THURBER ENGINEERING LTD.

FINAL

FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 11 UNDERPASS STRUCTURE
MUSKOKA RD 14/FRASERBURG RD, DISTRICT OF MUSKOKA
AGREEMENT NO. 5017-E-0003
Site No.: 42X-0189

G.W.P. 5138-13-00

Geocres No.: **31E-391**

Report to:

McIntosh Perry Consulting Engineers Limited

Latitude: 45.035188
Longitude: -79.292677

February 2019
Thurber File: 20244

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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation completed at the Muskoka Road 14 (Fraserburg Road) crossing of Highway 11, located approximately 4.6 km north of Highway 118 within the District of Muskoka. Thurber Engineering Limited (Thurber) carried out the current field investigation as a sub-consultant to McIntosh Perry Consulting Engineers Ltd. (MPCE) under Assignment No. 5017-E-0003.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and construction was developed in the course of the current investigation. The following historical foundation investigation report was obtained from the online Geocres library and reviewed in preparation of this report.

> Ministry of Transportation and Communications (1986); Foundation Investigation and Design Report for Muskoka Road 14 Underpass (Fraserburg Road), Highway 11, Huntsville; Geocres No. 31E-101

2 SITE DESCRIPTION

The project assignment includes an underpass structure that is a two span cast in place post tensioned voided concrete slab bridge. The existing underpass conveys Muskoka Road 14 (Fraserburg Road) in a west – east alignment at an approximate skew of 29 degrees over Highway 11.

The underpass (Structure No.42X-0189) has two spans of 39 m each, a road width of 8.5 m and an overall width of 9.46 m. The clearance under the structure is approximately 5.2 m. The structure is understood to have been constructed in 1989 and has not yet been rehabilitated. The foundations are documented to consist of H-piles driven to bedrock at the west abutment and H-piles driven to refusal at the east abutment and pier. Wingwalls are present at the structure ends.

At the location of the underpass structure, Highway 11 is a four-lane divided highway with a rural cross-section, paved shoulders and a grassed median. The approach fill height is approximately 5.3 to 7.1 m with the Muskoka Road 14 (Fraserburg Road) road surface at approximate elevation 260.2 m. The existing embankment slopes are inclined at approximately 2.4H:1V. Reinforced concrete barrier walls are situated on each side of the deck as guardrails.

The land adjacent to the highway is agricultural and vegetated with grasses, shrubs and trees. Traffic volumes on this section of Highway 11 are understood to be 14,800 AADT (2016).

Select photographs showing the existing conditions in the area of the underpass at the time of the field investigation are included in Appendix D for reference.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing program was carried out on April 29th, 2018. The field investigation consisted of advancing two boreholes identified as 18-1 and 18-2 near the abutments of the structure. The drilling was carried out using a truck mounted CME 55 drill rig. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). A thin walled (Shelby) tube sample was attempted at a depth of 14.0 m in Borehole 18-2. The boreholes were sampled to depths of 17.1 and 19.5 m (elev. 243.9 and 239.9 m) below the existing ground surface in Boreholes 18-1 and 18-2, respectively.

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

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawing included in Appendix A. The coordinates and elevations of the boreholes are provided on this drawing and on the individual Record of Borehole sheets. The northing and easting (MTM zone 10), elevation, and termination depth of the boreholes are summarized below in Table 3-1. The borehole elevations were surveyed relative to benchmark Pt. 301 (elev. 260.701 m), provided by MPCE, with a Nikon-AP-8 with an accuracy of +/- 1.5 mm. Horizontal locations were measured relative to existing site features.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Termination Depth (m)
18-1	West of Structure, EB Lane	4 988 350.1	321 076.7	260.9	17.1
18-2	East of Structure, EB Lane	4 988 392.0	321 192.7	259.4	19.5

Following completion of the field investigation the boreholes were backfilled in accordance with MOE requirements (O.Reg. 903 as amended). All boreholes were backfilled with granulars within the depth of pavement structure and capped with 150 mm of cold patch asphalt to reinstate the traveling surface.

4 LABORATORY TESTING

The recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected samples were also subjected to gradation analysis (hydrometer and/or sieve) and Atterberg Limit testing. The results of these tests are summarized on the Record of Borehole sheets included in Appendix B. One sample of soil recovered from within each Borehole was selected and submitted for analytical testing of corrosivity parameters. All laboratory test results from the field investigation are provided 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 B and the Borehole Location and Soil Strata drawing included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations.

In general terms, the site was found to be underlain by a pavement structure, sand fill overlying native silt which was underlain by a clay deposit and silt and silty sand layers. Bedrock was not encountered within the depth of the current investigation.

The historic 1986 boreholes from Geocres Report 31E-101 have also been included in Appendix B and their locations indicated on Drawing No. 608600-A in Appendix A. The locations and ground surface elevation for these boreholes are approximate. The 1986 borehole records indicate firm to stiff silty clay over very loose to compact silt over compact to very dense silty sand. Bedrock was proven by coring at elevation of 229.1 and 213.5 m near the west abutment and median pier, respectively. It is expected that conditions have changed as a result of the bridge and embankment construction since these holes were drilled in 1986, therefore the historic documents have not been included in the following descriptions.

5.1 Embankment

5.1.1 Asphalt

Both boreholes were drilled through the existing Muskoka Road 14 (Fraserburg Road) approach embankments and encountered a layer of asphalt at the surface with a thickness of 50 to 125 mm.

5.1.2 Fill: Sand with gravel

Encountered below the asphalt was a layer of granular fill making up the pavement structure and consisting of sand with various amounts of gravel. The underside depth of the granular fill was at 1.5 m (elev. 257.9 to 259.4 m) below the existing roadway.

SPT tests conducted in this fill gave N-values ranging from 25 to 41 blows indicating a relative density of compact to dense.

Recorded moisture contents ranged from 2 to 6%.

5.1.3 Fill: Sand with silt

Below the pavement structure in both boreholes was a layer of fill consisting predominantly of sand to sand with silt. The sand fill was 4.6 to 7.2 m thick and the underside of the sand fill was at 6.1 and 8.7 m (elev. 254.8 and 250.8 m) below the existing roadway surface in Boreholes 18-1 and 18-2, respectively.

The SPT tests conducted in this fill gave N-values ranging from 12 to 66 blows indicating a relative density of compact to very dense.

Recorded moisture contents ranged from 3 to 14%. The results of grain size analyses conducted on two samples of the sand fill are summarized below and are illustrated on Figure C1 in Appendix C.

Soil Particle	Percentage (%)
Gravel	3 – 14
Sand	81 – 91
Silt & Clay	5 – 6

5.2 Silt (ML)

Below the embankment in both boreholes was a native silt with varying amounts of sand. Wood fragments were encountered near the base of this layer in Borehole 18-2. The thickness of this layer ranged from 0.8 to 3.0 m with a base elevation ranging from 254.1 to 247.7 m.

The SPT tests conducted in the silt layer gave N-values ranging from 5 to 7 indicating a relative density of loose.

Recorded moisture contents ranged from 18 to 25%. One moisture content as high as 137% was recorded in Borehole 18-2 within the sample containing wood fragments. Atterberg Limits testing on two samples indicated that this material was non-plastic. The results of grain size analyses conducted on two samples of the silt are summarized below and illustrated on Figure C2 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0
Sand	11 – 23
Silt	64 – 82
Clay	7 – 13

5.3 Clay (CL to CH)

Both boreholes encountered a clay deposit below the silt layer. The thickness of this layer ranged from 3.1 to 5.3 m with a base elevation ranging from 244.7 to 248.7 m. Traces of wood fragments were noted in Borehole 18-2.

In-situ shear vane test results indicated undrained shear strength ranging from 45 to 75 kPa indicating a firm to stiff consistency. The results of the in-situ shear vane tests indicate that the clay exhibits sensitivity. SPT tests gave N-values ranging rom 1 to 3 blows.

Recorded moisture contents ranged from 32 to 59%. The results of grain size analyses conducted on two samples of the clay are summarized below and illustrated on Figure C3 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0
Sand	1 – 3
Silt	36 – 57
Clay	42 – 61

The results of Atterberg Limits testing completed on two samples of this material indicated a liquid limit ranging from 31 to 64, a plastic limit ranging from 17 to 27, and a plasticity index ranging from 14 to 37. The laboratory results indicate that the clay ranges from low to high plasticity (CL to CH). The results are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limits graph is included in Figure C5 of Appendix C.

5.4 Silty Sand (SM)

A deposit of silty sand was encountered below the clay in both boreholes. Traces of wood fibres were noted in Borehole 18-2. Borehole 18-2 was terminated within this layer at an elevation of 239.9 m. The thickness of this layer in Borehole 18-1 was 0.4 m with a base elevation of 248.3 m. A 0.6 m thick silt layer was encountered within this silty sand deposit in Borehole 18-2, see Section 5.5.

The SPT tests conducted in this silty sand layer gave N-values ranging from 6 to 38 blows indicating a relative density of loose to dense.

The recorded moisture contents ranged from 16 to 44%. The results of a grain size analysis conducted on one sample of the silty sand are summarized below and illustrated on Figure C4 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0
Sand	71
Silt	26
Clay	3

5.5 Lower Silt (ML)

A lower deposit of silt with varying amounts of sand was encountered below the silty sand in Borehole 18-1 and within the silty sand layer in Borehole 18-2. Borehole 18-1 was terminated within this lower silt layer at an elevation of 243.9 m. The thickness of this lower silt deposit in Borehole 18-2 was 0.6 m with a base elevation of 240.6 m.

The SPT tests conducted in the lower silt layer gave N-values ranging from 9 to 22 indicating a relative density of loose to compact.

Recorded moisture contents ranged from 19 to 30%. Atterberg Limits testing on one sample indicated that this material was non-plastic. The results of a grain size analysis conducted on one sample of the lower silt are summarized below and illustrated on Figure C2 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0
Sand	1
Silt	94
Clay	5

5.6 Bedrock

Bedrock was not encountered within the depth of the current investigation.

5.7 Groundwater

The groundwater level measured in both boreholes during drilling operations on April 29th, 2018 was recorded to be at an elevation of 251.3 and 252.4 m.

These observations are considered short term and it should be noted that the groundwater level at the time of construction could be different and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation events.

5.8 Analytical Testing

Two samples of soil were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate, sulphide and chloride concentrations, resistivity and conductivity. The analysis results are summarized in the table below:

Borehole (sample)	Depth (mbgs)	Sulphate (µg/g)	pH (-)	Resistivity (Ohm-cm)	Conductivity (uS/cm)	Chloride (µg/g)	Sulphide %
18-1 (SS10)	6.9 – 7.5	51	5.56	2,130	469	246	<0.02
18-2 (SS12A)	10.7 – 11.1	10	5.32	3,810	262	120	<0.02

6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to the bridge abutments and other site features. The as-drilled locations and ground surface elevation of the boreholes were measured by Thurber following completion of the field program. Base plan drawings and survey benchmarks were provided by MPCE.

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario supplied and operated the drilling equipment to conduct the drilling, soil sampling, in-situ testing and borehole decommissioning of the boreholes. The field investigation was supervised on a full time basis by Mr. Sean O'Bryan. of Thurber. Overall supervision of the field investigation program was provided by Mr. Stephen Peters, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa, Ontario. Interpretation of the factual data and preparation of this report were carried out by Miss Katya Edney, P.Eng. and Mr. Stephen Peters, P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng and Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundation Projects.

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PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

This section of the report provides an interpretation of the factual data from Part 1 of this report and presents geotechnical recommendations to assist the project team in the design of the proposed underpass rehabilitation works at the Muskoka Road 14 (Fraserburg Road) crossing of Highway 11 located approximately 4.6 km north of Highway 118 within the District of Muskoka. The discussion and recommendations presented in this report are based on the information provided by McIntosh Perry Consulting Engineers Ltd. (MPCE) and on the factual data obtained during the course of the investigation.

This foundation investigation and 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 construction or design-build 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.

In general terms, the site was found to be underlain by a pavement structure and sand fill overlying native silt which was underlain by a clay deposit and silt and silty sand layers. Bedrock was not encountered within the depth of the current investigation. The short-term groundwater level was recorded in the open boreholes to be at an elevation ranging from 251.3 to 252.4 m on April 29th, 2018.

7.1 Proposed Structure Rehabilitations

At the time of preparation of this final Foundation Investigation and Design Report, the proposed rehabilitation of the underpass structure, as described in the TPA, is to include the removal and replacement of asphalt and waterproofing, patch the concrete in the deck surface, replace the expansion joints and repair deteriorated concrete.

It is understood that the modifications will not add any further loading to the existing foundations.

8 GEOTECHNICAL RECOMMENDATIONS

The embankments range from 5.3 to 7.1 m in height above the adjacent ground level, with a clearance of approximately 5.2 m above Highway 11. On each end of the bridge structure, temporary protection systems are being considered to allow excavation behind the abutments while maintaining one lane of traffic on Muskoka Road 14/Fraserburg Road. In accordance with the RFP, geotechnical recommendations are provided herein for temporary protection systems and reinstatement of the highway embankments.

8.1 Excavation

All temporary excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of OHSA, the existing fills above the water table may be classified as Type 3. The existing fills and cohesionless soils below a water table are classified as Type 4 soil.

Newly placed granular fill constructed in accordance with OPSS 501 and the rehabilitation contract can be considered to be Type 2 soil.

It is anticipated that there will be space restrictions and excavations will need to be carried out within a protection system. Further discussion is presented in Section 8.2.

8.2 Temporary Protection Systems

Temporary Protection Systems may be required during construction and must be implemented in accordance with OPSS.PROV 539 and designed for Performance Level 2 (maximum 25 mm horizontal deflection). The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system. An interlocking sheet pile system or a soldier pile and lagging system are considered to be two feasible options. Bracing may be required.

Native deposits of loose silt and firm clay were encountered below the embankment. These loose/firm deposits are sensitive to disturbance and vibrations. Using vibratory methods could induce settlement of the bridge approach embankments. If the Temporary Protection Systems extends below the existing fill materials, vibratory equipment should not be permitted at this site for installation or removal of the temporary protections system. The sheet piles could be left in place provided they are cut-off in accordance with OPSS.PROV 539. Suggested wording for an NSSP is provided in Appendix E. However, if the Temporary Protection Systems remain within the fill materials, vibratory equipment is permitted at this site for installation or removal of the system.

Although not encountered within the boreholes, the Contractor should be aware that cobbles or obstructions could be present in the fill. A suggested NSSP to alert the Contractor is provided in Appendix E.

Typical lateral earth pressure coefficients for the soils encountered at this site are provided in Section 8.3.

Temporary protection systems are the responsibility of the Contractor and should be designed by a licensed Professional Engineer experienced in such designs and retained by the Contractor. The designer must undertake an assessment of the foundation soils ability to support the weight of cranes and/or other construction equipment used during the installation of the protection systems and the rehabilitation works.

8.3 Lateral Earth Pressures

Lateral earth pressures parameters provided in Table 8-1 and in the text below are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for buildup of hydrostatic pressures should be considered in design.

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC but generally are given by the following expression:

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

where:

p_h	=	horizontal pressure on the wall at depth h (kPa)
K	=	earth pressure coefficient (see table below)
γ	=	unit weight of retained soil (must adjust for groundwater level)
h	=	depth below top of fill where pressure is computed (m)
q	=	value of any surcharge (kPa)

A lateral earth pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with Clause 6.12.3 of the CHBDC. Typical earth pressure coefficients for backfill are shown in Table 8-1.

Table 8-1. Static Earth Pressure Coefficients with Level Backfill

Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^o$, $\gamma = 22.8$ kN/m^3	OPSS Granular B Type I $\phi = 32^o$, $\gamma = 21.2$ kN/m^3	OPSS SSM and Existing Sand Fill $\phi = 30^o$, $\gamma = 21.0$ kN/m^3	Native Silt $\phi = 28^o$, $\gamma = 19.0$ kN/m^3
Active, K_A (Movement away from Soil Mass)	0.27	0.31	0.33	0.36
At Rest, K_O (Non-Yielding Wall)	0.43	0.47	0.50	0.53
Passive, K_P (Movement towards Soil Mass)	3.7	3.3	3.0	2.8
Soil Group(*)	"medium dense sand"	"loose to medium dense sand"	"loose sand"	"loose sand"

Note: (*) for use with Figure C6.16 of the Commentary to the CHBDC.

The parameters in the table above 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 using the soil group designation as outlined in Table 8-1. Active pressures should be used for unrestrained walls. For rigid structures, it is recommended that at-rest horizontal earth pressures be used for design. Where ground surfaces are sloped behind the walls, the coefficients provided in the Table 8-1 are not applicable.

8.4 Embankment Design and Reinstatement

8.4.1 Embankment Reconstruction

It is recommended that where the existing embankment has been removed as part of the rehabilitation work, it be reinstated in accordance with OPSS 902 and OPSD 3101.150 and consist of free draining, non- frost susceptible granular materials such as Granular A material meeting the requirements of OPSS.PROV 1010 and should be placed and compacted as per OPSS.PROV 501.

Pavement structure reinstatement should follow the recommendations provided in the Pavement Design Report (completed by others).

Heavy compaction equipment, used adjacent to the bridge structure, must be restricted in accordance with OPSS.PROV 501. Care must be exercised when compacting the fill adjacent to the walls in order not to damage the structures. Embankment reconstruction after bridge rehabilitation should be carried out in accordance with OPSS.PROV 206.

The embankment should be reinstated with side slopes of 2H:1V (or flatter).

8.4.2 Embankment Settlement and Stability

The condition of the existing embankment slopes was examined in the field during the field investigation and no evidence of instability (tension cracks etc.) was noted at that time.

It is understood that the existing embankment geometry will not change following rehabilitation and therefore no permanent grade raise or embankment widening is proposed. Provided proper construction methods are used, no long term or global stability issues are anticipated for embankments reinstated at this site. Material stockpiling above the existing grades is a temporary construction measure and the stability implications are the responsibility of the Contractor. The selection and placement of construction equipment (such as cranes) are also the Contractor’s responsibility.

As no permanent grade raise is anticipated negligible settlement is expected to occur in the soils underlying the reinstated approach fills.

The magnitude of the embankment compression constructed with granular materials is in the order of 0.5% of the embankment height and is expected to occur during and following fill placement.

8.5 Cement Type and Corrosion Potential

Analytical tests were completed to determine the potential for degradation of the concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel. The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. Soluble sulphate concentrations less than 1000 μg/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. The class of concrete selected should consider the effects of road de-icing salts.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The tests results provided in Section 5.8 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects. The corrosive effects of road de-icing salts should also be considered.

9 CONSTRUCTION CONSIDERATIONS

9.1 Surface and Groundwater Control

Excavation for the rehabilitation is not expected to intersect the groundwater. Embankment reinstatement and structure backfilling required as part of the underpass structure rehabilitation must be carried out in the dry. The Contractor must be prepared to control the surface water flow at this site to permit construction in a dry and stable excavation. Temporary surface water control measures will be required to remain operational during construction until the structure rehabilitation is completed and backfilled.

9.2 Scour Protection and Erosion Control

Based on the subsurface conditions encountered at the drilled locations through the embankment at this site the embankment materials soils are considered to have low susceptibility to erosion as per the Wischmeier Nomograph.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the reinstatement of the embankment slopes. Slope vegetation should be established as soon as possible after completion of the embankment fills in order to control surficial erosion in general accordance with OPSS.PROV 804. The contractor should provide silt fences and erosion control blankets, as required, throughout the duration of the construction to prevent silt/sediment from running off the site as per OPSS 805.

10 CONSTRUCTION CONCERNS

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

- The Contractor's selection of construction equipment and methodology must include assessment of the capability of the existing embankment to support the proposed construction equipment and any temporary fill.

The successful performance of the rehabilitated bridge will depend largely upon good workmanship and quality control during construction.

11 CLOSURE

Engineering analysis and preparation of this report were carried out by Miss Katya Edney, P.Eng. and Mr. Stephen Peters, P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng and Dr. P.K. Chatterji, P.Eng a Designated Principal Contact for MTO Foundation Projects.

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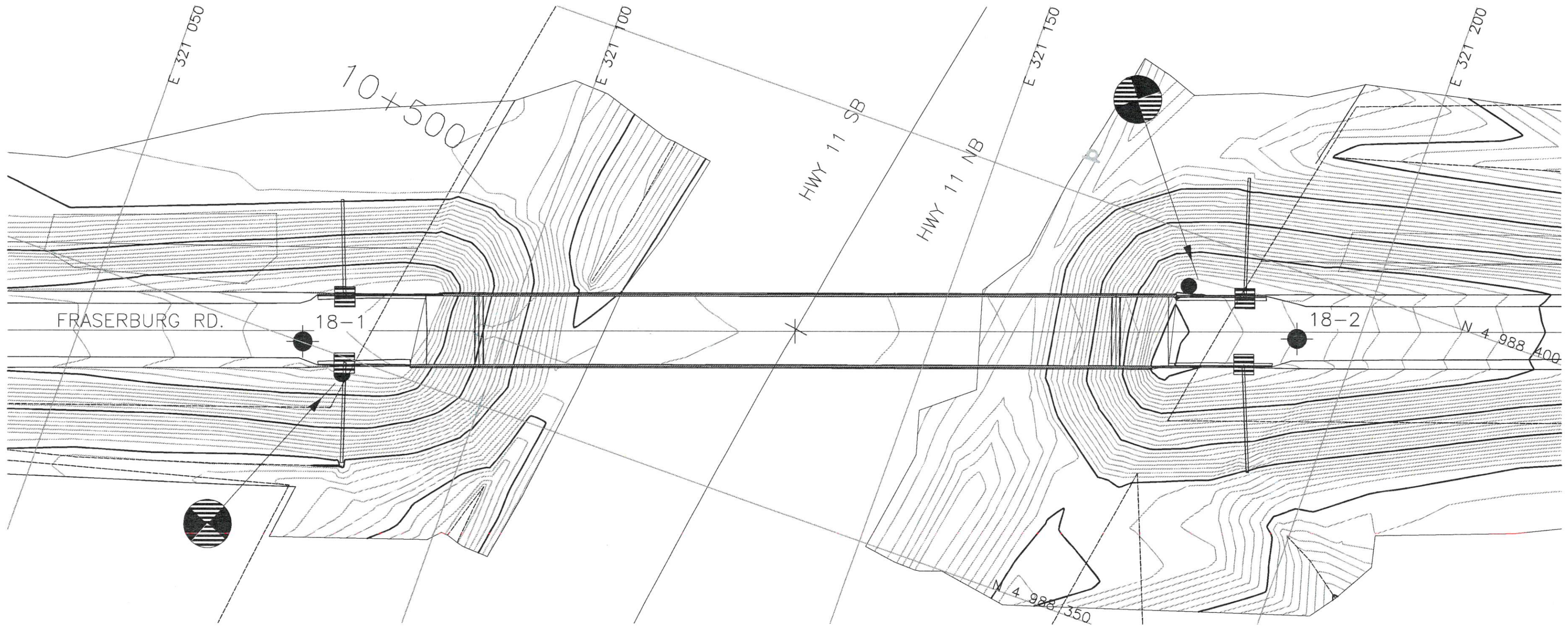
Appendix A.

Borehole Location Plan and Stratigraphic Drawings



PLAN

16 0 16 32m

SCALE 1:800

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

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CONT No 2019-XXXX
WP No 5137-13-01

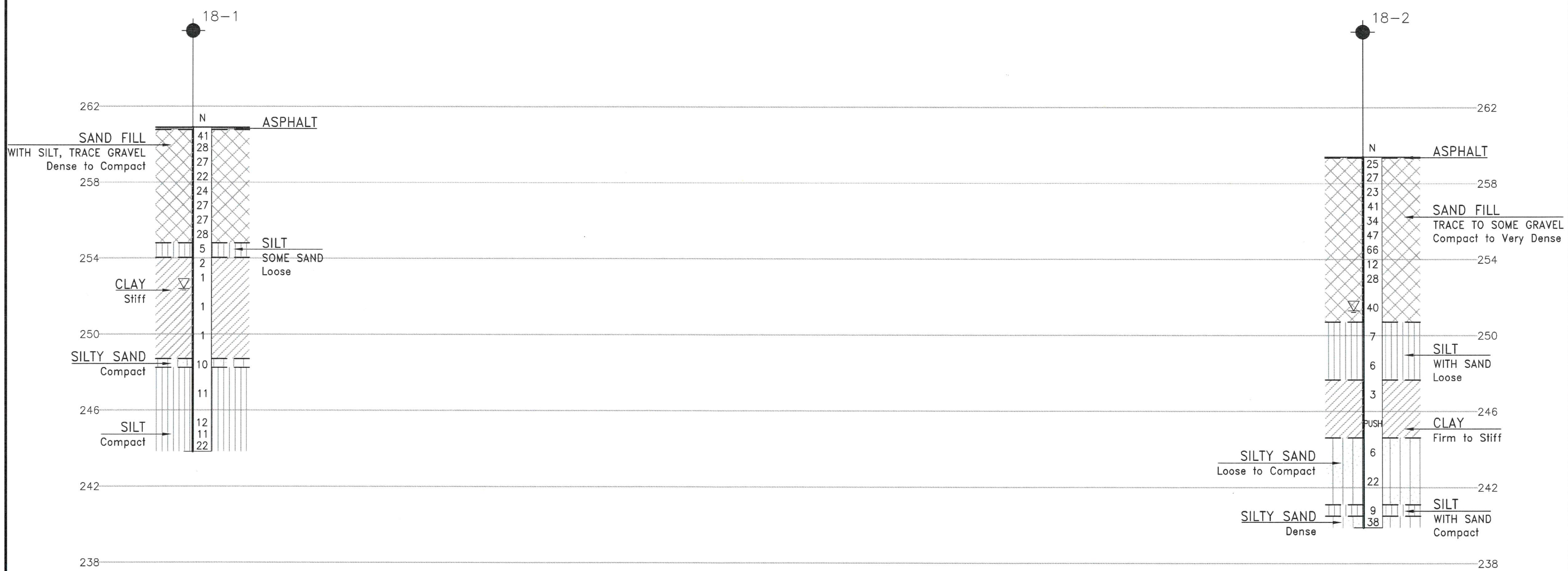
SHEET 48

FRASERBURG ROAD UNDERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

McINTOSH PERRY

THURBER ENGINEERING LTD.

KEYPLAN



PROFILE ALONG ℄ FRASERBURG ROAD

10 0 10 20m H 1:500

5 0 5 10m V 1:250

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
18-1	260.9	4 988 350.1	321 076.7
18-2	259.4	4 988 392.0	321 192.7

-NOTES-

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

GEOCRES No. 31E-391

REVISIONS	DATE	BY	DESCRIPTION

DESIGN KE	CHK SP	CODE	LOAD	DATE FEB 2019
DRAWN AN	CHK KE	SITE 42X-0189/B0	STRUCT	DWG R2-02

FILENAME: H:\Drafting\20000\20244\TED-20244-BHPP-FB.dwg
PLOTDATE: 2/1/2019 10:14 AM

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO PH-D-207 82 04

METRIC

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

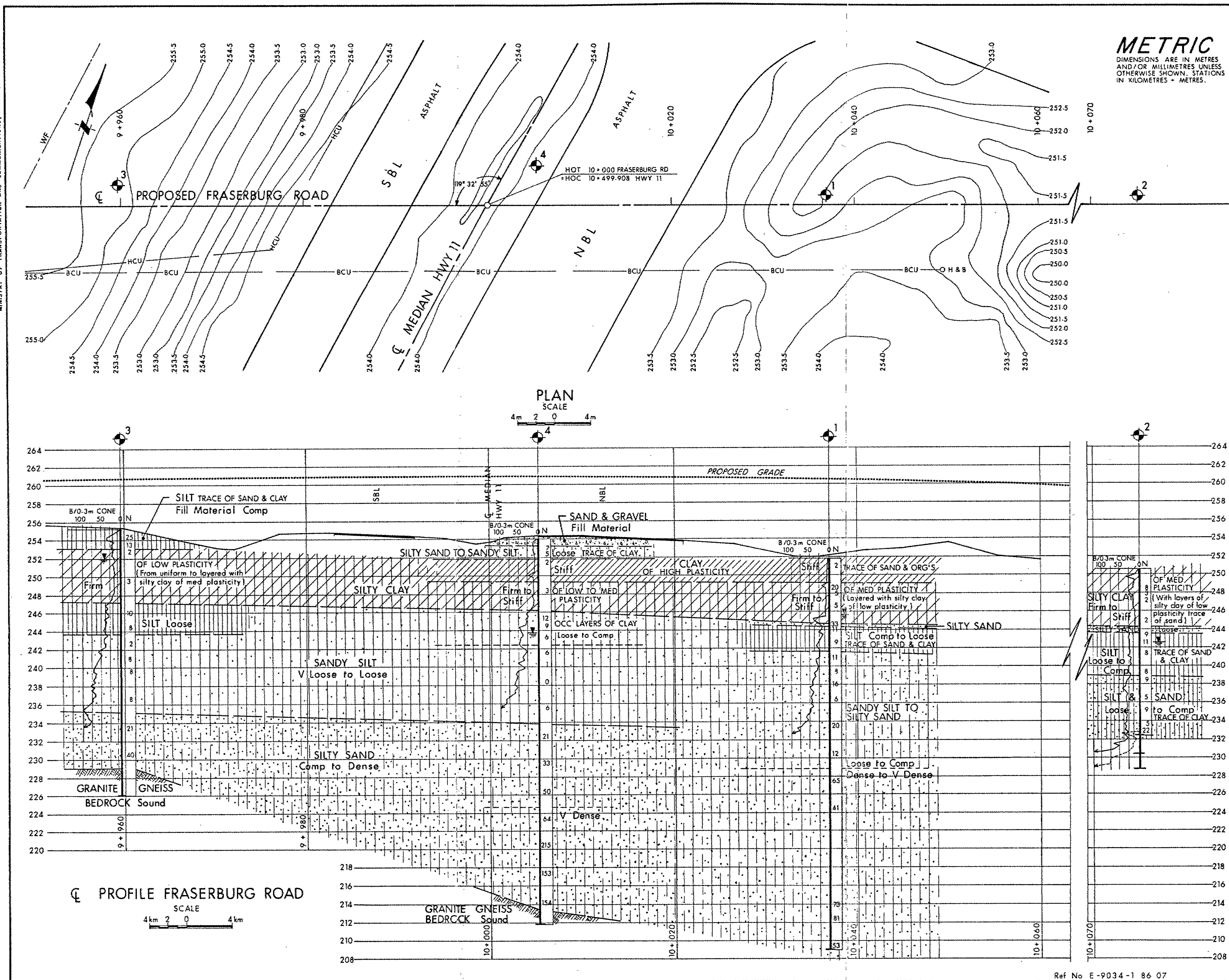
CONT No

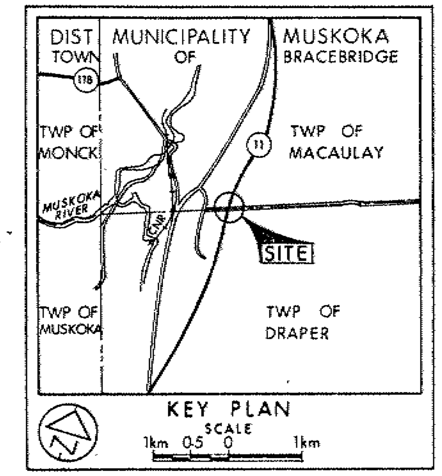
WP No 60-86-00

FRASERBURG ROAD

BORE HOLE LOCATIONS & SOIL STRATA

SHEET





LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation 86 06

No	ELEVATION	STATION	OFFSET
1	251.9	10+037.0	1.0m Lt
2	250.6	10+075.0	1.0m Lt
3	255.3	9+959.8	2.3m Lt
4	254.0	10+005.4	4.2m Lt

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV.	DATE	BY	DESCRIPTION

Geocres No 31E-101

HWY No 11			DIST 11
SUBM'D PM	CHECKED	DATE 1986 09 24	SITE
DRAWN DT	CHECKED	APPROVED	DWG 608600-A

Ref No E-9034-1 86 07

Appendix B.

Record of Borehole Sheets

THURBER

SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 2 mm in thickness

RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

N-VALUE:

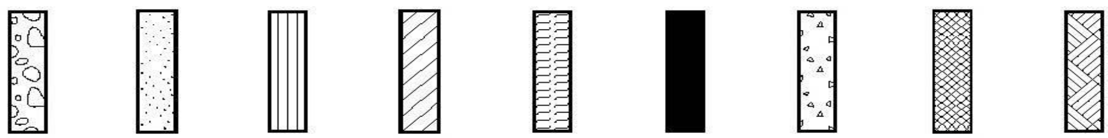
Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an “A” size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.

THURBER

STRATA PLOT:
Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders Cobbles Gravel	Sand	Silt	Clay	Organics	Asphalt	Concrete	Fill	Bedrock

TEXTURING CLASSIFICATION OF SOILS

Classification	**Particle Size**
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

SAMPLE TYPES

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	**Undrained Shear Strength (kPa)**
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

Descriptive Term	**SPT "N" Value**
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50

THURBER

MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	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	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, 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.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note - W_L= Liquid Limit

THURBER

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
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 structures are preserved.

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 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

DISCONTINUITY SPACING

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

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 18-1

METRIC

GWP# 5138-13-00

LOCATION Lat: 45.034948°, Long: -79.293419°
HWY 11 UP at Fraserburg, MTM Zone 10: N 4 988 350.1 E 321 076.7

ORIGINATED BY SOB

HWY 11

BOREHOLE TYPE CME55 Truck with HSA

COMPILED BY KE

DATUM Geodetic

DATE 2018.04.29 - 2018.04.29

CHECKED BY SP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
260.9					
0.0	**ASPHALT (125mm)**				
0.1	SAND trace gravel dense to compact, brown, moist **FILL**	1	SS	41	
		2	SS	28	
259.4 1.5	SAND with silt compact, brown-grey, moist **FILL**	3	SS	27	
		4	SS	22	3 91 6 (SI+CL)
		5	SS	24	
		6	SS	27	
		7	SS	27	
		8	SS	28	
254.8 6.1	**SILT (ML)** some sand loose, brown with grey seams, wet	9	SS	5	0 11 82 7 Non-Plastic
254.1 6.9	**CLAY (CH)** stiff, brown with grey seams	10	SS	2	
		11	SS	1	0 3 36 61
		12	SS	1	

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (260, 259, 258, 257, 256, 255, 254, 253, 252, 251); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Field vane shear strength values (sensitivity): 8.0, 10.0

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 18-1

METRIC

GWP#	5138-13-00	LOCATION	Lat: 45.034948°, Long: -79.293419° HWY 11 UP at Fraserburg, MTM Zone 10: N 4 988 350.1 E 321 076.7	ORIGINATED BY	SOB
HWY	11	BOREHOLE TYPE	CME55 Truck with HSA	COMPILED BY	KE
DATUM	Geodetic	DATE	2018.04.29 - 2018.04.29	CHECKED BY	SP

SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	FIELD VANE (kPa, sensitivity)	REMARKS GR SA SI CL
	Continued From Previous Page						
	CLAY (CH) stiff, brown with grey seams					7.0; 10.0	
		13	SS	1	250		
						6.0; 6.0	
248.7 / 12.2	**SILTY SAND (SM)** compact, brown-grey, moist to wet	14	SS	10	249		
248.3 / 12.6	**SILT (ML)** compact, brown-grey, wet				248	6.0	
		15	SS	11	247		0 1 94 5 Non-Plastic
		16	SS	12	246		
		17	SS	11	245		
		18	SS	22	244		
243.9 / 17.1	End of Borehole Water level during drilling operations at 8.5 mbgs						

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 18-2

METRIC

GWP#	5138-13-00	LOCATION	Lat: 45.035321°, Long: -79.291945° HWY 11 UP at Fraserburg, MTM Zone 10: N 4 988 392.0 E 321 192.7	ORIGINATED BY	SOB
HWY	11	BOREHOLE TYPE	CME55 Truck with HSA / NW Casing	COMPILED BY	KE
DATUM	Geodetic	DATE	2018.04.29 - 2018.04.29	CHECKED BY	SP

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
259.4							
0.0 / 0.1	**ASPHALT (50 mm)**						
	SAND trace to some gravel compact, brown, moist **FILL**	1	SS	25		259	
		2	SS	27			
257.9 / 1.5	SAND with silt some gravel compact to very dense, brown, moist **FILL**					258	
		3	SS	23			
		4	SS	41		257	
		5	SS	34		256	
		6	SS	47			14 81 5 (SI+CL)
		7	SS	66		255	
		8	SS	12		254	
		9	SS	28		253	
						252	
	wet below 8.1 m	10	SS	40	▽		
250.8 / 8.7	**SILT (ML)** with sand loose, brown-grey, wet					251	
		11	SS	7		250	0 23 64 13 Non-Plastic

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m^3

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

DOUBLE LINE 20244_FRASERBURG.GPJ 2012TEMPLATE(MTO).GDT 29/1/19

RECORD OF BOREHOLE No 18-2

METRIC

GWP# 5138-13-00	LOCATION Lat: 45.035321°, Long: -79.291945° HWY 11 UP at Fraserburg, MTM Zone 10: N 4 988 392.0 E 321 192.7		ORIGINATED BY SOB
HWY 11	BOREHOLE TYPE CME55 Truck with HSA / NW Casing		COMPILED BY KE
DATUM Geodetic	DATE 2018.04.29 - 2018.04.29		CHECKED BY SP

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILT (ML) with sand loose, brown-grey, wet - wood fragments below 10.8m	12	SS	6	
247.7 / 11.7	**CLAY (CL)** firm to stiff, brown-grey trace wood fragments	13	SS	3	0 1 57 42
		14	ST	PUSH	
244.7 / 14.8	**SILTY SAND (SM)** loose to compact, grey, wet trace wood fibres	15	SS	6	0 71 26 3 Non-Plastic
		16	SS	22	
241.2 / 18.3	**SILT (ML)** with sand compact, grey, wet	17	SS	9	
240.6 / 18.9	**SILTY SAND (SM)** dense, grey, wet	18	SS	38	
239.9 / 19.5	End of Borehole Water level during drilling operations at 8.1 mbgs				

ELEVATION SCALE: 249, 248, 247, 246, 245, 244, 243, 242, 241, 240

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100

Field vane values: 13.0, 12.0

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

137

UNIT WEIGHT γ kN/m^3

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 1

METRIC

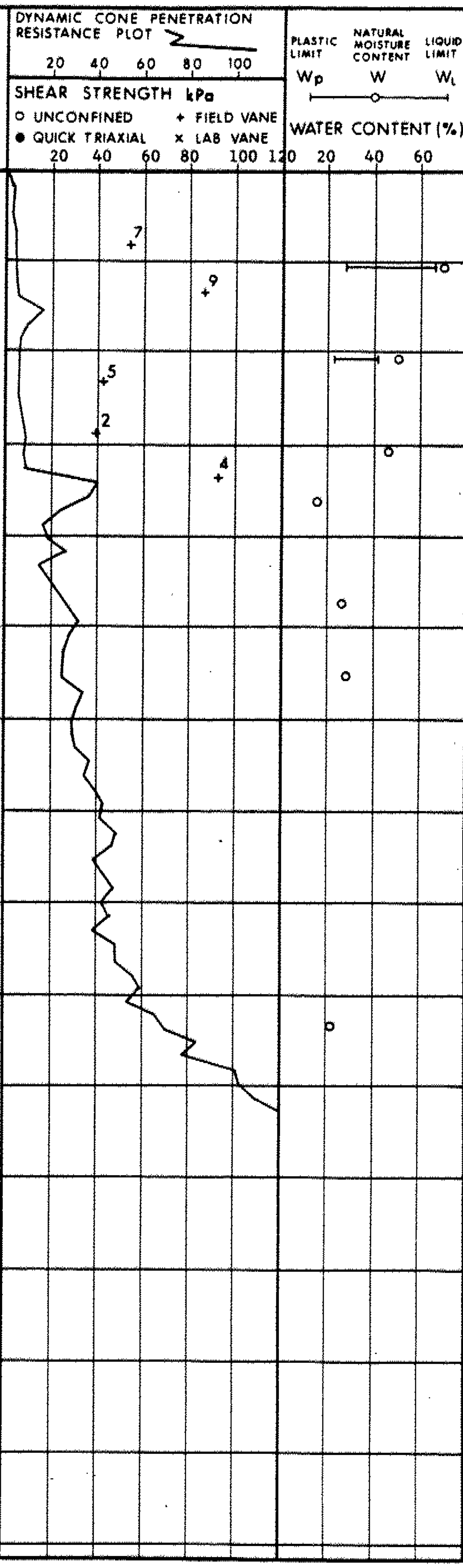
W P 60-86-00	LOCATION Sta. 10 + 037 O/S 1.0 m Lt.	ORIGINATED BY PM
DIST 11 HWY 11	BOREHOLE TYPE Cont. Flight Auger (HS) Casing (BW)	COMPILED BY
DATUM Geodetic	DATE 86 06 05 - 86 06 11	CHECKED BY

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
251.9	Ground Level
0.0 – 249.2	Clay of High Plasticity, trace of sand, trace of organics, Stiff
2.7 – 244.7	Silty Clay of Medium Plasticity layered with Silty Clay of Low Plasticity, Trace of Sand, Firm to Stiff
244.4	Silty Sand Layer
7.5 – 241.6	Silt, trace of sand, trace of clay, Compact to Loose
10.3 – 221.9 / 30.0	Sandy Silt to Silty Sand, trace of clay, Loose to Compact; Dense to very Dense

SAMPLES

NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
1	SS	2						
2	TW	PH		15.8	0	3	29	68
3	SS	20						
4	SS	5			0	2	50	48
5	SS	5						
6	TW	PH	▼	17.6				
7	SS	33			0	79	20	1
8	SS	11						
9	SS	9			0	4	94	2
10	SS	11			0	11	81	8
11	SS	8						
12	SS	16						
13	SS	6						
14	SS	20			0	64	36	0
15	SS	12						
16	SS	65						
19	SS	41						



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+3, x5 : Numbers refer to Sensitivity

20 15 ⌖ 5 10 (%) STRAIN AT FAILURE

Continued

OFFICE REPORT ON SOIL EXPLORATION

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RECORD OF BOREHOLE No 1 Continued — METRIC

W P. 60-86-00 — LOCATION Sta. 10 + 037, O/S 1.0 m Lt. — ORIGINATED BY PM

DIST 11 HWY 11 — BOREHOLE TYPE Continous Flight Auger (HS) Casing (BW) — COMPILED BY

DATUM Geodetic — DATE 86 06 05 - 86 06 11 — CHECKED BY

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	PLASTIC LIMIT W_p / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
221.9 30.0	Continued										
	Sandy Silt to Silty Sand trace of clay Dense to Very Dense						220				
							218				
							216				
			24	SS	73		214				
			25	SS	81				○		0 17 82 1
							212				
							210				
209.0			27	SS	53						
42.9	End of Borehole										

$+^3, \times^5$: Numbers refer to Sensitivity — 15 ⊕ 5 (20, 10) (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

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Ontario

RECORD OF BOREHOLE No 2

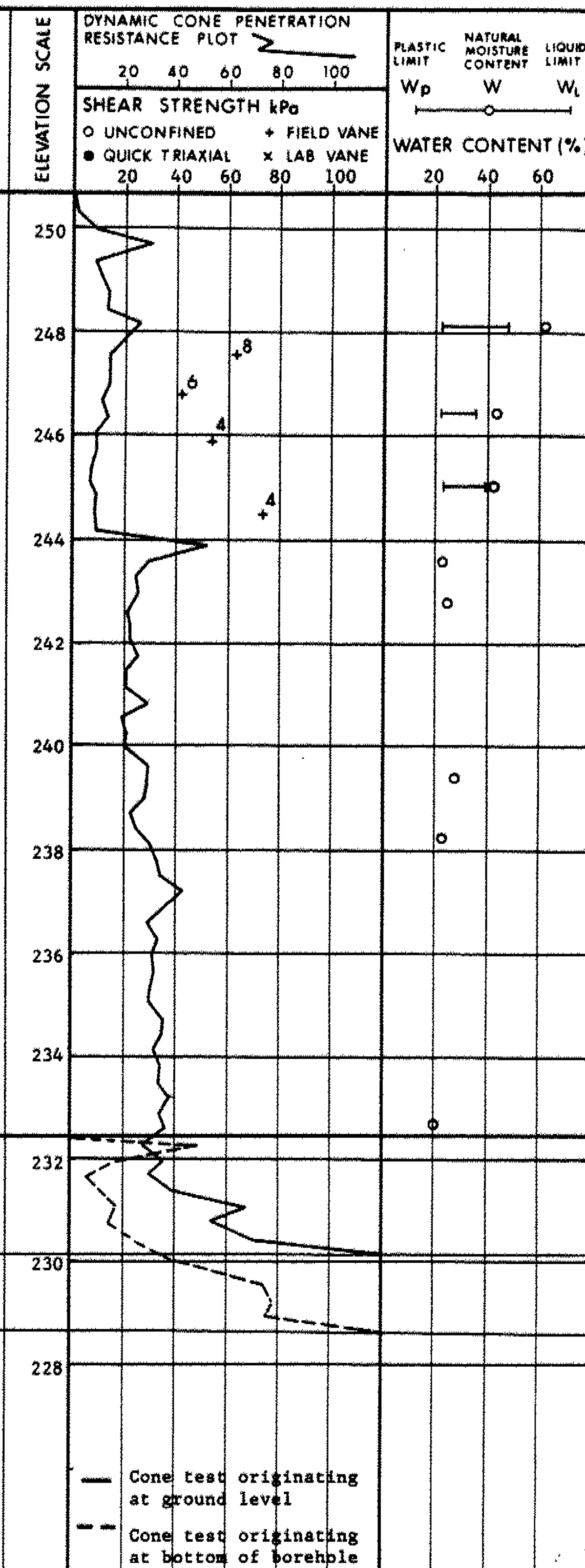
METRIC

W P 60-86-00 LOCATION Sta. 10 + 075, O/S 1.0 m Lt. ORIGINATED BY PM

DIST 11 HWY 11 BOREHOLE TYPE Cont. Flight Auger (HS) COMPILED BY

DATUM Geodetic DATE 86 06 12 - 86 06 13 CHECKED BY

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR SA SI CL
250.6	Ground Level						
0.0	Silty Clay of Medium Plasticity with layers of silty clay of Low Plasticity trace of sand. Firm to Stiff	2	SS	8			
		3	SS	3			0 1 38 61
		4	SS	2			
		5	TW	PH		17.8	
244.3 / 6.3		6	SS	2			0 1 64 35
243.6 / 7.0	Silty Sand, trace of clay. Loose						
	Silt. Trace of Sand. Trace of Clay. Loose to Compact	7	SS	9			0 66 29 5
		8	SS	11	▼		0 5 90 5
		9	SS	8			
238.8 / 11.8		10	SS	8			0 12 84 4
	Silt and Sand. Trace of Clay. Loose to Compact	11	SS	9			0 40 59 1
		12	SS	5			
		13	SS	9			
		14	SS	5			
232.4 / 18.2		15	SS	22			0 58 40 2
18.2	End of Borehole						
230.1 / 20.5	End of Cone Test						
228.6 / 22.0	End of Cone Test						



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

OFFICE REPORT ON SOIL EXPLORATION

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RECORD OF BOREHOLE No 3

METRIC

W P 60-86-00
LOCATION Sta. 9 + 959.8, O/S 2.3 m Lt.
ORIGINATED BY PM
DIST 11 HWY 11
BOREHOLE TYPE Cont. Flight Auger (HS), Casing (BW)
COMPILED BY
DATUM Geodetic
DATE 86 06 13 - 86 06 17
CHECKED BY

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa (FIELD VANE)	UNIT WEIGHT γ kN/m3	GR SA SI CL (%)
255.3	Ground Level								
0.0	Silt, trace of sand trace of clay Fill Material Compact	1	SS	25		254			
		2	SS	13					0 9 83 8
253.2 / 2.1	Silty Clay of Low Plasticity (From Uniform to Layered with Silty Clay of Medium Plasticity) Firm	3	SS	2			+7		
					▼	252			
		4	TW	PH			+5	16.3	
		5	SS	3		250	+4		0 1 67 32
		6	TW	PH		248		17.9	0 2 66 32
247.1 / 8.2	Silt Loose	7	SS	10		246			0 0 100 0
		8	SS	8		244			
243.7 / 11.6	Sandy Silt Very Loose to Loose	9	SS	2		242			
		10	SS	8					
		11	SS	8		240			0 25 73 2
						238			
		12	SS	8		236			
235.2 / 20.1	Silty Sand Compact to Dense	13	SS	21		234			
						232			
		14	SS	40		230			0 91 9
229.1 / 26.2	Granite Gneiss Sound Bedrock	15	RC BX	REC 100%		228			
		16	RC BX	REC 100%					
226.0 / 29.3	End of Borehole					226			

PLASTIC LIMIT W_p — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×5 : Numbers refer to Sensitivity

20 / 15 -◇- 5 / 10 (%) STRAIN AT FAILURE

OFFICE, REPORT ON SOIL EXPLORATION

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RECORD OF BOREHOLE No 4 — METRIC

W P 60-86-00 | LOCATION Sta. 10 + 005.4; O/S 4.2 m Lt. | ORIGINATED BY PM

DIST 11 HWY 11 | BOREHOLE TYPE Cont. Flight Auger (HS); Casing (BW) | COMPILED BY

DATUM Geodetic | DATE 86 06 18 - 86 06 20 | CHECKED BY

Soil Profile

ELEV / DEPTH	DESCRIPTION
254.0	Shoulder Level
0.0 / 253.3	Fill Material, Sand and Gravel
0.7 / 251.9	Silty Sand to Sandy Silt, trace of clay, Loose
2.1 / 249.4	Clay of High Plasticity, Stiff
4.6 / 246.2	Silty Clay of Low to Medium Plasticity, Firm to Stiff
7.8 / 242.3	Sandy Silt, Occasional Layers of Clay, Loose to Compact
11.7 / 233.9	Sandy Silt, Very Loose to Loose
20.1 / 224.0	Silty Sand, Compact to Dense; Very Dense
30.0	

Samples

NUMBER	TYPE	'N' VALUES	ELEVATION (approx.)	UNIT WEIGHT γ	GR	SA	SI	CL
1	SS	7						
2	SS	5			0	16	76	8
3	SS	2			0	3	43	54
4	TW	PH	250	16.5	0	4	43	53
5	SS	3						
6	TW	PH		17.9				
7	SS	12			0	2	93	5
8	SS	9						
9	SS	6			0	18	78	4
10	SS	6			0	27	70	3
11	SS	1						
12	SS	0						
13	SS	6			0	33	66	1
14	SS	21						
15	SS	33						
16	SS	50			0	93		7

Ground water conditions: water level shown at approx. elev. 243.5.

Dynamic Cone Penetration Resistance Plot (20, 40, 60, 80, 100); Shear Strength kPa: ○ Unconfined, ● Quick Triaxial, + Field Vane, × Lab Vane (20, 40, 60, 80, 100). Field vane sensitivity values plotted: 4, 6, 3, 2.

Water Content (%): Plastic Limit W_p, Natural Moisture Content W, Liquid Limit W_L (20, 40, 60).

Remarks & Grain Size Distribution (%): GR SA SI CL

Elevation scale: 252, 250, 248, 246, 244, 242, 240, 238, 236, 234, 232, 230, 228, 226, 224

Continued

$+^3$, $\times^5$: Numbers refer to Sensitivity

$15 \overset{20}{\underset{10}{\diamond}} 5$ (%) STRAIN AT FAILURE

Continued

◂ OFFICE, REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 4 Continued — METRIC

W P 60-86-00 LOCATION Sta. 10 + 005.4; O/S 4.2 m Lt. ORIGINATED BY PM
DIST 11 HWY 11 BOREHOLE TYPE Cont. Flight Auger (HS); Casing (BW) COMPILED BY
DATUM Geodetic DATE 86 06 18 - 86 06 20 CHECKED BY

ELEV / DEPTH	DESCRIPTION Continued	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, x LAB VANE)	PLASTIC LIMIT Wp, NATURAL MOISTURE CONTENT W, LIQUID LIMIT WL; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
224.0 / 30.0	Silty Sand, Very Dense		18	SS	64						
							222				
			20	SS	215		220				
							218				
			22	SS	153				o		0 76 23 1
							216				
			23	SS	154		214				
213.5 / 40.5	Granite Gneiss Sound Bedrock		24	RC BX	REC 98%						
211.9 / 42.1	End of Borehole						212				
							210				

$+^3, \times^5$: Numbers refer to Sensitivity

15 ⯐ 5 (%) STRAIN AT FAILURE (20 above, 10 below)

OFFICE REPORT ON SOIL EXPLORATION

Appendix C.

Laboratory Testing

Appendix C.1

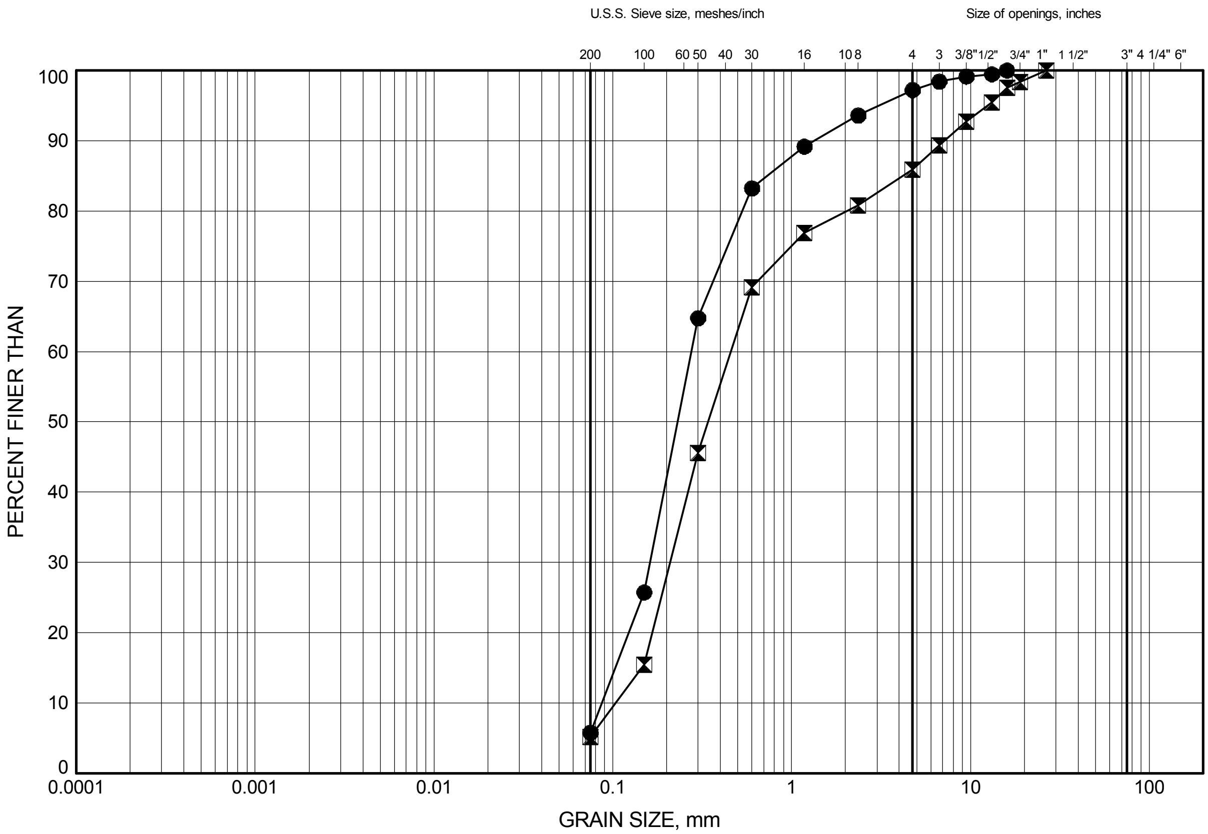
Particle Size Analysis Figures

Hwy's 11 and 118 - Fraserburg

GRAIN SIZE DISTRIBUTION

FIGURE C1

FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	2.6	258.3
⧗	18-2	4.1	255.3

Date January 2019

GWP# 5138-13-00

THURBER

Prep'd KE

Chkd. SP

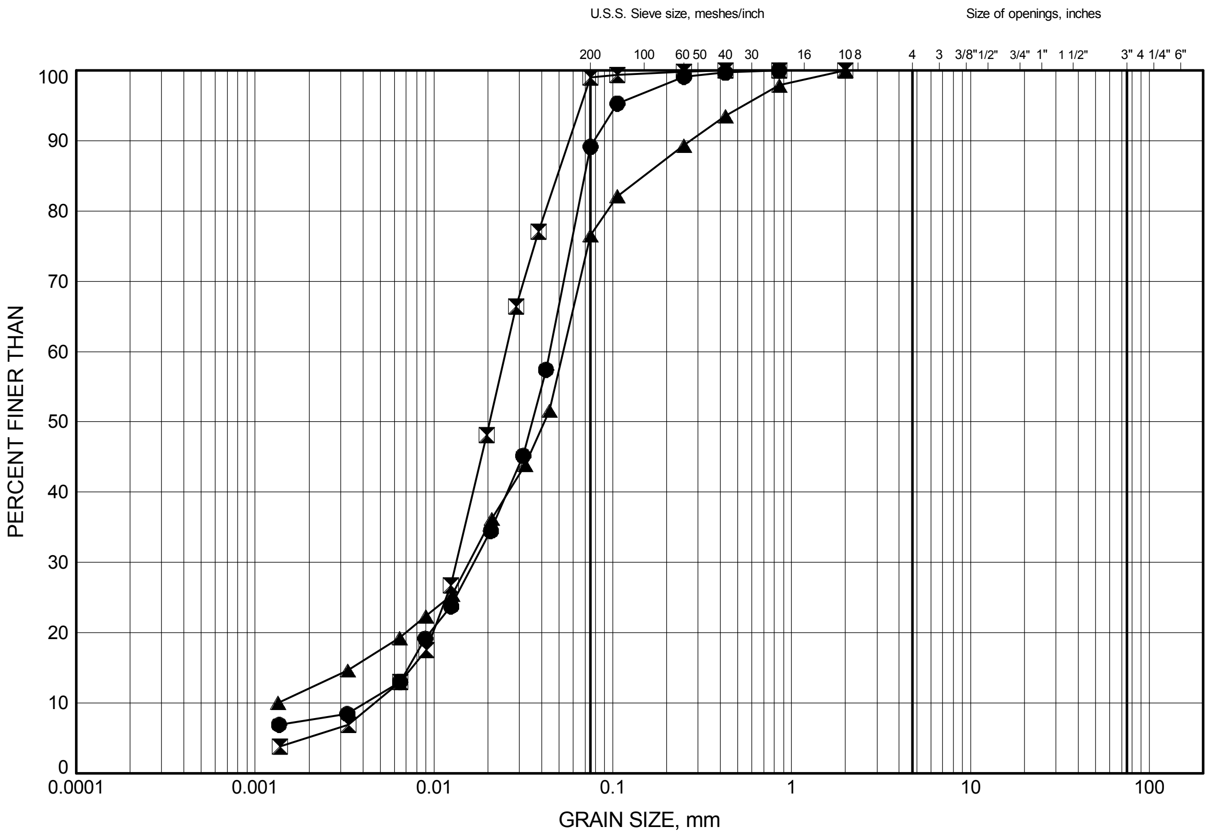
GRAIN SIZE DISTRIBUTION - THURBER 20244_FRASERBURG.GPJ 7/1/19

Hwy's 11 and 118 - Fraserburg

GRAIN SIZE DISTRIBUTION

FIGURE C2

SILT (ML) / LOWER SILT (ML)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	6.4	254.5
⧗	18-1	14.0	246.9
▲	18-2	9.4	250.0

Date January 2019

GWP# 5138-13-00

THURBER

Prep'd KE

Chkd. SP

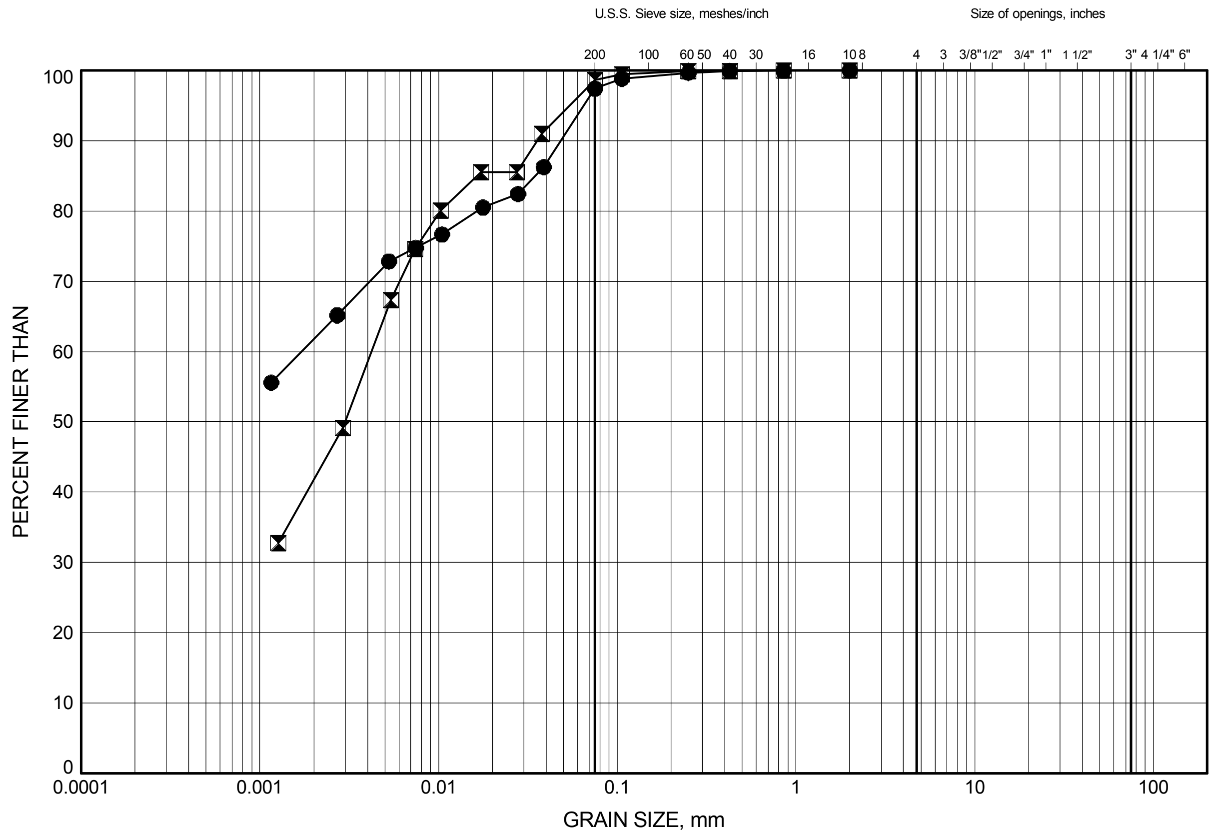
GRAIN SIZE DISTRIBUTION - THURBER 20244_FRASERBURG.GPJ 22/1/19

Hwy's 11 and 118 - Fraserburg

GRAIN SIZE DISTRIBUTION

FIGURE C3

CLAY (CL-CH)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	7.9	253.0
⧗	18-2	12.5	247.0

Date January 2019

GWP# 5138-13-00

THURBER

Prep'd KE

Chkd. SP

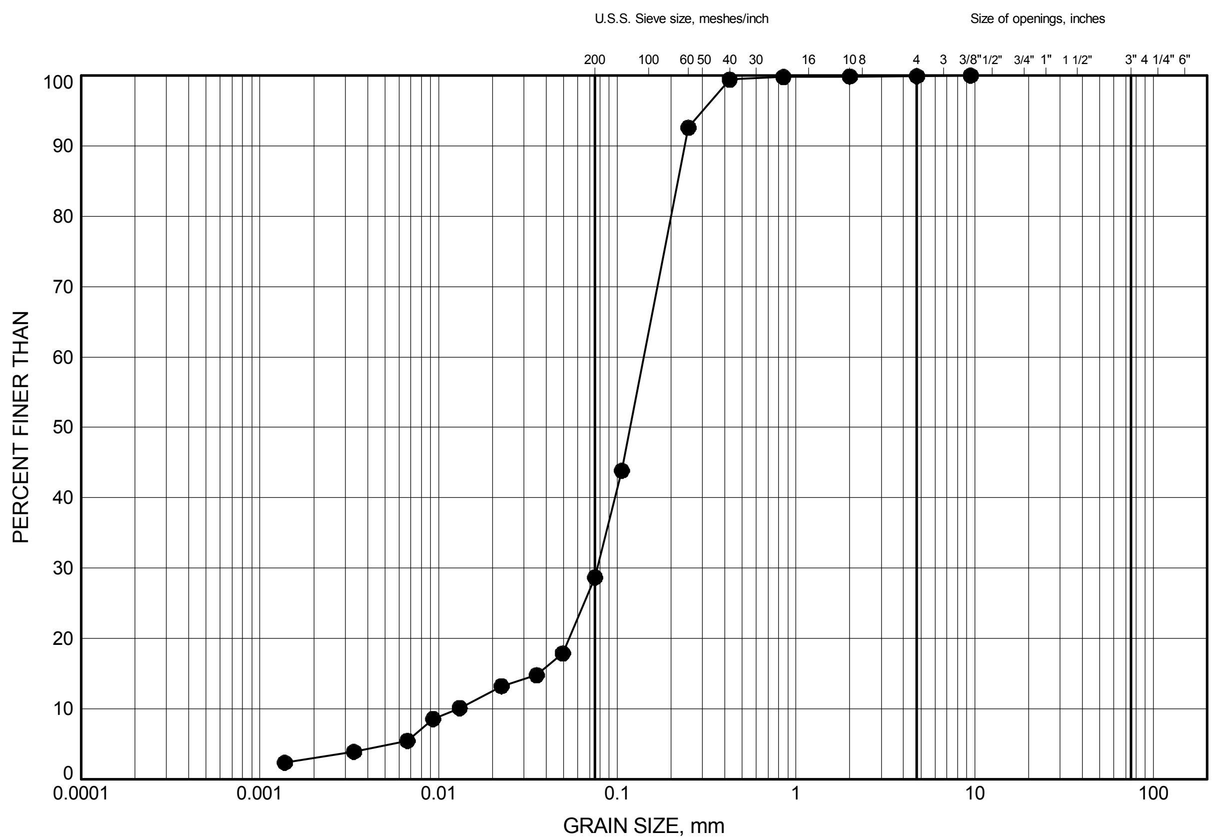
GRAIN SIZE DISTRIBUTION - THURBER 20244_FRASERBURG.GPJ 7/1/19

Hwy's 11 and 118 - Fraserburg

GRAIN SIZE DISTRIBUTION

FIGURE C4

SILTY SAND (SM)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-2	15.5	243.9

Date January 2019

GWP# 5138-13-00

Prep'd KE

Chkd. SP

GRAIN SIZE DISTRIBUTION - THURBER 20244_FRASERBURG.GPJ 22/1/19

Appendix C.2

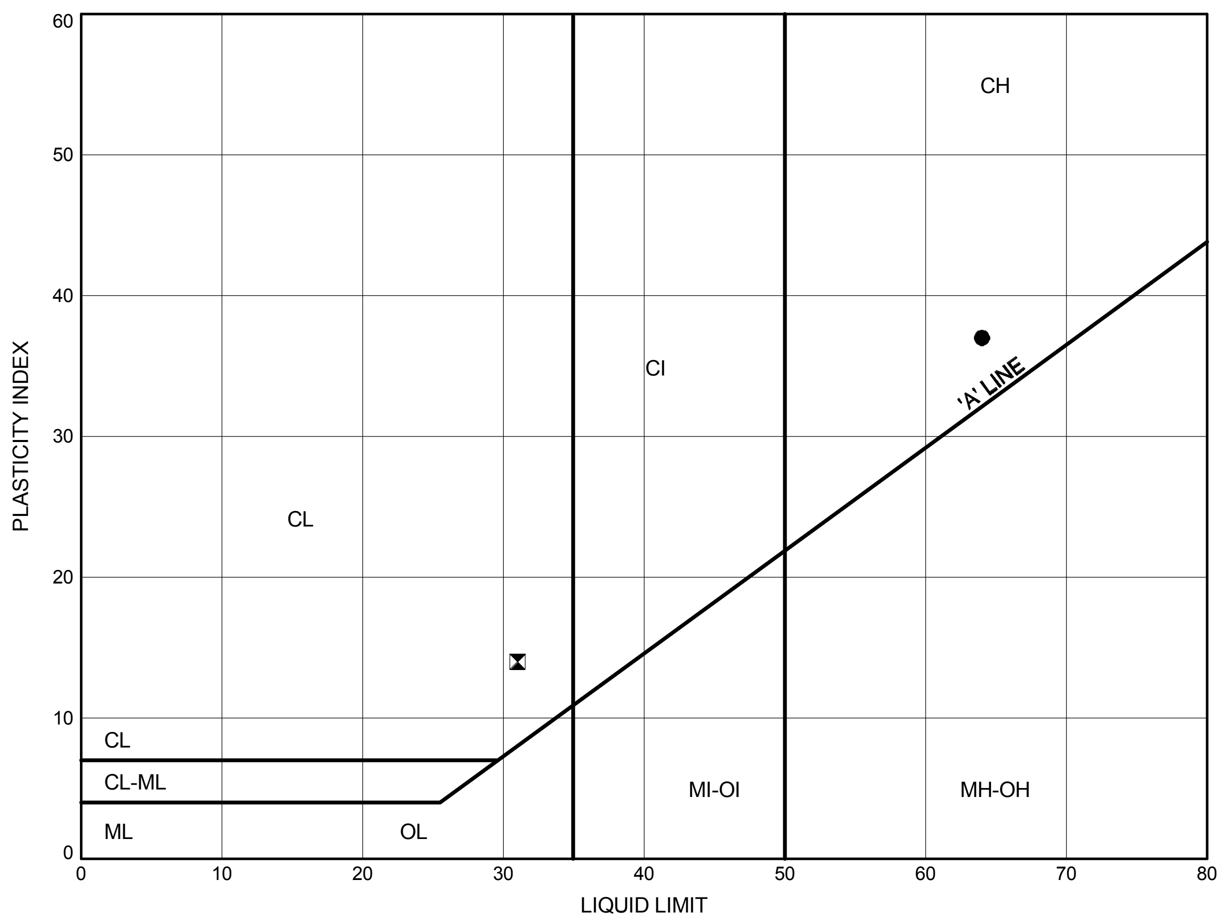
Atterberg Limits Figures

Hwy's 11 and 118 - Fraserburg

ATTERBERG LIMITS TEST RESULTS

FIGURE C5

CLAY (CL-CH)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	7.9	253.0
⧗	18-2	12.5	247.0

Date January 2019

GWP# 5138-13-00

THURBER

Prep'd KE

Chkd. SP

THURBALT 20244_FRASERBURG.GPJ 7/1/19

Appendix C.3

Analytical Testing Results

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Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B 4S5
Attn: Katya Edney

Client PO:
Project: HWY 11 + 118
Custody: 39845

Report Date: 10-May-2018
Order Date: 4-May-2018

Order #: 1818669

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1818669-01	Road 117 18-1'ss13 40-42'
1818669-02	Road 117 18-2 'SS12 35-37'
1818669-03	Fraserburg '18-1SS10 22'6-24'6"
1818669-04	Fraserburg'18-2 SS12A 35-36'6"
1818669-05	Road 2 '18-1 SS9 20-22'
1818669-06	Road 2 '18-2 SS10 25-27'
1818669-07	Bullens '18-1 SS11 23'3"-25'3"
1818669-08	Road 3 18-1 SS10 25-27'
1818669-09	Road 3 18-2 SS10 25-27'
1818669-10	Siding 18-2SS5 10-12'
1818669-11	Siding 18-3 SS5 10-12'

Approved By:

Dale Robertson, BSc
Laboratory Director

Order #: 1818669

Certificate of Analysis

Client: Thurber Engineering Ltd.

Client PO:

Report Date: 10-May-2018

Order Date: 4-May-2018

Project Description: HWY 11 + 118

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	8-May-18	8-May-18
Conductivity	MOE E3138 - probe @25 °C, water ext	8-May-18	9-May-18
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	7-May-18	7-May-18
Resistivity	EPA 120.1 - probe, water extraction	8-May-18	9-May-18
Solids, %	Gravimetric, calculation	7-May-18	7-May-18

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 10-May-2018
Order Date: 4-May-2018
Project Description: HWY 11 + 118

	Client ID:	Road 117 18-1'ss13 40-42'	Road 117 18-2 'SS12 35-37'	Fraserburg '18-1SS10 22'6-24'6"	Fraserburg'18-2 SS12A 35-36'6"
	Sample Date:	04/30/2018 09:00	04/30/2018 09:00	04/29/2018 09:00	04/29/2018 09:00
	Sample ID:	1818669-01	1818669-02	1818669-03	1818669-04
	MDL/Units	Soil	Soil	Soil	Soil
Physical Characteristics					
% Solids	0.1 % by Wt.	83.9	83.9	68.9	70.1
General Inorganics					
Conductivity	5 uS/cm	133	234	469	262
pH	0.05 pH Units	5.84	6.14	5.56	5.32
Resistivity	0.10 Ohm.m	75.0	42.7	21.3	38.1
Anions					
Chloride	5 ug/g dry	82	113	246	120
Sulphate	5 ug/g dry	12	9	51	10

	Client ID:	Road 2 '18-1 SS9 20-22'	Road 2 '18-2 SS10 25-27'	Bullens '18-1 SS11 23'3"-25'3"	Road 3 18-1 SS10 25-27'
	Sample Date:	04/28/2018 09:00	05/01/2018 09:00	04/21/2018 09:00	04/27/2018 09:00
	Sample ID:	1818669-05	1818669-06	1818669-07	1818669-08
	MDL/Units	Soil	Soil	Soil	Soil
Physical Characteristics					
% Solids	0.1 % by Wt.	87.0	72.7	77.5	80.3
General Inorganics					
Conductivity	5 uS/cm	218	1780	400	61
pH	0.05 pH Units	6.41	5.76	7.44	6.39
Resistivity	0.10 Ohm.m	45.8	5.61	25.0	164
Anions					
Chloride	5 ug/g dry	124	1170	23	21
Sulphate	5 ug/g dry	7	10	200	11

	Client ID:	Road 3 18-2 SS10 25-27'	Siding 18-2SS5 10-12'	Siding 18-3 SS5 10-12'	-
	Sample Date:	04/27/2018 09:00	04/24/2018 09:00	04/23/2018 09:00	-
	Sample ID:	1818669-09	1818669-10	1818669-11	-
	MDL/Units	Soil	Soil	Soil	-
Physical Characteristics					
% Solids	0.1 % by Wt.	82.5	79.5	72.3	-
General Inorganics					
Conductivity	5 uS/cm	158	2120	428	-
pH	0.05 pH Units	6.44	6.34	6.13	-
Resistivity	0.10 Ohm.m	63.1	4.71	23.4	-
Anions					
Chloride	5 ug/g dry	83	1590	154	-
Sulphate	5 ug/g dry	9	19	76	-

Certificate of Analysis

Client: Thurber Engineering Ltd.

Client PO:

Report Date: 10-May-2018

Order Date: 4-May-2018

Project Description: HWY 11 + 118

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 10-May-2018
Order Date: 4-May-2018
Project Description: HWY 11 + 118

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	55.9	5	ug/g dry	55.6			0.7	20	
Sulphate	23.4	5	ug/g dry	22.9			2.1	20	
General Inorganics									
Conductivity	443	5	uS/cm	424			4.4	6.2	
pH	7.77	0.05	pH Units	7.77			0.0	10	
Resistivity	22.6	0.10	Ohm.m	23.6			4.4	20	
Physical Characteristics									
% Solids	98.2	0.1	% by Wt.	98.0			0.2	25	

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	149	5	ug/g	55.6	93.2	78-113			
Sulphate	119	5	ug/g	22.9	95.8	78-111			

Qualifier Notes:

Login Qualifiers :

Container(s) - Bottle and COC sample ID don't match -

Applies to samples: Road 117 18-1'ss13 40-42', Road 117 18-2 'SS12 35-37', Fraserburg '18-1SS10 22'6-24'6'', Bullens '18-1 SS11 23'3''-25'3''

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

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Subcontracted Analysis

Thurber Engineering Ltd.
2460 Lancaster Rd, Suite 104
Ottawa, ON K1B 4S5
Attn: Katya Edney

Tel: (613) 247-2121
Fax: (613) 247-2185

Paracel Report No **1818669**
Client Project(s): **HWY 11 + 118**
Client PO:
Reference: **Standing Offer**
CoC Number: **39845**

Order Date: 04-May-18
Report Date: 15-May-18

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
1818669-01	Road 117 18-1'ss13 40-42'	Sulphide, solid
1818669-02	Road 117 18-2 'SS12 35-37'	Sulphide, solid
1818669-03	Fraserburg '18-1SS10 22'6-24'6"	Sulphide, solid
1818669-04	Fraserburg'18-2 SS12A 35-36'6"	Sulphide, solid
1818669-05	Road 2 '18-1 SS9 20-22'	Sulphide, solid
1818669-06	Road 2 '18-2 SS10 25-27'	Sulphide, solid
1818669-07	Bullens '18-1 SS11 23'3"-25'3"	Sulphide, solid
1818669-08	Road 3 18-1 SS10 25-27'	Sulphide, solid
1818669-09	Road 3 18-2 SS10 25-27'	Sulphide, solid
1818669-10	Siding 18-2SS5 10-12'	Sulphide, solid
1818669-11	Siding 18-3 SS5 10-12'	Sulphide, solid

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

15-May-2018

Paracel Laboratories
Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6,

Phone: 613-731-9577
Fax:613-731-9064

Date Rec. : 08 May 2018
LR Report: **CA13203-MAY18**
Reference: Project#: 1818669

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		14-May-18
2: Analysis Start Time		13:09
3: Analysis Completed Date		14-May-18
4: Analysis Completed Time		14:54
5: QC - Blank		< 0.02
6: QC - STD % Recovery		101%
7: QC - DUP % RPD		ND
8: RL		0.02
9: Road 117 18-1'ss13 40-42'	30-Apr-18	< 0.02
10: Road 117 18-2 'SS12 35-37'	30-Apr-18	< 0.02
11: Fraserburg '18-1SS10 22'6-24'6"	29-Apr-18	< 0.02
12: Fraserburg '18-2 SS12A 35-36'6"	29-Apr-18	< 0.02
13: Road 2 '18-1 SS9 20-22'	28-Apr-18	< 0.02
14: Road 2 '18-2 SS10 25-27'	01-May-18	< 0.02
15: Bullens '18-1 SS11 23'3"-25'3"	21-Apr-18	0.40
16: Road 3 18-1 SS10 25-27'	27-Apr-18	< 0.02
17: Road 3 18-2 SS10 25-27'	27-Apr-18	< 0.02
18: Siding 18-2SS5 10-12'	24-Apr-18	< 0.02
19: Siding 18-3 SS5 10-12'	23-Apr-18	< 0.02

RL - SGS Reporting Limit

Carrie Greenlaw
Project Specialist
Environmental Services, Analytical

OnLine LIMS

0001373275

Appendix D.

Site Photographs

Photo 1. Looking north along Highway 11 from West of Muskoka Road 14 Underpass Structure (April 29th, 2018)

Photo 2. Muskoka Road 14 (Fraserburg Road) Underpass Structure from west (April 29th, 2018)

Photo 3. Looking east along Muskoka Road 14 (Fraserburg Road) (April 29th, 2018)

Photo 4. Looking west along Muskoka Road 14 (Fraserburg Road) (April 29th, 2018)

Appendix E.

List of Special Provisions and OPSS Documents Referenced in this Report

1. The following Special Provisions and OPSS Documents are referenced in this report:

OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS. 805	Construction Specification for Temporary Erosion and Sediment Control Measures
OPSS 902	Construction Specification for Excavating and Backfilling Structures
OPSS.PROV 1010	Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material
OPSD 3101.150	Walls, Abutment, Backfill, Minimum Granular Requirement

2. Suggested text for a NSSP on “Installation of Temporary Protection System”

   Vibratory equipment is not permitted for installation or removal of temporary protection systems below elevation 254.8 m.

3. Suggested text for a NSSP on “Obstructions”

   Obstructions such as cobbles and boulders may be encountered in the embankment during excavation, installation of traffic protection systems. Such obstructions may impede the work from reaching the design depth of installation. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions and extend the work to the design depths