



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 401/COUNTY ROAD 30 INTERCHANGE
W-N/S RAMP AND PROCTOR CREEK CULVERT
BRIGHTON, ON
G.W.P. 4016-13-01**

GEOCRES NO. 31C-268

Report

to

AECOM

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the design and construction of the proposed: (1) realignment of the W-N/S Ramp embankment at Highway 401-County Road 30 interchange, (2) Proctor Creek Culvert under the realigned W-N/S Ramp, and (3) realignment of the Proctor Creek south of Highway 401, Brighton, Ontario. Thurber was retained by AECOM to carry out the foundation investigation at this site on behalf of the Ministry of Transportation Ontario (MTO).

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, provide borehole location and soil strata drawings with stratigraphic profile and cross-section(s), records of boreholes, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained during the course of the present investigation.

In the preparation of this report and in addition to the boreholes drilled under the current assignment, reference has been made to factual information contained in two previous reports titled "Draft Foundation Investigation and Design Report, W-N/S Ramp High Fill Embankment, Highway 401-County Road 30 Interchange, Ramp and Grade Improvements, G.W.P. 256-98-00, prepared by Golder Associates (Golder), dated November 2007; Geocres No. 31C-182" [Reference 1] and "Draft Foundation Investigation and Design Report, Culverts, Highway 401-County Road 30 Interchange, Ramp and Grade Improvements, G.W.P. 256-98-00, prepared by Golder Associates (Golder), dated November 2007; Geocres No. 31C-180" [Reference 2].

2 SITE AND PROJECT DESCRIPTION

The project site is located south of the existing W-N/S Ramp in the southwest quadrant of the Highway 401-County Road 30 interchange near Brighton, Ontario. The site location is shown on



the key plan on drawings provided in Appendix D.

This project involves realignment of the W-N/S Ramp, as part of the Highway 401-County Road 30 interchange improvement works. There were no concerns with the performance of the existing ramp or farm access road. However, MTO's intent is to ultimately widen Highway 401 through this area in the next 5 to 10 years. In preparation for the widening, the existing ramp and farm access road will be relocated to the south to accommodate the future widening of Highway 401.

The new ramp embankment will be constructed partially over the existing farm access road embankment. The high fill embankment portion of the realigned W-N/S Ramp will extend from approximately Station 10+220 to 10+480, and will range in height from about 4.5 m to a maximum of 9.0 m near Proctor Creek at approximately Station 10+420.

The area south of the existing W-N/S Ramp is a private farmland moderately covered by grass with scattered trees and shrubs. Proctor creek in the area flows in a meandering course from north to south. Adjacent to the creek is a floodplain with a natural terrain generally sloping towards the south.

From published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984), the site lies within the physiographic region known as Iroquois Plain. The Iroquois Plain generally consists of glacio-lacustrine sand and silty sand. The soil deposit is underlain by limestone bedrock.

3 INVESTIGATION PROCEDURES

The site investigation for this project was carried out between October 20 and October 21, 2016 during which time a total of six (6) boreholes denoted as Boreholes R16-01 to R16-06 were advanced to depths ranging from 5.2 m to 9.8 m (see Table 3.1).

Boreholes R16-01 to R16-04 were advanced within the footprint of the proposed W/N-S Ramp embankment between approximately Stations 10+305 and 10+395. Borehole R16-05 was advanced near the outlet of the proposed Proctor Creek Culvert under the new realigned ramp embankment. Borehole R16-06 was advanced south of the new ramp embankment near the existing Proctor Creek. The coordinates and elevations of the boreholes are given on the individual Record of Borehole Sheets in Appendix A and on the Borehole Locations and Soil Strata Drawings in Appendix D. The approximate locations of the boreholes are also shown on the Borehole Locations and Soil Strata Drawing provided in Appendix D.

The borehole investigation was carried out using a CME-55 track-mounted drilling rig supplied



and operated by George Downing Estate Drilling Ltd. of Hawkesbury, Ontario. Hollow stem auger drilling techniques were used to advance the boreholes. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT).

Table 3.1 – Borehole Details

Borehole Number	Approximate Station	Approximate Ground Elevation (m)	Borehole Termination Depth (m)	Borehole Termination Elevation (m)
R16-01	10+305	192.5	5.2	187.3
R16-02	10+330	190.8	5.2	185.6
R16-03	10+340	189.7	5.2	184.5
R16-04	10+395	191.1	5.2	185.9
R16-05	–	189.0	9.8	179.2
R16-06	–	188.3	6.7	181.6

Groundwater conditions were observed in the open boreholes throughout the drilling operations. Upon completion of drilling, the boreholes were backfilled in general accordance with Ontario Regulation 903.

The field work was supervised on a full-time basis by a member of Thurber's technical staff who marked/staked the boreholes in the field, arranged for the clearance of buried utilities, directed the drilling, sampling and in-situ testing operations, logged the boreholes and processed the recovered soil and rock samples for transport to Thurber's Oakville laboratory for further examination and testing.

4 LABORATORY TESTING

Geotechnical laboratory testing was carried out at Thurber's Oakville laboratory. All recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected samples were also subjected to grain size distribution analysis (hydrometer and/or sieve analysis) and Atterberg Limits testing, where appropriate. Laboratory testing results are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B. The Record of Borehole sheets from the previous investigation conducted by Golder are included in Appendix C.

5 DESCRIPTION OF SUBSURFACE CONDITIONS



Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix A and on the Borehole Locations and Soil Strata drawings in Appendix D. A general description of the stratigraphy, based on the conditions encountered in the current boreholes and in the boreholes conducted by Golder, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. Reference should be made to Golder's Reports (References 1 and 2) for details of soil conditions encountered in Golder's boreholes. It should be recognized and expected that soil conditions may vary between and beyond borehole locations.

In general, the subsurface stratigraphy encountered in all boreholes consists of surficial topsoil and/or very loose to loose fill overlying a native deposit of very loose to compact silty sand to silt followed by a compact to very dense till layer or compact to very dense sand and gravel to gravelly sand layer. The groundwater table encountered within open boreholes was found at approximate Elevations in the range of 186.8 m and 190.2 m. The soil stratigraphy encountered in the current investigation is generally consistent with those in the previous reports. A description of each major stratigraphic layer is provided below.

5.1 Topsoil

A layer of surficial topsoil with a thickness ranging from 75 mm to 150 mm was encountered in Boreholes R16-02, R16-03, R16-05, and R16-06.

5.2 Silty Sand Fill

A fill layer consisting of silty sand containing some gravel and silt, trace clay, and trace to some rootlets and organics was encountered at the surface in Boreholes R16-01 and R16-04. The thickness of the silty sand fill layer varied between 0.5 m and 0.6 m with base elevation of 190.5 to 192.0 m. The measured moisture contents within the fill was 10%.

Clayey silt fill and sand and gravel fill were encountered in Golder's Boreholes 07-1 and 07-8. Details of these fill materials are provided in the borehole logs included in Appendix C.

The result of grain size distribution analysis carried out on selected samples of the silty sand fill is presented on the Record of Borehole Sheets included in Appendix A and on Figure B1 of Appendix B. The results of the grain size distribution analyses are summarized below:



Soil Particle	Percentage (%)
Gravel	14-19
Sand	56-58
Silt	18-24
Clay	4-7

5.3 Peat

A 0.3 m to 0.7m thick layer of black peat was encountered below the existing fill in Boreholes R16-01 and R16-04 and below the topsoil in Boreholes R16-02, R16-03 and R16-05. The base elevation of the peat layer varied between approximately 188.2 m and 191.6 m.

SPT 'N' values recorded in this peat layer ranged between 1 and 2 blows per 0.3 m of penetration. Measured moisture contents within this layer varied between 30% and 65%.

5.4 Silty Sand to Silt

A native deposit of silty sand to silt with trace to some gravel and trace to some clay was encountered below the fill layer or the peat layer in all boreholes. The thickness of this layer in Boreholes R16-01 to R16-03 varied from 1.2 m to 3.6 m (base Elev. varied between 185.6 m and 190.4 m). This deposit was also encountered in Boreholes R16-04 to R16-06 below the peat layer or topsoil layer. Boreholes R16-04 to R16-06 were terminated within this silty sand to silt layer at elevation ranging from approximately 179.2 m and 185.9 m. Trace to some organics and wood fragments were also observed within this layer in Boreholes R16-01 and R16-03.

SPT 'N' values recorded in this layer ranged from 1 to 26 blows per 0.3 m penetration, indicating a very loose to compact condition. Measured moisture contents within this layer varied between 10% and 48%.

The results of grain size distribution analyses carried out on selected samples of this layer are presented on the Record of Borehole Sheets included in Appendix A and on Figure B2 and B4 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0 to 15
Sand	2 to 67
Silt	29 to 82
Clay	4 to 16



5.5 Sand and Gravel

A deposit of sand and gravel with trace silt and clay was encountered in Boreholes R16-02 and R16-03 underneath the silty sand to silt layer. Boreholes R16-02 and R16-03 were terminated within the sand and gravel layer at an Elevation of approximately 185.6 m and 184.5 m respectively.

SPT 'N' values recorded in this layer varied between 19 and 25 blows for 0.3 m of penetration, indicating a compact relative density. Measured moisture contents were approximately 8%.

The results of grain size distribution analysis carried out on one selected sample of this layer is presented on the Record of Borehole Sheets included in Appendix A and on Figures B3 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	40
Sand	47
Silt and Clay	13

5.6 Clayey Silt Till

A cohesive till layer of clayey silt with sand and trace gravel was encountered below the silty sand to silt layer in Borehole R16-01. Borehole R16-01 was terminated within the clayey silt till at an Elevation of approximately 187.3 m.

SPT 'N' values within the cohesive clayey silt till layer ranged from 10 to 33 blows per 0.3 m of penetration, indicating a stiff to hard consistency. The measured moisture contents of selected samples of this cohesive layer varied between 9% and 15%.

The results of grain size distribution analyses carried out on representative samples of the cohesive clayey silt till are presented on the Record of Borehole Sheets included in Appendix A and on Figure B5 of Appendix B. The results of the grain size distribution analysis are summarized below.

Soil Particle	Percentage (%)
Gravel	5 to 8
Sand	33 to 37
Silt	37 to 42
Clay	18 to 20

The results of an Atterberg Limits analysis carried out on one sample of the clayey silt till is



presented on the Record of Borehole sheets in Appendix A and on Figure B6 Appendix B. The results are summarized below.

Index Property	Percentage (%)
Plastic Limit	12
Liquid Limit	18

The results of the Atterberg Limits testing indicate the layer to be of low plasticity with group symbol CL-ML.

5.7 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. The groundwater levels measured in the current boreholes and Golder's boreholes are summarized in Table 5.9 below:

Table 5.9 – Groundwater Levels

Borehole	Date	Water Level below G.S. (m)		Remark
		Depth	Elevation	
07-1	7 May 2007	2.1	188.3	Open Borehole
07-2	8 May 2007	1.0	189.9	Open Borehole
07-3	8 May 2007	- 3.0 (Artesian)	195.7	In Piezometer upon completion of installation
07-5	10 May 2007	2.7	190.7	Open Borehole
07-6	9 May 2007	Dry		Open Borehole
07-7	10 May 2007	1.5	191.7	In Piezometer
	11 May 2007	0.0	193.2	
07-8	10 May 2007	1.8	194.6	Open Borehole
07-9	11 May 2007	0.7	188.5	Open Borehole
07-11	14 May 2007	Artesian	> 190.0	Open Borehole
R16-01	20 Oct 2016	Dry		Open Borehole
R16-02	20 Oct 2016	0.6	190.2	Open Borehole
R16-03	20 Oct 2016	1.5	188.2	Open Borehole
R16-04	20 Oct 2016	2.1	189.0	Open Borehole
R16-05	21 Oct 2016	1.5	187.5	Open Borehole
R16-06	21 Oct 2016	1.5	186.8	Open Borehole

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



6 MISCELLANEOUS

Thurber marked and/or staked the borehole locations in the field and obtained buried utility clearances prior to drilling.

Geotechnical laboratory testing was carried out at Thurber's MTO approved high complexity laboratory in Oakville.

George Downing Estate Drilling Ltd. supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation.

The field investigation was supervised on a full-time basis by a member of Thurber's technical staff. Compilation of data and preparation of the report was carried out by Cory Zanatta, P.Eng. and Keli Shi, P. Eng. The report was reviewed by Mr. Jason Lee, P.Eng. and Dr. P.K. Chatterji, P.Eng., MTO designated principal contact.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report provides interpretation of the geotechnical data in the factual report and presents geotechnical recommendations to assist the design team in the design of the proposed realignment of the W-N/S Ramp at Highway 401-County Road 30 interchange, Brighton, Ontario. As part of the W-N/S Ramp re-alignment, a new culvert will be constructed to carry Proctor Creek under the new re-aligned ramp embankment, and re-alignment of Proctor Creek downstream of the new culvert is also proposed.

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

Based on the preliminary embankment cross section drawings (dated October 2015) provided by AECOM to Thurber, the high fill embankment portion of the realigned W-N/S Ramp will extend from approximately Station 10+220 to 10+480, and will range in height from about 4.5 m to a maximum of approximately 9.0 m near Proctor Creek at approximately Station 10+420. The Proctor Creek Culvert General Arrangement (GA) drawing (dated October 2017) indicates that the new culvert will comprise a single closed concrete box. The proposed box will have a 6.0 m wide and 2.2 m high opening. The thickness of the base, roof and side walls of the culvert is shown to be 510 mm on the GA drawing. The overall length is 38.4 m. It is our understanding that consideration is being given to using rock fill for construction of the new high fill embankment to minimize encroachment into the Proctor Creek floodplain in this area.



8 HIGH FILL EMBANKMENT

8.1 Settlement

Settlement of the new W-N/S ramp fill embankment was analysed using the commercial software Settle^{3D} developed by Rocscience. It was assumed that the new embankment fill would be placed over the existing fill and peat deposits, and peat should be removed from fill widening area. Where rock fill is used for construction of the new W-N/S, the settlement of the foundation soils under the ramp fill embankment is expected to range between 75 mm and 110 mm based on 4.5 to 9.0 m of new fill. It is expected that a portion of this settlement, approximately 20 to 30 mm, will occur in the buried peat.

It is expected that the above settlements will occur during fill placement and within approximately 2 months following the completion of the embankment construction. Therefore, it is recommended that the final paving be delayed for 2 months following completion of the embankment construction. The embankment platform should be overbuilt to accommodate the estimated foundation settlement.

For embankments constructed with compacted rock fill, the post-construction settlement due to self-compression of the fill may be estimated for design purposes based on the following criteria:

- 0.45% of fill height for embankment height up to 5 m;
- 0.63% of fill height for embankment height between 5 m and 10 m.

For embankments constructed with compacted granular fill, the post-construction settlement due to self-compression of the fill may be estimated assuming 0.35% of the fill height.

It is anticipated that the post-construction settlement of the ramp embankment will be in the order of 50 to 70 mm in 20 years following construction, which meets the criteria set out in the document "Embankment Settlement Criteria for Design - MTO (dated July 2, 2010); Table 1.1 - Category: Freeways on Compressible Soils" with a maximum settlement limit of 100 mm over 20 years. This estimated post-construction embankment settlement includes the long-term compression of the embankment fills and secondary consolidation of the peat layer. The differential settlement along the new embankment is estimated to be less than 200:1, which is within the acceptable range.

The estimated magnitudes and rates of settlement are considered approximate and may vary along and across the ramp alignment subject to the thickness of compressible layers at particular locations, variations in the consolidation characteristics of the peat deposits with depth and location, layer boundary conditions, variations in the relative density of cohesionless soils, the presence or organics or silt/clay/sand partings within the various strata, the height of the embankment, and degree of compaction achieved in the fill.



8.2 Slope Stability

Based on the embankment configurations provided by AECOM, limit equilibrium global stability analyses were carried out for the most critical slope angle at station 10+400. The stability analyses were carried out using the commercially available slope stability program GEO-SLOPE and employing the Morgenstern-Price method of slices for limit equilibrium.

As per MTO practice, a minimum Factor of Safety of 1.3 is acceptable for maintaining global stability for highway embankment founded on predominantly cohesionless foundation soils.

The geotechnical parameters used in the stability analyses were determined from the in-situ testing conducted during the field investigation and/or estimated from soil index correlations. The groundwater level was assumed to be at approximately the existing ground surface as observed in the open boreholes and standpipe piezometer. As per Golder's report (Appendix C), an artesian condition was observed within the very dense sand and gravel layer at borehole 07-03. The artesian conditions reported within the very dense sand and gravel layer in Golder's boreholes have been considered in the slope stability analyses. The global stability of the proposed ramp embankment is found to be governed by the very loose to compact silty sand to sandy silt layer near surface.

Two configurations of the cross-section at 10+400 were analysed with the first configuration assuming granular fill and a 2 m wide mid-height berm with a slope angle of approximately 2H:1V, the second configuration assuming rock fill at a steeper slope of 1.25H:1V.

Global stability analyses were carried out under static and seismic conditions. The shear strength parameters and the results of the stability analyses for the case of earth fill and rock fill under static conditions are shown on Figures E1 and E2, respectively, in Appendix E. The results of the stability analyses under the seismic conditions are presented in Figures E1A and E2A, respectively, in Appendix E. The analyzed cases have achieved an acceptable factor of safety greater than 1.3 under static conditions and 1.0 under seismic conditions.

9 EMBANKMENT CONSTRUCTION

Construction of the new W-N/S Ramp embankment should be carried out in accordance with OPSS.PROV 206. The embankment material should consist of Granular A or B Type II material conforming to OPSS.PROV 1010. Excavated granular fill may be reused as backfill provided the following conditions are satisfied:

- There is sufficient space to stockpile on site and control moisture content within acceptable limits for compaction;



- No topsoil, peat/organics or asphalt pavement material are included in the fill;
- Gradation and compaction characteristics meet the requirements prior to reuse as backfill.

Earth fill consisting of silt and clay materials are not recommended for embankment construction at this site due to potentially higher post construction settlement, difficulties in achieving the specified compaction and potential embankment stability issues.

Embankment construction using granular fill or rock fill shall be as per OPSS.PROV 206.

It is understood that steeper embankment side slopes may be necessary for the construction of the embankments to remain within the MTO's Right of Way (ROW) between Stations 10+320 and 10+440. In this area, rock fill may be used for embankment construction. The top of the rock fill should be properly chinked before placing any granular fill for the pavement structure as per OPSS.PROV 206.

Prior to fill placement, the subgrade must be adequately prepared to receive the fill. Within the new W-N/S Ramp embankment footprint, all vegetation, topsoil, peat, organics, soft/loosened or wet soils should be sub-excavated. Part of the new ramp embankment will be constructed over the existing embankment fill. Sub-excavation of the peat layer buried under the existing fill is not required. All subgrade should be inspected and approved prior to placing fill.

Vegetation cover should be established on all exposed earth slopes for protection against surficial erosion. Reference should be made to OPSS.PROV 804. Erosion and sediment control should also be implemented with reference to OPSS 805. Surface runoff from the roadway and precipitation must be prevented from flowing perpendicularly down any slope surface.

Mid-height berms comprising 2 m wide benches should be incorporated along the length of embankments with heights at or exceeding 8 m in granular fill and 10 m in rock fill. Where new embankment fill is placed against existing embankment slopes or on a sloping ground surface steeper than 3H:1V, the existing earth or fill slope must be benched in accordance with OPSD 208.010.

10 CULVERT FOUNDATION

The proposed realignment of the W-N/S ramp will require construction of a new Proctor Creek culvert to carry the flow through the new ramp embankment. The subsurface conditions encountered at the location of the new proposed culvert consisted of fill and peat overlying a deposit of very loose to compact silt to silty sand.

It is understood that the existing culvert is a reinforced concrete box, approximately 3.2 m wide and 1.8 m high. The new proposed culvert will be approximately 6.0 m wide, 38.4 m long, with



invert elevations of 188.3 m and 188.2 m at the inlet and outlet, respectively.

Construction of the replacement culvert will require temporary diversion of the creek flow and implementation of a dewatering scheme prior to excavating below the groundwater table and to permit subgrade preparation and bedding placement in the dry. Construction staging must be carefully planned considering that the existing culvert will be replaced by the new culvert along the same alignment.

10.1 Settlement Under the New Culvert

The proposed culvert will have a fill cover up to 7.5 m from the new W-N/S ramp embankment. The estimated maximum ground settlement along the base of the new culvert is in the order of 90 mm. The estimated settlement profile along the new culvert alignment is presented in Appendix G. The culvert may be designed with a camber to accommodate the estimated settlement. Considerations should also be given to oversizing the culvert to accommodate the settlement.

It is expected that the foundation settlement under the new culvert will occur during the fill construction and will be essentially complete at the completion of the ramp fill construction.

10.2 Culvert Alternatives

Culvert alternatives that were considered for the culvert replacement at this site are listed below:

- Precast concrete or cast-in-place box culvert (closed)
- Steel or concrete pipe culvert
- Open footing concrete culvert

A comparison of the culvert types and foundation alternatives based on their respective advantages and disadvantages is provided in Appendix F.

Given the subsurface conditions at the site, a new precast or cast-in-place closed concrete box culvert is the preferred alternative from a geotechnical perspective. A pipe culvert (or multiple pipes) could also be considered. Use of an open footing culvert is not recommended in view of the relatively low geotechnical resistance available at the proposed founding elevations and the potential for differential settlement between footings. The open footing culvert will also require deeper temporary excavation below water level and additional dewatering. Therefore, the open footing culvert option has not been developed further.

Foundation recommendations for the design of the concrete box culvert and pipe culvert options are presented in the sections below.



10.2.1 Precast or Cast-in-Place Concrete Box Culvert

Based on the borehole information, the subgrade at the level of the culvert base will consist of compact silt to silty sand. Depending on final design invert elevations, peat may also be encountered at the culvert base. All organics and peat encountered at the culvert subgrade level must be sub-excavated and replaced with well compacted granular material. The native compact silt to silty sand is considered suitable for support of a box culvert.

In order to provide a uniform foundation subgrade, a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A requirements should be provided on the approved subgrade under the base of the box culvert, as per OPSS 422 and OPSD 803.010. The bedding material should be placed in the dry as soon as practical following subgrade inspection and approval. Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction. The subgrade surface prepared to support the precast box units should have a 75 mm minimum thickness top levelling course of un-compacted Granular A as per OPSS 422 and OPSD 803.010.

Protection of the subgrade should include installation of a Class II non-woven geotextile with a maximum FOS of 150 μm (OPSS 1860) installed beneath the 300 mm thick Granular A bedding layer. The geotextile should be extended above the high water level and fixed to ground by pins at the ends. A layer of granular material may be placed to protect the geotextile prior to placing rock fill. The geotextile should be placed as soon as possible after the subgrade level is reached and following the inspection and approval of the subgrade by a qualified geotechnical engineer.

The factored geotechnical resistance at the Ultimate Limit State (ULS) and the geotechnical resistance at Serviceability Limit State (SLS) for a 7.0 m wide box culvert founded on the compact silt to silty sand at or below Elev. 187.8 m as described above can be assumed as follows:

- Factored Geotechnical Resistance at ULS of 325 kPa
- Geotechnical Resistance at SLS of 230 kPa

The Factored Geotechnical Resistance at ULS and Geotechnical Resistance at SLS were estimated adopting geotechnical resistance factors of 0.5 and 0.8 for ultimate and serviceability limit states, respectively, for a “typical” degree of the site understanding, as per CHBDC 2014. If there will be any change in the dimensions of the culvert, re-assessment for the geotechnical resistance will be required. As discussed in Section 10.1, up to approximately 90 mm of total settlement will occur under the embankment loading at the culvert location. This culvert should be cambered to accommodate the total settlement and the maximum differential settlement based on the settlement profile provided in Appendix G.



The geotechnical resistance values provided above are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance used in design should be reduced in accordance with the CHBDC 2014 Clause 6.10.3 and Clause 6.10.4.

Resistance to lateral forces / sliding resistance between precast concrete and the underlying soil should be evaluated in accordance with the CHBDC (2014) assuming an ultimate coefficient of friction of 0.45 between the concrete slab and the underlying Granular A material for cast-in-place culvert or precast culvert.

The soil at the foundation level should be inspected by a qualified geotechnical engineer prior to placement of bedding layer. Preparation of the culvert subgrade should include removal of any peat, organic soils, fill, very loose sands and silts or other unsuitable materials remaining after excavation to the subgrade level. If sub-excavation is required, the width of the sub-excavation should be defined by a line extending from 0.3 m beyond the outside edge of the proposed culvert, outward and downward at 1H:1V. The sub-excavated area should then be backfilled with granular material meeting OPSS.PROV 1010 Granular A or Granular B Type II requirements compacted in accordance with OPSS.PROV 501. Subgrade preparation must be carried out in the dry.

The culvert should be designed to resist external loadings including lateral earth pressures, hydrostatic pressure, weight of embankment fill, traffic loadings and surcharge due to construction equipment.

10.2.2 Steel or Concrete Pipe Culvert

Replacement of the box culvert with pipe culverts on the same or adjacent alignment may be considered for this site. Based on the borehole information, the subgrade at the level of the culvert base will consist of compact silt to silty sand. Depending on final design invert elevations, peat may also be encountered at the culvert base which must be sub-excavated and replaced with well compacted granular material. The compact silt to silty sand is considered suitable for support of a pipe culvert.

If this alternative is selected, the pipe(s) should be placed on a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A requirements as per OPSD 802.014. The bedding material should be placed in the dry as soon as practical following inspection and approval.

Preparation of the culvert subgrade should include removal of peat, highly organic soils, fill, very loose sands and silts or other unsuitable materials remaining after excavation to the subgrade



level. If sub-excavation is required, the sub-excavated area should be backfilled with granular material meeting OPSS.PROV 1010 Granular A or Granular B Type II requirements compacted in accordance with OPSS.PROV 501. Subgrade preparation must be carried out in the dry. Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction.

Protection of the subgrade should include installation of a Class II non-woven geotextile with a maximum FOS of 150 μm (OPSS 1860) installed beneath the 300 mm thick Granular A bedding layer. The geotextile should be placed as soon as possible after the subgrade level is reached and following the inspection and approval of the subgrade by a qualified geotechnical engineer.

11 FROST TREATMENT

The design depth of frost penetration at this site is 1.4 m. The base of all footings, if employed, must be provided with a minimum of 1.4 m of earth cover as protection against frost action. The frost cover requirement does not apply to the base of a box culvert or pipe culvert.

Frost treatment should be as per OPSD 803.010 for a box culvert, and as per OPSD 803.030 or 803.031 for a pipe culvert. A frost taper is not required at this site given the thickness of the soil cover above the culvert.

12 CULVERT BACKFILL AND LATERAL EARTH PRESSURES

Backfill to the culvert should consist of granular material conforming to OPSS Granular A or Granular B Type II specifications. Backfill should be placed and compacted in accordance with OPSS.PROV 501 and OPSS 902.

The backfill should be placed in simultaneous equal lifts on both sides of the culvert, and the top of backfill elevation should be within 500 mm on both sides of the culvert at all times. Heavy compaction equipment should not be used adjacent to the walls and roof of the culvert. Compaction equipment to be used adjacent to culverts should be restricted in accordance with OPSS.PROV 501.

In general, earth pressures acting on the culvert walls may be assumed to impose a triangular distribution governed by the characteristics of the backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC 2014, Clause 6.12, but generally are given by the expression:

$$\begin{array}{lll} & p_h & = K (\gamma h + q) \\ \text{where} & p_h & = \text{horizontal pressure on the wall at depth } h \text{ (kPa)} \end{array}$$



K	=	earth pressure coefficient (see table below)
γ	=	bulk unit weight of retained soil (see table below)
h	=	depth below top of fill where pressure is computed (m)
q	=	value of any surcharge (kPa)

Earth pressure coefficients for backfill to the culvert and wingwalls are dependent on the material used as backfill and the inclination of the ground surface behind the wall. Recommended values are shown in Table 12.1.

The parameters in the table correspond to full mobilization of active and passive earth pressures, and require certain relative movements between the wall and adjacent soil to produce these conditions. The values to be used in design can be assessed from Figure C6.16 of the Commentary to the CHBDC 2014. Active pressures should be used for any wingwalls or unrestrained walls. For rigid structures, such as concrete box culverts, at-rest earth pressures should be used for design.

Table 12.1 - Lateral Earth Pressure Coefficients (K)

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ; \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I or Type III $\phi = 32^\circ; \gamma = 21.2 \text{ kN/m}^3$		Existing Sand Fill $\phi = 30^\circ; \gamma = 20 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.39	0.31	0.47	0.33	0.54
At-rest (Restrained Wall)	0.43	0.62	0.47	0.68	0.50	0.72
Passive	3.7	-	3.3	-	3.0	-

Note: Submerged unit weight should be used below groundwater level.

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

In accordance with Clause 6.12.3 of the CHBDC 2014, a compaction surcharge should be added. The magnitude of the surcharge should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 1.7 m for Granular B Type I, or at a depth of 2.0 m for Granular A or B Type II.

The design of the culvert should incorporate measures such as weep-holes or subdrains to permit drainage of the culvert backfill, or alternatively the culvert walls should be designed to withstand the potential build-up of hydrostatic pressures behind the walls.



13 SEISMIC CONSIDERATIONS

The seismic site classification for this site is based on the SPT- N_{60} criteria. The harmonic mean of the typical SPT- N_{60} values provided above is 15 blows, which corresponds to a Seismic Site Class D in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2% in 50-year probability of exceedance at this site is assessed to be 0.135 g.

In accordance with Clause 4.6.5 of the CHBDC 2014, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 13.1 may be used:

Table 13.1 – Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)	
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I or Type III $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$
Active (K_{AE})*	0.33	0.37
Passive (K_{PE})*	3.5	3.1
At Rest (K_{OE})**	0.61	0.65

* After Mononobe and Okabe

** After Woods

Given that the predominant deposits at the site are compact sandy silt to silty sand and stiff glacial till and in view of the low potential for seismic activity in the area, liquefaction is not considered to be a concern at this site based on the results of a site-specific liquefaction potential analysis. The liquefaction potential analysis results indicate that the cyclic resistance ratios (CRR) are greater than the cyclic stress ratios (CSR) for all soil layers with a minimum factor of safety of 1.5 against liquefaction.

14 RETAINING WALL

A retaining wall has been proposed at the northeast corner of the new culvert to retain the new ramp embankment fill. Three options are being considered for the retaining wall, i.e. concrete retaining wall, gabion wall and RSS wall. The retaining wall will be 4 m long and 4 m high. The proposed base widths are 2.0 m for the concrete wall option and 3.0 m for the gabion or RSS wall options. The wall is proposed to be founded at approximate Elev. 187.5 or the base of the culvert at inlet. At this elevation, the foundation soil consists primarily of compact silt based on Golder's borehole 07-11 drilled approximately 10 m west of the proposed wall location. Groundwater table

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Date: June 18, 2018

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was indicated at ground surface or Elev. 190 m in borehole 07-11.

14.1 General Requirements

Topsoil, organics, loose fill, and any soft/loose materials must be stripped and removed from the footprint of the wall. The wall subgrade should be inspected and any soft spots must be sub-excavated and replaced with compacted granular materials. Given the sensitive nature of the silt subgrade, the fill should be placed as soon as practical following subgrade inspection and approval. Construction equipment should not be allowed to travel on the prepared subgrade. Protection of the subgrade should include installation of a Class II non-woven geotextile as a separation layer before placing the fill.

Subgrade preparation and placement and compaction of the granular fill must be carried out in the dry. Construction dewatering will be required to maintain a dry excavation for wall construction.

The wall must be designed against various modes of failure including sliding and overturning taking into account the 1.25H:1V rock fill slope behind the wall. A rock fill unit weight of 19 kN/m^3 and a coefficient of active lateral earth pressure of 0.37 may be used to estimate the lateral load acting on the gabion wall.

The recommended geotechnical resistances provided below are for concentric, vertical loading. The effects of load inclination and eccentricity must be taken into account according to the CHBDC (2014).

Global stability analyses for the proposed retaining wall were carried out under static and seismic conditions. The shear strength parameters and the results of the stability analyses for the case of RSS/gabion wall and concrete wall are shown on Figures E3 to E4A in Appendix E. The RSS/gabion wall and concrete wall have both achieved acceptable factors of safety greater than 1.3 under static conditions and 1.0 under seismic conditions for a minimum 3 m wide wall.

14.2 RSS/Gabion Wall

The performance of a RSS or gabion wall is dependent on, among other factors, the characteristics of its foundation. The foundation under the entire RSS mass or gabion baskets must be considered, i.e. from the face of the wall to the furthest extent of the reinforcement or gabion baskets.

The RSS mass or gabion baskets should be founded on a 0.5 m thick engineered fill pad resting on the native silt subgrade at or below Elev. 187.5 m. A RSS or gabion wall founded on this



subgrade material may be designed using a factored geotechnical resistance at ULS of 175 kPa and a geotechnical reaction at SLS of 125 kPa (up to 25 mm of settlement). Engineered fill pad placed under the RSS mass or gabion baskets shall consist of OPSS.PROV 1010 Granular A or Granular B Type II compacted to 100% of its SPMDD at a moisture content within 2% of optimum. The engineered fill pad must be extended to at least 500 mm beyond the footprint of RSS mass or gabion baskets at all sides. Construction of the engineered fill pad must be carried out in the dry in general accordance with OPSS.PROV 501.

Sliding resistance along the base of the RSS or gabion wall may be computed using an ultimate friction coefficient of 0.45 on an engineered granular fill subgrade.

The maximum ground settlement under the base of the retaining wall is estimated to be less than 15 mm and the settlement will be essentially complete at the end of embankment construction.

A geotextile filter fabric must be incorporated in the RSS or gabion wall design to prevent loss of materials from granular material behind the wall when subject to fluctuating water level. The base of the RSS/gabion wall shall be protected against potential scour and erosion. If the RSS wall will be flooded, longer reinforcing strips may be required to ensure wall stability under submerged conditions.

The RSS or gabion system should be designed for medium performance and high appearance. The wall supplier/designer may specify more stringent design criteria or requirements. The internal stability of the RSS or gabion wall must be analyzed by the supplier/designer of the proprietary product selected for this site.

Installation of the gabion wall and specifications of the materials used for the construction of the gabion wall (e.g., aggregates, wire mesh, PVC coating, facing elements, fasteners, etc.) should meet the requirements of OPSS 1430, OPSS.PROV 1004, OPSS.PROV 512 and SP599S23. The design, supply and construction of the RSS wall should be carried out in general accordance with the SP 599S22.

14.3 Concrete Wall

Concrete retaining wall may be supported on a spread footing founded on the compact silt subgrade. The wall should be provided with a sufficient frost cover (a minimum 1.4 m at this site) and founded at or below Elev. 187.5 m. A factored geotechnical resistance at ULS of 175 kPa and a geotechnical reaction at SLS of 125 kPa (up to 25 mm of settlement) may be used for design of concrete wall supported on a minimum 2 m wide footing.



To provide a uniformly competent flat, level base, a minimum 300 mm thick compacted granular A material should be provided below the concrete footing.

Resistance to sliding between concrete and the granular levelling layer should be evaluated in accordance with the CHBDC (2014) assuming an ultimate coefficient of friction of 0.45.

Hydrostatic pressure acting behind the concrete wall must be considered in the design. Wall drains and subdrain should be provided behind the wall similar to OPSP 3101.150.

Backfill behind the retaining structure using rock fill shall only be comprised of rock fragments no larger than 250 mm in their greatest dimension as per OPSS.PROV 206. Rock backfill shall be placed in a manner that the structure is not damaged. Dumping of rock fill against a structure shall not be permitted.

15 EXCAVATION AND DEWATERING SYSTEM

Temporary excavations will be required during construction at this site for the ramp re-location work and the new culvert installation. All temporary excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA).

Excavation will take place through the existing embankment fill, buried peat and native loose to compact silt to silty sand. For the purpose of OHSA, the existing embankment fill and native soil may be classified as Type 3 soils above water level and Type 4 below water level.

All excavations must be carried out in a manner that avoids undermining or destabilising the foundations of all adjacent structures and utilities, if any.

Excavation and backfilling for foundation construction should be carried out in accordance with the requirements in OPSS 902. Selection of the equipment and methodology to excavate and prepare the founding surface is the responsibility of the Contractor.

The Contractor must be prepared to control the groundwater and surface water inflow at the site to permit the proposed culvert to be constructed in a dry and stable excavation. The sand and silt subgrade is prone to boiling if effective dewatering is not implemented. It is anticipated that excavation for the new culvert will be carried out at or below the groundwater level. The groundwater level at the time of the construction should be taken as the water level in the creek. It is recommended that the culvert replacement be conducted during a drier season such as after the spring freshet or prior to the fall season. Depending on the time of construction, a combination of sheet-pile cofferdam enclosure and creek diversion through a temporary bypass pipe culvert along with pumping from filtered sumps with typical dewatering requirements within an enclosure



will be required to maintain dry excavations throughout the course of staged construction. Dewatering activities should be carried out in accordance with OPSS 517 and SP No. FOUND003.

The design of an effective dewatering system is the responsibility of the Contractor and the Contract Documents must alert him to this responsibility and the need to engage a dewatering specialist. Dewatering must remain operational and effective until the culvert is installed and backfilled. Suggested wording for an NSSP in this regard is included in Appendix I.

16 SCOUR AND EROSION PROTECTION

Erosion protection should be provided at the culvert inlet and outlet and along the base and side slopes of the ditches. Design of the erosion protection measures should consider hydrologic and hydraulic factors and should be carried out by a specialist experienced in this field.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

A concrete cut-off wall or clay seal should be used to minimize the potential for erosion or piping around the culvert. The clay seal should extend to approximately 0.3 m above the high water level and laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The material requirements should be in accordance with OPSS.PROV 1205. A geosynthetic clay liner may be used in place of a compacted clay seal.

17 TEMPORARY ROADWAY PROTECTION

Temporary roadway protection may be required during the replacement of the existing culvert and/or the construction of the new W-N/S Ramp embankment. The design of roadway protection should be the responsibility of the Contractor. Any protection system must be designed by licensed Professional Engineers experienced in such designs. An item titled "Protection System" as per OPSS.PROV 539 (Level 2) shall be included in the contract documents

A potential temporary roadway protection system is a temporary interlocking sheet pile system or soldier piles and lagging. The temporary roadway protection system may be designed using the parameters in the table below:



Soil Parameter	Existing Fill	Native Sand / Silt
Bulk Unit Weight (γ)	20 kN/m ³	21 kN/m ³
Submerged Unit Weight (γ_w)	10 kN/m ³	11 kN/m ³
Coefficient of Active Earth Pressure (K_a)	0.36	0.33
Coefficient of Passive Earth Pressure (K_p)	2.8	3.0

The actual earth pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall, and these factors must be considered when designing the shoring system.

18 CONSTRUCTION CONCERNS AND CONSIDERATIONS

During construction, the Contract Administrator should employ experienced geotechnical staff to observe construction activities.

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

- Peat removal will be required in the embankment widening area where the new fill will be placed on the native ground including the proposed retaining wall footprint and under the proposed Proctor Creek Culvert.
- The water level may fluctuate and be at higher elevation at the time of construction than indicated in the report. Given the high groundwater level and presence of sensitive sand and silt subgrade at this site, implementation of an effective dewatering system is critical during excavation in order not to have a boiling base.
- In areas with the culvert foundation, care must be exercised during excavation to avoid disturbing the founding subgrade. When the excavation reaches the required elevation, the subgrade should be inspected and approved by qualified geotechnical personnel.



19 CLOSURE

Engineering analysis and preparation of this foundation design report was carried out by Mohamed Hosney, P.Eng. and Keli Shi, P.Eng. The report was reviewed by Jason Lee, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Contact for MTO foundation projects.

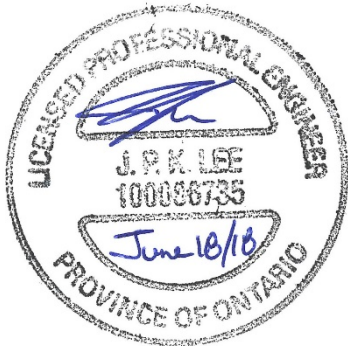
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Appendix A

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
 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.

EXPLANATION OF ROCK LOGGING TERMS


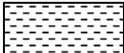



ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
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

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

SYMBOLS

	CLAYSTONE
	SILTSTONE
	SANDSTONE
	COAL
	BEDROCK

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)	Approximate Uniaxial Compressive Strength (psi)	Field Estimation of Hardness*
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
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 % 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.

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			

RECORD OF BOREHOLE No R16-01

1 OF 1

METRIC

W.P. 4016-13-01 LOCATION County Road 30 W-N/S Ramp N 4 882 136.5 E 202 928.3 ORIGINATED BY OA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.10.20 - 2016.10.20 CHECKED BY MH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					WATER CONTENT (%) w _p w w _L				GR	SA	SI	CL		
192.5	GROUND SURFACE							20	40	60	80	100										
0.0	Silty SAND , some gravel, trace clay, rootlets		1	GS			192							○					19	56	18	7
192.0	Dark Grey																					
0.5	Moist (FILL)																					
191.6	PEAT																					
0.9	Silty SAND , some organics		1	SS	8										○							
	Loose																					
	Black																					
	Moist																					
			2	SS	9		191								○							
190.4																						
2.1	Clayey SILT , with sand, trace gravel																					
	Stiff to Hard																					
	Grey		3	SS	10		190								○							
	Moist																					
	(TILL)																					
			4	SS	19		189								○							
							188															
			5	SS	33										○							
187.3																						
5.2	END OF BOREHOLE AT 5.2m. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.																					

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No R16-02

1 OF 1

METRIC

W.P. 4016-13-01 LOCATION County Road 30 W-N/S Ramp N 4 882 149.7 E 202 947.3 ORIGINATED BY OA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.10.20 - 2016.10.20 CHECKED BY MH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) w _P w w _L				GR	SA	SI	CL	
190.8	GROUND SURFACE						190														
0.0	TOPSOIL: (150mm)																				
0.2	PEAT		1	SS	2																
190.2																					
0.6	Silty SAND , trace clay, some wood fragments Very Loose to Compact Greyish Brown Wet		2	SS	3																
			3	SS	3																
	Some organics		4	SS	4																
			5	SS	23																
186.7																					
4.1	SAND and GRAVEL , trace silt and clay Compact Grey Wet		6	SS	25																
185.6																					
5.2	END OF BOREHOLE AT 5.2m. WATER LEVEL AT 0.6m DEPTH UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.																				

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

RECORD OF BOREHOLE No R16-03

1 OF 1

METRIC

W.P. 4016-13-01 LOCATION County Road 30 W-N/S Ramp N 4 882 150.9 E 202 962.5 ORIGINATED BY OA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.10.20 - 2016.10.20 CHECKED BY MH

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 (%)		
								<div><div><div></div><div></div><div></div><div></div><div></div></div><div>20406080100</div></div> <div>○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE</div>							<div><div><div></div><div></div><div></div></div><div>W P W W L</div><div>PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT</div></div> <div>204060</div>		
189.7	GROUND SURFACE																
0.0	TOPSOIL: (100mm)																
0.1	PEAT		1	SS	1	<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div></div>											
189.2																	
0.5	Silty SAND, trace clay, with organics																
189.0	Very Loose																
0.7	Black		2	SS	6												
	Moist																
	Sandy SILT, trace clay																
	Loose to Compact																
	Greyish Brown		3	SS	12												
	Wet																
			4	SS	12												
			5	SS	17												
185.6																	
4.1	SAND and GRAVEL, trace silt																
	Compact																
	Grey																
	Wet		6	SS	19												
184.5																	
5.2	END OF BOREHOLE AT 5.2m. WATER LEVEL AT 1.5m DEPTH UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.																





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

RECORD OF BOREHOLE No R16-04

1 OF 1

METRIC

W.P. 4016-13-01 LOCATION County Road 30 W-N/S Ramp N 4 882 190.7 E 202 998.0 ORIGINATED BY OA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.10.20 - 2016.10.20 CHECKED BY MH

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													
191.1	GROUND SURFACE																				
0.0	Silty SAND , some gravel, trace clay Brown Moist (FILL)		1	GS			191														
190.5																					
0.6	PEAT																				
190.2																					
0.9	Silty SAND , trace clay, trace gravel, some organics and roots Very Loose to Compact Brown Moist to Wet		1	SS	3			190													
			2	SS	1																
			4	SS	13		189														
			5	SS	13		188														
			6	SS	19		187														
185.9							186														
5.2	END OF BOREHOLE AT 5.2m. WATER LEVEL AT 2.1m DEPTH UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.																				





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

RECORD OF BOREHOLE No R16-05

1 OF 2

METRIC

W.P. 4016-13-01 LOCATION County Road 30 W-N/S Ramp N 4 882 168.0 E 203 010.3 ORIGINATED BY OA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.10.21 - 2016.10.21 CHECKED BY MH

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						
189.0	GROUND SURFACE							20 40 60 80 100						
0.0 0.1	TOPSOIL: (75mm) PEAT		1	SS	2									
188.2														
0.8	Silty SAND , some organics and rootlets Very Loose Dark Brown Moist		2	SS	3									
187.6														
1.4	SAND and SILT , some gravel, trace clay Compact Grey Wet		3	SS	20									
186.8														
2.2	SILT , trace to some clay, trace sand Loose to Compact Grey Wet		4	SS	12									
			5	SS	9									
			6	SS	19									
			7	SS	6									
			8	SS	12									
			9	SS	9									
179.2														
9.8	END OF BOREHOLE AT 9.8m.													

Continued Next Page

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

RECORD OF BOREHOLE No R16-05

2 OF 2

METRIC

W.P. 4016-13-01 LOCATION County Road 30 W-N/S Ramp N 4 882 168.0 E 203 010.3 ORIGINATED BY OA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.10.21 - 2016.10.21 CHECKED BY MH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _p	W	W _L		
	Continued From Previous Page													
	WATER LEVEL AT 1.5m DEPTH UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.													

ONTMT4S 0620.GPJ 2017TEMPLATE(MTO).GDT 6/15/17

RECORD OF BOREHOLE No R16-06

1 OF 1

METRIC

W.P. 4016-13-01 LOCATION County Road 30 W-N/S Ramp N 4 882 136.2 E 202 987.0 ORIGINATED BY OA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.10.21 - 2016.10.21 CHECKED BY MH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100					
188.3	GROUND SURFACE												
0.0 0.1	TOPSOIL: (75mm)												
187.6	Silty SAND , some organics Very Loose Brown Moist		1	SS	3		188						0 67 29 4
0.7	SAND and SILT , some organics, trace roots Compact Grey Wet		2	SS	17		187						
			3	SS	26								
186.1							186						
2.2	SILT , trace to some clay, trace sand Compact to Loose Grey Wet		4	SS	11								
			5	SS	12		185						0 6 78 16
							184						
			6	SS	6		183						
							182						0 2 82 16
181.6			7	SS	10								
6.7	END OF BOREHOLE AT 6.7m. WATER LEVEL AT 1.5m DEPTH UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.												

ONTMT4S 0620.GPJ 2017TEMPLATE(MTO).GDT 6/15/17



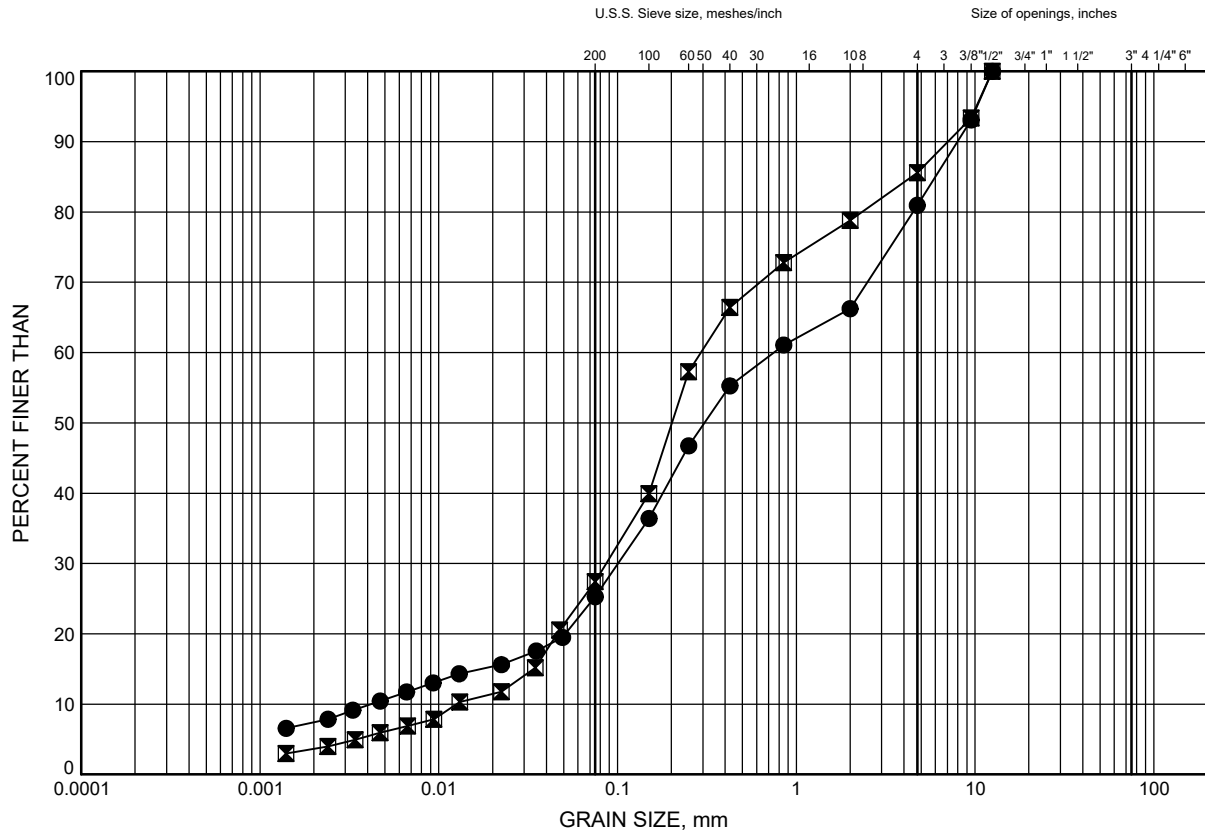
Appendix B

Laboratory Test Results

County Road 30 W-N/S Ramp
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)
●	R16-01	0.3	192.2
◻	R16-04	0.3	190.8

Date May 2018
W.P. 4016-13-01

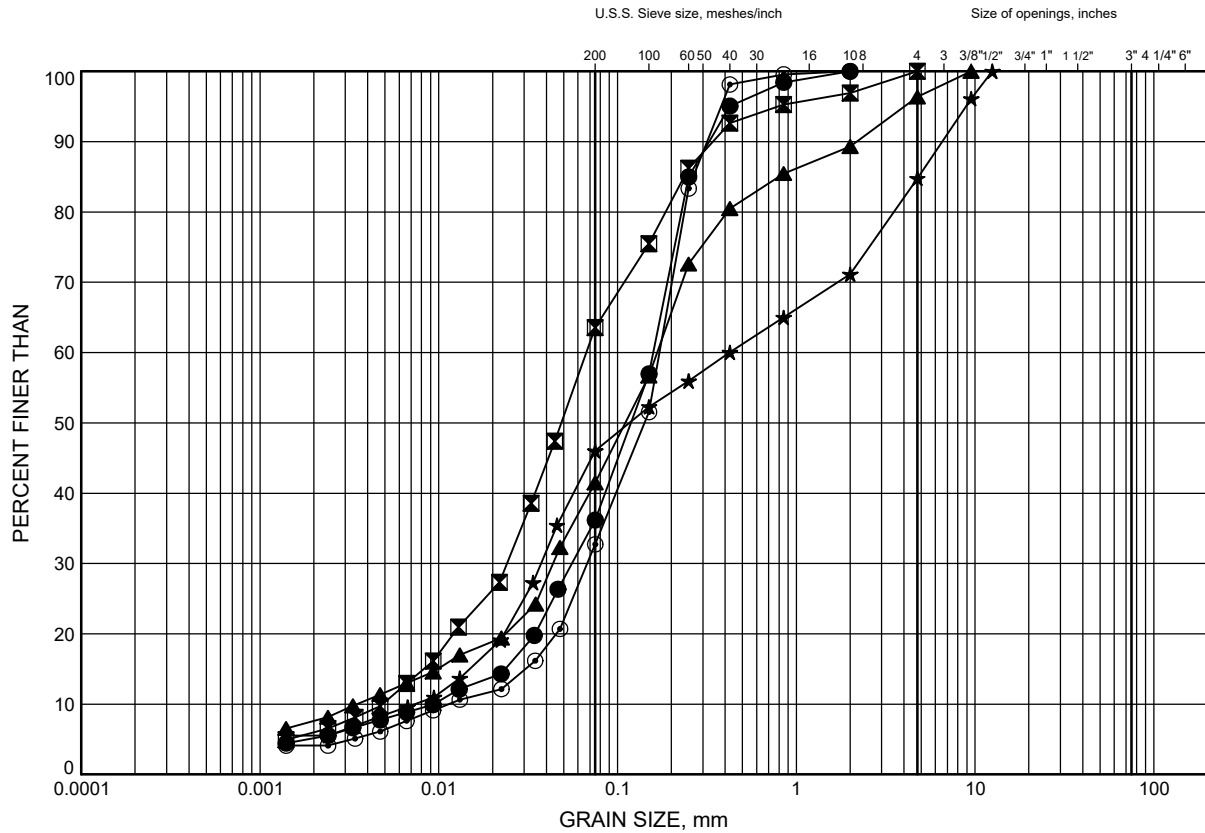


Prep'd AN
Chkd. MH

County Road 30 W-N/S Ramp
GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty SAND to SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	R16-02	1.1	189.7
⊠	R16-03	1.8	187.9
▲	R16-04	1.1	190.0
★	R16-05	1.8	187.2
⊙	R16-06	0.3	188.0

Date May 2018
W.P. 4016-13-01

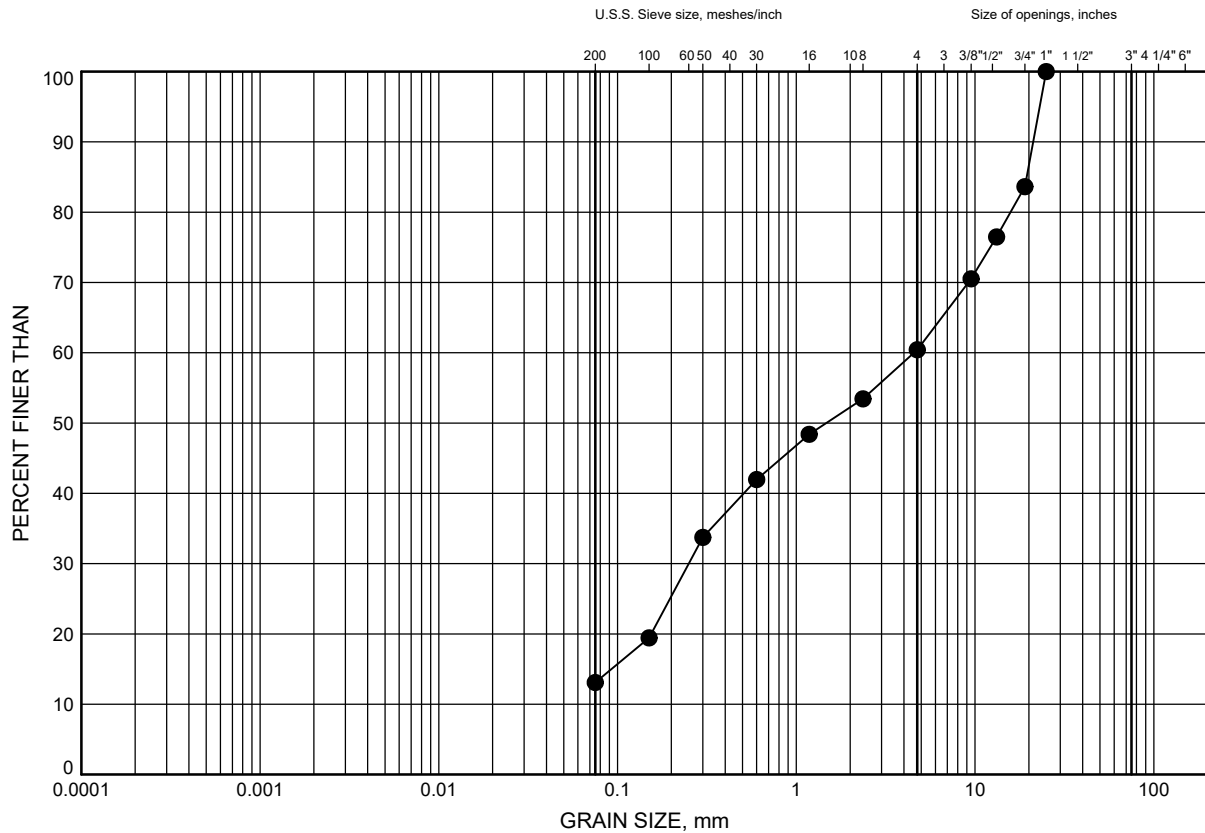


Prep'd AN
Chkd. MH

County Road 30 W-N/S Ramp
GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND and GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	R16-02	4.9	185.9

Date May 2018
W.P. 4016-13-01

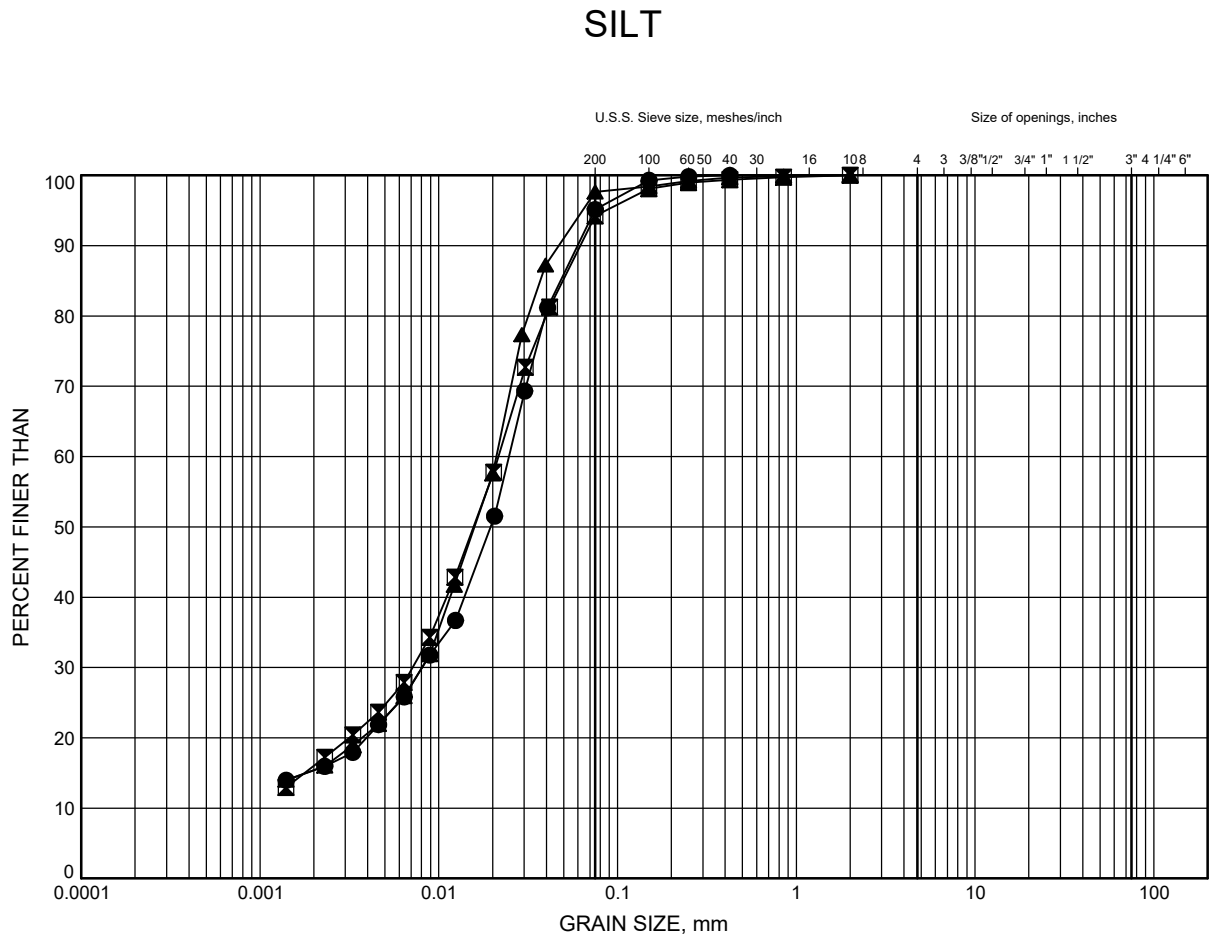


Prep'd AN
Chkd. MH

County Road 30 W-N/S Ramp

GRAIN SIZE DISTRIBUTION

FIGURE B4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	R16-05	3.4	185.6
⊠	R16-06	3.4	184.9
▲	R16-06	6.4	181.9

Date May 2018
W.P. 4016-13-01

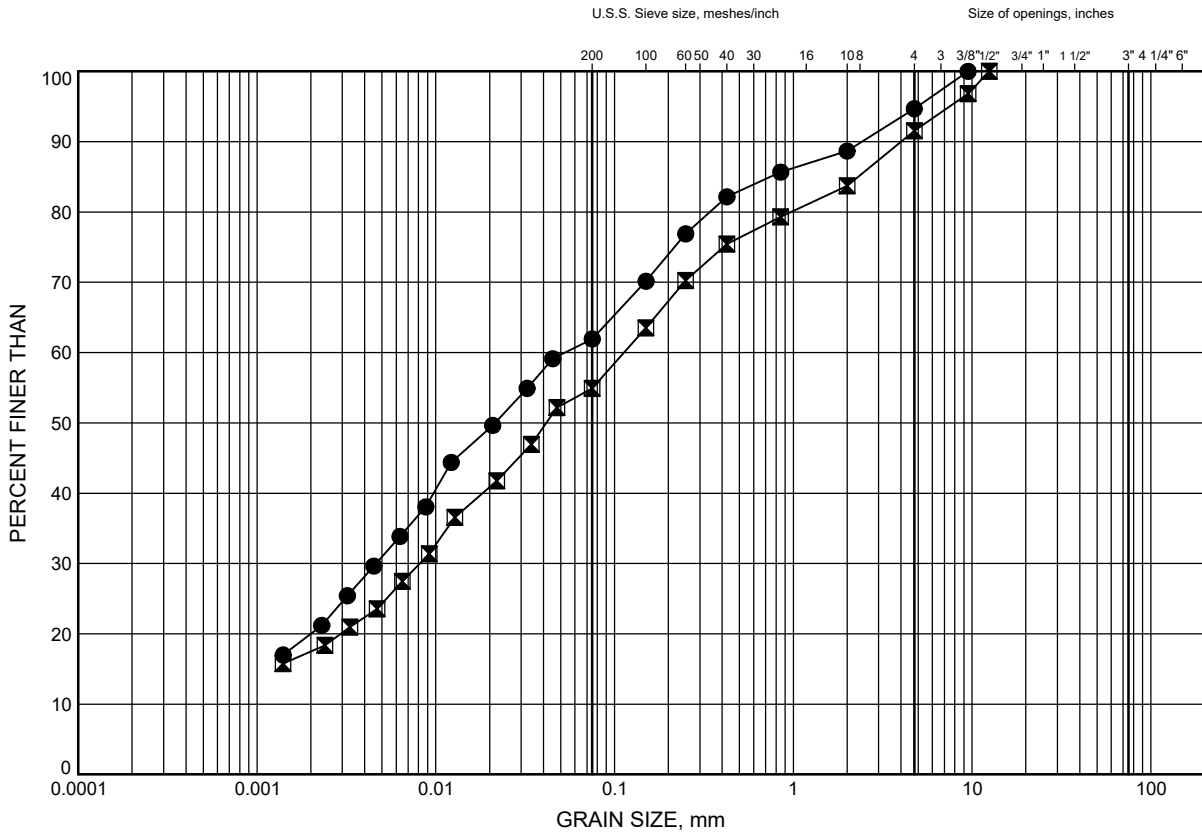


Prep'd AN
Chkd. MH

County Road 30 W-N/S Ramp
GRAIN SIZE DISTRIBUTION

FIGURE B5

Clayey SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	R16-01	2.6	189.9
⊠	R16-01	4.9	187.6

Date May 2018
W.P. 4016-13-01

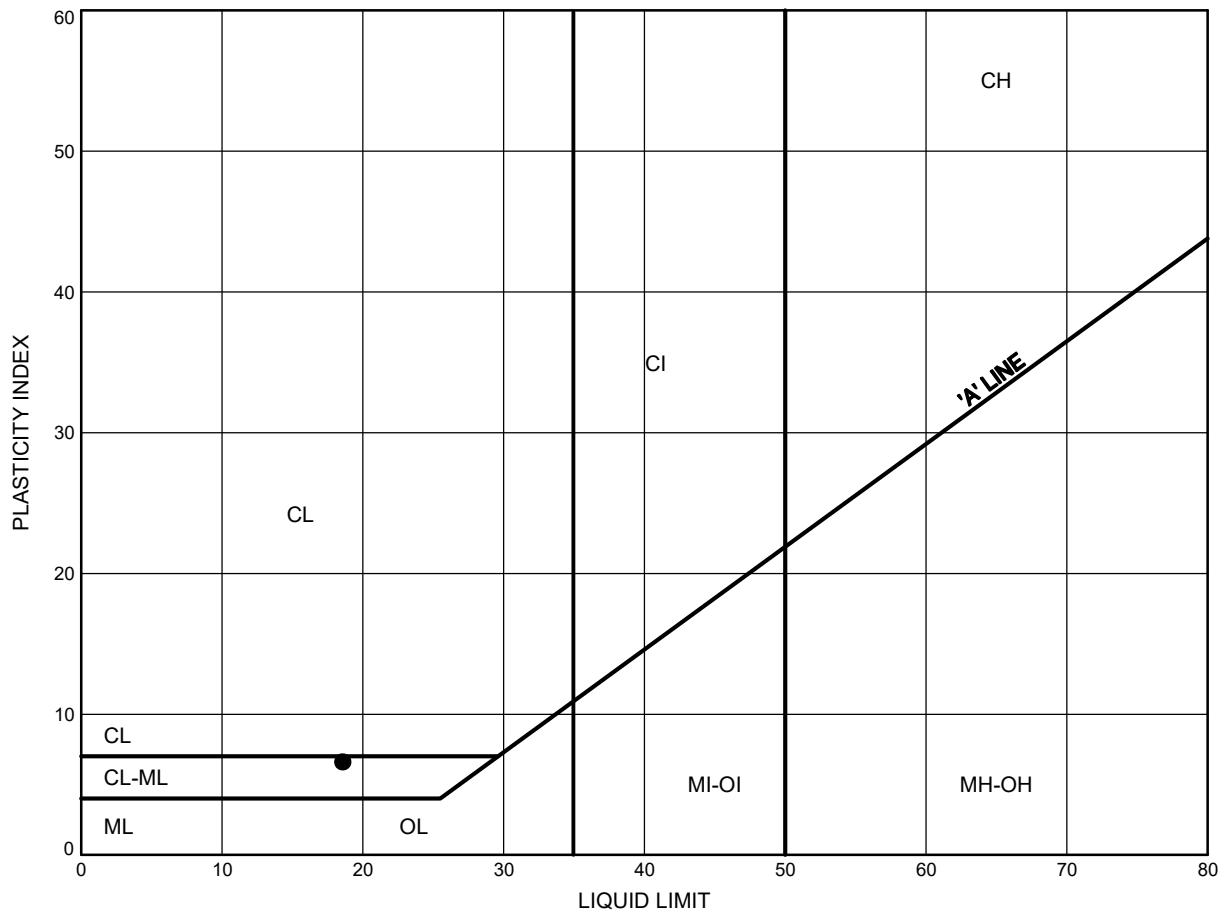


Prep'd AN
Chkd. MH

County Road 30 W-N/S Ramp
ATTERBERG LIMITS TEST RESULTS

FIGURE B6

Clayey SILT TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	R16-01	2.6	189.9

Date May 2018
 W.P. 4016-13-01



Prep'd AN
 Chkd. MH



Appendix C

Record of Borehole Sheets from Previous Investigation

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency	c_u, s_u kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. General

π	3.1416
$\ln x$	natural logarithm of x
$\log_{10} x$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ϵ	linear strain
ϵ_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation
*	Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity index $= (w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 + \sigma_3)/2$ or $(\sigma'_1 + \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 + \sigma_3)$
S_t	sensitivity

- Notes: 1 $\tau = c' + \sigma' \tan \phi'$
2 Shear strength $= (\text{Compressive strength})/2$

RECORD OF BOREHOLE No 07-1

1 OF 2 **METRIC**

PROJECT 06-1111-057

W.P. 256-98-00

LOCATION N 4882198.0 ; E 203025.3

ORIGINATED BY SB

DIST HWY 401

BOREHOLE TYPE Track-Mounted CME-55, 108mm I.D. Hollow Stem Augers

COMPILED BY MWK

DATUM Geodetic

DATE May 7, 2007

CHECKED BY LCC/JMAC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								20	40	60							80	100
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL							× REMOULDED	
190.4	GROUND SURFACE																	
0.0	TOPSOIL																	
0.2	Sand and silt, trace to some gravel, trace clay, containing rootlets (FILL) Loose Brown Moist		1	SS	7									12 43 40 5				
			2	SS	8													
188.8																		
1.6	Clayey silt, trace sand (FILL) Firm Brown Moist		3	SS	5									0 2 84 14				
188.0																		
	PEAT		4	SS	4													
2.6	SILT, trace to some sand, trace clay Compact Brown to grey Moist to wet		5	SS	16													
			6	SS	21									0 10 80 10				
			7	SS	13													
			8	SS	3*													
			9	SS	WH*									0 7 89 4				
			10	SS	19													
179.8																		
10.6	Silty SAND, some gravel, trace clay (TILL) Compact to very dense Grey Moist		11	SS	22													
			12	SS	47									23 49 25 3				
			13	SS	92													
175.5																		

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 061111057MTO.GPJ GAL-MISS.GDT 11/15/07 JFC

RECORD OF BOREHOLE No 07-1

2 OF 2 **METRIC**

PROJECT 06-1111-057

W.P. 256-98-00

LOCATION N 4882198.0 ;E 203025.3

ORIGINATED BY SB

DIST HWY 401


BOREHOLE TYPE Track-Mounted CME-55, 108mm I.D. Hollow Stem Augers

COMPILED BY MWK

DATUM Geodetic

DATE May 7, 2007

CHECKED BY LCC/JMAC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
14.9	SAND and GRAVEL		14	SS	91/1.15	175											
174.9	Very dense Grey Wet																
15.5	END OF BOREHOLE																
Notes: 1. * Low SPT "N" values (WH and 3 blows/0.3 m of penetration) are the result of sample disturbance due to groundwater inflow to the borehole. 2. Water level in open borehole at a depth of 2.1 m (Elev. 188.3 m) on completion of drilling.																	

RECORD OF BOREHOLE No 07-2

1 OF 1 **METRIC**

PROJECT 06-1111-057

W.P. 256-98-00

LOCATION N 4882182.2 : E 202973.8

ORIGINATED BY SB

DIST HWY 401


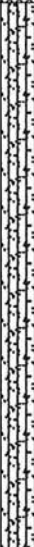

BOREHOLE TYPE Track-Mounted CME-55, 108mm I.D. Hollow Stem Augers

COMPILED BY MWK

DATUM Geodetic

DATE May 8, 2007

CHECKED BY LCC/JMAC

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED								WATER CONTENT (%)
190.9	GROUND SURFACE						20	40	60	80	100					
0.0	Silty sand, trace gravel, containing rootlets (FILL) Loose Brown to grey Moist		1	SS	5	▽	190									
			2	SS	5		189									
			3	SS	6		188									
188.8							187									
2.1	SAND and SILT, trace gravel Compact Grey-brown, becoming grey at a depth of 3.8 m Wet		4	SS	16		186									
			5	SS	17		185									
			6	SS	21		184									
			7	SS	20		183									
			8	SS	18		182									
								181								
183.3																
7.6	SAND and GRAVEL to gravelly SAND, some silt Compact to very dense Grey Wet		9	SS	18	180										
			10	SS	100/1											
180.0																
10.9	END OF BOREHOLE		11	SS	109/1											
	Notes: 1. Water level in open borehole at a depth of 1.0 m (Elev. 189.9 m) on completion of drilling.															

MIS-MTO 001 061111057MTO.GPJ GAL-MISS.GDT 11/15/07 JFC

RECORD OF BOREHOLE No 07-3

1 OF 1 **METRIC**

PROJECT 06-1111-057

W.P. 256-98-00

LOCATION N 4882149.2 ; E 202936.9

ORIGINATED BY SB

DIST HWY 401

BOREHOLE TYPE Track-Mounted CME-55, 108mm I.D. Hollow Stem Augers

COMPILED BY MWK

DATUM Geodetic

DATE May 8, 2007

CHECKED BY LCC/JMAC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)	
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× REMOULDED	20						40	60
192.7	GROUND SURFACE																GR SA SI CL		
0.0	Silly sand, trace gravel, containing rootlets (FILL) Very loose to loose Grey-brown to grey Moist		1	SS	2		192												
			2	SS	6														
190.9			3	SS	3		191												
1.8	PEAT																		
190.4																			
2.3	SAND and SILT, trace gravel and clay (TILL) Very loose to compact Grey Moist to wet		4	SS	3		190												
			5	SS	22												10 40 43 7		
			6	SS	22		189												
			7	SS	17		188												
186.9							187												
5.8	SAND and GRAVEL, some silt Very dense Grey Moist		8	SS	63/15		186										33 33 29 5		
			9	SS	78/15		185												
							184												
183.3			10	SS	92/15														
9.4	END OF BOREHOLE																		
	Notes: 1. Water level in piezometer flowing (artesian conditions) at 3.0 m above ground surface (i.e. at Elev. 195.7 m) upon completion of installation. 2. Piezometer removed and borehole sealed with bentonite.																		

+³, X³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

PROJECT 06-1111-057				RECORD OF BOREHOLE No 07-5				1 OF 1 METRIC							
W.P. 256-98-00				LOCATION N 4882110.9 ; E 202904.6				ORIGINATED BY SB							
DIST HWY 401				BOREHOLE TYPE Track-Mounted CME-55, 108mm I.D. Hollow Stem Augers				COMPILED BY MWK							
DATUM Geodetic				DATE May 10, 2007				CHECKED BY LCC/JMAC							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
193.4	GROUND SURFACE														
0.0	Silty sand (FILL) Very loose Brown Moist		1	SS	2										
192.7	PEAT														
0.8	SAND and SILT, some gravel, trace to some clay Compact Grey - brown Moist		2	SS	10										
			3	SS	11										
191.1	Silty SAND, some gravel, trace clay, containing cobbles and boulders (TILL) Dense to very dense Grey Moist		4	SS	36										
2.3			5	SS	100/1										
190.0	END OF BOREHOLE														
3.4	Notes: 1. Borehole terminated at 3.4 m depth due to auger refusal/grinding on probable boulder. 2. Water level in open borehole at a depth of 2.7 m (Elev. 190.7 m) on completion of drilling.														

RECORD OF BOREHOLE No 07-6

1 OF 1 **METRIC**

PROJECT 06-1111-057

W.P. 256-98-00

LOCATION N 4882070.0 ; E 202875.6

ORIGINATED BY SB

DIST HWY 401

BOREHOLE TYPE Track-Mounted CME-55, 108mm I.D. Hollow Stem Augers

COMPILED BY MWK

DATUM Geodetic

DATE May 9, 2007

CHECKED BY LCC/JMAC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
195.3	GROUND SURFACE													
0.0	Sand and silt, containing organics and rootlets (FILL) Very loose to loose Brown Moist		1	SS	3		195							
			2	SS	4		194							0 55 43 2
			3	SS	7									
193.0							193							
2.3	Sandy SILT, some clay, trace to some gravel Compact Grey-brown Moist to wet		4	SS	19									
			5	SS	24		192							
191.5							191							
3.8	CLAYEY SILT with sand, trace gravel (TILL) Hard Grey Moist		6	SS	57									
			7	SS	71		190							
							189							
188.6			8	SS	45									11 24 42 23
6.7	END OF BOREHOLE													
	Notes: 1. Borehole dry on completion of drilling.													

+³, X³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-7

1 OF 1 **METRIC**

PROJECT 06-1111-057

W.P. 256-98-00

LOCATION N 4882217.9 ; E 203071.4

ORIGINATED BY SB

DIST HWY 401

BOREHOLE TYPE Track-Mounted CME-55, 108mm I.D. Hollow Stem Augers

COMPILED BY MWK

DATUM Geodetic

DATE May 10, 2007

CHECKED BY LCC/JMAC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× REMOULDED						
193.2	GROUND SURFACE																
0.0	Sand and silt, trace gravel, containing rootlets and organics (FILL) Loose Brown Moist		1	SS	5		193										
			2	SS	6		192						○			1 64 33 2	
			3	SS	4		191							○			
190.9	Sandy SILT, trace gravel Compact Brown Wet		4	SS	18		190										
2.3			5	SS	15		190						○			1 20 77 2	
			6	SS	12		189										
			7	SS	17		188										
187.1	Silty SAND, trace gravel Loose to compact Brown Wet		8	SS	9		187							○			
6.1							186										
185.0	END OF BOREHOLE		9	SS	11		185										
8.2	Notes: 1. Water level in piezometer at a depth of 1.5 m (Elev. 191.7 m) on completion of installation. 2. Water level measured at a depth of 0.0 m (Elev. 193.2 m) on May 11, 2007.																

+³, X³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-8

1 OF 1 **METRIC**

PROJECT 06-1111-057

W.P. 256-98-00

LOCATION N 4882233.4 ; E 203118.9

ORIGINATED BY SB

DIST HWY 401



BOREHOLE TYPE Track-Mounted CME-55, 108mm I.D. Hollow Stem Augers

COMPILED BY MWK

DATUM Geodetic

DATE May 10, 2007

CHECKED BY LCC/JMAC

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED								WATER CONTENT (%)		
196.4	GROUND SURFACE							20	40	60	80	100						
0.0	Silty sand, trace gravel, containing rootlets (FILL)		1	SS	7	▽	196											
195.8	Loose Brown Moist																	
0.6	Sand, and gravel, trace to some silt (FILL)	2	SS	31			195											
194.9	Dense Brown Moist to wet		3	SS	6			194										
1.5	SAND and SILT to SILT, trace sand, trace clay and gravel		4	SS	12			193										
	Loose to dense		5	SS	20			192										
	Brown to grey		6	SS	32			191										
	Moist to wet		7	SS	29			190										
			8	SS	21													
189.7	END OF BOREHOLE																	
6.7	Notes: 1. Water level in open borehole at a depth of 1.8 m (Elev. 194.6 m) on completion of drilling.																	

RECORD OF BOREHOLE No 07-9

1 OF 2 **METRIC**

PROJECT 06-1111-057

W.P. 256-98-00

LOCATION N 4882190.1 ; E 203023.8

ORIGINATED BY SB

DIST HWY 401

BOREHOLE TYPE Track-Mounted CME-55, 108mm I.D. Hollow Stem Augers

COMPILED BY MWK

DATUM Geodetic

DATE May 11, 2007

CHECKED BY LCC/JMAC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
189.2 0.0	GROUND SURFACE PEAT		1	SS	2		189							
188.4 0.8	SILT, trace to some sand, trace clay Compact Brown to grey Moist to wet		2	SS	16		188							
			3	SS	11		187							
			4	SS	11		186							
			5	SS	13		185							
			6	SS	8*		184							
			7	SS	13		183							
			8	SS	5*		182							
			9	SS	16		181							
			10	SS	7*		180							
			11	SS	16		179							
177.6 11.6	SAND and GRAVEL Very dense Grey Wet		12	SS	116		178							
176.6 12.6	END OF BOREHOLE						177							

MIS-MTO 001 061111057MTO.GPJ GAL-MISS.GDT 11/15/07 JFC

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-9

2 OF 2 **METRIC**

PROJECT 06-1111-057

W.P. 256-98-00

LOCATION N 4882190.1 ; E 203023.8

ORIGINATED BY SB

DIST HWY 401

BOREHOLE TYPE Track-Mounted CME-55, 108mm I.D. Hollow Stem Augers

COMPILED BY MWK

DATUM Geodetic

DATE May 11, 2007

CHECKED BY LCC/JMAC

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)										
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80	100	20	40	60	80	100	10	20
— CONTINUED FROM PREVIOUS PAGE —																								
	<p>Notes:</p> <p>1. * Low SPT "N" values (5, 7 and 8 blows/0.3 m of penetration) are the result of sample disturbance due to groundwater inflow to the borehole.</p> <p>2. Slight artesian groundwater pressures encountered at a depth of 12.2 m. Artesian pressures subsided as augers withdrawn and soils caved into borehole below a depth of 6.1 m. Borehole sealed with bentonite from ground surface to depth of 6.1 m.</p> <p>3. Water level in open borehole at a depth of 0.7 m (Elev. 188.5 m) on completion of drilling.</p>																							

+³, X³: Numbers refer to Sensitivity

O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 07-11

1 OF 1 **METRIC**

PROJECT 06-1111-057

W.P. 256-98-00

LOCATION N 4882213.5 ; E 203017.2

ORIGINATED BY SB

DIST HWY 401

BOREHOLE TYPE Portable Drilling Equipment, HQ Casing

COMPILED BY MWK

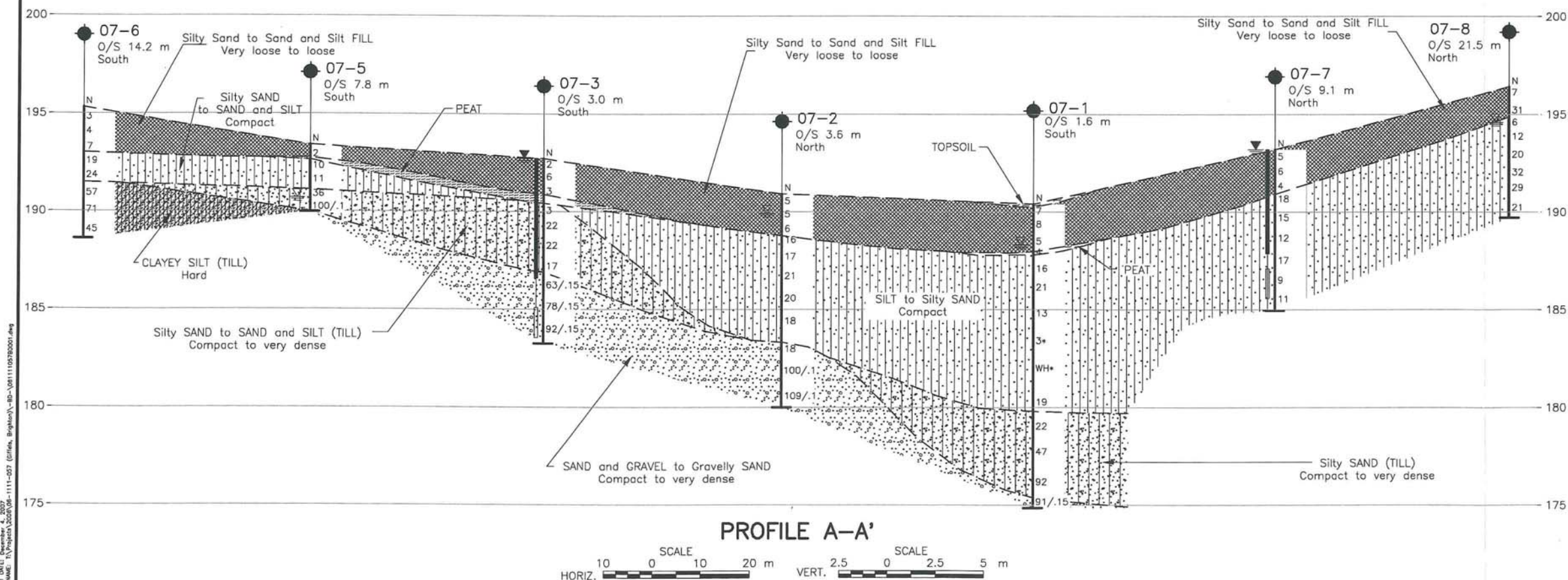
DATUM Geodetic

DATE May 14, 2007

CHECKED BY LCC/JMAC

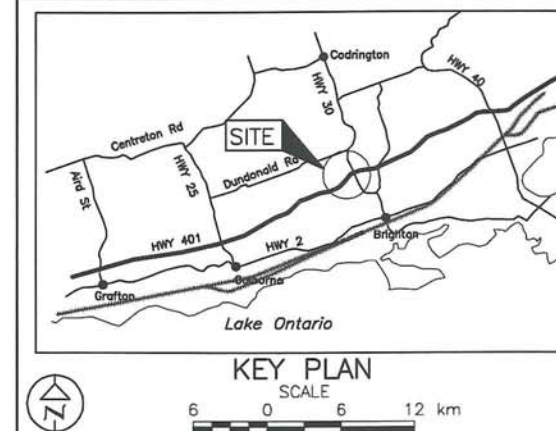
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
190.0	GROUND SURFACE													
0.0	Sand and silt, some gravel, trace clay, containing rootlets (FILL) Very loose Brown to grey Moist		1	SS	2									
188.8			2	SS	2		189							
1.2	PEAT, containing silty sand seams Very soft Wet		3	SS	2									
188.2														
1.8	SILT, trace to some sand, trace gravel, trace clay Compact Grey Wet		4	SS	10		188							7 13 74 6
							187							
			5	SS	12		186							
			6	SS	21		185							
							184							
			7	SS	6*									0 6 86 8
							183							
182.4														
7.6	Silty SAND, some gravel, trace clay (TILL) Very dense Grey Wet		8	SS	25/1		182							
180.9							181							
9.1	END OF BOREHOLE		9	SS	25/1									
Notes: 1. * Low SPT "N" value (6 blows/0.3 m of penetration) is the result of sample disturbance due to groundwater inflow to the borehole. 2. Borehole advanced using portable drilling equipment with a half-weight hammer. SPT "N" values shown on this log have been adjusted to reflect "N" values that would be obtained using a standard - weight hammer. 3. Water flowing (artesian conditions) from borehole on completion of drilling. 4. Borehole sealed with bentonite.														

+³, X³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE



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

SHEET



	Borehole — Current Investigation
	Seal
	Piezometer
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow); * indicates SPT "N" value affected by groundwater inflow to borehole
	WL in piezometer
	WL upon completion of drilling

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
07-1	190.4	4882198.0	203025.
07-2	190.9	4882182.2	202973.
07-3	192.7	4882149.2	202936.
07-5	193.4	4882110.9	202904.
07-6	195.3	4882070.0	202875.
07-7	193.2	4882217.9	203071.
07-8	196.4	4882233.4	203118.
07-9	189.2	4882190.1	203023.
07-11	190.0	4882213.5	203017.

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

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

The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

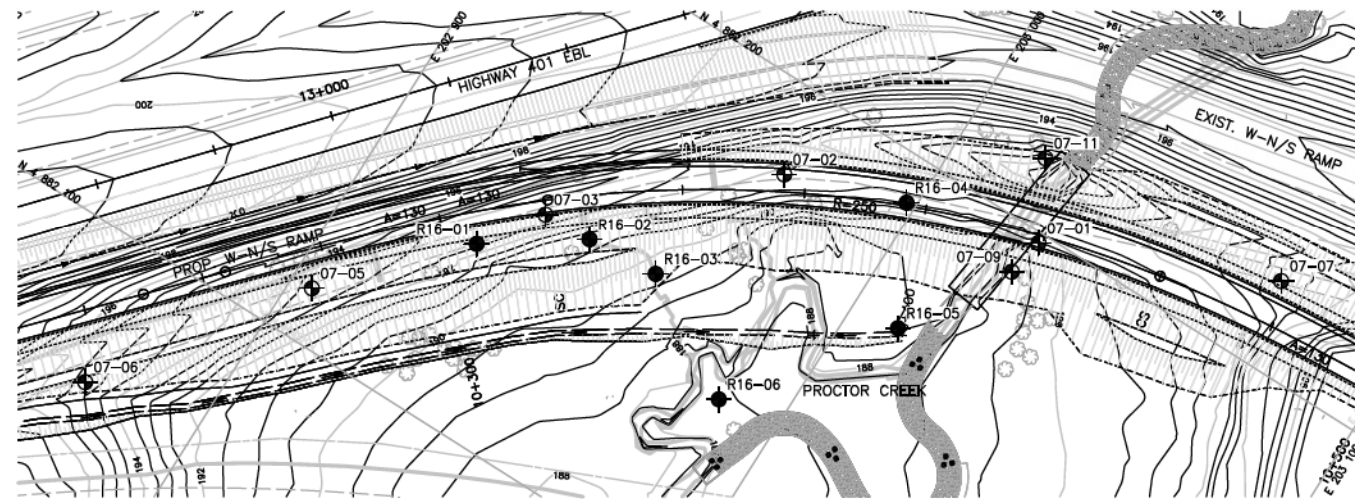
Base plan provided in digital format by Giffels (drawing file name "+401_30NEWC.dwg", received May 23, 2007).

NO.	DATE	BY	REVISION		
Geocres No.					
HWY. HIGHWAY 401			PROJECT NO. 06-1111-057		DIST.
SUBM'D. MWK		CHKD. LCC	DATE: 12/4/07		SITE:
DRAWN: JFC/RJ		CHKD. MWK/LCC	APPD. LCC/JMAC		DWG. 1

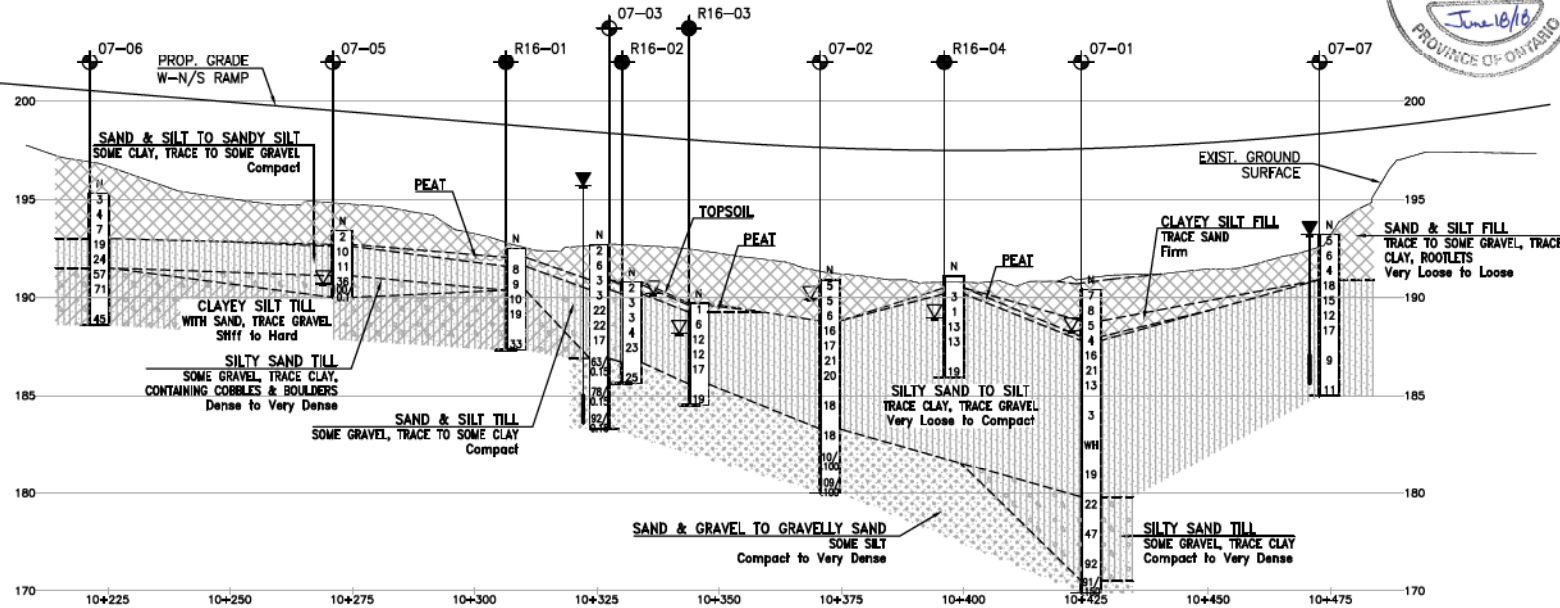


Appendix D

Drawings titled “Borehole Locations and Soil Strata”



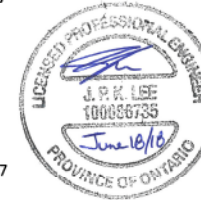
PLAN
SCALE 1:1000



SECTION ALONG W-N/S RAMP

SCALE 1:1000
H 1:1000
V 1:250

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

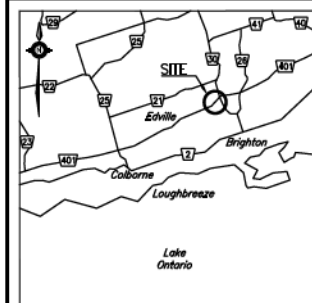


CONT No
WP No 4016-13-01

HIGHWAY 401
COUNTY ROAD 30
W-N/S RAMP
BORROW LOCATIONS AND SOIL STRATA

AECOM

THURBER ENGINEERING LTD.



KEYPLAN
LEGEND

- ◆ Borehole (By Thurber)
- ◆ Borehole (By Golder)
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONC Blows /0.3m (60' Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level
- HA Head Artesian Water
- PZ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

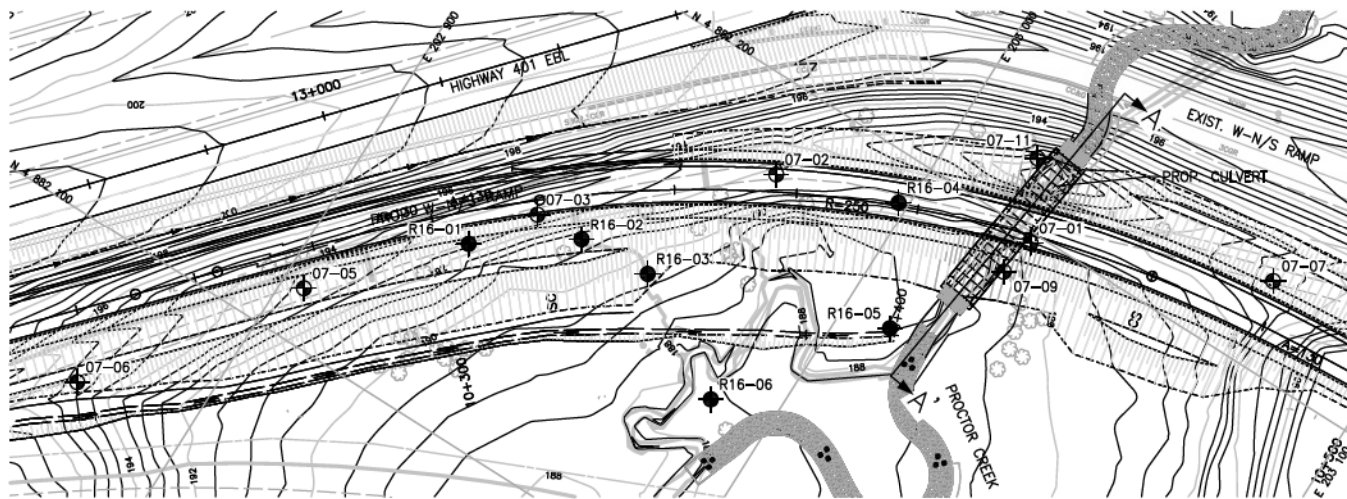
NO	ELEVATION	NORTHING	EASTING
07-01	190.4	4 882 198.0	203 025.3
07-02	190.9	4 882 182.2	202 973.6
07-03	192.7	4 882 149.2	202 936.9
07-05	193.4	4 882 110.9	202 904.6
07-06	195.3	4 882 070.0	202 875.6
07-07	193.2	4 882 217.9	203 071.4
07-09	189.2	4 882 190.1	203 023.8
07-11	190.0	4 882 213.5	203 017.2
R16-01	192.5	4 882 136.5	202 928.3
R16-02	190.8	4 882 149.7	202 947.3
R16-03	189.7	4 882 150.9	202 962.5
R16-04	191.1	4 882 190.7	202 998.0
R16-05	189.0	4 882 168.0	203 010.3
R16-06	188.3	4 882 136.2	202 987.0

- 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.

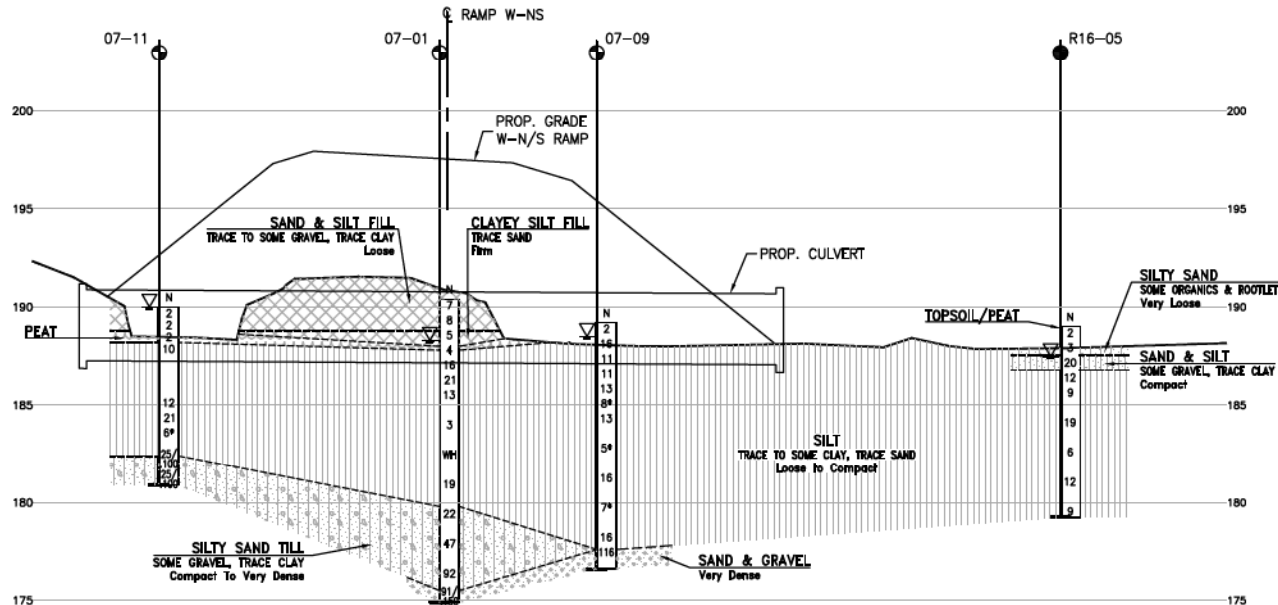
GEOCRE No. 31C-268

DATE	BY	DESCRIPTION	DATE
DESIGN	MM	CHK SHP	CODE
DRAWN	AN	CHK ON	DATE
		STRUCT	LDWG

FILENAME: H:\Projects\401\4016-13-01\4016-13-01.dwg
PLOTNAME: 6/16/2018 2:08 PM



PLAN
SCALE 1:1000



SECTION A-A'

SCALE 1:250

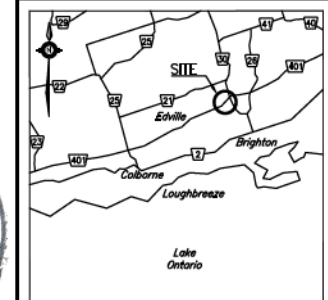
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 4016-13-01

HIGHWAY 401
COUNTY ROAD 30
W-N/S RAMP CULVERT
BORHOLE LOCATIONS AND SOIL STRATA

AECOM

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

◆	Borehole (By Thurber)
◆	Borehole (By Golder)
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
07-01	190.4	4 882 198.0	203 025.3
07-02	190.9	4 882 182.2	202 973.6
07-03	192.7	4 882 149.2	202 936.9
07-05	193.4	4 882 110.9	202 904.6
07-06	195.3	4 882 070.0	202 875.6
07-07	193.2	4 882 217.9	203 071.4
07-09	189.2	4 882 190.1	203 023.8
07-11	190.0	4 882 213.5	203 017.2
R16-01	192.5	4 882 136.5	202 928.3
R16-02	190.8	4 882 149.7	202 947.3
R16-03	189.7	4 882 150.9	202 962.5
R16-04	191.1	4 882 190.7	202 998.0
R16-05	189.0	4 882 168.0	203 010.3
R16-06	188.3	4 882 136.2	202 987.0

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.

GEOCRE No. 31C-268

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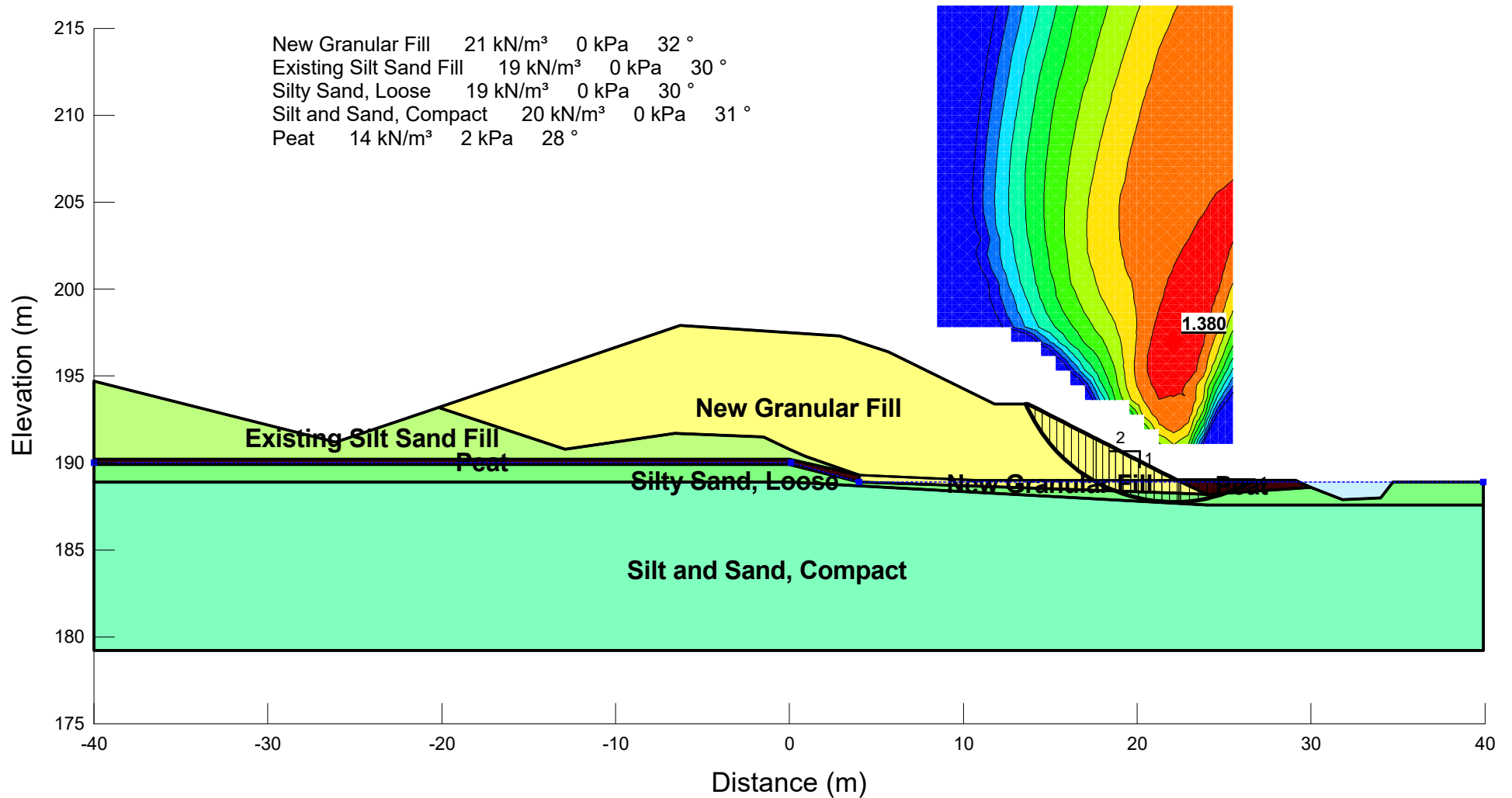


Appendix E

Slope Stability Analyses Results

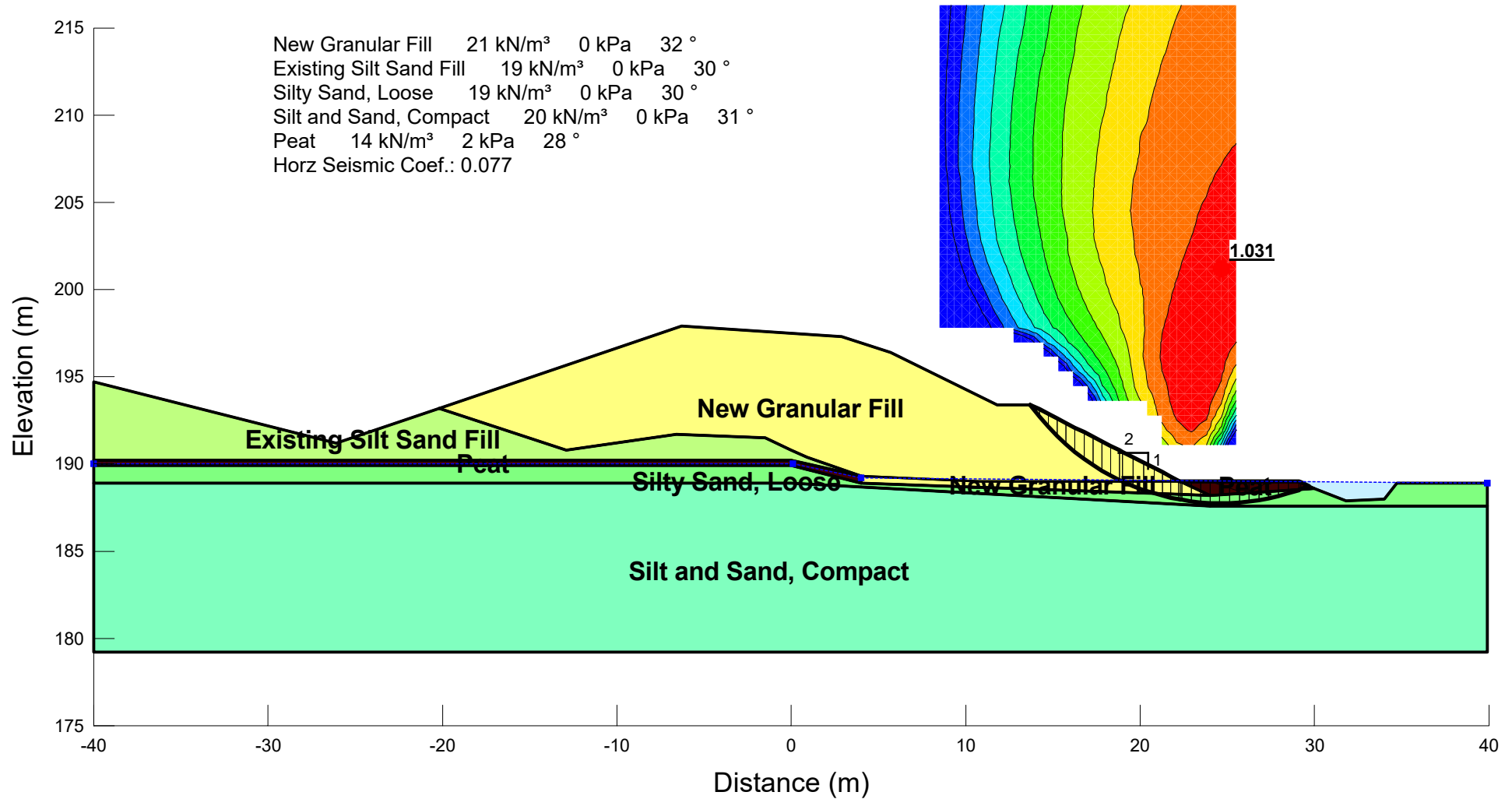
**MEGA FOUR – COUNTY ROAD 30 – W-N/S RAMP
BRIGHTON, ON
SLOPE STABILITY [GRANULAR FILL]**

FIGURE E1



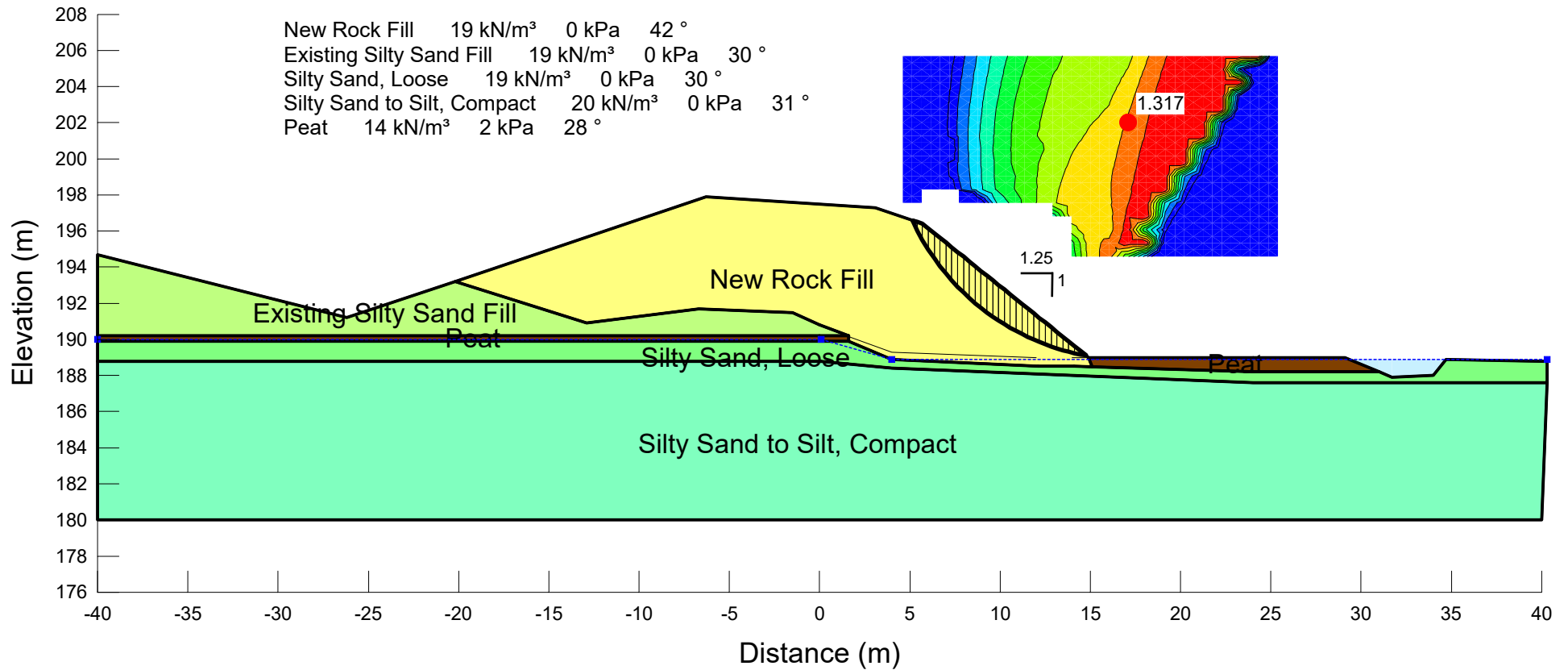
**MEGA FOUR – COUNTY ROAD 30 – W-N/S RAMP
BRIGHTON, ON
SLOPE STABILITY ANALYSIS UNDER SEISMIC LOADING [GRANULAR FILL]**

FIGURE E1A



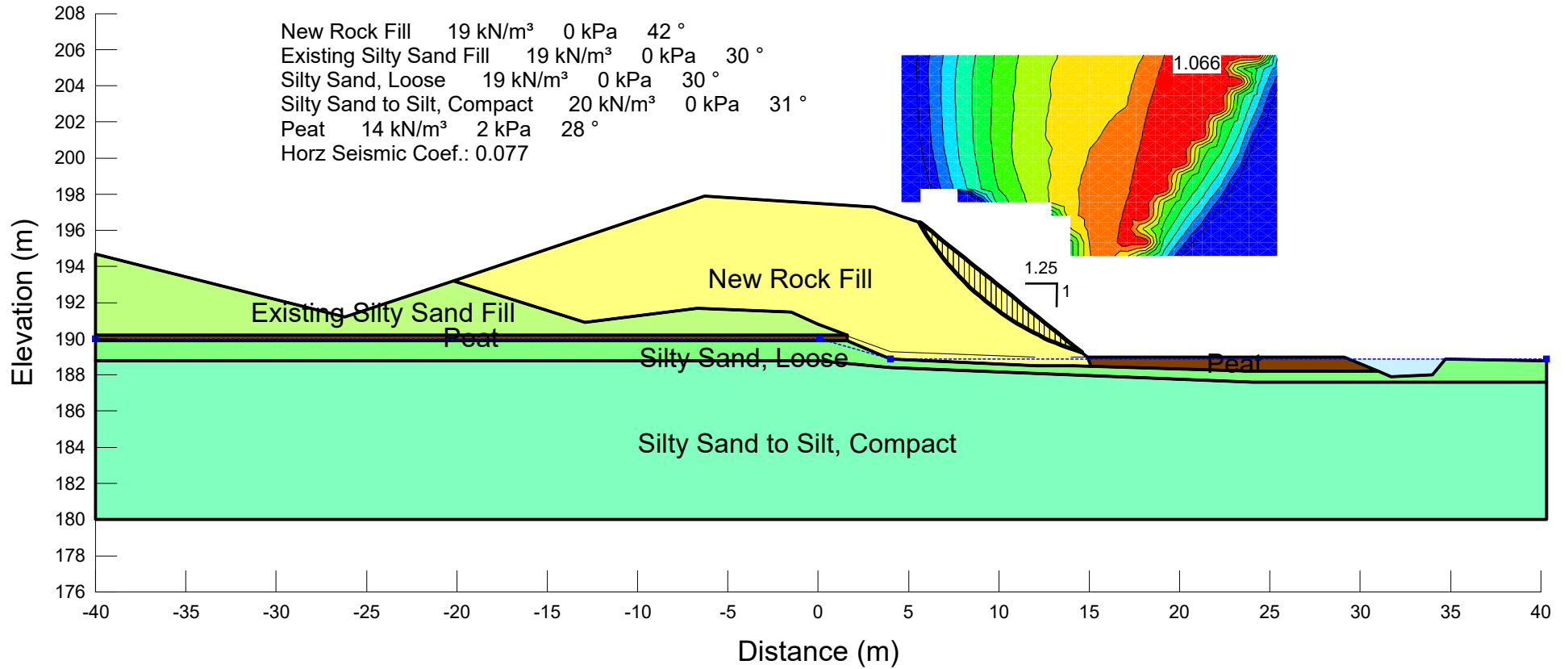
MEGA FOUR – COUNTY ROAD 30 – W-N/S RAMP BRIGHTON, ON SLOPE STABILITY [ROCK FILL]

FIGURE E2



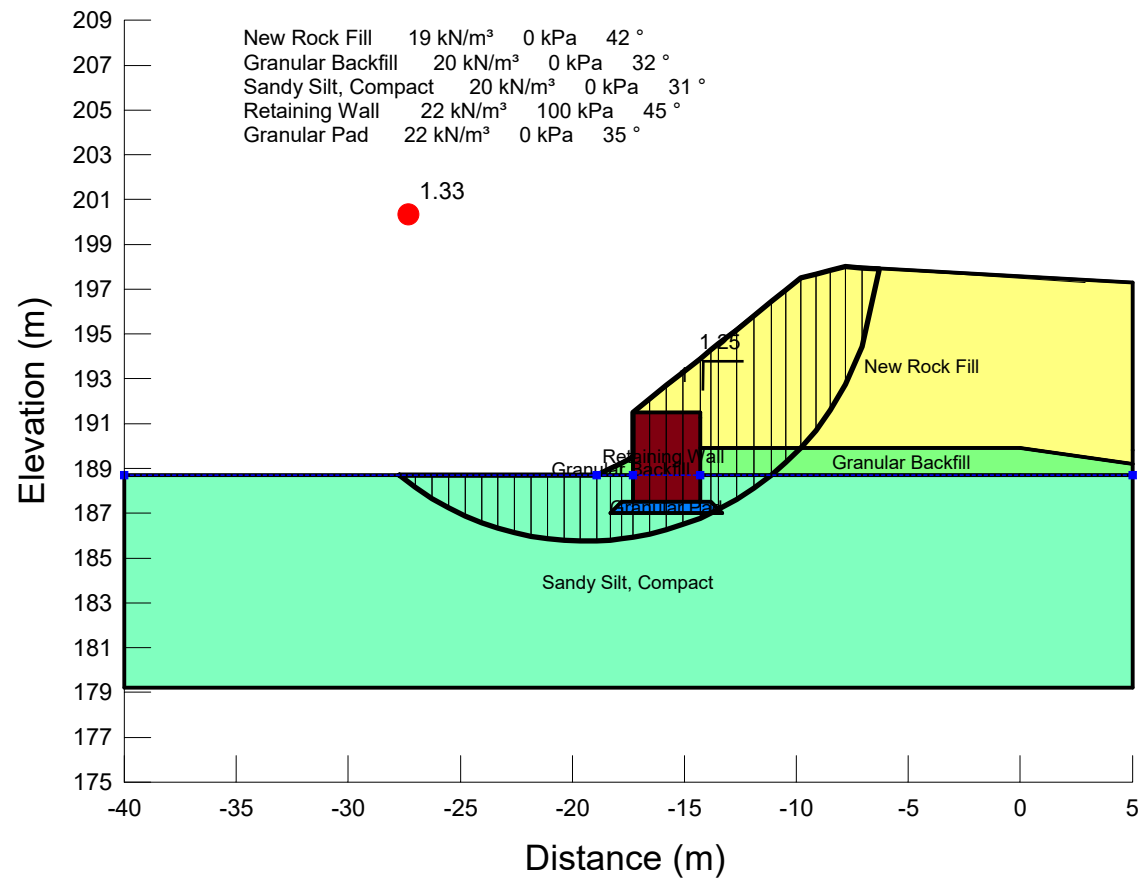
**MEGA FOUR – COUNTY ROAD 30 – W-N/S RAMP
BRIGHTON, ON
SLOPE STABILITY ANALYSIS UNDER SEISMIC LOADING [ROCK FILL]**

FIGURE E2A



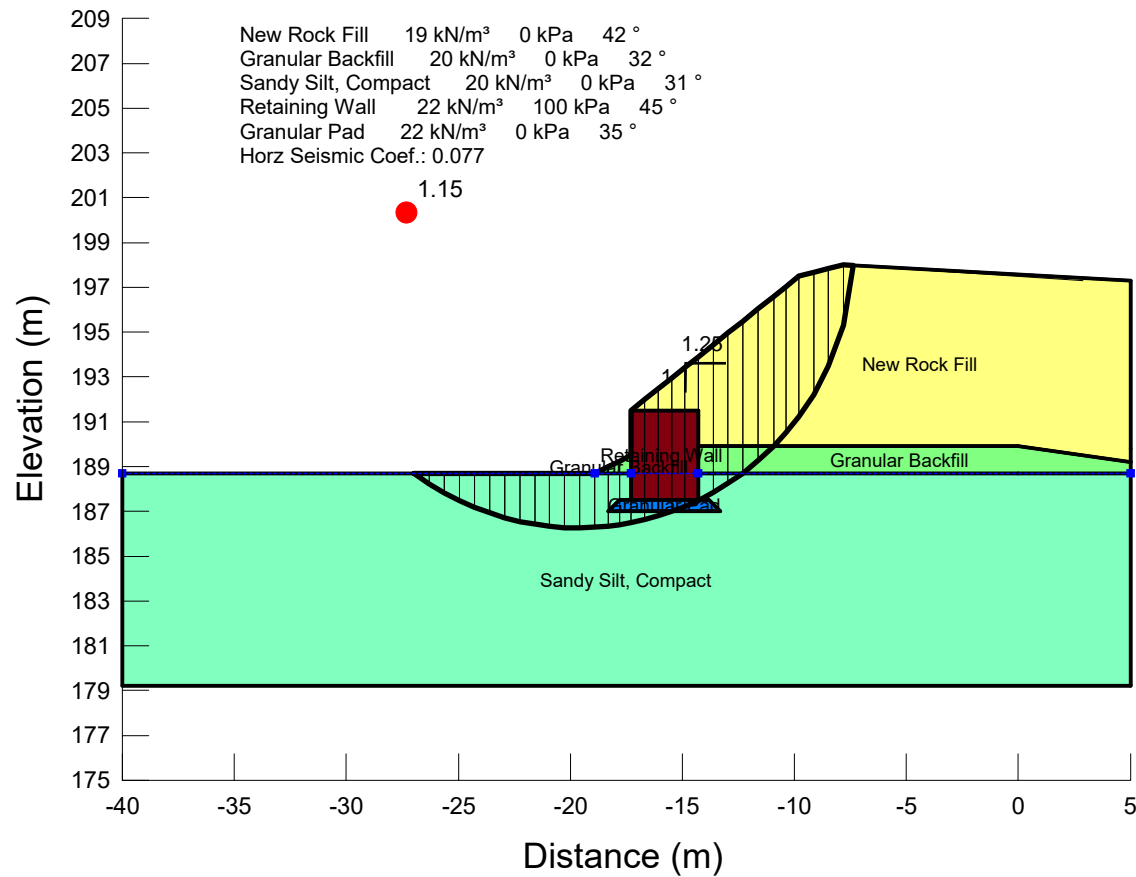
**MEGA FOUR – COUNTY ROAD 30 – W-N/S RAMP
R.W. AT THE NORTHEAST CORNER OF THE CULVERT
BRIGHTON, ON
SLOPE STABILITY ANALYSIS (3m WIDE RETAINING WALL)**

FIGURE E3



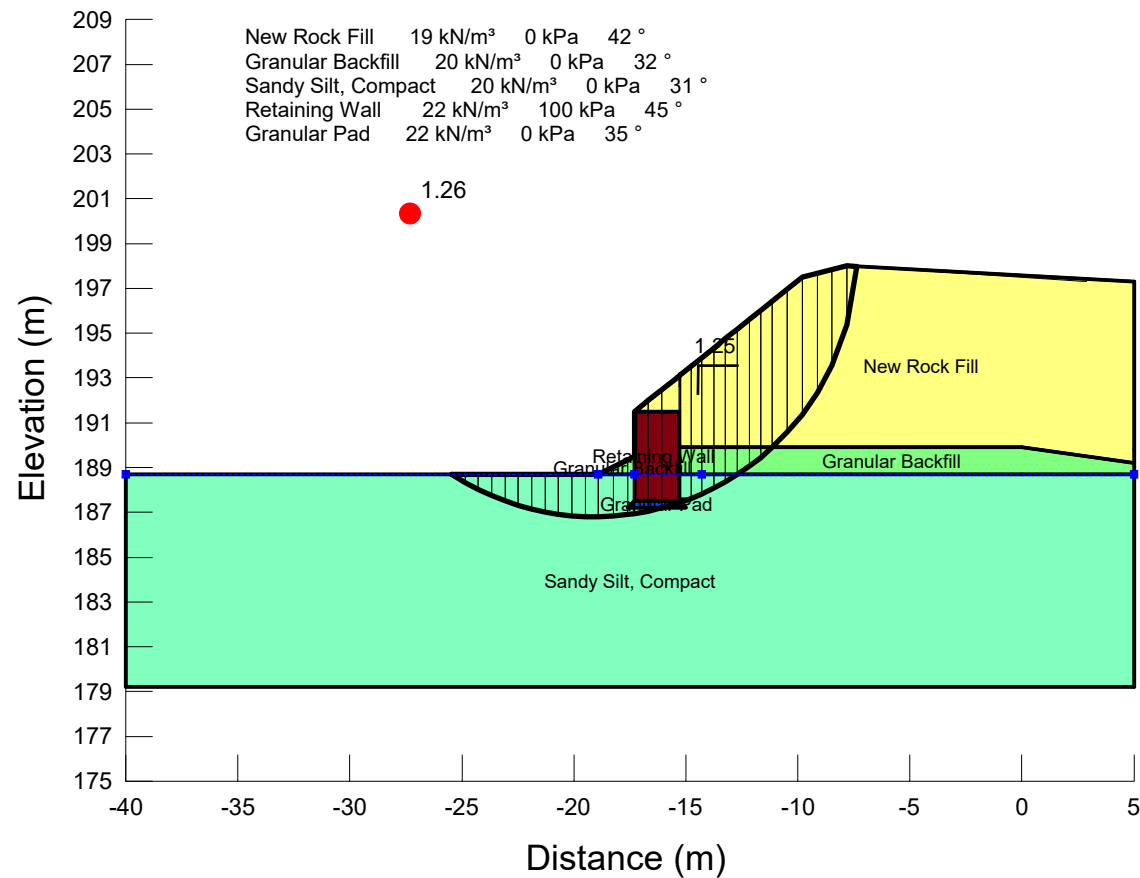
**MEGA FOUR – COUNTY ROAD 30 – W-N/S RAMP
R.W. AT THE NORTHEAST CORNER OF THE CULVERT
BRIGHTON, ON
SLOPE STABILITY ANALYSIS UNDER SEISMIC LOADING (3m WIDE RETAINING WALL)**

FIGURE E3A



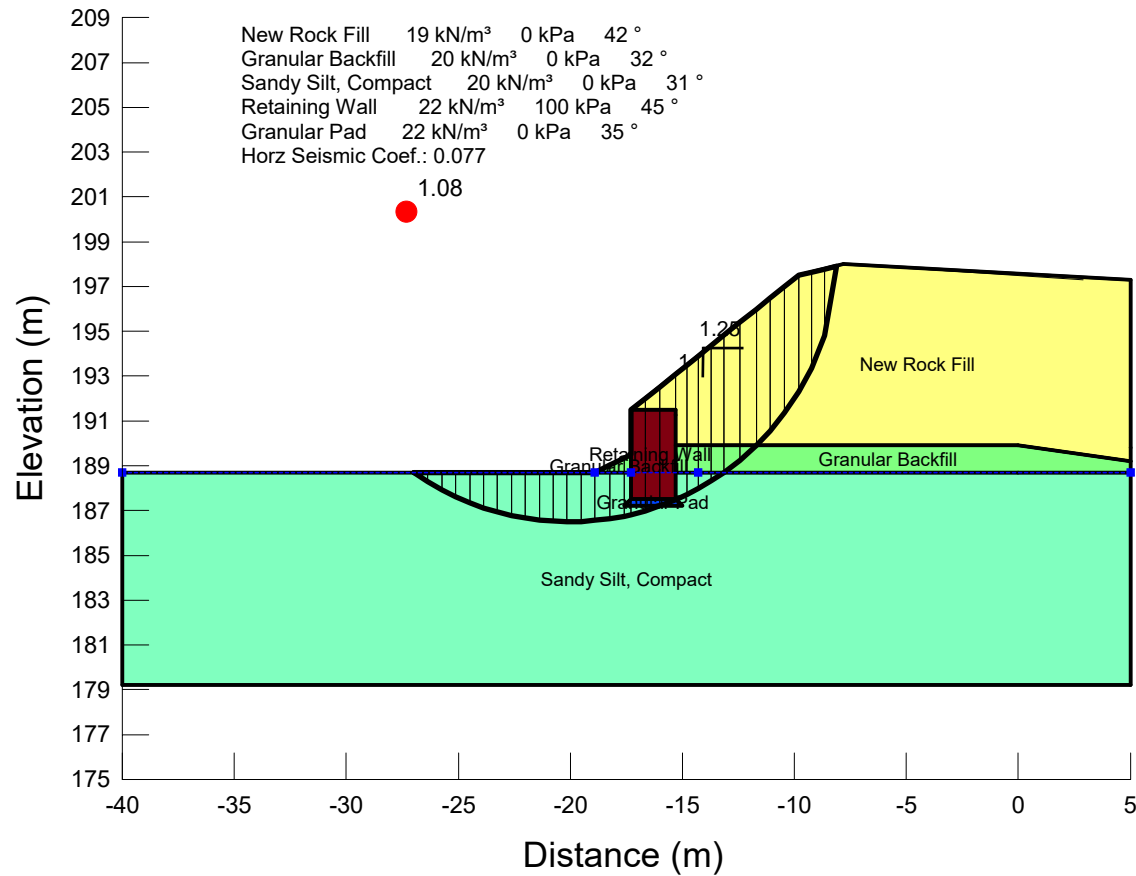
**MEGA FOUR – COUNTY ROAD 30 – W-N/S RAMP
R.W. AT THE NORTHEAST CORNER OF THE CULVERT
BRIGHTON, ON
SLOPE STABILITY ANALYSIS (2m WIDE RETAINING WALL)**

FIGURE E4



**MEGA FOUR – COUNTY ROAD 30 – W-N/S RAMP
R.W. AT THE NORTHEAST CORNER OF THE CULVERT
BRIGHTON, ON
SLOPE STABILITY ANALYSIS UNDER SEISMIC LOADING (2m WIDE RETAINING WALL)**

FIGURE E4A





Appendix F

Comparison of Culvert Types and Foundation Alternatives



COMPARISON OF FOUNDATION ALTERNATIVES

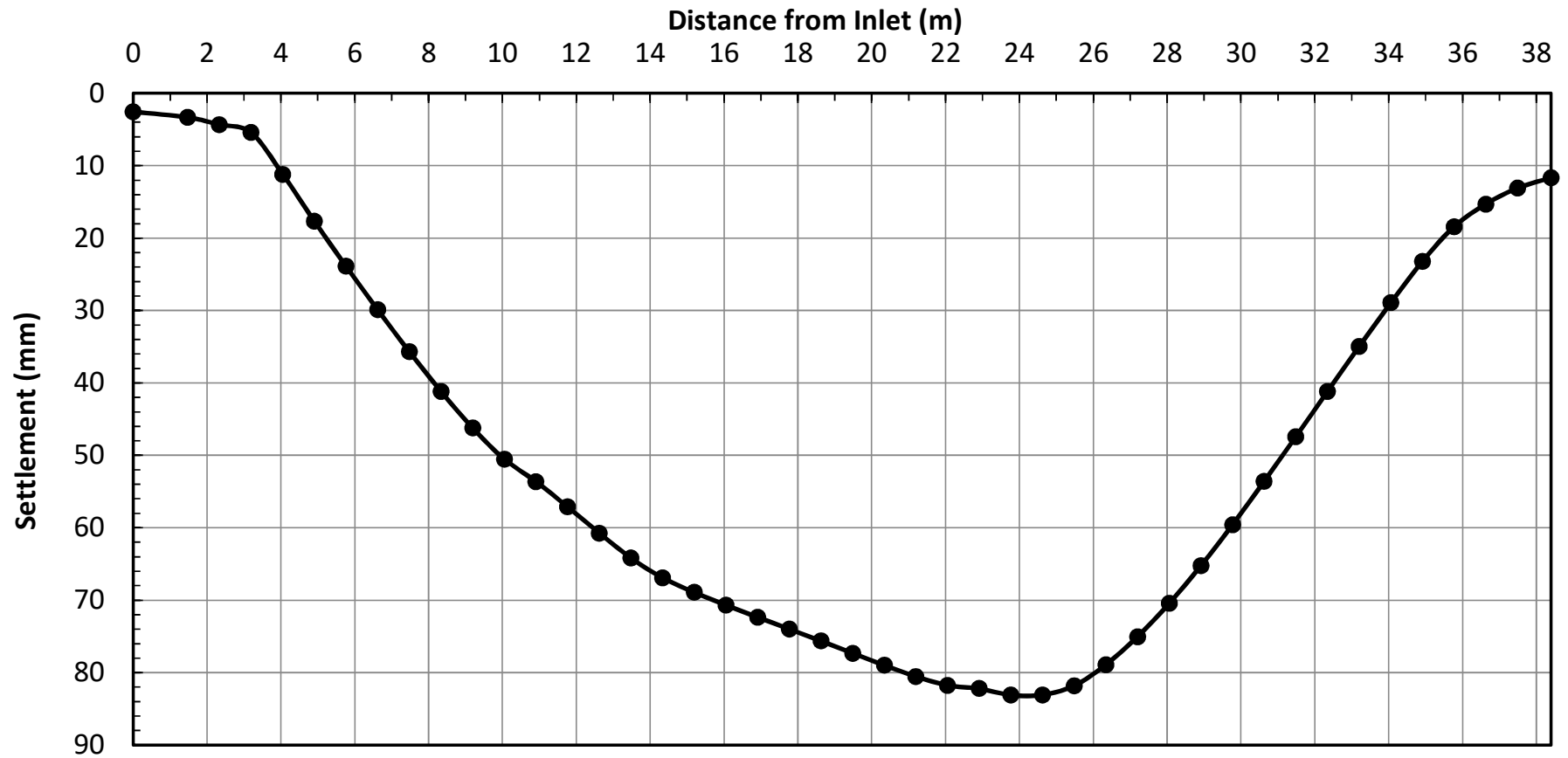
Concrete Box Culvert	Steel or Concrete Pipe Culvert	Concrete Open Footing Culvert
<u>Advantages:</u> <ul style="list-style-type: none"> i. Relatively rapid installation and less disturbance to subgrade soils if pre-cast segments are used. ii. Less stringent requirement for soil geotechnical resistances as loading is spread over a larger area. iii. Segmental option can accommodate potential differential settlement along culvert axis. 	<u>Advantages:</u> <ul style="list-style-type: none"> i. Ease of construction. ii. Less stringent requirement for soil geotechnical resistances. iii. Segmented pipes can accommodate potential differential settlement along culvert axis iv. Steel pipes may be more cost effective than concrete box or open footing culverts. 	<u>Advantages:</u> <ul style="list-style-type: none"> i. Conventional construction. ii. Possibly less disturbance of creek channel / less environmental issues such as those involving spawning fish species.
<u>Disadvantages:</u> <ul style="list-style-type: none"> i. More expensive than a steel or concrete pipe culvert. ii. Large excavation through approx. 7.5 m of fill required to install culvert. 	<u>Disadvantages:</u> <ul style="list-style-type: none"> i. Steel pipes may have shorter design life than concrete culverts. ii. Multiple pipes may be needed to meet hydraulic requirements. iii. Large excavation through approx. 7.5 m of fill required to install pipes. 	<u>Disadvantages:</u> <ul style="list-style-type: none"> i. Requires deeper excavation and potentially longer dewatering requirements. ii. Cannot tolerate differential settlement.
RECOMMENDED	FEASIBLE	NOT RECOMMENDED



Appendix G

Estimated Settlement Profile Under the New Culvert

County Road 30 - Ramp W-NS Culvert Settlement along Culvert





Soil Parameters used to calculate settlement below culvert and new embankment

Soil Layer: **Peat** Unit Weight: 14 kN/m³ Compression Ratio, C_{ce}: 0.4 Recompression Ratio, C_{re}: 0.04

Soil Layer: **Silty Sand to Silt** Unit Weight: 19 kN/m³ Constrained Modulus: 20 MPa

Soil Layer: **Silty Sand Till** Unit Weight: 21 kN/m³ Constrained Modulus: 40 MPa



Appendix H

NBCC 2015 Seismic Hazard Calculation

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

August 17, 2017

Site: 44.073 N, 77.7702 W User File Reference:

Requested by: ,

National Building Code ground motions: 2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.05)	Sa(0.1)	Sa(0.2)	Sa(0.3)	Sa(0.5)	Sa(1.0)	Sa(2.0)	Sa(5.0)	Sa(10.0)	PGA (g)	PGV (m/s)
0.149	0.190	0.168	0.135	0.104	0.060	0.030	0.0077	0.0032	0.105	0.087

Notes. Spectral ($S_a(T)$, where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s . Values are for "firm ground" (NBCC 2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are specified in **bold** font. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. *These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.*

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.05)	0.014	0.047	0.079
Sa(0.1)	0.022	0.067	0.107
Sa(0.2)	0.024	0.066	0.101
Sa(0.3)	0.021	0.057	0.084
Sa(0.5)	0.017	0.045	0.067
Sa(1.0)	0.0084	0.026	0.039
Sa(2.0)	0.0035	0.012	0.019
Sa(5.0)	0.0007	0.0029	0.0045
Sa(10.0)	0.0005	0.0012	0.0019
PGA	0.013	0.037	0.060
PGV	0.010	0.034	0.053

References

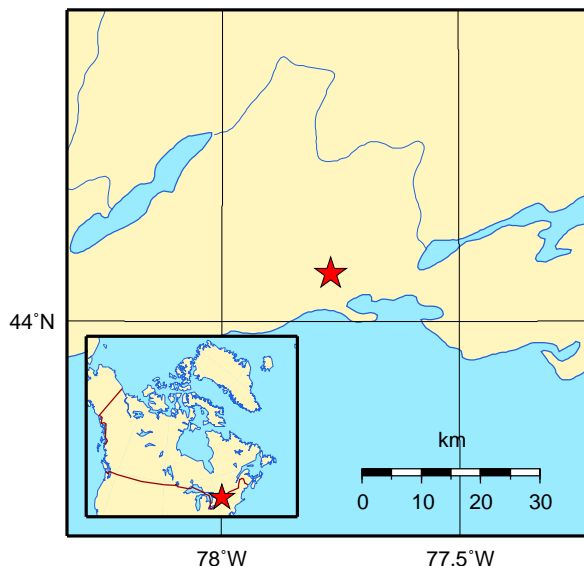
National Building Code of Canada 2015 NRCC no. 56190;
Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

User's Guide - NBC 2015, Structural Commentaries NRCC no. xxxxxx (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information

Aussi disponible en français



Natural Resources
Canada

Ressources naturelles
Canada

Canada



Appendix I

List of OPSS and OPSD and Suggested Wordings for NSSPs



1. List of OPSS and OPSD Documents Referenced in this Report

- OPSS.PROV 206
- OPSS 422
- OPSS.PROV 501
- OPSS.PROV 517
- OPSS 805
- OPSS 902
- OPSS.PROV 804
- OPSS.PROV 1010
- OPSS.PROV 1205
- OPSS 1860
- OPSD 208.010
- OPSD 802.014
- OPSD 803.010
- OPSD 803.030
- OPSD 803.031
- OPSD 3101.150
- Special Provision Foun0003

2. Suggested Wording for NSSP on “Dewatering”

Effective dewatering shall be designed and provided by the Contractor during structure excavation, bedding placement and backfilling to allow the work to proceed in the dry. Excavation below the creek and groundwater level will lead to subgrade softening and may cause boiling of the subgrade. The contractor shall engage a dewatering specialist for the design of an effective dewatering scheme to enable construction in the dry and prevent any disturbance of the foundation soil. The dewatering system must be effective to maintain the water level at a minimum depth of 0.5 m below the final subgrade level throughout construction. The dewatering system must remain operational and effective until the culvert is installed and backfilled.