

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

Geocres Number: 40P8-165

Report to

Ministry of Transportation Ontario
Southwestern Region

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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-N Ramp/Wellington Street E/W-N Ramp over Guelph Street in the Regional Municipality of Waterloo. The proposed E-N Ramp/Wellington Street E/W-N 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 borehole, 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 and from a previous investigation as outlined below.

The title of the previous foundation report is as follows:

- Foundation investigation report for Guelph Street Overpass, Kitchener-Waterloo Expressway, District #4 (Hamilton), W.J. 66-F-57, W.P. 638-64, Geocres Number 40P8-49, dated August 5, 1966. (Reference 1).

Records of Boreholes 1 and 7 from the previous report are attached in Appendix C for reference.

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 on the east side of Kitchener-Waterloo Expressway, approximately 350 m to the north of Wellington Street. At this location, the proposed E-N Ramp/Wellington Street E/W-N Ramp will cross over the existing Guelph Street. The site lies within an area of industrial and commercial lands. The site 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 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 was carried out on June 4 and 5, 2008. One borehole, numbered 08-003, was drilled approximately near the location of the north abutment of a possible single-span structure arrangement. The depth of Borehole 08-003 was 15.4 m (Elevation 297.1).

A previous geotechnical investigation was conducted in June 1966. Boreholes 1 and 7 were drilled on the south and north sides of the proposed structure and were terminated at 13.4 m and 15.4 m (Elevations 299.7 and 296.1), respectively.

The Record of Borehole sheets for the current and previous boreholes are included in Appendices A and C, respectively.

The approximate locations of the boreholes drilled during the present and previous investigations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix F.

Prior to commencing the site investigation, clearance was obtained from utility companies having plant in the area. Road occupancy permit was also obtained to complete the site investigation.

Borehole 08-003 was drilled using hollow stem auger equipment operated by a CME75 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 borehole were observed throughout the drilling operations.

Borehole 08-003 was backfilled with grout to 9.15 m, bentonite to 0.1 m and asphalt to surface.

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the borehole 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 sheet 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 sheet in Appendix A and on the figures contained in Appendix B.

Laboratory test results of Boreholes 1 and 7 drilled during the previous investigation (Reference 1) are enclosed in Appendix C.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheet in Appendix A. Details of the encountered soil stratigraphy at the proposed structure location are presented in this appendix and on the "Borehole Location and Soil Strata" drawing in Appendix F. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheet governs any interpretation of the site conditions.

In general, the site is underlain by native compact to very dense sandy silt and silty sand, very stiff to hard clayey silt and silty clay till and very dense sandy silt till. Pavement structure and granular fill were encountered in Borehole 08-003.

5.1 Pavement structure

Pavement structure consisting of approximately 50 mm of asphalt overlying silty sand fill was encountered in Borehole 08-003 drilled on Guelph Street.

5.2 Fill

Fill was encountered below the pavement structure in Borehole 08-003. The fill consists of dark grey to brown silty sand containing some gravel and trace clay. Strong gas odour was noted within the fill.

Thickness of the fill was 1.9 m. The depth to the base of the fill was 2.0 m (Elevation 310.5).

The silty sand fill is classified as dense to compact based on SPT 'N' values of 32 and 13 blows for 0.3 m of penetration. The natural moisture content ranged from 8 to 10%.

Grain size distribution curve for a silty sand fill sample is presented on the Record of Borehole sheet and on Figure B1 of Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	(%)
Gravel	20
Sand	48
Silt & Clay	32

5.3 Sandy Silt

Layers of native sandy silt containing trace gravel and clay were contacted surficially in Borehole 1 and at 9.1 m depth in Borehole 7. Thickness of the sandy silt was 4.6 m in Borehole 1.

In Borehole 1, the depth to the base of the sandy silt was 4.6 m (Elevation 308.6). In Borehole 7, the depth to the base of the sandy silt extended to borehole termination depth, 15.4 m (Elevation 293.1).

The sandy silt is classified as dense to very dense, based on SPT 'N' values ranging from 33 to 56 blows for 0.3 m of penetration in Borehole 1. SPT 'N' values higher than 100 blows per 0.2 m of penetration were measured in the sandy silt in Borehole 7, indicating a very dense relative density. The natural moisture content ranged from 8% to 22%.

Laboratory test results for two sandy silt samples of the previous investigation are presented in Appendix C.

The results of the laboratory test are summarized as follows:

Soil Particles	(%)
Gravel	19
Sand	9 to 33
Silt	39 to 87
Clay	4 to 9

5.4 Clayey Silt

Native greyish brown clayey silt containing trace gravel, trace sand, pockets of silt and occasional layers of silty clay was contacted in the boreholes.

A 300-mm thick layer of clayey silt was encountered below the fill in Borehole 08-003. The depth to the base of the clayey silt was 2.3 m (Elevation 310.2).

In Boreholes 1 and 7, the clayey silt was contacted at 4.6 m and 3.7 m depths (Elevations 308.6 and 307.8). Thickness of the clayey silt was 4.6 m and 5.5 m. The depth to the base of the clayey silt was 9.1 m depth (Elevations 304.0 and 302.4) in both boreholes.

The clayey silt is classified as stiff to hard, based on SPT 'N' values of 13 to 62 blows for 0.3 m of penetration.

The natural moisture content ranged from 18 to 22%.

Laboratory test results of previous investigation are presented in Appendix C.

The results of the laboratory tests are summarized as follows:

Soil Particles	(%)
Gravel	0
Sand	0 to 5
Silt	51 to 60
Clay	40 to 44

Liquid Limit	25 to 43
Plastic Limit	15 to 20

The above results show that the upper silty clay is of low to medium plasticity with group symbol of CL-CI.

5.5 Silty Sand

Native brown silty sand containing trace clay was encountered surficially in Borehole 7 and below the clayey silt in Borehole 08-003.

Thickness of the silty sand was 3.7 m and 4.1 m. The depth to the base of the native silty sand was 3.7 m and 6.4 m (Elevations 307.8 and 306.1), in Boreholes 7 and 08-003, respectively.

The silty sand is classified as compact to dense, based on SPT 'N' values ranging from 14 to 42 blows for 0.3 m of penetration. The natural moisture content ranged from 13% to 19%.

Grain size distribution curve for a silty sand sample is presented on the Record of Borehole sheet and on Figure B2 of Appendix B.

Laboratory test results of previous investigation are presented in Appendix C.

The results of the laboratory test are summarized as follows:

Soil Particles	(%)
Gravel	0
Sand	34 to 66
Silt	31 to 61
Clay	3 to 5

5.6 Sandy Silt to Clayey Silt

A layer of native sandy silt to clayey silt containing occasional gravel was contacted below the clayey silt at 9.1 m (Elevation 304.0) in Borehole 1. The sandy silt to clayey silt extended to borehole termination depth, 13.4 m (Elevation 299.7).

The layer is dense to very dense in density, based on SPT 'N' values ranging from 36 blows per 0.3 m of penetration to higher than 50 blows per 0.075 m. The moisture content varied from 8% to 10%.

Laboratory test results of previous investigation are presented in Appendix C. The results of the laboratory tests are summarized as follows:

Soil Particles	(%)
Gravel	9
Sand	15
Silt	36
Clay	40

5.7 Silty Clay Till

Native dark grey silty clay till containing trace sand was contacted below the native silty sand in Borehole 08-003. The silty clay till extended to 10.7 m (Elevation 301.8).

The cohesive layer is very stiff to hard in consistency, based on SPT 'N' values ranging from 26 to 31 blows per 0.3 m of penetration. The moisture content varied from 19% to 21%.

Grain size distribution curve for a sample of silty clay till is presented on the Record of Borehole sheet and on Figure B3 of Appendix B. Atterberg Limits test results are presented on Figure B5 of Appendix B.

The results of the laboratory tests are summarized as follows:

Soil Particles	(%)
Gravel	0
Sand	3
Silt	43
Clay	54

Liquid Limit	41
Plastic Limit	17

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

Although not encountered in the borehole, glacial till deposits are known to contain cobbles and boulders.

5.8 Sandy Silt Till

Grey sandy silt till containing trace gravel, some clay and occasional cobbles was contacted below the silty clay till at 10.7 m depth (Elevation 301.8) in Borehole 08-003. Borehole 08-003 was terminated within the sandy silt till at 15.4 m depth (Elevation 297.1).

SPT 'N' values ranged from 111 blows per 0.3 m of penetration to higher than 100 blows per 0.15 m of penetration, indicating a very dense relative density. Moisture content varied from 8% to 10%.

Grain size distribution curve for a sandy silt till sample is presented on the Record of Borehole sheet and on Figure B4 of Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	(%)
Gravel	0
Sand	35
Silt	53
Clay	12

Although not encountered in the borehole, this glacial till layer may contain cobbles and boulders which may account for the high SPT 'N' value.

5.9 Groundwater Conditions

Water level was observed during drilling at 2.7 m depth (Elevation 309.8) in Borehole 08-003. In Boreholes 1 and 7, drilled in 1966, water level was observed at 0.3 m and 1.3 m depth (Elevations 312.8 and 310.2), respectively.

Water level measured in a piezometer installed in Borehole 08-02, located approximately 100.0 m west of Borehole 08-003, was at 5.5 m depth (Elevation 307.0).

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 truck-mounted CME75 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 Ms. Eckie Siu of Thurber, under the direction of Mr. Alastair E. Gorman, P.Eng and Mr. Mark Farrant, P. Eng.

The coordinates for the borehole and the ground surface elevation were determined by Thurber Engineering Ltd. using GPS equipment.

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

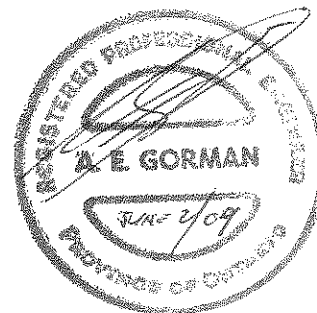
Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects, reviewed the report.

Thurber Engineering Ltd

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

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

Based on Plate 2B of the E.A:

- The proposed E-N Ramp/Wellington Street E/W-N Ramp will pass over the existing Guelph Street.
- Currently, Guelph Street grade at the site is near Elevation 312.5.
- As indicated in Plate 2B, clearance at Guelph Street will be confirmed during detail design. For preliminary purposes, the proposed grade of the E-N Ramp/Wellington Street E/W-N Ramp is expected to be at Elevation 319.0, resulting in a fill approximately 6.0 to 7.0 m high.

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 primarily of native compact to dense sandy silt and silty sand, very stiff to hard clayey silt and silty clay till and very dense sandy silt till. Pavement structure and granular fill were encountered in Borehole 08-003.

Water level was observed at 2.7 m depth (Elevation 309.8) in Borehole 08-003, drilled during the present investigation. Water level measured in a piezometer installed in Borehole 08-002, located approximately 100.0 m west of Borehole 08-003, was at 5.5 m depth (Elevation 307.0). For design purposes, water level elevation of 310.0 is considered in this report.

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

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

8.1 Spread Footings on Native Soil

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

The existing fill encountered in Borehole 08-003 is not considered to be suitable for the support of spread footings and the footings must be placed on the underlying native soils.

The design of spread footings bearing on native undisturbed compact to dense silty sand or sandy silt must be in accordance with the elevation and bearing resistances given in Table 8.1.

Table 8.1 – Bearing Resistances and elevations for Spread Footings

Foundation Unit	Borehole	Depth (m)	Elev.	ULS _r (kPa)	SLS (kPa)
North Abutment	08-003 7	3.0 2.0	309.5	300	200
South Abutment	1	1.5 3.4	311.7 309.8	450 600	300 400

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 elevation presented in Table 8.1 is generally at or below groundwater level observed during the present investigation. For temporary excavations required to construct these footings extending in cohesionless soils below the water table, groundwater control will be required prior to excavation to construct the footings in the dry, to prevent sloughing of the sides and to prevent disturbance of the footing bases due to the inflow of groundwater.

8.2 Spread Footings on Engineered Fill

Spread footings can also be founded on Granular “A” engineered fill pads. These would be most useful in the case of perched abutments on footings.

If an engineered fill pad is used, all deleterious materials and existing fill must be stripped from the footprint of the foundation to expose competent native subgrade material. The engineered fill must bear on native stiff clayey silt or compact silty sand/sandy silt. 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

North Abutment (BH 08-003, BH 7)	South Abutment (BH 1)
310.3	312.2

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 settlements are 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 of $\pm 2\%$. The geometry of the fill pad must conform to the general requirements shown in Figure 1 in Appendix E.

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, sandy silt/clayey silt or sandy silt till encountered at this site. The depth and elevation 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	Borehole	Pile Tip Depth (m)	Highest Pile Tip Elevation
North Abutment	08-003	12.0	300.5
	7	11.0	
South Abutment	1	11.5	301.7

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 sandy silt, sandy silt/silty clay or sandy silt till are presented in Table 8.4.

Table 8.4 – Axial Resistance of One Pile Sections Founded on Very Dense 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 sandy silt till 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 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.

8.5 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.

8.6 Recommended Foundation

From a geotechnical perspective, and based on current information, the recommended abutment foundation consists of steel H-piles driven into the very dense sandy silt and sandy silt till, despite the higher cost noted in Appendix D.

9 BRIDGE APPROACHES AND EMBANKMENTS

Based on the borehole drilled at the site, the approach embankments will be constructed over compact silty sand/sandy silt and may incorporate the silty sand fill of the existing embankment.

Clearance at Guelph Street will be confirmed during detail design. For preliminary purposes, the proposed approach embankments at this site are anticipated to be approximately 6.0 to 7.0 m high.

Preliminary assessment indicates that at the abutments, settlement in the order of 12 mm to 18 mm is estimated in the foundation soils under the loading imposed by approximately 6.0 to 7.0 m of the approach fill. Due to the compact to dense/stiff to hard nature of the foundation soils, these settlements will be immediate and essentially completed when construction of the fill is completed. Further settlement analysis should be conducted during the detail phase design.

No long term settlement or global stability issues are anticipated for approach embankments built at this site.

The approach embankments likely to be constructed will be stable at side slopes of 2H:1V if constructed using SSM or granular fill.

If during the final design phase the 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.

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

During detail design, when the grade has been finalized, permanent drainage (if necessary) and slope protection requirements must be addressed.

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 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.

Accordingly, it must be emphasized to the contractor that proper groundwater and surface water control measures must be in place prior to commencing excavation.

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. Borehole for structure foundations.

Additional borehole may be required for the structure foundations, especially if the structure is built off the current E-N Ramp/Wellington Street E/W-N Ramp over Guelph Street alignment and thus removed from the alignment of the current investigation.

2. Borehole for approaches.

A minimum of one borehole is recommended in each approach fill of the E-N Ramp/ Wellington Street E/W-N Ramp.

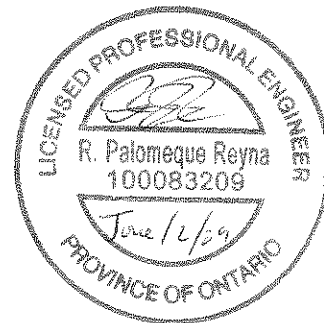
12 CLOSURE

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

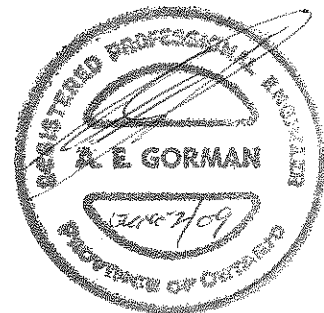
The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

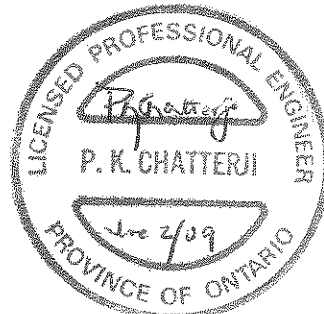
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Appendix A

Record of Borehole Sheet (Present 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

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

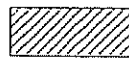

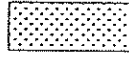


 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (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

ROCK WEATHERING CLASSIFICATION		SYMBOLS			
Fresh (FR)	No visible signs of weathering.	    	CLAYSTONE SILTSTONE SANDSTONE COAL Bedrock (general)		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.				
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.				
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.				
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.				
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.				
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	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Medium bedded	0.2 to 0.6m				
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				
TERMS		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.				
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

METRIC

[illegible]

+ 3 x 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 08-003

2 OF 2

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 757.53 E 226 058.02 ORIGINATED BY ES
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2008.06.04 - 2008.06.05 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							WATER CONTENT (%)		
								20 40 60 80 100									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
							20 40 60 80 100					PLASTIC LIMIT W _P NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L					
301.8	Continued From Previous Page						302										
10.7	Silty CLAY, trace sand Very Stiff Dark Grey (TILL)		9	SS	100/ .150												
	Sandy SILT, trace gravel, some clay, occasional cobbles Very Dense Grey Moist (TILL) Possible cobble at 11.1m		10	SS	114		301										
							300										0 35 53 12
			12	SS	111		299										
							298										
297.1			13	SS	100/ .175												
15.4	END OF BOREHOLE AT 15.4m. BOREHOLE OPEN AND WATER LEVEL AT 2.7m UPON COMPLETION. BOREHOLE BACKFILLED WITH GROUT TO 9.2m, BENTONITE TO 0.1m, THEN ASPHALT TO SURFACE.																

+ 3 . × 3

Numbers refer to
Sensitivity

20
15 5
10

(%) STRAIN AT FAILURE

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

JOB 66-P-57

W.P. 638-64

DATUM Geodetic

RECORD OF BOREHOLE NO. 1

FOUNDATION SECTION

LOCATION N 204.340.7 53, E 210.398.892

ORIGINATED BY D.T.W.

BORING DATE June 9-13, 1966

COMPILED BY S.S.

BOREHOLE TYPE Washboring and Cone Penetration

CHECKED BY K.G.S. *KS*

SOIL PROFILE		STRAT. PLOT	SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W	BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE		SHEAR STRENGTH P.S.F.				
1027.4	Groundlevel	1	SS	33	1020				

1026.2
Sa 9%
Si 87%
Cl 4%

Sa 0%
Si 60%
Cl 40%

Gr 9%
Sa 15%
Si 36%
Cl 40%

SOIL PROFILE		STRAT. PLT.	SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT % — W	REMARKS
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE				
0.0	Groundlevel				1020			Sa 34% Si 61%
0.0	Silty fine sand with occasional clay.		1	SS 14				Cl 5%
	Compact to dense.		2	SS 42				$\gamma = 1017.7$
10.0			3	SS 32	1010			
12.0	Clayey silt with pockets of silt and traces of coarse sand.		4	SS 35				Sa 5%
			5	SS 28				Si 51%
	Stiff to hard.		6	SS 34	1000			Cl 44%
992.0			7	SS 57				
30.0	Sandy silt with traces of gravel and clay.		8	SS 104	990			Gr 19%
	Very dense.		9	SS 105	986"			Sa 33%
961.6			10	SS 75	980			Si 39%
50.4	End of borehole.		11	SS 120	970"			Cl 9%
			12	SS 100	970"			

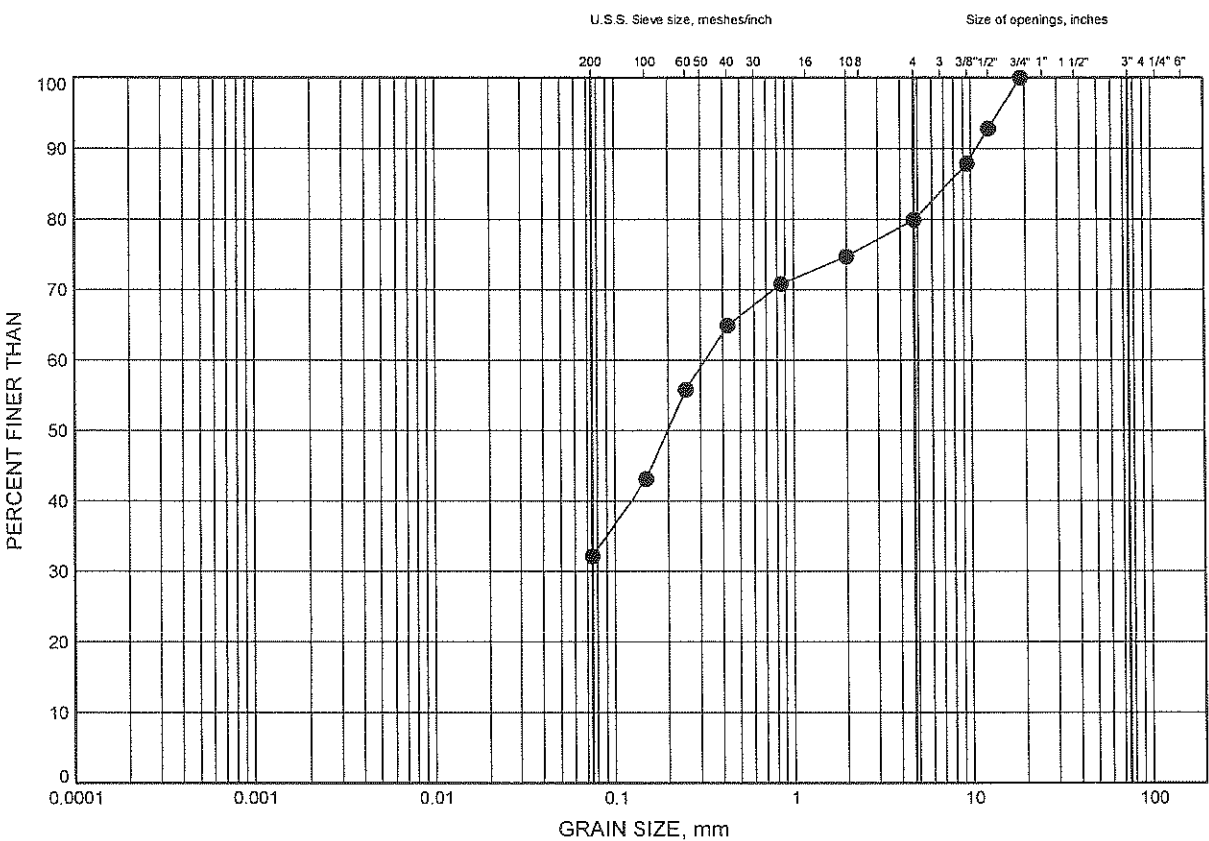
Appendix B

Laboratory Test Results

Highway 7 - New
GRAIN SIZE DISTRIBUTION

FIGURE B1

Silty Sand Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-003	1.07	311.43



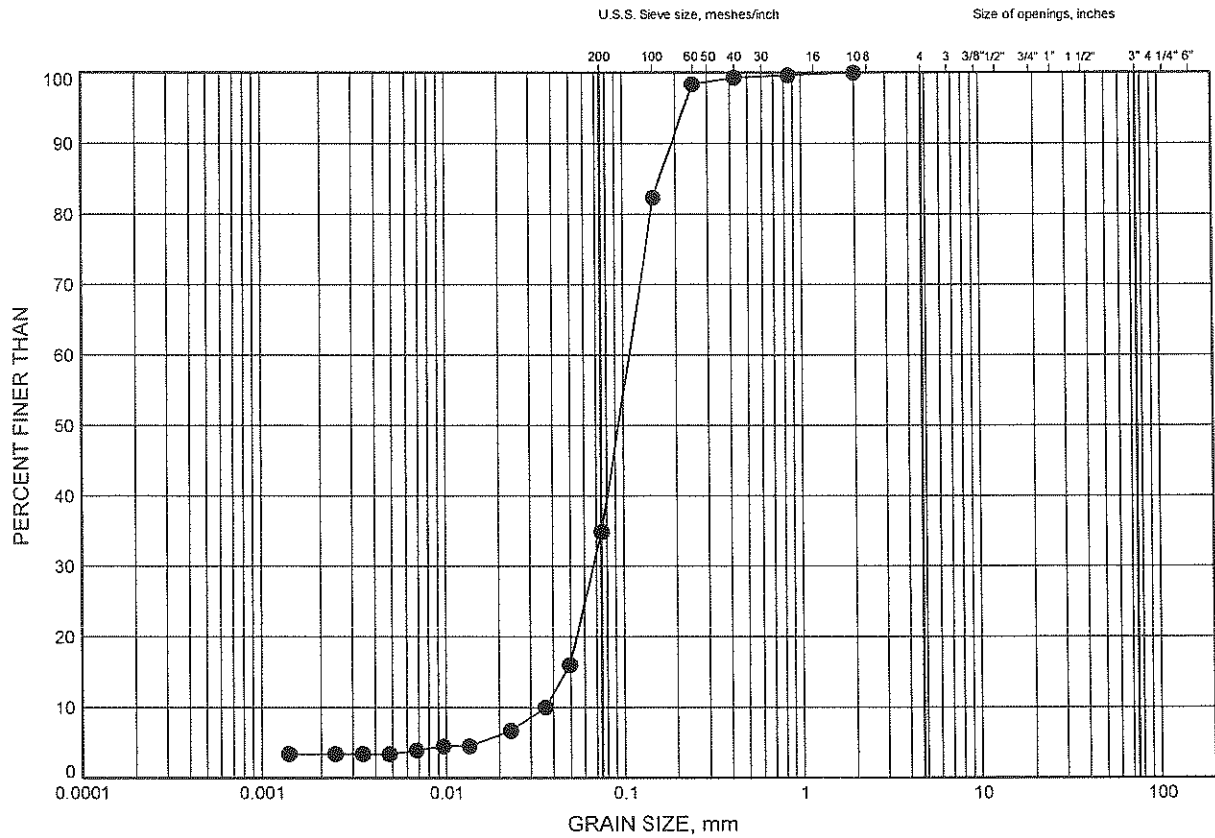
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 9/15/08

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

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B2

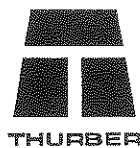
Silty Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-003	4.88	307.62

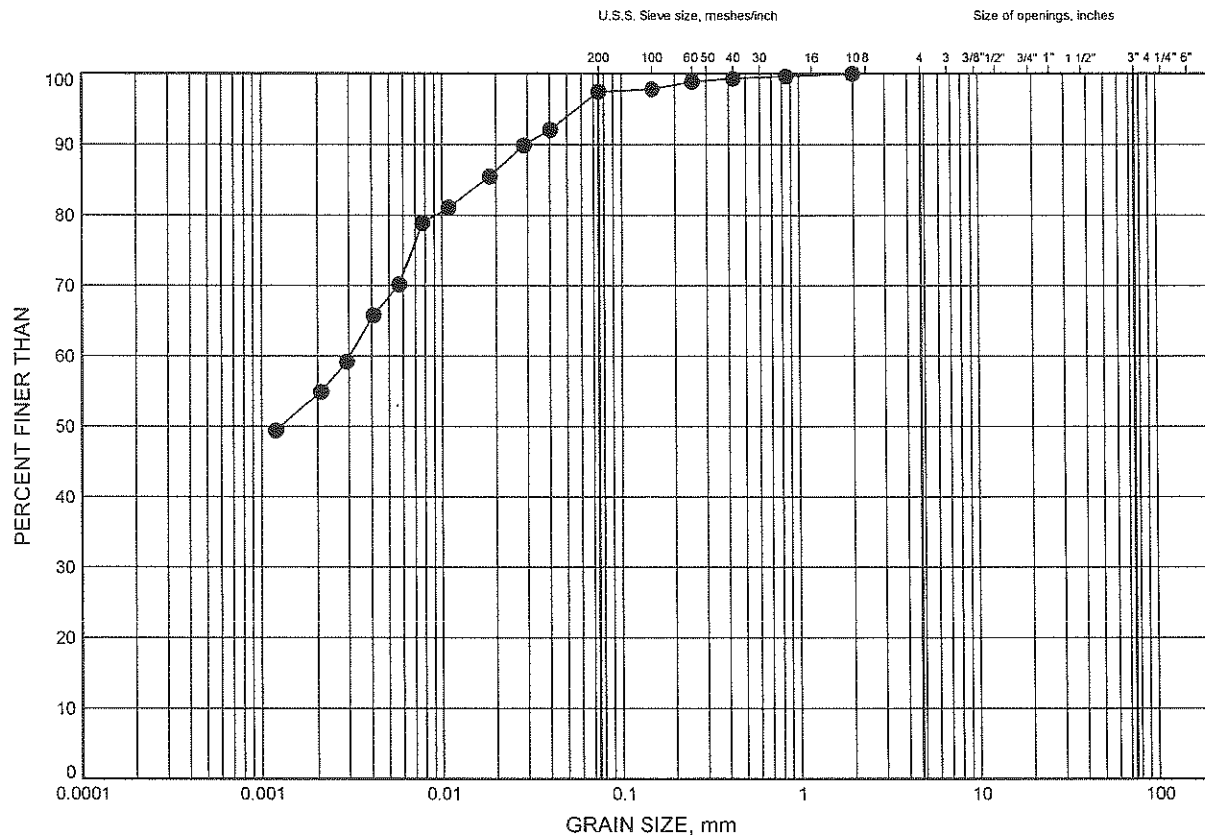


W.P.# .408-88-00.....
Prepared By .MFA.....
Checked By .RPR.....

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B3

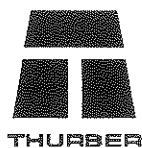
Silty Clay Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-003	7.92	304.58

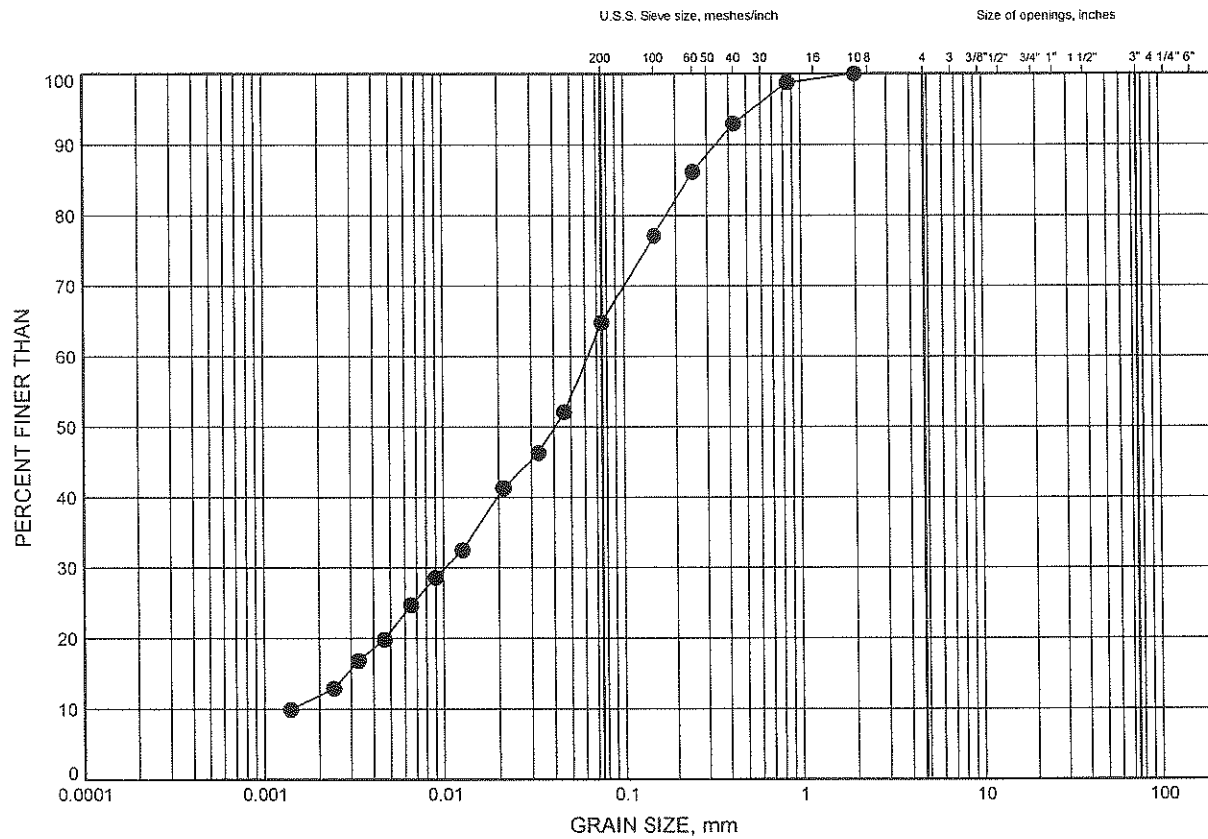


W.P.# 408-88-00
Prepared By MFA
Checked By RPR

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B4

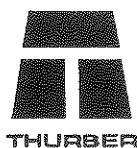
Sandy Silt Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-003	12.42	300.08

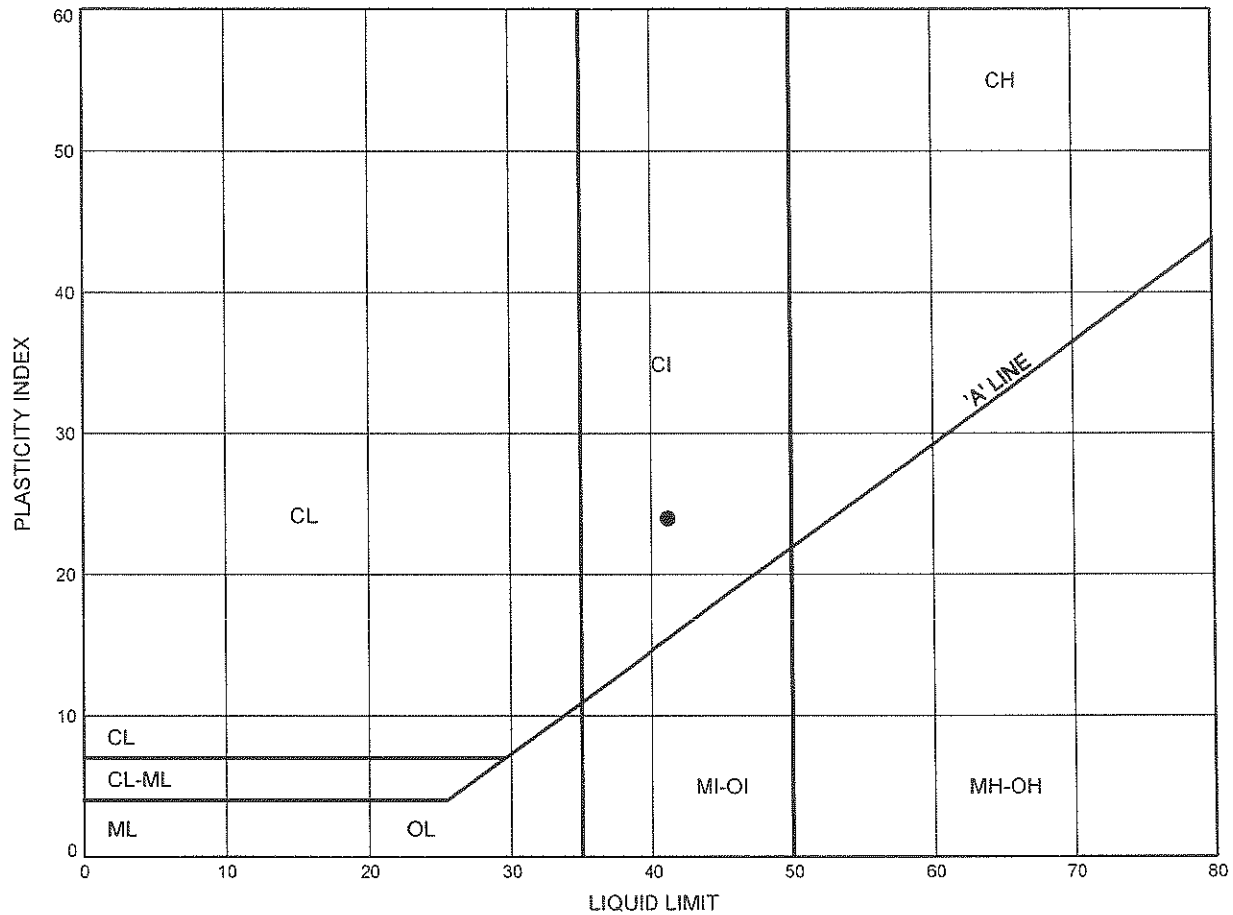


W.P.# 408-88-00
Prepared By MFA
Checked By RPR

Highway 7 - New ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty Clay Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-003	7.92	304.58

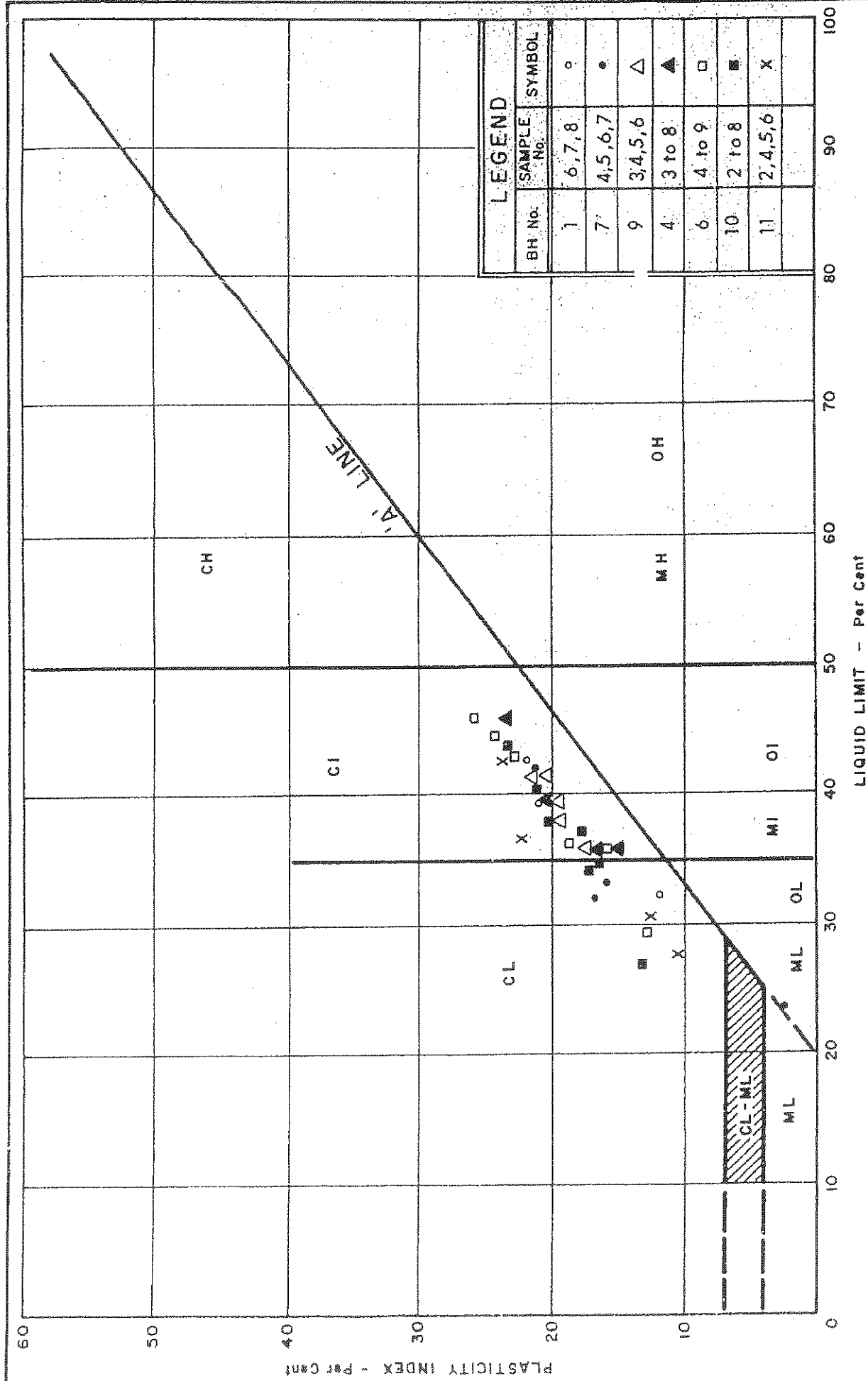
Date September 2008
 Project 408-88-00



Prep'd MFA
 Chkd. RPR

Appendix C

Record of Borehole Sheets (Previous Investigation)



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION



ONTARIO

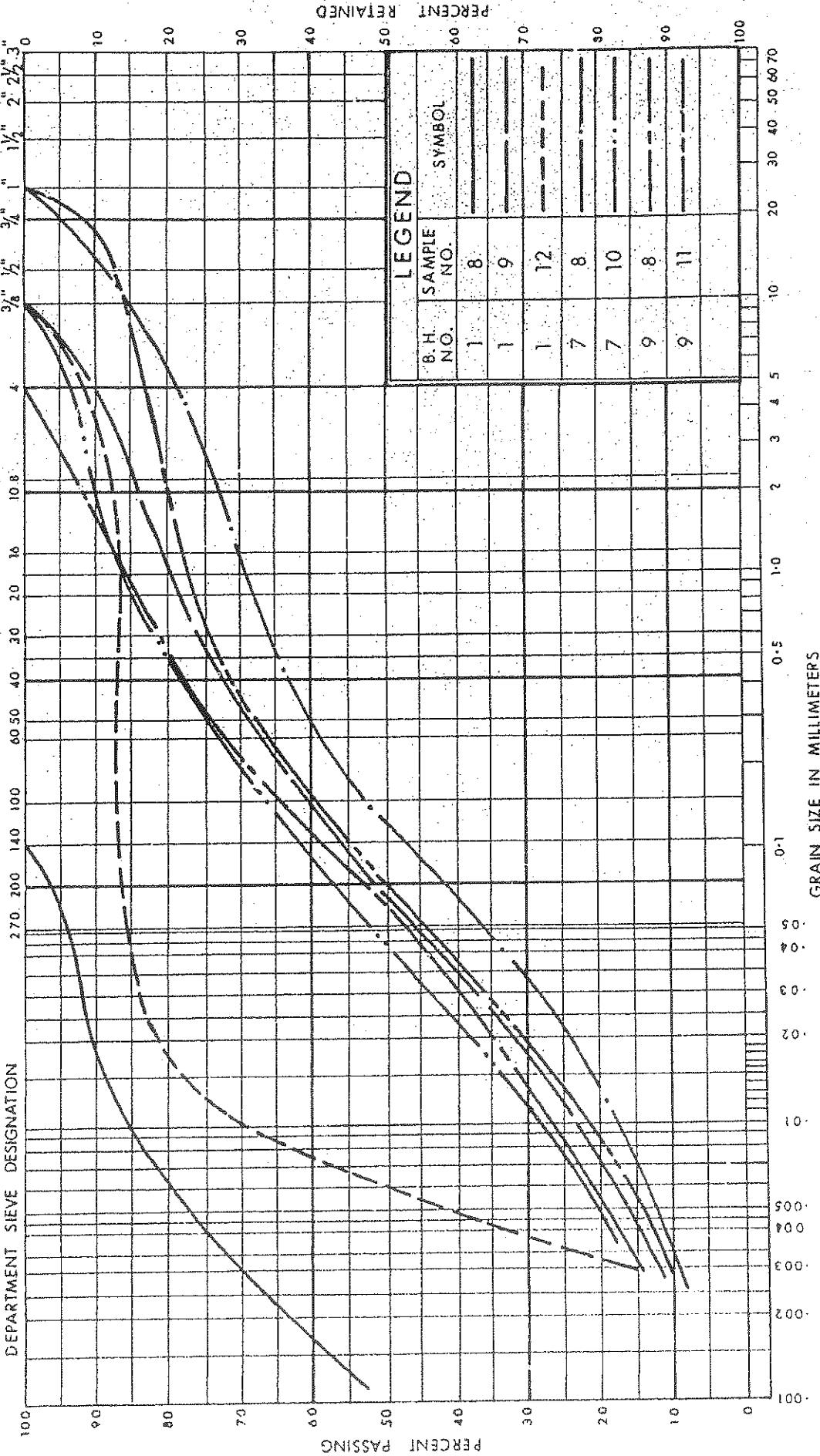
PLASTICITY CHART SILTY CLAY WITH TRACES OF SAND

WP No. 638-64

JOB No. 66-F-57

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND				GRAVEL	
	Fine		Medium	Coarse	Fine	Coarse



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION



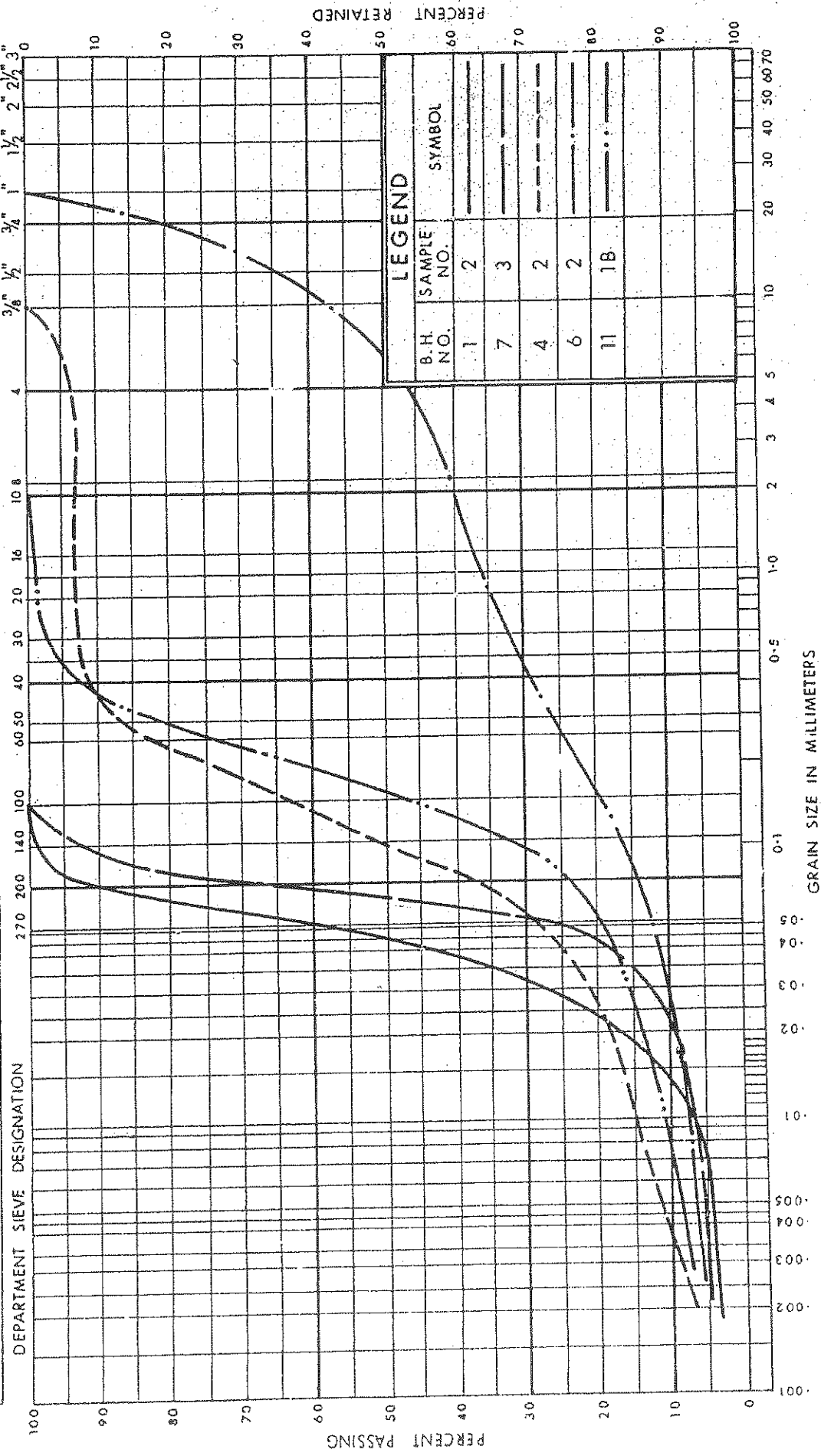
ONTARIO

GRAIN SIZE DISTRIBUTION
SILTY SAND
WITH TRACES OF GRAVEL & SAND

W.P. No. 638-64
JOB No. 66-F-57

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND					GRAVEL				
	Fine		Medium			Coarse		Fine		
	100	60	30	20	10	4	10.8	3/8"	1/2"	3/4"
	270	200	140	100	60	40	30	20	16	12.5
	20	10	5	2.5	1.25	0.6	0.3	0.15	0.075	0.0375



GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILTY SAND
WITH TRACES OF GRAVEL & CLAY

DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION



W.P. No. 638-64
JOB No. 66-F-57

- E-N Ramp/ Wellington St. E/W-N Ramp over Guelph St.
Highway 7-New, Kitchener to Guelph
-

Appendix D

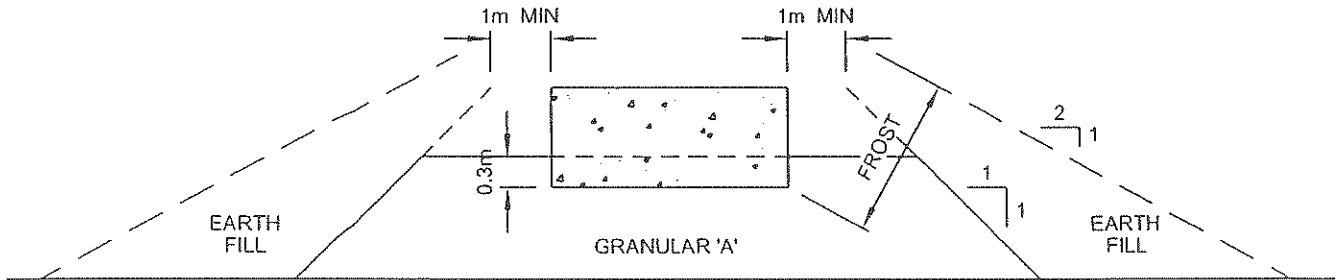
Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

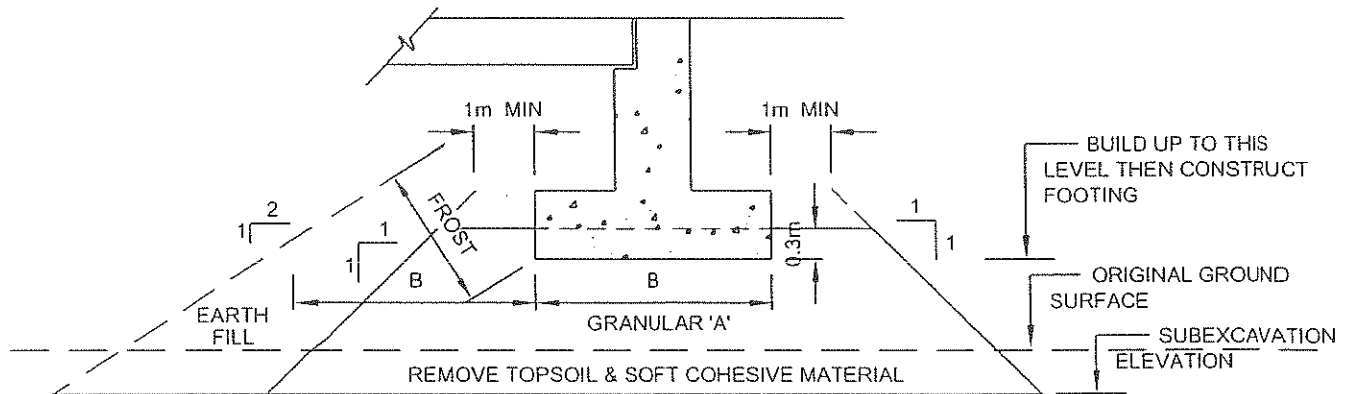
Foundation Element	Spread Footings	Spread Footings on Engineered Fill	Driven Piles
Abutments	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Lower geotechnical resistance available due to founding on compact soils near the surface. ii. 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 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.
	NOT RECOMMENDED	NOT RECOMMENDED	RECOMMENDED

Appendix E

Figure



CROSS-SECTION



LONGITUDINAL SECTION

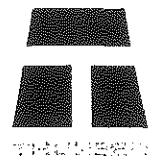
NOT TO SCALE

NOTES:

1. REMOVE TOPSOIL AND SOFT SILTY CLAY SUBSOIL UNDER FOOTPRINT OF COMPACTED GRANULAR 'A'.
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
DRAWN	SS
DATE	April , 2004
APPROVED	PKC
SCALE	NTS

ABUTMENT ON COMPACTED FILL SHOWING
GRANULAR A CORE



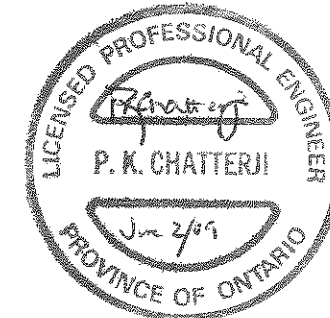
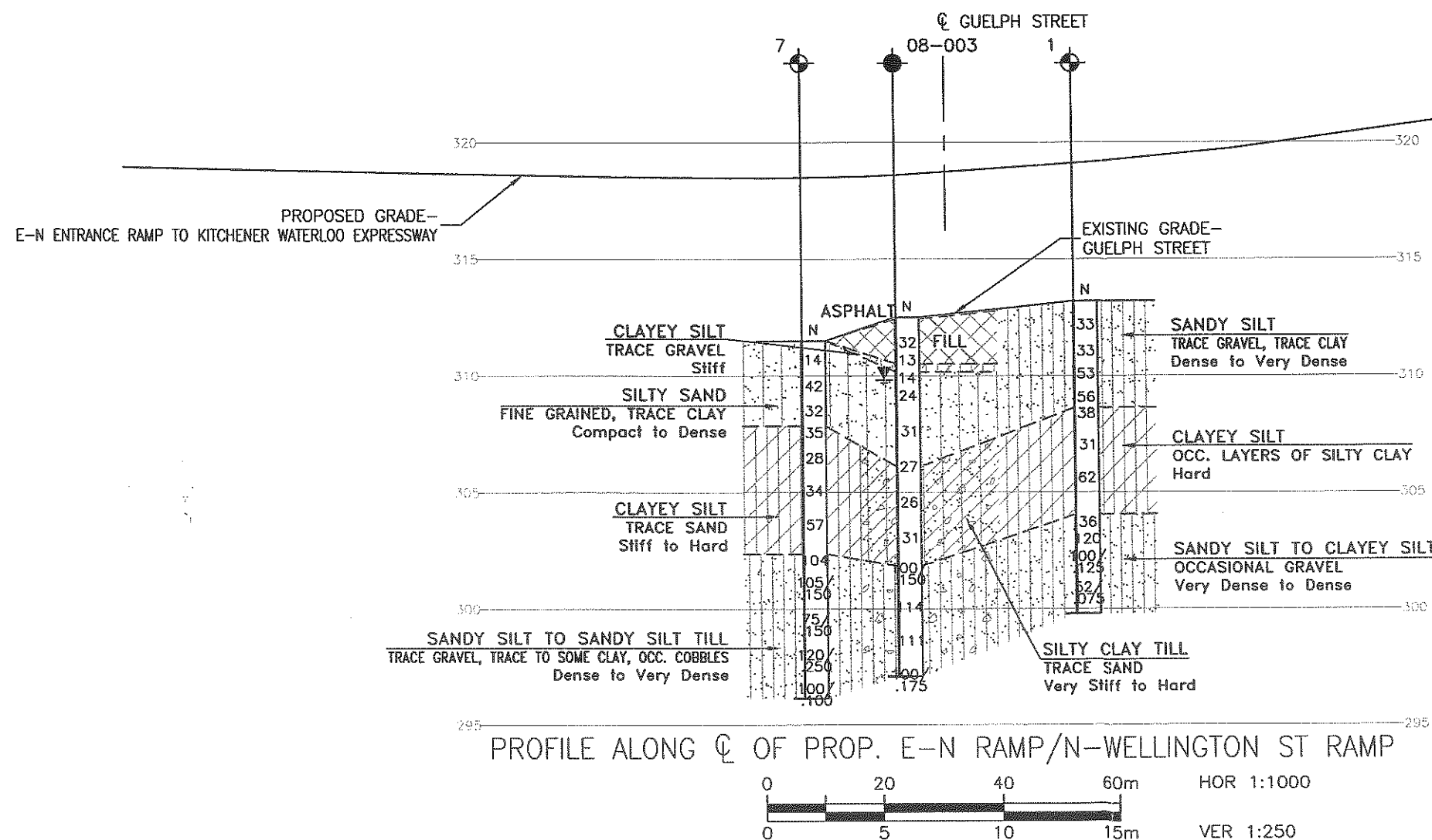
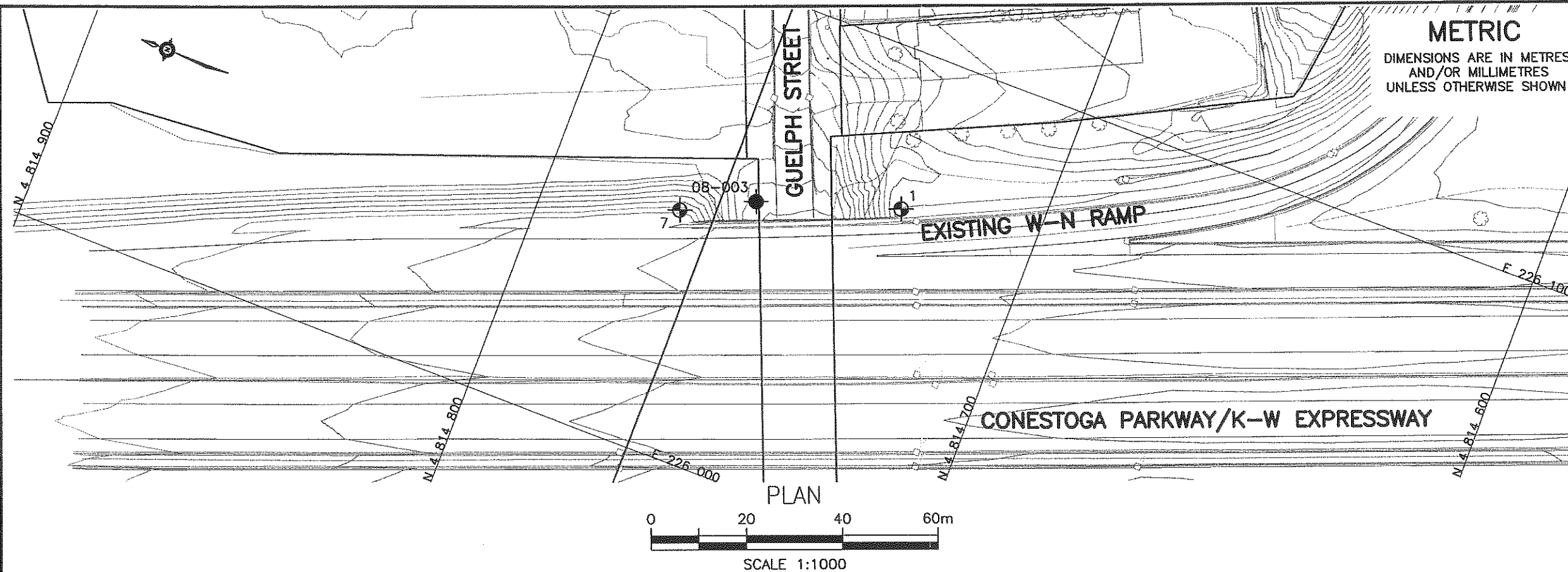
DWG. NO.

FIGURE 1

E-N Ramp/ Wellington St. E/W-N Ramp over Guelph St.
Highway 7-New, Kitchener to Guelph

Appendix F

Drawing titled "Borehole Location and Soil Strata"



CONT No
GWP No 408-88-00

HIGHWAY 7
RECOMMENDED ROUTE
E-N RAMP/N-WELLINGTON ST RAMP OVER GUELPH ST
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
08-003	312.5	4 814 757.5	226 058.0
1	313.2	4 814 728.7	226 067.4
7	311.5	4 814 771.9	226 050.5

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. 40P8-165

REVISIONS		DATE		BY		DESCRIPTION		DATE	
DESIGN	AEG	CHK	PKC	CODE	LOAD	DATE	JUN, 2009		
DRAWN	MFA	CHK	AEG	SITE	STRUCT	DWG			