

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 Number: 40P8-161

Report to

Ministry of Transportation Ontario
West Region

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

June 2, 2009
File: 15-64-17

\\Torserver1\Projects\15\64\17 Hwy 7 New\Reports &
Memos\Structures\E-S Ramp Over KWE-Wellington - 15-
16&19\156417-ES Ramp over KWE-WELLINGTON-FINAL.doc

TABLE OF CONTENTS

PART 1 FACTUAL INFORMATION

1	INTRODUCTION	1
2	SITE DESCRIPTION	1
3	SITE INVESTIGATION AND FIELD TESTING.....	2
4	LABORATORY TESTING.....	3
5	DESCRIPTION OF SUBSURFACE CONDITIONS	3
5.1	Topsoil	4
5.2	Pavement structure.....	4
5.3	Fill	4
5.4	Sand.....	4
5.5	Silty Clay	5
5.6	Silty Clay Till.....	6
5.7	Sandy Silt Till	7
5.8	Groundwater Conditions	7
6	MISCELLANEOUS	8

PART 2 ENGINEERING DISCUSSION AND RECOMMENDATIONS

7	GENERAL.....	9
8	STRUCTURE FOUNDATIONS.....	9
8.1	Spread Footings on Native Soil	10
8.2	Spread Footings on Engineered Fill.....	11
8.3	Steel H-Piles.....	11
8.3.1	Axial Resistance	12
8.3.2	Downdrag	13
8.4	Augered Caissons on Hard Silty Clay Till or Very Dense Sandy Silt Till (Drilled Shafts) ..	13
8.5	Abutment Design Considerations	14
8.6	Frost Cover.....	14
8.7	Recommended Foundation.....	14
9	BRIDGE APPROACHES AND EMBANKMENTS.....	14
10	CONSTRUCTION CONCERNS	15

11	INVESTIGATION FOR DETAIL DESIGN.....	16
12	CLOSURE.....	16

Appendices

Appendix A	Record of Borehole Sheets
Appendix B	Laboratory Test Results
Appendix C	Foundation Comparison
Appendix D	Figure
Appendix E	Slope Stability Output
Appendix F	Site Photographs
Appendix G	Drawing titled “Borehole Locations and Soil Strata”

**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 Number: 40P8-161

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a preliminary foundation investigation conducted at the site of the proposed E-S Ramp over Kitchener Waterloo Expressway (KWE) and Wellington Street in the Regional Municipality of Waterloo, Ontario.

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, 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.

The information collected in the course of the investigation and presented in this report is intended for preliminary design purposes only. Additional site investigation, field testing and engineering analysis will be required at the detail design stage. The extent of the additional investigation will depend, in part, on the final location and General Arrangement of the structure.

Thurber carried out the investigation for the Ministry of Transportation Ontario, Southwestern Region (MTO) under Purchase Order Number 3006-E-0123.

2 SITE DESCRIPTION

The site lies within the existing Kitchener Waterloo Expressway and Wellington Street interchange area in Waterloo, Ontario. At this location, the proposed E-S Ramp will cross over existing KWE and Wellington Street.

The lands surrounding the site are generally commercial and residential. The site slopes towards the northeast.

Two photographs of the site are included in Appendix E and show the general nature of the surrounding land.

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 and kames or kame moraines, with outwash sands occupying the intervening hollows.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing at this site consisted of drilling and sampling three boreholes, numbered 08-016, 08-015 and 08-019, from the north end of the proposed structure to the south end. The depths of the boreholes ranged from 16.9 m to 21.5 m.

Borehole 08-015 was originally drilled to 10.7 m depth on June 26 and 27, 2008. On September 28 and 29, Borehole 08-015 was further advanced to 21.5 m depth. Boreholes 08-16 and 08-19 were drilled on July 22, September 25 and 26, 2008.

The Record of Borehole sheets for the boreholes are included in Appendix A. The approximate locations of the three boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix G.

Prior to commencing the site investigation, clearance was obtained from utility companies having plant in the area.

The boreholes were drilled using hollow stem auger equipment mounted on a CME-75 truck-mounted drill rig. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the overburden soils.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Two standpipe piezometers were installed in Boreholes 08-016 and 08-019, drilled near the proposed north and south abutment locations. The standpipe piezometers consisted of 25 mm and 32 mm diameter PVC pipes with a slotted screen enclosed in filter sand to permit longer term groundwater level monitoring. The location and completion details of the piezometers are shown in Table 3.1. The borehole without a piezometer installation was grouted with holeplug upon completion. The borehole completion details are shown in Table 3.1.

The completion of the boreholes and the standpipe piezometers was carried out in accordance with the requirements of O. Reg. 903 (as amended by O. Reg. 372/07).

Table 3.1 – Borehole Completion Details

Foundation Unit	Borehole Location	Piezometer Tip Depth/ Elevation (m)	Completion Details
Near North Abutment	08-016	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.
Near Possible Pier	08-015	No Installation	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.
Near South Abutment	08-019	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.

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

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets in Appendix A. Selected samples were also subjected to gradation analysis (sieve and hydrometer) and Atterberg Limits testing where appropriate. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the figures contained in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil stratigraphy along the proposed alignment are presented in this appendix and on the "Borehole Locations and Soil Strata" drawing in Appendix G. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

The stratigraphy identified in the preliminary investigation consisted of topsoil or pavement structure overlying sand and gravel fill underlain by layers of native sand, silty clay/silty clay till and sandy silt till.

5.1 Topsoil

Topsoil was contacted surficially in Boreholes 08-016 and 08-019. Thickness of the topsoil ranged from 125 mm to 150 mm.

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

5.2 Pavement structure

Pavement structure consisting of approximately 200 mm of asphalt overlying granular (sand and gravel) fill was encountered in Borehole 08-015 drilled on the northbound lane of KWE.

5.3 Fill

Fill was encountered below the asphalt in Borehole 08-015 and surficially in Borehole 08-019. The fill consists of layers of brown sand and sand/gravel containing trace to some silt and occasional rootlets. Thickness of the fill was 0.6 m and 2.2 m in Boreholes 08-015 and 08-019, respectively.

The depth to the base of the fill was 0.8 m and 2.4 m (Elevations 317.5 and 319.3) in Boreholes 08-015 and 08-019, respectively.

The cohesionless fill is classified as dense to very dense, based on SPT 'N' values ranging from 30 to 58 blows for 0.3 m of penetration. The natural moisture content ranged from 5% to 8%.

5.4 Sand

An upper layer of native brown fine sand containing some silt, trace gravel and trace clay was encountered in Borehole 08-015 below the fill at 0.8 m depth (Elevation 317.5). A lower layer of native sand was contacted at 5.6 m depth (Elevation 312.7) in the same borehole. Thickness of the upper and lower sand layers were 3.3 m and 2.9 m, respectively.

The depth to the base of the upper and lower sand layers were 4.1 m and 8.5 m (Elevations 314.2 and 309.8).

In Borehole 08-016, a 600-mm thick layer of grey sand was contacted at 3.1 m depth (Elevation 314.6).

SPT 'N' values measured in the sand ranged from 10 to 59 blows per 0.3 m of penetration, indicating a compact to very dense relative density. An SPT 'N' value higher than 100 blows per 0.175 m of penetration was measured in Borehole 08-016. The natural moisture contents generally lay in the range of 8% to 21%.

The grain size distributions for two sand samples tested are presented on the Record of Borehole sheets and on Figure B1 of Appendix B. The results of laboratory tests are summarized as follows:

Soil Particles	(%)
Gravel	0 to 1
Sand	74 to 95
Silt and Clay	5 to 25

5.5 Silty Clay

Layers of native brown silty clay containing trace of gravel and trace sand were encountered in the boreholes at depths and elevations indicated in Table 5.1.

Table 5.1 – Depths and Elevations of Native Silty Clay

Foundation Unit	Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
Near North Abutment	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
Near Possible Pier Location	08-015	4.1 to 5.6	314.2 to 312.7	1.5
		10.7 to 17.8	307.6 to 300.5	7.1
Near South Abutment	08-019	11.0 to 15.6	310.7 to 306.1	4.6

SPT 'N' values measured in the silty clay ranged from 17 to 100 blows per 0.3 m of penetration, indicating very stiff to hard consistency. The natural moisture contents generally lay in the range of 19% to 32%.

The grain size distributions for the samples tested are presented on the Record of Borehole sheets and on Figure B2 of Appendix B. Atterberg Limits test results are presented on Figure B5 of Appendix B.

The results of laboratory tests carried are summarized below:

Soil Particles	(%)
Gravel	0
Sand	0 to 8
Silt	33 to 43
Clay	56 to 64

Liquid Limit	40 to 52
Plastic Limit	19 to 22

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

5.6 Silty Clay Till

Brown to grey silty clay till containing trace gravel, trace sand, occasional cobbles and occasional sand seams was contacted in all the boreholes at depths and elevations indicated in Table 5.2.

Table 5.2 – Depths and Elevations of Silty Clay Till

Foundation Unit	Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
Near North Abutment	08-016	8.7 to 13.3	309.0 to 304.4	4.6
Near Possible Pier Location	08-015	8.5 to 10.7 17.8 to 21.5 (borehole termination depth)	309.8 to 307.7 300.5 to 296.8	2.1 >3.7
Near South Abutment	08-019	2.4 to 11.0 15.6 to 21.3 (borehole termination depth)	319.3 to 310.7 306.1 to 300.4	8.6 >5.7

The silty clay till layer is classified as very stiff to hard, based on SPT 'N' values ranging from 22 blows per 0.3 m of penetration to higher than 100 blows per 0.125 m of penetration.

The natural moisture contents generally range from 9% to 21%.

The grain size distributions for silty clay till samples tested are presented on the Record of Borehole sheets and on Figure B3 of Appendix B. Atterberg Limits test results are presented on Figure B6 of Appendix B.

The results of laboratory tests carried are summarized below:

Soil Particles	(%)
Gravel	0
Sand	2 to 8
Silt	35 to 39
Clay	55 to 60

Liquid Limit	41 to 48
Plastic Limit	19 to 21

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

Glacial tills are known to contain cobbles and boulders which may account for some high blow counts.

5.7 Sandy Silt Till

Brown sandy silt till was contacted at 1.7 m depth (Elevation 316.0) in Borehole 08-016, drilled near the north abutment. The thickness of the sandy silt till was 2.0 m. The depth to the base of the layer was 3.7 m (Elevation 314.0).

A lower deposit of grey sandy silt till containing some clay, trace of gravel and occasional cobbles was contacted at 13.3 m depth (Elevation 304.4) in Borehole 08-016. Borehole 08-016 was terminated within the sandy silt till at 16.9 m depth (Elevation 300.8).

SPT 'N' values measured in the sandy silt till were higher than 100 blows per 0.125 m of penetration, indicating a very dense relative density. The natural moisture contents generally lay in the range of 4% to 20%.

The grain size distributions for two samples of the sandy silt till tested are presented on the Record of Borehole sheets and on Figure B4 of Appendix B.

The results of laboratory tests carried are summarized below:

Soil Particles	(%)
Gravel	0 to 2
Sand	24 to 45
Silt	40 to 66
Clay	10 to 13

5.8 Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. Standpipe piezometers were installed near the proposed north and south abutments to monitor water levels after completion of drilling. The water levels measured in the piezometers are summarized in Table 5.3, along with the measurements in the boreholes upon completion of drilling.

Table 5.3 – Water Level Measurements

Foundation Unit	Borehole	Date (2008)	Water Level (m)		Comment
			Depth	Elevation	
Near North Abutment	08-016	August 20	12.6	305.1	In piezometer
Near Possible Pier Location	08-015	June 27	2.4	315.9	Open borehole
Near South Abutment	08-019	November 18	6.3	315.4	In piezometer

The piezometric reading indicates that the groundwater level is near Elevation 315.5 m.

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

6 MISCELLANEOUS

All-Terrain Drilling of Waterloo, Ontario supplied a CME75 truck-mounted drill rig and conducted the drilling, sampling and in-situ testing operations.

The drilling and sampling operations in the field were supervised on a full time basis by Mr. Stephane Loranger, C.E.T., Mr. George Azzopardi and Mr. Keli Shi of Thurber, under the direction of Mr. Alastair E. Gorman, P.Eng and Mr. Mark Farrant, P. Eng.

The coordinates for the boreholes and the ground surface elevations were obtained by Thurber Engineering Ltd. using GPS equipment.

Overall supervision of the field program was conducted by Mr. Alastair E. Gorman, P.Eng. Interpretation of the data and preparation of the report were carried out by Mr. Alastair E. Gorman, P.Eng. and Ms. R. Palomeque Reyna, P.Eng.

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

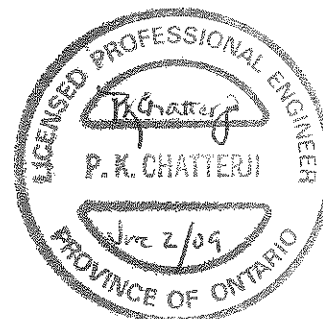
Thurber Engineering Ltd
Rocío Palomeque Reyna, P.Eng.
Geotechnical Engineer



Alastair E. Gorman, P.Eng.,
Senior Foundations Engineer



P.K. Chatterji, P.Eng.,
Review Principal, Designated MTO Contact



**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 Number: 40P8-161

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents preliminary geotechnical design recommendations to assist the design team to select and design a suitable foundation system for the new ramp structure.

Based on the Plates 2A and 2B of the E.A:

- The E-S Ramp will cross over KWE and Wellington Street. The proposed finished grade of the E-S ramp will vary from north to south from Elevation 334.0 to 331.5. The existing ground surface within the vicinity of the proposed ramp structure varies from north to south from Elevations 317.7 to 321.7. Hence, north and south approach embankments of the proposed E-S Ramp will be about 16.0 m and 9.8 m high, respectively, relative to the surrounding grade.
- The Wellington Street grade at the site is at Elevation 324.0 (approximately). The north and south embankments are 16.0 m and 10.0 m high relative to the surrounding lands.

The discussion and recommendations presented in this report are based on our understanding of the project and on the factual data obtained in the course of this investigation.

8 STRUCTURE FOUNDATIONS

The stratigraphy identified in the preliminary investigation consisted of topsoil or pavement structure overlying dense to very dense sand and gravel fill underlain by layers of native compact to dense sand and very stiff to hard silty clay/silty clay till. A deposit of very dense sandy silt till was encountered at 1.7 m and 13.3 m depth near the location of the north abutment.

Groundwater level was measured in the piezometer near Elevation 315.5.

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

- Spread footings bearing on native soil
- Spread footings on engineered fill
- Steel H-piles driven into the very dense soil
- Augered Caissons on Hard Silty Clay Till or Very Dense Sandy Silt Till (Drilled Shafts)

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

8.1 Spread Footings on Native Soil

Spread footings bearing on native soil generally are the least expensive form of construction.

All footings must be placed on the undisturbed native soils.

The design of spread footings bearing on native undisturbed hard silty clay/silty clay till, dense sand and very dense sandy silt till must be in accordance with the elevations and bearing resistances given in Table 8.1.

Table 8.1 – Bearing Resistances for Spread Footings

Element	Depth (m)	Elev.	ULS _r (kPa)	SLS (kPa)	Soil
Near North Abutment (BH 08-016)	1.4	316.5	600	400	Hard silty clay
	1.7	316.0	750	500	Very dense sandy silt till
Near Possible Pier (BH 08-015)	1.4	316.9	500	350	Dense to compact sand
Near South Abutment (BH 08-019)	3.0	318.7	675	450	Hard silty clay till

The bearing resistances in Table 8.1 are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be adjusted as shown in the CHBDC (2006) Clause 6.7.3 and Clause 6.7.4.

The geotechnical SLS resistance 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.

Founding elevations presented in Table 8.1 are generally 0.5 m to 3.0 m above the groundwater level observed during the investigation and groundwater level measured in the piezometer. However, if water is observed during footing excavation or if temporary excavations required to construct these footings extend in cohesionless soils below the water table, groundwater control will be required to construct the footing in the dry and to prevent sloughing of the sides of disturbance of the footing base.

8.2 Spread Footings on Engineered Fill

Spread footings can also be founded on Granular “A” engineered fill pads.

If an engineered fill pad is used, all topsoil, existing fill, native loose sands or other deleterious materials must be stripped from the footprint of the fill pad to expose competent native subgrade material. The highest permitted founding elevations at which engineered fill pads may be placed, are given in Table 8.2.

Table 8.2 – Founding Elevations for Engineered Fill Pads

Near North Abutment (BH 08-016)	Near Possible Pier (BH 08-015)	Near South Abutment (BH 08-019)
317.0	317.3	319.2

Typically, spread footings on pads of engineered granular fill at least 2 m thick may be designed for the following geotechnical resistances:

- Factored ULS 900 kPa
- 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 Clause 6.7.3 and Clause 6.7.4.

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 settlement is not expected to exceed 20 mm across the width of the structure or between foundation elements.

The Granular A pad must be compacted to 100% of Standard proctor maximum dry density (SPMDD) at optimum moisture content $\pm 2\%$. The geometry of the fill pad must conform to the general requirements shown in Figure 1 in Appendix D.

8.3 Steel H-Piles

The soil stratigraphy encountered at this site is considered to be suitable for the support of foundations on driven steel piles.

It is recommended that the H-piles be driven to achieve resistance in the very dense sandy silt till or hard silty clay till encountered at this site. The depths and elevations at which the H-piles are expected to develop the required resistance are given in Table 8.3.

Table 8.3 – Estimated Pile Tip Elevation

Foundation Unit	Anticipated pile length below existing ground (m)	Pile Tip Elevation	Comments
Near North Abutment (BH 08-016)	15.2	302.5	Pre-augering may be required within the upper sandy silt till layer from elevations 316.0 to 314.0
Near Possible Pier (BH 08-015)	19.3	299.0	-
Near South Abutment (BH 08-019)	18.7	303.0	-

8.3.1 Axial Resistance

For preliminary design, the vertical, axial, factored geotechnical resistance at Ultimate Limit States (ULS) and geotechnical resistance at Serviceability Limit States (SLS) for two pile sections when driven into the very dense and hard soils are presented in Tables 8.4.

Table 8.4 – Axial Resistance of Two Pile Sections Founded on Very Dense and Hard Soils

Pile Section	Geotechnical Resistance (kN)	
	Factored ULS	SLS
HP 310 X 110	1,600	1,400
HP 360 X 132	1,800	1,600

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

Installation of the piles must be in accordance with SP 903S01 and must be controlled using the Hiley Formula and an ultimate resistance of 3,200 kN for an HP 310 X 110 pile and 3,600 kN for the HP 360 X 132 pile.

These are preliminary recommendations and may change during detail design based on the final alignment, final bridge arrangement and the results of the site investigation and field testing to be completed at that time.

Due to the possible presence of cobbles and boulders in the silty clay till and sandy silt till layers and at the expected founding layer, the tips of all driven piles should be fitted with steel H-Pile driving shoes in accordance with OPSD 3000.100.

8.3.2 Downdrag

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

8.4 Augered Caissons on Hard Silty Clay Till or Very Dense Sandy Silt Till (Drilled Shafts)

Drilled shaft foundations are also suitable for the support of structural loads at this site. Since the caisson is a deep foundation unit, higher geotechnical resistance is available from a caisson in earth than from a similar sized spread footing.

The caissons must be founded in the hard silty clay till or the very dense sandy silt till at depths and elevations indicated in Table 8.5. Caisson lengths should be at least 6.0 m and each caisson should extend at least 3.0 m into the “100-blow” soils.

Table 8.5 – Founding Elevations for Augered Caissons

Foundation Unit	Borehole	Founding Depth (m)	Founding Elevation
Near North Abutment	08-016	16.9	300.8
Near Possible Pier	08-015	21.5	296.8
Near South Abutment	08-019	21.3	300.4

Typical preliminary geotechnical resistance has been calculated for a range of caisson diameters and founding depths given in Table 8.5. The values are shown in Table 8.6.

Table 8.6 – Vertical Geotechnical Resistance for Caisson Foundations

Caisson Diameter (m)	Typical Preliminary Axial Geotechnical Resistance	
	Factored ULS _r (kN)	SLS (kN)
1.0	5,000	3,500
1.5	8,000	6,500

The vertical geotechnical resistance for caisson foundations has been calculated assuming contributions from factored sidewall resistance in the sockets.

Caisson installation should be in accordance with Special Provision No. 903S01.

The soil providing the resistance, whether it is skin friction or end bearing, must be protected from disturbance.

The caisson installation equipment should be able to dislodge and remove any obstructions in the fill or cobbles and boulders in the till.

Permeable cohesionless soils under water table are encountered at this site. These conditions will make caisson installation difficult and sealing of caisson liners into the founding stratum to exclude groundwater will also be difficult.

8.5 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. Depending on final grades, integral abutment design may require pre-augering at the north abutment (Boreholes 08-016) to install the piles and achieve the flexibility required in the upper 3 m.

8.6 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.

8.7 Recommended Foundation

From a geotechnical perspective, and based on current information, the recommended abutment and pier foundations consist of steel H-piles driven into the very dense/hard native soil, despite the higher cost noted in Appendix C.

Caisson foundation is feasible at this site.

9 BRIDGE APPROACHES AND EMBANKMENTS

Based on the three boreholes drilled at the site, the approach embankments will be constructed over hard silty clay/silty clay till or dense to very dense sand.

Preliminary analysis indicates that at the abutments, settlement in the order of 55 mm to 65 mm is estimated in the foundation soils under the loading imposed by approximately 16.0 m of the approach fill. Due to the dense to very dense and hard nature of the foundation soils, these settlements, as well as the settlements of the fill itself, will be essentially completed when construction of the fill is completed. Further settlement analysis should be conducted during the detail phase design.

The 9.8 m and 16.0 m high embankments likely to be constructed will be stable at side slopes of 2H:1V if constructed using SSM or granular fill. Where earth fill embankments are higher than 8 m, mid-height berms should be incorporated in the design. 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.

For the purpose of preliminary embankment stability analyses, the commercially available slope stability program GSLOPE developed by Mitre Software Inc. was used. The Bishop's simplified method for stability analysis was employed.

Global stability analyses were conducted for a 16.0 m high, 2H:1V SSM or earth fill embankment. The stability of the embankment was also checked under seismic loading assuming an acceleration of 0.08g. The computed factors of safety are as shown in Table 9.1. Slope stability computation outputs are included in Appendix E.

Table 9.1 Computed Factors of Safety

Location / Material	Condition	Factor of Safety	Figure (Appendix E)
16 m High			
Earth Fill	Normal	2.1	1
Earth Fill	Seismic = 0.08g	1.7	2

These high factors of safety are consistent with the fact that the proposed embankment will be bearing on the dense/very dense or hard foundation soils present at this site.

The global, internal and surficial stability of the approach embankment fills should be further evaluated during the detail design phase.

10 CONSTRUCTION CONCERNS

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

1. Pile refusal at higher elevation.

Although there was little direct evidence of their presence during drilling, glacial till deposits inherently contain boulders. It is possible that a pile will achieve refusal at a higher elevation than anticipated due to encountering a boulder. If it is suspected that this is happening, the QVE must immediately bring it to the attention of the CA. If the CA cannot resolve the issue, it must be referred to the design team for resolution.

2. Pile fails to develop specified resistance.

If a pile has not developed the specified resistance after being driven 2 m beyond the anticipated pile tip elevation, stop driving and check the Hiley calculation and all input

values. If the calculation still shows that the pile has not reached the specified resistance, the following procedure should be implemented:

- a) Stop driving in that pile group for 48 hours (minimum)
- b) After 48 hours, warm up the hammer on another pile then commence redriving the subject pile and measure the resistance.
- c) If the pile still does not reach the specified resistance, the QVE must immediately advise the CA who, in turn, should refer the issue to the design team.

3. Destabilization of excavations

If excavation is carried out in cohesionless soil (especially at the proposed pier location, Borehole 08-015) without prior implementation of adequate measures to control groundwater and surface water, there is a risk that the sides and or base of the excavation will be destabilized. This could lead to a risk to personnel working on site, or to a loss of bearing resistance in the soil.

11 INVESTIGATION FOR DETAIL DESIGN

During the detail design phase of the project, additional site investigation and field testing will be required. The following minimum program is recommended:

1. Boreholes for structure foundations.

Additional boreholes may be required for the structure foundations, especially if the structure is built off the current alignment. Borehole should be drilled at the exact location of the proposed foundation elements.

2. Boreholes for approaches.

A minimum of one borehole is recommended in each approach fill.

12 CLOSURE

Engineering analysis and preparation of the report were carried out by Mr. Alastair E. Gorman, P.Eng. and Ms. R. Palomeque Reyna, P.Eng.

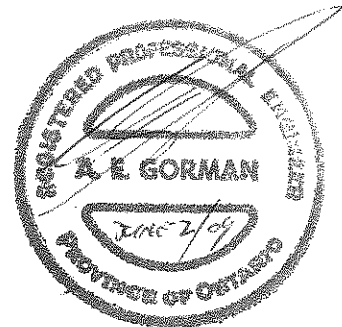
The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Rocio Palomeque Reyna, P.Eng., M.Eng.
Geotechnical Engineer



Alastair E. Gorman, P.Eng.,
Senior Foundations Engineer



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



Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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


4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level


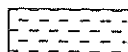


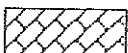
C_{pen} Shear Strength Determination by Pocket Penetrometer

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

UNIFIED SOILS CLASSIFICATION

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

EXPLANATION OF ROCK LOGGING TERMS

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

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
		Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
		Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

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

RECORD OF BOREHOLE No 08-015

1 OF 3

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 451.52 E 226 142.96 ORIGINATED BY SLL/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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
								20 40 60 80 100		20 40 60																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
								WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
318.3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							

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		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													
307.7	Silty CLAY, trace sand Very Stiff to Hard Grey (TILL)													
10.7	Silty CLAY, trace sand Hard Grey		10	SS	40									
			11	SS	53									0 1 35 64
			12	SS	44									
			13	SS	92									0 0 41 59
			14	SS	38									
300.5	Silty CLAY, trace gravel Hard Grey (TILL)													
17.8			15	SS	100/ .150									
			16	SS	100/									
	occasional cobbles													

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 w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								20 40 60 80 100										
Continued From Previous Page							○ UNCONFINED + FIELD VANE					WATER CONTENT (%)						
							● QUICK TRIAXIAL x LAB VANE											
							20 40 60 80 100					20 40 60						
	Silly CLAY, trace gravel Hard Grey (TILL)				.100		298											
296.8			17	SS	100/		297											
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.				.150													

+ 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 w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)	
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 UNCONFINED + FIELD VANE									
0.1									● QUICK TRIAXIAL X LAB VANE								
316.0								40 80 120 160 200									
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		317										
			3	SS	100/ 250		316										
			4	SS	100/ 175		315										
314.0																	
3.7	Silty CLAY, trace sand Hard Grey						314										
			5	SS	60		313										
							312										
			6	SS	51		311										
							310										
			7	SS	52												
309.0																	
8.7	Silty CLAY, trace gravel, trace sand Hard Grey (TILL)						309										
			8	SS	52		308										

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
	Continued From Previous Page						20 40 60 80 100						
							40 80 120 160 200						

ONTMT4S 6417R.GPJ 6/1/09

+ 3 . X 3 : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-019

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 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	20 40 60 80 100	W _p W W _L	20 40 60		
	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								0 0 40 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								0 2 38 60

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				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					
	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																

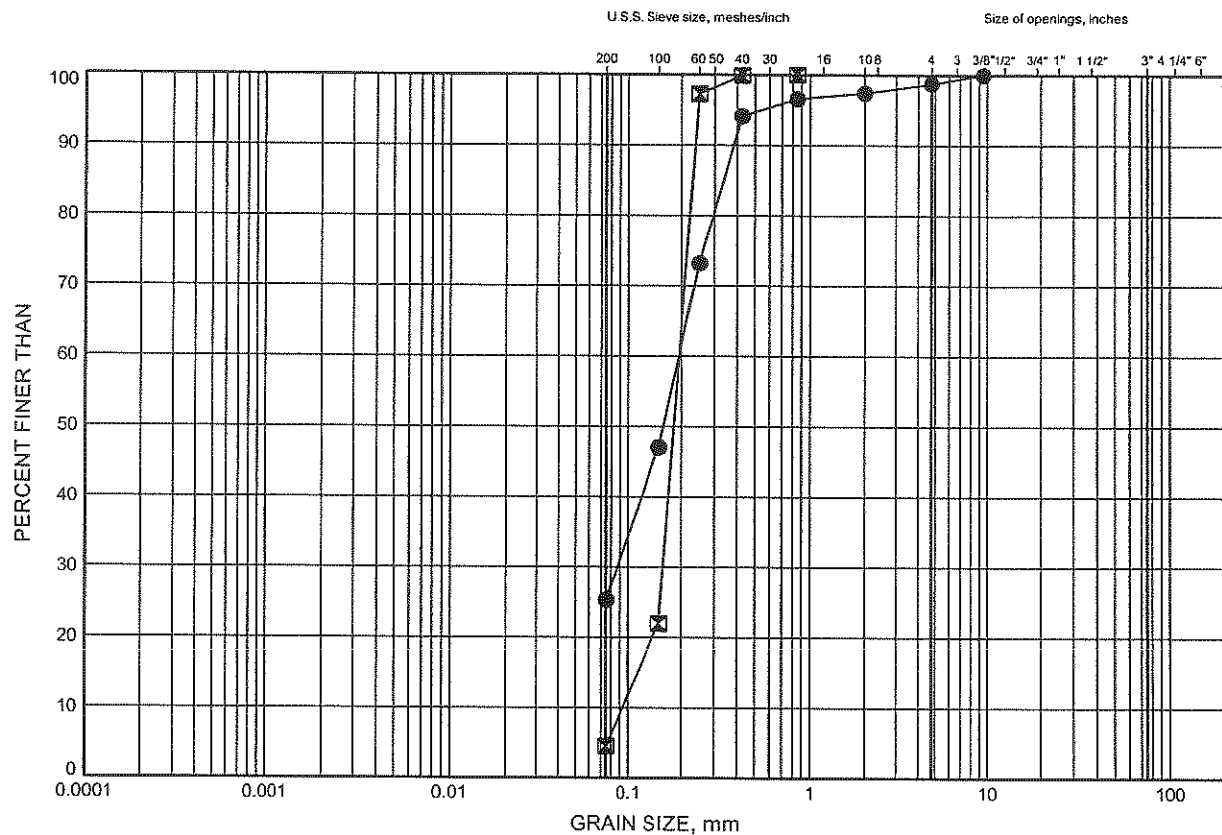
Appendix B

Laboratory Test Results

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B1

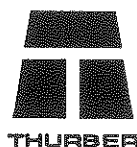
SAND



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

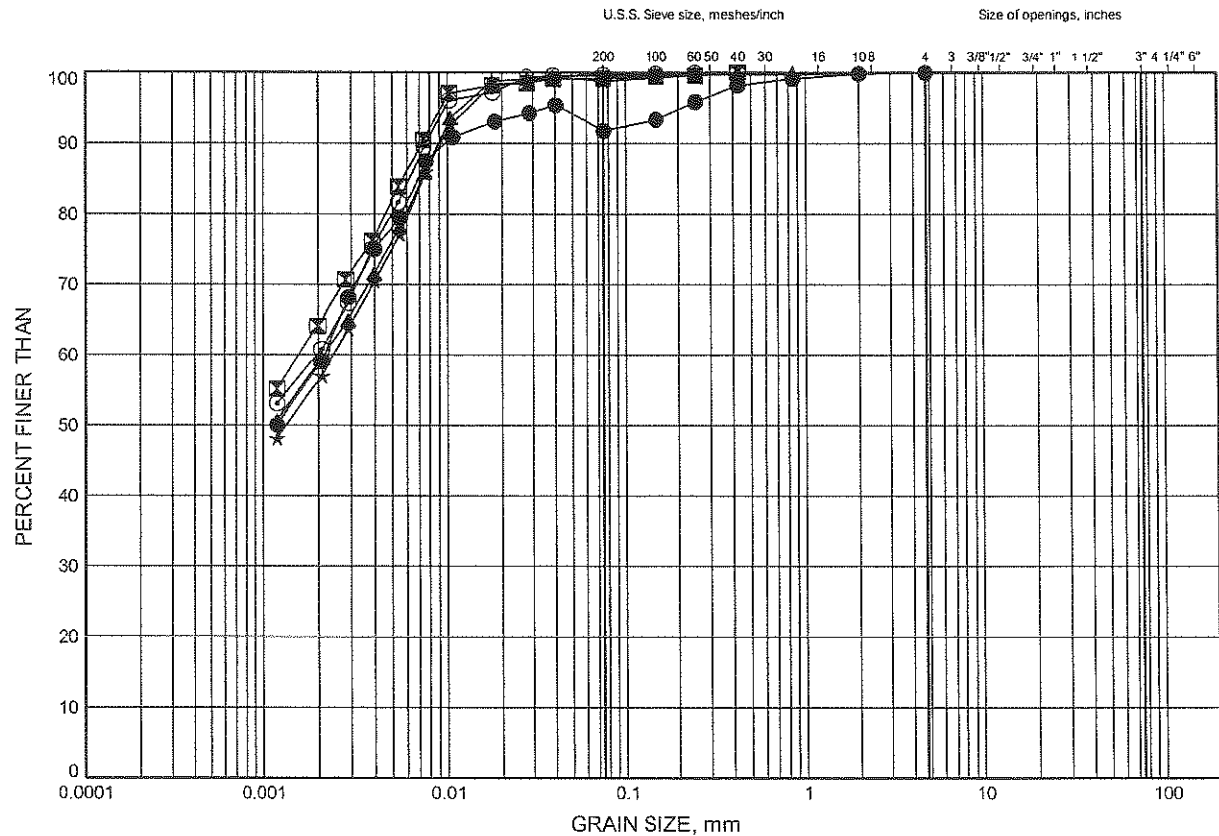


W.P.# .408-88-00.....
Prepared By .AN.....
Checked By .RPR.....

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B2

SILTY CLAY



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

LEGEND

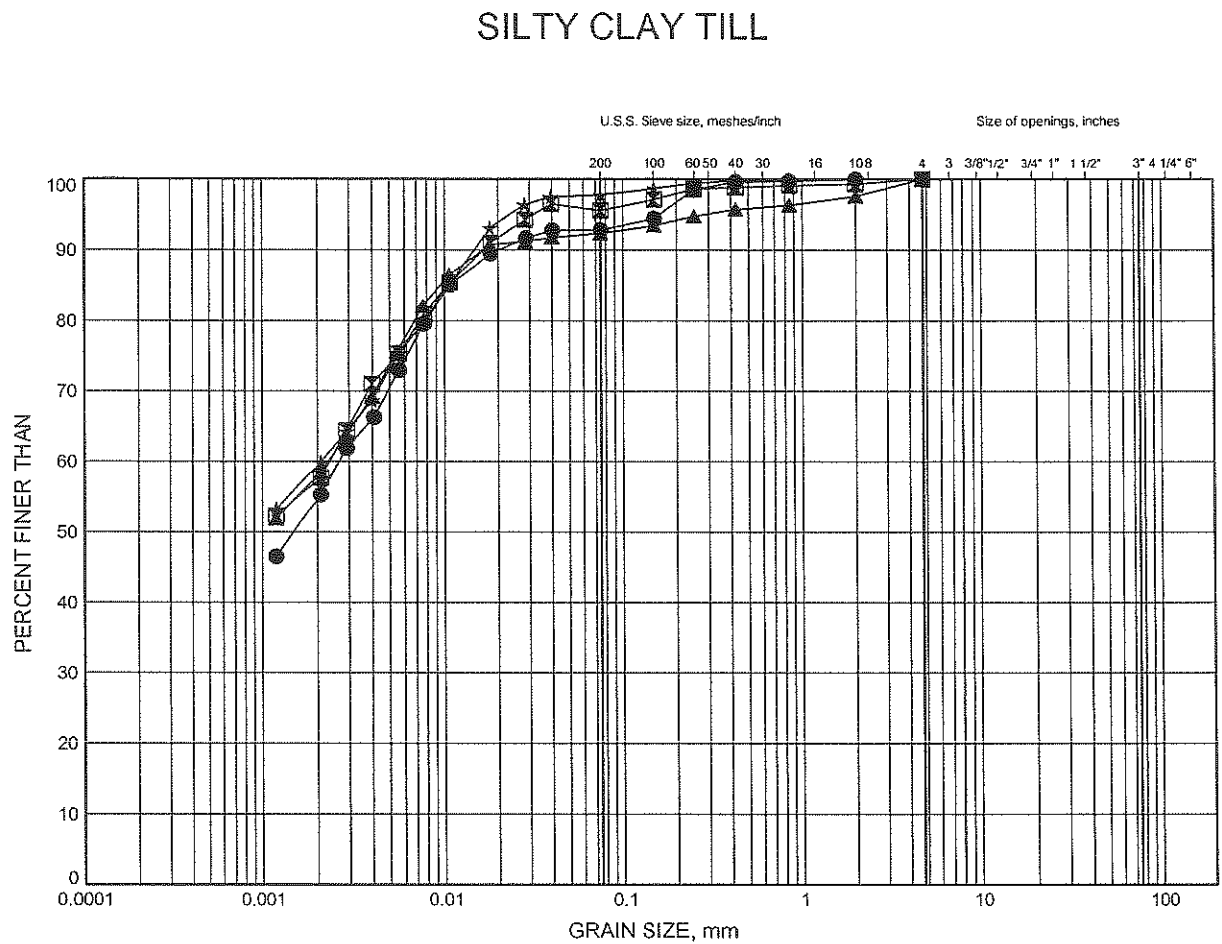
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-015	4.88	313.44
⊠	08-015	12.50	305.82
▲	08-015	15.53	302.79
☆	08-016	6.39	311.30
⊙	08-019	13.41	308.29



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

Highway 7 - New
GRAIN SIZE DISTRIBUTION

FIGURE B3



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

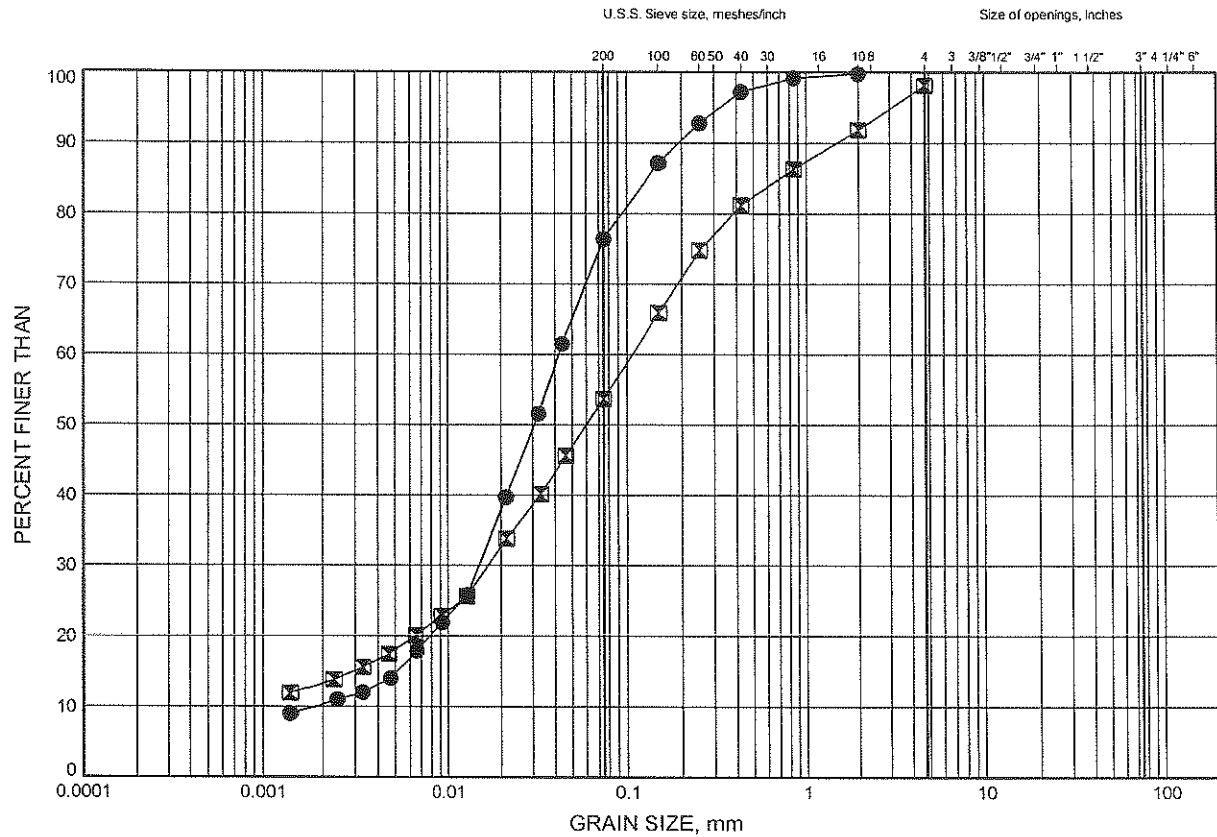


W.P.# 408-88-00
Prepared By AN
Checked By RPR

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B4

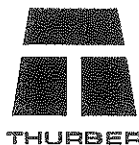
SANDY SILT TILL



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

LEGEND

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

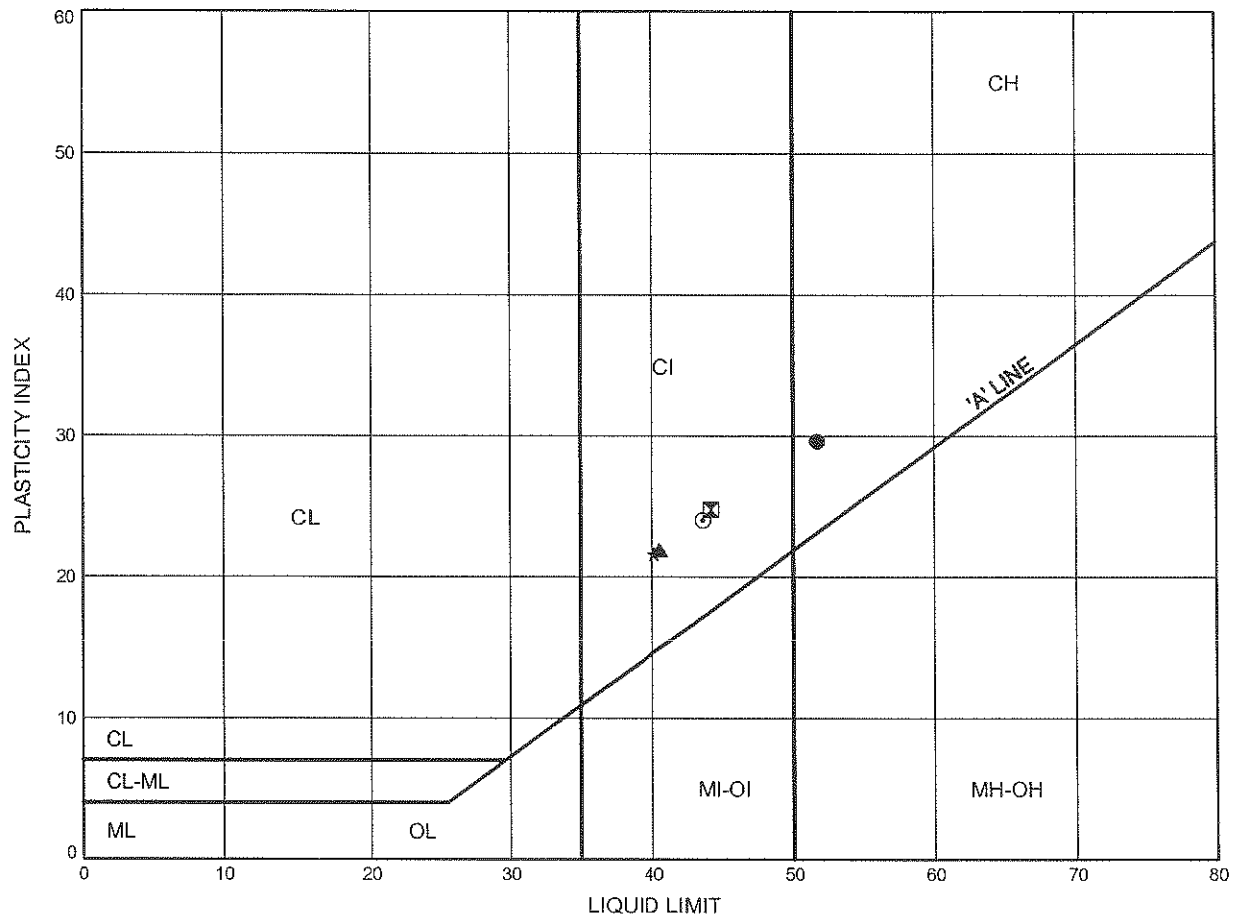


W.P.# 408-88-00
Prepared By AN
Checked By RPR

Highway 7 - New ATTERBERG LIMITS TEST RESULTS

FIGURE B5

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

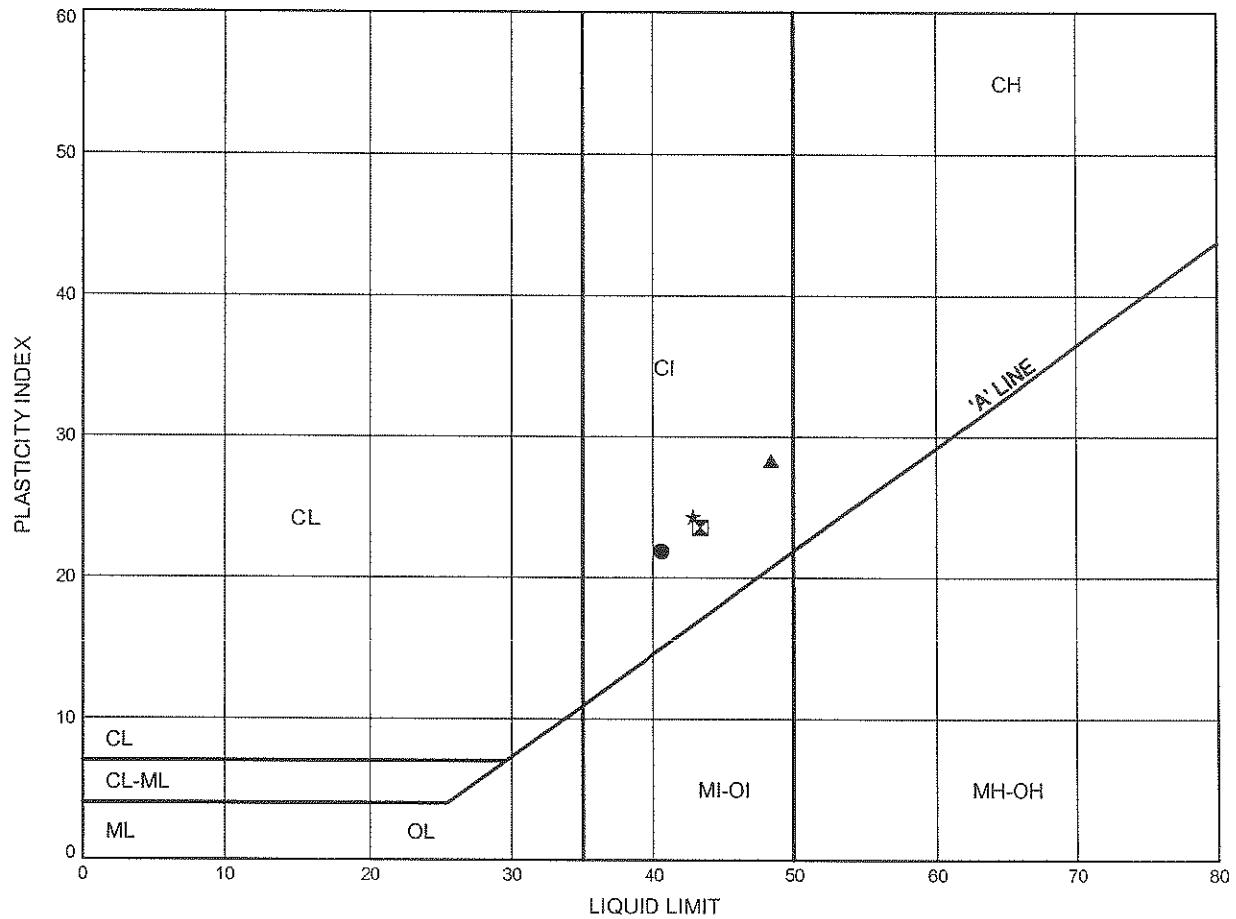


Prep'd AN
 Chkd. RPR

Highway 7 - New ATTERBERG LIMITS TEST RESULTS

FIGURE B6

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

Appendix C

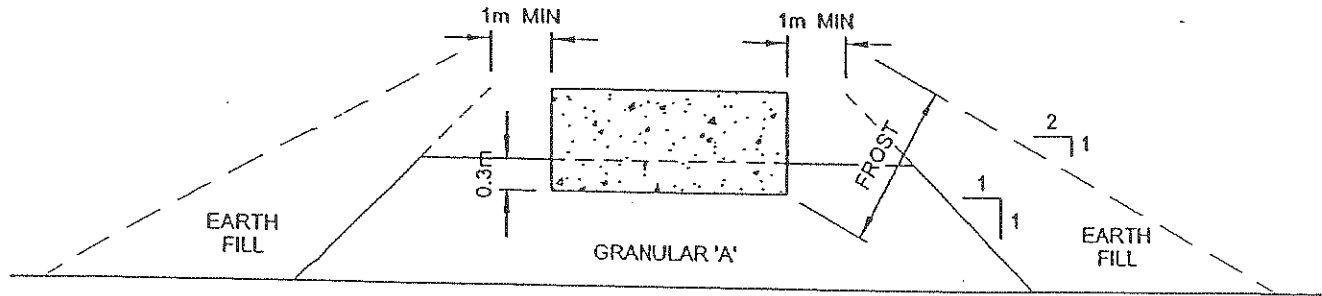
Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

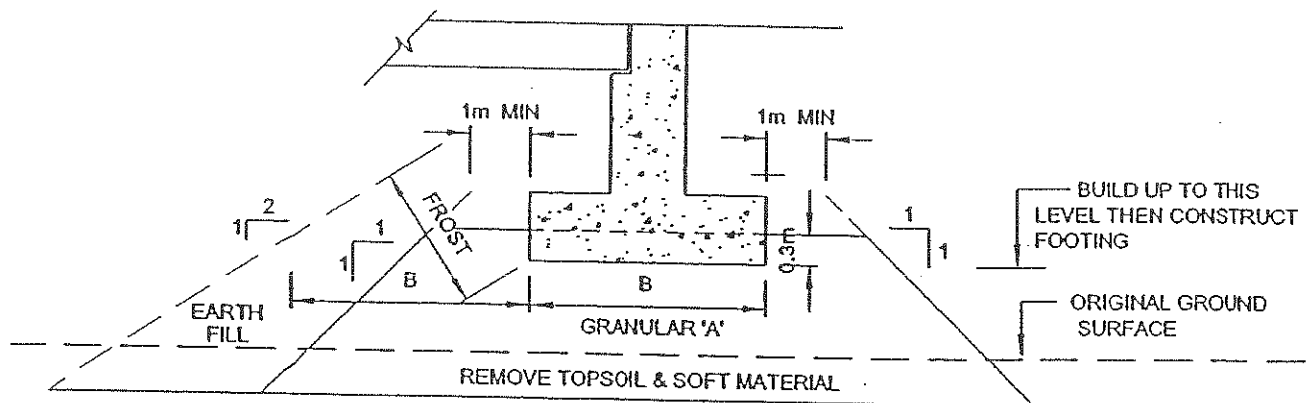
Foundation Element	Spread Footings	Spread Footings on Engineered Fill	Driven Piles	Caissons
	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. <p>Disadvantages:</p> <ul style="list-style-type: none"> ii. Lower geotechnical resistance available due to founding on compact soils near the surface. iii. Dewatering may be required, depending on depth of excavation. 	<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. Better geotechnical resistance than spread footings on native, but still influenced by the compact soils at the surface. ii. Dewatering may be required, depending on depth of excavation. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. High geotechnical resistance may be developed by driving the piles into very dense/hard soils. ii. Comparatively short abutment stem possible iii. Permits integral abutment design. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher unit cost compared to footings. ii. Very dense/hard soils at shallow depth will limit length of pile and geotechnical resistance that can be developed. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. High resistance is available for caissons socketed in bedrock. ii. Subexcavation of fill or variable material is not required. iii. Construction of caissons could continue in freezing weather. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher cost than spread footings. ii. Dewatering may be required. iii. Possibility of boulders being encountered during augering. iv. Potential difficulty in cleaning and inspecting bases.
Abutments	NOT RECOMMENDED	NOT RECOMMENDED	RECOMMENDED	FEASIBLE
Pier	NOT RECOMMENDED	NOT RECOMMENDED	RECOMMENDED	FEASIBLE

Appendix D

Figure



CROSS-SECTION

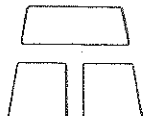


LONGITUDINAL SECTION

NOT TO SCALE

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.

ENGINEER	AEG	ABUTMENT ON COMPACTED FILL SHOWING GRANULAR A CORE	 THURBER
DRAWN	SS		
DATE	April , 2004		
APPROVED	PKC		
SCALE	NTS		
			DWG. NO.
			FIGURE 1

Appendix E

Slope Stability Output

Thurber Engineering Ltd. - Toronto
 15-64-17 Highway 7 - New
 E-S Ramp over KWE & Wellington Street
 December 2, 2008
 North Abutment
 16.0 m high

	Gamma C	Phi	Piezo
	kN/m3	kPa	deg Surf.
Earth Fill	21	0	30 1
Silty Clay	19	100	0 1
Sandy Silt	21	0	31 1

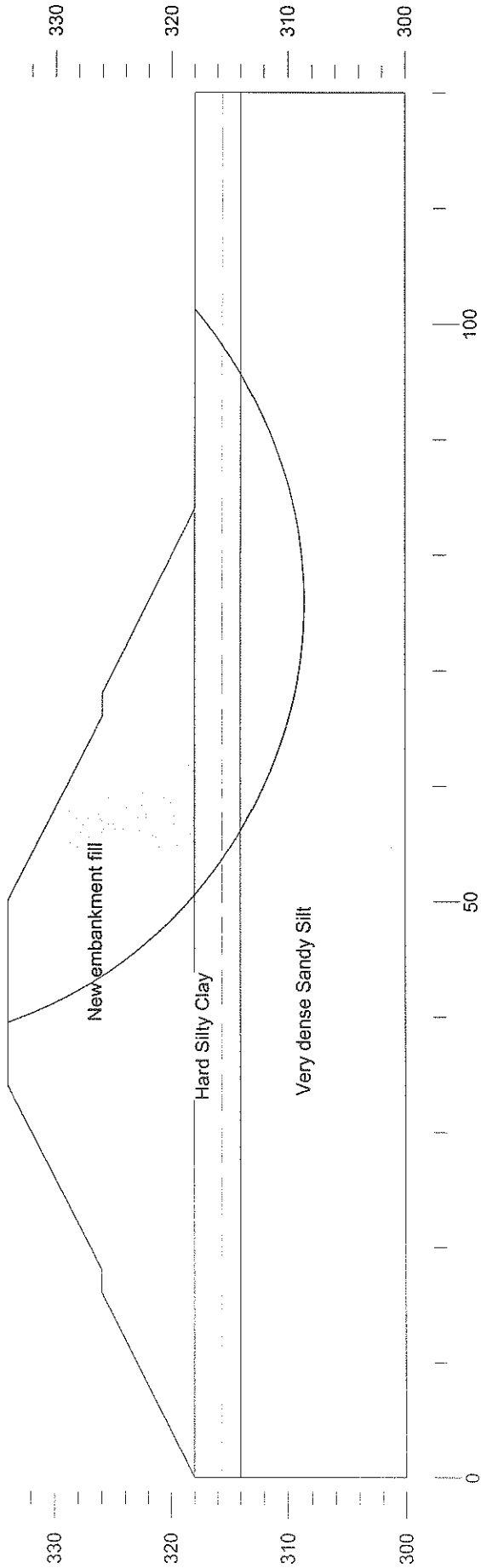
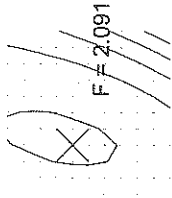


FIGURE 1

	Gamma C	Phi	Piezo
	kN/m ³	deg	Surf.
Earth Fill	21	30	1
Silty Clay	19	0	1
Sandy Silt	21	31	1

Seismic coefficient = 0.08

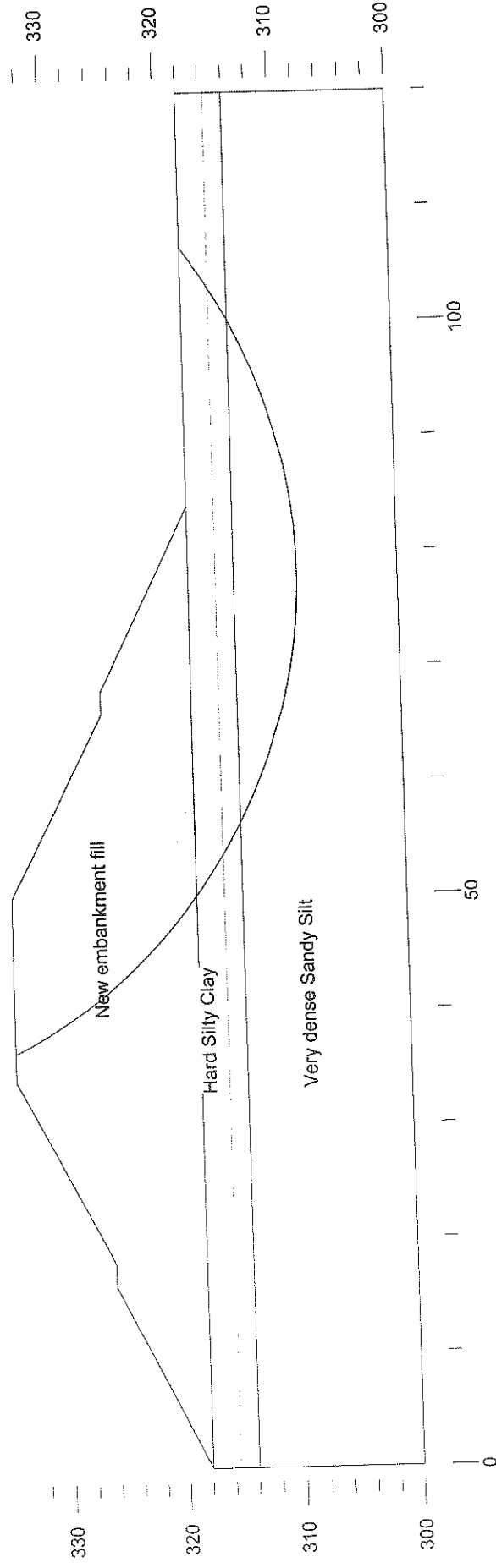
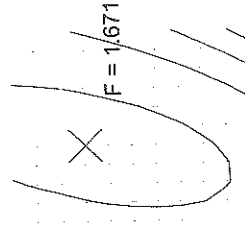


FIGURE 2

Appendix F

Site Photographs

E-S Ramp over KWE and Wellington Street
Highway 7-New, Kitchener to Guelph



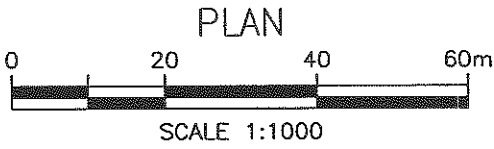
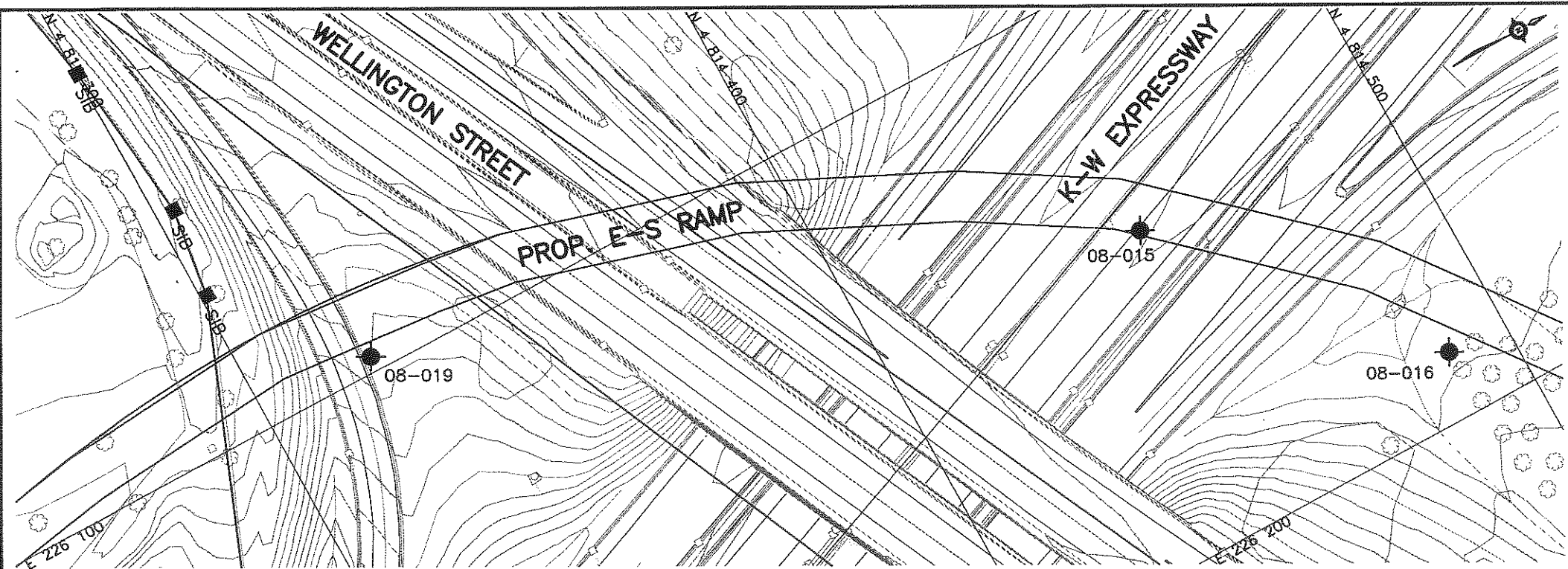
Photo 1. Looking at the south side of Wellington Street and west side of KWE, South Abutment (Borehole 08-019)



Photo 2. Looking at the east side of KWE and north side of Wellington Street– North Abutment (Borehole 08-016)

Appendix G

Drawing titled “Borehole Locations and Soil Strata”



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

LICENSED PROFESSIONAL ENGINEER
R. Palomeque Reyna
100083209
June 2/04
PROVINCE OF ONTARIO

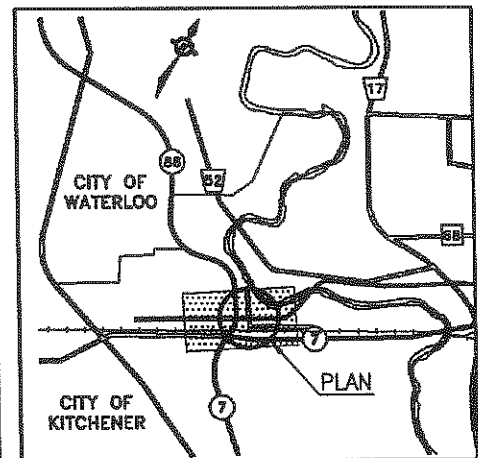
LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
June 2/04
PROVINCE OF ONTARIO

CONT No
GWP No 408-88-00

HIGHWAY 7
RECOMMENDED ROUTE
E-S RAMP OVER KWE & WELLINGTON ST
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



KEYPLAN

LEGEND

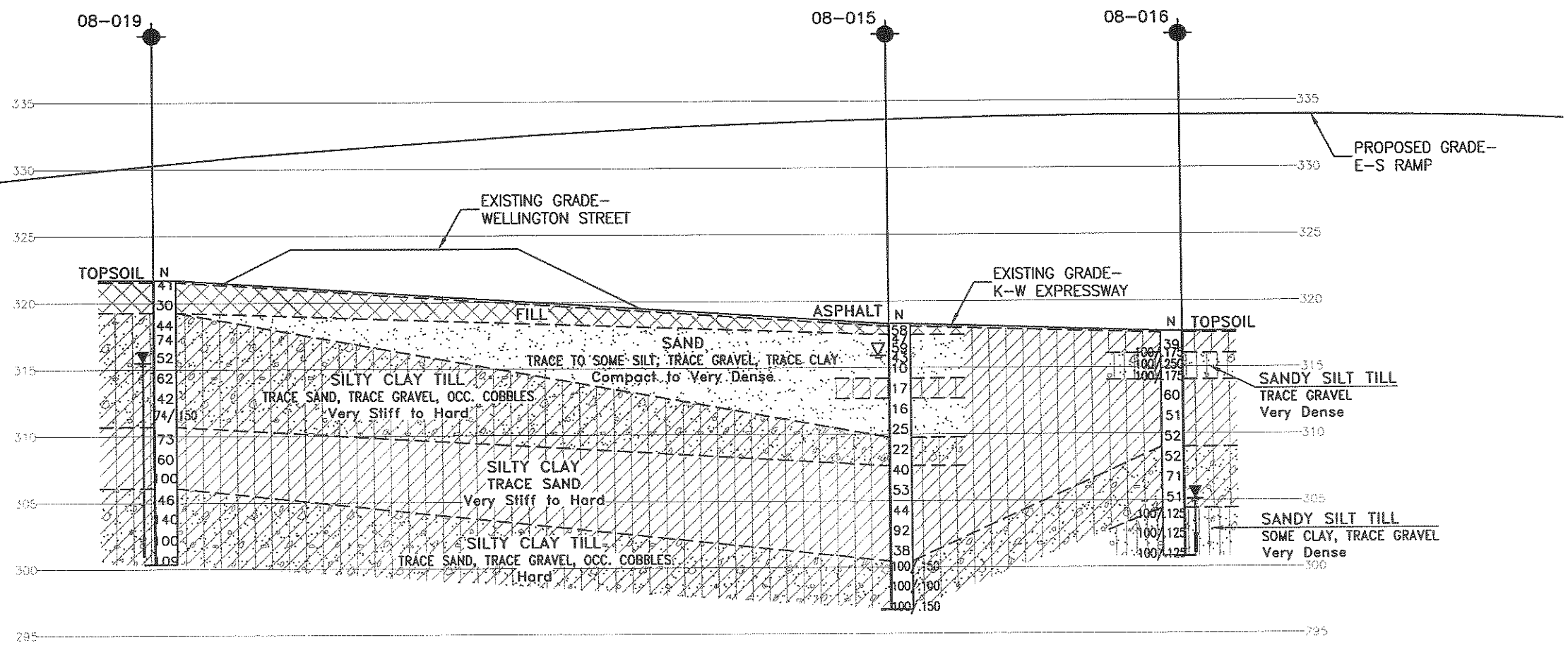
- Borehole
- Borehole and Cone
- N
Blows /0.3m (Std Pen Test, 475J/blow)
- CONE
Blows /0.3m (60' Cone, 475J/blow)
- PH
Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- 90%
Rock Quality Designation (RQD)
- A/R
Auger Refusal

NO	ELEVATION	NORTHING	EASTING
08-015	318.3	4 814 451.5	226 143.0
08-016	317.7	4 814 489.0	226 188.3
08-019	321.7	4 814 321.4	226 097.3

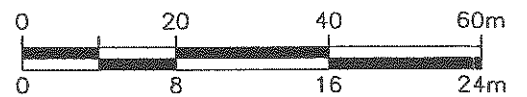
NOTES-

- 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.
- Proposed grades are from Plate 2B of the E.A. Study.

GEOCREs No. 40P8-161



PROFILE ALONG CL OF PROP. E-S RAMP OVER KWE & WELLINGTON ST



HOR 1:1000
VER 1:400

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	AEG	CHK	PKC
DRAWN	MFA	CHK	AEG
		SITE	STRUCT
			JOWG