



THURBER ENGINEERING LTD.

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

GEOCRES No. 40P8-281

Latitude 43.466067 °, Longitude -80.471974 °

Report

to

WSP

Date: July 17, 2020
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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a detailed foundation investigation conducted at the site of a new E-S Ramp over Wellington Street, in the Regional Municipality of Waterloo. The proposed E-S 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 information on subsurface conditions contained in previous foundation reports prepared for this site during the preliminary design phase. The titles of the reports are:

- Preliminary, Foundation Investigation and Design Report, E-S Ramp over Kitchener Waterloo Expressway and Wellington Street, Highway 7-New, Kitchener to Guelph, G.W.P. 408-88-00, Geocres No. 40P8-161, Report to Ministry of Transportation Ontario West Region, File: 15-64-17, dated June 2, 2009. (Reference 1).

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- Preliminary, Foundation Investigation and Design Report, E-S Ramp/Connector From Highway 7 over E-N and S-W Wellington Streets Ramps, Highway 7-New, Kitchener to Guelph, G.W.P. 408-88-00, Geocres No. 40P8-164, Report to Ministry of Transportation Ontario West Region, File: 15-64-17, dated June 1, 2009. (Reference 2).

2. SITE AND PROJECT DESCRIPTION

The site lies within the Kitchener-Waterloo Expressway (KWE) and Wellington Street interchange. At this location, the new E-S Ramp will cross over the proposed Wellington Street North, W/E-S Ramp, Highway 85, S-W Ramp, N-E Ramp, S-W Ramp, S-W to E Wellington and Wellington to E-N Ramp.

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 foundation investigation was carried out at this site between June 26 to September 26, 2008. Five boreholes, 08-015 to 08-019, were drilled at select locations along the proposed structure alignment. The depths of the boreholes ranged from 11.1 m to 21.5 m (Elevation 315.7 to 288.8). The Record of Borehole sheets for this previous investigation are included in Appendix B.

A detailed geotechnical investigation was conducted between April 11 and June 7, 2018 and consisted of drilling eight boreholes (numbered ES16-01 to ES16-08) near the proposed foundation elements of the ramp and three boreholes (numbered RW07-01, RW09-01 and RW09-02) near two proposed retaining walls (designated as RW-7, and RW-9) on the north side of the west abutment and north and south sides of the east abutment. Boreholes ES16-01 to ES16-07 were drilled at the abutments and the piers, and ES16-08 was drilled at the east approach. These Boreholes were extended to depths ranging from 14.3 m to 33.8 m (Elevations 309.1 and 288.8). Boreholes RW07-01, RW09-01, and RW09-02 were drilled to depths ranging from 8.2 m to 9.6



m (Elevations 315.7 to 313.2). The Record of Borehole sheets for the present investigation are included in Appendix A.

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

The ground surface elevations and coordinates of the 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 present investigation, a rubber track mounted B-57 drill rig, was used in conjunction with hollow-stem augers and tricone 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. Standpipe piezometers consisting of 25 mm diameter PVC pipe with a slotted screen and enclosed in filter sand, were installed in Boreholes ES16-01, ES16-03, ES16-05, and ES16-07 to permit longer-term groundwater level monitoring. Boreholes without piezometer installations were backfilled in general accordance with O. Reg. 903. The borehole completion details are also shown in Table 3.1.

The completion of the boreholes were carried out in accordance with the requirements of O. Reg. 903 (as amended by O. Reg. 372/07). The standpipe piezometers will be decommissioned in the summer of 2020.



Table 3.1 – Borehole Completion Details

Foundation Unit	Borehole	Ground Surface Elevation (m)	Borehole Depth / Base Elevation (m)	Piezometer Tip Elevation (m)	Completion Details
West Approach	08-019	321.7	21.3/300.4	20.7/301.0	Piezometer with 1.5 m slotted screen installed with sand filter to 17.4 m, holeplug from 17.4 m to 17.1 m, bentonite from 17.1 m to surface.
West Abutment	ES16-01	322.5	33.7/288.8	33.5/288.9	Piezometer with 3.0 m slotted screen installed with sand filter from 33.7 m to 28.1 m, holeplug from 28.1 m to ground surface.
Pier 1	ES16-02	324.5	33.8/290.7	None Installed	Borehole backfilled with bentonite holeplug to 0.3 m, then asphalt patch to surface.
Pier 2	ES16-03	320.3	26.2/294.1	25.9/294.4	Piezometer with 3.0 m slotted screen installed with sand filter from 25.9 m to 21.9 m, holeplug from 21.9 m to ground surface.
Pier 3	08-015	318.3	21.5/296.8	None Installed	On June 27, 2008, borehole caved to 6.4 m. Borehole was backfilled with holeplug from 6.4 m to 0.9 m, concrete to 0.1 m, then asphalt patch to surface. On September 29, 2008, borehole was backfilled with grout to surface.
Pier 4	ES16-04	317.6	17.2/300.4	None Installed	Borehole backfilled with bentonite holeplug to 0.3 m, then auger cuttings to surface.
	08-016	317.7	16.9/300.8	16.9/300.8	Piezometer with 1.5 m slotted screen installed with sand filter to 14.9 m, holeplug from 14.9 m to 14.6 m, bentonite from 14.6 m to 2.1 m, holeplug from 2.1 m to 1.5 m, auger cutting from 1.5 m to 0.6 m, then holeplug to surface.
Pier 5	ES16-05	318.8	16.9/301.8	16.7/302.0	Piezometer with 3.0 m slotted screen installed with sand filter from 16.9 m to 13.1 m, holeplug and auger cuttings from 13.1 m to 0.3m, then gravel to surface.



Foundation Unit	Borehole	Ground Surface Elevation (m)	Borehole Depth / Base Elevation (m)	Piezometer Tip Elevation (m)	Completion Details
Pier 6	ES16-06	320.3	17.1/303.3	None Installed	Borehole backfilled with bentonite holeplug to 0.3 m, then auger cuttings to surface.
	08-017	320.5	18.4/302.0	None Installed	Borehole backfilled with grout to surface
East Abutment	ES16-07	323.0	21.6/301.4	21.3/301.7	Piezometer with 3.0 m slotted screen installed with sand filter from 21.6 m to 17.7 m, holeplug from 17.7 m to 0.3m, then cement to surface.
East Approach	ES16-08	323.5	14.3/309.1	None Installed	Borehole backfilled with bentonite holeplug and grout to surface.
Retaining wall (RW07-01, North side of west approach)	RW07-01	323.9	8.2/315.7	None Installed	Borehole backfilled with bentonite holeplug to surface.
Retaining wall (RW09-01, south side of east approach) and (RW09-02, north side of east approach)	RW09-01	323.5	9.6/313.9	None Installed	Borehole backfilled with bentonite holeplug and grout to surface.
	08-018	323.1	11.1/311.9	10.6/312.4	Piezometer with 1.5 m slotted screen installed with sand filter from 10.6 m to 8.4 m, holeplug and cuttings from 8.4 m to surface
	RW09-02	322.8	9.6/313.2	None Installed	Borehole backfilled with bentonite holeplug and grout 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 the current and the previous investigations are presented on the Record of Borehole sheets in Appendices A and B, respectively, 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 samples of the sand fill from Boreholes



RW07-01 and RW09-02 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

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendices A and B. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for 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 cohesionless and cohesive fill overlaying extensive native deposits of sand, silty clay till, and silty clay, which are all underlain by sand and silt till. Topsoil was encountered surficially in some boreholes. Asphalt was observed in three boreholes. Descriptions of the individual strata are presented below.

5.1 Topsoil

A topsoil layer ranging from 100 mm to 300 mm in thickness was encountered at the ground surface in Boreholes 08-016, 08-017, 08-018, 08-019, ES16-01, ES16-03, ES16-08 and RW07-01.

The topsoil thickness may vary between and beyond the borehole locations, and the limited data presented in this report should not be used for quantity estimation purposes.

5.2 Asphalt

Boreholes 08-015, ES16-02, ES16-07 and RW09-01 were drilled through an approximately 60 mm to 200 mm thick layer of asphalt.



5.3 Fill

Layers of cohesionless and cohesive fill were encountered in all the boreholes, except for Boreholes 08-016 and 08-017.

The cohesionless fill consisted on brown to grey sand, silty sand, sandy silt with trace to some clay, trace gravel and occasional organics, and was contacted at depths ranging from ground surface to 1.4 m (Elevations 324.4 to 316.9). The thickness of the cohesionless fill varied from 0.7 m to 5.5 m and extended to depths ranging from 1.4 m to 5.6 m (Elevation 321.6 to 314.6).

A layer of cohesionless sand and gravel fill with some silt and clay was contacted below the asphalt in Boreholes 08-015, and RW09-01 and below the topsoil in Borehole 08-018 and ranged in thickness from 0.4 m to 1.3 m thick and extended to depths ranging from 0.6 m to 1.4 m (Elevation 322.4 to 317.5).

The cohesive fill consisted of brown silty clay containing occasional organics, rootlets and wood fibres and was encountered surficially in Boreholes ES16-04, ES16-05 and ES16-06, below the sand fill at 1.4 m depth in Borehole ES16-07 and below the topsoil in Borehole ES16-08. The cohesive fill ranged in thickness from 0.5 m to 1.6 m and extended to depths ranging from 0.6 to 3.0 m (Elevation 322.9 to 316.9).

In general, the depth to the base of the fill ranged from 0.6 m to 5.6 m (Elevations 322.9 to 314.6).

The cohesionless fill is classified as loose to dense, based on SPT 'N' values ranging from 6 to 59 blows for 0.3 m of penetration. SPT 'N' values measured in the silty clay fill varied from 6 to 27 blows per 0.3 m of penetration, indicating a firm to hard consistency. The natural moisture content in the cohesionless fill varied from 2 percent to 18 percent. The moisture content in the silty clay fill varied from 10 percent to 19 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 to A3 of Appendix A and Figure B1 of Appendix B. The result of a laboratory test carried out on a selected sample are as follows:



Soil Particle	Sand/Silt Fill Percentage (%)	Silty Clay Fill Percentage (%)	Sand and Gravel Fill Percentage (%)
Gravel	0 to 3	0 to 10	45
Sand	26 to 90	0 to 24	39
Silt	7 to 66	40 to 50	-
Clay	3 to 20	23 to 50	-
Silt and Clay	-	-	16

The results of Atterberg Limits conducted on the clay fill samples are presented on the Record of Borehole sheets in Appendix A and on Figure A12 of Appendix A. The results of Atterberg Limits testing are summarized below:

Liquid Limit	37
Plastic Limit	16
Plasticity Index	21

The above results show that the silty clay fill is of medium plasticity with a group symbol of CI.

5.4 Layer of Organics

A 0.7 m thick layer of dark grey organics with some silt and trace sand and gravel was encountered below the silty sand fill in Borehole ES16-03 and extended to a depth of 3.7 m (Elevation 316.6). The SPT 'N' value was 8 indicating a loose relative density. The moisture content of the organics layer was 17 percent.

5.5 Silty Clay Till to Silty Clay

Native brown to grey silty clay and silty clay till containing trace sand and trace gravel were observed in all the boreholes at depths and elevations indicated in Table 5.1.



Table 5.1 – Depths and Elevations of Native Silty Clay and Silty Clay Till

Foundation Unit	Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
West Approach	08-019	2.4 to 11.0	319.3 to 310.7	8.6
		11.0 to 15.6*	310.7 to 306.1*	4.6
		15.6 to 21.3 (borehole termination depth)	306.1 to 300.4	>5.7
West Abutment	ES16-01	5.6 to 14.5	316.8 to 308.0	8.9
		14.5 to 18.3*	308.0 to 304.2*	3.8
		18.3 to 30.0	304.2 to 292.5	11.7
Pier 1	ES16-02	5.6 to 10.0	318.9 to 314.5	4.4
		11.7 to 20.0	312.8 to 304.5	8.3
		20.0 to 24.6*	304.5 to 299.9*	4.6
		24.6 to 30.0	299.9 to 294.5	5.4
Pier 2	ES16-03	3.7 to 7.2	316.6 to 313.2	3.5
		10.0 to 13.3	310.3 to 307.0	3.3
		13.3 to 16.3*	307.0 to 304.0*	3.0
		16.3 to 20.0	304.0 to 300.3	3.7
Pier 3	08-015	4.1 to 5.6*	314.2 to 312.7*	1.5
		8.5 to 10.7	309.8 to 307.7	2.2
		10.7 to 17.8*	307.7 to 300.5*	7.1
		17.8 to 21.5 (borehole termination depth)	300.5 to 296.8	>3.7
Pier 4	ES16-04	7.2 to 13.3*	310.4 to 304.3*	6.1
	08-016	0.1 to 1.7*	317.6 to 316.0*	1.6
		3.7 to 8.7*	314.0 to 309.0*	5.0
Pier 5	ES16-05	8.7 to 13.3	309.0 to 304.4	4.6
Pier 6	ES16-06	11.7 to 13.3*	307.0 to 305.5*	2.5
	08-017	4.1 to 13.5*	316.2 to 306.8*	2.2
		0.2 to 2.4*	320.3 to 318.0	9.4
East Abutment	ES16-07	4.7 to 14.9*	315.8 to 305.5*	2.2
East Approach	ES16-08	10.2 to 18.3*	312.8 to 304.7*	8.1
		2.2 to 4.5	321.3 to 319.0	2.3
Retaining wall (RW07-01,	RW07-01	10.5 to 14.3* (borehole termination depth)	313.0 to 309.1	>3.8
		5.6 to 8.2 (borehole termination depth)	318.3 to 315.7	>2.6



Foundation Unit	Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
south side of west approach)				
Retaining wall (RW09-01, south side of east approach) and (RW09-02, north side of east approach)	RW09-01	2.2 to 4.6	321.3 to 318.9	2.4
	08-018	2.4 to 6.2	320.6 to 316.9	3.8
	RW09-02	2.4 to 4.4*	320.4 to 318.4*	2.0

* Silty clay

SPT 'N' values within the silty clay to silty clay till ranging from 17 to over 100 blows per 0.3 m of penetration indicating a very stiff to hard consistency. The natural moisture contents generally range between 9 percent and 32 percent.

Grain size distribution curves of the silty clay to silty clay till are presented on the Record of Borehole sheets in Appendices A and B, and on Figures A4 to A6 of Appendix A and Figures B4 to B6 of Appendix B. The result of a laboratory test carried out on selected samples are as follows:

Soil Particle	Silty Clay till Percentage (%)	Silty Clay Percentage (%)
Gravel	0 to 10	0
Sand	2 to 37	0 to 9
Silt	35 to 61	31 to 49
Clay	14 to 60	42 to 69

The results of Atterberg Limits are presented on the Record of Borehole sheets in Appendix A and on Figures A13 to A15 of Appendix A and Figures B9 to B11 of Appendix B. The results of Atterberg Limits testing are summarized below:

	Silty Clay Till Percentage (%)	Silty Clay Percentage (%)
Liquid Limit	18 to 48	29 to 52
Plastic Limit	11 to 21	15 to 22

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The above results show that the silty clay till is of low plasticity with group symbols of CL-ML and CL, and the silty clay is low to medium plasticity with group symbols of CL and CI.

5.6 Sand

Layers of brown to grey sand containing trace to some silt and trace clay, and brown silt containing some clay, some sand, trace gravel, and occasional cobbles were contacted in Boreholes 08-015, 08-017, ES16-03 to ES16-05, ES16-07, ES16-08, and RW07-01 at depths ranging from 0.8 m to 7.2 m (Elevation 322.9 to 313.2). The thickness of the sand layers varied from 1.5 m to 8.8 m.

The depth to the base of the sand varied from 2.2 m to 10.2 m (Elevation 321.3 to 308.6).

There was a 1.5 m thick layer of Silt with some clay, some sand and trace gravel at a depth of 10.2 m (Elevation 308.6) in Borehole ES16-05.

The SPT 'N' values of the sand layers ranged from 10 to over 100 blows per 0.3 m of penetration indicating a compact to very dense relative density. The natural moisture contents generally lay in the range of 4 percent to 21 percent.

Grain size distribution curves for the sand and silt samples tested are presented on the Record of Borehole sheets in Appendices A and B and on Figure A7 and A8 of Appendix A and Figures B2 and B3 of Appendix B. The results of gradation tests carried out on selected samples are summarized follows:

Soil Particles	Sand Percentage (%)	Silt Percentage (%)
Gravel	0 to 4	2
Sand	74 to 95	11
Silt	7 to 10	73
Clay	2 to 3	14
Silt and Clay	5 to 25	-

5.7 Sand and Gravel

A layer of brown to grey sand and gravel containing some silt and trace clay was encountered at 10.0 m (Elevation 314.5) and 1.4 m depth (Elevation 318.9) in Boreholes ES16-02 and ES16-06, respectively. The thickness of the sand and gravel was 1.7 m and 2.7 m.



The depth to the base of the sand and gravel was 11.7 m and 4.1 m (Elevations 312.8 and 316.2), in Boreholes ES16-02 and ES16-06, respectively.

The SPT 'N' values in the sand and gravel ranged from 39 to 45 blows per 0.3 m of penetration, indicating a dense relative density. The measured natural moisture content ranged from 2 percent to 16 percent.

Grain size distribution curves for the sand and gravel samples tested is presented on the Record of Borehole sheets in Appendix A and on Figure A9 of Appendix A. The results of a laboratory tests carried out on the samples are summarized as follows:

Soil Particles	(%)
Gravel	35
Sand	47
Silt	11
Clay	7

5.8 Sand and Silt Till

A layer of brown to grey sand and silt till with trace to some clay, trace gravel and occasional cobbles was generally encountered below the silty clay or silty clay till in all the boreholes, except in Boreholes 08-015, 08-019, and RW07-01 at depths ranging from 13.3 m and 30.0 m (Elevations 306.8 to 292.5). In Boreholes 08-016, 08-018, ES16-08, RW09-01 and RW09-02, the sand and silt till was encountered at higher depths ranging from 1.7 m to 6.2 m (Elevation 319.0 to 316.0).

Boreholes 08-016, 08-017, 08-018, ES16-01 to ES16-07, RW09-01 and RW09-02 were terminated within the sand and silt till at depths ranging from 9.6 m to 33.8 m (Elevations 313.9 to 288.8).

The SPT 'N' values in the sand and silt till ranged from 49 blows per 0.3 m of penetration to higher than 100 blows per 0.1 m of penetration, indicating a dense to very dense relative density. Auger grinding was noted in this layer in borehole ES16-04. The measured natural moisture content ranged from 4 percent to 27 percent.



Grain size distribution curves for the sand and silt till samples tested is presented on the Record of Borehole sheets in Appendices A and B and on Figures A10 and A11 of Appendix A and Figures B7 and B8 of Appendix B. The results of a laboratory tests carried out on the samples are summarized as follows:

Soil Particles	(%)
Gravel	0 to 10
Sand	27 to 84
Silt	27 to 66
Clay	3 to 26
Silt and Clay	15

Although not specifically identified in all the boreholes, auger grinding was noted in one borehole, and glacial tills are known to contain cobbles and boulders.

Clayey zones were encountered within the sand and silt till. The results of Atterberg Limits are presented on the Record of Borehole sheets and in Figure A16 included in Appendix A. The results of Atterberg Limits testing are summarized below:

Liquid Limit	15 to 18
Plastic Limit	11 to 12
Plasticity Index	4 to 7

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

5.9 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 ES16-01, ES16-03, ES16-05, and ES16-07 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	
West Approach	08-019	November 18, 2008	6.3	315.4	Piezometer
West Abutment	ES16-01	June 25, 2018	14.0	308.5	Piezometer
Pier 1	ES16-02	May 31, 2018	14.6	309.9	Open borehole
Pier 2	ES16-03	June 25, 2018	10.8	309.5	Piezometer
Pier 3	08-015	September 29, 2008	2.4	315.9	Open borehole
Pier 4	08-016	July 22, 2008	12.6	305.1	Piezometer
Pier 5	ES16-05	May 16, 2018	6.3	312.4	Piezometer
		May 31, 2018	9.0	309.8	
		June 25, 2018	9.0	309.8	
East Abutment	ES16-07	May 4, 2018	9.8	313.2	Piezometer
		May 16, 2018	15.3	307.7	
		June 25, 2018	15.6	307.4	
East Approach	ES16-08	April 11, 2018	11.9	311.6	Open borehole
Retaining wall (RW07-01, south side of west approach)	RW07-01	June 5, 2018	Dry	-	Open borehole
Retaining wall (RW09-01, north side of east approach)	RW09-01	April 11, 2018	8.5	315.0	Open borehole
	08-018	July 7, 2008	4.6	318.5	Piezometer
		August 15, 2008	6.6	316.5	
		August 20, 2018	6.6	316.5	
	RW09-02	April 11, 2018	7.1	315.7	Open borehole

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

Two samples of the sand fill from Boreholes RW07-01 and RW09-02 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	
		RW7-01 SS 3 Depth 2.3 m	RW9-02 SS 3 Depth 1.5 m
		Sand Fill	Sand Fill
Sulphide	%	<0.02	<0.02
Chloride	µg/g	13	53
Sulphate	µg/g	6.6	13
pH	No unit	9.36	9.04
Electrical Conductivity	µS/cm	95	150
Resistivity	Ohms.cm	10,500	6,670
Redox Potential	mV	362	274

7. MISCELLANEOUS

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

The coordinates and elevations for the boreholes were provided by WSP.

The drilling and sampling operations in the field, 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 present investigation was conducted by Dr. Nancy Berg, P.Eng. Interpretation of the data and preparation of the 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.

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Review Principal, Designated MTO Contact



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

GEOCRES No. 40P8-281

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 E-S Ramp structure over the Wellington Street North (at the Wellington Street and Kitchener-Waterloo Expressway interchange) and interchange ramps in the Regional Municipality of Waterloo, Ontario.

The General Arrangement (GA) drawing provided by WSP, dated July 2012, indicates that the new E-S ramp has seven spans, with a total length of 350.2 m and approximately 14.0 m in wide, supported by two abutments (west and east) and six piers (Piers 1 to 6). The two conventional abutments and the six piers are designed to be supported by driven piles. The length of each span (from west to east abutments) is 32.0 m, 44.0 m, 54.2 m, 56.0 m, 56.0 m, 56.0 m and 52.0 m.

The proposed grades of the E-S ramp over Wellington Street North varies from the West Abutment to Pier 5 from Elevations 331.9 to 339.2, then decreases from Elevations 339.2 to 337.1 from Pier 5 to the East Abutment. The existing ground surface near the west abutment is at Elevation 322.5, therefore the west approach fill will be approximately 9.4 m high. The existing ground surface at the East Abutment, is near Elevation 323.0, resulting in an approach fill height of 14.1 m at the East Abutment.



Two retaining walls are proposed at this site. One retaining wall (RW-07) on the north side of the west abutment, and one (labelled RW-09) on the north and south sides of the east abutment.

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 discussion 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, ψ , 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 and asphalt, overlaying layers of cohesive fill (silty clay) and cohesionless fill (sand, silty sand and sandy silt), over an extensive deposit of very stiff to hard silty clay till, layers of very stiff to hard silty clay, and compact to very dense sands, silts, and, sand and gravel. The site is underlain



by very dense sand and silt till. The groundwater levels measured in the piezometers ranged from 2.4 m to 15.6 m below the ground surface (Elevations 318.5 to 305.1).

In 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 driven into the very dense/hard glacial till soils

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 generally are feasible at this site, however deep excavation is required at some foundation elements.

The existing fill is not considered suitable for the support of spread footings, and the spread footings should bear on native undisturbed very dense silty sand or hard silty clay. 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)	Approx. Depth from ground surface (m)	Founding strata	Factored ULS _f (kPa)	Factored SLS _f (up to 25 mm settlement) (kPa)
West Abutment	ES16-01	316.0	6.5	Very stiff to hard silty clay till	500	350
Pier 1	ES16-02	317.0	7.5	Very stiff to hard silty clay till	500	350
Pier 2	ES16-03	316.0	4.3	Hard silty clay till	500	350
Pier 3	08-015	317.5	0.8	Dense sand	500	350
Pier 4	ES16-04	313.5	4.1	Dense sand	500	350
Pier 5	ES16-05	317.0	1.8	Dense sand	500	350
Pier 6	ES16-06	318.5	1.8	Dense sand and gravel	500	350
East Abutment	ES16-07	319.5	3.5	Dense sand	500	350

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) Clauses 6.10.2 to 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 till may be computed based on an ultimate coefficient of friction, $\tan \delta$, of 0.45 and 0.5 for the dense sand, and sand and gravel. 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).

The groundwater levels measured in the piezometers ranged from 4.6 m and 14.0 m below the ground surface (Elevations 318.5 to 305.1). If temporary excavations required to construct these footings extend below the water table, local groundwater control 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 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 class of concrete.

10.2 Spread Footing on Engineered Fill

Spread footings founded on Granular “A” engineered fill pads are a feasible foundation option, where this is beneficial to the overall design. These would be useful in the case of spread footings perched on a granular engineered fill pad within the approach embankment fill. However, it should be noted that construction of engineered fill pads will require deep excavation (up to 6m) for the east and west abutments and for Piers 1, 2 and 4 to bear on competent native soils.

If this foundation 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 fill soils will be required. The engineered fill should bear on native very stiff to hard silty clay till or compact to dense sand and sand and gravel, and the highest permitted founding/base 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

Foundation Element	Borehole	Approximately Founding Elevation (m)	Depth from ground surface (m)
West Abutment	ES16-01	316.5	6.0
Pier 1	ES16-02	318.5	6.0
Pier 2	ES16-03	316.5	3.8
Pier 3	08-015	317.5	0.8
Pier 4	ES16-04	314.5	3.1
Pier 5	ES16-05	317.0	1.8
Pier 6	ES16-06	318.5	1.8
East Abutment	ES16-07	320.0	3.0

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) Clauses 6.10.2 to 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 founding elevations of engineered fill pad may extend below the measured groundwater levels (i.e. Elev. 318.5). If temporary excavations required to construct the engineered fill pad extend below the water table, local groundwater control 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 geotechnical engineer 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 optimum moisture content $\pm 2\%$, 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 the depth to suitable bearing material being greater than 20 m, and potential caisson installation difficulties through water bearing cohesionless sand, sand and gravel, and sand and silt till. Basal boiling and heave in the cohesionless deposits may be encountered and sealing of the caisson liner into the founding stratum may be difficult. Therefore this option 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 and hard silty clay 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/hard silty clay till deposits are more prone to pile tip damage in comparison to H-piles.

The GA drawing indicates that the approximate underside elevations of the abutment and pier pile cap are as indicated in Table 10.3 below.



Table 10.3 – Underside pile cap elevation

Foundation Unit	Borehole	Approx. U/S pile cap Elevation (m)
West Abutment	ES16-01	323.5
Pier 1	ES16-02	323.0
Pier 2	ES16-03	316.5
Pier 3	08-015	316.5
Pier 4	ES16-04	316.0
Pier 5	ES16-05	321.0
Pier 6	ES16-06	316.5
East Abutment	ES16-07	322.0

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 the very dense/hard 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 10.4 and 10.5.

Table 10.4 – Estimated 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 _r (kN)	Factored ULS (kN)	Factored SLS _r (kN)
West Abutment	ES16-01	290.0	33.5	1,500	1,300	1,650	1,450
Pier 1	ES16-02	292.0	31.5	1,500	1,300	1,650	1,450
Pier 2	ES16-03	295.0	25	1,300	1,100	1,450	1,250
Pier 3	08-015	298.0	22	1,300	1,100	1,450	1,250
Pier 4	ES16-04	301.5	18.5	1,200	1,000	1,400	1,200
Pier 5	ES16-05	302.5	17.5	1,200	1,000	1,400	1,200
Pier 6	ES16-06	304.0	16	1,200	1,000	1,400	1,200
East Abutment	ES16-07	302.0	18	1,200	1,000	1,400	1,200



Table 10.5 – 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 _r (kN)	Factored ULS (kN)	Factored SLS _r (kN)
West Abutment	ES16-01	290.0	33.5	1,300	1,100	1,450	1,250
Pier 1	ES16-02	292.0	31.5	1,300	1,100	1,450	1,250
Pier 2	ES16-03	295.0	25	1,200	1,000	1,400	1,200
Pier 3	08-015	298.0	22	1,200	1,000	1,400	1,200
Pier 4	ES16-04	301.5	18.5	1,050	900	1,200	1,000
Pier 5	ES16-05	302.5	17.5	1,050	900	1,200	1,000
Pier 6	ES16-06	304.0	16	1,050	900	1,200	1,000
East Abutment	ES16-07	302.0	18	1,050	900	1,200	1,000

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)

$$\begin{aligned}k_s &= 67 C_u / B \quad (\text{kN/m}^3) \\p_{ult} &= 9 C_u \quad (\text{kPa}) \text{ at and below a depth of } 3B \text{ reduced to zero at ground surface} \\ \text{where } p_{ult} &= \text{ultimate lateral resistance mobilized by a pile, kPa} \\ C_u &= \text{undrained shear strength of cohesive soils, kPa} \\ \gamma &= \text{unit weight of soil, kN/m}^3 \\ B &= \text{width of pile, m}\end{aligned}$$

Sand, sand and silt till (cohesionless soils)

$$\begin{aligned}k_s &= n_h \cdot z / B \quad (\text{kN/m}^3) \\p_{ult} &= 3 \cdot \gamma' \cdot z \cdot K_p \quad (\text{kPa}) \\ \text{where } z &= \text{depth of embedment of pile, m} \\ B &= \text{pile width, m} \\ n_h &= \text{coefficient related to soil density, kN/m}^3, \text{ Table 10.6} \\ \gamma' &= \text{Bouyant unit weight of soil, kN/m}^3, \text{ Table 10.6} \\ K_p &= \text{passive earth pressure coefficient, Table 10.6}\end{aligned}$$

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/m³), 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 coefficient of horizontal subgrade reaction values provided in Table 10.6 below.

Table 10.6 – Recommended Geotechnical Parameters for Lateral Resistance Design

Location	Reference Boreholes	Approx. Elevation (m)	Undrained Shear Strength C_u (kPa)	Unit Weight γ (kN/m ³)	K_p	n_h (kN/m ³)	Soil Conditions
West Abutment	ES16-01	322.5 to 317.0	-	20	3.0	2,500	Compact to Dense Sand Fill
		317.0 to 292.5	200	10*	-	-	Very Stiff to Hard Silty Clay Till/Silty Clay
		292.5 to 289.0	-	11*	3.8	10,000	Very Dense Sand and Silt Till
Pier 1	ES16-02	324.5 to 319.0	-	20	3.0	2,500	Compact Silty Sand Fill
		319.0 to 314.5	150	10*	-	-	Very stiff to Hard Silty Clay Till
		314.5 to 312.5	-	11*	3.3	5,000	Dense Sand and Gravel
		312.5 to 294.5	200	10*	-	-	Very Stiff to Hard Silty Clay Till/Silty Clay
		294.5 to 290.5	-	11*	3.8	10,000	Very Dense Sand and Silt Till
Pier 2	ES16-03	320.0 to 316.5	-	20	3.0	2,500	Loose to Compact Silty Sand Fill/Organics
		316.5 to 313.2	200	10*	-	-	Hard Silty Clay Till
		313.2 to 310.5	-	11*	3.3	5,000	Dense to Very Dense Sand
		310.5 to 300.0	200	10*	-	-	Hard Silty Clay Till/Silty Clay
		300.0 to 294.0	-	11*	3.8	10,000	Very Dense Sand and Silt Till
Pier 3	08-015	318.5 to 317.5	-	20	3.0	2,500	Very Dense Sand and Gravel Fill
		317.5 to 314.0	-	11*	3.3	5,000	Dense to Very Dense Sand

		314.0 to 313.0	120	10*	-	-	Very Stiff Silty Clay
		313.0 to 310.0	-	11*	3.2	3,500	Compact Sand
		310.0 to 300.5	150	10*	-	-	Very Stiff to Hard Silty Clay Till/Silty Clay
		300.5 to 297.0	200	10*	-	-	Hard Silty Clay Till
Piers 4 and 5	ES16-04 ES16-05	318.8 to 315.0	-	20	3.0	2,500	Compact to Dense Sandy Silt Fill/Firm Silty Clay Fill
		315.0 to 308.0	-	11*	3.3	5,000	Compact to Very Dense Sand/Silt
		308.0 to 305.0	200	10*	-	-	Hard Silty Clay
		305.0 to 300.8	-	11*	3.8	10,000	Very Dense Sand and Silt Till
Pier 6	ES16-06	320.3 to 319.0	100	20	-	-	Firm to Stiff Silty Clay Fill
		319.0 to 316.0	-	11*	3.3	5,000	Dense Sand and Gravel
		316.0 to 306.8	200	10*	-	-	Hard Silty Clay
		306.8 to 303.0	-	11*	3.8	10,000	Very Dense Sand and Silt Till
East Abutment	ES16-07	323.0 to 320.0	-	20	3.0	1,500	Compact to Dense Sand Fill/Very Stiff Silty Clay Fill
		320.0 to 312.8	-	11*	3.4	5,000	Very Dense to Dense Sand
		312.8 to 304.5	200	11*	-	-	Very Stiff to Hard Silty Clay
		304.5 to 301.5	-	11*	3.8	10,000	Very Dense Sand and Silt Till

* Bouyant unit weight below the 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).



Depending on the construction sequence, embankment loadings from the N-E Ramp adjacent to Piers 4 and 5 and from the S-W Ramp adjacent to Pier 6 and East Abutment may need to be included as part of the lateral pile analysis.

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 through very dense sand and hard silty clay till into very dense sand and 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.

Auger grinding was noted during drilling in the sand and silt till deposit. Glacially derived soils inherently contain cobbles and boulders. Hard driving conditions through the very dense 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 soil resistance, it is recommended that the pile tips be reinforced with Titus steel (Standard H-point) or equivalent.

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, the recommended foundations at this site are that the abutments and piers be supported on steel H-piles driven into the very dense sand and silt till.

11. RETAINING WALLS

The GA drawing dated July 2012 includes construction of two retaining walls (RSS walls) at this site. Available information of proposed RSS walls is provided in Table 11.1. RW-10 is proposed to near the east abutment but is discussed in the Proposed Retaining Wall Foundation Investigation and Design Report (Geocress Number 40P9-58) dated May 6, 2020 and will not be discussed in this report.

Table 11.1 – Retaining Wall Details

Retaining Wall	Location	Borehole	Height (m)	Length (m)
RW-7	West abutment North side	RW07-01	1.8	24.0
RW-9	East abutment South/North side	RW09-01 RW09-02	8.1	53.0

RSS walls used on this project must be specified to be “High Performance” and “High Appearance”. Therefore, it is important that the RSS walls be founded on soil capable of supporting the imposed loading and limiting settlements under the RSS wall to acceptable magnitudes. The design of the RSS walls adjacent to the bridge structure should follow the guidelines in CHBDC S6-19 (2019) Section 6.19 – MSE Wall Systems and MTO Bridge Office Memo #2019-02 dated March 13, 2019 for use of RSS walls adjacent to structure.

Provided the RSS design takes into account the subsurface conditions at this site and proper foundation preparation is carried out prior to construction of the walls, RSS systems are expected to meet the aesthetic and structural requirements.

To provide an acceptable foundation performance, the RSS must be founded on the very stiff silty clay till and compact sandy silt. The highest recommended base levels for the underside of the RSS system are as presented in Table 11.2.

Table 11.2 – Retaining Wall Geotechnical Resistance, Founding Strata and Elevations

Retaining Wall	Borehole	Highest Founding Elevation (m)	Founding Stratum	Factored ULS _r (kN)	Factored SLS settlement (kPa)(up to 25 mm settlement) (kN)
RW-7	RW07-01	319.0	Compact sandy silt	350	250
RW-9	RW09-01 RW09-02	320.0	Very stiff to hard silty clay Till	350	250

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



If required, the RSS may be founded on engineered fill founded on the native, very stiff to hard silty clay till and compact sandy silt. Engineered fill placed under the RSS mass to achieve the design founding level must consist of OPSS Granular "A" compacted to 100% of its SPMDD at a moisture content within 2% of optimum. The engineered pad must extend at least 500 mm beyond the limits of the RSS mass and levelling strip.

As per MTO RSS Design Guidelines, the minimum soil cover to the underside of the levelling pad shall be at least 800mm, or 40% of the actual frost depth for the area, whichever is greater.

The entire block of reinforced earth must be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall or engineered granular fill in contact with the very stiff to hard silty clay till may be estimated using an ultimate friction coefficient of 0.40, and for 0.45 for compact sandy silt. 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 RSS. The subgrade under the RSS foundation should be inspected and any soft spots sub-excavated and replaced with compacted granular materials prior to placing fill. The subgrade preparation for the RSS wall and placement and compaction of the granular fill must be carried out in the dry. Dewatering may be required to remove surface and/or perched water from the cohesionless fills and native soils.

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

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.

Reference should be made to MTO RSS Design Guideline (2008) and, the TAC Design, Construction, Maintenance and Inspection Guide for MSE Walls (2017) for design and construction of retaining wall structures.



RSS walls must be constructed in accordance with MTO RSS SP 599S22 and SP 599S23, and the RSS must be selected from the MTO DSMM List for RSS.

11.1 Slope Stability of Retained Soil System

Slope stability is not a concern for the proposed west abutment retaining wall RW-7, which will be 1.8 m high.

A preliminary analysis of the global stability of the RSS walls proposed on the north and south sides of the east abutment, was conducted to assess stability of a maximum 8.1 m high wall founded on the native very stiff silty clay till, with a 2H:1V slope behind the retaining wall.

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 RSS wall was also checked under seismic loading assuming an acceleration of 0.097g. The computed factors of safety are as shown in Table 11.3. Slope stability computation outputs are included in Appendix F.

Table 11.3 Computed Factors of Safety for RSS wall

Condition	Factor of Safety	Figure (Appendix F)
RSS wall up to 8.1 m high at the east abutment		
Normal Drained	1.6	1F
Normal Undrained	1.7	2F
Seismic = 0.097g	1.4	3F

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 factors of safety against global failure was 1.6 for drained conditions and 1.7 for undrained conditions. Under the estimated seismic loading, the minimum factor of safety calculated was 1.4. These factors of safety are considered to be acceptable for the proposed RSS walls bearing on the soils encountered at this site.



11.2 Settlement of Retained Soil System

The construction of a maximum 8.1 m high RRS wall on a 0.5 m thick pad of granular engineered fill will induce settlement in the underlying silty clay till/silty clay.

The settlement was assessed using elastic methods. Based on these analyses, the settlement is estimated to be 25 mm.

This settlement will be immediate and essentially complete when construction of the RSS wall at the west abutment is completed.

Inspection of the RSS walls and placing of additional granular material to re-establish grades as necessary should be implemented during and after construction.

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)
 γ = 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 the support system allows yielding of the wall (unrestrained system), active horizontal earth pressure may be used in the geotechnical design of the structure. If the support system does not allow yielding (restrained system), 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. 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 at the structure will be at about Elevations 331.9 and 337.1 at the west and east abutments, respectively. The existing ground surface at the west and east abutments is near Elevations 322.5 and 323.0. As a result, placement of new fill of approximately 9.4 m and 14.1 m, will be required for the west and east approaches, respectively, of the proposed E-S ramp over Wellington Street.

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. It is important to note that slopes steeper than 2H:1V may be subject to surficial instability which may include sloughing and gullying. Surface runoff and precipitation must be prevented from flowing perpendicularly down any slope surface. Erosion protection measures will have to be taken 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 Side Slope

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 and 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 for the new forward slope configuration including the RSS wall, was presented in Section 11. In this section of the report typical 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	Figure (Appendix F)
Side Slope, Max. height 14.1 m		
Normal Drained	1.6	4F
Normal Undrained	1.6	5F
Seismic = 0.097g	1.3	6F

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 factors of safety against global failure were 1.6 for drained and undrained conditions. Under the estimated seismic loading, the minimum factor of safety calculated was 1.3. These range of factors of safety are considered to be acceptable for this site.

13.2 Settlement

It is estimated that at the approach embankments, settlements of up to 25 mm will occur in the foundation soils under the loading imposed by new approach embankments with proposed fill height up to 9.4 m and 14.1 m behind the west and east abutments, respectively.

This settlement will be immediate and essentially complete when construction of the fills 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 25 to 35 mm at this site will occur after construction.

No long-term foundation settlement is anticipated for the 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.

Excavation for foundation construction will be extended through the sand fill, native hard silty clay/silty clay till, and into the native compact to very dense sand.

For the purposes of the OHSA, the fill and native compact to dense sand above the water table are classified as Type 3. The native very stiff to hard silty clay/silty clay till above the water table may be classified as Type 2. Cohesionless 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 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 should 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 4.6 m and 14.0 m below the ground surface (Elevations 318.5 to 305.1). Based on groundwater levels measured in the piezometers, the excavation for footing or pile cap construction may extend below the groundwater level. Also, seepage from perched water from the cohesionless fill and native soils should also be expected.

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 a dewatered condition at this site, include pumping from filtered sumps for nominal penetration below the groundwater level, and sheeted excavation (cofferdam) or vacuum well-points for deeper penetration below the ground water table, particularly in cohesionless soils. 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 fill and native soils are as follows:

Soil	Permeability, k (cm/sec)
Sand fill/Silty sand fill/sandy silt fill	6.3×10^{-3} to 7.5×10^{-2}
Sand	2.0×10^{-3}
Sand and silt till	2.3×10^{-6} to 3.2×10^{-4}
Silty clay/Silty Clay Till	1×10^{-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.

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 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.

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:

γ	=	20 kN/m ³
γ_w	=	10 kN/m ³
K_a	=	0.33 (approach fills)
	=	0.33 (silty clay/silty clay till)
	=	0.31 (sand, silt)
K_p	=	3.0 (approach fills)
	=	3.0 (silty clay/silty clay till)
	=	3.2 (sand, silt)

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, asphalt and fill overlaying an extensive deposit of very stiff to hard silty clay till, over layers of compact to very dense sand, silt, and, sand and gravel, and very stiff

to hard silty clay. The site is underlain by dense to 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 (2019). 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 STRUCTURES AND 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 replacement 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. The proposed E-S ramp will be located near the existing Wellington St North bridge over the Kitchener Waterloo Expressway (KWE) and the proposed N-E ramp over the KWE.



If pile driving is required close to adjacent structure(s), the following recommendations should be carried out prior to commencement of foundation construction:

- Carry out pre-construction condition survey including documentation of any existing distress on the existing structure (bridge).
- Implement a vibration and settlement monitoring program during and after construction of the new abutments to assess any potential adverse impact on the existing operating structure.
- Inspection of the existing operating structure during foundation construction to monitor if there is any movement or distress.
- The structural designers should assess the magnitude of settlement or horizontal displacement that would constitute a concern for the stability or serviceability of the existing operational structures. These limits should be incorporated into the monitoring program as review and alert levels.

20. CORROSION AND SULPHATE ATTACK POTENTIAL

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

- The potential for sulphate attack on concrete foundations from the surrounding fill 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 very mild to mild.
- 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. 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. The Contractor's dewatering plan must be available for rapid implementation should the need arise. 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.



22. CLOSURE

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

Thurber Engineering Ltd.



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Principal/Senior Geotechnical Engineer



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

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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


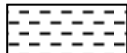



 Water Level
 Shear Strength Determination by Pocket Penetrometer

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

UNIFIED SOILS CLASSIFICATION

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

EXPLANATION OF ROCK LOGGING TERMS

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

<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>		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.				
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

RECORD OF BOREHOLE No ES16-01

1 OF 4

METRIC

GWP# 408-88-00 LOCATION E-S Ramp, MTM NAD 83 Zone 10: N 4 814 334.3 E 226 089.6 ORIGINATED BY AF
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance/Mud Rotary COMPILED BY MP
 DATUM Geodetic DATE 2018.06.04 - 2018.06.05 LATITUDE 43.464783 LONGITUDE -80.472745 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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	W _P W W _L	WATER CONTENT (%)			GR	SA		SI	CL		
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
322.5	GROUND SURFACE																		
0.0	TOPSOIL																		
322.2																			
0.3	SAND, some silt, trace gravel, trace clay Compact to Dense Brown Moist (FILL)		1	SS	22														
			2	SS	20														
			3	SS	22														
			4	SS	18														
			5	SS	39														
316.8																			
5.6	Silty CLAY, some sand to with sand, trace to some gravel Very Stiff to Hard Grey Moist (TILL)		6	SS	25														
			7	SS	37														
			8	SS	33														
				</															

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

METRIC

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ONTMT4S2 MTO-11375.GPJ 2017TEMPLATE(MTO).GDT 11/29/18

RECORD OF BOREHOLE No ES16-01

3 OF 4

METRIC

GWP# 408-88-00 LOCATION E-S Ramp, MTM NAD 83 Zone 10: N 4 814 334.3 E 226 089.6 ORIGINATED BY AF
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance/Mud Rotary COMPILED BY MP
 DATUM Geodetic DATE 2018.06.04 - 2018.06.05 LATITUDE 43.464783 LONGITUDE -80.472745 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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
	Continued From Previous Page		15	SS	35			20	40	60	80	100		W _P W W _L				
	Silty CLAY , some sand, trace gravel Hard Grey Moist (TILL)						302							○				
							301											
							300											
							299								○			
							298											
							297											
							296								○			
							295											
							294											
							293									○		
						16	SS	45										
			17	SS	33									○				
			18	SS	76									○				

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Sensitivity

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(%) STRAIN AT FAILURE

METRIC

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+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No ES16-02

1 OF 4

METRIC

GWP# 408-88-00 LOCATION E-S Ramp, MTM NAD 83 Zone 10: N 4 814 365.6 E 226 094.7 ORIGINATED BY AF
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Mud Rotary COMPILED BY MP
 DATUM Geodetic DATE 2018.05.30 - 2018.05.31 LATITUDE 43.465066 LONGITUDE -80.472687 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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE					w _p w w _L				
								● QUICK TRIAXIAL × LAB VANE									
324.5	GROUND SURFACE						20	40	60	80	100						
0.0	ASPHALT																
0.1	Silty SAND , some clay, trace gravel Compact Brown Moist (FILL)																
	occasional organics		1	SS	20								○				
			2	SS	30								○			3 53 24 20	
	Grey		3	SS	15								○				
			4	SS	25								○				
			5	SS	14								○				
318.9																	
5.6	Silty CLAY , trace sand, trace gravel Very Stiff to Hard Grey Moist (TILL)																
			6	SS	18								○				
			7	SS	26								○				
			8	SS	31								○				
314.5																	

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+³, ×³: Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ES16-02

2 OF 4

METRIC

GWP# 408-88-00 LOCATION E-S Ramp, MTM NAD 83 Zone 10: N 4 814 365.6 E 226 094.7 ORIGINATED BY AF
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Mud Rotary COMPILED BY MP
 DATUM Geodetic DATE 2018.05.30 - 2018.05.31 LATITUDE 43.465066 LONGITUDE -80.472687 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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10.0	SAND and GRAVEL , some silt, trace clay Dense Grey Wet						314																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													

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METRIC

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RECORD OF BOREHOLE No ES16-03

1 OF 3

METRIC

GWP# 408-88-00 LOCATION E-S Ramp, MTM NAD 83 Zone 10: N 4 814 407.6 E 226 108.7 ORIGINATED BY AF
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Mud Rotary COMPILED BY MP
 DATUM Geodetic DATE 2018.06.06 - 2018.06.07 LATITUDE 43.465446 LONGITUDE -80.472519 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
320.3	GROUND SURFACE													
0.0	TOPSOIL													
0.2	Silty SAND , trace gravel Loose to Compact Brown Moist (FILL)		1	SS	11		320							
			2	SS	9		319							
			3	SS	11		318							
317.3			4	SS	8		317							
316.6							316							
3.7	Silty CLAY , sandy, trace gravel Hard Grey Wet (TILL)		5	SS	38		315							
			6	SS	73		314							
313.2							313							
7.2	SAND , trace to some silt, trace clay Dense to Very Dense Grey Wet		7	SS	44		312							
			8	SS	77		311							
310.3														

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+³, ×³: Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

METRIC

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+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No ES16-03

3 OF 3

METRIC

GWP# 408-88-00 LOCATION E-S Ramp, MTM NAD 83 Zone 10: N 4 814 407.6 E 226 108.7 ORIGINATED BY AF
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Mud Rotary COMPILED BY MP
 DATUM Geodetic DATE 2018.06.06 - 2018.06.07 LATITUDE 43.465446 LONGITUDE -80.472519 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								20 40 60 80 100							
								○ UNCONFINED + FIELD VANE							
								● QUICK TRIAXIAL × LAB VANE							
								20 40 60 80 100							
								20 40 60							
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+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ES16-04

1 OF 2

METRIC

GWP# 408-88-00 LOCATION E-S Ramp, MTM NAD 83 Zone 10: N 4 814 495.7 E 226 173.6 ORIGINATED BY MB
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.04.26 - 2018.04.26 LATITUDE 43.466246 LONGITUDE -80.471730 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)											
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																				
								20	40	60	80	100																
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)																	
						20					20					40					60							
317.6	GROUND SURFACE																											
0.0	Silty CLAY , occasional rootlets Firm Brown Moist (FILL)		1	SS	7																							
316.9																												
0.7	Sandy SILT , trace clay Compact to Dense Brown Moist (FILL)		2	SS	25																							
			3	SS	24																							
			4	SS	34																							
314.6																												
3.0	SAND , trace silt, trace clay Compact to Very Dense Brown Moist		5	SS	19																							
			6	SS	38																							
			7	SS	54																							
310.4																												
7.2	Silty CLAY Hard to Very Stiff Brown Moist		8	SS	34																							
			9	SS	26																							

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+³, ×³: Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ES16-04

2 OF 2

METRIC

GWP# 408-88-00 LOCATION E-S Ramp, MTM NAD 83 Zone 10: N 4 814 495.7 E 226 173.6 ORIGINATED BY MB
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.04.26 - 2018.04.26 LATITUDE 43.466246 LONGITUDE -80.471730 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) 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									
								20 40 60 80 100	20 40 60								
	Continued From Previous Page																
304.3	Silty CLAY Hard Brown Moist						307										
			10	SS	45								○				
							306										
			11	SS	36		305						○				
13.3	SAND and SILT , some clay, trace gravel Very Dense Brown Moist (TILL) Auger grinding from 14.0m to 14.3m						304						○				
			12	SS	100/ 0.175												
							303										
	Auger grinding from 15.2m to 15.8m		13	SS	100/ 0.175		302						○				
300.4			14	SS	100/ 0.275		301						○				
17.2	END OF BOREHOLE AT 17.2m. BOREHOLE OPEN TO 17.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.3m, THEN AUGER CUTTINGS TO SURFACE.																

ONTMT452 MTO-11375.GPJ 2017TEMPLATE(MTO).GDT 11/29/18

RECORD OF BOREHOLE No ES16-05

1 OF 2

METRIC

GWP# 408-88-00 LOCATION E-S Ramp, MTM NAD 83 Zone 10: N 4 814 527.7 E 226 219.4 ORIGINATED BY MB
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.04.25 - 2018.04.25 LATITUDE 43.466538 LONGITUDE -80.471169 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
318.8	GROUND SURFACE							20 40 60 80 100								
0.0	Silty CLAY , some sand to sandy Firm Brown Moist (FILL)		1	SS	6			20 40 60 80 100				20 40 60			0	22 40 38
318.1																
0.7	Sandy SILT , trace clay Dense Brown Moist (FILL)		2	SS	41		318									
317.3																
1.4	SAND , trace silt, trace clay Compact to Very Dense Brown Moist		3	SS	32		317									
			4	SS	41		316									
			5	SS	18		315									
			6	SS	55		314									
	occasional cobbles															
							313									
			7	SS	64		312									
			8	SS	63		311									
	occasional cobbles															
							310									
			9	SS	76											
							309									

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

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	UNCONFINED	FIELD VANE	WATER CONTENT (%)	W _P	W	W _L			
Continued From Previous Page																	
308.6 10.2	SILT , some clay, some sand, trace gravel Very Dense Brown Moist																
			10	SS	57												
307.0 11.7	Silty CLAY Hard Brown Moist																
			11	SS	51												
305.5 13.3	SAND and SILT , some clay, trace to some gravel, occasional cobbles Very Dense Brown Moist to Wet (TILL)																
			12	SS	100/ 0.050												
			13	SS	100/ 0.175												
301.8 16.9	END OF BOREHOLE AT 16.91m. WATER LEVEL AT 7.0m UPON COMPLETION. Well installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.																
			14	SS	100/ 0.150												
WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.05.16 6.3 312.4 2018.05.31 9.0 309.8 2018.06.25 9.0 309.8																	


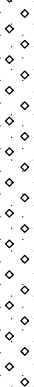

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No ES16-06

1 OF 2

METRIC

GWP# 408-88-00 LOCATION E-S Ramp, MTM NAD 83 Zone 10: N 4 814 548.6 E 226 271.1 ORIGINATED BY MB
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.04.23 - 2018.04.24 LATITUDE 43.466732 LONGITUDE -80.470532 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20 40 60 80 100					W P W W L				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
320.3	GROUND SURFACE																
0.0	Silty CLAY , occasional organics, rootlets and wood fibres Firm to Stiff Brown Moist (FILL)		1	SS	6		320										
			2	SS	14												0 0 50 50
318.9							319										
1.4	SAND and GRAVEL Dense Brown Moist		3	SS	41												
			4	SS	42												
			5	SS	45												
316.2																	
4.1	Silty CLAY Hard Brown Moist		6	SS	36		316										
																0 0 40 60	
			7	SS	32												
			8	SS	58												
							312										
			9	SS	34		311										

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+³, ×³: Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ES16-06

2 OF 2

METRIC

GWP# 408-88-00 LOCATION E-S Ramp, MTM NAD 83 Zone 10: N 4 814 548.6 E 226 271.1 ORIGINATED BY MB
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.04.23 - 2018.04.24 LATITUDE 43.466732 LONGITUDE -80.470532 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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								20 40 60 80 100				w _P w w _L				
Continued From Previous Page							○ UNCONFINED + FIELD VANE									
							● QUICK TRIAXIAL × LAB VANE									
306.8	Silty CLAY Hard Brown Moist		10	SS	45		310									
							309									
			11	SS	44		308								0 0 33 67	
							307									
13.5	SAND and SILT , some clay, trace to some gravel Very Dense Brown Wet (TILL)		12	SS	100/ 0.250		306									
							305									
			13	SS	100/ 0.125		304									
303.3			14	SS	100/ 0.175										10 41 34 15	
17.1	END OF BOREHOLE AT 17.1m. BOREHOLE OPEN TO 17.1m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.3m, THEN AUGER CUTTINGS TO SURFACE.															

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RECORD OF BOREHOLE No ES16-07

1 OF 3

METRIC

GWP# 408-88-00 LOCATION E-S Ramp, MTM NAD 83 Zone 10: N 4 814 561.0 E 226 321.8 ORIGINATED BY MB
DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
DATUM Geodetic DATE 2018.05.02 - 2018.05.03 LATITUDE 43.466848 LONGITUDE -80.469908 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 (%)				
323.0	GROUND SURFACE						20	40	60	80	100						
0.0	ASPHALT						20	40	60	80	100						
0.2	SAND, some gravel Compact to Dense Brown Moist (FILL)		1	SS	34												
			2	SS	18												
321.6																	
1.4	Silty CLAY, sandy, trace gravel Very Stiff Brown Moist (FILL)		3	SS	19											10 24 43 23	
			4	SS	27												
320.0																	
3.0	SAND, trace silt, trace clay Dense to Very Dense Brown Moist		5	SS	34												
			6	SS	55												
			7	SS	67												
			8	SS	64											0 89 9 2	
			9	SS	71												

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

RECORD OF BOREHOLE No ES16-07

2 OF 3

METRIC

GWP# 408-88-00 LOCATION E-S Ramp, MTM NAD 83 Zone 10: N 4 814 561.0 E 226 321.8 ORIGINATED BY MB
DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
DATUM Geodetic DATE 2018.05.02 - 2018.05.03 LATITUDE 43.466848 LONGITUDE -80.469908 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE							
	Continued From Previous Page							20 40 60 80 100								
312.8	SAND															
10.2	Silty CLAY Very Stiff to Hard Brown Moist		10	SS	25		312									
			11	SS	44											
							310									
			12	SS	35		309							0 0 36 64		
							308									
			13	SS	39											
							307									
			14	SS	57		306									
							305									
304.7																
18.3	SAND and SILT , some clay, trace gravel Very Dense Brown Moist to Wet (TILL)		15	SS	100/ 0.100											

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+³, ×³: Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ES16-07

3 OF 3

METRIC

GWP# 408-88-00 LOCATION E-S Ramp, MTM NAD 83 Zone 10: N 4 814 561.0 E 226 321.8 ORIGINATED BY MB
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.05.02 - 2018.05.03 LATITUDE 43.466848 LONGITUDE -80.469908 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
	Continued From Previous Page		16	SS	100/												
	SAND and SILT , some clay, trace gravel Very Dense Brown Moist (TILL)				0.175												
301.4			17	SS	100/												
21.6	END OF BOREHOLE AT 21.6m. WATER LEVEL AT 9.78m UPON COMPLETION. Well installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.05.04 9.8 313.2 2018.05.16 15.3 307.7 2018.06.25 15.6 307.4				0.150												

METRIC

[illegible]

(%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375.GPJ 2017TEMPLATE(MTO).GDT 11/29/18

METRIC

[illegible]





+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No RW07-01

1 OF 1

METRIC

GWP# 408-88-00 LOCATION Retaining Wall 7, MTM NAD 83 Zone 10: N 4 814 321.3 E 226 058.4 ORIGINATED BY AF
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.06.05 - 2018.06.05 LATITUDE 43.464664 LONGITUDE -80.473128 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
							WATER CONTENT (%) 20 40 60							
323.9	GROUND SURFACE													
0.0	TOPSOIL													
0.2	SAND , trace silt, trace clay Loose to Compact Brown Moist (FILL)		1	SS	8		323							
			2	SS	27		322							
			3	SS	22									
			4	SS	20									
319.8							320							
4.1	Sandy SILT Compact Brown Wet		5	SS	24		319							
318.3														
5.6	Silty CLAY , some sand, trace gravel Very Stiff to Hard Grey Moist (TILL)						318							
			6	SS	25									
							317							
			7	SS	51		316							
315.7														
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													

ONTMT452 MTO-11375.GPJ 2017TEMPLATE(MTO).GDT 11/29/18

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RW09-01

1 OF 2

METRIC

GWP# 408-88-00 LOCATION Retaining Wall 9, MTM NAD 83 Zone 10: N 4 814 541.9 E 226 332.8 ORIGINATED BY GA
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.04.11 - 2018.04.11 LATITUDE 43.466678 LONGITUDE -80.469769 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20	40	60	80			100
323.5	GROUND SURFACE													
0.0 0.1	ASPHALT: (60mm)		1	SS	40									45 39 16 (SI+CL)
	SAND and GRAVEL, trace to some silt and clay Dense Brown Moist (FILL)		2	SS	39									
322.1														
1.4	SAND Compact Brown Moist (FILL)		3	SS	20									
321.3														
2.2	Silty CLAY, some sand to sandy, trace gravel Very Stiff Brown Moist (TILL)		4	SS	24									
			5	SS	29									0 22 49 29
318.9														
4.6	Silty SAND, trace clay Very Dense Brown Wet (TILL)		6	SS	111									
			7	SS	114									
			8	SS	110									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RW09-01

2 OF 2

METRIC

GWP# 408-88-00 LOCATION Retaining Wall 9, MTM NAD 83 Zone 10: N 4 814 541.9 E 226 332.8 ORIGINATED BY GA
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.04.11 - 2018.04.11 LATITUDE 43.466678 LONGITUDE -80.469769 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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
	Continued From Previous Page																
	WATER LEVEL AT 8.5m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND GROUT TO SURFACE.																

RECORD OF BOREHOLE No RW09-02

1 OF 2

METRIC



GWP# 408-88-00 LOCATION Retaining Wall 9, MTM NAD 83 Zone 10: N 4 814 582.8 E 226 319.4 ORIGINATED BY GA
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.04.11 - 2018.04.11 LATITUDE 43.467045 LONGITUDE -80.469941 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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					
322.8	GROUND SURFACE							20	40	60	80	100						
0.0	SAND , some silt, trace clay, trace gravel Loose to Compact Brown Moist (FILL)		1	SS	8		322											2 79 14 5
			2	SS	11													
			3	SS	6		321											
320.4	Silty CLAY , trace to some sand, trace gravel Very Stiff to Hard Brown Wet		4	SS	20		320											0 9 49 42
2.4			5	SS	33													
							319											
318.4	SAND and SILT , trace to some clay Very Dense Grey Wet (TILL)		6	SS	109		318											0 52 38 10
4.4																		
							317											
			7	SS	104													
							316											
			8	SS	102		315											
							314											

Continued Next Page

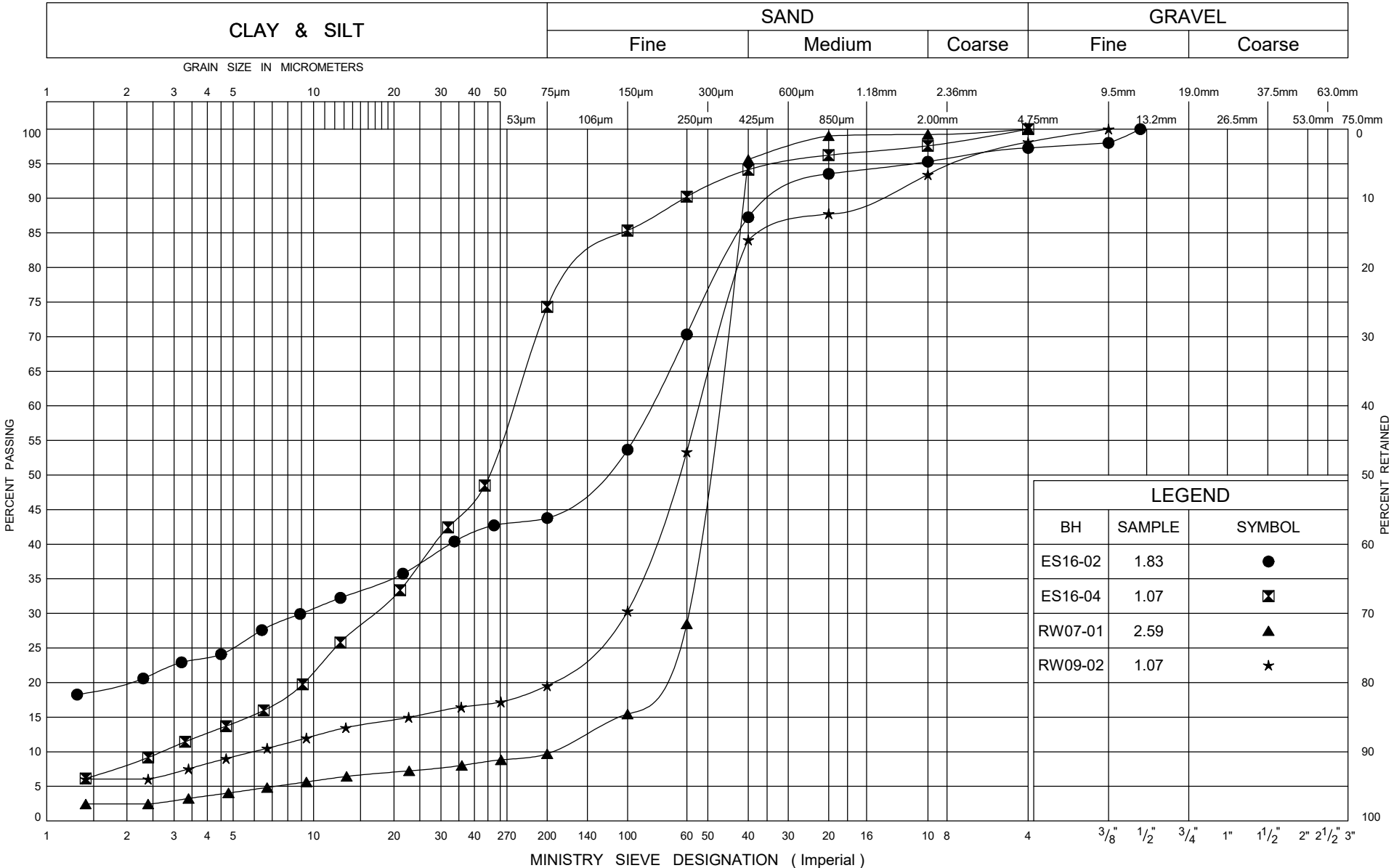
+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

METRIC

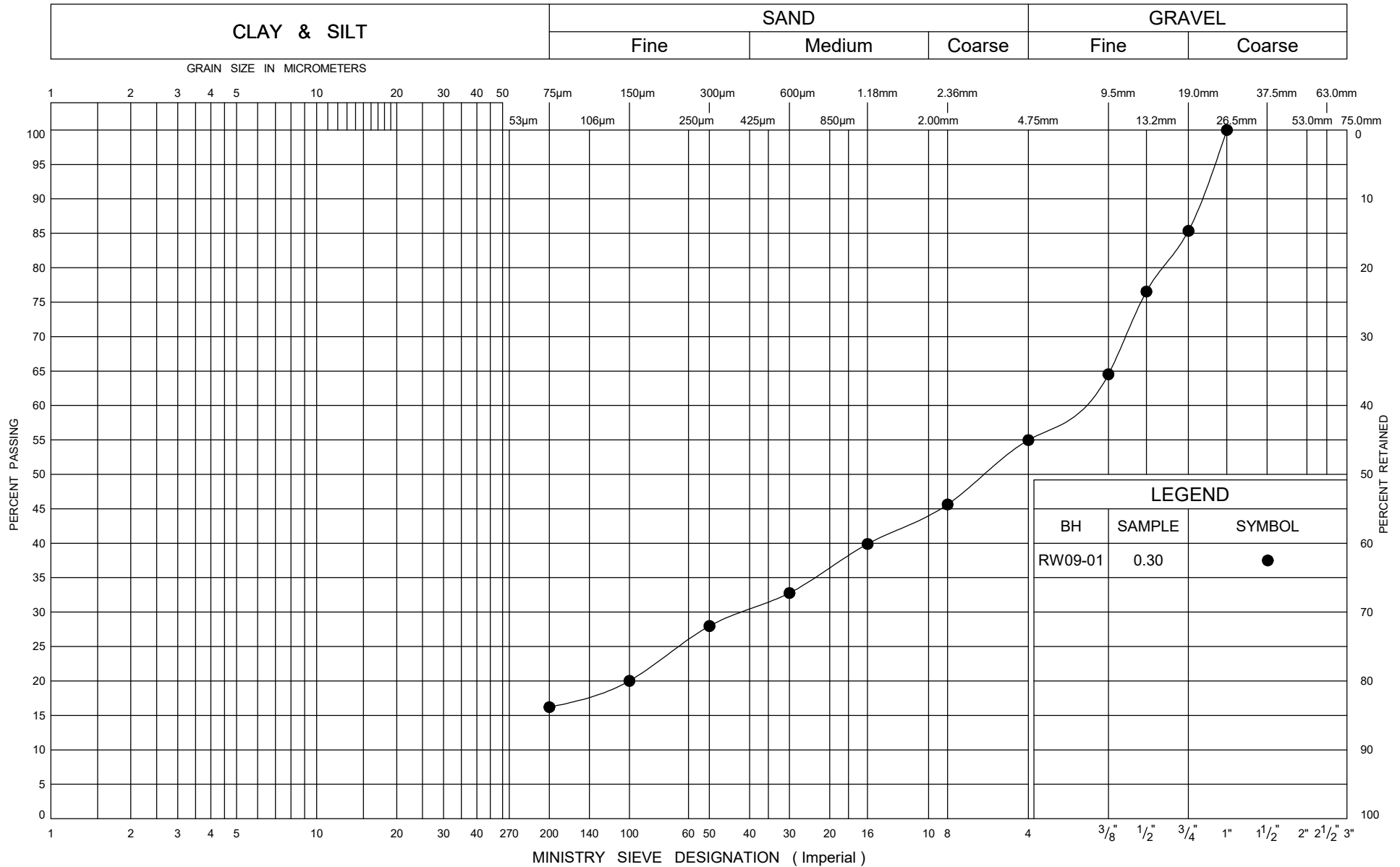
ELEV DEPTH	SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE LIMIT LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100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

[illegible]

UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

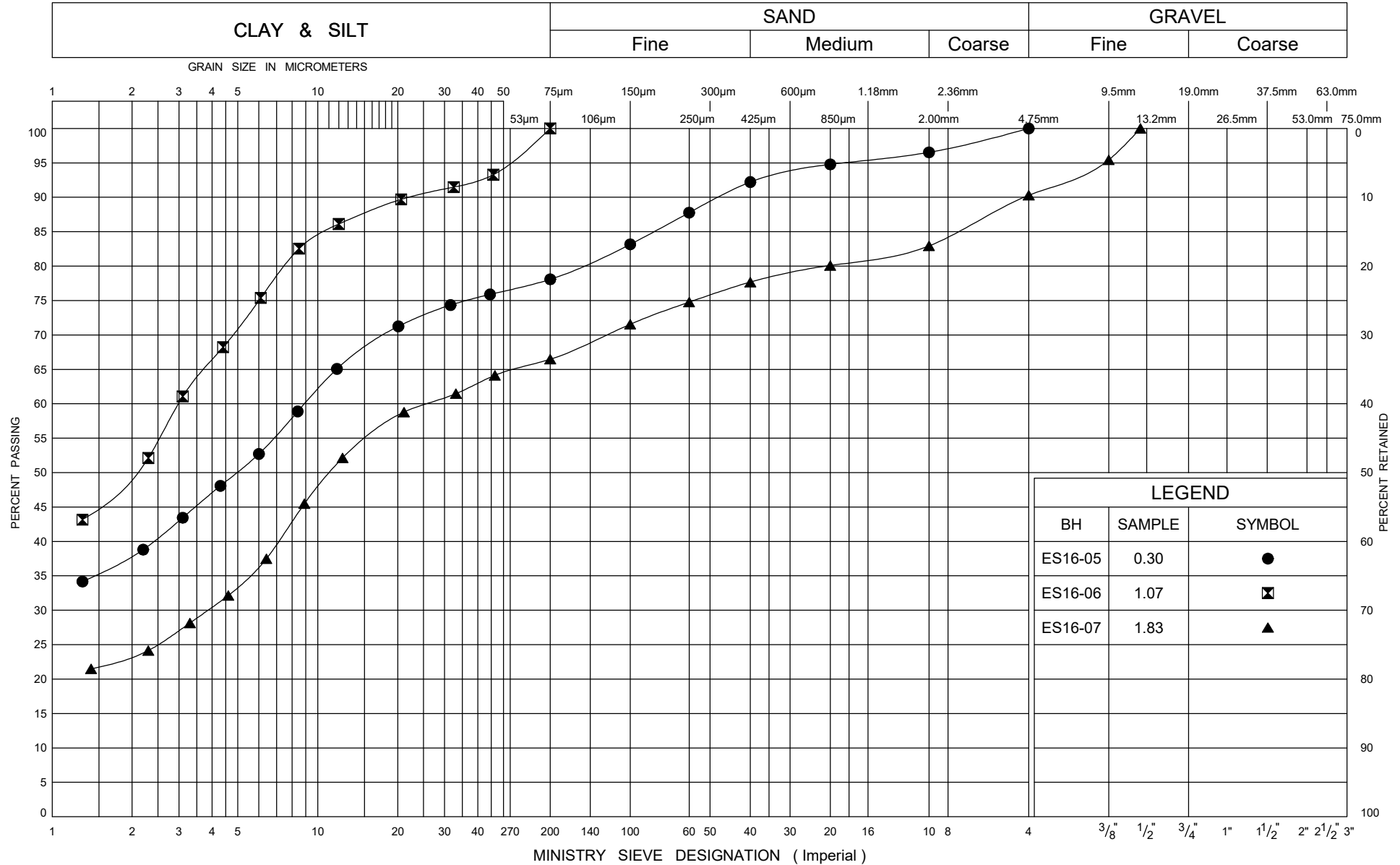
SAND and GRAVEL FILL

FIG No A2

W P 408-88-00

E-S Ramp

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

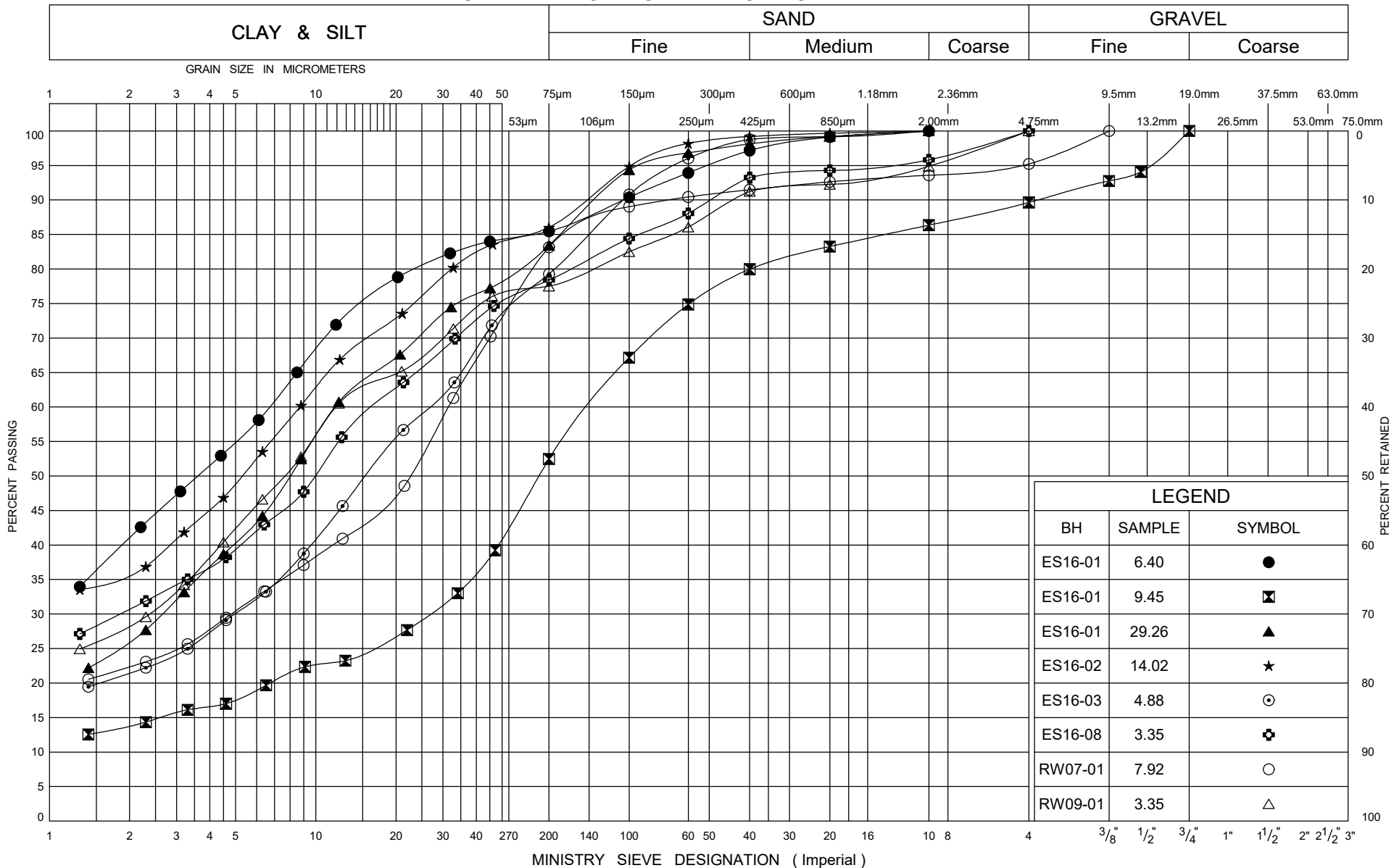
Silty CLAY FILL

FIG No A3

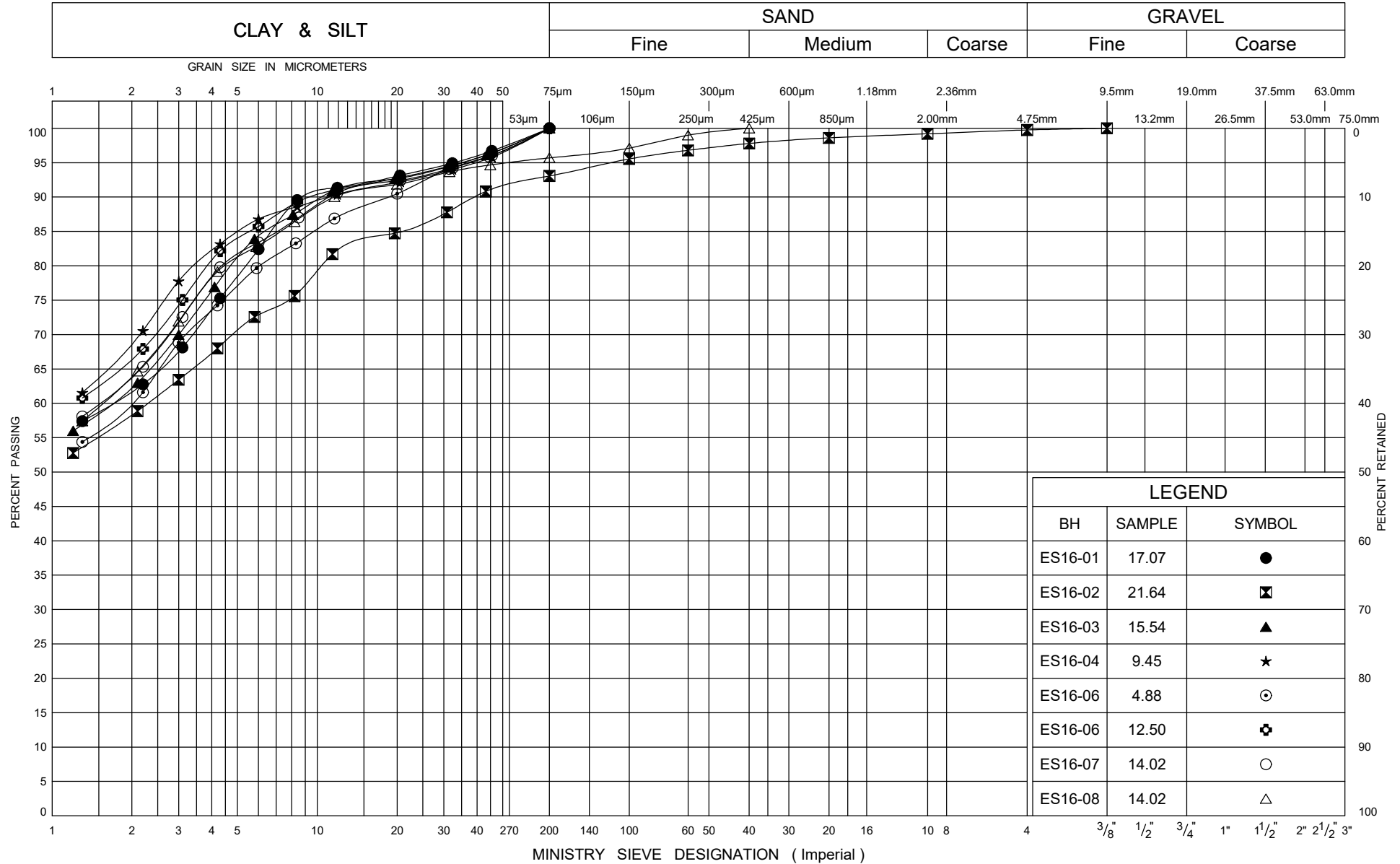
W P 408-88-00

E-S Ramp

UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

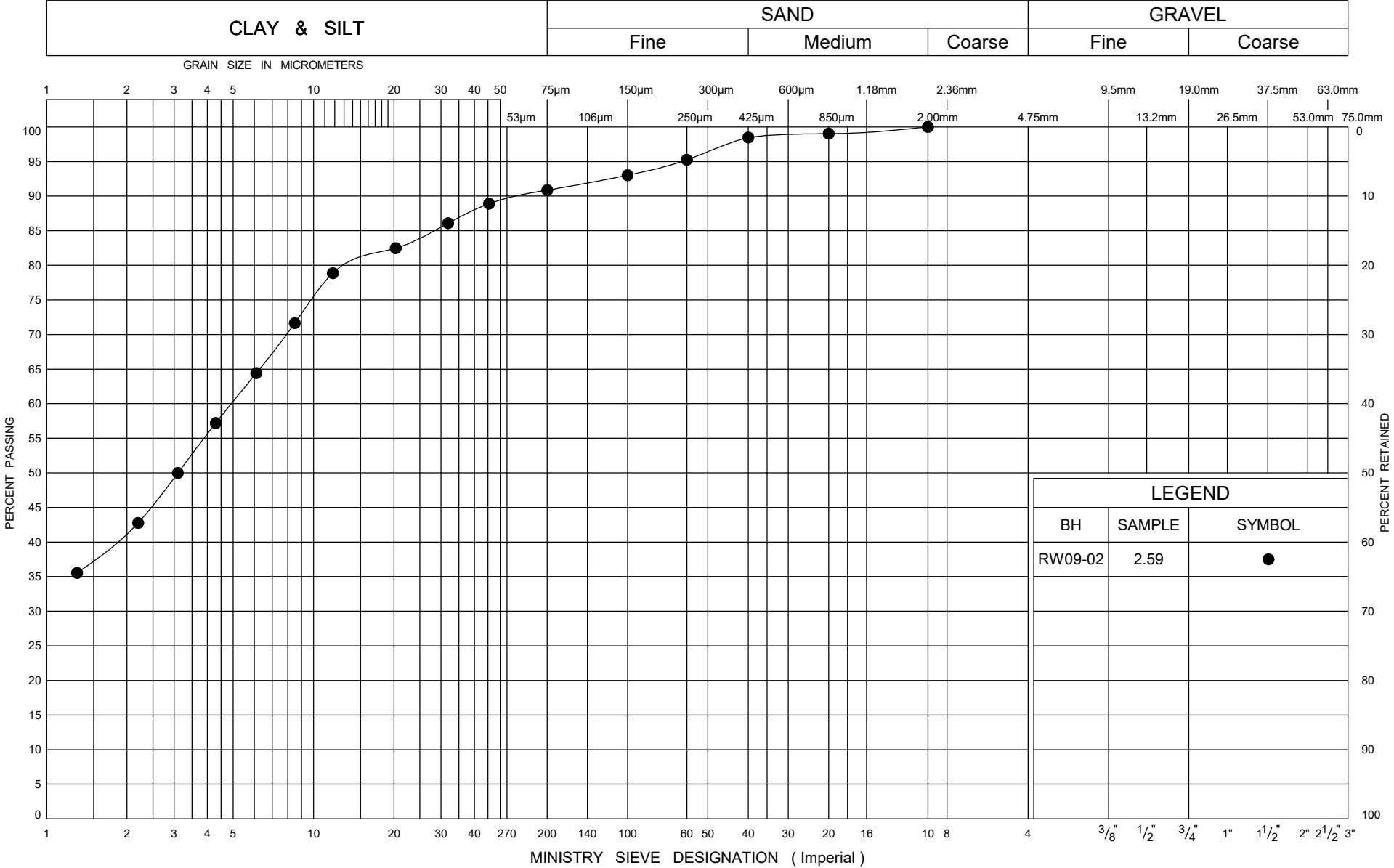
Silty CLAY

FIG No A5

W P 408-88-00

E-S Ramp

UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM

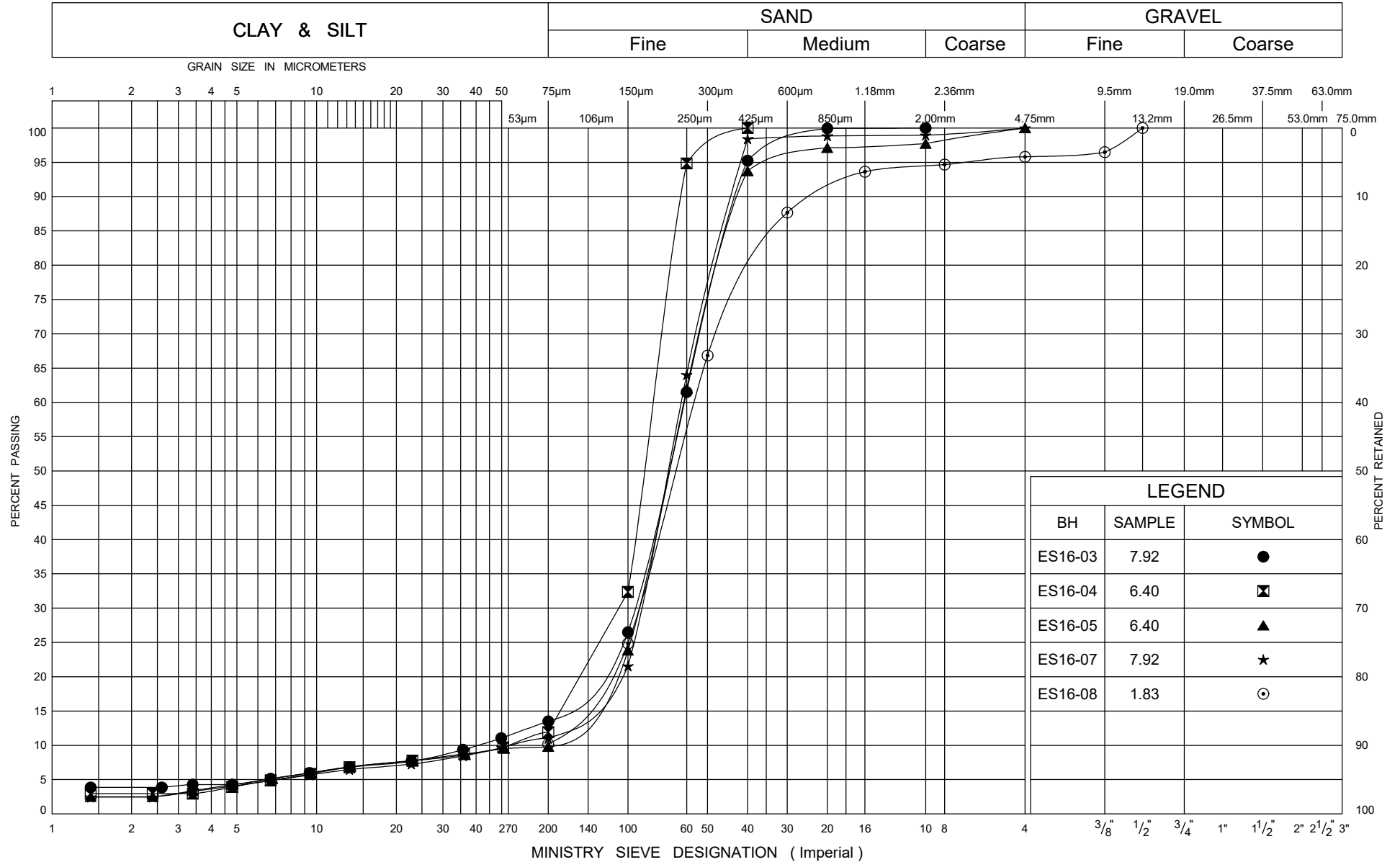
GRAIN SIZE DISTRIBUTION
SAND

FIG No A7

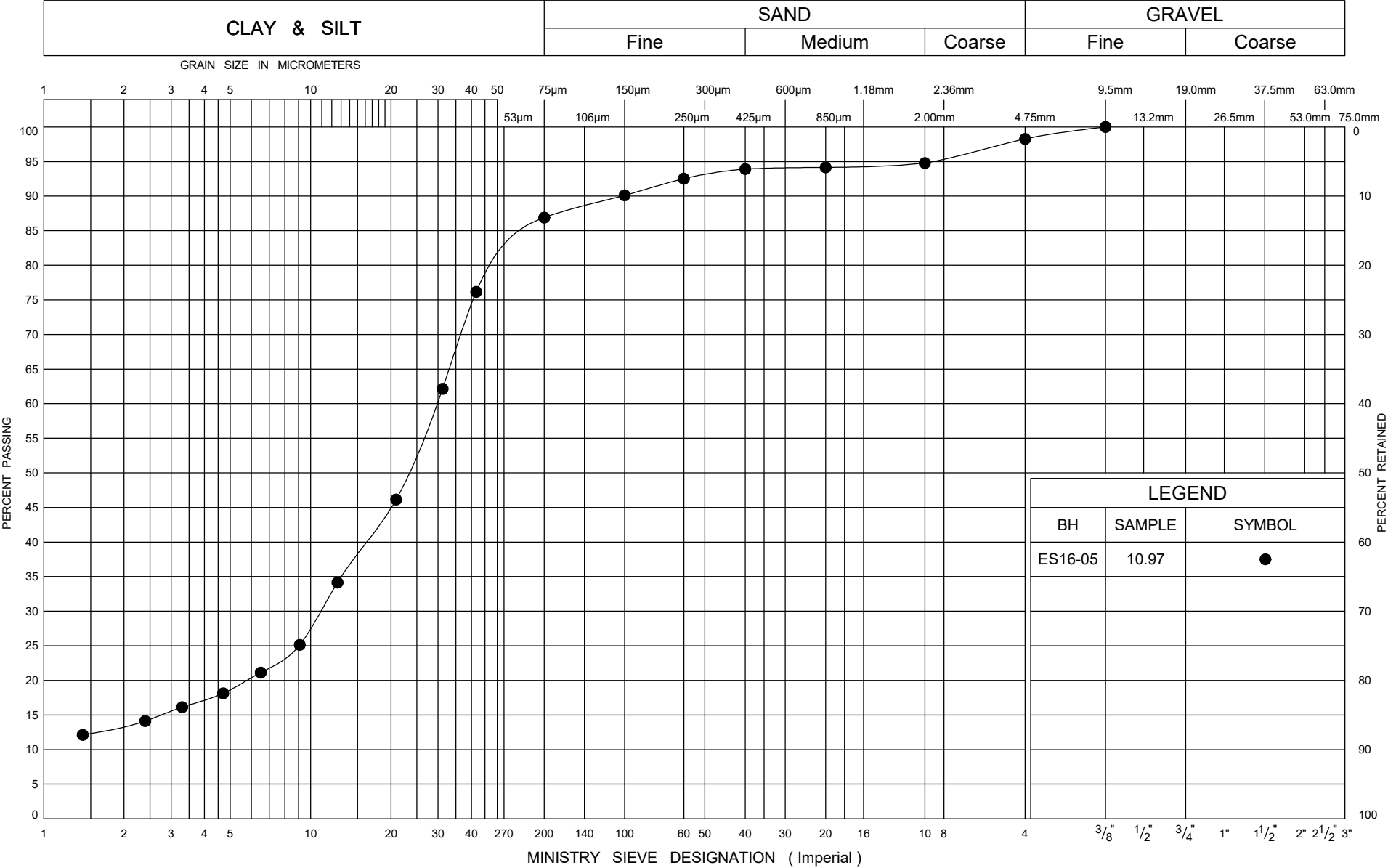
W P 408-88-00

E-S Ramp

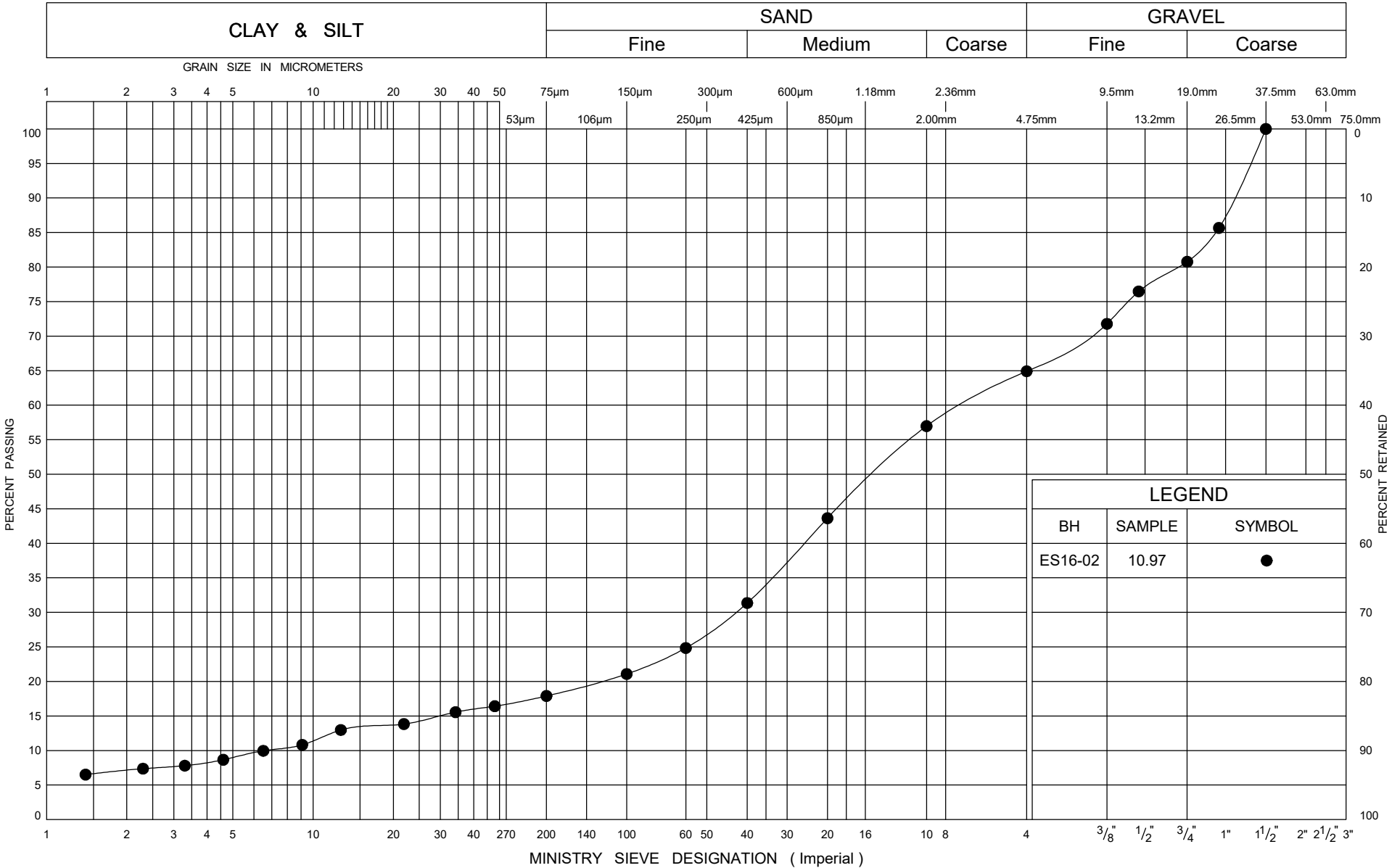
Ministry of
Transportation

Ontario

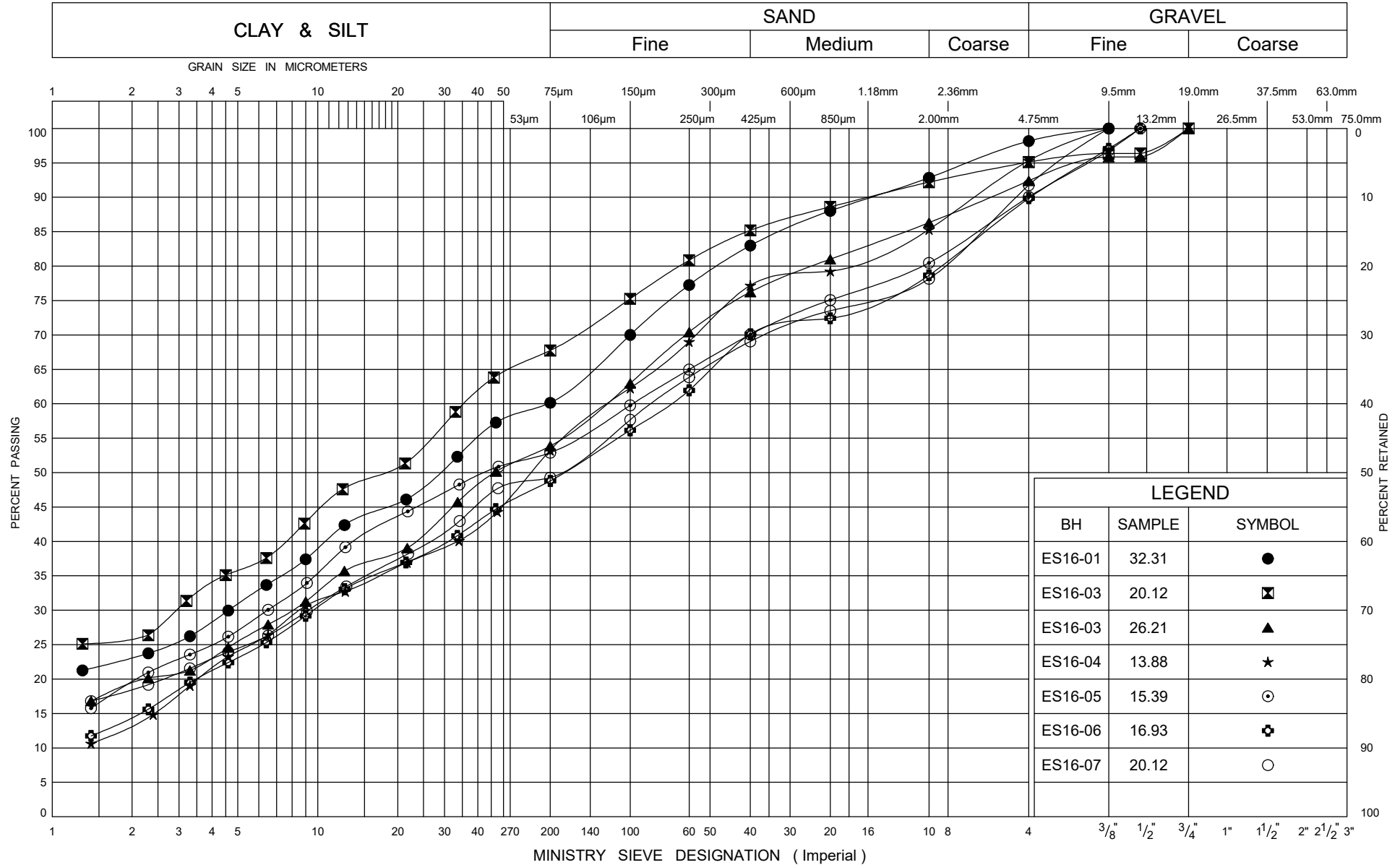
UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

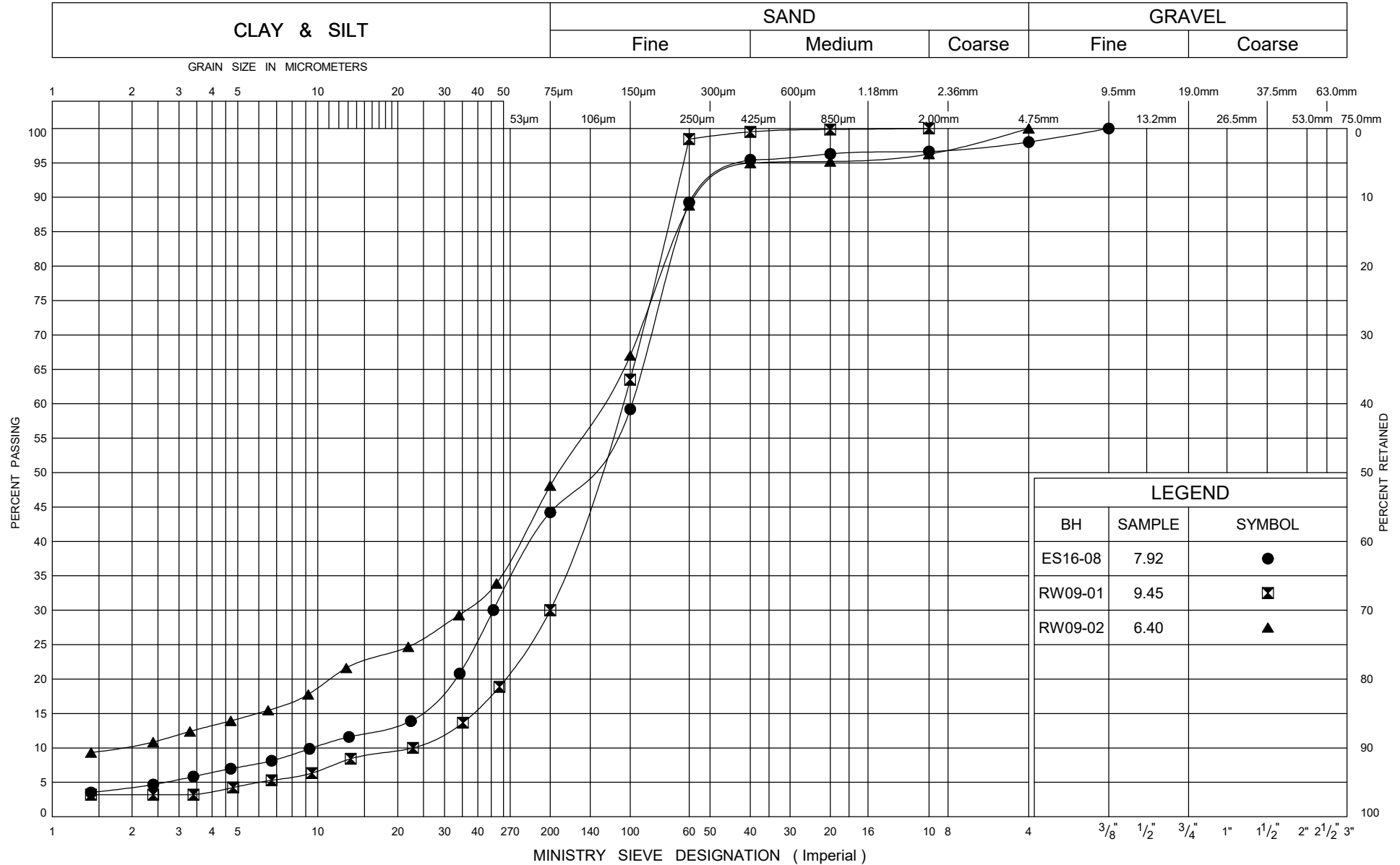
GRAIN SIZE DISTRIBUTION
SAND and SILT TILL, some clay

FIG No A10

W P 408-88-00

E-S Ramp

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

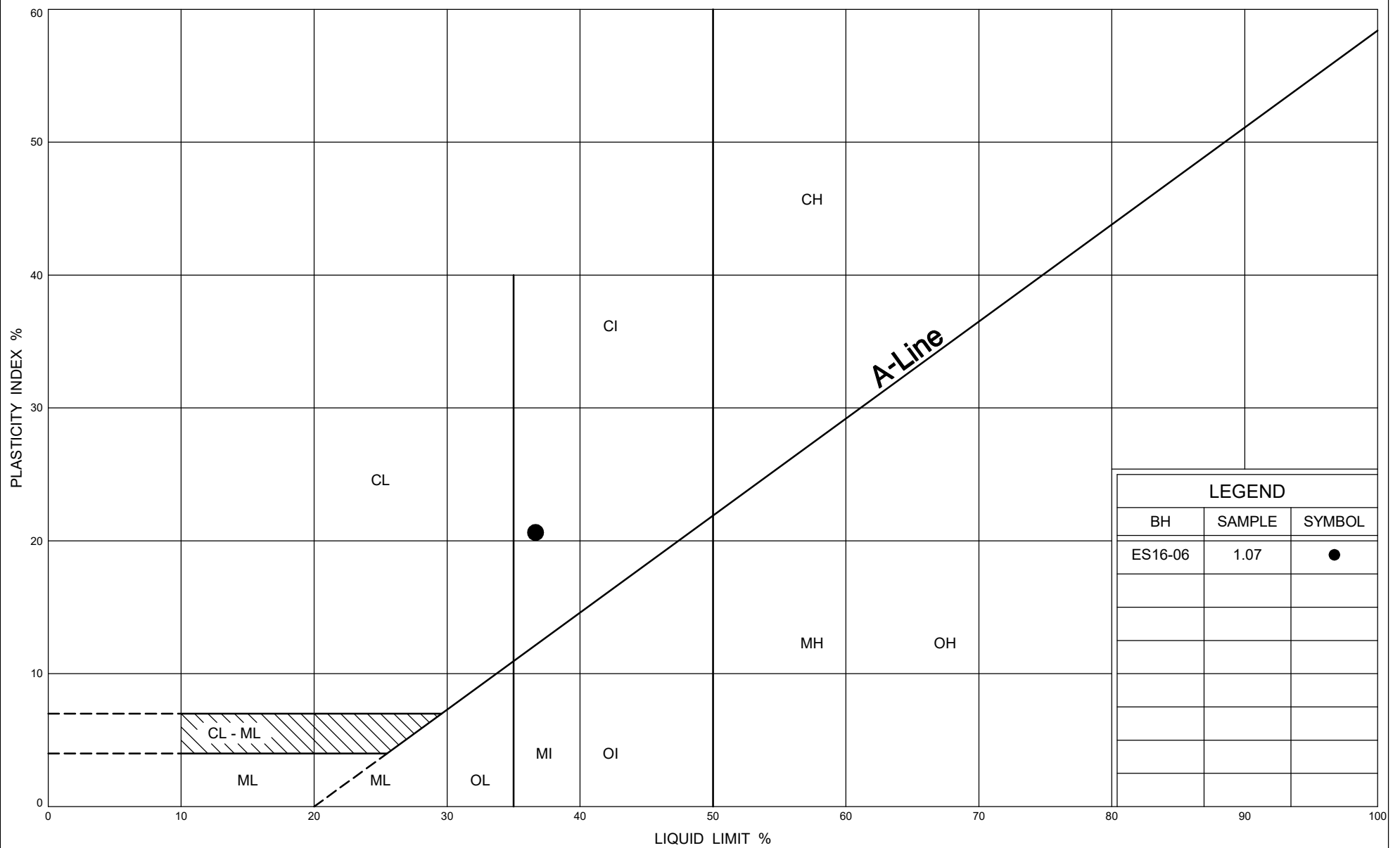
GRAIN SIZE DISTRIBUTION

SAND and SILT TILL

FIG No A11

W P 408-88-00

E-S Ramp



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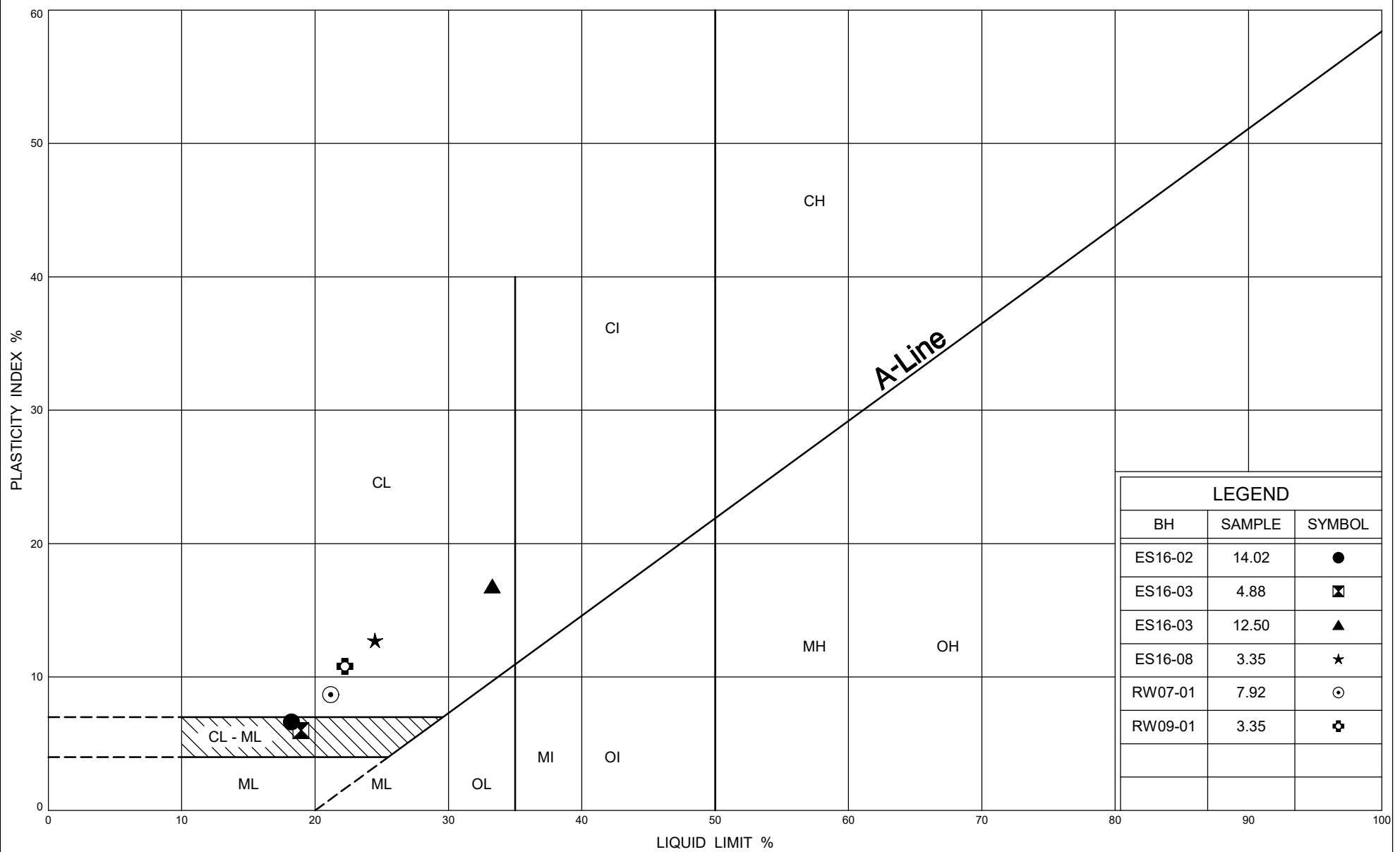
PLASTICITY CHART

Silty CLAY FILL

FIG No A12

W P 408-88-00

E-S Ramp



Ministry of
Transportation

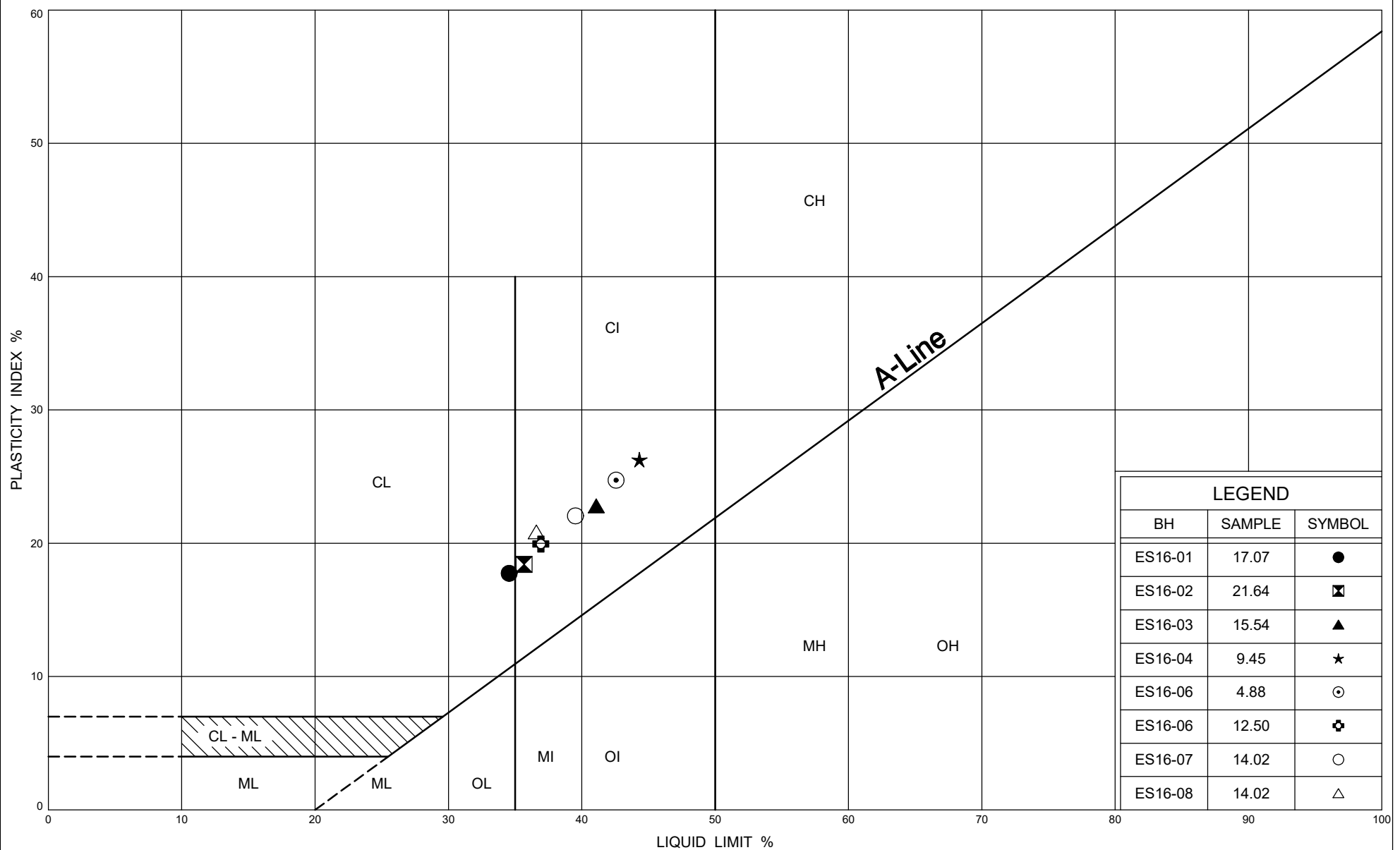
PLASTICITY CHART

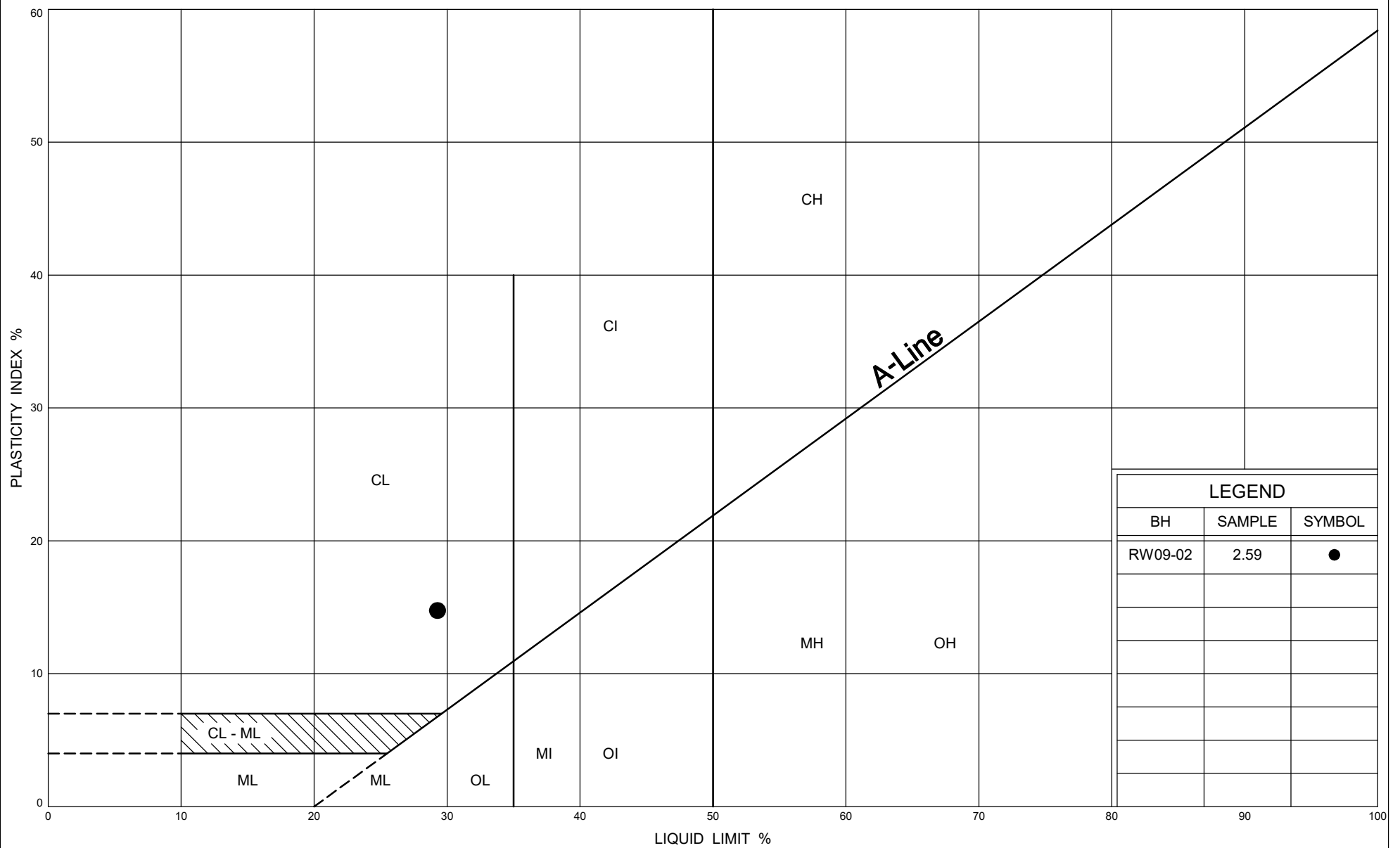
Silty CLAY TILL

FIG No A13

W P 408-88-00

E-S Ramp





LEGEND		
BH	SAMPLE	SYMBOL
RW09-02	2.59	●



Ministry of
Transportation

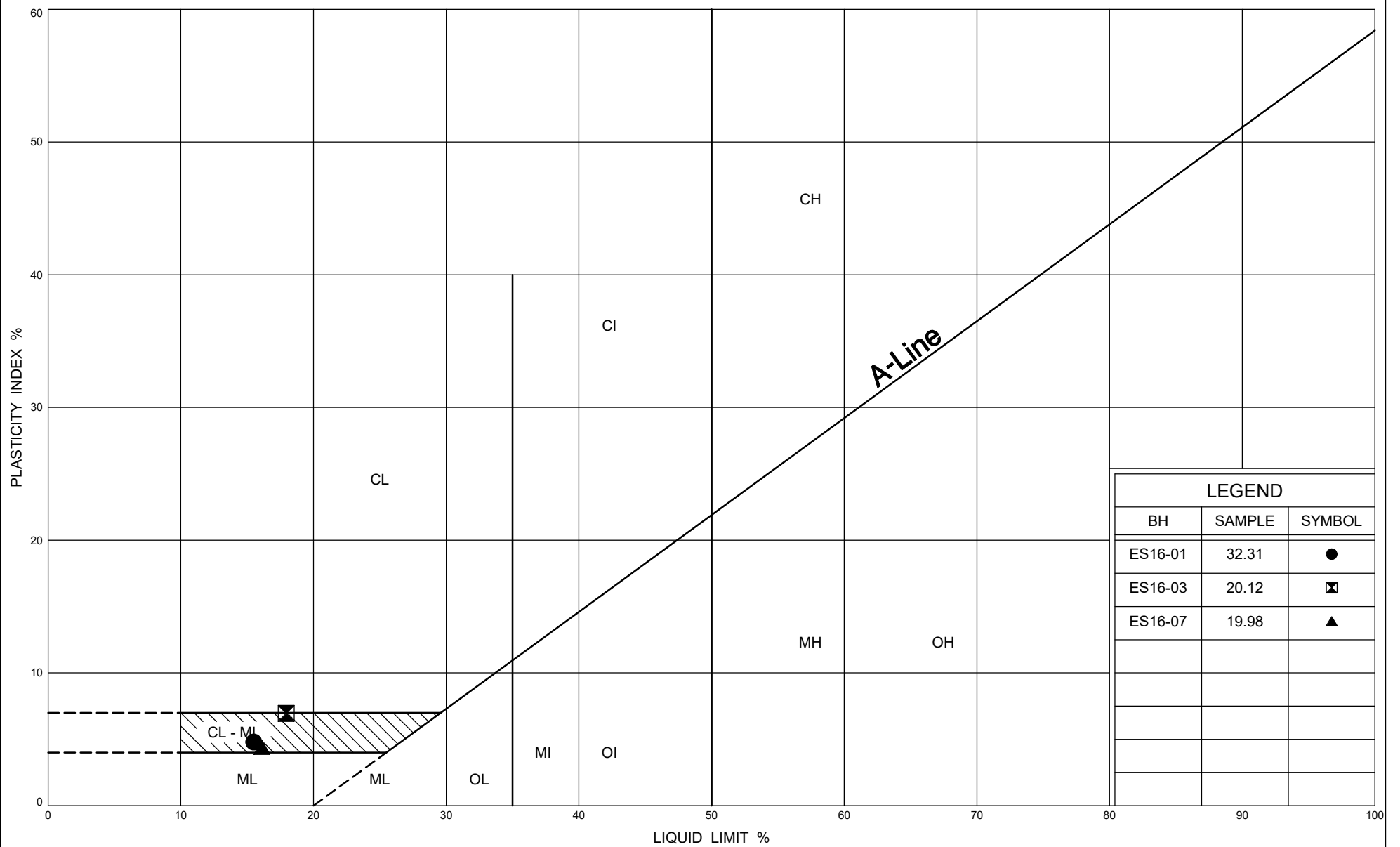
PLASTICITY CHART

Silty CLAY

FIG No A15

W P 408-88-00

E-S Ramp



Ministry of
Transportation

PLASTICITY CHART

SAND and SILT TILL (clayey zone)

FIG No A16

W P 408-88-00

E-S Ramp



FINAL REPORT

CA14445-AUG18 R1

11375

Prepared for

Thurber Engineering Ltd.

First Page

CLIENT DETAILS

Client Thurber Engineering Ltd.

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

Contact Rocio Palomeque

Telephone 905-829-8666 x 263

Facsimile

Email rreyna@thurber.ca

Project 11375

Order Number

Samples Soil (5)

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 CA14445-AUG18

Received 08/16/2018

Approved 08/23/2018

Report Number CA14445-AUG18 R1

Date Reported 08/23/2018

COMMENTS

Temperature of Sample upon Receipt: 6 degrees C

Cooling Agent Present.

Custody Seal Present&intact.

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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FINAL REPORT

CA14445-AUG18 R1

Client: Thurber Engineering Ltd.

Project: 11375

Project Manager: Rocío Palomeque

Samplers: N/A

PACKAGE: - Corrosivity Index (SOIL)

Sample Number	5	6	7	8	9
Sample Name	RS16-03-SS4	RW7-01-SS3	RW1-04-SS2	NE16-10 SS4	EC16-08 SS3
Sample Matrix	Soil	Soil	Soil	Soil	Soil
Sample Date	18/05/2018	05/06/2018	06/06/2018	27/04/2018	27/04/2018

Parameter	Units	RL	Result	Result	Result	Result	Result
-----------	-------	----	--------	--------	--------	--------	--------

Corrosivity Index

Corrosivity Index	none	1	4.0	4.0	6.5	4.0	4.5
Soil Redox Potential	mV	-	246	362	187	205	169
Sulphide	%	0.02	< 0.02	< 0.02	0.04	< 0.02	0.86
pH	no unit	0.05	8.87	9.36	10.7	9.02	8.15
Resistivity (calculated)	ohms.cm	-9999	3320	10500	4120	4070	4410

PACKAGE: - General Chemistry (SOIL)

Sample Number	5	6	7	8	9
Sample Name	RS16-03-SS4	RW7-01-SS3	RW1-04-SS2	NE16-10 SS4	EC16-08 SS3
Sample Matrix	Soil	Soil	Soil	Soil	Soil
Sample Date	18/05/2018	05/06/2018	06/06/2018	27/04/2018	27/04/2018

Parameter	Units	RL	Result	Result	Result	Result	Result
-----------	-------	----	--------	--------	--------	--------	--------

General Chemistry

Conductivity	uS/cm	2	301	95	243	246	227
--------------	-------	---	-----	----	-----	-----	-----

PACKAGE: - Metals and Inorganics (SOIL)

Sample Number	5	6	7	8	9
Sample Name	RS16-03-SS4	RW7-01-SS3	RW1-04-SS2	NE16-10 SS4	EC16-08 SS3
Sample Matrix	Soil	Soil	Soil	Soil	Soil
Sample Date	18/05/2018	05/06/2018	06/06/2018	27/04/2018	27/04/2018

Parameter	Units	RL	Result	Result	Result	Result	Result
-----------	-------	----	--------	--------	--------	--------	--------

Metals and Inorganics

Moisture Content	%	0.1	19.4	3.0	7.6	11.0	13.9
Sulphate	µg/g	0.4	70	6.6	270	9.1	710



FINAL REPORT

CA14445-AUG18 R1

Client: Thurber Engineering Ltd.

Project: 11375

Project Manager: Rocío Palomeque

Samplers: N/A

PACKAGE: - Other (ORP) (SOIL)

Sample Number	5	6	7	8	9
Sample Name	RS16-03-SS4	RW7-01-SS3	RW1-04-SS2	NE16-10 SS4	EC16-08 SS3
Sample Matrix	Soil	Soil	Soil	Soil	Soil
Sample Date	18/05/2018	05/06/2018	06/06/2018	27/04/2018	27/04/2018

Parameter	Units	RL	Result	Result	Result	Result	Result
Other (ORP)							
Chloride	µg/g	0.4	240	13	60	130	4.4



FINAL REPORT

CA14445-AUG18 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	DIO0280-AUG18	µg/g	0.4	<0.4	2	20	96	80	120	97	75	125
Sulphate	DIO0280-AUG18	µg/g	0.4	<0.4	5	20	97	80	120	81	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	ECS0022-AUG18	%	0.02	<0.02	99	20	99	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	EWL0253-AUG18	uS/cm	2	< 0.002	0	10	99	90	110	NA		



FINAL REPORT

CA14445-AUG18 R1

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	EWL0253-AUG18	no unit	0.05	NA	0		101			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

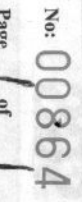
Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

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. 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.

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-- End of Analytical Report --

Page 1 of 1


CA 14445-
LAB LIMS #: A0618

PROJECT INFORMATION

Quotation # _____ P.O. # _____
Project # _____ 11375 _____ Site Location/ID: _____
TURNAROUND TIME (TAT) REQUIRED
☒ Regular TAT (5-7days) TATs 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: _____

[illegible]

RECORD OF SITE CONDITION (RSC)					<input type="checkbox"/> YES	<input type="checkbox"/> NO											Preserved (P)	
SAMPLE IDENTIFICATION		DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Corrosive												
1	RS16-03 - SS4	May 18, 2018		1	Soil	✓												
2																		
3	RW7-01 -SS3	June 5, 2018		1	Soil	✓												
4																		
5	RMV-04 -SS2	June 6, 2018		1	Soil	✓												
6																		
7	NE16-10 SS4	Aug 23, 2018		1	Soil	✓												
8																		
9	EQ16-08 SS3	July 16, 2018		1	Soil	✓												
10																		
Observations/Comments/Special Instructions																		

Sampled By (NAME):		Signature: 	Date: <u>08/15/2018</u>	(mm/dd/yy)	Pink Copy - Client
Relinquished by (NAME):		Signature:	Date: ____/____/____	(mm/dd/yy)	Yellow & White Copy- SGS

Revision #: 1.1
Rate of Issue: 25 July, 2016

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SAMPLE INTEGRITY REPORT

Project Number: 11375

ONTARIO REGULATION 153/04

SGS Sample ID CA14445-Aug18

Date / Time Sampled see CoC

Client Sample ID

ALL

Sample Submission General Sample Integrity Violations

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

Sample Specific Sample Integrity Violations

- | | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 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

- | | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 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:

KH



FINAL REPORT

CA14058-MAY18 R1

11375

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 Palomeque

Telephone 905-829-8666 x 263

Facsimile

Email rreyna@thurber.ca

Project 11375

Order Number

Samples Soil (7)

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 CA14058-MAY18

Received 05/02/2018

Approved 05/09/2018

Report Number CA14058-MAY18 R1

Date Reported 05/09/2018

COMMENTS

Temperature of Sample upon Receipt: 8 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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FINAL REPORT

CA14058-MAY18 R1

Client: Thurber Engineering Ltd.

Project: 11375

Project Manager: Rocío Palomeque

Samplers: N/A

PACKAGE: - Corrosivity Index (SOIL)

Sample Number	5	6	7	8	9	10	11
Sample Name	RW12-05	RW10-04 SS4	RW 09-02 SS3	NE 16-16 SS4	RW13-01 SS4	SE16-05 SS3	SE16-06 SS5
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date	20/04/2018	18/04/2018	11/04/2018	11/04/2018	11/04/2018	12/04/2018	23/04/2018

Parameter	Units	RL	Result	Result	Result	Result	Result	Result	Result
-----------	-------	----	--------	--------	--------	--------	--------	--------	--------

Corrosivity Index

Corrosivity Index	none	1	4	3	4	4	4	3	4
Soil Redox Potential	mV	-	230	182	274	164	133	232	215
Sulphide	%	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
pH	no unit	0.05	8.67	9.11	9.04	9.19	8.50	9.11	9.25
Resistivity (calculated)	ohms.cm	-9999	4610	17100	6670	13200	5250	13400	10100

PACKAGE: - General Chemistry (SOIL)

Sample Number	5	6	7	8	9	10	11
Sample Name	RW12-05	RW10-04 SS4	RW 09-02 SS3	NE 16-16 SS4	RW13-01 SS4	SE16-05 SS3	SE16-06 SS5
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date	20/04/2018	18/04/2018	11/04/2018	11/04/2018	11/04/2018	12/04/2018	23/04/2018

Parameter	Units	RL	Result	Result	Result	Result	Result	Result	Result
-----------	-------	----	--------	--------	--------	--------	--------	--------	--------

General Chemistry

Conductivity	uS/cm	2	217	59	150	76	190	75	99
--------------	-------	---	-----	----	-----	----	-----	----	----

PACKAGE: - Metals and Inorganics (SOIL)

Sample Number	5	6	7	8	9	10	11
Sample Name	RW12-05	RW10-04 SS4	RW 09-02 SS3	NE 16-16 SS4	RW13-01 SS4	SE16-05 SS3	SE16-06 SS5
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date	20/04/2018	18/04/2018	11/04/2018	11/04/2018	11/04/2018	12/04/2018	23/04/2018

Parameter	Units	RL	Result	Result	Result	Result	Result	Result	Result
-----------	-------	----	--------	--------	--------	--------	--------	--------	--------

Metals and Inorganics

Moisture Content	%	0.1	9.3	4.4	11.3	8.3	13.4	4.1	8.8
Sulphate	µg/g	0.4	15	1.1	13	5.5	11	4.0	8.7



FINAL REPORT

CA14058-MAY18 R1

Client: Thurber Engineering Ltd.

Project: 11375

Project Manager: Rocío Palomeque

Samplers: N/A

PACKAGE: - Other (ORP) (SOIL)

Sample Number	5	6	7	8	9	10	11
Sample Name	RW12-05	RW10-04 SS4	RW 09-02 SS3	NE 16-16 SS4	RW13-01 SS4	SE16-05 SS3	SE16-06 SS5
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date	20/04/2018	18/04/2018	11/04/2018	11/04/2018	11/04/2018	12/04/2018	23/04/2018

Parameter	Units	RL	Result	Result	Result	Result	Result	Result	Result
Other (ORP)									
Chloride	µg/g	0.4	70	3.2	53	12	46	19	30



FINAL REPORT

CA14058-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	DIO0131-MAY18	µg/g	0.4	<0.4	6	20	95	80	120	106	75	125
Sulphate	DIO0131-MAY18	µg/g	0.4	<0.4	42	20	98	80	120	98	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	ECS0004-MAY18	%	0.02	<0.02	8	20	99	80	120			

pH

Method: SM 4500 | Internal ref.: ME-CA-IENVIEWL-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	EWL0048-MAY18	no unit	0.05	NA	1		100			NA		

QC SUMMARY

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. 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.

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-- End of Analytical Report --



Request for Laboratory Services and CHAIN OF CUSTODY

SGS Environmental Services

- 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

No:

Page 1 of 1

Laboratory Information Section - Lab use only

Received By: 15mail
Received Date (mm/dd/yyyy): 05/02/18 (mm/dd/yyyy)
Received Time: 11:00 Am

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

Cooling Agent Present: ☐ no
Temperature Upon Receipt (°C): 12.1/1.10

LAB LIMS #: CA14058-May

8x3

REPORT INFORMATION

Company: Thurber Eng.
Contact: Rocio Palomede Reyna
Address: 103-2010 Winston Park Dr
Oakville, ON L6H 5R7
Phone: _____
Fax: _____
Email: rreyna@thurber.ca

INVOICE INFORMATION

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

PROJECT INFORMATION

Quotation #: _____
Project #: 11375
P.O. #: _____
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: _____

REGULATIONS

Regulation 153 (2011):

☐ Table 1 ☐ Res/Park ☐ Soil Texture: _____
☐ Table 2 ☐ Ind/Com ☐ Coarse _____
☐ Table 3 ☐ Agri/Other ☐ Medium _____
☐ Table _____ ☐ Fine _____

Other Regulations:

☐ Reg 347/558 (3 Day min TAT)
☐ PWQO ☐ MMER
☐ CCME ☐ Other: _____
☐ MISA

Sewer By-Law:

☐ Sanitary
☐ Storm

Municipality: _____

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX
1 <u>RW12-05</u>	<u>April 20/18</u>		<u>1</u>	<u>Soil</u>
2 <u>RW10-04</u>	<u>April 18/18</u>		<u>1</u>	<u>"</u>
3 <u>RW09-02</u>	<u>April 11/18</u>		<u>1</u>	<u>"</u>
4 <u>NE16-16</u>	<u>April 13/18</u>		<u>1</u>	<u>"</u>
5 <u>RW13-01</u>	<u>April 9/18</u>		<u>1</u>	<u>"</u>
6 <u>SE16-05</u>	<u>April 12/18</u>		<u>1</u>	<u>"</u>
7 <u>ES16-06</u>	<u>April 23</u>		<u>1</u>	<u>"</u>
8				
9				
10				

Observations/Comments/Special Instructions

ANALYSIS REQUESTED

PHC F1-F4 BTEX
O.Reg 153 Metals
(CP & hydride metals)
☐ Hg ☐ B-HWS ☐ Cr(VI)
O.Reg 153 VOCs

Contaminants

COMMENTS:
Field Filtered (F)
Preserved (P)

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

Sampled By (NAME): _____

Relinquished by (NAME): _____

Revision #: 1.0
Date of Issue: 01 June, 2014

Signature: _____

Signature: _____

Date: _____ / _____ / _____ (mm/dd/yy)

Date: 01/10/2018 (mm/dd/yy)

Pink Copy - Client

Yellow & White Copy - SGS



SAMPLE INTEGRITY REPORT

Project Number:

11375

ONTARIO REGULATION 153/04

SGS Sample ID

ON14058-May 18

Date / Time Sampled

Apr 11, 12, 18, 19, 20, 23

Client Sample ID

See CoC

ALL

Sample Submission General Sample Integrity Violations

- Temperature >10 C upon receipt If not sampled same day ☐
- No evidence of cooling trend initiated If sampled same day ☐
- Chain of Custody not submitted ☐
- Chain of Custody incomplete ☐
- Chain of Custody not signed / dated ☐
- Chain of Custody not a current version ☐
- Bottles / Samples listed on CoC but not received ☐
- Bottles / Samples received but not listed on the CoC ☐
- Sample container received empty ☐

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 ☐
- Groundwater contains greater than 1cm of sediment / particulate matter in bottle ☐

Additional Comments/Remarks:

No Issues upon receipt



Initials:

BM



Appendix B

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

RECORD OF BOREHOLE No 08-015

1 OF 3

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 451.52 E 226 142.96 ORIGINATED BY SLI/GA
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2008.06.26 - 2008.09.29 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
318.3						20	40	60	80	100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
0.0	ASPHALT (200mm)													
0.2	SAND and GRAVEL, occasional silt Very Dense Brown		1	SS	58									
317.5	Damp (FILL)													
0.8	SAND, fine grained, some silt, trace gravel, trace clay Dense to Very Dense Brown Damp to Moist		2	SS	47									
			3	SS	59									
			4	SS	43									
	Compact		5	SS	10									
314.2														
4.1	Silty CLAY, trace sand Very Stiff Brown		6	SS	17									
312.7														
5.6	SAND, fine grained, trace silt, trace clay Compact Brown Wet		7	SS	16									
			8	SS	25									
309.8														
8.5	Silty CLAY, trace sand Very Stiff Brown (TILL)		9	SS	22									

Continued Next Page

+³ . X³ : Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-015

2 OF 3

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 451.52 E 226 142.96 ORIGINATED BY SLI/GA
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2008.06.26 - 2008.09.29 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
								20 40 60 80 100				
								20 40 60 80 100				
						<div><div></div><div></div><div></div></div> <div><div></div><div></div><div></div></div> <div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div></div> <div><div></div><div></div><div></div></div> <div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div></div> <div><div></div><div></div><div></div></div> <div><div></div><div></div><div></div></div>				
	Continued From Previous Page											
307.7	Silty CLAY, trace sand Very Stiff to Hard Grey (TILL)						308					
10.7	Silty CLAY, trace sand Hard Grey		10	SS	40							
							307					
			11	SS	53		306					0 1 35 64
							305					
			12	SS	44		304					
							303					0 0 41 59
			13	SS	92		302					
							301					
			14	SS	38		300					
300.5	Silty CLAY, trace gravel Hard Grey (TILL)		15	SS	100/ .150		299					
17.8												
	occasional cobbles		16	SS	100/							

Continued Next Page

+³ . X³ : Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-015

3 OF 3

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 451.52 E 226 142.96 ORIGINATED BY SLU/GA
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2008.06.26 - 2008.09.29 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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
						20	40	60	80	100	20	40	60			
	Continued From Previous Page															
	Silly CLAY, trace gravel Hard Grey (TILL)															
296.8			17	SS	100/											
21.5	END OF BOREHOLE AT 21.5m. WATER LEVEL OBSERVED AT 2.4m UPON COMPLETION OF DRILLING ON JUNE 27, 2008. BOREHOLE BACKFILLED WITH GROUT TO SURFACE.															

+ 3 . X 3 : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-016

1 OF 2

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 488.96 E 226 188.31 ORIGINATED BY SLL
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA
 DATUM Geodetic DATE 2008.07.22 - 2008.07.22 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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE		WATER CONTENT (%) w _p w w _L							
317.7							20 40 60 80 100										
0.0	TOPSOIL: (125mm), occasional roots and rootlets Moist Silty CLAY, trace rootlets, occasional sand seams Hard Brown																
0.1																	
316.0																	
1.7	Sandy SILT, trace gravel Very Dense Brown Moist (TILL) wet sand seams (100mm thick) Layer of grey silty sand (600mm) Wet		2	SS	100/ 175									0 24 66 10			
			3	SS	100/ 250												
			4	SS	100/ 175												
314.0																	
3.7	Silty CLAY, trace sand Hard Grey													0 1 43 56			
			5	SS	60												
			6	SS	51												
			7	SS	52												
309.0																	
8.7	Silty CLAY, trace gravel, trace sand Hard Grey (TILL)																
			8	SS	52												

Continued Next Page

+³ X³: Numbers refer to
Sensitivity

20
15-5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-016

2 OF 2

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 488.96 E 226 188.31 ORIGINATED BY SLL
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA
 DATUM Geodetic DATE 2008.07.22 - 2008.07.22 CHECKED BY RPR

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
	Continued From Previous Page												
	Silty CLAY, trace sand Hard Grey (TILL)		9	SS	71								0 4 39 57
304.4													
13.3	Sandy SILT, some clay, trace gravel Very Dense Grey Moist (TILL)		11	SS	100/ .125								2 45 40 13
	occasional cobbles		12	SS	100/ .125								
300.8			13	SS	100/ .125								
16.9	END OF BOREHOLE AT 16.9m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2008.08.20 12.6 305.1												

ONTMT4S 6417R.GPJ 6/1/09

+ 3 . X 3 : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-017

1 OF 2

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 534.75 E 226 282.11 ORIGINATED BY LG
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA
 DATUM Geodetic DATE 2008.07.21 - 2008.07.21 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
320.5												
0.0	TOPSOIL: (150mm), roots, rootlets											
0.2	Silty CLAY, trace to some gravel, trace rootlets Hard Light Brown to Brown		1	SS	47		320					
	Hard		2	SS	87		319					
318.0			3	SS	100/ .150		318					
2.4	Silty SAND, some gravel Very Dense Light Brown Moist		4	SS	100/ .225		317					
315.8			5	SS	75		316					
4.7	Silty CLAY, trace sand Hard Brown		6	SS	59		315					
			7	SS	58		314					
	Mottled Grey to Brown		8	SS	50		313					
							312					
							311					

Continued Next Page

+ ³ . X ³ : Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-017

2 OF 2

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 534.75 E 226 282.11 ORIGINATED BY LG
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA
 DATUM Geodetic DATE 2008.07.21 - 2008.07.21 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	20						40	60	80
	Continued From Previous Page																			
	Silty CLAY Hard Mottled Grey to Brown																			
			9	SS	38															
			10	SS	52											0 2 49 49				
			11	SS	50															
305.5																				
14.9	Sandy SILT, some clay, trace gravel Very Dense Brown Moist to wet (TILL)		12	SS	100/ .225											3 40 41 16				
			13	SS	100/ 200															
302.0			14	SS	100/ .150															
18.4	END OF BOREHOLE AT 18.4m. BOREHOLE BACKFILLED WITH GROUT TO SURFACE.																			

ONTMT4S 6417R.GPJ 9/10/08

RECORD OF BOREHOLE No 08-018

1 OF 2

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 548.71 E 226 330.85 ORIGINATED BY SA
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA
 DATUM Geodetic DATE 2008.06.25 - 2008.06.25 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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+ ³ × ³ : Numbers refer to
Sensitivity 20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-018

2 OF 2

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 548.71 E 226 330.85 ORIGINATED BY SA
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA
 DATUM Geodetic DATE 2008.06.25 - 2008.06.25 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA Si CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page													
311.9	Sandy SILT, trace gravel, trace clay Very Dense Grey Moist (TILL)		10	SS	129		313							1 84 15 (Si+CL)
11.1	Layer of sand													
	END OF BOREHOLE AT 11.1m. Piezometer installation consists of 25mm diameter schedule 40 PVC pipe with a 1.52m slotted screen.													
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2008.07.07 4.6 318.5 2008.06.15 6.6 316.5 2008.08.20 6.6 316.5													

RECORD OF BOREHOLE No 08-019

1 OF 3

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 321.35 E 226 097.34 ORIGINATED BY
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2008.09.25 - 2008.09.26 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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _P W W _L	20 40 60			
321.7														
0.0	TOPSOIL (150mm)													
0.2	SAND, trace to some silt, trace gravel, occasional rootlets Dense Brown Moist (FILL)		1	SS	41									
							321							
			2	SS	30		320							
319.3														
2.4	Silty CLAY, trace sand, trace gravel, occasional cobbles, occasional sand seams Hard Grey (TILL)						319							
			3	SS	44									
							318							
			4	SS	74									
							317							
			5	SS	52		316							
			6	SS	62		315							
							314							
			7	SS	42		313							
							312							

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-019

2 OF 3

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 321.35 E 226 097.34 ORIGINATED BY
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2008.09.25 - 2008.09.26 CHECKED BY RPR

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
Continued From Previous Page													
310.7	Silty CLAY, trace sand Hard Grey (TILL)		8	SS	74/ 150								
11.0	Silty CLAY Hard Grey		9	SS	73								
			10	SS	60								
			11	SS	100								
306.1	Silty CLAY, trace sand, trace gravel Hard Grey (TILL)		12	SS	46								
15.6		13	SS	140									
		14	SS	100									

Continued Next Page

+³ ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-019

3 OF 3

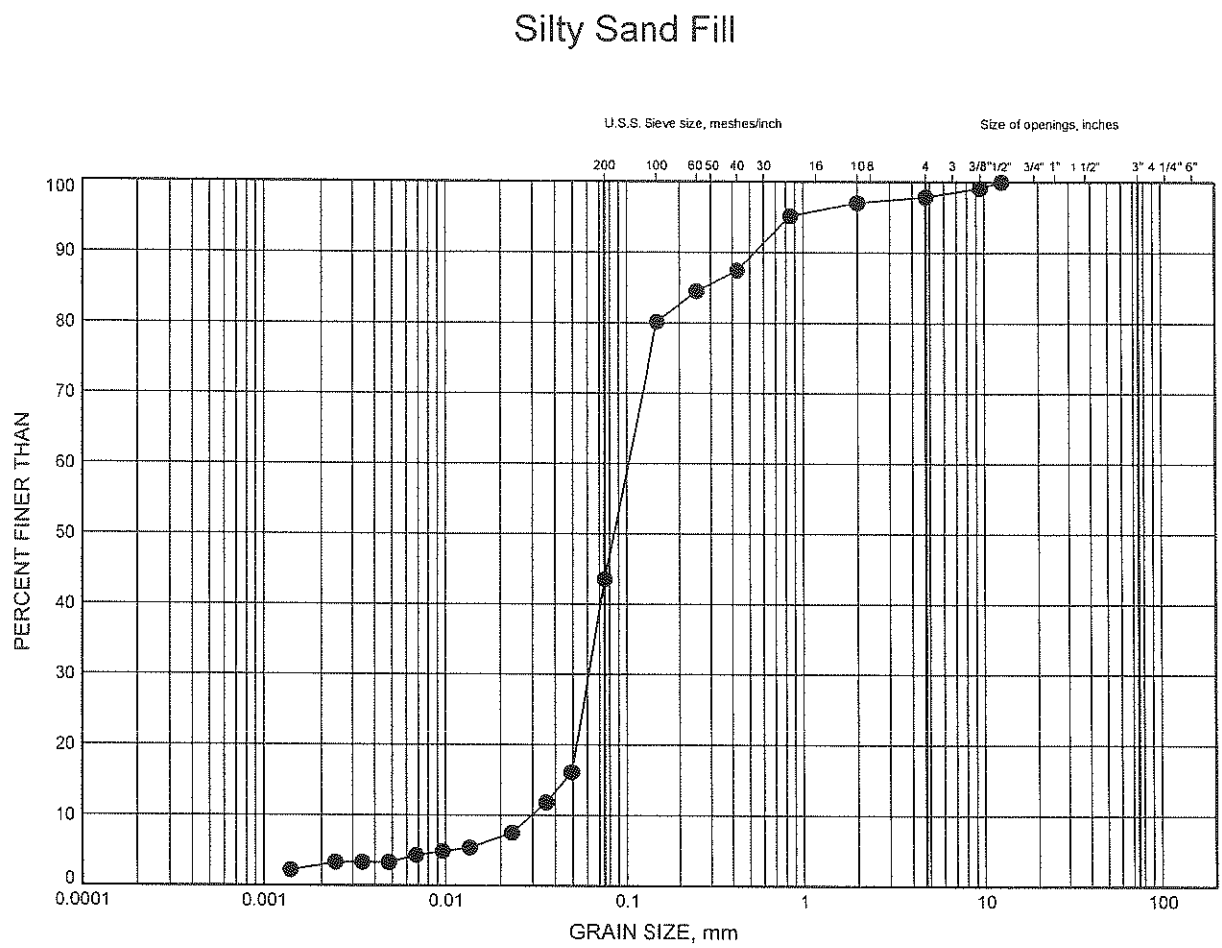
METRIC

G.W.P. 408-88-00 LOCATION N 4 814 321.35 E 226 097.34 ORIGINATED BY
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2008.09.25 - 2008.09.26 CHECKED BY RPR

SOIL PROFILE		SAMPLES				ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		GROUND WATER CONDITIONS	20 40 60 80 100	20 40 60 80 100	W P W W L	20 40 60		
	Continued From Previous Page												
300.4	Silty CLAY, trace sand, occasional cobbles Hard Grey (TILL)		15	SS	109								
21.3	END OF BOREHOLE AT 21.3m. Piezometer installation consists of 32mm diameter Schedule 32 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 18/08 6.31 315.4												

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B1



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-018	2.06	321.00

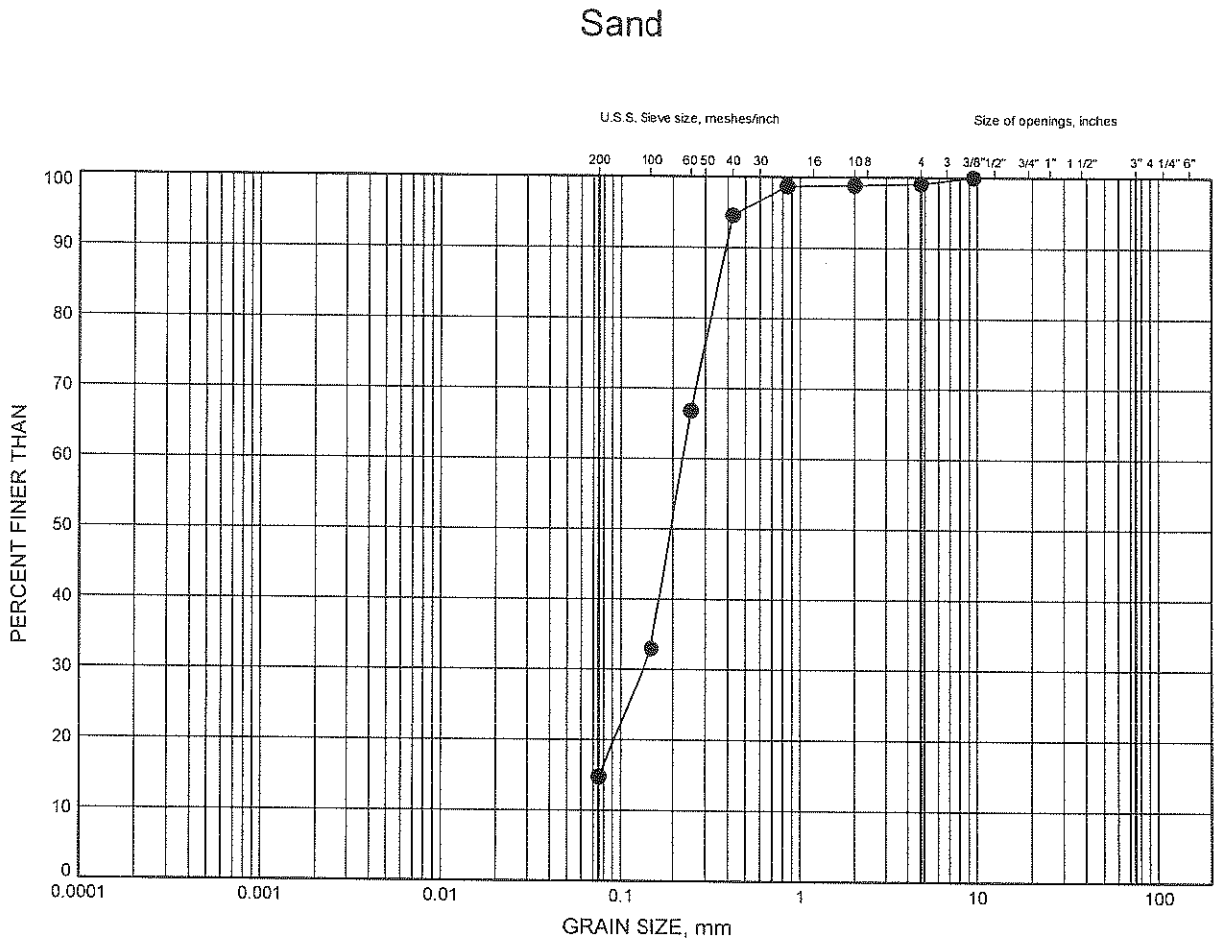


THURBER

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

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B2



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-018	10.90	312.16

GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 9/4/08

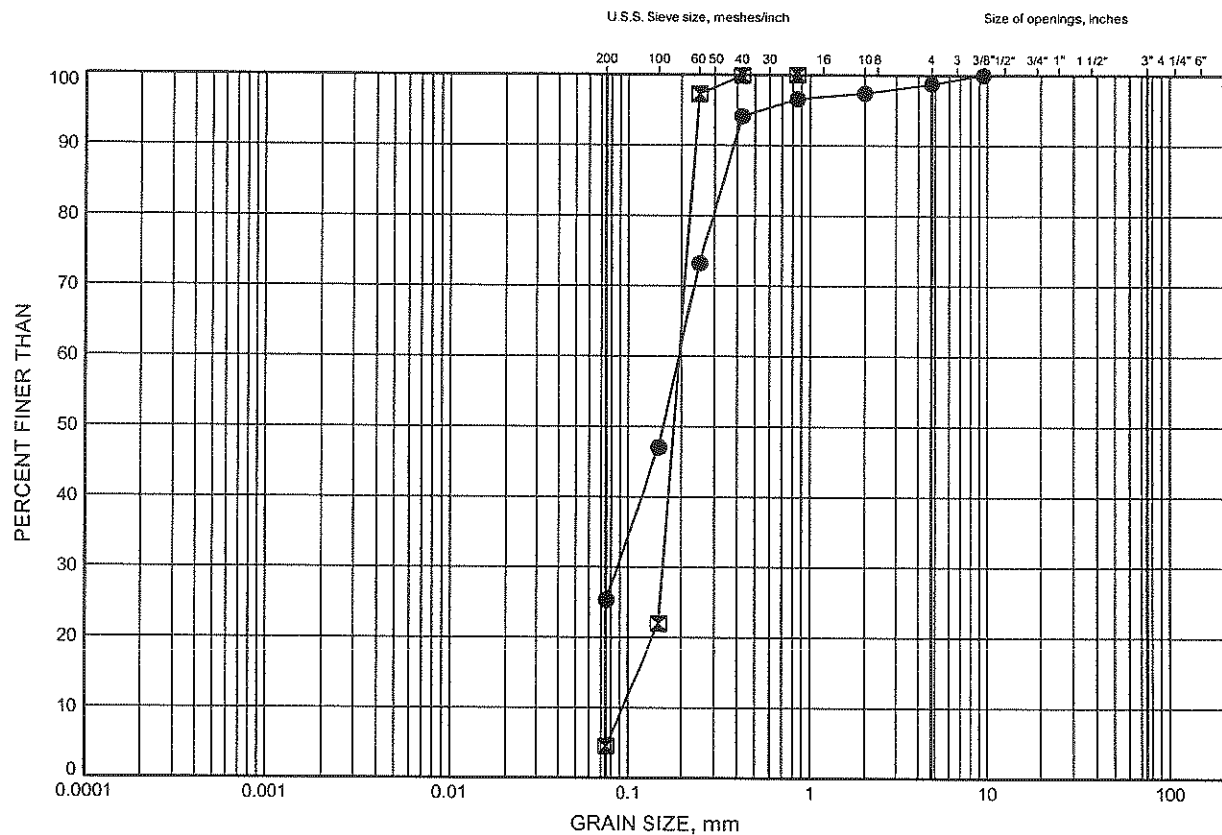
W.P.# . 408-88-00.....
 Prepared By . MFA.....
 Checked By . RPR.....



Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-015	1.83	316.49
⊠	08-015	6.40	311.92

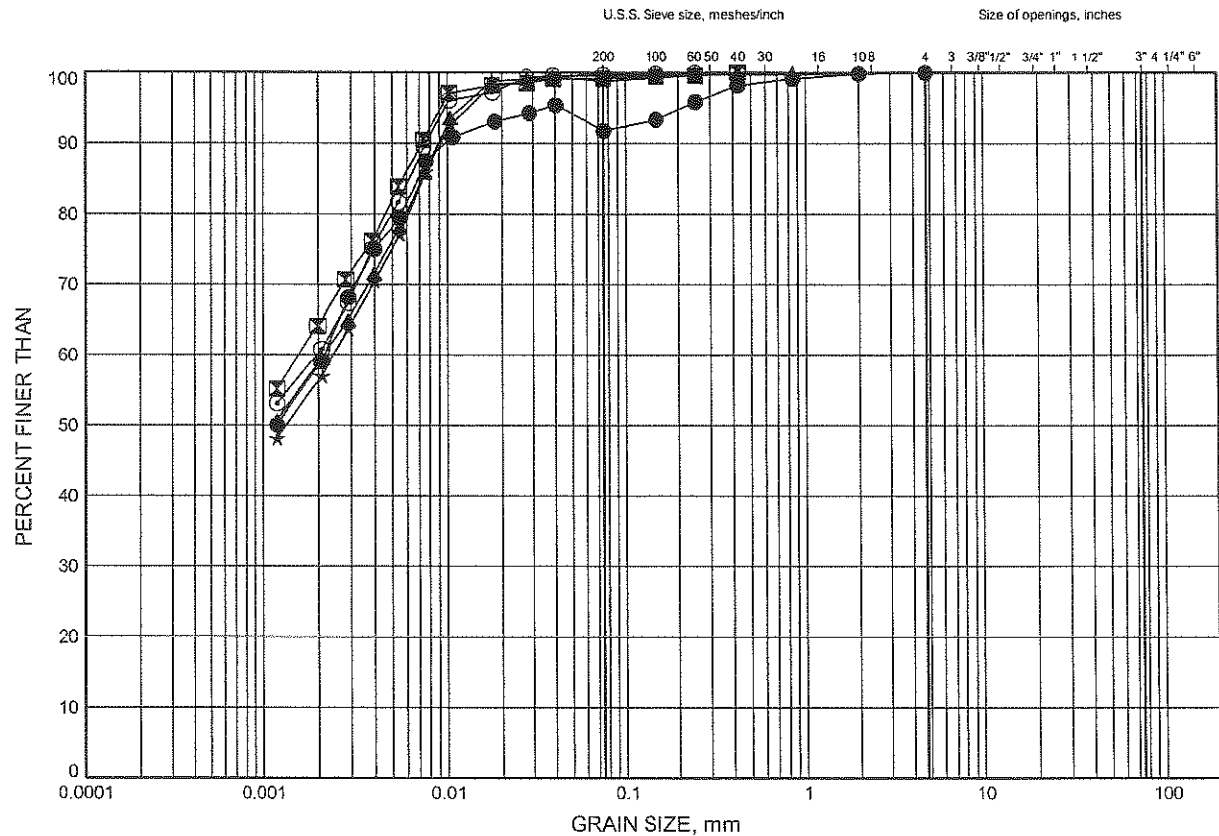


W.P.# .408-88-00.....
Prepared By .AN.....
Checked By .RPR.....

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B4

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-015	4.88	313.44
⊠	08-015	12.50	305.82
▲	08-015	15.53	302.79
☆	08-016	6.39	311.30
⊙	08-019	13.41	308.29

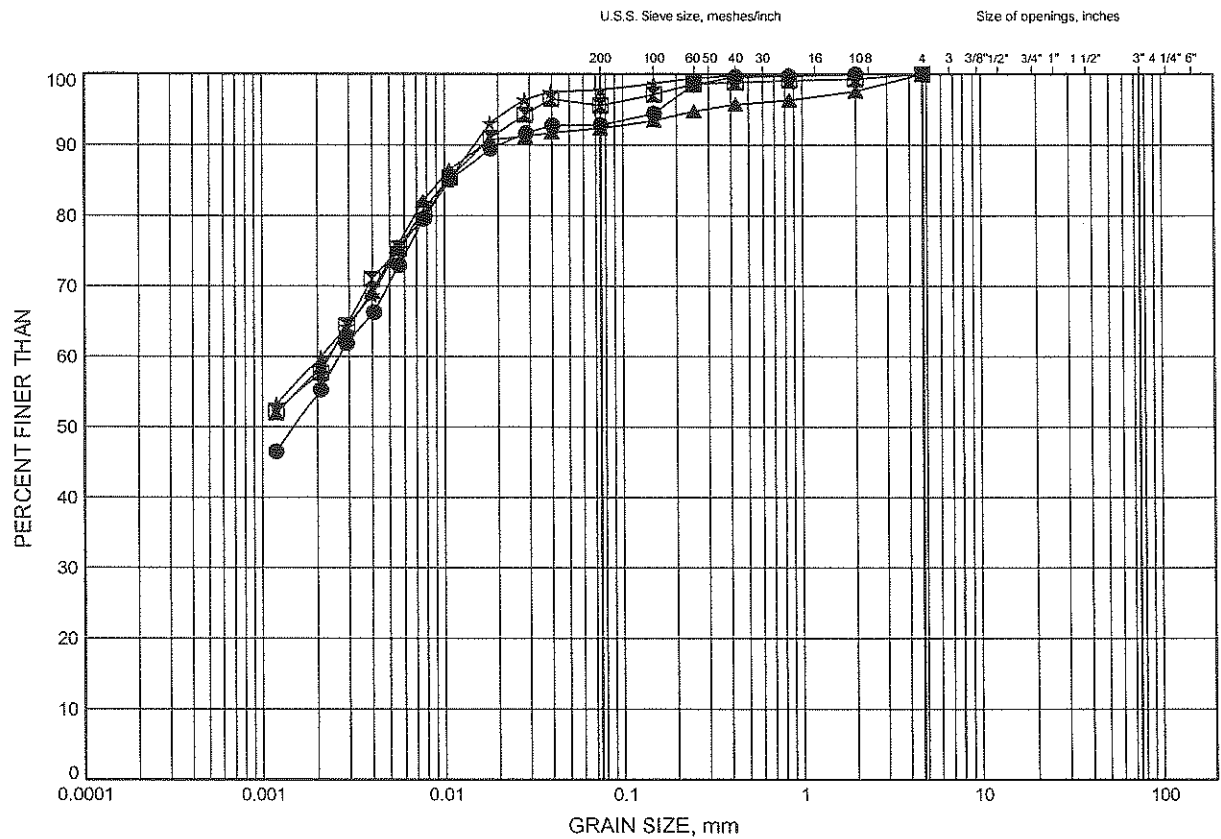


W.P.# 408-88-00
Prepared By AN
Checked By RPR

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY CLAY TILL



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

LEGEND

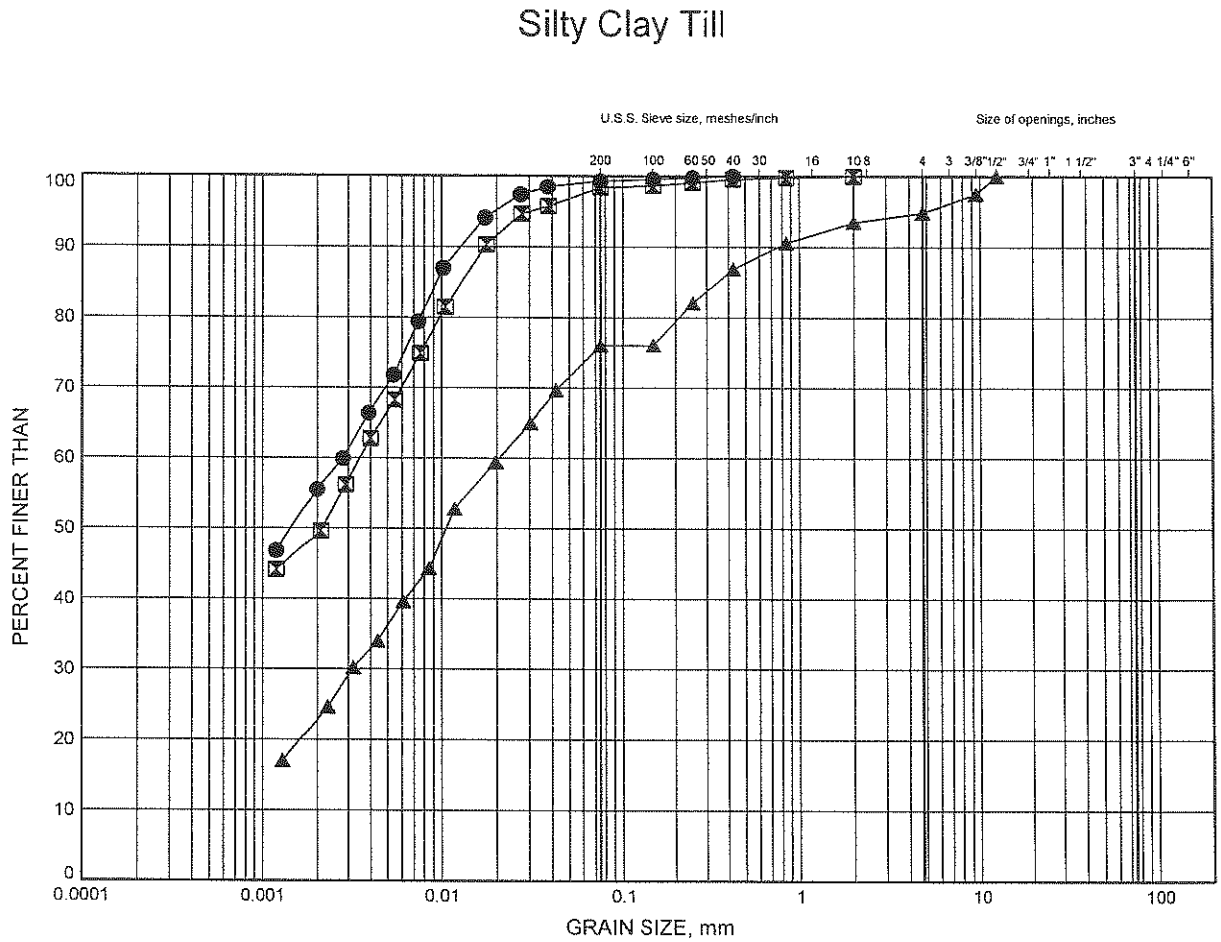
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-015	9.45	308.87
⊠	08-016	10.97	306.72
▲	08-019	8.84	312.86
☆	08-019	19.51	302.19



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

Highway 7 - New
GRAIN SIZE DISTRIBUTION

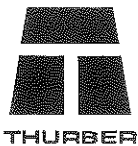
FIGURE B6



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-017	6.40	314.06
◻	08-017	12.50	307.96
▲	08-018	3.28	319.78

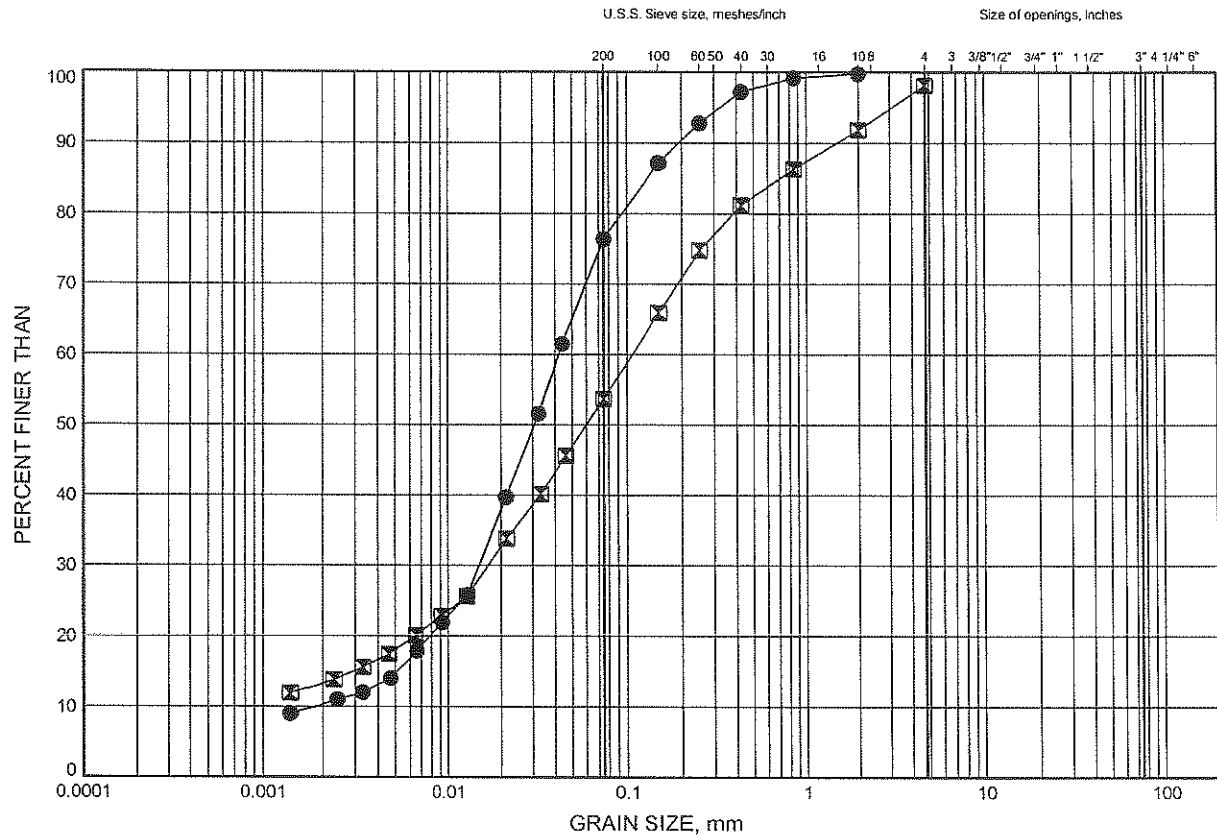


W.P.# 408-88-00
Prepared By MFA
Checked By RPR

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B7

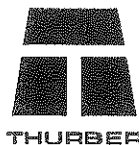
SANDY SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-016	1.83	315.86
⊠	08-016	13.85	303.84

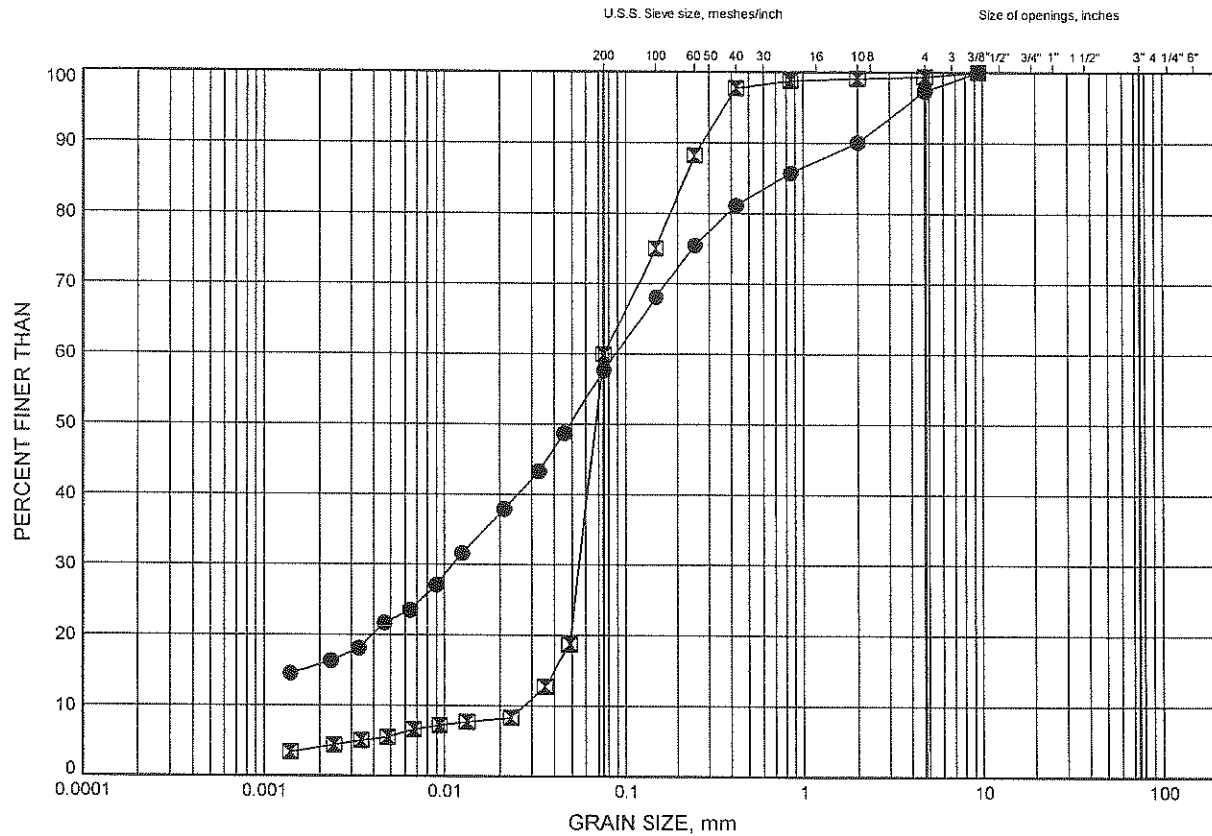


W.P.# 408-88-00
Prepared By AN
Checked By RPR

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B8

Sandy Silt Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-017	15.35	305.11
☒	08-018	7.81	315.25

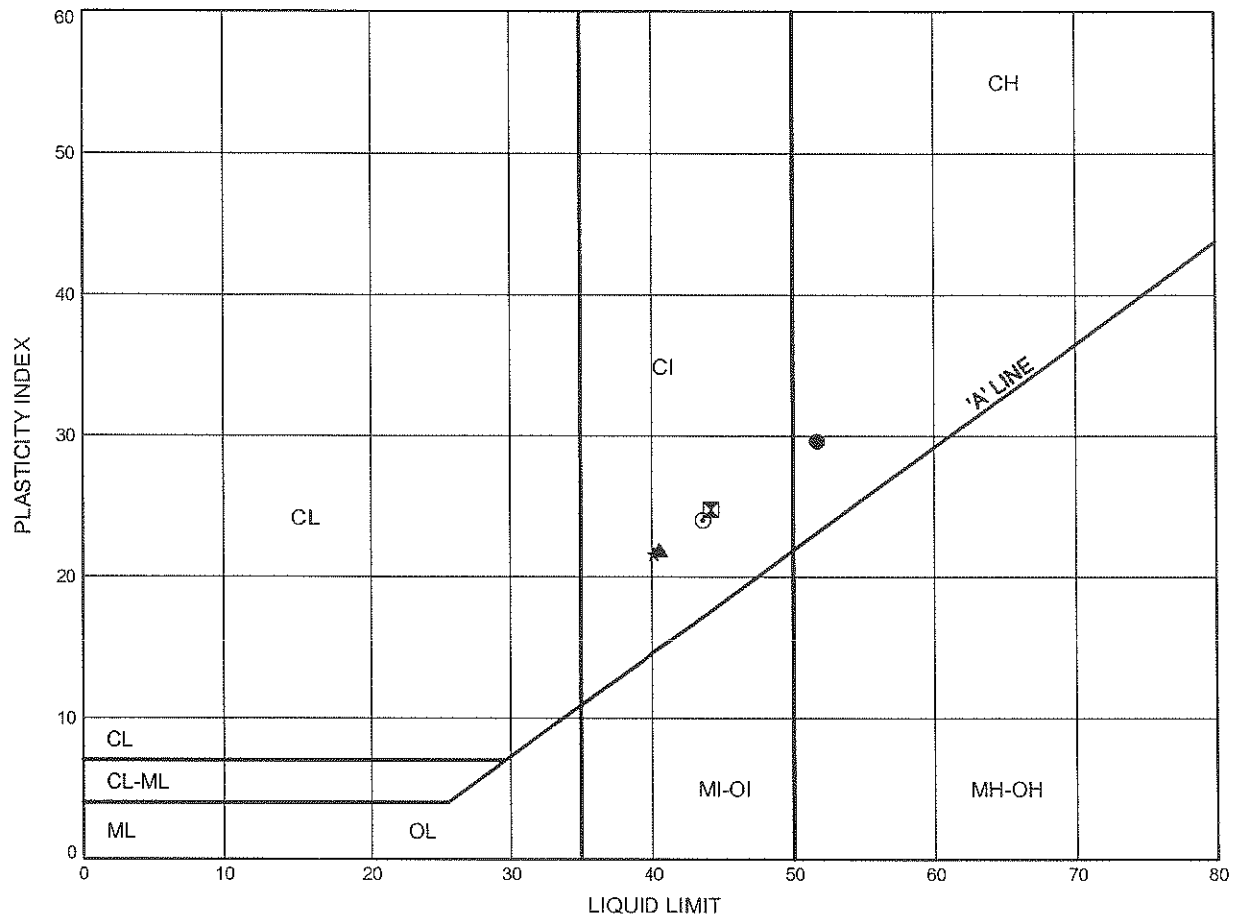


W.P.# 408-88-00.....
Prepared By MFA.....
Checked By RPR.....

Highway 7 - New ATTERBERG LIMITS TEST RESULTS

FIGURE B9

SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-015	4.88	313.44
⊠	08-015	12.50	305.82
▲	08-015	15.53	302.79
★	08-016	6.39	311.30
⊙	08-019	13.41	308.29

Date November 2008
 Project 408-88-00

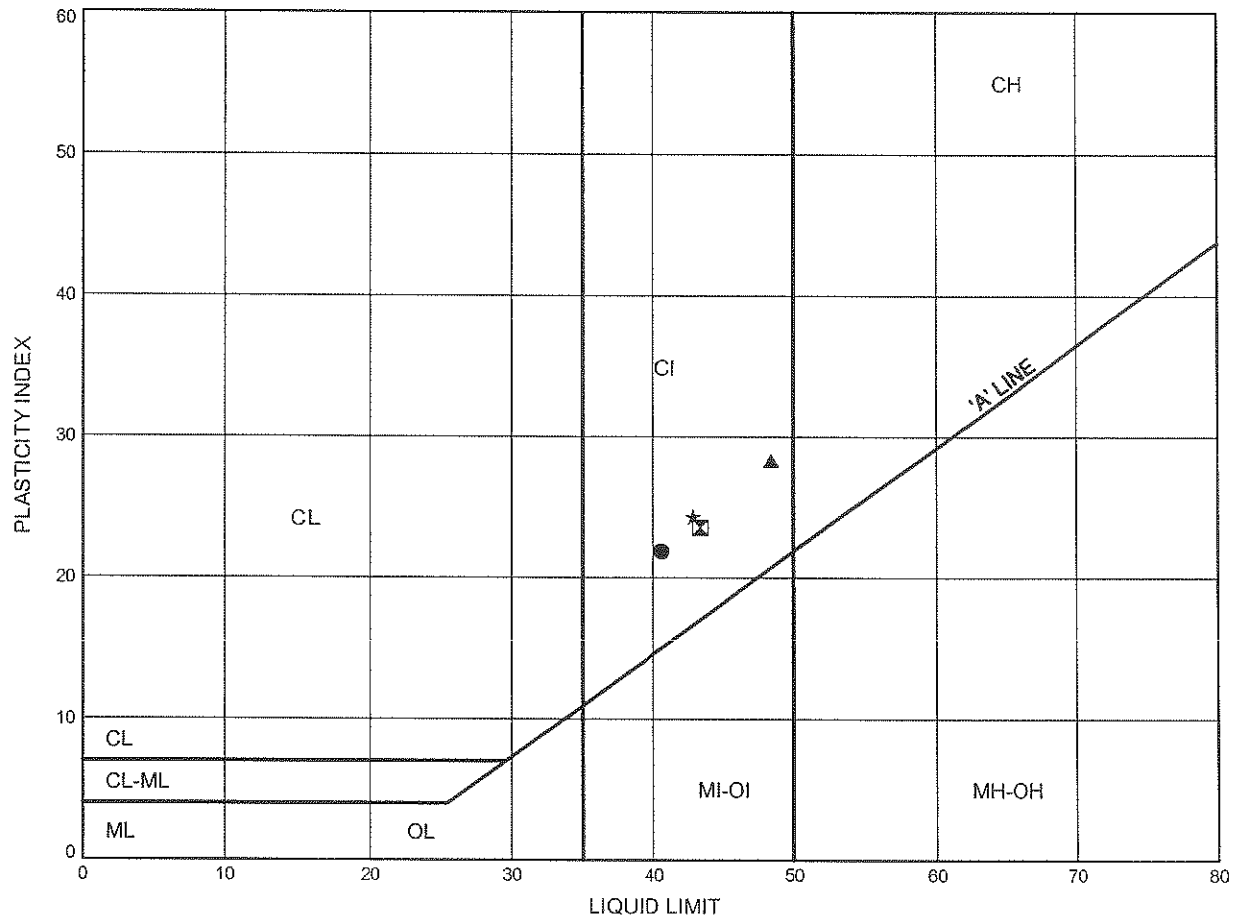


Prep'd AN
 Chkd. RPR

Highway 7 - New ATTERBERG LIMITS TEST RESULTS

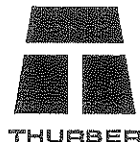
FIGURE B10

SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-015	9.45	308.87
⊠	08-016	10.81	306.88
▲	08-019	8.84	312.86
★	08-019	19.51	302.19

Date November 2008
Project 408-88-00

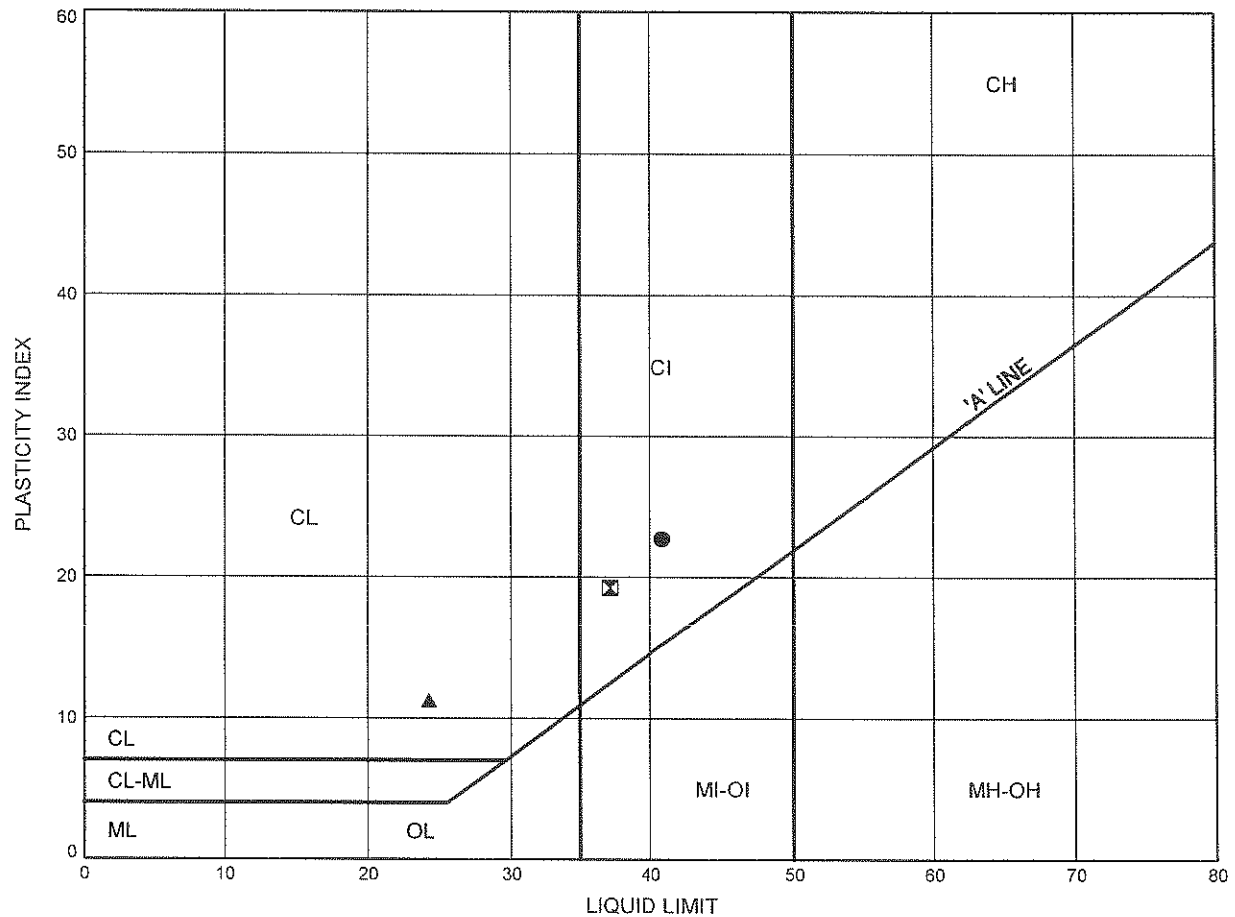


Prep'd AN
Chkd. RPR

Highway 7 - New
ATTERBERG LIMITS TEST RESULTS

FIGURE B11

Silty Clay Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-017	6.40	314.06
⊠	08-017	12.50	307.96
▲	08-018	3.28	319.78

Date September 2008
 Project 408-88-00

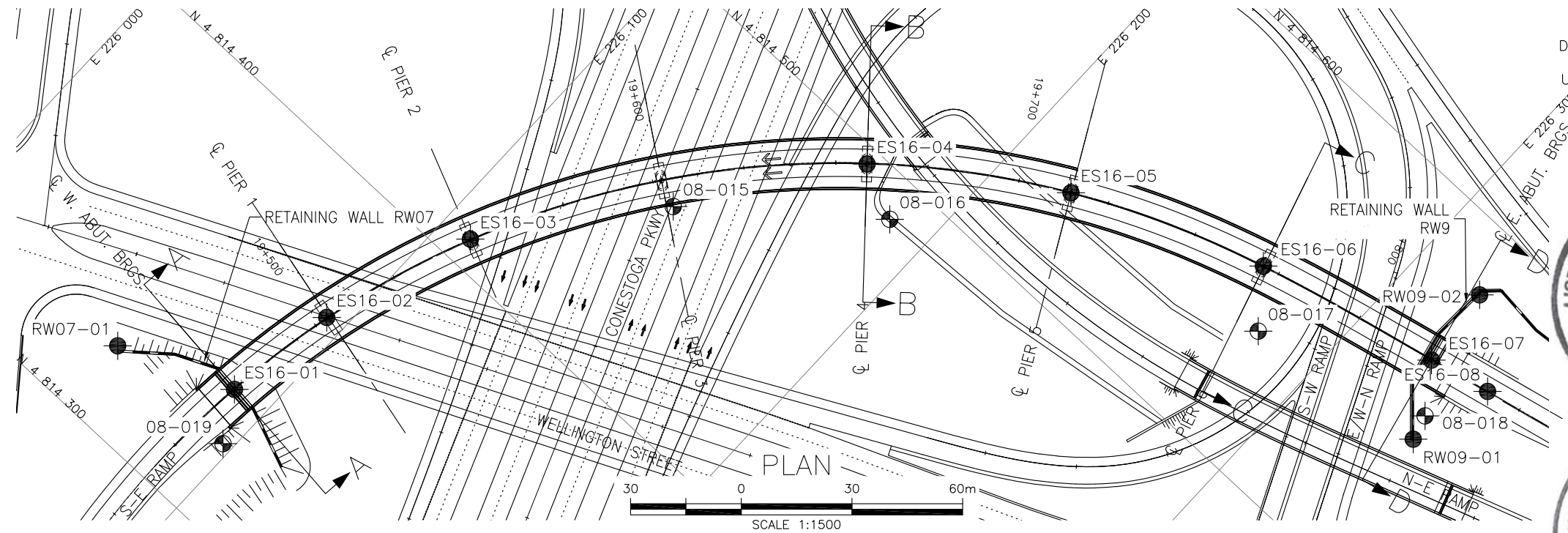


Prep'd MFA
 Chkd. RPR



Appendix C

Borehole Locations and Soil Strata Drawing



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

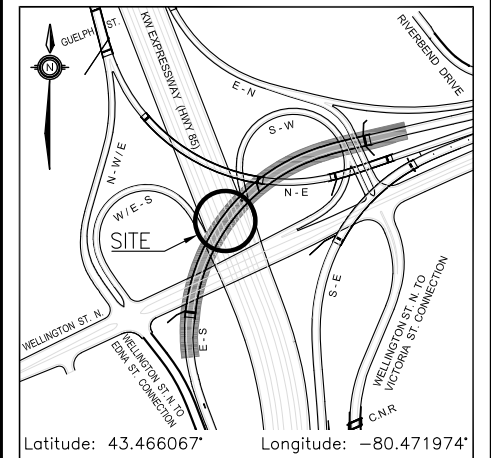


CONT No
GWP No 408-88-00

HIGHWAY 7
E-S RAMP OVER WELLINGTON ST
PROPOSED BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



KEYPLAN

LEGEND

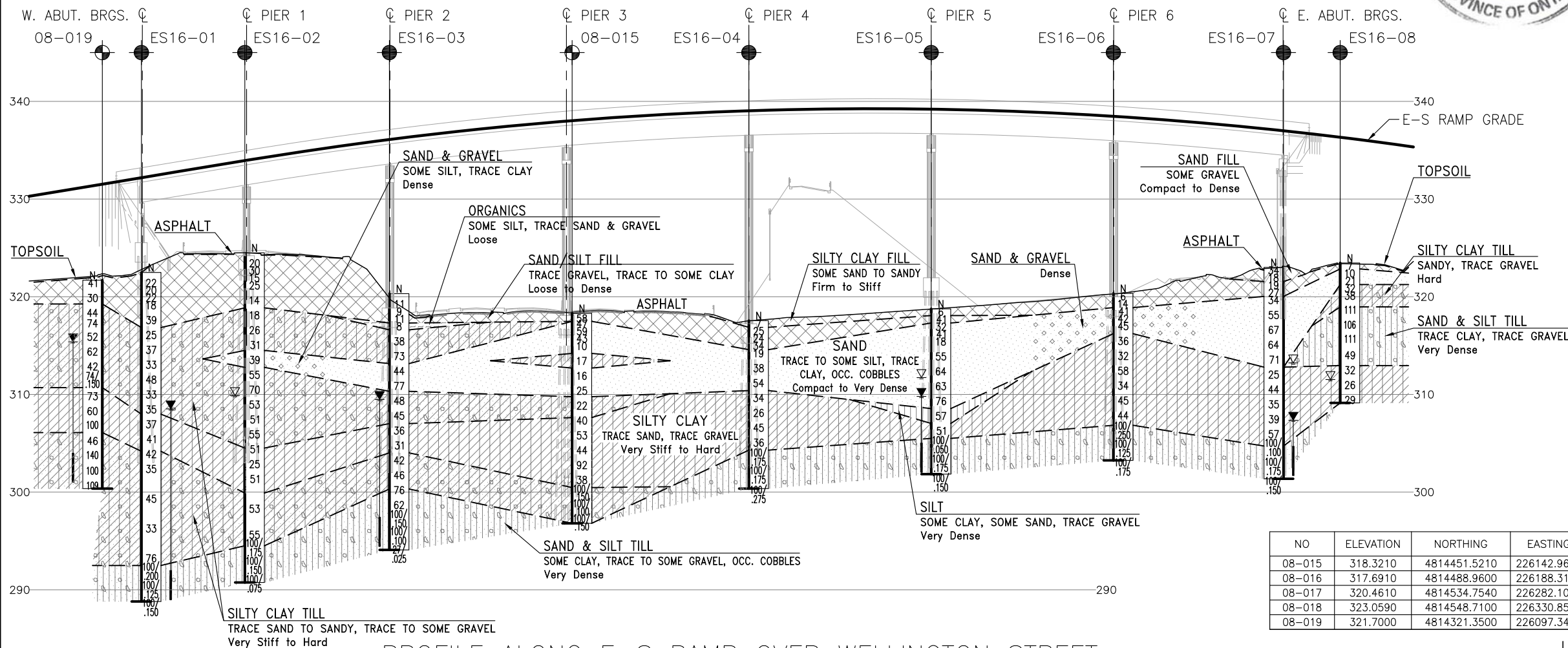
●	Borehole (Current Investigation)
○	Borehole (2008 Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
⬇	Head Artesian Water
⬆	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
ES16-01	322.5	4 814 334.3	226 089.6
ES16-02	324.5	4 814 365.6	226 094.7
ES16-03	320.3	4 814 407.6	226 108.7
ES16-04	317.6	4 814 495.7	226 173.6
ES16-05	318.8	4 814 527.7	226 219.4
ES16-06	320.3	4 814 548.6	226 271.1
ES16-07	323.0	4 814 561.0	226 321.8
ES16-08	323.5	4 814 565.1	226 338.7
RW07-01	323.9	4 814 321.3	226 058.4
RW09-01	323.5	4 814 541.9	226 332.8
RW09-02	322.8	4 814 582.8	226 319.4

-NOTES-

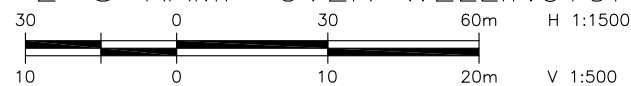
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD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

GEOCRES No. 40P8-281



NO	ELEVATION	NORTHING	EASTING
08-015	318.3210	4814451.5210	226142.9610
08-016	317.6910	4814488.9600	226188.3100
08-017	320.4610	4814534.7540	226282.1090
08-018	323.0590	4814548.7100	226330.8520
08-019	321.7000	4814321.3500	226097.3400

PROFILE ALONG E-S RAMP OVER WELLINGTON STREET



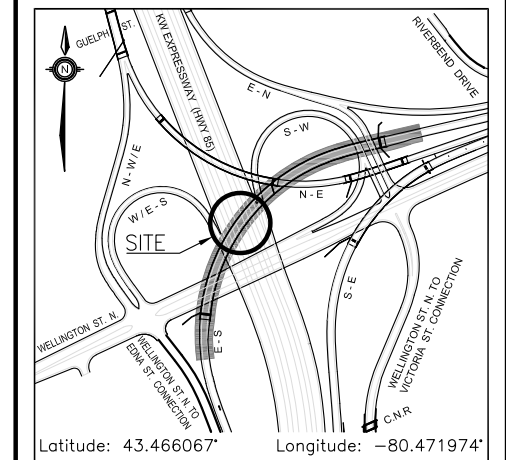
REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK	PKC
DRAWN	MFA	CHK	RPR
LOAD	DATE	JUL 2020	
STRUCT	DWG	1	

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

CONT No
GWP No 408-88-00

HIGHWAY 7
E-S RAMP OVER WELLINGTON ST
PROPOSED BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



KEYPLAN

LEGEND

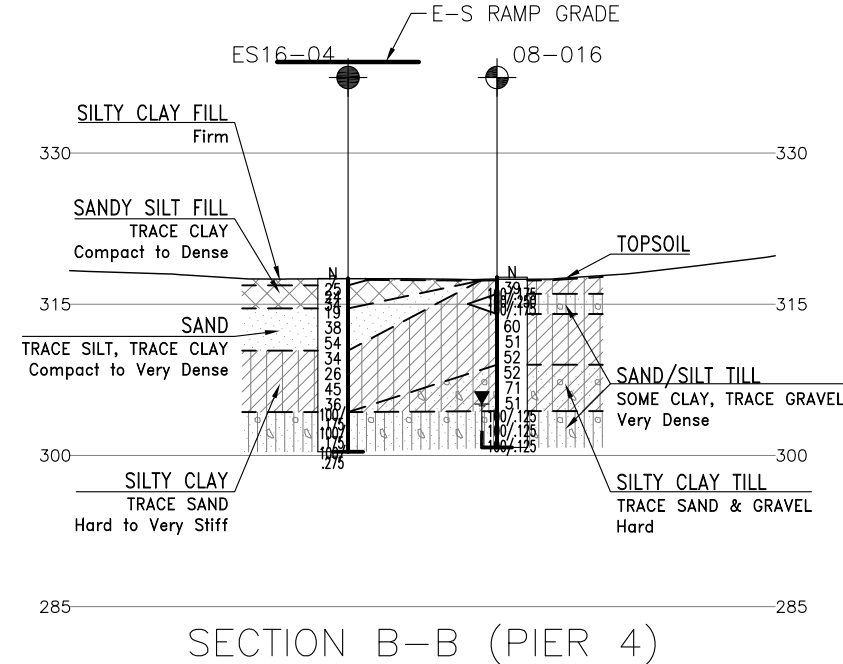
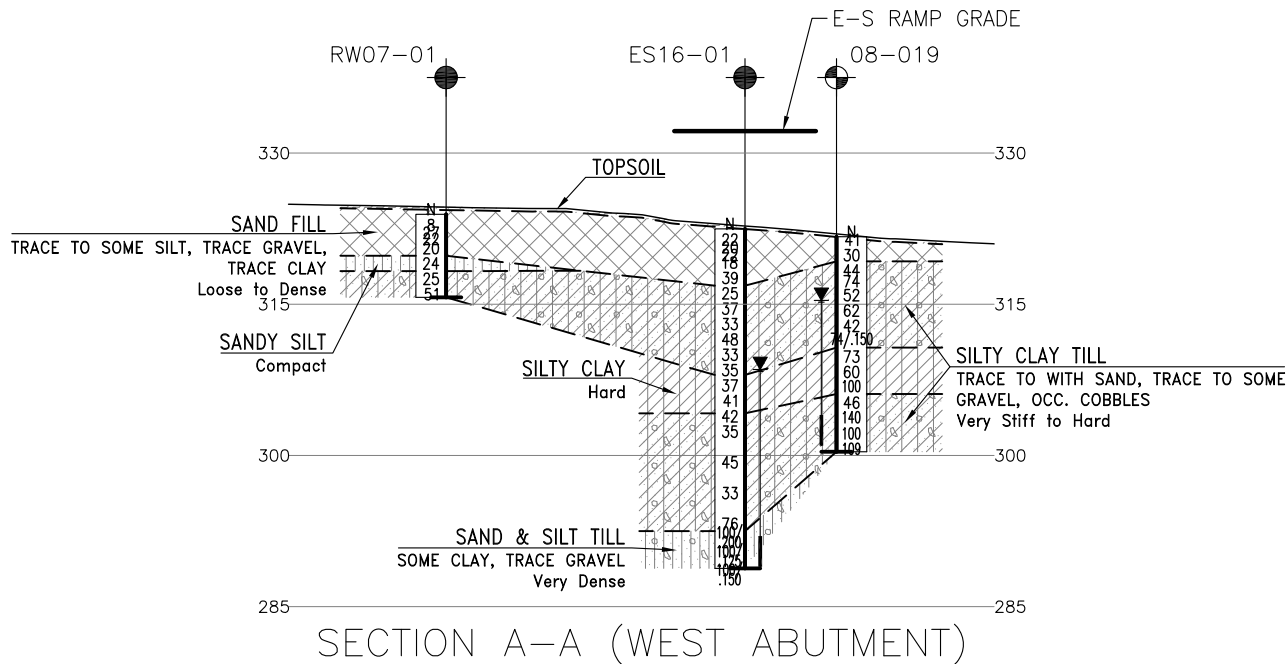
	Borehole (Current Investigation)
	Borehole (2008 Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
ES16-01	322.5	4 814 334.3	226 089.6
ES16-02	324.5	4 814 365.6	226 094.7
ES16-03	320.3	4 814 407.6	226 108.7
ES16-04	317.6	4 814 495.7	226 173.6
ES16-05	318.8	4 814 527.7	226 219.4
ES16-06	320.3	4 814 548.6	226 271.1
ES16-07	323.0	4 814 561.0	226 321.8
ES16-08	323.5	4 814 565.1	226 338.7
RW07-01	323.9	4 814 321.3	226 058.4
RW09-01	323.5	4 814 541.9	226 332.8
RW09-02	322.8	4 814 582.8	226 319.4

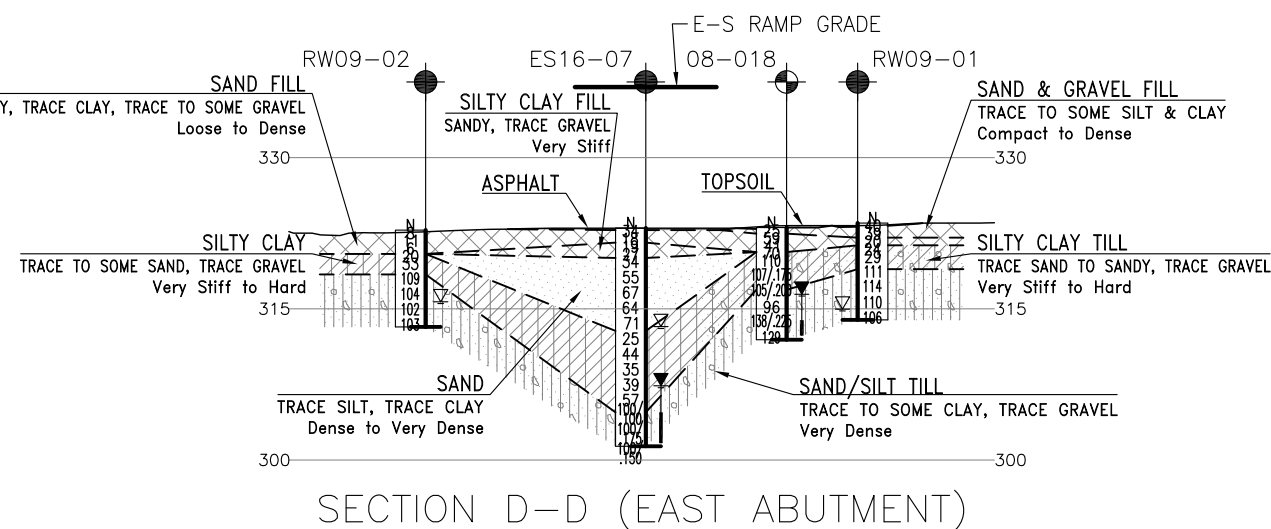
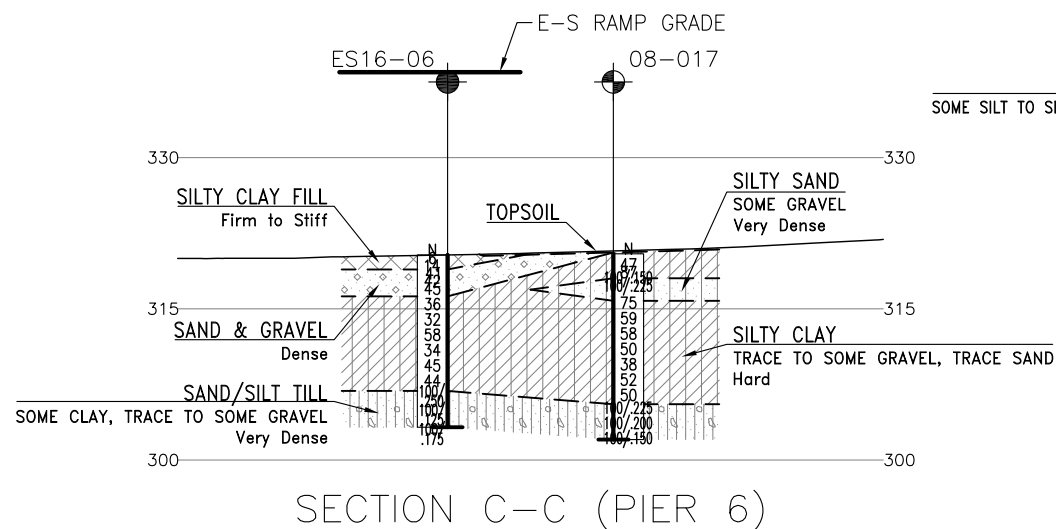
-NOTES-

- 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. 40P8-281



NO	ELEVATION	NORTHING	EASTING
08-015	318.3	4 814 451.5	226 143.0
08-016	317.7	4 814 489.0	226 188.3
08-017	320.5	4 814 534.8	226 282.1
08-018	323.1	4 814 548.7	226 330.9
08-019	321.7	4 814 321.4	226 097.3

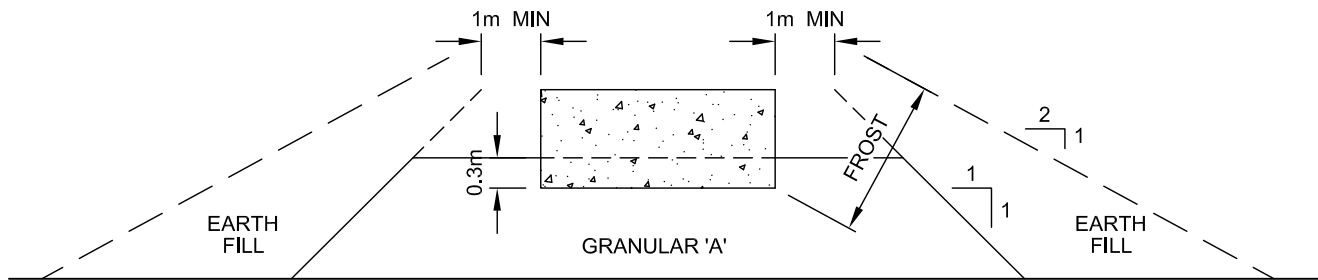


REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK	PKC
DRAWN	MFA	CHK	RPR
CODE	LOAD	DATE	JUL 2020
SITE	STRUCT	DWG	2

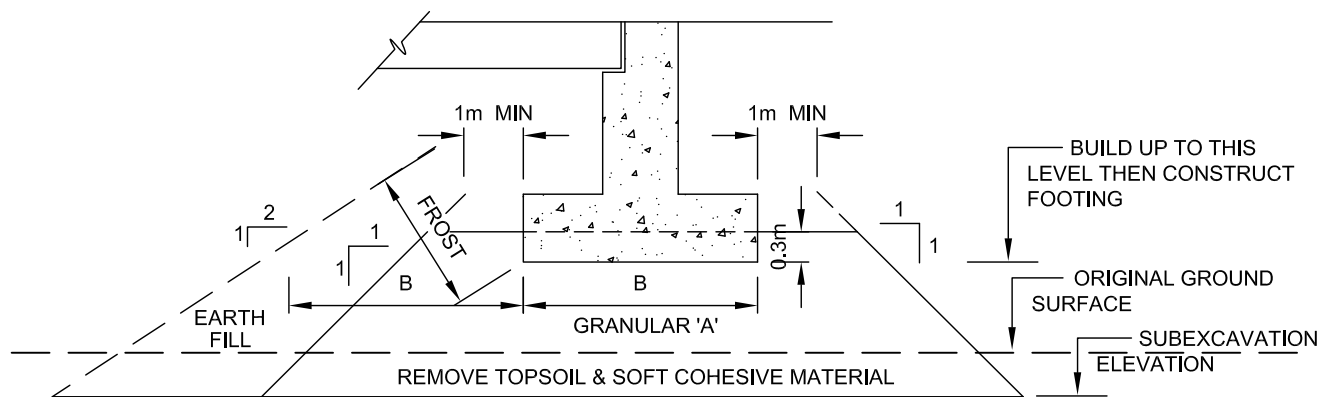


Appendix D

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 :	APPROVED :
-	MFA	-
DATE :	SCALE :	DRAWING No.
SEPTEMBER 2016	N.T.S.	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>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Dewatering may be required, depending on depth of excavation. <p style="text-align: center;">FEASIBLE</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. ii. Better geotechnical resistance than spread footings on native soils. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Excavation (up to 4.0 m deep) of existing fill will be required to place the engineered fill on competent native soils. ii. Dewatering may be required, depending on depth of excavation. <p style="text-align: center;">FEASIBLE</p>	<p>Advantages:</p> <ul style="list-style-type: none"> ii. High geotechnical resistance may be developed by driving the piles into very dense till. iii. Comparatively short abutment stem possible. iv. Permits integral abutment design. v. Readily installed. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher unit cost compared to footings. ii. When driven into hard/very dense till deposits, pipe piles are more prone to pile tip damage in comparison to H-piles. iii. Construction concerns related to the possibility of piles being obstructed by a boulder during driving. <p style="text-align: center;">RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Construction of caissons could continue in freezing weather. ii. High geotechnical resistance available for units founded on very dense till. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher cost than spread footings ii. Specialized installation measures such as temporary liners and drilling mud will be required to install caissons under the water table. iii. Potential difficulty in cleaning and inspecting bases. <p style="text-align: center;">NOT RECOMMENDED</p>
Piers	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. ii. High geotechnical resistances available on the very dense native soils. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Dewatering will be required, depending on depth of excavation. <p style="text-align: center;">FEASIBLE</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. ii. Better geotechnical resistance than spread footings on native soils. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Dewatering may be required, depending on depth of excavation. <p style="text-align: center;">FEASIBLE</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. High geotechnical resistance may be developed by driving the piles into very dense till ii. Comparatively short abutment stem possible iii. Permits integral abutment design. iv. Readily installed. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher unit cost compared to footings. ii. When driven into hard/very dense till deposits, pipe piles are more prone to pile tip damage in comparison to H-piles. iii. Construction concerns related to the possibility of piles being obstructed by a boulder during driving. <p style="text-align: center;">RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Construction of caissons could continue in freezing weather. ii. High geotechnical resistance available for units founded on very dense till. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher cost than spread footings ii. Specialized installation measures such as temporary liners and drilling mud will be required to install caissons under the water table. iii. Potential difficulty in cleaning and inspecting bases. <p style="text-align: center;">NOT RECOMMENDED</p>



Appendix F

Slope Stability Output

Project Number: 11375
 Highway 7 - New
 ES Ramp over
 Wellington St.
 Retaining wall (RSS Wall)
 RW-9
 Height: 8.1 m approx
 Drained Analysis

Name: New embankment Fill Unit Weight: 22 kN/m³ Cohesion': 0 kPa Φ' : 32 ° Φ -B: 0 ° Piezometric Line: 1
 Name: Existing loose to compact sand fill Unit Weight: 19 kN/m³ Cohesion': 0 kPa Φ' : 30 ° Φ -B: 0 ° Piezometric Line: 1
 Name: Very dense sand and silt till Unit Weight: 21 kN/m³ Cohesion': 0 kPa Φ' : 33 ° Φ -B: 0 ° Piezometric Line: 1
 Name: Very stiff to hard silty clay Unit Weight: 20 kN/m³ Cohesion': 0 kPa Φ' : 30 ° Φ -B: 0 ° Piezometric Line: 1
 Name: RSS Wall Unit Weight: 22 kN/m³ Cohesion': 200 kPa Φ' : 45 ° Φ -B: 0 ° Piezometric Line: 1
 Name: Granular pad Unit Weight: 22 kN/m³ Cohesion': 0 kPa Φ' : 34 ° Φ -B: 0 ° Piezometric Line: 1

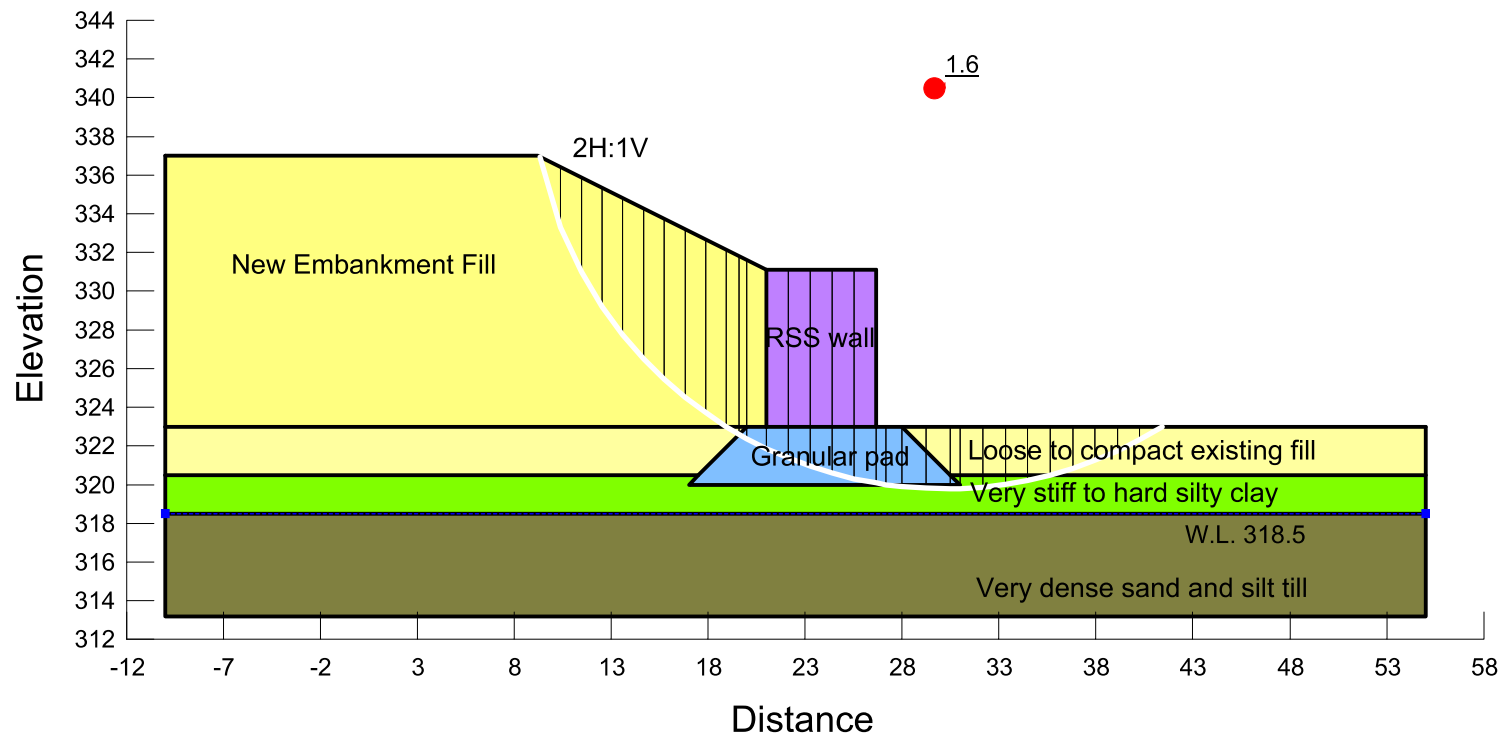


Figure 1F

Project Number: 11375
 Highway 7 - New
 ES Ramp over
 Wellington St.
 Retaining wall (RSS Wall)
 RW-9
 Height: 8.1 m approx
 Undrained Analysis

Name: New embankment Fill Unit Weight: 22 kN/m³ Cohesion': 0 kPa Φ' : 32 ° Φ -B: 0 ° Piezometric Line: 1
 Name: Existing loose to compact sand fill Unit Weight: 19 kN/m³ Cohesion': 0 kPa Φ' : 30 ° Φ -B: 0 ° Piezometric Line: 1
 Name: Very dense sand and silt till Unit Weight: 21 kN/m³ Cohesion': 0 kPa Φ' : 33 ° Φ -B: 0 ° Piezometric Line: 1
 Name: Very stiff to hard silty clay Unit Weight: 20 kN/m³ Cohesion': 150 kPa Piezometric Line: 1
 Name: RSS Wall Unit Weight: 22 kN/m³ Cohesion': 200 kPa Φ' : 45 ° Φ -B: 0 ° Piezometric Line: 1
 Name: Granular pad Unit Weight: 22 kN/m³ Cohesion': 0 kPa Φ' : 34 ° Φ -B: 0 ° Piezometric Line: 1

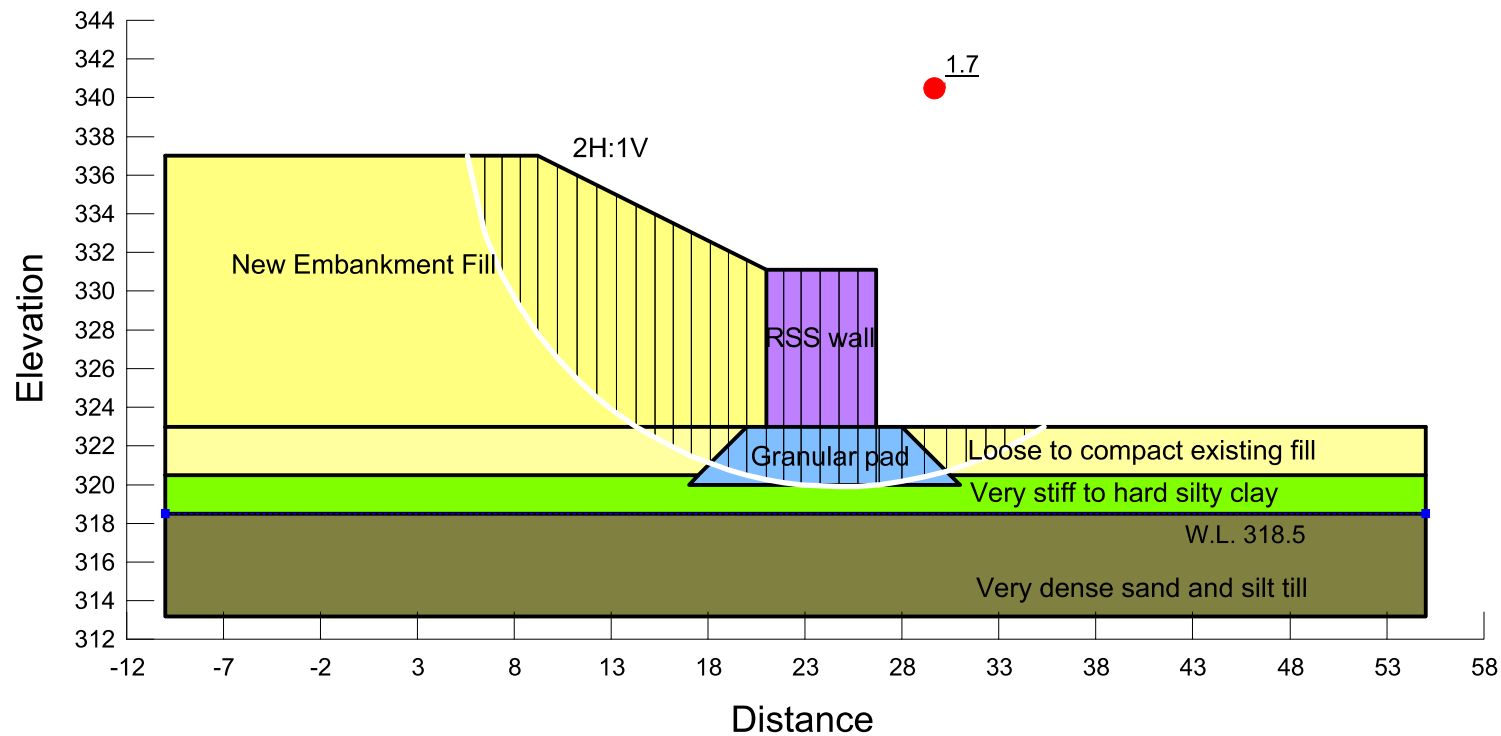


Figure 2F

Project Number: 11375
 Highway 7 - New
 ES Ramp over
 Wellington St.
 Retaining wall (RSS Wall)
 RW-9
 Height: 8.1 m approx
 Seismic Analysis PGA=0.097g

Name: New embankment Fill Unit Weight: 22 kN/m³ Cohesion': 0 kPa Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Existing loose to compact sand fill Unit Weight: 19 kN/m³ Cohesion': 0 kPa Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Very dense sand and silt till Unit Weight: 21 kN/m³ Cohesion': 0 kPa Phi': 33 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Very stiff to hard silty clay Unit Weight: 20 kN/m³ Cohesion': 150 kPa Piezometric Line: 1
 Name: RSS Wall Unit Weight: 22 kN/m³ Cohesion': 200 kPa Phi': 45 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Granular pad Unit Weight: 22 kN/m³ Cohesion': 0 kPa Phi': 34 ° Phi-B: 0 ° Piezometric Line: 1

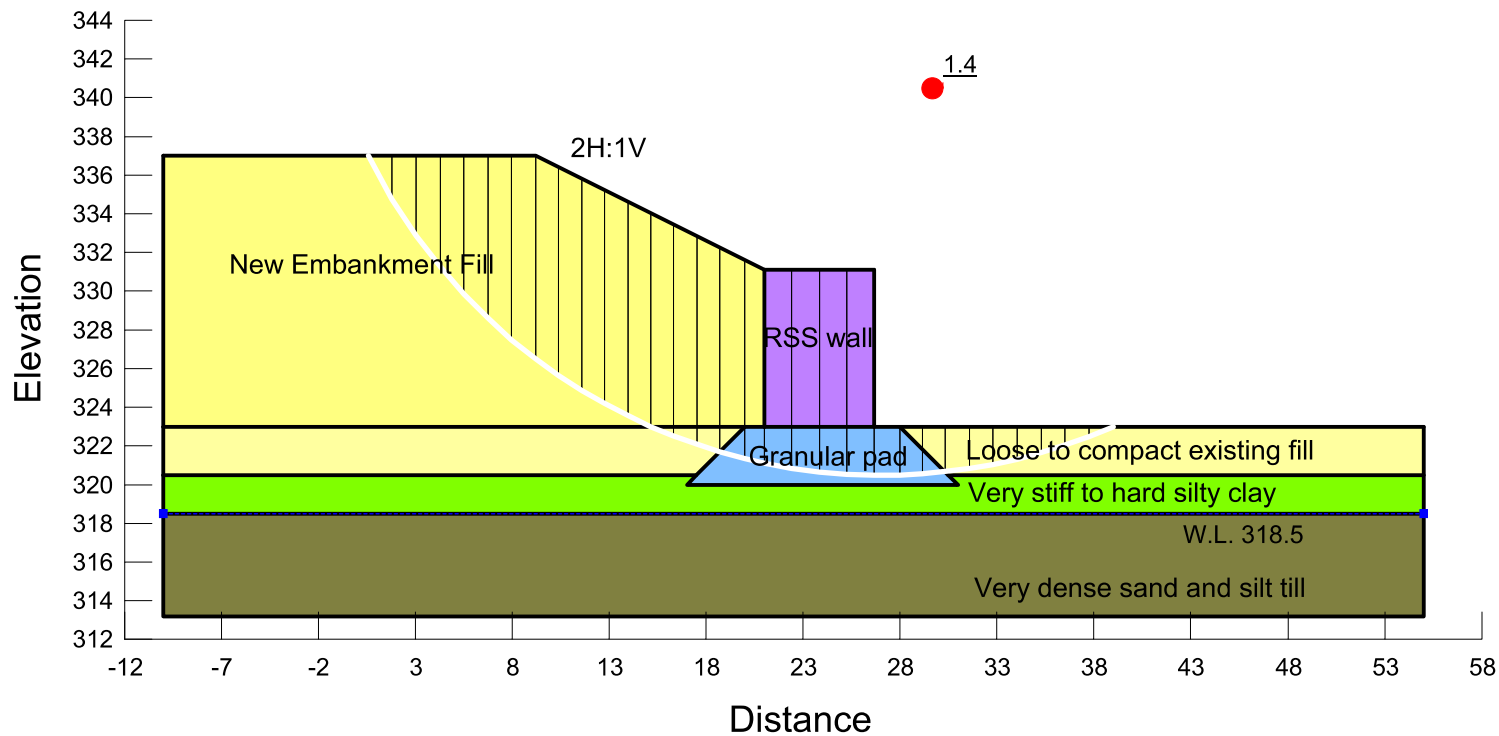


Figure 3F

Project Number: 11375
 Highway 7 - New
 ES Ramp over
 Wellington St.
 East abutment
 Height: 14.1 m
 Drained Analysis

Name: New embankment fill Unit Weight: 22 kN/m³ Cohesion': 0 kPa Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Existing loose to compact sand fill Unit Weight: 19 kN/m³ Cohesion': 0 kPa Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Very dense sand and silt till Unit Weight: 21 kN/m³ Cohesion': 0 kPa Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Very stiff to hard silty clay Unit Weight: 20 kN/m³ Cohesion': 0 kPa Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1

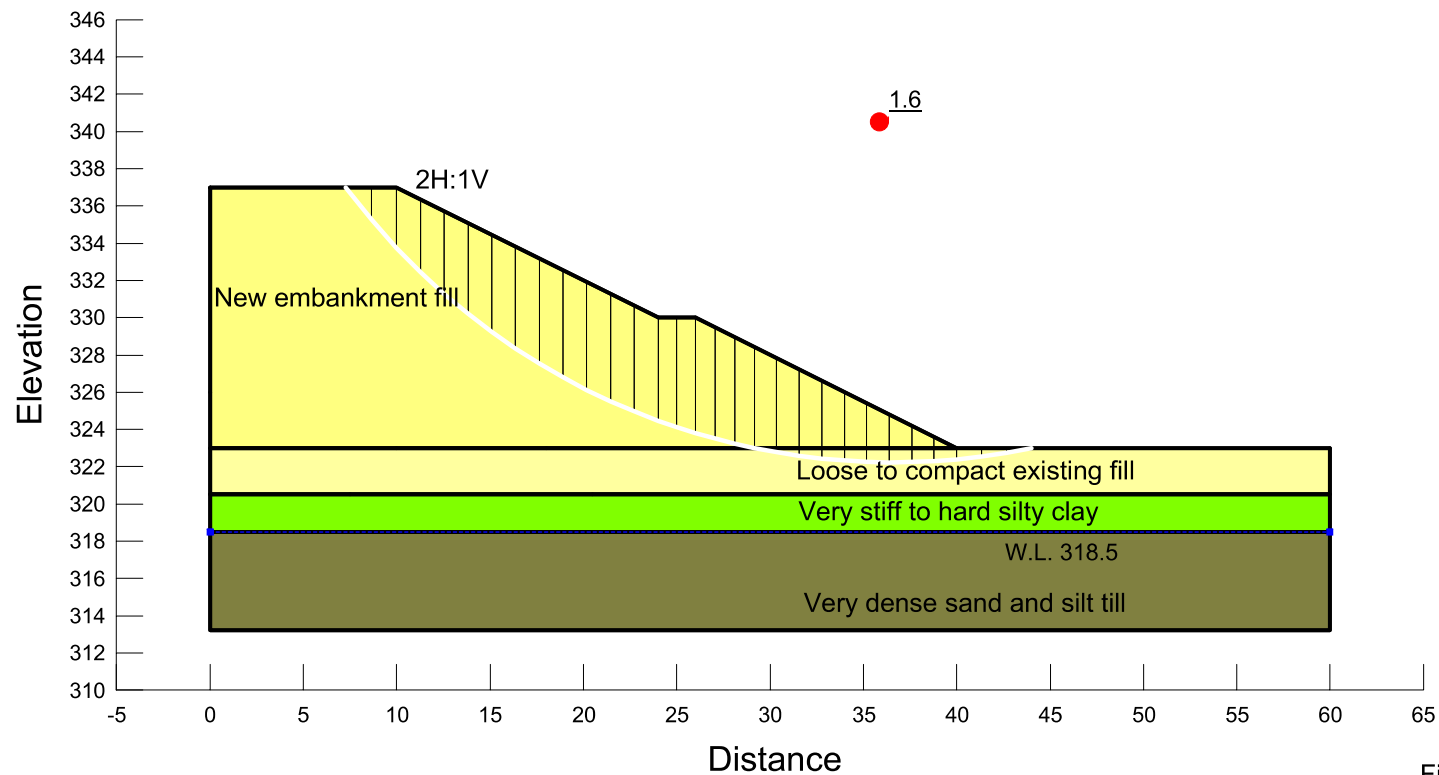


Figure 4F

Project Number: 11375
 Highway 7 - New
 ES Ramp over
 Wellington St.
 East abutment
 Height: 14.1 m
 Undrained Analysis

Name: New embankment Fill Unit Weight: 22 kN/m³ Cohesion': 0 kPa Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Existing loose to compact sand fill Unit Weight: 19 kN/m³ Cohesion': 0 kPa Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Very dense sand and silt till Unit Weight: 21 kN/m³ Cohesion': 0 kPa Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Very stiff to hard silty clay Unit Weight: 20 kN/m³ Cohesion': 150 kPa Phi': 0 ° Phi-B: 0 ° Piezometric Line: 1

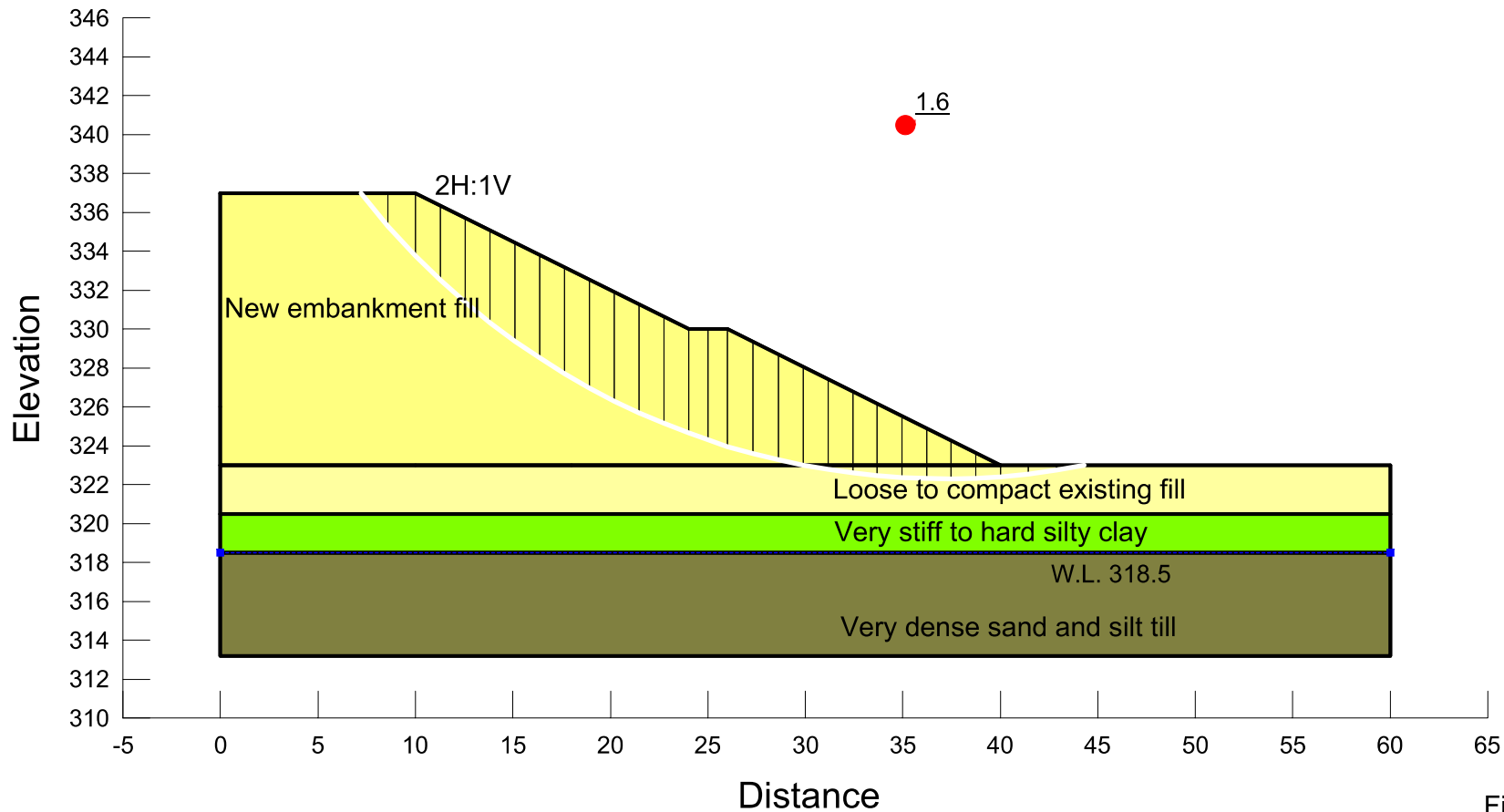


Figure 5F

Project Number: 11375
 Highway 7 - New
 ES Ramp over
 Wellington St.
 East abutment
 Height: 14.1 m
 Seismic Analysis PGA=0.097

Name: New embankment Fill Unit Weight: 22 kN/m³ Cohesion': 0 kPa Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Existing loose to compact sand fill Unit Weight: 19 kN/m³ Cohesion': 0 kPa Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Very dense sand and silt till Unit Weight: 21 kN/m³ Cohesion': 0 kPa Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Very stiff to hard silty clay Unit Weight: 20 kN/m³ Cohesion': 150 kPa Phi': 0 ° Phi-B: 0 ° Piezometric Line: 1

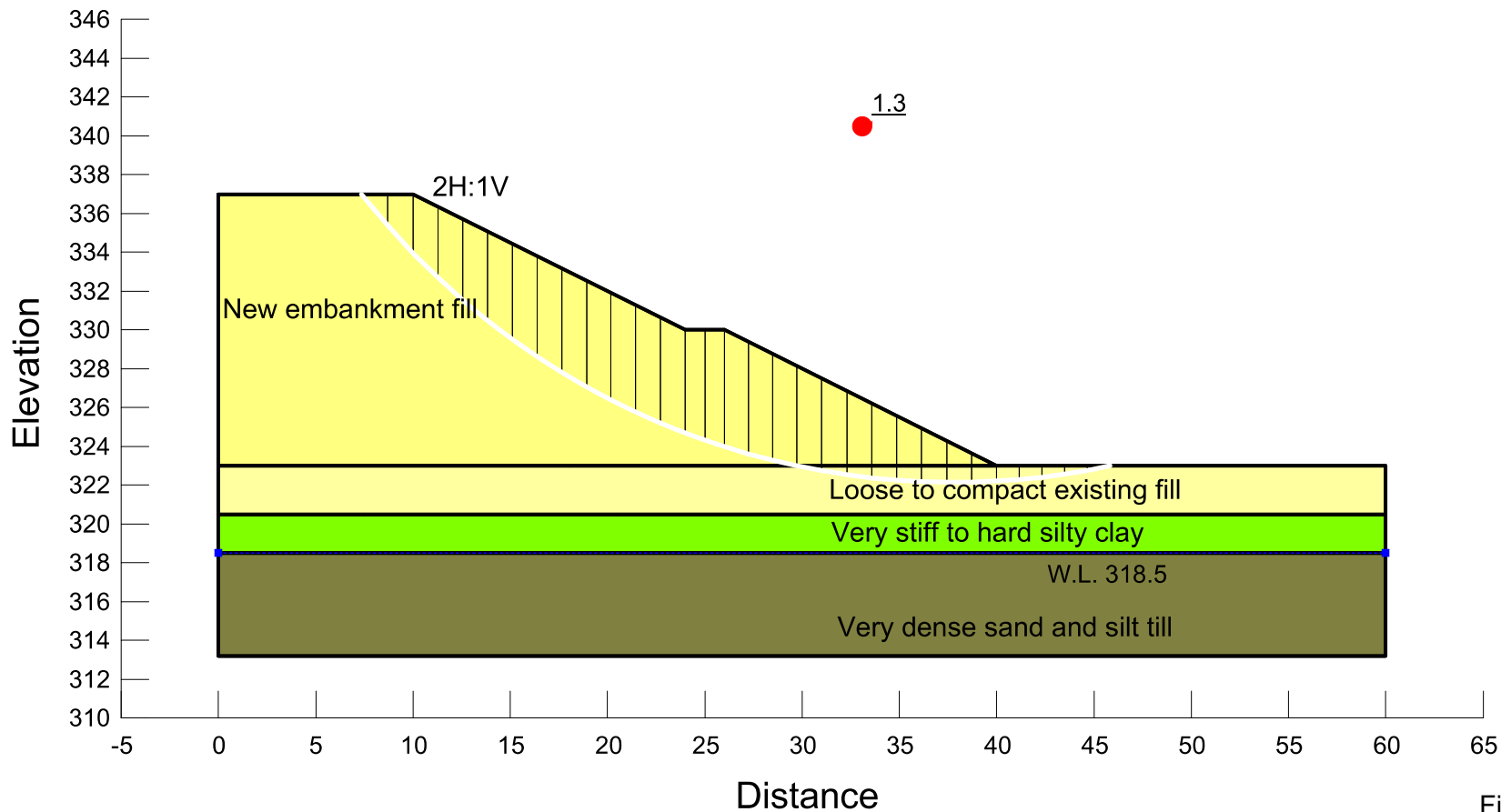


Figure 6F



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
- SP 105S09 Amendment to OPSS 539
- 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

The native soils at the E-S Ramp over Wellington Street include glacial till that is 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. For temporary excavations for retaining wall construction at this site, 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. For bridge foundation construction, appropriate 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 silty sand surfaces by limiting construction traffic.

4. Suggested Text for NSSP on “Impact on Adjacent Structure”

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 structures or underground utilities:

- The lanes of the Kitchener-Waterloo Express way and Wellington Street will be open to traffic during excavation and foundation construction of E-S Ramp over Wellington Street.



- Protection of structure foundations and utilities (if present at this site) during excavation and pile driving.
- Protection of existing approach fills.