



**THURBER** ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
N-E/W RAMP OVERPASS OVER GUELPH STREET  
HIGHWAY 7-NEW, KITCHENER TO GUELPH  
G.W.P. 408-88-00**

**GEOCRES No. 40P8-282**

**Latitude 43.466555 °, Longitude -80.469897 °**

**Report**

**to**

**WSP**

Date: August 5, 2020  
File: 11375



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**GEOCRES No. 40P8-282**

**PART 1: FACTUAL INFORMATION**

**1. INTRODUCTION**

This report presents the factual findings obtained from a detailed foundation investigation conducted at the site of the proposed N-E/W Ramp over the existing Guelph Street, in the Regional Municipality of Waterloo. The proposed N-E/W Ramp is part of the Highway 7-New Project.

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

Thurber was retained by WSP to carry out the site investigation under the Ministry of Transportation Ontario (MTO) Agreement Order Number 3014-E-0013.

Reference has been made to the information on subsurface conditions contained in a previous foundation report prepared for this site during the preliminary design phase. The title of the report is:

- Preliminary, Foundation Investigation and Design Report, N-E Ramp/N – Wellington Ramp Over Guelph Street, Highway 7-New, Kitchener to Guelph, G.W.P. 408-88-00, Geocres No. 40P8-155, Report to Ministry of Transportation Ontario West Region, File: 15-64-17, dated December 2, 2008. (Reference 1).

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## **2. SITE DESCRIPTION**

The site lies within the Kitchener-Waterloo Expressway (KWE) and Guelph Street interchange. At this location, the proposed N-E/W Ramp will cross over an existing section of Guelph Street. A drainage channel, approximately 4m wide and 0.5 to 1m deep, is located on the south side of Guelph Street at this site, running in an approximate east to west direction below the proposed overpass.

The site lies within an area of industrial and commercial lands and is generally flat.

Based on the Ontario Geological Survey Special Volume 2, The Physiography of Southern Ontario, Third Edition by Chapman and Putnam, the site lies within the physiographic region known as the Waterloo Hills, characterized by ridges of sandy till kames or kame moraines, with outwash sands occupying the intervening hollows.

## **3. INVESTIGATION PROCEDURES**

A preliminary investigation was carried out at this site in June 2008. Two boreholes numbered 08-002 and 08-004, were drilled at this site. The depths of Boreholes 08-002 and 08-004 were 15.5 m and 17.0 m (Elevations 292.8 and 291.8), respectively.

A detailed geotechnical investigation was conducted between May 9 and June 13, 2018, and consisted of drilling five boreholes (numbered NE16-01 to NE16-05) at the proposed foundation elements of the ramp, and four boreholes (numbered RW18-01 to RW18-04) for two proposed armour stone retaining walls. Boreholes NE16-01 and NE16-05 were drilled at the north and south approach embankments, respectively, extending to 14.2 m and 17.4 m (Elevations 296.1 and 293.4). Boreholes NE16-02, NE16-03, and NE16-04 were drilled at the approximate locations of the north abutment, pier, and south abutment. The foundation boreholes ranged in depth from 17.0 m to 20.2 m (Elevations 292.9 to 290.4). The boreholes for the armour stone retaining walls ranged in depth from 15.6 m to 18.5 (Elevation 294.5 to 291.2).

The Record of Borehole sheets for the present and previous investigations are included in Appendices A and B, respectively.

The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix C. The coordinates and elevations of the current and previous



boreholes are given on the drawings and on the individual Record of Borehole Sheets in Appendices A and B, respectively.

The ground surface elevations and coordinates of the recent as-drilled boreholes were provided by WSP.

Prior to commencing the site investigation, utility clearances were obtained for all borehole locations. Road occupancy permit was also obtained to complete site investigation.

During the current investigation, a rubber-track mounted B-57 drill rig was used in conjunction with hollow-stem augers, tri-cone and casing advancer methods to advance the boreholes. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the overburden soils.

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

Groundwater conditions in the open boreholes were observed throughout the drilling operations. In Boreholes NE16-02, NE16-04, RW18-01, and RW18-02 a standpipe piezometer consisting of 25 mm diameter PVC pipe with a slotted screen was installed and enclosed in filter sand to permit longer-term groundwater level monitoring. The details of standpipe piezometer installations and borehole completion are summarized in Table 3.1. The completion of the boreholes and the standpipe piezometers were carried out in accordance with the requirements of O. Reg. 903 (as amended by O. Reg. 372/07).

**Table 3.1 – Borehole Completion Details**



Foundation Unit	Borehole	Ground Surface Elevation (m)	Borehole Depth / Base Elevation (m)	Piezometer Tip Elevation (m)	Completion Details
North Approach	NE16-01	310.2	14.2/296.1	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
North Abutment	NE16-02	309.9	17.0/292.9	16.7/293.2	Piezometer with 3.0 m slotted screen installed with sand filter to 13 m, bentonite mixed with auger cuttings from 13 m to ground surface.
	08-002	308.3	15.5/292.8	15.3/293.0	Piezometer with 1.5 m slotted screen installed with sand filter to 13.1 m, holeplug from 13.1 m to 12.5 m, grout from 12.5 m to 0.9 m, sand from 0.9 m to 0.6 m, holeplug from 0.6 to 0.15, then concrete to surface.
Pier 1	NE16-03	309.9	18.4/291.4	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
	08-004	308.8	17.0/291.8	No Installation	Benseal to 5.8 m, holeplug from 5.8 m to 75 mm, then asphalt to surface.
South Abutment	NE16-04	310.6	20.2/290.4	18.3/292.3	Piezometer with 3.0 m slotted screen installed with sand filter to 14 m, bentonite mixed with auger cuttings from 14 m to ground surface.
South Approach	NE16-05	310.8	17.4/293.4	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
Armour Stone Retaining walls	RW18-01	310.4	18.4/291.9	18.2/292.1	Piezometer with 3.0 m slotted screen installed with sand filter to 14.5 m, bentonite mixed with auger cuttings from 14.5 m to ground surface.
	RW18-02	309.9	18.5/291.4	17.7/292.2	Piezometer with 3.0 m slotted screen installed with sand filter to 14 m, bentonite mixed with auger cuttings from 14 m to ground surface.
	RW18-03	310.1	15.6/294.5	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
	RW18-04	309.8	18.5/291.2	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.

#### 4. LABORATORY TESTING



The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size analysis and Atterberg Limits testing. All the laboratory tests were carried out in accordance with MTO and/or ASTM Standards, as appropriate. The results of the laboratory testing of current and previous investigations are summarized on the Record of Borehole sheets in Appendices A and B, and also presented on the figures included in Appendices A and B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, two soil samples were collected. The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix A.

## **5. DESCRIPTION OF SUBSURFACE CONDITIONS**

Reference is made to the Record of Borehole sheets in Appendices A and B. Details of the encountered soil stratigraphy along the proposed alignment are presented in these appendices and on the “Borehole Locations and Soil Strata” drawings in Appendix C. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions. It should be recognized and expected that soil conditions may vary between and beyond borehole locations.

In general, the site is underlain by silty sand fill and silty clay fill overlaying layers of native sands/silts, silty clay to silty clay till, and sand and silt till. Topsoil was encountered surficially in some boreholes. Descriptions of the individual strata are presented below.

### **5.1 Topsoil**

Topsoil was identified at the ground surface in Boreholes NE16-02, NE16-03, and RW18-03. The topsoil thickness ranged from 75 mm to 150 mm.

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

### **5.2 Fill**





A layer of fill was encountered surfically in Boreholes NE16-01, NE16-04, NE16-05, RW18-01, RW18-02, and RW18-04, below the topsoil in Boreholes NE16-02, NE16-03, and RW18-03 and below asphalt in Boreholes 08-002 and 08-004. The fill consisted of layers of cohesive and cohesionless soils. The cohesionless fill consisted of brown to dark brown silty sand/sandy silt, with trace clay, trace to some gravel and occasional organics. The cohesive fill consisted of brown silty clay containing some sand and occasional organics.

The fill layer ranged in thickness from 1.3 m to 3.7 m. The depth to the base of the fill ranged from 1.4 to 3.7 m (Elevations 308.6 to 305.4).

The cohesionless fill is classified as very loose to compact, based on SPT 'N' values ranging from 3 to 26 blows for 0.3 m of penetration. The natural moisture content ranged from 3 percent to 52 percent. The cohesive fill is classified as soft to very stiff, based on SPT 'N' values ranging from 3 to 22 blows for 0.3 m of penetration. The natural moisture content ranged from 11 percent to 26 percent.

Grain size distribution curves of the cohesive and cohesionless fill are presented on the Record of Borehole sheets in Appendices A and B and on Figures A1 and A2 of Appendix A and Figure B1 of Appendix B. The result of laboratory tests carried out on selected samples are as follows:

Soil Particle	Silty clay fill (%)	Silty sand fill (%)
Gravel	0	3 to 5
Sand	0 to 14	49 to 56
Silt	48 to 73	27
Clay	27 to 38	12 to 22

The results of Atterberg Limits for the cohesive fill are presented on the Record of Borehole sheets and in Figure A7 included in Appendix A. The results of Atterberg Limits testing are summarized below:

Liquid Limit	32
Plastic Limit	19
Plasticity Index	13



The above results show that the cohesive fill is of low plasticity with a group symbol of CL.

### 5.3 Upper Silty Sand, Sandy Silt, Sand and Silt

Layers of native brown to grey silty sand, sandy silt and, sand and silt containing trace clay to clayey, trace to some gravel, and occasional cobbles and boulders were contacted below the fill at depths ranging from 2.2 m to 3.0 m (Elevations 308.1 to 306.9) in Boreholes NE16-03, NE16-04 and RW18-01 to RW18-04. Sand and silt was also encountered at 4.3 m depth in Borehole RW18-03. The thickness of the silty sand, sandy silt and, sand and silt layers ranged from 0.7 m to 3.4 m. The depth to the base of the silty sand, sandy silt and, sand and silt ranged from 3.0 m to 6.1 m (Elevations 307.3 to 304.2).

A 1.3-m thick layer of silty clay was encountered within the sand and silt layer at 3.0 m depth (Elevation 307.1) in Borehole RW18-03.

The SPT 'N' values of the silty sand, sandy silt and, sand and silt layers ranged from 5 to 31 blows per 0.3 m of penetration indicating a loose to dense relative density. The natural moisture contents generally lay in the range of 9 percent to 21 percent.

Grain size distribution curves for the silty sand, sandy silt and, sand and silt samples tested are presented on the Record of Borehole sheets in Appendix A in Figure A3. The results of gradation tests carried out on selected sampled are summarized follows:

Soil Particles	Percentage (%)
Gravel	0
Sand	37 to 79
Silt	19 to 57
Clay	2 to 10

### 5.4 Silty Clay

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Brown to grey silty clay with trace to some sand and trace gravel was encountered below the fill and silty sand/sandy silt/sand and silt layers at depths ranging from 1.4 m to 6.1 m (Elevations 308.6 to 304.2) in all of the boreholes. The silty clay layer ranged in thickness from 7.3 m to greater than 15.4 m.

A 300-mm thick layer of silty sand was contacted within the silty clay near Elevation 295.6 in Borehole NE16-05.

The depth to the base of the silty clay ranged from 11.9 m to 16.3 (Elevations 298.0 to 294.5) in all the boreholes, except in Borehole RW18-01. Borehole RW18-01 was terminated in the silty clay layer at a depth of 18.4 m (Elevation 291.9).

SPT 'N' values in the silty clay ranged from 2 to 46 blows per 0.3 m of penetration, indicating a soft to hard consistency. SPT 'N' values of 88 blows per 0.3 m of penetration to greater than 100 blows per 0.15 m of penetration, indicating a hard consistency, were measured below Elevation 294.0 in Borehole RW18-01. The natural moisture contents generally lay in the range of 15 percent to 33 percent.

Grain size distribution curves for the silty clay samples tested are presented on the Record of Borehole sheets in Figure A4 of Appendix A. The results of gradation tests carried out on selected samples are summarized follows:

<b>Soil Particles</b>	<b>Percentage (%)</b>
Gravel	0
Sand	0 to 13
Silt	29 to 47
Clay	53 to 64

The results of Atterberg Limits are presented on the Record of Borehole sheets and in Figures A8 and A9 included in Appendix A. The results of Atterberg Limits testing are summarized below:

Liquid Limit	36 to 47
Plastic Limit	17 to 21



Plasticity Index	18 to 26
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The above results show that the silty clay is of medium plasticity with a group symbol of CI.

### 5.5 Lower Sand

Native grey sand containing trace to some silt, trace gravel and trace of clay was contacted in Borehole 08-004 at a depth of 12.2 m (Elevation 296.6).

Thickness of the lower sand layer was 1.5 m. The depth to the base of the sand layer was 13.7 m (Elevation 295.1).

The sand is classified as very dense, based on SPT 'N' value of 90 blows for 0.3 m of penetration. The natural moisture content measured was 20 percent.

Grain size distribution curve for a sand sample, is presented on the Record of Borehole sheets in Appendix B and on Figure B2 of Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	Percent (%)
Gravel	2
Sand	85
Silt & Clay	13

### 5.6 Silty Clay Till

Grey silty clay till layers containing some sand to sandy, trace gravel and occasional cobbles were encountered below the silty clay at 11.9 m and 13.3 m depth (Elevations 298.0 and 296.5) in Boreholes RW18-02 and RW18-04 and below the fill at depths of 2.9 m to 3.0 m (Elevation 305.8 to 305.4) in Boreholes 08-002 and 08-004. The silty clay till layers were 2.1 m and 4.8 m in thickness in Boreholes RW18-04 and RW18-02. The till thickness ranged from 8.2 m to 9.2 m in Borehole 08-002 and 08-004.

The depth to the base of the silty clay till was at 16.7 m and 15.4 m (Elevations 293.2 and 294.4) in Borehole RW18-02 and RW18-04, respectively. The depth to the base of till were 11.1 m and 12.2 m (Elevation 297.2 and 296.6) in Borehole 08-002 and 08-004.



SPT 'N' values in the silty clay till ranged from 20 to 68 blows per 0.3 m of penetration, indicating a very stiff to hard consistency. The natural moisture contents generally lay in the range of 15 percent to 31 percent.

Grain size distribution curves for the silty clay till samples tested are presented on the Record of Borehole sheets in Appendices A and B and on Figure A5 of Appendix A and Figure B3 of Appendix B. The results of gradation tests carried out on selected sampled are summarized follows:

Soil Particles	Percentage (%)
Gravel	0 to 4
Sand	1 to 39
Silt	21 to 59
Clay	19 to 78

The results of Atterberg Limits are presented on the Record of Borehole sheets and in Figures B5 included in Appendix B. The results of Atterberg Limits testing are summarized below:

Liquid Limit	41 to 51
Plastic Limit	18 to 22

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

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

## 5.7 Sand and Silt Till

A deposit of native grey sand and silt till containing some clay to clayey and trace to some gravel and occasional boulders was contacted below the silty clay and silty clay till at depths ranging from 11.1 m to 16.7 m (Elevations 293.2 to 297.2) in all the boreholes, except in Borehole RW18-01.



All of the boreholes, except Borehole RW18-01, were terminated within the sand and silt till at depths ranging from 14.2 m to 20.2 m (Elevation 296.1 to 290.4).

The SPT 'N' values of the sand and silt till ranged from 50 to over 100 blows per 0.3 m of penetration indicating a very dense state. The natural moisture contents generally lay in the range of 6 percent to 19 percent.

Grain size distribution curves for the sand and silt till samples tested are presented on the Record of Borehole sheets in Appendices A and B and on Figure A6 of Appendix A and Figure B4 in Appendix B. The results of gradation tests carried out on selected sampled are summarized follows:

Soil Particles	Percentage (%)
Gravel	0 to 17
Sand	29 to 50
Silt	30 to 55
Clay	10 to 24

The results of Atterberg Limits conducted on the clayey zone encountered within the sand and silt till, are presented on the Record of Borehole sheets and in Figure A10 included in Appendix A. The results of Atterberg Limits testing are summarized below:

Liquid Limit	16
Plastic Limit	11
Plasticity Index	5

The above results show that the clayey zone of the sand and silt till is of low plasticity with a group symbol of CL-ML.

Glacial tills inherently contain cobbles and boulders.

## 5.8 Groundwater Conditions



Groundwater conditions were observed during drilling operations, and groundwater levels were measured in the open boreholes upon completion of drilling. Standpipe piezometers were installed in Boreholes NE16-02, NE16-04, RW18-01, and RW18-02 to monitor the groundwater level at the site. The groundwater levels measured in the open boreholes and in the standpipe piezometers are summarized below.

**Table 5.1 – Water Level Measurements**

Foundation Unit	Borehole	Date	Water Level (m)		Remark
			Depth	Elevation	
North Approach	NE16-01	June 11, 2018	Dry	-	Open Borehole
North Abutment	NE16-02	June 25, 2018	2.8	307.1	Piezometer
	08-002	July 16, 2008	5.5	302.8	Piezometer
		Aug. 20, 2008	5.5	302.8	
Pier 1	NE16-03	June 12, 2018	13.6	296.3	Open Borehole
	08-004	June 11, 2008	1.5	307.3	Open Borehole
South Abutment	NE16-04	May 16, 2018	3.1	307.5	Piezometer
		May 31, 2018	3.0	307.6	
		June 25, 2018	3.5	307.1	
South Approach	NE16-05	June 14, 2018	Water level not taken due to the use of mud while drilling		-
Amour Stone Retaining Walls	RW18-01	June 25, 2018	3.5	306.9	Piezometer
	RW18-02	May 14, 2018	2.8	307.1	Piezometer
		May 31, 2018	2.7	307.2	
		June 25, 2018	2.7	307.2	
	RW18-03	June 13, 2018	4.7	305.4	Open Borehole
	RW18-04	May 10, 2018	Water level not taken due to the use of mud while drilling		-

The groundwater levels above are short-term readings, and seasonal fluctuations of the groundwater levels are to be expected. The groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

## 6. CORROSIVITY AND SULPHATE TEST RESULTS

Samples of the silty sand fill and native silty sand from Boreholes NE16-04 and RW18-04 were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix A.

**Table 6.1 – Analytical Test Results**

Parameter	Units (Soil)	Test Results	Test Results
		RW18-04 SS 4 Depth 2.3 m	NE16-04 SS 4 Depth 2.4 m
		Silty sand	Silty sand fill
Sulphide	%	<0.02	0.03
Chloride	µg/g	200	100
Sulphate	µg/g	130	130
pH	No unit	8.16	8.72
Electrical Conductivity	µS/cm	300	291
Resistivity	Ohms.cm	3330	3440
Redox Potential	mV	192	217

## 7. MISCELLANEOUS

Landshark Drilling of Brantford, Ontario supplied a rubber-track mounted B-57 drill rig and conducted the drilling, sampling and in-situ testing operations for the present investigation.

The coordinates for the boreholes were obtained with GPS equipment by Thurber, and the elevations were provided by WSP.

The drilling and sampling operations in the field for the current investigation were supervised on a full-time basis by Thurber field technicians.

Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory in Oakville. Analytical laboratory testing was carried out by SGS Canada Inc.





Overall supervision of the field program for the investigation was conducted by Dr. Nancy Berg, P.Eng. Interpretation of the data and preparation of the current report was carried out by Ms. R. Palomeque Reyna, P.Eng. and Dr. Nancy Berg, P.Eng.

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

Thurber Engineering Ltd.



Nancy Berg, Ph.D., P.Eng.  
Geotechnical Engineer



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Review Principal, Designated MTO



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**PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

**8. GENERAL**

This report presents an interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations to assist the design team to select and design a suitable foundation system for a new structure to carry the N-E/W Ramp over Guelph Street (northwest of the Wellington Street and Kitchener-Waterloo Expressway interchange) in the Regional Municipality of Waterloo, Ontario.

The General Arrangement (GA) drawing provided by WSP, dated July 2012, indicates that the new N-E ramp structure has two spans, the spans are 31.0 m and 25.0 m in length, and varies from 12.8 m to 14.0 m in width, supported by two abutments and one pier. All foundation elements are shown to be supported on driven steel H-piles. The north and south approach embankments will be in the order of 8.6 m to 9.8 m high, respectively.

Retaining walls are proposed to retain the approach fills beyond the abutment wingwalls at the north abutment. Lightweight fill is proposed in an area east of the new east retaining wall at the north abutment in order to reduce the embankment loading on the existing culvert. The details and conditions of the existing culvert are not known.

Armour stone walls (labelled RW-18) are proposed at this site to retain the forward slope in front of the south abutment adjacent to the drainage channel banks. This wall type is proposed by the MTO Region to preserve the natural environment within the area. The armour stone wall face is inclined at approximately 75 degree to horizontal and runs parallel to an existing channel. The length of the wall is proposed to be approximately 60.0 m, and the height is proposed to be up to approximately 9.0 m high. The forward slope of the north abutment is proposed to be 2H:1V with concrete slope paving covering the slope.

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This foundation investigation and design report, with the interpretation and recommendations, is intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The contractors must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects, which could affect the design of the project. Contractors must make their own interpretation of the information provided as it may affect equipment selection, proposed construction methods and scheduling.

The discussions and recommendations presented in this report are based on the information provided by WSP and on the factual data obtained in the course of this investigation.

## **9. STRUCTURE CLASSIFICATION**

In accordance with the currently applicable Canadian Highway Bridge Design Code (CHBDC) (2019) CSA S6-19, the analysis and design of structures are influenced by its importance category and consequence classification. Such designations are defined by the Regulatory Authority, which in this case, is the Ministry of Transportation of Ontario (MTO).

For the purpose of reporting, this structure has been classified as a Major-Route Bridge with Typical Consequence based on CHBDC S6-19 Sections 4.4.2 and 6.5.2, respectively.

Based on the above classification and Table 6.1 in Section 6.5.2 in the CHBDC (2019), a consequence factor,  $\psi$ , of 1.0 has been used for assessing ULS and SLS factored geotechnical resistances. Should the consequence classification changes, the geotechnical assessment and recommendations will need to be reviewed and revised as necessary.

## **10. STRUCTURE FOUNDATIONS**

The stratigraphy identified in the geotechnical investigations consisted primarily of surficial topsoil overlaying loose to compact cohesionless fill (silty sand) and soft to very stiff cohesive fill (silty clay), overlaying native layers of soft to hard silty clay and silty clay till, loose to compact sands and silts, which are underlain by very dense sand and silt till. The groundwater levels measured in the piezometers ranged from 2.7 m and 3.5 m below the ground surface (Elevations 306.9 to 307.6).



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

1. Spread footings bearing on native soil
2. Spread footings on engineered fill
3. Augered caissons (drilled shafts)
4. Steel H-piles or steel pipe piles driven into the very dense sand and silt till

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

### 10.1 Spread Footing on Native Soil

Spread footings bearing on native soil are generally a cost-effective form of foundation and are feasible at this site, however relatively deep excavation in the order of 5 to 6 m is required

The existing fill is not considered suitable for the support of spread footings, and the spread footings should bear on native undisturbed very stiff to hard silty clay/silty clay till. Provided a minimum footing width of 2 m is maintained, the spread footings may be designed in accordance with the elevations and bearing resistances given in Table 10.1.

**Table 10.1 – Geotechnical Resistances for Spread Footings**

Foundation Element	Borehole	Approximately Founding Elevation (m)	Founding strata	Factored $ULS_f$ (kPa)	Factored $SLS_f$ (up to 25 mm settlement) (kPa)
North Abutment	08-002 NE16-02	305	Native Very stiff silty clay/silty clay till	350	250
Pier	08-004 NE16-03	304	Native Very stiff to hard silty clay/silty clay till	350	250
South Abutment	NE16-04 RW18-04	304.5	Native Very stiff silty clay	350	250



The values of the Factored Geotechnical Resistance at ULS were assessed assuming a Consequence Factor equal to 1 (Typical), and a Resistance Factor equal to 0.5 (Typical degree of understanding of the subsurface conditions), as per CHBDC 2019. The factored Geotechnical Resistance at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.

The bearing resistances in Table 10.1 are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be adjusted as shown in the CHBDC (2019) Clause 6.10.2 to Clause 6.10.5.

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

The sliding resistance of cast-in-place concrete placed on the native, undisturbed silty clay/silty clay till may be computed based on an ultimate coefficient of friction,  $\tan \delta$ , of 0.35. A resistance Factor of 0.6 should be applied for cohesive soils, as indicated in Table 6.2 in the CHBDC (2019).

The groundwater levels measured in the piezometers ranged from 2.7 m and 3.5 m below the ground surface (Elevations 306.9 to 307.6). The above founding elevations are below the measured groundwater levels. For temporary excavations required to construct the footings, local groundwater control and dewatering will be required to construct the footing in the dry and to prevent disturbance of the footing base.

The bases of the foundation excavations should be inspected by a Foundation Specialist to confirm that the exposed subgrade surface conforms to the design requirements and has been adequately prepared to receive concrete. Once approved, the subgrade should be protected by a working mat with a minimum thickness of 100 mm and consisting of concrete of the same strength and class as that of the footing. Where sub-excavation is required to remove unsuitable material from below the design founding level, the founding surface should be re-established using the same concrete.



## 10.2 Spread Footing on Engineered Fill

Spread footings can also be founded on Granular “A” engineered fill pads, where this is beneficial to the overall design.

However, it should be noted that construction of engineered fill pads will require deep excavation (up to 5 m) for the North abutment and Pier to bear on competent native soils.

If an engineered fill pad option is selected, all topsoil or other deleterious materials must be stripped from the footprint of the foundation to expose competent native subgrade material. Subexcavation of existing surficial fill soils will be required. The engineered fill will bear on native stiff to very stiff silty clay/silty clay till and compact sandy silt/silty sand, and the highest permitted elevations at which engineered fill pads may be placed, are given in Table 10.2.

**Table 10.2 – Highest Founding Elevations for Engineered Fill Pads**

North Abutment (BH 08-002, NE16-02)	Pier (BH 08-004, NE16-03)	South Abutment (BH RW18-04, NE16-04)
305.0	305.5	307.0

Provided a minimum footing width of 2 m is maintained footings bearing on the well compacted engineered fill pad, at least 2 m thick, may be designed for the following geotechnical resistances:

Factored Geotechnical Resistance at ULS 900 kPa

Factored Geotechnical Resistance at SLS 350 kPa

These resistance values are for concentric, vertical loads only. In the case of eccentric or inclined loading, the geotechnical resistance must be calculated as illustrated in the CHBDC (2019) Clause 6.10.2 and Clause 6.10.5.

The values of the Factored Geotechnical Resistance at ULS were assessed assuming a Consequence Factor equal to 1 (Typical), and a Resistance Factor equal to 0.5 (Typical degree of understanding of the subsurface conditions), as per CHBDC 2019. The Factored Geotechnical Resistance at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.



The above founding elevations of engineered fill pad are below the measured groundwater levels (i.e. Elev. 307.6).

For temporary excavations required to construct the engineered fill local groundwater control and dewatering will be required to construct the engineered fill pad in the dry and to prevent disturbance of the engineered fill pad base.

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

The sliding resistance of cast-in-place concrete placed on the engineered fill may be computed based on an ultimate coefficient of friction,  $\tan \delta$ , of 0.55. Resistance Factor of 0.8 should be applied for cohesionless soils, as indicated in Table 6.2 in the CHBDC (2019).

The bases of the foundation excavations should be inspected by a Foundation Specialist to confirm that the exposed surface conforms to the design requirements and has been adequately prepared to place the engineered fill. The Granular A for the engineered fill pad must be compacted to 100% Standard proctor maximum dry density (SPMDD) at the optimum moisture content of  $\pm 2\%$ , and placed in 300 mm lifts. The geometry of the fill pad must conform to the general requirements shown in Figure 1 in Appendix D.

### **10.3 Augered Caissons (Drilled Shafts)**

Drilled shaft foundations founded on very dense silt and sand till were considered for the support of foundation loads at this site. However, augered caissons (drilled shafts) are not recommended for use as foundation support at this site due to high groundwater level and potential caisson installation difficulties including basal boiling and heave with the water bearing sand and silt till deposit below the silty clay. Therefore, this option is not recommended and has not been developed further.

### **10.4 Steel H-Piles and Steel Pipe Piles**

From a foundation engineering perspective, it is feasible to support the structure on steel H-piles driven to practical refusal in the very dense sand and silt till/sandy silt till. Open ended steel pipe piles may also be considered as an alternate foundation option. It should be noted that pipe piles



driven into very dense sand and silt till/sandy silt till deposits are more prone to pile tip damage in comparison to H-piles.

The GA drawing indicates that the underside elevations of the abutment stem at the north and south abutments are approximately 312.3 m and 313.1 m respectively, and at the pier it is at approximate elevation 308.0 m.

#### 10.4.1 Axial Resistance

The axial resistances of HP 310 X 110 and HP 360 x 132 steel piles, and 324 mm diameter and 356 mm diameter steel piles driven to refusal in very dense till were assessed based on the subsurface conditions encountered at the abutment and pier locations. The estimated Ultimate Limit States (ULS) and geotechnical resistance at Serviceability Limit States (SLS), as well as the recommended pile tip elevations are summarized in Tables 10.3 and 10.4.

**Table 10.3 – Estimated Axial Resistance and Pile Tip Elevation for H-Piles**

Foundation Unit	Borehole	Approx. Pile Tip Elevation (m)	Minimum Pile Length Assumed (m)	Pile Section HP 310 X 110		Pile Section HP 360 X 132	
				Factored ULS (kN)	Factored SLS <sub>r</sub> (kN)	Factored ULS (kN)	Factored SLS <sub>r</sub> (kN)
North Abutment	08-002 NE16-02	293.0	19.0	1,300	1,100	1,450	1,250
Pier	08-004 NE16-03	292.0	16.0	1,200	1,000	1,350	1,150
South Abutment	NE16-04 RW18-04	291.0	22.0	1,300	1,100	1,450	1,250





**Table 10.4 – Estimated Axial Resistance and Pile Tip Elevation for pipe piles**

Foundation Unit	Borehole	Approx. Pile Tip Elevation (m)	Minimum Pile Length Assumed (m)	Pile Section 324 mm diameter Wall Thickness 12.7 mm		Pile Section 356 mm diameter Wall Thickness 12.7 mm	
				Factored ULS (kN)	Factored SLS <sub>r</sub> (kN)	Factored ULS (kN)	Factored SLS <sub>r</sub> (kN)
North Abutment	08-002 NE16-02	293.0	19.0	1,150	950	1,350	1,150
Pier	08-004 NE16-03	292.0	16.0	1,050	900	1,250	1,050
South Abutment	NE16-04 RW18-04	291.0	22.0	1,150	950	1,350	1,150

The values of the Factored Geotechnical Resistance at ULS were assessed assuming a Consequence Factor equal to 1 (Typical), and a Resistance Factor equal to 0.4 (Typical degree of understanding of the subsurface conditions), as per CHBDC 2019. The SLS values correspond to a maximum pile settlement of 25 mm. The Factored Geotechnical Resistance at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.

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

#### 10.4.2 Downdrag

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

#### 10.4.3 Lateral Resistance

The geotechnical lateral resistance of a pile may be calculated using the coefficient of horizontal subgrade reaction ( $k_s$ ) and the ultimate lateral resistance ( $P_{ult}$ ) as follows:

Silty Clay/Silty Clay Till (cohesive soils)

$$k_s = 67 C_u / B \text{ (kN/m}^3\text{)}$$



$$p_{ult} = 9 C_u \quad (\text{kPa}) \text{ at and below a depth of } 3B \text{ reduced to zero at ground surface}$$

where  $p_{ult}$  = ultimate lateral resistance mobilized by a pile, kPa

$C_u$  = undrained shear strength of cohesive soils, kPa

$\gamma$  = unit weight of soil, kN/m<sup>3</sup>

$B$  = width of pile, m

Silty sand, sand and silt till/sandy silt till (cohesionless soils)

$$k_s = n_h \cdot z / B \quad (\text{kN/m}^3)$$

$$p_{ult} = 3 \cdot \gamma' \cdot z \cdot K_p \quad (\text{kPa})$$

where  $z$  = depth of embedment of pile, m

$B$  = pile width, m

$n_h$  = coefficient related to soil density, kN/m<sup>3</sup>, Table 10.5

$\gamma'$  = Bouyant unit weight of soil, kN/m<sup>3</sup>, Table 10.5

$K_p$  = passive earth pressure coefficient, Table 10.5

The above equations and recommended parameters may be used to analyze the interaction between a pile and the surrounding soil. The lateral pressure obtained from the analysis should not exceed the ultimate lateral resistance.

The spring constant,  $K$ , for analysis may be obtained by the expression,  $K = k_s \times d_z \times B$  (kN/m), where  $k_s$  is the coefficient of horizontal subgrade reaction (kN/m<sup>3</sup>),  $B$  is the pile width (m),  $d_z$  is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance on any one segment of pile,  $P_{ult}$ , may be obtained from the expression,  $P_{ult} = p_{ult} \times d_z \times B$ . This represents the ultimate load at which the pile fails and will not support any additional load at greater displacements.

For pile lateral resistance design below the flexible zone, soil-pile interaction analyses may be carried out using the soil parameters provided in Table 10.5 below.

**Table 10.5 – Recommended Geotechnical Parameters for Lateral Resistance Design**

Location	Reference Boreholes	Approx. Elevation (m)	Undrained Shear Strength $C_u$ (kPa)	Unit Weight $\gamma$ (kN/m <sup>3</sup> )	$K_p$	$n_h$ (kN/m <sup>3</sup> )	Soil Conditions
North Abutment	08-002 NE16-02	309.5 to 306.0	-	20	3.0	2,000	Loose to compact sand and gravel fill/silty sand fill, firm to stiff silty clay fill
		306.0 to 297.0	150	10*	-	-	Very stiff to hard silty clay till/silty clay
		297.0 to 292.8	-	11*	4.0	10,000	Very dense sand and silt till/sandy silt till
Pier	08-004 NE16-03	309.0 to 306.0	-	20	3.0	2,000	Very loose to compact sand and gravel fill, sand fill, silty sand fill
		306.0 to 304.0	-	11*	3.0	2,500	Loose to compact silty sand
		304.0 to 295.0	150	10*	-	-	Very stiff to hard silty clay till
		295.0 to 291.5	-	11*	4.0	10,000	Very dense sand and silt till/sandy silt till
South Abutment	NE16-04 RW18-04	310.0 to 307.5	-	20	3.0	2,000	Firm silty clay fill, very loose to compact silty sand fill, sandy silt fill
		307.5 to 305.0	-	11*	3.1	2,800	Compact sandy silt/silty sand
		305.0 to 295.0	150	10*	-	-	Stiff to hard silty clay/silty clay till
		295.0 to 290.4	-	11*	4.0	10,000	Very dense sand and silt till

\* Buoyant unit weight below water table

The group efficiency factors can be calculated based on side-by-side and line-by-line factors shown in Figures C6.22, C6.23 and C6.24 of the CHBDC (2019), S6:19 (Commentary).



#### **10.4.4 Pile Installation**

All piles shall be installed in accordance with OPSS 903 and SP 109F57.

At this site, the piles will have to be driven into the very dense sand and silt till/sandy silt till.

Pile driving must be controlled in accordance with Standard Provision SS103-11 (Hiley Formula) and an ultimate pile resistance must be specified by the designer. The Hiley formula does not need to be used until the pile tip is within 2 m of the design tip elevation. The appropriate pile driving note to be shown on the contract drawing is "Piles to be driven in accordance with Standard SS103-11 using an ultimate geotechnical resistance of R kN per pile" where "R" must have a minimum value of twice the factored design load at ULS. It is recommended that Pile Driving Analysis (PDA) testing be conducted in conjunction with the Hiley tests at this site, to ensure the integrity of the pile and to verify pile ultimate geotechnical resistance. PDA testing should be completed for 10 percent the piles for each foundation element or a minimum of 2 piles tested at each foundation element, whichever is more.

To facilitate pile installation, embankment fill through which piles will be driven must not contain any material with particle sizes greater than 75 mm.

Glacially derived soils inherently contain cobbles and boulders. Hard driving conditions through the very dense till soils should be expected. In order to minimize pile damage while driving through boulders, cobbles and harder/dense zones to achieve the required tip elevations and pile resistance, it is recommended that the pile tips be reinforced with Titus steel (Standard H-point).

Pile tip protection should be provided for open ended pipe piles.

The Contract Documents must contain a NSSP alerting the Bidders to the presence of cobbles and boulders in the glacial tills. Suggested texts for the NSSP's are included in Appendix G. The NSSP should contain a requirement to terminate driving before the pile is damaged by overdriving.

#### **10.5 Abutment Design Considerations**

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



For integral abutments, the flexibility of the upper portion of the pile may be provided by a single corrugated steel pipe (CSP) system. Reference should be made to the integral abutment manual for details of this system. Piles should be driven first before pouring in loose uniform sand between the CSP surround and the pile.

## **10.6 Frost Cover**

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

## **10.7 Recommended Foundation**

From a geotechnical perspective, and based on available information, it is recommended that the foundations for the north and south abutments and the pier be supported on steel H-piles driven into the very dense sand and silt till/sandy silt till.

## **11. RETAINING WALLS**

The GA drawing dated July 2012, indicates that construction of two retaining walls, one on each side connecting to the north abutment wingwalls are proposed behind the north abutment. The west and east retaining walls are proposed to be 6 m and 10 m long, respectively. The GA also indicates that light weight fill is proposed in an area east of the east retaining wall in order to reduce the embankment loading on the existing culvert.

Armour stone retaining walls (identified as RW-18) are proposed along the existing channel and in front of the south abutment, extending towards the southwest. The armour stone walls run parallel to an existing drainage channel and has a forward slope angle of approximately 75 degrees. The length of the armour stone wall is proposed to be 60.0 m, and the proposed height ranges from approximately 6.5 m to 9.0 m on the south side of the channel and is approximately 1.5 m tall on the north side of the existing channel. Tiebacks are shown in the GA to provide reinforcement for the armour stone wall for the south forward slope. Based on the GA, the tiebacks range in length from approximately 7 m to 9.5 m, and should be similar to typical tiebacks/reinforcing strips used for RSS walls. Excavation for the armour stone wall foundation will extend below the existing surface water level shown on the GA. Excavation within a sheet



pile cofferdam will be required to construct the armour stone wall foundation below the existing surface water level.

To provide an acceptable foundation performance, the retaining walls must be founded on the very stiff silty clay or compacted Granular A fill. The highest recommended base levels for the underside of the retaining walls are as presented in Table 11.1.

**Table 11.1 – Founding Strata and Elevations**

Retaining Wall	Borehole	Approx. Founding Elevation (m)	Founding Stratum	Factored ULS <sub>r</sub> (kN)	Factored SLS settlement) (kPa)(up to 25 mm settlement) (kN)
North abutment East side	08-002	311.0	New Granular A Engineered Fill	450	300
North abutment West side	NE16-02	314.5	New Granular A fill	450	300
South abutment RW-18 South bank	RW18-02 RW18-04	305.0	Very stiff silty clay	350	250
South abutment RW-18 north bank	RW18-01 RW18-03	308.0	Compact to Dense Sand and Silt	350	250

The factored ULS and SLS for the retaining walls on the east and west sides of the north abutment are contingent on the retaining wall footing be founded on an Engineered Fill Pad consisting of compacted Granular “A” following the configuration shown in Appendix D. The Engineered Fill Pad under the retaining wall footing must not contain earth fill. Sub-excavation of existing fill materials will be required. to achieve the minimum 2m thick engineered fill pad requirement.

The founding elevation for the retaining wall on the east side of the north abutment is lower than shown in GA to prevent additional loading from being added to the existing culvert since the



retaining wall can not be founded on the light-weight fill that is planned to be placed on the east side of the north abutment to limit the loading on the existing culvert.

The geotechnical SLS values given above are based on an estimated total settlement not exceeding 25 mm.

If required, the armour stone walls may be founded on engineered fill founded on the native very stiff silty clay. Engineered fill placed under the retaining walls, to achieve the design founding level must consist of OPSS Granular "A" placed in 200 mm lifts compacted to 100% of its SPMD at a moisture content within 2% of optimum.

The geotechnical resistances provided above are for concentric, vertical loading. The effects of load inclination and eccentricity need to be taken into account according to the CHBDC (2019) Clauses 6.10.2 to 6.10.5.

Retaining walls must be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall or engineered granular fill in contact with the stiff to very stiff silty clay till/silty clay and compact sandy silt/silty sand may be estimated using ultimate friction coefficients of 0.35 and 0.45, respectively. A resistance Factor of 0.6 should be applied for cohesive soils and, 0.8 for cohesionless soils, as indicated in Table 6.2 in the CHBDC (2019).

Topsoil, organics, loose fill, and any soft/wet material must be stripped from the footprint of the retaining walls. The subgrade under the retaining wall foundations should be inspected and any soft spots sub-excavated and replaced with compacted granular materials prior to placing fill. The subgrade preparation for the retaining wall and placement and compaction of the granular fill must be carried out in the dry.

The armour stone walls used on this project should be specified to be "High Performance" and "High Appearance". Therefore, it is important that the walls be founded on soil capable of supporting the imposed loading and limiting settlements under the wall to acceptable magnitudes.

For any wall system selected by the Contractor which is not included on the MTO RSS DSM List (9.70.56), the selected proprietary wall supplier/designer will need to submit the retaining wall design to MTO for review and approval. A NSSP has been prepared to reflect this and is included



in Appendix G. The internal stability and integrity of the armour stone wall must be analyzed by the supplier/designer of the proprietary product selected for this site.

Since the armour stone wall foundation is constructed below the creek level, it is recommended that scour protection measures be designed to prevent undermining of the wall foundation. The depth of scour must be determined by a river/creek hydraulics specialist during the detailed design stage based on Section 1.9 of the CHBDC 2019.

Lateral earth pressures acting on the walls should be computed as described in Section 12. If the wall is retaining sloping backfill, appropriate earth pressure parameters for sloping backfill should be used.

### 11.1 Slope Stability of the Armour Stone Wall

A preliminary analysis of the global stability was conducted to assess the stability of the proposed armour stone retaining wall (RW-18). The stability analysis will need to be revisited when the final design is provided by the proprietary wall supplier to check the required tie back length. The armour stone retaining wall will be up to 9.0 m high and 60.0 m long.

For the purpose of embankment stability analyses a commercially available slope stability program GEO-SLOPE was used. The Morgenstern-Price method was employed. The stability of the retaining wall was also checked under seismic loading assuming an acceleration of 0.097g. The computed factors of safety are as shown in Table 11.2. Slope stability computation outputs are included in Appendix F.

**Table 11.2 Computed Factors of Safety**

Condition	Factor of Safety	Figure (Appendix F)
<b>Retaining wall up to 9.0 m high</b>		
Drained	1.6	F1
Undrained	1.6	F2
Seismic = 0.097g	1.3	F3

As per typical MTO requirements, a Factor of Safety (F.S.) of 1.3 is acceptable for short term conditions and for total stress (undrained) conditions. A F.S. of 1.5 is acceptable for long term





(drained) conditions. Under the assumed seismic loading, the minimum acceptable factor of safety is 1.1. In the case of static loading, the factor of safety against global failure was 1.6 for drained and undrained conditions. Under the estimated seismic loading, the minimum factor of safety calculated was 1.3. These factors of safety are considered to be acceptable for the proposed embankment bearing on the compact sand and silt soils below the fill encountered at this site.

## 11.2 Settlement of the Armour Stone Wall

The construction of armour stone walls on 0.5 m thick pads of granular engineered fill will induce immediate (elastic) settlement and consolidation in the underlying loose to compact silty sand/sand and silt and stiff to very stiff silty clay.

The immediate settlement were assessed using elastic methods. Based on these analyses, the settlement under a 9.0-m high armour stone wall is estimated to be approximately 40 mm to 50 mm. For armour stone walls less than 4.5-m high, the anticipated settlement is less than 25 mm. The proprietary designer of the Armour stone wall must be consulted to see if the proprietary design can accommodate the expected settlement and if the settlement would reduce the tensile resistance of the tie backs.

This settlement will be essentially complete when construction of the armour stone wall and approach fill placement are completed.

## 12. LATERAL EARTH PRESSURES

Earth pressures acting on a structure (e.g. abutment or retaining wall), may be assumed to be triangular and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC 2019 but are generally given by the expression:

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

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

$K$  = earth pressure coefficient (see Table 12.1)

$\gamma$  = unit weight of retained soil (see Table 12.1)

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

$q$  = value of any surcharge (kPa).

In accordance with Clause 6.12.3 of the CHBDC 2019, a compaction surcharge should be added. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS.PROV 501.

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown in Table 12.1.

**Table 12.1 – Earth Pressure Coefficients**

Wall Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.40	0.31	0.48
At rest (Restrained Wall)	0.43	0.62	0.47	0.70
Passive (Movement Towards Soil Mass)	3.7	-	3.2	-

If some movement of the wall is allowed (unrestrained system), active horizontal earth pressure may be used in the geotechnical design of the structure. For rigid walls, at-rest horizontal earth pressures should be used.

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the wall.

The factors in Table 12.1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to be used in the design can be estimated from Figure C6.27 in the Commentary to the CHBDC 2019.

It is recommended that perforated sub-drains and/or weep holes be installed, where applicable, to provide positive drainage of the granular backfill behind the abutment walls and the retaining walls. Reference may be made to OPSD 3102.100 where appropriate.



### **13. APPROACH EMBANKMENTS**

Based on the GA drawing dated July 2012, the proposed finished grade of the N-E/W ramp over Guelph Street vary from approximate Elevations 318.6 to 320.3, from north to south. The proposed grade of Guelph Street will be at approximately Elevation 310.0 to 310.5. As a result, placement of new fill up to 9.8 m will be required for the south and north approaches.

All embankment fill must be constructed with adequate quality control in accordance with OPSS.PROV 206 and OPSS.PROV 501 requirements and the clean earth fill must not contain medium or high plastic clay.

It is also recommended that all permanent and temporary slope surfaces be vegetated and seeded in accordance with current MTO practice with reference to OPSS.PROV 804. Surface runoff and precipitation must be prevented from flowing perpendicularly down any slope surface. Erosion protection measures must be provided as necessary to maintain slope stability.

Prior to fill placement, the subgrade must be adequately prepared to receive the new fill. All vegetation, topsoil, organics, soft/loosened or wet soils should be sub-excavated.

#### **13.1 Slope Stability of Embankment Side Slopes**

The global, internal and surficial stability of the approach embankment fills will depend on the slope geometry and also to a large degree on the material used to construct the embankments. Embankments constructed using granular material, select subgrade material, or clean earth fill will have stable side slopes at inclinations of up to 2H:1V.

Where earth fill embankments are higher than 8 m, mid-height berms should be incorporated in each 8 m vertical interval. The berms should:

- extend for the length through which the embankment height exceeds 8 m
- be at least 2 m wide
- have 2% positive grade to shed run-off water

The analyses of global stability of a 8 m high side slope configuration was analysed.

The Morgenstern-Price method was employed in conjunction with a commercially available slope stability program GEO-SLOPE to carry out the analyses. The computed factors of safety are as shown in Table 13.1. Graphical outputs of these analyses are included in Appendix F.

**Table 13.1 Computed Factors of Safety**

Condition	Factor of Safety (8 m high embankment)	Figure (Appendix F)
<b>Side Slope</b>		
Drained	1.9	F4
Undrained	1.9	F5
Seismic = 0.097g	1.5	F6

As per typical MTO requirements, a Factor of Safety (F.S.) of 1.3 is acceptable for short term conditions and for total stress (undrained) conditions. A F.S. of 1.5 is acceptable for effective stress (drained) conditions. Under the assumed seismic loading, the minimum acceptable factor of safety is 1.1. In the case of static loading, the factor of safety against global failure was 1.9 for drained and undrained conditions. Under the estimated seismic loading, the minimum factor of safety calculated was 1.5. These range of factors of safety are considered to be acceptable for this site.

### 13.2 Settlement of Approach Embankments

It is estimated that at the approach embankments, settlements of 40 mm to 50 mm will occur in the foundation soils under the loading imposed by approximately 9.8 m of the new approach fill. This settlement will be immediate and essentially complete when construction of the fill is completed.

Embankment settlement due to fill compression is estimated to 0.5% of the fill height. Approximately 50% of the total fill compression (or 0.25% of the fill height) will occur during construction and the remaining 50% or approximately 20 to 25 mm at this site will occur after construction.

No long-term settlement issues are anticipated for approach embankments built at this site.



#### **14. TEMPORARY EXCAVATION**

All excavations at this site must be carried out in accordance with the Occupational Health and Safety Act (OHSA). The excavation and backfilling for foundations must be carried out in accordance with OPSS.PROV 902 and SP 109S12.

Excavation for foundation construction will be extended through the loose to compact sand and gravel fill, silty sand fill, sandy silt fill, soft to very stiff silty clay fill and native soft to very stiff silty clay/silty clay till.

For the purposes of the OHSA, the fill and native soils (silty clay/silty clay till) above the water table are classified as Type 3. Soils below the water table are classified as Type 4.

The selection of the method of excavation is the responsibility of the contractor and must be based on his equipment, experience and interpretation of the site conditions. Excavations should regularly be inspected for evidence of instability if they have been left open for extended periods of time and following periods of heavy rain or thawing. If required, remedial actions must be taken to ensure the stability of the excavation and the safety of workers.

#### **15. BACKFILL TO ABUTMENTS**

For backfilling immediately behind the new abutment wall, it is recommended that the new fill be Granular A or Granular B Type II materials meeting the gradation and relevant requirements stipulated in OPSS.PROV 1010. Beyond this zone, Granular B Type I, Select Subgrade Material (SSM) or clean earth fill may be used.

The backfill should be in accordance with OPSS.PROV 206 requirements and OPSD 3101.150. Compaction equipment to be used adjacent to abutments/retaining structures must be restricted in accordance to OPSS.PROV 501.

The design of the abutment must incorporate a subdrain as shown in OPSD 3102.100.

#### **16. GROUNDWATER AND SURFACE WATER CONTROL**

The groundwater levels measured in the piezometers ranged from 2.7 m and 3.5 m below the ground surface (Elevations 306.9 to 307.6). Seasonal fluctuations of the groundwater level are



to be expected. Excavation for footing or pile cap construction may extend below the groundwater level at some locations. In general, seepage from perched water from the granular fill is to be expected.

Excavation for pile cap at the pier location for the case of deep foundation is not anticipated to extend below the groundwater level. Groundwater control will likely be limited to diverting surface runoff and preventing precipitation from entering the excavations and supplemented by sump pumping for this case. Filtered sumps must be properly designed to control loss of fines/ground loss.

However, if footing is the selected foundation type, the recommended founding levels are below the groundwater level. Excavation of the cohesionless soils below the groundwater level without prior dewatering is not recommended since the inflow of groundwater will cause base boiling and side wall sloughing of the soil below the water table making it difficult to maintain a dry, sound base on which to work. Suitable systems that might be considered to maintain an unwatered condition at this site, include pumping from filtered sumps for nominal penetration below the groundwater level. For deeper penetration below the groundwater level, sheeted excavation (cofferdam) or vacuum well-points may be required. The dewatering system must be effective to maintain the water level at a minimum depth of 0.5 m below the final footing/pile cap grade throughout construction.

Based on the grain size distribution curves, the coefficients of permeability (k) of the native soils are as follows:

Soil	Permeability, k (cm/sec)
Sand/Silt	$1 \times 10^{-2}$ to $2 \times 10^{-4}$
sand and silt till	$1 \times 10^{-5}$ to $1 \times 10^{-6}$
Silty clay/Silty clay till	$1 \times 10^{-7}$ to $1 \times 10^{-8}$

Dewatering of all excavations should be carried out in accordance with OPSS. PROV 517, SP 517F01 Amendment to OPSS 517, November 2016 (issued July 2017), and OPSS. PROV 902 and SP 109S12.

The design of the dewatering system that may be required is the responsibility of the Contractor, and the Contract Documents must alert him to this responsibility. The design the dewatering



system must take account of the maximum water level in the existing channel likely to occur during construction of the armour stone wall footings. Suitable systems that might be considered to maintain an unwatered condition at this site include sheeted excavation (cofferdam) and/or vacuum well-points.

The groundwater and surface runoff must be controlled during construction to maintain a stable excavation and to allow concrete to be placed in a dewatered excavation. Placement of concrete or compacting engineered fill must be done in the dry. Dewatering must remain operational and effective until the footings are constructed and backfilled. Suggested wording for an NSSP in the regard is included in Appendix G.

A Ministry of Environment (MOE) Permit to Take Water (PTTW) or requesting with Environmental Activity and Sector Registry (EASR), depending on the groundwater pumping volume, will likely be required prior to construction and should be anticipated by the Contractor.

Water discharged from unwatering operations or displaced during concrete placement may not be suitable for direct discharge to the existing water channel. The contract documents must alert the contractor to this fact and include an item for treatment of the water to the satisfaction of MOE, Ministry of Natural Resources (MNR), Department of Fisheries and Oceans (DFO) or other agencies having jurisdiction, prior to discharge to the channel.

## 17. ROADWAY PROTECTION

If roadway protection is required during construction of the proposed ramp, an item titled "Protection System" as per OPSS 539 should be included in the contract documents. It is recommended that Performance Level 2 as per Clause 539.04.01.01 and the alignment of the shoring be specified on the contract drawings.

The design of roadway protection should be the responsibility of the Contractor. However, one option that is considered to be suitable for use as temporary shoring at this site is a soldier pile and lagging wall.

A temporary soldier pile and lagging wall may be designed using the parameters given below:

$$\begin{aligned}\gamma &= 20 \text{ kN/m}^3 \\ \gamma_w &= 10 \text{ kN/m}^3 \\ K_a &= 0.36 \text{ (fills)}\end{aligned}$$



	=	0.33 (sands and silts)
	=	0.35 (silty clay)
	=	0.24 (sand and silt till)
$K_p$	=	2.8 (fills)
	=	3.0 (sands and silts)
	=	2.9 (silty clay)
	=	4.2 (sand and silt till)

The actual pressure distribution acting on the shoring system is a function of the construction sequence, and the relative flexibility of the wall and these factors must be considered when designing the shoring system. All shoring systems should be designed by a Professional Engineer experienced in such designs.

## 18. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2019, the selection of the seismic site classification is based on the averaged soil conditions encountered in the upper 30 m of the stratigraphy. The stratigraphy of the site consists of topsoil and loose to compact cohesionless fill and soft to very stiff cohesive fill, overlaying native layers of soft to hard silty clay and silty clay till, layers of loose to compact sands and silts, which are underlain by very dense sand and silt till.

This would correspond to a Seismic Site Class D in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2% in 50-year probability of exceedance at this site is 0.075 g as per the National Building Code of Canada (NBCC). Since this site is classified as Class D, the factored PGA for a 2% in 50-year probability of exceedance at this site is 0.097 g.

In accordance with Clause 6.14.7 of the CHBDC 2019, retaining structures should be designed using active ( $K_{AE}$ ) and passive ( $K_{PE}$ ) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 18.1 may be used:



**Table 18.1 – Earth Pressure Coefficients for Earthquake Loading**

Condition	Earth Pressure Coefficient (K)	
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$
Active ( $K_{AE}$ )*	0.31	0.35
Passive ( $K_{PE}$ )	3.6	3.1
At Rest ( $K_{OE}$ )**	0.55	0.6

\* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall / \*\* After Woods  
Liquefaction is not considered to be a concern at this site.

## 19. ADJACENT BURIED UTILITIES

The potential presence of underground utilities at the site should be confirmed prior to construction. It is recommended that the exact locations and elevations of any utilities be established by the designer and compared with the extent of the potential work zones related to the foundations of the proposed structures and associated works. Protection and/or relocation of utilities may be required. Underground utilities should not be undermined or damaged during new foundation construction.

## 20. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on silty sand fill and native silty sand samples indicate the following conditions at the locations tested:

- The potential for sulphate attack on concrete foundations from the surrounding silty sand fill and native silty sand is considered to be negligible due to the low concentration of sulphate and chloride in the samples tested. The selection of class of concrete should consider the effects of the road de-icing salts.
- The potential for soil corrosion on metal is considered to be moderate.
- Appropriate protection measures commensurate with the above are recommended if metal structural elements are used. The effects of road de-icing salts should be also considered.



## 21. CONSTRUCTION CONCERNS

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

### 1. Pile Installation

Although there was little direct evidence of their presence during drilling, glacial till deposits inherently contain boulders. Hard driving conditions through the hard/very dense soils should be expected. Pile tips should be reinforced with Titus steel (Standard H-point) to protect the driven piles from damage.

### 2. Excavation

Hydraulic equipment is expected to be capable of excavating to the required depths at this site. If excavations advance below the existing groundwater level, groundwater control measures may have to be implemented in order to maintain stable sides and base in the excavation. The glacial till contain cobbles and boulders. Equipment selected for excavation must be capable of penetrating, handling and/or removing these obstructions.

### 3. Groundwater Control

Seepage and perched groundwater may be encountered within the cohesionless fill and native cohesionless soils. The impact of seepage or surface water could destabilize the sides and or base of the excavation. Proper groundwater and surface water control measures must be in place prior to commencing excavation. All footings/pile caps must be constructed in the dry. Excavations for the armour stone retaining wall will extend below the surface water level of the existing drainage channel at this site. Proper groundwater and surface water control measures must be in place prior to commencing excavation to avoid destabilizing the sides or base of the excavation. The Contractor's unwatering plan must be in place prior to commencing excavation.



## 22. CLOSURE

Engineering analysis and preparation of the report were carried out by Dr. Nancy Berg, P.Eng., and Ms. R. Palomeque Reyna, P.Eng.

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

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Review Principal, Designated MTO Contact



## **Appendix A**

### **Record of Borehole Sheets, Laboratory Test Results, and Analytical Laboratory Test Results (Current Investigation)**

## SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

### 1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

### 2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

### 3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT <sup>(1)</sup> 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

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



### 4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

### 5. LEGEND FOR RECORDS OF BOREHOLES

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

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


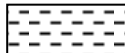



 Water Level  
 Shear Strength Determination by Pocket Penetrometer

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

# UNIFIED SOILS CLASSIFICATION

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

## EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
<b>Fresh (FR)</b>	No visible signs of weathering.		
<b>Fresh Jointed (FJ)</b>	Weathering limited to the surface of major discontinuities.		CLAYSTONE
<b>Slightly Weathered (SW)</b>	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
<b>Moderately Weathered (MW)</b>	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
<b>Highly Weathered (HW)</b>	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
<b>Completely Weathered (CW)</b>	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Very thinly bedded	20 to 60mm				
Laminated	6 to 20mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Thinly Laminated	Less than 6mm				

<u>TERMS</u>		Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.				
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.				
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.				
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

# RECORD OF BOREHOLE No NE16-01

1 OF 2

METRIC

GWP# 408-88-00 LOCATION N-E/W Ramp over Guelph Street, MTM NAD 83 Zone 10: N 4 814 741.0 E 225 955.1 ORIGINATED BY AF  
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP  
 DATUM Geodetic DATE 2018.06.11 - 2018.06.11 LATITUDE 43.468430 LONGITUDE -80.474466 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				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					
310.2	GROUND SURFACE												
0.0	Silty SAND, some gravel, occasional rootlets and organics Compact to Loose Brown to Dark Brown Moist (FILL)		1	SS	12								
			2	SS	8								
308.0													
2.3	Silty CLAY, trace gravel, trace sand Stiff to Very Stiff Brown Moist		3	SS	16								
	Grey		4	SS	14								
			5	SS	14								
			6	SS	22								
			7	SS	17								
			8	SS	19								

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No NE16-01

2 OF 2

METRIC

GWP# 408-88-00 LOCATION N-E/W Ramp over Guelph Street, MTM NAD 83 Zone 10: N 4 814 741.0 E 225 955.1 ORIGINATED BY AF  
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP  
 DATUM Geodetic DATE 2018.06.11 - 2018.06.11 LATITUDE 43.468430 LONGITUDE -80.474466 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE												
	Continued From Previous Page							20	40	60	80	100								
	Silty CLAY, trace gravel, trace sand Very Stiff Grey Moist						300													
			9	SS	16		299							○						
							298													
			10	SS	19									○						
297.0							297													
13.3	SAND and SILT, some gravel, some clay Very Dense Grey Moist (TILL)																			
296.1			11	SS	100									○				16 39 30 15		
14.2	END OF BOREHOLE AT 14.2m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.																			

ONTMT4S2 MTO-11375(GINTDATA)\GPU 2017TEMPLATE(MTO).GDT 5/19/20

# RECORD OF BOREHOLE No NE16-02

1 OF 2

METRIC

GWP# 408-88-00 LOCATION N-E/W Ramp over Guelph Street, MTM NAD 83 Zone 10: N 4 814 729.5 E 225 959.7 ORIGINATED BY AF  
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Mud Rotary COMPILED BY MP  
 DATUM Geodetic DATE 2018.06.10 - 2018.06.10 LATITUDE 43.468327 LONGITUDE -80.474407 CHECKED BY RPR

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 $\gamma$  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    × LAB VANE								
309.9	GROUND SURFACE						20	40	60	80	100					
0.0 0.1	TOPSOIL: (75mm)															
	Silty SAND, some gravel, trace clay, occasional organics Loose Brown Moist (FILL)		1	SS	8								○			
308.6																
1.4	Silty CLAY, trace gravel, trace sand Soft to Stiff Brown Moist		2	SS	2								○			
			3	SS	6								●	—		0   0   47   53
	Grey		4	SS	13								○			
			5	SS	21								○			
	Very Stiff to Hard															
			6	SS	25								○			
			7	SS	35								○			
			8	SS	23								●	—		0   0   36   64

Continued Next Page

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

# RECORD OF BOREHOLE No NE16-02

2 OF 2

METRIC

GWP# 408-88-00 LOCATION N-E/W Ramp over Guelph Street, MTM NAD 83 Zone 10: N 4 814 729.5 E 225 959.7 ORIGINATED BY AF  
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Mud Rotary COMPILED BY MP  
 DATUM Geodetic DATE 2018.06.10 - 2018.06.10 LATITUDE 43.468327 LONGITUDE -80.474407 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE				WATER CONTENT (%) W <sub>P</sub> W      W <sub>L</sub>				GR	SA	SI	CL
	Continued From Previous Page							20	40	60	80	100	20	40	60				
	Silty CLAY, trace gravel, trace sand Very Stiff to Stiff Grey Moist		9	SS	26		299							○					
							298												
			10	SS	13		297							○					
296.7																			
13.3	SAND and SILT, some gravel, some clay, occasional boulders Very Dense Grey Moist (TILL)		11	SS	100/ 0.275		296							○					
							295												
			12	SS	100/ 0.150		294							○				17	35 32 16
292.9			13	SS	100/ 0.125		293							○					
17.0	END OF BOREHOLE AT 17.0m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.  WATER LEVEL READINGS DATE      DEPTH(m)      ELEV.(m) 2018.06.25      2.8      307.1																		

ONTMT4S2 MTO-11375(GINTDATA)\GPJ 2017TEMPLATE(MTO).GDT 5/19/20

# RECORD OF BOREHOLE No NE16-03

1 OF 2

METRIC

GWP# 408-88-00 LOCATION N-E/W Ramp over Guelph Street, MTM NAD 83 Zone 10: N 4 814 698.6 E 225 965.5 ORIGINATED BY AF  
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Mud Rotary COMPILED BY MP  
 DATUM Geodetic DATE 2018.06.12 - 2018.06.12 LATITUDE 43.468050 LONGITUDE -80.474330 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL	
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE	20	40	60	80	100	W <sub>p</sub>		W	W <sub>L</sub>			
309.9	GROUND SURFACE																			
0.0 0.1	TOPSOIL: (75mm)  Silty SAND, some clay, trace gravel Compact to Very Loose Brown Moist (FILL)																			
			1	SS	11								○							
			2	SS	3									○					5 56 27 12	
307.7																				
2.2	Silty SAND, trace to some gravel, trace clay Loose to Compact Brown Moist		3	SS	23								○							
			4	SS	5								○							
	occasional boulders		5	SS	16								○							
304.2																				
5.6	Silty CLAY, trace sand, trace gravel Very Stiff Grey Moist		6	SS	25								○							
			7	SS	27								○							
			8	SS	20								○							

Continued Next Page

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

20  
15  
10

(%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375(GINTDATA)\GPJ 2017TEMPLATE(MTO).GDT 5/19/20

RECORD OF BOREHOLE No NE16-03

2 OF 2

METRIC

GWP# 408-88-00 LOCATION N-E/W Ramp over Guelph Street, MTM NAD 83 Zone 10: N 4 814 698.6 E 225 965.5 ORIGINATED BY AF  
DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Mud Rotary COMPILED BY MP  
DATUM Geodetic DATE 2018.06.12 - 2018.06.12 LATITUDE 43.468050 LONGITUDE -80.474330 CHECKED BY RPR

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									WATER CONTENT (%)			
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE												
	Continued From Previous Page							20	40	60	80	100	20	40	60					
	Silty CLAY, trace sand Very Stiff to Hard Grey Moist		9	SS	18		299						●	—			0 7 30 63			
			10	SS	23		298						○							
							297													
			11	SS	46		296						○							
295.1							295													
14.8	SAND and SILT, some clay to clayey, trace gravel Very Dense Grey Moist (TILL)		12	SS	100/ 0.100		294						○							
			13	SS	100/ 0.175		293						○				2 33 41 24			
							292						○							
291.4			14	SS	100/ 0.150															
18.4	END OF BOREHOLE AT 18.4m. WATER LEVEL AT 13.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.				0.150															

ONTMT4S2 MTO-11375(GINTDATA)\GPJ 2017TEMPLATE(MTO).GDT 5/19/20

# RECORD OF BOREHOLE No NE16-04

1 OF 3

METRIC

GWP# 408-88-00 LOCATION N-E/W Ramp over Guelph Street, MTM NAD 83 Zone 10: N 4 814 679.8 E 225 980.2 ORIGINATED BY JP  
DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance COMPILED BY MP  
DATUM Geodetic DATE 2018.05.10 - 2018.05.11 LATITUDE 43.467882 LONGITUDE -80.474146 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE							WATER CONTENT (%) w <sub>p</sub> w      w <sub>L</sub>			
310.6	GROUND SURFACE							20	40	60	80	100		20	40	60		
0.0	Silty CLAY, some sand, trace gravel Firm Brown Moist (FILL)		1	SS	6		310							○				
														○				
			2	SS	8									○				0 14 48 38
309.1																		
1.5	Silty SAND, trace to some gravel, trace clay Loose to Compact Brown Moist (FILL)		3	SS	5		309							○				
	occasional organics		4	SS	17		308								○			
307.6																		
3.0	Sandy SILT, trace gravel, occasional cobbles Compact Grey Wet		5	SS	20		307							○				
							306							○				
			6	SS	13													
							305											
304.5																		
6.1	Silty CLAY, trace gravel, trace sand Very Stiff Grey Moist		7	SS	18		304							○				
							303											
			8	SS	18									○				
							302											
			9	SS	29		301							○				

Continued Next Page

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

20  
15 10 5  
(%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375(GINTDATA)\GPJ 2017TEMPLATE(MTO).GDT 5/19/20

## METRIC

[illegible]

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

ONTMT4S2 MTO-11375(GINTDATA).GPJ 2017TEMPLATE(MTO).GDT 5/19/20

# RECORD OF BOREHOLE No NE16-04

3 OF 3

METRIC

GWP# 408-88-00 LOCATION N-E/W Ramp over Guelph Street, MTM NAD 83 Zone 10: N 4 814 679.8 E 225 980.2 ORIGINATED BY JP  
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance COMPILED BY MP  
 DATUM Geodetic DATE 2018.05.10 - 2018.05.11 LATITUDE 43.467882 LONGITUDE -80.474146 CHECKED BY RPR

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			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>													
290.4	SAND and SILT: (TILL)	q	16	SS	135/																							
20.2	END OF BOREHOLE AT 20.2m. Piezometer installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.  WATER LEVEL READINGS <table border="1"> <thead> <tr> <th>DATE</th> <th>DEPTH(m)</th> <th>ELEV.(m)</th> </tr> </thead> <tbody> <tr> <td>2018.05.16</td> <td>3.1</td> <td>307.5</td> </tr> <tr> <td>2018.05.31</td> <td>3.0</td> <td>307.6</td> </tr> <tr> <td>2018.06.25</td> <td>3.5</td> <td>307.1</td> </tr> </tbody> </table>	DATE	DEPTH(m)	ELEV.(m)	2018.05.16	3.1	307.5	2018.05.31	3.0	307.6	2018.06.25	3.5	307.1				0.200											
DATE	DEPTH(m)	ELEV.(m)																										
2018.05.16	3.1	307.5																										
2018.05.31	3.0	307.6																										
2018.06.25	3.5	307.1																										

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

20  
15  
10

(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No NE16-05

1 OF 2

METRIC

GWP# 408-88-00 LOCATION N-E/W Ramp over Guelph Street, MTM NAD 83 Zone 10: N 4 814 667.0 E 225 983.9 ORIGINATED BY JP  
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance COMPILED BY MP  
 DATUM Geodetic DATE 2018.05.11 - 2018.05.14 LATITUDE 43.467767 LONGITUDE -80.474099 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED      + FIELD VANE	● QUICK TRIAXIAL      × LAB VANE										
310.8	GROUND SURFACE							20	40	60	80	100	20	40	60				
0.0	Silty SAND to Sandy SILT, trace gravel, trace to some clay Loose to Compact Brown Wet (FILL)		1	SS	5								○						
			2	SS	5								○						
			3	SS	11								○						
			4	SS	26								○						
			5	SS	12									○					
307.1																			
3.7	Silty CLAY, trace sand, trace gravel Very Stiff to Hard Grey Moist																		
			6	SS	15								○						
			7	SS	23								○						
			8	SS	30								○	—				0	0
																		38	62
			9	SS	29								○						

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
 15  
 10  
 (%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375(GINTDATA)\GPJ 2017TEMPLATE(MTO).GDT 5/19/20

RECORD OF BOREHOLE No NE16-05

2 OF 2

METRIC

GWP# 408-88-00 LOCATION N-E/W Ramp over Guelph Street, MTM NAD 83 Zone 10: N 4 814 667.0 E 225 983.9 ORIGINATED BY JP  
DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance COMPILED BY MP  
DATUM Geodetic DATE 2018.05.11 - 2018.05.14 LATITUDE 43.467767 LONGITUDE -80.474099 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL	
								20    40    60    80    100	W <sub>P</sub> W      W <sub>L</sub>											
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE												
Continued From Previous Page																				
	Silty CLAY, trace sand, trace gravel Very Stiff Grey Moist						300													
			10	SS	20															
								299												
			11	SS	28															
								298												
							297													
			12	SS	20															
							296													
295.6																				
15.2	Silty SAND, trace gravel																			
295.3	Grey		13	SS	26															
15.5	Wet							295												
294.5																				
16.3	SAND and SILT, some clay, trace gravel Very Dense Grey Wet (TILL)						294													
			14	SS	100															
293.4																				
17.4	END OF BOREHOLE AT 17.4m. BOREHOLE OPEN UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.																			

ONTMT4S2 MTO-11375(GINTDATA)GPJ 2017TEMPLATE(MTO).GDT 5/19/20

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

20  
15  
10

(%) STRAIN AT FAILURE

## METRIC

[illegible]

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

# RECORD OF BOREHOLE No RW18-01

2 OF 2

METRIC

GWP# 408-88-00 LOCATION Retaining Wall 18, MTM NAD 83 Zone 10: N 4 814 668.4 E 225 945.1 ORIGINATED BY AF  
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP  
 DATUM Geodetic DATE 2018.06.11 - 2018.06.11 LATITUDE 43.467775 LONGITUDE -80.474578 CHECKED BY RPR

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 (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	20	40		60			
	Continued From Previous Page																		
	Silty <b>CLAY</b> , trace sand Very Stiff Grey Moist		9	SS	28														
			10	SS	21														
			11	SS	15														
	Hard		12	SS	30														
			13	SS	88														
291.9			14	SS	100/														
18.4	END OF BOREHOLE AT 18.4m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.  WATER LEVEL READINGS DATE            DEPTH(m)    ELEV.(m) 2018.06.25        3.5        306.9				0.150														

ONTMT4S2 MTO-11375.GPJ 2017TEMPLATE(MTO).GDT 10/19/18

# RECORD OF BOREHOLE No RW18-02

1 OF 3

METRIC

GWP# 408-88-00 LOCATION Retaining Wall 18, MTM NAD 83 Zone 10: N 4 814 657.2 E 225 955.6 ORIGINATED BY JP  
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance COMPILED BY MP  
 DATUM Geodetic DATE 2018.05.09 - 2018.05.09 LATITUDE 43.467676 LONGITUDE -80.474447 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20 40 60 80 100							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE							
							WATER CONTENT (%)								
							20 40 60								
309.9	GROUND SURFACE														
0.0	Silty <b>CLAY</b> , some sand, with organics Soft to Very Stiff Brown Moist (FILL)  Layer of silty sand (300mm)		1	SS	3										
			2	SS	12		309								
			3	SS	12		308								
			4	SS	22		307							0 0 73 27	
306.9															
3.0	<b>SAND</b> and <b>SILT</b> , trace clay, occasional cobbles Loose Brown Wet		5	SS	8		306							0 37 57 6	
305.3															
4.6	Silty <b>CLAY</b> , trace sand Stiff to Very Stiff Grey Moist		6	SS	10		305								
							304								
			7	SS	22		303								
			8	SS	22		302								
							301								
			9	SS	30		300								
	Hard														

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No RW18-02

2 OF 3

METRIC

GWP# 408-88-00 LOCATION Retaining Wall 18, MTM NAD 83 Zone 10: N 4 814 657.2 E 225 955.6 ORIGINATED BY JP  
DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance COMPILED BY MP  
DATUM Geodetic DATE 2018.05.09 - 2018.05.09 LATITUDE 43.467676 LONGITUDE -80.474447 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
	Continued From Previous Page							<div>20406080100</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div>					
								<div>20406080100</div> <div>W P W W L</div> <div>WATER CONTENT (%)</div>					
298.0	Silty <b>CLAY</b> , some sand, trace gravel Hard Grey Moist		10	SS	35		299						
11.9	Silty <b>CLAY</b> , some sand to sandy, trace gravel Very Stiff to Hard Grey Moist (TILL)		11	SS	28		298						4 39 38 19
			12	SS	35		296						
			13	SS	49		294						
293.2	<b>SAND</b> and <b>SILT</b> , some clay, trace sand Very Dense Grey Moist (TILL)		14	SS	95		293						
16.7	Clayey zone at 18.1m		15	SS	50/		292						6 35 36 23
291.4	END OF BOREHOLE AT 18.5m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.				0.075								
18.5													

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No RW18-02

3 OF 3

METRIC

GWP# 408-88-00 LOCATION Retaining Wall 18, MTM NAD 83 Zone 10: N 4 814 657.2 E 225 955.6 ORIGINATED BY JP  
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance COMPILED BY MP  
 DATUM Geodetic DATE 2018.05.09 - 2018.05.09 LATITUDE 43.467676 LONGITUDE -80.474447 CHECKED BY RPR

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			20 40 60 80 100	20 40 60 80 100	W P W W L	20 40 60			
Continued From Previous Page														
WATER LEVEL READINGS														
DATE	DEPTH(m)	ELEV.(m)												
2018.05.14	2.8	307.1												
2018.05.31	2.7	307.2												
2018.06.25	2.7	307.2												

# RECORD OF BOREHOLE No RW18-03

1 OF 2

METRIC

GWP# 408-88-00 LOCATION Retaining Wall 18, MTM NAD 83 Zone 10: N 4 814 690.4 E 225 966.9 ORIGINATED BY AF  
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP  
 DATUM Geodetic DATE 2018.06.13 - 2018.06.13 LATITUDE 43.467976 LONGITUDE -80.474313 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)							
								20   40   60   80   100			w <sub>P</sub> w                      w <sub>L</sub>							
						○ UNCONFINED      + FIELD VANE												
						● QUICK TRIAXIAL      × LAB VANE												
310.1	GROUND SURFACE																	
0.0	TOPSOIL: (150mm)																	
0.2	Silty <b>SAND</b> , trace gravel, occasional organics Compact to Loose Brown Moist (FILL)						310											
			1	SS	25		309						○					
			2	SS	4		308							○				
307.8																		
2.3	<b>SAND</b> and <b>SILT</b> , some gravel Dense Brown Wet		3	SS	31		307						○					
307.1			4	SS	18		306						○					
3.0	Silty <b>CLAY</b> , trace sand, trace gravel Very Stiff Grey Moist						305						○					
305.9			5	SS	20		304						○					
4.3	<b>SAND</b> and <b>SILT</b> , trace to some clay Compact Grey Wet						303						○					
304.5			6	SS	24		302						○					
5.6	Silty <b>CLAY</b> , trace sand, trace gravel Very Stiff to Hard Grey Moist		7	SS	21		301						○					
			8	SS	33								○					

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
 15  
 10  
 (%) STRAIN AT FAILURE



## METRIC

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES		GROUND WATER CONDITIONS
			NUMBER	"N" VALUES	
<div>DYNAMIC CONE PENETRATION RESISTANCE PLOT</div>					
<div>SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE</div>					
<div>WATER CONTENT (%)  PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w<sub>P</sub> w w<sub>L</sub></div>					
UNIT WEIGHT γ kN/m³					
REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
	Continued From Previous Page				
	Silty <b>CLAY</b> , trace sand, trace gravel Very Stiff to Hard Grey Moist				
			9	SS	31
			10	SS	19
			11	SS	33
295.3					
14.8	<b>SAND</b> and <b>SILT</b> , some clay, trace gravel Very Dense Grey Moist (TILL)(Clayey zone)				
294.5			12	SS	100/ 0.225
15.6	END OF BOREHOLE AT 11.0m. WATER LEVEL AT 4.7m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.				




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

# RECORD OF BOREHOLE No RW18-04

1 OF 2

METRIC

GWP# 408-88-00 LOCATION Retaining Wall 18, MTM NAD 83 Zone 10: N 4 814 681.7 E 225 972.5 ORIGINATED BY JP  
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance COMPILED BY MP  
 DATUM Geodetic DATE 2018.05.09 - 2018.05.10 LATITUDE 43.467898 LONGITUDE -80.474242 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT      NATURAL MOISTURE      LIQUID CONTENT      LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)				
								20   40   60   80   100	○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE			W <sub>P</sub> W      W <sub>L</sub>			
309.8	GROUND SURFACE														
0.0	Sandy <b>SILT</b> , some clay, trace gravel Very Loose to Loose Brown Moist (FILL)		1	SS	3										
			2	SS	4										
			3	SS	5										
307.6															
2.2	Silty <b>SAND</b> , trace gravel, trace clay, occasional cobbles Compact Grey Wet		4	SS	11										
			5	SS	11										
305.2															
4.6	Silty <b>CLAY</b> , trace to some sand Stiff to Very Stiff Grey Moist		6	SS	27										
			7	SS	15										
			8	SS	14										
			9	SS	29										

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No RW18-04

2 OF 2

METRIC

GWP# 408-88-00 LOCATION Retaining Wall 18, MTM NAD 83 Zone 10: N 4 814 681.7 E 225 972.5 ORIGINATED BY JP  
DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance COMPILED BY MP  
DATUM Geodetic DATE 2018.05.09 - 2018.05.10 LATITUDE 43.467898 LONGITUDE -80.474242 CHECKED BY RPR

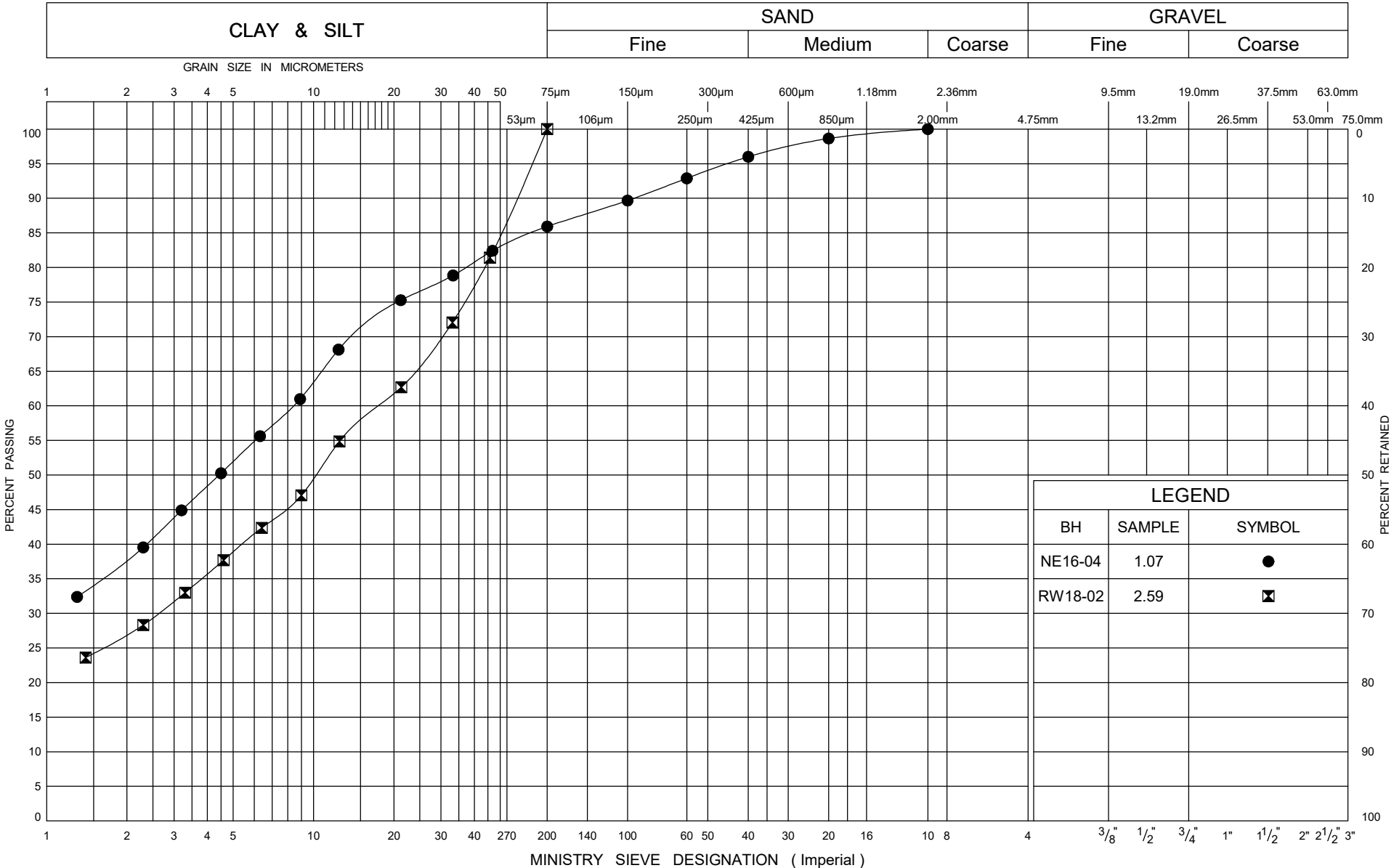
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT							UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa														
								○ UNCONFINED + FIELD VANE									PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT	
								● QUICK TRIAXIAL × LAB VANE									W P		W		W L	
							WATER CONTENT (%)															
	Continued From Previous Page							20	40	60	80	100										
296.5	Silty <b>CLAY</b> , some sand, trace gravel Very Stiff Grey Moist		10	SS	20		299							○								
							298							○								
			11	SS	26		297							○								
13.3	Silty <b>CLAY</b> , some sand, trace gravel, occasional cobbles Hard Grey Moist (TILL)		12	SS	37		296							○			0 22 59 19					
							295															
294.4	<b>SAND</b> and <b>SILT</b> , some clay, trace gravel Very Dense Grey Wet (TILL)		13	SS	88		294							○								
							293							○								
			14	SS	55/ 0.100		292															
291.2			15	SS	100/ 0.100									○								
18.5	END OF BOREHOLE AT 18.54m. BOREHOLE OPEN UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.				0.100																	

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

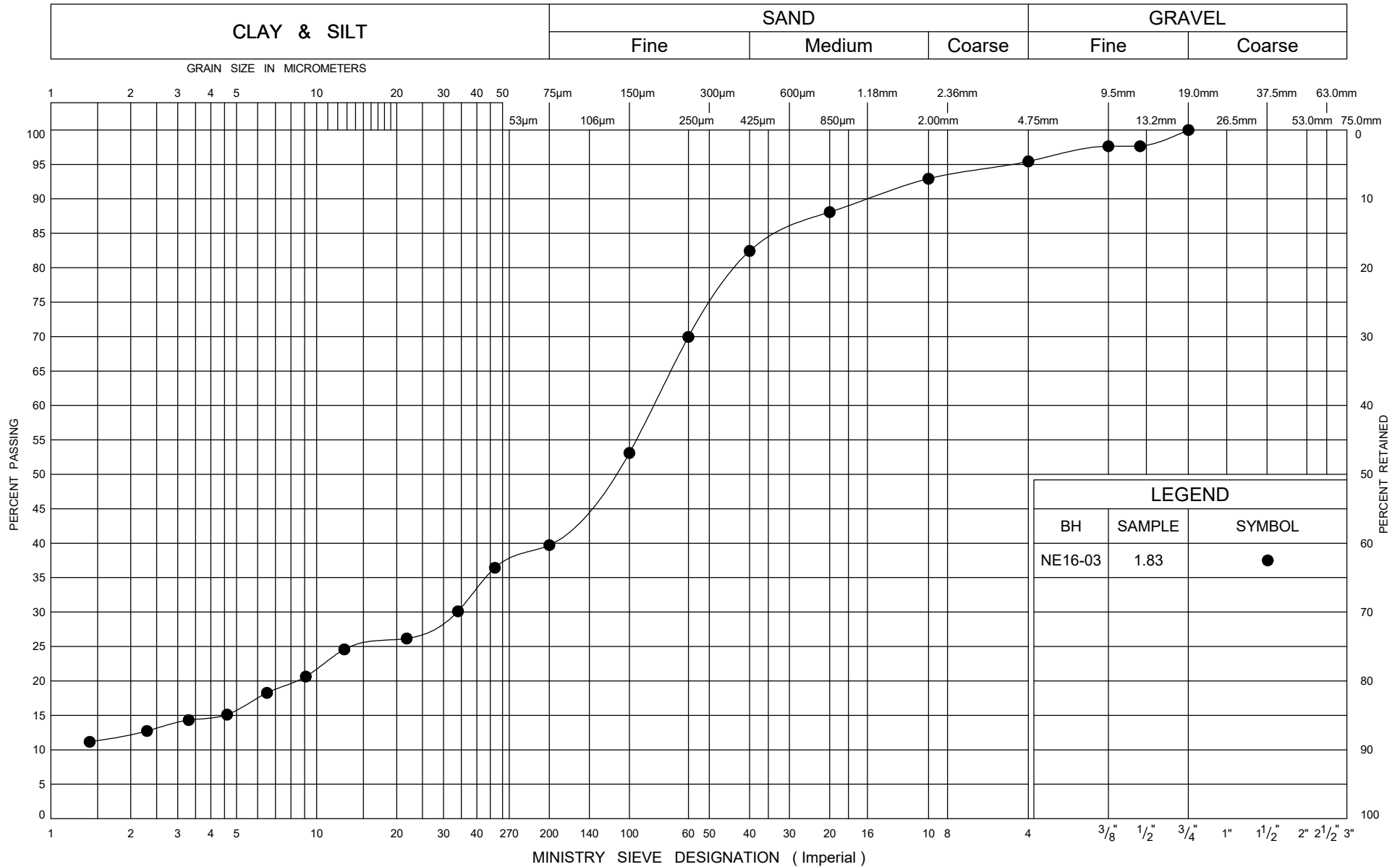
20  
15  
10

(%) STRAIN AT FAILURE

UNIFIED SOIL CLASSIFICATION SYSTEM



## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

## GRAIN SIZE DISTRIBUTION

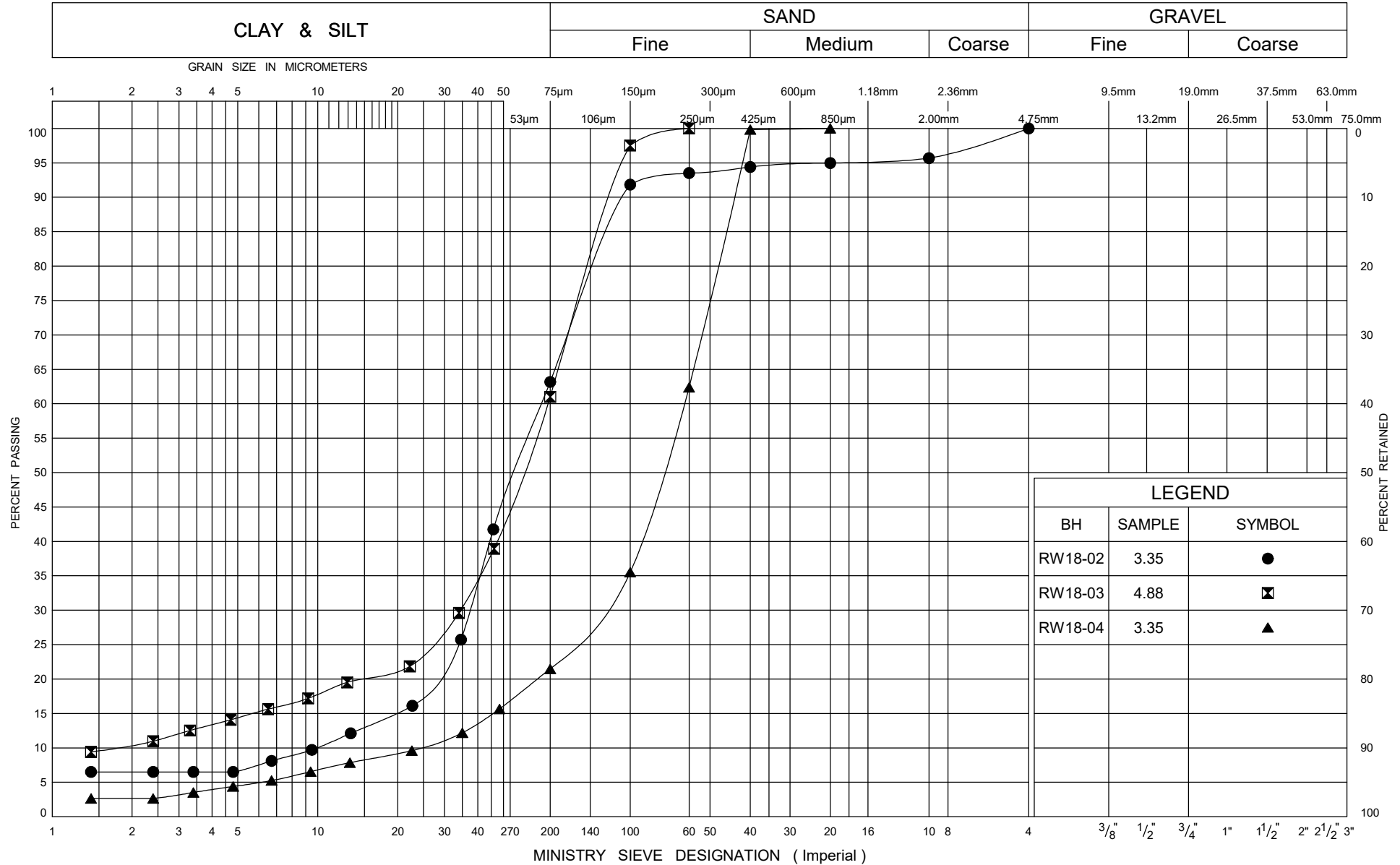
Silty Sand Fill

FIG No A2

W P 408-88-00

N-E/W Ramp over Guelph Street

## UNIFIED SOIL CLASSIFICATION SYSTEM



# GRAIN SIZE DISTRIBUTION

## Sand and Silt and Silty Sand

FIG No A3

W P 408-88-00

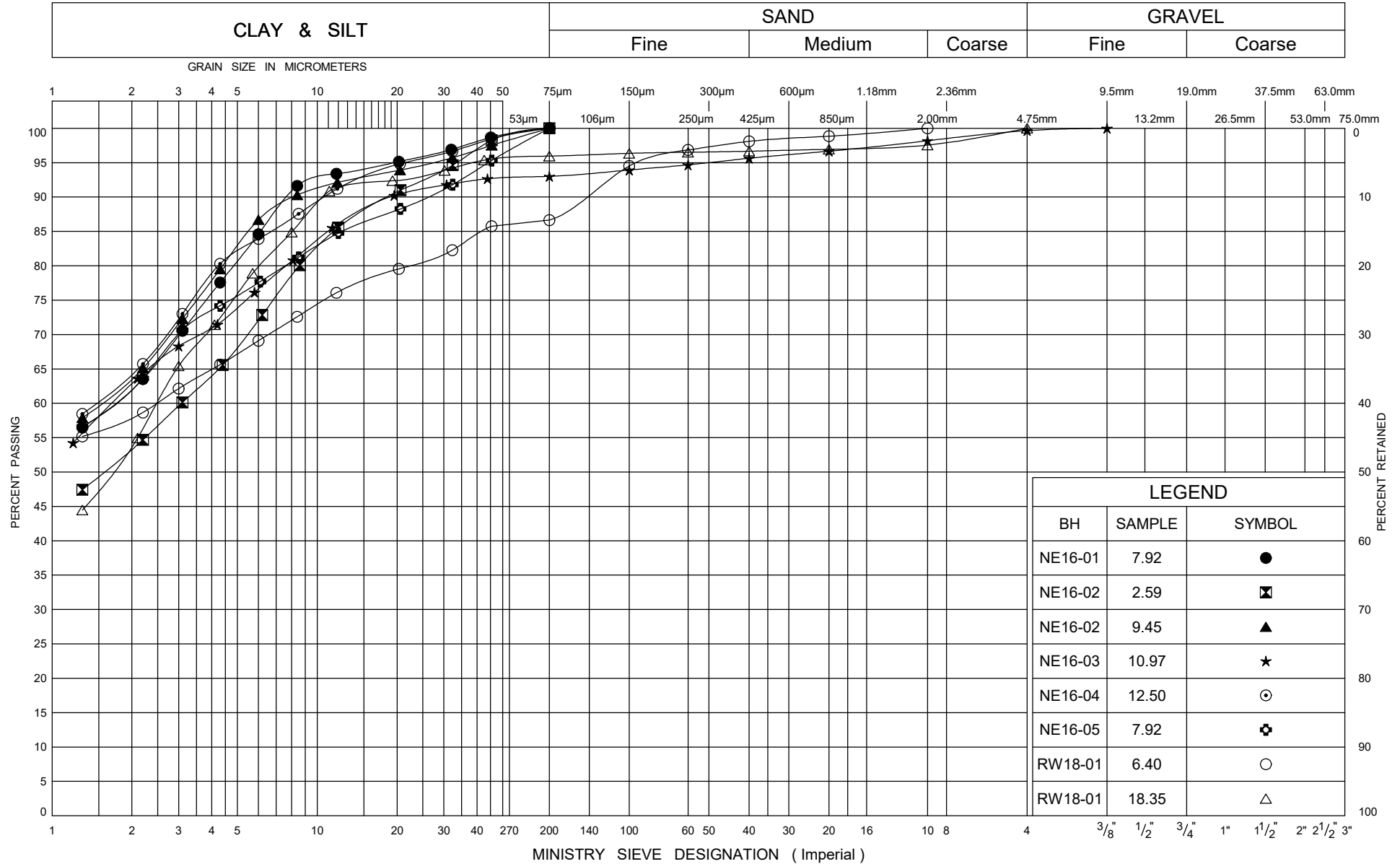
N-E/W Ramp over Guelph Street



Ministry of  
Transportation

Ontario

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

# GRAIN SIZE DISTRIBUTION

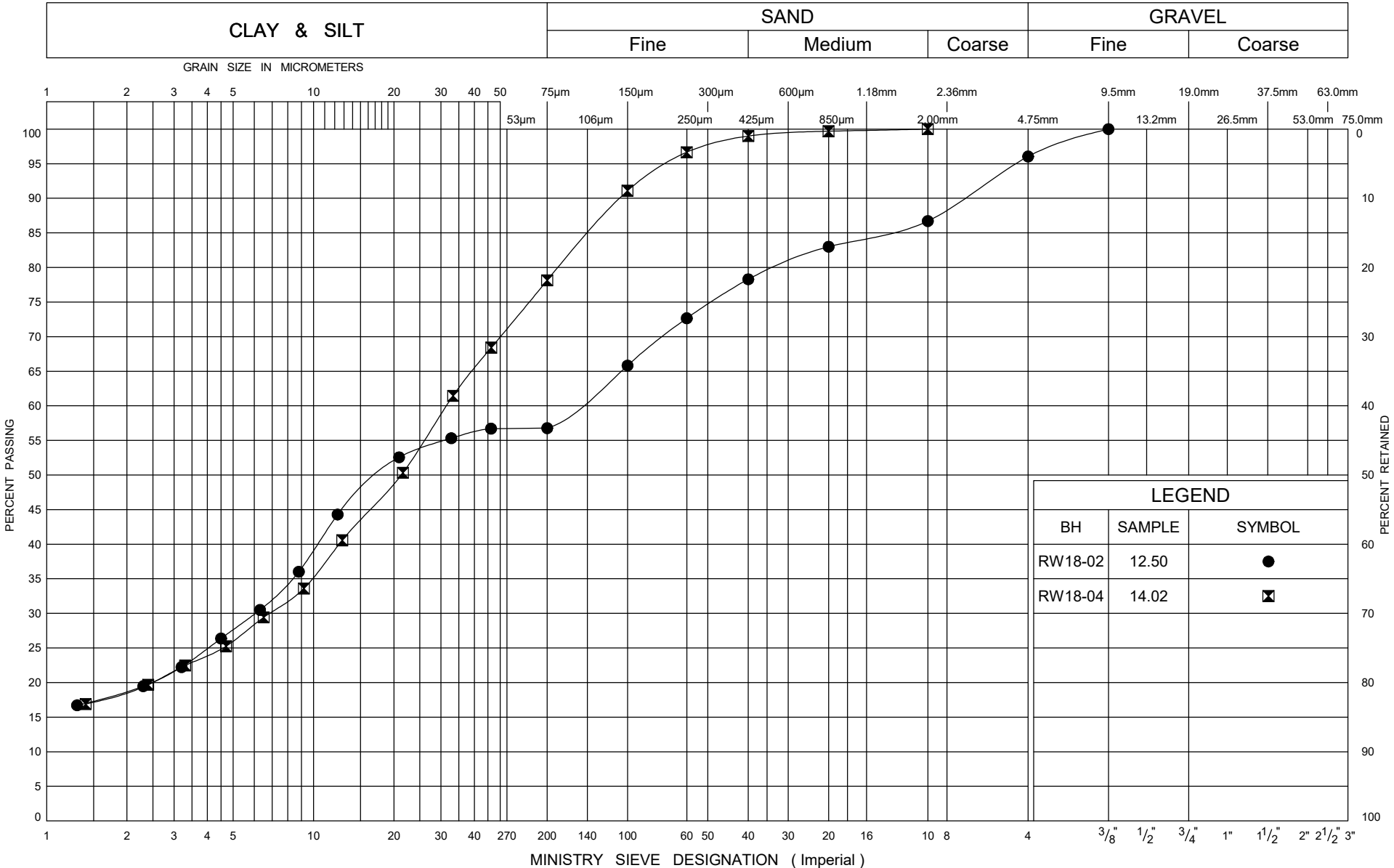
Silty Clay

FIG No A4

W P 408-88-00

N-E/W Ramp over Guelph Street

UNIFIED SOIL CLASSIFICATION SYSTEM

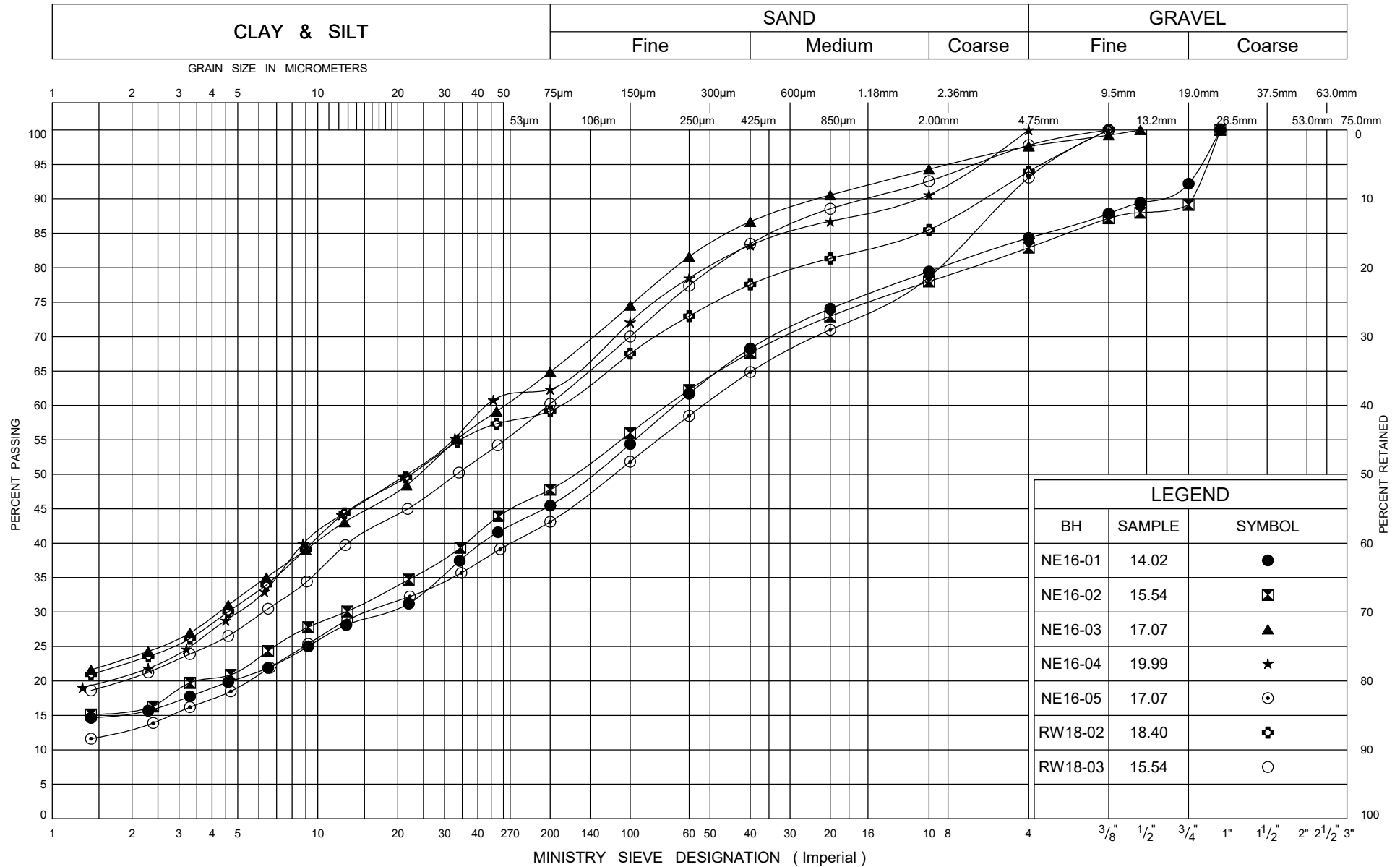


GRAIN SIZE DISTRIBUTION  
Silty Clay Till

FIG No A5  
W P 408-88-00  
N-E/W Ramp over Guelph Street



## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

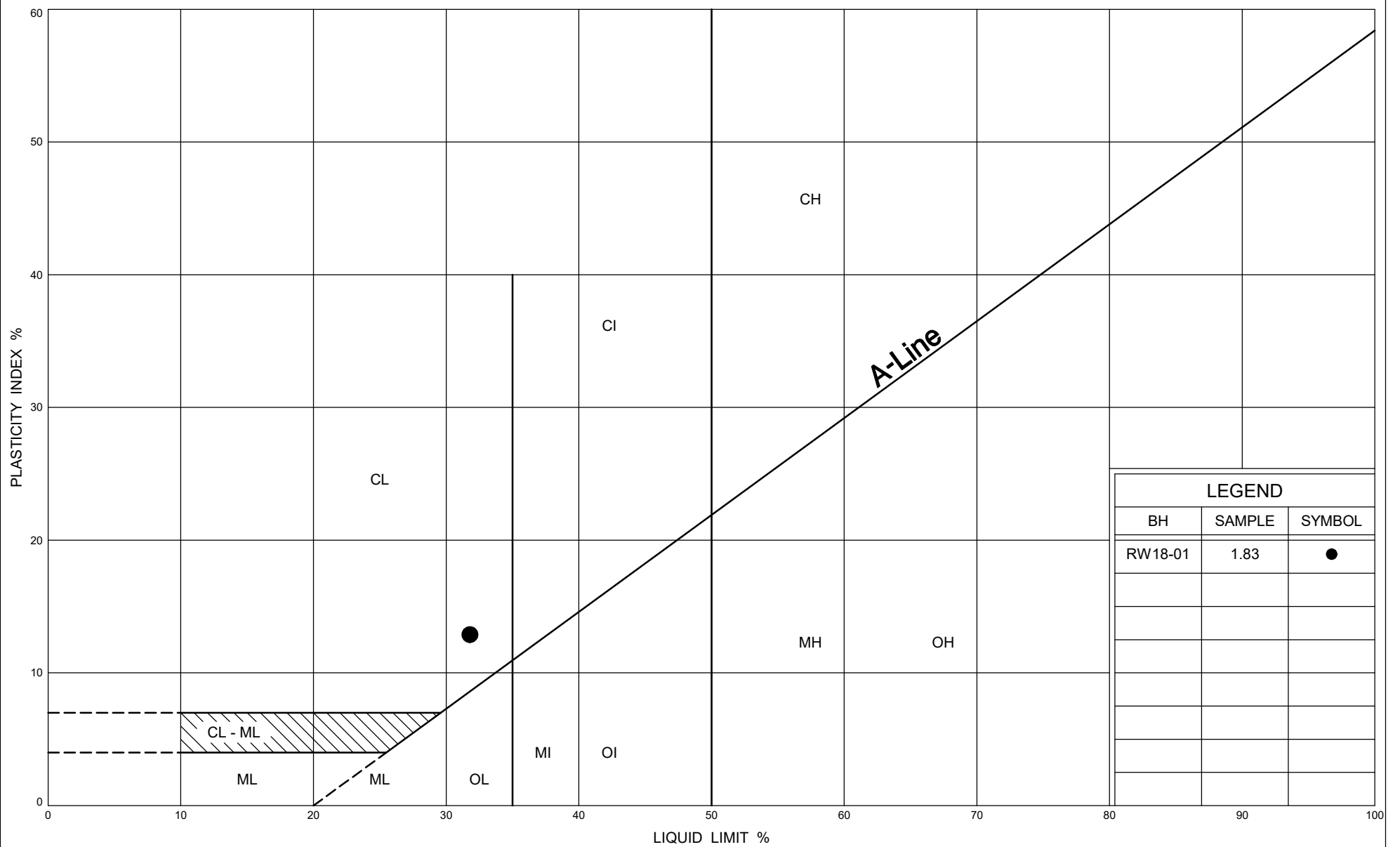
## GRAIN SIZE DISTRIBUTION

Sand and Silt Till

FIG No A6

W P 408-88-00

N-E/W Ramp over Guelph Street



Ministry of  
Transportation

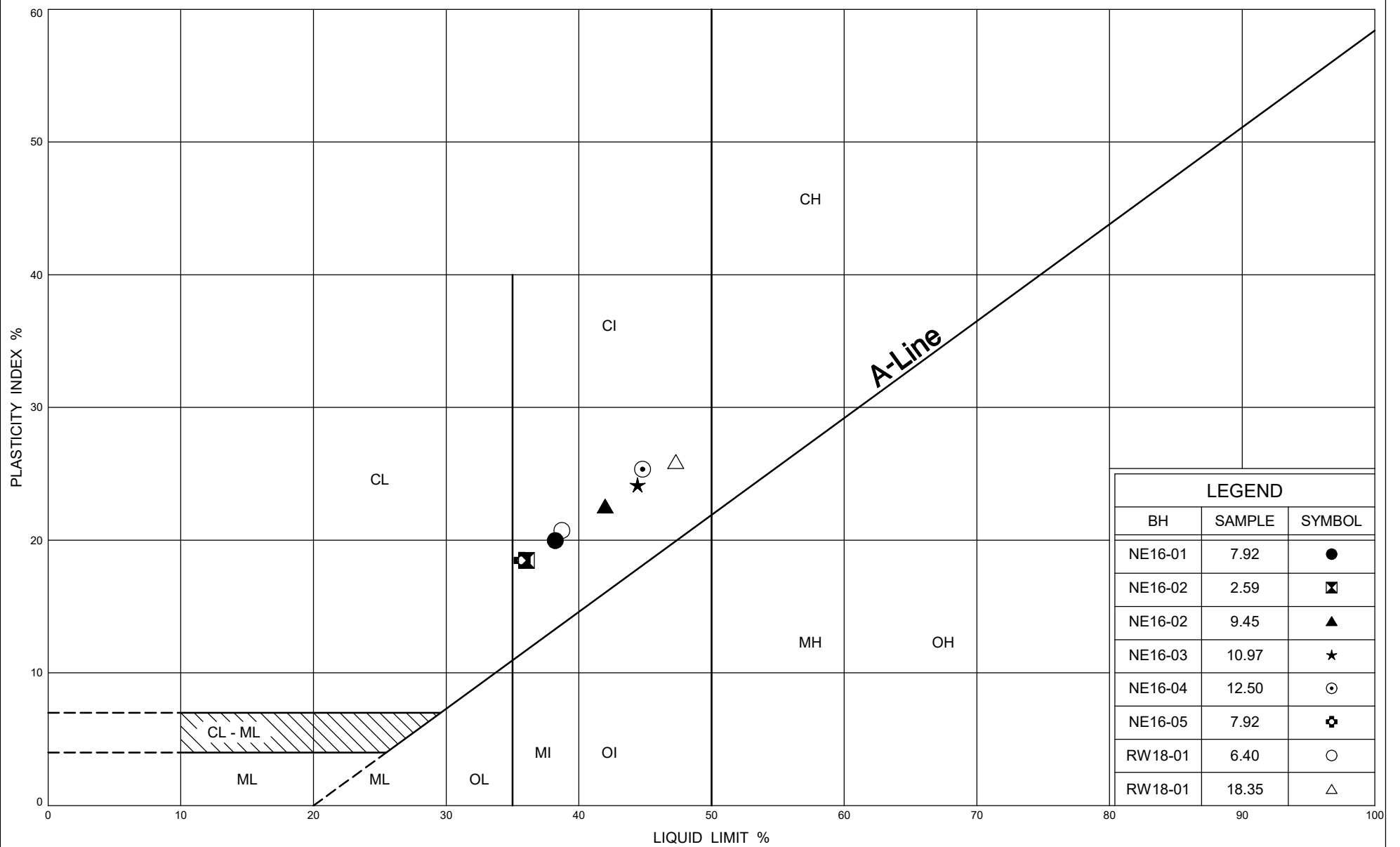
## PLASTICITY CHART

Silty Clay Fill

FIG No A7

W P 408-88-00

N-E/W Ramp over Guelph Street



Ministry of  
Transportation

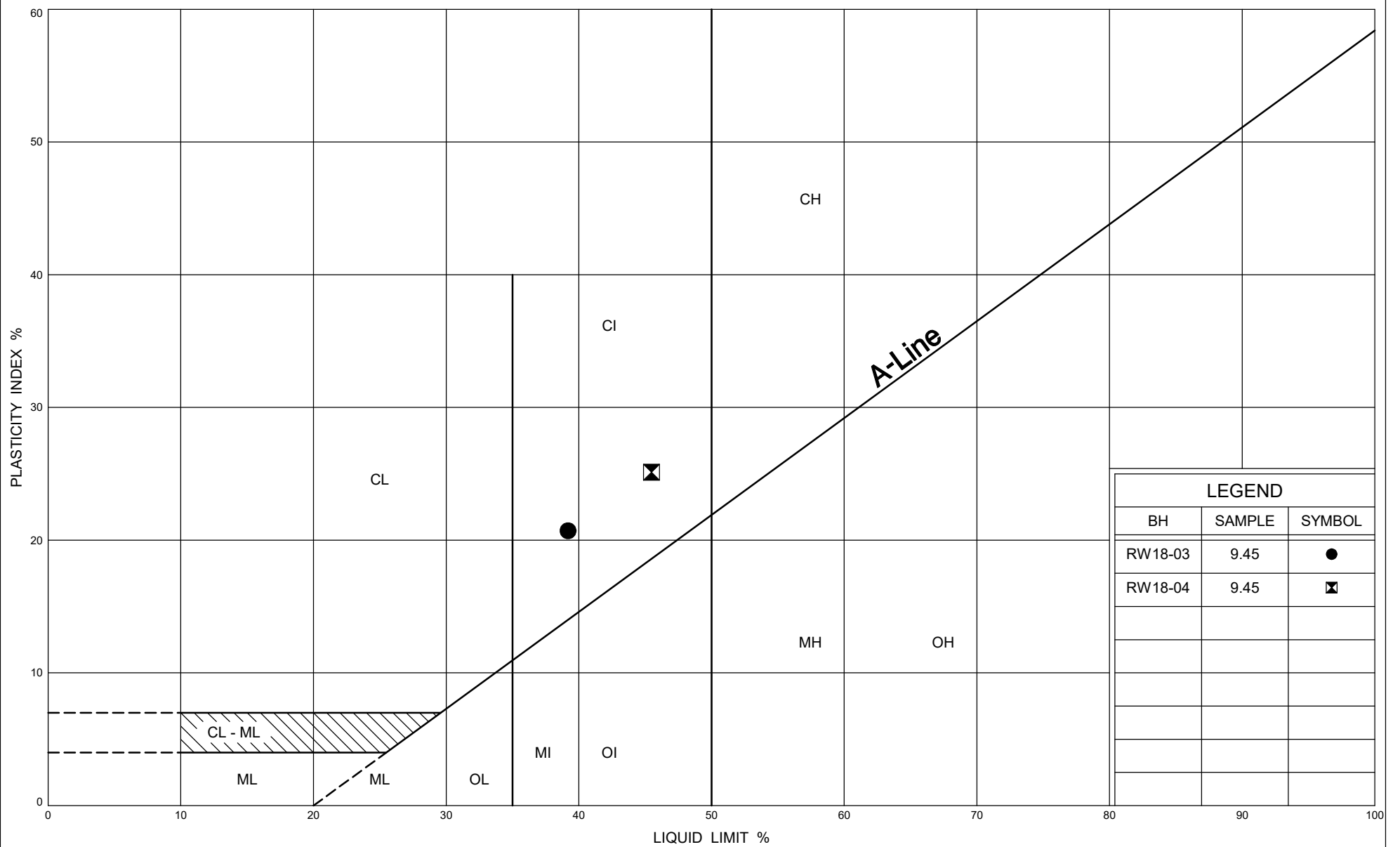
## PLASTICITY CHART

Silty Clay

FIG No A8

W P 408-88-00

N-E/W Ramp over Guelph Street



Ministry of  
Transportation

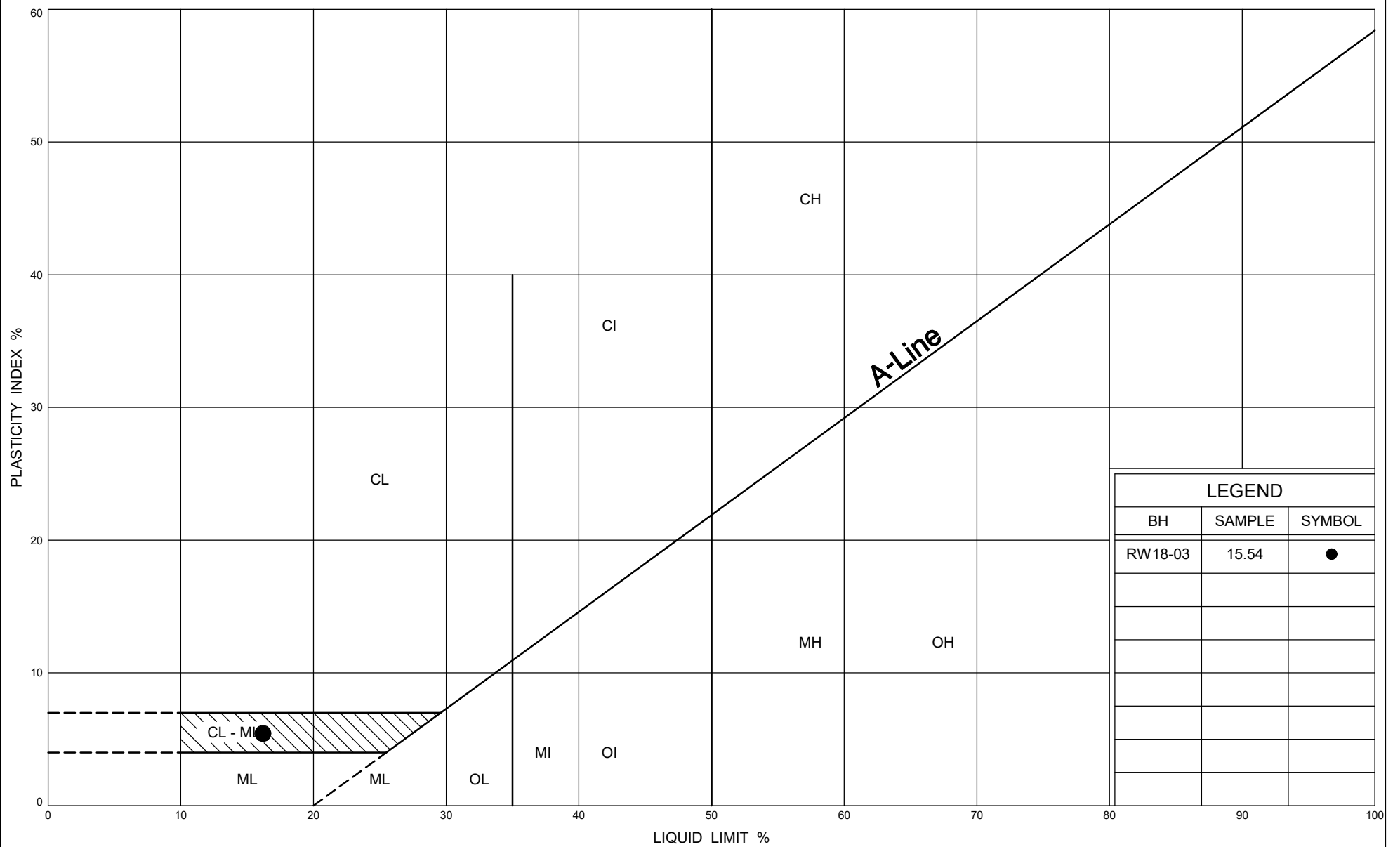
## PLASTICITY CHART

Silty Clay

FIG No A9

W P 408-88-00

N-E/W Ramp over Guelph Street



Ministry of  
Transportation

## PLASTICITY CHART

Sand and Silt Till (Clayey zone)

FIG No A10

W P 408-88-00

N-E/W Ramp over Guelph Street



## FINAL REPORT

CA14855-MAY18 R1

11375 Rocío Reyna

Prepared for

**Thurber Engineering Ltd.**

## First Page

### CLIENT DETAILS

Client Thurber Engineering Ltd.

Address 103, 2010 Winston Park Drive  
Oakville, ON  
L6H 5R7.

Contact Rocio Reyna

Telephone 905-829-8666 x 263

Facsimile

Email rreyna@thurber.ca

Project 11375 Rocio Reyna

Order Number

Samples Soil (2)

### LABORATORY DETAILS

Project Specialist Deanna Edwards, B.Sc, C.Chem

Laboratory SGS Canada Inc.

Address 185 Concession St., Lakefield ON, K0L 2H0

Telephone 705-652-2000

Facsimile 705-652-6365

Email deanna.edwards@sgs.com

SGS Reference CA14855-MAY18

Received 05/28/2018

Approved 06/01/2018

Report Number CA14855-MAY18 R1

Date Reported 06/01/2018

### COMMENTS

Temperature of Sample upon Receipt: 11 degrees C

Cooling Agent Present: No

Custody Seal Present: No

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

### SIGNATORIES

Deanna Edwards, B.Sc, C.Chem





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Legend..... 7

Annexes..... 8-9





# FINAL REPORT

CA14855-MAY18 R1

**Client:** Thurber Engineering Ltd.

**Project:** 11375 Rocío Reyna

**Project Manager:** Rocío Reyna

**Samplers:** N/A

## PACKAGE: - Corrosivity Index (SOIL)

<b>Sample Number</b>	5	6
<b>Sample Name</b>	NE16-04 SS4	RW18-04 SS4
<b>Sample Matrix</b>	Soil	Soil
<b>Sample Date</b>	05/05/2018	09/05/2018

Parameter	Units	RL		Result	Result
<b>Corrosivity Index</b>					
Corrosivity Index	none	1		7.5	1.0
Soil Redox Potential	mV	-		217	192
Sulphide	%	0.02		0.03	< 0.02
pH	no unit	0.05		8.72	8.16
Resistivity (calculated)	ohms.cm	-9999		3440	3330

## PACKAGE: - General Chemistry (SOIL)

<b>Sample Number</b>	5	6
<b>Sample Name</b>	NE16-04 SS4	RW18-04 SS4
<b>Sample Matrix</b>	Soil	Soil
<b>Sample Date</b>	05/05/2018	09/05/2018

Parameter	Units	RL		Result	Result
<b>General Chemistry</b>					
Conductivity	uS/cm	2		291	300

## PACKAGE: - Metals and Inorganics (SOIL)

<b>Sample Number</b>	5	6
<b>Sample Name</b>	NE16-04 SS4	RW18-04 SS4
<b>Sample Matrix</b>	Soil	Soil
<b>Sample Date</b>	05/05/2018	09/05/2018

Parameter	Units	RL		Result	Result
<b>Metals and Inorganics</b>					
Moisture Content	%	0.1		10.6	18.7
Sulphate	µg/g	0.4		130	130



FINAL REPORT

CA14855-MAY18 R1

**Client:** Thurber Engineering Ltd.  
**Project:** 11375 Rocío Reyna  
**Project Manager:** Rocío Reyna  
**Samplers:** N/A

PACKAGE: - Other (ORP) (SOIL)

Sample Number	5	6
Sample Name	NE16-04 SS4	RW18-04 SS4
Sample Matrix	Soil	Soil
Sample Date	05/05/2018	09/05/2018

Parameter	Units	RL		Result	Result
Other (ORP)					
Chloride	µg/g	0.4		100	200



# FINAL REPORT

CA14855-MAY18 R1

## QC SUMMARY

### Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0502-MAY18	µg/g	0.4	<0.4	12	20	93	80	120	108	75	125
Sulphate	DIO0502-MAY18	µg/g	0.4	<0.4	0	20	97	80	120	97	75	125

### Carbon/Sulphur

Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide	ECS0053-MAY18	%	0.02	<0.02	ND	20	91	80	120			

### Conductivity

Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0517-MAY18	uS/cm	2	< 0.002	5	10	101	90	110	NA		



QC SUMMARY

pH  
Method: SM 4500 | Internal ref.: ME-CA-|ENVIEWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0517-MAY18	no unit	0.05	NA	0		100			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

**Multielement Scan Qualifier:** as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

**Duplicate Qualifier:** for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

**Matrix Spike Qualifier:** for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

## LEGEND

### FOOTNOTES

**NSS** Insufficient sample for analysis.

**RL** Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

**NA** The sample was not analysed for this analyte

**ND** Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at [http://www.sgs.com/terms\\_and\\_conditions.htm](http://www.sgs.com/terms_and_conditions.htm). The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

This report must not be reproduced, except in full. This report supersedes all previous versions.

-- End of Analytical Report --

## Request for Laboratory Services and CHAIN OF CUSTODY

No:

- Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Toll Free: 877-747-7658 Fax: 705-652-6365  
- London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361 Web: www.ca.sgs.com

Page 1 of 1

### Laboratory Information Section - Lab use only

Received By: Ismael  
Received Date (mm/dd/yyyy): 08-28-18 (mm/dd/yyyy)  
Received Time: 12:45 PM

Received By (signature): [Signature]  
Custody Seal Present: ☐ no  
Custody Seal Intact: ☐ no

Cooling Agent Present: ☐ no  
Temperature Upon Receipt (°C): 9.8, 10.1, 10.3

LAB LIMS #: CA44855-Mag 18

### REPORT INFORMATION

Company: Thurber Engineering  
Contact: Rocio Palomero Rofina  
Address: 103-2010 Winston Park Dr.  
Oakville, ON L6H 5R7

### INVOICE INFORMATION

☒ (same as Report Information)  
Company: \_\_\_\_\_  
Contact: \_\_\_\_\_  
Address: \_\_\_\_\_  
Phone: \_\_\_\_\_  
Email: \_\_\_\_\_

### PROJECT INFORMATION

Quotation #: \_\_\_\_\_ P.O. #: \_\_\_\_\_  
Project #: 11375 Site Location/ID: \_\_\_\_\_

### TURNAROUND TIME (TAT) REQUIRED

☒ Regular TAT (5-7 days) TAT's are quoted in business days (exclude statutory holidays & weekends).  
Samples received after 3pm or on weekends : TAT begins the next business day

☐ RUSH TAT (Additional Charges May Apply) ☐ 1 Day ☐ 2 Days ☐ 3-4 Days

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date: \_\_\_\_\_ Rush Confirmation ID: \_\_\_\_\_

DRINKING WATER SAMPLES (POTABLE WATER FOR HUMAN CONSUMPTION) MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

ANALYSIS REQUESTED

PHC F1-F4 BTEX

O.Reg 153 Metals (ICP & hydride metals)

☐ Hg ☐ B-HWS ☐ Cr(VI)

O.Reg 153 VOCs

Corrosivity

1

1

1

1

1

1

1

1

1

1

1

1

1

1

1

1

1

1

1

1

1

1

COMMENTS:  
Field Filtered (F)  
Preserved (P)

RECORD OF SITE CONDITION (RSC)

YES ☐ NO ☐

Regulation 153 (2011):

Other Regulations:

Reg 347/558 (3 Day min TAT)

PWQO ☐ MMER

CCME ☐ Other:

MISA ☐

Sewer By-Law:

Sanitary ☐

Storm ☐

Municipality:

Table 1 ☐ Res/Park ☐ Soil Texture:

Table 2 ☐ Ind/Com ☐ Coarse

Table 3 ☐ Agri/Other ☐ Medium

Table ☐ Fine

SAMPLE IDENTIFICATION

DATE SAMPLED

TIME SAMPLED

# OF BOTTLES

MATRIX

Sampled By (NAME):

Relinquished by (NAME):

Signature:

Signature:

Date: May 1, 2018

Date: May 1, 2018

Date: May 1, 2018

Date: May 1, 2018

(mm/dd/yy)

(mm/dd/yy)

(mm/dd/yy)

(mm/dd/yy)

Pink Copy - Client

Yellow & White Copy - SGS

Yellow & White Copy - SGS

Yellow & White Copy - SGS



# SAMPLE INTEGRITY REPORT

Project Number: 11375

SGS Sample ID CA14855-May 18  
Date / Time Sampled May 5 + 9, 2018  
Client Sample ID See CoC

ONTARIO REGULATION 153/04

ALL

## Sample Submission General Sample Integrity Violations

- |  |                          |
|--|--------------------------|
| Temperature >10 C upon receipt if not sampled same day     | <input type="checkbox"/> |
| No evidence of cooling trend initiated if sampled same day | <input type="checkbox"/> |
| Chain of Custody not submitted                             | <input type="checkbox"/> |
| Chain of Custody incomplete                                | <input type="checkbox"/> |
| Chain of Custody not signed / dated                        | <input type="checkbox"/> |
| Chain of Custody not a current version                     | <input type="checkbox"/> |
| Bottles / Samples listed on CoC but not received           | <input type="checkbox"/> |
| Bottles / Samples received but not listed on the CoC       | <input type="checkbox"/> |
| Sample container received empty                            | <input type="checkbox"/> |

## Sample Specific Sample Integrity Violations

- |   |                          |                          |                          |                          |                          |                          |                          |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Sample received past hold time                                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Incorrect preservation (including no preservation where required) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Headspace present in VOC vial (aqueous)                           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Sample(s) received frozen   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Bottle(s) broken or damaged in transport                          | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Discrepancy between sample label and chain of custody             | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Analysis requirements absent / unclear                            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Missing or incorrect sample label(s)                              | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Inappropriate sample container used                               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Insufficient number of bottles received                           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Limited sample volume   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Insufficient sample volume  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Sample contains multiple phases                                   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

## Sediment Log

- |  |                          |                          |                          |                          |                          |                          |                          |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Groundwater samples contain visible sediment / particulate                       | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Groundwater contains greater than 1cm of sediment / particulate matter in bottle | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

## Additional Comments/Remarks:

No issues upon receipt



Initials:

*[Handwritten Signature]*



## **Appendix B**

### **Record of Borehole Sheets and Laboratory Test Results (Previous Investigation)**



# RECORD OF BOREHOLE No 08-002

1 OF 2

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 728.23 E 225 979.86 ORIGINATED BY ES  
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM  
 DATUM Geodetic DATE 2008.06.05 - 2008.06.06 CHECKED BY RPR

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						
308.3								20 40 60 80 100	20 40 60					
0.9	ASPHALT: (50mm)		1	AS			308							
307.5	SAND and GRAVEL, some silt Grey to Brown Moist (FILL)													
0.8	Silty CLAY, some sand, trace gravel, some organics, occasional black staining Firm to Stiff Dark Grey (FILL)		1	SS	13		307							
			2	SS	5									
306.2														
2.1	SAND and GRAVEL, trace silt, occasional clayey silt seams Compact Grey Wet (FILL)		3	SS	10		306							
305.4														
2.9	Silty CLAY, trace sand Very Stiff to Hard Dark Grey (TILL)		4	SS	21		305							0 1 44 55
			5	SS	29		304							
			6	SS	41		302							
			7	SS	38		301							0 3 43 54
			8	SS	42		299							

Continued Next Page

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



## METRIC

CHECKED BY RPF

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

# RECORD OF BOREHOLE No 08-004

2 OF 2

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 712.58 E 225 985.09 ORIGINATED BY SLL  
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM  
 DATUM Geodetic DATE 2008.06.10 - 2008.06.12 CHECKED BY RPR

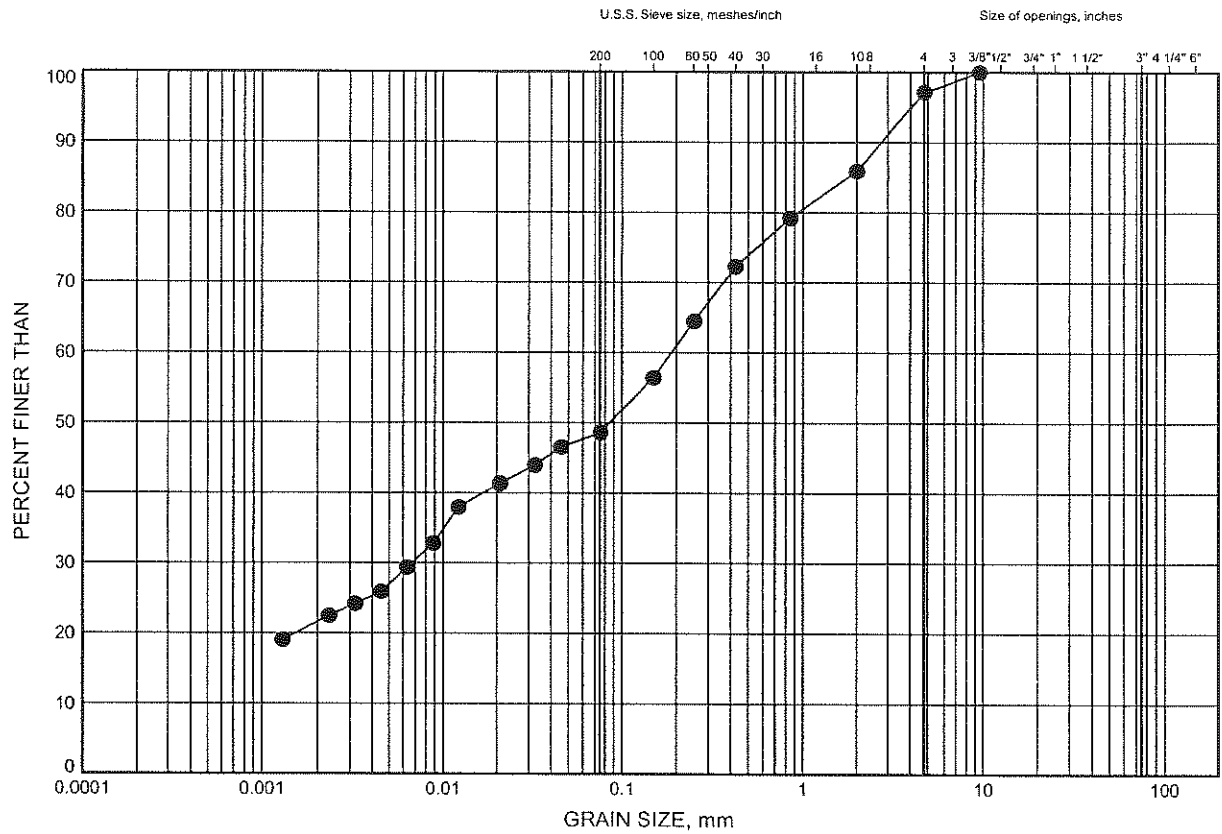
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
	Continued From Previous Page							20 40 60 80 100	20 40 60					GR SA SI CL	
	Silty CLAY, trace sand Hard Grey (TILL)						298							0 1 21 78	
296.6	Layer of silt: (700mm)		9	SS	42										
							297								
12.2	SAND, trace to some silt, trace gravel, trace clay Very Dense Grey Wet		10	SS	90		296							2 85 13 (SI+CL)	
295.1															
13.7	Sandy SILT, some clay, trace gravel, occasional cobbles Very Dense Grey Moist (TILL)		11	SS	101/ 275		295								
	occasional clayey silt seams		12	SS	137		294							2 29 55 14	
							293								
291.8			13	SS	110/ 200		292								
17.0	END OF BOREHOLE AT 17.0m. BOREHOLE OPEN TO 16.8m AND WATER LEVEL AT 1.5m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENSEAL TO 5.8m THEN HOLEPLUG TO 75mm AND ASPHALT TO SURFACE.														

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

# Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B1

Sand, Silt and Clay FILL



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-004	1.07	307.73

GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 12/3/08

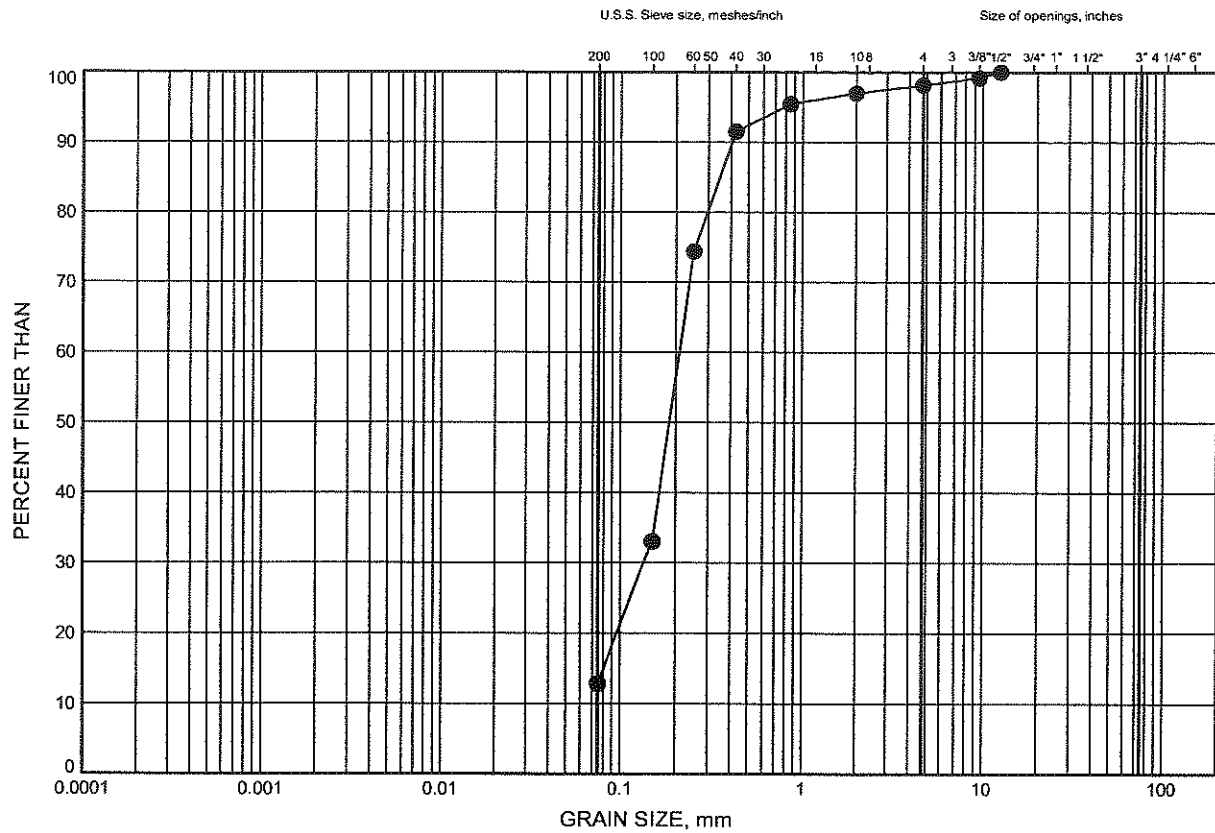
W.P.# 408-88-00.....  
Prepared By AN.....  
Checked By RPR.....



# Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B2

Sand



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-004	12.48	296.32

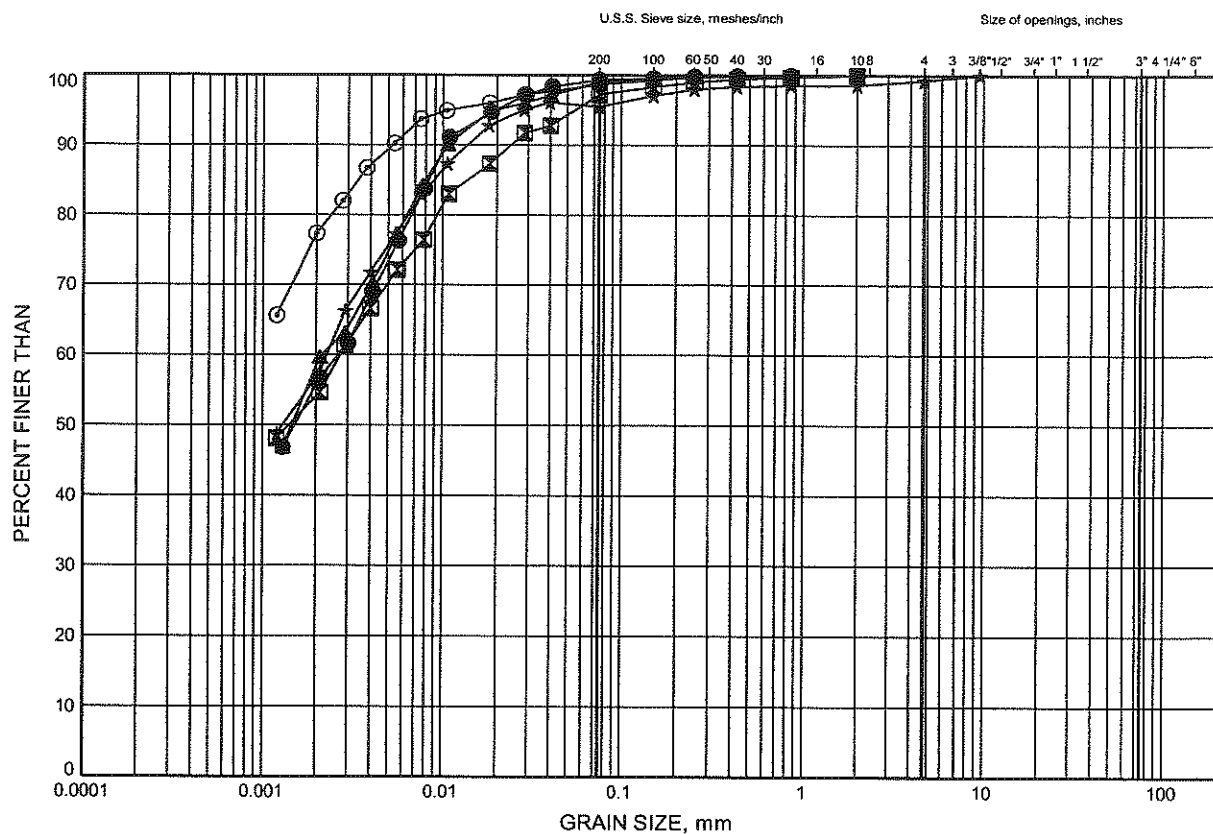


W.P.# 408-88-00  
Prepared By AN  
Checked By RPR

# Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B3

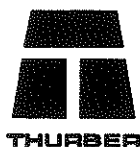
## Silty Clay TILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-002	3.35	304.95
⊠	08-002	7.92	300.38
▲	08-004	4.88	303.92
★	08-004	7.92	300.88
⊙	08-004	10.82	297.98

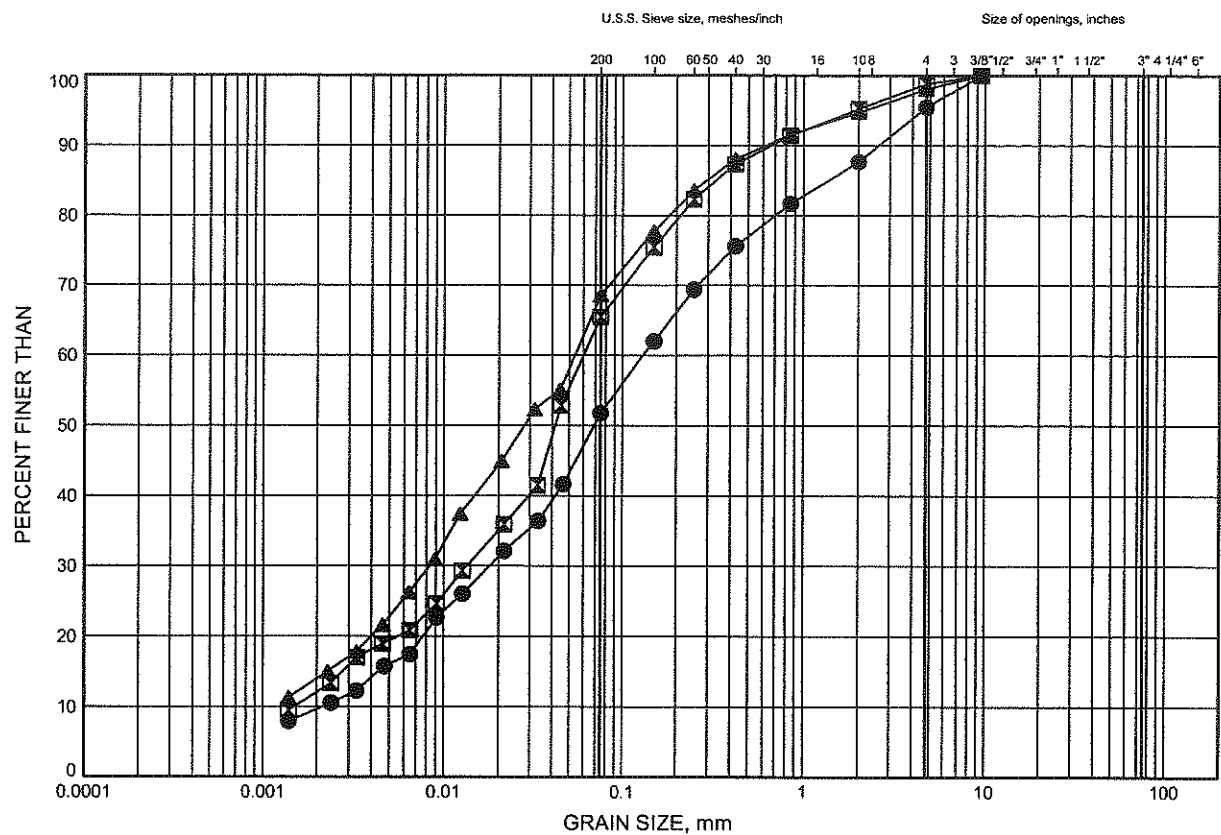


W.P.# .408-88-00.....  
Prepared By .AN.....  
Checked By .RPR.....

Highway 7 - New  
GRAIN SIZE DISTRIBUTION

FIGURE B4

Sandy Silt TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-002	12.42	295.88
⊠	08-002	15.36	292.94
▲	08-004	15.39	293.41

GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 11/29/08

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

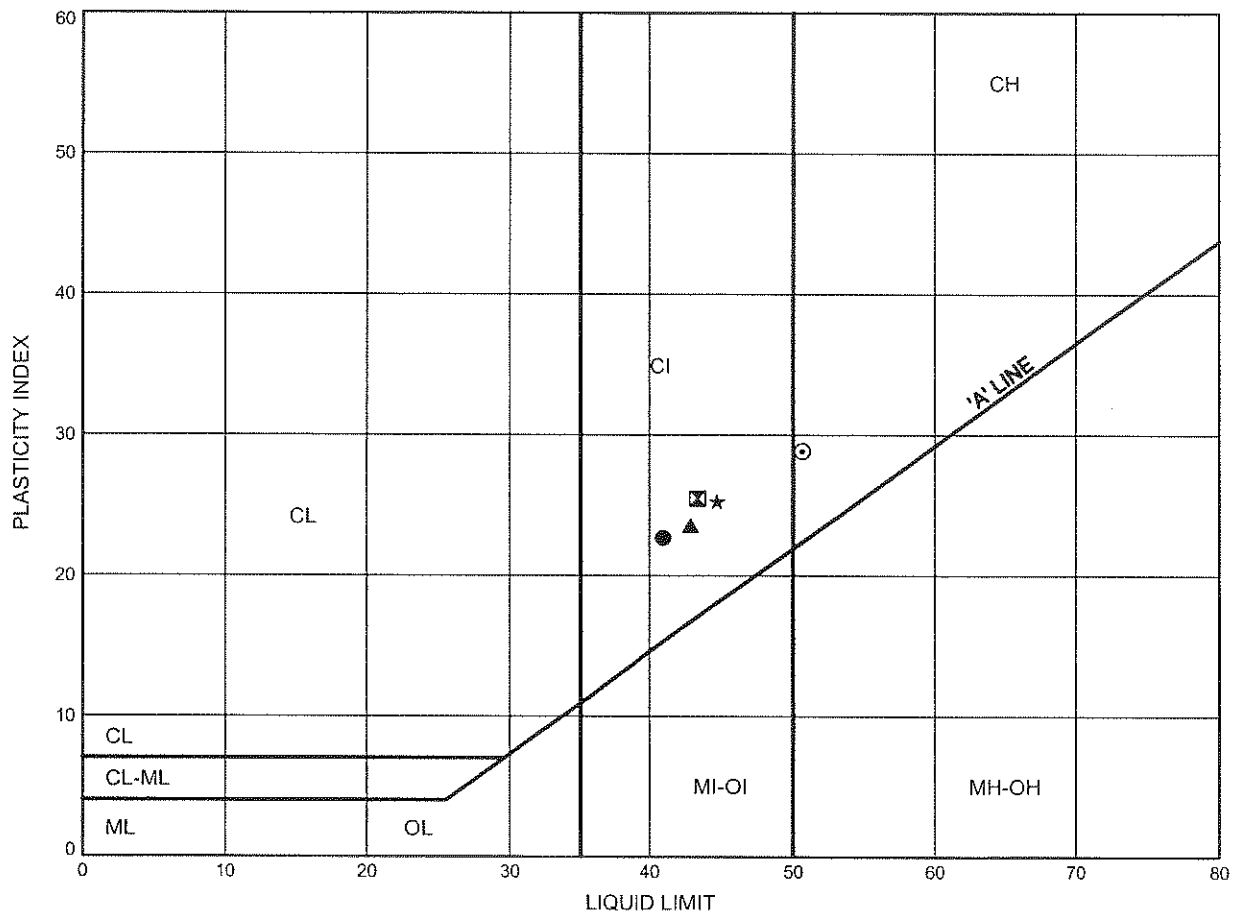




# Highway 7 - New ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty Clay TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-002	3.35	304.95
⊠	08-002	7.92	300.38
▲	08-004	4.88	303.92
★	08-004	7.92	300.88
⊙	08-004	10.82	297.98

Date December 2008  
 Project 408-88-00

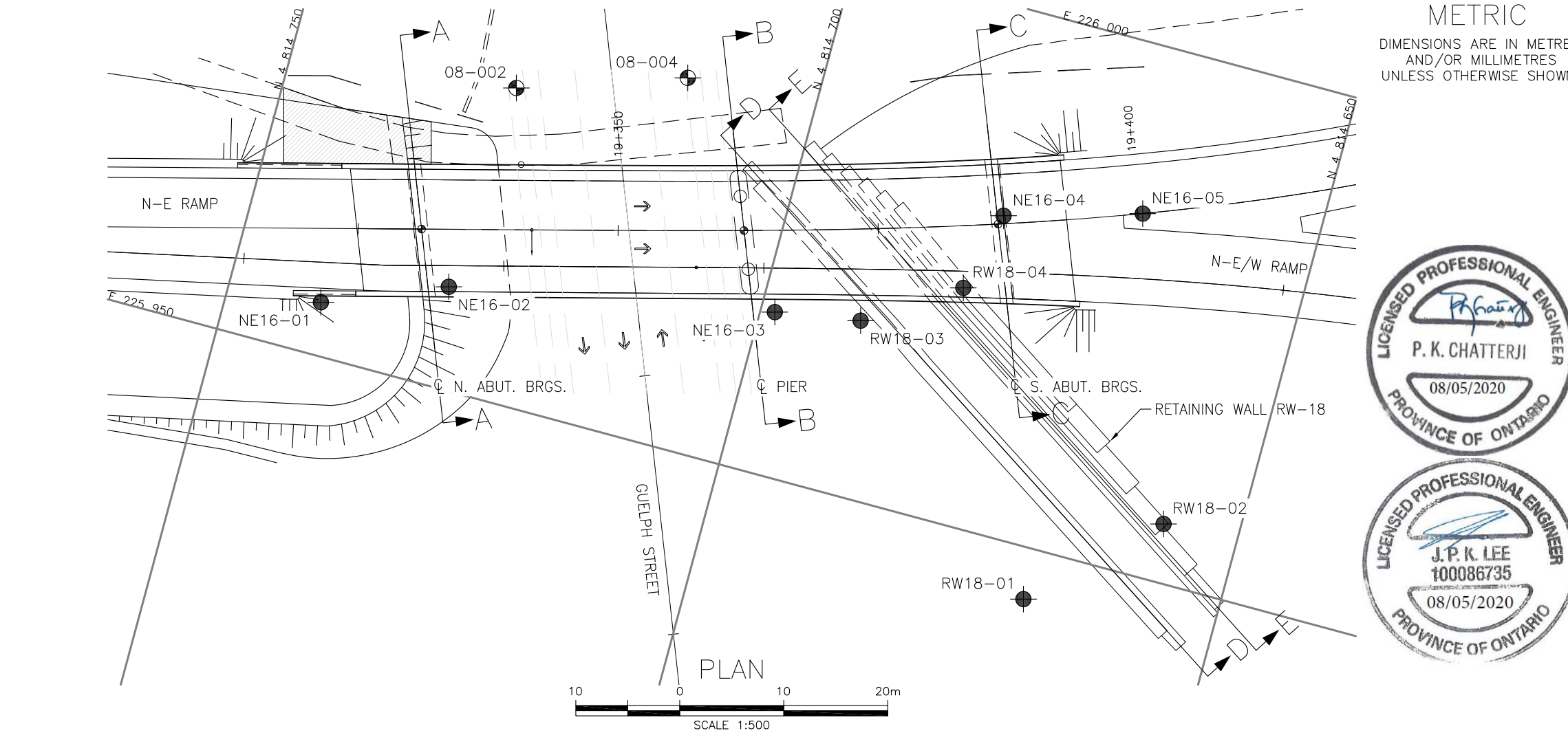


Prep'd AN  
 Chkd. RPR



## **Appendix C**

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

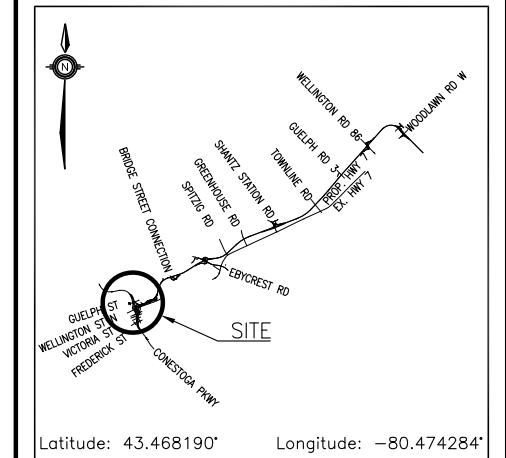


METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN



CONT No  
GWP No 408-88-00

HIGHWAY 7  
N-E/W RAMP OVER GUELPH ST  
PROPOSED BRIDGE  
BOREHOLE LOCATIONS AND SOIL STRATA



### KEYPLAN

### LEGEND

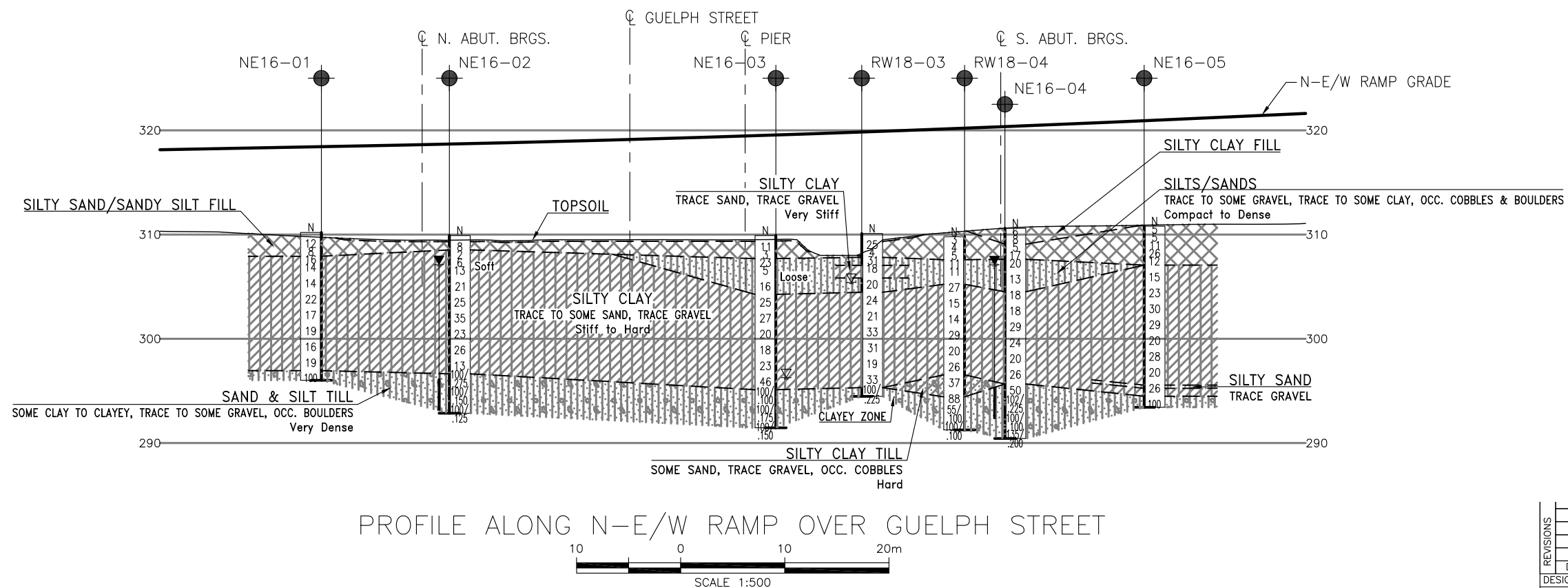
	Borehole (Current Investigation)
	Borehole (2008 Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
NE16-01	310.2	4 814 741.0	225 955.1
NE16-02	309.9	4 814 729.5	225 959.7
NE16-03	309.9	4 814 698.6	225 965.5
NE16-04	310.6	4 814 679.8	225 980.2
NE16-05	310.8	4 814 667.0	225 983.9
RW18-01	310.4	4 814 668.4	225 945.1
RW18-02	309.9	4 814 657.2	225 955.6
RW18-03	310.1	4 814 690.4	225 966.9
RW18-04	309.8	4 814 681.7	225 972.5
08-002	308.3	4 814 728.2	225 979.9
08-004	308.8	4 814 712.6	225 985.1

### -NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 40P8-282



### PROFILE ALONG N-E/W RAMP OVER GUELPH STREET

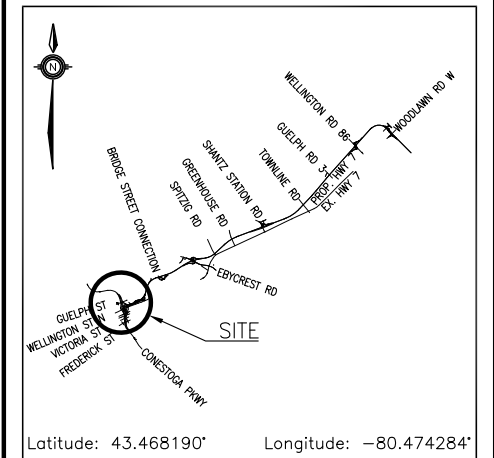
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METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
GWP No 408-88-00

HIGHWAY 7  
N-E/W RAMP OVER GUELPH ST  
PROPOSED BRIDGE  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



Latitude: 43.468190° Longitude: -80.474284°

### KEYPLAN

### LEGEND

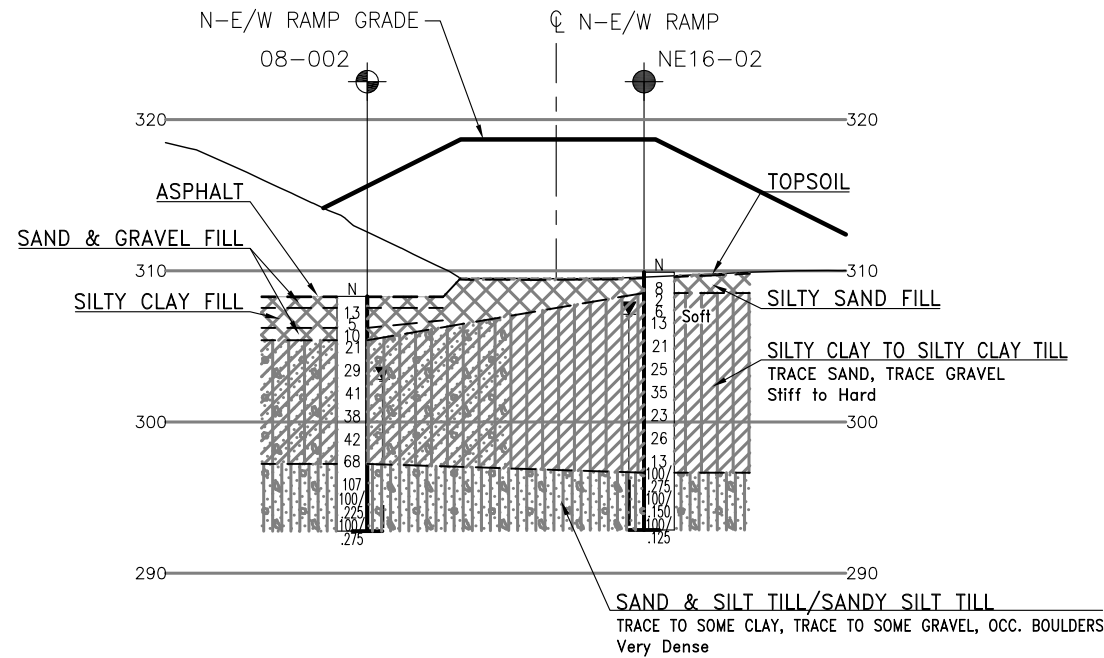
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	Borehole (2008 Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
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	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

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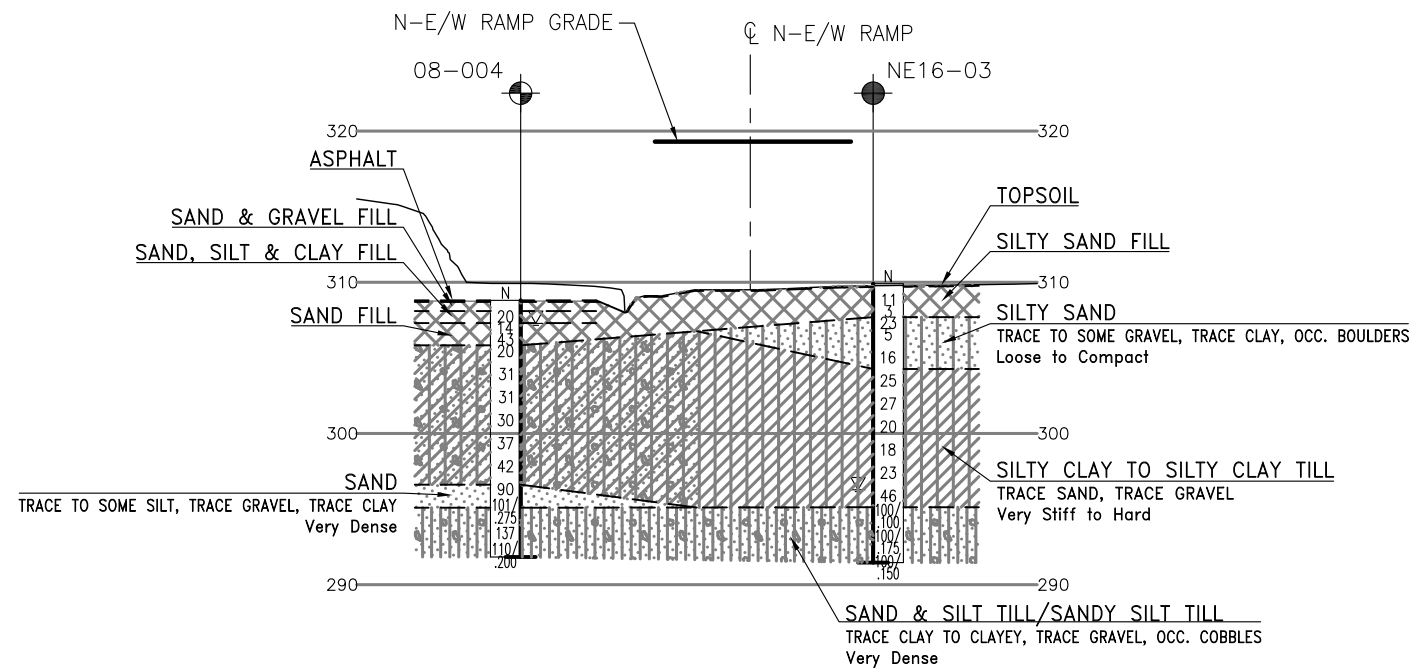
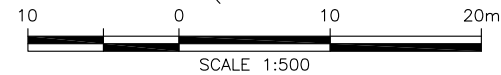
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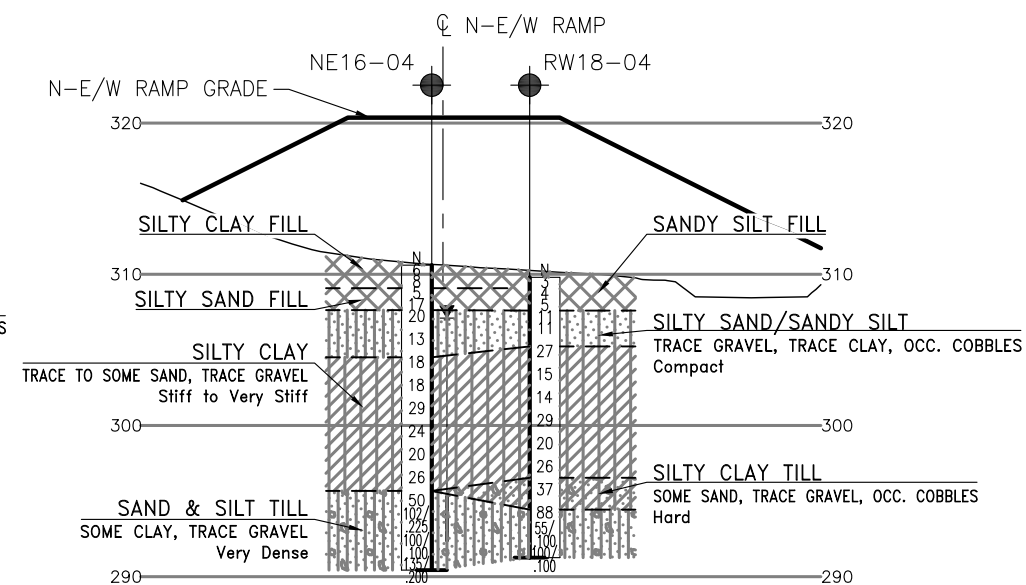
GEOCRES No. 40P8-282



### SECTION A-A (NORTH ABUTMENT)



### SECTION B-B (PIER)



### SECTION C-C (SOUTH ABUTMENT)

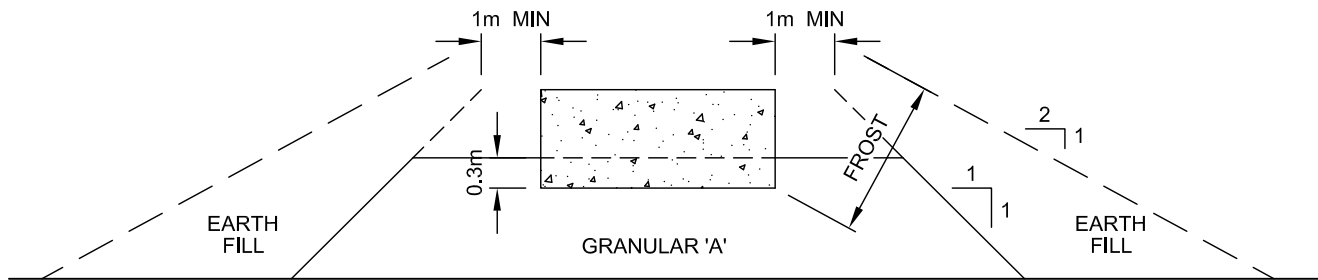


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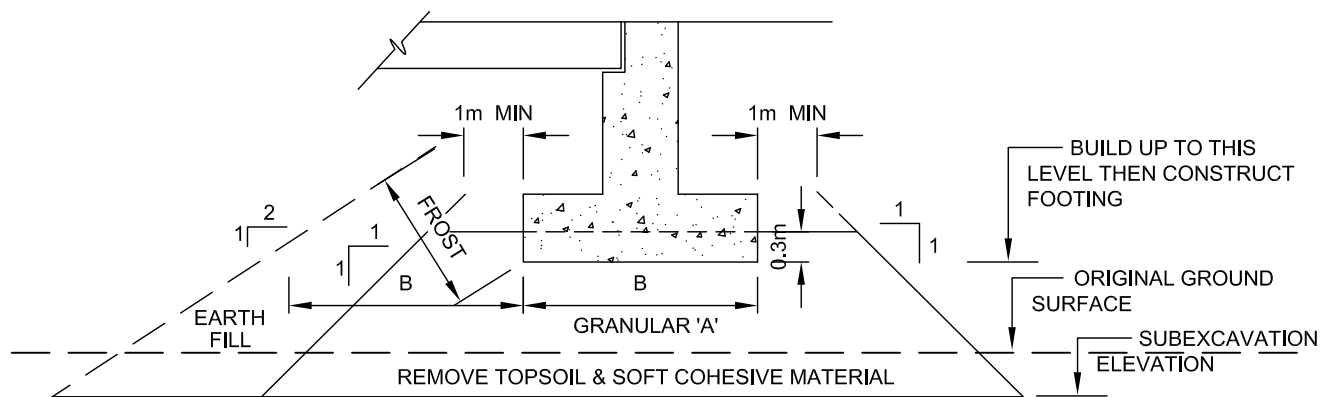


## **Appendix D**

### **Figure For Engineered Fill Pad**



## CROSS-SECTION



## LONGITUDINAL SECTION

### NOTES:

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

ABUTMENT ON COMPACTED FILL  
SHOWING GRANULAR 'A' CORE



**THURBER ENGINEERING LTD.**

ENGINEER :

-

DRAWN :

MFA

APPROVED :

-

DATE :

SEPTEMBER 2016

SCALE :

N.T.S.

DRAWING No.

FIGURE 1



## **Appendix E**

### **Foundation Comparison**

### COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Foundation Element	Spread Footings	Spread Footings on Engineered Fill	Driven Piles	Caisson
Abutments	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Generally less costly construction than deep foundation elements.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Dewatering may be required, depending on depth of excavation.</li> </ul> <p style="text-align: center;"><b>FEASIBLE</b></p>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Generally less costly construction than deep foundation elements.</li> <li>ii. Better geotechnical resistance than spread footings on native soils.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Excavation (up to 4.9 m deep) of existing fill will be required to place the engineered fill on competent native soils.</li> <li>ii. Dewatering may be required, depending on depth of excavation.</li> </ul> <p style="text-align: center;"><b>FEASIBLE</b></p>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. High geotechnical resistance may be developed by driving the piles into very dense till</li> <li>ii. Comparatively short abutment stem possible</li> <li>iii. Permits integral abutment design.</li> <li>iv. Readily installed.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Higher unit cost compared to footings.</li> <li>ii. When driven into hard/very dense till deposits, pipe piles are more prone to pile tip damage in comparison to H-piles.</li> <li>iii. Construction concerns related to the possibility of piles being obstructed by a boulder during driving.</li> </ul> <p style="text-align: center;"><b>RECOMMENDED</b></p>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Construction of caissons could continue in freezing weather.</li> <li>ii. High geotechnical resistance available for units founded on very dense till.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Higher cost than spread footings</li> <li>ii. Specialized installation measures such as temporary liners and drilling mud will be required to install caissons under the water table.</li> <li>iii. Potential difficulty in cleaning and inspecting bases.</li> </ul> <p style="text-align: center;"><b>NOT RECOMMENDED</b></p>
Pier	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Generally less costly construction than deep foundation elements.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Dewatering will be required, depending on depth of excavation.</li> </ul> <p style="text-align: center;"><b>FEASIBLE</b></p>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Generally less costly construction than deep foundation elements.</li> <li>ii. Better geotechnical resistance than spread footings on native soils.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Dewatering may be required, depending on the depth of excavation.</li> </ul> <p style="text-align: center;"><b>FEASIBLE</b></p>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. High geotechnical resistance may be developed by driving the piles into very dense till</li> <li>ii. Comparatively short abutment stem possible</li> <li>iii. Permits integral abutment design.</li> <li>iv. Readily installed.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Higher unit cost compared to footings.</li> <li>ii. When driven into hard/very dense till deposits, pipe piles are more prone to pile tip damage in comparison to H-piles.</li> <li>iii. Construction concerns related to the possibility of piles being obstructed by a boulder during driving.</li> </ul> <p style="text-align: center;"><b>RECOMMENDED</b></p>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Construction of caissons could continue in freezing weather.</li> <li>ii. High geotechnical resistance available for units founded on very dense till.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Higher cost than spread footings</li> <li>ii. Specialized installation measures such as temporary liners and drilling mud will be required to install caissons under the water table.</li> <li>iii. Potential difficulty in cleaning and inspecting bases.</li> </ul> <p style="text-align: center;"><b>NOT RECOMMENDED</b></p>





## **Appendix F**

### **Slope Stability Output**

11375  
Hwy 7-New  
N-E/W Ramp Over Guelph Street  
Armour Stone Wall  
Height 9.0 m , Length 60.0 m  
Drained Analysis

Name: New embankment Fill	Unit Weight: 20 kN/m <sup>3</sup>	Cohesion': 0 kPa	Phi': 30 °	Phi-B: 0 °	Piezometric Line: 1
Name: Existing fill (sandy silt/silty sand)	Unit Weight: 19 kN/m <sup>3</sup>	Cohesion': 0 kPa	Phi': 30 °	Phi-B: 0 °	Piezometric Line: 1
Name: Compact sand and silt	Unit Weight: 20 kN/m <sup>3</sup>	Cohesion': 0 kPa	Phi': 30 °	Phi-B: 0 °	Piezometric Line: 1
Name: Stiff to hard silty clay	Unit Weight: 19 kN/m <sup>3</sup>	Cohesion': 0 kPa	Phi': 29 °	Phi-B: 0 °	Piezometric Line: 1
Name: Granular pad	Unit Weight: 22 kN/m <sup>3</sup>	Cohesion': 0 kPa	Phi': 34 °	Phi-B: 0 °	Piezometric Line: 1
Name: Armour stone	Unit Weight: 22 kN/m <sup>3</sup>	Cohesion': 200 kPa	Phi': 45 °	Phi-B: 0 °	Piezometric Line: 1

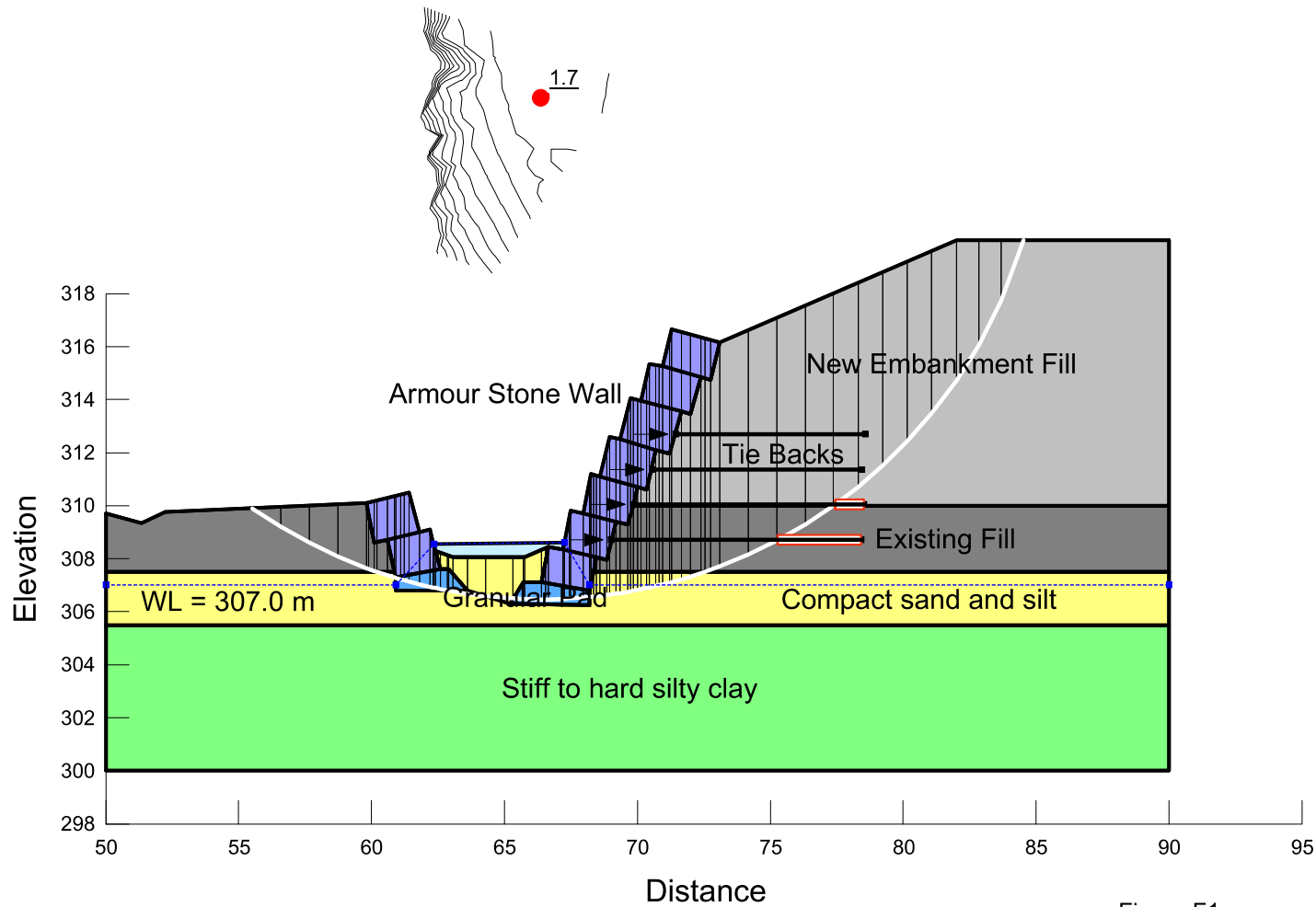


Figure F1

Directory: H:\10000+11375 Hwy 7 New PD and DD Foundations\Reports & Memos\Interchange Ramps\N-E Ramp over Guelph St\Analysis\Slope Stability\  
File Name: 11375- Slope stability - armour stone wall- June 3- drained.gsz  
Date: 2020-06-03, Time: 9:00:41 PM

11375  
Hwy 7-New  
N-E/W Ramp Over Guelph Street  
Armour Stone Wall  
Height 9.0 m , Length 60.0 m  
Undranined Analysis

Name: New embankment Fill    Unit Weight: 20 kN/m³    Cohesion': 0 kPa    Phi': 30 °    Phi-B: 0 °    Piezometric Line: 1  
Name: Existing fill (sandy silt/silty sand)    Unit Weight: 19 kN/m³    Cohesion': 0 kPa    Phi': 30 °    Phi-B: 0 °    Piezometric Line: 1  
Name: Compact sand and silt    Unit Weight: 20 kN/m³    Cohesion': 0 kPa    Phi': 30 °    Phi-B: 0 °    Piezometric Line: 1  
Name: Stiff to hard silty clay    Unit Weight: 19 kN/m³    Cohesion': 120 kPa    Piezometric Line: 1  
Name: Granular pad    Unit Weight: 22 kN/m³    Cohesion': 0 kPa    Phi': 34 °    Phi-B: 0 °    Piezometric Line: 1  
Name: Armour stone    Unit Weight: 22 kN/m³    Cohesion': 200 kPa    Phi': 45 °    Phi-B: 0 °    Piezometric Line: 1

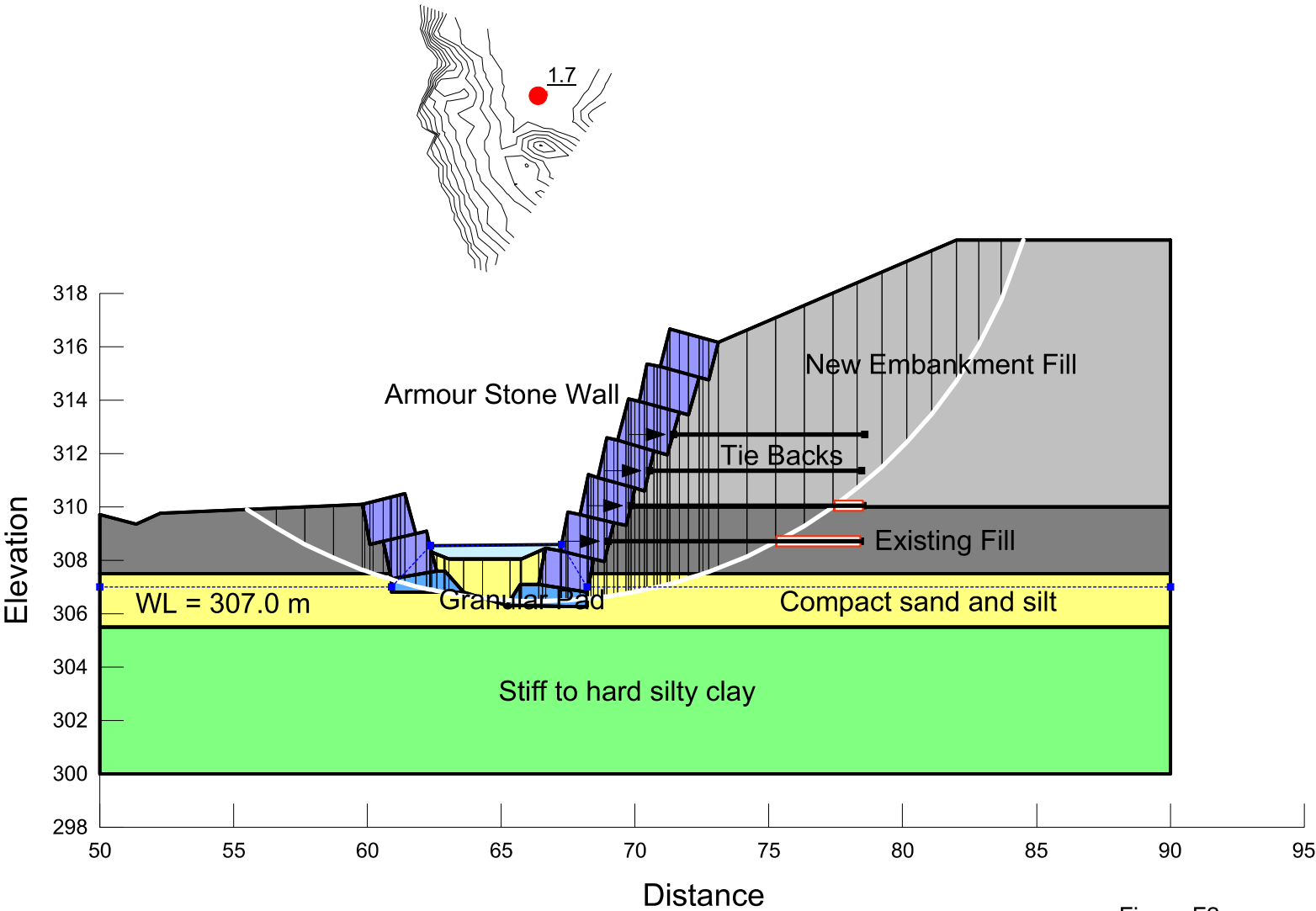


Figure F2

11375  
Hwy 7-New  
N-E/W Ramp Over Guelph Street  
Armour Stone Wall  
Height 9.0 m , Length 60.0 m  
Seismic Analysis PGA=0.097

Name: New embankment Fill    Unit Weight: 20 kN/m<sup>3</sup>    Cohesion': 0 kPa    Phi': 30 °    Phi-B: 0 °    Piezometric Line: 1  
Name: Existing fill (sandy silt/silty sand)    Unit Weight: 19 kN/m<sup>3</sup>    Cohesion': 0 kPa    Phi': 30 °    Phi-B: 0 °    Piezometric Line: 1  
Name: Compact sand and silt    Unit Weight: 20 kN/m<sup>3</sup>    Cohesion': 0 kPa    Phi': 30 °    Phi-B: 0 °    Piezometric Line: 1  
Name: Stiff to hard silty clay    Unit Weight: 19 kN/m<sup>3</sup>    Cohesion': 120 kPa    Piezometric Line: 1  
Name: Granular pad    Unit Weight: 22 kN/m<sup>3</sup>    Cohesion': 0 kPa    Phi': 34 °    Phi-B: 0 °    Piezometric Line: 1  
Name: Armour stone    Unit Weight: 22 kN/m<sup>3</sup>    Cohesion': 200 kPa    Phi': 45 °    Phi-B: 0 °    Piezometric Line: 1

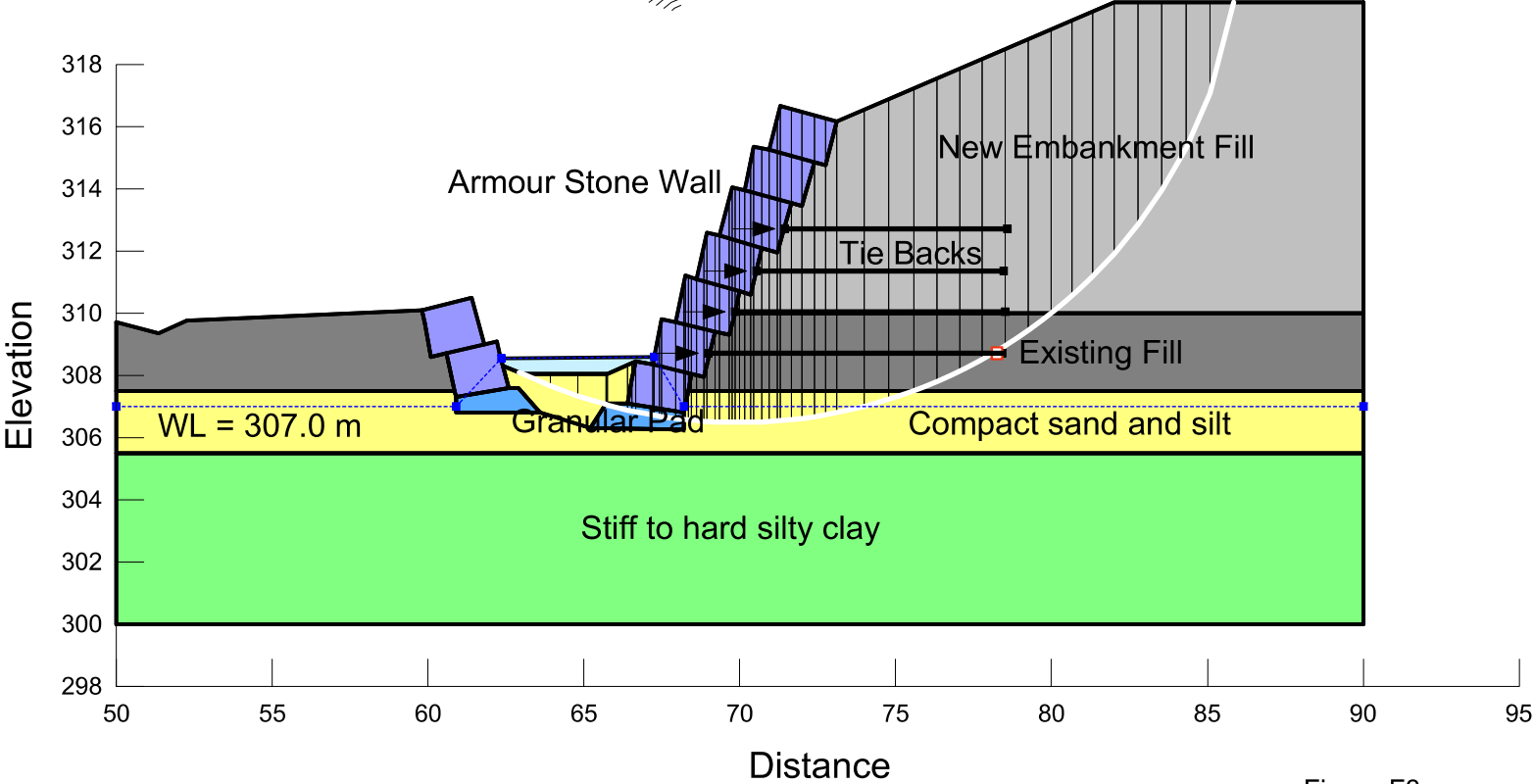
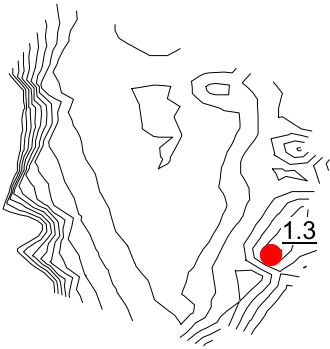


Figure F3

Project Number: 11375  
 N-E/W Ramp over Guelph Street  
 Overpass  
 Embankment height 8 m approximately  
 Drained Analysis

Name: Existing fill (silty clay)	Unit Weight: 19 kN/m <sup>3</sup>	Cohesion': 0 kPa	Phi': 29 °	Piezometric Line: 1
Name: Compact sandy silt	Unit Weight: 20 kN/m <sup>3</sup>	Cohesion': 0 kPa	Phi': 30 °	Piezometric Line: 1
Name: Very stiff to hard silty clay till	Unit Weight: 19 kN/m <sup>3</sup>	Cohesion': 0 kPa	Phi': 30 °	Piezometric Line: 1
Name: New embankment fill	Unit Weight: 22 kN/m <sup>3</sup>	Cohesion': 0 kPa	Phi': 32 °	Piezometric Line: 1
Name: Existing fill (silty sand)	Unit Weight: 19 kN/m <sup>3</sup>	Cohesion': 0 kPa	Phi': 30 °	Piezometric Line: 1

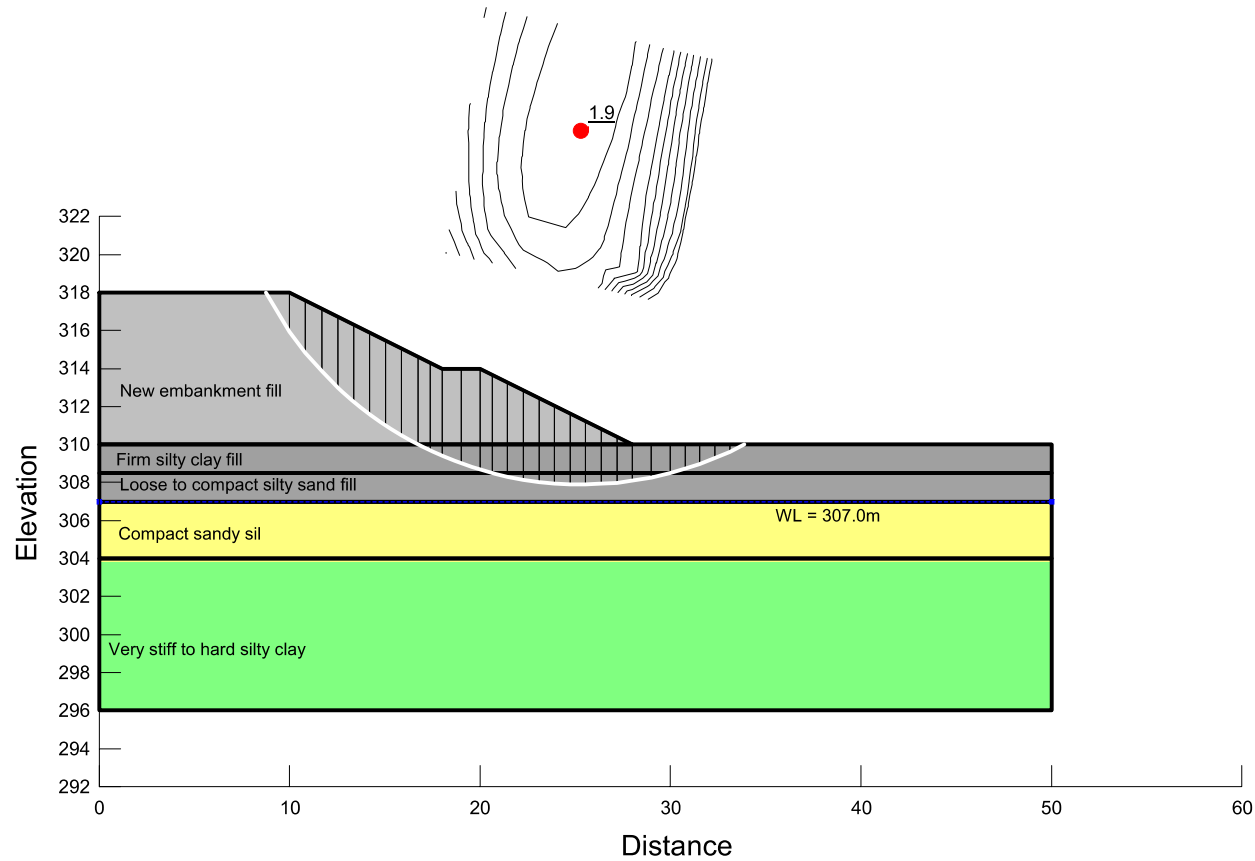


Figure F4

Directory: H:\10000+11375 Hwy 7 New PD and DD Foundations\Reports & Memos\Interchange Ramps\N-E Ramp over Guelph St\Analysis\Slope Stability\  
 File Name: 11375- Slope stability - side slope-drained\_May 22.gsz  
 Date: 2020-05-22 ,Time: 2:34:36 PM

Project Number: 11375  
 N-E/W Ramp over Guelph Street  
 Overpass  
 Embankment height 8 m approximately  
 Undrained Analysis

Name: Existing fill (silty clay)	Unit Weight: 19 kN/m <sup>3</sup>	Cohesion': 35 kPa	Piezometric Line: 1
Name: Compact sandy silt	Unit Weight: 20 kN/m <sup>3</sup>	Cohesion': 0 kPa	Phi': 30 °
Name: Very stiff to hard silty clay till	Unit Weight: 19 kN/m <sup>3</sup>	Cohesion': 150 kPa	Piezometric Line: 1
Name: New embankment fill	Unit Weight: 22 kN/m <sup>3</sup>	Cohesion': 0 kPa	Phi': 32 °
Name: Existing fill (silty sand)	Unit Weight: 19 kN/m <sup>3</sup>	Cohesion': 0 kPa	Phi': 30 °

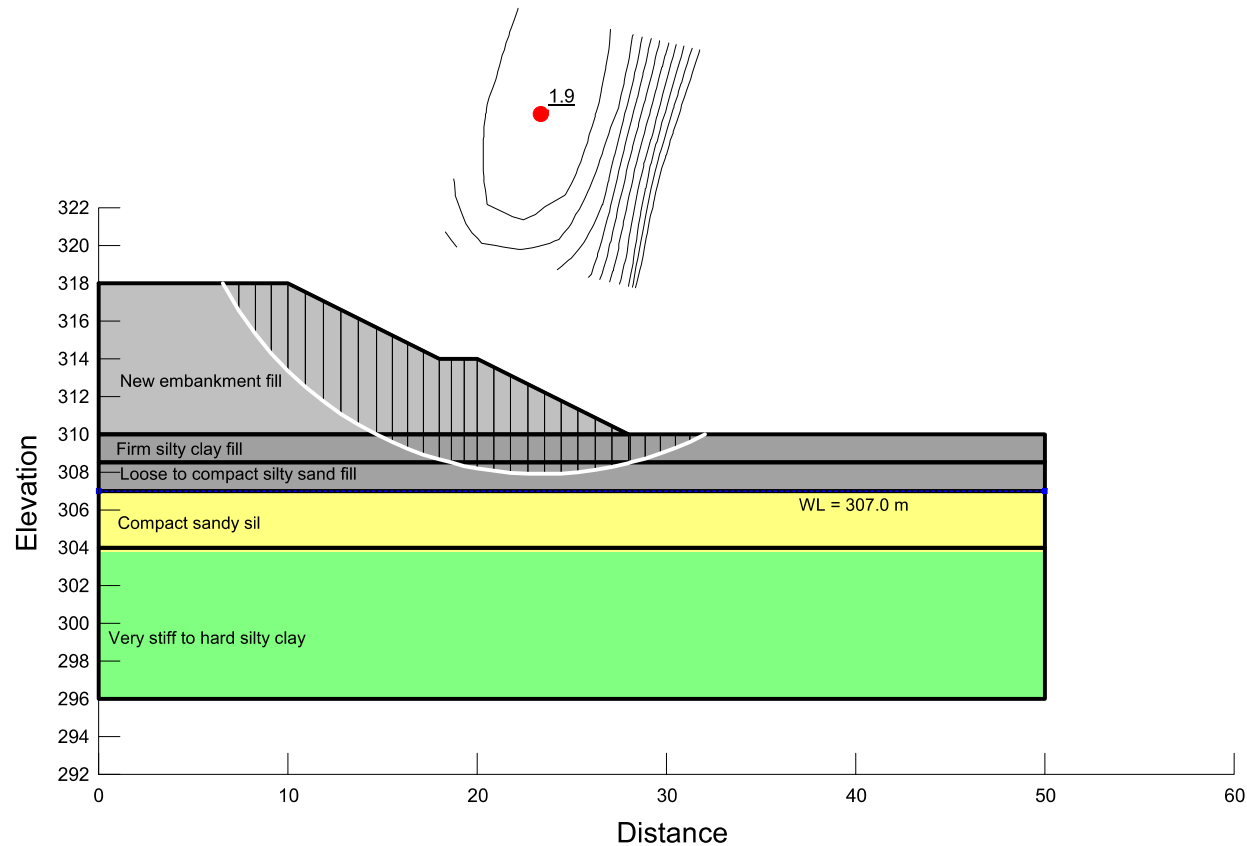


Figure F5

Directory: H:\10000+11375 Hwy 7 New PD and DD Foundations\Reports & Memos\Interchange Ramps\N-E Ramp over Guelph St\Analysis\Slope Stability\  
 File Name: 11375- Slope stability - side slope-undrained\_May 22.gsz  
 Date: 2020-05-22 , Time: 2:46:45 PM

Project Number: 11375  
N-E/W Ramp over Guelph Street  
Overpass  
Embankment height 8 m approximately  
Seismic Analysis PGA=0.097

Name: Existing fill (silty clay)	Unit Weight: 19 kN/m <sup>3</sup>	Cohesion': 35 kPa	Piezometric Line: 1
Name: Compact sandy silt	Unit Weight: 20 kN/m <sup>3</sup>	Cohesion': 0 kPa	Phi': 30 °
Name: Very stiff to hard silty clay till	Unit Weight: 19 kN/m <sup>3</sup>	Cohesion': 150 kPa	Piezometric Line: 1
Name: New embankment fill	Unit Weight: 22 kN/m <sup>3</sup>	Cohesion': 0 kPa	Phi': 32 °
Name: Existing fill (silty sand)	Unit Weight: 19 kN/m <sup>3</sup>	Cohesion': 0 kPa	Phi': 30 °

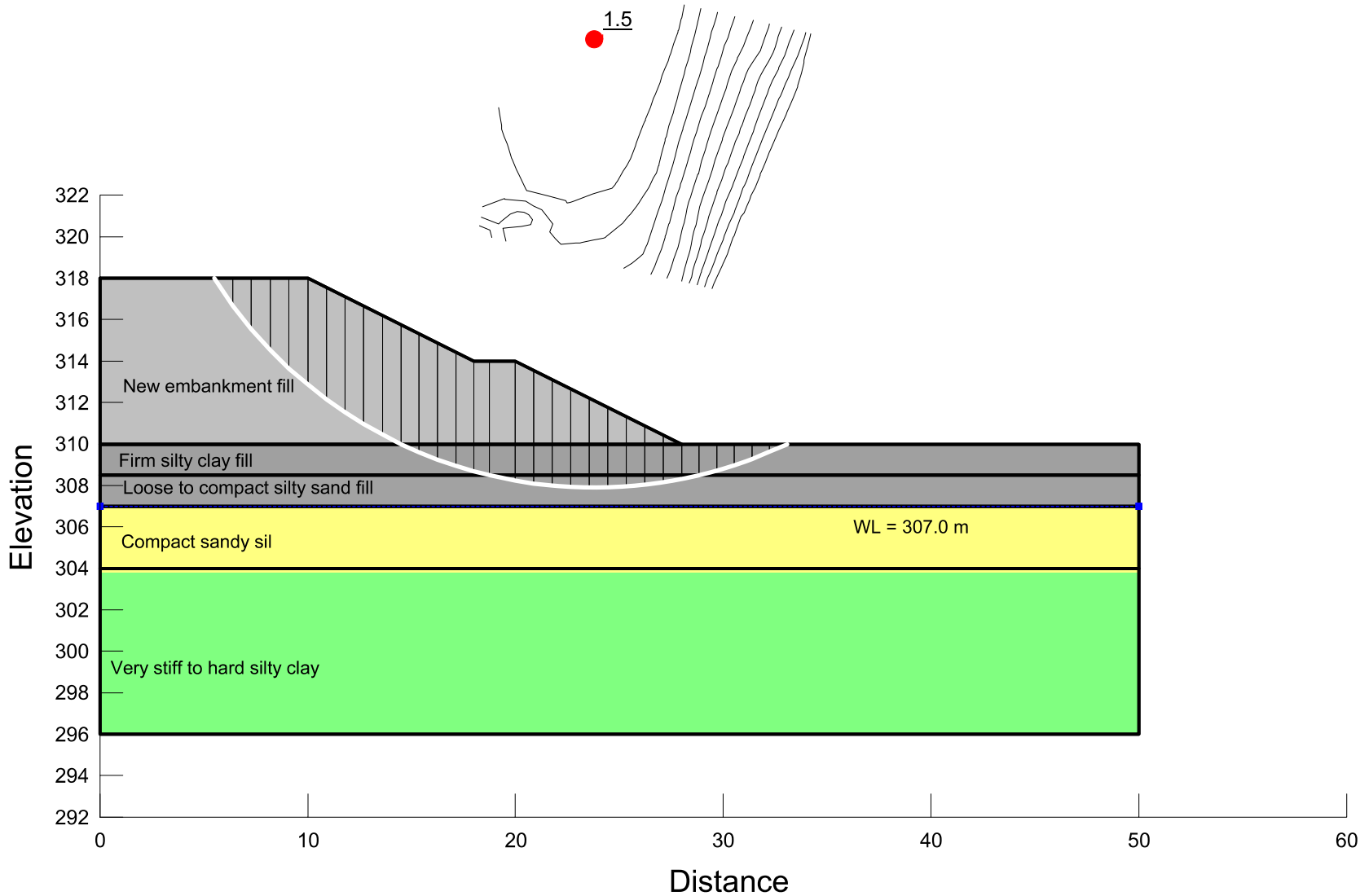


Figure F6



## **Appendix G**

### **List of OPSS Documents and Nssp Wording**





## **1. List of Special Provisions and OPSS Documents Referenced in this Report**

- OPSS PROV 206 Construction specification for grading
- OPSS PROV 501 Construction specification for compacting
- OPSS.PROV 517 Construction specification for dewatering
- SP 517F01 Amendment to OPSS 517
- OPSS PROV 539 Construction specification for temporary protection systems
- OPSS PROV 804 Construction specification for seed and cover
- OPSS PROV 902 Construction specification for excavating and backfilling - Structures
- SP 109S12 Amendment to OPSS 902
- OPSS PROV 903 Construction specification for deep foundations
- SP 109F57 Amendment to OPSS 903
- OPSS PROV 1010 Material specification for aggregates - base, subbase, select subgrade, and backfill material
- OPSD 3102.100 Wall abutments, backfill drain
- OPSD 3101.150 Wall abutment, backfill minimum granular requirement

## **2. Suggested text for a NSSP on Pile Installation**

Installation of H-piles shall be in accordance with OPSS.PROV 903 and the following.

The native soils at the N-EW Ramp Overpass Structure over Guelph Street are comprised of glacial till and are known to contain cobbles and boulders. Appropriate equipment and construction procedures will be required to penetrate or remove obstructions, such as cobbles



and boulders, to permit pile installation. Pile driving must be controlled according to the criteria specified for the site.

Should a pile achieve the design ultimate geotechnical resistance or refusal at a tip elevation higher than that indicated in the contract, the Contract Administrator (CA) shall be informed immediately who should consult with the design team for resolution. Over-driving must be avoided to minimize the risk of damaging the pile.

### **3. Suggested Text for NSSP on Groundwater Control**

Water seepage due to perched water in the slope, random fill, surface runoff and precipitation should be expected. Excavation for the armour stone wall foundation will extend below the existing creek level. Sheeted excavation (cofferdam) or vacuum well-points may be required to dewater the excavation. For temporary excavations for retaining wall construction at the north abutment, groundwater control will likely be limited to diverting surface runoff and preventing precipitation from entering the excavations supplemented by sump pumping and use of perimeter ditches where required. Filtered sumps must be designed properly so that construction drainage water containing eroded soil and fines do not flow onto the existing roadways. Dewatering systems must be installed and made operational prior to excavating below the groundwater level. The dewatering scheme must be effective to lower the groundwater level at least 0.5 m below the footing/pile cap grade level to avoid base boiling in the native soils. It is also important to minimize disturbance of the exposed silt/sand surfaces by limiting construction traffic.

### **4. Suggested Text for NSSP on “Impact on Adjacent Buried Utilities”**

It is critical that Contractor’s excavation and construction activities do not undermine or have any adverse impact on the integrity and performance of any adjacent underground utilities:

- Protection of utilities during excavation and pile driving.



## **5. Suggested Text for NSSP on “Armour Stone Retaining Walls”**

The proposed armour stone walls downstream of the south abutment of N-EW Ramp Structure over Guelph Street shall be designed by the proprietary wall supplier retained by the Contractor. For any selected wall system not approved on the MTO RSS DSM List #9.70.56, the Contractor shall submit the proprietary retaining wall design to MTO Foundations Office for review and approval. The design shall meet MTO's high performance and high appearance requirements. The Contractor and proprietary wall supplier/designer shall allow a minimum of 4 weeks for the MTO to review the selected retaining wall type and design details prior to construction.