



May 19, 2017

## PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT

### Salem Road Overpasses Structure Site No. 22-547 Highway 401 Improvements from Brock Road to Courtice Road Regional Municipality of Durham W.O. 10-20011

**Submitted to:**  
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REPORT



**GEOCRES No. 30M14-450**

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# **PART A**

**PRELIMINARY FOUNDATION INVESTIGATION REPORT  
SALEM ROAD OVERPASSES  
STRUCTURE SITE NO. 22-547  
HIGHWAY IMPROVEMENTS FROM BROCK ROAD TO COURTICE ROAD  
REGIONAL MUNICIPALITY OF DURHAM  
W.O. 10-20011**



## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide preliminary foundation engineering services for the future improvements and widening of Highway 401 from Brock Road to Courtice Road in the Regional Municipality of Durham, Ontario.

This report addresses the proposed widening of the existing Salem Road overpasses, based on information from a previous geotechnical/foundations investigation at the Salem Road overpass site, as follows:

- **MTO GEOCREs No. 30M14-276:** *Foundation Investigation Report, Highway 401 and Carruthers Creek Drive Interchange, Preliminary Design, W.P. 242-86-00*, prepared by Golder Associates Ltd., dated January 2000.

The terms of reference for the preliminary foundation engineering services are outlined in MTO's Request for Proposals (RFP) for Assignment No. 2010-E-0062, dated June 2011. The scope of work for the preliminary foundation engineering services is presented in Section 5.8 of URS's *Technical Proposal* for this assignment, as well as Golder's Scope Change for Foundations Engineering Services letter dated December 8, 2014.

## **2.0 SITE DESCRIPTION**

The Salem Road overpasses are located approximately 2.5 km east of the Westney Road interchange and approximately 6.5 km west of the Brock Street interchange, in the Town of Ajax. The existing Salem Road overpasses are single-span structures supported on steel H-piles.

The natural ground surface at this site is at approximately Elevation 95 m to 97 m, and Salem Road has been constructed in a cut with its grade at approximately Elevation 88 m to 88.5 m below the overpass. Highway 401 has been constructed on a low embankment, with its grade varying from about Elevation 98 m to 100 m from east to west of Salem Road. GO Transit and CN Rail tracks are located south of and parallel to Highway 401, with the rail at about Elevation 97 m. Retaining walls are present along the south side of Highway 401, between the highway and rail line.

A hotel is present in the northeast quadrant of the structure site, and a car dealership is present in the southeast quadrant. Residential areas are present in the northwest and southwest quadrants of the structure site.

## **3.0 INVESTIGATION PROCEDURES**

Sixteen boreholes were advanced at this site as part of a previous geotechnical investigation by Golder in September 1999. Boreholes ST-1 to ST-6 and G-13 were advanced in the area of the overpass, while Boreholes RW-1 through RW-9 were advanced on the south side of Highway 401 along the alignment of the retaining walls.

The boreholes were advanced using a track-mounted CME-55 drill rig, supplied and operated by Masters Soil Investigations Ltd of Toronto, Ontario. Soil samples were obtained at approximately 0.75 m and 1.5 m intervals of depth, using 50 mm outside diameter split-spoon samplers driven using a manual hammer, in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586-11 – Standard Test Method for Standard



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Penetration Tests and Split-Barrel Sampling of Soil). Bedrock was cored in Boreholes ST-3 to ST-6, using an NQ-size core barrel.

The groundwater conditions were observed in the open boreholes throughout the drilling operations. Standpipe piezometers were installed in five selected boreholes to allow monitoring of the groundwater level; the details of the piezometer installation are shown on the borehole records contained in Appendix A.

Index and classification testing (water content, Atterberg limits and grain size distributions) was completed on selected samples. The results of the geotechnical laboratory testing are included in Appendix B.

The borehole locations, including MTM NAD83 northing and easting coordinates and the ground surface elevations referenced to geodetic datum, are summarized in the following table and are shown on Drawings 1 and 2. The northing and easting coordinates as shown on the borehole records in Appendix A are referenced to the MTM NAD27 coordinate system.

Borehole No.	Northing	Easting	Ground Surface Elevation (m)	Depth (m)
G-13	4,857,485.4	343,981.8	98.3	7.8
RW-1	4,857,291.9	343,908.5	98.2	6.7
RW-2	4,857,307.4	343,956.7	95.0	8.2
RW-3	4,857,322.4	344,005.2	94.9	12.5
RW-4	4,857,337.4	344,052.3	94.7	12.5
RW-5	4,857,349.4	344,091.2	94.6	15.2
RW-6	4,857,364.4	344,138.7	95.6	12.8
RW-7	4,857,379.9	344,186.2	95.8	10.8
RW-8	4,857,394.8	344,234.2	95.5	9.6
RW-9	4,857,409.8	344,281.6	95.5	8.2
ST-1	4,857,381.9	344,023.0	97.0	18.3
ST-2	4,857,393.9	344,060.7	96.7	18.3
ST-3	4,857,399.4	344,012.2	97.2	20.6
ST-4	4,857,410.6	344,049.4	97.4	19.2
ST-5	4,857,416.5	344,001.2	97.8	19.5
ST-6	4,857,428.4	344,038.2	97.5	19.1

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

This section of Highway 401 is located within the Iroquois Plain physiographic region, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984) and *Urban Geology of Canadian Cities* (Brennand, 1998). The Iroquois Plain extends around the western shores of Lake Ontario. The Plain is comprised of the flat to undulating lakebed and beaches of the former glacial Lake Iroquois, which occupied this area during the last glacial recession.



The surficial soils in this area of the Iroquois Plain are typically comprised of glaciolacustrine clays, silts and sands to gravelly sands, which are underlain by an extensive till deposit that is mapped in this area as the Bowmanville Till. More recent alluvial deposits of gravel, sand, silt and/or clay are present in the creek valleys.

## **4.2 Subsurface Conditions**

The detailed subsurface soil and groundwater conditions encountered in the boreholes advanced as part of the 1999 investigation, together with the results of in situ and geotechnical laboratory testing are presented on the borehole records in Appendix A; the geotechnical laboratory test results are also provided in Appendix B.

The interpreted stratigraphic sections are shown on Drawings 1 and 2. The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic sections are inferred from observations of drilling progress and non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In general, the subsurface conditions at the site consist of relatively thin layers of topsoil and/or fill underlain by a succession of glacial till deposits. The glacial till units vary in composition from silty sand to clayey silt and extend to depths of about 15 m to 16 m below the original ground surface. The till units are underlain by shale bedrock of the Whitby Formation. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

### **4.2.1 Topsoil**

Approximately 150 mm to 600 mm of topsoil was encountered immediately below the then-existing ground surface in Boreholes RW-7 through RW-9, advanced on the south side of Highway 401 and in Boreholes ST-1 to ST-6 and G-13, advanced at the overpass site and north of Highway 401. This material is likely to have been removed, or largely removed, in conjunction with the structure works in this area.

### **4.2.2 Fill**

Fill material was encountered either immediately below the then-existing ground surface or beneath the topsoil in Boreholes RW-1 to RW-9, and ST-5. The thickness of the fill at the time of the 1999 investigation ranged from approximately 0.5 m to 2.1 m.

The fill material encountered in the boreholes typically consists of clayey silt to silty clay containing trace to some sand, trace gravel and organics. A layer of sand and gravel fill was encountered in Borehole RW-6.

The SPT 'N'-values measured within the cohesive fill range from 5 blows to 135 blows per 0.3 m penetration, but are generally less than 25 blows per 0.3 m penetration, suggesting a firm to very stiff consistency. One SPT 'N'-value of 15 blows per 0.3 m of penetration was measured within the sand and gravel fill in Borehole RW-6, indicating a compact relative density. The natural water content measured on selected samples of the fill varies between 7 per cent and 20 per cent.

### **4.2.3 Upper Silty Clay Till**

An upper deposit of silty clay till was encountered underlying the topsoil and fill in Boreholes ST-1 through ST-6. The thickness of this upper silty clay till deposit ranges from about 1.6 m to 2.0 m. The base of the upper silty clay till was encountered between approximately Elevation 95.5 m and 94.5 m.





The SPT 'N'-values measured within the upper silty clay till range from 19 blows to greater than 145 blows per 0.3 m of penetration, suggesting a very stiff to hard consistency.

The silty clay till contains some sand and trace to some gravel; cobbles and boulders were encountered in the boreholes at varying depths. The result of a grain size distribution test completed on one sample of the till is shown on Figure 1 in Appendix B. Measured water contents of samples of the silty clay till deposit range from about 6 per cent to 15 per cent.

#### **4.2.4 Upper Clayey Silty Sand to Silty Sand Till**

A deposit of clayey silty sand to silty sand till was encountered in all the boreholes underlying the topsoil, fill or upper silty clay till. Boreholes RW-1, RW-2 and G-13 were terminated within this upper silty sand till deposit, penetrating it for a thickness of 4.6 m to 7.6 m. The thickness of the upper clayey silty sand to silty sand till deposit varied from approximately 0.8 m to 8.2 m at the other borehole locations, but was generally greater than 6 m. The base of the upper clayey silty sand to silty sand till was encountered between approximately Elevation 92.5 m and 85.8 m.

This till deposit varies in composition from clayey silty sand to silty sand, with typically about 50 per cent coarse fractions (sand and gravel) and varying proportions of clay, typically less than 12 per cent. Interlayers of silty clay till, about 0.8 m thick, were encountered within this till stratum in Boreholes RW-1, RW-3 and RW-6. The results of grain size distribution tests completed on selected samples of this till deposit are shown on Figures 2 through 5 in Appendix B.

Atterberg limits tests were carried out on selected samples of this deposit, and measured liquid limits ranging from about 15 per cent to 24 per cent, plastic limits ranging from about 10 per cent to 17 per cent, and plasticity indices ranging from about 5 per cent to 12 per cent. An Atterberg limits test carried out on one sample in Borehole ST-4 indicated that the material was non-plastic. The results of the Atterberg limits tests are shown on Figures 7 and 8 in Appendix B, and confirm that the cohesive material is generally classified as a clayey silt of low plasticity. The measured water contents of samples of the till generally range from about 5 per cent to 20 per cent.

The SPT 'N'-values measured within the upper clayey silty sand to silty sand till range from 19 blows to greater than 100 blows per 0.3 m of penetration, indicating that the deposit is very stiff to hard/compact to very dense, typically being hard/very dense.

#### **4.2.5 Lower Silty Clay to Clay Till**

A lower deposit of silty clay to clay till was encountered underlying the upper clayey silty sand to silty sand till in all boreholes except Boreholes RW-1, RW-2 and G-13, which terminated within the upper clayey silty sand to silty sand till. Boreholes RW-3, RW-4, RW-6, RW-8 and RW-9 were terminated within the lower silty clay till deposit, penetrating it for a thickness of about 3.7 m to 6.6 m. The thickness of this lower silty clay till deposit varied from approximately 2.3 m to 7.9 m at the other borehole locations. The base of the lower silty clay to clay till was encountered between approximately Elevation 87.3 m and 81.2 m.

The lower silty clay till deposit contains trace to some sand and gravel as well as frequent silt partings in the eastern portion of the site. Cobbles were encountered within the lower silty clay till deposit at some borehole locations. The result of a grain size distribution test completed on one selected sample of this deposit is shown on Figure 6 in Appendix B.



Atterberg limits testing was carried out on selected samples of this deposit and measured liquid limits ranging from about 41 per cent to 58 per cent, plastic limits ranging from 17 per cent to 24 per cent, and plasticity indices ranging from 24 per cent to 34 per cent. The results of the Atterberg limits tests are shown on Figure 9 in Appendix B, and these confirm that the material is classified as a silty clay to clay of intermediate to high plasticity. The measured water contents of samples of the lower silty clay till deposit ranged from about 6 per cent to 28 per cent.

The SPT 'N'-values measured within the lower silty clay to clay till range from 36 blows per 0.3 m penetration to greater than 100 blows per 0.15 m of penetration, suggesting a hard consistency.

#### **4.2.6 Lower Silty Sand Till**

Underlying the upper silty clay till in Boreholes RW-7, ST-4 and ST-6, a relatively thin deposit of silty sand till containing cobbles, trace to some gravel, and trace clay was encountered. Borehole RW-7 terminated within the lower silty sand till deposit, penetrating it for a thickness of 2.3 m. The thickness of the lower silty sand till in Boreholes ST-4 and ST-6 was 0.9 m and 1.2 m, respectively.

The SPT 'N'-values measured within the lower silty sand till were in excess of 100 blows per 0.3 m penetration indicating that this deposit is a very dense relative density.

#### **4.2.7 Shale Bedrock**

Shale bedrock of the Whitby Formation was encountered in Boreholes ST-1 to ST-6 and RW-5. Rock coring was carried out in Boreholes ST-3 through ST-6. The upper portion of the bedrock was penetrated and recovered by augering and split-spoon sampling, and the bedrock was cored using NQ-size coring equipment.

The depth to bedrock and approximate bedrock surface elevation is summarized in the following table.

<b>Borehole No.</b>	<b>Depth to Bedrock Surface (m)</b>	<b>Bedrock Surface Elevation (m)</b>
ST-1	15.2	81.8
ST-2	15.2	81.5
ST-3	14.9	82.3
ST-4	15.5	81.9
ST-5	15.2	82.6
ST-6	16.4	81.1
RW-5	13.4	81.2

In general, the bedrock is described as moderately to highly weathered, thinly bedded, dark grey, Whitby Formation Shale, containing occasional thin limestone interlayers. The Rock Quality Designation (RQD) values measured on the core samples retrieved ranged between 26 per cent and 62 per cent, indicating a rock mass of poor to fair quality.

### **4.3 Groundwater Conditions**

The groundwater conditions were observed in the open boreholes during and on completion of drilling. Several of the boreholes were observed to be dry at that time, although this is not considered to represent the stabilized



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groundwater level at the site. Piezometers were installed in Boreholes RW-3, RW-5, RW-7, ST-4 and ST-5 to monitor the groundwater level at the site. The observed groundwater conditions are shown on the borehole records contained in Appendix A, and the water levels measured in the piezometers are summarized as follows:

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Screened Unit	Date
RW-3	94.9	5.8	89.1	Lower Silty Clay Till	Oct. 19, 1999
RW-5	94.6	4.1	90.5	Shale	Oct. 19, 1999
RW-7	95.8	2.0	93.8	Lower Silty Sand Till	Oct. 19, 1999
ST-4	97.4	4.5	92.9	Shale	Oct. 19, 1999
ST-5	97.8	5.2	92.6	Shale	Oct. 19, 1999

Measurements taken in the piezometers on October 19, 1999 indicate that the groundwater level is between 2.0 m and 5.8 m below ground surface corresponding to about Elevations 89.1 m to 93.8 m. These historic stabilized groundwater levels may have been affected (lowered) by the construction of the Salem Road cut.

The water level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring and periods of precipitation.

## 5.0 CLOSURE

This Preliminary Foundation Investigation Report was prepared by Ms. Nikol Kochmanová, P.Eng., and was reviewed by Ms. Lisa Coyne, P.Eng., a Designated MTO Foundations Contact and Principal with Golder.

### GOLDER ASSOCIATES LTD.



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SALEM ROAD OVERPASSES, W.O. 10-20011**

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# **PART B**

**PRELIMINARY FOUNDATION DESIGN REPORT  
SALEM ROAD OVERPASSES  
STRUCTURE SITE NO. 22-547  
HIGHWAY IMPROVEMENTS FROM BROCK ROAD TO COURTICE ROAD  
REGIONAL MUNICIPALITY OF DURHAM  
W.O. 10-20011**



## **6.0 DISCUSSION AND PRELIMINARY GEOTECHNICAL ENGINEERING RECOMMENDATIONS**

### **6.1 General**

This section of the report provides preliminary foundation recommendations in support of the proposed widening of the existing Salem Road overpasses on Highway 401 (MTO Structure Site 22-547), together with associated wingwalls / retaining walls. These preliminary recommendations are based on interpretation of the factual data obtained from the boreholes advanced during a previous subsurface investigation at this site. This Preliminary Foundation Design Report, including the interpretations and recommendations contained herein, are intended for the use of MTO to provide the designers with sufficient information to assess the feasible foundation alternatives and to carry out the preliminary design of the structure foundations. This Preliminary Foundation Design Report shall not be used or relied upon for any other purpose or by any other parties, including contractors. Further investigation and design will be required during the detailed design stage.

Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions or operational constraints may be required in the contract documents. Contractors must make their own interpretation of the factual information provided in the Preliminary Foundation Investigation Report, as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

### **6.2 Foundation Options**

The existing overpasses were constructed in 2002 (Contract Nos. 2000-0087 and 2001-0029). The following design drawings are available:

- Contract No. 2000-0087, WP No. 110-00-01, Sheets 55 to 67: "Highway 401 WBL, Carruthers Creek Drive Overpass", prepared by McCormick Rankin Corporation, dated July 2000.
- Contract No. 2001-0029, WP No. 124-99-01, Sheets 544 to 554: "Highway 401 EBL, Carruthers Creek Drive Overpass", prepared by McCormick Rankin Corporation, dated May 2001.

Based on these drawings, the existing single-span structures are supported on integral abutments with steel HP310x132 piles driven to found on or within the bedrock, at approximately Elevation 80.6 m for the west abutment and approximately Elevation 80.4 m for the east abutment.

It is understood that as part of the future improvements and widening of Highway 401 from Brock Road to Courtice Road in the Regional Municipality of Durham, the existing Salem Road overpasses will be widened. The widening will be constructed to match the existing bridge, which has a total span of 42.8 m (skew). Based on the preliminary General Arrangement (GA) drawing provided by AECOM, the structure will be widened by about 15 m to 16 m along the eastbound lanes. Along the westbound lanes, widening of about 7 m to 10 m will be required; this will incorporate an existing abutment extension at the north end of the west abutment, as well as an existing RSS wall in this quadrant. New wingwalls/retaining walls will be required adjacent to the south side of the abutments.

Both shallow and deep foundation options have been considered for the widening of the Salem Road overpasses. A summary of the advantages and disadvantages associated with each option is provided below,



and a comparison of the alternative foundation options based on advantages, disadvantages, risks and relative costs is provided in Table 1 following the text of this report.

- **Strip footings founded on the very dense clayey silty sand to silty sand till deposit:** Shallow footings are feasible at this site due to the generally very dense nature of the overburden soils. However, this foundation type will preclude the use of integral abutments and would not match the existing structure type; it would be most suitable if a separate structure (for example, for a single-lane ramp) were required. This option would require excavation to a depth of about 1.2 m to 2 m below the Salem Road grade. Temporary protection systems would be required along Highway 401 to facilitate the removal of the existing retaining wall and the construction of the widening, and along Salem Road to facilitate excavation to the founding level. The proposed founding level will be below the groundwater level at the site, and some groundwater control is expected to be required to enable shallow foundations to be constructed in “dry” conditions. There is potential for up to about 15 mm to 20 mm of settlement of the widened portion of the overpass structure foundations relative to the existing pile-supported overpass structures.
- **Driven steel H-piles or pipe piles founded on the shale bedrock:** Driven steel H-piles or steel pipe (tube) piles are feasible for support of the abutments, and would permit integral abutments to match the existing structure. A perched pile cap (relative to Salem Road grade) in a false abutment configuration would minimize excavation and groundwater control requirements at the new abutments. Deep foundations would minimize the differential settlement between the widened and existing portions of the structure, as compared with a spread footing option for the widening. The piles would be driven through several metres of 100-blow till to reach the shale bedrock. As a result, heavier pile sections (e.g., HP310x132 piles, which were used for the existing structures) and pile driving shoes are recommended to protect the piles and pile tips from damage during driving. Pre-augering may also be required to start the pile driving operations.
- **Caissons founded in the shale bedrock:** Caissons are considered feasible for the support of the abutments; however this option would preclude integral abutment design. As for piles, caissons are considered to have a technical advantage over spread footings as the differential settlement between the widened portion for the overpass structures and the existing overpass structures would be negligible. This option will be more expensive than either shallow foundations or pile foundations, although fewer caisson elements would be required in comparison to the number of steel piles that would be required. If caissons are adopted for support of the abutments, they would extend into and through water-bearing non-cohesive layers within the till; temporary liners would be required during construction to control potential ground losses.

Based on the above considerations, pile foundations are preferred from a geotechnical/foundations perspective as they would match the existing structure foundations and permit integral abutments. A perched pile cap would minimize groundwater control requirements as compared with spread footings.

## **6.3 Shallow Foundations**

### **6.3.1 Founding Elevation**

If shallow foundations are adopted for support of the abutment widening, or for associated concrete retaining walls, spread/strip footings should be founded below the existing Highway 401 embankment fill and Salem Road pavement structure/fill, on the hard/very dense clayey silty sand to silty sand till deposit. The footings should be founded at a minimum depth of 1.2 m below the lowest surrounding grade to provide adequate protection





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against frost penetration (per OPSD 3090.101 – *Foundation Frost Depths for Southern Ontario*). If adequate soil cover cannot be provided for the footing, rigid styrofoam insulation could be installed to compensate for the lack of soil cover and provide protection from frost penetration.

The Salem Road grade is at approximately Elevation 88 m to 88.5 m under the bridge. Footings would therefore be founded at approximately 86.8 m to 87.3 m. If concrete retaining walls are adopted, this founding level could be “stepped up” into the approach embankments.

### 6.3.2 Geotechnical Axial Resistance and Reaction

Strip or spread footings approximately 3 m wide, placed on the properly prepared, very dense clayey silty sand to silty sand till deposit, at or below the design depths/elevations given in the preceding section, should be designed based on a factored geotechnical resistances at Ultimately Limit States (ULS) of 500 kPa and a geotechnical resistance at Serviceability Limit States (SLS) of 350 kPa for 25 mm of settlement.

These preliminary geotechnical resistances should be reviewed if the selected footing width or founding elevation differs from those given above. These resistances are provided for loads applied perpendicular to the surface of the footings; where applicable, inclination of the load should be taken into account in accordance with Section 6.7.4 of the *Canadian Highway Bridge Design Code (CHBDC 2006)* and its *Commentary*.

## 6.4 Driven Steel H-Pile or Steel Pipe (Tube) Pile Foundations

### 6.4.1 Founding Elevation

For preliminary design purposes, if integral abutments are adopted for the widening, it has been assumed that the abutment pile caps would be constructed to match the existing east and west abutment pile caps, at the elevations summarized in the table below. The table below also provides pile tip levels for preliminary design of pile foundations driven to refusal on or in the shale bedrock. These recommendations assume nominal penetration into the bedrock at the widened abutment locations, based on the observed weathering and/or ability to penetrate the bedrock by augering and split-spoon sampling.

Foundation Element	Estimated Pile Cap Elevation (m)	Bedrock Surface Elevation (m)	Design Pile Tip Elevation (m)	Approximate Pile Length (m)
East Abutment	91.3	81.1 to 81.7	81.0	10
West Abutment	91.1	81.8 to 82.6	81.0	10

For the installation of steel H-piles or steel pipe piles, consideration must be given to the potential presence of cobbles and boulders within the glacially-derived soils at this site, as well as the potential for damage to the pile tips during seating on the bedrock. In this regard, steel H-piles are preferred over steel pipe piles as pipe piles are considered to pose a higher risk of experiencing refusal on boulders or being deflected away from the vertical/battered orientation during installation due to their larger end area. Piles should be reinforced at the tip with driving shoes and/or flange plates in accordance with OPSD 3000.100 (*Steel H-Pile Driving Shoe*) or OPSD 3001.100 (*Steel Tube Pile Driving Shoe*) Type II, as appropriate, to reduce the potential for damage to the piles during driving. In very dense strata containing cobbles and/or boulders, as encountered at this site, driving shoes (such as Titus Standard ‘H’ Bearing Pile Points) are preferred over flange plates.



## **6.4.2 Geotechnical Axial Resistance/Reaction**

For HP310x110 piles driven to the design tip elevations given above, the factored axial geotechnical resistance at ULS may be taken as 1,600 kN, and the axial geotechnical reaction at SLS may be taken as 1,400 kN for 25 mm of settlement. The same axial resistances may be used in the design of closed-end, concrete-filled, 324 mm (12 ¾ in.) diameter steel pipe piles having a minimum wall thickness of 9.5 mm (3/8 in.). If heavier HP360x132 piles are adopted, as recommended based on the presence of 100-blow soils below the pile cap level down to bedrock, the factored axial geotechnical resistance at ULS may be taken as 2,100 kN, and the geotechnical reaction at SLS may be taken as 1,900 kN. These preliminary geotechnical resistances/reactions will have to be re-evaluated and modified, as necessary, during detailed design in consideration of additional subsurface investigation at the foundation elements.

Pile installation should be in accordance with OPSS.PROV 903 (*Deep Foundations*). The drawings should note that the piles should be equipped with driving shoes or bearing points and driven to bedrock. For piles driven to refusal on bedrock, it is a generally accepted practice to reduce the hammer energy after abrupt peaking is met on the bedrock surface, and to then gradually increase the energy over a series of blows to seat the pile.

## **6.5 Caisson Foundations**

### **6.5.1 Founding Elevation**

Caissons founded on or socketed into the shale bedrock could be considered for support of the abutment widening, although this would not match the existing pile-supported integral abutment structure. For preliminary design purposes, it is recommended that the caissons extend a minimum of two diameters into the bedrock (below the weathered portion of the bedrock). For 1,200 mm diameter caissons, the design caisson base elevation would be approximately Elevation 78.5 m to 79 m.

If caisson foundations are adopted, a temporary liner and/or drilling slurry will be required to support the overburden soils during construction and balance groundwater pressures to minimize disturbance to the side walls and to control base disturbance/basal heave. Depending on the strength of the bedrock and the presence of strong limestone interbeds, the sockets may have to be advanced into the rock by churn drilling or rock coring. In addition, placement of concrete by tremie methods would be required.

### **6.5.2 Geotechnical Axial Resistance/Reaction**

The caissons will derive the majority of their capacity from base resistance, although some shaft friction has also been taken into account based on "socketting" approximately 1 m into the bedrock. Using the preliminary design elevations given above, and assuming that the caisson subgrade is inspected, the factored axial geotechnical resistance at ULS may be taken as 4,500 kN for a 0.9 m diameter caisson and 6,500 kN for a 1.2 m diameter caisson. The axial geotechnical reaction at SLS (for 25 mm of settlement) will be greater than the factored axial resistance at ULS and as such, the SLS condition will not apply.

The preliminary geotechnical resistances/reactions provided above will need to be re-evaluated and modified, as necessary, during detailed design in consideration of any additional subsurface investigation at the foundation elements.





## **6.6 Retained Soil System (RSS) Walls**

### **6.6.1 Founding Elevations**

Where retaining walls are required adjacent to the abutments and wingwalls at this site, RSS walls are a suitable and feasible alternative to conventional concrete retaining walls supported on shallow foundations. It is anticipated that such walls would be constructed parallel to Highway 401, with the base of the wall “stepped up” into the approach embankment as the retaining wall moves away from the abutment.

The front facing panels and the reinforced soil mass of the RSS wall should be founded below any existing topsoil or unsuitable fill soils. Typically, the front facing panels are founded at a minimum depth of 0.5 m below the ground surface in front of the wall, and supported on a granular levelling pad or narrow footing (depending on the proprietary system), in accordance with MTO's *RSS Design Guidelines*. The levelling pad should consist of a minimum thickness of 300 mm of compacted OPSS.PROV 1010 Granular A, which should extend at least 0.5 m beyond the outside edge of both sides of the facing footing, then outward/downward at 1H:1V.

### **6.6.2 Geotechnical Resistance/Reaction**

For the RSS facing panels founded on compacted granular fill as described above, preliminary design may be completed based on a factored geotechnical resistance at ULS of 150 kPa, and a geotechnical reaction at SLS (for 25 mm of settlement) of 100 kPa.

The RSS walls will be up to about 8 m in height immediately adjacent to the abutments, becoming shorter as the walls step up into the embankment. Assuming that the RSS wall acts as a unit and uses the full width of the reinforced soil mass (which should be taken as approximately 0.8 times the wall height at this stage of preliminary design), a factored geotechnical resistance at ULS of 600 kPa and a geotechnical reaction at SLS of 400 kPa may be used for preliminary design. The preliminary geotechnical resistance/reaction values should be reviewed and revised if necessary during the design-build assignment after the RSS wall configuration and “step” elevations are confirmed, taking into account any additional subsurface information at that time.

### **6.6.3 Global Stability of RSS Walls**

Preliminary slope stability analyses have been performed for conceptual RSS walls adjacent to the east and west abutments using the commercially available program *Slide 6.0*, produced by Rocscience Inc., to check that a minimum factor of safety of 1.5 is achieved for the proposed maximum retaining wall heights and geometries under static conditions. This minimum factor of safety is considered appropriate for the proposed walls on this site, considering the design requirements and the available field and laboratory testing data.

The following parameters have been used in the analyses, based on field and laboratory test data as well as accepted correlations (Bowles, 1984 and Kulhawy and Mayne, 1990):

<b>Soil Deposit</b>	<b>Bulk Unit Weight (kN/m<sup>3</sup>)</b>	<b>Effective Friction Angle</b>	<b>Undrained Shear Strength (kPa)</b>
Embankment fill	21	32°	-
Clayey silty sand to silty sand till	21	35°	-
Silty clay to clay till	21	35°	-



The results of the static global stability analysis indicate that a minimum factor of safety of 1.5 is achieved for RSS walls up to approximately 8 m in retained soil height, as shown on Figure 1. These analyses assume a minimum reinforcing length of  $0.8H$ ; where shorter walls are stepped up into the embankment, longer ratios of reinforcing strips may be required due to the presence of sloping ground in front of the wall toe. This preliminary assessment of the global stability of the retaining walls, and the minimum reinforcing strip lengths, should be reviewed and confirmed as part of the detail design.

It should be noted that the internal stability of a reinforced earth structure is to be assessed by the proprietary product designer.

#### **6.6.4 Settlement**

At this preliminary stage, it is estimated that for widened approach embankments (which will essentially be contained by retaining walls) along Highway 401, the settlement of the native soils will be less than 25 mm. This settlement is expected to be completed essentially during construction. Therefore, it is anticipated that the settlement performance for RSS walls and facing panels will be acceptable. The RSS wall design must accommodate the anticipated differential settlement between pile-supported abutments/wingwalls and the RSS panels, to prevent loss of finer soil particles from the backfill.

### **6.7 Approach Embankments**

#### **6.7.1 Subgrade Preparation and Embankment Construction**

For widening of the Highway 401 approach embankment (beyond the limits of the retaining walls), the new side slopes should be formed at a maximum gradient of 2H:1V. It is recommended that any topsoil within the footprint of the embankment widening be stripped. Benching the existing embankment side slopes should be carried out in accordance with OPSD 208.010 (*Benching of Earth Slopes*).

To reduce erosion of the embankment side slopes due to surface water runoff, placement of topsoil and seeding or pegged sod should be carried out as soon as practicable after construction of the embankments. The erosion protection should be in accordance with OPSS 804 (*Seed and Cover*).

#### **6.7.2 Slope Stability**

Preliminary static slope stability analysis have been completed for the Highway 401 approach embankments, using the commercially available program *Slide 6.0*, from Rocscience, to check that the target minimum factor of safety is achieved. A target minimum factor of safety of 1.3 is normally used in the design of slopes under static conditions. This minimum factor of safety is considered appropriate for the proposed slope widening on this project, considering the design requirements and the available field and laboratory testing data.

The preliminary global stability analyses were completed for a hypothetical 8 m high slope, although lower overall heights are anticipated based on the cut/fill geometry and the requirement for retaining walls at this site. The analyses were completed for long-term, effective stress conditions using the parameters outlined in Section 6.6.3. The results of the static global stability analysis indicate that a minimum factor of safety of 1.3 is achieved for 8 m high slopes, oriented no steeper than 2H:1V, as shown on Figure 2. This preliminary assessment of the slope stability of the approach embankments should be reviewed and confirmed during detail design.



### 6.7.3 Settlement Under Widened Embankment Loading

Preliminary settlement assessments have been completed for the Highway 401 widening using the commercially available computer program *Settle-3D 2.0* from Rocscience, using the estimated elastic deformation moduli given in the table below, based on the results from correlations with the SPT “N” values and engineering judgement from experience with similar soils in this region of Ontario (Bowles, 1984; Kulhawy and Mayne, 1990; Peck et al., 1974).

Soil Deposit	Bulk Unit Weight (kN/m <sup>3</sup> )	Elastic Modulus (MPa)
Embankment fill	21	-
Very stiff to hard/compact to very dense clayey silty sand to silty sand till	21	150 MPa
Hard silty clay to clay till	21	150 MPa

Based on this preliminary assessment, the settlement of the foundation soils under the Highway 401 embankment widening, which is anticipated to be up to about 3 m in height relative to the existing ground surface, is estimated to be less than 10 mm. This settlement will occur during construction.

The above preliminary estimate does not include compression of the fill itself, which would occur during and after the construction of the embankment depending on the type of materials used. The magnitude of fill compression may range from 0.5 to 1 per cent of the height of the embankment, assuming approximately 98 per cent compaction of the embankment fill is achieved, relative to the material's standard Proctor maximum dry density. In the case where granular fill is used for embankment construction, settlement of the fill itself is expected to occur essentially during embankment construction, whereas non-granular earth fill materials are expected to exhibit some additional settlement over time.

## 6.8 Construction Considerations

The following sections identify future construction considerations that may impact the future detail design, and for which provision may be required in the contract documents produced as part of detail design.

### 6.8.1 Open-Cut Excavation and Temporary Protection Systems

Removal of the existing retaining walls and construction of the abutment widening and associated retaining walls will require excavation through the existing Highway 401 embankment and Salem Road cut, and will be made through the existing embankment fill and native till deposit. The existing fill is most likely classified as a Type 3 soil, while the native very dense/hard till deposits are classified as Type 2 soils, according to the Occupational Health and Safety Act (OHSA). As such, temporary open-cut excavations above the groundwater level should be made with side slopes no steeper than 1H:1V. All excavations must be carried out in accordance with Ontario Regulation 213 (Ontario Occupational Health and Safety Act for Construction Projects) (as amended).

Temporary protection systems will be required along Highway 401 to facilitate the removal of the existing retaining walls and construction of the widening; protection systems will also likely be required along Salem Road, in front of the abutments. Temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection System*). The lateral movement of the protection



systems should meet Performance Level 2 as specified in OPSS.PROV 539, provided that any adjacent utilities can tolerate this magnitude of deformation.

The selection and design of the protection system will be the responsibility of the Contractor.

### **6.8.2 Groundwater Control**

Provided that the widening work involves removal only down to Salem Road grade (i.e., with a perched pile cap and grade-supported RSS walls), it is anticipated that excavation will remain above the groundwater level at the site as it has likely been modified by the Salem Road cut. However, it is recommended that additional investigation of the groundwater level be completed during detail design.

Some groundwater seepage should be anticipated from fill materials perched on top of cohesive soils, or from more permeable zones within the till deposit. However, such seepage is anticipated to be manageable using filtered sumps within the excavation.

### **6.8.3 Subgrade Protection**

The native soils that will be exposed within the excavations at the foundation subgrade level will be susceptible to disturbance from construction traffic and/or precipitation and ponded water. To limit the effects of this disturbance, it is recommended that a concrete working slab be placed on the subgrade within four hours after preparation, inspection and approval of the subgrade. The minimum thickness of the concrete working slab should be 100 mm and the concrete should have a minimum 28-day compressive strength of 20 MPa.

### **6.8.4 Obstructions**

The soils at this site are glacially derived and as such should be expected to contain cobbles and boulders, which could affect the installation of deep foundations or protection systems. Further observation is recommended in any future investigation at this site, to further assess the presence of cobbles and boulders and permit the contractor to assess the impact on foundation construction.

### **6.8.5 Vibration Monitoring During Pile or Caisson Installation**

A maximum peak particle velocity (PPV) of 100 mm/s is generally considered applicable for bridge structures in good condition; lower thresholds are applicable for nearby residential and commercial facilities (between 25 mm/s and 50 mm/s). Vibration monitoring is recommended adjacent to the abutment areas to demonstrate/confirm that vibration levels do not exceed the threshold levels for receptors adjacent to the site.

## **6.9 Recommendations for Future Work during Detail Design**

During the detail design phase, additional work is recommended to confirm or assess the following the stabilized groundwater level with the Salem Road cut in place, to confirm groundwater control requirements. The preliminary assessments of founding elevation, geotechnical resistances, global stability and settlement analyses should be revisited based on the geometry and other requirements at the detailed design stage.



## PRELIMINARY FOUNDATION REPORT SALEM ROAD OVERPASSES, W.O. 10-20011

### 7.0 CLOSURE

This Preliminary Foundation Design Report was prepared by Ms. Nikol Kochmanová, P.Eng., and was reviewed by Ms. Lisa Coyne, P.Eng., a Designated MTO Foundations Contact and Principal with Golder.

#### GOLDER ASSOCIATES LTD.



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Geotechnical Engineer



Lisa Coyne, P.Eng.  
Designated MTO Foundations Contact, Principal

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## PRELIMINARY FOUNDATION REPORT SALEM ROAD OVERPASSES, W.O. 10-20011

### REFERENCES

- Bowles, J.E., 1984. *Physical and Geotechnical Properties of Soils*, Second Edition, McGraw Hill Book Company, New York.
- Brennand, T.A. 1998. Urban Geology Note: Oshawa Ontario. In P.F. Karrow, and O. L. White (Eds.), Geological Association of Canada, Special Paper 42: Urban Geology of Canadian Cities, p. 353-364.
- Canadian Geotechnical Society, 1992. *Canadian Foundation Engineering Manual*, 3<sup>rd</sup> Edition. The Canadian Geotechnical Society, BiTech Published Ltd., British Columbia.
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- Canadian Standards Association (CSA), 2006. *Canadian Highway Bridge Design Code and Commentary on CAN/CSA S6 06*. CSA Special Publication, S6.1 06.
- Chapman, L.J., and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, 3<sup>rd</sup> Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.
- Kulhawy, F.H. and Mayne, P.W., 1990. *Manual on Estimating Soil Properties for Foundation Design*. EL 6800, Research Project 1493 6. Prepared for Electric Power Research Institute, Palo Alto, California.
- NAVFAC, 1982. *Design Manual DM 7.2: Soil Mechanics, Foundation and Earth Structures*. U.S. Navy. Alexandria, Virginia.

#### **ASTM International:**

ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

#### **Ministry of Transportation Ontario:**

Drawing SS103-11 Pile Driving Control

#### **Ontario Occupational Health and Safety Act:**

Ontario Regulation 213 Construction Projects (as amended)

#### **Ontario Provincial Standard Specifications (OPSS)**

OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS 804	Construction Specification for Seed and Cover
OPSS.PROV 903	Construction Specification for Deep Foundations
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material



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## **PRELIMINARY FOUNDATION REPORT SALEM ROAD OVERPASSES, W.O. 10-20011**

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### **Ontario Provincial Standard Drawings (OPSD)**

OPSD 208.010	Benching of Earth Slopes
OPSD 3000.100	Foundation, Piles, Steel H-Pile, Driving Shoe
OPSD 3001.100	Foundation, Piles, Steel Tube Piles, Driving Shoe
OPSD 3090.101	Foundation Frost Depths for Southern Ontario
OPSD 3121.150	Walls, Retaining, Backfill, Minimum Granular Requirement

### **Ontario Water Resources Act:**

Ontario Regulation 903	Wells (as amended)
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## PRELIMINARY FOUNDATION REPORT SALEM ROAD OVERPASSES, W.O. 10-20011

**TABLE 1 – COMPARISON OF FEASIBLE FOUNDATION ALTERNATIVES**

Foundation Option	Feasibility	Advantages	Disadvantages	Estimated Costs	Risk / Consequences
Spread/strip footings	<ul style="list-style-type: none"> <li>Geotechnically feasible for support of the new abutments</li> <li>However, not compatible with existing pile-supported abutments</li> </ul>	<ul style="list-style-type: none"> <li>Conventional excavation and construction techniques</li> <li>Very dense soils (with SPT “N” values greater than 100 blows per 0.3 m of penetration) present at shallow depth, with good geotechnical resistance and settlement performance</li> </ul>	<ul style="list-style-type: none"> <li>Deeper protection systems relative to existing highway/local road</li> <li>Up to 15 mm to 20 mm of settlement relative to pile-supported structure</li> </ul>	<ul style="list-style-type: none"> <li>Estimated cost is approximately \$600/m<sup>3</sup> for construction of shallow foundations</li> </ul>	<ul style="list-style-type: none"> <li>More significant protection systems required; risk of impacts to existing structure/RSS walls</li> </ul>
Steel H-piles or pipe piles	<ul style="list-style-type: none"> <li>Feasible for support of abutments, and compatible with existing integral abutments</li> </ul>	<ul style="list-style-type: none"> <li>Conventional construction methods</li> <li>Abutment pile caps could be maintained higher than spread footings, reducing depth of excavation and protection system requirements</li> <li>H-piles allow for integral abutments, and pipe piles for semi-integral</li> <li>Higher geotechnical resistance than for shallow foundations</li> <li>Negligible differential settlement between existing structures and widening</li> </ul>	<ul style="list-style-type: none"> <li>Protection systems still required to facilitate widening</li> </ul>	<ul style="list-style-type: none"> <li>Estimated cost is approximately \$250/m length for pile installation and \$600/m<sup>3</sup> for pile cap construction</li> </ul>	<ul style="list-style-type: none"> <li>Minor potential for pile damage / deflection if cobbles and boulders are encountered during pile driving</li> <li>Slightly greater risk in this regard for pipe piles as compared with H-piles if boulders are encountered during pile driving</li> </ul>



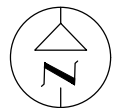


## PRELIMINARY FOUNDATION REPORT SALEM ROAD OVERPASSES, W.O. 10-20011

Foundation Option	Feasibility	Advantages	Disadvantages	Estimated Costs	Risk / Consequences
Caissons	<ul style="list-style-type: none"><li>• Feasible but not recommended for support of abutments</li></ul>	<ul style="list-style-type: none"><li>• Abutment pile caps could be maintained higher than spread footings</li><li>• Higher capacity than for driven piles, so reduced number of deep foundation elements compared to piles</li><li>• Negligible differential settlement between existing structures and widening</li></ul>	<ul style="list-style-type: none"><li>• Caissons would extend below the groundwater level at the site into water-bearing cohesionless soils, with potential for loss of ground or base disturbance</li><li>• Temporary liners would be required, plus special measures such as use of drilling mud and tremie placement of concrete; likely not possible to inspect caisson base</li><li>• Precludes use of integral abutments</li></ul>	<ul style="list-style-type: none"><li>• Most expensive option</li><li>• Estimated cost is approximately \$1,000/m length for caisson installation and \$600/m<sup>3</sup> for pile cap construction; the cost may be higher to account for temporary liners</li></ul>	<ul style="list-style-type: none"><li>• Risk of loosening or disturbing soils during construction; temporary or permanent liners required</li></ul>

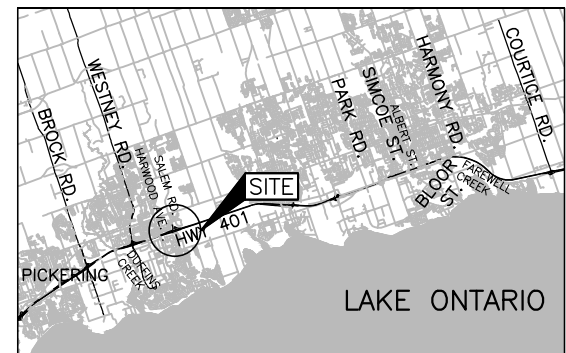
**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
GWP No. 10-2011



SALEM ROAD OVERPASS  
HIGHWAY 401 IMPROVEMENTS  
BOREHOLE LOCATIONS

SHEET



KEY PLAN  
SCALE  
4 0 4 8 km

LEGEND

Borehole - Previous Investigation 1 (Golder, 2000)

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
G-13	98.3	4857485.4	343981.8
RW-1	98.2	4857291.9	343908.5
RW-2	95.0	4857307.4	343956.7
RW-3	94.9	4857322.4	344005.2
RW-4	94.7	4857337.4	344052.3
RW-5	94.6	4857349.4	344091.2
RW-6	95.6	4857364.4	344138.7
RW-7	95.8	4857379.9	344186.2
RW-8	95.5	4857394.8	344234.2
RW-9	95.9	4857409.8	344281.6
ST-1	97.0	4857381.9	344023.0
ST-2	96.7	4857393.9	344060.7
ST-3	97.2	4857399.4	344012.2
ST-4	97.4	4857410.6	344049.4
ST-5	97.8	4857416.5	344001.2
ST-6	97.5	4857428.4	344038.2

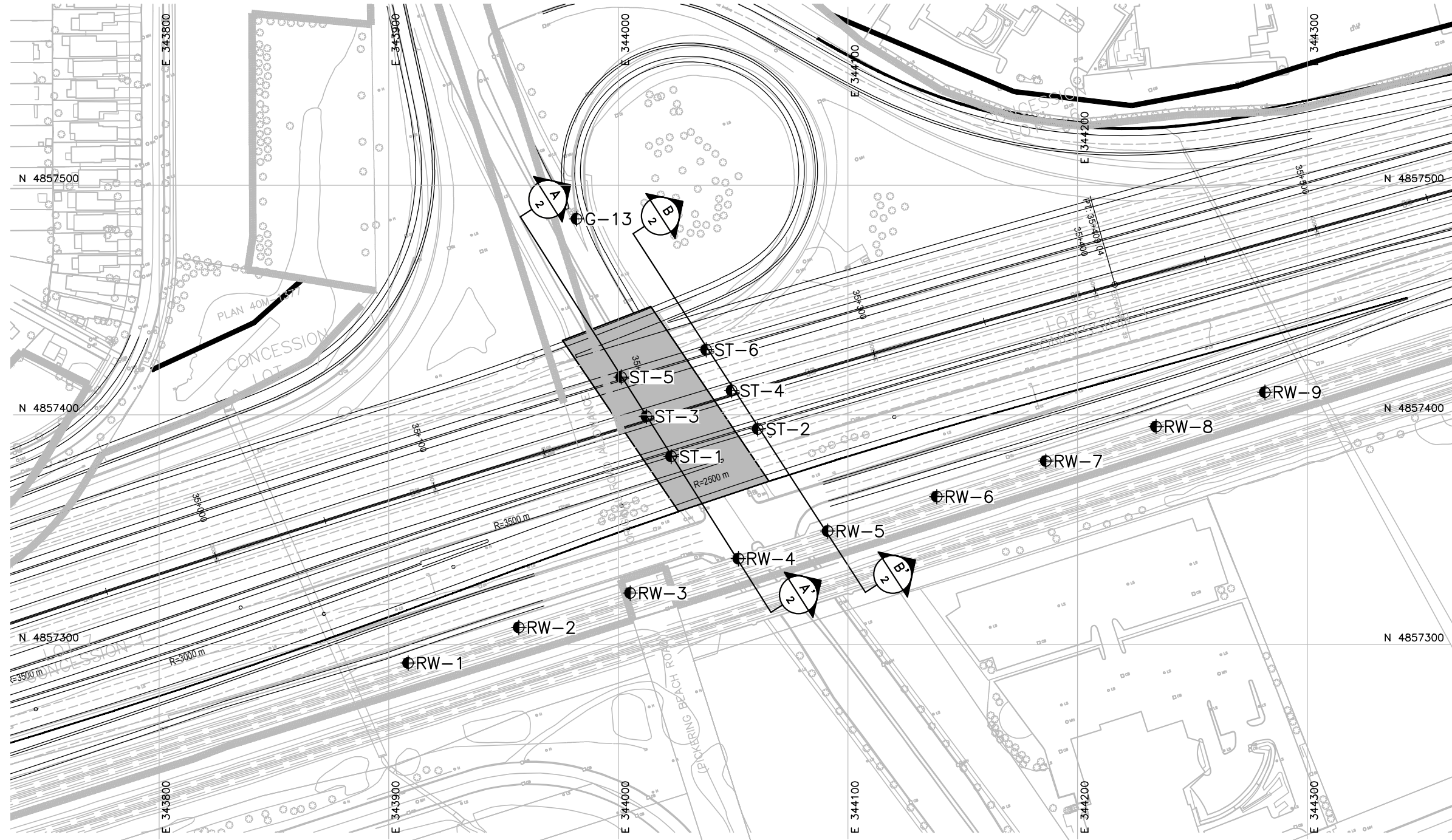
NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Preliminary Design Report.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

Base plans provided in digital format by URS, drawing file nos. X-Base.dwg, X-Property.dwg and Street Names.dwg, and the Proposed Design obtained from drawing file x-design\_130625.dwg, all dated July 05, 2013, received April 11, 2014.

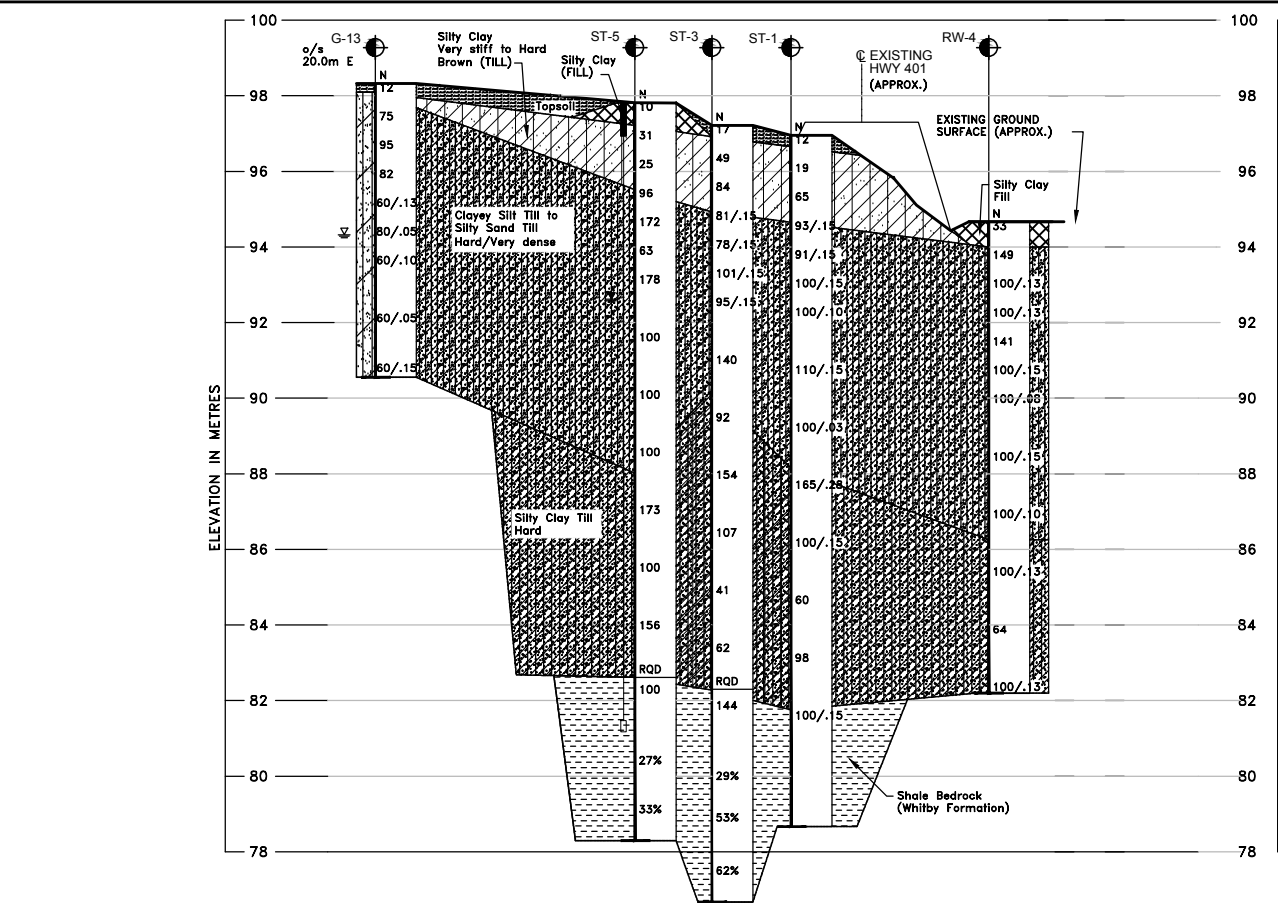


PLAN

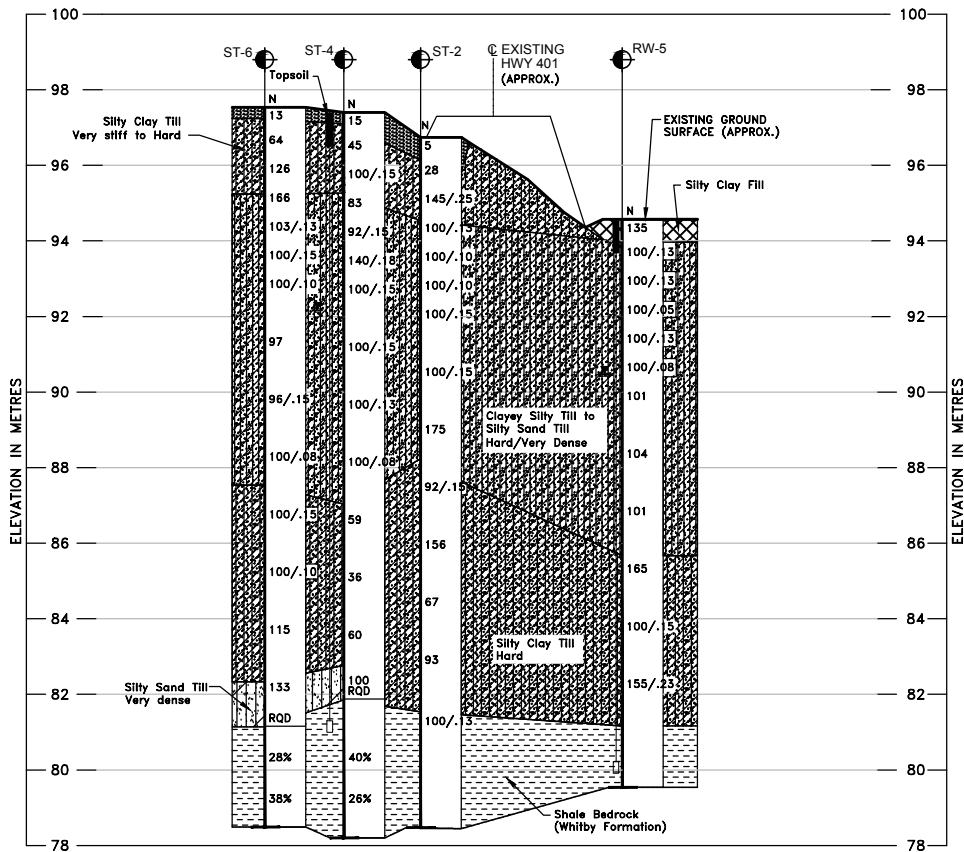
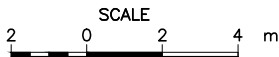
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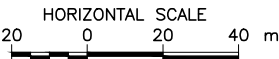
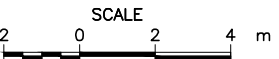
NO.	DATE	BY	REVISION
Geocres No. 30M14-450			
HWY. 401	PROJECT NO. 11-1184-0143		DIST. CENTRAL
SUBM'D. NK	CHKD. NK	DATE: 4/5/2017	SITE: 22-547
DRAWN: JFC/DD	CHKD. NK	APPD. LCC	DWG. 1



WEST ABUTMENT SECTION A-A'



EAST ABUTMENT SECTION B-B'

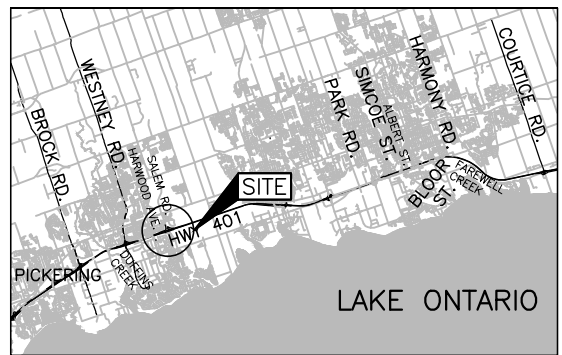


**METRIC**  
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STATIONS IN KILOMETRES + METRES.

CONT No. 10-2011  
GWP No. 10-2011

SALEM ROAD OVERPASS  
HIGHWAY 401 IMPROVEMENTS  
SOIL STRATA

SHEET



KEY PLAN

SCALE  
4 0 4 8 km

LEGEND

- Borehole - Previous Investigation 1 (Golder, 2000)
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
G-13	98.3	4857485.4	343981.8
RW-4	94.7	4857337.4	344052.3
RW-5	94.6	4857349.4	344091.2
ST-1	97.0	4857381.9	344023.0
ST-2	96.7	4857393.9	344060.7
ST-3	97.2	4857399.4	344012.2
ST-4	97.4	4857410.6	344049.4
ST-5	97.8	4857416.5	344001.2
ST-6	97.5	4857428.4	344038.2

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REFERENCE

Base plans provided in digital format by URS, drawing file nos. X-Base.dwg, X-Property.dwg and Street Names.dwg, and the Proposed Design obtained from drawing file x-design\_130625.dwg, all dated July 05, 2013, received April 11, 2014.

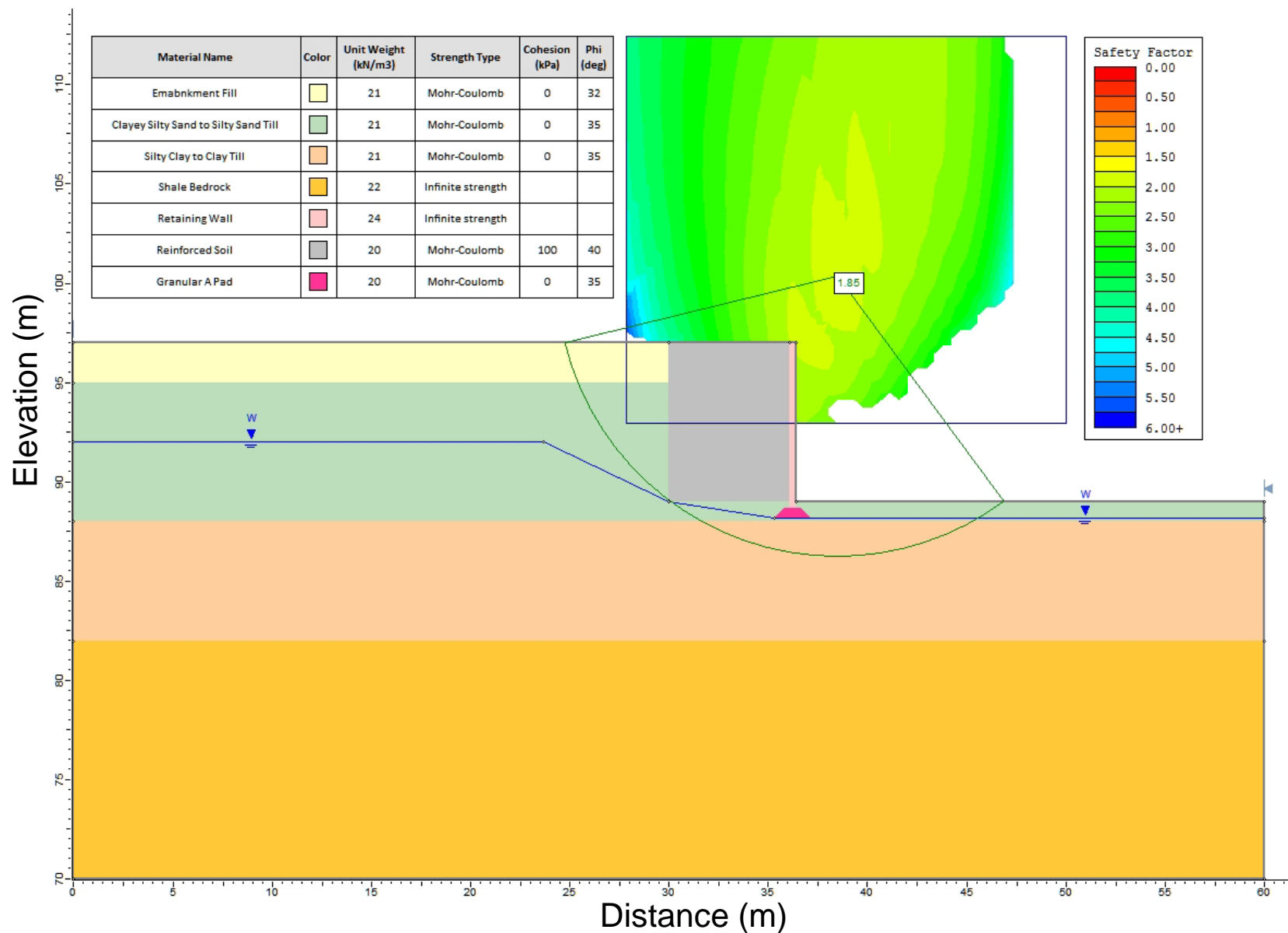


NO.	DATE	BY	REVISION
Geocres No. 30M14-450			
HWY. 401	PROJECT NO. 11-1184-0143		DIST. CENTRAL
SUBM'D. NK	CHKD. NK	DATE: 4/5/2017	SITE: 22-547
DRAWN: JFC	CHKD. NK	APPD. LCC	DWG. 2



## STATIC GLOBAL STABILITY SALEM ROAD OVERPASS – RETAINED SOIL SYSTEM WALLS

Figure 1

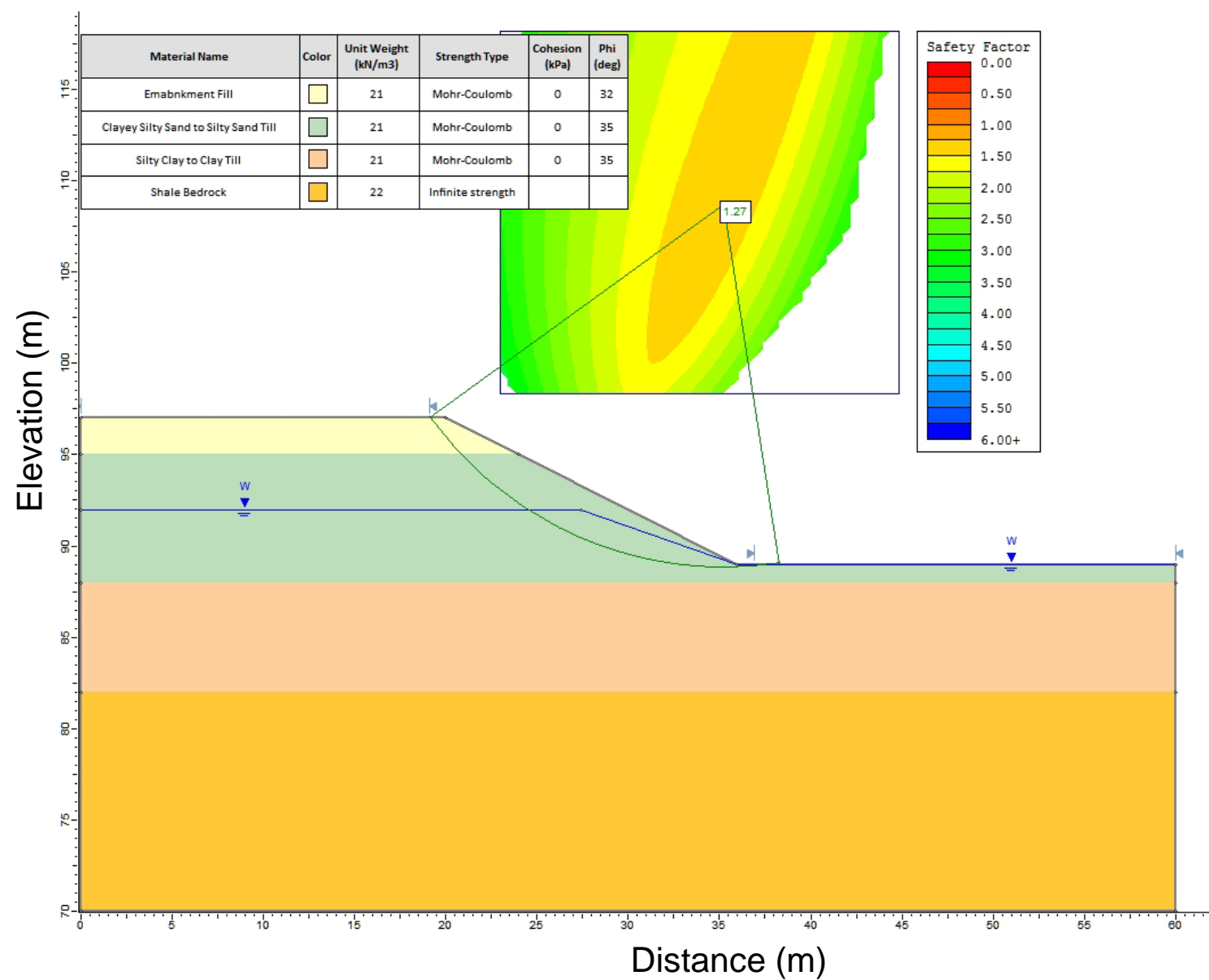






STATIC GLOBAL STABILITY  
SALEM ROAD OVERPASS – APPROACH EMBANKMENT

Figure 2





# **APPENDIX A**

## **Borehole Records – 1999 Investigation**

PROJECT <u>991-1158</u>			<b>RECORD OF BOREHOLE No RW-1</b>			1 OF 1			<b>METRIC</b>						
W.P. <u>242-86-00</u>			LOCATION <u>N 4857069.50; E 343880.00</u>			ORIGINATED BY <u>SB</u>									
DIST <u>6</u> HWY <u>401</u>			BOREHOLE TYPE <u>CME 55 Bombardier</u>			COMPILED BY <u>AMP</u>									
DATUM <u>Geodetic</u>			DATE <u>15.9.99 - 15.9.99</u>			CHECKED BY <u>AMP</u>									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60					
98.18 0.00	Clayey Silt, some sand, trace gravel and organics Firm (Fill)		1	50 DO	7	▽	98								8 44 38 10
			2	50 DO	13		97								
			3	50 DO	12		96								
96.05 2.13	Clayey Silty Sand, some gravel, occ. cobbles Compact to very dense Grey and brown (Till)		4	50 DO	26		95								
			5	50 DO	38		94								
			6	50 DO	38		93								
			7	50 DO	56		92								
91.47 6.71	-Silty Clay with sand, trace gravel between 3.7m and 4.5m depth.		8	50 DO	64										
	END OF BOREHOLE														
	Note: Water level in open borehole at Elev.94.3m upon completion of drilling.														

ON\_MOT\_991-1158.GPJ ON\_MOT.GDT 30/12/99

PROJECT 991-1158				RECORD OF BOREHOLE No RW-2				1 OF 1		METRIC						
W.P. 242-86-00				LOCATION N 4857085.00; E 343927.50				ORIGINATED BY SB								
DIST 6 HWY 401				BOREHOLE TYPE CME 55 Bombardier				COMPILED BY AMP								
DATUM Geodetic				DATE 15.9.99 - 15.9.99				CHECKED BY AMP								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED								
95.00																
0.00	Silty Clay, some sand and gravel, trace organics and brick fragments		1	50 DO	11											
94.39	Brown (Fill)															
0.61	Clayey Silty Sand with gravel, occ. cobble		2	50 DO	30											
	Compact to very dense															
	Brown to 2.8m depth then becoming grey (Till)		3	50 DO	24											
			4	50 DO	30											
			5	50 DO	19											
			6	50 DO	28											
			7	50 DO	47											
			8	50 DO	47											
			9	50 DO	60											
86.77																
8.23	END OF BOREHOLE															
	Note: Open hole dry on completion of drilling.															

ON\_MOT\_991-1158.GPJ ON\_MOT.GDT 30/12/99



PROJECT 991-1158				RECORD OF BOREHOLE No RW-3				1 OF 1				METRIC				
W.P. 242-86-00				LOCATION N 4857100.00; E 343976.00				ORIGINATED BY SB								
DIST 6 HWY 401				BOREHOLE TYPE CME 55 Bombardier				COMPILED BY AMP								
DATUM Geodetic				DATE 15.9.99 - 15.9.99				CHECKED BY AMP								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED								
94.90																
0.00	Silty Clay, some sand, trace gravel Very stiff Brown (Fill)		1	50 DO	18											
94.22																
0.67	Clayey Silty Sand to Silty Sand, some gravel Compact to very dense Brown to 2m depth, then becoming grey (Till)		2	50 DO	43											
			3	50 DO	29											
			4	50 DO	52											
			5	50 DO	63											
			6	50 DO	100/15											
			7	50 DO	100/15											
			8	50 DO	80/15											
			9	50 DO	142											
86.40																
8.50	Silty Clay, some sand and gravel, occ. cobbles Hard Grey (Till)		10	50 DO	100/13											
			11	50 DO	100/10											
			12	50 DO	100/13											
82.40																
12.50	END OF BOREHOLE															
	Note: Water level in piezometer at Elev.89.1m on Oct.19, 1999.															

ON MOT 991-1158 GPJ ON MOT GDT 30/12/99

RECORD OF BOREHOLE No RW-4										1 OF 1		METRIC			
PROJECT 991-1158			LOCATION N 4857115.00; E 344023.00			ORIGINATED BY SB									
W.P. 242-86-00			BOREHOLE TYPE CME 55 Bombardier			COMPILED BY AMP									
DIST 6 HWY 401			DATE 16.9.99 - 16.9.99			CHECKED BY AMP									
DATUM Geodetic															
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED		WATER CONTENT (%) W <sub>p</sub> — W — W <sub>L</sub>		γ	GR SA SI CL		
94.66								20 40 60 80 100							
0.00	Silty Clay, some sand, trace gravel Hard Brown (Fill)		1	50 DO	33		94								
93.96															
0.70	Clayey Silty Sand with gravel Very dense Grey (Till)		2	50 DO	149		93								
			3	50 DO	100/13										
			4	50 DO	100/13		92								
			5	50 DO	141										
			6	50 DO	100/15		91								
			7	50 DO	100/08		90								
							89								
			8	50 DO	100/15		88								
			9	50 DO	100/10		87								
86.26															
8.40	Silty Clay to Clay, some sand, trace gravel Hard Grey (Till)		10	50 DO	100/13		86								
							85								
			11	50 DO	64		84								
							83								
82.19			12	50 DO	100/13										
12.47	END OF BOREHOLE  Note: Open borehole dry on completion of drilling.														

ON MOT 991-1158.GPJ ON MOT GDT 30/12/99

PROJECT 991-1158				RECORD OF BOREHOLE No RW-5				1 OF 2		METRIC					
W.P. 242-86-00				LOCATION N 4857127.00; E 344062.00				ORIGINATED BY SB							
DIST 6 HWY 401				BOREHOLE TYPE CME 55 Bombardier				COMPILED BY AMP							
DATUM Geodetic				DATE 16.9.99 - 16.9.99				CHECKED BY AMP							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED			20 40 60 W <sub>P</sub> — W — W <sub>L</sub>			kN/m <sup>3</sup>	GR SA SI CL
94.57															
0.00	Silty Clay, some sand, trace gravel Hard Brown (Fill)		1	50 DO	135										
93.97															
0.60	Clayey Silty Sand, some gravel Very dense Grey (Till)		2	50 DO	100/13										
			3	50 DO	100/13										
			4	50 DO	100/05										
91.87															
2.70	Silty Clay with sand, some gravel Hard Grey (Till)		5	50 DO	100/13										
91.07															
3.50	Clayey Silty Sand, some gravel Very dense Grey (Till)		6	50 DO	100/05										
			7	50 DO	101										
			8	50 DO	104										
			9	50 DO	101										
85.77															
8.80	Silty Clay, some sand, trace gravel Hard Grey (Till)		10	50 DO	165										
			11	50 DO	100/15										
			12	50 DO	155/23										
81.17															
13.40	Weathered, dark grey Shale Bedrock. (Whitby Formation)														

ON MOT 991-1158.GPJ ON MOT.GDT 30/12/99

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No RW-5										2 OF 2		METRIC				
PROJECT 991-1158			LOCATION N 4857127.00; E 344062.00			ORIGINATED BY SB										
W.P. 242-86-00			BOREHOLE TYPE CME 55 Bombardier			COMPILED BY AMP										
DIST 6 HWY 401			DATE 16.9.99 - 16.9.99			CHECKED BY AMP										
DATUM Geodetic																
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X REMOULDED			W <sub>p</sub>	W	W <sub>L</sub>	γ	GR SA SI CL	
79.33																
15.24	END OF BOREHOLE  Note: Water level in piezometer at Elev.90.5m on Oct.19, 1999.						79									

ON\_MOT\_991-1158.GPJ ON\_MOT.GDT 30/12/99

PROJECT 991-1158			RECORD OF BOREHOLE No RW-6			1 OF 1			METRIC			
W.P. 242-86-00			LOCATION N 4857142.00; E 344109.50			ORIGINATED BY SB						
DIST 6 HWY 401			BOREHOLE TYPE CME 55 Bombardier			COMPILED BY AMP						
DATUM Geodetic			DATE 17.9.99 - 17.9.99			CHECKED BY AMP						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
95.64 0.00	Sand and Gravel Brown Compact (Fill)		1	50 DO	15		95					0 3 41 56
95.04 0.60	Clayey Silty Sand, some gravel Dense to very dense Brown to grey (Till)		2	50 DO	44		94					
			3	50 DO	100/15		93					
			4	50 DO	100/13		92					
			5	50 DO	100/15		91					
			6	50 DO	100/08		90					
			7	50 DO	100/10		89					
			8	50 DO	95		88					
			9	50 DO	129		87					
			10	50 DO	120		86					
			11	50 DO	49		85					
88.44 7.20	Silty Clay, trace to some sand, trace gravel Hard Grey (Till)			12	50 DO	68		84				
82.84 12.80	END OF BOREHOLE						83					
Note: Open hole dry on completion of drilling.												

ON MOT 991-1158.GPJ ON MOT.GDT 30/12/99

PROJECT 991-1158				RECORD OF BOREHOLE No RW-7				1 OF 1		METRIC			
W.P. 242-86-00				LOCATION N 4857157.50; E 344157.00				ORIGINATED BY SB					
DIST 6 HWY 401				BOREHOLE TYPE CME 55 Bombardier				COMPILED BY AMP					
DATUM Geodetic				DATE 17.9.99 - 17.9.99				CHECKED BY AMP					
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
95.78							20 40 60 80 100						
0.00	Topsoil		1	50 DO	5								
0.15	Silty Clay, trace sand and gravel												
95.18													
0.60	Clayey Silty Sand to Silty Sand, trace clay, trace to some gravel Dense to very dense Grey (Till)		2	50 DO	42								
			3	50 DO	58								
			4	50 DO	125								
			5	50 DO	90/15								5 55 34 6
			6	50 DO	90/15								
			7	50 DO	100/15								
89.58													
6.20	Silty Clay, trace to some sand, trace gravel Hard Grey (Till)		*8										
			9	50 DO	90/15								
87.28													
8.50	Clayey Silty Sand to Silty Sand, trace clay, trace to some gravel Dense to very dense Grey (Till)		10	50 DO	100/15								
84.96			11	50 DO	92/15								
10.82	END OF BOREHOLE												
Note: Open hole dry on completion of drilling. Water level in piezometer at Elev.93.8m on Oct.19, 1999. * no recovery spoon bouncing													

ON\_MOT 991-1158.GPJ ON\_MOT.GDT 5/1/00

PROJECT 991-1158				RECORD OF BOREHOLE No RW-8				1 OF 1		METRIC						
W.P. 242-86-00				LOCATION N 4857172.50; E 344205.00				ORIGINATED BY SB								
DIST 6 HWY 401				BOREHOLE TYPE CME 55 Bombardier				COMPILED BY AMP								
DATUM Geodetic				DATE 17.9.99 - 17.9.99				CHECKED BY AMP								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED								WATER CONTENT (%)
95.47								20	40	60	80	100				
0.00	Topsoil		1	50 DO	8		95									
0.15	Silty Clay, trace sand and gravel, trace organics Firm to hard Brown and grey (Fill)		2	50 DO	9											
			3	50 DO	35		94									
93.27																
2.20	Clayey Silty Sand, trace clay, trace gravel Very dense Grey (Till)		4	50 DO	100/08		93									
92.47																
3.00	Silty Clay, trace sand and gravel, frequent silt partings Hard Grey (Till)		5	50 DO	42		92									
			6	50 DO	63		91									
			7	50 DO	61											
							90									
			8	50 DO	95		89									
							88									
			9	50 DO	105		87									
85.86			10	50 DO	91		86									
9.60	END OF BOREHOLE  Note: Open hole dry on completion of drilling.															

ON\_MOT\_991-1158.GPJ ON\_MOT.GDT 30/12/99

PROJECT 991-1158				RECORD OF BOREHOLE No RW-9				1 OF 1		METRIC							
W.P. 242-86-00				LOCATION N 4857187.50; E 344252.50				ORIGINATED BY SB									
DIST 6 HWY 401				BOREHOLE TYPE CME 55 Bombardier				COMPILED BY AMP									
DATUM Geodetic				DATE 19.9.99 - 19.9.99				CHECKED BY AMP									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
95.92 0.00	Topsoil	1	50 DO	6													
95.46 0.46	Silty Clay, some sand, trace gravel, trace organics Very stiff Brown (Fill)	2	50 DO	24													
93.82 2.10	Clayey Silty Sand, some gravel, occ. shale fragments at depth, occ. silty sand seams Dense to very dense Grey (Till)	3	50 DO	41													
		4	50 DO	127													
		5	50 DO	178/18													
		6	50 DO	106													
91.42 4.50	Silty Clay, some sand, trace gravel, occ. shale fragments at depth, occ. silty sand seam Hard Grey (Till)	7	50 DO	46													
		8	50 DO	45													
		9	50 DO	49													
87.69 8.23	END OF BOREHOLE  Note: Open hole dry on completion of drilling.																

ON\_MOT\_991-1158.GPJ ON\_MOT\_GDT\_30/12/99



# RECORD OF BOREHOLE No ST-1

1 OF 2

METRIC

PROJECT 991-1158

W.P. 242-86-00

LOCATION N 4857159.50; E 343995.50

ORIGINATED BY SB

DIST 6 HWY 401

BOREHOLE TYPE CME 55 Bombardier

COMPILED BY AMP

DATUM Geodetic

DATE 27.9.99 - 27.9.99

CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40					
96.95	Topsoil		1	50 DO	12									
96.65	Silty Clay, some sand, trace gravel Stiff to hard Brown (Till)		2	50 DO	19									
			3	50 DO	65									
94.65	Clayey Silty Sand to Silty Sand, trace clay, trace to some gravel, cobbles encountered at depth Very dense Grey (Till)		4	50 DO	93/15									
			5	50 DO	91/15									
			6	50 DO	100/15									
			7	50 DO	100/10									
			8	50 DO	110/15									
			9	50 DO	100/03									
88.15	Silty Clay, trace sand and gravel, frequent silt partings below 11.6m depth Hard Grey (Till)		10	50 DO	165/28									
			11	50 DO	100/15									
			12	50 DO	60									
			13	50 DO	98									

ON\_MOT\_991-1158.GPJ ON\_MOT.GDT 30/12/99

Continued Next Page

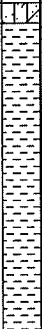
+ 3, X 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

PROJECT <u>991-1158</u>										RECORD OF BOREHOLE No <u>ST-1</u>										2 OF 2										METRIC									
W.P. <u>242-86-00</u>										LOCATION <u>N 4857159.50; E 343995.50</u>										ORIGINATED BY <u>SB</u>																			
DIST <u>6</u> HWY <u>401</u>										BOREHOLE TYPE <u>CME 55 Bombardier</u>										COMPILED BY <u>AMP</u>																			
DATUM <u>Geodetic</u>										DATE <u>27.9.99 - 27.9.99</u>										CHECKED BY <u>AMP</u>																			
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			LIQUID LIMIT	UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL																					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x REMOULDED					W <sub>p</sub>	W	W <sub>L</sub>				WATER CONTENT (%)																				
81.75 15.20	Weathered, dark grey Shale. (Whitby Formation)		14	50 DO	100/15																																		
78.66 18.29	END OF BOREHOLE																																						
	Note: Open hole dry on completion of drilling.																																						


ON\_MOT\_991-1158.GPJ ON\_MOT\_GDT\_30/12/99

ON MOT 991-1158.GPJ ON MOT.GDT 30/12/99

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

<div style="display: flex; justify-content: space-between;"> <span>PROJECT <u>991-1158</u></span> <span><b>RECORD OF BOREHOLE No ST-2</b></span> <span>2 OF 2</span> <span><b>METRIC</b></span> </div>																		
W.P. <u>242-86-00</u>			LOCATION <u>N 4857171.50; E 344032.50</u>			ORIGINATED BY <u>SB</u>												
DIST <u>6</u> HWY <u>401</u>			BOREHOLE TYPE <u>CME 55 Bombardier</u>			COMPILED BY <u>AMP</u>												
DATUM <u>Geodetic</u>			DATE <u>27.9.99 - 27.9.99</u>			CHECKED BY <u>AMP</u>												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W <sub>p</sub> — W — W <sub>L</sub> WATER CONTENT (%)			γ	GR SA SI CL	
								20	40	60	80	100	20	40	60	kN/m <sup>3</sup>		
81.54	Weathered, dark grey Shale. (Whitby Formation)		14	50 DO	100/13		81											
15.20																		
78.45	END OF BOREHOLE																	
18.29	Note: Open hole dry on completion of drilling.																	


ON\_MOT 991-1158.GPJ ON\_MOT.GDT 30/12/99

PROJECT 991-1158			RECORD OF BOREHOLE No ST-3			1 OF 2		METRIC							
W.P. 242-86-00			LOCATION N 4857177.00; E 343984.00			ORIGINATED BY SB									
DIST 6 HWY 401			BOREHOLE TYPE CME 55 Bombardier			COMPILED BY AMP									
DATUM Geodetic			DATE 23.9.99 - 23.9.99			CHECKED BY AMP									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED							
97.22 0.00 96.92	Topsoil		1	50 DO	17										
0.30	Silty Clay, some sand, trace gravel, occasional cobbles Hard Brown (Till)		2	50 DO	49										
			3	50 DO	84										
94.93			4	50 DO	81/15										
2.29	Clayey Silty Sand, trace gravel, occ. clayey silt seams Very dense Grey (Till)		5	50 DO	78/15										
			6	50 DO	101/15										
			7	50 DO	95/15										
			8	50 DO	140										
90.21 7.01	Silty Clay, trace sand and gravel, frequent silt partings below 11.6m depth Hard Grey (Till)		9	50 DO	92										
			10	50 DO	154										
			11	50 DO	107										
			12	50 DO	41										
			13	50 DO	62										
82.28															

ON MOT 991-1158.GPJ ON MOT.GDT 30/12/99

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

<div style="display: flex; justify-content: space-between;"> <span>PROJECT <u>991-1158</u></span> <span><b>RECORD OF BOREHOLE No ST-3</b></span> <span>2 OF 2</span> <span><b>METRIC</b></span> </div>															
W.P. <u>242-86-00</u>			LOCATION <u>N 4857177.00; E 343984.00</u>			ORIGINATED BY <u>SB</u>									
DIST <u>6</u> HWY <u>401</u>			BOREHOLE TYPE <u>CME 55 Bombardier</u>			COMPILED BY <u>AMP</u>									
DATUM <u>Geodetic</u>			DATE <u>23.9.99 - 23.9.99</u>			CHECKED BY <u>AMP</u>									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60					
14.94	Weathered, dark grey Shale Bedrock. (Whitby Formation)(continued)		14	50 DO	144										
76.67 20.55	Bedrock cored between 16.76m and 20.55m depth. For bedrock coring details refer to Record of Drillhole ST-3.														
	END OF BOREHOLE  Note: Open hole dry during drilling through the soils.														

ON\_MOT\_991-1158.GPJ ON\_MOT.GDT 30/12/99

PROJECT: 991-1158

## RECORD OF DRILLHOLE: ST-3

SHEET 1 OF 1

LOCATION: N 4857177.00; E 343984.00

DRILLING DATE: 23/9/99

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Bombardier

DRILLING CONTRACTOR: Master Soils Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH	COLOUR % RETURN	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN	F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED	SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR	FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED	BC-BROKEN CORE MB-MECH. BREAK B-BEDDING	HYDRAULIC CONDUCTIVITY k, cm/sec	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
15				82.22 15.00												
16		For soil description refer to Record of Borehole ST-3														
17		Shale, dark grey, highly fractured and weathered to about 18m depth, becoming moderately weathered to fresh, fine grained, thinly bedded, occ. thin limestone layers. (Whitby Formation)		80.46 16.76												
18					1	0.2	100									
19					2	0.1	100									
20					3	0.1	100									
21		END OF HOLE		76.67 20.59												
22																
23																
24																
25																

DEPTH SCALE

1:50



LOGGED: SB

CHECKED: AMP

DRILLHOLE 1158 ROCK GPJ GLDR CAN GDT 22/11/99 PS

# RECORD OF BOREHOLE No ST-4

1 OF 2

METRIC

PROJECT 991-1158

W.P. 242-86-00

LOCATION N 4857188.20; E 344021.00

ORIGINATED BY SB

DIST 6 HWY 401

BOREHOLE TYPE CME 55 Bombardier

COMPILED BY AMP

DATUM Geodetic

DATE 22.9.99 - 22.9.99

CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80	100	20	40
97.40																			
0.00	Topsoil		1	50 DO	15														
0.30	Silty Clay, some sand, trace gravel, occ. cobble Very stiff to hard Brown (Till)		2	50 DO	45														
			3	50 DO	100/15														
95.27																			
2.13	Clayey Silty Sand, trace to some gravel, occ. clayey silt seams Very dense Grey (Till)		4	50 DO	83														
			5	50 DO	92/15														
			6	50 DO	140/23														
			7	50 DO	100/15														
			8	50 DO	100/15														
			9	50 DO	100/15														
			10	50 DO	100/05														
87.04																			
10.36	Silty Clay, trace sand and gravel, frequent silt partings Hard Grey (Till)		11	50 DO	59														
			12	50 DO	36														
			13	50 DO	60														
82.77																			
14.63																			

Continued Next Page

+ 3, X 3: Numbers refer to  
Sensitivity

○ 3% STRAIN AT FAILURE

ON MOT 991-1158.GPJ ON MOT.GDT 30/12/99



PROJECT <u>991-1158</u>										RECORD OF BOREHOLE No <u>ST-4</u>										2 OF 2										METRIC									
W.P. <u>242-86-00</u>										LOCATION <u>N 4857188.20; E 344021.00</u>										ORIGINATED BY <u>SB</u>																			
DIST <u>6</u> HWY <u>401</u>										BOREHOLE TYPE <u>CME 55 Bombardier</u>										COMPILED BY <u>AMP</u>																			
DATUM <u>Geodetic</u>										DATE <u>22.9.99 - 22.9.99</u>										CHECKED BY <u>AMP</u>																			
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			LIQUID LIMIT	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL																					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X REMOULDED					WATER CONTENT (%) w <sub>p</sub> — w — w <sub>L</sub>																										
81.86 15.54	Silty Sand, trace clay, trace gravel, occ. shale fragments Very dense Grey (Till)(continued) Weathered, dark grey Shale Bedrock. (Whitby Formation)		14	50 DO	100		82																																
78.20 19.20	Bedrock cored between 16.61m and 19.20m depth. For bedrock coring details refer to Record of Drillhole ST-4. END OF BOREHOLE  Note: Water level in piezometer at Elev.92.9m on Oct.19,1999.						81																																
							80																																
							79																																

ON MOT 991-1158.GPJ ON MOT.GDT 30/12/99

PROJECT: 991-1158

## RECORD OF DRILLHOLE: ST-4

SHEET 1 OF 1

LOCATION: N 4857188.20; E 344021.00

DRILLING DATE: 23/9/99

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55 Bombardier

DRILLING CONTRACTOR: Master Soils Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN	F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED	SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR	FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED	BC-BROKEN CORE MB-MECH. BREAK B-BEDDING	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
15				82.40 15.00										
16		Borehole continued For soil description refer to Record of Borehole ST-4												
17		Shale, dark grey, moderately weathered, fine grained, thinly bedded, occ. thin limestone layers. (Whitby Formation)		80.79 16.61	1	100								PL BC M P,S
18					2	100								PL S,UE PL M PL M PL M UE M PL UE
19		END OF HOLE		78.20 19.20										
20														
21														
22														
23														
24														
25														

DEPTH SCALE

1 : 50



LOGGED: SB

CHECKED: AMP

DRILLHOLE 1158ROCK.GPJ GLDR.CAN.GDT 22/11/99 PS

# RECORD OF BOREHOLE No ST-5

1 OF 2

METRIC

PROJECT 991-1158  
W.P. 242-86-00  
DIST 6 HWY 401  
DATUM Geodetic

LOCATION N 4857194.10; E 343973.00  
BOREHOLE TYPE CME 55 Bombardier  
DATE 20.9.99 - 20.9.99

ORIGINATED BY SB  
COMPILED BY AMP  
CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
97.81	Topsoil		1	50 DO	10										
0.00 8.10 97.21	Silty Clay, some sand, some gravel, trace organics. (FILL)														
0.60	Silty Clay, some sand, trace gravel, occ. cobble Very stiff to hard Brown and grey (Till)		2	50 DO	31		97								
			3	50 DO	25		96								
95.51			4	50 DO	96		95								
2.30	Clayey Silty Sand to Silty Sand, trace clay, trace to some gravel, occ. sandy silt and clayey silt seams, cobbles encountered with depth Very dense Grey (Till)		5	50 DO	172		94								
			6	50 DO	63		93								
			7	50 DO	178		92								
			8	50 DO	100		91								
			9	50 DO	100		90								
			10	50 DO	100		89								
88.01			11	50 DO	173		88								
9.80	Silty Clay, trace sand, trace gravel, frequent silt partings Hard Grey (Till)		12	50 DO	100/15		87								
			13	50 DO	156		86								
							85								
							84								
							83								

ON\_MOT\_991-1158.GPJ ON\_MOT\_GDT 30/12/99

Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON MOT 991-1158.GPJ ON MOT.GDT 30/12/99

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT: 991-1158

## RECORD OF DRILLHOLE: ST-5

SHEET 1 OF 1

LOCATION: N 4857194.10; E 343973.00

DRILLING DATE: 20/9/99

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Bombardier

DRILLING CONTRACTOR: Master Soils Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.																ELEV. (m)	RUN No.	PENETRATION RATE (mm/min)	COLOUR (mm)	FLUSH % RETURN	FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE												DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION																																												
				CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK																																																																														
				SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING																																																																														
				VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED																																																																														
RECOVERY																DISCONTINUITY DATA																HYDRAULIC CONDUCTIVITY k, cm/sec																																																		
TOTAL CORE %																R.Q.D. %																FRACT. INDEX PER 0.3																DIP w.r.t. CORE AXIS																TYPE AND SURFACE DESCRIPTION																		
20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100																20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100																5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100																0 30 60 90 120 150 180 210 240 270 300 330 360 390 420 450 480 510 540 570 600 630 660 690 720 750 780 810 840 870 900 930 960 990 1020 1050 1080 1110 1140 1170 1200 1230 1260 1290 1320 1350 1380 1410 1440 1470 1500 1530 1560 1590 1620 1650 1680 1710 1740 1770 1800 1830 1860 1890 1920 1950 1980 2010 2040 2070 2100 2130 2160 2190 2220 2250 2280 2310 2340 2370 2400 2430 2460 2490 2520 2550 2580 2610 2640 2670 2700 2730 2760 2790 2820 2850 2880 2910 2940 2970 3000 3030 3060 3090 3120 3150 3180 3210 3240 3270 3300 3330 3360 3390 3420 3450 3480 3510 3540 3570 3600 3630 3660 3690 3720 3750 3780 3810 3840 3870 3900 3930 3960 3990 4020 4050 4080 4110 4140 4170 4200 4230 4260 4290 4320 4350 4380 4410 4440 4470 4500 4530 4560 4590 4620 4650 4680 4710 4740 4770 4800 4830 4860 4890 4920 4950 4980 5010 5040 5070 5100 5130 5160 5190 5220 5250 5280 5310 5340 5370 5400 5430 5460 5490 5520 5550 5580 5610 5640 5670 5700 5730 5760 5790 5820 5850 5880 5910 5940 5970 6000 6030 6060 6090 6120 6150 6180 6210 6240 6270 6300 6330 6360 6390 6420 6450 6480 6510 6540 6570 6600 6630 6660 6690 6720 6750 6780 6810 6840 6870 6900 6930 6960 6990 7020 7050 7080 7110 7140 7170 7200 7230 7260 7290 7320 7350 7380 7410 7440 7470 7500 7530 7560 7590 7620 7650 7680 7710 7740 7770 7800 7830 7860 7890 7920 7950 7980 8010 8040 8070 8100 8130 8160 8190 8220 8250 8280 8310 8340 8370 8400 8430 8460 8490 8520 8550 8580 8610 8640 8670 8700 8730 8760 8790 8820 8850 8880 8910 8940 8970 9000 9030 9060 9090 9120 9150 9180 9210 9240 9270 9300 9330 9360 9390 9420 9450 9480 9510 9540 9570 9600 9630 9660 9690 9720 9750 9780 9810 9840 9870 9900 9930 9960 9990 10020 10050 10080 10110 10140 10170 10200 10230 10260 10290 10320 10350 10380 10410 10440 10470 10500 10530 10560 10590 10620 10650 10680 10710 10740 10770 10800 10830 10860 10890 10920 10950 10980 11010 11040 11070 11100 11130 11160 11190 11220 11250 11280 11310 11340 11370 11400 11430 11460 11490 11520 11550 11580 11610 11640 11670 11700 11730 11760 11790 11820 11850 11880 11910 11940 11970 12000 12030 12060 12090 12120 12150 12180 12210 12240 12270 12300 12330 12360 12390 12420 12450 12480 12510 12540 12570 12600 12630 12660 12690 12720 12750 12780 12810 12840 12870 12900 12930 12960 12990 13020 13050 13080 13110 13140 13170 13200 13230 13260 13290 13320 13350 13380 13410 13440 13470 13500 13530 13560 13590 13620 13650 13680 13710 13740 13770 13800 13830 13860 13890 13920 13950 13980 14010 14040 14070 14100 14130 14160 14190 14220 14250 14280 14310 14340 14370 14400 14430 14460 14490 14520 14550 14580 14610 14640 14670 14700 14730 14760 14790 14820 14850 14880 14910 14940 14970 15000 15030 15060 15090 15120 15150 15180 15210 15240 15270 15300 15330 15360 15390 15420 15450 15480 15510 15540 15570 15600 15630 15660 15690 15720 15750 15780 15810 15840 15870 15900 15930 15960 15990 16020 16050 16080 16110 16140 16170 16200 16230 16260 16290 16320 16350 16380 16410 16440 16470 16500 16530 16560 16590 16620 16650 16680 16710 16740 16770 16800 16830 16860 16890 16920 16950 16980 17010 17040 17070 17100 17130 17160 17190 17220 17250 17280 17310 17340 17370 17400 17430 17460 17490 17520 17550 17580 17610 17640 17670 17700 17730 17760 17790 17820 17850 17880 17910 17940 17970 18000 18030 18060 18090 18120 18150 18180 18210 18240 18270 18300 18330 18360 18390 18420 18450 18480 18510 18540 18570 18600 18630 18660 18690 18720 18750 18780 18810 18840 18870 18900 18930 18960 18990 19020 19050 19080 19110 19140 19170 19200 19230 19260 19290 19320 19350 19380 19410 19440 19470 19500 19530 19560 19590 19620 19650 19680 19710 19740 19770 19800 19830 19860 19890 19920 19950 19980 20010 20040 20070 20100 20130 20160 20190 20220 20250 20280 20310 20340 20370 20400 20430 20460 20490 20520 20550 20580 20610 20640 20670 20700 20730 20760 20790 20820 20850 20880 20910 20940 20970 21000 21030 21060 21090 21120 21150 21180 21210 21240 21270 21300 21330 21360 21390 21420 21450 21480 21510 21540 21570 21600 21630 21660 21690 21720 21750 21780 21810 21840 21870 21900 21930 21960 21990 22020 22050 22080 22110 22140 22170 22200 22230 22260 22290 22320 22350 22380 22410 22440 22470 22500 22530 22560 22590 22620 22650 22680 22710 22740 22770 22800 22830 22860 22890 22920 22950 22980 23010 23040 23070 23100 23130 23160 23190 23220 23250 23280 23310 23340 23370 23400 23430 23460 23490 23520 23550 23580 23610 23640 23670 23700 23730 23760 23790 23820 23850 23880 23910 23940 23970 24000 24030 24060 24090 24120 24150 24180 24210 24240 24270 24300 24330 24360 24390 24420 24450 24480 24510 24540 24570 24600 24630 24660 24690 24720 24750 24780 24810 24840 24870 24900 24930 24960 24990 25020 25050 25080 25110 25140 25170 25200 25230 25260 25290 25320 25350 25380 25410 25440 25470 25500 25530 25560 25590 25620 25650 25680 25710 25740 25770 25800 25830 25860 25890 25920 25950 25980 26010 26040 26070 26100 26130 26160 26190 26220 26250 26280 26310 26340 26370 26400 26430 26460 26490 26520 26550 26580 26610 26640 26670 26700 26730 26760 26790 26820 26850 26880 26910 26940 26970 27000 27030 27060 27090 27120 27150 27180 27210 27240 27270 27300 27330 27360 27390 27420 27450 27480 27510 27540 27570 27600 27630 27660 27690 27720 27750 27780 27810 27840 27870 27900 27930 27960 27990 28020 28050 28080 28110 28140 28170 28200 28230 28260 28290 28320 28350 28380 28410 28440 28470 28500 28530 28560 28590 28620 28650 28680 28710 28740 28770 28800 28830 28860 28890 28920 28950 28980 29010 29040 29070 29100 29130 29160 29190 29220 29250 29280 29310 29340 29370 29400 29430 29460 29490 29520 29550 29580 29610 29640 29670 29700 29730 29760 29790 29820 29850 29880 29910 29940 29970 30000 30030 30060 30090 30120 30150 30180 30210 30240 30270 30300 30330 30360 30390 30420 30450 30480 30510 30540 30570 30600 30630 30660 30690 30720 30750 30780 30810 30840 30870 30900 30930 30960 30990 31020 31050 31080 31110 31140 31170 31200 31230 31260 31290 31320 31350 31380 31410 31440 31470 31500 31530 31560 31590 31620 31650 31680 31710 31740 31770 31800 31830 31860 31890 31920 31950 31980 32010 32040 32070 32100 32130 32160 32190 32220 32250 32280 32310 32340 32370 32400 32430 32460 32490 32520 32550 32580 32610 32640 32670 32700 32730 32760 32790 32820 32850 32880 32910 32940 32970 33000 33030 33060 33090 33120 33150 33180 33210 33240 33270 33300 33330 33360 33390 33420 33450 33480 33510 33540 33570 33600 33630 33660 33690 33720 33750 33780 33810 33840 33870 33900 33930 33960 33990 34020 34050 34080 34110 34140 34170 34200 34230 34260 34290 34320 34350 34380 34410 34440 34470 34500 34530 34560 34590 34620 34650 34680 34710 34740 34770 34800 34830 34860 34890 34920 34950 34980 35010 35040 35070 35100 35130 35160 35190 35220 35250 35280 35310 35340 35370 35400 35430 35460 35490 35520 35550 35580 35610 35640 35670 35700 35730 35760 35790 35820 35850 35880 35910 35940 35970 36000 36030 36060 36090 36120 36150 36180 36210 36240 36270 36300 36330 36360 36390 36420 36450 36480 36510 36540 36570 36600 36630 36660 36690 36720 36750 36780 36810 36840 36870 36900 36930 36960 36990 37020 37050 37080 37110 37140 37170 37200 37230 37260 37290 37320 37350 37380 37410 37440 37470 37500 37530 37560 37590 37620 37650 37680 37710 37740 37770 37800 37830 37860 37890 37920 37950 37980 38010 38040 38070 38100 38130 38160 38190 38220 38250 38280 38310 38340 38370 38400 38430 38460 38490 38520 38550 38580 38610 38640 38670 38700 38730 38760 38790 38820 38850 38880 38910 38940 38970 39000 39030 39060 39090 39120 39150 39180 39210 39240 39270 39300 39330 39360 39390 39420 39450 39480 39510 39540 39570 39600 39630 39660 39690 39720 39750 39780 39810 39840 39870 39900 39930 39960 39990 40020 40050 40080 40110 40140 40170 40200 40230 40260 40290 40320 40350 40380 40410 40440 40470 40500 40530 40560 40590 40620 40650 40680 40710 40740 40770 40800 40830 40860 40890 40920 40950 40980 41010 41040 41070 41100 41130 41160 41190 41220 41250 41280 41310 41340 41370 41400 41430 41460 41490 41520 41550 41580 41610 41640 41670 41700 41730 41760 41790 41820 41850 41880 41910 41940 41970 42000 42030 42060 42090 42120 42150 42180 42210 42240 42270 42300 42330 42360 42390 42420 42450 42480 42510 42540 42570 42600 42630 42660 42690 42720 42750 42780 42810 42840 42870 42900 42930 42960 42990 43020 43050 43080 43110 43140 43170 43200 43230 43260 43290 43320 43350 43380 43410 43440 43470 43500 43530 43560 43590 43620 43650 43680 43710 43740 43770 43800 43830 43860 43890 43920 43950 43980 44010 44040 44070 44100 44130 44160 44190 44220 44250 44280 44310 44340 44370 44400 44430 44460 44490 44520 44550 44580 44610 44640 44670 44700 44730 44760 44790 44820 44850 44880 44910 44940 44970 45000 45030 45060 45090 45120 45150 45180 45210 45240 45270 45300 45330 45360 45390 45420 45450 45480 45510 45540 45570 45600 45630 45660 45690 45720 45750 45780 45810 45840 45870 45900 45930 45960 45990 46020 46050 46080 46110 46140 46170 46200 46230 46260 46290 46320 46350 46380 46410 46440 46470 46500 46530 46560 46590 46620 46650 46680 46710 46740 46770 46800 46830 46860 46890 46920 46950 46980 47010 47040 47070 47100 47130 47160 47190 47220 47250 47280 47310 47340 47370 47400 47430 47460 47490 47520 47550 47580 47610 47640 47670 47700 47730 47760 47790 47820 47850 47880 47910 47940 47970 48000 48030 48060 48090 48120 48150 48180 48210 48240 48270 48300 48330 48360 48390 48420 48450 48480 48510 48540 48570 48600 48630 48660 48690 48720 48750 48780 48810 48840 48870 48900 48930 48960 48990 49020 49050 49080 49110 49140 49170 49200 49230 49260 49290 49320 49350 49380 49410 49440 49470 49500 49530 49560 49590 49620 49650 49680 49710 49740 49770 49800 49830 49860 49890 49920 49950 49980 50010 50040 50070 50100 50130 50160 50190 50220 50250 50280 50310 50340 50370 50400 50430 50460 50490 50520 50550 50580 50610 50640 50670 50700 50730 50760 50790 50820 50850 50880 50910 50940 50970 51000 51030 51060 51090 51120 51150 51180 51210 51240 51270 51300 51330 51360 51390 51420 51450 51480 51510 51540 51570 51600 51630 51660 51690 51720 51750 51780 51810 51840 51870 51900 51930 51960 51990 52020 52050 52080 52110 52140 52170 52200 52230 52260 52290 52320 52350 52380 52410 52440 52470 52500 52530 52560 52590 52620 52650 52680 52710 52740 52770 52800 52830 52860 52890 52920 52950 52980 53010 53040 53070 53100 53130 53160 53190 53220 53250 53280 53310 53340 53370 53400 53430 53460 53490 53520 53550 53580 53610 53640 53670 53700 53730 53760 53790 53820 53850 53880 53910 53940 53970 54000 54030 54060 54090 54120 54150 54180 54210 54240 54270 54300 54330 54360 54390 54420 54450 54480 54510 54540 54570 54600 54630 54660 54690 54720 54750 54780 54810 54840 54870 54900 54930 54960 54990 55020 55050 55080 55110 55140 55170 55200 55230 55260 55290 55320 55350 55380 55410 55440 55470 55500 55530 55560 55590 55620 55650 55680 55710 55740 55770 55800 55830 55860 55890 55920 55950 55980 56010 56040 56070 56100 56130 56160 56190 56220 56250 56280 56310 56340 56370 56400 56430 56460 56490 56520 56550 56580 56610 56640 56670 56700 56730 56760 56790 56820 56850 56880 56910 56940 56970 57000 57030 57060 57090 57120 57150 57180 57210 57240 57270 57300 57330 57360 57390 57420 57450 57480 57510 57540 57570 57600 57630 57660 57690 57720 57750 57780 57810 57840 57870 57900 57930 57960 57990 58020 58050 58080 58110 58140 58170 58200 58230 58260 58290 58320 58350 58380 58410 58440 58470 58500 58530 58560 58590 58620 58650 58680 58710 58740 58770 58800 58830 58860 58890 58920 58950 58980 59010 59040 59070 59100 59130 59160 59190 59220 59250 59280 59310 59340 59370 59400 59430 59460 59490 59520 59550 59580 59610 59640 59670 59700 59730 59760 59790 59820 59850 59880 59910 59940 59970 60000 60030 60060 60090 60120 60150 60180 60210 60240 60270 60300 60330 60360 60390 60420 60450 60480 60510 60540 6																																		

For soil description refer to Record of Borehole ST-5

Shale, dark grey, highly to moderately weathered, fine grained, thinly bedded, occ. thin limestone layers. (Whitby Formation)

UE, 25mm BC

PL

M

PL, 50mm BC

PL

70mm BC

PL

PL

25mm BC

UE

M

PL, 75mm BC

UE

PL

UE, 25mm BC

12mm BC

PL

END OF HOLE

DEPTH SCALE

1 : 50



LOGGED: SB

CHECKED: AMP

DRILLHOLE 1158 ROCK GPJ GLDR CAN.GDT 22/11/99 PS

ON MOT 991-1158.GPJ ON MOT.GDT 5/1/00

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT 991-1158				RECORD OF BOREHOLE No ST-6				2 OF 2		METRIC							
W.P. 242-86-00				LOCATION N 4857206.00; E 344010.00				ORIGINATED BY SB									
DIST 6 HWY 401				BOREHOLE TYPE CME 55 Bombardier				COMPILED BY AMP									
DATUM Geodetic				DATE 21.9.99 - 21.9.99				CHECKED BY AMP									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					20 40 60 WATER CONTENT (%)					
82.34																	
15.20	Silty Sand, trace gravel, trace clay Very dense Grey (Till)		14	50 DO	133		82										
81.14																	
16.40	Weathered, dark grey Shale Bedrock. (Whitby Formation)						81										
							80										
							79										
78.49	Bedrock cored between 16.76m and 19.05m depth. For bedrock coring details refer to Record of Drillhole ST-6.																
19.05	END OF BOREHOLE																
	Note: Open hole dry on completion of drilling through the soils.																

ON\_MOT 991-1158.GPJ ON\_MOT.GDT 5/1/00

PROJECT: 991-1158

## RECORD OF DRILLHOLE: ST-6

SHEET 1 OF 1

LOCATION: N 4857206.00; E 344010.00

DRILLING DATE: 22/9/99

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Bombardier

DRILLING CONTRACTOR: Master Soils Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	COLOUR FLUSH % RETURN	FR-FRACTURE	F-FAULT	SM-SMOOTH	FL-FLEXURED	BC-BROKEN CORE	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
								CL-CLEAVAGE	J-JOINT	R-ROUGH	UE-UNEVEN	MB-MECH. BREAK		
								SH-SHEAR	P-POLISHED	ST-STEPPED	W-WAVY	B-BEDDING		
								VEIN-VEIN	S-SLICKENSIDED	PL-PLANAR	C-CURVED			
								RECOVERY	R.Q.D.	FRACT. INDEX PER 0.3	DISCONTINUITY DATA	HYDRAULIC CONDUCTIVITY k, cm/sec		
								TOTAL CORE %	SOLID CORE %	%				
								100	100	100				
15				82.54										
				15.00										
16		For soil description refer to Record of Borehole ST-6												
17		Shale, dark grey, moderately weathered, fine grained, thinly bedded, occ. thin limestone layers. (Whitby Formation)		80.78 16.76	1		100							
18					2		100							
19		END OF HOLE		78.49 19.05										
20														
21														
22														
23														
24														
25														

DEPTH SCALE

1 : 50



LOGGED: SB

CHECKED: AMP

DRILLHOLE 1158ROCK.GPJ GLDR CAN.GDT 22/11/99 PS



<div style="display: flex; justify-content: space-between;"> <span>PROJECT <u>991-1158</u></span> <span><b>RECORD OF BOREHOLE No G-13</b></span> <span>1 OF 1</span> <span><b>METRIC</b></span> </div>															
W.P. <u>242-86-00</u>			LOCATION <u>N 4857263.00; E 343953.00</u>				ORIGINATED BY <u>SB</u>								
DIST <u>6</u> HWY <u>401</u>			BOREHOLE TYPE <u>CME 55 Bombardier</u>				COMPILED BY <u>AMP</u>								
DATUM <u>Geodetic</u>			DATE <u>21.9.99 - 21.9.99</u>				CHECKED BY <u>AMP</u>								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
98.32															
98.09	Topsoil		1	50 DO	12		98								
0.23	Clayey Silty Sand to Silty Sand, trace clay, trace to some gravel, cobbles encountered with depth Very dense Brown to 2.1m depth, then grey (Till)		2	50 DO	75		97								
			3	50 DO	95		96								
			4	50 DO	82		95								
			5	50 DO	60/13		94								
			6	50 DO	80/05		93								
			7	50 DO	60/10		92								
			8	50 DO	80/05		91								
			9	50 DO	60/15										
90.55	END OF BOREHOLE														
7.77	Note: Water level in open hole at 4m depth on completion of drilling.														

ON\_MOT\_991-1158.GPJ ON\_MOT\_GDT 30/12/99



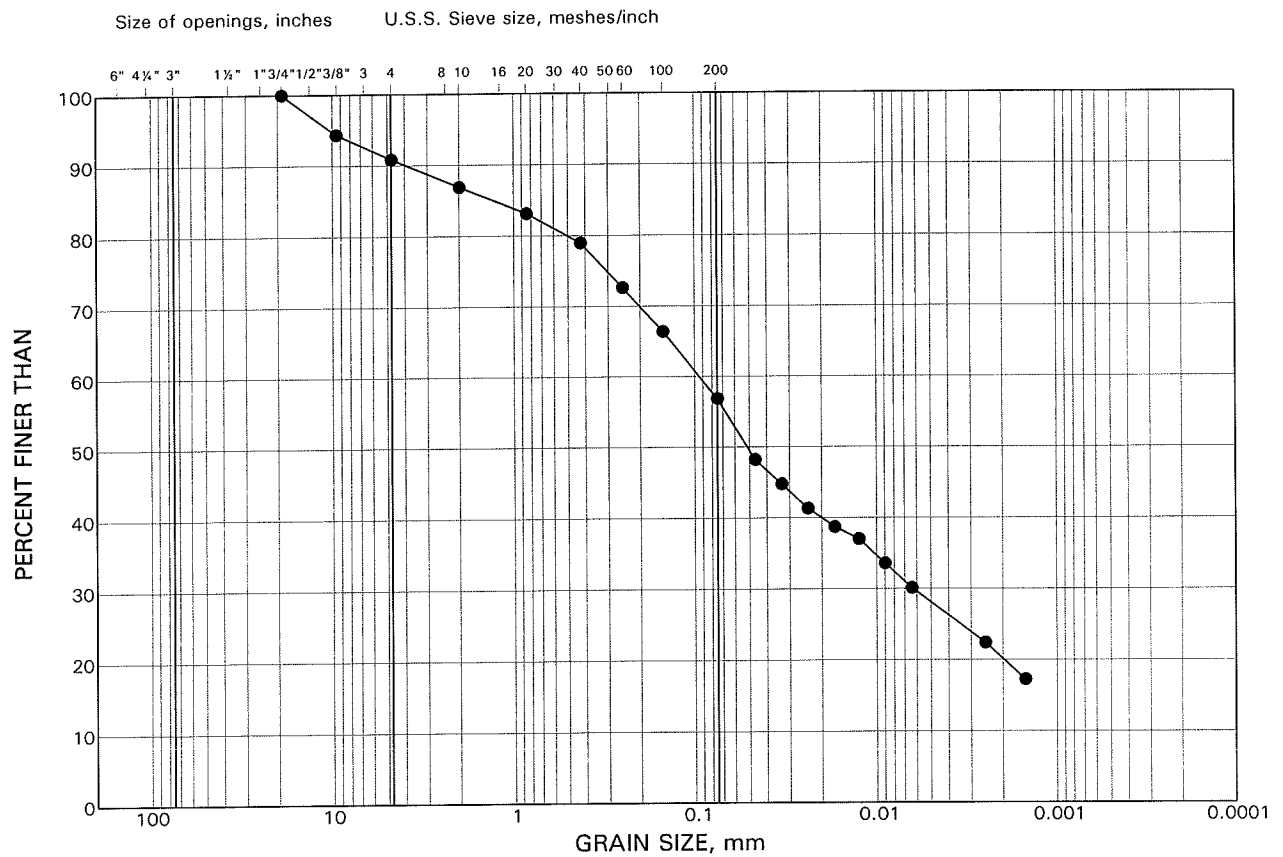
# **APPENDIX B**

## **Geotechnical Laboratory Test Results – 1999 Investigation**

# GRAIN SIZE DISTRIBUTION

Silty Clay (Till)

FIGURE 1



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
	GRAVEL SIZE		SAND SIZE			FINE GRAINED

## LEGEND

SYMBOL      BOREHOLE      SAMPLE ELEVATION(m)

•

RW5

5

95.2

## FIGURE 2



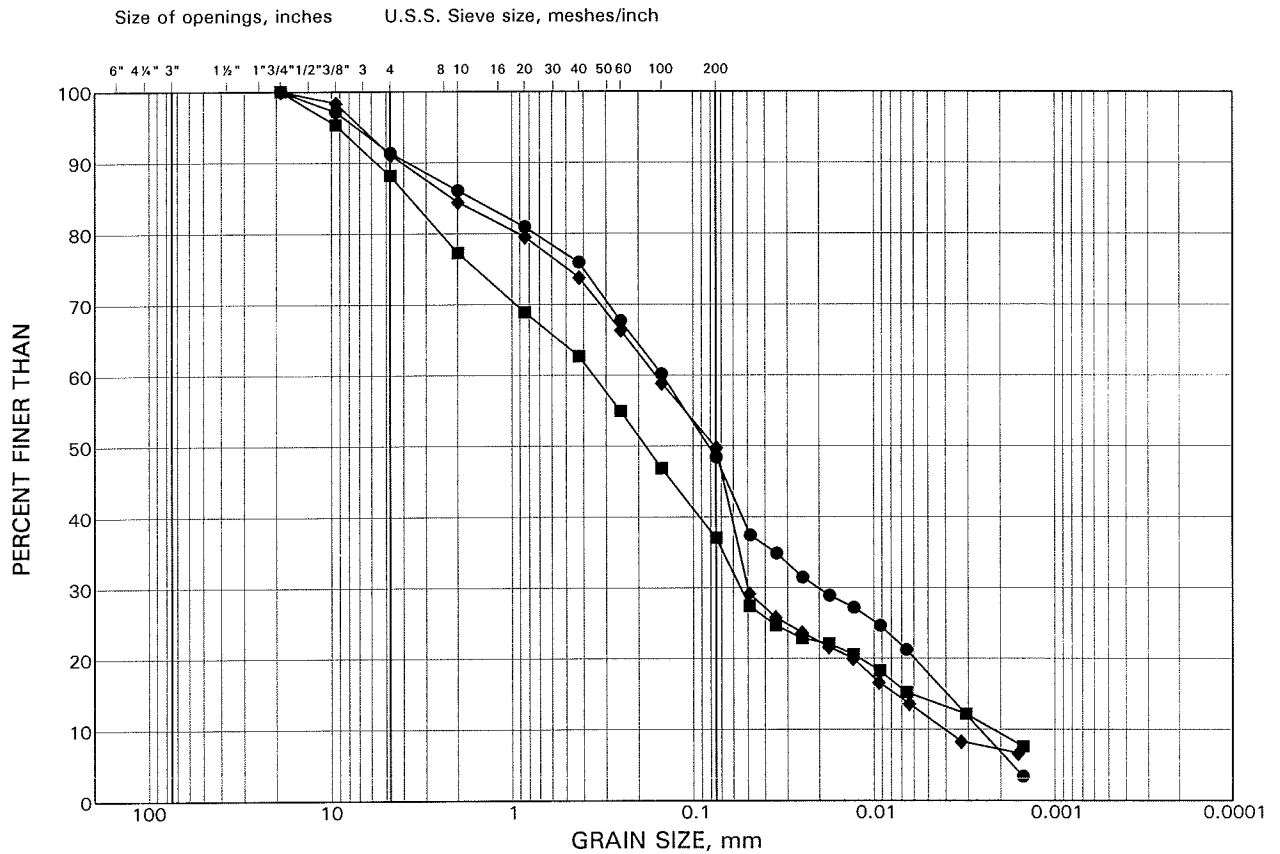
SYMBOL	BOREHOLE	SAMPLE ELEVATION(m)
--------	----------	---------------------

●	ST-3	5	94.1
■	ST-4	5	92.3
◆	ST-5	8	91.6
○	ST-6	6	93.6

# GRAIN SIZE DISTRIBUTION

## Clayey Silty Sand (Till)

FIGURE 3



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

### LEGEND

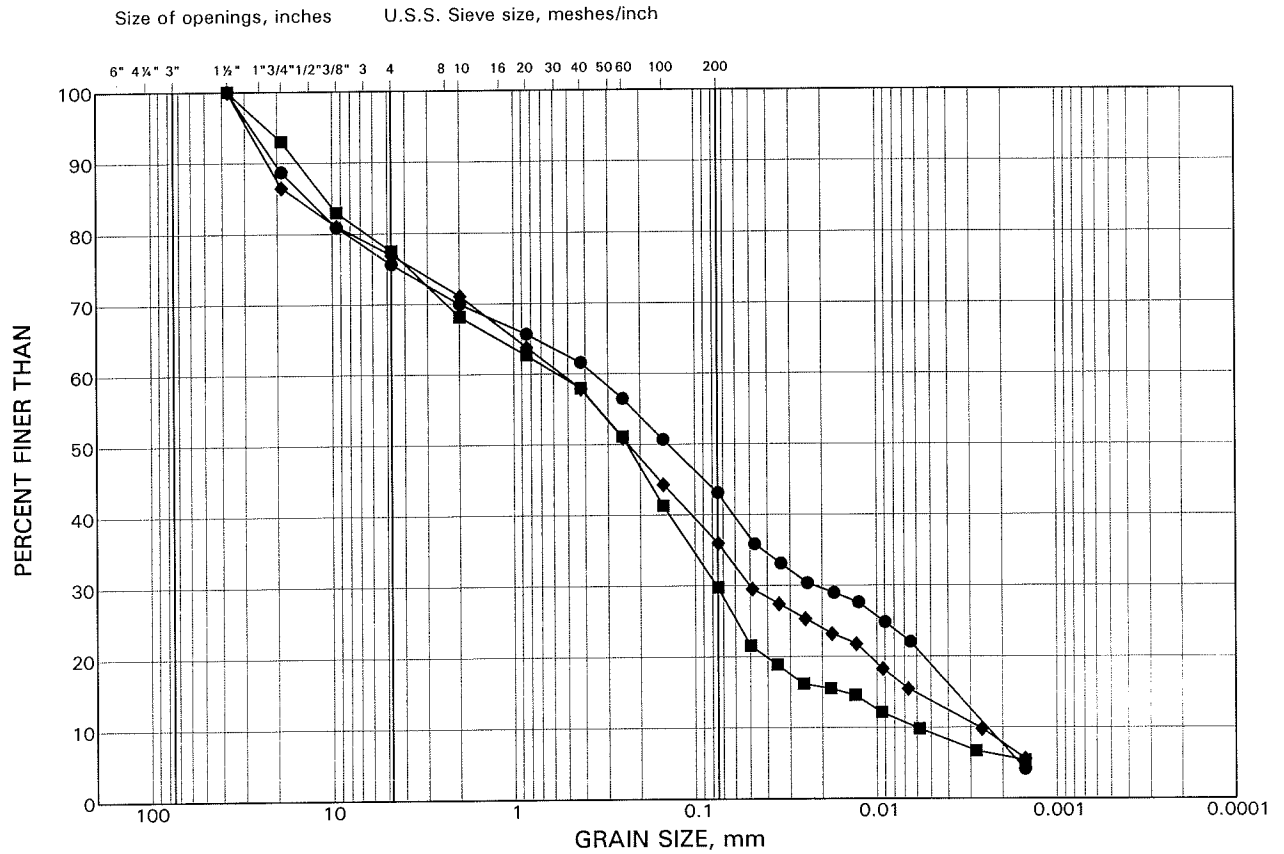
SYMBOL      BOREHOLE      SAMPLE ELEVATION(m)

●	RW1	4	95.6
■	RW9	4	93.5
◆	ST-1	8	90.7

# GRAIN SIZE DISTRIBUTION

Clayey Silty Sand with Gravel (Till)

FIGURE 4



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

## LEGEND

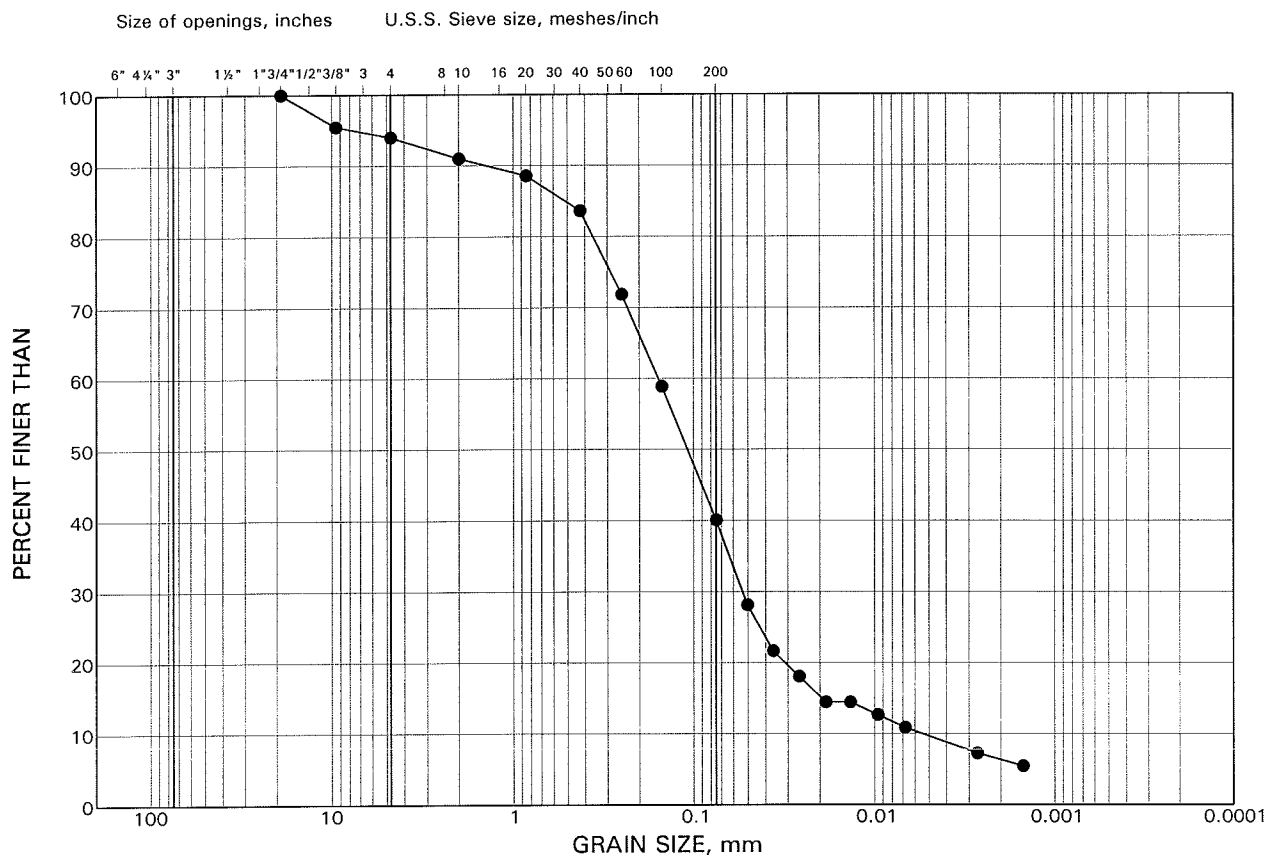
SYMBOL      BOREHOLE      SAMPLE ELEVATION(m)

●	RW2	6	90.8
■	RW4	5	91.3
◆	ST-2	7	92.1

# GRAIN SIZE DISTRIBUTION

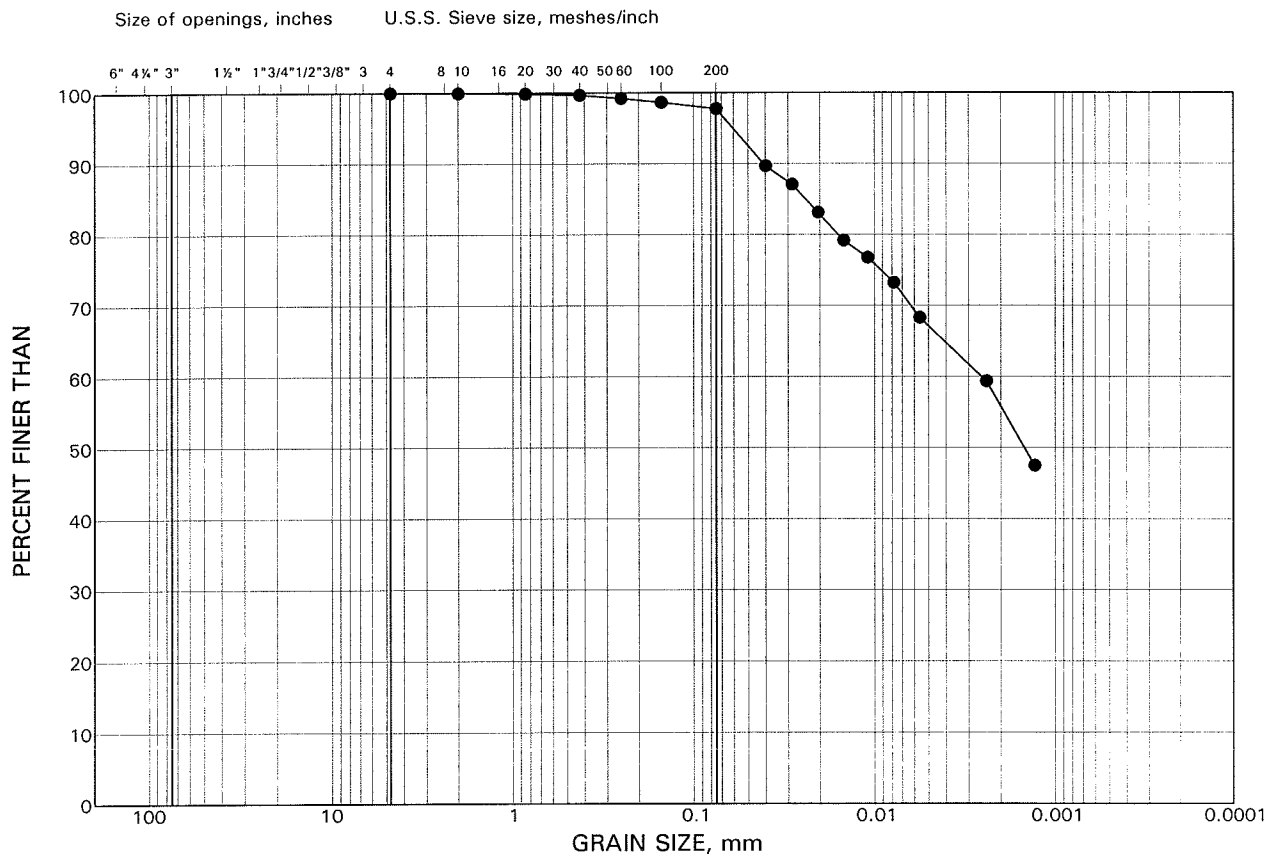
Silty Sand (Till)

FIGURE 5



# GRAIN SIZE DISTRIBUTION Clay (Till)

FIGURE 6



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

## LEGEND

SYMBOL      BOREHOLE      SAMPLE ELEVATION(m)

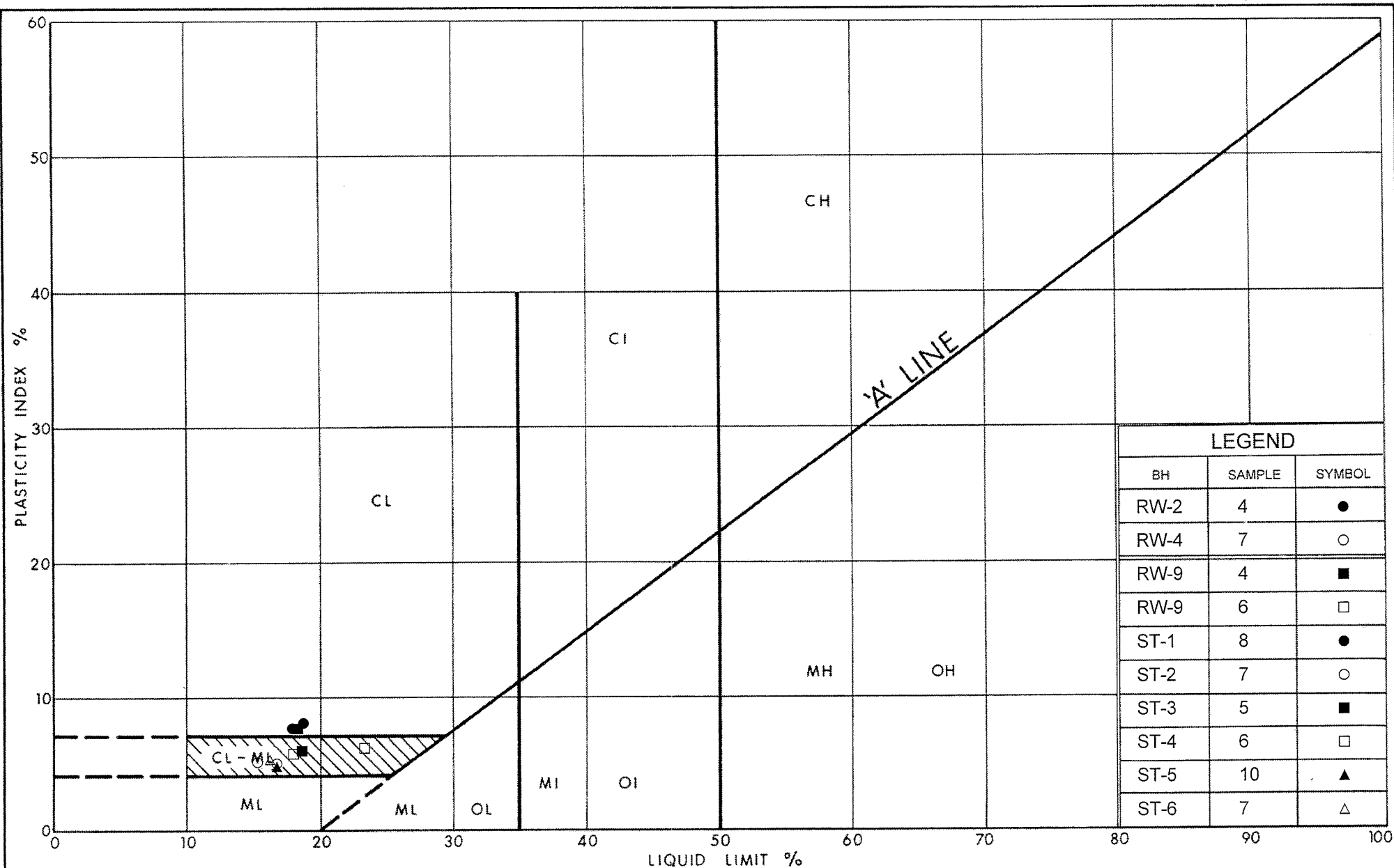
•

RW6

9

87.8





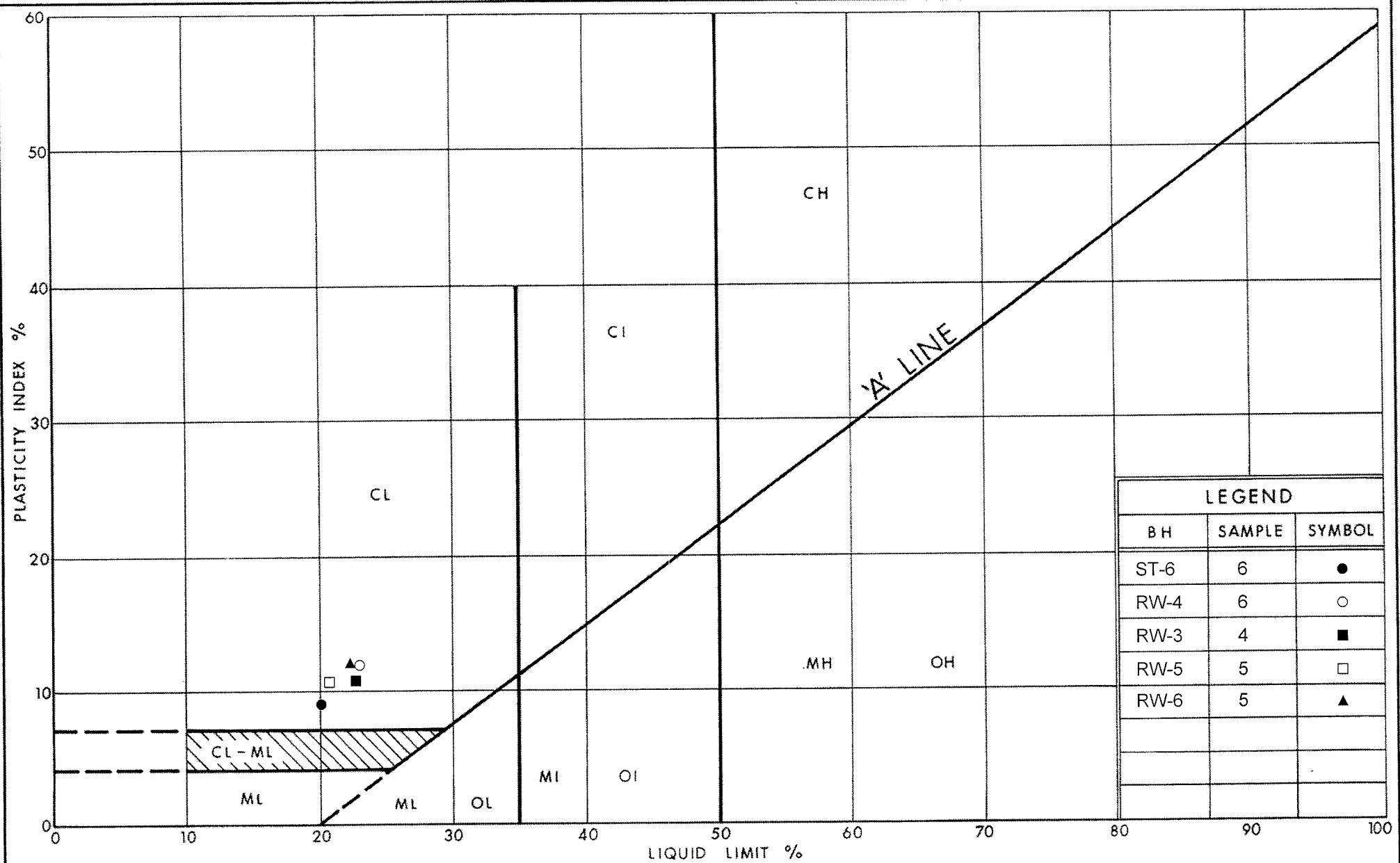
Ministry of  
Transportation

# PLASTICITY CHART Clayey Silty Sand (Till)

FIG No 7

W P 242-86-00

PROJECT No 991-1158



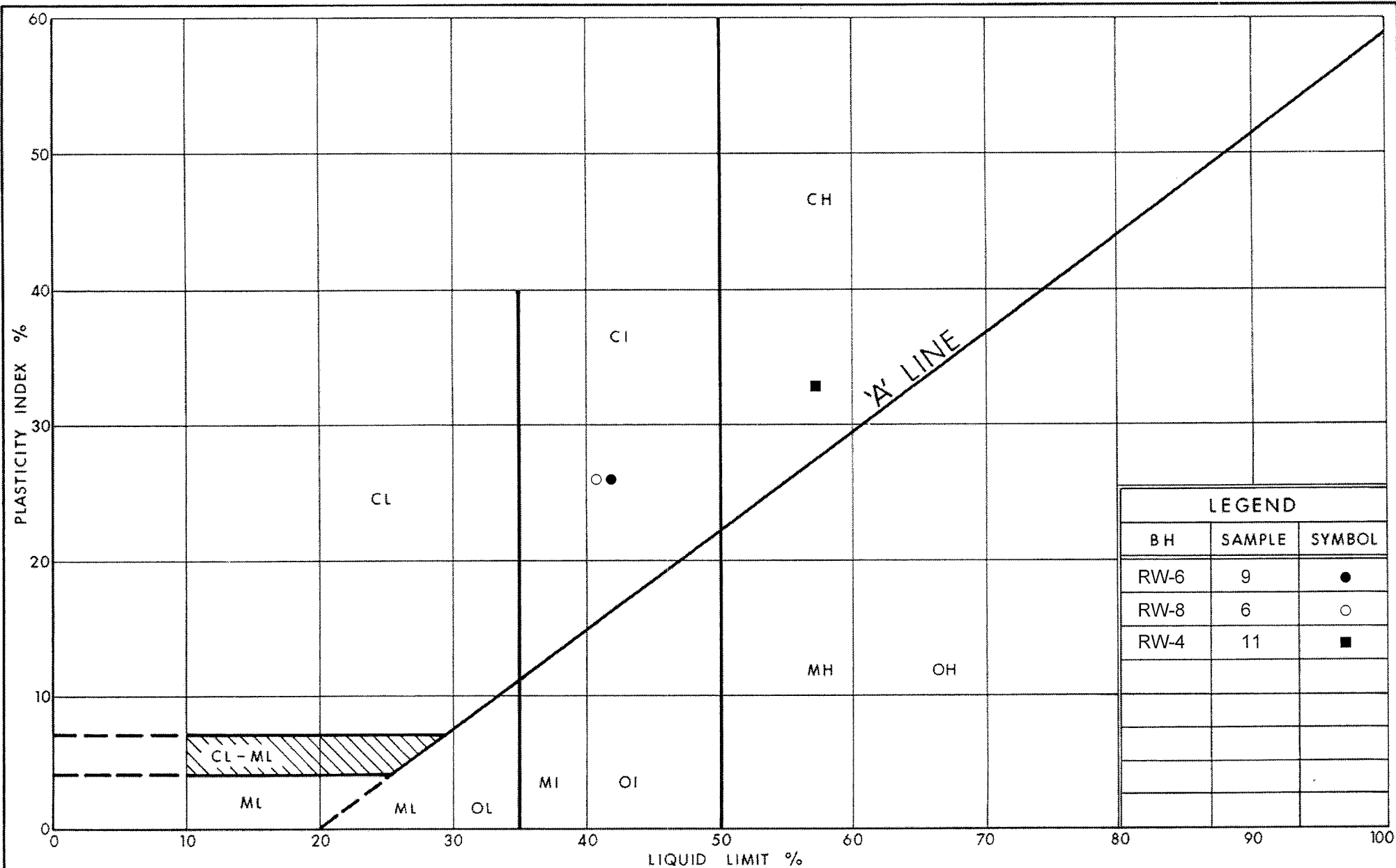
Ministry of  
Transportation

# PLASTICITY CHART Silty Clay (Till)

FIG No 8

W P 242-86-00

PROJECT No 991-1158



Ministry of  
Transportation

Ontario

# PLASTICITY CHART Silty Clay to Clay

FIG No 9

W P 242-86-00

PROJECT No 991-1158

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