

**FOUNDATION INVESTIGATION AND DESIGN REPORT
RSS SLOPE, KING STREET EAST N-W RAMP
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: 40P8-157

Report to

Morrison Hershfield Limited

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

November 28, 2008
File: 19-479-38

H:\19\479\38 Hwy 8\Reports & Memos\King N-W Ramp
FINAL FIDR.doc

TABLE OF CONTENTS

PART 1: FACTUAL INFORMATION

1	INTRODUCTION	1
2	SITE DESCRIPTION	1
3	SITE INVESTIGATION AND FIELD TESTING	2
4	LABORATORY TESTING	3
5	DESCRIPTION OF SUBSURFACE CONDITIONS	3
5.1	Topsoil	3
5.2	Gravelly Sand Fill	3
5.3	Sand and Gravel, Sand, and Silty Sand to Sandy Silt Deposit.....	4
5.4	Silty Clay	5
5.5	Groundwater Conditions	5
6	MISCELLANEOUS	6

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7	GENERAL.....	7
8	RSS SLOPE DESIGN	7
8.1	Stability Analysis	8
8.2	Settlement Analysis	9
9	ALTERNATIVE WALL DESIGN	9
9.1	RSS Wall.....	9
9.2	Cantilever Wall on Spread Footings	11
9.3	Backfill and Lateral Earth Pressures.....	11
10	EMBANKMENT CONSTRUCTION	13
11	EXCAVATION AND DEWATERING.....	13
12	SEISMIC CONSIDERATIONS.....	14
13	CONSTRUCTION CONCERNS	14
14	CLOSURE	15

Appendices

Appendix A	Record of Borehole Sheets
Appendix B	Laboratory Test Results
Appendix C	Slope Stability Analysis
Appendix D	Borehole Locations and Soil Strata Drawing

**FOUNDATION INVESTIGATION AND DESIGN REPORT
RSS SLOPE, KING STREET EAST N-W RAMP
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: 40P8-157

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for a proposed RSS slope along the west side of the North-West ramp of the Highway 8/King Street East interchange 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. As part of the widening project, the King Street East N-W ramp will be shifted west of the current alignment for a length of 350 m. Realignment and steepening of an earth berm using a RSS slope is planned as part of the ramp realignment.

The purpose of this investigation was to explore the subsurface conditions along the RSS slope alignment and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile and cross-sections, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to Morrison Hershfield Limited, under the Ministry of Transportation Ontario (MTO) Agreement Number 3005-E-0035.

2 SITE DESCRIPTION

A combined cut slope and earth berm of 4 to 8 m in height exists along the west side of the existing King Street East N-W Ramp. Ramp grades rise from near elevation 302 m at the Highway 8 southbound bullnose to elevation 308 at the King Street East bullnose. An approximate 1.0 to 1.5 m deep ditch runs along the west side of the ramp, and a small residential subdivision lies west of the berm/cut slope.

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 this component of the widening project were carried out during the period May 23 to 27, 2008 and consisted of drilling and sampling nine boreholes (Nos. 08-10 to 08-18) to depths of 8.2 to 11.3 m. Boreholes 08-10 to 08-17 were drilled along the top of the existing berm and borehole 08-18 was drilled near the west toe.

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawing in Appendix D. The coordinates and elevations of the boreholes are given on this drawing and on the individual Record of Borehole Sheets in Appendix A.

Prior to commencement of drilling, utility clearances were obtained for all borehole locations.

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 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 3.1. The piezometers will be decommissioned in accordance with MOE Reg. 903.

Table 3.1 – Borehole Completion Details

Borehole	Piezometer Tip (Sand Filter) Details			Backfill
	Depth	Elevation	Stratum	
08-10	-	-	-	Bentonite/cuttings mixture to surface
08-11	-	-	-	Bentonite/cuttings mixture to surface
08-12	10.7 – 9.0	301.4 – 303.1	Sand and gravel	Bentonite seal to 8.7 m, grout to surface
08-13	-	-	-	Bentonite/cuttings mixture to surface
08-14	10.7 – 8.8	303.2 – 305.1	Sand and gravel	Bentonite seal to 8.2 m, grout to surface
08-15	-	-	-	Bentonite/cuttings mixture to surface
08-16	9.8 – 7.8	303.5 – 305.5	Sand	Bentonite seal to 7.3 m, grout to surface
08-17	9.1 – 7.0	299.0 – 301.1	Gravelly sand	Bentonite seal to 6.6 m, grout to surface
08-18	9.1 – 7.3	296.5 – 298.3	Silty clay	Bentonite seal to 6.6 m, grout to surface

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 where appropriate. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the figures contained in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

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 Drawing in Appendix D. 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 layer of topsoil overlying gravelly sand fill, underlain by a native deposit comprising sand and gravel, sand, and silty sand to sandy silt. Silty clay was encountered locally below the sand/gravel/silt. More detailed descriptions of the individual strata are presented below.

5.1 Topsoil

A 50 to 225 mm thick layer of topsoil was encountered at the ground surface in all boreholes. A buried topsoil layer, 200 and 100 mm thick, was encountered in boreholes 08-12 and 08-16 at depths of 4.4 and 3.8 m (elevation 307.7 and 309.5 m), respectively.

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 Gravelly Sand Fill

A layer of non-cohesive granular fill was encountered below the topsoil in all boreholes drilled along the top of the existing berm (borehole 08-10 to 08-17). The fill typically comprised gravelly sand, trace silt to silty, with occasional cobbles and zones of sand and gravel. It was described as moist and brown to grey.

Based on recorded SPT N-values of 12 to 75 blows/0.3 m, the fill is typically compact to very dense. One value of 7 blows/0.3 m was recorded in borehole 08-10, indicating a loose zone. Several tests achieving 50 blows for 75 to 125 mm of penetration likely reflect the presence of cobbles in the fill.

The moisture content of recovered fill samples ranged from 2 to 11%.

The results of grain size analyses conducted on eight samples as follows:

Gravel %	21 to 38
Sand %	42 to 65
Silt & Clay %	7 to 34

The grain size curves for the samples tested are shown in Figures B1 and B2, Appendix B.

The interpreted depth/thickness of the fill ranged from 3.0 to 4.4 m (base at elevation 302.0 to 310.4 m). The boundary between the fill and underlying native soil is difficult to ascertain due to the non-cohesive nature and similarity of the materials. The actual fill depth may vary from that reported.

5.3 Sand and Gravel, Sand, and Silty Sand to Sandy Silt Deposit

A native heterogeneous deposit comprising various zones of sand, sand and gravel, silty sand to sandy silt, and locally silt was encountered below the fill in all boreholes drilled upon the existing berm, and below the topsoil in borehole 08-18. These deposits were described as moist to wet and brown to grey.

Recorded SPT N-values in this deposit varied significantly, ranging from 3 blows/0.3 m (very loose) to 83 blows/0.025 m (very dense) of penetration. Loose to very loose zones, indicated by N-values of less than 10, included the upper 0.6 to 2.0 m of the native soil in boreholes 08-11, 08-16, 08-17 and 08-18. Tests achieving 50 blows in 150 mm of penetration or less likely reflect the presence of cobbles in the fill.

The natural moisture content of recovered samples of the native deposits ranged from 2 to 22%, typically less than 10%.

The results of grain size analyses conducted on 19 samples are as follows:

	Sand and Gravel to Gravelly Sand (8 samples)	Sand to Silty Sand (6 samples)	Silt to Sand and Silt (5 samples)
Gravel %	26 to 56	0 to 17	0 to 1
Sand %	33 to 67	63 to 85	14 to 49
Silt %		12 to 32	40 to 75
Clay %	7 to 25		3 to 15

The grain size distribution curves for the samples tested are shown in Figures B3 to B6, Appendix B.

The lower boundary of the sand/gravel/silt deposit was encountered at depths of 7.0 to 9.1 m (elevation 297.1 to 299.0 m) in boreholes 08-10, 08-17 and 08-18 drilled at the north end of the site. In these boreholes, the thickness of the deposit was 4.9 to 6.8 m. The remaining boreholes were terminated in this material at depths of 9.8 to 11.3 m (elevation 300.2 to 303.5 m).

5.4 Silty Clay

In boreholes 08-10, 08-17 and 08-18 drilled at the north end of the site, a cohesive grey silty clay stratum was encountered below the cohesionless deposits at depths of 7.0 to 9.1 m (elevation 297.1 to 299.0 m). The clay contained trace sand to sandy, trace gravel and occasional cobbles.

Based on SPT values of 53 to 61 blows/0.3 m, the cohesive material is described as being hard.

The natural moisture content of recovered samples ranged from 14 to 22%, locally 6% in a sample from borehole 08-18 described as sandy.

The results of grain size analyses conducted on two samples are as follows:

Gravel %	0 to 2
Sand %	5 to 22
Silt %	44 to 59
Clay %	32 to 36
Liquid Limit	26 to 30
Plastic Limit	13 to 15

The grain size distribution curves for the samples tested are shown in Figure B7, Appendix B. The Atterberg Limits are plotted on Figure B8. The results indicate that the silty clay is a CL soil (low plasticity).

Boreholes 08-10, 08-17 and 08-18 were terminated in the silty clay at 8.2 to 9.8 m depth (elevation 295.9 to 298.3 m).

5.5 Groundwater Conditions

Groundwater was not observed in the boreholes during or upon completion of drilling.

Standpipe piezometers were installed in selected boreholes to monitor water levels after completion of 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
08-12	27-May-2008	Dry	-
	19-Aug-2008	Could not locate	-
08-14	19-Aug-2008	Dry	-
08-16	19-Aug-2008	Dry	-
08-17	19-Aug-2008	7.8	300.3
08-18	19-Aug-2008	Could not locate	-

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 silty clay.

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.

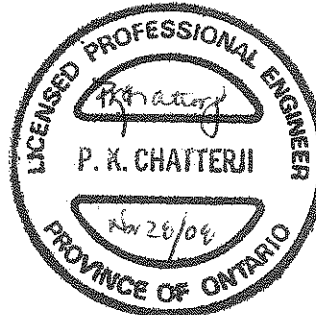
All-Terrain Drilling of Waterloo supplied and operated the drilling and sampling equipment used for the investigation. Full time supervision of the field activities, including obtaining utility clearances, was carried out by Mr. David Elwood and Mr. Keli Shih.

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 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.

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



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



**FOUNDATION INVESTIGATION AND DESIGN REPORT
RSS SLOPE, KING STREET EAST N-W RAMP
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: 40P8-157

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 RSS slope.

Highway 8 will be widened from four to eight lanes from 1 km north of the Grand River southerly to Sportsworld Drive. As part of the widening project, the King Street East N-W ramp will be shifted west of the current alignment for a length of 350 m. Realignment and steepening of a combined cut slope and earth berm up to 8 m high using a RSS slope is planned as part of the realignment.

At present, a combined cut slope and earth berm of 4 to 8 m in height rises above the base of the ditch along the west side of the existing King Street East N-W Ramp. The ditch is approximately 1.0 to 1.5 m deep.

The existing slope is inclined near 2H:1V with an approximate 3 m wide mid-height bench provided where the slope height exceeds 6 m. The proposed inclination of the new RSS slope ranges up to 1H:1V. The slope height will be essentially unchanged.

Although the current design calls for an RSS slope, recommendations for alternative retaining wall designs (concrete cantilever wall and RSS wall) are also provided.

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 RSS SLOPE DESIGN

In general terms, the site was found to be underlain by gravelly sand fill, overlying a native heterogeneous deposit comprising sand and gravel, sand, and silty sand to sandy silt. The fill and

native soils are typically compact to very dense, with occasional zones of loose to very loose material. The groundwater level is below the depth of influence on design.

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 slope face to the furthest extent of the reinforcement (typically equal to 70% of the slope height).

To provide an acceptable foundation performance, the RSS mass must be founded on compact to very dense gravelly sand fill and/or the native sand/gravel/silt deposit. The highest permitted level for the base of the RSS, defined at the borehole locations drilled on top of the existing berm, ranges from elevation 304.9 to 313.7 m. In the area of borehole 08-18 drilled near the west toe, the highest permitted level is elevation 304.5 m.

Topsoil, loose fill, and any soft/wet material should be stripped from the footprint of the RSS, and the exposed subgrade should be proof rolled. Fill placed under the RSS mass to achieve the design founding level must be placed as engineered fill, consisting of OPSS Granular “A” or “B” compacted at a moisture content within 2% of optimum.

Geotechnical analysis of the proposed RSS slope design was carried out to assess the external stability of the proposed slope inclination and the immediate and long-term settlement of the embankment. The analyses were based on the soil profiles encountered in the boreholes and engineering properties assessed from the field and laboratory index/strength tests. The results of the analyses are presented in the sections below.

Retained soil system (RSS) slopes should be specified to be “High Performance” and “High Appearance”. The contract drawings should include information on the longitudinal alignment of the slope in plan, the top and base elevations of the RSS slope in profile, cross-sectional space constraints and the NSSP for construction of RSS walls/slopes.

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 slope should be analyzed by the supplier/designer of the proprietary product selected for this site.

8.1 Stability Analysis

Stability analyses were carried out for a maximum embankment slope inclination of 1H:1V under static and seismic loading conditions. The external stability of the RSS slope was assessed by forcing the failure surface to pass behind the reinforced soil mass, assuming a reinforcing length of 70% of the slope height. The design and internal stability of the RSS system must be determined by the RSS supplier, and the global stability should be reviewed when the design is available.

The stability analyses were carried out using the commercially available slope stability program GSLOPE developed by Mitre Software Inc. Bishop's modified method of slices was used for the limit equilibrium analyses. Based on consideration of the risk involved and past experience with highway embankment design/monitoring, the minimum factor of safety considered appropriate to achieve stability is 1.3 for short-term and long-term stability of embankments founded on cohesionless foundation soils.

The stability of the embankments under seismic loading was assessed based on a pseudo-static approach using the parameters presented in Section 10. The pseudo-static analysis considers the application of the peak horizontal acceleration (PHA) to the soil mass on a non-softening foundation to assess the embankment stability. A minimum factor of safety of 1.0 is considered appropriate for seismic loading.

Results of the stability analyses conducted on a typical section are presented in Figures C1 and C2 of Appendix C for static and seismic loading conditions, respectively. The results indicate that the Factor of Safety (FS) for the embankment geometry will be greater than 1.7 for static conditions and 1.5 for the seismic analysis. The proposed RSS slope inclination is therefore considered to be stable externally.

The potential for liquefaction of the foundation soils during a seismic event is considered to be low in accordance with CHBDC Section C4.6.

8.2 Settlement Analysis

New berm construction will require placement of up to 4 m of new fill behind the existing berm alignment and removal of material in the existing berm. For a length of approximately 200 m at the north end, the berm alignment will be shifted up to 10 m west of the current alignment.

Settlement of the cohesionless foundation soils under the new embankment fill was assessed using elastic theory. The results indicate that the maximum immediate (elastic) foundation settlement under an approximate 4 m high embankment loading will be in the order of 25 mm for the subsurface conditions at this site. This settlement is expected to occur essentially as the fill is placed.

9 ALTERNATIVE WALL DESIGN

9.1 RSS Wall

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.

As the RSS wall concept has not been developed, the proposed alignment, wall height and wall base elevations have not been established. For the purposes of this report, it has been assumed that the wall will be positioned along the proposed ditchline indicated on preliminary cross-sections, with the wall base at the elevation of the ditch and the wall height being the difference in elevation between the proposed and existing ground elevation along the ditchline. Based on these assumptions, the anticipated wall height is as follows:

Table 9.1 – Anticipated Retaining Wall Levels

Borehole No.	Ground Surface at Proposed Ditchline		Anticipated Wall Height (m)
	Existing	Proposed	
08-10	305.2	301.2	4.0
08-17	309.0	303.0	6.0
08-11, 08-18	309.8	304.0	5.8
08-12	311.2	305.4	5.8
08-13	311.6	306.3	5.3
08-14	310.8	306.9	3.9
08-15	310.8	306.8	4.0
08-16	310.9	307.0	3.9

The native foundation soils along the wall alignment generally vary from compact sandy silt to very dense sand and gravel. However, loose zones are present at various levels within the more competent material. To minimize the potential impacts of the loose zones on wall performance, it is recommended that the highest permitted level for the base of the RSS be established at the proposed ditch levels indicated in Table 9.1.

In localized areas such as borehole 08-11, loose material may be present below the recommended highest base level. Proof rolling of the entire founding surface with a heavy roller is recommended to improve the uniformity of support and compact any remaining loose zones.

The RSS wall founded on the native compact to very dense foundation soils at or below the highest levels indicated above should be designed for a factored bearing resistance of 450 kPa at ULS and a bearing resistance of 200 kPa at SLS.

The levelling pad below the wall face should be placed at least 0.6 m below the ground surface in front of the wall, on a minimum 0.6 m thick pad of granular engineered fill at

least twice as wide as the levelling pad. The wall base should be stepped down from south to north correspondingly with the proposed final grades.

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 sandy silt or sand and gravel may be estimated using an ultimate friction coefficient of 0.5. This is an "ultimate" value and requires a degree of sliding movement to occur to fully mobilize the resistance.

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.

9.2 Cantilever Wall on Spread Footings

Design of spread footings to support a concrete cantilever wall should be carried out using the highest founding levels, bearing resistance values, and subgrade preparation procedures recommended for RSS wall design in the preceding section. Any loose zones identified below the founding level, such as that encountered in borehole 08-11, should be subexcavated and the footings stepped down to found on compact native soil.

All footings should be provided with a minimum of 1.4 m of earth cover over the footing base as protection against frost action.

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 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 compact to very dense native soil below the level of all fill or excessively loose material.

9.3 Backfill and Lateral Earth Pressures

If a cantilever wall is employed, the backfill should consist of Granular A or Granular B material. 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.

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

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 below)

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

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

q = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the retaining wall are dependent on the material used as backfill. Typical values for granular backfill are shown in Table 9.2.

Table 9.2 – Earth Pressure Coefficients (K)

Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (Unrestrained Wall)	0.27	0.40	0.31	0.43
At rest (Restrained Wall)	0.43	-	0.47	-
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-

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 factors in Table 9.2 above 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.

10 EMBANKMENT CONSTRUCTION

Embankment construction should be carried out in accordance with OPSS 206 as amended by the most recent Special Provision. Earth fill may consist of granular materials and Select Subgrade Material (SSM) in compliance with Special Provision 110S13, August 2007, "Amendment to OPSS 1010, April 2004".

All topsoil and highly organic material should be stripped from the footprint of the embankment prior to placing fill. Prior to placement of new fill against the existing embankment slope, the existing earth slope should be benched in accordance with OPSS 208.010.

Earth fill embankment slopes must be provided with erosion protection in accordance with OPSS 572.

11 EXCAVATION AND DEWATERING

Excavation and backfilling for RSS or cantilever wall foundation 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 fill and loose to very dense native materials should be classified as Type 3 soils.

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.

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 ramp, 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 fill or localized more permeable pockets/lenses in the underlying 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.

12 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

The soil profile type at this site has been classified as Type I. 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 0.5ϕ . For the design of retaining walls, the coefficients of horizontal earth pressure in Table 12.1 may be used:

Table 12.1 – 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

13 CONSTRUCTION CONCERNS

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

- Cobbles and boulders may be encountered during excavation of the fill and native soils in areas of cut. Localized seepage of perched water may also be experienced, requiring drainage.
- The thickness and presence of fill and topsoil were investigated at the borehole locations only. These deposits may extend to greater depths or be encountered at other locations between boreholes.

- Geotechnical confirmation is required that all topsoil and otherwise deleterious materials within the proposed RSS slope footprint are sub-excavated and replaced with compacted approved backfill.

14 CLOSURE

Engineering analysis and preparation of the foundation design report was conducted by Mr. Murray Anderson, P.Eng. The report was reviewed by 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



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 ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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






 Water Level
 C_{pen} Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

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

EXPLANATION OF ROCK LOGGING TERMS

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 08-10

1 OF 1

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 808 776.17 E 231 273.83 ORIGINATED BY KS
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2008.05.23 - 2008.05.23 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
305.0								20	40	60	80	100					
0.0	TOPSOIL: (100mm)					305											
0.1	SAND and GRAVEL, trace silt Compact Grey/Brown Moist to Dry (FILL)		1	SS	22												
304.1																	
0.9	Gravelly SAND, trace to some silt, occasional cobbles Loose to Compact Moist Brown (FILL)		2	SS	14	304											
			3	SS	22	303										28 65 7 (SI+CL)	
			4	SS	7	302											
302.0																	
3.0	SAND and GRAVEL, trace silt, occasional cobbles Compact to Dense Grey/Brown Moist		5	SS	14	301										33 57 10 (SI+CL)	
			6	SS	35	300											
			7	SS	36												
299.5																	
5.5	SAND, some silt, trace gravel Very Dense Mottled Grey/Brown to Brown Wet		8	SS	72	299											

ONTMT4S 7938.GPJ 10/6/08

RECORD OF BOREHOLE No 08-11

1 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 808 731.50 E 231 332.80 ORIGINATED BY KS
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY VM
 DATUM Geodetic DATE 2008.05.23 - 2008.05.23 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
310.0								20	40	60	80	100				
0.0	TOPSOIL: (200mm)						310									
0.2	SAND, some silt to silty, trace gravel, trace clay Compact Brown Moist (FILL)		1	SS	20											
			2	SS	17		309									
308.5																
1.5	Silty, gravelly SAND, occasional cobbles Very Dense Grey Moist (FILL)		3	SS	68		308									26 42 32 (SI+CL)
			4	SS	50/ .075											
			5	SS	70		307									26 53 21 (SI+CL)
			6	SS	50/ .125		306									
305.7																
4.3	Silty SAND to sandy SILT, trace clay Loose to Compact Brown Moist to Wet		7	SS	11		305									
							304									
			8	SS	7		303									0 22 75 3
			9	SS	25		302									
301.5																
8.5	SILT, some sand, some clay Compact Brown Wet						301									0 14 74 12
			10	SS	13											
300.2																
9.8																

Continued Next Page

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

RECORD OF BOREHOLE No 08-11

2 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 808 731.50 E 231 332.80 ORIGINATED BY KS
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2008.05.23 - 2008.05.23 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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page							20 40 60 80 100	20 40 60					
	END OF BOREHOLE AT 9.8m. BOREHOLE BACKFILLED WITH A MIXTURE OF BENTONITE AND CUTTINGS.													

ONTMT4S 7938.GPJ 10/6/08

RECORD OF BOREHOLE No 08-12

1 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 806 701.90 E 231 369.77 ORIGINATED BY KS
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2008.05.23 - 2008.05.23 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
312.1								20	40	60	80	100				
0.0	TOPSOIL: (100mm)															
0.1	Silty, gravelly SAND , occasional cobbles Compact to Very Dense Moist Brown to Grey (FILL)		1	SS	20											
			2	SS	34											
			3	SS	56											21 45 34 (SI+CL)
			4	SS	50											
			5	SS	59											
			6	SS	12											
307.7																
307.4	TOPSOIL: (200mm)															
307.5	Dark Brown															
4.6	Sandy SILT , some clay to clayey Compact Brown		7	SS	12											0 35 50 15
306.6																
5.5	SAND and GRAVEL , trace silt, occasional cobbles Very Dense Grey Moist															
			8	SS	57											56 33 11 (SI+CL)
			9	SS	56/ .150											
			10	SS	53/ .150											

Continued Next Page

+³ ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-12

2 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 808 701.90 E 231 369.77 ORIGINATED BY KS
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2008.05.23 - 2008.05.23 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 ³	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					
	Continued From Previous Page													
300.9			11	SS	50/ 100		302							
11.2	END OF BOREHOLE AT 11.2m. 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) 2008.05.27 dry - 2008.08.19 could not locate -						301							

RECORD OF BOREHOLE No 08-13

1 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 808 668.63 E 231 410.31 ORIGINATED BY KS
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2008.05.26 - 2008.05.26 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
313.4								20	40	60	80	100					GR SA SI CL
0.0	TOPSOIL: (150mm)																
0.2	Silty, gravelly SAND, occasional cobbles Compact to Dense Brown to Grey Moist (FILL)		1	SS	30		313										
			2	SS	50		312										
			3	SS	42		311										30 47 23 (SI+CL)
			4	SS	19		310										
310.4																	
3.0	Silty, gravelly SAND Loose to Very Dense Grey/Brown Moist		5	SS	42		310										
			6	SS	43		309										
			7	SS	83		308										32 48 20 (SI+CL)
			8	SS	7		307										
							306										
305.8																	
7.6	SAND and GRAVEL, some silt, occasional cobbles Dense to Very Dense Grey Moist		9	SS	66		305										
					.025		304										39 48 13 (SI+CL)
			10	SS	35												

Continued Next Page

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

RECORD OF BOREHOLE No 08-13

2 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 808 668.63 E 231 410.31 ORIGINATED BY KS
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2008.05.26 - 2008.05.26 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page							20	40	60	80	100					
						</											

RECORD OF BOREHOLE No 08-14

1 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 808 635.58 E 231 447.74 ORIGINATED BY KS
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2008.05.26 - 2008.05.26 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
313.9								20 40 60 80 100					
0.0	TOPSOIL: (175mm)							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
0.2	Silty, gravelly SAND, occasional cobbles Compact to Very Dense Brown to Grey Moist (FILL)		1	SS	19								
			2	SS	53		313						
			3	SS	51		312						
			4	SS	33		311						26 44 30 (SI+CL)
			5	SS	50/ .125								
310.2													
3.7	Silty, gravelly SAND, occasional cobbles Compact to Dense Grey/Brown Moist		6	SS	40		310						
			7	SS	37		309						28 47 25 (SI+CL)
			8	SS	11		308						
			9	SS	23		306						
305.2													
8.7	SAND and GRAVEL, some silt, occasional cobbles Compact Brown Moist		10	SS	22		305						36 47 17 (SI+CL)

Continued Next Page

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

RECORD OF BOREHOLE No 08-14

2 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 808 635 58 E 231 447.74 ORIGINATED BY KS
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2008.05.26 - 2008.05.26 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w			LIQUID LIMIT w _L
Continued From Previous Page								20 40 60 80 100			WATER CONTENT (%) 20 40 60		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
302.6			11	SS	25		303						
11.3	END OF BOREHOLE AT 11.3m. Piezometer installation consists of 25.4mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH (m) ELEV. (m) 2008.08.19 dry -												

RECORD OF BOREHOLE No 08-15

1 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 808 603.17 E 231 486.99 ORIGINATED BY KS
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2008.05.27 - 2008.05.27 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100					w _p	w	w _L					
								SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE												
313.9																				
0.0	TOPSOIL: (200mm)																			
0.2	Gravelly SAND, some silt to silty, occasional cobbles Compact to Very Dense Brown to Grey Moist (FILL)		1	SS	22															
			2	SS	50/ .125		313													
			3	SS	50/ .075		312													
			4	SS	39		311													
	trace wood fragments		5	SS	62															
310.2																				
3.7	SAND, some silt, some gravel, occasional sandy silt seams, occasional cobbles Compact to Very Dense Grey Moist		6	SS	47		310													
			7	SS	25		309													
							308													
			8	SS	13		307													
			9	SS	50/ .150		306													
							305													
			10	SS	31															

Continued Next Page

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

RECORD OF BOREHOLE No 08-15

2 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 808 603.17 E 231 486.99 ORIGINATED BY KS
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2008.05.27 - 2008.05.27 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page													
302.6			11	SS	30		303							8 74 18 (SI+CL)
11.3	END OF BOREHOLE AT 11.3m. BOREHOLE BACKFILLED WITH MIXTURE OF BENTONITE AND CUTTINGS.													

RECORD OF BOREHOLE No 08-16

1 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 808 573.04 E 231 526.22 ORIGINATED BY KS
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2008.05.27 - 2008.05.27 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
313.3							<div>20 40 60 80 100</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div>						
0.0	TOPSOIL: (225mm)						<div>20 40 60 80 100</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div>						
0.2	Gravelly SAND, some silt to silty, occasional cobbles Compact to Very Dense Brown to Grey Moist (FILL)		1	SS	24								
			2	SS	36								
			3	SS	27								
			4	SS	75								
			5	SS	23								
309.5													
308.8	TOPSOIL: (100mm)												
3.9	Silty SAND, trace gravel Loose Brown Wet		6	SS	6								
			7	SS	6								
307.8													
5.5	SAND, some silt, some gravel, occasional silt lenses, occasional cobbles Compact Brown Moist to Wet		8	SS	29								
			9	SS	25								
			10	SS	27								
303.5													
9.8	END OF BOREHOLE AT 9.8m.												

Continued Next Page

+³, x³: Numbers refer to
Sensitivity 20
15 5
10 (%) STRAIN AT FAILURE

METRIC

[illegible]

RECORD OF BOREHOLE No 08-17

1 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 808 746.85 E 231 312.54 ORIGINATED BY KS
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2008.05.27 - 2008.05.27 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
308.1							20	40	60	80	100								
0.0	TOPSOIL: (50mm)																		
0.1	Silty, gravelly SAND, occasional cobbles Dense to Compact Grey Moist (FILL)		1	SS	32														
			2	SS	45														
			3	SS	69														
			4	SS	24														
305.1																			
3.0	SAND and SILT Loose to Compact Brown Moist		5	SS	8														
			6	SS	16														
			7	SS	10														
302.3																			
5.8	Gravelly SAND, trace silt, occasional cobbles Dense to Very Dense Brown to Grey Moist to Wet		8	SS	34														
			9	SS	53														
299.0																			
9.1	Silty CLAY, trace sand Hard Grey		10	SS	53														
298.3																			
9.8	END OF BOREHOLE AT 9.8m.																		

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-17

2 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 808 746.85 E 231 312.54 ORIGINATED BY KS
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2008.05.27 - 2008.05.27 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
Continued From Previous Page																	
	Piezometer installation consists of 25.4mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH (m) ELEV. (m) 2008.08.19 7.8 300.3																

RECORD OF BOREHOLE No 08-18

1 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 808 721.44 E 231 324.13 ORIGINATED BY KS
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2008.05.23 - 2008.05.23 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
305.6								20	40	60	80	100					
0.0	TOPSOIL: (150mm)																
0.2	Silty SAND to sandy SILT Loose to Very Loose Brown Moist		1	SS	4												
			2	SS	3												
			3	SS	10												
303.6																	
2.0	SAND, some silt Loose to Dense Brown Moist		4	SS	20												
			5	SS	32												
			6	SS	9												
301.1																	
4.5	SAND and GRAVEL, trace silt, occasional layers of silt and clay Compact Brown Wet		7	SS	15												
299.8																	
5.8	SAND and SILT, some clay, trace gravel, occasional cobbles Dense Brown Wet		8	SS	30												
298.6																	
7.0	Sandy, silty CLAY, trace gravel, occasional cobbles Hard Grey Moist		9	SS	55												
			10	SS	61												
295.9																	
9.8	END OF BOREHOLE AT 9.8m.																

Continued Next Page

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

RECORD OF BOREHOLE No 08-18

2 OF 2

METRIC

G.W.P. 277-97-00 LOCATION Hwy 8 Widening, Grand River to Sportsworld Dr. N 4 808 721.44 E 231 324.13 ORIGINATED BY KS
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2008.05.23 - 2008.05.23 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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	IN VALUES			20 40 60 80 100	20 40 60	W P W W L				
	Continued From Previous Page													
	Piezometer installation consists of 25.4mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH (m) ELEV. (m) 2008.08.19 could not locate -													

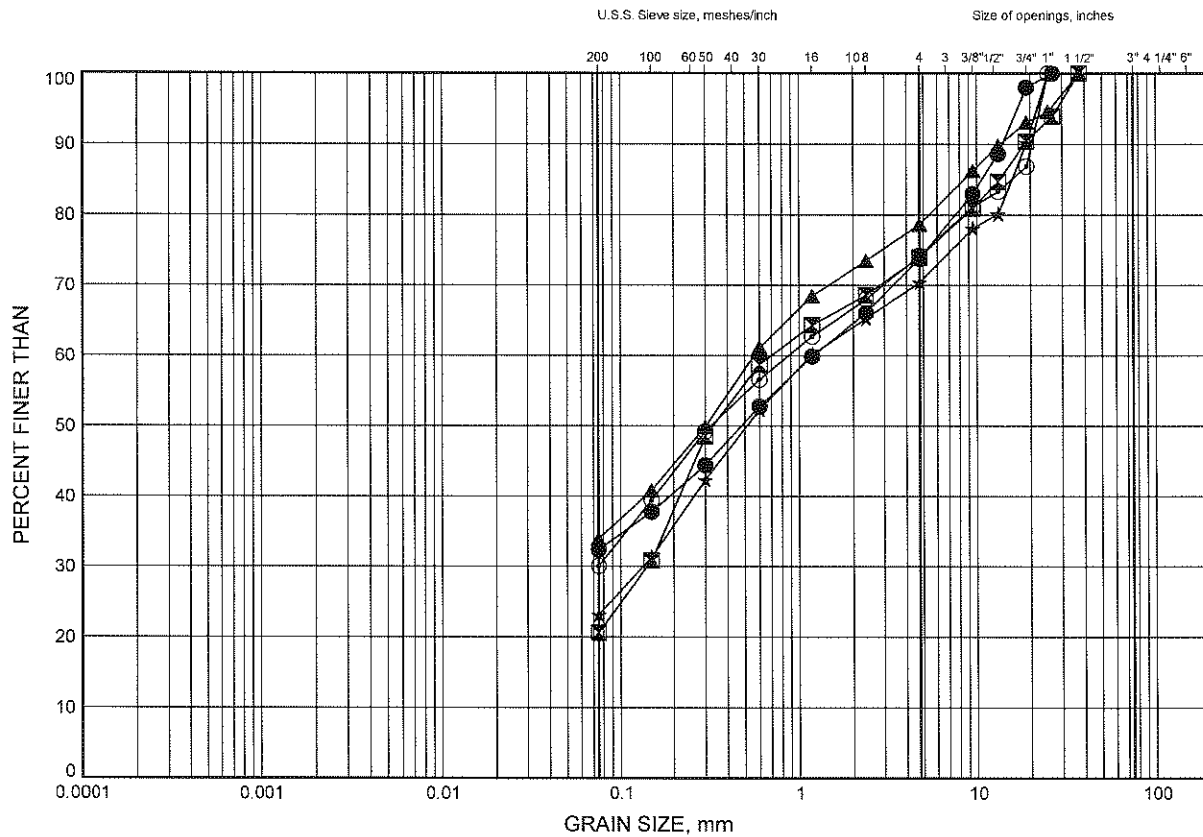
Appendix B

Laboratory Test Results

Highway 8 Widening Over Grand River GRAIN SIZE DISTRIBUTION

FIGURE B1

SILTY GRAVELLY SAND FILL



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

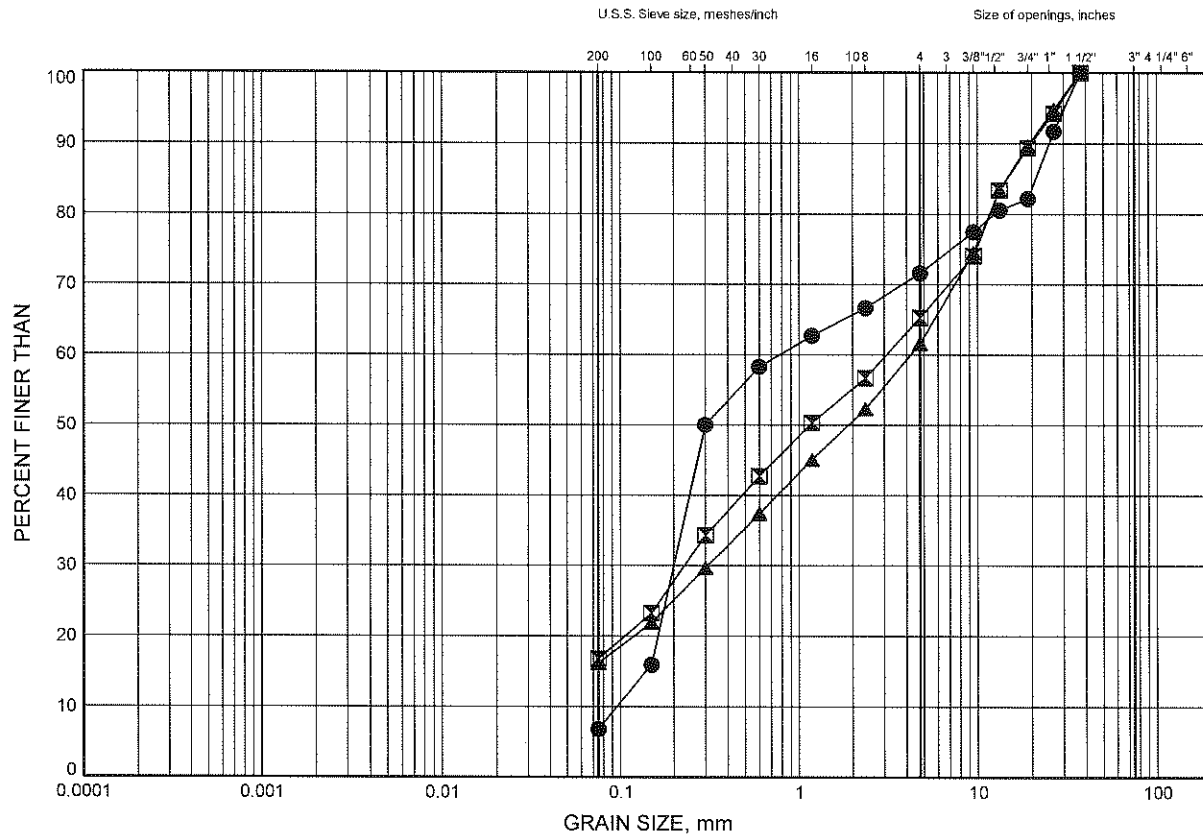
LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-11	1.83	308.17
⊠	08-11	3.35	306.65
▲	08-12	1.83	310.27
☆	08-13	2.59	310.81
⊙	08-14	2.59	311.31

Highway 8 Widening Over Grand River GRAIN SIZE DISTRIBUTION

FIGURE B2

GRAVELLY SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-10	1.83	303.17
⊠	08-15	3.35	310.55
▲	08-16	2.59	310.71

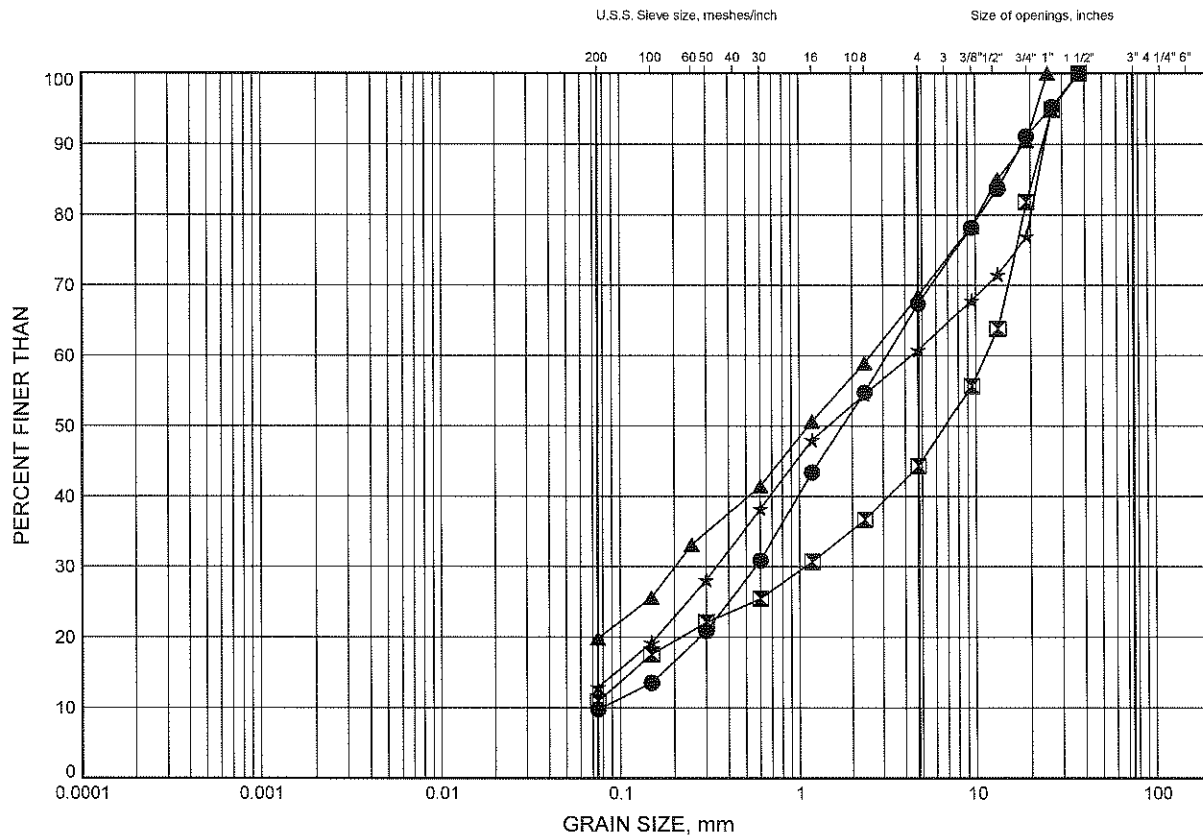


W.P.# 277-97-00
Prepared By MFA
Checked By MRA

Highway 8 Widening Over Grand River GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND AND GRAVEL TO GRAVELLY SAND



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

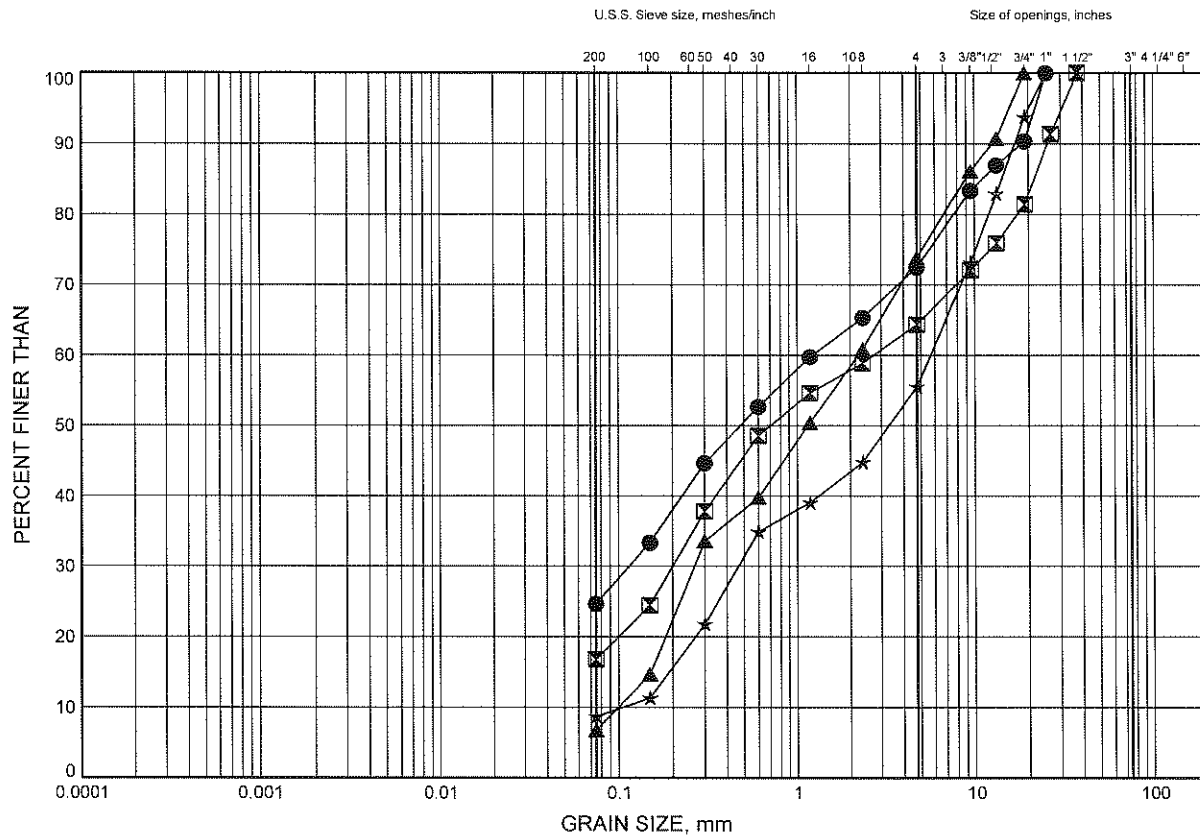
LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-10	4.11	300.89
⊠	08-12	6.40	305.70
▲	08-13	4.88	308.52
★	08-13	9.45	303.95

Highway 8 Widening Over Grand River GRAIN SIZE DISTRIBUTION

FIGURE B4

SAND AND GRAVEL TO GRAVELLY SAND



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

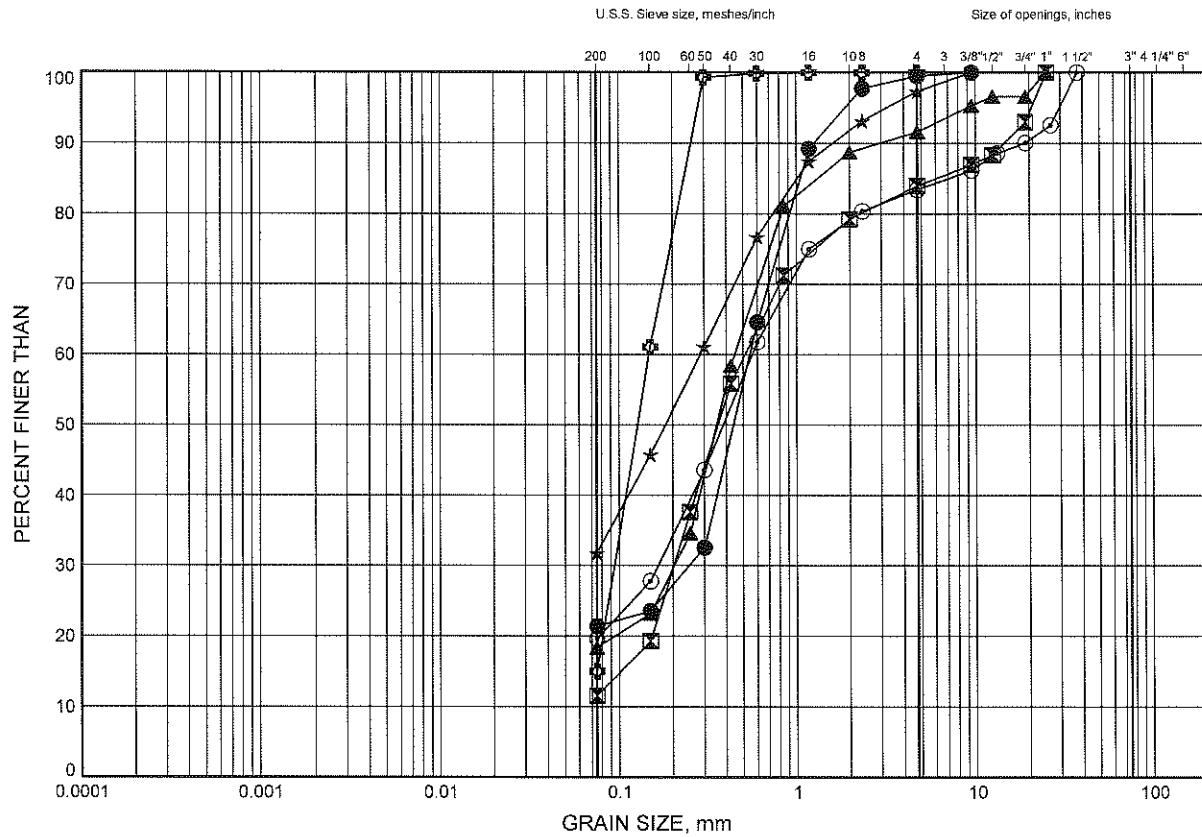
LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-14	4.88	309.02
⊠	08-14	9.45	304.45
▲	08-17	6.40	301.70
☆	08-18	4.88	300.73

Highway 8 Widening Over Grand River GRAIN SIZE DISTRIBUTION

FIGURE B5

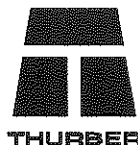
SAND TO SILTY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-10	7.75	297.25
⊠	08-15	6.40	307.50
▲	08-15	10.97	302.93
☆	08-16	4.88	308.42
⊙	08-16	7.92	305.38
⊕	08-18	2.59	303.02

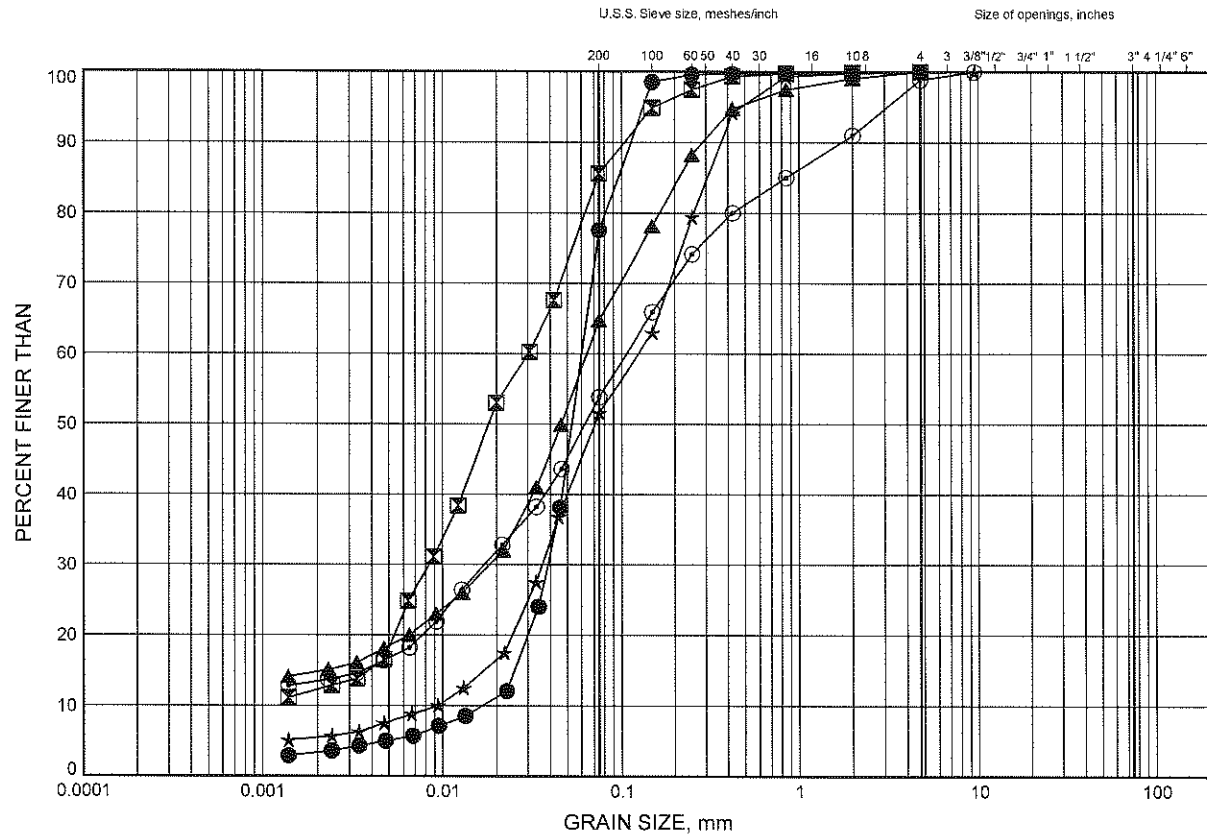


W.P.# 277-97-00
Prepared By MFA
Checked By MRA

Highway 8 Widening Over Grand River GRAIN SIZE DISTRIBUTION

FIGURE B6

SILT TO SAND AND SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-11	6.40	303.60
⊠	08-11	9.40	300.60
▲	08-12	4.88	307.22
☆	08-17	3.35	304.75
⊙	08-18	6.40	299.21

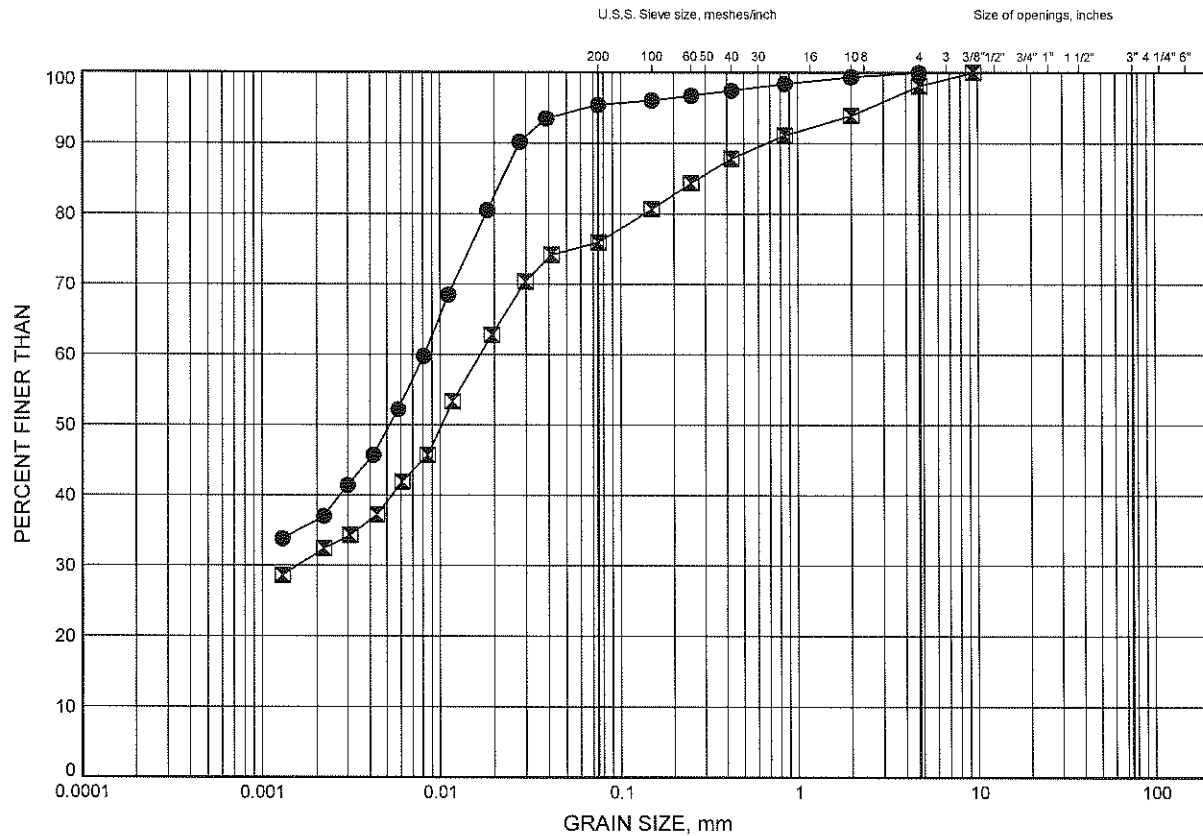


W.P.# .277-97-00.....
Prepared By .MFA.....
Checked By .MRA.....

Highway 8 Widening Over Grand River GRAIN SIZE DISTRIBUTION

FIGURE B7

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-17	9.45	298.65
⊠	08-18	7.92	297.69

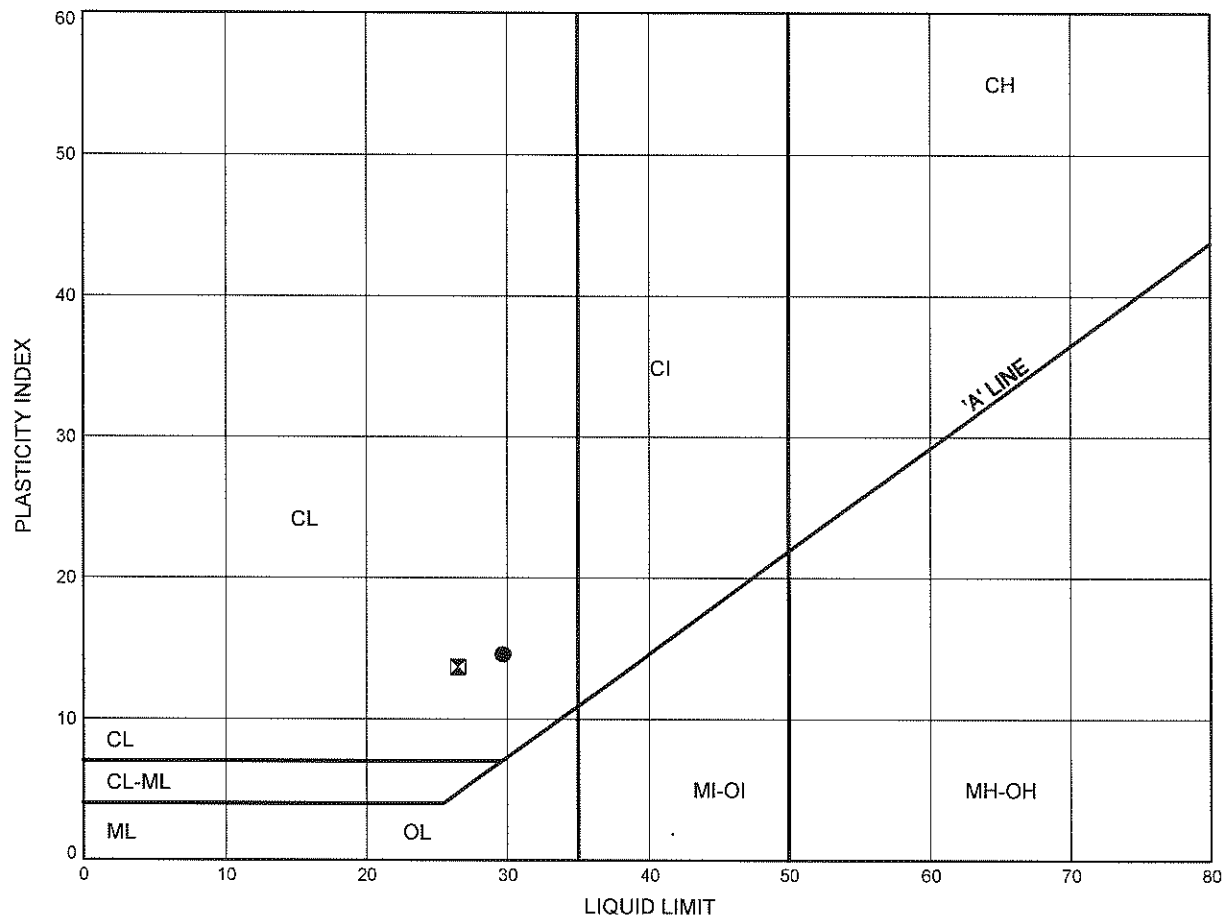


W.P.# 277-97-00
Prepared By MFA
Checked By MRA

Highway 8 Widening Over Grand River
ATTERBERG LIMITS TEST RESULTS

FIGURE B8

SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-17	9.45	298.65
⊗	08-18	7.91	297.70

Date October 2008
 Project 277-97-00



Prep'd MFA
 Chkd. MRA

Appendix C

Slope Stability Analysis

Thurber Engineering Ltd. - Toronto
 19-479-38
 Highway 8 Widening
 August 2008
 King St N-W Ramp
 1:1 RSS Slope Typical Section

	Gamma	C	Phi	Piezo
	kN/m ³	kPa	deg	Surf.
Grly Sand Fill	20	0	32	0
Sand	20	0	32	1

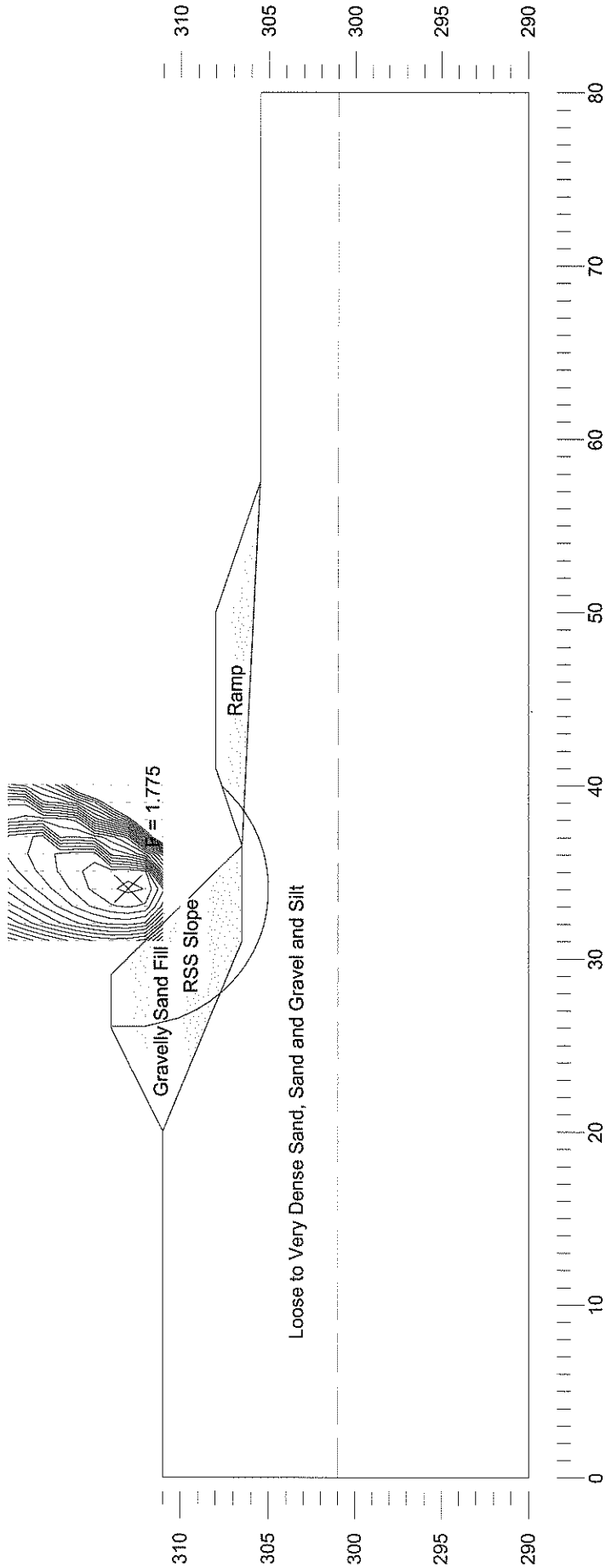


Figure C1

	Gamma	C	Phi	Piezo
	kN/m ³	kPa	deg	Surf.
Grly Sand Fill	20	0	32	0
Sand	20	0	32	1
Seismic coefficient = 0.08				

Thurber Engineering Ltd. - Toronto
 19-479-38
 Highway 8 Widening
 August 2008
 King St N-W Ramp
 1:1 RSS Slope Typical Section

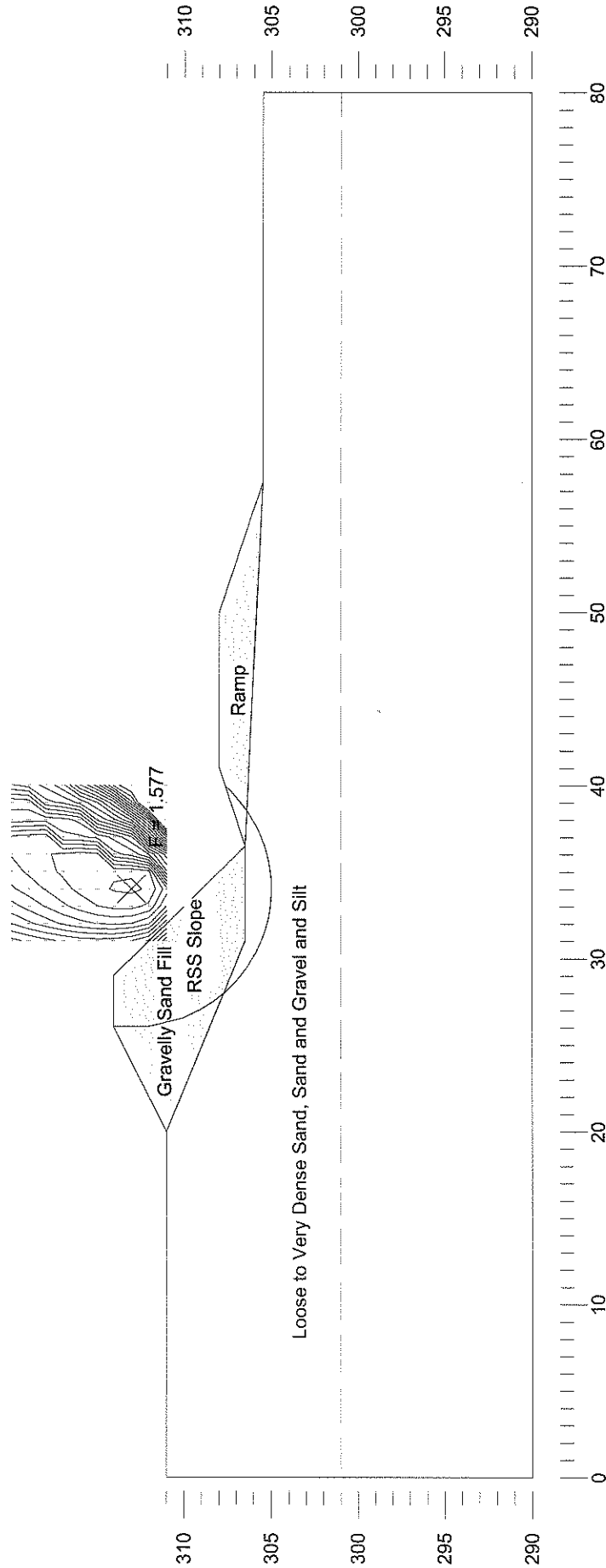
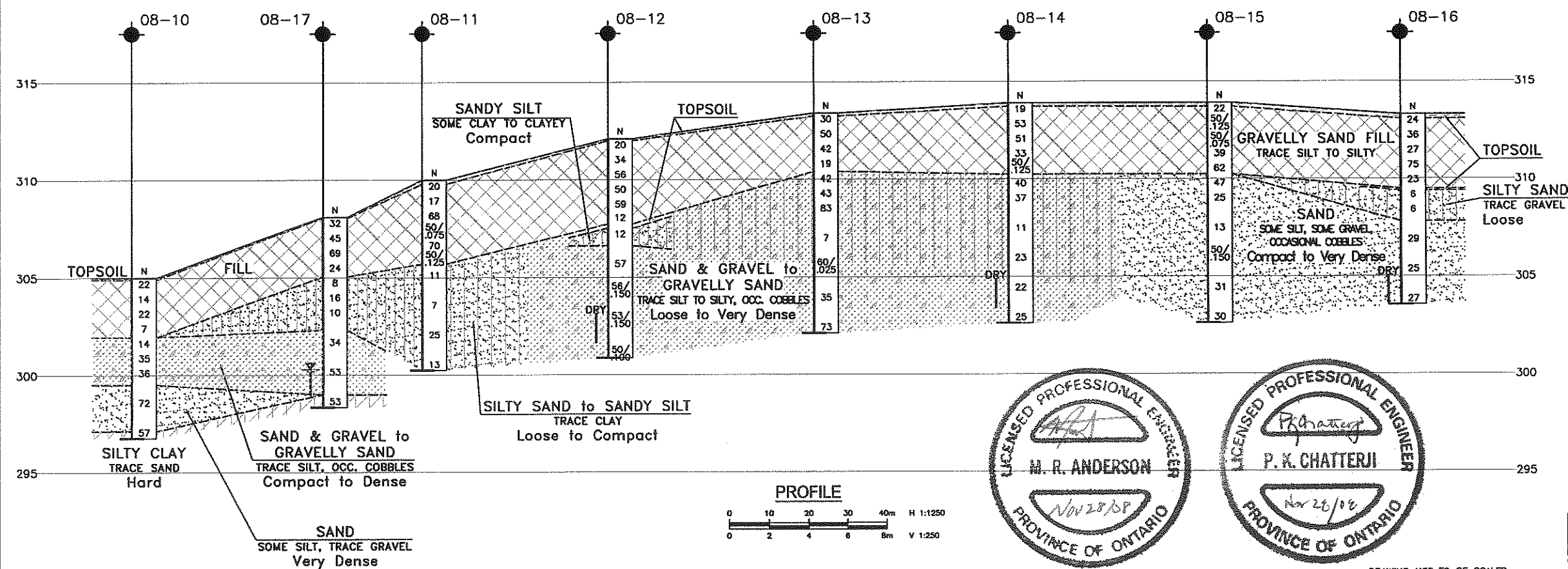
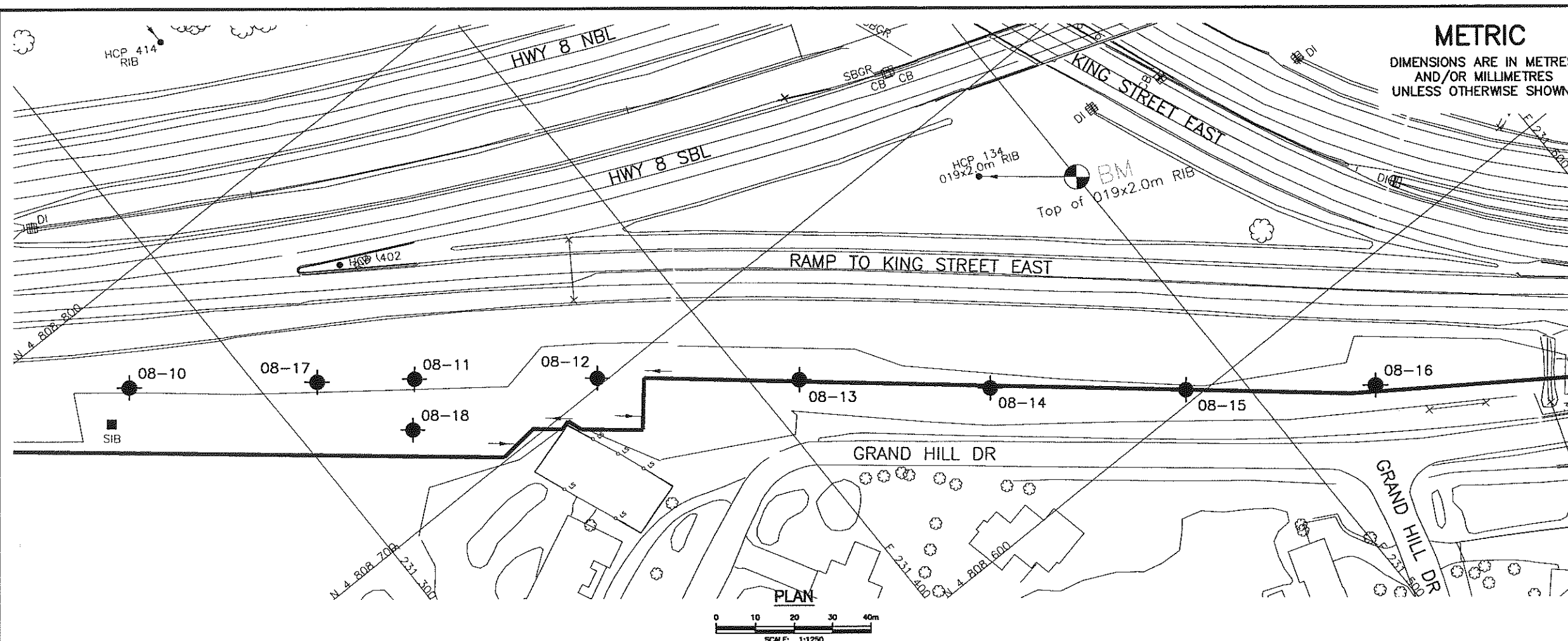


Figure C2

Appendix D

Drawing

Borehole Locations and Soil Strata



DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

References

RE	DATE	BY	DESCRIPTION			
DESIGN	MRA	CHK	PKC	CODE	LOAD	DATE SEP. 2008
DRAWN	MFA	CHK	MRA	SITE	STRUCT	DWG 1

NAME: n\ Question\ :n\ 470\ 78 Home \$! 1607939 | KnowledgeShare.ded

CONT No
GWP No

KING STREET EAST RAMP
HIGHWAY 8 WIDENING
KITCHENER
BOREHOLE LOCATIONS AND SOIL STRATA






SHEET

MORRISON
HERSHFIELD



THURBER ENGINEERING LTD.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

KEYPLAN
LEGEND

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

NO	ELEVATION	NORTHING	EASTING
08-10	305.0	4 808 776.2	231 273.8
08-11	310.0	4 808 731.5	231 332.8
08-12	312.1	4 808 701.9	231 369.8
08-13	313.4	4 808 668.6	231 410.3
08-14	313.9	4 808 635.6	231 447.7
08-15	313.9	4 808 603.2	231 487.0
08-16	313.3	4 808 573.0	231 526.2
08-17	308.1	4 808 746.8	231 312.5
08-18	305.6	4 808 721.4	231 324.1

-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.

GEOCRES No. 40P8-157