

**FOUNDATION INVESTIGATION AND DESIGN REPORT
WIDENING OF KING STREET OVERPASS AT HIGHWAY 8
NORTHBOUND STRUCTURE
KITCHENER, ONTARIO
G.W.P. 277-97-00, SITE: 33-214W**

Geocres Number: 40P8-145

Report to

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the northbound lane structure of the King Street East overpass at Highway 8 in Kitchener, Ontario. The existing structure was constructed in 1987, consists of a two-span girder bridge on an approximate 40-degree skew, and currently carries two lanes of through traffic plus a ramp speed change lane. The proposed project involves widening of the structure towards the median to accommodate an additional lane of traffic.

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

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

2 SITE DESCRIPTION

The site is located on Highway 8 in Kitchener, Ontario, between the Grand River to the north and Sportsworld Drive to the south. The lands to the east of the site are generally vacant and a small residential subdivision exists to the west. Lands along King Street East to the west of Highway 8 have been developed for commercial and retail use.

The topography is typically rolling. Drainage at the site is generally towards the Grand River, which flows westerly within a deep valley located approximately 1 km to the north of the overpass. Vegetation consists of grass and small shrubs, with mature trees present in the southeast quadrant of the interchange.

The general site area is located within the physiographic region known as Waterloo Hills, characterized by ridges of sandy till and kames or kame moraines, with outwash sands occupying the intervening hollows.

3 SITE INVESTIGATION AND FIELD TESTING

3.1 Current Investigation

The site investigation and field testing for this project were carried out between May 8 and 27, 2006 and consisted of drilling and sampling nine boreholes at the site, including boreholes drilled concurrently for investigation at the southbound structure. Boreholes 06-15 to 06-23 (excluding 06-18 and 06-19) were drilled within the Highway 8 median in line with the existing abutments and pier, and were terminated at depths of 20.1 to 27.7 m. Boreholes 06-14 and 06-24 were drilled to 11.1 m depth in the approaches approximately 20 m from the abutments.

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 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. Road occupancy and lane closure permits were also obtained.

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 mm PVC pipes with slotted tip, were installed in selected boreholes to monitor groundwater levels. The completion details are shown in Table 3.1. The remaining boreholes were grouted in accordance with the abandonment requirements of MOE Reg. 903.

Table 3.1 – Piezometer Installation Details

Piezometer Location	Tip (Sand Filter) Details			Backfill
	Depth	Elevation	Stratum	
06-15	20.0 – 21.8	282.3 – 280.5	Clayey Silt and Sand Till	Bentonite and grout to 0.3 m, concrete to surface
06-23	25.3 – 27.1	278.2 – 276.4	Silt and Sand Till	Bentonite and grout to 0.3 m, concrete to surface

3.2 Previous Investigation

A foundation investigation was carried out for the existing overpass structures in 1980 (Foundation Investigation for Freeport Drive Overpass, W.P. 31-76-04/05, Site Nos. 33-214A/B, Mar 1982). The Record of Borehole sheets for that investigation are included in Appendix A, and the approximate borehole locations are indicated on the drawing in Appendix D. The work was carried out prior to construction of the King Street cut and the overpass structure, and will not be referenced further in the current report.

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 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 sand and gravel fill overlying, in succession, native sand and gravel, a layer of heterogeneous silt and sand to clayey silt till, a thick deposit of silty clay till, and a second layer of sand and silt to clayey sandy silt till.

More detailed descriptions of the individual strata are presented below.

5.1 Asphaltic Concrete

The boreholes were drilled through the pavement structure on King Street or the shoulder of Highway 8. The asphaltic concrete layer varied in thickness from 50 to 190 mm in the boreholes.

5.2 Sand and Gravel Fill

Sand and gravel fill was encountered below the asphalt in all boreholes. The fill extended to depths of 0.8 to 2.6 m (elevation 300.3 to 302.4 m) in Boreholes 06-15 to 06-23, and to 1.5 m depth (elevation 307.9 and 309.6 m) in Boreholes 06-14 and 06-24.

SPT N-values ranged from 50 blows/0.3 m penetration to 50 blows/0.125 m in the fill, indicating a very dense relative density. N-values greater than 50 blows/0.15 m may reflect the presence of cobbles or boulders in the fill. Grain size distribution results for the

fill are presented on the Record of Borehole sheets and Figure B1 of Appendix B. The silt content in the tested samples ranged from 6 to 11%. Moisture contents in this material ranged from 2% to 5%.

5.3 Silty Sand to Sand and Gravel

Native deposits of brown silty sand, sand, and sand and gravel were encountered below the granular fill in all boreholes. In Boreholes 06-15 to 06-23 drilled on King Street, the upper boundary of this material was encountered at depths of 0.8 to 2.6 m (elevation 300.3 to 302.4 m), and the lower boundary was encountered at depths of 2.3 to 4.6 m (elevation 298.9 to 300.6 m). In Borehole 06-24 drilled from Highway 8, the upper and lower boundaries were encountered at depths of 1.5 and 9.1 m (elevation 309.6 and 302.0 m), respectively. Borehole 06-14 encountered native sand and gravel at 1.5 m depth (elevation 307.9 m) and was terminated in this material at 11.1 m depth (elevation 298.3 m).

SPT N-values in the silty sand to sand and gravel generally ranged from 24 blows/0.3 m penetration to 50 blows/0.15 m, indicating a compact to very dense relative density. N-values greater than 50 blows/0.15 m may reflect the presence of cobbles or boulders. A loose to compact condition was indicated by N-values of 6 to 14 blows/0.3 m obtained between 0.9 and 2.3 m depth (elevation 302.0 and 300.6 m) in Borehole 06-17, between 3.0 and 4.6 m depth (elevation 300.5 and 298.9 m) in Borehole 06-23, and between 4.5 and 7.5 m depth (elevation 306.6 and 303.6 m) in Borehole 06-24.

Grain size distribution results for the silty sand to sand and gravel are presented on the Record of Borehole sheets and Figure B2 of Appendix B. The fines content (silt and clay) in the tested samples ranged from 13 to 34%. Moisture contents in this material ranged from 2% to 15%, typically less than 10%.

5.4 Upper Heterogeneous Till (Silt and Sand to Clayey Silt)

A brown heterogeneous till deposit varying in gradation from cohesionless silt and sand, some clay to clayey, to cohesive clayey silt, some sand to sandy, was encountered below the silty sand to sand and gravel deposit. The results of sieve and hydrometer analyses conducted on samples of this unit, presented on the Record of Borehole Sheets and Figure B3 of Appendix B, indicate the following particle size distribution:

Gravel	1 – 5 %
Sand	30 – 41 %
Silt	44 – 56 %
Clay	11 – 16 %

The thickness of this till deposit in Boreholes 06-15 to 06-23 ranged from 1.5 to 3.0 m. The upper boundary was encountered at 2.3 m depth (elevation 300.0 to 300.6 m) adjacent to the existing northbound lanes structure, at depths of 3.7 to 4.6 m (elevation 298.9 to 299.7 m) adjacent to the southbound lane structure, and at 3.0 m (elevation 300.2 m) in

Borehole 06-20 drilled along the highway centreline. The lower boundary was encountered at depths of 3.8 to 4.6 m (elevation 297.7 to 299.1 m) adjacent to the northbound lanes, at depths of 6.1 to 7.6 m (elevation 295.9 to 297.4 m) adjacent to the southbound lanes, and at 5.5 m (elevation 297.7 m) at the centreline.

Borehole 06-24 drilled at the south approach encountered the till at 9.1 m depth (elevation 302.0 m) and was terminated in this unit at 11.1 m (elevation 300.0 m).

SPT N-values obtained in the till deposit ranged from 31 blows/0.3 m to 50 blows/0.15 m penetration, indicating a hard or dense to very dense condition. Moisture contents from this deposit ranged from 5 to 19%.

A pocket of silt was encountered within the till unit at 3.8 m depth in Borehole 06-15. The results of a grain size analysis conducted on the silt are shown on Figure B2, Appendix B.

Although not encountered in the boreholes, glacial till may contain cobbles and large boulders.

5.5 Silty Clay Till

The upper heterogeneous till layer is underlain by a thick deposit of brown to grey silty clay till. The silty clay till deposit ranges in thickness from 10.7 to 14.5 m, and has upper and lower boundaries at depths of 3.8 to 7.6 m (elevation 295.9 to 299.1 m) and 16.8 to 21.3 m (elevation 282.2 to 286.7 m), respectively.

Standard Penetration Tests conducted in this deposit typically yielded N-values ranging from 30 to 102 blows/0.3 m penetration, indicating a hard consistency. In Boreholes 06-16 to 06-21, N-values of 20 to 25 blows/0.3 m were obtained at depths of 13.7 to 16.8 m, indicating a very stiff zone. Moisture contents generally ranged from 11 to 22%, with higher values of up to 42% measured in the very stiff zones.

Samples from this deposit were subjected to grain size distribution and Atterberg Limits tests. The results of the grain size analyses are reported on the Record of Borehole Sheets and plotted in Figures B4 and B5 of Appendix B. The Atterbergs Limits, plotted on Figure B7, indicate that the silt clay till has a low to medium plasticity.

Although not encountered in the boreholes, glacial till may contain cobbles and large boulders.

5.6 Lower Heterogeneous Till (Silt and Sand to Clayey Sandy Silt)

A second deposit of heterogeneous till was encountered below the silty clay till at depths of 16.8 to 21.3 m (elevation 282.2 to 286.7 m). This deposit varies in gradation from cohesionless silt and sand, some clay, to cohesive clayey sandy silt. The results of sieve and hydrometer analyses conducted on samples of this unit, presented on the Record of

Borehole Sheets and Figure B6 of Appendix B, indicate the following particle size distribution:

Gravel	0 – 3 %
Sand	31 – 48 %
Silt	42 – 48 %
Clay	8 – 22 %

SPT N-values obtained in this till deposit were greater than 100 blows/0.3 m penetration, indicating a hard or very dense condition. Moisture contents ranged from 5 to 15%, with one value of 21%. The boreholes were terminated in the till deposit at depths of 20.1 to 27.7 m (elevation 275.8 to 283.4 m).

Although not encountered in the boreholes, glacial till may contain cobbles and large boulders.

5.7 Water Levels

Upon completion of drilling, water was measured at depths of 7.0 to 18.9 m in open Boreholes 06-15, 06-17, 06-20 and 06-23. In addition, wet conditions and/or a wet split spoon sampler were observed at various depths in the majority of the boreholes during drilling. These observations are believed to reflect the presence of groundwater contained within lenses or pockets of more permeable sands and silts within the heterogeneous tills of overall lower permeability. Water also appears to be perched within the fill locally (such as in Borehole 06-17).

Standpipe piezometers were installed in Boreholes 06-15 and 06-23 to monitor water levels after completion of drilling. The water levels measured in the piezometers are summarized in Table 5.1, along with the measurements in the boreholes upon completion of drilling.

Table 5.1 – Measured Groundwater Levels

Borehole	Date	Water Level (m)		Comment
		Depth	Elevation	
06-15	19-May-2006	18.9	283.4	In open borehole
	19-May-2006	Dry	-	In piezometer
	08-Aug-2006	19.2	283.1	In piezometer
06-17	15-May-2006	7.0	295.9	In open borehole
06-20	11-May-2006	18.9	284.3	In open borehole
06-23	10-May-2006	18.9	284.6	In open borehole
	10-May-2006	20.6	282.9	In piezometer
	18-May-2006	19.9	283.6	In piezometer
	08-Aug-2006	21.2	282.3	In piezometer

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 pockets or zones of more permeable sands and silts within the heterogeneous tills, or within the fill locally.

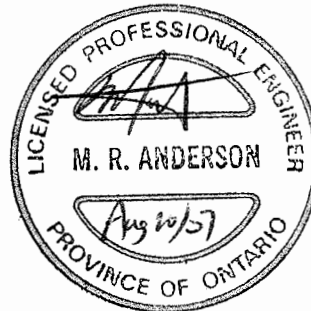
6 MISCELLANEOUS

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. George Azzopardi and Mr. Kenneth Hui of Thurber.

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 to assist the design team to select and design a suitable foundation system and approach embankments for the proposed structure.

Widening of the existing King Street overpass structures on Highway 8 in Kitchener is proposed as part of the planned widening and reconstruction of Highway 8 from 1.0 km north of Grand River, southerly to Sportsworld Drive. This report addresses the northbound lane structure.

The existing structure was constructed in 1987 and consists of a two-span girder bridge on an approximate 40-degree skew, spanning approximately 40 m. It presently carries two lanes of through traffic plus a ramp speed change lane. The structure will be widened towards the median to accommodate an additional lane of traffic.

Existing road grades are near elevation 309.1 to 310.5 m on Highway 8 and elevation 303.2 m on King Street at the overpass. Design drawings from Contract 86-53 indicate that King Street was constructed in a cut ranging in depth from approximately 1.5 m at the east end of the north abutment to 5.5 m at the west end of the south abutment. Grades on Highway 8 were established by an approximate 3.5 to 4.5 m fill at the north approach, and a 2 to 5 m fill at the south approach.

The foundation design for the existing structure, indicated on the previous Contract Drawings, consists of spread footings with design elevations and dimensions as follows:

Table 7.1 – Existing Foundation Design Details

Foundation Unit	Top of Footing Elevation (m)	Footing Thickness (m)	Plan Dimensions (m)	
			Width	Length
North Abutment	301.0	1.0	5.55	21.1
Pier	301.7	1.6	5.00	20.2
South Abutment	301.6	1.0	6.05	22.9

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 STRUCTURE FOUNDATIONS

In general terms, the site was found to be underlain by sand and gravel fill overlying, in succession, deposits of silty sand to sand and gravel, a layer of heterogeneous silt and sand to clayey silt till, a thick deposit of silty clay till, and a second layer of heterogeneous sand and silt to clayey silt till. The groundwater level is anticipated to be near 19 to 20 m depth although perched water may be encountered at higher levels within the till and overlying fill.

As noted above, previous Contract Drawings indicate that the existing structure is supported on spread footings. To provide consistent performance with the existing foundation system, it is recommended that the new sections of the widened structure be supported on spread footings to match the existing design. Recommendations for spread footing design are presented below.

Although not recommended from a geotechnical perspective, consideration could be given to the use of spread footings on engineered fill, driven piles or augered caissons (drilled shafts). A comparison of the foundation alternatives based on advantages and disadvantages of each is included in Appendix C. To match the performance of the existing foundations, use of the alternative foundation types is not recommended. Detailed design recommendations for these types are therefore not presented.

8.1 Spread Footings on Native Ground

The design founding level of the existing footings (based on the previous contract drawings) and the subsurface conditions anticipated at these levels (based on the borehole information) are summarized in Table 8.1.

Table 8.1 – Summary of Anticipated Founding Conditions

Foundation Unit	Design Founding Elevation (m)	Reference Borehole	Anticipated Soil Conditions at Design Level
North Abutment	300.0	06-15	Hard, native clayey silt till, some sand to sandy.
Pier	300.1	06-16	Hard, native silt and sand till, some clay to clayey.
South Abutment	300.6	06-17	Dense to very dense silt and sand till, some clay.

Footings for the structure widening should be founded at the same level as the existing foundations to avoid undermining of these units and disturbing the founding soils. As noted in the above table, native heterogeneous till comprising silt and sand to clayey silt is anticipated at the design level.

For a footing width of 5.0 m or greater as per the existing design, footings bearing on hard/dense to very dense till may be designed for a concentric, vertical geotechnical resistance of 700 kPa at factored ULS and a resistance of 380 kPa at SLS.

The resistance values are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance used in design must be reduced in accordance with the CHBDC Clauses 6.7.3 and 6.7.4.

For footings designed on the basis of the geotechnical resistance values given above, total settlement under a footing is not expected to exceed 25 mm. Differential settlements are not expected to exceed 15 mm across the width of the structure.

The lateral resistance of the footings founded on the till may be computed using an unfactored friction coefficient of 0.6. This is an “ultimate” value and requires 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 and has been adequately prepared to receive concrete. Where subexcavation is required to remove unsuitable material from below the design founding level, the founding surface should be re-established using engineered fill. The engineered fill must consist of OPSS Granular “A” placed in 150 mm lifts, compacted to 100% of its SPMDD at $\pm 2\%$ of optimum moisture content.

All footings should be provided with a minimum of 1.4 m of earth cover over the footing base (founding elevation) 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. Synthetic insulation must be covered to provide protection where it is used.

9 EXCAVATION

Excavation and backfilling for structures 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 within the probable depth of excavation at this site may be classed as Type 3 soils. Although the SPT N-values indicate that the sand and gravel is typically dense to very dense, a Type 3 classification is recommended based on the lack of cohesion in the soils and the resulting possibility that excavation slopes will collapse if excavated vertically for the lower 1.2 m.

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. However, one option that is considered to be suitable at this site is a soldier pile and lagging wall.

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.

10 UNWATERING

Based on the borehole information, excavation for footing construction is not expected to extend below the groundwater level at the site. However, seepage may be experienced from perched zones in the granular fill, the sand and gravel, 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.

11 APPROACH EMBANKMENTS

The foundation soils governing stability of the approach embankments consist of existing compact to very dense sand and gravel overlying hard/dense to very dense till soils. Since the structure widening will be constructed within the highway median, construction will involve minor infilling of the existing median ditch between the southbound and northbound lane structures. The embankment will not be raised or widened.

The embankment foundation soils are assessed to provide satisfactory resistance to instability under the increased loading imposed by structure approach widening. Earth fill slopes inclined at 2H:1V are considered suitable.

Considering the embankment height and consistency/relative density of the foundation soils, settlement induced by the increase in embankment loading will be negligible. Completing embankment construction three months in advance of road paving is recommended as a good construction practice to minimize any time-dependent settlement due to consolidation or particle re-organization in the embankment fill itself.

All topsoil and organic soils should be stripped from the footprint of the approach fills. Particular attention should be paid to existing ditches to remove all softened material. Prior to placement of new fill against the existing embankment slope, the existing earth slope should be benched in accordance with OPSD 208.010.

Embankment construction should be in accordance with OPSS 206, as amended by Special Provision "Amendment to OPSS 206, December 1993", dated November 2002.

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

12 RETAINED SOIL SYSTEMS

Retained soil system (RSS) walls may be used subject to the requirements presented in this section. RSS walls 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 the compact to very dense sand and gravel at or below elevation 302.5 m. A wall founded on this material should be designed for a factored bearing resistance of 650 kPa at ULS and a bearing resistance of 300 kPa at SLS.

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 engineered granular fill or native sand and gravel may be estimated using an ultimate friction coefficient of 0.7.

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.

If a RSS wall system is selected, the global stability must be analyzed after the location of the wall is known. The global stability of the RSS wall is dependent on the characteristics of the embankment fill and the foundation soils, the geometry of the embankment and location of the RSS within the embankment.

13 BACKFILL TO ABUTMENTS

Backfill to the abutments 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 3101.150.

Structure backfill should be compacted as per SP 105S10. Compaction equipment to be used adjacent to retaining structures must be restricted in accordance with Section 501.07.02 of the SP.

The design of the abutment must include a subdrain as shown in OPSD 3102.100 and 3190.100.

14 EARTH PRESSURE COEFFICIENTS

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

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

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

K = earth pressure coefficient (see table 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 abutment wall are dependent on the material used as backfill. Typical values are shown in Table 14.1.

Table 14.1 – 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	-

* For wing walls.

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.

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 14.1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.9.1 (a) in the Commentary to the Canadian Highway Bridge Design Code.

15 SEISMIC CONSIDERATIONS

15.1 Seismic Design Parameters

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 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.

15.2 Liquefaction Potential

The potential for liquefaction of the foundations soils was assessed using the Seed and Idriss (1971) method¹.

Using this method, it was determined that the foundation soils are not in danger of liquefaction.

15.3 Retaining Wall Dynamic Earth Pressures

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 15.1 may be used:

¹ Seed, H.B. and Idriss, I.M. 1971, “Simplified Procedure for Evaluating Soil Liquefaction Potential” *Journal of Soil Mechanics and Foundations Division*, ASCE, Vol. 101, No. SM9, September, pp. 1249-1273.

Table 15.1 – Earth Pressure Coefficient for Earthquake Loading

Earth Pressure Coefficient (K) 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

16 CONSTRUCTION CONCERNS

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

- The sand and gravel and till soils may contain cobbles and boulders which will require removal if encountered during excavation.
- Perched water may be encountered within the granular fill and in lenses or pockets of sand and silt within the heterogeneous till soil.
- Care must be taken during footing excavation to avoid disturbing and undermining the existing structure foundations and travelled lanes of the roadways.

17 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



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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

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

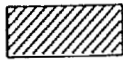

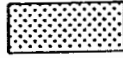

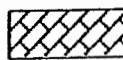
 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (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.

TERMS		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
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 06-14

1 OF 2

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 713.1 E 231 485.9 ORIGINATED BY GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 27.05.06 - 27.05.06 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			20	40	60	80	100		
309.4														
0.0	ASPHALT (100 mm)													
0.1	SAND and GRAVEL, trace to some silt Very Dense Brown Dry (FILL)		1	SS	85		309							
			2	SS	50/ .150									
307.9							308							
1.5	SAND and GRAVEL, some silt Very Dense to Dense Brown Dry		3	SS	50/ .150									
			4	SS	76		306							
			5	SS	43		305							
			6	SS	36		303							
			7	SS	35		302							
			8	SS	41		301							
							300							

Continued Next Page

+³ ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 06-14

2 OF 2

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 713.1 E 231 485.9 ORIGINATED BY GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 27.05.06 - 27.05.06 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	W _p	W	W _L				
298.3			9	SS	35		299												
11.1	END OF BOREHOLE AT 11.13 m. BOREHOLE OPEN TO 11.13 m AND DRY UPON COMPLETION. BOREHOLE GROUTED TO SURFACE.																		

ONTMT4S 7938-2.GPJ 08/01/07

RECORD OF BOREHOLE No 06-15

1 OF 3

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 728.1 E 231 500.9 ORIGINATED BY GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 18.05.06 - 19.05.06 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			20	40	60	80	100		
302.3														
0.0	ASPHALT: (75 mm)													
0.1	SAND and GRAVEL, trace silt, occasional cobbles Very Dense Brown (FILL)		1	SS	50/ .150		302							
			2	SS	50/ .150									
300.8							301							53 40 8 (SI+CL)
1.5	Silty SAND, trace gravel Compact Brown (SM)		3	SS	27									
300.0							300							
2.3	Clayey SILT, some sand to sandy, trace gravel Hard Brown (TILL) occasional wet sand seams		4	SS	64									
			5	SS	38		299							Sampler wet
	pocket of silt, some clay		6	SS	100									
297.7							298							0 2 85 13
4.6	Silty CLAY, trace to some sand, trace gravel Hard Brown (TILL)		7	SS	88		297							
			8	SS	53		296							
							295							
			9	SS	74		294							
							293							
			10	SS	54									

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+³ ×³: Numbers refer to
Sensitivity

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15
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(%) STRAIN AT FAILURE

METRIC

G.W.P.	277-97-00	LOCATION	King Street Overpass N 4 808 728.1 E 231 500.9	ORIGINATED BY	GA
HWY	8	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	WM
DATUM	Geodetic	DATE	2006-05-18 - 2006-05-19	CHECKED BY	MRA

[illegible]

+³, ×³: Numbers refer to Sensitivity

ONTMT4S 7938-2.GPJ 5/25/07

RECORD OF BOREHOLE No 06-15

3 OF 3

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 728.1 E 231 500.9 ORIGINATED BY GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2006-05-18 - 2006-05-19 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		17	SS	106								
						282							
						281							
280.5			18	SS	104								
21.8	END OF BOREHOLE AT 21.79 m. BOREHOLE OPEN TO 21.79 m AND WATER LEVEL AT 18.90 m UPON COMPLETION. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 19.05.06 dry - 08.08.06 19.22 283.08												

RECORD OF BOREHOLE No 06-16

1 OF 3

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 720.6 E 231 518.7 ORIGINATED BY KH
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 17.05.06 - 17.05.06 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			20	40	60	80	100		
302.9	ASPHALT: (50 mm)		1	SS	50/									
0.1	SAND and GRAVEL, trace silt				.125									
	Very Dense													
	Brown													
	Moist													
302.1	(FILL)													
0.8	Silty SAND, some gravel		2	SS	67		302							
	Very Dense to Compact													
	Brown													
	Dry													
			3	SS	29		301							
300.6														
2.3	SILT and SAND, some clay to clayey,		4	SS	64		300							3 41 44 12
	trace gravel, trace limestone fragments													
	Hard													
	Brown													
	(TILL)													
			5	SS	45		299							
			6	SS	62		298							
298.3							297							
4.6	Silty CLAY, trace sand		7	SS	55		296							
	Hard													
	Grey													
	Moist													
	(TILL)													
			8	SS	76		295							0 3 61 37
			9	SS	39		294							
			10	SS	54		293							

Continued Next Page

+ 3, X 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

METRIC

CONCRETE	SAMPLES			DYNAMIC CONE PENETRATION			
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+³, ×³: Numbers refer to Sensitivity

ONTMT4S 7938-2.GPJ 5/25/07

RECORD OF BOREHOLE No 06-16

3 OF 3

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 720.6 E 231 518.7 ORIGINATED BY KH
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2006-05-17 - 2006-05-17 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		WATER CONTENT (%)			
						20 40 60 80 100	20 40 60 80 100	W _p	W	W _L			
	Continued From Previous Page		17	SS	76/								
					.150								
281.4						282							
21.5	END OF BOREHOLE AT 21.5 m. BOREHOLE OPEN TO 21.5m AND DRY UPON COMPLETION. BOREHOLE GROUTED TO SURFACE.		18	SS	100/								
					.125								

+³, X³: Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 06-17

1 OF 3

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 715.6 E 231 533.5 ORIGINATED BY KH/GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 12.05.06 - 15.05.06 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			20	40	60	80	100		
302.9	ASPHALT: (75mm)													
0.0	SAND and GRAVEL, trace silt													
0.1	Very Dense		1	SS	95									
	Brown													
	Moist													
302.0	(FILL)													
0.9	SAND, fine grained, some silt		2	SS	26		302							
	Compact to Loose													
	Brown													
	Moist		3	SS	6		301							Sampler wet
300.6														
2.3	SILT and SAND, some clay, trace		4	SS	31		300							4 41 44 11
	gravel													
	Dense to Very Dense													
	Brown		5	SS	61									
	Moist													
	(TILL)													
299.1														
3.8	Silty CLAY, trace sand		6	SS	82		299							
	Hard													
	Grey		7	SS	92		298							0 2 60 38
	(TILL)													
							297							
			8	SS	52									
							296							
			9	SS	58		295							
							294							
			10	SS	78									
							293							

Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 06-17

2 OF 3

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 715.6 E 231 533.5 ORIGINATED BY KH/GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 12.05.06 - 15.05.06 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y 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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
			11	SS	43		292							
			12	SS	52		291							
			13	SS	24		289							
			14	SS	22		288							
			15	SS	30		286							
284.6 18.3	SILT and SAND, some clay, trace gravel Very Dense Brown Moist to Wet (SM)		16	SS	105		284							
							283							

Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

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Water level at
6.1m before
continuing drilling
after 3 days.

RECORD OF BOREHOLE No 06-17

3 OF 3

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 715.6 E 231 533.5 ORIGINATED BY KH/GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 12.05.06 - 15.05.06 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	W _P	W	W _L		
			17	SS	110/ .300												
281.3							282										
21.6	END OF BOREHOLE AT 21.56 m. BOREHOLE OPEN TO 21.56 m AND WATER LEVEL AT 7.01 m UPON COMPLETION OF DRILLING. BOREHOLE GROUTED TO SURFACE.		18	SS	100/ .225												

RECORD OF BOREHOLE No 06-20

1 OF 3

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 706.1 E 231 537.0 ORIGINATED BY GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 10.05.06 - 11.05.06 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			20	40	60	80	100		
303.2	ASPHALT: (50 mm)													
0.1	SAND and GRAVEL, some silt Very Dense to Dense Brown (FILL)		1	SS	57		303							32 58 11 (SI+CL)
302.4														
0.8	SAND, fine to medium grained, trace silt Compact to Dense Brown		2	SS	33		302							
			3	SS	26									
			4	SS	30		301							
300.2														
3.0	Clayey SILT and SAND, trace gravel Hard Brown (TILL)		5	SS	56		300							
			6	SS	100									
							299							
			7	SS	46									
							298							
297.7														
5.5	Silty CLAY, some sand, trace gravel Hard Brown (TILL)		8	SS	100		297							
							296							
			9	SS	82									
							295							
			10	SS	69		294							

Continued Next Page

+³ × 3³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 06-20

3 OF 3

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 706.1 E 231 537.0 ORIGINATED BY GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 10.05.06 - 11.05.06 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			20	40	60	80	100		
			17	SS	115		283							1 31 48 19
281.7			18	SS	104		282							
21.5	END OF BOREHOLE AT 21.49 m. BOREHOLE OPEN TO 21.49 m AND WATER LEVEL AT 18.90 m UPON COMPLETION OF DRILLING. BOREHOLE GROUTED TO SURFACE.				.150									

RECORD OF BOREHOLE No 06-21

1 OF 3

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 709.1 E 231 508.7 ORIGINATED BY GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 19.05.06 - 19.05.06 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						WATER CONTENT (%)
								20 40 60 80 100		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				
302.9														
0.0														
0.1	ASPHALT: (50 mm) SAND and GRAVEL, trace silt , trace clay, occasional cobbles Very Dense to Dense Brown Dry (FILL)		1	SS	50/ .150									
			2	SS	34									
300.3														
2.6	SAND, some gravel, some silt Dense Brown Moist		3	SS	38									
299.2														
3.7	SILT and SAND, some clay to clayey, trace gravel Hard Brown (TILL)		4	SS	104									
296.8														
6.1	Silty CLAY, trace sand Hard Brown (TILL)		5	SS	84									
			6	SS	61									
			7	SS	74									

Continued Next Page

+ 3, X 3: Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 06-21

3 OF 3

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 709.1 E 231 508.7 ORIGINATED BY GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 19.05.06 - 19.05.06 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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) W _P W W _L				
			14	SS	100/ .225			20	40	60	80	100					
							282										
281.4			15	SS	100/ .200												
21.5	END OF BOREHOLE AT 21.54 m. BOREHOLE OPEN TO 21.54 m AND DRY UPON COMPLETION. BOREHOLE GROUTED TO SURFACE.																

RECORD OF BOREHOLE No 06-22

1 OF 3

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 702.3 E 231 525.8 ORIGINATED BY GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 15.05.06 - 16.05.06 CHECKED BY MRA

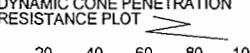
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE			w _p w w _L					
								● QUICK TRIAXIAL × LAB VANE								
303.5							20	40	60	80	100	20	40	60		
0.0	ASPHALT: (150 mm)															
0.2	SAND and GRAVEL, trace silt, occasional cobbles Very Dense to Dense Brown Moist (FILL)		1	SS	50/ .125		303									
			2	SS	60											
			3	SS	40		302									
301.2																
2.3	SAND, fine grained, trace gravel, trace silt Compact to Dense Brown Moist		4	SS	24		301									
			5	SS	36		300									
299.7																
3.8	Clayey Sandy SILT, trace gravel Hard Brown (TILL)		6	SS	80		299									5 31 48 16
			7	SS	50/ .150											
							298									
297.4																
6.1	Silty CLAY, trace sand Hard Brown (TILL)		8	SS	59		297									
			9	SS	100		296									Sampler wet
			10	SS	76		295									
							294									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

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								
			11	SS	46		293						0 8 50 42
							292						
			12	SS	45		291						
							290						
			13	SS	55		289						
							288						0 0 37 63
			14	SS	40		287						
							286						
286.7 16.8	SILT and SAND, some clay Very Dense Brown (TILL)		15	SS	115		285						
							284						

+ 3, x 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 06-22

3 OF 3

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 702.3 E 231 525.8 ORIGINATED BY GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 15.05.06 - 16.05.06 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									
								20 40 60 80 100									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
							20 40 60 80 100					WATER CONTENT (%) 20 40 60					
283.4			17	SS	110												
20.1	END OF BOREHOLE AT 20.12 m. BOREHOLE OPEN TO 20.12 m AND DRY UPON COMPLETION. BOREHOLE GROUTED TO SURFACE.						283										

RECORD OF BOREHOLE No 06-23

1 OF 3

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 697.3 E 231 540.7 ORIGINATED BY GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 08.05.06 - 10.05.06 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						
303.5							20 40 60 80 100	20 40 60						
0.0	ASPHALT: (50 mm)													
0.1	SAND and GRAVEL, trace silt Very Dense Brown Damp (FILL)		1	SS	52									
			2	SS	75									
	occasional cobbles													
301.7			3	SS	50/ .075									
1.8	SAND and GRAVEL, some silt Very Dense Brown Damp		4	SS	68									
300.5														
3.0	SAND, some silt, trace gravel Compact Brown Moist to Wet (SP)		5	SS	10									
			6	SS	13									
298.9														
4.6	Sandy SILT, some clay to clayey, trace gravel Hard Brown (TILL)		7	SS	38									
			8	SS	60									
295.9														
7.6	Silty CLAY, some sand Hard Brown (TILL)		9	SS	102									
			10	SS	74									

Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 06-23

2 OF 3

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 697.3 E 231 540.7 ORIGINATED BY GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2006-05-08 - 2006-05-10 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	W _p	W	W _L			
Continued From Previous Page														
			11	SS	80									
			12	SS	84									
			13	SS	82									
			14	SS	36									
			15	SS	33									
			16	SS	33									0 14 24 62

Continued Next Page

+ ³ . X ³ : Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 06-23

3 OF 3

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 697.3 E 231 540.7 ORIGINATED BY GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2006-05-08 - 2006-05-10 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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE				WATER CONTENT (%) w _p w w _L															
Continued From Previous Page																											
282.2	SILT and SAND, trace to some clay, trace gravel Very Dense Brown Moist (TILL)		17	SS	100/ .075		283																				
282																											
281																											
280																											
279			18	SS	100/ .225												3 47 42 8										
278			19	SS	119		278																				
277																											
276	20	SS	108			276																					
27.7	<p>END OF BOREHOLE AT 27.74 m. BOREHOLE OPEN TO 27.13 m AND WATER LEVEL AT 18.90 m UPON COMPLETION. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen.</p> <p>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>10.05.06</td> <td>20.64</td> <td>282.86</td> </tr> <tr> <td>18.05.06</td> <td>19.85</td> <td>283.65</td> </tr> <tr> <td>08.08.06</td> <td>21.23</td> <td>282.27</td> </tr> </tbody> </table>															DATE	DEPTH(m)	ELEV.(m)	10.05.06	20.64	282.86	18.05.06	19.85	283.65	08.08.06	21.23	282.27
DATE	DEPTH(m)	ELEV.(m)																									
10.05.06	20.64	282.86																									
18.05.06	19.85	283.65																									
08.08.06	21.23	282.27																									

ONTMT4S 7938-2.GPJ 5/25/07

RECORD OF BOREHOLE No 06-24

1 OF 2

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 714.5 E 231 550.0 ORIGINATED BY GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 24.05.06 - 24.05.06 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			20	40	60	80	100		
311.1														
0.0	ASPHALT: (190 mm)													
0.2	SAND and GRAVEL crusher run limestone Very Dense Brown Dry (FILL)		1	SS	50/ .150		311							42 47 11 (SI+CL)
			2	SS	50		310							
309.6														
1.5	Silty SAND, trace gravel, trace clay Dense to Very Dense Brown Dry to Damp		3	SS	33		309							
							308							
			4	SS	60		307							
							306							
	Becoming Compact to Loose, some silt		5	SS	14		305							
							304							
			6	SS	8		303							
							302							
			7	SS	25									3 63 25 9
302.0														
9.1	SILT, some clay, some sand to sandy, trace gravel Very Dense Brown Dry (TILL)		8	SS	53									

Continued Next Page

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

ONTMT4S 7938-2.GPJ 10/01/07

RECORD OF BOREHOLE No 06-24

2 OF 2

METRIC

G.W.P. 277-97-00 LOCATION King Street Overpass N 4 808 714.5 E 231 550.0 ORIGINATED BY GA
 HWY 8 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 24.05.06 - 24.05.06 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 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	W P W W L	20 40 60						
300.0			9	SS	102		301										
11.1	END OF BOREHOLE AT 11.13 m. BOREHOLE OPEN TO 11.13 m AND DRY UPON COMPLETION. BOREHOLE GROUTED TO SURFACE.																

ONTMT4S 7938-2.GPJ 08/01/07



Ministry of
Transportation and
Communications
Ontario

RECORD OF BOREHOLE No 1

W P 31-76-04/05 LOCATION Co-ords. N 4 808 491; E 231 481 ORIGINATED BY BL
DIST 3 HWY 8N BOREHOLE TYPE Constant Flight Auger; Hollow Stem COMPILED BY BL
DATUM Geodetic DATE 80-02-12 CHECKED BY _____

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			VALUES	20					
308.9	Ground Level												
0.0													
	Sand and Gravel		1	SS	22								
	Traces of Silt and Clay		2	SS	12								
	Compact to V. Dense		3	SS	14								
			4	SS	37								
			5	SS	41								
			6	SS	57								
			7	SS	50/76 mm								
302.8			8	SS	100/127 mm								
6.2	End of Borehole												

+3, x5; Numbers refer to
Sensitivity

20
15 + 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



Ministry of
Transportation and
Communications

RECORD OF BOREHOLE No 2

W P 31-76-04/05 LOCATION Co-ords. N 4 808 490; E 231 504 ORIGINATED BY BL
DIST 3 HWY 8N BOREHOLE TYPE Constant Flight Auger; Hollow Stem COMPILED BY BL
DATUM Geodetic DATE 80-02-13 & 14 CHECKED BY

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N' VALUES			20 40 60 80 100	WATER CONTENT (%) 10 20 30					
308.5 0.0	Ground Level													
	Sand and Gravel		1	SS	13		308	Auger to 1.0 m						
	Traces of Silt and Clay		2	SS	96		306							57 31 (12)
			3	SS	54									
			4	SS	47									
	Compact to Very Dense		5	SS	47									41 49 (10)
			6	SS	63									
			7	SS	63									
			8	SS	114/	280 mm	302							
			9	SS	48									
			10	SS	39									
300.0 8.5	Silty Clay (Plasticity: Low to Intermediate)		11	SS	100/	127 mm	300							
			12	SS	146		298							0 0 59 41
	Trace of Gravel		13	SS	166		296							
			14	SS	86									
	Very Stiff to Hard		15	SS	70		294							
			16	SS	104		292							0 6 49 45
			17	SS	60		290							
			18	SS	34		288							
			19	SS	37									
			20	SS	28		286							
284.4														
24.1	Het. Mixture of Silty Clay Sand and Gravel		21	SS	92/	152 mm	284							14 51 30 5
283.0	Hard. Glacial Till		22	SS	40/	0 mm								
25.5	End of Borehole													

+3, x5: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

W P 31-76-04 / n5 LOCATION Co-ords. N 4 808 487; E 231 542 ORIGINATED BY BL
DIST 3 HWY 8N BOREHOLE TYPE Constant Flight Auger; Hollow Stem COMPILED BY BL
DATUM Geodetic DATE 80-02-15 80-02-18 to 20 CHECKED BY

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								
308.3	Ground Level											
0.0												
	Sand and Gravel		1	SS	11							
	Traces of Silt and Clay		2	SS	16							
			3	SS	39							
			4	SS	81							
			5	SS	39							
			6	SS	26							
	Compact to Dense		7	SS	36							
			8	SS	22							
			9	SS	89							
299.8			10	SS	154							
8.5												
	Silty Clay		11	SS	122							
	(Plasticity: Low to Intermediate)		12	SS	86							
			13	SS	64							
	Trace of Sand		14	SS	86							
			15	SS	50							
	Hard		16	SS	82							
			17	SS	46							
			18	SS	37							
			19	SS	35							
284.5			20	SS	30							
23.8												
	Heterogeneous Mixture of Silty Clay, Sand and Gravel		21	SS	1057	152 mm						
			22	SS	1377	152 mm						
	Hard											
	Glacial Till											
280.6			23	SS	1307	152 mm						
27.7	End of Borehole											

+3, x5: Numbers refer to
Sensitivity

20
15-20.5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

W P 31-76-04 /05 LOCATION Co-ords. N 4 808 491; E 231 477 ORIGINATED BY BL
DIST 3 HWY 8N BOREHOLE TYPE Constant Flight Auger; Hollow Stem COMPILED BY BL
DATUM Geodetic DATE 80-02-21; 80-02-25 CHECKED BY

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
308.9																	
0.0	Sand and Gravel																
	Traces of Silt and Clay																
	Very Dense		1	SS	131												
			2	SS	81												46 45 (9)
			3	SS	122	292 H											
			4	SS	51												45 46 (9)
			5	SS	85												
297.4																	
11.6	Silty Clay (Plasticity: Low to Intermediate)		6	SS	119												
			7	SS	109												
	Some Sand		8	SS	91												
	Trace of Gravel		9	SS	76												
	Hard		10	SS	57												0 5 38 57
			11	SS	77												
			12	SS	31												
			13	SS	48												8 16 38 28
285.5																	
23.5	Heterogeneous Mixture of Silty Clay, Sand and Gravel		14	SS	124	76 mm											
	Hard		15	SS	100	152 mm											0 28 49 23
	Glacial Till																
281.4			16	SS	100	64 mm											
27.6	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15 x 5 (%) STRAIN AT FAILURE
10



Ministry of
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RECORD OF BOREHOLE No 5

W P 31-76-04/05 LOCATION Co-ords. N 4 808 499; E 231 501 ORIGINATED BY BL
DIST 3 HWY 8N BOREHOLE TYPE Constant Flight Auger; Hollow Stem COMPILED BY BL
DATUM Geodetic DATE 80-02-26 & 27 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
308.8 0.0	Ground Level										
	Sand and Gravel		1	SS	9		308	Auger to 1.0 m			
	Some Silt		2	SS	18		306		○		
	Trace of Clay		3	SS	18						
			4	SS	4						
			5	SS	23						
	Loose		6	SS	22		304		○		0 77 (23)
	to		7	SS	29						
	Dense		8	SS	20		302				
			9	SS	32						
			10	SS	33				○		4 60 (36)
299.6							300				
8.2			11	SS	55						
	Silty Clay		12	SS	82		298		○	—	0 2 59 39
	(Plasticity: Low to Intermediate)		13	SS	77		296				
	Some Sand		14	SS	52		294				
			15	SS	64		292				
	Hard		16	SS	67		290			○	0 0 26 74
			17	SS	89						
			18	SS	39		288				
			19	SS	40		286			○	0 13 33 49
285.0			20	SS	58						
23.8	Heterogeneous Mixture of Clayey Silt Sand and Gravel		21	SS	172	254 mm	284				
	Hard		22	SS	105	127 mm	282				
	Glacial Till		23	SS	100	114 mm			○	—	12 30 46 12
281.1											
27.7	End of Borehole										

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6

W P 31-76-04/05 LOCATION Co-ords. N 4 808 459; E 231 550 ORIGINATED BY BL
 DIST 3 HWY 88 BOREHOLE TYPE Constant Flight Auger; Hollow Stem COMPILED BY BL
 DATUM Geodetic DATE 80-02-28 & 29 CHECKED BY

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			20 40 60 80 100	10 20 30					
308.5	Ground Level													
0.0														
	Sand and Gravel		1	SS	9		308	Auger to 1.0 m						
			2	SS	26									
	Traces of Silt and Clay		3	SS	60		306							46 40 12 2
			4	SS	61									
	Loose to Very Dense		5	SS	68		304							
			6	SS	98/	127 mm	302							
			7	SS	35		300							
300.0														
8.5														
	Silty Clay (Plasticity: Low to Intermediate)		8	SS	46		298							0 77 (23)
	Occ. Silty Sand Layers		9	SS	26									
	Trace of Sand		10	SS	50/	76 mm	296							
	Very Stiff to Hard		11	SS	145		294							
			12	SS	98		292							0 8 53 39
			13	SS	89		290							
			14	SS	99		288							
			15	SS	58		286							
			16	SS	40		284							
			17	SS	34		282							0 1 24 75
284.7														
23.8														
	Heterogeneous Mixture of silty clay Sand and Gravel		18	SS	155/	76 mm	284							16 25 44 15
	Hard		19	SS	100/	127 mm	282							
	Glacial Till		20	SS	106/	146 mm								26 28 39 7
280.9														
27.6	End of Borehole													

+3, x5: Numbers refer to 20
Sensitivity 15-5 (%) STRAIN AT FAILURE
10

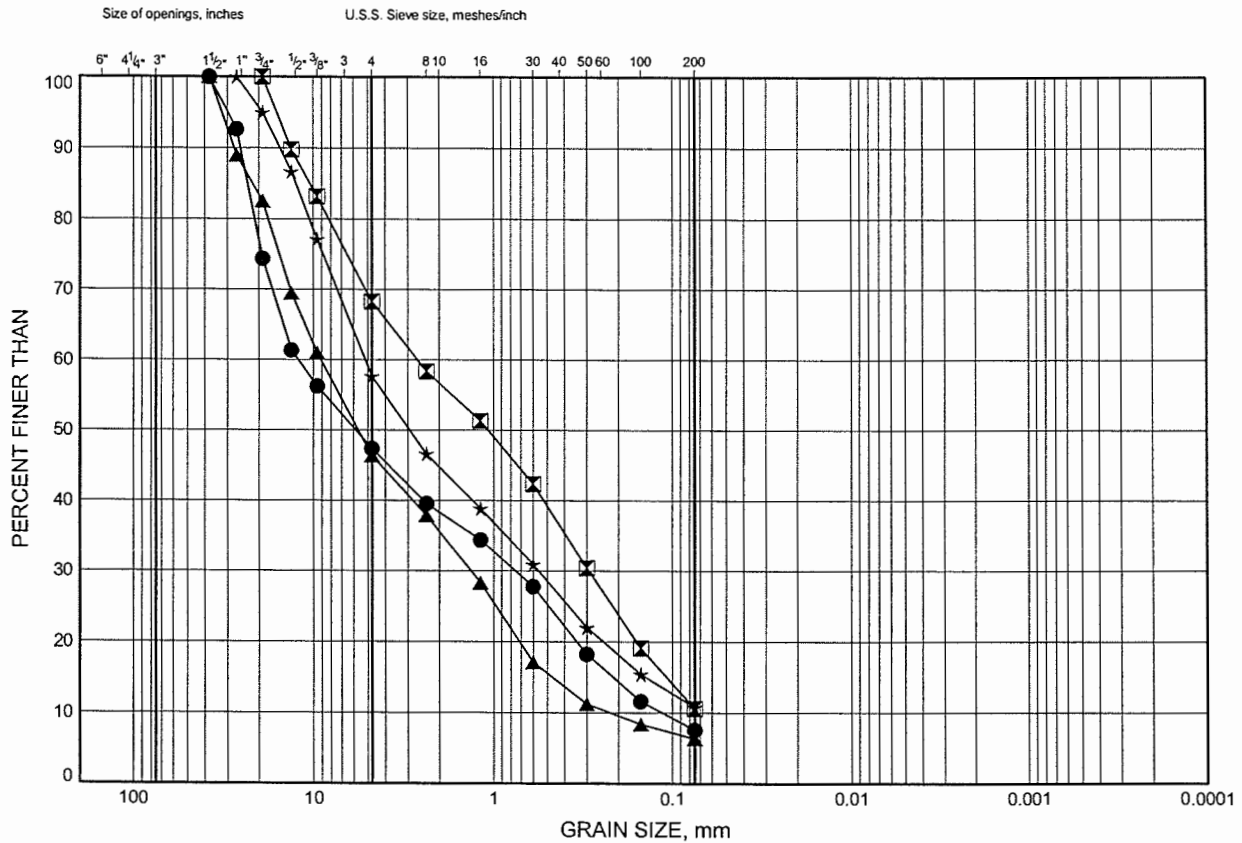
Appendix B

Laboratory Test Results

Geotechnical Investigation GRAIN SIZE DISTRIBUTION

FIGURE B1

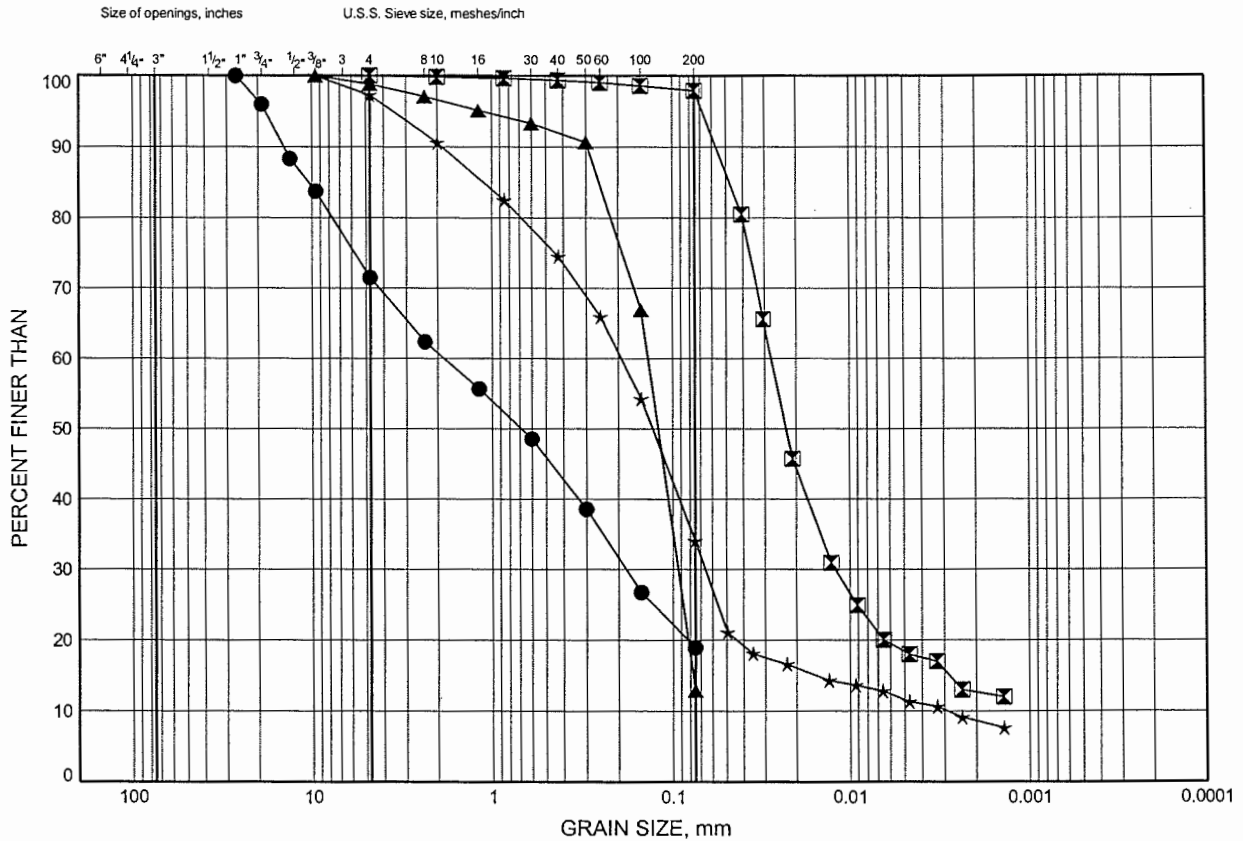
SAND AND GRAVEL FILL, SAND FILL



Geotechnical Investigation GRAIN SIZE DISTRIBUTION

FIGURE B2

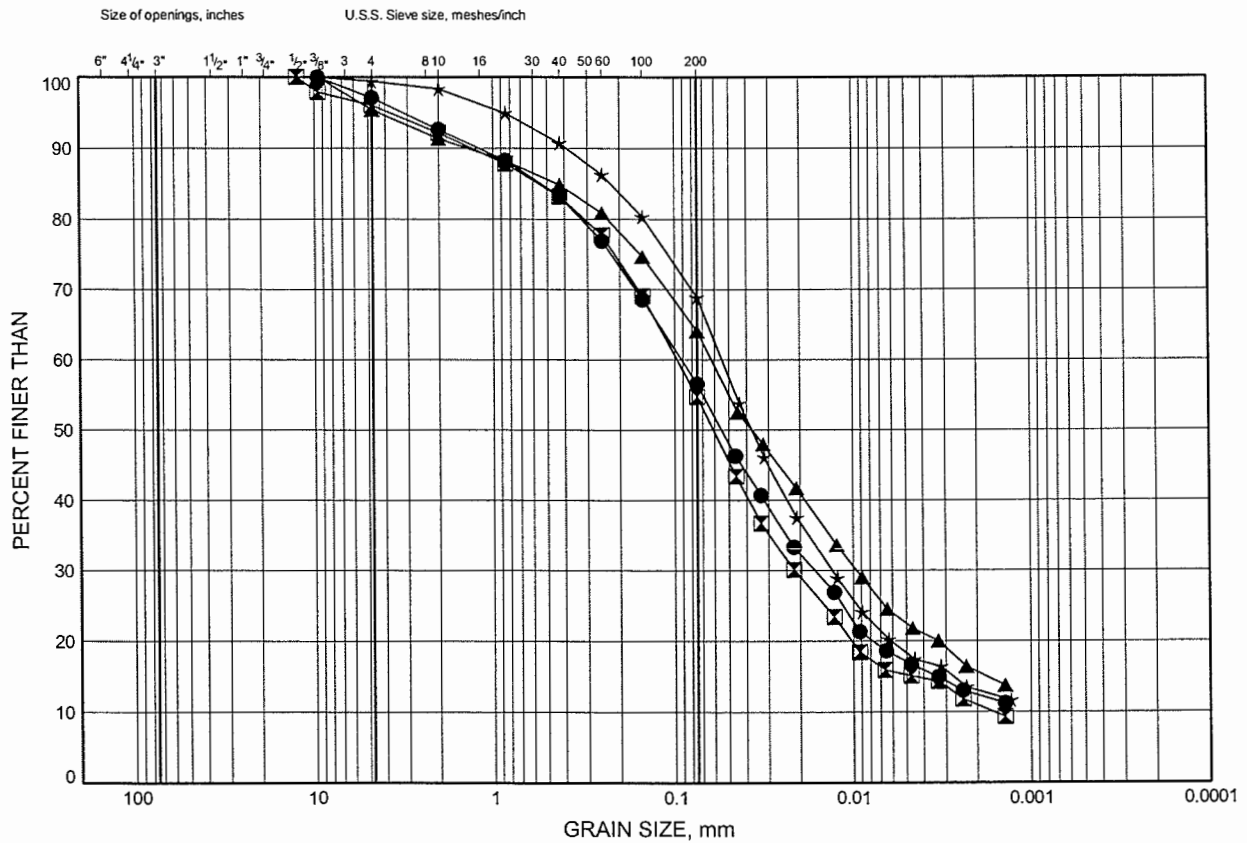
SAND TO SAND AND GRAVEL, SILT



Geotechnical Investigation GRAIN SIZE DISTRIBUTION

FIGURE B3

SILT AND SAND TO CLAYEY SANDY SILT (TILL)

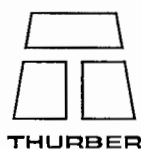


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-16	2.59	300.31
⊠	06-17	2.59	300.31
▲	06-22	4.80	298.70
★	06-23	6.32	297.17

Date January 2007

Project 277-97-00



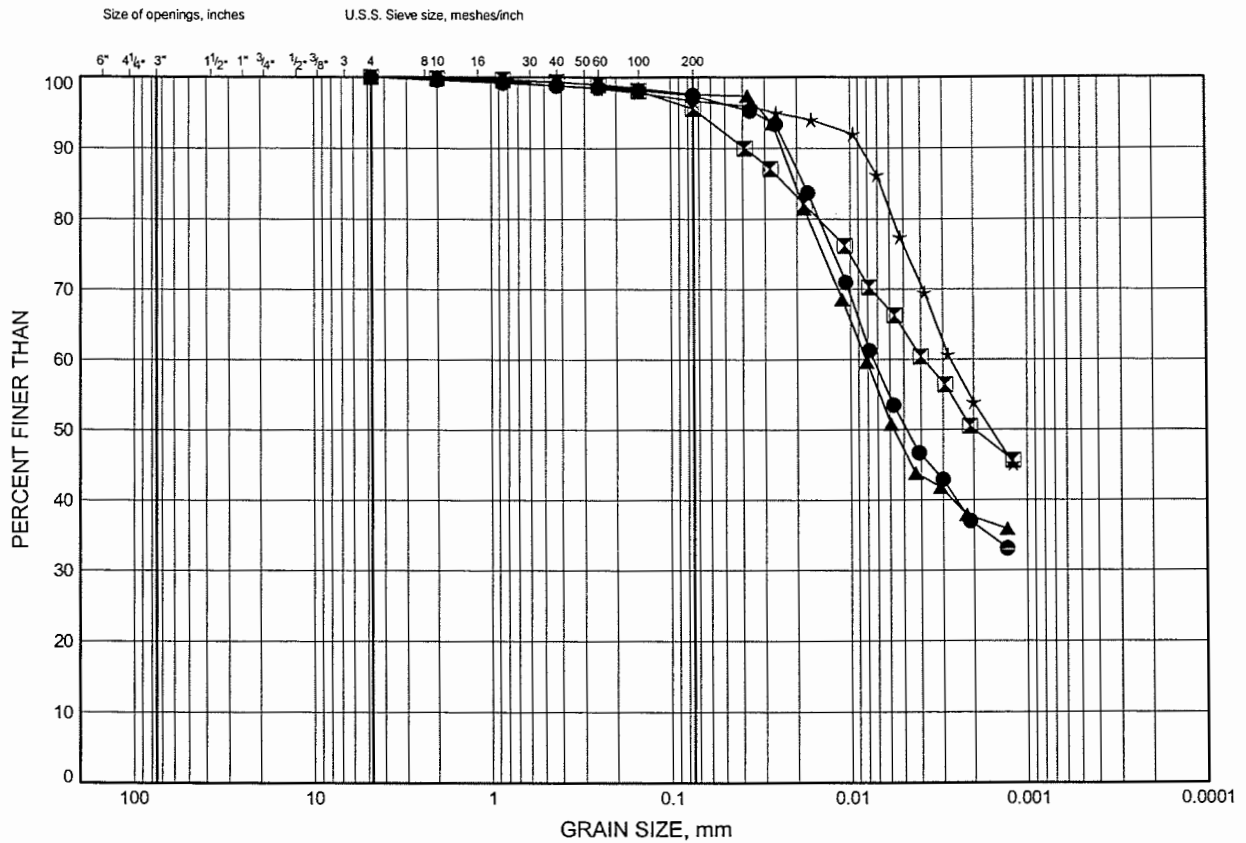
Prep'd MFA

Chkd. MRA

Geotechnical Investigation GRAIN SIZE DISTRIBUTION

FIGURE B4

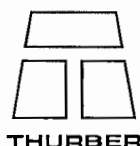
SILTY CLAY TILL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-16	6.32	296.58
◻	06-16	10.90	292.00
▲	06-17	4.80	298.10
★	06-20	16.99	286.21

Date January 2007
Project 277-97-00

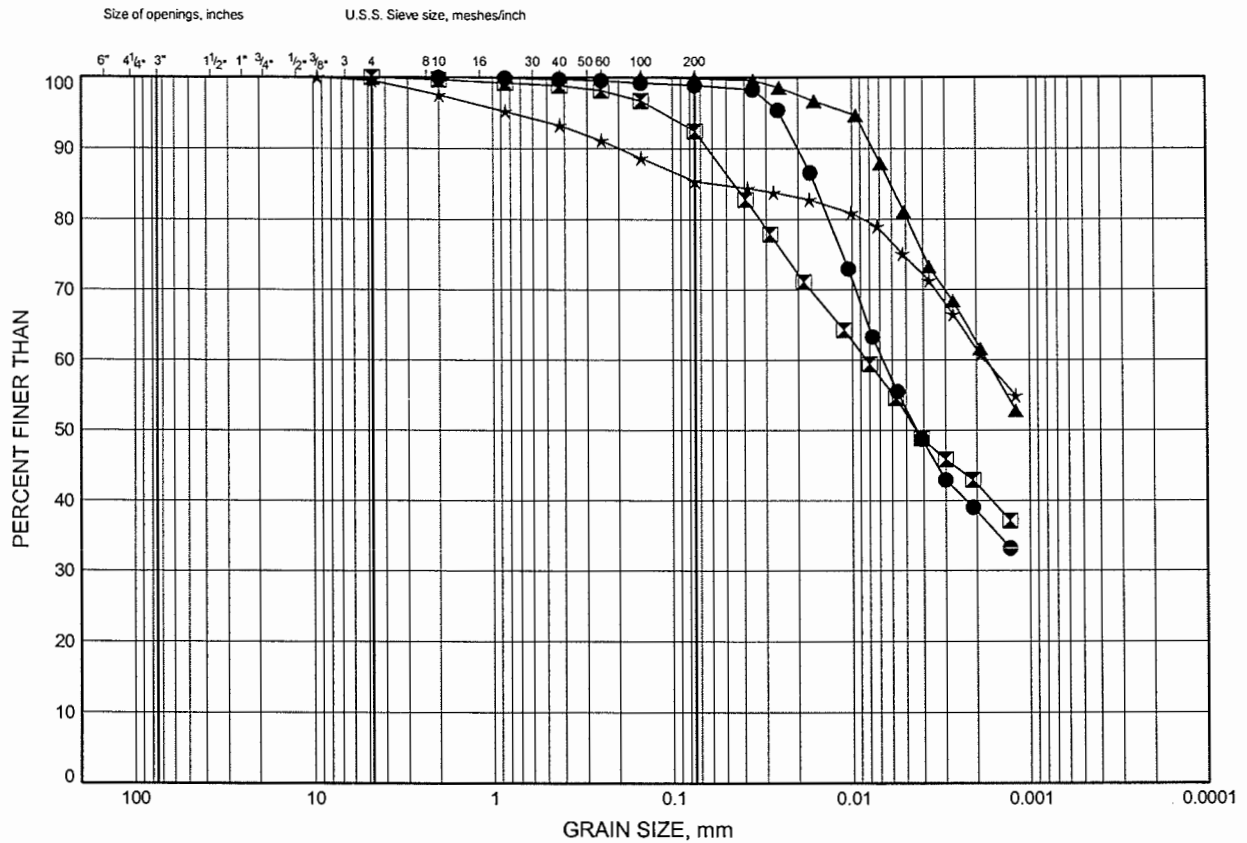


Prep'd MFA
Chkd. MRA

Geotechnical Investigation GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY CLAY TILL

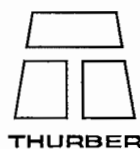


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-21	7.85	295.05
⊠	06-22	10.90	292.60
▲	06-22	15.47	288.03
★	06-23	18.52	284.98

Date January 2007

Project 277-97-00



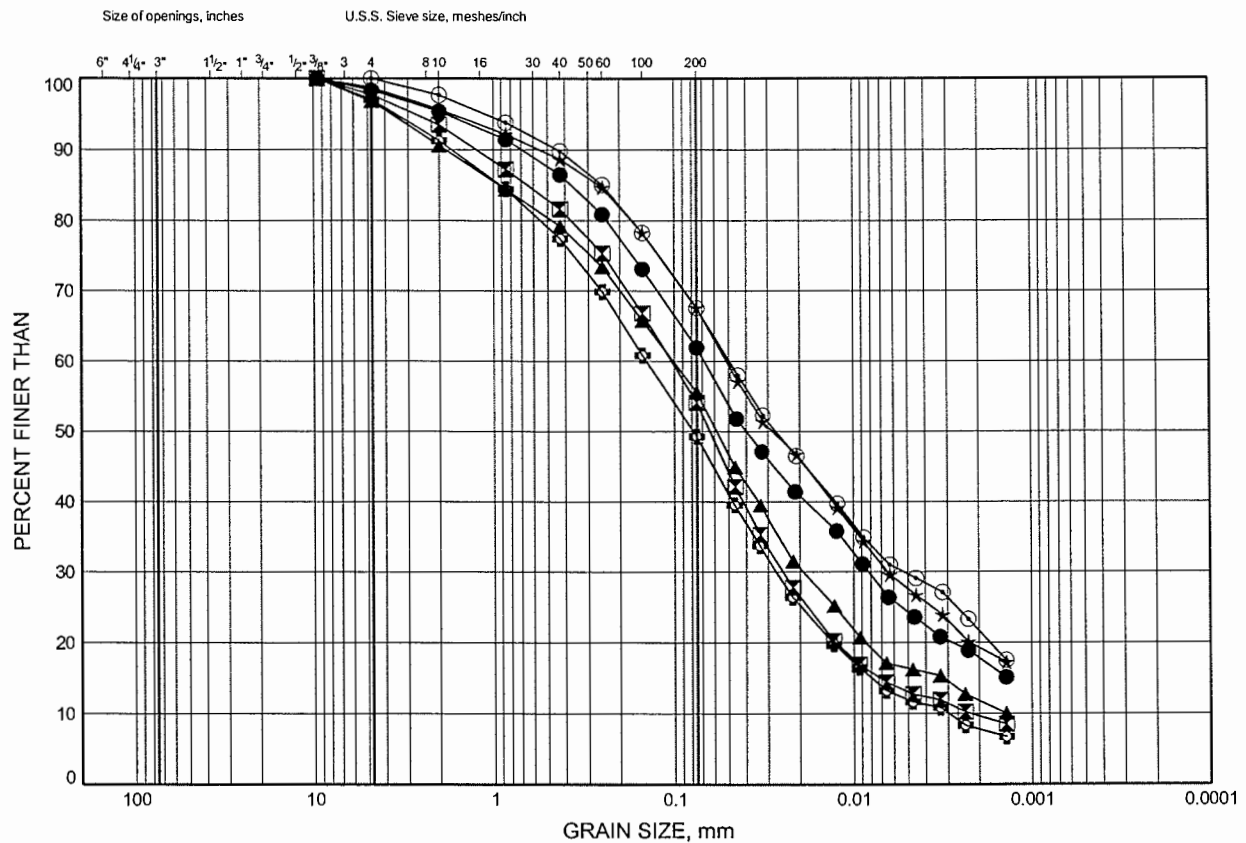
Prep'd MFA

Chkd. MRA

Geotechnical Investigation GRAIN SIZE DISTRIBUTION

FIGURE B6

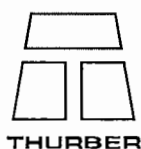
SILT AND SAND TO CLAYEY SANDY SILT (TILL)



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-15	18.52	283.78
⊠	06-16	18.52	284.38
▲	06-17	20.04	282.86
★	06-20	20.04	283.16
⊙	06-21	20.04	282.86
⊛	06-23	24.61	278.89

Date January 2007
Project 277-97-00

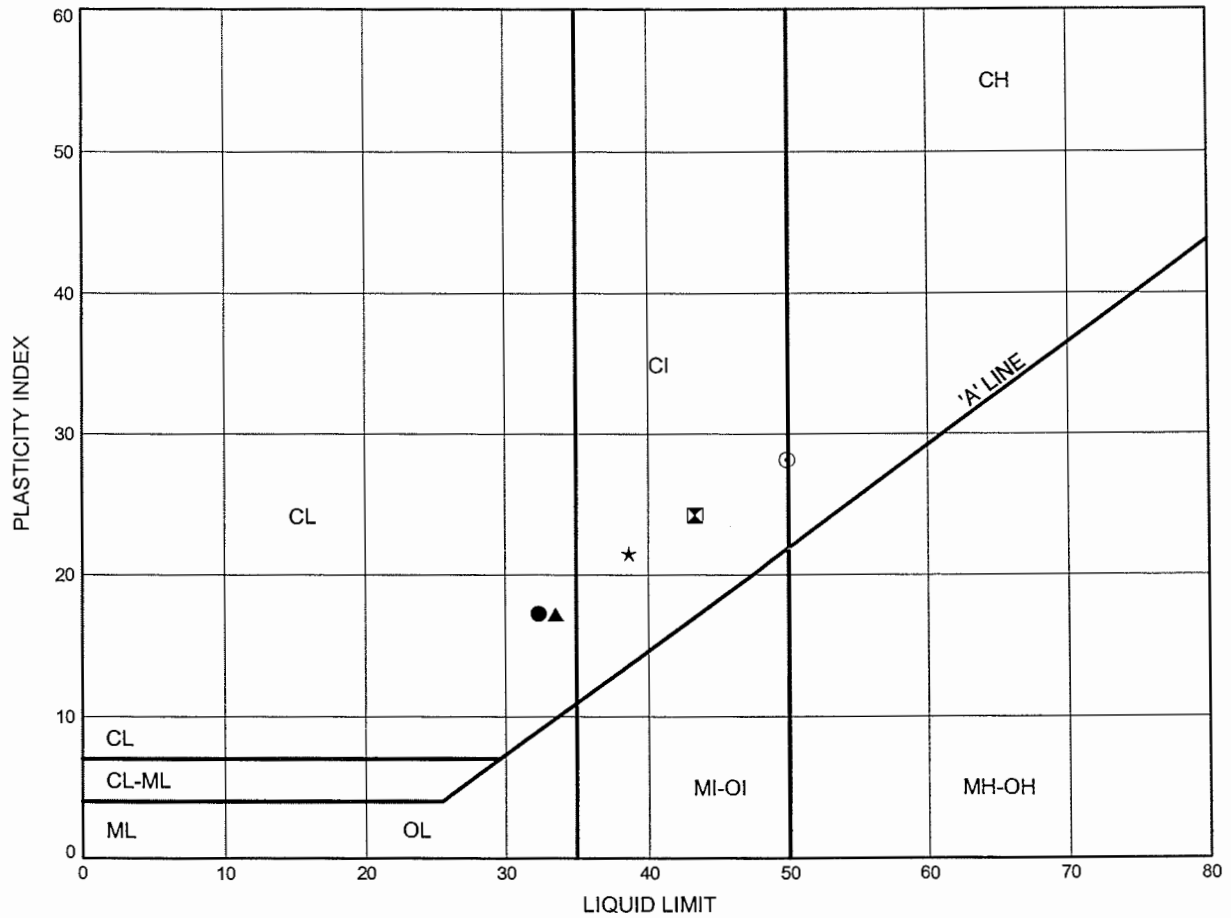


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Geotechnical Investigation
ATTERBERG LIMITS TEST RESULTS

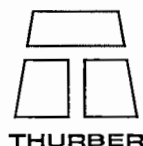
FIGURE B7

SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-17	4.80	298.10
⊠	06-20	16.99	286.21
▲	06-21	7.85	295.05
★	06-22	10.90	292.60
⊙	06-23	18.52	284.98

Date January 2007
 Project 277-97-00



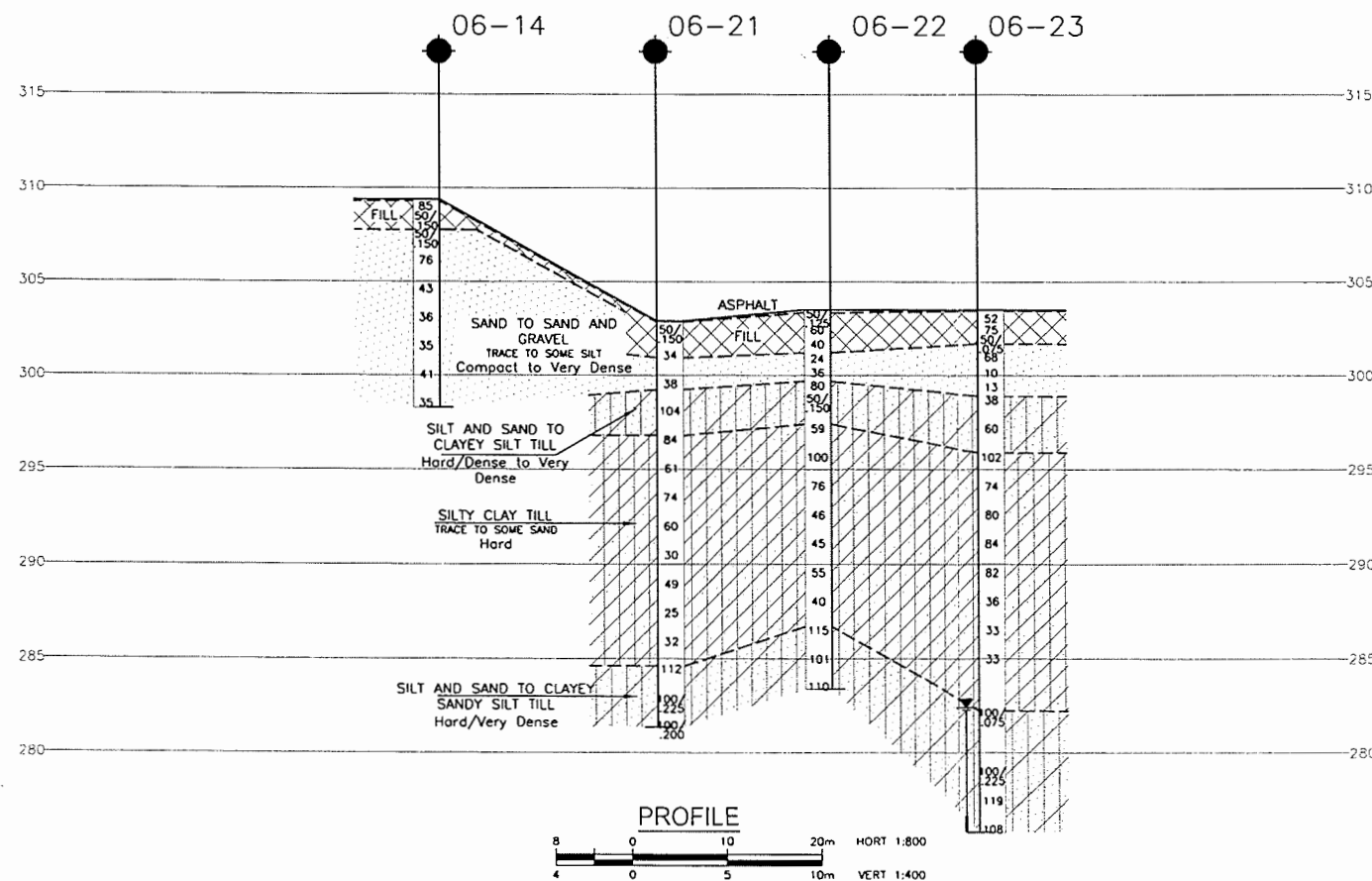
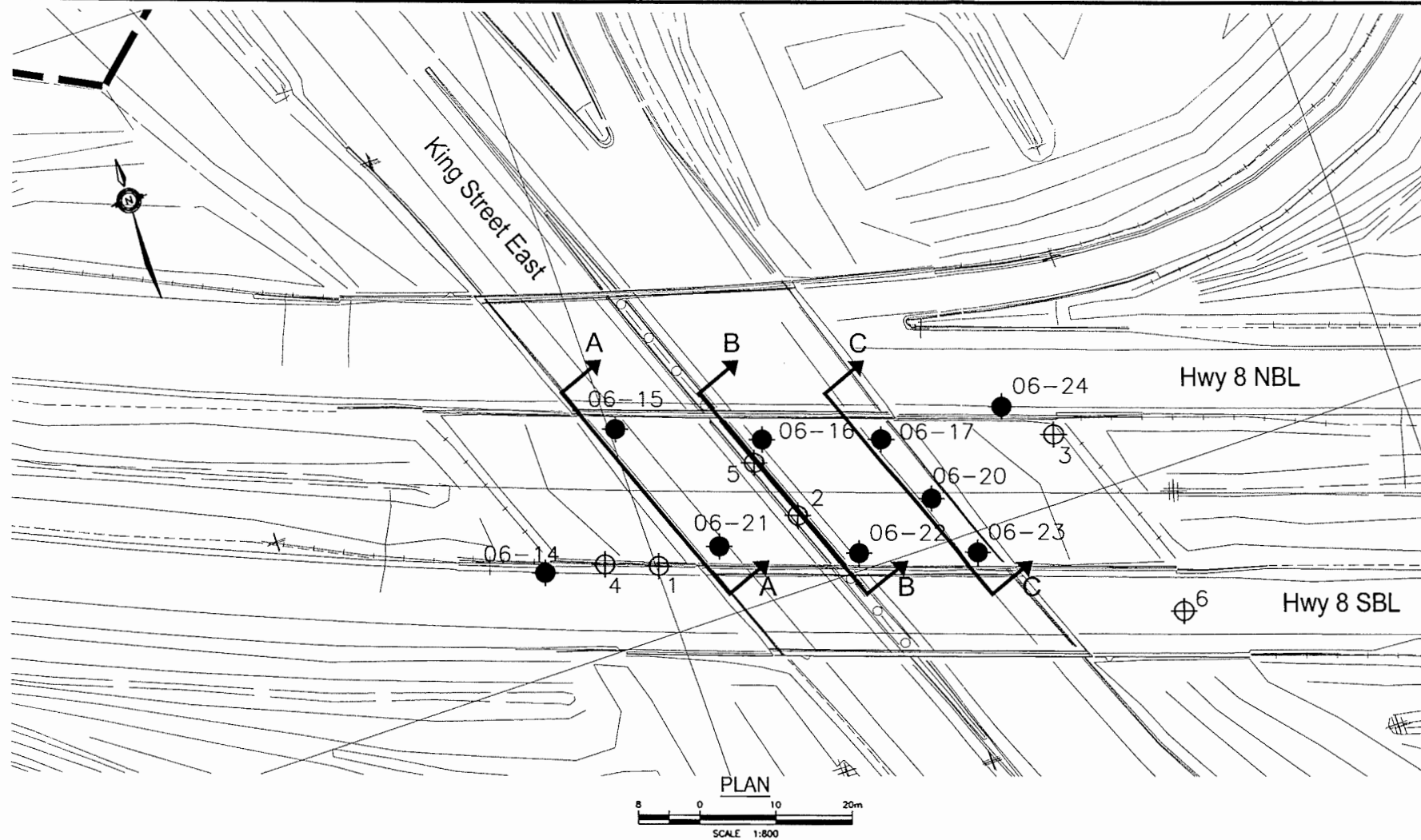
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 Chkd. MRA

Appendix C

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES

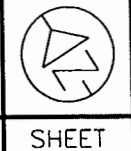
Footings on Native Soil	Footings on Engineered Fill	Driven Piles	Caissons
<p>Advantages:</p> <ul style="list-style-type: none"> i. Ease of construction. ii. Allows choice of conventional or semi-integral abutment. iii. Lower cost than deep foundations. iv. Compatible with existing foundations. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. None <p>RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Would permit use of higher geotechnical resistance than is available on the native soil. ii. Allows choice of conventional or semi-integral abutment. iii. Allows use of perched abutments. iv. Lower cost than deep foundations. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Cost of constructing engineered fill. ii. Requires excavation below founding level of existing footings, with potential disturbance of existing footing subgrade. <p>NOT RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Piles will develop high geotechnical resistance in hard/dense soils. ii. Construction of piles could continue in freezing weather. iii. Readily installed. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher unit costs than footings. ii. Possibility that cobbles and boulders may be encountered in till. iii. Vibrations and soil displacement by pile driving may disturb the existing footings. iv. Incompatible with spread footings supporting existing bridge due to potential differential performance. <p>NOT RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. High resistance is available for caissons founded in hard/dense till. ii. Construction of caissons could continue in freezing weather. iii. Choice of conventional or semi-integral abutment design. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Possibility of boulders being encountered during augering. ii. Significant depth to bedrock bearing stratum. iii. Caisson augering may disturb existing foundations. iv. Incompatible with spread footings supporting existing bridge due to potential differential performance. <p>NOT RECOMMENDED</p>



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AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

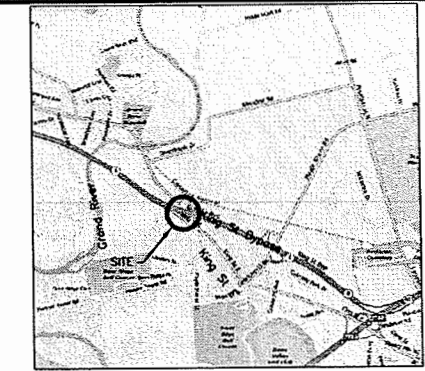
CONT No
GWP No.277-97-00

KING STREET OVERPASS
HWY 8 WIDENING
KITCHENER
BOREHOLE LOCATIONS AND SOIL STRATA



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LEGEND**

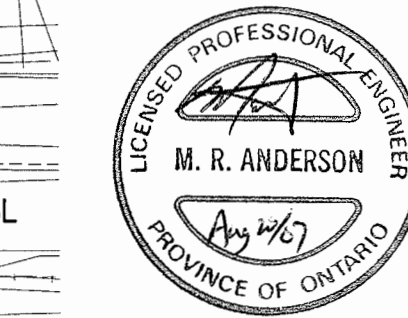
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- BoreHole and Cone
- BoreHole from Previous Investigation (Approximate)
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- PH Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- Rock Quality Designation (RQD)
- 90% Auger Refusal

NO	ELEVATION	NORTHING	EASTING
06-14	309.4	4 808 713.1	231 485.9
06-15	302.3	4 808 728.1	231 500.9
06-16	302.9	4 808 720.6	231 518.7
06-17	302.9	4 808 715.6	231 533.5
06-20	303.2	4 808 706.1	231 537.0
06-21	302.9	4 808 709.1	231 508.7
06-22	303.5	4 808 702.3	231 525.8
06-23	303.5	4 808 697.3	231 540.7
06-24	311.1	4 808 714.5	231 550.0

-NOTES-

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

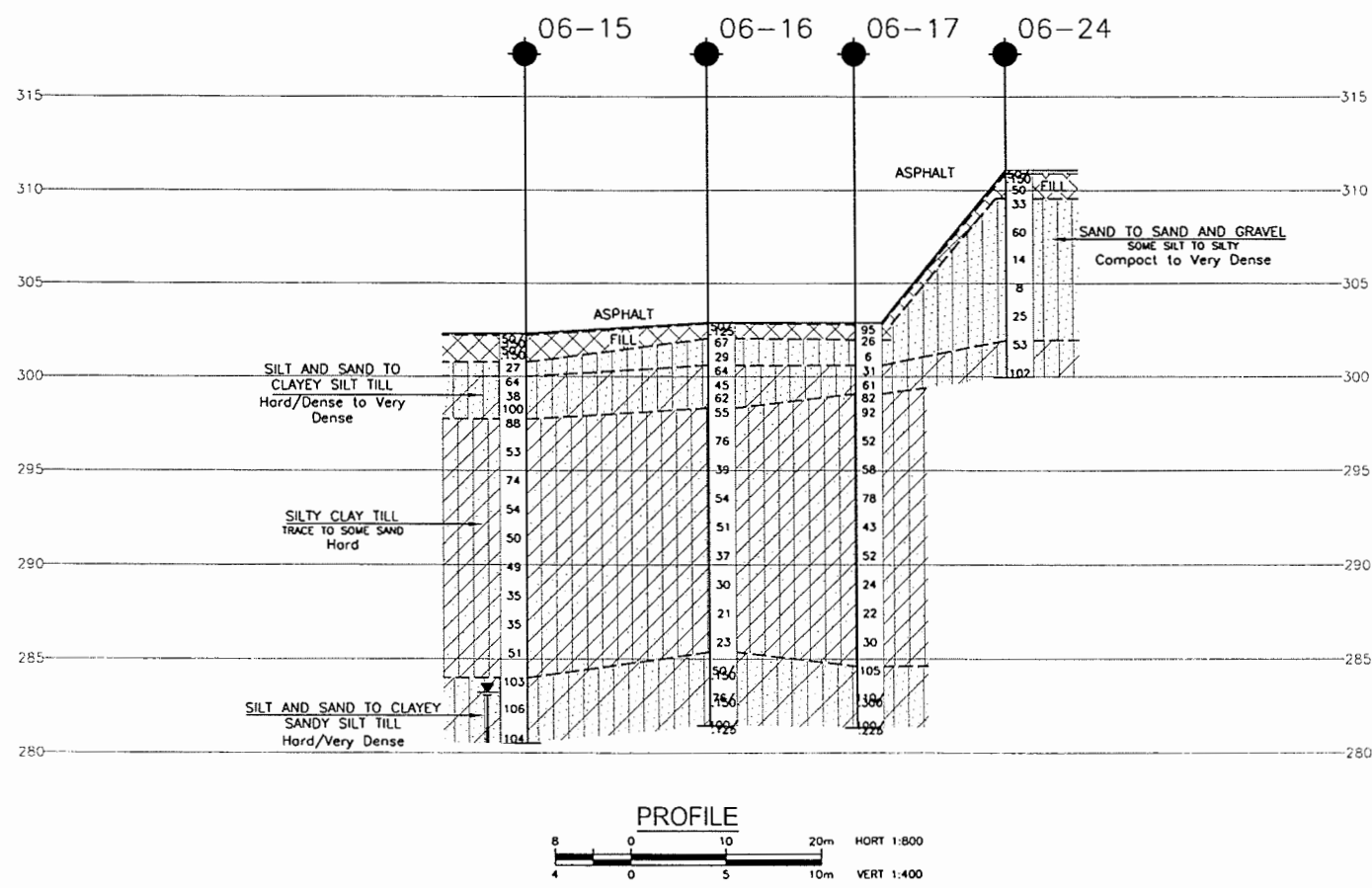
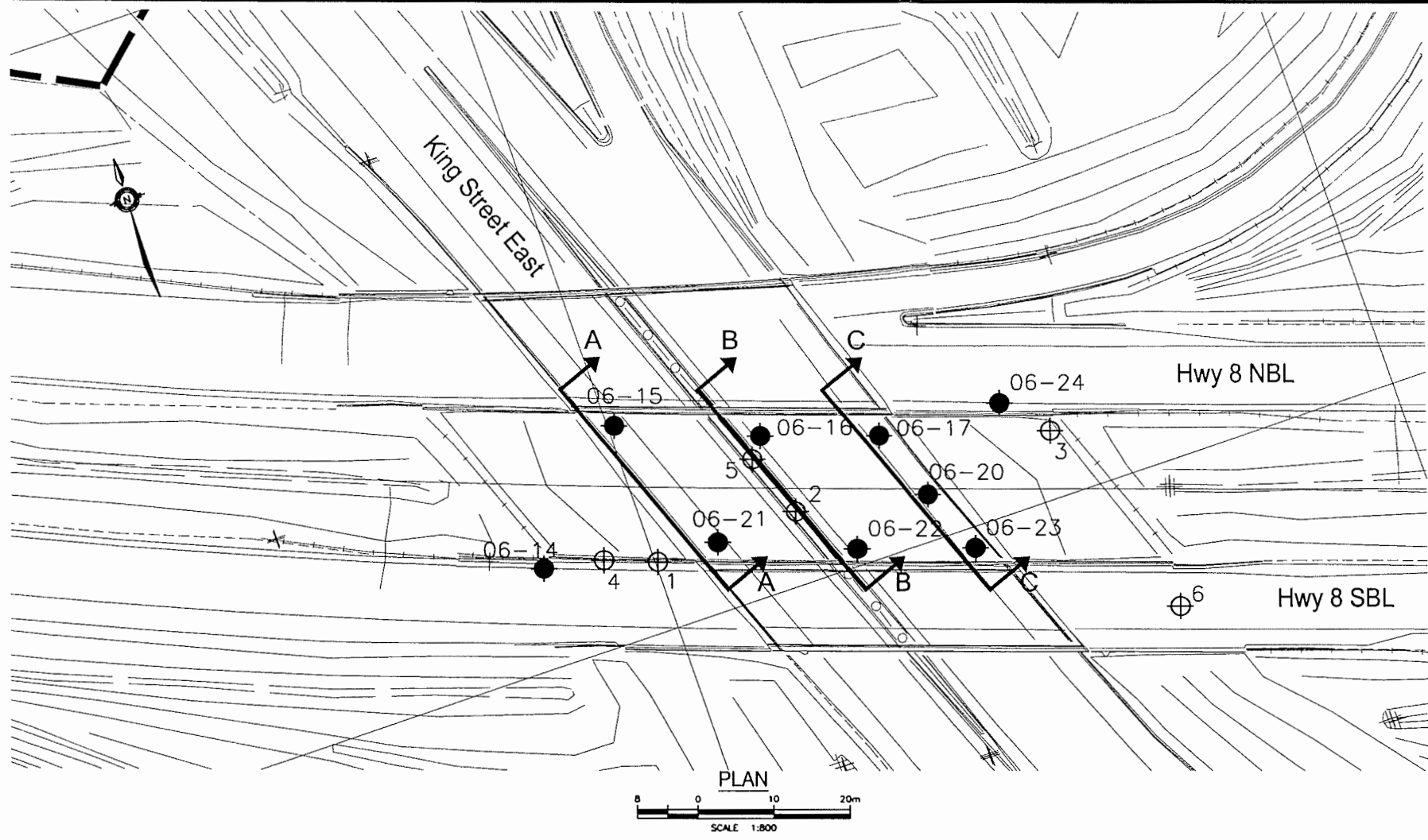
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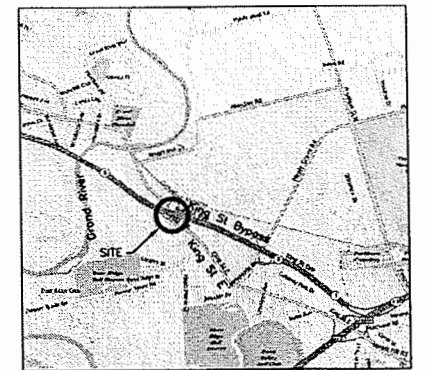
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**KEYPLAN
LEGEND**

- BoreHole
- BoreHole and Cone
- BoreHole from Previous Investigation (Approximate)
- 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
06-14	309.4	4 808 713.1	231 485.9
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06-20	303.2	4 808 706.1	231 537.0
06-21	302.9	4 808 709.1	231 508.7
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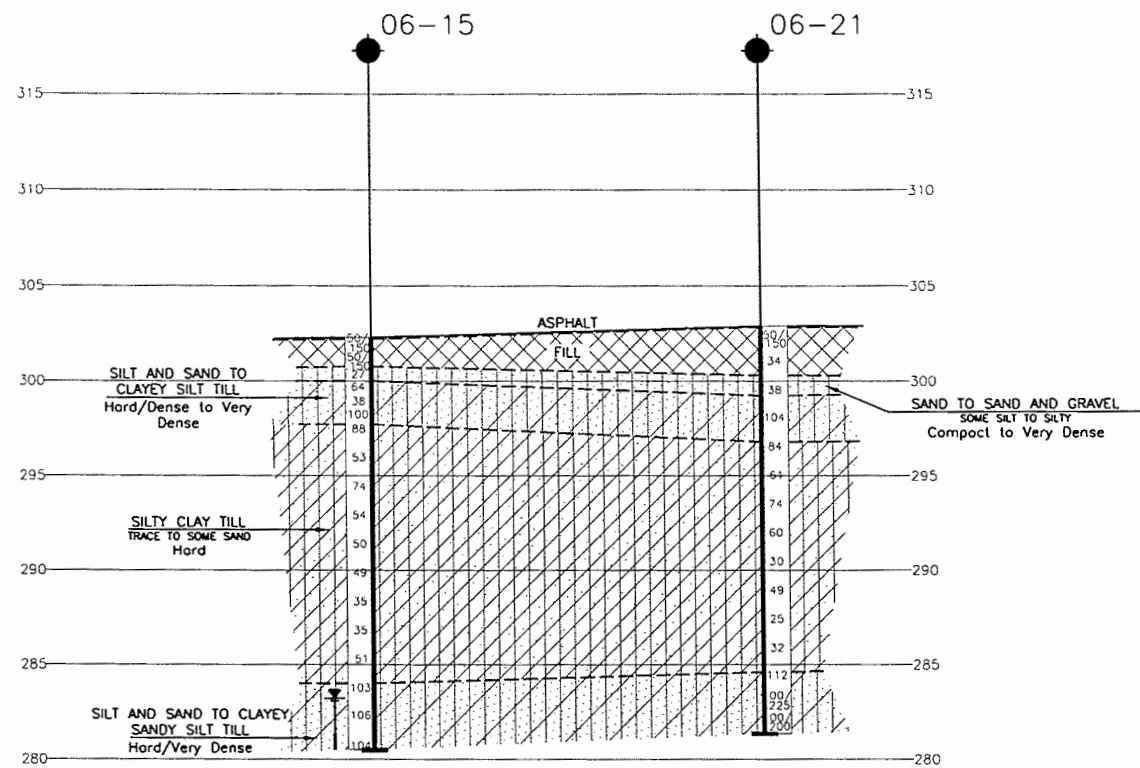
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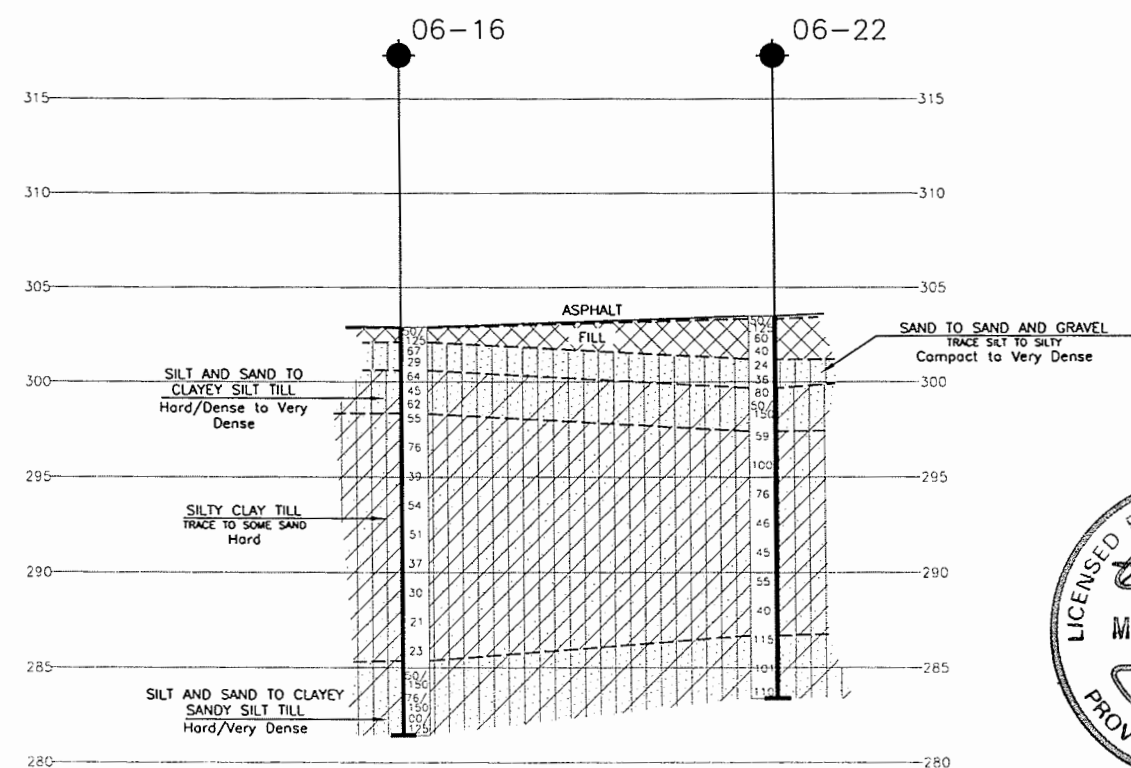
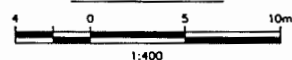
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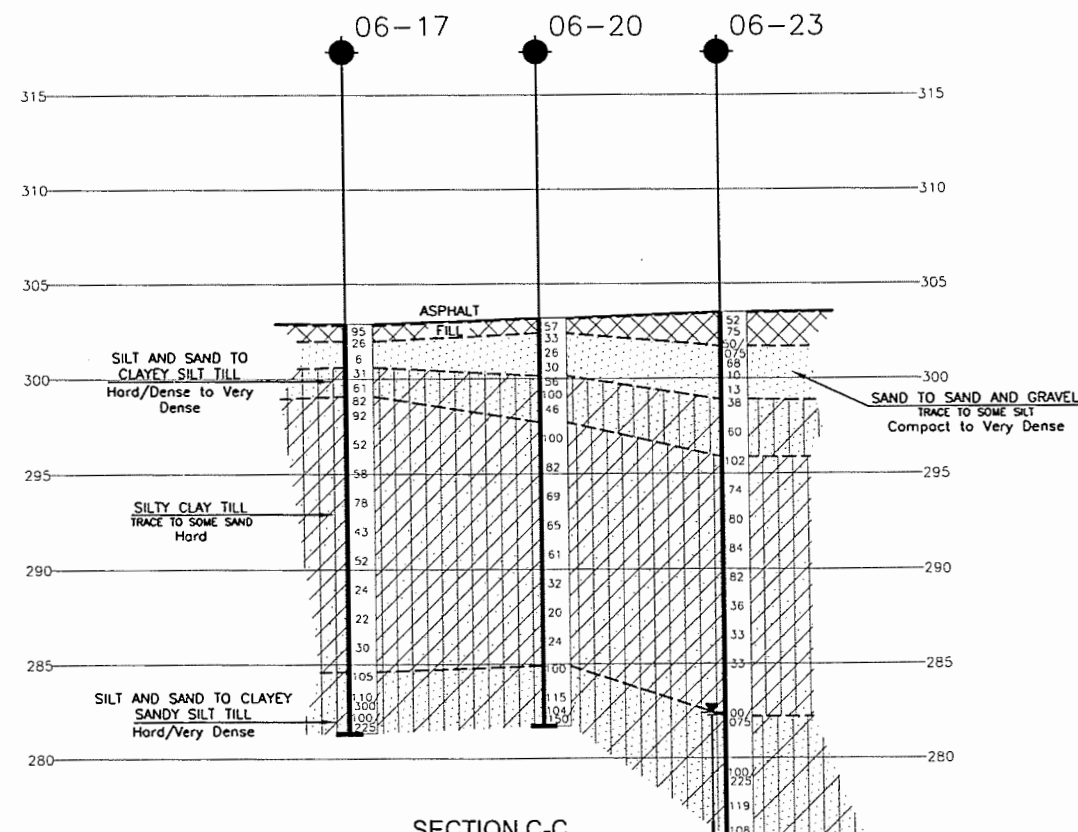
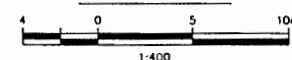
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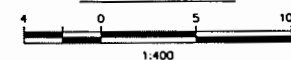
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SECTION B-B



SECTION C-C



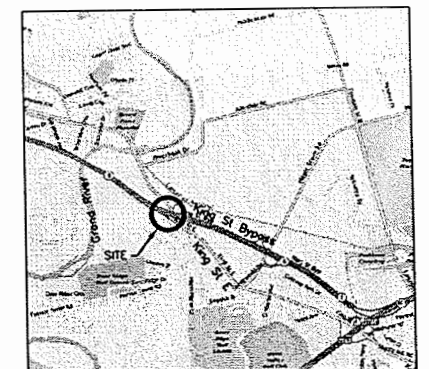
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GEOCRES No. 40P8-145



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