



**THURBER** ENGINEERING LTD.

**FINAL**  
**FOUNDATION INVESTIGATION REPORT**  
**HIGHWAY 17 TWINNING, RENFREW AREA**  
**CULVERT 14+666 WBL, MCNAB/BRAESIDE**  
**WP 4068-09-00 / ASSIGNMENT NO. 4018-E-0009**

Geocres No.: 31F-218

Report to:

**Ministry of Transportation Ontario**

Latitude: 45.446333°  
Longitude: -76.546906°

July 2021  
Thurber File No.: 24726



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**PART 1. FACTUAL INFORMATION**

## **1 INTRODUCTION**

Thurber Engineering Ltd. (Thurber) has been engaged by the Ministry of Transportation Ontario (MTO) to carry out Foundation Investigations to support the design of the Highway 17 Twinning Project which extends from Scheel Drive westerly to 3 km west of Bruce Street in the Renfrew area.

This report addresses the proposed culvert to be located at Station 14+666 McNab/Braeside Township near Renfrew, Ontario. The existing Highway 17 alignment will become the future Highway 17 eastbound lanes and new westbound lanes will be constructed. A new culvert is required to convey an unnamed tributary of Liffey Creek below an embankment supporting the proposed Highway 17 westbound lanes.

This section of the report presents the factual findings obtained from a foundation investigation completed at the future culvert structure at Station 14+666. Thurber carried out the investigation under Ministry of Transportation (MTO) Assignment No. 4018-E-0009.

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 of the culvert was developed in the course of the investigation. No previous foundation information was available for this site in the Geocres Library.

## **2 SITE DESCRIPTION**

### **2.1 General**

The site is currently undeveloped and located approximately 55 m north of the existing Highway 17 alignment, 1.2 km east of McCallum Drive and 1.1 km west of Miller Road. For project purposes, Highway 17 is herein described as oriented east-west.

The land adjacent to the site generally consists of undeveloped, forested and marshy areas with an agricultural field beyond a recreational trail on an abandoned CNR alignment to the north. The



terrain is relatively flat with slight downward slope towards the small, unnamed tributary of Liffey Creek. The ground surface at the proposed culvert location was wet and covered with tall grass. At the time of the field investigation, no discernible creek bed was present. Standing water was observed near 14+666. The topography suggests flow through the new culvert would be from south to north.

The existing Highway 17 south of the site consists of a two-lane undivided highway with gravel shoulders and a posted speed limit of 90 km/hr. Three-cable guiderails are present on both sides. The AADT for this existing section of Highway 17 near the site had a reported AADT of 13,200 in 2012.

Photographs showing the existing conditions in the area of the site at the time of the field investigation are included in Appendix D for reference.

## **2.2 Site Geology**

Based on published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984), the site lies within the physiographic region known as the Ottawa Valley Clay Plains. The Ottawa Valley Clay Plains are characterized primarily by clay plains deposited by the Champlain Sea (Leda Clay) interrupted by ridges of rock or sand.

A Physical Setting Report for the overall project prepared by ERIS and based on Ontario Geological Mapping Indicates that the underlying bedrock at the site is typically granodiorite, tonalite, monzogranite, syenogranite; derived gneisses and migmatites rocks of the Grenville Province.

## **3 SITE INVESTIGATION AND FIELD TESTING**

The site investigation and field-testing program was carried out between September 30<sup>th</sup> and October 2<sup>nd</sup>, 2019. The field investigation consisted of advancing 3 boreholes identified as Boreholes CV-19 through CV-21. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

The locations and elevations of the boreholes were surveyed by Thurber with a Trimble Catalyst DA1 antenna with centimeter accuracy. The northing, easting and elevation of the boreholes 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 in Table 3-1 below. The site is located within MTM Zone 9.



**Table 3-1: Borehole Summary**

<b>Borehole No.</b>	<b>Drilled Location</b>	<b>Northing (Latitude)</b>	<b>Easting (Longitude)</b>	<b>Ground Surface Elevation (m)</b>	<b>Termination Depth (m)</b>
CV-19	Proposed Culvert Inlet	5 034 030.9 (45.446201)	301 124.5 (-76.546986)	139.9	11.3
CV-20	Proposed HWY17 WBL C/L	5 034 045.7 (45.446332)	301 130.8 (-76.546906)	140.0	10.8
CV-21	Proposed Culvert Outlet	5 034 059.0 (45.446453)	301 139.7 (-76.546792)	140.1	10.8

The investigation was carried out using a track-mounted CME 45 drill rig equipped with hollow-stem augers and rotary diamond drilling equipment.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). In situ vane shear testing was completed in cohesive soils with an MTO 'N' sized vane.

A standpipe piezometer, 19 mm in diameter, was installed in Borehole CV-21. The installation details are illustrated on the respective Record of Borehole sheet provided in Appendix B. The boreholes were backfilled in accordance with MOE requirements (O.Reg 903, as amended). The piezometer will be utilized as part of a hydrogeological study and subsequently decommissioned by Thurber.

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

#### **4 LABORATORY TESTING**

Laboratory testing was selected in accordance with the current MTO Guideline for Foundation Engineering Services, Section 5. Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. At least 25% of the recovered soil samples were subjected to grain size distribution analysis and Atterberg limits tests, where appropriate. The testing was carried out to MTO and ASTM standards. Chemical analysis for determination of pH, conductivity, resistivity, sulphide, sulphate and chloride was carried out on one soil sample from Borehole CV-21.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory results are presented on the figures included 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 Location and Soil Strata Drawing included in Appendix A. A general description of the stratigraphy based on the conditions encountered in the boreholes is given in the following sections. However, the factual data presented on the Borehole Records 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. Soil classification is in accordance with ASTM D2487. Cohesive soils are described per current MTO protocols.

In general terms, the site was found to consist of organic silt overlying native clay to clayey silt deposit, which is underlain by a deposit of sandy clayey silt to clayey silty sand till.

### 5.1 Organic Silt

A thin layer of organic silt with an approximate thickness of 0.6 m was encountered at surface in all borehole locations. SPT tests conducted within the organic silt gave N-values of weight of hammer indicating a relative density of very loose.

### 5.2 Clay (CI) to Clayey Silt (CL)

A glaciomarine native deposit of clay to clayey silt was encountered below the organic silt at all borehole locations. The deposit extended to a depth of 7.6 m with an underside elevation ranging from 132.3 to 132.5 m. Sand was noted in the upper 0.9 m of the clay deposit in Borehole CV-19.

SPT tests conducted within the cohesive unit gave N-values ranging from weight of hammer to 18. In situ shear vane tests in several locations in the lower clayey silt indicated undrained shear strengths ranging from 59 to greater than 100 kPa indicating a stiff to very stiff consistency. Sensitivity ranged from 4.0 to 8.5.

The moisture content of the clay to clayey silt samples tested ranged from 26 to 41%. The results of six grain size analysis tests conducted on samples of this material are summarized below and are illustrated on Figures C1 in Appendix C.

**Summary of Grain Size Distribution Testing – Clay to Clayey Silt**

Soil Particle	Percentage (%)
Gravel	0 – 2
Sand	0 – 22
Silt	42 – 65
Clay	32 – 46

The results of Atterberg Limits testing carried out on six samples of this material are summarized below and are illustrated on Figure C3 in Appendix C. The laboratory results indicate that the material is generally a clay of intermediate to low plasticity (CI to CL). In general, the upper portion

of this layer was found to have a higher plasticity than the lower portion. It should be noted in accordance with the MTO Guideline for Foundation Engineering Services (May 2019) the lower cohesive deposit has been described as a “clayey silt” where Atterberg limits tests indicate a CL material.

#### **Summary of Atterberg Limit Testing – Clay to Clayey Silt**

<b>Parameter</b>	<b>Value</b>
Liquid Limit	25 – 43
Plastic Limit	15 – 19
Plasticity Index	10 – 24

### **5.3 Sandy Clayey Silt (CL) to Clayey Silty Sand (SC-SM) (Till)**

A native deposit of glacial till was encountered below the clayey silt in all boreholes. The till consists of a mixture ranging from sandy clayey silt to clayey silty sand with traces of gravel. Possible cobbles were noted in Borehole CV-20. All boreholes were terminated within the till at a final depth ranging from 10.8 to 11.3 m (elev. 128.6 to 129.3 m).

SPT tests conducted in this layer gave N-values ranging from 1 to greater than 100 blows for 175 mm of penetration, however, the refusal likely represents the presence of cobbles or boulders rather than the relative density of the soil deposit. This deposit is considered to be non-cohesive in behaviour and loose to dense relative density, typically compact.

The moisture content of this unit ranged from 9 to 18%. The results of grain size distribution testing carried out on three samples of this material are summarized below and are illustrated on Figure C2 in Appendix C.

#### **Summary of Grain Size Distribution Testing – Sandy Clayey Silt to Clayey Silty Sand**

<b>Soil Particle</b>	<b>Percentage (%)</b>
Gravel	5 – 8
Sand	41 – 46
Silt	30 – 33
Clay	16 – 19

The results of Atterberg Limits testing carried out on three samples of the fine grained portion of the till are summarized below and are illustrated on Figure C4 in Appendix C. The laboratory results indicate that the fine grained material consists of clay to silty clay of low plasticity (CL to CL-ML). It should be noted in accordance with the MTO Guideline for Foundation Engineering Services (May 2019) the lower cohesive deposit has been described as a “clayey silt” where Atterberg limits tests indicate a CL material.





#### Summary of Atterberg Limit Testing – Sandy Clayey Silt to Clayey Silty Sand

Parameter	Value
Liquid Limit	16 – 18
Plastic Limit	9 – 10
Plasticity Index	7 – 8

#### 5.4 Groundwater

A standpipe piezometer with a diameter of 19 mm was installed in Borehole CV-21. Groundwater levels recorded in the piezometer are presented in Table 5-1 below:

**Table 5-1: Summary of Groundwater Levels**

Borehole No.	Bottom of Screen Elevation (m)	Depth (m)	Groundwater Elevation (m)	Date of Measurement
CV-21	129.6	6.4 below g.s.*	133.7	October 1, 2019
		0.7 above g.s.*	140.8	November 26, 2019
		0.7 above g.s.*	140.8	April 21, 2020

\*g.s. = ground surface

The groundwater level was recorded in the open Borehole CV-20 prior to backfilling at a depth of approximately 1.7 m (elev. 138.3 m) on October 1<sup>st</sup>, 2019.

At the time of the field investigation, no discernible creek bed was present. Standing water was observed.

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.



## 5.5 Analytical Testing

One sample of the native clay was submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate, sulphide and chloride concentrations, resistivity and conductivity. The analysis results are summarized in Table 5-2. Copies of the test results are provided in Appendix C.

**Table 5-2: Results of Chemical Analysis**

<b>Borehole</b>	<b>CV-21</b>
Sample	SS6
Depth (m)	3.8 – 4.4
Chloride (µg/g)	8
Sulphate (µg/g)	38
Sulphide (%)	0.08
pH (-)	7.58
Resistivity (Ohm-cm)	5,460
Conductivity (µS/cm)	183



## 6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to existing site features. The as-drilled locations and ground surface elevation of the boreholes were surveyed by Thurber following completion of the field program. The elevation survey was carried out with reference to geodetic elevation benchmarks provided by the MTO.

Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied and operated the drilling equipment and carried out the drilling, soil sampling, in-situ testing, piezometer installation and borehole decommissioning. The field investigation was supervised on a full-time basis by Michel Johnston of Thurber. Overall supervision of the investigation program was provided by Justin Gray, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa.

Overall project management and direction of the field program was provided by Fred Griffiths, P.Eng. Interpretation of the factual data and preparation of this report were carried out by Katya Edney, P.Eng. and Fred Griffiths, P.Eng. The report was reviewed by P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

 for:

Katya Edney, M.Eng, P.Eng.  
Geotechnical Engineer



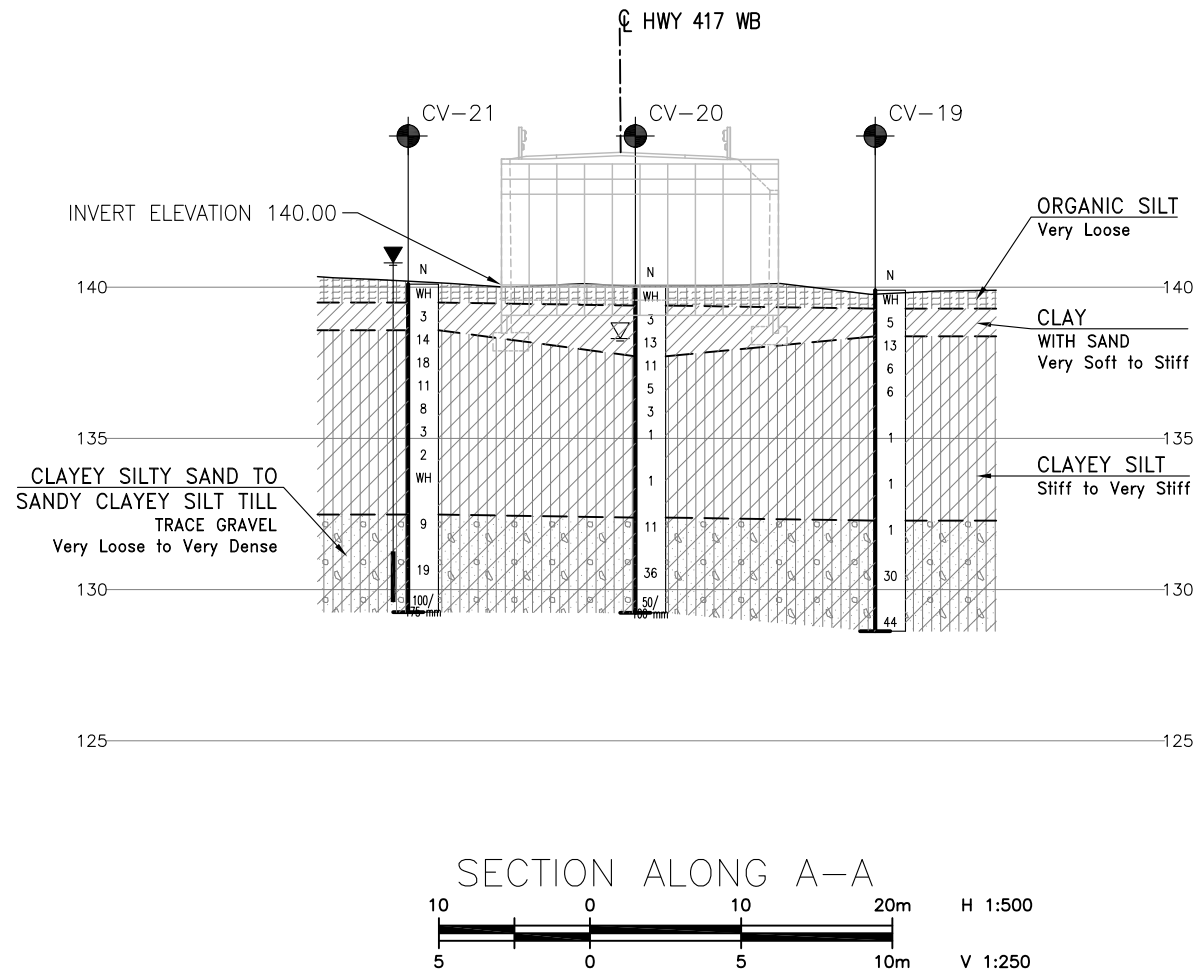
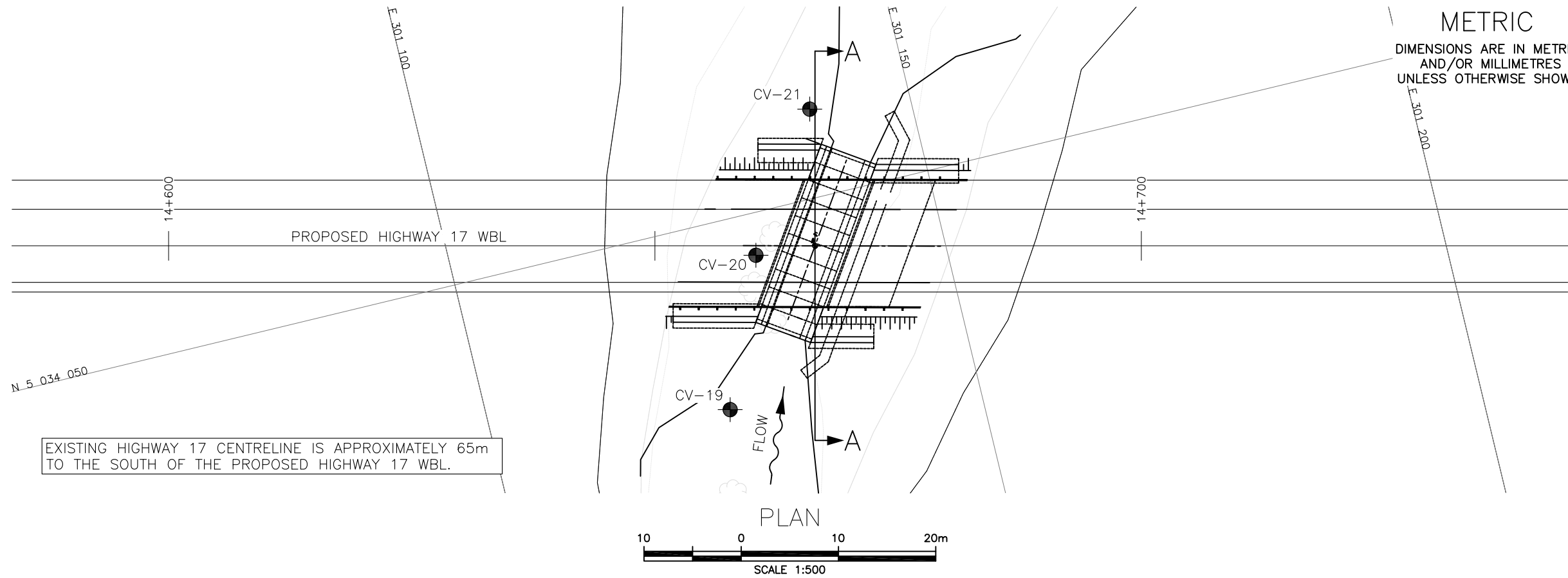
Dr. Fred Griffiths, P.Eng.  
Senior Geotechnical Engineer,  
Senior Associate



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

## **Appendix A.**

### **Borehole Location Plan and Stratigraphic Drawings**



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

CONT No  
WP No 4068-09-00  
HIGHWAY 17 TWINNING  
CULVERT STA. 14+666

BOREHOLE LOCATIONS AND SOIL STRATA



KEYPLAN

LEGEND

●	Borehole
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
CV-19	139.9	5 034 030.9	301 124.5
CV-20	140.0	5 034 045.7	301 130.8
CV-21	140.1	5 034 059.0	301 139.7

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. Structural elements, surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 9.

GEOCRES No. 31F-218

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	KE	CHK -	CODE	LOAD	DATE	JUL 2021
DRAWN	AN	CHK KE	SITE	STRUCT	DWG	1

**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).

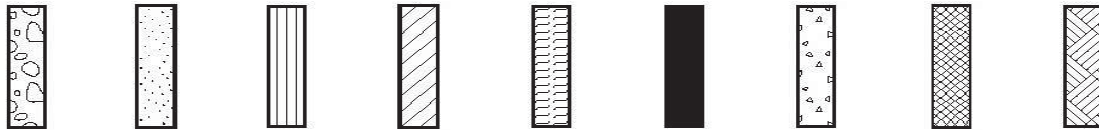
### DYNAMIC CONE PENETRATION TEST (DCPT):

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

**METRIC**[illegible]


+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No CV-19

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.446201°, Long: -76.546986° ORIGINATED BY MJJ  
Culvert 14+666 N 5 034 030.9 E 301 124.5  
 HWY 17 BOREHOLE TYPE CME 45 Trackmount, HSA COMPILED BY JP  
 DATUM Geodetic DATE 2019.10.01 - 2019.10.02 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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE					WATER CONTENT (%) w <sub>p</sub> w      w <sub>L</sub>				GR	SA	SI	CL	
	Continued From Previous Page							20	40	60	80	100									
	<b>SANDY CLAYEY SILT (CL)</b> , trace gravel Very Loose to Dense Grey (TILL)		10	SS	44		129											8	41	32	19
128.6																					
11.3	End of Borehole																				

DOUBLE LINE 24726 CULVERT 14+666 GINT.GPJ 2012TEMPLATE(MTO).GDT 21/4/21

# RECORD OF BOREHOLE No CV-20

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.446332°, Long: -76.546906°  
Culvert 14+666 N 5 034 045.7 E 301 130.8 ORIGINATED BY MJJ  
HWY 17 BOREHOLE TYPE CME 45 Trackmount, HSA COMPILED BY JP  
DATUM Geodetic DATE 2019.09.30 - 2019.10.01 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					
140.0	Ground Surface							20 40 60 80 100					
0.0	ORGANIC SILT Very Loose		1	SS	WH			○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
139.4								20 40 60 80 100					
0.6	CLAY (Cl) Firm to Stiff Grey		2	SS	3		139						
			3	SS	13		138						2 1 56 41
137.7													
2.3	CLAYEY SILT (CL) Stiff to Very Stiff Grey		4	SS	11		137						
			5	SS	5		136						
			6	SS	3		135						0 0 57 43
			7	SS	1								
							134						
			8	SS	1		133						

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

DOUBLE LINE 24726 CULVERT 14+666 GINT.GPJ 2012TEMPLATE(MTO).GDT 21/4/21

## METRIC

[illegible]

# RECORD OF BOREHOLE No CV-21

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.446453°, Long: -76.546792°  
Culvert 14+666 N 5 034 059.0 E 301 139.7 ORIGINATED BY MJJ  
HWY 17 BOREHOLE TYPE CME 45 Trackmount, HSA COMPILED BY JP  
DATUM Geodetic DATE 2019.10.01 - 2019.10.01 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE LIQUID LIMIT CONTENT		UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60	W P W W L	WATER CONTENT (%)		
140.1	Ground Surface												
0.0	ORGANIC SILT Very Loose		1	SS	WH								
139.5													
0.6	CLAY (CI) Very Soft to Firm Grey		2	SS	3								0 6 48 46
138.6													
1.5	CLAYEY SILT (CL) Stiff to Very Stiff Grey		3	SS	14								
			4	SS	18								
			5	SS	11								
			6	SS	8								
			7	SS	3								
			8	SS	2								
			9	SS	WH								0 1 57 42
132.5													
7.6	CLAYEY SILTY SAND (SC-SM), trace gravel Loose to Very Dense Grey (TILL)		10	SS	9								8 45 30 17
			11	SS	19								

Continued Next Page

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


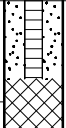
DOUBLE LINE 24726 CULVERT 14+666 GINT.GPJ 2012TEMPLATE(MTO).GDT 21/4/21

# RECORD OF BOREHOLE No CV-21

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.446453°, Long: -76.546792° ORIGINATED BY MJJ  
 HWY 17 BOREHOLE TYPE CME 45 Trackmount, HSA COMPILED BY JP  
 DATUM Geodetic DATE 2019.10.01 - 2019.10.01 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 (%)								
	Continued From Previous Page							20	40	60	80	100					
129.3	CLAYEY SILTY SAND (SC-SM), trace gravel Loose to Very Dense Grey (TILL)		12	SS	100/		130										
10.8	End of Borehole WATER LEVEL READINGS: DATE      DEPTH (m)      ELEV. (m) 2019.10.01      6.4      133.7 2019.11.26      0.7 above g.s.      140.8 2020.04.21      0.7 above g.s.      140.8				175 mm												

DOUBLE LINE 24726 CULVERT 14+666 GINT.GPJ 2012TEMPLATE(MTO).GDT 21/4/21



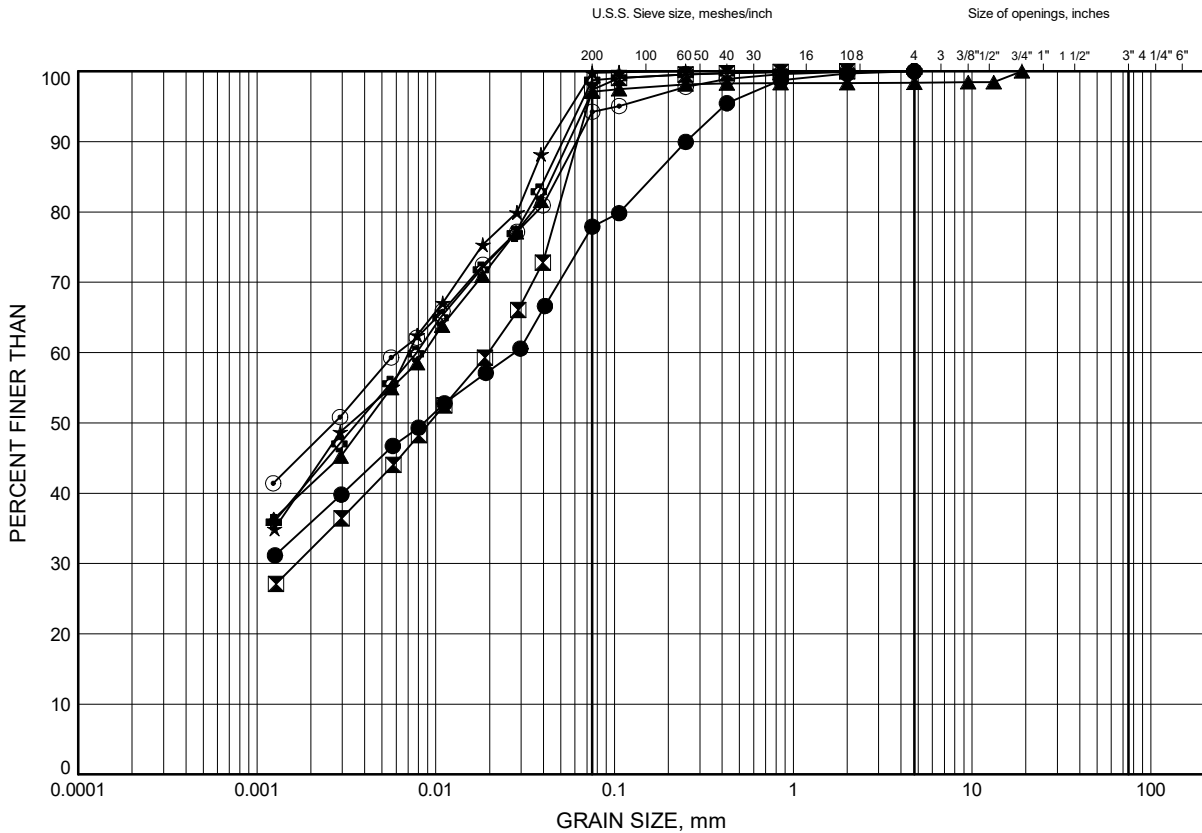
**Appendix C.**  
**Laboratory Testing**

**Appendix C.1**  
**Particle Size Analysis Figures**  
**Atterberg Limit Test Results**

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C1

## CLAY (CI) TO CLAYEY SILT (CL)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CV-19	1.1	138.8
⊠	CV-19	4.9	135.0
▲	CV-20	1.8	138.2
★	CV-20	4.1	135.9
⊙	CV-21	1.1	139.0
⊕	CV-21	6.4	133.7

Date June 2020  
WP# 4068-09-00

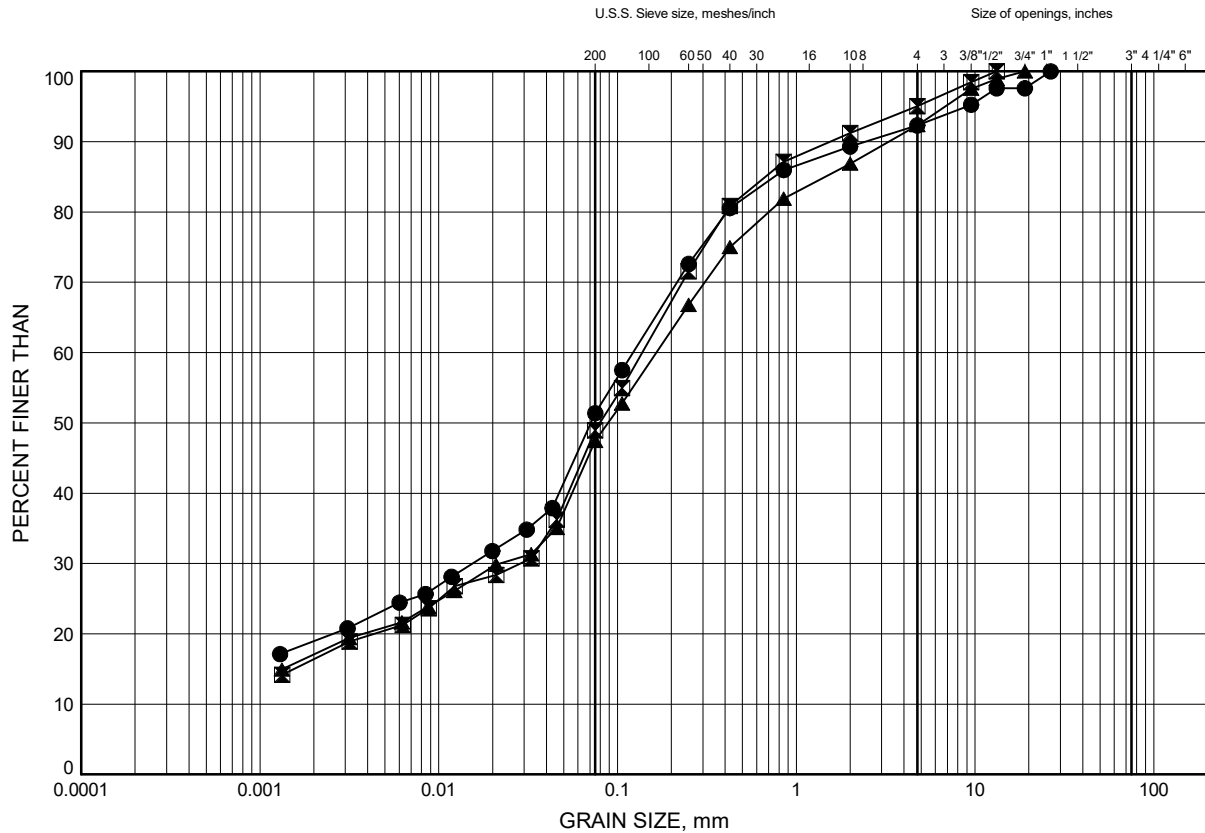


Prep'd KE  
Chkd. FG

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C2

## SANDY CLAYEY SILT (CL) TO CLAYEY SILTY SAND (SC-SM) (TILL)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CV-19	11.0	128.9
⊠	CV-20	9.4	130.6
▲	CV-21	7.9	132.2

Date June 2020  
WP# 4068-09-00

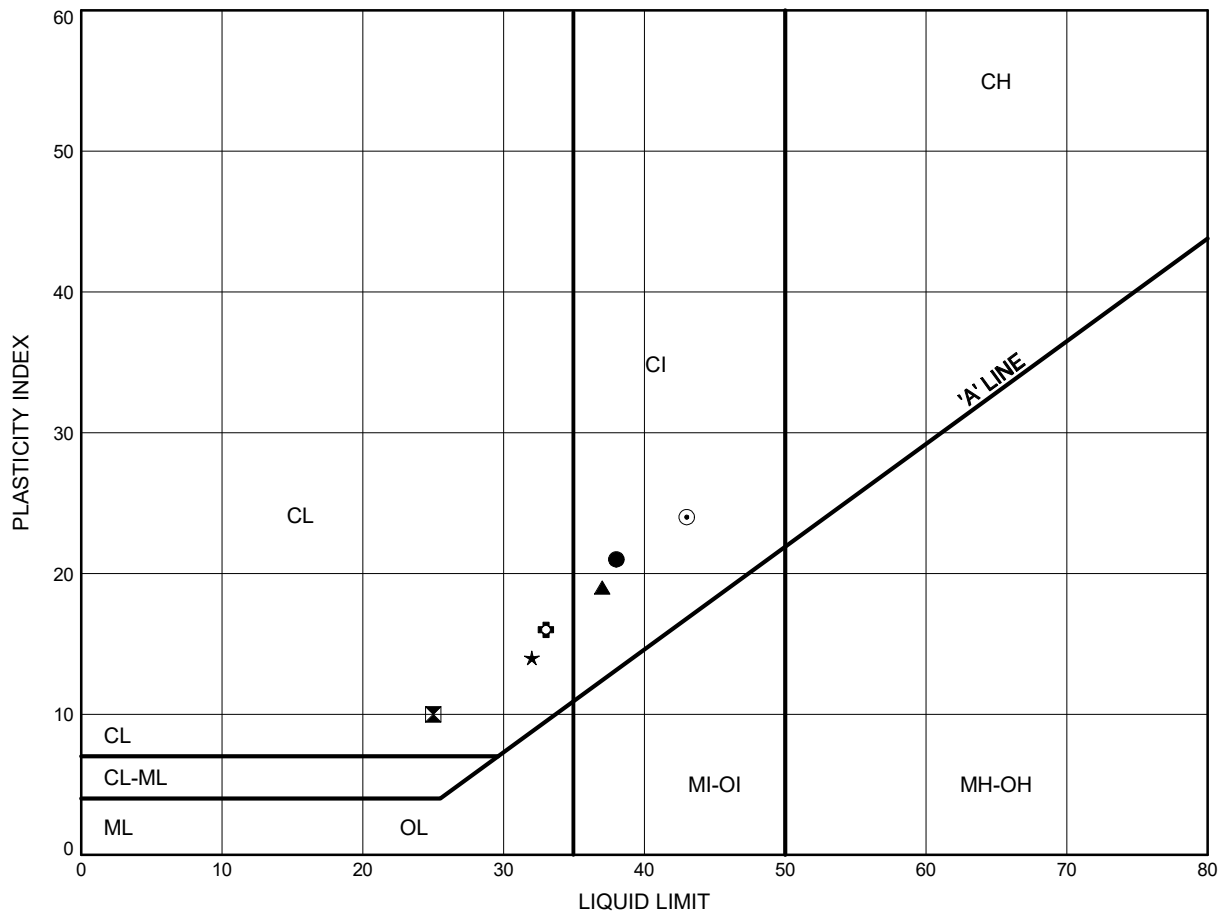


Prep'd KE  
Chkd. FG

# Highway 17 Twinning ATTERBERG LIMITS TEST RESULTS

FIGURE C3

## CLAY (CI) TO CLAYEY SILT (CL)



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CV-19	1.1	138.8
⊠	CV-19	4.9	135.0
▲	CV-20	1.8	138.2
★	CV-20	4.1	135.9
⊙	CV-21	1.1	139.0
⊕	CV-21	6.4	133.7

Date June 2020  
 WP# 4068-09-00

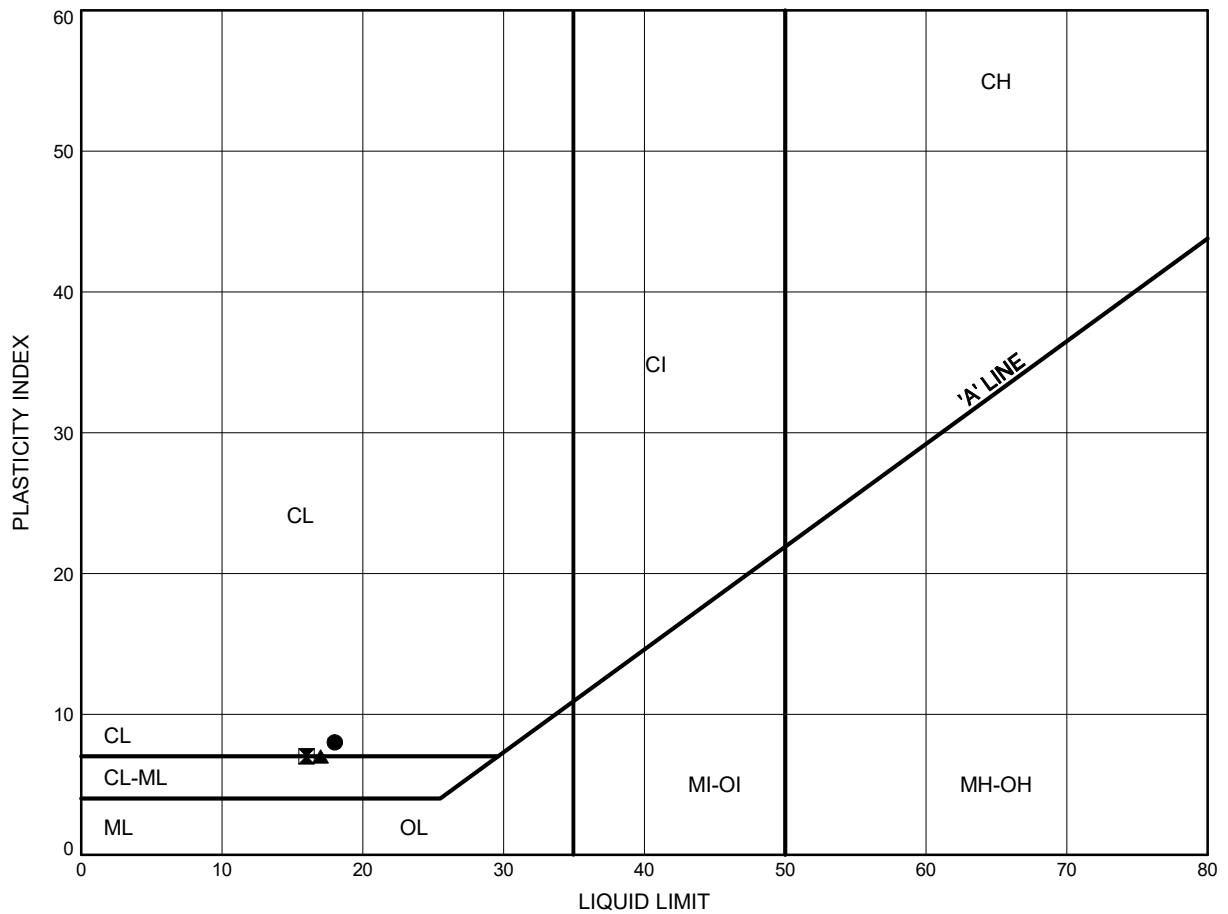


Prep'd KE  
 Chkd. FG

# Highway 17 Twinning ATTERBERG LIMITS TEST RESULTS

FIGURE C4

SANDY CLAYEY SILT (CL) TO CLAYEY SILTY SAND (SC-SM) (TILL)



### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CV-19	11.0	128.9
⊠	CV-20	9.4	130.6
▲	CV-21	7.9	132.2

Date June 2020  
 WP# 4068-09-00



Prep'd KE  
 Chkd. FG

**Appendix C.2**  
**Analytical Testing Results**

## Certificate of Analysis

**Thurber Engineering Ltd.**

2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B4S5  
Attn: Chris Murray

Client PO:  
Project: 24726  
Custody: 49912

Report Date: 10-Oct-2019  
Order Date: 4-Oct-2019

**Order #: 1940635**

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

**Paracel ID**  
1940635-01

**Client ID**  
CV-21, SS6 (12'6"-14'6")

Approved By:



Mark Foto, M.Sc.  
Lab Supervisor



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

Report Date: 10-Oct-2019  
Order Date: 4-Oct-2019  
Project Description: 24726

### Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	8-Oct-19	8-Oct-19
Conductivity	MOE E3138 - probe @25 °C, water ext	9-Oct-19	9-Oct-19
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	9-Oct-19	9-Oct-19
Resistivity	EPA 120.1 - probe, water extraction	9-Oct-19	9-Oct-19
Solids, %	Gravimetric, calculation	7-Oct-19	7-Oct-19

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

Report Date: 10-Oct-2019

Order Date: 4-Oct-2019

Project Description: 24726

Client ID:	CV-21, SS6 (12'6"-14'6")	-	-	-
Sample Date:	01-Oct-19 09:00	-	-	-
Sample ID:	1940635-01	-	-	-
MDL/Units	Soil	-	-	-

**Physical Characteristics**

% Solids	0.1 % by Wt.	79.6	-	-	-
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**General Inorganics**

Conductivity	5 uS/cm	183	-	-	-
pH	0.05 pH Units	7.58	-	-	-
Resistivity	0.10 Ohm.m	54.6	-	-	-

**Anions**

Chloride	5 ug/g dry	8	-	-	-
Sulphate	5 ug/g dry	38	-	-	-

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

Report Date: 10-Oct-2019

Order Date: 4-Oct-2019

Project Description: 24726

### 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:

Report Date: 10-Oct-2019

Order Date: 4-Oct-2019

Project Description: 24726

### Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	502	5	ug/g dry	486			3.1	20	
Sulphate	123	5	ug/g dry	122			0.6	20	
<b>General Inorganics</b>									
pH	7.16	0.05	pH Units	7.13			0.4	2.3	
Resistivity	90.0	0.10	Ohm.m	89.9			0.2	20	
<b>Physical Characteristics</b>									
% Solids	94.3	0.1	% by Wt.	94.2			0.2	25	

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

Report Date: 10-Oct-2019

Order Date: 4-Oct-2019

Project Description: 24726

### Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	576	5	ug/g	486	90.0	82-118			
Sulphate	229	5	ug/g	122	107	80-120			

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

Report Date: 10-Oct-2019  
Order Date: 4-Oct-2019  
Project Description: 24726

**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 K1B4S5

Attn: Chris Murray

Tel: (613) 247-2121

Fax: (613) 247-2185

Paracel Report No **1940635**

Client Project(s): **24726**

Client PO:

Order Date: 04-Oct-19

Report Date: 10-Oct-19

Reference: **Standing Offer**

CoC Number: **49912**

---

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
1940635-01	CV-21, SS6 (12'6"-14'6")	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, Canada

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

10-October-2019

**Date Rec. :** 08 October 2019  
**LR Report:** CA13304-OCT19  
**Reference:** Project#: 1940635

**Copy:** #1

## CERTIFICATE OF ANALYSIS

### Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		10-Oct-19
2: Analysis Start Time		14:36
3: Analysis Completed Date		10-Oct-19
4: Analysis Completed Time		14:53
5: QC - Blank		< 0.02
6: QC - STD % Recovery		115%
7: QC - DUP % RPD		16%
8: RL		0.02
9: CV-21, SS6 (12'6"-14'6")	01-Oct-19	0.08

RL - SGS Reporting Limit

Kimberley Didsbury  
Project Specialist,  
Environment, Health & Safety



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



**Photo 1. Looking south towards existing Highway 17 alignment (2019/10/02)**



**Photo 2. Looking east near Station 14+666 (2019/10/02)**





**Photo 3. Standing Water near Sta 14+666 looking east (2019/10/02)**