE A–A ALONG ℄ OF PROP. HIGHWAY 7

0 20 40 60m HOR 1:1000

0 5 10 15m VER 1:250

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

METRIC

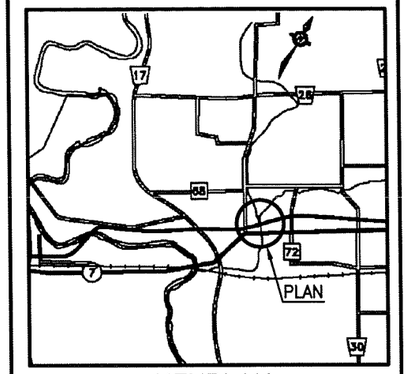
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
GWP No 408-88-00

SHEET

HIGHWAY 7
RECOMMENDED ROUTE
HOPEWELL CREEK
BOREHOLE LOCATIONS AND SOIL STRATA

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
▼	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
08-130	316.0	4 817 526.7	231 156.5
08-131	315.1	4 817 555.4	231 188.3
08-132	317.2	4 817 498.7	231 169.6
08-133	316.0	4 817 528.4	231 195.0

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Proposed grades are from Plate 9 of the E.A. Study.

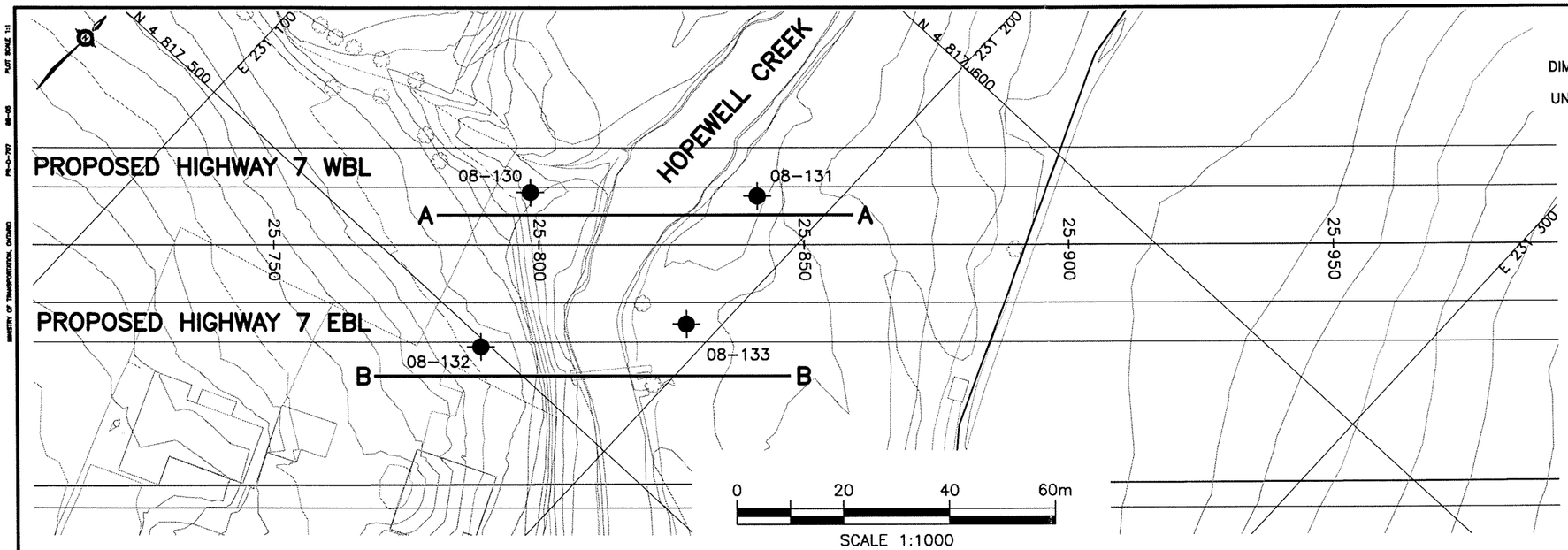
GEOCRES No. 40P8-153

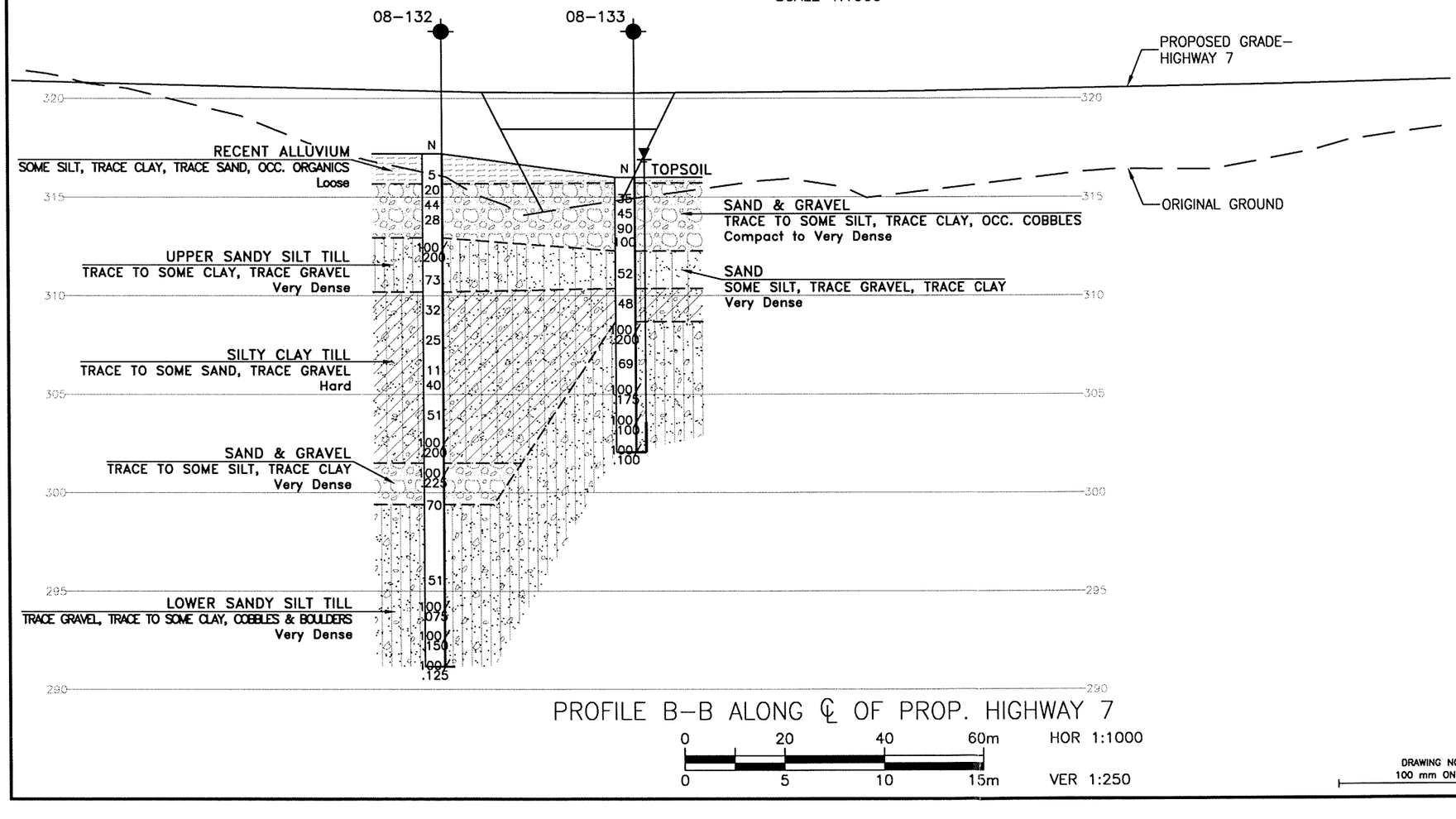
REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN AEG	CHK PKC	CODE	LOAD
DRAWN MFA	CHK AEG	SITE	STRUCT

DATE NOV. 2009
DWG

PLOT SCALE 1:1
PLOT DATE 88-05
PR-A-707
MINISTRY OF TRANSPORTATION, ONTARIO

FILENAME: H:\Drafting\13\64\17\1ed8417-HopewellCreek.dwg
PLOTDATE: Nov 12, 2009 - 4:40pm





PROFILE B–B ALONG ℄ OF PROP. HIGHWAY 7

0 20 40 60m HOR 1:1000

0 5 10 15m VER 1:250

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

METRIC

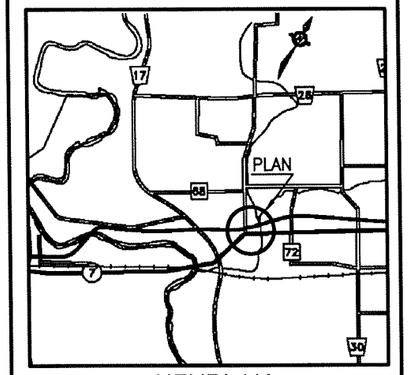
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
GWP No 408-88-00

HIGHWAY 7
RECOMMENDED ROUTE
HOPEWELL CREEK
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



KEYPLAN

LEGEND

●	Borehole
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N	Blows /0.3m (Std Pen Test, 475J/blow)
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▼	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
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GEOCRES No. 40P8-153

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	AEG	CHK	PKC	CODE		LOAD	
DRAWN	MFA	CHK	AEG	SITE		STRUCT	DWG

DATE NOV. 2009