

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
RETAINING WALL NORTH OF GRAND RIVER  
RECONSTRUCTION AND WIDENING OF HIGHWAY 8  
FROM 1.0 KM NORTH OF GRAND RIVER, SOUTHERLY  
TO SPORTSWORLD DRIVE, KITCHENER, ONTARIO  
G.W.P. 277-97-00**

**Geocres Number: 40P8-152**

**Report to**

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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual findings obtained from a foundation investigation conducted for a proposed retaining wall to be constructed in connection with the planned widening of Highway 8 in Kitchener, Ontario.

Highway 8 will be widened from four to eight lanes from 1 km north of the Grand River southerly to Sportsworld Drive. The project will require widening of an existing deep cut between Stations 13+400 and 13+650 located north of the Grand River.

A foundation investigation was previously carried out for the deep cut, and the results were documented in a report dated June 27, 2007 (Geocres No. 40P8-148). Since that time, the design has evolved to include a retaining wall within the cut section. This report presents information obtained from boreholes drilled along the proposed retaining wall alignment as well as data from the previous deep cut investigation.

The purpose of this investigation was to explore the subsurface conditions along the retaining wall alignment and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profiles, 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 Morrison Hershfield Limited, under the Ministry of Transportation Ontario (MTO) Agreement Number 3005-E-0035.

## **2 SITE DESCRIPTION**

The site is located along existing Highway 8 in Kitchener, Ontario. In the project area, Highway 8 rises in a northerly direction from near elevation 295 m at the Grand River bridge to near elevation 303 m at the north limit of the deep cut section. The existing cut section is approximately 250 m in length with a depth of up to 13 m below the adjacent tableland.

The ground surface on the tableland above the cut typically rises from about elevation 307 m at the north limit to elevation 310 m near the centre, and then falls gradually to elevation 308 m near the crest of the slope to the Grand River. The valley slope to the river is some 25 m high and inclined at approximately 2H:1V. Trees, brush and several residential dwellings are present on the tablelands.

Geologically, the site area is located within the physiographic region known as the Waterloo Hills, which is characterized by sandy hills consisting of ridges of sandy till as well as kames and kame moraines, with outwash sands occupying the intervening hollows. Locally, the Grand River spillway system contains alluvial terraces of uniform sandy and gravelly materials. The soils overlie Silurian limestone bedrock of the Guelph Formation.

## **3 SITE INVESTIGATION AND FIELD TESTING**

The site investigation and field testing for the current study (retaining wall) were carried out between May 16 and 22, 2008 and consisted of drilling and sampling six boreholes (Nos. 08-04 to 08-09) to depths of 6.7 to 20.1 m. The site investigation for the previous (deep cut) study was carried out during the period September 19 to 25, 2006 and consisted of drilling and sampling six boreholes (Nos. 06-28 to 06-33) to depths of 12.5 to 20.1 m.

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawings in Appendix E. The coordinates and elevations of the boreholes are given on these drawings and on the individual Record of Borehole Sheets in Appendix A.

Prior to commencement of drilling, utility clearances were obtained for all borehole locations. Permission to Enter was obtained before entering private properties.

Hollow stem augers were used to advance the boreholes. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). A member of Thurber's engineering staff supervised the drilling and sampling operations on a full time basis. The inspector logged the boreholes, visually examined the recovered samples, and transported them to Thurber's laboratory for further examination and testing.

Standpipe piezometers, consisting of 19 or 25 mm PVC pipes with slotted tip, were installed in selected boreholes to monitor groundwater levels. The remaining boreholes were grouted on completion of drilling. The completion details of the boreholes and piezometers are shown in Table C1 of Appendix C. The piezometers will be decommissioned in accordance with MOE Reg. 903.

#### **4 LABORATORY TESTING**

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets in Appendix A. Approximately 25% of the recovered samples were also subjected to grain size distribution analyses (sieve and hydrometer) and Atterberg Limits testing. 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**

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets in Appendix A and on the Borehole Locations and Soil Strata Drawings in Appendix E. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

In general terms, the site was found to be underlain by a unit of sand to silt, overlying silty clay till with interbeds of sandy silt till and sand and gravel. A deposit of sandy silt to silty sand till underlies the cohesive till. More detailed descriptions of the individual strata are presented below.

##### **5.1 Topsoil**

A 100 to 275 mm thick layer of topsoil was encountered at the ground surface in all boreholes. 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 Sand Fill**

A layer of sand fill extending to 1.4 m depth (elevation 306.6 m) was encountered below the topsoil in borehole 06-33. The fill was loose with a recorded SPT N-value of 8 blows/0.3 m. The moisture content was about 10%.

##### **5.3 Sand to Silt and Sand**

Native deposits of brown, non-cohesive sand to silt and sand were encountered below the topsoil and fill in all boreholes. These deposits typically contained a trace to some gravel and locally contained cobbles.

SPT N-values in the sand/silt deposits varied widely from 7 to 63 blows/0.3 m penetration, with several counts exceeding 50 blows/0.15 m. The relative density indicated by the N-values ranges from loose to very dense. It must be noted however that N-values of less than 10 blows (loose) were relatively isolated, and that N-values greater than 50 may reflect the presence of cobbles or boulders.

Moisture contents in this material varied significantly from 1 to 22%.

Grain size distribution results for the sand to silt and sand are presented on the Record of Borehole sheets and Figures B1, B2 and B9 of Appendix B. The results of laboratory tests carried out on 12 samples were as follows:

Gravel %	0 to 26
Sand %	13 to 95
Silt %	44 to 81 (where hydrometer was conducted)
Clay %	3 to 14 (where hydrometer was conducted)
Silt & Clay %	5 to 24 (sieve analysis only)

The lower boundary of the sand/silt material was encountered at depths of 1.4 to 6.3 m, generally increasing towards the south (elevation 301.7 to 306.1 m, highest near Station 13+500).

#### 5.4 Silty Clay Till

The upper sand/silt layer is underlain by a deposit of brown to grey silty clay till. The upper boundary at which clay till was first encountered in the boreholes ranged from depths of 1.4 to 9.2 m (elevation 298.8 to 306.1 m). The lower boundary was encountered at depths of 10.7 to 16.0 m (elevation 294.0 to 296.7 m). Boreholes 08-04 and 08-05 were terminated in the clay till at 6.7 and 9.8 m depth.

In five boreholes, a 0.5 to 2.8 m thick layer of sand and gravel to gravelly sand was encountered within the clay till, typically within 0.7 to 1.5 m of the upper boundary of this unit. At two locations (boreholes 06-33 and 08-05), the sand and gravel was encountered between the upper sand deposit and the clay till. Zones of sandy silt to silty sand till, 1.3 to 3.5 m thick, were also encountered in or above the clay till in three boreholes (boreholes 06-31, 06-32 and 08-08).

Standard Penetration Tests conducted in the clay till yielded N-values ranging from 25 blows/0.3 m penetration to 50 blows/0.075 m, indicating a very stiff to hard consistency. The higher N-values may reflect the presence of cobbles in the till. In borehole 08-04, N-values of 7 to 24 were obtained, indicating a firm to very stiff consistency.

Moisture contents generally ranged from 10 to 20%, with localized values as low as 3% likely resulting from the presence of gravel particles in the sample tested.

The results of grain size analyses carried out on 17 samples are tabulated below. One other sample from near 3.4 m depth in borehole 08-06 indicated a coarser gradation, with 13% gravel and 26% sand.

Gravel %	0 to 3
Sand %	1 to 15
Silt %	33 to 51
Clay %	36 to 65

Liquid Limit	28 to 51
Plastic Limit	14 to 21

The Atterberg Limits indicate that the silt clay till varies from a CL to marginal CH classification (low to high plasticity).

The grain size distribution curves for the samples tested are shown in Figures B4, B5, B11 and B12, Appendix B. The Atterberg Limits are plotted on Figures B7, B8, B14 and B15.

Glacial till is known to contain cobbles and boulders.

### **5.5 Sand and Gravel to Gravelly Sand**

Localized deposits of sand and gravel to gravelly sand were encountered within or above the silty clay till stratum in seven boreholes. The sand and gravel deposits were 0.5 to 2.8 m thick, with an upper boundary contacted at depths of 2.1 to 9.2 m (elevation 299.8 to 304.6 m).

SPT N-values in the sand and gravel layers ranged from 22 to 88 blows/0.3 m, indicating a compact to very dense condition. Moisture contents ranged from 5 to 20%. The results of grain size analyses conducted on five samples of this material (Figures B3 and B10) were as follows:

Gravel %	33 to 56
Sand %	37 to 56
Silt & Clay %	6 to 13

### **5.6 Interbedded Sandy Silt to Silty Sand Till**

Zones of sandy silt to silty sand till were encountered within or above the clay till locally in boreholes 06-31, 06-32 and 08-08. These zones ranged in thickness from 1.3 to 3.5 m, with upper boundaries at depths of 5.1 to 10.4 m (elevation 299.6 to 304.8 m).

N-values of 25 blows/0.3 m to 50 blows/0.1 m were obtained, indicating a compact to very dense condition. Moisture contents ranged from 6 to 12%. The results of grain size analyses conducted on two samples of this material are included on Figures B6 and B13.

### **5.7 Sandy Silt to Silty Sand Till**

Very dense, grey sandy silt to silty sand till was encountered below the clay till in all boreholes except boreholes 08-04 and 08-05. The upper boundary of this till was encountered at depths of 10.7 to 16.0 m (elevation 294.0 to 296.7 m). Drilling was terminated in the till at depths of 11.0 to 20.1 m (elevation 288.0 to 296.4 m).

All SPT test conducted in the silt/sand till deposit achieved 50 blows for less than 150 mm of penetration, indicating a very dense condition. Moisture contents from this deposit ranged from 4 to 12%, with one value of 19% obtained locally.



The results of the grain size distribution analyses conducted on nine samples are presented on Figures B6 and B13. The results are summarized below. Glacial till is known to contain cobbles and boulders.

Gravel %	2 to 24 (typically 2 to 6)
Sand %	27 to 48
Silt %	28 to 53
Clay %	11 to 16

## 5.8 Groundwater Conditions

The sand and gravel and/or upper sand/silt deposits immediately above or within the upper part of the clay till unit were described as wet in eight of the boreholes. The wet conditions indicate that groundwater may be perched in the non-cohesive soils above or within the less permeable clay till.

Standpipe piezometers were installed in selected boreholes to monitor water levels after drilling. The water levels measured in the piezometers are summarized in Table 5.1.

**Table 5.1 – Measured Groundwater Levels**

Borehole	Date	Water Level (m)	
		Depth	Elevation
06-28	18-Sept-2006	11.3	295.8
	20-Sept-2006	11.4	295.7
	21-Sept-2006	11.4	295.7
	22-Sept-2006	11.5	295.6
	29-Sept-2006	11.5	295.6
06-29	20-Sept-2006	17.0	291.2
	21-Sept-2006	13.4	294.8
	22-Sept-2006	13.3	294.9
	29-Sept-2006	13.3	294.9
06-30	21-Sept-2006	11.8	298.7
	22-Sept-2006	12.2	298.3
	29-Sept-2006	15.9	294.6
06-31	21-Sept-2006	19.7	290.3
	22-Sept-2006	14.5	295.5
	29-Sept-2006	16.3	293.7
06-32	29-Sept-2006	17.5	291.7
06-33	22-Sept-2006	16.0	292.0
	25-Sept-2006	17.5	290.5
	29-Sept-2006	17.6	290.4
08-05	22-May-2008	4.3	302.3
	19-Aug-2008	Destroyed	-
08-07	22-May-2008	16.5	291.9
	19-Aug-2008	14.0 (damaged)	294.4
08-09	22-May-2008	17.4	291.6
	19-Aug-2008	17.3	291.7

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. Further, perched water may be encountered at higher levels in zones of more permeable sand and gravel, or sand/silt above or within the clay till.

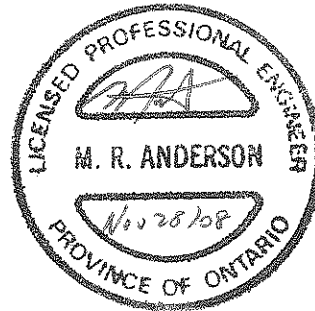
## 6 MISCELLANEOUS

Thurber Engineering Ltd. selected the borehole locations in the field relative to existing site features with consideration of access restraints, terrain conditions, and utility locations. Callon Dietz Inc., retained by Morrison Hershfield, subsequently established the co-ordinates and ground surface elevations at the staked borehole locations.

All-Terrain Drilling of Waterloo supplied and operated the drilling and sampling equipment used for the investigation. Full time supervision of the field activities, including obtaining utility clearances, was carried out by Mr. Stephane Loranger and Mr. Keli Shi.

Interpretation of the field data and preparation of the investigation report were conducted by Mr. Murray Anderson, P.Eng. Overall supervision of the field program and review of the report was provided by Mr. Alastair 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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**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 for the proposed retaining wall north of Grand River.

Highway 8 will be widened from four to eight lanes from 1 km north of the Grand River southerly to Sportsworld Drive. The project will require widening of an existing deep cut within an elevated area of land north of the Grand River. The existing cut section is approximately 250 m in length with a depth of up to 13 m below the adjacent tableland.

The current design calls for the retaining wall to be constructed along the west edge of the southbound shoulder, with the slope behind the wall cut upwards at an inclination of 2H:1V. Three alternative wall designs are being considered: a conventional cantilever wall with granular backfill, a soldier pile wall with no excavation behind the wall, and an RSS wall.

The foundation investigation was originally carried out for a proposed retaining wall to be constructed at the toe of the cut slope for a distance of 250 m (Station 13+375 and 13+625). The preliminary General Arrangement drawing dated February 6, 2008 indicated that the top of wall would fall from El. 305.0 at the north end to El. 298.0 at the south end, and the edge-of-shoulder at the wall base would fall correspondingly from El. 303.8 to El. 295.6. The exposed wall height would typically be about 2.5 m. Since that time, the wall length has been reduced to 85 m (Station 13+370 to 13+455) with a maximum wall height of 2.7 m.

A separate Foundation Investigation and Design Report was prepared for the deep cut section (report dated June 27, 2007). This report addresses the design and construction of the proposed retaining wall.

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 the investigation.

## 8 RETAINING WALL FOUNDATIONS

The subsurface stratigraphy at the site generally consists of an upper unit of sand to silt (typically compact), underlain by very stiff to hard silty clay till with interbeds of sandy silt till and sand and gravel, overlying very dense sandy silt to silty sand till.

As noted above, three alternative wall designs are being considered: a conventional cantilever wall with granular backfill, a soldier pile wall with no excavation behind the wall, and an RSS wall. Foundation recommendations for each type of wall are presented below.

### 8.1 Cantilever Wall on Spread Footings

For a cantilever wall, the bottom of the footing is expected to fall from approximate El. 301.5 at Station 13+375 to approximate El. 294.5 at Station 13+625. Based on the borehole data, the subgrade material at the anticipated founding level will typically comprise very stiff to hard clay till and very dense sandy silt till, as summarized in Table 8.1 below.

**Table 8.1 – Anticipated Conditions at Wall Founding Level**

Station	Founding* Elevation	Borehole No.	Stratigraphy	
			Elevation	Material
13+375	301.5	08-04	301.5 to 301.4	Compact sand and gravel
			301.4 to 301.0	Firm clay till
			301.0 to 297.9	Very stiff clay till
13+400	300.8	08-05	300.8 to 296.8	Very stiff to hard clay till
13+450	299.4	08-06	299.4 to 296.7	Very stiff to hard clay till
			296.7 to 296.4	Very dense silt and sand till
13+500	298.0	08-07	298.0 to 296.1	Hard clay till
			296.1 to 291.6	Very dense sandy silt till
13+550	296.6	08-08	296.6 to 296.1	Hard clay till
			296.1 to 288.2	Very dense sandy silt till
13+600	295.2	08-09	295.2 to 288.9	Very dense silt and sand till
13+625	294.5	06-33	294.5 to 288.0	Very dense silt and sand till

\* The founding levels at Stations 13+400 to 13+600 were estimated by linear interpolation.

It is recommended that all retaining wall footings be founded on the very stiff to hard clay till and/or the underlying very dense sandy silt till. Locally at the north limit of the wall (Sta. 13+375), compact sand and gravel and firm clay till are present at the design founding level. At this location, it will be necessary to extend the footing down approximately 0.5 m below the design level to found on the very stiff clay till at El. 301.0.

The following geotechnical parameters are recommended for design of spread footings founded at the elevations indicated in Table 8.1:

**Table 8.2 – Recommended Design Parameters for Spread Footings on Native Soil**

Parameter	Sta. 13+375 to 13+400	Sta. 13+400 to 13+600	Sta. 13+600 to 13+625
Founding Soil	Very Stiff Clay Till	Very Stiff to Hard Clay Till	Very Dense Silt and Sand Till
Factored Resistance at ULS (kPa)	300	550	750
Resistance at SLS (kPa)	200	375	Will not govern
Ultimate Coefficient of Friction at Footing Base	0.5	0.5	0.6

The resistance values are for approximate 3 m wide footings and vertical, concentric loads. In accordance with the CHBDC Clauses 6.7.3 and 6.7.4, the design must also account for the effects of any eccentric or inclined loads applied.

The friction coefficients presented in the table are “ultimate” values and require a degree of sliding movement to occur to fully mobilize the resistance.

The bases of the foundation excavations should be inspected by a geotechnical engineer to confirm that the exposed surface conforms to the design requirements, has been adequately prepared to receive concrete, and consists of very stiff to hard native till below the level of all fill, loose or firm material.

All footings should be provided with a minimum of 1.4 m of earth cover over the footing base as protection against frost action. It is possible to reduce the thickness of earth cover by the substitution of synthetic insulation. Typically, 25 mm of extruded polystyrene insulation is equivalent to 600 mm of soil cover.

## 8.2 Soldier Pile and Lagging Wall

The preliminary general arrangement drawing provided by Morrison Hershfield indicates a conceptual soldier pile and lagging wall design consisting of steel piles installed in 900 mm diameter pre-augered holes filled with concrete (caisson). A typical caisson length of 7.5 m and caisson spacing of 2.4 m is indicated.

Based on the borehole data, the caissons will extend through native very stiff to hard silty clay till and into very dense silt/sand till. Resistance to axial loads will be developed through a combination of sidewall shear and end bearing of the caisson in the till. However, to avoid potential difficulties in preparing the caisson base (dewatering, cleaning and inspection), it is recommended that the caisson design be based on sidewall shear only. The recommended values for sidewall resistance are as follows:

	Very Stiff to Hard Clay Till	Very Dense Silty Sand to Sandy Silt Till
Factored Shaft Resistance at ULS	50 kPa	100 kPa
Shaft Resistance at SLS	40 kPa	80 kPa

Resistance to lateral movement of a soldier pile retaining wall will be provided by the passive earth pressure developed on the face of the caisson embedded in native, very stiff to hard silty clay till or the underlying very dense silt/sand till. Resistance within the upper 1.4 m of the finished ground surface should be neglected.

The lateral resistance that can be mobilized in front of the pile socket may be computed using the coefficient of horizontal subgrade reaction  $k_s$  and ultimate lateral resistance  $p_{ult}$  estimated as follows:

$$\begin{aligned} k_s &= n_h z / D && (\text{kN/m}^3) \text{ for cohesionless soils} \\ &= 67 c_u / D && (\text{kN/m}^3) \text{ for cohesive soils} \\ p_{ult} &= 3 \gamma z K_p (\text{kPa}) && \text{for cohesionless soils} \\ &= 2 c_u \text{ at the surface, increasing linearly to } 9 c_u \text{ at a depth of} && \\ &\quad \text{three caisson diameters (D), and } 9 c_u \text{ below this depth,} && \\ &\quad \text{for cohesive soils (kPa)} && \end{aligned}$$

where	$z$	=	depth of embedment of caisson (m)
	$D$	=	caisson diameter (m)
	$n_h$	=	coefficient of horizontal subgrade reaction (Table C2)
	$c_u$	=	undrained shear strength (Table C2)
	$\gamma$	=	bulk unit weight (Table C2), use submerged unit weight below water table
	$K_p$	=	passive earth pressure coefficient (Table C2)

The recommended parameters for lateral design are provided in Table C2, Appendix C.

The above equations and recommended parameters may be used for numerical analysis of the interaction between the caisson and surrounding soil. The lateral pressures obtained by the numerical analysis should not exceed the ultimate lateral resistance.

The spring constant  $K_s$  and ultimate spring load  $P_{ult}$  values for numerical analysis can be obtained by multiplying the  $k_s$  and  $p_{ult}$  values by the caisson diameter and the vertical distance between nodal points of the numerical model mesh along the caisson.

### 8.3 Retained Soil Systems

A retained soil system (RSS) wall may be used subject to the requirements presented in this section. The RSS wall should be specified to be “High Performance” and “High Appearance”. The contract drawings should include information on the longitudinal alignment of the wall in plan, the top and base elevations of the wall in profile, cross-sectional space constraints and an NSSP for the RSS wall.

The performance of a RSS is dependent on, among other factors, the characteristics of its foundation. Failure to provide an adequate foundation may lead to settlement and distortion of the RSS and, in severe cases, to possible failure of the system. The foundation of the entire RSS mass must be considered, i.e. from the face of the wall to the furthest extent of the reinforcement.

To provide an acceptable foundation performance, the RSS mass must be founded on native very stiff to hard clay till or compact to very dense sand/silt till. The levelling pad below the wall face should be placed on a minimum 0.6 m thick pad of granular engineered fill at least twice as wide as the levelling pad, and at least 0.6 m below the ground surface in front of the wall.

Based on the edge-of-shoulder grades shown on the preliminary General Arrangement drawing, the anticipated wall founding level will fall from near elevation 302.4 at Station 13+375 to elevation 295.0 m at Station 13+625 (similar to the top-of-caisson elevation shown in Table C2, Appendix C). The borehole data indicates that the subgrade at this level will comprise native very stiff to hard clay till, locally very dense sand/silt till.

In general, a wall founded on the very stiff to hard clay till should be designed for a factored bearing resistance of 550 kPa at ULS and a bearing resistance of 375 kPa at SLS. Locally at the north end of the wall (Station 13+375 to 14+000), reduced values of 300 kPa at factored ULS and 200 kPa at SLS are recommended to account for the compact sand and firm to very stiff clay till encountered in borehole 08-04.

Topsoil, loose fill, and any soft/wet native material should be stripped from the footprint of the RSS. Fill placed under the RSS mass to achieve the design founding level must be placed as engineered fill, consisting of OPSS Granular "A" compacted to 100% of its SPMDD at a moisture content within 2% of optimum.

The entire block of reinforced earth must be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall on native clay till or sand/silt till may be estimated using an ultimate friction coefficient of 0.5.

The supplier of the proprietary RSS system must demonstrate that it will meet the Ministry's specifications for performance and appearance. The RSS supplier/designer may specify more stringent criteria or other requirements related to the particular design. The internal stability of the RSS wall should be analyzed by the supplier/designer of the proprietary product selected for this site.

## 9 EXTERNAL STABILITY

The stability of the cut slope was analysed during preparation of the Deep Cuts and High Fill Embankments Foundation Design Report. Using the commercially available slope stability program GSLOPE (Mitre Software Inc.) and Bishop's modified method of slices, a cut slope

inclination of 2H:1V with a mid-height bench was found to be stable at this site in short-term, long-term and seismic conditions.

The stability analysis was revisited to assess the impact of construction of a 2.5 m high retaining wall at the toe of the slope. The computed factor of safety for critical long-term conditions was not significantly affected by wall construction (F.S. = 1.5). Based on these results, the proposed geometry of the cut slope and retaining wall is considered to be stable.

## 10 BACKFILL AND LATERAL EARTH PRESSURES

Earth pressures acting on the walls may be assumed to be triangular and to be governed by the characteristics of the backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC (2006) but generally are given by the expression:

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

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

$K$  = earth pressure coefficient (see Table C3)

$\gamma$  = unit weight of retained soil (see Table C3)

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

$q$  = value of any surcharge (kPa)

The lateral earth pressure coefficients to be employed during wall design are dependent on the type of material used as backfill (if any), provision of drainage, the relative movement between the wall and adjacent soil, and the inclination of the backslope behind the wall. The recommended earth pressure coefficients for a fully drained condition are provided in Table C3, Appendix C.

If a cantilever wall with backfill is employed, the backfill should consist of Granular A or Granular B material, and corresponding lateral earth pressure coefficients for granular material should be used for design. The backfill must be in accordance with OPSS 902 as amended by Special Provision 902S01, and placed to the extents shown in OPSD 3121.150 where applicable.

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) might be preferred as it results in lower earth pressures acting on the wall.

The coefficients for native clay till should be employed where excavation will not be carried out behind the wall (ie., soldier pile wall supporting native material) or where the back face of the excavation behind the wall is inclined steeper than 1H:2V from the heel of the wall (such as shown for “cut treatment” on OPSD 3121.150).

For a wall restrained from lateral movement by such means as soil anchors, the at-rest earth pressure coefficients should be employed. In this case, the weight of the material in the backslope



above the top of the wall should be treated as a surcharge load when computing the earth pressure acting on the wall.

The factors in Table C3 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 Canadian Highway Bridge Design Code.

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

Compaction equipment to be used adjacent to retaining structure must be restricted in accordance with OPSS 501.07.

The design of the retaining walls must incorporate a subdrain as shown in OPSD 3121.150 and 3190.100, or as per the RSS supplier specifications.

## 11 SEISMIC CONSIDERATIONS

The site is treated as lying in Seismic Zone 1. The following seismic parameters should be used for design:

- Velocity Related Seismic Zone                      0
- Zonal Velocity Ratio                                      0.05
- Acceleration Related Seismic Zone                1
- Zonal Acceleration Ratio                              0.05
- Peak Horizontal Acceleration                        0.08

The soil profile type at this site has been classified as Type 1. Therefore, according to Table 4.4.6.1 of the CHBDC, a Site Coefficient “S” (ground motion amplification factor) of 1.0 should be used in seismic design.

The potential for liquefaction of the foundations soils was assessed using the Seed and Idriss (1971) method. Using this method, it was determined that the foundation soils are not in danger of liquefaction.

In accordance with Clause 4.6.4 of the CHBDC, retaining structures should be designed using active ( $K_{AE}$ ) and passive ( $K_{PE}$ ) earth pressure coefficients that incorporate the effects of earthquake loading. In calculating the active, passive and at rest earth pressure coefficients the angle of friction between the wall and backfill material is assumed to be  $0.5 \phi$ . For the design of retaining walls, the coefficients of horizontal earth pressure in Table 11.1 may be used:

**Table 11.1 – Earth Pressure Coefficients for Earthquake Loading**

Wall Condition	Granular A or Granular B Type II $\phi = 35^\circ \delta = 17.5^\circ \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ \delta = 16^\circ \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active ( $K_{AE}$ )*	0.28	0.46	0.31	0.58
Passive ( $K_{PE}$ )	7.0	-	5.5	-
At Rest ( $K_{OE}$ )**	0.53	-	0.58	-

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

\*\* After Woods

## 12 EXCAVATION AND DEWATERING

Excavation and backfilling for retaining wall construction should be carried out in accordance with SP 902S01 and the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the soils near the level of the retaining wall foundations may generally be classified as Type 2 soils. North of Station 13+400, a Type 3 classification should be applied.

Temporary excavation slopes should not exceed 1V:1H. Where this cannot be accommodated, a shored and braced excavation should be used. Roadway protection should be supplied in accordance with SP 105S19 and designed for Performance Level 2. The design of roadway protection should be the responsibility of the Contractor.

Soldier pile/caisson installation should generally be carried out in accordance with SP 903S01. The contract documents should contain an NSSP alerting the contract bidders of the specific aspects relating to caisson construction at this site. Suggested wordings for this NSSP are provided in Appendix D. Caisson installation equipment must be able to dislodge, handle and remove cobbles and boulders that may be present in the glacial till.

Selection of the appropriate excavation procedures and dewatering system is the responsibility of the Contractor. The Contract documents should alert him to the requirement to maintain a stable excavation and a dry, sound base on which to work. Any shoring system should be designed by a shoring specialist, taking account of the need to maintain the integrity of the existing structure foundations, and the potential for groundwater seepage.

Based on the borehole information, excavation for foundation construction is not expected to extend below the groundwater level at the site. However, seepage may be experienced from perched zones in the upper sand/silt deposit, sand and gravel layers (such as in Borehole 08-05), or from sand and silt pockets/lenses in the underlying heterogeneous till deposits. Removal of this water from the excavation using sumps and pumps is considered feasible. The design of any dewatering system that may be required is the responsibility of the Contractor.

Caisson installation may extend below the measured groundwater levels, however seepage from the very dense sand/silt till is expected to be minimal. Temporary liners should be available on site to support the caisson sidewalls and provide seepage cut-off if more permeable zones are encountered in the till.

### 13 CONSTRUCTION CONCERNS

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

- Caisson installation in the very dense till soils may require laborious augering.
- Cobbles and boulders may be encountered during caisson installation and foundation excavation in the till and sand and gravel.
- Localized seepage of perched water may be experienced, requiring drainage.

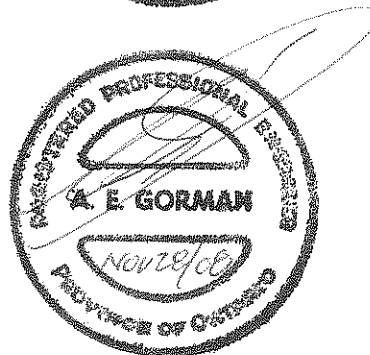
### 14 CLOSURE

Engineering analysis and preparation of the foundation design report was conducted by Mr. Murray Anderson, P.Eng. The report was reviewed by Mr. Alastair Gorman, P.Eng., and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

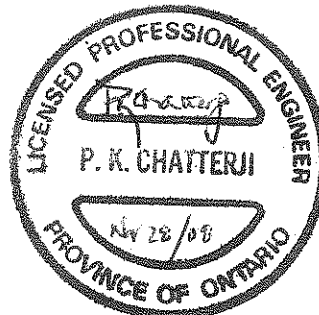
Thurber Engineering Ltd.  
Murray R. Anderson, P.Eng., M.Eng.  
Senior Geotechnical Engineer



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



P.K. Chatterji, P.Eng., Ph.D.  
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 <sup>(1)</sup> '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
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

## EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION		SYMBOLS	
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)

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
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

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.

# RECORD OF BOREHOLE No 06-28

1 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 498.24 E 230 248.75 ORIGINATED BY SLL  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2006-09-19 - 2006-09-19 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
307.1							20	40	60	80	100		
0.0	TOPSOIL: (250mm), black												
306.8													
0.3	SILT and SAND, some clay, trace gravel Compact Brown Moist: (TILL)		1	SS	11								
			2	SS	22								0 36 48 14
304.8													
2.3	SAND, trace silt, trace gravel Very dense Brown Moist to wet		3	SS	63								
303.9													
3.1	Silty CLAY, trace sand Hard Brown (TILL)		4	SS	71								
302.9													
4.2	Gravelly SAND, some silt Compact to Dense Brown Wet		5	SS	27								33 54 13 (SI+CL)
	Occasional cobbles		6	SS	38								
300.1													
7.0	Silty CLAY, trace sand, trace gravel Hard Grey (TILL)(CH)		7	SS	56								
			8	SS	72								0 2 35 63

Continued Next Page

+<sup>3</sup> X<sup>3</sup> Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 06-28

2 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 498.24 E 230 248.75 ORIGINATED BY SLL  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2006-09-19 - 2006-09-19 CHECKED BY MEF

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)				
Continued From Previous Page							20 40 60 80 100 O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE					20 40 60 W <sub>p</sub> W W <sub>L</sub>					
295.5	11.6		9	SS	76/ 275		297										
								296									
294.6			10	SS	50/ 150		295										
12.5	END OF BOREHOLE AT 12.50m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 18/09/06 11.32 295.76 20/09/06 11.35 295.73 21/09/06 11.41 295.67 22/09/06 11.45 295.63 29/09/06 11.49 295.59																

## METRIC

[illegible]

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 06-29

2 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 480.35 E 230 275.72 ORIGINATED BY SLL  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2006-09-19 - 2006-09-20 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100						20 40 60
Continued From Previous Page															
296.3	SILT and SAND, trace clay, trace gravel Very dense Grey Moist: (TILL)		9	SS	44									0 2 37 61	
11.9															
			10	SS	50/ .125										
			11	SS	50/ .125										2 41 41 16
			12	SS	50/ .125										
			13	SS	50/ .025										
			14	SS	50/ .125										
288.3			15	SS	50/ .125										

Continued Next Page

+ 3 . X 3 : Numbers refer to  
Sensitivity

20  
15 10 5  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 06-29

3 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 460.35 E 230 275.72 ORIGINATED BY SLL  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2006-09-19 - 2006-09-20 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	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 (%) W <sub>p</sub> W W <sub>L</sub>				
19.9	<p>Continued From Previous Page</p> <p>END OF BOREHOLE AT 19.94M. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.</p> <p>WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 20/09/06 17.00 291.19 21/09/06 13.38 294.81 22/09/06 13.28 294.91 29/09/06 13.33 294.86</p>				125												

ONTMT4S 7938.GPJ 11/26/08

# RECORD OF BOREHOLE No 06-30

1 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 440.12 E 230 337.88 ORIGINATED BY SLL  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2006-09-20 - 2006-09-20 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100					
310.5													
0.0	TOPSOIL: (250mm), black												
310.3													
0.3	SILT and SAND, trace gravel, trace clay Loose to Compact Brown Moist		1	SS	8								
308.5			2	SS	11								
2.0	SAND, trace silt Compact Brown Moist		3	SS	28								
			4	SS	24								
306.5													
4.0	SILT and SAND, trace gravel, trace clay Dense Brown Wet		5	SS	35								
305.0													
5.5	Silty CLAY, trace sand, trace gravel Grey (TILL)												
304.3													
6.2	SAND and GRAVEL, trace silt Very dense Grey Wet		6	SS	72								
303.8													
6.7	Silty CLAY, trace sand, trace gravel Grey (TILL)												
303.2													
7.3	SAND and GRAVEL, trace silt Very dense Grey Wet		7	SS	88								
301.3													
9.2	Silty CLAY, trace sand, trace gravel Hard Grey (TILL)(CH)		8	SS	50/ .150								

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+<sup>3</sup>.X<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 06-30

2 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 440.12 E 230 337.88 ORIGINATED BY SLL  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2006-09-20 - 2006-09-20 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	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							
			9	SS	66		300								
							299								
			10	SS	40		298							0 2 33 65	
							297								
			11	SS	50/ .125		296								
295.7							295								
14.8	SILT and SAND, some clay, trace gravel, occasional cobbles Very dense Grey Moist: (TILL)		12	SS	50/ .150		294								
							293								
			13	SS	50/ .125		292							5 40 39 16	
							291								
			14	SS	50/ .125										
			15	SS	50/ .125										
290.6															

Continued Next Page

+<sup>3</sup> × 3: Numbers refer to  
Sensitivity

20  
15 10 5  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 06-30

3 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 440.12 E 230 337.88 ORIGINATED BY SLL  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2006-09-20 - 2006-09-20 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	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 (%) W <sub>P</sub> W W <sub>L</sub>				
19.9	Continued From Previous Page  END OF BOREHOLE AT 19.94m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 21/09/06 11.84 298.67 22/09/06 12.19 298.32 29/09/06 15.95 294.56				125												

ONTMT4S 7938.GPJ 11/26/08

# RECORD OF BOREHOLE No 06-31

1 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 416.03 E 230 366.92 ORIGINATED BY SLL  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2006-09-21 - 2006-09-21 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>
310.0								20 40 60 80 100							
0.0															
0.1	TOPSOIL: (100mm), black														
	SAND, trace silt, trace gravel														
	Dense to Compact														
	Brown														
	Moist														
			1	SS	44										
			2	SS	32										
			3	SS	27										
307.0															
2.9	SILT, some sand to sandy, trace clay														
	Compact														
	Brown														
	Moist to wet														
			4	SS	23										
			5	SS	13										
304.8															
5.1	Sandy SILT, some clay, trace gravel														
	Compact														
	Grey														
	Moist: (TILL)														
			6	SS	25										
			7	SS	71										
302.3															
7.6	Silty CLAY, trace sand, occasional cobbles														
	Hard														
	Grey														
	(TILL)														
			8	SS	64										

Continued Next Page

+<sup>3</sup> × 3<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 06-31

2 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 416.03 E 230 366.92 ORIGINATED BY SLL  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2006-09-21 - 2006-09-21 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	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 × LAB VANE		WATER CONTENT (%) W <sub>P</sub> W W <sub>L</sub>				
	Continued From Previous Page						20 40 60 80 100							
299.6														
10.4	Sandy SILT, some clay, trace gravel, occasional cobbles Very dense Grey Moist: (TILL)		9	SS	50/ .125									
298.2														
11.7	Silty CLAY, trace sand, occasional cobbles Hard Grey (TILL)(CH)		10	SS	90									0 1 36 63
			11	SS	50/ .125									
			12	SS	50/ .125									
294.0														
16.0	Silty SAND, some gravel, occasional cobbles Very Dense Grey Moist: (TILL)		13	SS	50/ .125									
			14	SS	50/ .125									24 48 28 (SI+CL)
290.0			15	SS	50/ .125									

Continued Next Page

+<sup>3</sup> X<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15-5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 06-31

3 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 416.03 E 230 366.92 ORIGINATED BY SLL  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2006-09-21 - 2006-09-21 CHECKED BY MEF

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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
19.9	<p>Continued From Previous Page</p> <p>END OF BOREHOLE AT 19.94m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.</p> <p>WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 21/09/06 19.68 290.28 22/09/06 14.48 295.48 29/09/06 16.28 293.68</p>				125												

+ 3 . X 3 : Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 06-32

1 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 393.01 E 230 412.34 ORIGINATED BY SLL  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2006-09-22 - 2006-09-25 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)	
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL				× LAB VANE
309.2							20 40 60 80 100							
0.0	TOPSOIL: (275mm), black													
308.9														
0.3	SAND, trace silt, trace gravel Compact Brown Moist		1	SS	10									
			2	SS	12									
307.0														
2.2	SAND, some silt to silty, trace gravel Dense to Compact Brown Moist		3	SS	33									
			4	SS	17									
			5	SS	37									
303.6														
5.6	Silty CLAY, trace sand, trace gravel Hard Grey (TILL)		6	SS	47									
302.0														
7.2	Sandy SILT, some clay, trace gravel Very dense Grey Moist: (TILL)		7	SS	50/ .100									
			8	SS	50/ .100									

Continued Next Page

+ <sup>3</sup> , X <sup>3</sup> : Numbers refer to  
Sensitivity

20  
15 10 5  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 06-32

2 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 393.01 E 230 412.34 ORIGINATED BY SLL  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2006-09-22 - 2006-09-25 CHECKED BY MEF

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20						40
Continued From Previous Page														
298.5	Silty CLAY, trace sand Hard Grey (TILL)(CI)		9	SS	60/	.100								
298														
297			10	SS	92/	.250								
296														
295			11	SS	50/	.075								
294.3	Sandy SILT, some clay, trace gravel Very dense Grey Moist: (TILL)		12	SS	50/	.100								
294														
293														
292			13	SS	50/	.075								
291			14	SS	50/	.125								
289.3			15	SS	50/									

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 06-32

3 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 393.01 E 230 412.34 ORIGINATED BY SLL  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2006-09-22 - 2006-09-25 CHECKED BY MEF

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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40					
19.9	<p>Continued From Previous Page</p> <p>END OF BOREHOLE AT 19.91m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.</p> <p>WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 29/09/06 17.49 291.72</p>				.100									

ONTMT4S 7938.GPJ 11/26/08

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 06-33

1 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 377.69 E 230 442.29 ORIGINATED BY SLL  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2006-09-21 - 2006-09-22 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
308.0							20 40 60 80 100	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w <sub>p</sub> w w <sub>L</sub>				
0.0	TOPSOIL: (100mm), black						20 40 60 80 100	WATER CONTENT (%)				
0.1	SAND, trace gravel, trace wood fragments Loose Brown Moist: (FILL)		1	SS	8		20 40 60 80 100					
306.6							20 40 60 80 100					
1.4	SAND, some gravel, trace silt Loose to Very Dense Brown Moist		2	SS	7		20 40 60 80 100					
			3	SS	38		20 40 60 80 100					
			4	SS	52		20 40 60 80 100					
			5	SS	50/ .150		20 40 60 80 100					
	Occasional cobbles		6	SS	50/ .125		20 40 60 80 100					
301.7							20 40 60 80 100					
6.3	SAND and GRAVEL, trace silt Very dense Grey Wet		7	SS	67		20 40 60 80 100					
							20 40 60 80 100					
298.8							20 40 60 80 100					
9.2	Silty CLAY, trace sand Hard Grey (TILL)		8	SS	67		20 40 60 80 100					

Continued Next Page

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 10 5  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 06-33

3 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 377.69 E 230 442.29 ORIGINATED BY SLL  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2006-09-21 - 2006-09-22 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
288.0	Continued From Previous Page																
20.1	END OF BOREHOLE AT 20.07m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 22/09/06 16.03 292.00 25/09/06 17.50 290.53 29/09/06 17.62 290.41																

ONTMT4S 7938.GPJ 11/26/08

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 08-04

1 OF 1

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 531.23 E 230 211.92 ORIGINATED BY KS  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM  
 DATUM Geodetic DATE 2008-05-22 - 2008-05-22 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
304.6								20	40	60	80	100		
0.0	TOPSOIL: (150mm)													
0.2	SAND and SILT, trace clay, trace gravel Compact Brown Moist		1	SS	11									
			2	SS	17									
303.2														
1.4	Silty CLAY, some sand, trace gravel Stiff Brown Moist to Wet (TILL)		3	SS	12									
302.5														
2.1	SAND and GRAVEL, trace silt, with sand layers Compact Brown Wet		4	SS	22									40 53 7 (SI+CL)
301.4														
3.3	Silty CLAY, trace sand Firm to Very Stiff Grey to Brown Moist (TILL)		5	SS	7									0 7 49 44
			6	SS	16									
			7	SS	16									
			8	SS	24									0 4 36 60
297.9														
6.7	END OF BOREHOLE AT 6.7m. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.													

ONTMT4S 7938.GPJ 8/27/08

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 08-05

1 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 507.61 E 230 250.18 ORIGINATED BY KS  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM  
 DATUM Geodetic DATE 2008-05-21 - 2008-05-22 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
								○ UNCONFINED	+ FIELD VANE	x LAB VANE		
306.6						20 40 60 80 100	PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>			
0.0	TOPSOIL: (225mm)											
0.2	SAND, some gravel, trace silt to silty Compact Brown Moist		1	SS	7							
			2	SS	20							
			3	SS	27						26 56 18 (SI+CL)	
			4	SS	30							
303.5												
3.0	SAND and GRAVEL, trace silt Compact to Dense Grey/Brown Moist to Wet		5	SS	27							
			6	SS	35						56 38 6 (SI+CL)	
301.8												
4.8	Silty CLAY, trace sand Very Stiff to Hard Brown to Grey Moist (TILL)		7	SS	34						0 7 49 44	
			8	SS	25							
			9	SS	33						0 4 39 57	
			10	SS	32							
296.8												
9.8	END OF BOREHOLE AT 9.8m.											

Continued Next Page

+ 3, x 3. Numbers refer to  
Sensitivity 20  
15 5  
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-05

2 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 507 61 E 230 250 18 ORIGINATED BY KS  
HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM  
DATUM Geodetic DATE 2008-05-21 - 2008-05-22 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)														
	Continued From Previous Page																						
	<p>Piezometer installation consists of 25.4mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS:</p> <table border="1"> <thead> <tr> <th>DATE</th> <th>DEPTH(m)</th> <th>ELEV.(m)</th> </tr> </thead> <tbody> <tr> <td>2008-05-22</td> <td>4.3</td> <td>302.3</td> </tr> <tr> <td>2008-08-19</td> <td>Destroyed</td> <td></td> </tr> </tbody> </table>	DATE	DEPTH(m)	ELEV.(m)	2008-05-22	4.3	302.3	2008-08-19	Destroyed														
DATE	DEPTH(m)	ELEV.(m)																					
2008-05-22	4.3	302.3																					
2008-08-19	Destroyed																						

# RECORD OF BOREHOLE No 08-06

1 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 479.70 E 230 295.23 ORIGINATED BY KS  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM  
 DATUM Geodetic DATE 2008-05-21 - 2008-05-21 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								○ UNCONFINED      + FIELD VANE	W P      W      W L					
								● QUICK TRIAXIAL      × LAB VANE						
307.4						20   40   60   80   100								
0.0	TOPSOIL: (200mm)													
0.2	SAND and SILT, trace to some clay, trace to some gravel Loose to Compact Brown Moist		1	SS	10									
			2	SS	9									
306.0														
1.4	Sandy, silty CLAY, some gravel, occasional cobbles, occasional sand seams Firm to Hard Brown Moist (TILL)													
			3	SS	7									
			4	SS	19									
			5	SS	27									
			6	SS	42									
302.8														
4.6	Silty CLAY, trace sand, trace gravel Very Stiff to Hard Grey Moist (TILL)													
			7	SS	56									
			8	SS	29									
			9	SS	29									
			10	SS	31									

Continued Next Page

+ 3, X 3.

Numbers refer to  
Sensitivity

20  
15  
10

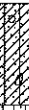

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 08-06

2 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 479.70 E 230 295.23 ORIGINATED BY KS  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM  
 DATUM Geodetic DATE 2008-05-21 - 2008-05-21 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	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	20 40 60					
296.7	Silty <b>CLAY</b> , trace sand, trace gravel Very Stiff to Hard Grey Moist (TILL)						297							
10.7														
296.4	<b>SILT</b> and <b>SAND</b> , trace to some clay, trace gravel Very Dense Grey Moist (TILL)		11	SS	61/									4 39 43 14
11.0	END OF BOREHOLE AT 11.0m. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.				150									

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 08-07

1 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 458.92 E 230 327.35 ORIGINATED BY KS  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM  
 DATUM Geodetic DATE 2008-05-21 - 2008-05-21 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
308.4							20	40	60	80	100					
0.0	TOPSOIL: (100mm)		1	SS	9											
0.1	SAND, trace to some silt Loose to Compact Light Brown Moist		2	SS	18											
			3	SS	9											
306.1			4	SS	8											
2.3	Silty CLAY, trace to some sand, trace gravel, with sand lenses Stiff Brown to Grey Moist (TILL)		5	SS	12											
304.6			6	SS	34											
3.8	SAND and GRAVEL, trace silt Dense Brown Moist		7	SS	32											
303.9			8	SS	50											
4.6	Silty CLAY, some sand, trace gravel, occasional sand and gravel layers Hard Grey Moist (TILL)		9	SS	36											
			10	SS	44											
		</														

Continued Next Page

+ 3, x 3: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

## METRIC

ELEV. DEPTH	SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	W <sub>P</sub> W W <sub>L</sub>	WATER CONTENT (%)				
	Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100		20 40 60		kN/m <sup>3</sup>	GR SA SI	

[illegible]

ONTMT4S 7938.GPJ 8/27/08

+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 08-08

1 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 430.57 E 230 370.41 ORIGINATED BY KS  
 HWY 8 BOREHOLE TYPE Solid Stem Augers / Hollow Stem Augers COMPILED BY WM  
 DATUM Geodetic DATE 2008-05-16 - 2008-05-16 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
308.3								SHEAR STRENGTH kPa						
0.0	TOPSOIL: (225mm)							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE						
0.2	SAND, trace to some gravel, trace to some silt Compact Light Brown Moist		1	SS	10		308							
			2	SS	13		307							
			3	SS	16		306							
			4	SS	13		305							
			5	SS	18		304							
304.1			6	SS	35		303							
4.1	SILT, some clay, trace sand Dense to Very Dense Brown Moist to Wet		7	SS	59		302							
303.2							301							
5.0	Silty CLAY, some sand Hard Grey Moist (TILL)		8	SS	115		300							
301.9							299							
6.4	Silty SAND, some gravel Very Dense Grey Moist to Wet (TILL)		9	SS	93/ 150									
	occasional cobbles													
299.4														
8.8	Silty CLAY, trace sand Hard Grey Moist (TILL)		10	SS	32									

Continued Next Page

+ 3 x 3: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 08-08

2 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 430.57 E 230 370.41 ORIGINATED BY KS  
 HWY 8 BOREHOLE TYPE Solid Stem Augers / Hollow Stem Augers COMPILED BY WM  
 DATUM Geodetic DATE 2008-05-16 - 2008-05-16 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	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 × LAB VANE	WATER CONTENT (%) 20 40 60						
Continued From Previous Page															
296.1	Silty CLAY, trace sand Hard Grey Moist (TILL)		11	SS	64		298								0 4 35 61
12.2	Sandy SILT, trace to some gravel, occasional sand layers, occasional cobbles Very Dense Grey Moist to Wet (TILL)		12	SS	50/ .075		296								
			13	SS	50/ .100		295								
			14	SS	60/ .150		294								4 35 46 15
			15	SS	86/ .150		293								
			16	SS	100/ .150		292								
			17	SS	50/		291								
							290								
							289								

Continued Next Page

+ <sup>3</sup>/<sub>3</sub> × <sup>3</sup>/<sub>3</sub>: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-08

3 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 430.57 E 230 370.41 ORIGINATED BY KS  
 HWY 8 BOREHOLE TYPE Solid Stem Augers / Hollow Stem Augers COMPILED BY WM  
 DATUM Geodetic DATE 2008-05-16 - 2008-05-16 CHECKED BY MRA

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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
288.2	Continued From Previous Page													
20.1	END OF BOREHOLE AT 20.1m. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.						288							

ONTMT4S 7938.GPJ 8/27/08

# RECORD OF BOREHOLE No 08-09

1 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 402.11 E 230 413.11 ORIGINATED BY KS  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM  
 DATUM Geodetic DATE 2008-05-20 - 2008-05-20 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
309.0								20 40 60 80 100						
0.0	TOPSOIL: (150mm)						309							
0.2	SAND, some gravel, trace silt Compact Light Brown Moist to Dry		1	SS	7									
			2	SS	15		308							
307.5														
1.5	SAND and SILT, occasional cobbles Compact Brown Moist to Wet		3	SS	24		307							
			4	SS	21		306							0 53 44 3
			5	SS	22		305							
			6	SS	28		304							
			7	SS	15		303							
303.5	Grinding at 5.2m, probable cobbles.						302							
5.5	Silty CLAY, trace sand, occasional sand pockets, occasional cobbles Hard Grey Moist (TILL)		8	SS	52		301							0 6 49 45
			9	SS	51		300							
	Grinding at 7.9m, probable gravel or cobbles.													
299.8	Grinding at 9.1m.													
9.2	SAND and GRAVEL, trace to some silt Dense Grey Moist		10	SS	42									

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 10 5  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 08-09

2 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 402.11 E 230 413.11 ORIGINATED BY KS  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM  
 DATUM Geodetic DATE 2008-05-20 - 2008-05-20 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE	WATER CONTENT (%) 20 40 60			GR SA SI CL
298.9 10.1	Silty <b>CLAY</b> , trace sand, occasional cobbles and boulders Hard Grey Moist (TILL)		11	SS	54		299					
	Grinding at 12.2m.		12	SS	41		298					1 9 38 52
	Grinding at 12.8m to 13.1m, probable boulder.						297					
295.2 13.8	Grinding at 13.7m to 14.0m, probable cobble.		13	SS	100/ .150		296					
	Silty <b>SAND</b> , trace to some clay, trace to some gravel Very Dense Grey Moist (TILL)		14	SS	50/ .100		295					6 49 34 11
	Grinding at 14.9m to 15.2m.		15	SS	50/ .125		294					
			16	SS	50/ .075		293					
			17	SS	100/ .075		292					
							291					
							290					

Continued Next Page

+ 3, x 3: Numbers refer to Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 08-09

3 OF 3

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 809 402.11 E 230 413.11 ORIGINATED BY KS  
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM  
 DATUM Geodetic DATE 2008-05-20 - 2008-05-20 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80					
288.9	Continued From Previous Page					100	289									
20.1	END OF BOREHOLE AT 20.1m. Piezometer installation consists of 25.4mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.  WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 2008-05-22 17.4 291.6 2008-08-19 17.3 291.7															

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+<sup>3</sup>, x<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

## **Appendix B**

### **Laboratory Test Results**

## FIGURE B1

Size of openings, inches

U.S.S. Sieve size, meshes/inch

PERCENT FINER THAN

GRAIN SIZE, mm

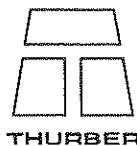
Grain Size (mm)	Percent Finer (%) - Circles	Percent Finer (%) - Squares	Percent Finer (%) - Triangles
100	100	100	100
10	100	100	100
1	100	100	96
0.85	100	93	96
0.6	99	81	73
0.425	93	78	33
0.3	79	74	11
0.25	62	60	5
0.2	51	42	
0.15	43	32	
0.106	35	22	
0.075	29	15	
0.06	23	13	
0.0425	21	10	
0.03	19	9	
0.025	15	8	
0.02	14	7	
0.015	13	7	

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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-28	1.83	305.25
⊠	06-30	1.83	308.68
▲	06-30	3.35	307.16

Prep'd ..... MFA .....

Chkd. .... MRA .....

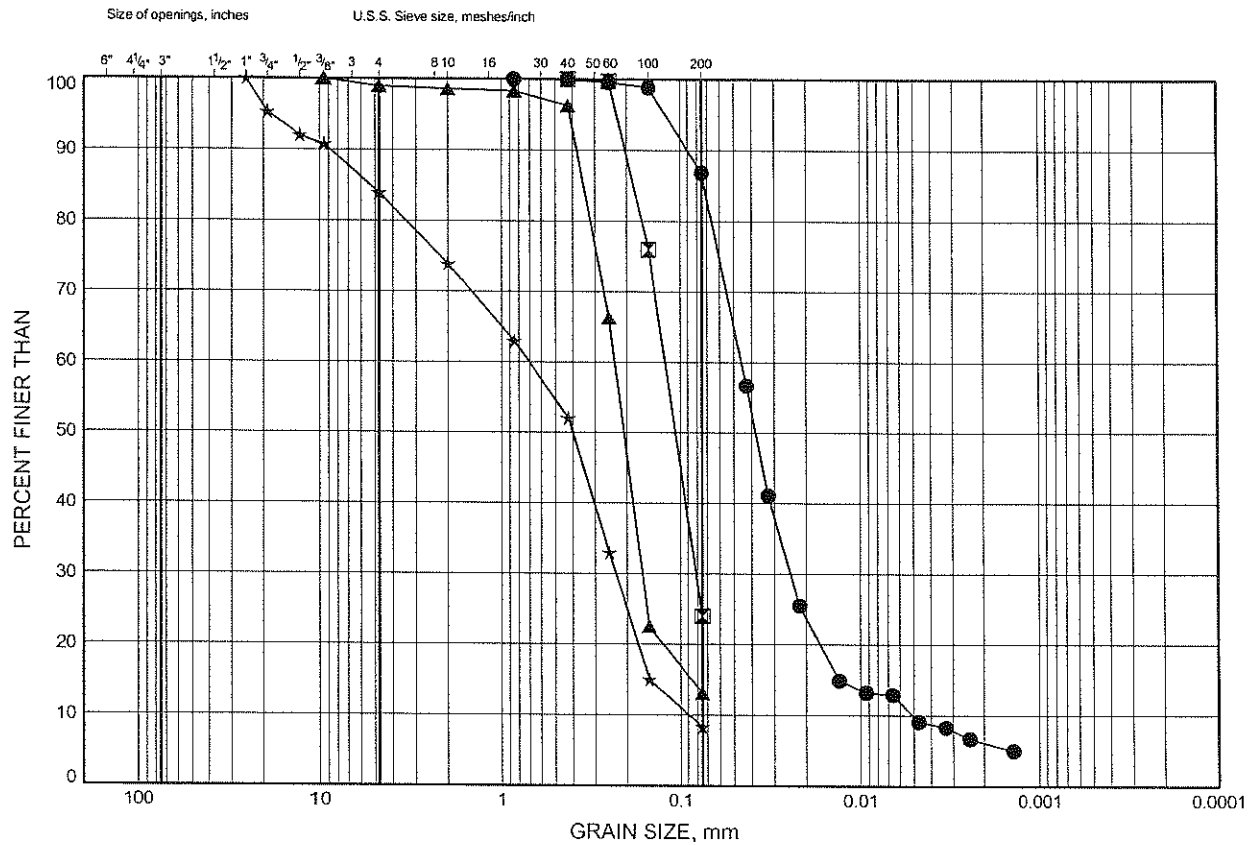


# Highway 8 Widening Over Grand River

## GRAIN SIZE DISTRIBUTION

FIGURE B2

### SAND TO SILT AND SAND



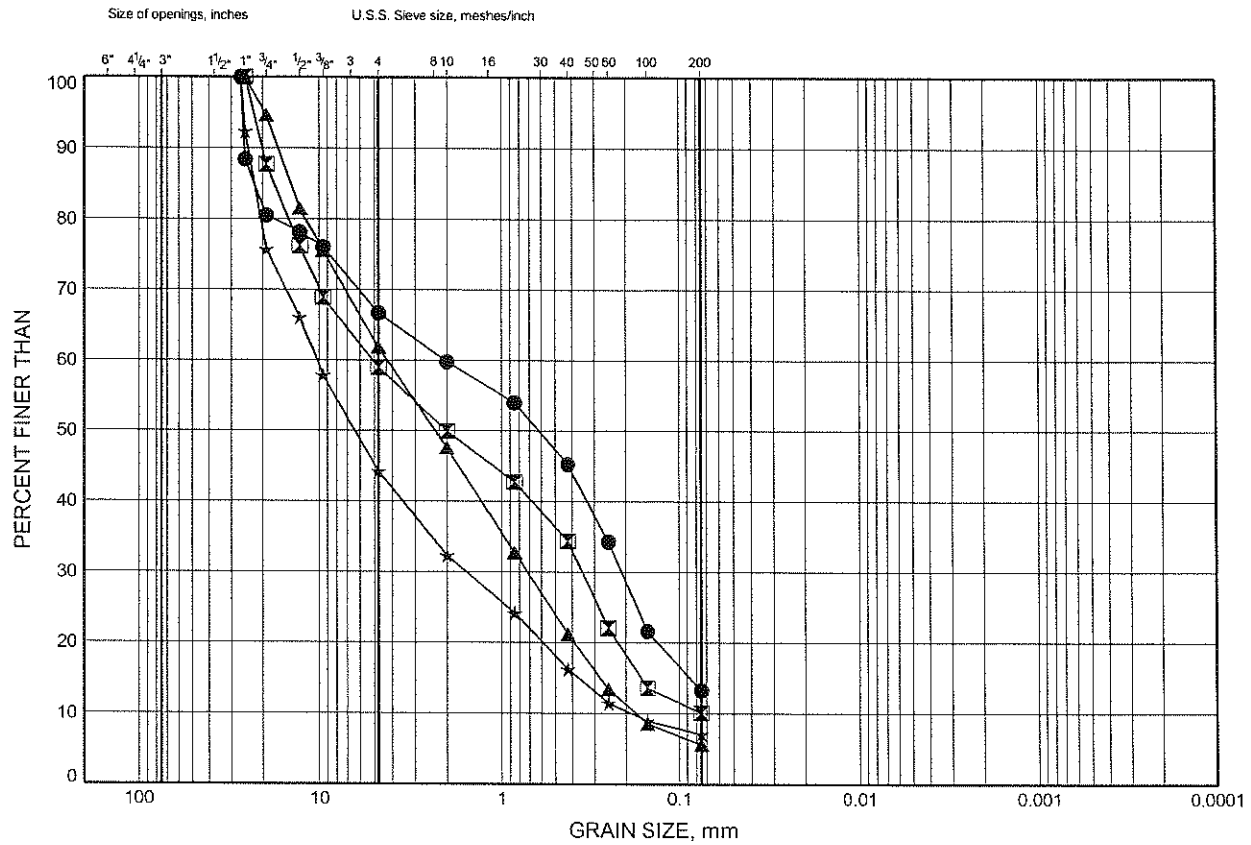


# Highway 8 Widening Over Grand River

## GRAIN SIZE DISTRIBUTION

FIGURE B3

### SAND AND GRAVEL TO GRAVELLY SAND

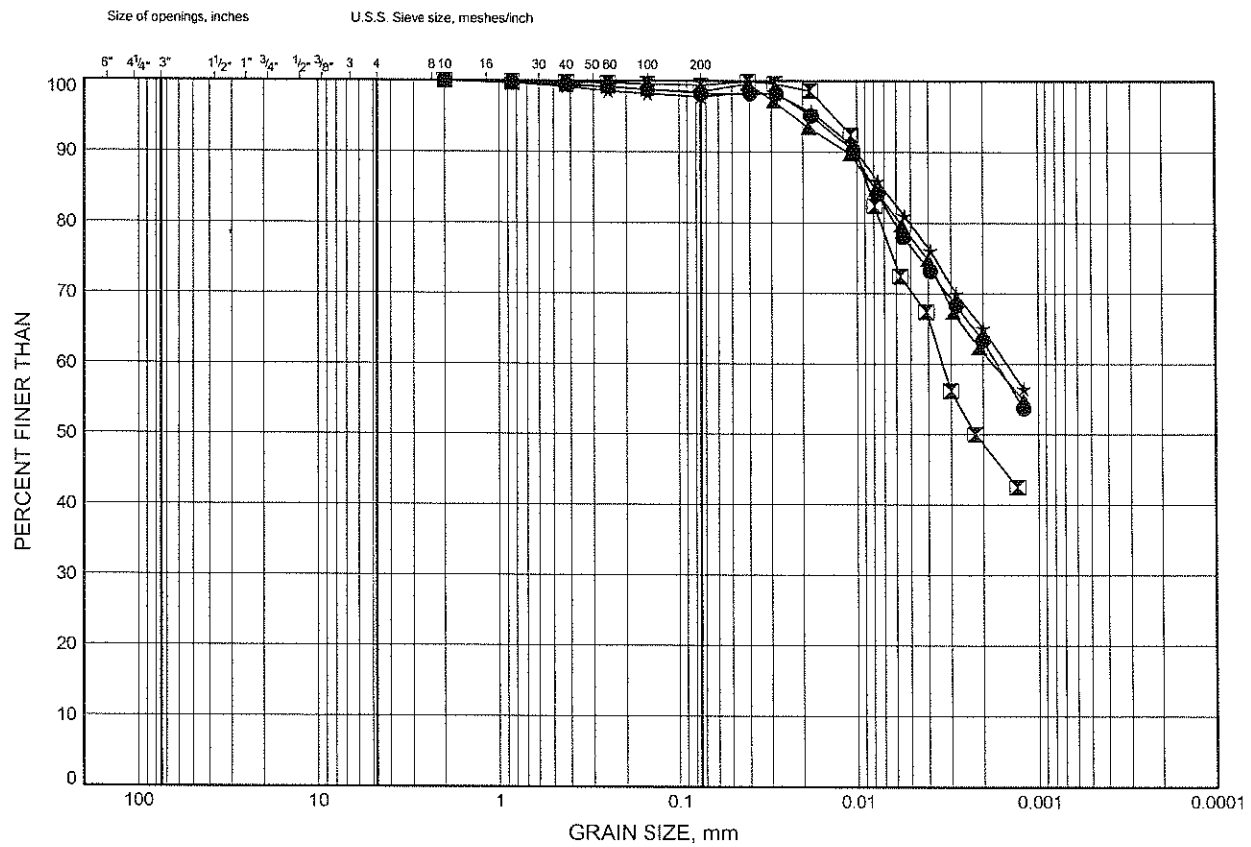


# Highway 8 Widening Over Grand River

## GRAIN SIZE DISTRIBUTION

FIGURE B4

### SILTY CLAY TILL

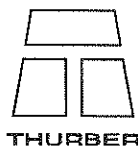


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-28	9.35	297.73
⊠	06-29	6.40	301.79
▲	06-29	10.97	297.22
★	06-30	12.50	298.01

Date January 2007

Project 277-97-00



Prep'd MFA

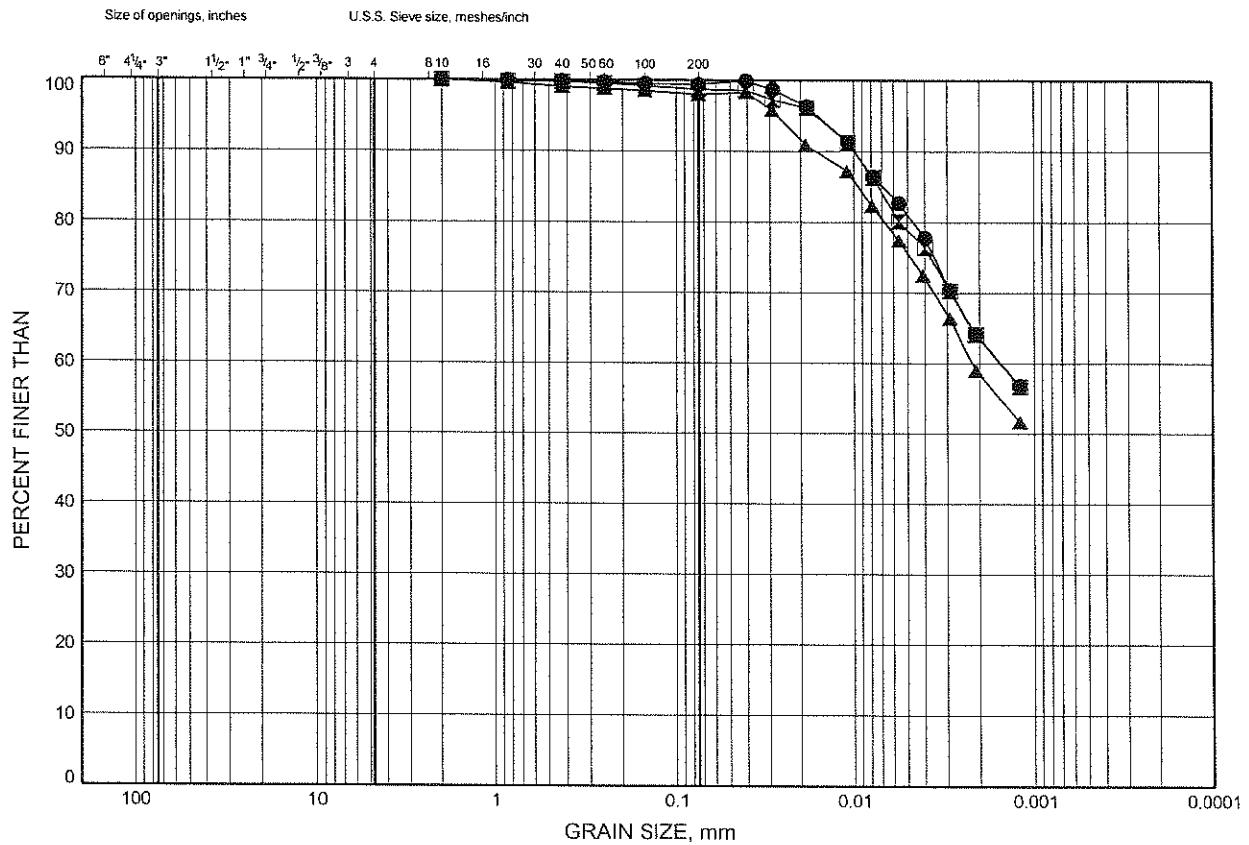
Chkd. MRA

# Highway 8 Widening Over Grand River

## GRAIN SIZE DISTRIBUTION

FIGURE B5

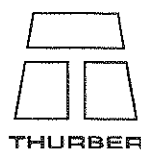
### SILTY CLAY TILL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-31	12.42	297.53
■	06-32	12.40	296.81
▲	06-33	10.90	297.13

Date January 2007  
Project 277-97-00



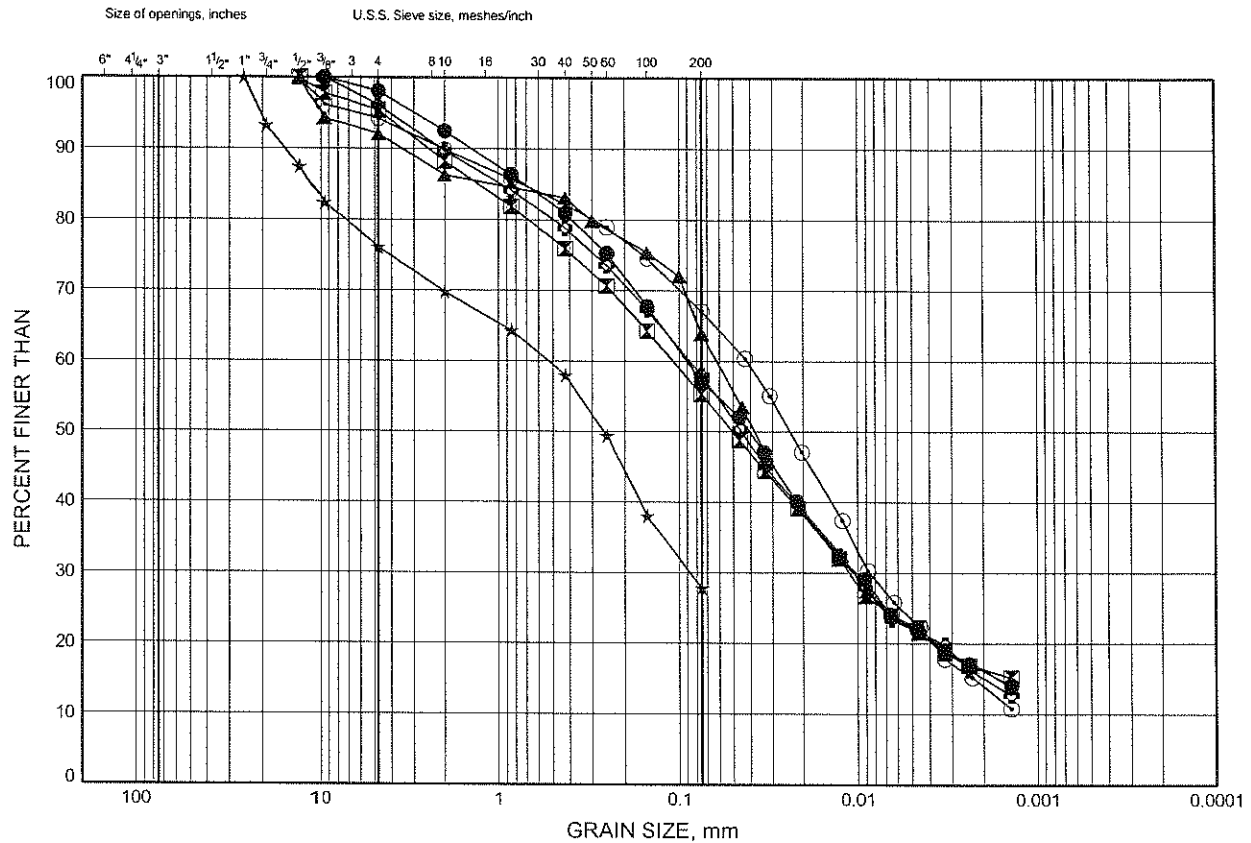
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# Highway 8 Widening Over Grand River

## GRAIN SIZE DISTRIBUTION

FIGURE B6

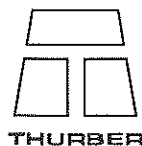
### SANDY SILT TO SILTY SAND TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-29	13.78	294.41
⊠	06-30	16.90	293.60
▲	06-31	6.40	303.55
★	06-31	18.58	291.37
⊙	06-32	18.34	290.87
⊛	06-33	15.38	292.65

Date January 2007

Project 277-97-00



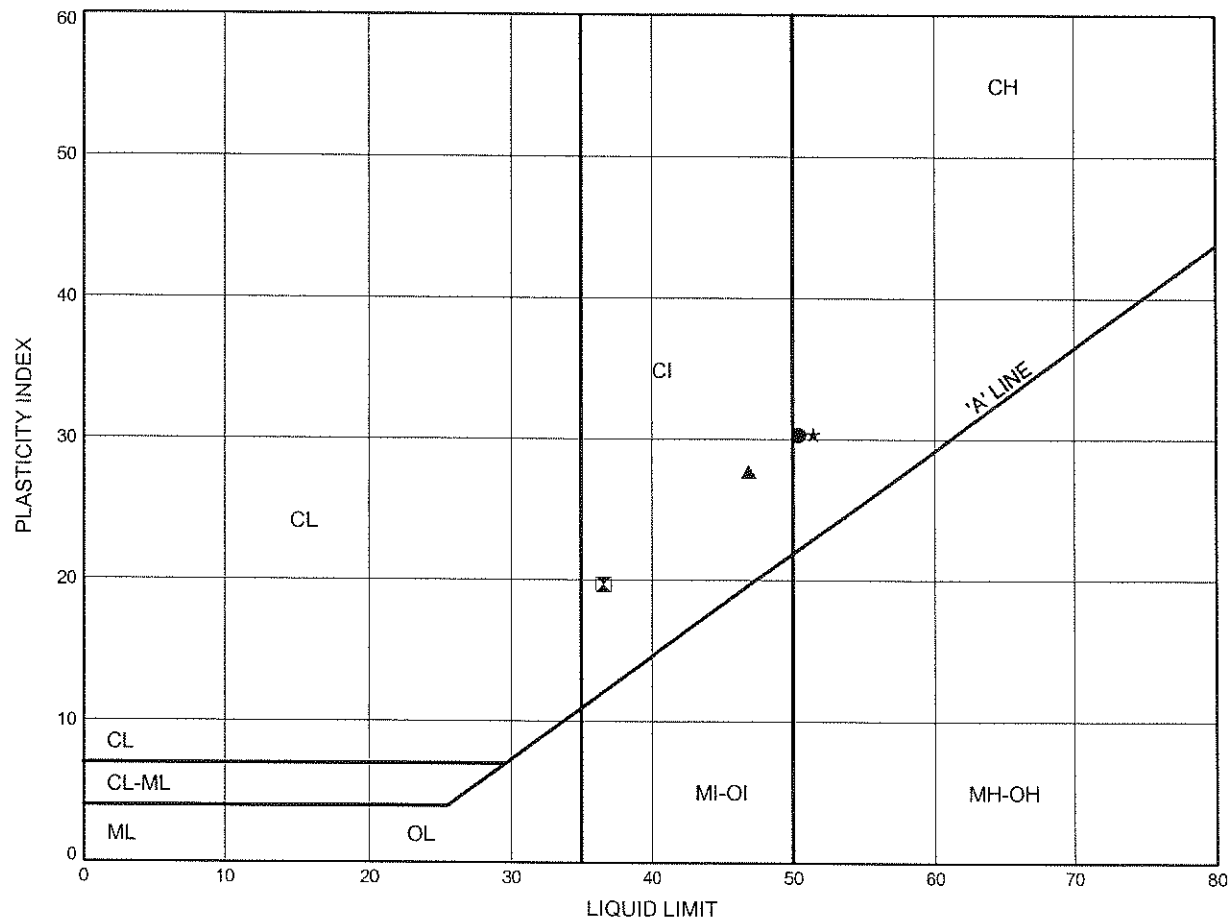
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Chkd. MRA

# Highway 8 Widening Over Grand River ATTERBERG LIMITS TEST RESULTS

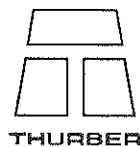
FIGURE B7

### SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-28	9.35	297.73
⊠	06-29	6.40	301.79
▲	06-29	10.97	297.22
★	06-30	12.50	298.01

Date January 2007  
Project 277-97-00

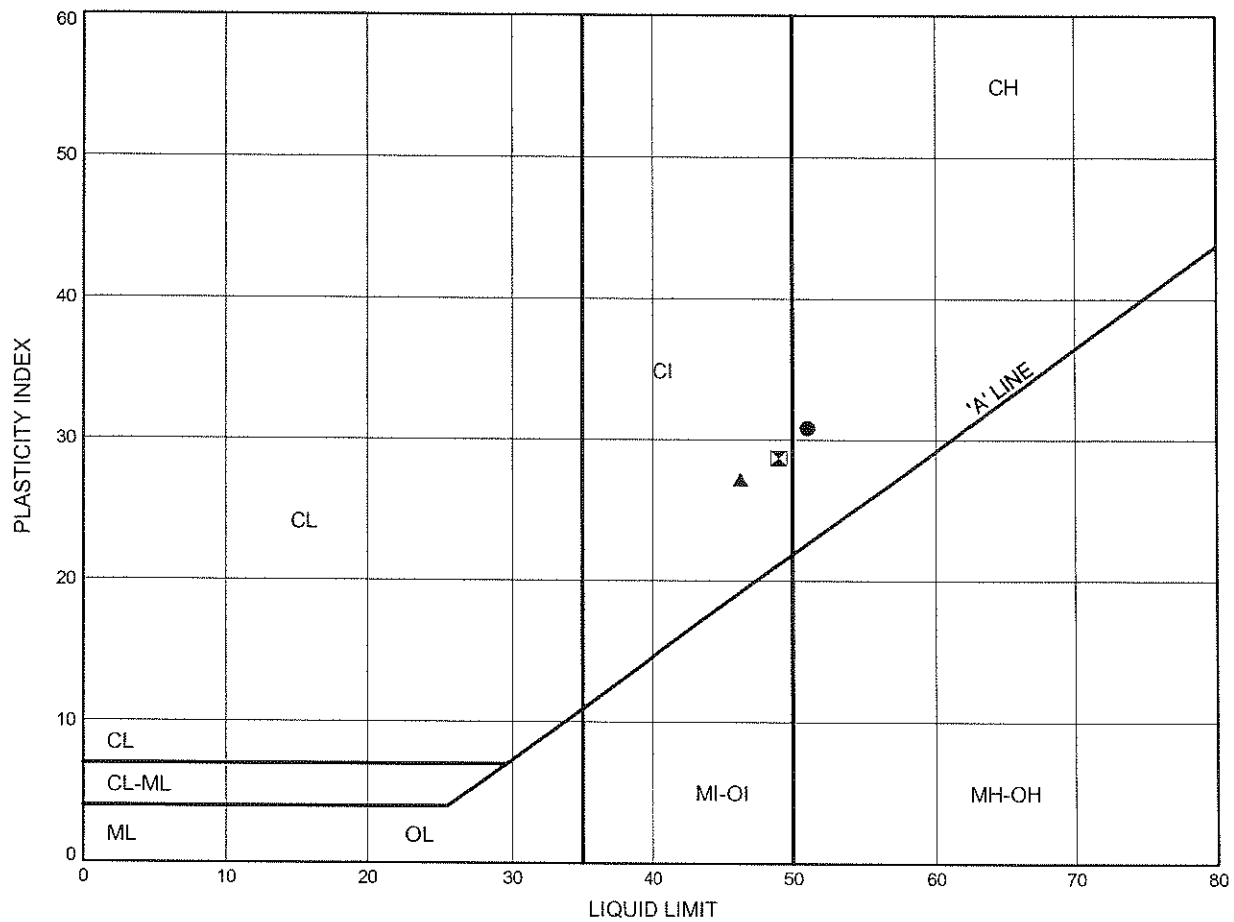


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# Highway 8 Widening Over Grand River ATTERBERG LIMITS TEST RESULTS

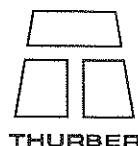
FIGURE B8

### SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-31	12.42	297.53
⊠	06-32	12.40	296.81
▲	06-33	10.72	297.31

Date January 2007  
 Project 277-97-00



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 Chkd. MRA

## FIGURE B9

[illegible]

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

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-05	1.83	304.77
⊗	08-07	1.83	306.59
▲	08-08	2.59	305.67
☆	08-08	4.11	304.14
⊙	08-09	2.59	306.39

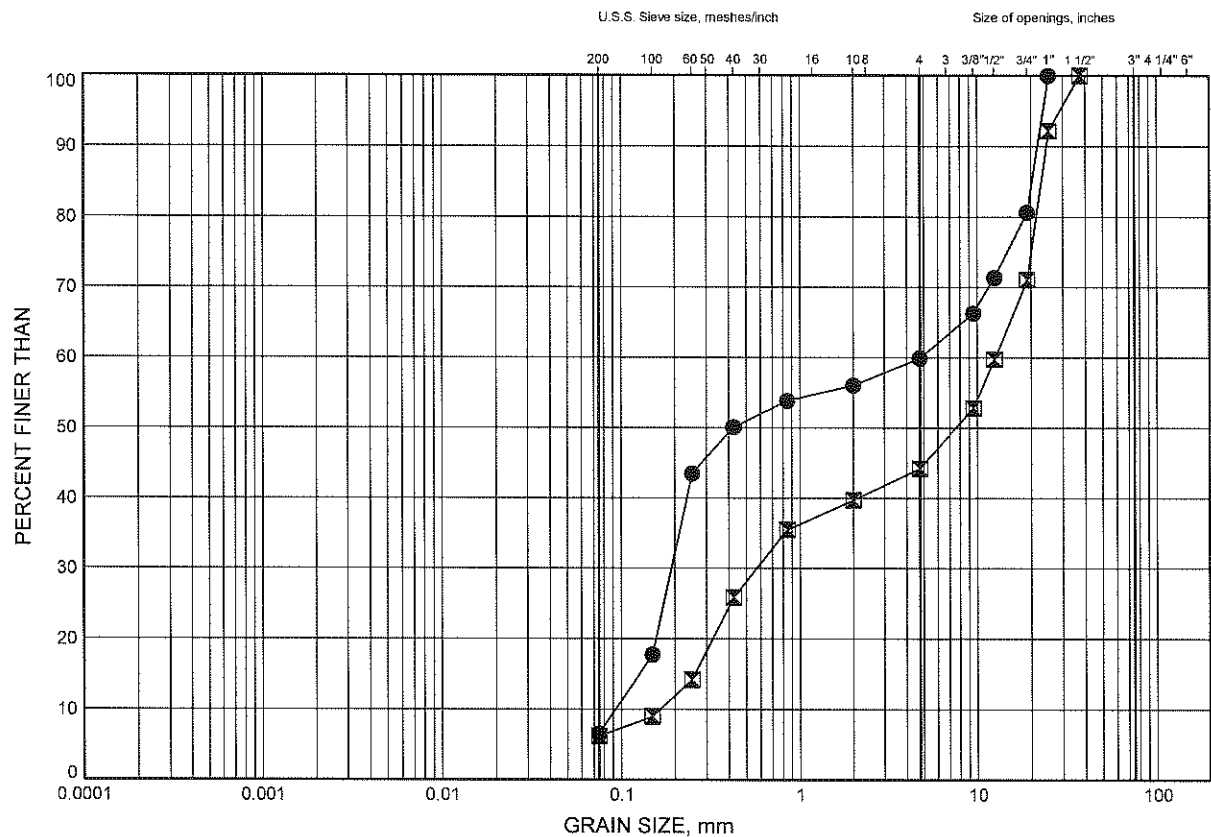


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Checked By MRA

# Highway 8 Widening Over Grand River GRAIN SIZE DISTRIBUTION

FIGURE B10

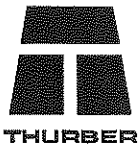
## SAND AND GRAVEL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-04	2.59	302.02
⊠	08-05	4.11	302.48



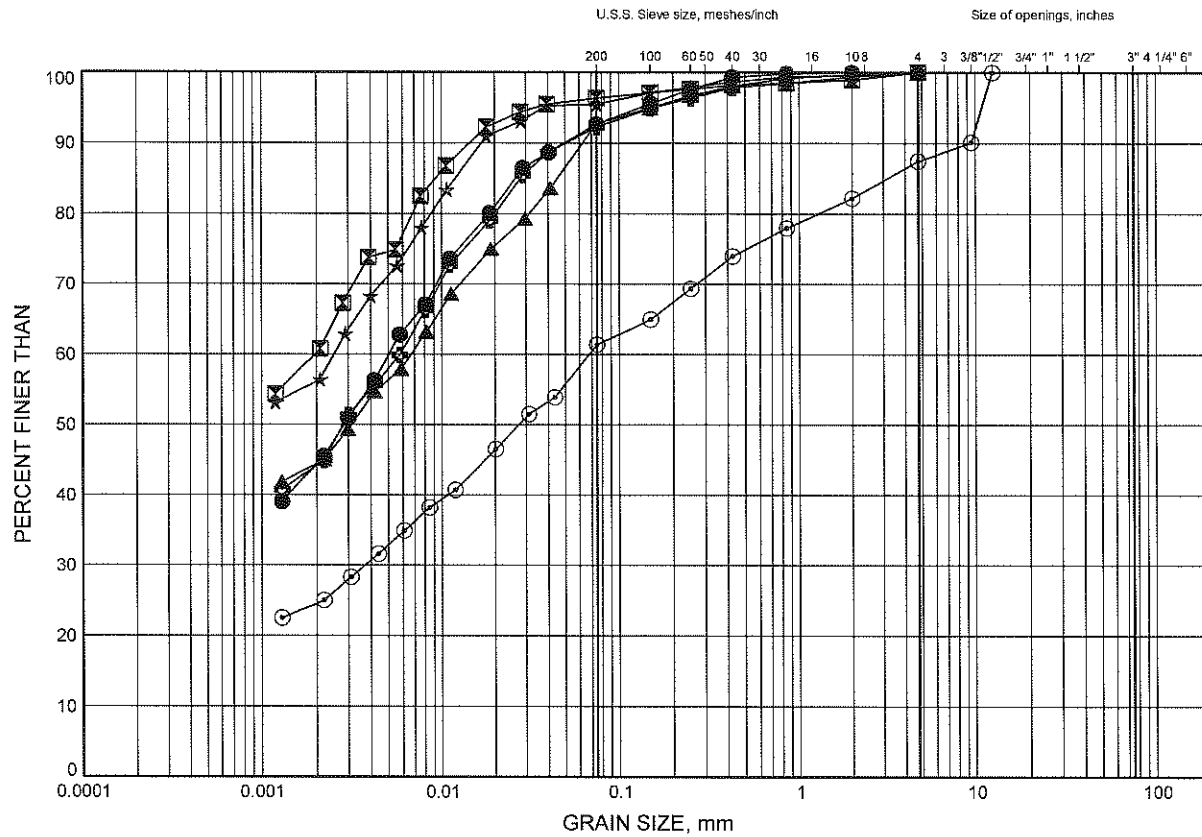
W.P.# 277-97-00  
Prepared By MFA  
Checked By MRA



# Highway 8 Widening Over Grand River GRAIN SIZE DISTRIBUTION

FIGURE B11

## SILTY CLAY TILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-04	3.35	301.25
⊠	08-04	6.40	298.21
▲	08-05	4.88	301.72
☆	08-05	7.92	298.67
⊙	08-06	3.35	304.00
⊗	08-06	6.40	300.95

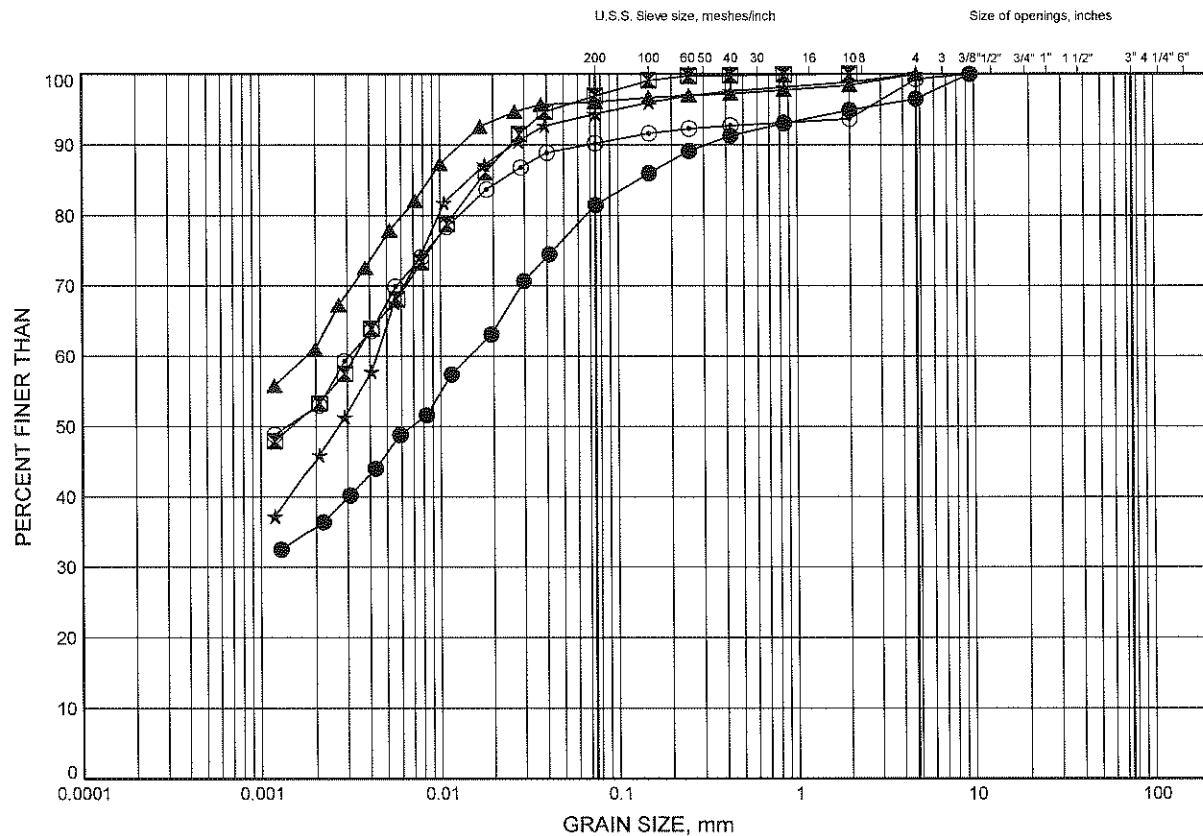


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# Highway 8 Widening Over Grand River GRAIN SIZE DISTRIBUTION

FIGURE B12

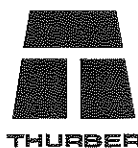
## SILTY CLAY TILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-07	3.35	305.07
⊠	08-07	9.45	298.97
▲	08-08	10.97	297.28
☆	08-09	7.92	301.06
⊙	08-09	12.50	296.49

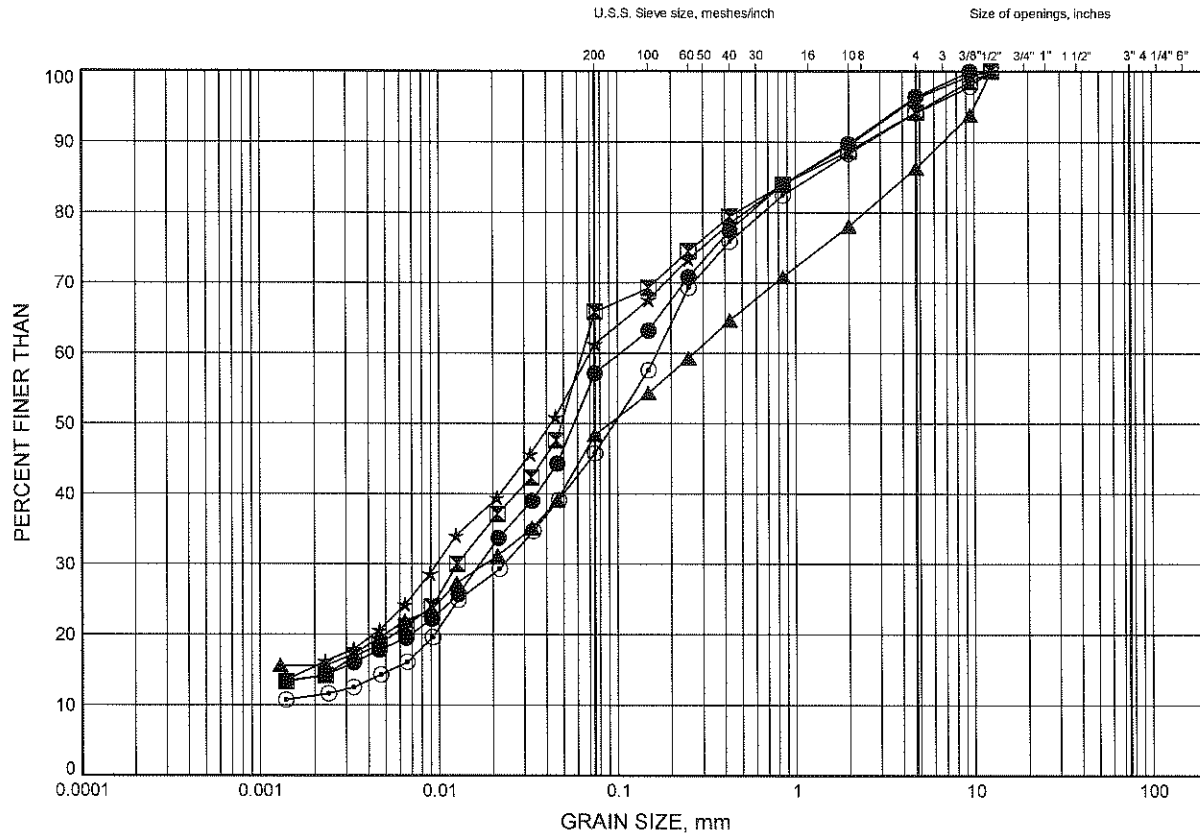


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Checked By MRA.....

# Highway 8 Widening Over Grand River GRAIN SIZE DISTRIBUTION

FIGURE B13

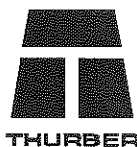
## SANDY SILT TO SILTY SAND TILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-06	10.82	296.53
⊠	08-07	13.84	294.58
▲	08-08	7.77	300.48
☆	08-08	15.39	292.86
⊙	08-09	15.37	293.62

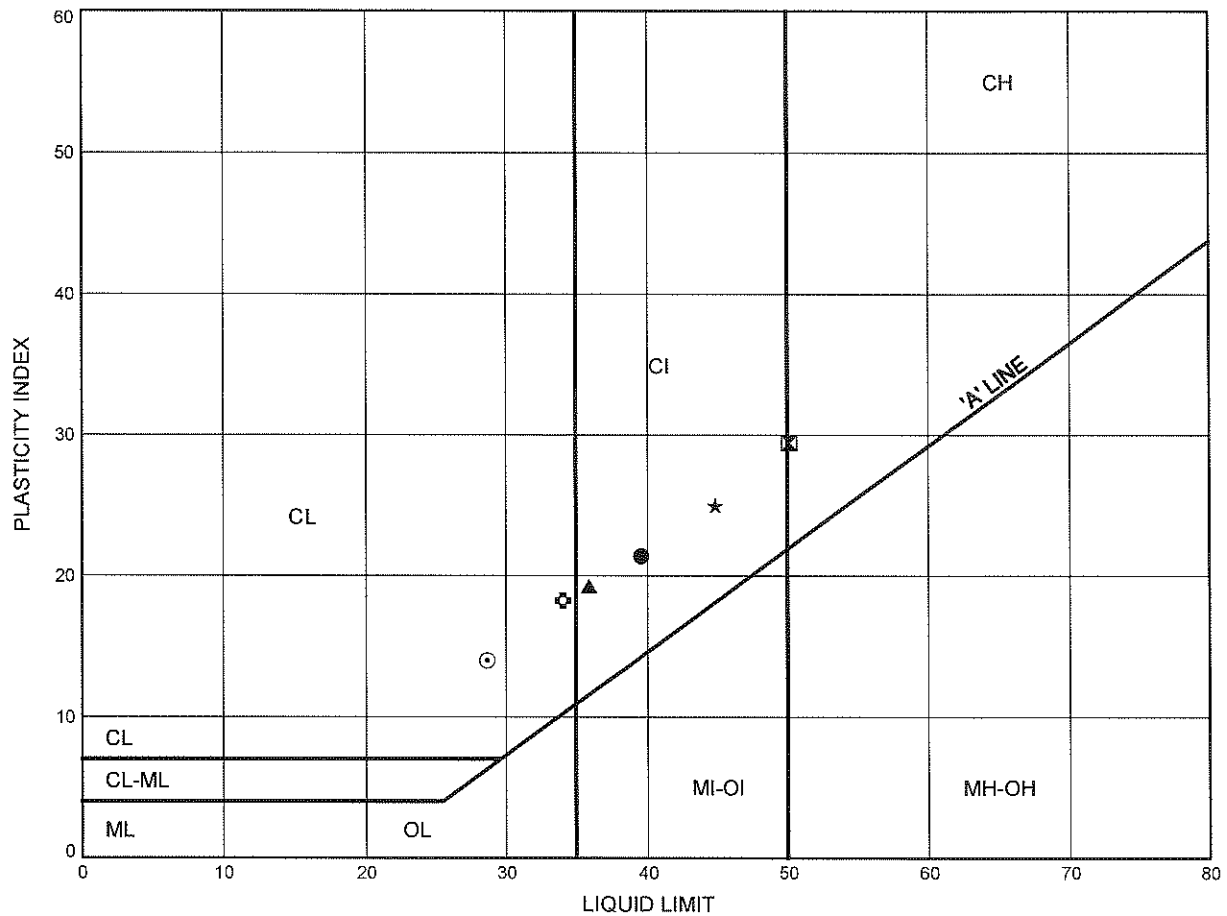


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Prepared By MFA  
Checked By MRA

# Highway 8 Widening Over Grand River **ATTERBERG LIMITS TEST RESULTS**

FIGURE B14

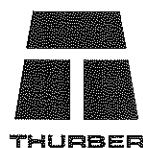
## **SILTY CLAY TILL**



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-04	3.35	301.25
⊠	08-04	6.40	298.21
▲	08-05	4.88	301.72
★	08-05	7.92	298.67
⊙	08-06	3.35	304.00
⊠	08-06	6.40	300.95

THURBALT 7938.GPJ 8/27/08

Date August 2008  
 Project 277-97-00

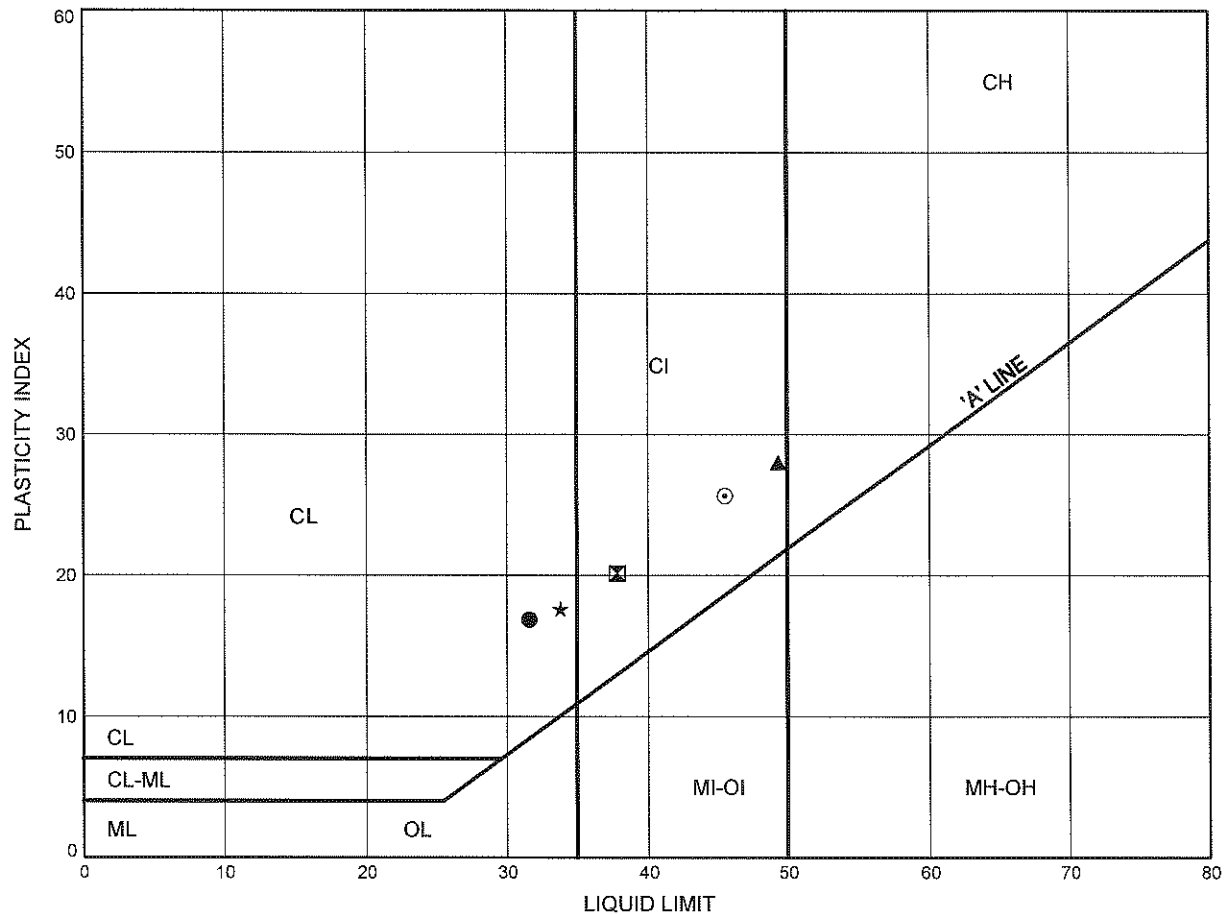


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 Chkd. MRA

# Highway 8 Widening Over Grand River ATTERBERG LIMITS TEST RESULTS

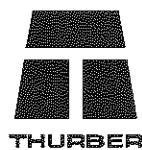
FIGURE B15

### SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-07	3.35	305.07
⊠	08-07	9.45	298.97
▲	08-08	10.97	297.28
★	08-09	7.92	301.06
⊙	08-09	12.50	296.49

Date August 2008  
 Project 277-97-00



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## Appendix C

### Tables and Figures

**TABLE C1 – BOREHOLE COMPLETION DETAILS**

Borehole	Piezometer Tip (Sand Filter) Details			Backfill
	Depth	Elevation	Stratum	
06-28	12.0 – 9.6	295.1 – 297.5	Silty clay till, sandy silt till	Bentonite seal to 8.9 m, grout to 1.2 m, cuttings to surface
06-29	19.9 – 17.7	288.3 – 290.5	Silt and sand till	Bentonite seal to 17.2 m, grout to 1.2 m, cuttings to surface
06-30	19.8 – 18.0	290.7 – 292.5	Silt and sand till	Bentonite seal to 17.2 m, grout to surface
06-31	19.9 – 17.8	290.1 – 292.2	Silty sand till	Bentonite seal to 17.3 m, grout to 0.9 m, cuttings to 0.6 m, bentonite to surface
06-32	19.9 – 17.8	289.3 – 291.4	Sandy silt till	Bentonite seal to 17.1 m, grout to 0.9 m, bentonite to 0.3 m, cuttings to surface
06-33	20.1 – 18.1	287.9 – 289.9	Silt and sand till	Bentonite seal to 17.0 m, grout to 0.9 m, cuttings to surface
08-04	-	-	-	Bentonite grout to ground surface
08-05	9.1 – 5.6	297.5 – 301.0	Silty clay till	Bentonite seal to 5.0 m, grout to surface
08-06	-	-	-	Bentonite grout to ground surface
08-07	16.8 – 13.3	291.6 – 295.1	Sandy silt till	Bentonite seal to 12.8 m, grout to surface
08-08	-	-	-	Bentonite grout to ground surface
08-09	19.8 – 16.3	289.2 – 292.7	Silty sand till	Bentonite grout to 2.4 m, cuttings to surface

TABLE C2 – PARAMETERS FOR LATERAL PILE RESISTANCE

Station	Borehole No.	Top of Caisson <sup>1</sup> Elevation (m)	Elevation (m)	Soil	$n_h$ (kN/m <sup>3</sup> )	$c_u$ (kPa)	$K_p$	Unit Weight <sup>2</sup> (kN/m <sup>3</sup> )	Water Level (m)
13+375	08-04	302.4	302.4 to 301.4	Compact sand and gravel	6,000	-	3.3	21	-
			301.4 to 301.0	Firm clay till	-	50	2.7	19	
			301.0 to 297.9	Very stiff clay till	-	125	2.9	20	
13+400	08-05 06-28	301.6	301.6 to 295.5	Very stiff to hard clay till	-	175	2.9	20	295.5
			295.5 to 294.6	Very dense silt and sand till	8,000	-	3.5	11	
13+450	08-06 06-29	299.9	299.9 to 296.7	Very stiff to hard clay till	-	175	2.9	20	295.0
			296.7 to 295.0	Very dense silt and sand till	12,000	-	3.5	21	
			295.0 to 288.3	Very dense silt and sand till	8,000	-	3.5	11	
13+500	08-07 06-30	298.2	298.2 to 296.1	Hard clay till	-	200	3.0	20	294.5
			296.1 to 294.5	Very dense sandy silt till	12,000	-	3.5	21	
			294.5 to 290.6	Very dense sandy silt till	8,000	-	3.5	11	
13+550	08-08 06-31	296.9	296.9 to 296.1	Hard clay till	-	250	3.0	20	294.0
			296.1 to 294.0	Very dense sandy silt till	12,000	-	3.5	21	
			294.0 to 288.2	Very dense sandy silt till	8,000	-	3.5	11	
13+600	08-09 06-32	295.5	295.5 to 295.2	Hard clay till	-	250	3.0	20	292.0
			295.2 to 292.0	Very dense silty sand till	12,000	-	3.5	21	
			292.0 to 288.9	Very dense silty sand till	8,000	-	3.5	11	
13+625	06-33	295.0	295.0 to 294.5	Hard clay till	-	250	3.0	20	290.5
			294.5 to 290.5	Very dense silt and sand till	12,000	-	3.5	21	
			290.5 to 288.0	Very dense silt and sand till	8,000	-	3.5	11	

1. Assumed at 0.6 m below finished edge of shoulder shown on preliminary General Arrangement drawing.
2. Buoyant unit weight below the water table.



### TABLE C3 - EARTH PRESSURE COEFFICIENTS FOR RETAINING WALL DESIGN

Earth Pressure Coefficient (K)								
Condition	OPSS Granular A or OPSS Granular B Type II		OPSS Granular B Type I		Native Clay Till		Native Sandy Silt Till	
	$\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		$\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$		$\phi = 29^\circ, \gamma = 19.6 \text{ kN/m}^3$		$\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	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)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
	0.27	0.38	0.31	0.46	0.35	0.60	*	*
	0.43	-	0.47	-	0.52	-	*	-
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-	2.9	-	3.3	-

\* The upper boundary of the silt till will be below the level of the wall base, and therefore active and at-rest coefficients for this material are not applicable to the wall design.

## **Appendix D**

### **Suggested Text for NSSP**

**Suggested Text for NSSP on:  
“Augered Caisson Construction for Soldier Pile Foundations”**

The Contractor is advised that variable types of subsurface materials may be encountered at the locations of the augered caisson soldier piles. For additional information regarding subsurface conditions, the Contractor is referred to the Foundation Investigation Report.

For bidding purposes, the Contractor shall assume the following:

1. The subsurface conditions at an augered caisson location are the same as those encountered in the borehole closest to the subject caisson location.
2. Portions of the glacial till are very dense and penetration may require laborious augering. Further, there is a probability that cobbles and boulders may be encountered within the glacial till deposits. Caisson installation equipment must be able to penetrate very dense material and dislodge, handle, remove or otherwise penetrate cobbles and boulders.
3. Till soils may contain zones of permeable, water bearing, cohesionless soils. Temporary liners shall be available on site, or be made available on very short notice, to support the caisson sidewalls and provide seepage cut-off where required.

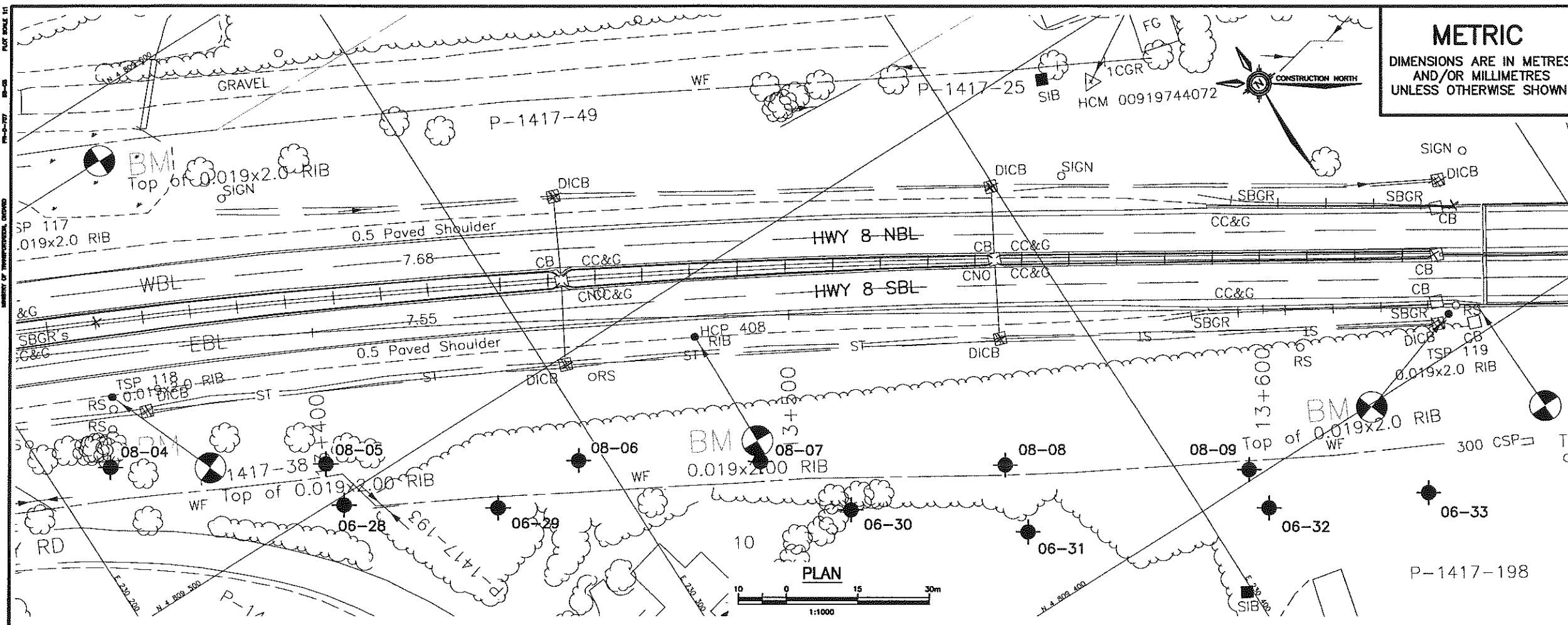
The Contractor is responsible for constructing the soldier pile foundations without disturbing the material at the sides or bases of the foundations.

## **Appendix E**

### **Drawings**

#### **Borehole Locations and Soil Strata**





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

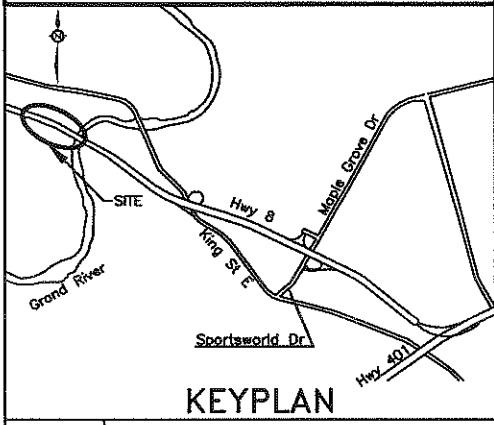
CONT No  
GWP No.277-97-00

DEEP CUT  
HWY 8 WIDENING  
KITCHENER  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

**MORRISON  
HERSHFIELD**

**THURBER ENGINEERING LTD.**  
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



- LEGEND**
- Borehole
  - Borehole and Cone
  - N
  - CONE
  - PH
  - Water Level
  - Head Artesian Water
  - Piezometer
  - 90% Rock Quality Designation (RQD)
  - A/R Auger Refusal

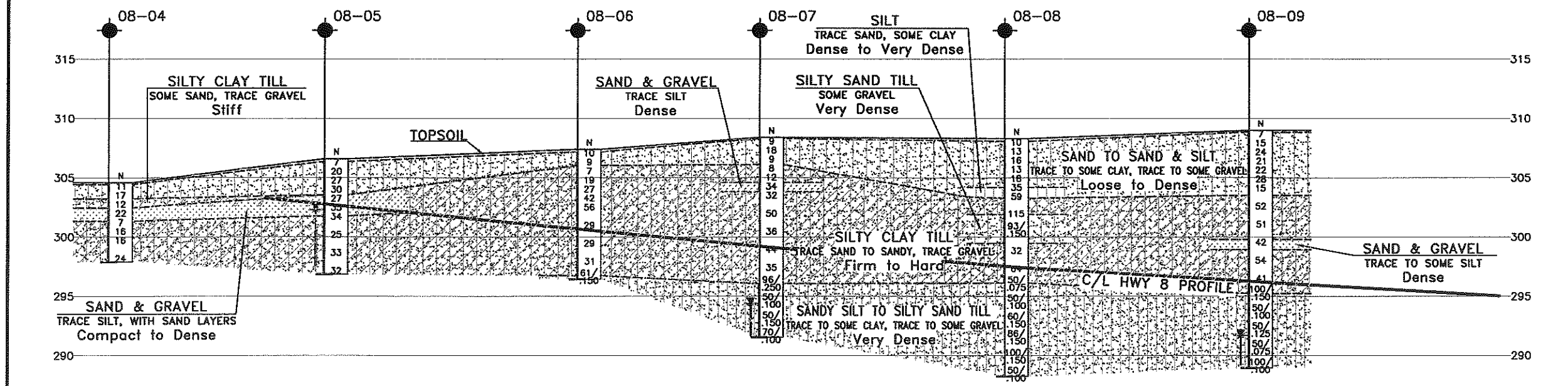
NO	ELEVATION	NORTHING	EASTING
06-28	307.1	4 809 498.2	230 248.8
06-29	308.2	4 809 480.4	230 275.7
06-30	310.5	4 809 440.1	230 337.9
06-31	310.0	4 809 416.0	230 366.9
06-32	309.2	4 809 393.0	230 412.3
06-33	308.0	4 809 377.7	230 442.3
08-04	304.6	4 809 531.2	230 211.9
08-05	306.6	4 809 507.6	230 250.2
08-06	307.4	4 809 479.7	230 295.2
08-07	308.4	4 809 458.9	230 327.4
08-08	308.3	4 809 430.6	230 370.4
08-09	309.0	4 809 402.1	230 413.1

**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.

**GEOCRE No. 40P8-152**



**LICENSED PROFESSIONAL ENGINEER**  
**M. R. ANDERSON**  
Nov 28/08  
PROVINCE OF ONTARIO

**LICENSED PROFESSIONAL ENGINEER**  
**P. K. CHATTERJI**  
Nov 28/08  
PROVINCE OF ONTARIO

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