



THURBER ENGINEERING LTD.

FINAL
FOUNDATION INVESTIGATION AND DESIGN REPORT
CULVERT 27-362/C REHABILITATION
HWY 417 COUNTY ROAD 7 UNDERPASS, CASSELMAN ON

G.W.P. 451-98-00

Geocres No.: 31G-271

Report to:

Ainley Group

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TABLE OF CONTENTS

PART 1. FACTUAL INFORMATION

1	INTRODUCTION	1
2	SITE DESCRIPTION	1
3	SITE INVESTIGATION AND FIELD TESTING.....	2
4	LABORATORY TESTING.....	3
5	GENERAL DESCRIPTION OF SUBSURFACE CONDITIONS.....	3
5.1	Embankment Fill	3
5.1.1	Asphalt	3
5.1.2	Fill: Silty Sand with gravel	3
5.1.3	Fill: Silty Sand trace gravel.....	4
5.1.4	Fill: Interlayered Clay, Silt, Silty Sand and Gravel.....	4
5.2	Clay (Cl to CH).....	4
5.3	Silty Sand to Sandy Silt (Glacial Till).....	5
5.4	Bedrock.....	5
5.5	Groundwater	6
5.6	Analytical Testing.....	6
6	MISCELLANEOUS	8

PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7	INTRODUCTION	9
7.1	Proposed Structure	10
7.2	Cement Type and Corrosion Potential.....	10
8	SETTLEMENT	11
9	CONSTRUCTION CONSIDERATIONS	11
9.1	Excavation	11
9.2	Temporary Protection Systems.....	11
9.3	Dewatering.....	12
9.4	Scour Protection and Erosion Control.....	13
10	CONSTRUCTION CONCERNS	13
11	CLOSURE	14

APPENDICES

- Appendix A. Borehole Location Plan and Stratigraphic Drawings
- Appendix B. Record of Borehole Sheets
- Appendix C. Laboratory Testing
- Appendix D. Site Photographs
- Appendix E. List of Special Provisions and OPSS Documents Referenced in this Report

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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 for Culvert 27-362/C crossing of County Road 7 near the underpass of the Highway 417 Interchange. The culvert is located approximately 400 m north of Aurele Road on County Road 7 East within the Township of Cambridge. Thurber Engineering Limited (Thurber) carried out the current investigation as a sub-consultant to Ainley Graham & Associates Limited (Ainley) under Agreement No. 4016-E-0036.

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.

Foundation Investigation Report for Proposed Crossing, New Hwy. #417 and County Road #7, Twp. of Cambridge, Co. of Russell, Lot 9 Conc. 7, District No. 9 (Ottawa), W.J.70-F-3 – W.P. 35-66-16 [Geocres 31G-47]

2 SITE DESCRIPTION

The existing culvert is a corrugated steel sectional plate arch culvert servicing the Leo Denis Municipal Drain and is noted to have been constructed in 1971. The culvert is reported to be 3.5 m wide by 2.2 m high and approximately 37 m long with a generally east to west alignment. The flow through the culvert is to the west.

At the location of the culvert, County Road 7 is a two-lane road with narrow paved shoulders and steel beam guiderails on both sides. The underpass embankment fill height is approximately 6.6 m over the culvert with the road surface at approximate elevation of 69.9 m. The existing embankment side slopes are inclined at approximately 2H:1V. Adjacent to the highway right-of-way, are commercial properties and agriculture land. No signs of erosion or slope instability were noted on the existing highway embankments during the field investigation. The roadway surface over the culvert was generally in good condition with no dips or bumps noted during the field investigation. The existing culvert, however, did show minimal signs of corrosion. Traffic volumes are understood to be 1812 AADT (2014). County Road 7 is also known as Rue Principale.

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Photographs showing the existing conditions in the area of the culvert are included in Appendix D for reference.

3 SITE INVESTIGATION AND FIELD TESTING

The current site investigation and field testing program was carried out between June 19th and June 26th, 2018. Drilling consisted of advancing four boreholes identified as 17-9 through 17-12. The drilling was carried out using truck and track mounted CME 55 drill rigs equipped with hollow stem augers. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

The northing, easting, and elevation of the boreholes from the current investigation are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A. The individual Record of Borehole sheets are provided in Appendix B and summarized in Table 3-1. The termination depth of each of the boreholes is also provided, below. The borehole elevations were surveyed using geodetic benchmark GBM 00819758419 (elev. 71.241 m) and a Trimble Catalyst with centimetre precision in conjunction with a Nikon-AP-8 with an accuracy of +/- 1.5 mm. Borehole locations were measured off existing site features and translated to northings and eastings based on the available base plans. The site is within MTM Zone 8.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Termination Depth (m)
17-9	Near Culvert inlet	5 019 259.2	180 937.0	63.9	10.0
17-10	County Road 7 NB lane	5 019 243.3	180 926.6	69.7	17.0
17-11	Country Road 7 SB lane	5 019 248.9	180 918.2	70.1	16.4
17-12	Near Culvert outlet	5 019 243.7	180 898.9	63.3	11.1

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). In-situ shear vane testing was carried out within the cohesive strata using an N-vane. Bedrock was cored with NQ size coring equipment.

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

A 19 mm diameter standpipe piezometer was installed in Borehole 17-9 to allow for measurements of the groundwater level after completion of drilling. The piezometer installation details are illustrated on the Record of Borehole sheet for Borehole 17-9, provided in Appendix B. Following completion of the field investigation the remaining

boreholes were backfilled in accordance with MOE requirements (O.Reg. 903, as amended).

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawing included in Appendix A. The coordinates and elevation of the boreholes are provided on this drawing and on the individual Record of Borehole sheets.

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 the boreholes was selected and submitted for analytical testing of corrosivity parameters and sulphate content. All laboratory test results from the field investigation are provided in Appendix C.

5 GENERAL 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 Locations 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 the Soil Strata Drawing and the general description. 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 granular embankment fill overlying a thin deposit of native clay over glacial till. Bedrock was encountered within the depth of investigation in all boreholes.

The conditions reported in Geocres Report 31G-47 indicate a similar stratigraphy. The borehole records have not been included in this report due to the significant grade modifications which occurred during construction of the Highway 417 Underpass.

5.1 Embankment Fill

5.1.1 Asphalt

Boreholes 17-10 and 17-11 were drilled through the existing County Road 7 pavement and encountered a layer of asphalt at the surface with a thickness of 100 mm.

5.1.2 Fill: Silty Sand with gravel

At surface in the on-road boreholes was a layer of silty sand fill with gravel. The underside of the fill was 0.5 to 0.6 m below the existing pavement surface (elev. 69.1 to 69.6 m).

The moisture content was measured to be 2% on one sample.

Gradation analysis was completed on one sample of this granular fill layer. The grain size distribution curve for this sample is included in Figure C1 of Appendix C. The results of the test indicated the material consisted of 39% gravel, 41% sand and 20% fines.

5.1.3 Fill: Silty Sand trace gravel

At surface in Borehole 17-9 and below the pavement structure in Boreholes 17-10 and 17-11 was a layer of silty sand fill with trace amounts of gravel. The underside of the layer was 1.7 to 5.7 m below the existing ground / pavement surface (elev. 62.2 to 64.4 m).

The SPT tests conducted in this layer typically gave N-values ranging from 6 to 49 blows indicating a relative density of loose to dense. Recorded moisture contents ranged from 2 to 25%.

Gradation analyses were completed on two samples of this granular fill layer. The grain size distribution curves for these samples are included in Figure C1 of Appendix C. The results of the tests are summarized in Table 5-1 and are presented on the corresponding Record of Borehole sheets in Appendix B.

Table 5-1: Gradation Results for Silty Sand trace Gravel Fill

Soil Particle	Percentage (%)
Gravel	6 – 7
Sand	70 – 74
Silt and Clay	19 – 24

5.1.4 Fill: Interlayered Clay, Silt, Silty Sand and Gravel

Below the silty sand fill in the on-road boreholes was a fill material composed of an interlayered mixture of clay, silty clay, silty sand, silt and gravel. The underside of this fill was 6.9 to 7.6 m below the existing pavement surface (elev. 62.5 to 62.8 m).

The SPT tests conducted in this fill layer typically gave N-values ranging from 6 to 12 blows indicating a relative density of loose to compact and a firm to stiff consistency. Recorded moisture contents ranged from 13 to 42%.

5.2 Clay (CI to CH)

Below the fill materials in Boreholes 17-9 through 17-11 and at surface at Borehole 17-12 was a clay deposit. The thickness of this layer ranged from 0.9 to 1.2 m with a base elevation ranging from 61.2 to 62.1 m.

In-situ shear vane test results near the base of the layer indicated an undrained shear strength ranging from 25 to 55 kPa indicating a firm to stiff consistency. The results of the in-situ shear vane tests indicate that the clay exhibits some sensitivity. SPT tests gave N-values ranging from Weight of Rods (WR) for 300 mm penetration to 100 blows for 75 mm. The high blow count indicated the start of the glacial till beneath the clay deposit.

Recorded moisture contents ranged from 20 to 82%. The results of grain size analyses conducted on four samples of the clay are summarized in Table 5-2 and illustrated on Figure C2 in Appendix C.

Table 5-2: Gradation Results for Clay

Soil Particle	Percentage (%)
Gravel	0 – 3
Sand	2 – 10
Silt	23 – 54
Clay	36 – 75

The results of Atterberg Limits testing completed on three samples of this material indicated a liquid limit ranging from 40 to 72, a plastic limit ranging from 20 to 26, and a plasticity index of 20 to 46. The laboratory results indicate that the clay has intermediate to high plasticity (CI to CH). The results are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limits graph is included as Figure C4 of Appendix C.

5.3 Silty Sand to Sandy Silt (Glacial Till)

A native deposit of glacial till consisting of silty sand to sandy silt with varying amounts of gravel was observed underlying the clay deposit in all boreholes. Occasional to frequent cobbles and boulders were encountered within this deposit at Borehole 17-10 and 17-12. A 0.6 m thick silt bed was encountered at a depth of 11.4 m below existing pavement surface within the glacial till deposit in Borehole 17-10. The thickness of the till ranged from 3.7 to 6.6 m with a base elevation ranging from 55.5 to 57.5 m.

SPT tests gave N-values ranging from 4 for 300 mm penetration to 100 blows for 75 mm, indicating a relative density of loose to very dense. The recorded moisture contents ranged from 2 to 25%.

Gradation analyses was completed on six samples of the glacial till. The grain size distribution curves are included in Figure C3 of Appendix C. The results of the tests are summarized in Table 5-3 and are presented on the corresponding Record of Borehole sheets in Appendix B and indicate an SM to ML material.

Table 5-3: Gradation Results for Glacial Till

Soil Particle	Percentage (%)	
Gravel	4 – 36	
Sand	24 – 51	
Silt	39 – 69	13 – 43
Clay	3 – 10	

5.4 Bedrock

Bedrock was proven by coring in all four boreholes. Information on the bedrock surface from the current investigation is summarized in the Table 5-4.

Table 5-4: Summary of Bedrock Elevations

Borehole No.	Depth to Bedrock (m)	Bedrock Elevation (m)
17-9	6.4	57.5
17-10	13.8	55.9
17-11	13.2	56.9
17-12	7.8	55.5

The bedrock encountered within Boreholes 17-9 through 17-12 consisted of slightly weathered to fresh limestone with shale partings. The Total Core Recovery (TCR) measured on the recovered bedrock core ranged from 78 to 100%, the Solid Core Recovery (SCR) ranged from 78 to 100% and the Rock Quality Designation (RQD) ranged from 65 to 100%. It should be noted that a possible void (lost core) with an approximate thickness of 20 cm was encountered in Borehole 17-9 at a depth of 9.2 m below existing ground surface (elev. 54.7 m). Based on the measured RQD values, the bedrock is classified as fair to excellent quality, but predominantly ranges from good to excellent quality.

Unconfined Compressive Strength (UCS) testing was carried out on the bedrock. The results of UCS testing carried out on two samples of the rock core ranged from 98 to 127 MPa, indicating the intact bedrock to be strong to very strong. Photographs of the bedrock core are provided in Appendix C.

5.5 Groundwater

The groundwater level measured in the standpipe piezometer installed in Borehole 17-9 was recorded at a depth of 0.8 m below the ground surface (elev. 63.1m) on August 3, 2018.

The water level of the Leo Denis Municipal Drain was also surveyed during the field investigation and measured to be at an elevation of 62.0 and 62.1 m on June 20 and June 21, 2018, respectively. It is expected that the groundwater level will likely reflect the water level in the creek.

These observations are considered short term and it should be noted that the groundwater level at the time of construction may 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.

5.6 Analytical Testing

One sample of the native soil was submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, sulphides, resistivity and conductivity. The analysis results are summarized in the Table 5-5.

Table 5-5: Summary of Analytical Testing

Borehole (Sample)	Depth (mbgs)	Sulphate (µg/g)	pH (-)	Resistivity (Ohm-cm)	Conductivity (uS/cm)	Chloride (µg/g)	Sulphide (%)
17-12 (SS4)	2.3 – 2.9	69	7.91	1,600	326	91	0.17

6 MISCELLANEOUS

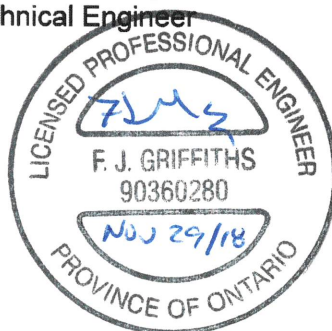
Borehole locations were selected by Thurber relative to existing site features. The as-drilled locations and ground surface elevations were surveyed by Thurber following completion of the field program.

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. Beacon Lite of Ottawa, Ontario supplied the traffic control equipment and personnel for TL-20A lane closures required for the on-road boreholes in conformance with Ontario Book 7 requirements. The field investigation was supervised on a full time basis by Miss Katya Edney, P.Eng. of Thurber. Overall supervision of the investigation program was conducted by Dr. Fred Griffiths, P.Eng.

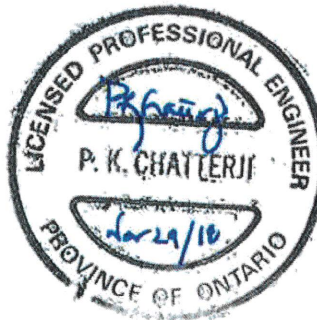
Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa, Ontario. Rock testing was completed by Stantec in Ottawa, Ontario. Interpretation of the factual data and preparation of this report were carried out by Miss Katya Edney, P.Eng. and Dr. Fred Griffiths, P.Eng. The report was reviewed by 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 designing the proposed rehabilitation of Culvert 27-362/C crossing County Road 7 near Highway 417 in Casselman, Ontario. The discussion and recommendations presented in this report are based on the information provided by Ainley 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.

The existing culvert is a corrugated steel sectional plate arch culvert servicing the Leo Denis Municipal Drain and is noted to have been constructed in 1971. The culvert is reported to be 3.5 m wide by 2.2 m high and approximately 37 m long with a generally east to west alignment. Flow through the culvert is to the west. The existing invert is at approximately elevation 61.5 m. The water level of the Leo Denis Municipal Drain was also surveyed during the field investigation and measured to be at an elevation of 62.0 and 62.1 m on June 20 and June 21, 2018, respectively.

The embankment fill height is approximately 6.6 m over the culvert with the road surface at approximate elevation of 69.9 m. The existing embankment side slopes are inclined at approximately 2H:1V.

The following historical foundation investigation report was obtained from the online Geocres library and reviewed in preparation of this report.

Foundation Investigation Report for Proposed Crossing, New Hwy. #417 and County Road #7, Twp. of Cambridge, Co. of Russell, Lot 9 Conc. 7, District No. 9 (Ottawa), W.J.70-F-3 – W.P. 35-66-16 [Geocres 31G-47]

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Thurber Engineering Limited (Thurber) carried out the current investigation as a sub-consultant to Ainley Consulting Engineers Planners (Ainley) under Assignment No. 4016-E-0036.

7.1 Proposed Structure

The following three options were initially considered for this site:

- Replacement of existing with a new concrete box culvert with approximate width of 4.0 m and height of 3.0 m. The replacement would be constructed with an open cut staged to allow one lane of traffic throughout the duration of the work.
- A trenchless installation utilizing tunneling techniques with the replacement culvert installed on a new alignment adjacent to the existing and sized to achieve drainage requirements.
- A trenchless installation consisting of a liner placed within the existing culvert.

The initial assessment concluded that third option (liner) was preferred due to the traffic implications of the first option and the costs associated with the second.

The drainage report by Ainley dated September 2018 and the General Arrangement (GA) drawing received on July 17, 2018 (copy provided in Appendix A) indicate that the existing culvert will be lined with a structural plate corrugated steel pipe arch liner approximately 1.6 m in height with a span of approximately 2.2 m. The resulting opening will have reduced cross-sectional area compared to the existing culvert opening, however it has been confirmed by the drainage team that the liner meets the specified culvert design criteria. Cementitious grout will be used to fill the annulus around the liner pipe. The invert of the proposed culvert liner is expected to be at approximately elevation 61.7 m.

From a foundation engineering perspective, the rehabilitation of the existing culvert using the proposed liner is preferred provided the additional load imposed by the addition of grout in the annulus between the existing culvert and the liner does not induce unacceptable settlements. If the proposed SPCSPA liner reduces in size, resulting in a greater annulus, thus increasing the grout requirement, further review will be required.

7.2 Cement Type and Corrosion Potential

Analytical tests were completed to determine the potential for degradation of the concrete or grout 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 a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. The class of concrete or grout 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 test results provided in Section 5.6 may be used to aid in the selection of coatings and corrosion protection systems for the liner or other buried steel objects. The corrosion effects of road de-icing salts should also be considered.

8 SETTLEMENT

It is estimated, based on the GA received on July 17, 2018, that approximately 3.1 m³ of grout will be required per m of culvert length to fill the annulus around the liner. This represents a stress increase on the underlying soils of approximately 21 kPa.

A thin layer of clay was encountered within this investigation, however, the underside of the bedding layer of the existing culvert is in the glacial till below this clay stratum.

An assessment of the elastic settlement of the non-cohesive underlying soils has been carried out, assuming a Deformation Modulus, E, of 15 MPa for the silty sand (glacial till). It is estimated that the elastic settlement induced by the load imposed by grouting around the liner will be less than 5 mm. It is our opinion that this will be acceptable, geotechnically. Confirmation from the structural and drainage engineering team has been provided.

9 CONSTRUCTION CONSIDERATIONS

The condition of the existing culvert should be inspected to determine if there is any sag of the existing culvert crown or inward movement at spring line that will adversely impact installation of the new liner.

From a foundation engineering perspective, the rehabilitation of the existing culvert with a steel pipe arch liner and grout backfill will cause no traffic disruption during the construction. Cofferdams may be needed to facilitate appropriate dewatering during construction.

The base of the culvert must be cleaned of any soil deposit and debris before liner is installed.

9.1 Excavation

Excavations, if needed, must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of OHSA, the fills and native soils above the water table may be classified as Type 3 soil. The native soils below the groundwater level are classified as Type 4 soils.

Excavation for the culvert rehabilitation must be carried out in accordance with OPSS 902. The sides of temporary excavations must be sloped in accordance with the requirement of the OHSA. Selection of the equipment and methodology to excavate and prepare the founding surface is the responsibility of the Contractor. Stockpiling or surface surcharge should not be allowed on the embankment or side slopes.

At locations where there are space restrictions or where a slope has to be retained, the excavations will need to be carried out within a protection system. Further discussion on temporary protection systems (TPS) is presented in Section 9.2.

9.2 Temporary Protection Systems

Temporary Protection Systems, if required during construction 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.

The design of roadway protection is the responsibility of the Contractor. All protection systems should be designed by a licensed Professional Engineer experienced in such designs and retained by the Contractor. The design of the roadway protection system must incorporate traffic loading and surcharge loading due to construction equipment and operations.

It is recommended that an NSSP be included in the tender documents to alert the Contractor to the potential for cobbles and boulders and obstructions within the till and fill. Deadman tie-backs, struts and/or raker supports may be needed to achieve the specified performance level due to the shallow depth of refusal noted during the field investigation.

The protection system should be installed at a sufficient distance away from the culvert to limit the disturbance to subgrade associated with removal of the protection system following complete of construction. Alternatively, protection systems near the culvert could be left in place and cut off in accordance with OPSS.PROV 539.

The lateral earth pressure coefficient for the fill materials, existing native clay and glacial till material foundation soils are given below for a vertical wall with a horizontal backslope:

SILTY SAND FILL / GLACIAL TILL

γ	=	19.5 kN/m ³	(use submerged unit weight for soil below groundwater level)
K_A	=	0.31	
K_P	=	3.2	

CLAY

γ	=	19 kN/m ³	(use submerged unit weight for soil below groundwater level)
K_A	=	0.39	
K_P	=	2.6	

9.3 Dewatering

Creek diversion controlled by coffer dams will be required for the installation of the proposed culvert liner.

The work will extend below the groundwater level and ditch water level observed at the time of the investigation. The Contractor must be prepared to control the groundwater and surface water flow at the site to permit construction in a dry and stable excavation. Water from surface flow and/or groundwater must be diverted away from any excavation at all times. Groundwater perched within the embankment fill and, surface runoff will tend to seep into, and accumulate in excavations.

The design of dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with NSSP FOUN0003 which amends OPSS 902. A preconstruction survey is recommended, thus Designer Fill-In ** in the SP should be "100 m".

For structural rehabilitations, the dewatering system is to be designed in accordance with OPSS.PROV 517 and SP517F01 should be invoked for this site. The hydrogeology is not considered to be complex, thus Designer Fill-In ***** in SP517F01 should be "No". A preconstruction survey is recommended, thus Designer Fill-In ***** in this SP should be "100 m".

The groundwater level will fluctuate and the minimum groundwater elevation for the site at the time of the proposed work should be taken as the drain water level of the design storm return period defined by the contract documents for the dewatering system.

Temporary groundwater and surface water control measures will be required to remain operational during construction until the liner is installed and grouted. It is anticipated that the culvert rehabilitation work will be isolated within a water tight enclosure. It is anticipated that Sheet Pile cofferdams will be difficult to install and may not be water tight. Therefore, it is recommended to pump from within sand bag cofferdams.

Further assessment of dewatering requirements and the need for a PTTW should be carried out by specialists experienced in this field.

9.4 Scour Protection and Erosion Control

Based on the subsurface conditions encountered at the drilled locations through the embankment at this site the embankment soils are considered to have moderate susceptibility to erosion as per the Wischmeier Nomograph. The native soils at the inlet and outlet are considered to have moderate susceptibility to erosion.

Scour and erosion protection should be provided for the culvert inlet and outlet areas. Design of the scour and erosion protection measures must consider hydrologic and hydraulic concerns and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all earth surfaces subjected to flowing water in accordance with OPSS 511. Treatment at the outlet should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

10 CONSTRUCTION CONCERNS

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

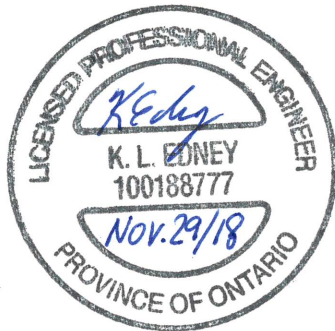
- The existing culvert should be inspected to confirm that there are no crown sags or inward bulging at spring line that will interfere with installation of the new liner.
- Buried obstructions may be encountered in the existing glacial till and shallow depth of refusal may interfere with installation of sheet piles.
- 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 structure fill (i.e., as a pad for crane support).

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

11 CLOSURE

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

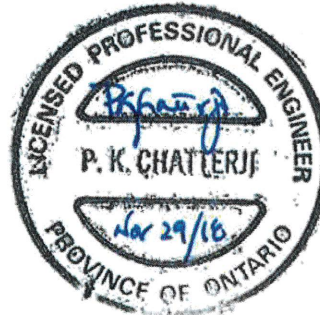
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Senior Associate
Senior Geotechnical Engineer

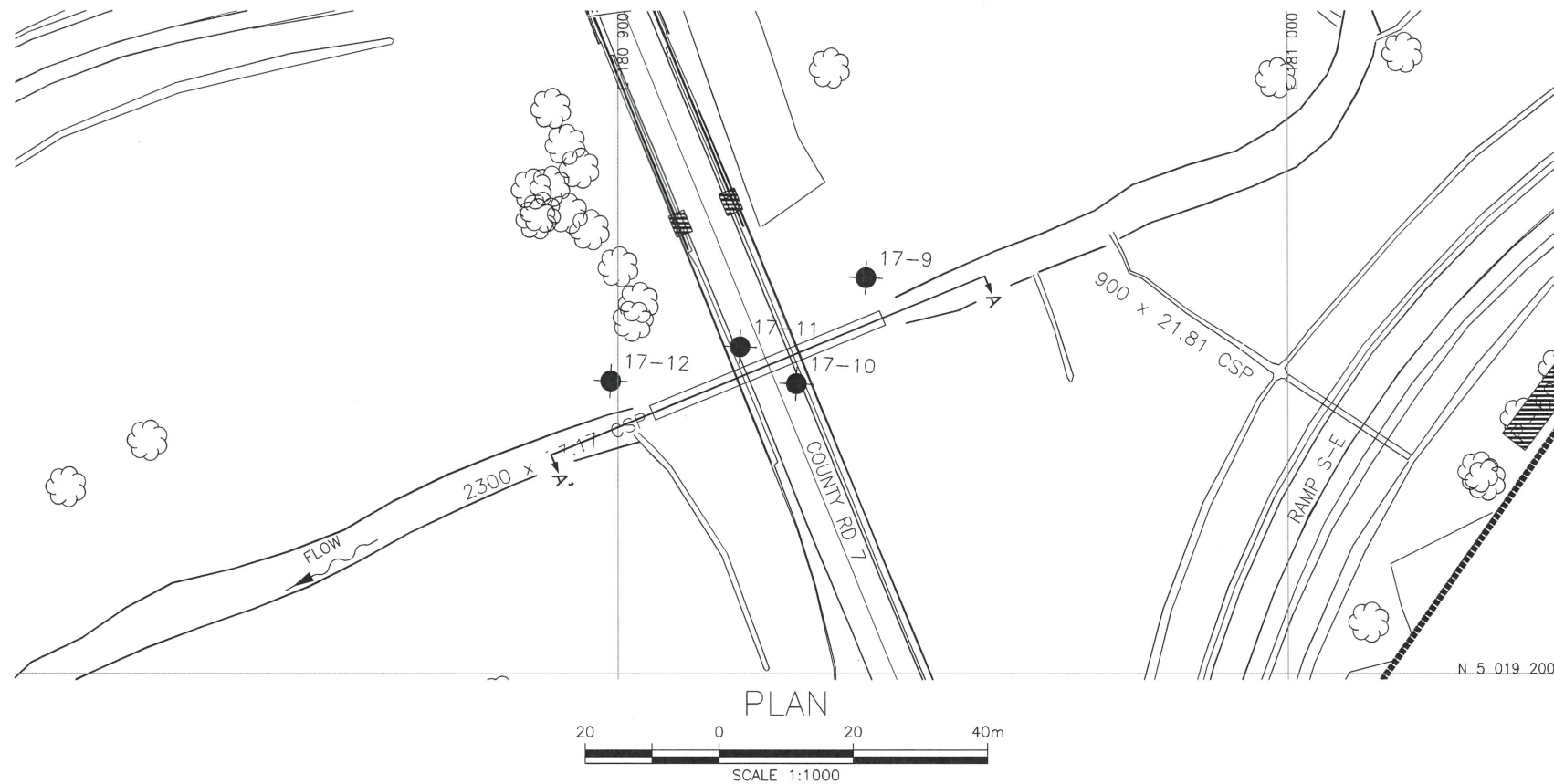


Dr. P.K. Chatterji, P.Eng.
Review Principal,
Senior Geotechnical Engineer

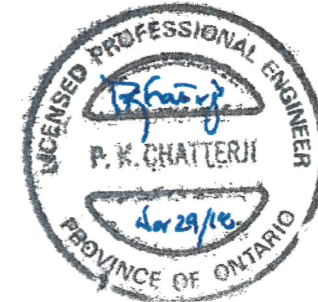
FINAL

Appendix A.

Borehole Location Plan and Stratigraphic Drawings



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



CONT No
GWP No 451-98-00

HIGHWAY 417
CULVERT 27-362/C
REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



KEYPLAN

LEGEND

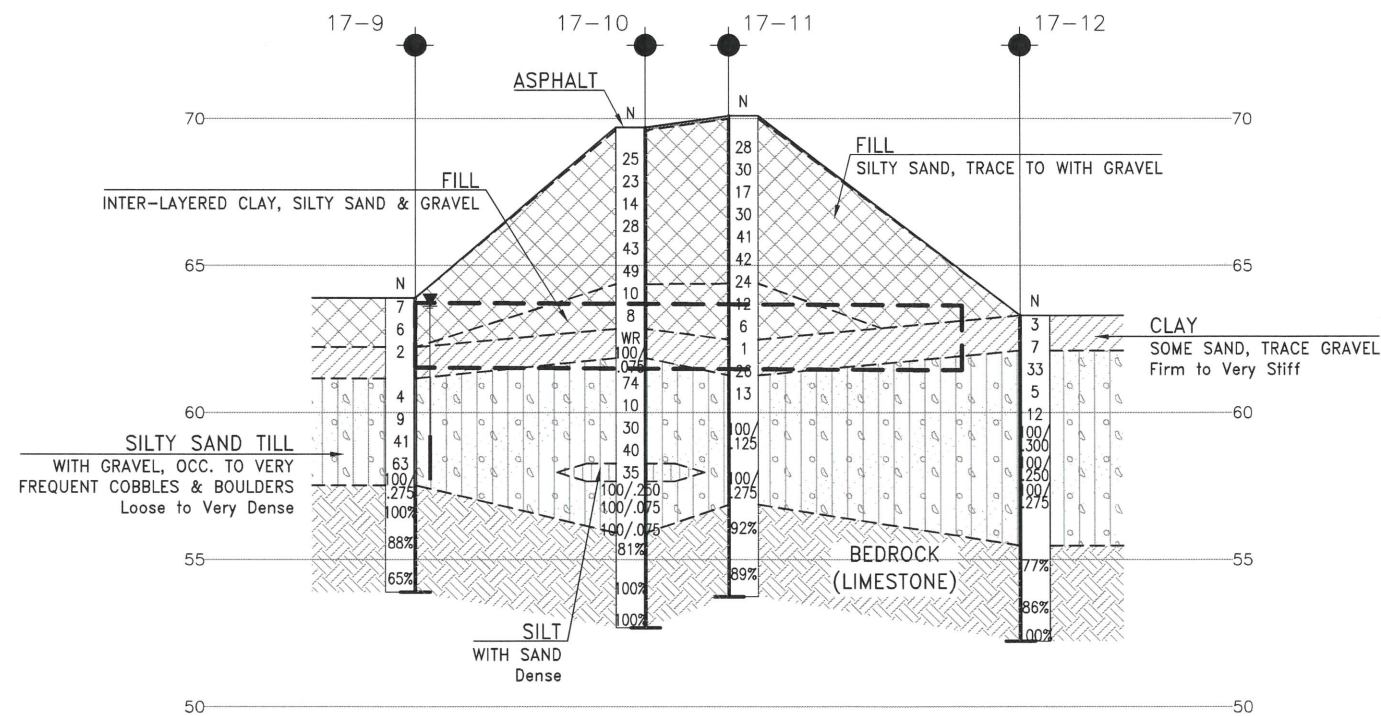
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
17-9	63.9	5 019 259.2	180 937.0
17-10	69.7	5 019 243.3	180 926.6
17-11	70.1	5 019 248.9	180 918.2
17-12	63.3	5 019 243.7	180 898.9

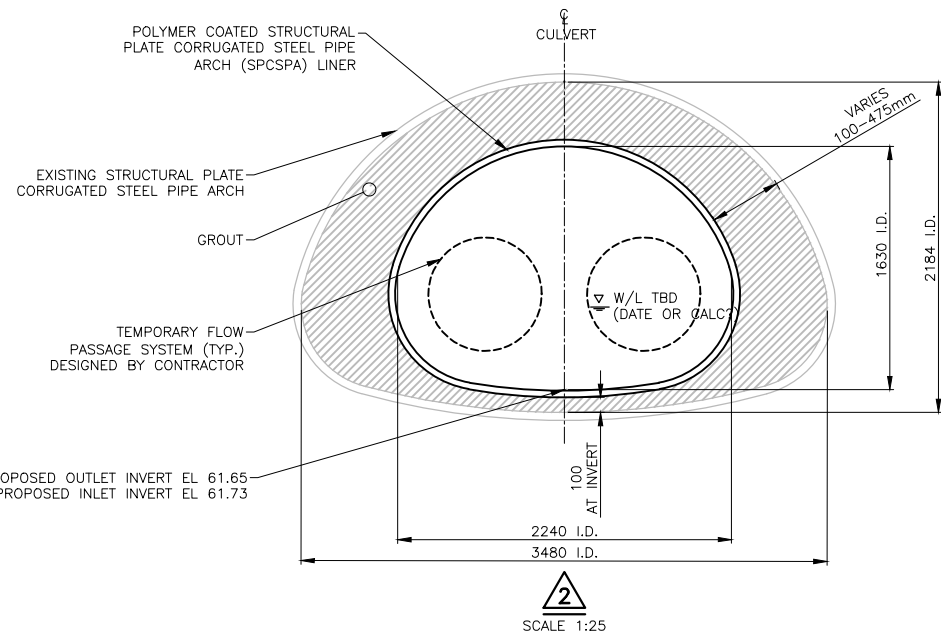
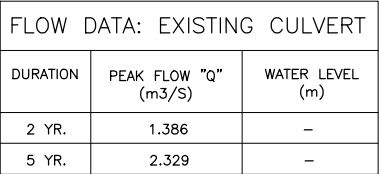
-NOTES-

- 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 8.

GEOCRES No. 31G-271



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	KE	CHK	PC
DRAWN	MFA	CHK	KE
CODE			
LOAD			
STRUCT			
DWG			
DATE	NOV 2018		



DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

GENERAL NOTES

1. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS AND ELEVATION OF THE EXISTING WORK AND ALL DETAILS ON SITE AGAINST THE PROPOSED WORK AND REPORT ANY DISCREPANCIES TO THE CONTRACT ADMINISTRATOR BEFORE PROCEEDING WITH THE WORK.
2. THE CONTRACTOR SHALL CONTROL OPERATIONS TO PREVENT ENTRY OF DELETERIOUS MATERIAL INTO WATERCOURSES.
3. THE CONTRACTOR SHALL COMPLY WITH THE REQUIREMENTS OF THE ONTARIO OCCUPATIONAL HEALTH AND SAFETY ACT AND REGULATIONS FOR CONSTRUCTION PROJECTS O.REG. 213/91 AND CONFINED SPACES O.REG. 632/05.
4. GROUT NEW SPCSPA LINER COMMENCING FROM DOWNSTREAM END AND PROGRESSING TOWARDS UPSTREAM END. GROUTING TO BE COMPLETED IN LIFTS AND STAGES IN ACCORDANCE WITH CONTRACTOR'S SUBMITTED METHODOLOGY.

CONSTRUCTION NOTES

1. DESIGN, INSTALL AND CONTINUOUSLY MONITOR TEMPORARY FLOW PASSAGE SYSTEM. TEMPORARY FLOW PASSAGE SYSTEM SHALL PERMIT FLOW OF WATER COURSES THROUGH THE WORK ZONE SUCH THAT WORK IS EXECUTED IN THE DRY AND SHALL PERMIT STAGING OF THE WORK.
2. CLEAN EXISTING CULVERTS OF ALL SEDIMENT AND DEBRIS.
3. IN ADVANCE OF INSTALLATION OF THE NEW STEEL LINER, THE CONTRACTOR SHALL COMPLETE A PRECONSTRUCTION SURVEY TO CONFIRM CROSS SECTION DIMENSIONS OF EXISTING CULVERT, ANY OBSTRUCTIONS AND/OR DAMAGE, AND CONFIRM CROSS SECTION DIMENSIONS TO ACCOMMODATE NEW STEEL LINER.
4. THE NEW STEEL LINER SHALL BE MONITORED FOR DEFLECTIONS AND/OR DISTORTION DURING THE GROUTING OPERATION. THE CONTRACTOR SHALL NOTIFY THE CONTRACT ADMINISTRATOR AND CEASE ALL GROUTING IF DEFLECTION AND/OR DISTORTION IS OBSERVED.
5. DAMAGE TO POLYMER COATING SYSTEM IS TO BE REPAIRED IN ACCORDANCE WITH SUBMITTED METHODOLOGY.

SCOPE OF WORK *

1. INSTALL AND CONTINUOUSLY MONITOR TEMPORARY FLOW PASSAGE SYSTEM AND MANAGE FLOW OF WATER FOR DURATION OF THE WORK.
2. COMPLETE PRECONSTRUCTION SURVEY.
3. REMOVE DEBRIS AND CLEAN CULVERT SURFACES.
4. SUPPLY AND INSTALL POLYMER COATED STRUCTURAL PLATE CORRUGATED STEEL PIPE ARCH (SPCSPA) LINER.

* NOT INTENDED TO SHOW SEQUENCE OF WORK

MATERIALS:

1. CEMENTITIOUS GROUT FOR BACKGROUTING STEEL LINER SHALL BE 20 MPa COMPRESSIVE STRENGTH AT 28 DAYS.
2. LINER END TREATMENT TO MATCH BEVELLED ENDS OF EXISTING CULVERT.
3. STEEL LINER SHALL BE 2240 x 1630mm POLYMER COATED STRUCTURAL PLATE CORRUGATED STEEL PIPE ARCH (SPCSPA), 152 x 51mm CORRUGATIONS, MINIMUM 3.0mm THICK, $F_y = 230\text{MPa}$.

LIST OF ABBREVIATIONS

TYP.	TYPICAL
DIA	DIAMETER
STA	STATION
W/L	WATER LEVEL
I.D.	INNER DIAMETER
N.B.	NORTHTBOUND
S.B.	SOUTHBOUND

LIST OF DRAWINGS

1	GENERAL ARRANGEMENT									
	REVIEWS									
	DATE	BY	DESCRIPTION							
	DESIGN ###	CHK ###	CODE CSA-S6-14	LOAD CL-625-ONT	DATE	###				
	DRAWN MRF	CHK ECL	SITE 27-362/C		DWG	P1				

Appendix B.

Record of Borehole Sheets



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.



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

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.

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 (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

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



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

RECORD OF BOREHOLE No 17-9

1 OF 2

METRIC

GWP# 451-98-00 LOCATION Lat: 45.302363°, Long: -75.079421° Site 27-362/C Culvert MTM z8: N 5 019 259.2 E 180 937.0 ORIGINATED BY KE
HWY 417 BOREHOLE TYPE HSA/NQ coring COMPILED BY AC
DATUM Geodetic DATE 2018.06.21 - 2018.06.21 CHECKED BY FG

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						
63.9								20 40 60 80 100	20 40 60					
0.0	SILTY SAND trace gravel, trace organics loose to very loose brown FILL		1	SS	7									
			2	SS	6									
62.2														
1.7	CLAY (CH) some sand firm to stiff grey		3	SS	2									1 10 24 65
61.2								4.0 +						
2.7	SILTY SAND (SM) to SANDY SILT (ML) TILL trace to with gravel loose to very dense grey		4	SS	4									
			5	SS	9									12 39 39 10 Non plastic
			6	SS	41									
			7	SS	63									19 38 43 (SI+CL)
57.5			8	SS	100/									
6.4	BEDROCK LIMESTONE with shale partings slightly weathered to fresh thinly bedded fine grained strong grey		1	NQ		275 mm							FI	RUN #1 TCR=100% SCR=100% RQD=100%
			2	NQ									0	RUN #2 TCR=100% SCR=98% RQD=88%
													1	
													4	
	- Possible void (lost core) from 9.2 to 9.5 m		3	NQ										RUN #3 TCR=78% SCR=78% RQD=65%
53.9														

Continued Next Page

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

DOUBLE LINE SITE 27-362C.GPJ 2012TEMPLATE(MTO).GDT 14/11/18

RECORD OF BOREHOLE No 17-9

2 OF 2

METRIC

GWP# 451-98-00 LOCATION Lat: 45.302363°, Long: -75.079421°
Site 27-362/C Culvert MTM z8: N 5 019 259.2 E 180 937.0
 HWY 417 BOREHOLE TYPE HSA/NQ coring
 DATUM Geodetic DATE 2018.06.21 - 2018.06.21

ORIGINATED BY KE
 COMPILED BY AC
 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W P	W	W L		
	Continued From Previous Page							20	40	60	80	100					
10.0	End of Borehole Water level in well: 2018.06.25 0.6 mbgs (elev. 63.3 m) 2018.08.03 0.8 mbgs (elev. 63.1 m)																

DOUBLE LINE SITE 27-362C.GPJ 2012TEMPLATE(MTO).GDT 14/11/18

RECORD OF BOREHOLE No 17-10

1 OF 2

METRIC

GWP# 451-98-00 LOCATION Lat: 45.302218°, Long: -75.079548° Site 27-362/C Culvert MTM z8: N 5 019 243.3 E 180 926.6 ORIGINATED BY KE/AC
 HWY 417 BOREHOLE TYPE HSA/NQ coring COMPILED BY AC
 DATUM Geodetic DATE 2018.06.25 - 2018.06.25 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100	W _P	W						W _L
69.7																				
0.0																				
0.1																				
69.1																				
0.6																				

Continued Next Page

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

DOUBLE LINE SITE 27-362C.GPJ 2012TEMPLATE(MTO).GDT 14/11/18

METRIC

SOIL PROFILE			SAMPLES		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES
	Continued From Previous Page				
58.3	SILTY SAND (SM) with gravel TILL dense grey -occasional cobbles and boulders		13	SS	30
57.7			14	SS	40
55.9			15	SS	35
52.7			16	SS	100/ 250 mm
52.0			17	SS	100/ 75 mm
51.8			18	SS	100/ 75 mm
52.7	BEDROCK LIMESTONE with shale partings slightly weathered to fresh thinly bedded fine grained strong grey		1	NQ	
52.0			2	NQ	
50.0			3	NQ	
End of Borehole					

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 17-11

1 OF 2

METRIC

GWP# 451-98-00 LOCATION Lat: 45.302267°, Long: -75.079657° Site 27-362/C Culvert MTM z8: N 5 019 248.9 E 180 918.2 ORIGINATED BY KE/AC
 HWY 417 BOREHOLE TYPE HSA/NQ coring COMPILED BY AC
 DATUM Geodetic DATE 2018.06.26 - 2018.06.26 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
				WATER CONTENT (%)				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _P W W _L					
70.1													
0.0	ASPHALT (100 mm)												
0.1	SILTY SAND with gravel brown		1	GS									39 41 20 (SI+CL)
69.6	FILL												
0.5	SILTY SAND trace gravel compact to dense brown		2	SS	28								
	FILL												
			3	SS	30								
			4	SS	17								7 74 19 (SI+CL)
			5	SS	30								
			6	SS	41								
			7	SS	42								
			8	SS	24								
64.4	Interlayered SILT, SILTY CLAY and CLAY loose to compact / stiff to very stiff grey to grey-brown		9	SS	12								
5.7	FILL		10	SS	6								
62.5													
7.6	CLAY (CH) very stiff grey		11	SS	1								0 2 23 75
			12	SS	26								
61.3													
8.8	SILTY SAND (SM) with gravel TILL compact grey		13	SS	13								

Continued Next Page

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

DOUBLE LINE SITE 27-362C.GPJ 2012TEMPLATE(MTO).GDT 14/11/18

METRIC

Lat: 45.302267°, Long: -75.079657°
Site 27-362/C Culvert MTM z8: N 5 019 248.9 E 180 918.2

+³, ×³: Numbers refer to Sensitivity

DOUBLE LINE SITE 27-362C.GPJ 2012TEMPLATE(MTO).GDT 14/11/18

RECORD OF BOREHOLE No 17-12

1 OF 2

METRIC

GWP# 451-98-00 LOCATION Lat: 45.302217°, Long: -75.079902° Site 27-362/C Culvert MTM z8: N 5 019 243.7 E 180 898.9 ORIGINATED BY KE
HWY 417 BOREHOLE TYPE HSA/NQ coring COMPILED BY AC
DATUM Geodetic DATE 2018.06.19 - 2018.06.19 CHECKED BY FG

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		W P W W L			
63.3								20 40 60 80 100					
0.0	CLAY (CI) trace sand, trace organics Stiff to firm Grey-brown		1	SS	3		63						
62.1			2	SS	7								3 7 54 36
1.2	SILTY SAND (SM) with gravel TILL occasional to frequent cobbles and boulders loose to very dense grey		3	SS	33		62						
			4	SS	5		61						
			5	SS	12		60						
			6	SS	100/ 300 mm		59						
			7	SS	100/ 250 mm		58						30 46 24 (SI+CL)
			8	SS	100/ 275 mm		57						
	- very frequent cobbles and boulders below 5.9 m		9	NQ			56						
55.5							55						
7.8	BEDROCK LIMESTONE with shale partings slightly weathered to fresh thinly bedded fine grained strong grey		1	NQ			54						
			2	NQ									

DOUBLE LINE SITE 27-362C.GPJ 2012TEMPLATE(MTO).GDT 14/11/18

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-12

2 OF 2

METRIC

GWP# 451-98-00 LOCATION Lat: 45.302217°, Long: -75.079902° Site 27-362/C Culvert MTM z8: N 5 019 243.7 E 180 898.9 ORIGINATED BY KE
 HWY 417 BOREHOLE TYPE HSA/NQ coring COMPILED BY AC
 DATUM Geodetic DATE 2018.06.19 - 2018.06.19 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) W P W W L				
	Continued From Previous Page																
52.2	BEDROCK LIMESTONE with shale partings slightly weathered to fresh thinly bedded fine grained strong grey		3	NQ			53										
11.1	End of Borehole																

DOUBLE LINE SITE 27-362C.GPJ 2012TEMPLATE(MTO).GDT 14/11/18

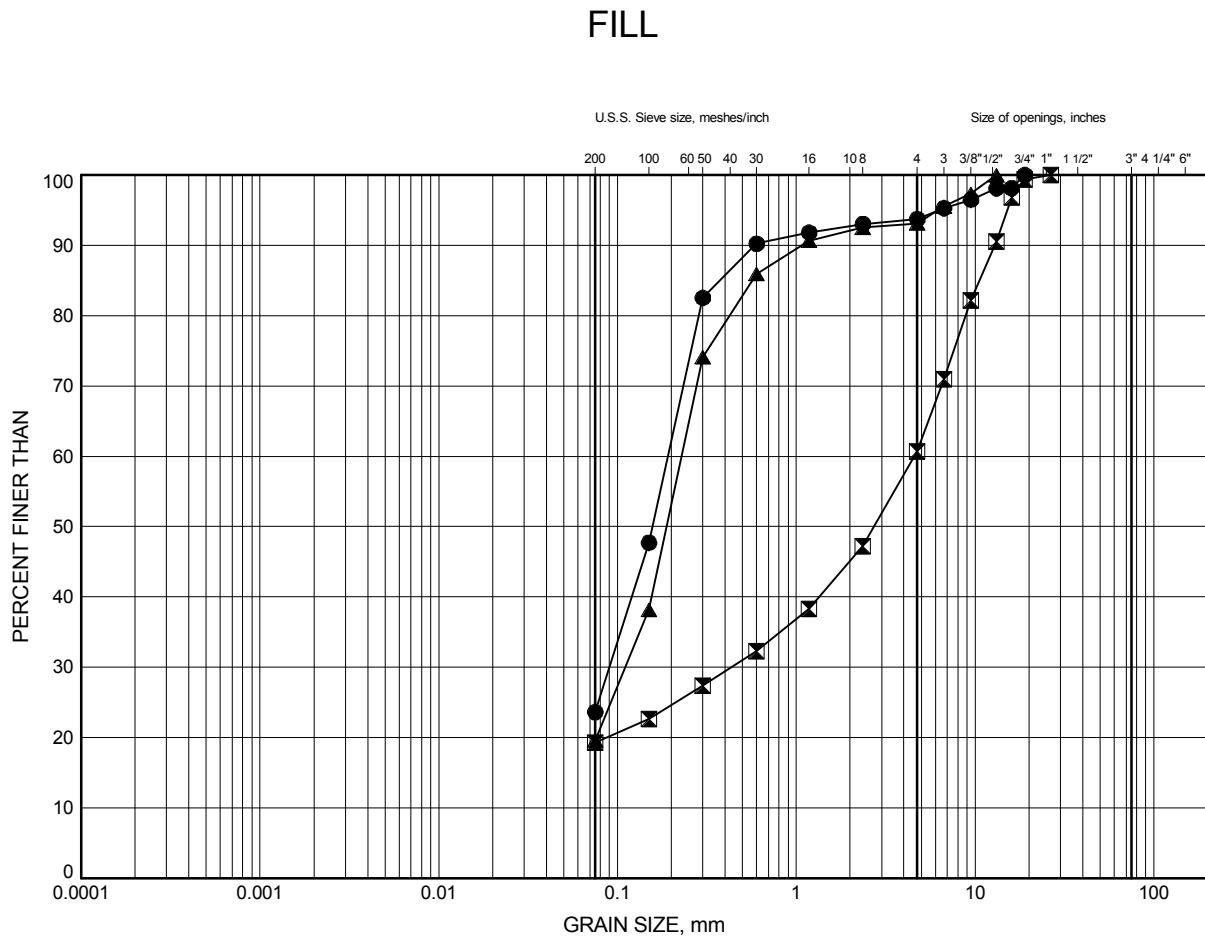
Appendix C.
Laboratory Testing

Appendix C.1
Particle Size Analysis Figures

Site 27-362/C

GRAIN SIZE DISTRIBUTION

FIGURE C1



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-10	4.9	64.8
⊠	17-11	0.3	69.8
▲	17-11	2.6	67.5

Date November 2018
GWP# 451-98-00

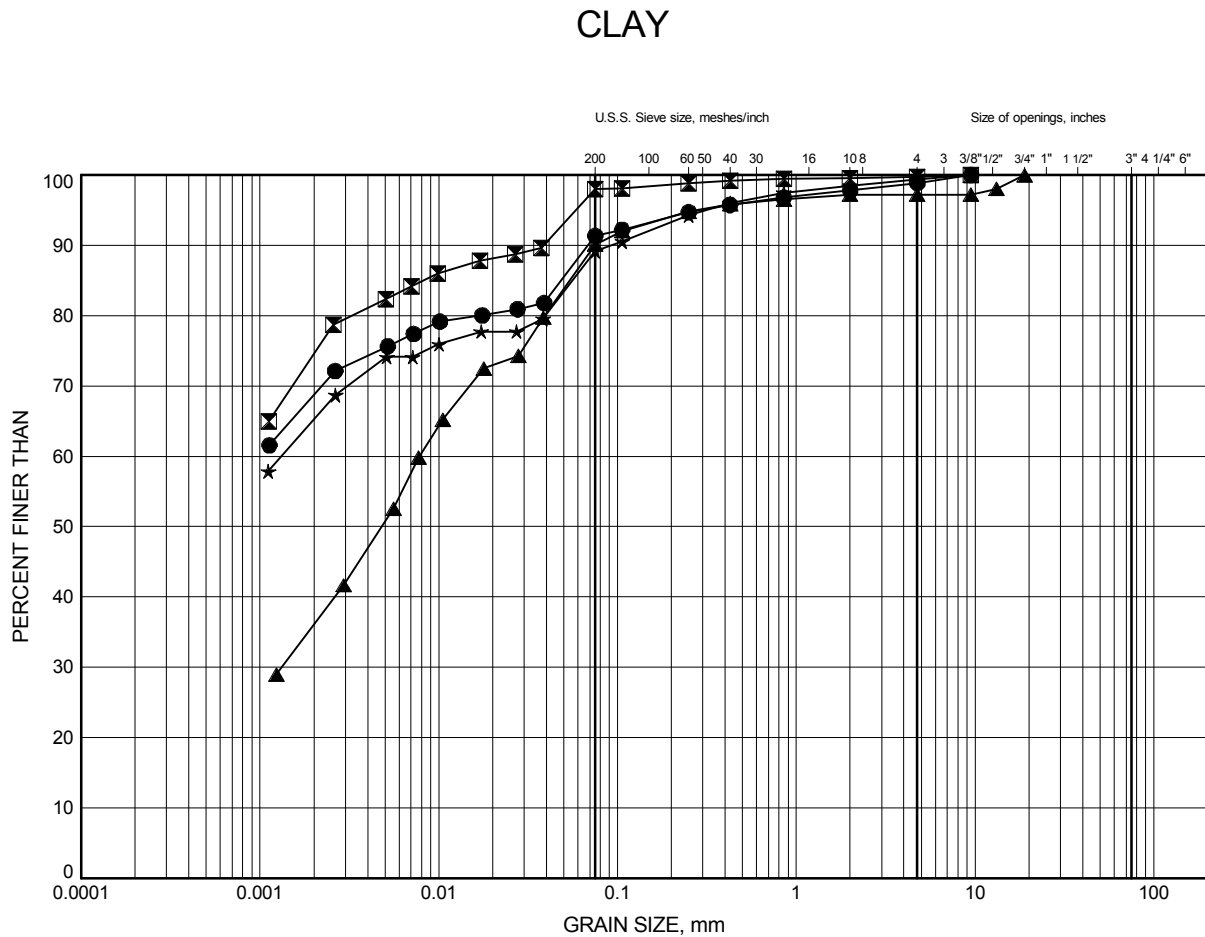


Prep'd KE
Chkd. FG

Site 27-362/C

GRAIN SIZE DISTRIBUTION

FIGURE C2



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-10	7.2	62.5
⊠	17-11	7.9	62.2
▲	17-12	1.0	62.3
★	17-9	1.9	62.0

Date November 2018
GWP# 451-98-00



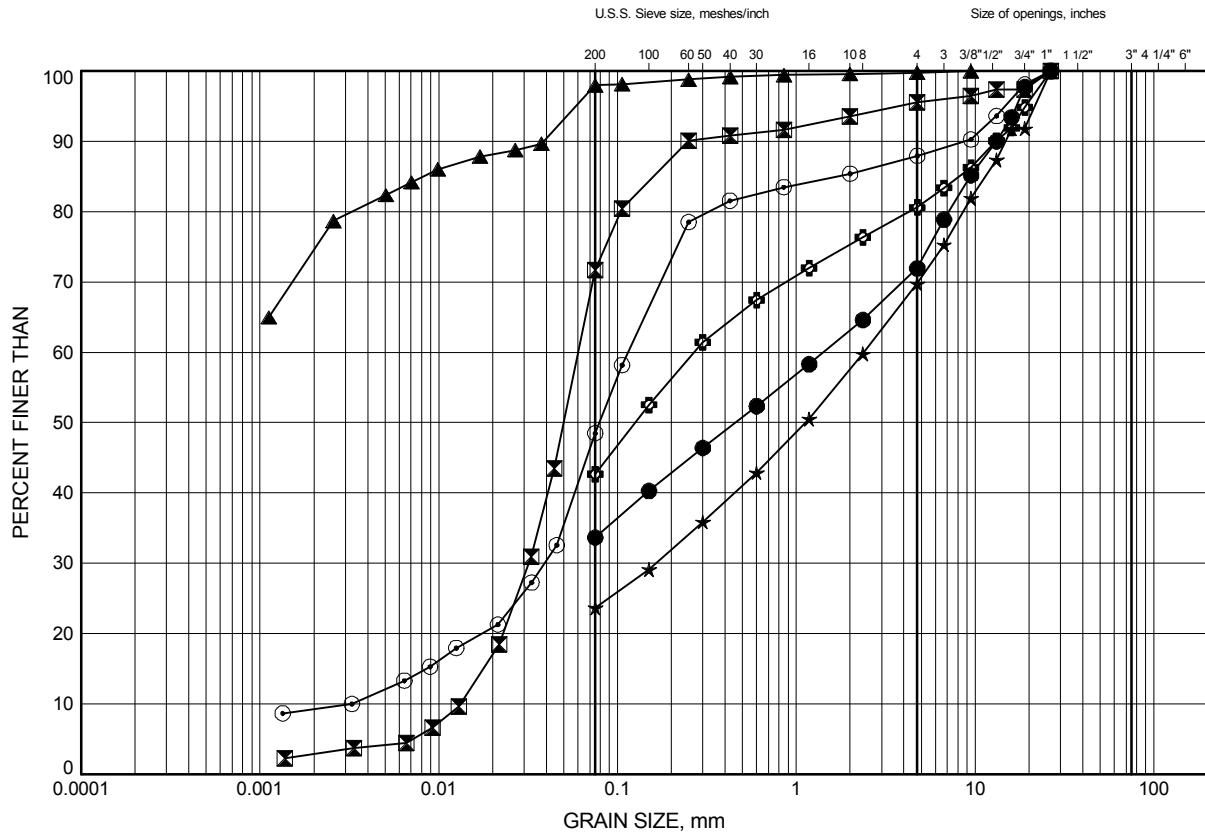
Prep'd KE
Chkd. FG

Site 27-362/C

GRAIN SIZE DISTRIBUTION

FIGURE C3

Silty Sand to Sandy Silt (GLACIAL TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-10	10.2	59.5
⊠	17-10	11.7	58.0
▲	17-11	7.9	62.2
★	17-12	4.8	58.5
⊙	17-9	4.1	59.8
⊕	17-9	5.6	58.3

Date November 2018

GWP# 451-98-00



Prep'd KE

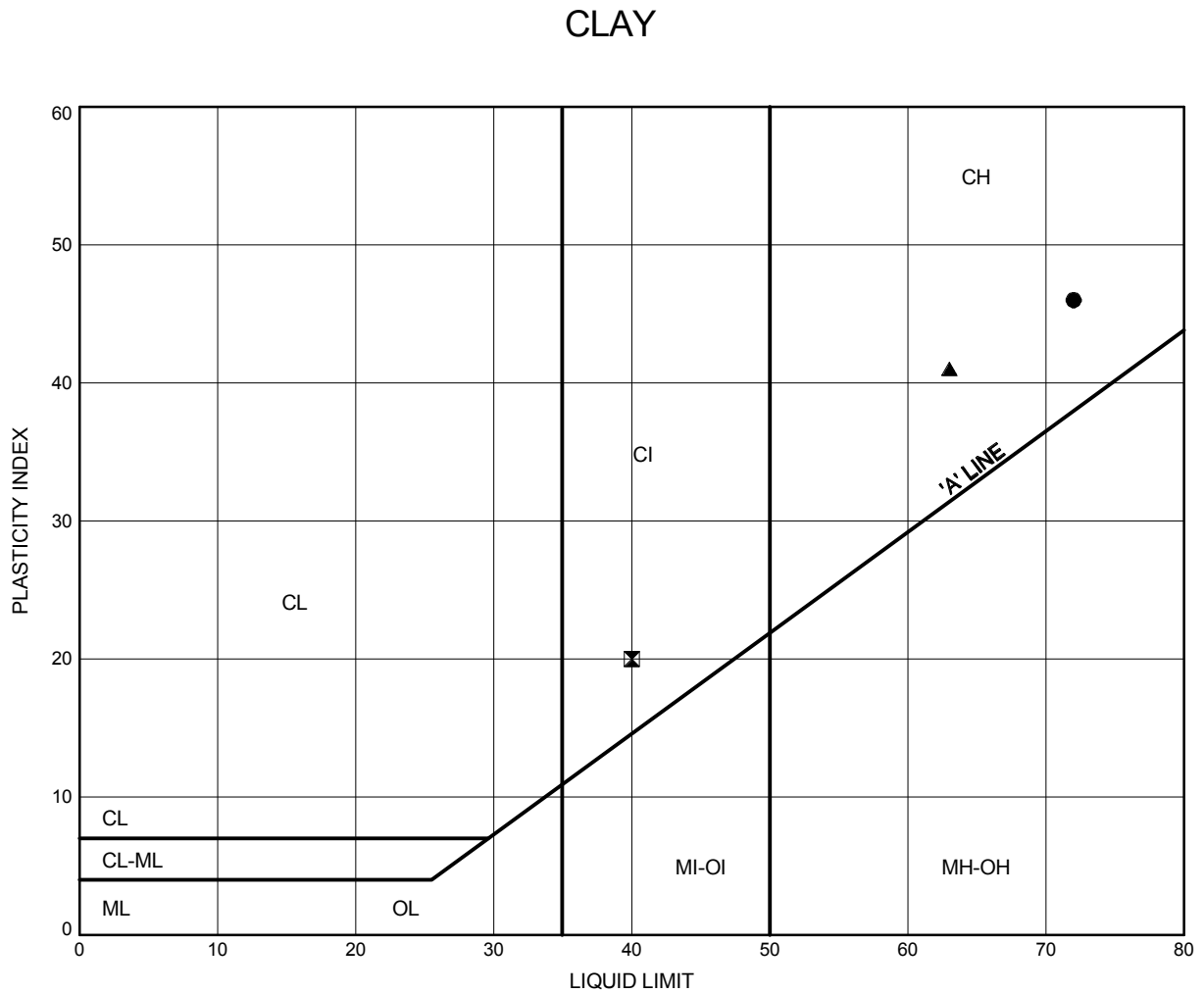
Chkd. FG

Appendix C.2
Atterberg Limits Analysis Figure

Site 27-362/C

ATTERBERG LIMITS TEST RESULTS

FIGURE C4



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-11	7.9	62.2
⊠	17-12	1.0	62.3
▲	17-9	1.9	62.0

Date November 2018
GWP# 451-98-00

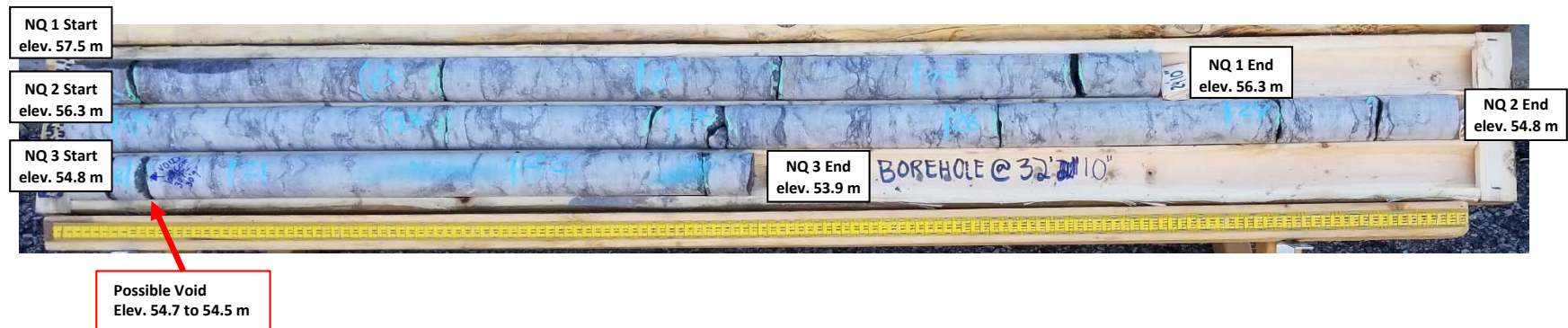


Prep'd KE
Chkd. FG

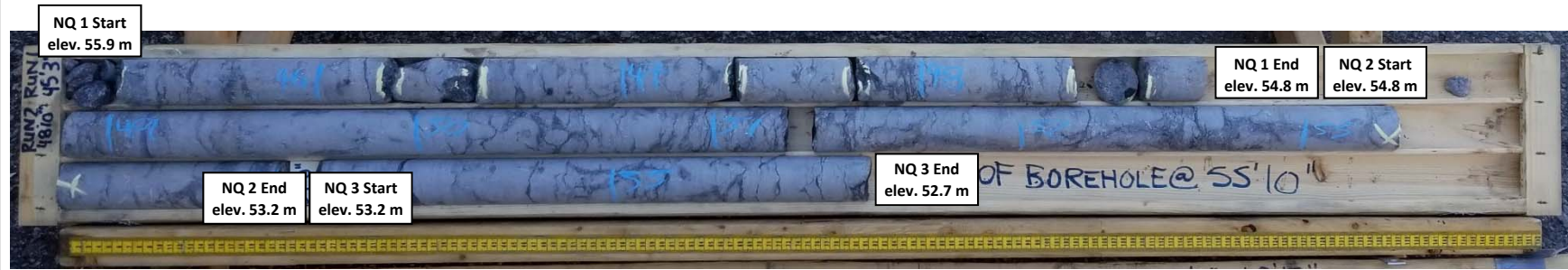
Appendix C.3

Rock Core Photos and Testing Results

Borehole 17-9
Run 1 to 3 (of 3)
Elevation 57.5 m to 53.9 m



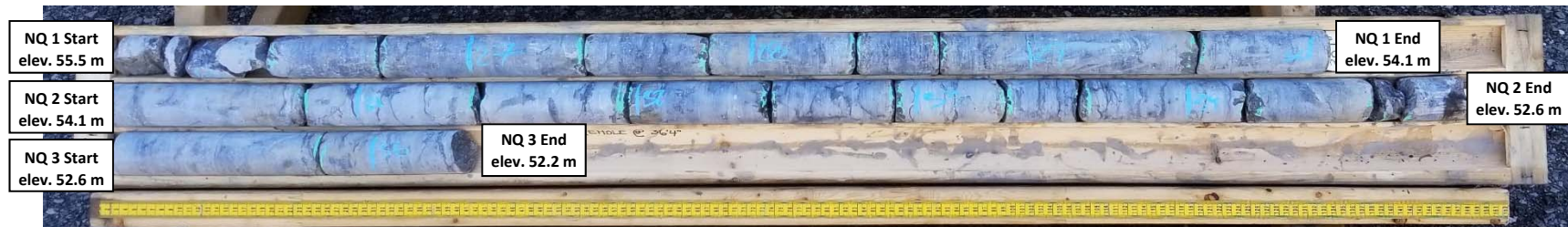
Borehole 17-10
Run 1 to 3 (of 3)
Elevation 55.9 m to 52.7 m



Borehole 17-11
Run 1 to 2 (of 2)
Elevation 56.9 m to 53.7 m



Borehole 17-12
Run 1 to 3 (of 3)
Elevation 55.5 m to 52.2 m



THURBER ENGINEERING LTD.

Foundation Investigation
Highway 417 – Site 27-362/C Culvert
Foundations

GWP: 451-98-00

Project No.: 18310



Stantec

Stantec Consulting Ltd
2781 Lancaster Rd, Suite 100 A&B
Ottawa, ON K1B 1A7
Tel: (613) 738-6075
Fax: (613) 722-2799

July 11, 2018
File: 122410864

Attention: Thurber Engineering Ltd., File #18310

Reference: ASTM D7012, Method C, Unconfined Compressive Strength of Intact Rock Core

The table below summarizes five (5) rock core unconfined compressive strength results.

Location	Sample Depth	Compressive Strength (MPa)	Description of Break
17-1	Run 2 @ 22'4"	143.6	Well-formed cone on one end
17-5	Run 2 @ 36'4"	138.0	Well-formed cone on one end
17-10	Run 2 @ 53'7"	98.0	Reasonably well-formed cones on both ends
17-11	Run 3 @ 51'10"	127.4	Vertical cracking through both ends
17-13	Run 2 @ 23'10"	140.4	Specimen shattered

Sincerely,

Stantec Consulting Ltd

Denis Rodriguez
Laboratory Technician
Tel: 613-738-6075
denis.rodriguez@stantec.com

Appendix C.4
Analytical Testing Results

Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B 4S5
Attn: Justin Gray

Client PO: 18310
Project: Site 27-362/C
Custody: 39854

Report Date: 28-Jun-2018
Order Date: 25-Jun-2018

Order #: 1826162

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

Paracel ID

1826162-01

Client ID

17-12, SS4, 7'6"-9'6"

Approved By:



Dale Robertson, BSc
Laboratory Director

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 18310

Report Date: 28-Jun-2018
Order Date: 25-Jun-2018
Project Description: Site 27-362/C

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	27-Jun-18	27-Jun-18
Conductivity	MOE E3138 - probe @25 °C, water ext	27-Jun-18	27-Jun-18
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	26-Jun-18	27-Jun-18
Resistivity	EPA 120.1 - probe, water extraction	27-Jun-18	27-Jun-18
Solids, %	Gravimetric, calculation	27-Jun-18	27-Jun-18

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 18310

Report Date: 28-Jun-2018

Order Date: 25-Jun-2018

Project Description: Site 27-362/C

Client ID:	17-12, SS4, 7'6"-9'6"	-	-	-
Sample Date:	06/19/2018 09:00	-	-	-
Sample ID:	1826162-01	-	-	-
MDL/Units	Soil	-	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	93.3	-	-	-
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General Inorganics

Conductivity	5 uS/cm	326	-	-	-
pH	0.05 pH Units	7.91	-	-	-
Resistivity	0.10 Ohm.m	16.0	-	-	-

Anions

Chloride	5 ug/g dry	91	-	-	-
Sulphate	5 ug/g dry	69	-	-	-

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 18310

Report Date: 28-Jun-2018
Order Date: 25-Jun-2018
Project Description: Site 27-362/C

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: 18310

Report Date: 28-Jun-2018
Order Date: 25-Jun-2018
Project Description: Site 27-362/C

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	265	5	ug/g dry	282			6.1	20	
Sulphate	146	5	ug/g dry	151			3.0	20	
General Inorganics									
Conductivity	293	5	uS/cm	290			1.1	6.2	
pH	7.89	0.05	pH Units	7.83			0.8	10	
Resistivity	34.1	0.10	Ohm.m	34.5			1.1	20	
Physical Characteristics									
% Solids	84.4	0.1	% by Wt.	85.3			1.0	25	

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 18310

Report Date: 28-Jun-2018
Order Date: 25-Jun-2018
Project Description: Site 27-362/C

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	374	5	ug/g	282	92.2	78-113			
Sulphate	254	5	ug/g	151	104	78-111			

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 18310

Report Date: 28-Jun-2018
Order Date: 25-Jun-2018
Project Description: Site 27-362/C

Qualifier Notes:

None

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.

Subcontracted Analysis

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

Tel: (613) 408-6795
Fax: (613) 247-2185

Paracel Report No **1826162**
Client Project(s): **Site 27-362/C**
Client PO: **18310**
Reference: **Standing Offer**
CoC Number: **39854**

Order Date: 25-Jun-18
Report Date: 05-Jul-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
1826162-01	17-12, SS4, 7'6"-9'6"	Sulphide, solid

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Paracel Laboratories

Attn : Dale Robertson

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

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

05-July-2018

Date Rec. : 27 June 2018
LR Report: CA12933-JUN18
Reference: Project#:1826162

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		05-Jul-18
2: Analysis Start Time		10:43
3: Analysis Completed Date		05-Jul-18
4: Analysis Completed Time		13:07
5: QC - Blank		<0.02
6: QC - STD % Recovery		85%
7: QC - DUP % RPD		11%
8: RL		0.02
9: 17-12, SS4, 7'6"-9'6"	19-Jun-18	0.17

RL - SGS Reporting Limit

Kimberley Didsbury
Project Specialist
Environmental Services, Analytical

Appendix D.

Site Photographs



Photo 1. Looking west along culvert alignment. (25/06/2018)



Photo 2. Looking east along culvert alignment. (26/06/2018)



Photo 3. Looking north along County Road 7 Underpass. (26/06/2018)



Photo 4. Looking south along County Road 7 Underpass. (26/06/2018)



Photo 5. Looking at culvert outlet. (19/06/2018)



Photo 6. Looking north at culvert inlet. (21/06/2018)

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 517	Construction Specification for Dewatering of Pipeline, Utility and Associated Structure Excavation
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
NSSP FOUN0003	Dewatering Structure Excavations
OPSS 902	Construction Specification for Excavating and Backfilling Structures
OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets
SP 517F01	Design Storm Return Period and Preconstruction Survey
OPSS 511	Construction Specification for Rip-Rap, Rock Protection, and Granular Sheetting
SP 109S12	QVE, Backfilling, Compaction, and Certificate of Conformance

2. Suggested text for a NSSP on "Obstructions"

Installation of roadway protection system and coffer dams will encounter obstructions such as cobbles and boulders in the native soils. Such obstructions may impede the work from reaching bedrock. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions.