



**THURBER** ENGINEERING LTD.

**FINAL  
FOUNDATION INVESTIGATION REPORT  
CULVERT SITE 27-252/C  
HIGHWAY 417, CASSELMAN ON**

**G.W.P. 451-98-00**

Geocres No.: 31G-269

Report to:

**Ainley Group**

Latitude: 45.303090  
Longitude: -75.078481

November 2018  
Thurber File: 18310

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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 27-252/C beneath the eastbound and westbound lanes of Highway 417. The culvert is located approximately 125 m east of County Road 7 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 Assignment 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. No previous foundation investigation information was available for the subject culvert site within the Geocres Library.

**2 SITE DESCRIPTION**

The existing culvert is a corrugated steel sectional plate arch culvert servicing the Leo Denis Municipal Drain and is understood to have been constructed in 1971. The culvert is reported to be 3.4 m wide by 2.2 m high and approximately 88 m long with a generally north to south alignment. The flow through the culvert is to the south.

At the location of the culvert, Highway 417 is a four-lane rural divided freeway with two 3.75m wide driving lanes in each direction. The embankment fill heights are approximately 1.8 m and 1.6 m over the culvert with the road surface at approximate elevations of 65.7 m and 65.4 m for the westbound and eastbound lanes, respectively. The existing embankment side slopes are inclined at approximately 3H:1V. No signs of erosion or slope instability were noted on the existing highway embankment 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. The land adjacent to the highway is mainly agricultural with occasional commercial properties present. Traffic volumes are understood to be 24,500 AADT (2016).

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

**FINAL**

### 3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing program was carried out on September 25<sup>th</sup>, 2017 for the on-road investigation and between June 20<sup>th</sup> and 22<sup>nd</sup>, 2018 for the off-road investigation. Drilling consisted of advancing four boreholes identified as 17-5 through 17-8. The drilling was carried out using a track mounted CME 55 drill rig for both off-road and on-road boreholes. 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 in Appendix B and are 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**

<b>Borehole No.</b>	<b>Drilled Location</b>	<b>Northing (m)</b>	<b>Easting (m)</b>	<b>Ground Surface Elevation (m)</b>	<b>Termination Depth (m)</b>
17-5	Near Culvert inlet	5 019 386.5	181 019.9	64.2	11.9
17-6	Westbound inside shoulder	5 019 362.5	181 026.2	65.7	13.5
17-7	Eastbound inside shoulder	5 019 332.7	181 003.1	65.4	13.5
17-8	Near Culvert outlet	5 019 304.4	181 015.1	64.0	11.7

The boreholes were advanced through soil using hollow stem augers. 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 17-8 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 17-8, 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).

#### **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 Borehole 17-8 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 native deposits of clay and glacial till over bedrock. A veneer of topsoil was present at the surface of the off-road boreholes.

##### **5.1 Surficial Materials**

###### **5.1.1 Silt to Silty Sand with Organics**

A layer consisting of silt to silty sand ranging in thickness from 100 to 150 mm was encountered at surface in Boreholes 17-5 and 17-8. Wood fragments and organics were encountered in this layer. The moisture content was measured to be 12% on one sample.

###### **5.1.2 Fill: Silty Sand with Gravel**

A layer of silty sand with varying amounts of gravel was encountered below the topsoil in Boreholes 17-5 and 17-8, and at surface in Boreholes 17-6 and 17-7. The underside of this fill ranged from 2.9 to 3.1 m below ground surface in Boreholes 17-5 and 17-8 (elev. 61.1 m). The underside depth of this fill was 0.5 m below the gravel shoulder in Boreholes 17-7 and 17-6 (elev. 64.9 to 65.2 m).

The SPT tests conducted in this layer gave N-values ranging from 10 to 39 blows, indicating a relative density of compact to dense. Recorded moisture contents ranged from 2 to 16%.

Gradation analyses were completed on three samples of the silty sand with gravel fill. 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 below and are presented on the corresponding Record of Borehole sheets in Appendix B.

**Table 5-1 Gradation Results for Silty Sand with Gravel Fill**

Soil Particle	Percentage (%)
Gravel	30 – 44
Sand	44 – 52
Silt	12 – 18
Clay	

### 5.1.3 Fill: Silty Sand

A layer of silty sand was encountered below the silty sand with gravel fill in Boreholes 17-6 and 17-7. The underside of this fill ranged from 1.2 to 1.6 m below the existing gravel shoulder (elev. 63.8 to 64.5 m).

The SPT tests conducted in this layer gave an N-value of 15, indicating a compact relative density. Recorded moisture contents for the sample tested ranged from 11 to 17%.

Gradation analysis was completed on one sample of the silty sand 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 to consist of 1% gravel, 67% sand and 32% fines and are presented on the corresponding Record of Borehole sheet in Appendix B.

### 5.2 Silt

A layer of silt was encountered below the silty sand fill in Borehole 17-6. The silt layer has a thickness of 0.5 m with an underside elevation of 64.0 m. An SPT test gave an N-value of 11 blows, indicating a compact relative density. A single moisture content of 30% was measured.

### 5.3 Clay (CH)

A deposit of native clay was encountered beneath the embankment fill in Boreholes 17-5, 17-7, and 17-8 and below the silt layer in Borehole 17-6. The thickness of this layer was found to range from 2.7 to 5.3 m with underside elevations ranging from 55.9 to 58.8 m. The upper portion in Boreholes 17-6 and 17-7 was noted to be a firm to stiff weathered crust, ranging in thickness from 1.0 to 1.3 m.

In-situ shear vane test results throughout the layer indicated undrained shear strengths ranging from 17 to 64 kPa, indicating a soft to stiff consistency. The results of the in-situ shear vane tests indicated that the clay exhibits moderate to high sensitivity. SPT tests below the crust gave N-values ranging from Weight of Hammer (WH) to 3 blows. Recorded moisture contents ranged from 23 to 86%.

The results of grain size analyses conducted on six samples of the clay are summarized in Table 5-2 and illustrated on Figure C2 of Appendix C.

**Table 5-2 Gradation Results for Clay**

Soil Particle	Percentage (%)
Gravel	0
Sand	0 – 2
Silt	21 – 49
Clay	51 – 77

The results of Atterberg Limits testing completed on six samples of this material are summarized in Table 5-3 and are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limits graph is included in Figure C4 of Appendix C.

**Table 5-3 Atterberg Limits Results for Clay**

Parameter	Value
Liquid Limit	54 – 72
Plastic Limit	20 – 30
Plasticity Index	30 – 45

The laboratory results indicate that the clay has high plasticity (CH).

Near the base of the clay layer in Boreholes 17-7 and 17-8 a silt layer was observed. This layer has a thickness of 0.2 to 0.8 m with an underside elevation of 55.9 to 58.8 m.

#### **5.4 Silty Sand with Gravel (Glacial Till)**

A native deposit of glacial till consisting of varying amounts of sand, silt, and gravel was encountered underlying the clay in all boreholes. The glacial till extended to a depth of 8.1 to 10.1 m (elev. 55.3 to 55.9 m).

SPT tests gave N-values ranging from 12 to 100 blows for 125 mm, indicating a relative density of compact to very dense. Occasional to frequent cobbles and boulders were encountered within this deposit at Boreholes 17-5 through 17-7. A 1 m boulder was observed at a depth of 6.8 m below ground surface in Borehole 17-5 (elev. 57.4 m). The recorded moisture contents ranged from 6 to 21%.

Gradation analysis was completed on one sample of the glacial till. The grain size distribution curve is included in Figure C3 of Appendix C. The results of the test indicated the material to consist of 29% gravel, 50% sand and 21% fines and are presented on the corresponding Record of Borehole sheet in Appendix B. Test results indicate an SM material.

#### **5.5 Bedrock**

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

**Table 5-4 Summary of Bedrock Elevations**

Borehole No.	Depth to Bedrock (m)	Bedrock Elevation (m)
17-5	8.9	55.3
17-6	10.1	55.6
17-7	9.6	55.8
17-8	8.1	55.9

The bedrock encountered within Boreholes 17-5 through 17-8 consisted of slightly weathered to fresh limestone with shale partings. The Total Core Recovery (TCR) measured on the bedrock core ranged from 67 to 100%, the Solid Core Recovery (SCR) ranged from 67 to 100%, and the Rock Quality Designation (RQD) ranged from 63 to 100%, with one value of 43%. Based on the measured RQD values, the bedrock is classified as fair to excellent, but predominantly excellent.

Unconfined Compressive Strength (UCS) testing was carried out on the bedrock. The results of UCS testing carried out on three samples of the rock core ranged from 105 to 153 MPa, indicating the intact limestone bedrock to be very strong. Photographs of the bedrock core are provided in Appendix C.

## 5.6 Groundwater

The groundwater level measured in the standpipe piezometer in Borehole 17-8 was recorded at a depth of 0.3 m on June 26, 2018 (elev. 63.7 m). The water level of the Leo Denis Municipal Drain was measured to be at an elevation of 62.2 m on June 22, 2018. It is expected that the groundwater level will likely reflect the water level in the municipal drain ditch. 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 events.

## 5.7 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, sulphide content, resistivity and conductivity. Results of the analysis are summarized in Table 5-5.

**Table 5-5 Summary of Analytical Testing**

Borehole (Sample)	Depth (mbgs)	Sulphate ( $\mu\text{g/g}$ )	pH (-)	Resistivity (Ohm-cm)	Conductivity ( $\mu\text{S/cm}$ )	Chloride ( $\mu\text{g/g}$ )	Sulphide (%)
17-8 (SS4)	2.3 – 2.9	89	7.89	2,750	363	105	0.14

## 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. Beaconlite of Ottawa, Ontario supplied the traffic control equipment and personnel for TL-29 lane closures required for the on-road boreholes and TL-12 shoulder closures for the off-road boreholes in conformance with Ontario Book 7 requirements. The field investigation was supervised on a full-time basis by either Mr. Justin Gray, E.I.T. or 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 Parcel Laboratories in Ottawa, Ontario. Interpretation of the factual data and preparation of this report were carried out by Miss Allison Chow, E.I.T. 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.

Allison Chow, B.A.Sc  
Geotechnical Engineer-in-Training



Dr. Fred Griffiths, P.Eng.  
Senior Associate  
Senior Geotechnical Engineer

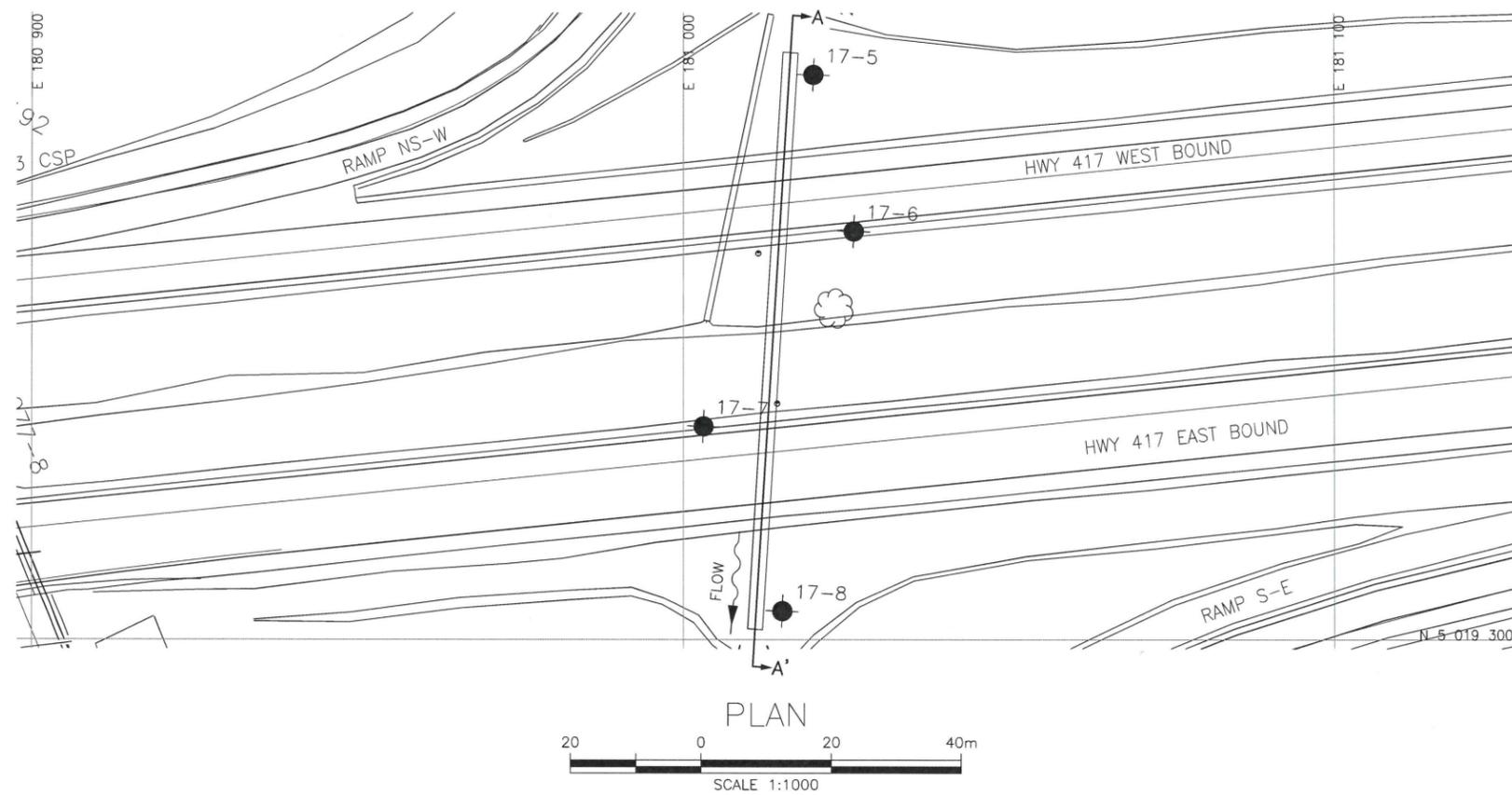


Dr. P.K. Chatterji, P.Eng.  
Review Principal  
Senior Geotechnical Engineer

FINAL

**Appendix A.**

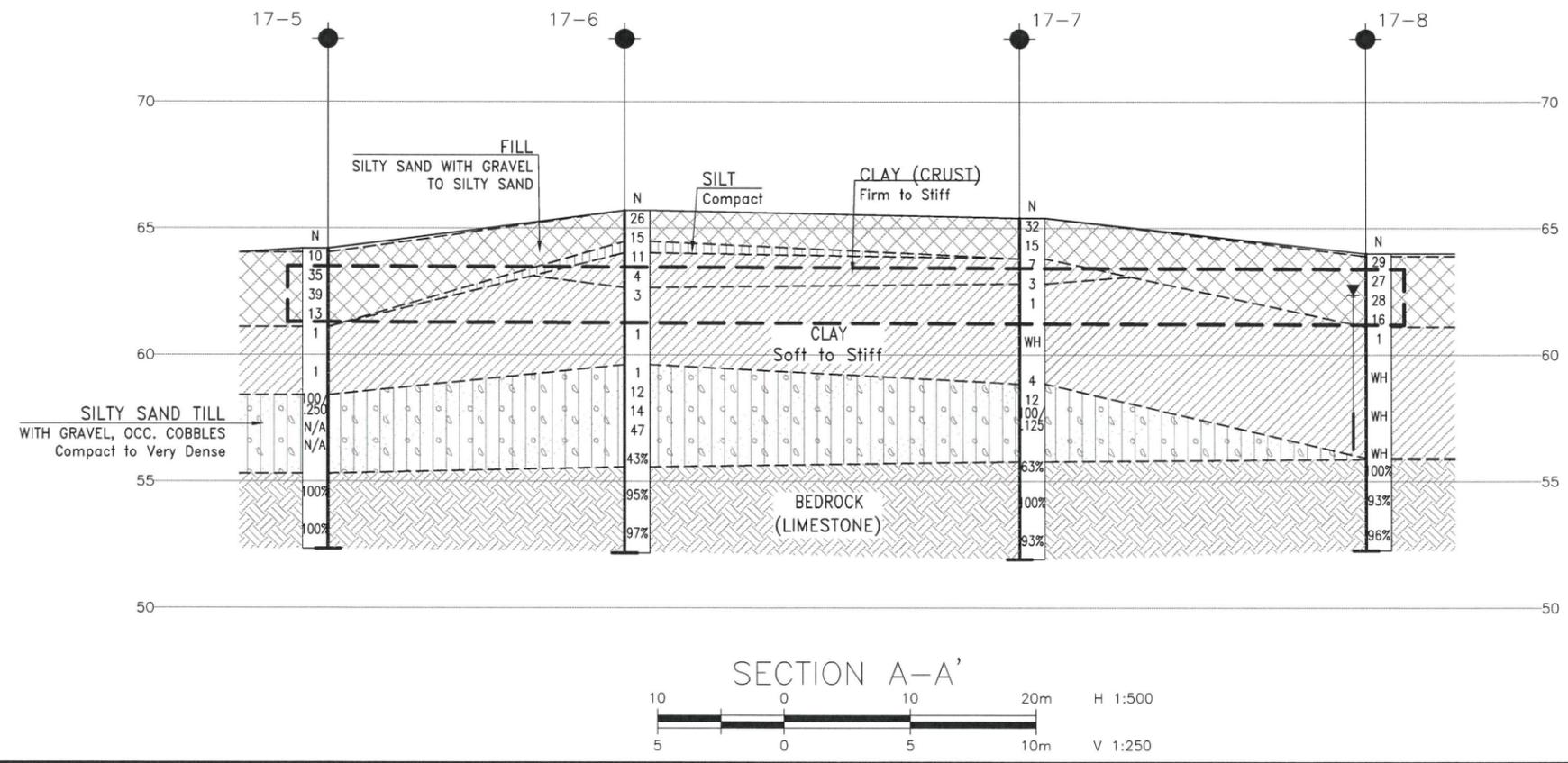
**Borehole Location Plan and Stratigraphic Drawings**



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



CONT No GWP No 451-98-00	SHEET
HIGHWAY 417 CULVERT 27-252/C REPLACEMENT BOREHOLE LOCATIONS AND SOIL STRATA	



LEGEND

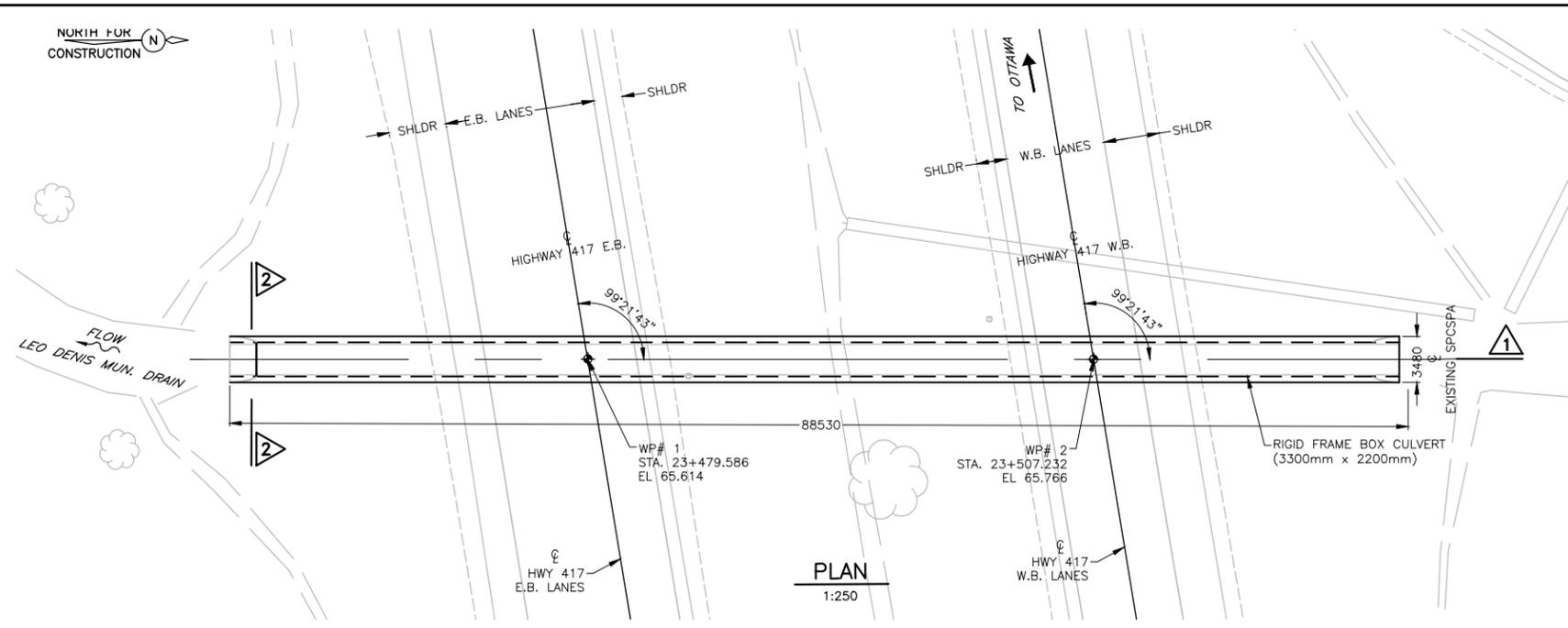
- Borehole
- ⊕ Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- ∇ Water Level
- ⊕ Head Artesian Water
- ⊕ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
17-5	64.2	5 019 386.5	181 019.9
17-6	65.7	5 019 362.5	181 026.2
17-7	65.4	5 019 332.7	181 003.1
17-8	64.0	5 019 304.4	181 015.1

- NOTES-**
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
  - This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
  - Coordinate system is MTM NAD 83 Zone 8.

GEOCRES No. 31G-269

DATE	BY	DESCRIPTION
DESIGN	KE	CHK PC
DRAWN	MFA	CHK KE



**LEGEND:**

	BEDDING MATERIAL
	NEW CONCRETE
	SUBSTRATE

<b>METRIC</b> DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN	CONT WP	### 451-98-00	
	SITE No. 27-252/C		
<b>PRELIMINARY GENERAL ARRANGEMENT</b>			

**FLOW DATA: EXISTING CULVERT**

DURATION	PEAK FLOW "Q" (m <sup>3</sup> /S)	WATER LEVEL (m)
2 YR.	1.361	-
5 YR.	2.297	-

- GENERAL NOTES**
- CLASS OF CONCRETE**  
35MPa UNLESS OTHERWISE NOTED.
  - CLEAR COVER TO REINFORCING STEEL**  
PRECAST CONCRETE 50±10  
ALL EXPOSED CORNERS TO BE CHAMFERED 20mm.
  - REINFORCING STEEL**  
REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.  
UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES SHALL BE CLASS B.  
BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWINGS SS12-1, UNLESS INDICATED OTHERWISE.

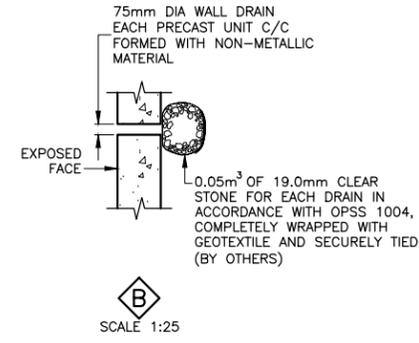
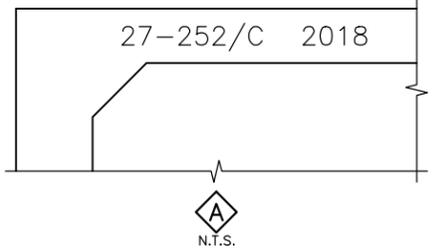
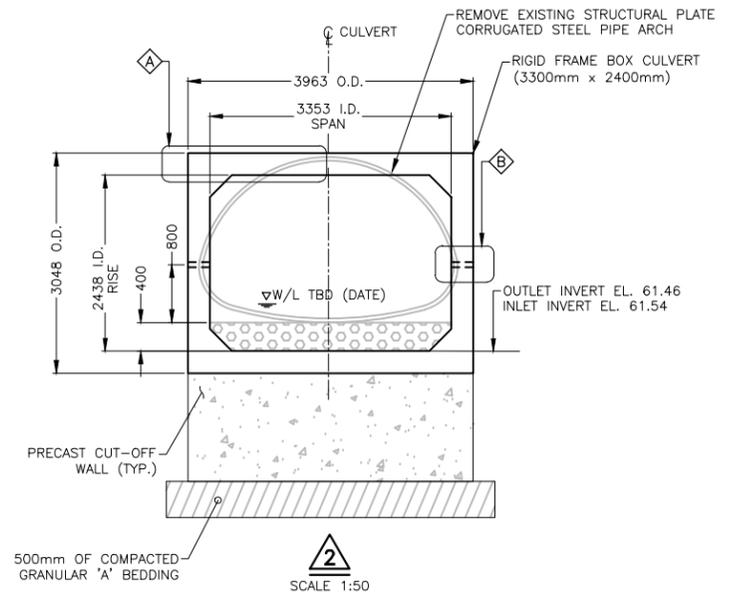
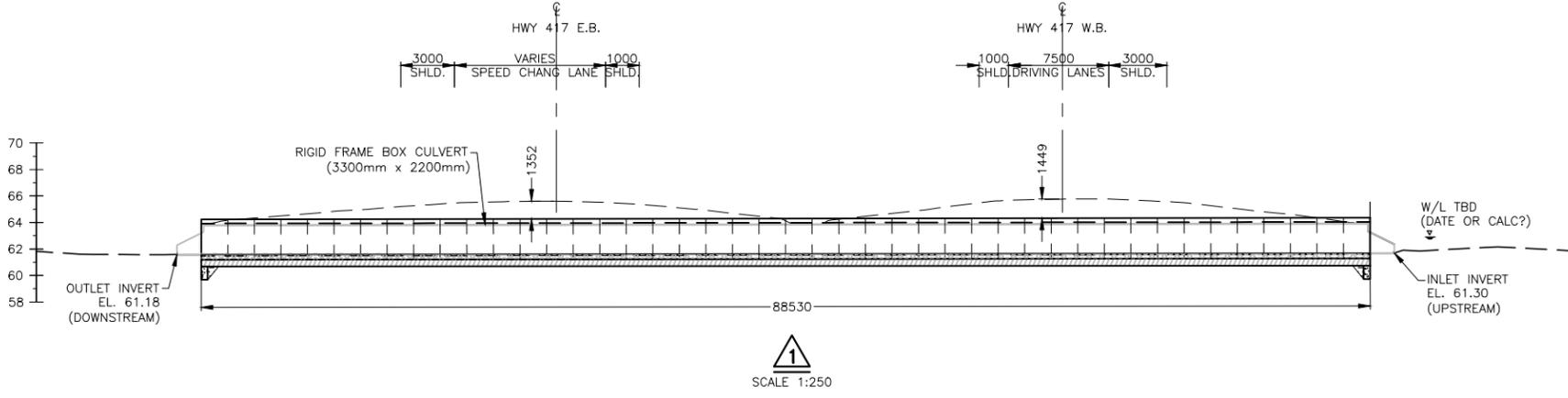
- CONSTRUCTION NOTES**
- PRECAST END UNITS SHALL BE EQUAL LENGTH. ALL INTERNAL UNITS SHALL BE EQUAL LENGTH.
  - BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH SIDES OF STRUCTURE KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 500mm.
  - NO PRECAST UNIT SHALL BE PLACED UNTIL THE DEPTH OF THE EXCAVATION AND THE CHARACTER OF THE FOUNDATION HAVE BEEN APPROVED BY THE QUALITY VERIFICATION ENGINEER. CARE SHALL BE TAKEN NOT TO DISTURB THE FOUNDING SOILS.
  - DESIGN SOILS BEARING CAPACITIES MUST BE VERIFIED BY THE QUALITY VERIFICATION ENGINEER ON SITE:  
AT SLS = \_\_\_ kPa (TBD)  
AT ULS = \_\_\_ kPa (ALONG THE JOINTS) (TBD)

- SCOPE OF WORK \***
- INSTALL AND CONTINUOUSLY MONITOR TEMPORARY FLOW PASSAGE SYSTEM AND MANAGE FLOW OF WATER FOR DURATION OF THE WORK.
  - COMPLETE PRECONSTRUCTION SURVEY.
  - REMOVE DEBRIS AND CLEAN CULVERT SURFACES.
  - SUPPLY AND INSTALL RIGID BOX CULVERT AND CUT-OFF WALLS.
- \* NOT INTENDED TO SHOW SEQUENCE OF WORK

**LIST OF ABBREVIATIONS**

WP#	WORKING POINT NUMBER
EL.	ELEVATION
TYP.	TYPICAL
SHLD.	SHOULDER
DIA.	DIAMETER
STA.	STATION
W/L	WATER LEVEL
I.D.	INNER DIAMETER
O.D.	OUTTER DIAMETER

- LIST OF DRAWINGS**
- GENERAL ARRANGEMENT



DRAWING NOT TO BE SCALED  
100mm ON ORIGINAL DRAWING

DATE	BY	DESCRIPTION
DESIGN ###	CHK ###	CODE ###
DRAWN ###	CHK ###	SITE ###

**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).

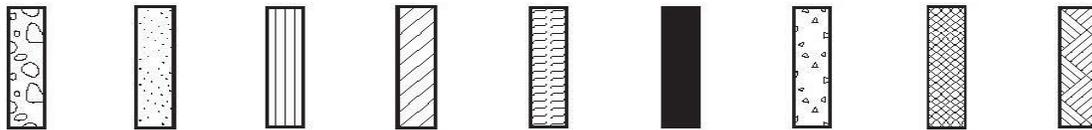
### DYNAMIC CONE PENETRATION TEST (DCPT):

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
<b>COARSE GRAINED SOIL</b>	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.
<b>FINE GRAINED SOILS</b>	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 or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
<b>HIGHLY ORGANIC SOILS</b>		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 17-5

1 OF 2

METRIC

GWP# 451-98-00 LOCATION Lat: 45.303522°, Long: -75.078395°  
 Culvert Site 27-252/C MTM z8: N 5 019 386.5 E 181 019.9 ORIGINATED BY AC  
 HWY 417 BOREHOLE TYPE HSA/NQ coring COMPILED BY AC  
 DATUM Geodetic DATE 22.06.2018 - 22.06.2018 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
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 (%) 20 40 60								
64.2														
0.0	SILTY SAND with organics and wood fragments compact brown FILL  SILTY SAND with gravel compact to dense grey-brown FILL	[Hatched pattern]	1	SS	10									
0.2			2	SS	35									
			3	SS	39									40 46 14 (SI+CL)
			4	SS	13									
61.1	CLAY (CH) firm to stiff grey	[Diagonal lines]	5	SS	1								0 2 39 59	
3.1														
			6	SS	1									
58.4	SILTY SAND (SM) with gravel TILL very frequent cobbles and boulders very dense grey  1 m boulder at 6.8 m	[Dotted pattern]	7	SS	100/ 250 mm									
5.8														
			8	NQ	N/A									
			9	NQ	N/A									
55.3	BEDROCK LIMESTONE with shale partings and silt seams fine grained fresh thinly bedded very strong	[Diagonal lines]												
8.9														
			1	NQ									RUN #1 TCR=100% SCR=100% RQD=100%	

DOUBLE LINE SITE 27-252C.GPJ 2012TEMPLATE(MTO).GDT 28/11/18

Continued Next Page

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

### RECORD OF BOREHOLE No 17-5

2 OF 2

**METRIC**

GWP# 451-98-00 LOCATION Lat: 45.303522°, Long: -75.078395°  
Culvert Site 27-252/C MTM z8: N 5 019 386.5 E 181 019.9 ORIGINATED BY AC  
 HWY 417 BOREHOLE TYPE HSA/NQ coring COMPILED BY AC  
 DATUM Geodetic DATE 22.06.2018 - 22.06.2018 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 $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	Continued From Previous Page						20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
52.3	<b>BEDROCK</b> LIMESTONE with silt seams, shale partings, and very thin shale beds fine grained fresh thinly bedded very strong grey		2	NQ		54									0	RUN #2 TCR=100% SCR=100% RQD=100% UCS=138MPa
53																
															2	
															0	
11.9	End of Borehole															

DOUBLE LINE SITE 27-252C.GPJ 2012TEMPLATE(MTO).GDT 28/11/18

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

### RECORD OF BOREHOLE No 17-6

1 OF 2

METRIC

GWP# 451-98-00 LOCATION Lat: 45.303308°, Long: -75.078309°  
 Culvert Site 27-252/C MTM z8: N 5 019 362.5 E 181 026.2 ORIGINATED BY JG  
 HWY 417 BOREHOLE TYPE HSA/NQ coring COMPILED BY JG  
 DATUM Geodetic DATE 25.09.2017 - 25.09.2017 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80			100
65.7	WB Gravel Shoulder													
0.0	SILTY SAND with gravel dense grey		1	SS	26									
65.2	FILL													
0.5	SILTY SAND compact brown													
64.5	FILL		2	SS	15									1 67 32 (SI+CL)
1.2	SILT compact grey													
64.0	CLAY (CH) (crust) stiff brown		3	SS	11									
1.7														
			4	SS	4									0 0 49 51
62.7	CLAY (CH) firm grey													
3.0			5	SS	3									
			6	SS	1									0 1 45 54
			7	SS	1									
			8	SS	12									
			9	SS	14									
			10	SS	47									29 50 21 (SI+CL)
			1	NQ										RUN #1 TCR=87%

DOUBLE LINE SITE 27-252C.GPJ 2012TEMPLATE(MTO).GDT 28/11/18

Continued Next Page

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

### RECORD OF BOREHOLE No 17-6

2 OF 2

METRIC

GWP# 451-98-00 LOCATION Lat: 45.303308°, Long: -75.078309° Culvert Site 27-252/C MTM z8: N 5 019 362.5 E 181 026.2 ORIGINATED BY JG  
 HWY 417 BOREHOLE TYPE HSA/NQ coring COMPILED BY JG  
 DATUM Geodetic DATE 25.09.2017 - 25.09.2017 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
							20	40	60	80	100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	GR SA SI CL	
55.6	Continued From Previous Page															
10.1	BEDROCK LIMESTONE fresh very strong grey		2	NQ											RUN #2 TCR=100% SCR=100% RQD=95% UCS=104.5MPa	
					3	NQ										
52.2	End of Borehole															
13.5																

DOUBLE LINE SITE 27-252C.GPJ 2012TEMPLATE(MTO).GDT 28/11/18

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

### RECORD OF BOREHOLE No 17-7

1 OF 2

METRIC

GWP# 451-98-00 LOCATION Lat: 45.303035°, Long: -75.078596° Culvert Site 27-252/C MTM z8: N 5 019 332.7 E 181 003.1 ORIGINATED BY JG  
 HWY 417 BOREHOLE TYPE HSA/NQ coring COMPILED BY JG  
 DATUM Geodetic DATE 25.09.2017 - 25.09.2017 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
						20	40	60	80	100	20	40	60	GR	SA	SI	CL	
65.4	EB Gravel Shoulder																	
0.0	SILTY SAND with gravel dense grey	[Hatched pattern]	1	SS	32									30	52	18	(SI+CL)	
64.9	FILL																	
0.5	SILTY SAND compact brown	[Hatched pattern]	2	SS	15													
63.8	FILL																	
1.6	CLAY (CH) (crust) firm brown	[Diagonal lines]	3	SS	7									0	0	44	56	
62.8																		
2.6	CLAY (CH) firm grey	[Diagonal lines]	4	SS	3													
62.8																		
2.6		[Diagonal lines]	5	SS	1													
62.8																		
6.4		[Diagonal lines]	6	SS	WH									0	1	28	71	
6.6																		
58.8	silt layer from 6.4 m to 6.6 m	[Diagonal lines]	7	SS	4													
6.6	SILTY SAND (SM) with gravel TILL occasional to frequent cobbles compact to very dense grey	[Stippled pattern]	8	SS	12													
6.6				9	SS	100/125mm												
6.6				10	NQ													
55.8	frequent cobbles at 8.8 m	[Stippled pattern]																
9.6	BEDROCK LIMESTONE	[Cross-hatched pattern]	1	NQ														

DOUBLE LINE SITE 27-252C.GPJ 2012TEMPLATE(MTO).GDT 28/11/18

Continued Next Page

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

### RECORD OF BOREHOLE No 17-7

2 OF 2

**METRIC**

GWP# 451-98-00 LOCATION Lat: 45.303035°, Long: -75.078596°  
Culvert Site 27-252/C MTM z8: N 5 019 332.7 E 181 003.1 ORIGINATED BY JG  
 HWY 417 BOREHOLE TYPE HSA/NQ coring COMPILED BY JG  
 DATUM Geodetic DATE 25.09.2017 - 25.09.2017 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 $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
	Continued From Previous Page						20 40 60 80 100											
51.9	BEDROCK LIMESTONE fresh very strong grey																RUN #1 TCR=67% SCR=67% RQD=63%	
			2	NQ														RUN #2 TCR=100% SCR=100% RQD=100% UCS=152.7MPa
			3	NQ														RUN #3 TCR=98% SCR=98% RQD=93%
13.5	End of Borehole																	

DOUBLE LINE SITE 27-252C.GPJ 2012TEMPLATE(MTO).GDT 28/11/18



### RECORD OF BOREHOLE No 17-8

2 OF 2

METRIC

GWP# 451-98-00 LOCATION Lat: 45.302783°, Long: -75.078436°  
 Culvert Site 27-252/C MTM z8: N 5 019 304.4 E 181 015.1 ORIGINATED BY KE  
 HWY 417 BOREHOLE TYPE HSA/NQ coring COMPILED BY AC  
 DATUM Geodetic DATE 20.06.2018 - 21.06.2018 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 $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
	Continued From Previous Page					20 40 60 80 100	20 40 60 80 100	20 40 60	W P	W	W L						
52.3	<b>BEDROCK</b> LIMESTONE with shale partings fine grained with calcite nodules slightly weathered to fresh thinly bedded very strong grey		3	NQ		53										2 0 2 1 0 0	RUN #3 TCR=100% SCR=100% RQD=96%
11.7	End of Borehole Water level in well at 0.3 mbgs (elev. 63.7 m) on June 26, 2018																

DOUBLE LINE SITE 27-252C.GPJ 2012TEMPLATE(MTO).GDT 28/11/18

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

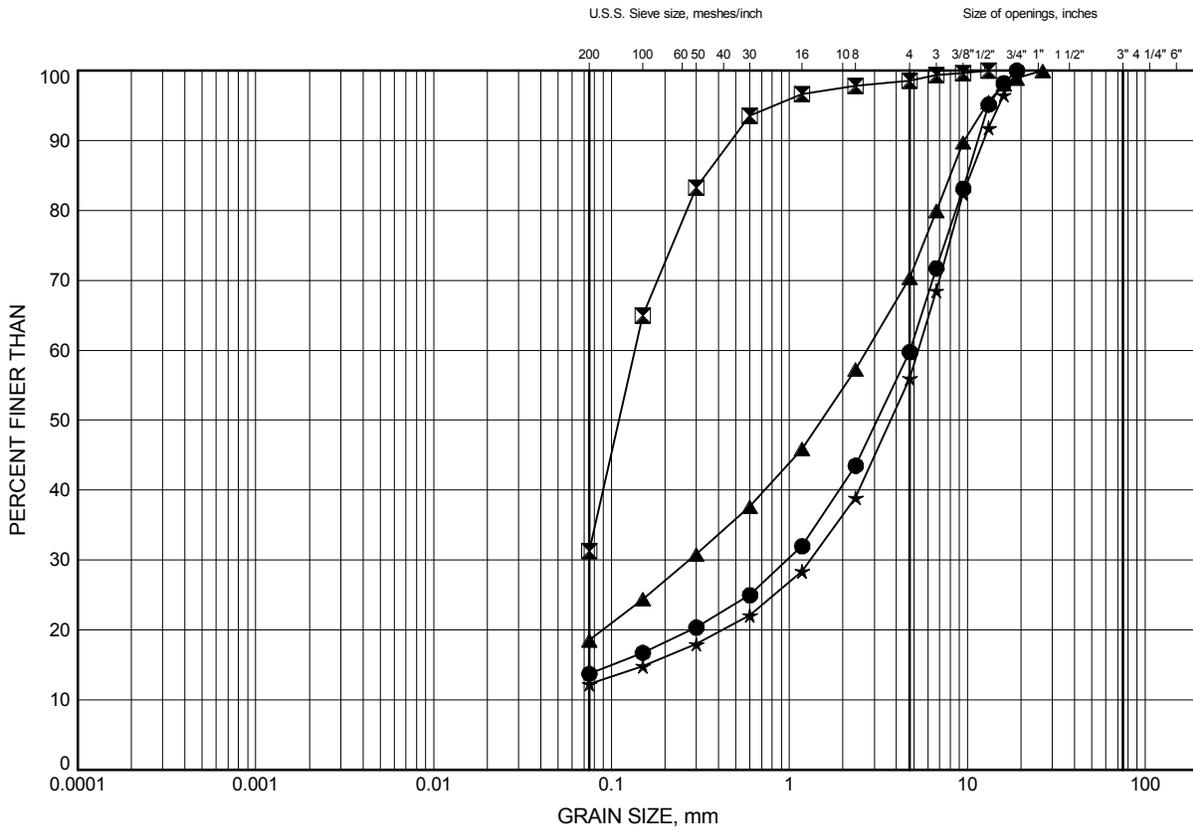
**Appendix C.**  
**Laboratory Testing**

**Appendix C.1**  
**Particle Size Analysis Figures**

Site 27-252/C  
**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)
●	17-5	1.8	62.4
☒	17-6	1.1	64.6
▲	17-7	0.3	65.1
★	17-8	1.8	62.2

GRAIN SIZE DISTRIBUTION - THURBER SITE 27-252C.GPJ 9/11/18

Date November 2018  
 GWP# 451-98-00

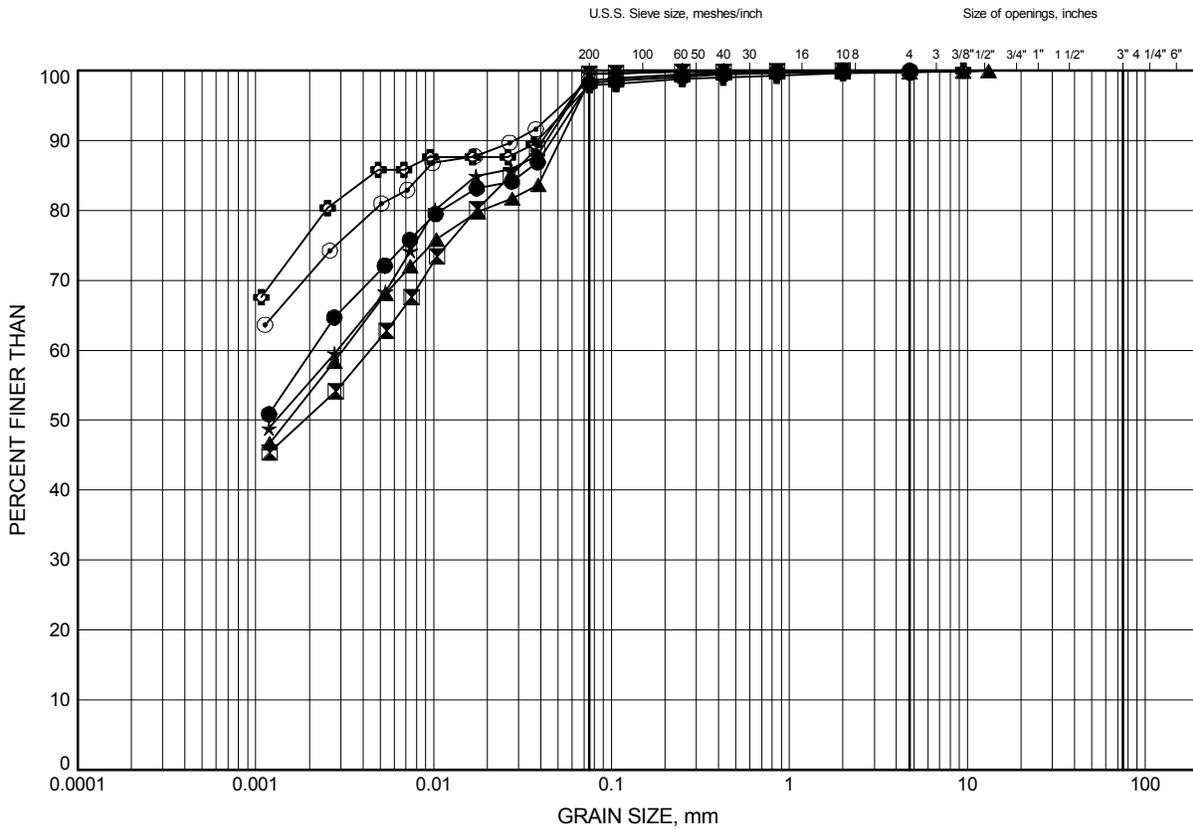


Prep'd KE  
 Chkd. FG

Site 27-252/C  
**GRAIN SIZE DISTRIBUTION**

FIGURE C2

**CLAY**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-5	3.4	60.8
⊠	17-6	2.6	63.1
▲	17-6	4.9	60.8
★	17-7	1.8	63.6
⊙	17-7	4.9	60.5
⊕	17-8	4.9	59.1

GRAIN SIZE DISTRIBUTION - THURBER - SITE 27-252C.GPJ 9/11/18

Date November 2018  
 GWP# 451-98-00

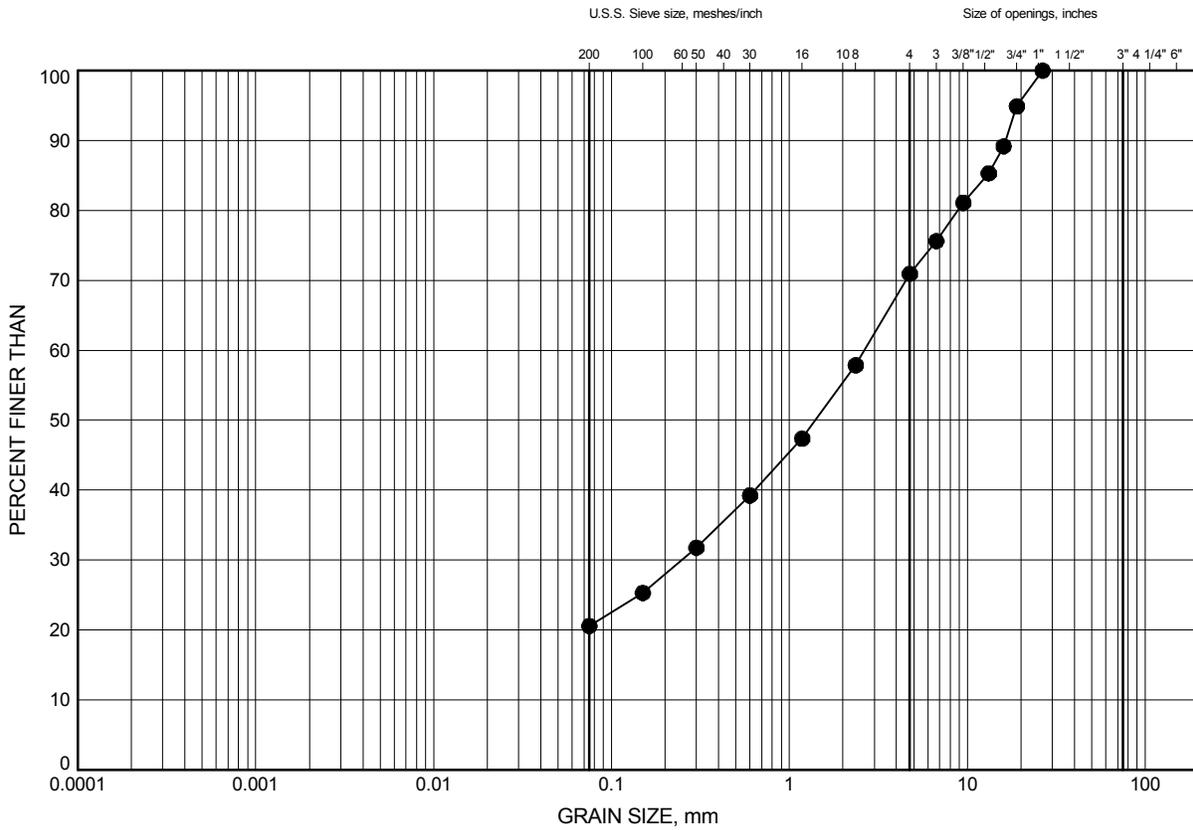


Prep'd KE  
 Chkd. FG

Site 27-252/C  
**GRAIN SIZE DISTRIBUTION**

FIGURE C3

**SILTY SAND WITH GRAVEL (GLACIAL TILL)**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-6	8.7	57.0

GRAIN SIZE DISTRIBUTION - THURBER - SITE 27-252C.GPJ 9/11/18

Date November 2018  
 GWP# 451-98-00

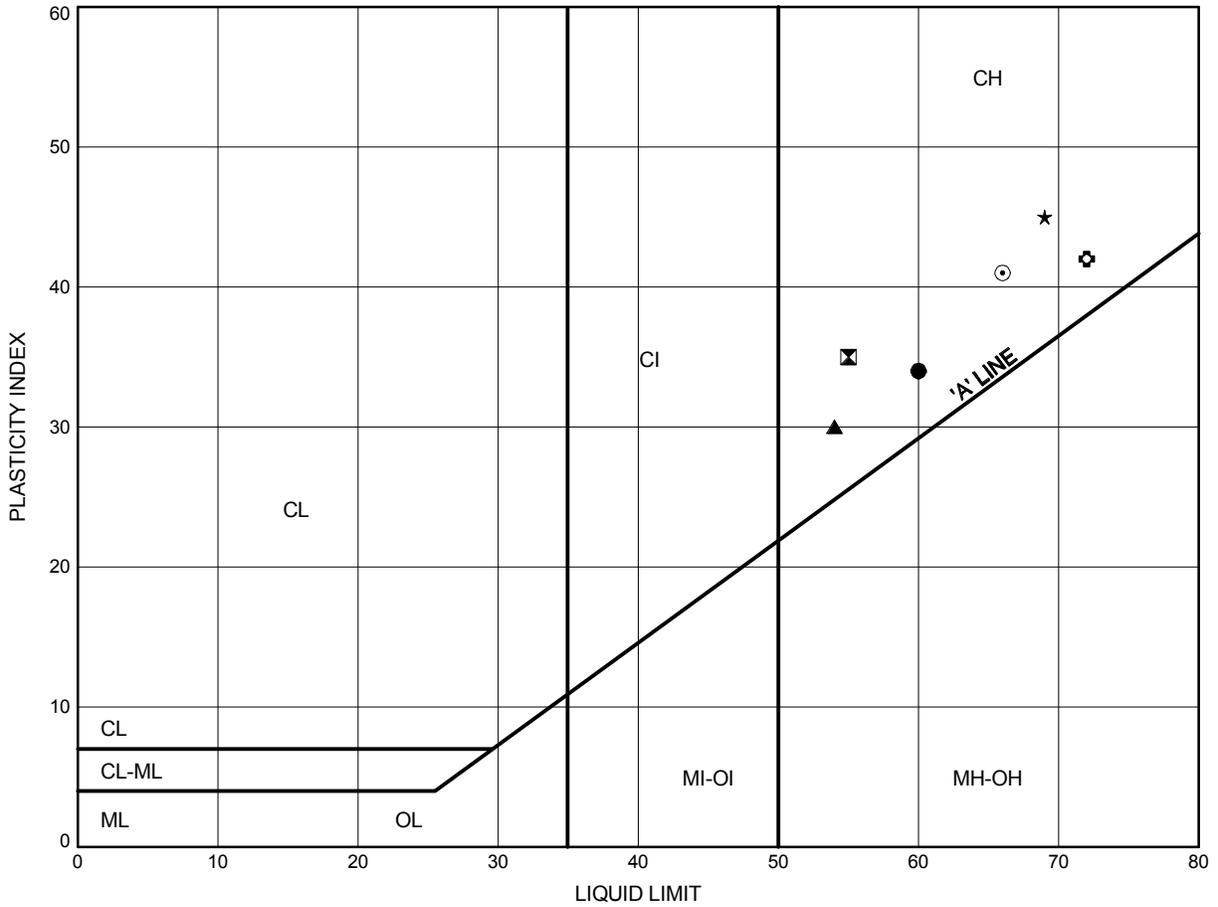


Prep'd KE  
 Chkd. FG

**Appendix C.2**  
**Atterberg Limits Figures**

# ATTERBERG LIMITS TEST RESULTS

## CLAY



### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-5	3.4	60.8
⊠	17-6	2.6	63.1
▲	17-6	4.9	60.8
★	17-7	1.8	63.6
⊙	17-7	4.9	60.5
⊕	17-8	4.9	59.1

THURBALT SITE 27-252C.GPJ 9/11/18

Date .. November 2018 ..  
 GWP# .. 451-98-00 ..



Prep'd .. KE ..  
 Chkd. .... FG ..

**Appendix C.3**  
**Rock Core Photos and Testing Results**

**Borehole 17-5**  
**Run 1 to 2 (of 2)**  
**Elevation 55.3 m to 52.3 m**

NQ 1 Start  
elev. 55.3 m

NQ 2 Start  
elev. 53.9 m

NQ 1 End  
elev. 53.9 m

NQ 2 End  
elev. 52.3 m



**THURBER** ENGINEERING LTD.

**Foundation Investigation**  
**Highway 417 Interchange 27-252/C**  
**Foundations**

**GWP: 451-98-00**

**Project No.: 18310**

**Borehole 17-6**  
**Run 1 to 3 (of 3)**  
**Elevation 56.5 m to 52.2 m**



**THURBER** ENGINEERING LTD.

**Foundation Investigation**  
**Highway 417 Interchange 27-252/C**  
**Foundations**

**GWP: 451-98-00**

**Project No.: 18310**

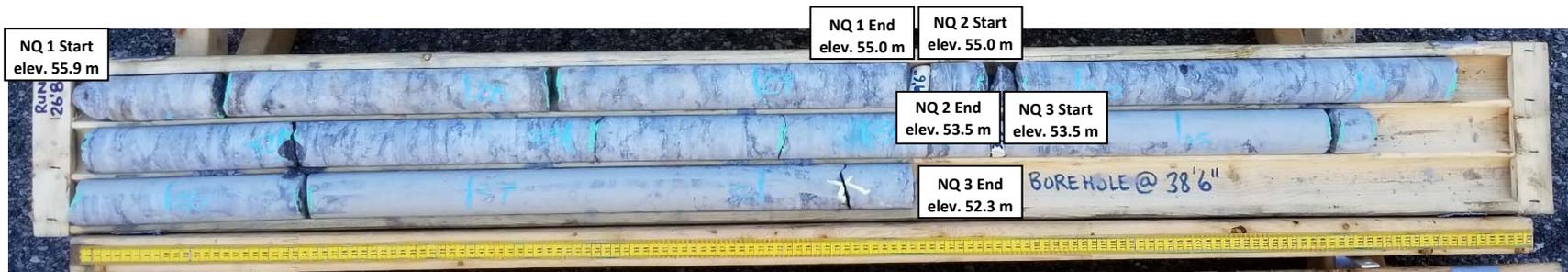
**Borehole 17-7**  
**Run 1 to 4 (of 4)**  
**Elevation 57.5 m to 51.9 m**



**Foundation Investigation**  
**Highway 417 Interchange 27-252/C**  
**Foundations**

**GWP: 451-98-00**  
**Project No.: 18310**

**Borehole 17-8**  
**Run 1 to 3 (of 3)**  
**Elevation 55.9 m to 52.3 m**



**THURBER** ENGINEERING LTD.

**Foundation Investigation**  
**Highway 417 Interchange 27-252/C**  
**Foundations**

**GWP: 451-98-00**

**Project No.: 18310**



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

**Stantec**

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.rodriquez@stantec.com](mailto:denis.rodriquez@stantec.com)



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

**Stantec**

November 6, 2017  
File: 122410864

**Attention: Thurber Engineering Ltd., File #18310**

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

The table below summarizes six rock core unconfined compressive strength results.

Location	Sample Depth	Compressive Strength (MPa)	Description of Break
BH17-2 Run-2	35'9"	134.1	Two well-formed cones on either end
BH17-3 Run-2	33'6"	133.5	Two well-formed cones on either end
BH17-6 Run-3	41'2"	104.5	Well-formed cone on bottom, vertical cracks through top
BH17-7 Run-2	32'8"	152.7	Well-formed cone on bottom, vertical cracks through top
Bh17-14 Run-3	36'10"	105.2	Two well-formed cones on either end
BH17-15 Run-2	32'5"	107.5	No well-formed cones, cracks throughout core

Sincerely,

**Stantec Consulting Ltd**

*Brian Prevost*

Brian Prevost  
Laboratory Supervisor  
Tel: 613-738-6075  
[brian.prevost@stantec.com](mailto:brian.prevost@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 27-252/C  
Custody: 39857

Report Date: 29-Jun-2018  
Order Date: 25-Jun-2018

**Order #: 1826165**

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

<b>Parcel ID</b>	<b>Client ID</b>
1826165-01	17-8, SS4, 7'6"-9'6"

Approved By:



Dale Robertson, BSc  
Laboratory Director

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

Report Date: 29-Jun-2018  
Order Date: 25-Jun-2018  
**Project Description: Site 27-252/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	29-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: 29-Jun-2018

Order Date: 25-Jun-2018

Project Description: Site 27-252/C

<b>Client ID:</b>	17-8, SS4, 7'6"-9'6"	-	-	-
<b>Sample Date:</b>	06/20/2018 09:00	-	-	-
<b>Sample ID:</b>	1826165-01	-	-	-
<b>MDL/Units</b>	Soil	-	-	-

**Physical Characteristics**

% Solids	0.1 % by Wt.	92.2	-	-	-
----------	--------------	------	---	---	---

**General Inorganics**

Conductivity	5 uS/cm	363	-	-	-
pH	0.05 pH Units	7.89	-	-	-
Resistivity	0.10 Ohm.m	27.5	-	-	-

**Anions**

Chloride	5 ug/g dry	105	-	-	-
Sulphate	5 ug/g dry	89	-	-	-

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

Report Date: 29-Jun-2018  
 Order Date: 25-Jun-2018  
**Project Description: Site 27-252/C**

**Method Quality Control: Blank**

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

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

Report Date: 29-Jun-2018  
 Order Date: 25-Jun-2018  
**Project Description: Site 27-252/C**

**Method Quality Control: Duplicate**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	265	5	ug/g dry	282			6.1	20	
Sulphate	146	5	ug/g dry	151			3.0	20	
<b>General Inorganics</b>									
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	
<b>Physical Characteristics</b>									
% Solids	84.4	0.1	% by Wt.	85.3			1.0	25	

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

Report Date: 29-Jun-2018  
 Order Date: 25-Jun-2018  
 Project Description: Site 27-252/C

**Method Quality Control: Spike**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
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: 29-Jun-2018  
Order Date: 25-Jun-2018  
**Project Description: Site 27-252/C**

**Qualifier Notes:**

***Login Qualifiers :***

Received at temperature > 25C  
*Applies to samples: 17-8, SS4, 7'6"-9'6"*

**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 **1826165**  
Client Project(s): **Site 27-252/C**  
Client PO: **18310**  
Reference: **Standing Offer**  
CoC Number: **39857**

Order Date: 25-Jun-18  
Report Date: 05-Jul-18

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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
1826165-01	17-8, 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

05-July-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. :** 27 June 2018  
**LR Report:** CA12932-JUN18  
**Reference:** Project#:1826165

**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		13:06
5: QC - Blank		<0.02
6: QC - STD % Recovery		85%
7: QC - DUP % RPD		11%
8: RL		0.02
9: 17-8, SS4, 7'6"-9'6"	20-Jun-18	0.14

RL - SGS Reporting Limit

Kimberley Didsbury  
Project Specialist  
Environmental Services, Analytical

**Appendix D.**  
**Site Photographs**



**Photo 1. Looking north upstream at culvert inlet**



**Photo 2. Looking south along Highway 11.**



**Photo 3. Looking south downstream at culvert outlet**



**Photo 4. Looking west on eastbound Highway 417**