

**Prepared By:** Keli Shi, P.Eng.

**Date:** Thursday, October 11, 2018

**Reviewed By:** Jason Lee, P.Eng.  
P.K. Chatterji, P.Eng.

**No.** H427-0-FND-REP-003-D

**Prepared For:** Peter Bamforth, P.Eng.  
Tatiana Ojala, P.Eng.

**Subject:** **Foundation Investigation and Design Report**  
**Highway 427 Expansion – Structural Culverts (100% Submission)**  
**at Sta. 11+130 and Sta. 13+556, MMD Sta. 10+524 (S51, S52 and S53)**

## TABLE OF CONTENTS

1.	INTRODUCTION .....	2
2.	SITE DESCRIPTION AND GEOLOGY BACKGROUND .....	2
3.	PROJECT DESCRIPTION .....	2
4.	GEOTECHNICAL INVESTIGATION .....	2
5.	SUBSURFACE CONDITIONS .....	4
5.1	Culvert U022 (Rain-1).....	4
5.2	Culvert U046 (Rob-2) .....	5
5.3	Culvert W017 (MMD Sta. 10+524) .....	5
6.	GEOTECHNICAL RECOMMENDATIONS .....	6
6.1	General.....	6
6.2	Subgrade Preparation .....	6
6.3	Geotechnical Resistances .....	7
6.4	Sliding Resistance .....	7
6.5	Frost Protection .....	7
6.6	Backfill to Culverts .....	7
6.7	Lateral Earth Pressure.....	8
6.8	Seismic Considerations .....	8
6.9	Excavation and Dewatering .....	9
6.10	Erosion and Scour Protection .....	9
6.11	Corrosion and Sulphate Attack Potential .....	10

## Statement of Limitations and Conditions

## APPENDICES

Appendix A	Record of Borehole Sheets
Appendix B	Results of Geotechnical and Analytical Laboratory Testing
Appendix C	Borehole Locations and Soil Strata Drawings
Appendix D	Record of Borehole Sheets (Geocres No. 30M13-176)

## 1. INTRODUCTION

This report presents the results of a foundation investigation and provides recommendations for the design and construction of foundations of the proposed structural culverts at Station 11+130 (U022) and Station 13+556 (U046) along the proposed Highway 427 alignment and at Station 10+524 (W017) along the realigned Major Mackenzie Drive in the City of Vaughan, Ontario as a part of the Highway 427 Expansion project.

The geotechnical parameters used in the analyses presented in this report were selected based on the subsurface conditions encountered in the boreholes advanced during recently completed investigation by Thurber Engineering. Reference has also been made to available information on subsurface conditions from previous investigation documented in the report listed below:

- GEOCRE 30M13-176: Preliminary Foundation Investigation and Design Report, Culverts, Highway 427 Extension (NBL and SBL) from Highway 7 to Major Mackenzie Drive, Ministry of Transportation, Ontario, W.O. 05-20012, dated August 2009, prepared by Golder Associates.

General Arrangement (GA) drawings H427-D-H-1-STR-S51-DWG-800-A (dated March 16, 2018), H427-D-H-2-STR-S52-DWG-500-A and H427-D-H-3-STR-S53-DWG-700-A (both dated March 2, 2018) have been utilized in preparation of foundation recommendations presented in this report.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

## 2. SITE DESCRIPTION AND GEOLOGY BACKGROUND

The proposed structural culverts are located along the Highway 427 Extension alignment. Lands surrounding the sites have been developed mainly for agricultural uses. Moderate tree and brush covers were noted around perimeters of the fields and near the creeks. The topography of the site is flat to gently undulating.

The site is situated within the physiographic region known as the Peel Plain (*The Physiography of Southern Ontario* by L. J. Chapman and D. F. Putnam 1984). The subsurface conditions in the region generally comprise clayey silt to silty clay till (Halton Till) with interlayers of sand and silt. Localized recent deposits of sands, silts and soft clays formed in small glacial meltwater ponds throughout the region may be encountered near the river and creek valleys. The site is underlain by shale bedrock of the Georgian Bay Formation with siltstone and limestone interlayers.

## 3. PROJECT DESCRIPTION

Culvert U022 (Rain-1) proposed at Sta. 11+130 will be located approximately 500 m north of Zenway Boulevard and will carry the south tributary to Rainbow Creek. Culvert U046 (Rob-2) proposed at Sta. 13+556 will be located approximately 600 m south of Rutherford Road and will carry a tributary to West Robinson Creek. Culvert W017 proposed at Major Mackenzie Drive Sta. 10+524 will divert drainage water in the westbound lane ditch into the nearest storm water pond south of Major Mackenzie Drive.

Precast segmental concrete box culverts are proposed at all three sites.

## 4. GEOTECHNICAL INVESTIGATION

The recent field investigation program for this project was conducted between June 12 and June 13, 2017, and July 5 and July 6, 2017. The field investigation program consisted of drilling and sampling ten (10) boreholes, designated as CLRN17-01 to CLRN17-04, CLRB17-01 to CLRB17-03, and CLM17-04 to CLM17-06. At each culvert site, the boreholes were located along or near the proposed alignments of the culverts. All boreholes were advanced to a depth of 12.8 m.

Borehole coordinates and ground surface elevations at the borehole locations were derived from topographic drawings provided by WSP. The Record of Borehole sheets and the Borehole Locations and Soil Strata Drawings are included in the appendices. The locations of boreholes are provided in MTM NAD 83, Zone 10 coordinates.

Track-mounted CME 55 drill rig supplied by Landshark Drilling Ltd. Of Ontario was used to advance the boreholes. Soil samples were obtained at selected intervals using a 50 mm nominal inner diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT) procedures as per ASTM D1586. The drilling and sampling operations were supervised on a full-time basis by members of Thurber's technical staff. The drilling supervisors logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes throughout the drilling operations and attempt was made to measure groundwater level upon completion of drilling. Two standpipe piezometers were installed in CLRN17-01 and single piezometers were installed in CLRB17-03, CLM17-04 and CLM17-06. Boreholes without piezometers have been decommissioned as per O. Reg. 903. After the final water level readings, the piezometers will be decommissioned in general accordance with O. Reg. 903. Completion details of each borehole in the recent investigation are summarized in Table 1.

Boreholes C8 and C9 from the previous investigation conducted in 2009 (Geocres No. 30M13-176) have been included in Appendix D.

**Table 1 – Piezometer Installation and Borehole Backfilling Details**

Borehole	Borehole Depth/ Base Elevation (m)	Borehole Backfilling Details
CLRN17-01	12.8 / 168.2	Two piezometers with 1.5 m and 3.0 m slotted screens installed. Deep piezometer tip at 9.1 m, sand filter to 5.8 m, bentonite holeplug to surface. Shallow piezometer tip at 4.8 m installed in the adjacent hole with sand filter to 3.0 m and bentonite holeplug to surface.
CLRN17-02	12.8 / 167.5	Backfilled with bentonite holeplug and cuttings to surface.
CLRN17-03	12.8 / 166.7	Backfilled with bentonite holeplug and cuttings to surface.
CLRN17-04	12.8 / 166.6	Piezometer with 1.5 m slotted screen installed and tip at 3.0 m, sand filter to 1.2 m and bentonite holeplug to surface.
CLRB17-01	12.8 / 176.7	Piezometer with 1.5 m slotted screen installed and tip at 3.1 m, sand filter to 1.3 m and bentonite holeplug to surface.
CLRB17-02	12.8 / 177.2	Backfilled with bentonite holeplug and cuttings to surface.
CLRB17-03	12.8 / 173.1	Bentonite to 6.1 m depth, piezometer with 1.5 m slotted screen installed and tip at 6.0 m, sand filter to 4.3 m and bentonite holeplug to surface.
CLM17-04	12.8 / 188.2	Bentonite to 6.1 m depth, piezometer with 1.5 m slotted screen installed and tip at 6.0 m, sand filter to 3.9 m and bentonite holeplug to surface.
CLM17-05	12.8 / 189.7	Backfilled with bentonite holeplug and cuttings to surface.
CLM17-06	12.8 / 190.0	Piezometer with 3.0 m slotted screen installed and tip at 12.2 m, sand filter to 8.5 m and bentonite holeplug to surface.

## 5. SUBSURFACE CONDITIONS

In general, the stratigraphy of the native soil at these culvert sites comprises surficial clayey silt overlying clayey silt to silty clay till, which was underlain by interbedded cohesive and cohesionless tills. Highly weathered shale bedrock was encountered in CLRN17-03 at 12.4 m depth or Elev. 167.1. More detailed descriptions of the individual strata at each proposed culvert location are presented below.

Boreholes drilled during the recent investigation were typically dry upon completion of drilling. The latest water levels measured in the standpipe piezometers typically ranged between 1 m and 2 m below ground surface at Culverts U022 and U046, and between 4 m and 5 m below ground surface at Culvert W017.

### 5.1 Culvert U022 (Rain-1)

Subsurface information was obtained in CLRN17-01 to CLRN17-04 drilled near Mainline Sta. 11+130.

A layer of topsoil approximately 125 to 150 mm in thickness was encountered in all four boreholes. The thickness of topsoil may vary across the site between and beyond borehole locations.

Native brown to dark brown surficial clayey silt with trace sand and gravel and trace rootlets was encountered underlying the topsoil in all four boreholes. SPT 'N' values in the clayey silt ranged from 3 to 5 blows indicating a soft to firm consistency. The clayey silt was encountered to depths of 0.7 m to 0.8 m (Elevation 178.7 to 180.3).

Underlying the surficial clayey silt was a layer of cohesive till ranging from silty clay to clayey silt. Trace to some sand, trace gravel and occasional cobbles were noted in the till. The deposit was typically brown to approximately 4 to 6 m depth and then became grey. The thickness of the cohesive till varied from 8.0 to 11.2 m with the base between depths of 8.7 m and 12.0 m (Elev. 172.3 and 168.3). SPT 'N' values recorded in the cohesive till ranged typically from 11 to 37 indicating a stiff to hard consistency. SPT 'N' values of 7 and 8 were recorded in the upper 1.5 m of the till in CLRN17-03, indicating a firm consistency. SPT "N" values greater than 100 were recorded typically where cobbles were encountered.

A cohesionless till consisting of grey silty sand to sand and silt was encountered beneath the cohesive till. Trace clay and trace gravel were noted in the deposit. The thickness of the silty sand till penetrated in CLRN17-03 was 3.7 m. The remaining three boreholes were terminated within this till at 12.8 m depth. SPT 'N' values recorded in the cohesionless till ranged from 35 to more than 100, indicating a dense to very dense relative density. Glacial tills inherently contain cobbles and boulders.

Grey shale bedrock was encountered in CLRN17-03 at a depth of 12.4 m (Elev. 167.1), and the borehole was terminated at 0.4 m into the highly weathered shale.

Two standpipe piezometers were installed in CLRN17-01 and a shallow piezometer was installed in CLRN17-04. The measured water levels were summarized in the table below.

Borehole	Date	Water Level (m)		Screen Location (m)		Native Material at Screen
		Depth	Elevation	Depth	Elevation	
CLRN17-01 (S)	July 10, 2017	1.5	179.5	3.4 - 4.9	177.6 - 176.1	Clayey silt to silty clay till
	Oct 24, 2017	1.5	179.5			
CLRN17-01 (D)	July 10, 2017	4.6	176.4	6.1 - 9.1	174.9 - 171.9	Silt/clay to sand/silt till
	Oct 24, 2017	1.5	179.5			
CLRN17-04	July 10, 2017	0.9	178.5	11.0 - 12.5	168.4 - 166.9	Silty sand till
	Oct 24, 2017	0.8	178.6			

The groundwater level will fluctuate seasonally and reflect the creek level. The groundwater level may be at a higher level after the spring snowmelt or after periods of heavy rainfall.

## 5.2 Culvert U046 (Rob-2)

Subsurface information was obtained in CLRB17-01 to CLRB17-03 drilled near Mainline Sta. 13+556 and Geocres boreholes C8 and C9.

A layer of topsoil approximately 150 to 225 mm in thickness was encountered in all three boreholes. Topsoil was not encountered in C8 and 200 mm of topsoil was encountered in C9. The thickness of topsoil will vary across the site between and beyond borehole locations.

Native, brown surficial deposit of silty clay to clayey silt with trace sand, trace gravel and occasional cobbles underlies the topsoil. Trace organics (rootlets) were noted in this deposit. SPT 'N' values in the silty clay/clayey silt ranged from 2 to 6 indicating a soft to firm consistency. The silty clay to clayey silt was encountered to depths of 0.6 m to 1.4 m (Elevation 189.3 to 185.3).

Underlying the surficial clayey silt to silty clay was a layer of cohesive till ranging from silty clay to clayey silt. Trace to some sand, trace gravel and occasional cobbles were noted in the till. The deposit was typically brown to approximately 4 m depth and then changing to grey. The deposit was investigated to a depth of 12.8 m (from Elev. 173.1 to 177.2) in Boreholes CLRB17-01 to CLRB17-03. Boreholes C8 and C9 were terminated in this deposit at a depth of 9.8 m (Elev. 177.2 and 178.6). SPT 'N' values in the cohesive till ranged from 12 to more than 100 indicating a stiff to hard consistency. The high SPT 'N' values of more than 100 may be indicative of the presence of cobbles in the deposit.

CLRB17-01 and CLRB-02 were dry on completion of drilling to the depths of 10.4 m and 10.7 m, respectively. Standpipe piezometers were installed in Borehole CLRB17-01 and CLRB17-03. The water levels were measured at 0.6 m (Elev. 188.8) and 1.2 m (Elev. 184.7) and may not represent the stabilized groundwater levels. Boreholes C8 and C9 were dry upon completion of drilling. Water levels measured in the piezometers are summarized in the table below.

Borehole	Date	Water Level (m)		Screen Location (m)		Native Material at Screen
		Depth	Elevation	Depth	Elevation	
CLRB17-01	Jun 19, 2017	0.6	188.9	1.5 – 3.0	188.0 – 186.5	Clayey silt to silty clay till
	Oct 23, 2017	1.1	188.4			
CLRB17-03	Jun 19, 2017	1.2	184.7	4.6 – 6.1	181.3 – 179.8	Clayey silt to silty clay till
	Oct 23, 2017	1.2	184.7			
	Oct 31, 2017	2.1	183.8			

The groundwater level will fluctuate seasonally and reflect the creek level. The groundwater level may be at a higher level after the spring snowmelt or after periods of heavy rainfall.

## 5.3 Culvert W017 (MMD Sta. 10+524)

Subsurface information was obtained in CLM17-04 to CLM17-06 drilled near Major Mackenzie Drive Sta. 10+524.

A layer of topsoil 150 to 200 mm in thickness was encountered in the recent boreholes. The thickness of topsoil will vary across the site between and beyond borehole locations.

A layer of surficial silty clay to clayey silt underlies the topsoil in all three boreholes. The deposit was brown to dark brown in colour. Trace organics (rootlets) and oxidation staining were noted in the upper zone of the deposit. SPT 'N' values in the surficial cohesive layer ranged from 8 to 15 indicating a stiff to very stiff consistency. The layer was encountered to a depth of 0.7 m (Elevation 200.3 to 202.1).

Brown to grey cohesive till varying in composition from silty clay to clayey silt with trace to some sand, trace gravel and occasional cobbles was encountered below the surficial silty clay to clayey silt. SPT 'N' values in the silty clay to clayey silt till ranged from 9 to 116 indicating a firm to hard consistency. The deposit was typically very stiff to hard to approximately 5 m depth. Between approximately depths of 5 m and 11.5 m, the till was stiff with SPT 'N'

values ranging from 9 to 16. The cohesive till became hard below 11.5 m depth with SPT “N” values of 75 to 116. A dense sand and silt till deposit was encountered within the cohesive till in CLM17-06 with a thickness of 1.6 m.

Standpipe piezometers were installed in CLM17-04 and CLM17-06. Water levels measured in the piezometers are summarized in the table below.

Borehole	Date	Water Level (m)		Screen Location (m)		Native Material at Screen
		Depth	Elevation	Depth	Elevation	
CLM17-04	July 10, 2017 Oct 23, 2017	Dry 4.8	- 196.2	4.6 – 6.1	196.4 – 194.9	Clayey silt to silty clay till
CLM17-06	July 10, 2017 Oct 23, 2017	7.7 4.1	195.1 198.7	9.2 – 12.2	193.6 – 190.6	Sand and Silt till and Silty Clay Till

The groundwater level will fluctuate seasonally and may be at a higher level after the spring snowmelt or after periods of heavy rainfall.

## 6. GEOTECHNICAL RECOMMENDATIONS

### 6.1 General

The proposed culverts are shown on the GA drawings as precast concrete box culverts. Details of the culverts shown on GA drawings are summarized in the table below:

**Table 2 – Culvert Design Information**

Culvert (Station)	Culvert Type	Box Size (m)	Invert Elevation (m)		Length (m)	Fill Cover
			Inlet	Outlet		
U022 (Rain-1) (Sta. 11+130)	Single-Cell Concrete Box	4.5 x 1.8	178.97 (West)	178.45 (East)	98.4	Up to 5 m
U046 (Rob-2) (Sta. 13+556)	Single-Cell Concrete Box	3.0 x 2.4	188.04 (West)	184.76 (East)	125.4	Up to 4.5 m
W017 (MMD Sta. 10+524)	Single-Cell Concrete Box	3.0 x 1.8	200.83 (North)	200.50 (South)	64.6	Up to 2 m

Precast concrete box culverts are feasible at these sites. From a foundation perspective, a precast box culvert option is preferred as its construction generally requires relatively shallow excavation, expeditious construction and less extensive groundwater control in comparison with open footing culvert option.

### 6.2 Subgrade Preparation

After the foundation excavation reaches the design subgrade level, the exposed surface should be inspected to confirm that the subgrade is suitable and uniformly competent. Any topsoil/organics, disturbed soils, loose/soft deposits and deleterious materials within the foundation footprint of the culvert should be removed and replaced with suitable granular material compacted as per OPSS.PROV 501. The subgrade preparation must be carried out in the dry.

A minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A or Granular B Type II requirements should be provided under the base of the box culvert, as shown on OPSD 803.010. The prepared surface to support the precast concrete box units should have a 75 mm minimum thickness top levelling course consisting of uncompacted Granular A as per OPSS 422. If the culvert is constructed in wet condition, the bedding material may consist of a minimum 300 mm thick 19 mm clear stone conforming to OPSS.PROV 1004. A layer of geotextile (e.g. Terrafix 360R) should be placed between the bedding material and subgrade for separation purpose.

The bedding material should be placed on the prepared subgrade as soon as practicable following its inspection



and approval. Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction.

### 6.3 Geotechnical Resistances

The values of factored geotechnical resistance at the Ultimate Limit State (ULS) and the factored geotechnical resistance at Serviceability Limit State (SLS) for the proposed box culverts placed on properly prepared subgrade are summarized in Table 3 below.

**Table 3 – Recommended Geotechnical Resistances**

Culvert (Station)	Proposed Culvert Base Elevation	Founding Stratum at Subgrade Level	Factored ULS	Factored SLS
U022 (Rain-1) (Sta. 11+130)	Inlet (178.50) Outlet (177.98)	Stiff to hard cohesive till	300 kPa	200 kPa
U046 (Rob-2) (Sta. 13+556)	Inlet (187.65) Outlet (184.37)	Stiff to hard cohesive till	300 kPa	200 kPa
W017 (MMD Sta. 10+524)	Inlet (200.59) Outlet (200.26)	Stiff to hard cohesive till	300 kPa	200 kPa

The factored geotechnical resistance at SLS are provided for the settlement not exceeding 25 mm.

The factored Geotechnical Resistance at ULS was assessed assuming a Consequence Factor of 1.0 (Typical), and a Resistance Factor of 0.5 (Typical degree of understanding), as per CHBDC 2014. The factored Geotechnical Resistance at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.

The geotechnical resistance quoted above is for concentric, vertical loads only. In the case of eccentric or inclined loading, the geotechnical resistance should be calculated as indicated in the CHBDC (2014) Clause 6.10.3 and Clause 6.10.4.

The ULS resistance and settlement are dependent on the footing/culvert size, configuration and applied loads. Accordingly, the geotechnical resistances should be reviewed if the culvert width or founding elevation differs significantly from that indicated above.

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

### 6.4 Sliding Resistance

Resistance to lateral forces/sliding between concrete box culvert and the underlying bedding material should be evaluated assuming an unfactored ultimate coefficient of friction of 0.45.

### 6.5 Frost Protection

The design depth of frost penetration at these sites is 1.2 m. Provision of frost protection cover for the box culvert is not required given the design soil cover above the culverts.

### 6.6 Backfill to Culverts

Backfill to the culvert should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of OPSS.PROV 1010 and as per OPSD 803.010.

All fills should be placed and compacted in accordance with OPSS.PROV 501. The backfill should be maintained equal on both sides of the culvert walls, with one side not exceeding the other by more than 500 mm. Heavy compaction equipment should not be used adjacent to the walls and roof of the culvert. Compaction equipment

to be used adjacent to retaining structures/culvert walls should be restricted in accordance with OPSS.PROV 501.

## 6.7 Lateral Earth Pressure

Lateral earth pressures acting on the culvert walls may be assumed to impose a triangularly distributed load. For a fully drained backfill, the pressures should be computed in accordance with the CHBDC, but are generally given by the expression:

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

Where:

$p_h$	=	horizontal pressure on the wall at depth $h$ (kPa)
$K$	=	earth pressure coefficient
$\gamma$	=	unit weight of retained soil (kN/m <sup>3</sup> )
$H$	=	depth below top of fill where pressure is computed (m)
$q$	=	value of any surcharge (kPa)

Earth pressure coefficients for backfill to the culvert sidewall are dependent on properties of the granular fill used as the backfill. Recommended values of the earth pressure coefficients are provided in Table 4. For rigid structures, such as concrete box culverts, at-rest horizontal earth pressures can be used for design, and active pressures should be used for any unrestrained walls.

In accordance with Clause 6.12.3 of the CHBDC (2014), a compaction surcharge should be added.

**Table 4 – Earth Pressure Coefficients (K)**

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I or Type III $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active ( $K_A$ ) (Unrestrained Wall)	0.27	0.38	0.31	0.46
At-rest ( $K_o$ ) (Restrained Wall)	0.43	-	0.47	-
Passive ( $K_P$ )	3.7	-	3.3	-

## 6.8 Seismic Considerations

Based on the encountered subsurface conditions from the previous investigation, Site Class D can be assumed to evaluate the seismic site response, as per Table 4.1, Clause 4.4.3.2 of the CHBDC 2014.

The peak ground acceleration, PGA, for a 2% in 50-year probability of exceedance at these sites is 0.110 g as per the National Building Code of Canada 2015 (NBCC 2015).

In accordance with Clause 4.6.5 of the CHBDC 2014, retaining structures should be designed using active ( $K_{AE}$ ) and passive ( $K_{PE}$ ) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 5 may be used:



**Table 5 – Seismic Earth Pressure Coefficients ( $K_E$ )**

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I or Type III $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$
Active ( $K_{AE}$ )*	0.31	0.35
Passive ( $K_{PE}$ )	3.5	3.1
At-rest ( $K_{OE}$ )**	0.57	0.62

\* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.

\*\* After Woods

Given the low seismic ground motions and the presence of typically stiff to hard silty clay/clayey silt till and dense to very dense cohesionless till, the potential for liquefaction is considered low at the culvert sites.

## 6.9 Excavation and Dewatering

All excavations should be carried out in accordance with the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the soils within the likely depth of excavation at these sites may be classed as Type 3 soils for surficial clayey silt, and Type 2 for native stiff to hard silty clay/clayey silt till.

The excavation and backfilling for culverts should be carried out in accordance with OPSS 902.

Earth excavations required at these sites will penetrate through the firm to very stiff native silty clay/clayey silt. Temporary shallow excavation through most soils at these sites may be formed unsupported with side slopes not steeper than 1H: 1V. Flatter slopes may be required at locations where the soils are less competent or where water seepage affects surficial stability. The native till may contain cobbles and boulders.

The bases of temporary excavations for culvert construction will be below the measured groundwater levels at Culverts U022 and U046 and above the measured water levels at Culvert W017. Surface runoff and perched groundwater may seep into the excavations during culvert construction.

Given the consistency and relatively low permeability of the silty clay/clayey silt soils, groundwater control measures such as pumping from filtered sumps may be sufficient to remove any accumulation of water from the excavation for culvert installation and lower the groundwater table to below the base of excavation.

The culvert installation should be carried out in the dry. Silty clay to clayey silt subgrade should be covered as soon as practical upon exposure and be protected from any disturbances that may weaken the material.

## 6.10 Erosion and Scour Protection

Erosion protection should be provided in the areas of the culvert inlet and/or outlet. Design of the erosion protection measures should consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

A concrete cut-off wall should be used to minimize the potential for erosion or piping beneath the culvert.

Typically, rock protection should be provided over all embankment slope surface where creek water is likely to be in contact. Treatment at the outlets 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.

Culvert design drawings prepared by structural designer and water resources designer have been reviewed from a geotechnical perspective. The culvert design drawings are generally consistent with the geotechnical recommendations provided above.

## 6.11 Corrosion and Sulphate Attack Potential

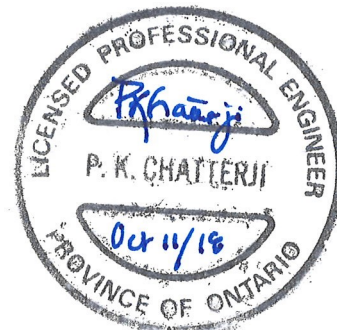
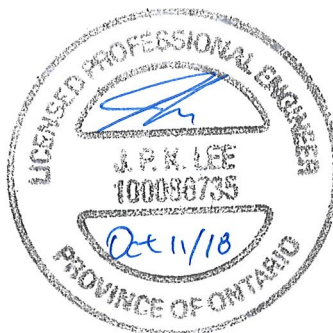
Soil samples of the native silty clay collected from each culvert site were submitted for analytical testing of corrosivity parameters and sulphate. The laboratory certificates of analyses are presented in Appendix B. The results of the analytical tests are summarized in Table 6.

**Table 6 – Analytical Test Results**

Parameter Tested	Unit	Culvert U022 (CLRN)			Culvert U046 (CLRB)		Culvert W017 (CLM)	
		17-01	17-02	17-04	17-01	17-03	17-04	17-06
		SS2	SS4	SS5	SS2	SS3	SS5	SS2
Moisture	%	12.0	12.7	12.0	23.1	12.6	13.3	12.4
Corrosivity Index	-	4.0	4.0	7.5	1.0	1.0	1.0	4.0
pH	-	8.66	8.52	8.61	8.12	8.42	8.38	8.73
Redox Potential	mV	333	203	222	285	274	239	250
Sulphide	%	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chloride	µg/g	1.5	3.0	2.4	8.7	1.5	43	1.3
Sulphate	µg/g	56	62	140	31	70	280	18
Electrical Conductivity	µS/cm	132	164	149	142	138	272	90
Resistivity	ohms.cm	7550	6110	6700	7030	7220	3680	11100

The results of the analytical tests for soil corrosivity and sulphate content conducted on the samples collected near the water courses indicate the following:

- The potential for sulphate attack on structure concrete from the surrounding soil is negligible based on the generally low concentration of sulphate in the samples tested.
- The potential for corrosion on metal elements of the structure is low based on the low corrosivity index.



## STATEMENT OF LIMITATIONS AND CONDITIONS

### 1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

### 2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

### 3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

### 4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

### 5. INTERPRETATION OF THE REPORT

- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

### 6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

### 7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

## Appendix A

### Record of Borehole Sheets

## SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

### 1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

### 2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

### 3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT <sup>(1)</sup> 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



### 4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

### 5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 Water Level  
 C<sub>pen</sub> Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value      Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT              Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

# UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS W <sub>L</sub> < 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. (W <sub>L</sub> < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W <sub>L</sub> < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W <sub>L</sub> > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			



## EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
<b>Fresh (FR)</b>	No visible signs of weathering.		
<b>Fresh Jointed (FJ)</b>	Weathering limited to the surface of major discontinuities.		CLAYSTONE
<b>Slightly Weathered (SW)</b>	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
<b>Moderately Weathered (MW)</b>	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
<b>Highly Weathered (HW)</b>	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
<b>Completely Weathered (CW)</b>	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Very thinly bedded	20 to 60mm				
Laminated	6 to 20mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Thinly Laminated	Less than 6mm				

<u>TERMS</u>					
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

# RECORD OF BOREHOLE No CLRN 17-01

1 OF 2

METRIC

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 11+130 N 4 848 935.7 E 293 815.0 ORIGINATED BY KK  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.13 - 2017.06.13 CHECKED BY ME

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  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									
181.0	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL: (150mm)							20	40	60	80	100					
0.2	Clayey <b>SILT</b> , trace sand, trace gravel Firm Brown Moist		1	SS	5												
180.3																	
0.7	Clayey <b>SILT</b> to Silty <b>CLAY</b> , trace sand, trace gravel, occasional cobbles Very Stiff to Hard Brown to 4.0m depth then Grey Moist (TILL)		2	SS	17		180										
			3	SS	19		179										
			4	SS	29		178										
			5	SS	37		177										
			6	SS	24		176									3	30 47 20
							175										
			7	SS	33		174										
			8	SS	18		173										
172.3							172										
8.7	<b>SAND</b> and <b>SILT</b> , trace clay, trace gravel Very Dense Grey Moist (TILL)		9	SS	100/ 0.125											9	49 34 8

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

**RECORD OF BOREHOLE No CLRN 17-01 2 OF 2 METRIC**

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 11+130 N 4 848 935.7 E 293 815.0 ORIGINATED BY KK  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.13 - 2017.06.13 CHECKED BY ME

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 $\gamma$ 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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
							20	40	60	80	100	20	40	60			
	Continued From Previous Page																
			10	SS	100/												
					0.125												
							170										
							169										
168.2			11	SS	100/												
					0.100												
12.8	END OF BOREHOLE AT 12.8m. Piezometer installation consists of two 25mm diameter Schedule 40 PVC pipe with a 1.52m and 3.05m slotted screen.  <b>DEEP PIEZOMETER</b> WATER LEVEL READINGS: DATE      DEPTH (m)      ELEV. (m) 2017.07.10      4.6      176.4 2017.10.24      1.5      179.5  <b>SHALLOW PIEZOMETER</b> WATER LEVEL READINGS: DATE      DEPTH (m)      ELEV. (m) 2017.07.10      1.5      179.5 2017.10.24      1.5      179.5																

RECORD OF BOREHOLE No CLRN 17-02 1 OF 2 METRIC

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 11+130 N 4 848 956.3 E 293 845.5 ORIGINATED BY ES/KK  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.12 - 2017.06.13 CHECKED BY ME

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 (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
180.3	GROUND SURFACE							20   40   60   80   100						
0.0	TOPSOIL: (150mm)							○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE						
0.2	Clayey <b>SILT</b> , trace sand, trace roots Soft Dark Brown Moist		1	SS	3		180							
179.5														
0.8	Clayey <b>SILT</b> to Silty <b>CLAY</b> , some sand, trace gravel, occasional oxide stains in upper 0.5m zone Stiff to Hard Brown to Grey Moist (TILL)		2	SS	18		179							
			3	SS	24		178							
			4	SS	36		177							
			5	SS	12		176							
			6	SS	20		175							
			7	SS	24		174							
							173							
	Occasional sand seam		8	SS	23		172							
							171							
	Cobbles at 9.2m depth			SS	100/ 0.025									

Continued Next Page

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

20  
15  
10

(%) STRAIN AT FAILURE

## 2 OF 2

ORIGINATED BY ES/KK

HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.06.12 - 2017.06.13 CHECKED BY ME

[illegible]

RECORD OF BOREHOLE No CLRN 17-03 1 OF 2 METRIC

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 11+130 N 4 848 962.9 E 293 889.9 ORIGINATED BY KK  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.13 - 2017.06.13 CHECKED BY ME

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa													
179.5	GROUND SURFACE							20	40	60	80	100									
0.0	TOPSOIL: (125mm)																				
0.1	Clayey <b>SILT</b> , trace sand, trace gravel Firm Brown Moist		1	SS	3		179														
178.8																					
0.7	Clayey <b>SILT</b> to Silty <b>CLAY</b> , some sand to sandy, trace gravel Firm to Hard Brown to 4.0m depth then Grey Moist (TILL)		2	SS	7		178														
			3	SS	8																
			4	SS	32		177											0	20	46	34
			5	SS	35		176														
							175														
			6	SS	17													0	26	45	29
							174														
			7	SS	24		173														
							172														
			8	SS	24																
							171														
170.8																					
8.7	<b>SAND</b> and <b>SILT</b> , trace clay, trace gravel Dense to Very Dense Grey Moist (TILL)		9	SS	58		170											5	43	43	9

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CLRN 17-03 2 OF 2 METRIC

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 11+130 N 4 848 962.9 E 293 889.9 ORIGINATED BY KK  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.13 - 2017.06.13 CHECKED BY ME

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  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 ○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE						
	Continued From Previous Page							20 40 60 80 100						
			10	SS	35		169							
							168							
167.1			11	SS	102/ 0.200		167							
12.4	SHALE highly weathered, thinly bedded, weak, grey: (Probably Bedrock)													
166.7														
12.8	END OF BOREHOLE AT 12.8m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.													

RECORD OF BOREHOLE No CLRN 17-04 1 OF 2 METRIC

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 11+130 N 4 848 981.2 E 293 914.1 ORIGINATED BY KK  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.13 - 2017.06.13 CHECKED BY ME

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				WATER CONTENT (%)					
179.4	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL: (150mm)							20	40	60	80	100					
0.2	Clayey <b>SILT</b> , trace sand, trace gravel, trace organics Soft Brown Moist		1	SS	3		179										
178.7																	
0.7	Clayey <b>SILT</b> to Silty <b>CLAY</b> , trace sand, trace gravel, occasional cobbles Stiff to Hard Brown to Grey Moist (TILL)		2	SS	11		178										
			3	SS	22												
			4	SS	35		177										
			5	SS	32		176										
							175										
			6	SS	27		174										
							173										
							172										
			8	SS	6		171										
170.7							170										
8.7	Silty <b>SAND</b> , trace clay, trace gravel Dense to Very Dense Grey Moist (TILL)		9	SS	44												

Continued Next Page

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

RECORD OF BOREHOLE No CLRN 17-04 2 OF 2 METRIC

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 11+130 N 4 848 981.2 E 293 914.1 ORIGINATED BY KK  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.13 - 2017.06.13 CHECKED BY ME

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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 20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) 20 40 60 W <sub>p</sub> W W <sub>L</sub>												
	Continued From Previous Page																								
			10	SS	35		169																		
							168																		
			11	SS	100/ 0.175		167																		
166.6 12.8	END OF BOREHOLE AT 12.8m. BOREHOLE DRY UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS <table border="1"> <thead> <tr> <th>DATE</th> <th>DEPTH(m)</th> <th>ELEV.(m)</th> </tr> </thead> <tbody> <tr> <td>2017.07.10</td> <td>0.9</td> <td>178.5</td> </tr> <tr> <td>2017.10.24</td> <td>0.8</td> <td>178.6</td> </tr> </tbody> </table>	DATE	DEPTH(m)	ELEV.(m)	2017.07.10	0.9	178.5	2017.10.24	0.8	178.6															
DATE	DEPTH(m)	ELEV.(m)																							
2017.07.10	0.9	178.5																							
2017.10.24	0.8	178.6																							

# RECORD OF BOREHOLE No CLR B 17-01

1 OF 2

METRIC

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 13+564 N 4 851 356.7 E 293 380.3 ORIGINATED BY CAR  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.12 - 2017.06.12 CHECKED BY ME

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		W <sub>p</sub>	W	W <sub>L</sub>		
189.5	GROUND SURFACE													
0.0	TOPSOIL: (225mm)													
0.2	Silty <b>CLAY</b> , trace sand, trace gravel, trace organics (rootlets), occasional cobbles Soft to Firm Brown Moist		1	SS	2									
			2	SS	4									
188.1														
1.4	Silty <b>CLAY</b> to Clayey <b>SILT</b> , trace to sone sand, trace gravel, occasional cobbles Stiff to Hard Brown to Grey Moist (TILL)		3	SS	19									
			4	SS	34									
			5	SS	56									
			6	SS	61									
			7	SS	18									
			8	SS	14									
			9	SS	100/ 0.250									

Continued Next Page

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

20  
15  
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CLRB 17-01 2 OF 2 METRIC

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 13+564 N 4 851 356.7 E 293 380.3 ORIGINATED BY CAR  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.12 - 2017.06.12 CHECKED BY ME

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) W <sub>p</sub> W W <sub>L</sub>				
	Continued From Previous Page																
			10	SS	100/ 0.175		179										
							178										
176.7			11	SS	74		177										
12.8	END OF BOREHOLE AT 12.8m. BOREHOLE OPEN TO 10.4m AND DRY. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.  WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.06.19 0.6 188.9 2017.10.23 1.1 188.4																

## 1 OF 2

W.P.	LOCATION	Culvert at Sta 13+564 N 4 851 354.8 E 293 471.7	ORIGINATED BY	CAR
HWY	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	DATE	2017.06.12 - 2017.06.12	CHECKED BY	ME

[illegible]

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



RECORD OF BOREHOLE No CLRb 17-02 2 OF 2 METRIC

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 13+564 N 4 851 354.8 E 293 471.7 ORIGINATED BY CAR  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.12 - 2017.06.12 CHECKED BY ME

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT							UNIT WEIGHT  γ  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											
								○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE											
	Continued From Previous Page							20	40	60	80	100		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT			
			10	SS	68/ 0.125		179												
							178												
177.2			11	SS	46														
12.8	END OF BOREHOLE AT 12.8m. BOREHOLE OPEN TO 10.7m AND DRY. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																		

RECORD OF BOREHOLE No CLRB 17-03 1 OF 2 METRIC

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 13+564 N 4 851 345.7 E 293 508.8 ORIGINATED BY CAR  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.13 - 2017.06.13 CHECKED BY ME

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 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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
185.9	GROUND SURFACE													
0.0	TOPSOIL: (225mm)													
0.2	Silty <b>CLAY</b> , trace sand, trace gravel, trace organics (rootlets) Firm Brown Moist		1	SS	6									
185.3			2	SS	14									
0.6	Silty <b>CLAY</b> to Clayey <b>SILT</b> , trace to some sand, trace gravel, occasional cobbles Stiff to Hard Brown to 4.0m depth then Grey Moist (TILL)		3	SS	24									
			4	SS	31									
			5	SS	19									
			6	SS	14									
			7	SS	100/ 0.200									
			8	SS	71									
			9	SS	32									
	Silty clay seam													

Continued Next Page

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

RECORD OF BOREHOLE No CLRB 17-03 2 OF 2 METRIC

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 13+564 N 4 851 345.7 E 293 508.8 ORIGINATED BY CAR  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.13 - 2017.06.13 CHECKED BY ME

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  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								
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE								
	Continued From Previous Page							20	40	60	80	100				
			10	SS	100/ 0.175		175							○		
							174									
173.1			11	SS	40									○		
12.8	END OF BOREHOLE AT 12.8m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS DATE            DEPTH(m)    ELEV.(m) 2017.06.19        1.2        184.7 2017.10.23        1.2        184.7 2017.10.31        2.1        183.8															

## METRIC

[illegible]

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

# RECORD OF BOREHOLE No CLM 17-04

2 OF 2

METRIC

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 10+524 N 4 853 887.4 E 292 378.7 ORIGINATED BY TF  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.06 - 2017.07.06 CHECKED BY AMP

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) W <sub>p</sub> W W <sub>L</sub>				
	Continued From Previous Page																
	Becoming hard below 11.6m depth		10	SS	11		190										
188.2			11	SS	90		189									1 17 48 34	
12.8	END OF BOREHOLE AT 12.8m. BOREHOLE DRY UPON COMPLETION. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.07.10 Dry - 2017.10.23 4.8 196.2																

# RECORD OF BOREHOLE No CLM 17-05

1 OF 2

METRIC

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 10+524 N 4 853 869.0 E 292 353.2 ORIGINATED BY TF  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.05 - 2017.07.05 CHECKED BY AMP

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 $\gamma$ 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						
202.5	GROUND SURFACE													
0.0	TOPSOIL: (150mm)													
0.2	Silty <b>CLAY</b> , trace to some sand, trace organics: (rootlets)		1	SS	8									
	Firm													
201.8	Brown													
0.7	Moist													
	Silty <b>CLAY</b> to Clayey <b>SILT</b> , trace to some sand, trace gravel, occasional cobbles		2	SS	27									
	Stiff to Very Stiff													
	Brown to Grey													
	Moist													
	(TILL)													
			3	SS	13									
			4	SS	26									
			5	SS	27									
			6	SS	10									
			7	SS	10									
			8	SS	10									
			9	SS	9									

Continued Next Page

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



# RECORD OF BOREHOLE No CLM 17-05

2 OF 2

METRIC

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 10+524 N 4 853 869.0 E 292 353.2 ORIGINATED BY TF  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.05 - 2017.07.05 CHECKED BY AMP

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) W <sub>p</sub> W W <sub>L</sub>				
	Continued From Previous Page																
			10	SS	16		192										
	Becoming hard below 11.7.m depth						191										
189.7			11	SS	116		190										
12.8	END OF BOREHOLE AT 12.8m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.																

# RECORD OF BOREHOLE No CLM 17-06

1 OF 2

METRIC

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 10+524 N 4 853 848.1 E 292 340.9 ORIGINATED BY TF  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.06 - 2017.07.06 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  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						
202.8	GROUND SURFACE							20	40	60	80	100		
0.0	TOPSOIL: (200mm)							20	40	60	80	100		
0.2	Silty <b>CLAY</b> , trace sand, trace gravel, trace organics: (rootlets) Stiff Dark Brown Moist		1	SS	15		202							
202.1														
0.7	Silty <b>CLAY</b> to Clayey <b>SILT</b> , trace to some sand, trace gravel, occasional cobbles Stiff to Hard Brown to Grey Moist (TILL)		2	SS	28									
			3	SS	23		201							
			4	SS	38		200							
			5	SS	37		199							
			6	SS	18		198							
							197							
			7	SS	12		196							
							195							
	Becoming sand and silt, with some clay and trace gravel between 8.5m and 10.0m depth		8	SS	13									
194.2														
8.6	<b>SAND</b> and <b>SILT</b> , some clay, trace gravel Dense Grey Moist (TILL)		9	SS	32		194							
							193							

Continued Next Page

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

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No CLM 17-06

2 OF 2

METRIC

W.P. \_\_\_\_\_ LOCATION Culvert at Sta 10+524 N 4 853 848.1 E 292 340.9 ORIGINATED BY TF  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.06 - 2017.07.06 CHECKED BY AMP

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 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																	
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)														
						20 40 60 80 100 20 40 60 80 100					20 40 60 20 40 60														
192.6	Continued From Previous Page																								
10.2	Silty <b>CLAY</b> , some sand, trace gravel, occasional cobbles Stiff to Hard Grey Moist (TILL)		10	SS	14																				
			11	SS	75																				
190.0																									
12.8	END OF BOREHOLE AT 12.8m. BOREHOLE DRY UPON COMPLETION. Well installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.  WATER LEVEL READINGS <table border="1"> <thead> <tr> <th>DATE</th> <th>DEPTH(m)</th> <th>ELEV.(m)</th> </tr> </thead> <tbody> <tr> <td>2017.07.10</td> <td>7.7</td> <td>195.1</td> </tr> <tr> <td>2017.10.23</td> <td>4.1</td> <td>198.7</td> </tr> </tbody> </table>	DATE	DEPTH(m)	ELEV.(m)	2017.07.10	7.7	195.1	2017.10.23	4.1	198.7															
DATE	DEPTH(m)	ELEV.(m)																							
2017.07.10	7.7	195.1																							
2017.10.23	4.1	198.7																							

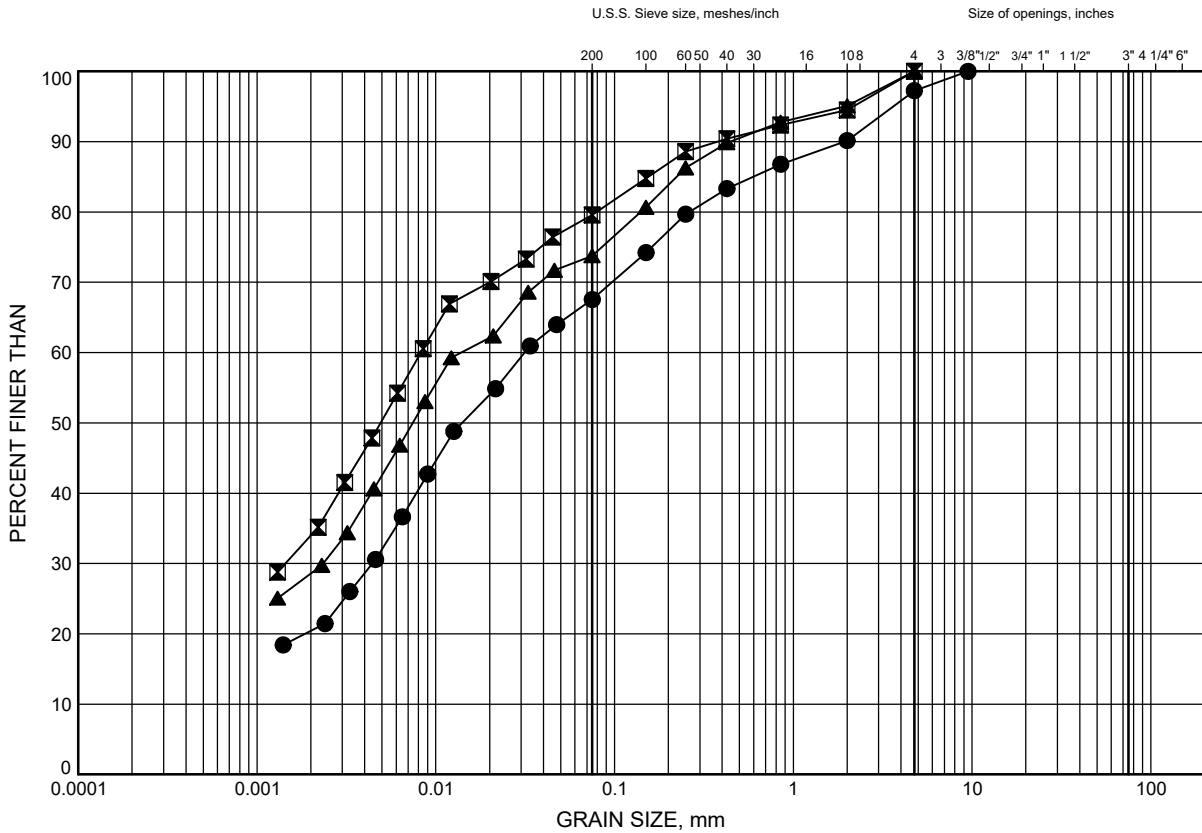
## Appendix B

### Results of Geotechnical and Analytical Laboratory Testing

# GRAIN SIZE DISTRIBUTION

FIGURE B1

## Clayey SILT to Silty CLAY TILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLRN 17-01	4.9	176.1
⊠	CLRN 17-03	2.6	176.9
▲	CLRN 17-03	4.9	174.6

Date December 2017  
W.P. ....

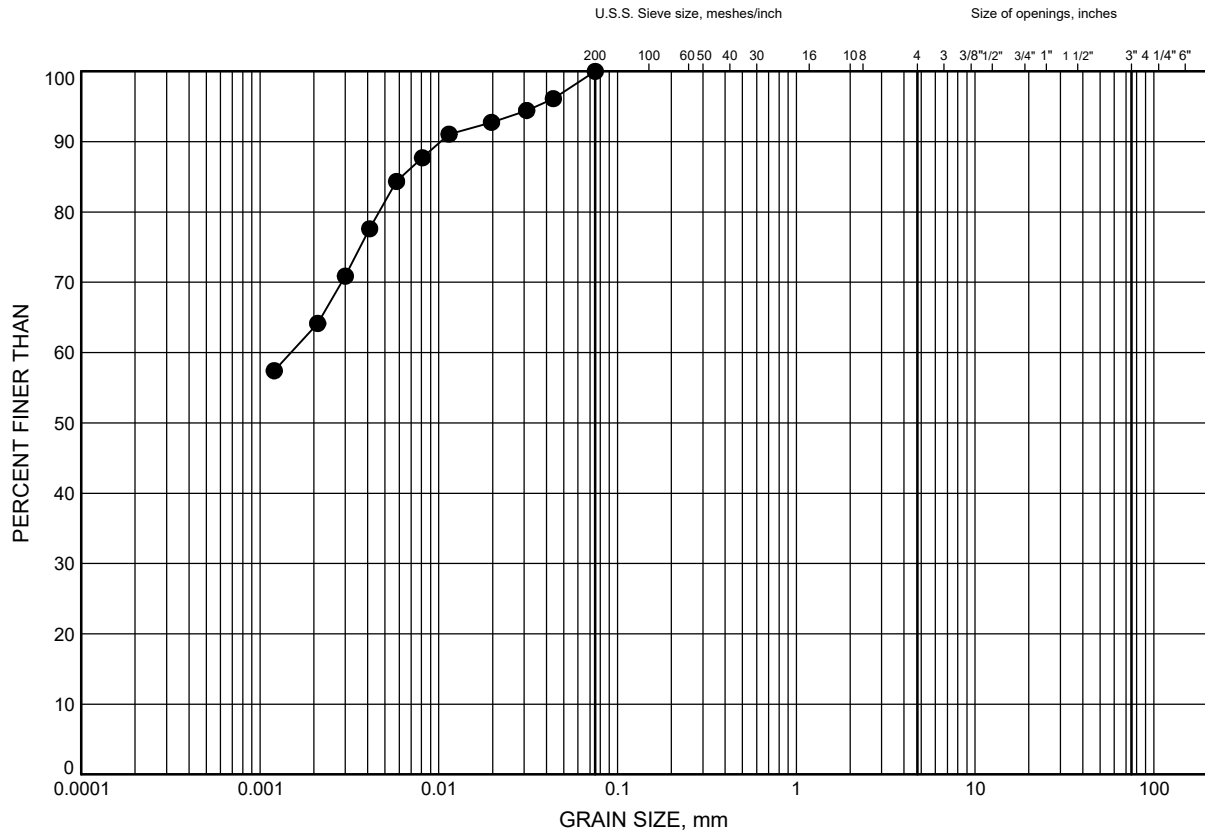


Prep'd AN  
Chkd. GRL

# GRAIN SIZE DISTRIBUTION

FIGURE B2

## Silty CLAY Seam



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLRN 17-04	7.9	171.5

Date December 2017  
W.P.

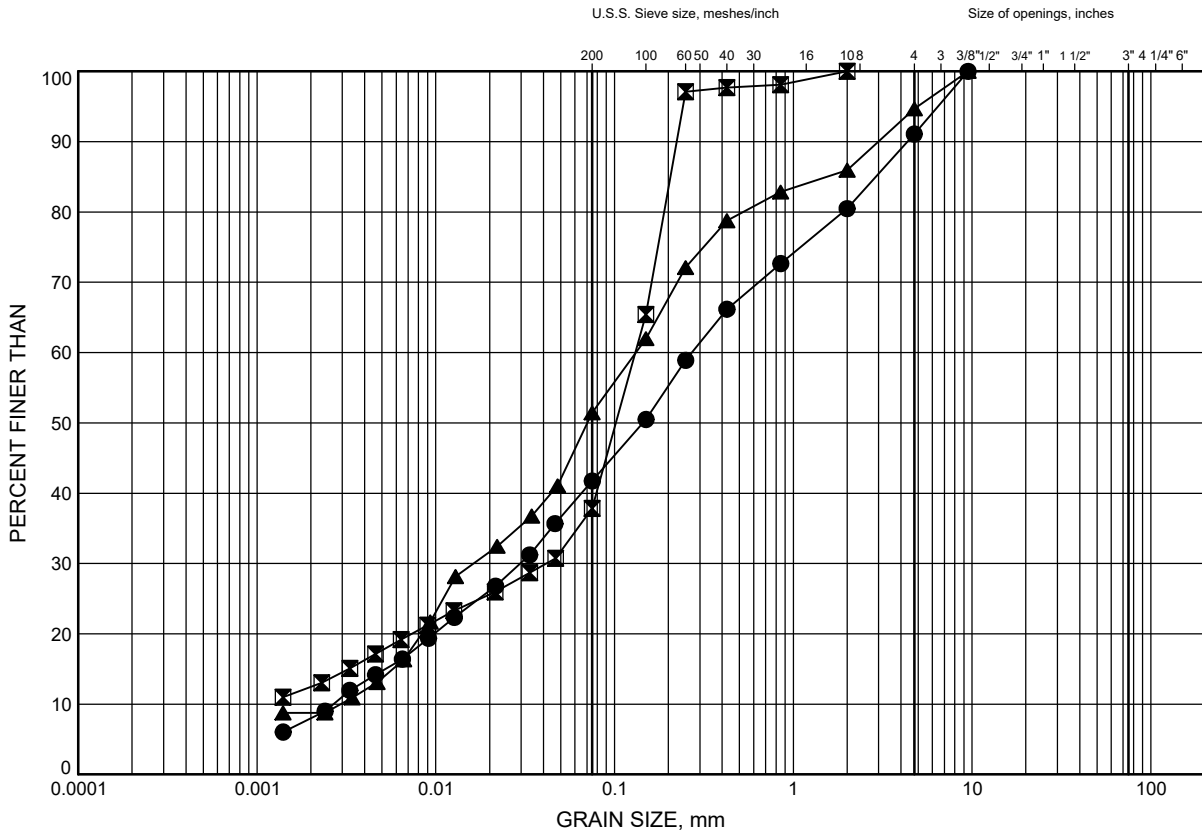


Prep'd AN  
Chkd. GRL

# GRAIN SIZE DISTRIBUTION

FIGURE B3

## SAND & SILT TILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLRN 17-01	9.2	171.8
⊠	CLRN 17-02	12.4	167.9
▲	CLRN 17-03	9.4	170.1

Date December 2017  
W.P. \_\_\_\_\_

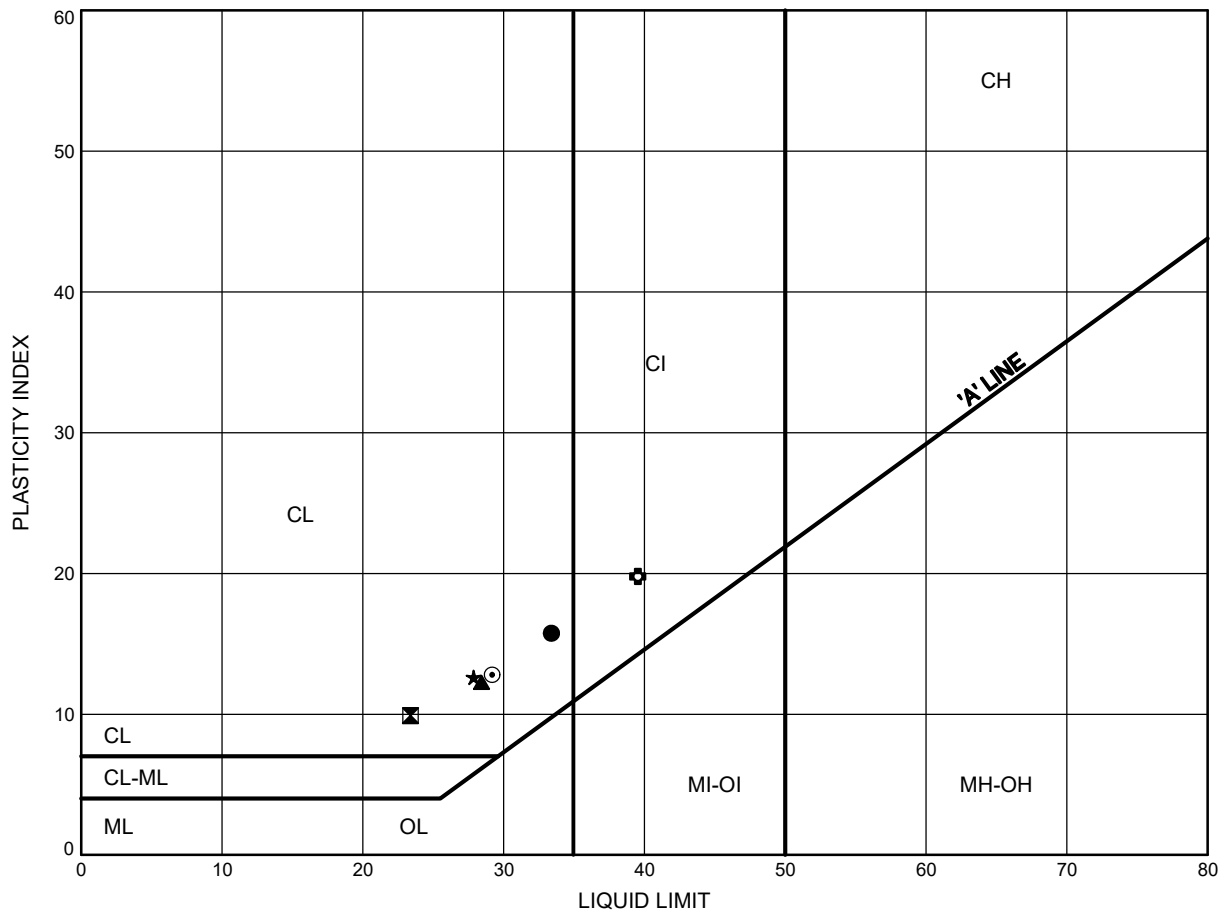


Prep'd AN  
Chkd. GRL

# ATTERBERG LIMITS TEST RESULTS

FIGURE B4

Clayey SILT to Silty CLAY TILL



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLRN 17-01	1.1	179.9
⊠	CLRN 17-01	4.9	176.1
▲	CLRN 17-01	7.9	173.1
★	CLRN 17-02	2.6	177.7
⊙	CLRN 17-02	7.9	172.4
⊕	CLRN 17-03	2.6	176.9

Date December 2017

W.P.



Prep'd AN

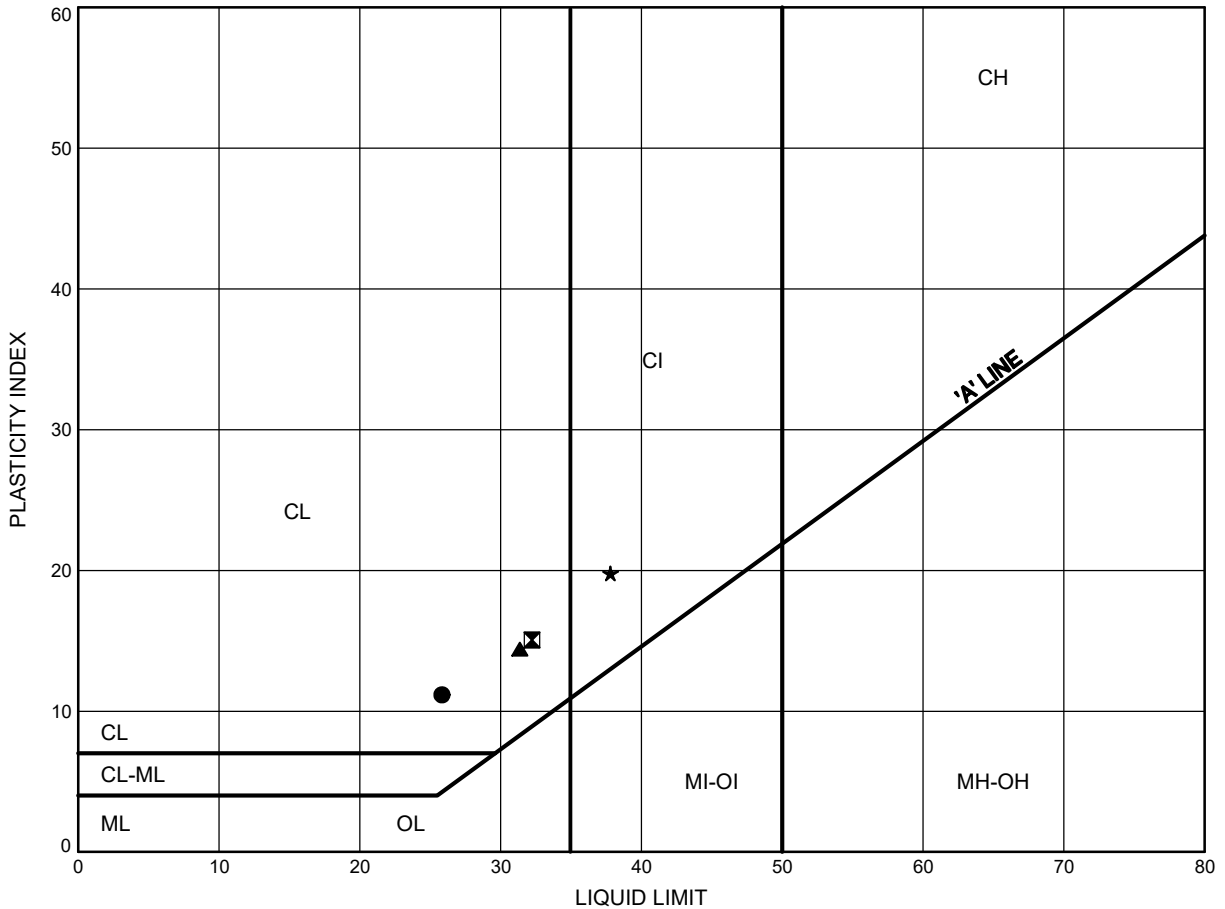
Chkd. GRL



# ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Clayey SILT to Silty CLAY TILL



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLRN 17-03	4.9	174.6
⊠	CLRN 17-03	7.9	171.6
▲	CLRN 17-04	1.8	177.6
★	CLRN 17-04	11.0	168.4

Date December 2017

W.P.



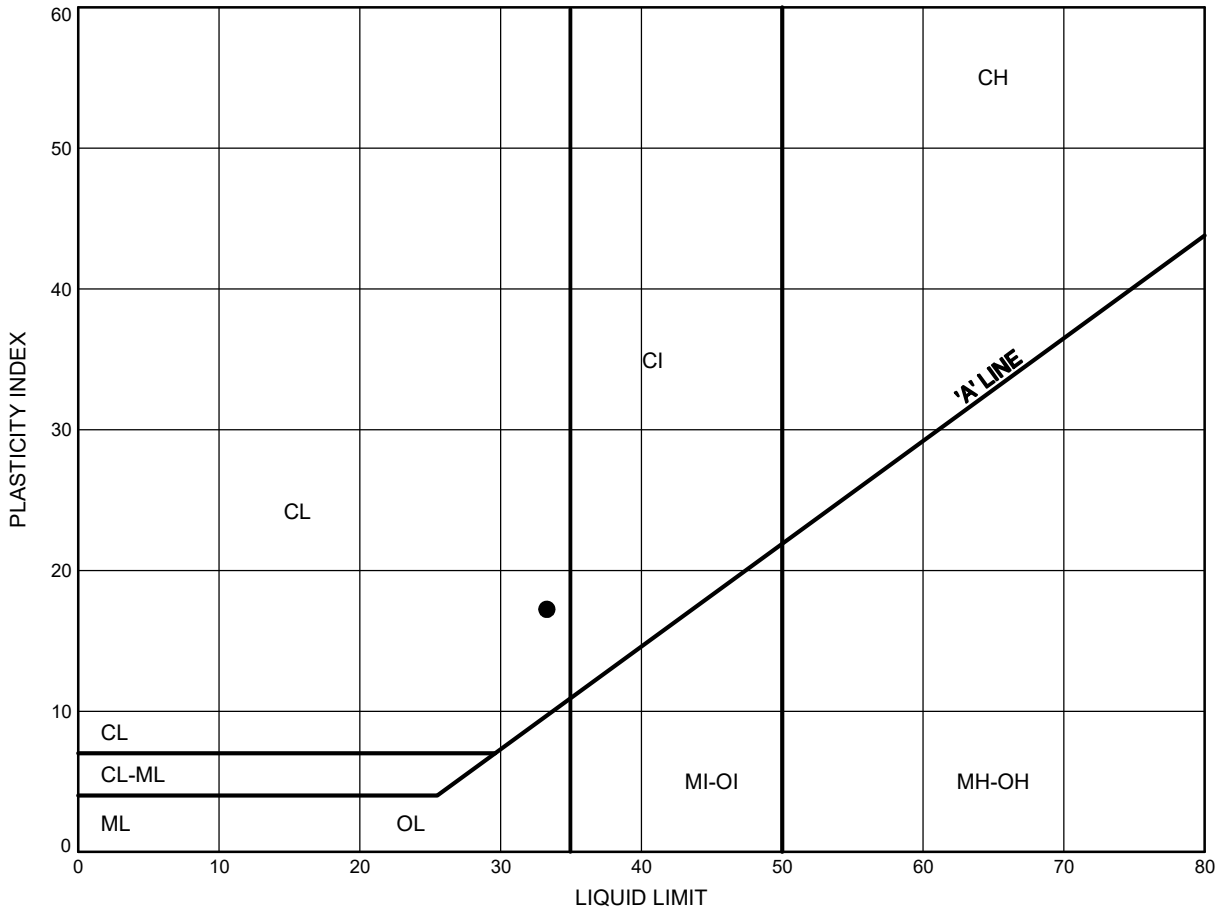
Prep'd AN

Chkd. GRL

# ATTERBERG LIMITS TEST RESULTS

FIGURE B6

Silty CLAY Seam



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLRN 17-04	7.9	171.5

Date December 2017  
W.P. ....

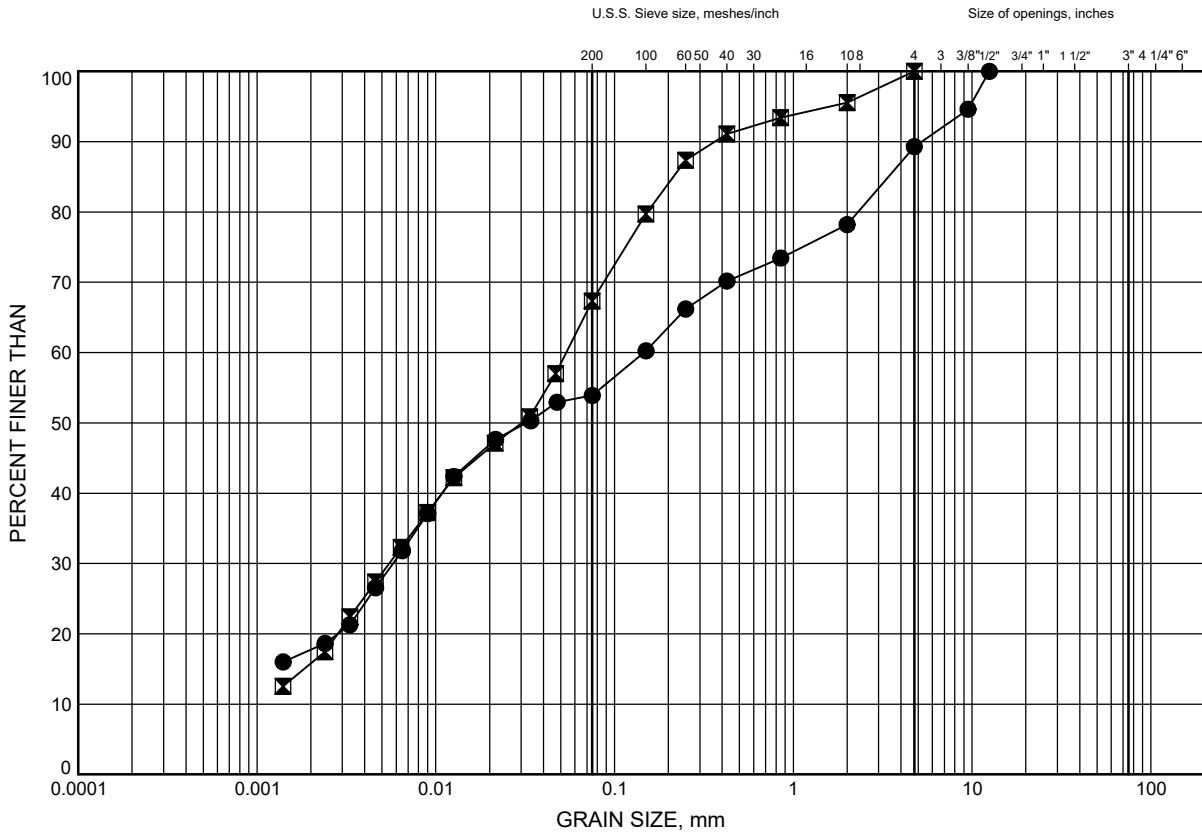


Prep'd AN  
Chkd. GRL

# GRAIN SIZE DISTRIBUTION

FIGURE B7

## Clayey SILT to Silty CLAY TILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLRB 17-02	9.4	180.6
■	CLRB 17-03	6.4	179.5

Date December 2017  
W.P. ....

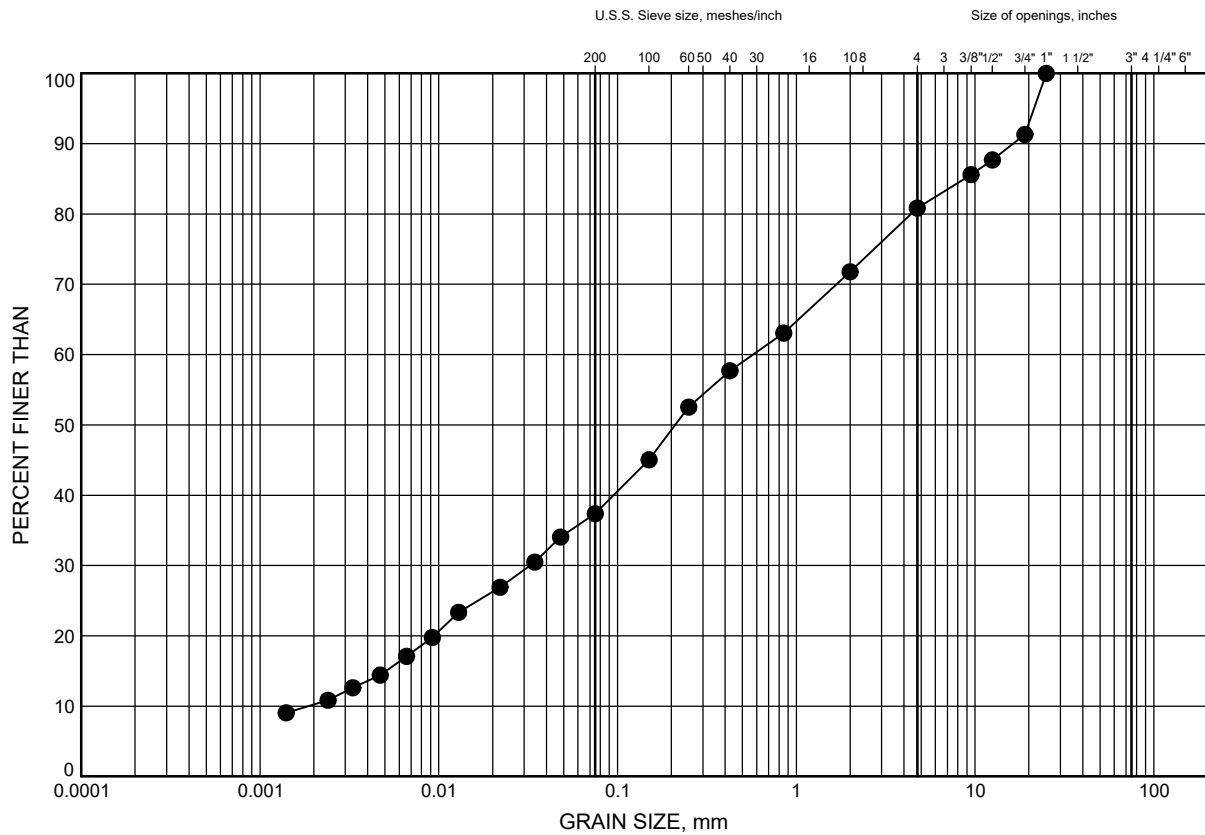


Prep'd AN  
Chkd. GRL

# GRAIN SIZE DISTRIBUTION

FIGURE B8

## Silty SAND TILL Seam



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLRB 17-01	4.9	184.6

Date December 2017  
W.P.

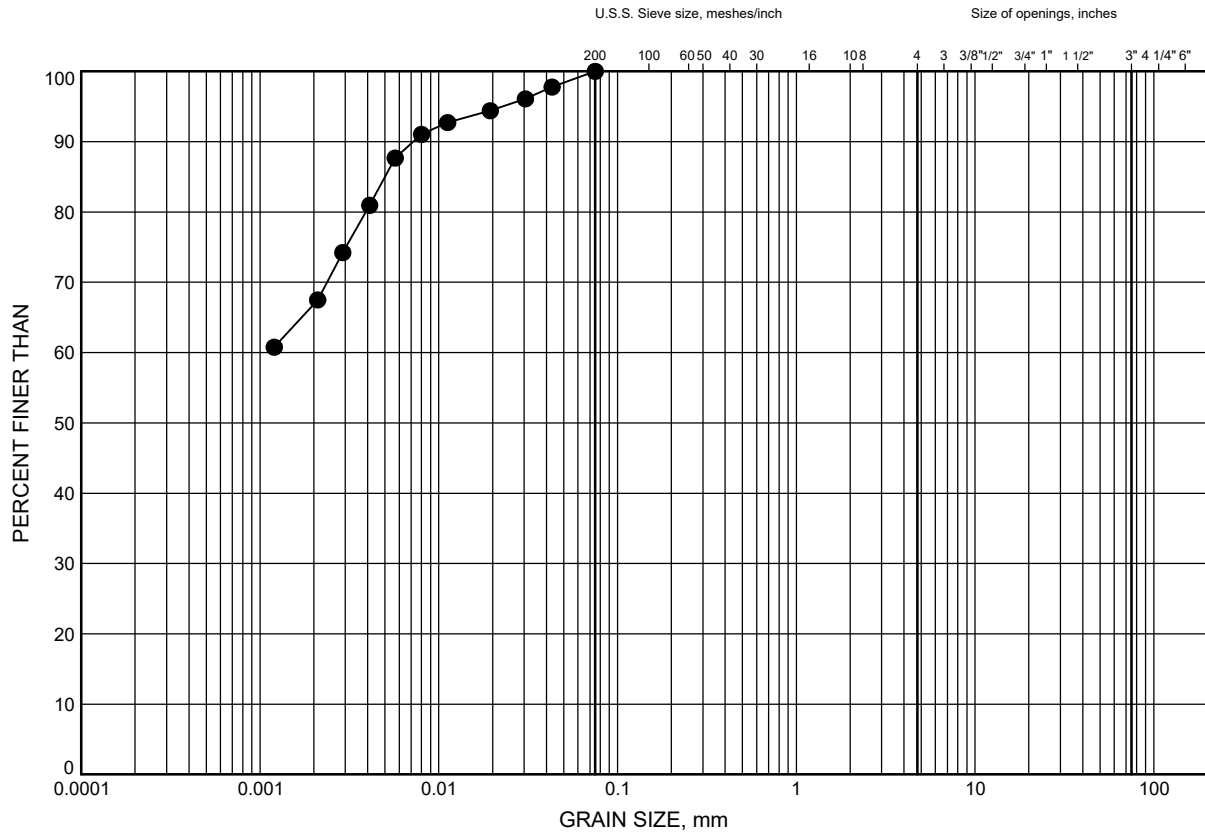


Prep'd AN  
Chkd. GRL

# GRAIN SIZE DISTRIBUTION

FIGURE B9

## Silty CLAY Seam



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLRB 17-03	9.4	176.5

Date December 2017  
W.P. ....

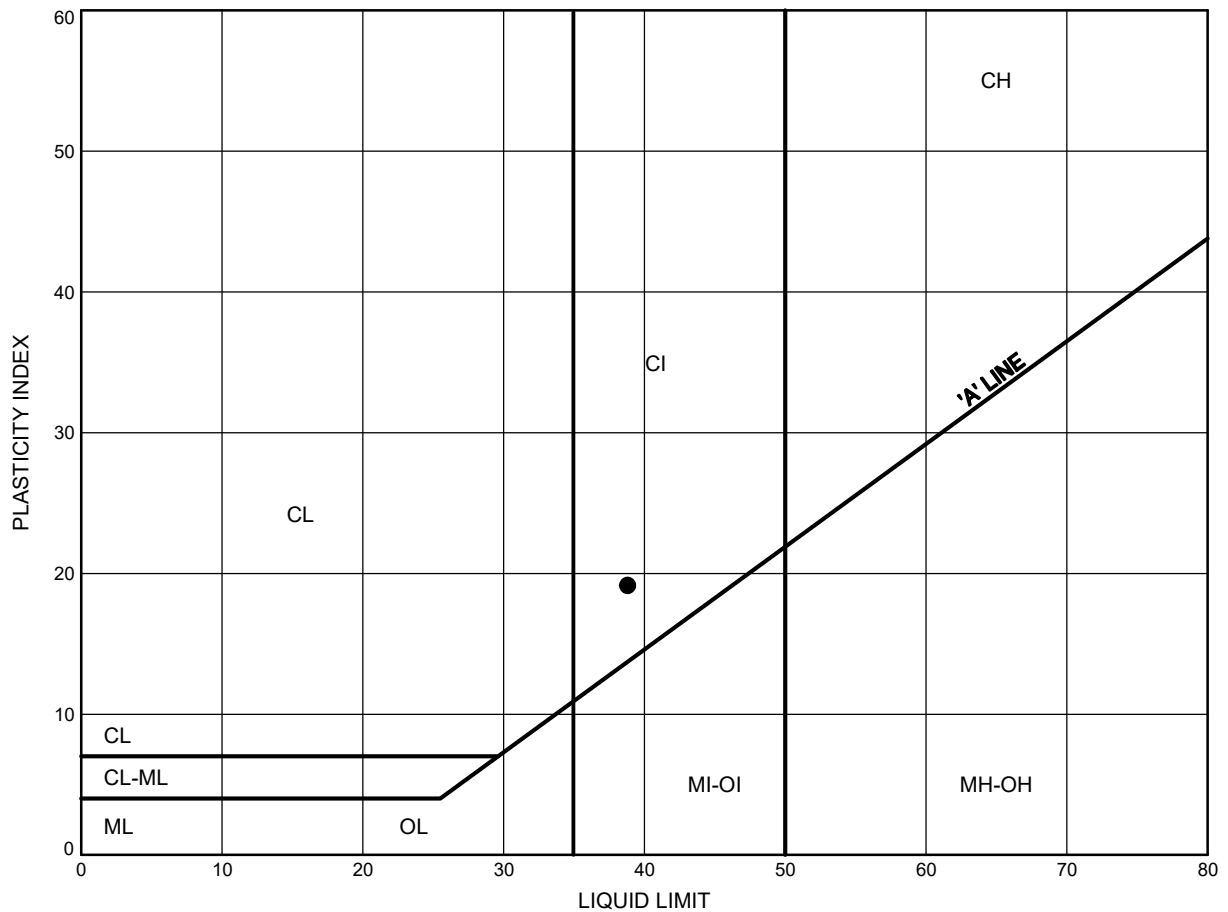


Prep'd AN  
Chkd. GRL

# ATTERBERG LIMITS TEST RESULTS

FIGURE B10

Silty CLAY



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLRB 17-01	1.1	188.4

Date December 2017  
W.P. ....

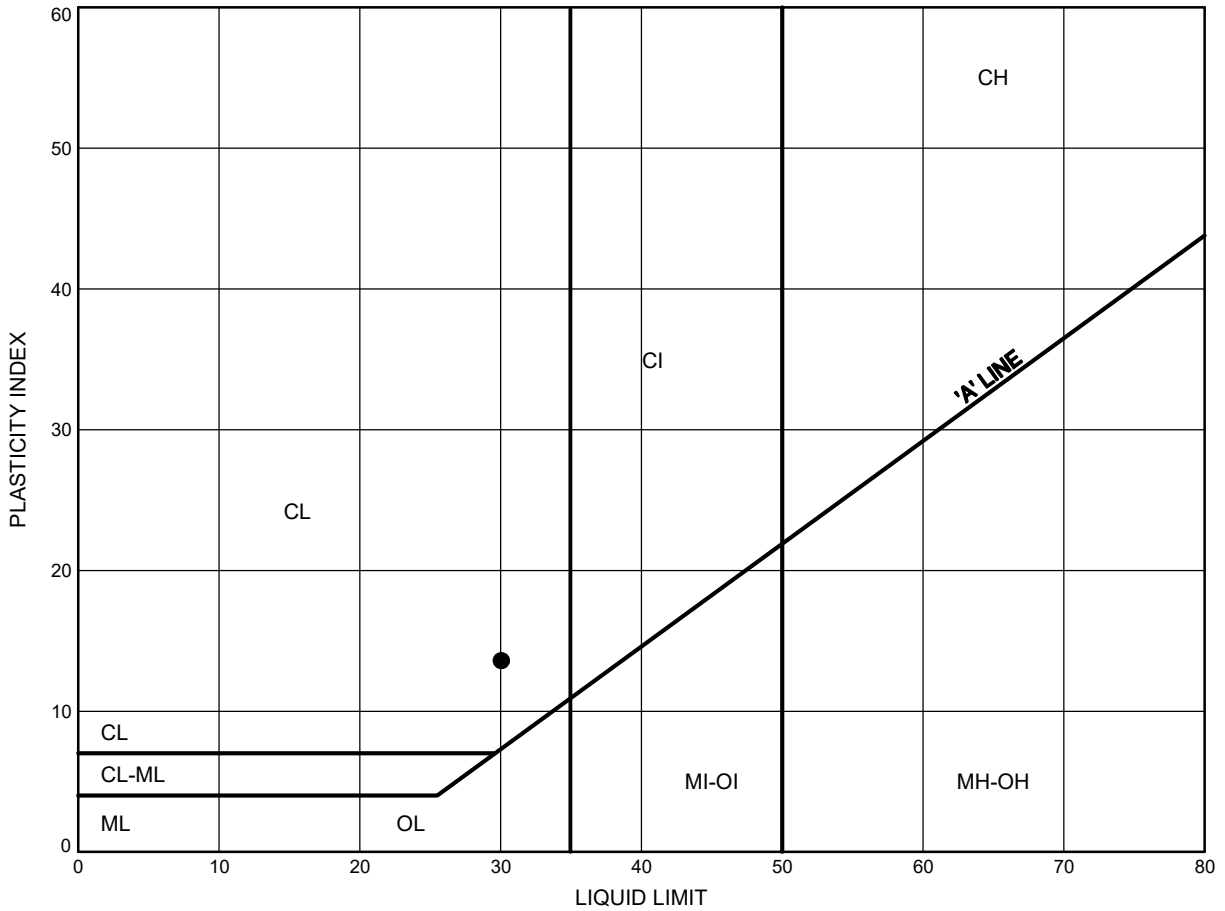


Prep'd AN  
Chkd. GRL

# ATTERBERG LIMITS TEST RESULTS

FIGURE B11

Clayey SILT to Silty CLAY TILL



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLRB 17-02	2.6	187.4

Date December 2017  
W.P. ....

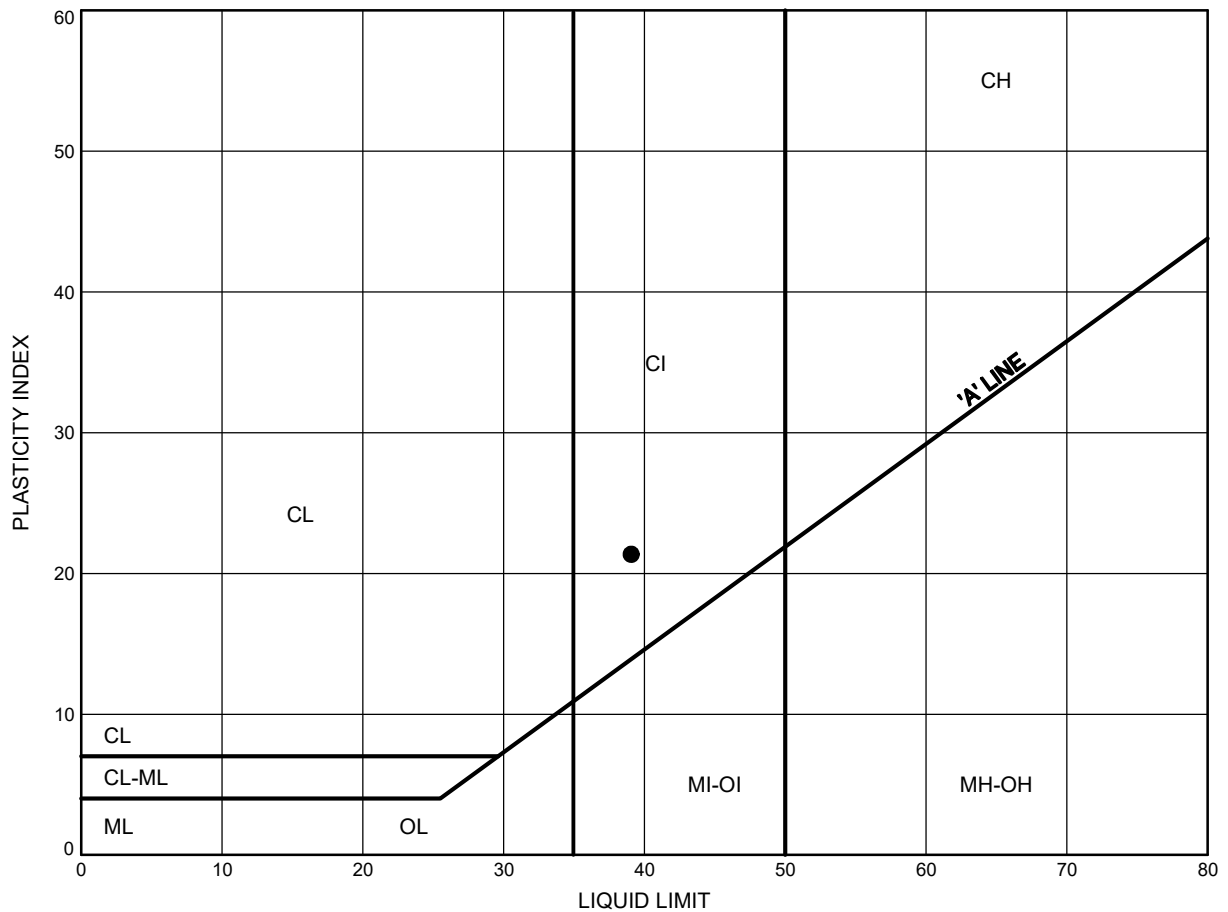


Prep'd AN  
Chkd. GRL

# ATTERBERG LIMITS TEST RESULTS

FIGURE B12

Silty CLAY Seam



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLRB 17-03	9.4	176.5

Date December 2017  
W.P. ....



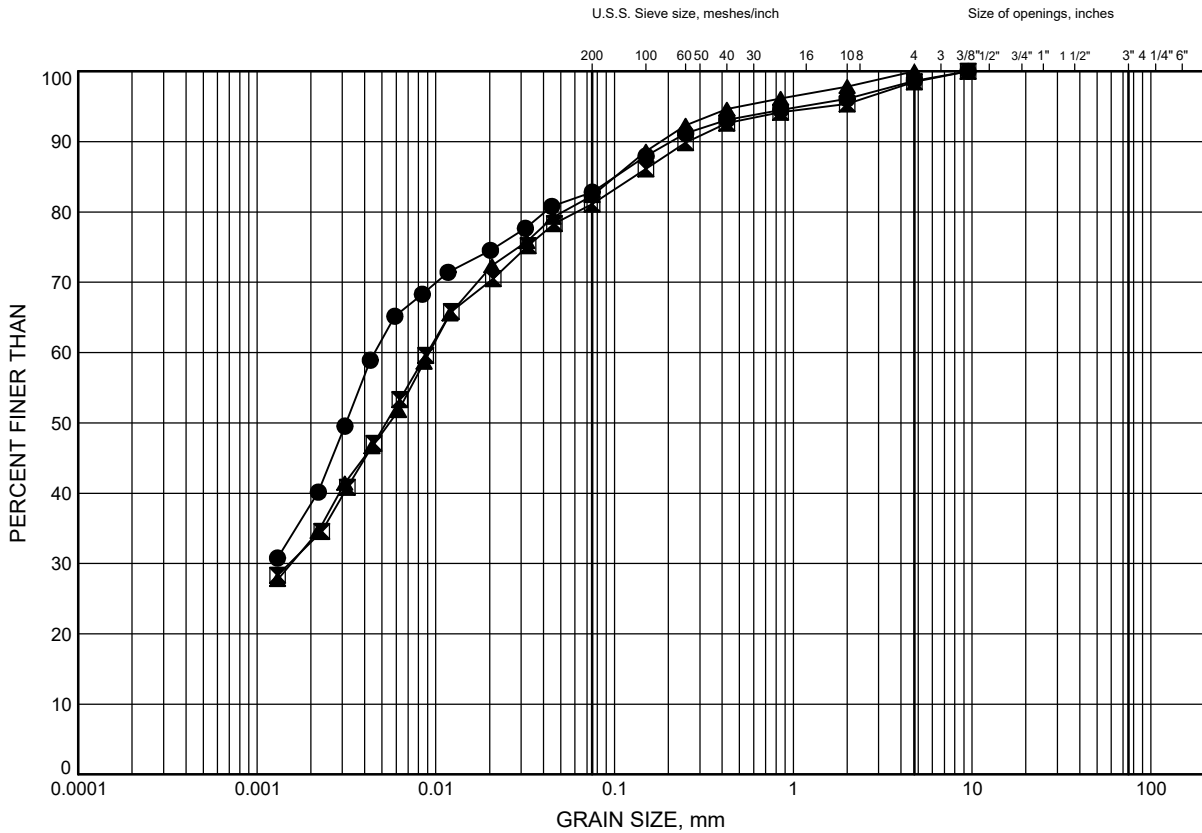
Prep'd AN  
Chkd. GRL



# GRAIN SIZE DISTRIBUTION

FIGURE B13

## Clayey SILT to Silty CLAY TILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLM 17-04	9.4	191.6
⊠	CLM 17-04	12.5	188.5
▲	CLM 17-05	1.8	200.7

Date December 2017

W.P.



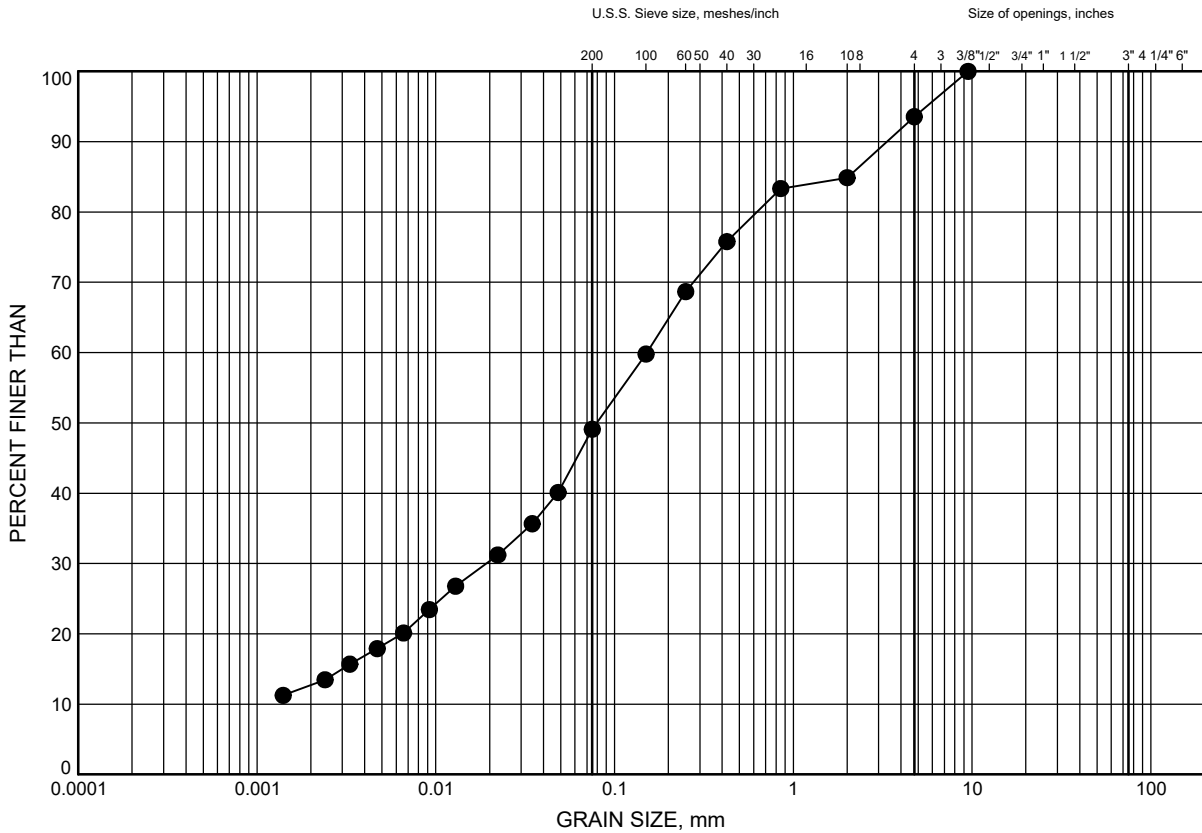
Prep'd AN

Chkd. GRL

# GRAIN SIZE DISTRIBUTION

FIGURE B14

## SAND and SILT TILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLM 17-06	9.4	193.4

Date December 2017  
W.P.

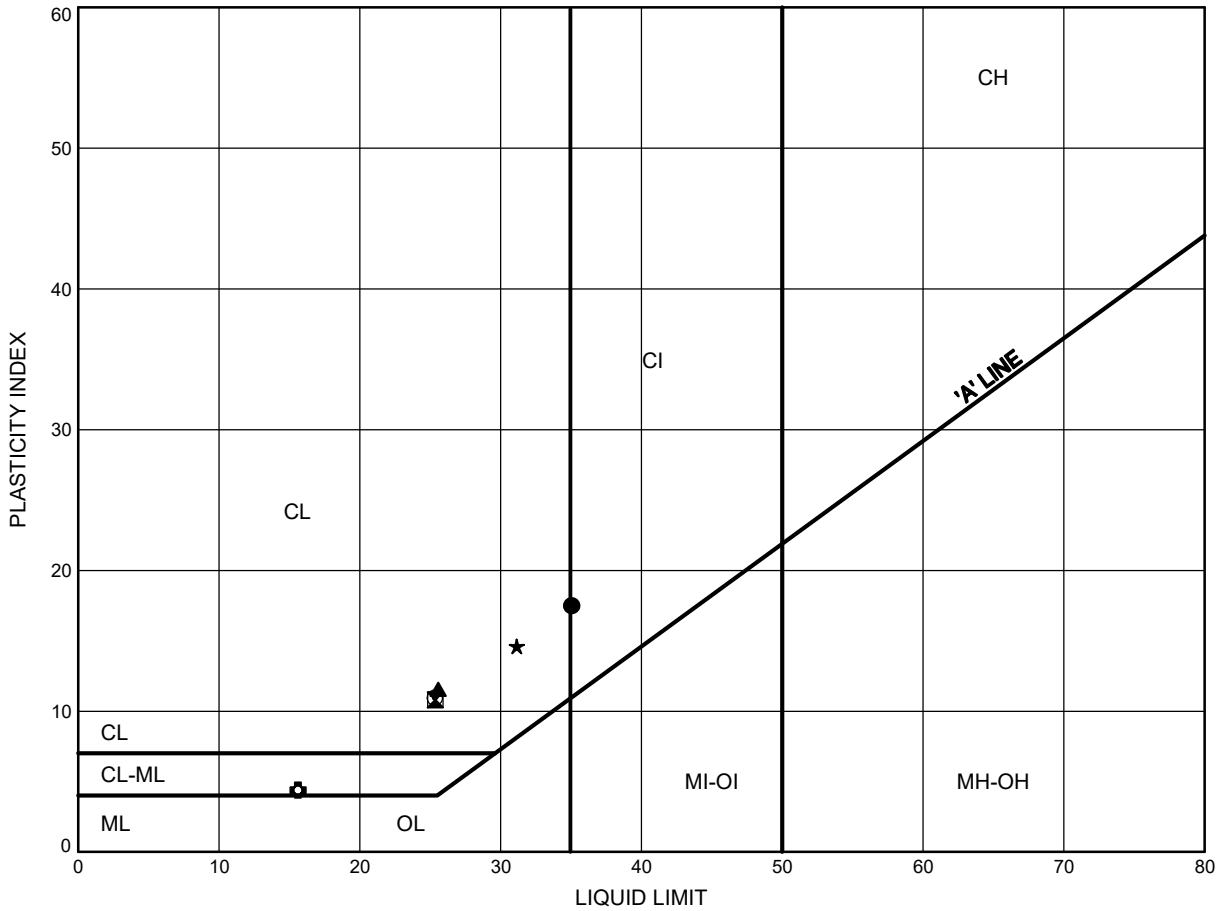


Prep'd AN  
Chkd. GRL

# ATTERBERG LIMITS TEST RESULTS

FIGURE B15

Clayey SILT to Silty CLAY TILL



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLM 17-04	3.4	197.6
⊠	CLM 17-04	9.4	191.6
▲	CLM 17-04	12.5	188.5
★	CLM 17-05	1.8	200.7
⊙	CLM 17-05	6.4	196.1
⊕	CLM 17-06	7.9	194.9

Date December 2017  
W.P. ....

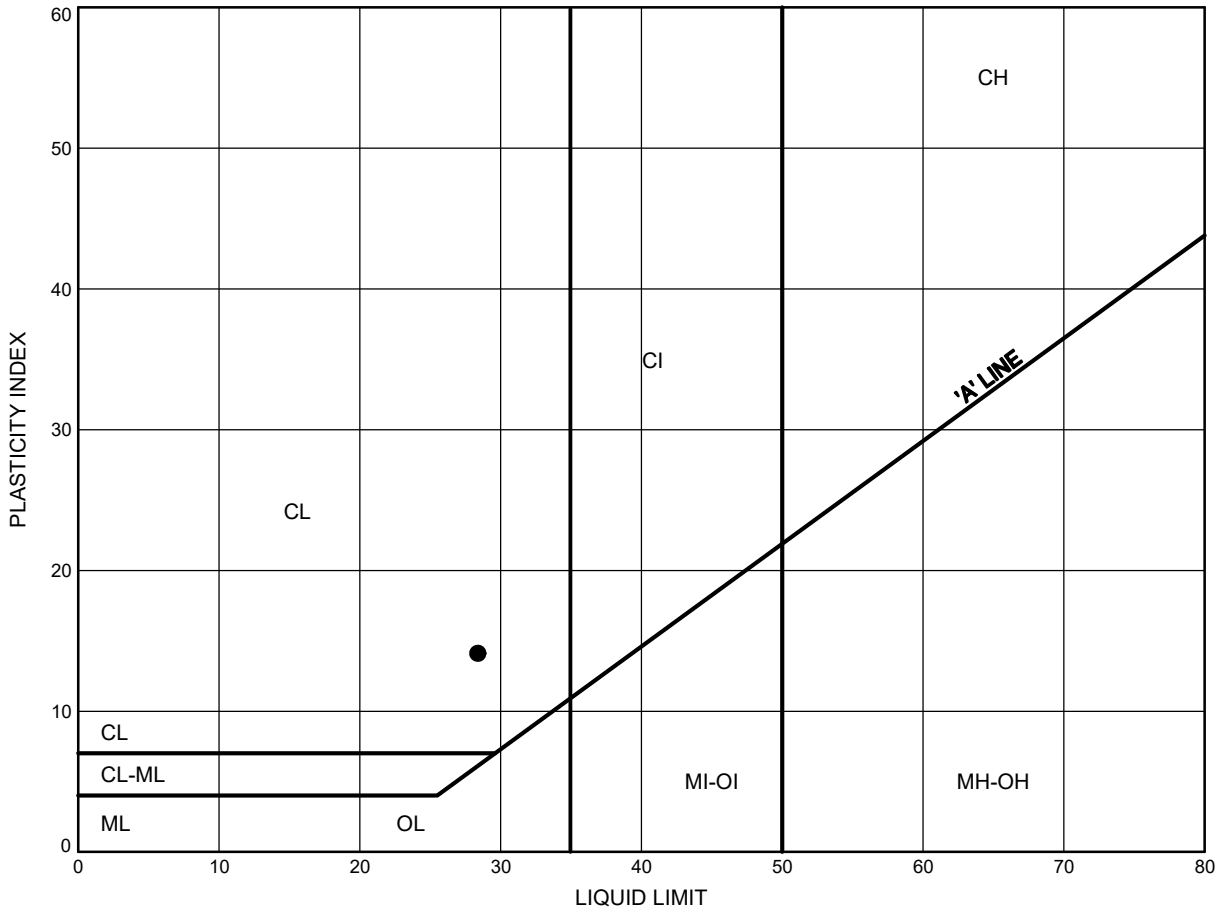


Prep'd AN  
Chkd. GRL

# ATTERBERG LIMITS TEST RESULTS

FIGURE B16

Clayey SILT to Silty CLAY TILL



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CLM 17-06	12.5	190.3

Date December 2017  
W.P. ....



Prep'd AN  
Chkd. GRL

## Certificate of Analysis

SGS Canada Inc.  
185 Concession St. Box 4300  
Lakefield, Ont., Canada, K0L 2H0



Client  
SGS LIMS Number  
Analysis Package:

Attention: Mohammad Eghtsadi  
Project#: 12307-427  
Thurber Engineering Ltd.  
CA14595-JUL17  
Corrosivity (Soil)

Sample ID	Unit	CLM 17-04, SS5 (10-12')	CLM 17-06, SS2 (2.6'-16')
-----------	------	-------------------------	---------------------------

Sample Date/Time		06-Jul-17	06-Jul-17
Moisture	%	13.3	12.4
pH	no unit	8.38	8.73
Corrosivity Index	none	1.0	4.0
Soil Redox Potential	mV	239	250
Sulphide	%	<0.02	<0.02
Chloride	µg/g	43	1.3
Sulphate	µg/g	280.0	18
Conductivity	uS/cm	272	90
Resistivity (calculated)	Ohms.cm	3680	11100

Corrosivity Scale according to AWWA C-105.  
An index greater than 10 indicates the  
soil matrix may be corrosive to cast iron alloys.

Deanna Edwards B.Sc., C.Chem  
Project Specialist  
Environment, Health and Safety

## Certificate of Analysis

SGS Canada Inc.  
185 Concession St. Box 4300  
Lakefield, Ont., Canada, K0L 2H0



Client  
SGS LIMS Number  
Analysis Package:

Attention: Mohammad Eghtesadi  
Project#: 12307 427  
Thurber Engineering Ltd.  
CA14883-JUN17  
Corrosivity (Soil)

Sample ID	Unit	CLRB17-01, SS2 (2'6"-4'6")	CLRB17-03, SS3 (5'- 7')
-----------	------	-------------------------------	----------------------------

Sample Date/Time		12-Jun-17	13-Jun-17
------------------	--	-----------	-----------

Moisture	%	23.1	12.6
pH	no unit	8.12	8.42
Corrosivity Index	none	1.0	1.0
Soil Redox Potential	mV	285	274
Sulphide	mg/L	<0.02	<0.02
Chloride	mg/L	8.7	1.5
Sulphate	mg/L	31	70
Conductivity	uS/cm	142	138
Resistivity (calculated)	ohms.cm	7030	7220

Corrosivity Scale according to AWWA C-105.

An index greater than 10 indicates the  
soil matrix may be corrosive to cast iron alloys.

Deanna Edwards B.Sc., C.Chem  
Project Specialist  
Environment, Health and Safety

Data reported represents the sample submitted to SGS. Reproduction of this analytical report in full or in part is prohibited without prior written approval. Please refer to SGS General Conditions of Services located at [http://www.sgs.com/terms\\_and\\_conditions\\_service.htm](http://www.sgs.com/terms_and_conditions_service.htm).  
(Printed copies are available upon request.). Test Method information available upon request. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.



Client  
SGS LIMS Number  
Analysis Package:

Attention: Mohammad Eghtesadi  
Project#: 12307 427  
Thurber Engineering Ltd.  
CA14884-JUN17  
Corrosivity (Soil)

Sample ID	Unit	CLRN17-01, SS2 (2'6"-4'6")	CLRN17-02, SS4 (7'6"-9'6")	CLRN17-04, SS5 (10'- 12')
Sample Date/Time		13-Jun-17	12-Jun-17	13-Jun-17
Moisture Content	%	12.0	12.7	12.0
pH	no unit	8.66	8.52	8.61
Corrosivity Index	none	4.0	4.0	7.5
Soil Redox Potential	mV	333	203	222
Sulphide	%	< 0.02	< 0.02	0.03
Chloride	µg/g	1.5	3.0	2.4
Sulphate	µg/g	56	62	140
Conductivity	uS/cm	132	164	149
Resistivity (calculated)	Ohms.cm	7550	6110	6700

Corrosivity Scale according to AWWA C-105.

An index greater than 10 indicates the  
soil matrix may be corrosive to cast iron alloys.

Deanna Edwards B.Sc., C.Chem  
Project Specialist  
Environment, Health and Safety

Data reported represents the sample submitted to SGS. Reproduction of this analytical report in full or in part is prohibited without prior written approval. Please refer to SGS General Conditions of Services located at [http://www.sgs.com/terms\\_and\\_conditions\\_service.htm](http://www.sgs.com/terms_and_conditions_service.htm).  
(Printed  
copies are available upon request.). Test Method information available upon request. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

## Appendix C

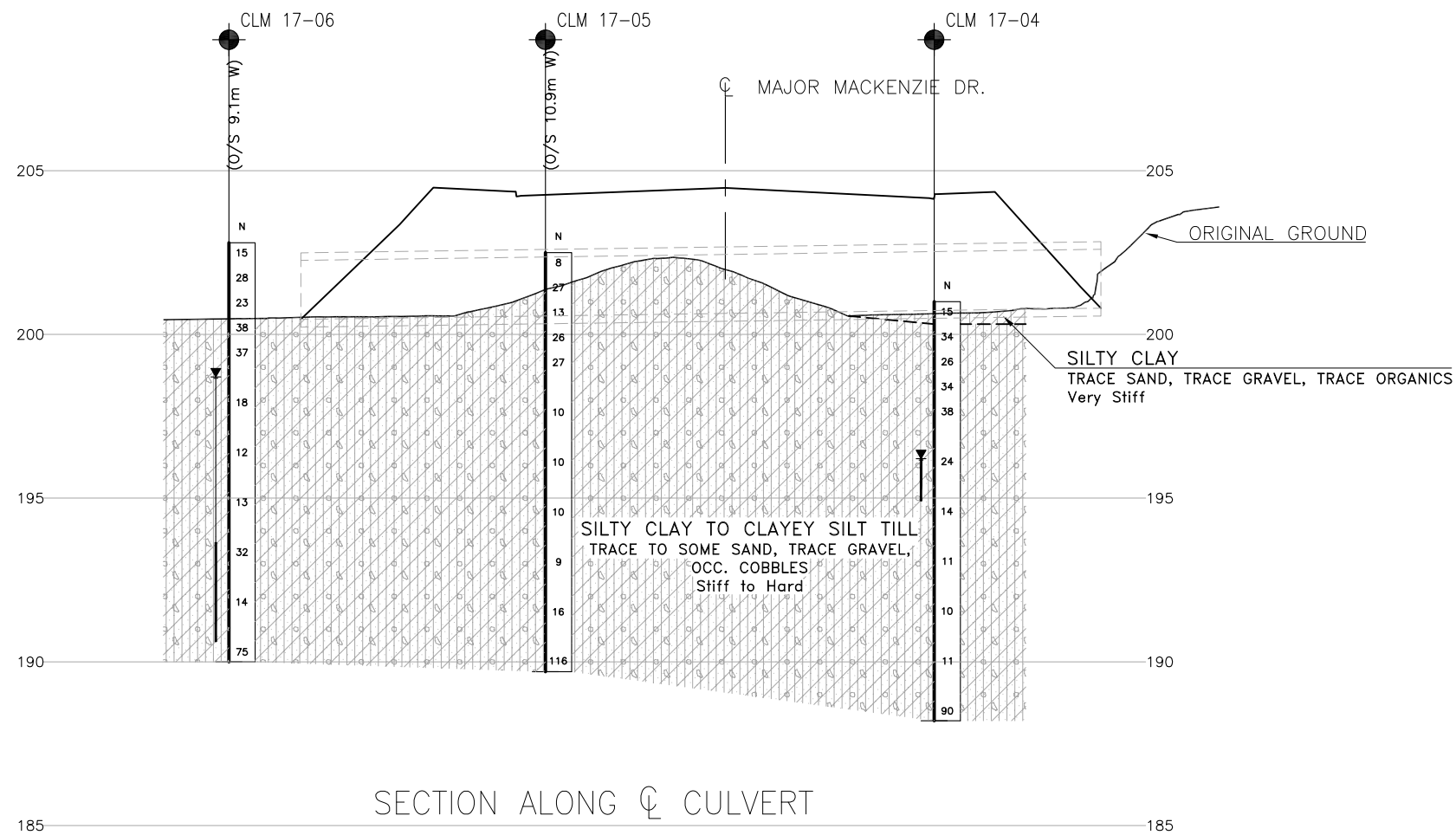
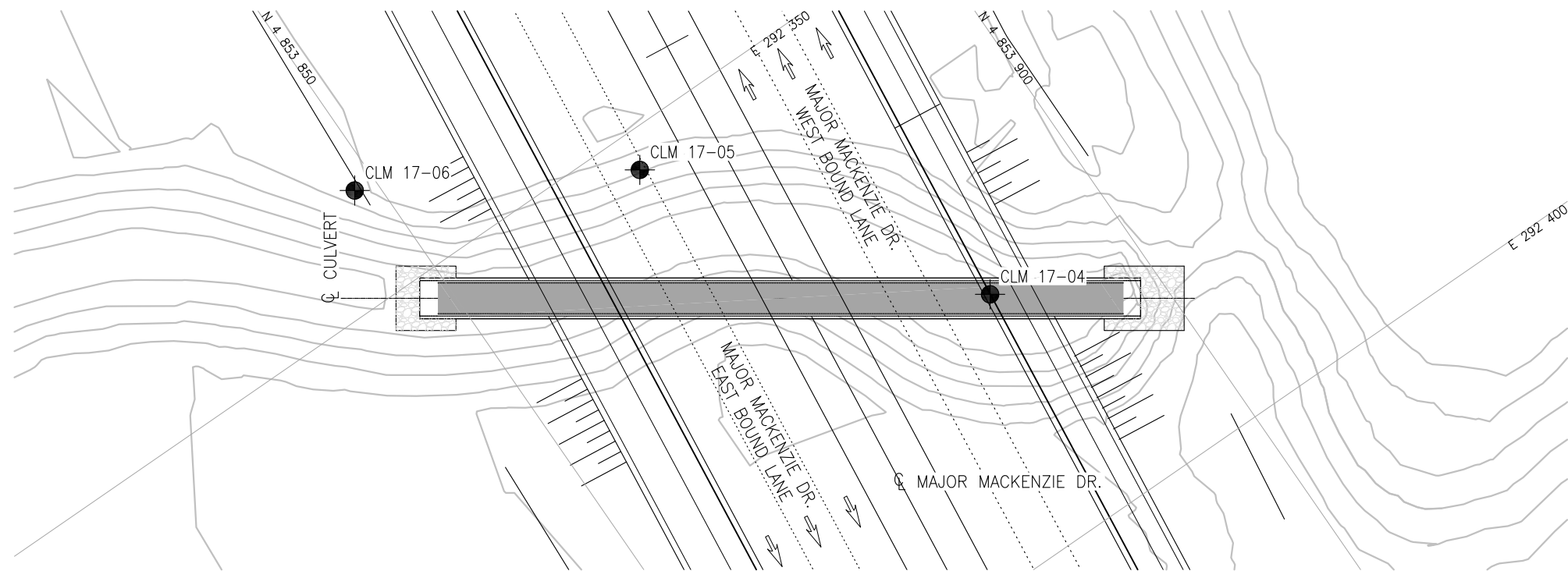
### Borehole Locations and Soil Strata Drawings
















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

CONT No  
WP No



## 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

[illegible]

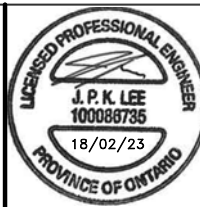
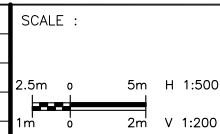
-NOTES-

- 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.

GEOCRES No.

PLOTDATE: 2/22/2018 6:18 PM

LOT/DATE: 2/22/2018 6:18 PM						
A	18/02/23	100% SUBMISSION TO CA	AN	KS	JL	JL
NO.	DATE	REVISIONS	BY	CHK	LEAD DISC.	PROD. MAN.



CONSULTANT	DESIGNED	A. PIASCIK	AP	18/02/23
	DRAWN	A. NOOR	AN	18/02/23
	CHECKED	K. SHI	KS	18/02/23
	APPROVED LEAD ENGINEER	J. LEE	JL	18/02/23
	APPROVED PROJ. MANAGER	J. LEE	JL	18/02/23
	NAME (PRINT)	INIT.	DATE	



TITLE HWY 427 EXPANSION BOX CULVERT W017 MAJOR MACKENZIE DRIVE STA 10+524 BOREHOLE LOCATIONS AND SOIL STRATA							
PROJECT ID.	STAGE NUMBER	DESIGN PACKAGE NUMBER	DISCIPLINE	STRUCTURE NUMBER	DOCUMENT TYPE	DRAWING NUMBER	REVISION NUMBER
H427-D	H	3	STR	S53	DWG	701	A

#### Appendix D

Record of Borehole Sheets – Previous Investigation

(Geocres Report No.: 30M13-176)

# RECORD OF BOREHOLE No C8

1 OF 1 **METRIC**

PROJECT 06-1111-012

W.O. 05-20012

LOCATION N 4851323.3;E 293481.9

ORIGINATED BY JEB

DIST Central HWY 427

BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers

COMPILED BY PKS/VA

DATUM Geodetic

DATE March 30, 2009

CHECKED BY SM

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			20	40	60	80	100				
186.9	GROUND SURFACE															
0.0	CLAYEY SILT, trace gravel, trace sand, containing rootlets		1	SS	4											
186.3	Firm Brown Moist															
0.6	CLAYEY SILT, some sand, trace gravel, containing sand seams and cobbles (TILL)		2	SS	17		186									1 13 62 24
	Very stiff to hard		3	SS	29		185									
	Brown to grey Moist		4	SS	47		184									
	Containing sand seams between depths of 3.0 m and 3.7 m		5	SS	36		183									
	Becoming grey below a depth of 3.8 m		6	SS	27		182									
			7	SS	20		181									
			8	SS	38		180									
	Cobbles encountered at a depth of 7.0 m		9	SS	101		179									
			10	SS	107		178									
177.2	END OF BOREHOLE															
9.8	NOTES:  1. A 50 mm diameter monitoring well was installed at a depth of 9.1 m (Elev. 177.8 m).  Water level measurements  Date Depth Elev.  On Completion Dry April 24, 2009 1.7 m 185.2 m May 21, 2009 2.5 m 184.4 m June 15, 2009 2.3 m 184.6 m July 09, 2009 2.2 m 184.7 m															

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No C9

1 OF 1 **METRIC**

PROJECT 06-1111-012

W.O. 05-20012

LOCATION N 4851338.9 : E 293427.6

ORIGINATED BY JEB

DIST Central HWY 427

BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers

COMPILED BY PKS/VA

DATUM Geodetic

DATE March 27, 2009

CHECKED BY SMG *SMG*

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							
188.3	GROUND SURFACE							20	40	60	80	100			
0.0	TOPSOIL														
0.2	CLAYEY SILT, trace gravel, trace sand, containing rootlets (Reworked)		1	SS	4		188								
187.7	Firm Brown Moist		2	SS	12		187								
0.6	CLAYEY SILT, some sand, trace gravel (TILL)		3	SS	25		186								
	Stiff to hard Brown to grey Moist		4	SS	36		185								
			5	SS	37		184								
	Becoming grey below a depth of 3.8 m		6	SS	26		183								
			7	SS	15		182								
			8	SS	16		181								
	Containing sand partings at a depth of 7.5 m		9	SS	52		180								
			10	SS	49		179								
178.6	END OF BOREHOLE														
9.8	NOTES:  1. Open borehole dry upon completion of drilling.  2. Borehole backfilled with bentonite.														

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD