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Highway 427 Expansion – Package 3A (100% Submission)  
Highway 427 NBL/SBL over West Robinson Creek Bridges (Structures B16A/B16B)

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## Statement of Limitations and Conditions

### APPENDICES

Appendix A	Record of Borehole Sheets – Current Investigation
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## 1. INTRODUCTION

This report presents the results of a foundation investigation and provides foundation recommendations for the design and construction of the proposed bridges to carry northbound lane (NBL) and southbound lane (SBL) of Highway 427 over West Robinson Creek (WRC). The project is part of the proposed 6.6 km long extension of Highway 427 from Highway 7 to Major Mackenzie Drive in the City of Vaughan, Ontario.

Recommendations on the foundation aspects of the bridge design presented in this report were based on the interpretation of the subsurface information obtained during the current foundation investigation by Thurber Engineering (Thurber) as well as previous investigations at the site the results of which were presented in the reports listed below:

1. GEOCRE 30M13-172: Preliminary Foundation Investigation and Design Report, West Robinson Creek Bridges (NBL and SBL), Highway 427 Extension from Highway 7 to Major Mackenzie Drive, Ministry of Transportation, Ontario, W.O. 05-20012, dated August 2009, prepared by Golder Associates Ltd.
2. GEOCRE 30M13-216: Preliminary Foundation Investigation and Design Report, Highway 427 Expansion Project, Extension from Highway 7 to Major Mackenzie Drive, City of Vaughan, Ontario, W.O. 18, dated March 2016, prepared by Peto MacCallum Ltd.

Foundation recommendations presented in this report were prepared based on General Arrangement (GA) drawings H427-D-N-3A-STR-B16A-DWG-500-A and H427-D-N-3A-STR-B16B-DWG-600-A.

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, GEOLOGY BACKGROUND AND PROJECT DESCRIPTION

The site is located approximately 350 m east of Huntington Road and 450 m south of McGillivray Road in Vaughan.

The proposed bridges will be located within the flood plain of the WRC valley. The WRC at the site is about 3 m to 4 m wide and the stream flows west to east. The bottom of the creek elevation varies between 192 m and 194 m. The crest of the south and north valleys at the site are up to 8 m to 10.5 m above the creek level, with existing slopes between 2.5 and 3.5 horizontal to one vertical (2.5H:1V and 3.5H:1V).

The site is situated within the Peel Plain physiographic region the subsurface condition in which generally comprises clayey silt to silty clay 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.

Based on the GA drawing, the two proposed bridges for the site are two-span bridges (NBL and SBL) with integral abutment configuration and the foundation of the piers supported either on driven steel piles or on a spread footing (as an option). The side slopes and foreslopes of the approaches and the abutments will be at a slope of 2H:1V.

## 3. GEOTECHNICAL INVESTIGATION

The current field investigation at the proposed bridge site was conducted between June 12 and July 13, 2017, and consisted of advancing six (6) boreholes, designated as Boreholes WR17-01 to WR17-06 to depths ranging between 9.8 m and 42.1 m.

Borehole coordinates and ground surface elevations at the borehole locations were derived from topographic

drawings provided by WSP/MMM. The Record of Borehole sheets (which includes the approximate locations in MTM NAD 83, Zone 10 coordinates), the Borehole Locations and Soil Strata Drawing are included in the appendices.

Track mounted CME 55 drill rigs supplied by Walker Drilling Ltd. Of Utopia, Ontario, were 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 bedrock was confirmed by a minimum of 3 m coring using NQ-sized coring in two boreholes. All rock cores were logged, and Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and Fracture Indices (FI) were determined.

Groundwater conditions were observed in the open boreholes throughout the drilling operations and measured upon completion of drilling. However, since water was used during the drilling operations these measurements were considered not reliable. Standpipe piezometers were installed in Boreholes WR17-02 to WR17-06. Borehole WR17-01 was backfilled as per O. Reg. 903.

Nine borehole records are available from the previous investigations. Boreholes S19A, S19 to S24 from the 2009 report and Boreholes WRB-1 and WRB-2 from the 2016 report are enclosed in the appendices.

#### **4. SUBSURFACE CONDITIONS**

A general description of the stratigraphy is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description which was prepared for interpretation of the site conditions. Subsurface soil conditions may vary between and beyond borehole locations.

In general, the subsurface conditions at the site consist of a layer of surficial silty clay overlying an upper cohesive till which is underlain by a silt to sand layer over a lower deposit of cohesive till which is in turn underlain by shale bedrock. Interlayers of non-cohesive till were also encountered at the borehole locations. Occasional auger grinding, hard augering, and/or split spoon bouncing were noted during advancing the boreholes in both cohesive and non-cohesive till deposits which are indications of presence of cobbles and/or boulders as expected to be present in till deposits of southern Ontario.

More descriptions of the subsurface conditions at the site are presented below.

##### **4.1 Topsoil**

Topsoil with its thickness ranging from 125 mm to 300 mm was encountered at the ground surface in Boreholes WR17-01, 02, 04 to 06. Topsoil thickness may vary between boreholes and in other areas of the site.

##### **4.2 Surficial Clayey Silt to Silty Clay**

A 0.6 m to 1.4 m thick deposit of clayey silt to silty clay was encountered in all current boreholes underlying the topsoil and extended to depths ranging between 0.7 m and 1.7 m (Elev. 192.0 m and 199.1 m). The SPT-N values within the deposit ranged from 2 to 8 blows per 0.3 m of penetration indicating a soft to stiff (predominantly firm) consistency.

##### **4.3 Upper Cohesive Till**

Clayey silt to silty clay till was encountered underlying the topsoil and/or clayey silt to silty clay, and extended to depths ranging between 8.7 m and 16.3 m (Elev. 185.0 m and 178.4 m).

SPT-N values within the upper cohesive till ranged from 6 blows to greater than 100 blows per 0.3 m of penetration indicating a firm to hard (predominantly very stiff to hard) consistency.

##### **4.4 Silt to Sand**

A deposit of silt, silty sand and/or sand was encountered below the upper cohesive till in all boreholes except WR17-01 and extended to depths ranging between 16.3 m and 28.5 m (Elev. 166.2 m and 178.4 m).

SPT-N values within the deposit ranged from 13 to 117 blows per 0.3 m of penetration indicating the deposit is compact to very dense (predominantly dense).

#### 4.5 Silt and Sand Till

Layers of silty sand to silt and sand till were encountered below the cohesive till, and below the silt to sand in Boreholes WR17-02 to -04 and -06 and extended to depths ranging between 31.7 m and 37.2 m (Elev. 159.4 m and 164.7 m). The SPT-N values within the layer ranged from 19 blows to greater than 100 blows per 0.3 of penetration indicating that the layer is compact to very dense (predominantly very dense).

#### 4.6 Lower Cohesive Till

A lower deposit of clayey silt to silty clay till was encountered below or within the silt to sand and extended to depths ranging between 19.7 m and 40.2 m (Elev. 174.0 m and 154.5 m).

SPT-N values within the lower cohesive till ranged from 14 blows to greater than 100 blows per 0.3 m of penetration indicating a stiff to hard (predominantly very stiff to hard) consistency.

#### 4.7 Shale Bedrock

Grey shale bedrock of the Georgian Bay Formation was confirmed by coring in Boreholes WR17-02 and 05. The bedrock surface was encountered at depths of 34.4 m and 38.1 m (Elev. 164.7 m and 155.6 m), respectively. The TCR, SCR, and RQD values recorded in Borehole WR17-02 are not considered reliable due to coring equipment deficiencies.

#### 4.8 Groundwater Levels

Water levels measured in the piezometers installed during the current investigation are summarized in Table 4.1.

**Table 4.1 – Piezometer Details and Groundwater Level Measurements**

Borehole	Measurement Date	Water Level (m)		Native Material at Screen
		Depth	Elevation	
WR17-02	August 8, 2017	18.1	181.0	Sand
	Oct 23, 2017	17.9	181.2	
WR17-03 (S)	August 8, 2017	1.3	192.4	Upper cohesive till
	Oct 23, 2017	1.6	192.1	
WR17-03 (D)	August 8, 2017	4.3	189.4	Silty sand
	Oct 23, 2017	4.6	189.1	
WR17-04	August 8, 2017	3.7	191.0	Silt
	Oct 23, 2017	3.9	190.8	
WR17-05 (S)	August 8, 2017	1.6	192.1	Upper cohesive till
	Oct 23, 2017	2.5	191.2	
WR17-05 (D)	August 8, 2017	11.0	182.7	Sand
	Oct 23, 2017	12.1	181.6	
WR17-06	August 8, 2017	18.1	179.4	Sand
	Oct 23, 2017	16.8	180.7	

(S) denotes Shallow piezometer, (D) denotes Deep piezometer

The above groundwater levels represent relatively short-term readings and seasonal fluctuations of the groundwater level are to be expected. The groundwater level may be at higher elevations after the spring snowmelt or after periods of heavy rainfall. Perched water may be present at higher levels in lenses or zones of

more permeable sands and silts within the till.

The preliminary General Arrangement drawing indicates a 100-year flood level up to Elev. 194.7 m and a regional storm level up to Elev. 195.6 m. The water level in the creek during construction will influence the groundwater level.

#### 4.9 Corrosion and Sulphate Test Results

Soil samples of the native soil collected from selected boreholes 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 4.2.

**Table 4.2 – Analytical Test Results**

Parameter Tested	Unit	WR17-02	WR17-03	WR17-05	WR17-06
		SS5	SS3	SS4	SS2
Moisture	%	18.6	15.4	17.5	14.9
Corrosivity Index	-	4	4	2	4
pH	-	8.66	8.66	8.28	8.62
Soil Redox Potential	mV	277	282	284	303
Sulphide	%	< 0.02	< 0.02	< 0.02	< 0.02
Chloride	µg/g	3	33	200	2
Sulphate	µg/g	5	14	200	3.9
Electrical Conductivity	µS/cm	95	106	367	68
Resistivity	ohms.cm	10500	9430	2720	14700

### 5. GEOTECHNICAL RECOMMENDATIONS

#### 5.1 Foundation Design

The available GA Drawing shows an integral abutment configuration for the abutments of both NBL and SBL bridges. Therefore, spread footings are not recommended for the abutments of the proposed bridges.

##### 5.1.1 Spread Footings

Spread footings with a width of about 4.5 m and a length of 17.2 m (as shown in the GA drawing) may be designed for the piers of the proposed structures based on the factored axial geotechnical resistances at ULS and SLS, provided in Table 5.1.

**Table 5.1 – Axial Geotechnical Resistances for Spread Footings**

Structure	Reference Borehole	Founding Elevation (m)	Founding Stratum	Factored ULS (kPa)	Factored SLS (for up to 25 mm of Settlement) (kPa)
NBL Pier	WR17-05	190.0	Hard cohesive till	600	400
SBL Pier	WR17-03				

The Geotechnical Reaction at SLS given above is for up to 25 mm of settlement. The Factored Geotechnical Resistance at ULS was assessed assuming a Consequence Factor equal to 1 (Typical), and a Resistance Factor equal to 0.5 (Typical degree of understanding of the subsurface conditions), as per CHBDC (2014). The Geotechnical Reaction 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 resistances should be calculated as indicated in the CHBDC 2014 Clause 6.10.3 and Clause 6.10.4.

Dewatering will be required to construct the pier footings in the dry.

#### 5.1.1.1 Lateral Resistance

The lateral resistance to sliding of the concrete footings founded on hard silty clay till may be computed using an unfactored friction coefficient of 0.45 for cast-in-place concrete. This value of friction coefficient is an “ultimate” value and requires a degree of sliding movement to occur to fully mobilize the resistance.

#### 5.1.1.2 Subgrade Preparation for Spread Footings

After the foundation excavation reaches the design subgrade level, the exposed surface should be inspected by qualified geotechnical personnel to confirm its conformance with the design requirements. Where sub-excavation is required to remove unsuitable material below the design founding level, the founding subgrade level should be re-established using mass concrete of the same class as the footing concrete.

The work should be carried out in accordance with OPSS 902 and construction must be carried out in the dry.

Once the subgrade is prepared the construction equipment should not travel on the subgrade. A 100 mm thick protective cover of mass concrete should be placed on the subgrade.

### 5.1.2 Driven H-Piles

Based on the available subsurface information, supporting the proposed bridges on steel H-piles driven in the very dense/hard till is feasible. The recommendations and discussion on design and construction of driven H-piles are presented below. Cobbles and boulders generally exist within the till deposits in the project area. Driving the piles through the till deposits to reach the shale bedrock for higher resistances may result in pile miss-alignment and/or structural damages to the piles.

Alternatively, pre-augering through the upper “100-blow” hard cohesive till and then driving the piles to lower hard till or shale will permit use of higher geotechnical resistances.

#### 5.1.2.1 Axial Pile Resistance

The axial resistances of a HP310x110 steel pile driven into the upper hard cohesive till and the very dense silt and sand till were reassessed based on the subsurface conditions obtained at the abutment and pier locations. The recommended axial geotechnical resistances and the pile tip elevations are summarized in Table 5.2.

**Table 5.2 - Geotechnical Resistances for HP310x110**

Location (Reference Borehole)	Estimated Pile Tip Elevation (m)*	Founding Stratum	Factored ULS (kN)	Factored SLS (kN)
<b>SBL Structure</b>				
South Abutment (WR17-01 and 02)	186.0	Hard cohesive till	1,000	800
Pier (S19/19A, WR17-03)	165.0 or Lower	Very dense silt and sand till	1,600	1,400
North Abutment (S21)	186.0	Hard cohesive till	1,000	800
<b>NBL Structure</b>				
South Abutment (S20 & S24, WR17-06)	186.0	Hard cohesive till	1,000	800
Pier (S20 & S22, WR17-05)	185.0	Hard cohesive till	1,000	800
North Abutment (WRB-2 & S22, WR17-04)	185.5	Hard cohesive till	1,000	800

\* The actual pile tip elevation to achieve design pile resistances may vary during pile driving.



The factored Geotechnical Reaction at SLS given above is for up to 25 mm of settlement. The Factored Geotechnical Resistance at ULS was assessed assuming a Consequence Factor equal to 1 (Typical), and a Resistance Factor equal to 0.4 (Typical degree of understanding of the subsurface conditions), as per CHBDC (2014). The factored Geotechnical Reaction at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.

The recommended pile tip elevation assumes that piles will be driven a minimum 2 m into the very dense or hard (i.e. SPT-N greater than 100 blow) till. Deeper penetration may result in lower axial geotechnical resistances as looser/softer soils maybe encountered with depth. The factored geotechnical resistances at ULS provided above are based on proving the pile resistances using the Hiley Formulae during construction.

### 5.1.2.2 Lateral Pile Resistance

Lateral behavior of the proposed HP 310x110 piles depends only on the properties of the surficial silty clay and/or the upper cohesive till as lower deposits don't contribute in the lateral resistance of the piles unless the founding elevation of the pile caps change in future design drawings. The geotechnical lateral resistance acting on a pile in cohesive soils may be calculated using coefficient of horizontal subgrade reaction ( $k_s$ ) and ultimate lateral resistance ( $p_{ult}$ ) as follows:

$$k_s = 67 s_u / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 9 s_u \quad (\text{kPa})$$

Where:  $s_u$  = undrained shear strength (kPa)

$D$  = pile width in metres (0.310 m for HP 310x110)

The lateral resistance in the cohesionless soils may be calculated using a value for the coefficient of horizontal subgrade reaction ( $k_s$ ) and ultimate lateral resistance ( $p_{ult}$ ) as follows:

$$k_s = n_h z / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 3 K_p \gamma' z \quad (\text{kPa})$$

Where:  $z$  = depth of embedment of pile (m)

$D$  = pile width in metres (0.310 m for HP310x110)

$n_h$  = coefficient related to soil relative density (kN/m<sup>3</sup>)

$\gamma'$  = effective unit weight (kN/m<sup>3</sup>)

$K_p$  = passive earth pressure coefficient

The above equations and parameters provided in Table 5.3 may be used to analyze the interaction between a pile and the surrounding soil. Lateral pressures obtained from analysis must not exceed the ultimate lateral resistance.

The spring constant,  $K_s$ , for analysis may be obtained by the expression,  $K_s = k_s L D$  (kN/m), where  $k_s$  is the coefficient of horizontal subgrade reaction (kN/m<sup>3</sup>),  $D$  is the pile width (m) and  $L$  is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance,  $P_{ult}$ , can be obtained from the expression,  $P_{ult} = p_{ult} L D$ . This represents the ultimate load at which the pile fails and will not support any additional load at greater displacements.



**Table 5.3 – Geotechnical Design Parameters for Lateral Pile Resistance**

Location (Borehole)	Soil Unit	Elevation (m)		$\gamma'$ (kN/m <sup>3</sup> )	S <sub>u</sub> (kPa)	n <sub>h</sub> (kN/m <sup>3</sup> )	K <sub>p</sub>
		Top	Bottom				
North Abutment							
SBL (S21)	Cohesive till – firm	194.0	192.0	19	50	-	-
	Cohesive Till – very stiff to hard	192.0	186.0	11 (*)	150	-	-
NBL (WR17-04)	Clayey Silt – soft	194.6	194.0	19	25	-	-
	Cohesive till – firm to stiff	194.0	190.3	10 (*)	75	-	-
	Cohesive till - hard	190.3	185.5	11 (*)	300	-	-
Pier							
SBL (WR17-03)	Silty clay – firm	193.7	192.3	19	40	-	-
	Cohesive till – very stiff to hard	192.3	185.0	11 (*)	100	-	-
NBL (WR17-05)	Clayey Silt – soft	193.4	192.0	19	25	-	-
	Cohesive till – stiff to hard	192.0	183.6	11 (*)	100	-	-
	Silty sand – dense to very dense	183.6	180.3	12	-	5,500	3.2
	Cohesive till - hard	180.3	174.0	12	300	-	-
	Silt - compact	174.0	167.6	10.5	-	3,500	3.0
	Silt and sand till – very dense	167.6	165.0	12	-	8,000	3.3
South Abutment							
SBL (WR17-02)	Silty clay - stiff	198.5	197.8	19	75	-	-
	Cohesive till – stiff to hard	197.8	186.0	11 (*)	100	-	-
NBL (WR17-06)	Silty clay– firm	197.3	196.8	20	50	-	-
	Cohesive till – stiff to hard	196.8	186.0	11 (*)	100	-	-

Note (\*): Submerged Unit weights

The modulus of subgrade reaction and ultimate lateral resistance may have to be reduced, based on the pile spacing. The reduction factors to be used for a pile group oriented perpendicular or parallel to the direction of loading are provided in Table 5.4. Intermediate values may be obtained by linear interpolation.

**Table 5.4 - Subgrade Reaction Reduction Factors for Pile Spacing**

Condition	Pile Spacing (Centre to Centre)	Reduction Factor
Pile group oriented <b>perpendicular</b> to direction of loading	4D	1.0
	1D	0.5
Pile group oriented <b>parallel</b> to direction of loading	8D	1.0
	6D	0.7
	4D	0.4
	3D	0.25

### 5.1.2.3 H-Pile Installation

Pile driving must be controlled in accordance with Standard Drawing SS103-11 (Hiley Formula) and an ultimate pile resistance (2 times the design load at ULS) should be specified by the designer.

The piles may encounter refusal on the cobbles and/or boulders that may be present in the till deposit above the design tip elevations. The pile installation equipment should be capable of penetrating through the cobbles and boulders. Oversize materials (e.g. greater than 75 mm nominal diameter) should not be used for any new fill which the piles will be driven through.

#### 5.1.2.4 Pile Tips

To prevent structural damages to the piles when setting them in the very dense/hard till or if cobbles or boulders are encountered, piles should be equipped with tip protection. All driven H-piles should be fitted with pile tip protection from an approved manufacturer such as Titus Steel (Standard H-point) or approved equivalent.

#### 5.2 Frost Protection

The design depth of frost penetration at this site is 1.2 m. All pile caps and footing bases should be provided with 1.2 m of earth cover or an equivalent thickness of synthetic insulation.

#### 5.3 Backfill to Abutments

Backfill to the abutment walls should be Granular A or Granular B Type II material meeting the requirements of OPSS. PROV 1010. The backfill should be in accordance with OPSS 902 and placed to the extent shown in OPSD 3101.150.

Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS 501. The design of the abutment should incorporate a subdrain as shown in OPSD 3101.150.

#### 5.4 Lateral Earth Pressure

Lateral earth pressures acting on the structure may be assumed to be triangular and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are 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)

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be applied in the design.

Earth pressure coefficients for backfill to the abutment walls are dependent on properties of the granular fill used as the backfill. Typical values are shown in Table 5.5.

**Table 5.5 – Coefficients of Lateral Earth Pressure**

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 Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.38*	0.31	0.46*
At-rest (Restrained Wall)	0.43	-	0.47	-
Passive	3.7	-	3.3	-

\* For wing walls

The active and passive earth pressure coefficients in Table 5.5 are ultimate values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.16 in the Commentary to the Canadian Highway Bridge Design Code (CHBDC).

## 5.5 Seismic Considerations

Based on the encountered subsurface conditions, Site Class C may 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 this site is 0.11 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 5.6 may be used:

**Table 5.6 – Earth Pressure Coefficients for Earthquake Loading**

Loading Condition	OPSS Granular A or OPSS 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 very dense sand and silt till and hard clayey silt to silty clay till, the potential for liquefaction is considered low at this site.

## 5.6 Approach Embankments and Reinforced Soil System (RSS)

### 5.6.1 General

The existing soils at the abutments and approach embankments consist of a surficial layer of very soft to firm clayey silt underlying the topsoil or extending from ground surface to a depth of up to 1.7 m. The surficial silty clay/clayey silt is underlain by very stiff to hard cohesive till. The construction of the WRC bridges will require up to 10.5 m of fill at the north approaches and up to 6 m at the south approaches. The side slopes of the approach embankment will be at an inclination of 2 horizontal to 1 vertical (2H:1V).

A 25 m long RSS wall is proposed at the NBL Bridge North Abutment along the east shoulder of the approach embankment. The RSS wall will be up to approximately 11 m high above the existing ground surface. An armour stone wall with reinforcing strips is proposed to retain the embankment slope at the west corner of the SBL Bridge North Abutment. The armour stone wall will be inclined at a 10-degree slope and up to approximately 4 m above the ground surface retaining a 5 m high 2H:1V embankment slope.

It is understood that the proposed retaining walls will become partially submerged during high water level periods in the floodplain. The designer of these walls must carefully address the following aspects which include but are not limited to:

- Erosion and scour protection of the walls during and after flood events
- Type of backfill material and control of migration of fines
- Reinforcement strength, facing connection strength and pullout resistance of reinforcement under submerged conditions

- Lateral stability of the walls, including sliding and overturning
- Durability of the reinforcing strips against potential corrosion under submerged conditions

### 5.6.2 Geotechnical Resistances

As per MTO RSS Design Guidelines, the minimum soil cover to the underside of the levelling pad shall be at least 800 mm or 40% of the frost depth in the area, whichever is greater. The minimum soil cover to the top of the levelling pad shall be at least 500 mm.

The RSS wall and armour stone wall founded on the stiff to very stiff clayey silt till should be designed for a Factored Geotechnical Resistance at ULS of 350 kPa and a Factored Geotechnical Reaction at SLS of 250 kPa. The highest founding elevations for RSS wall and armour stone wall are recommended to be Elev. 192 m. If required, higher wall base elevations may be achieved by placing thicker engineered granular fill pad. The resistance values assume that the length of RSS wall reinforcement will extend for a distance equal at least 70% height behind the wall face. For the armour stone wall, the length of reinforcing strips should extend for a distance at least equal to the wall height to achieve global stability of the upper slope. The actual lengths of the reinforcing strips for the RSS wall and armour stone wall must be determined by the wall suppliers.

The recommended geotechnical resistances are for vertical concentric loading. The effects of load inclination and eccentricity need to be considered in accordance with the CHBDC.

The RSS mass of both the RSS wall and armour stone wall must be designed against various modes of failure including sliding and overturning. Sliding resistance along the base on native clayey silt till and engineered fill may be estimated using ultimate friction coefficients of 0.4 and 0.55, respectively.

The internal stability or structural integrity of the RSS masses should be analyzed by the supplier/designer of the proprietary product selected for this site.

### 5.6.3 Subgrade Preparation

Topsoil and any soft surficial clayey silt/silty clay, disturbed soils and deleterious materials within the footprint (and about 500 mm beyond that) of the approach embankments should be removed and replaced with suitable granular material compacted (to 100% of its SPMDD at a moisture content within 2% of optimum) as per OPSS.PROV 501. The exposed subgrade surface should be proof rolled and inspected to confirm that the subgrade is suitable and uniformly competent.

The work should be carried out in accordance with OPSS.PROV 902 and construction should be carried out in the dry. Once the subgrade is prepared the construction traffic and equipment should not travel on the subgrade.

The RSS wall and armour stone wall should be founded on a minimum 500 mm thick layer of bedding material conforming to OPSS Granular A requirements to form a uniform subgrade. Engineered fill placed under the RSS mass to achieve the design founding level should be compacted to 100% of its SPMDD at a moisture content within 2% of optimum. The engineered fill layer should extend at least 500 mm beyond the limits of the RSS mass.

### 5.6.4 Approach Embankment Stability

Slope stability analyses were carried out to assess the approach embankments. The results of the analysis indicate a Factor of Safety of greater than 1.3 for short-term conditions and greater than 1.5 for long term conditions are achieved which meet the requirements of Table 6.2 of CHBDC for a typical degree of understanding, and assuming appropriate subgrade preparation and proper placement and compaction of granular fill materials. For the seismic condition, a FOS greater than 1.3 was computed. Results of slope stability assessment for the approach embankments are provided on Figures E1 to E3 in Appendix E. Results of the global stability assessment of the RSS wall and armour stone wall are provided on Figures E4 to E9 in Appendix E.

### 5.6.5 Approach Embankment Settlement

The total settlement at the surface of the approach embankments have two components (i.e., settlement of the fill itself and settlement of the subgrade soil). The settlement of the embankment fill itself (consisting of compacted clean granular fills) is expected to be between 40 and 50 mm at the north approaches and 20 to 30 mm at the south approaches. Approximately 50% of these settlements are expected to occur during construction and 50% are expected to occur post-construction. The settlement of the prepared foundation subgrade (after placement of the fill) is expected to be less 35 mm at the north approach embankments and less than 25 mm at the south approaches. About 75% of the foundation settlement is expected to occur within a month after completion of approach embankment construction. After backfilling the structure, a waiting period of minimum 2 months should be allowed for embankment settlement to take place prior to approach slab construction and final paving.

### 5.6.6 Approach Embankment Construction

It is understood that the contractor's intention is to reuse the excavated soils from the site as embankment fill. Embankments constructed with earth fill compacted as per OPSS.PROV 501 will have stable side slopes at inclinations not steeper than 2H:1V. Careful selection and/or treatment of the earth fill prior to reuse will be required.

Slope face treatment/surficial erosion protection should be in general accordance with OPSS.PROV 804. Erosion protection should be provided along any soil surfaces that may be in contact with the creek flow. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

## 5.7 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 surficial very soft to soft clayey silt within the depth of excavation may be classed as Type 3 soil.

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

The water level measured in the upper cohesive till and silt varied between Elev. 191.0 and 192.4, which is above the base of excavation (Elev. 190.0) for construction of the pier footings. In addition, perched groundwater may be present at shallower levels. Due to proximity to creek and the possibility of undetected permeable alluvium at the surface, a sheet pile cofferdam around the pier excavations is recommended at this site. Given the consistency and relatively low permeability of the clayey silt to silty clay till, groundwater control measures such as perimeter ditches and pumping from filtered sumps inside the cofferdam should be adequate to lower the groundwater table to below the base of excavations. The possibility exists that additional pumps may be required if localized zones of high volume of perched groundwater are encountered.

All pile caps and spread footings should be constructed in the dry.

## 5.8 Erosion and Scour Protection

Slope face treatment/surficial erosion protection should be in general accordance with OPSS.PROV 804. Erosion protection should be provided along any soil surface that may be in contact with the creek flow.

Design of the erosion protection measures should consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field. Typically, rock protection should be provided at the abutment and pier locations as per OPSS 511 where creek water is likely to be in contact.

The erosion and scour protection measures shown on the structure design drawings and water resources design drawings have been reviewed from a geotechnical perspective and are generally consistent with the above geotechnical recommendations. For detailed design of the erosion and scour protection, please refer to design



report H427-3-ENV-REP-004.

### 5.9 Corrosion and Sulphate Attack Potential

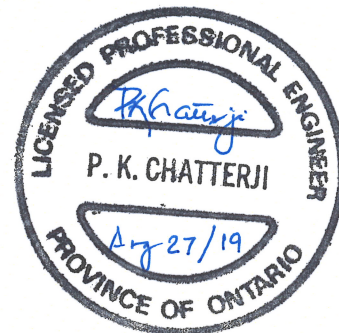
The results of the analytical tests for soil corrosivity and sulphate content conducted on the samples collected near the water course indicate the following:

- The potential for sulphate attack on structural concrete from the surrounding soil is moderate based on the concentration of sulphate in the samples tested.
- The potential for corrosion on metal elements of the structure is considered to be very mild to moderate.
- Appropriate protection measures are recommended for the structural concrete and metal structural elements.

### 5.10 Construction Concerns

Potential construction concerns include, but not necessarily limited to:

- The driven steel H-pile installation in both cohesive and non-cohesive till materials which typically include cobbles and boulders may result in pile miss-alignment and/or damages near the toe. The piling contractors should be warned of the associated risks.
- All pile caps and pier footings should be constructed in the dry. Clayey silt subgrade should be covered/protected as soon as practical upon exposure and be protected from any disturbances that will likely weaken the material.
- The excavation for the foundation of the centre piers may be extended below the groundwater level within the upper cohesive till. Therefore, water inflow into the excavation should be expected. The water inflow may be handled by pumping from filtered sumps.
- H-piles may be driven deeper for higher capacity.



## STATEMENT OF LIMITATIONS AND CONDITIONS

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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.

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### 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.
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### 6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

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## Appendix A

### Record of Borehole Sheets – Current Investigation

## 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

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


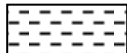



 Water Level  
 Shear Strength Determination by Pocket Penetrometer

- (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>		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
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.	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 WR 17-01

1 OF 2

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 852 916.1 E 292 436.3 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Solid 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  <b>γ</b>  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						
199.8	GROUND SURFACE													
0.0	TOPSOIL: (125mm)													
0.1	Silty <b>CLAY</b> , trace sand, trace gravel, trace organics, rootlets Firm Dark Brown Moist		1	SS	7									
199.1														
0.7	Silty <b>CLAY</b> , trace sand, trace gravel Stiff to Hard Brown to Grey Moist (TILL)		2	SS	21									
			3	SS	34									
			4	SS	24									
			5	SS	24									
			6	SS	22									
			7	SS	10									
			8	SS	13									
			9	SS	34									
190.0														
9.8	END OF BOREHOLE AT 9.8m.													

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

## METRIC

[illegible]

## METRIC

[illegible]

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



# RECORD OF BOREHOLE No WR 17-02

2 OF 5

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 852 937.5 E 292 429.1 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.10 - 2017.07.11 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						
	Continued From Previous Page													
	Silty <b>CLAY</b> , trace to some sand, trace gravel Hard Grey Moist (TILL)		10	SS	162									
			11	SS	129									
			12	SS	85									
183.7														
14.8	<b>SAND</b> , some silt, trace gravel Very Dense Grey Wet		13	SS	117									0 79 16 5
	Hard augering													
			14	SS	54									

Continued Next Page

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

# RECORD OF BOREHOLE No WR 17-02

3 OF 5

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 852 937.5 E 292 429.1 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.10 - 2017.07.11 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						
	Continued From Previous Page													
177.8							178							
20.7	Clayey <b>SILT</b> , trace to some sand Very Stiff to Hard Grey Moist (TILL)		15	SS	59		177							0 0 81 19
							176							
							175							
			16	SS	50		174							
							173							
							172							
			17	SS	15		171							
							170							
							169							

Continued Next Page

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

## METRIC

Continued Next Page

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

# RECORD OF BOREHOLE No WR 17-02

5 OF 5

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 852 937.5 E 292 429.1 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.10 - 2017.07.11 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					WATER CONTENT (%)				
							20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>			
	Continued From Previous Page																
158.0																	
40.5	END OF BOREHOLE AT 40.5m. BOREHOLE BACKFILLED TO 18.3m TO INSTALL PIEZOMETER. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.  WATER LEVEL READINGS DATE          DEPTH(m)    ELEV.(m) 2017.08.08      18.1        180.4  NOTE: LOW RECOVERIES IN THE BEDROCK DUE TO CORING EQUIPMENT DEFICIENCIES.																

# RECORD OF BOREHOLE No WR 17-03

1 OF 4

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 852 992.5 E 292 415.0 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.12 - 2017.07.13 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					
193.7	GROUND SURFACE							20 40 60 80 100		PLASTIC LIMIT w <sub>P</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	
0.0	Silty <b>CLAY</b> , trace to some sand, trace gravel, trace organics, rootlets and topsoil Firm Brown Moist		1	SS	8								
			2	SS	6								
192.3													
1.4	Silty <b>CLAY</b> , trace sand, trace gravel Very Stiff Brown Moist (TILL)  Hard augering		3	SS	16								
			4	SS	20								
190.6													
3.1	Clayey <b>SILT</b> , sandy, trace gravel Hard Grey Moist (TILL)  Hard augering		5	SS	37								
			6	SS	79								
			7	SS	83								
			8	SS	82								
185.0													
8.7	Silty <b>SAND</b> , trace clay Dense to Very Dense Grey Wet		9	SS	74								

Continued Next Page

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

# RECORD OF BOREHOLE No WR 17-03

2 OF 4

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 852 992.5 E 292 415.0 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.12 - 2017.07.13 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 $\gamma$ 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>		
							20 40 60 80 100							
	Continued From Previous Page													
180.3	Silty <b>SAND</b> , trace clay Dense to Very Dense Grey Wet		10	SS	48									0 72 22 6
			11	SS	33									
13.4	Clayey <b>SILT</b> Hard Grey Moist to Wet (TILL) Hard augering		12	SS	49									
			13	SS	50									
			14	SS	68									0 0 79 21
174.0	<b>SILT</b> , trace clay, trace sand Compact													
19.7														

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No WR 17-03

3 OF 4

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 852 992.5 E 292 415.0 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.12 - 2017.07.13 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	WATER CONTENT (%)					
	Continued From Previous Page													
	<b>SILT</b> , trace clay, trace sand Compact Grey Moist to Wet		15	SS	28		173							
							172							
							171							
							170							
			16	SS	22		169							
							168							
167.6							167							
26.1	<b>SILT</b> and <b>SAND</b> , trace gravel, occasional shale fragments Very Dense Grey Moist (TILL)  Hard augering, split spoon bouncing		17	SS	121/ 0.250		166							4 42 42 12
							165							
							164							

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No WR 17-03

4 OF 4

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 852 992.5 E 292 415.0 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.12 - 2017.07.13 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  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
	Continued From Previous Page							20 40 60 80 100	○ UNCONFINED	+ FIELD VANE									
								20 40 60 80 100	● QUICK TRIAXIAL	× LAB VANE									
162.0			18	SS	77		163												
31.7	SHALE highly weathered, weak, grey						162												
161.3			19	SS	161/ 0.275														
32.4	END OF BOREHOLE AT 32.4m. Piezometer installation consists of 25mm (deep) and 50mm (shallow) diameter Schedule 40 PVC pipes with 1.52m slotted screens.  <b>DEEP</b> WATER LEVEL READINGS: DATE      DEPTH (m)      ELEV. (m) 2017.08.08      4.3      189.4  <b>SHALLOW</b> WATER LEVEL READINGS: DATE      DEPTH (m)      ELEV. (m) 2017.08.08      1.3      192.4																		

# RECORD OF BOREHOLE No WR 17-04

1 OF 5

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 853 081.4 E 292 428.4 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.26 - 2017.06.28 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						
194.7	GROUND SURFACE							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>						
0.0	TOPSOIL: (100mm)							<div><div>204060</div><div>W<sub>P</sub> W W<sub>L</sub></div><div>PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT</div><div>WATER CONTENT (%)</div></div>						
0.1	Clayey <b>SILT</b> , trace sand, trace gravel, trace organics, rootlets Soft Grey Moist		1	SS	3		194							
194.0														
0.7	Clayey <b>SILT</b> , trace sand, trace gravel Firm to Stiff Brown to Grey Moist (TILL)  Hard augering		2	SS	6									
			3	SS	8		193							
			4	SS	14		192							
			5	SS	10									
							191							
190.3							190							
4.4	Silty <b>CLAY</b> , sandy, trace gravel Hard Grey Moist (TILL)		6	SS	131									
							189							
			7	SS	94		188							
			8	SS	144/ 0.200		187							
			9	SS	153/ 0.275		186							
							185							
														0 29 46 25

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

## METRIC

[illegible]

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

# RECORD OF BOREHOLE No WR 17-04

3 OF 5

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 853 081.4 E 292 428.4 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.26 - 2017.06.28 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>		
							20 40 60 80 100							
	Continued From Previous Page													
	<b>SILT</b> , trace clay to clayey, trace sand Dense to Compact Grey Wet		16	SS	39									
							174							
			17	SS	16		173							
							172							
			18	SS	13		171							
							170							
			19	SS	13		169							
							168							
			20	SS	16		167							
							166							
			21	SS	22		165							
166.2 28.5	Sandy <b>SILT</b> , trace clay, trace gravel Compact to Dense Grey Wet (TILL)		22	SS	46									0 26 67 7

Continued Next Page

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

# RECORD OF BOREHOLE No WR 17-04

4 OF 5

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 853 081.4 E 292 428.4 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.26 - 2017.06.28 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						
							20 40 60 80 100	20 40 60 80 100	20 40 60					
	Continued From Previous Page													
			23	SS	24		164							
							163							
			24	SS	19		162							
							161							
			25	SS	20		160							
							159.4							
			26	SS	26		159							
	Clayey <b>SILT</b> , with sand, trace gravel Very Stiff to Hard Grey Moist (TILL)						158							
			27	SS	144/ 0.275		157							
							156							
	Shale fragments		28	SS	146/ 0.225		155							
			29	SS	100/ 0.025									

Continued Next Page

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

# RECORD OF BOREHOLE No WR 17-04

5 OF 5

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 853 081.4 E 292 428.4 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.26 - 2017.06.28 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									
	Continued From Previous Page																
154.5																	
40.2	END OF BOREHOLE AT 40.2m ON REFUSAL. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS DATE                  DEPTH(m)    ELEV.(m) 2017.08.08            3.7            191.0																

## METRIC

[illegible]

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



## METRIC

[illegible]

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

# RECORD OF BOREHOLE No WR 17-05

3 OF 5

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 853 022.2 E 292 459.5 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.16 - 2017.06.26 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		W <sub>p</sub>	W	W <sub>L</sub>		
							20 40 60 80 100							
							20 40 60 80 100							
	Continued From Previous Page		16	SS	31									
	Clayey <b>SILT</b> , trace to some sand, trace gravel Hard Grey Wet (TILL)													
			17	SS	24									
			18	SS	25									0 0 76 24
			19	SS	14									
			20	SS	21									0 0 76 24
			21	SS	20									
			22	SS	36									

Continued Next Page

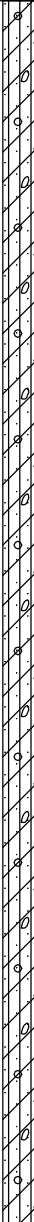


+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity 20  
15 10 5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No WR 17-05

4 OF 5

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 853 022.2 E 292 459.5 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.16 - 2017.06.26 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  <b>γ</b>  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 (%)					
								○ UNCONFINED      + FIELD VANE		● QUICK TRIAXIAL      × LAB VANE		W <sub>P</sub>	W	W <sub>L</sub>			
Continued From Previous Page							20	40	60	80	100	20	40	60			
	Clayey <b>SILT</b> , trace to some sand, trace gravel Very Stiff to Hard Grey Wet (TILL)		23	SS	23		163										
			24	SS	18												
			25	SS	19												
			26	SS	111		158										
			27	SS	186/ 0.275		157										
							156										
155.6 38.1	<b>SHALE</b> slightly weathered, thinly bedded, grey, medium strong		1	RUN			155										
	Limestone interbed (225mm) at 38.3m																
	Fossiliferous limestone (75mm) at 38.7m																
	Limestone interbed (150mm) at 39.5m																
	Vertical fracture (75mm) at 39.3m		2	RUN			154										

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No WR 17-05

5 OF 5

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 853 022.2 E 292 459.5 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2017.06.16 - 2017.06.26 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										WATER CONTENT (%)		
								20	40	60	80	100						20	40	60
	Continued From Previous Page																			
	Fossiliferous limestone (25mm) at 40.1m and (50mm) at 10.2m						153									5				
	Limestone interbed (25mm) at 41.3m and 41.5m		3	RUN												3				
151.6							152									2				
42.1	END OF BOREHOLE AT 42.1m. Well installation consists of 25mm (deep) and 50mm (shallow) diameter Schedule 40 PVC pipe with 3.05m and 1.52m slotted screen.  <b>DEEP</b> WATER LEVEL READINGS: DATE      DEPTH (m)      ELEV. (m) 2017.06.29      11.0      182.7  <b>SHALLOW</b> WATER LEVEL READINGS: DATE      DEPTH (m)      ELEV. (m) 2017.06.29      1.6      192.1															3				

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

# RECORD OF BOREHOLE No WR 17-06

1 OF 4

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 852 972.0 E 292 465.3 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.05 - 2017.07.07 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 ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE				W <sub>P</sub>	W	W <sub>L</sub>		WATER CONTENT (%)	GR	SA	SI	CL
197.5	GROUND SURFACE							20	40	60	80	100								
0.0	TOPSOIL: (175mm)							20	40	60	80	100								
0.2	Silty <b>CLAY</b> , some sand, trace gravel, trace organics, trace rootlets Firm		1	SS	7		197							○						
196.8	Brown																			
0.7	Moist																			
	Silty <b>CLAY</b> , trace to some sand, trace gravel Very Stiff Brown Moist (TILL)		2	SS	21		196							○						
			3	SS	25									○	—	—				
			4	SS	28		195							○						
			5	SS	29		194							○						
							193													
			6	SS	14		192							○						
							191							○						
							190													
			8	SS	13		189							○	—	—				0   9   50   41
							188							○						

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

## METRIC

[illegible]

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

## METRIC

[illegible]

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

# RECORD OF BOREHOLE No WR 17-06

4 OF 4

METRIC

W.P. \_\_\_\_\_ LOCATION N 4 852 972.0 E 292 465.3 ORIGINATED BY JZ  
 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.05 - 2017.07.07 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									WATER CONTENT (%)		
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE											
	Continued From Previous Page						20	40	60	80	100	20	40	60					
	Clayey <b>SILT</b> , trace sand, trace gravel Hard to Very Stiff Grey Wet (TILL)		23	SS	36														
			24	SS	18														
164.4																			
33.1	<b>SILT</b> and <b>SAND</b> , trace gravel to gravelly, occasional shale fragments Very Dense Grey Moist (TILL)		25	SS	83											23 36 34 7			
			26	SS	176														
160.3			27	SS	142														
37.2	END OF BOREHOLE AT 37.2m. BOREHOLE BACKFILLED TO 18.3m TO INSTALL PIEZOMETER. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.  WATER LEVEL READINGS DATE            DEPTH(m)    ELEV.(m) 2017.08.08        18.7        178.8																		

ONTMT4S MTO-19484.GPJ 2017TEMPLATE(MTO).GDT 17/8/9



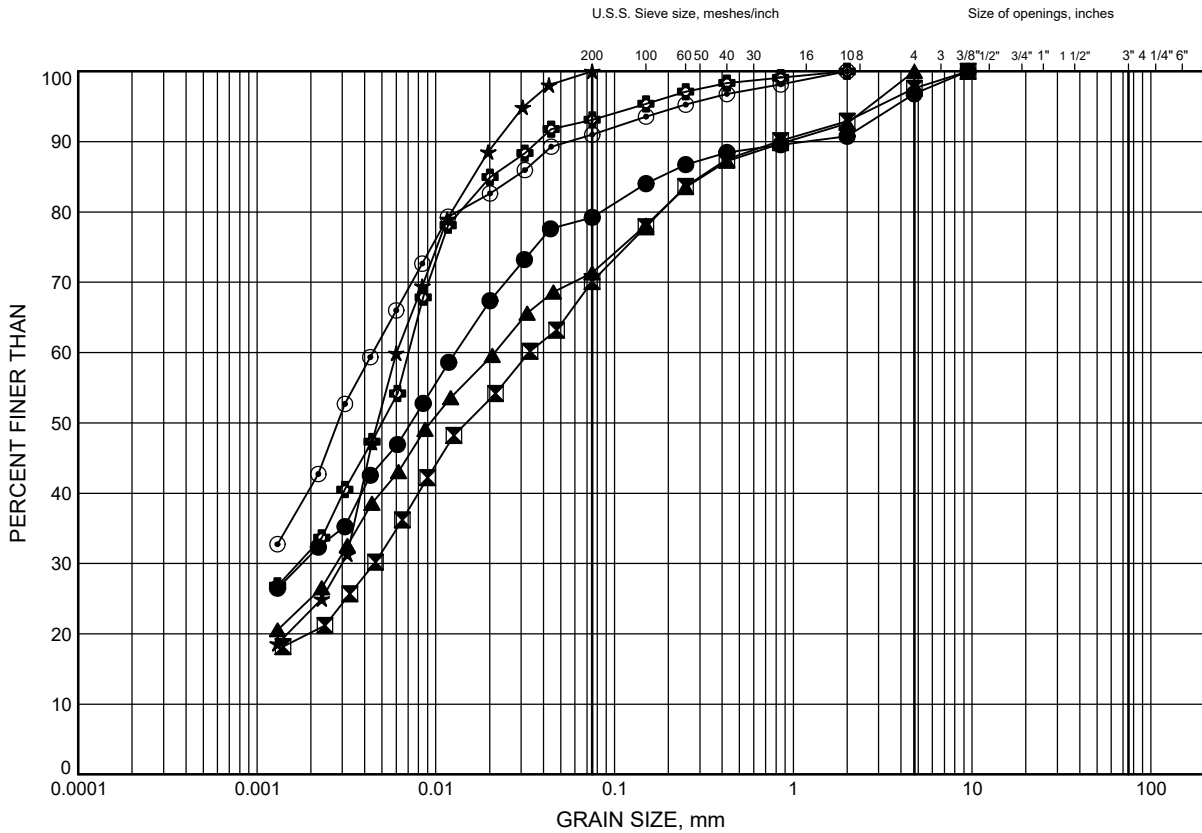
## Appendix B

### Geotechnical and Analytical Laboratory Test Results – Current Investigation

# GRAIN SIZE DISTRIBUTION

FIGURE B1

## Upper Cohesive TILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WR 17-02	9.4	189.1
⊠	WR 17-03	4.9	188.8
▲	WR 17-04	9.4	185.3
★	WR 17-04	15.5	179.2
⊙	WR 17-06	7.9	189.6
⊕	WR 17-06	12.5	185.0

Date August 2017  
W.P. \_\_\_\_\_

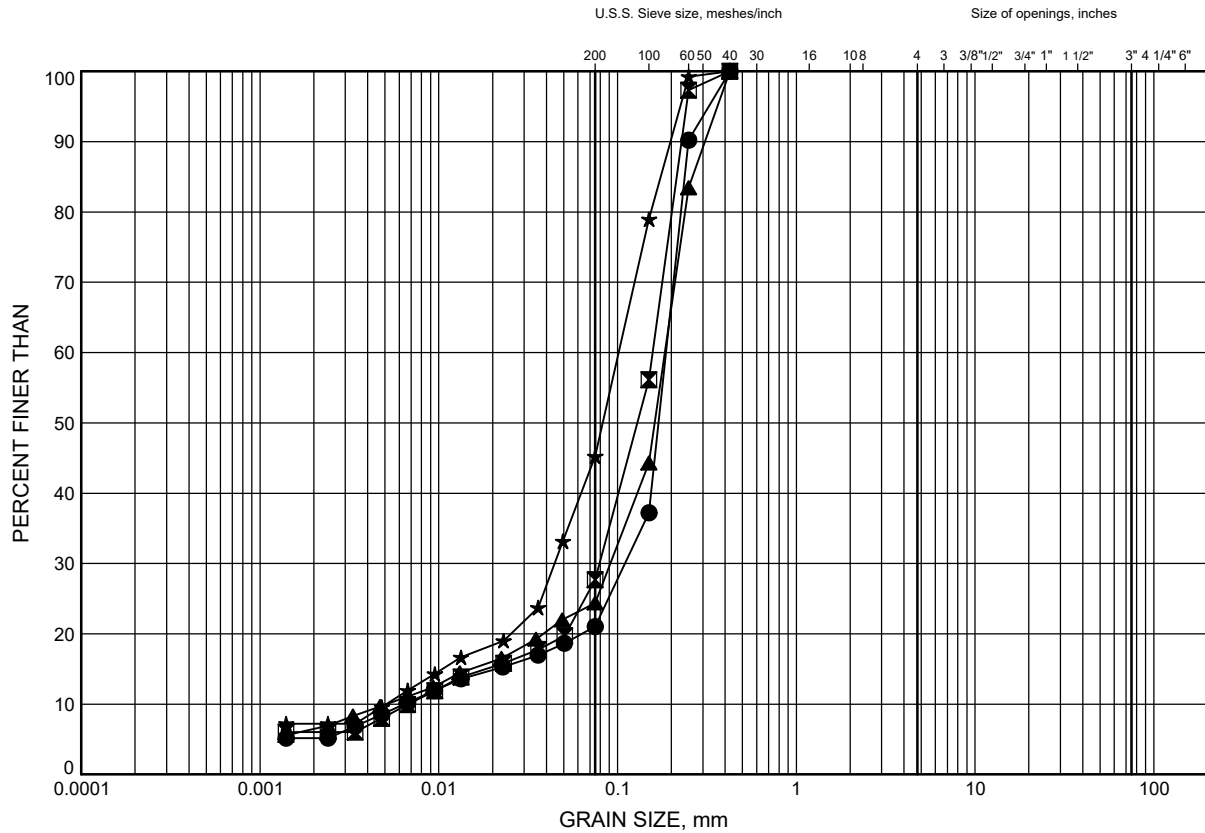


Prep'd AN  
Chkd. ME

# GRAIN SIZE DISTRIBUTION

FIGURE B2

## SILT to SAND



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WR 17-02	15.5	183.0
⊠	WR 17-03	11.0	182.7
▲	WR 17-05	11.0	182.7
★	WR 17-06	20.1	177.4

Date August 2017  
W.P. \_\_\_\_\_

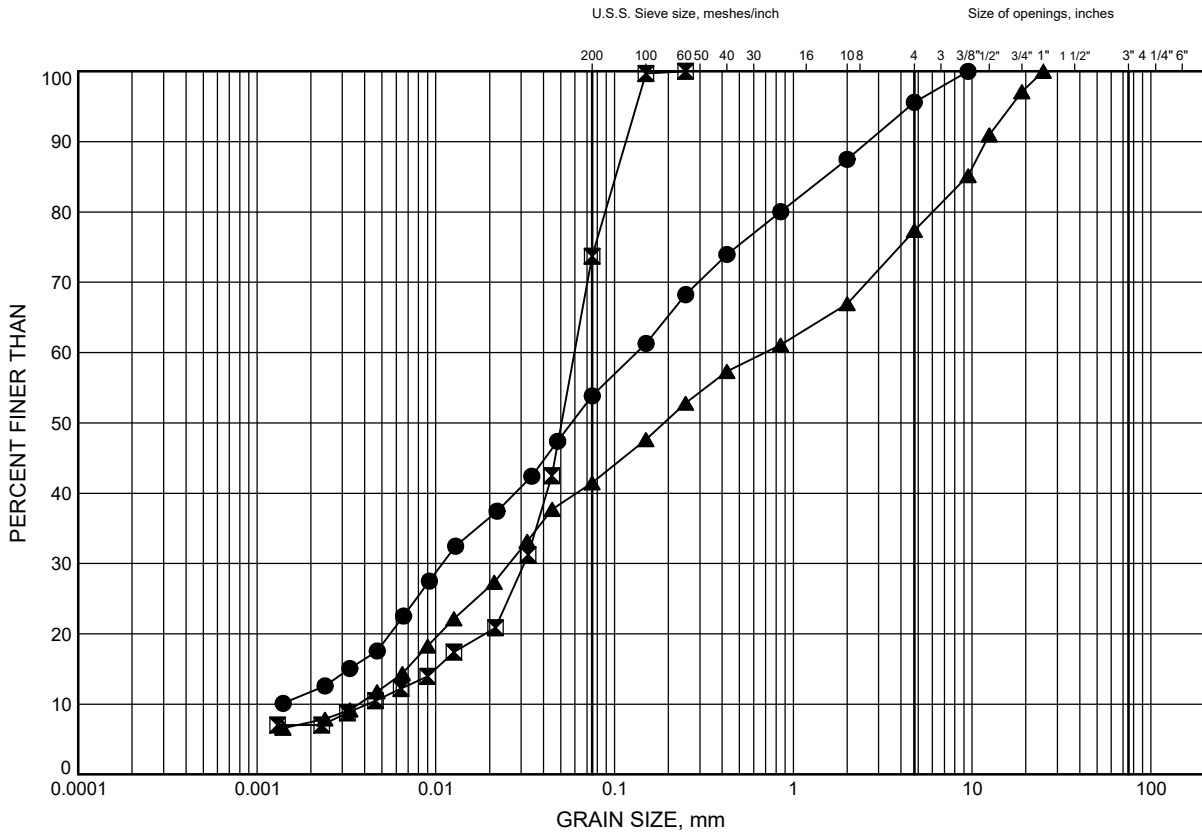


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# GRAIN SIZE DISTRIBUTION

FIGURE B3

## SILT and SAND TILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WR 17-03	27.7	166.0
⊠	WR 17-04	29.3	165.4
▲	WR 17-06	33.8	163.7

Date August 2017  
W.P.

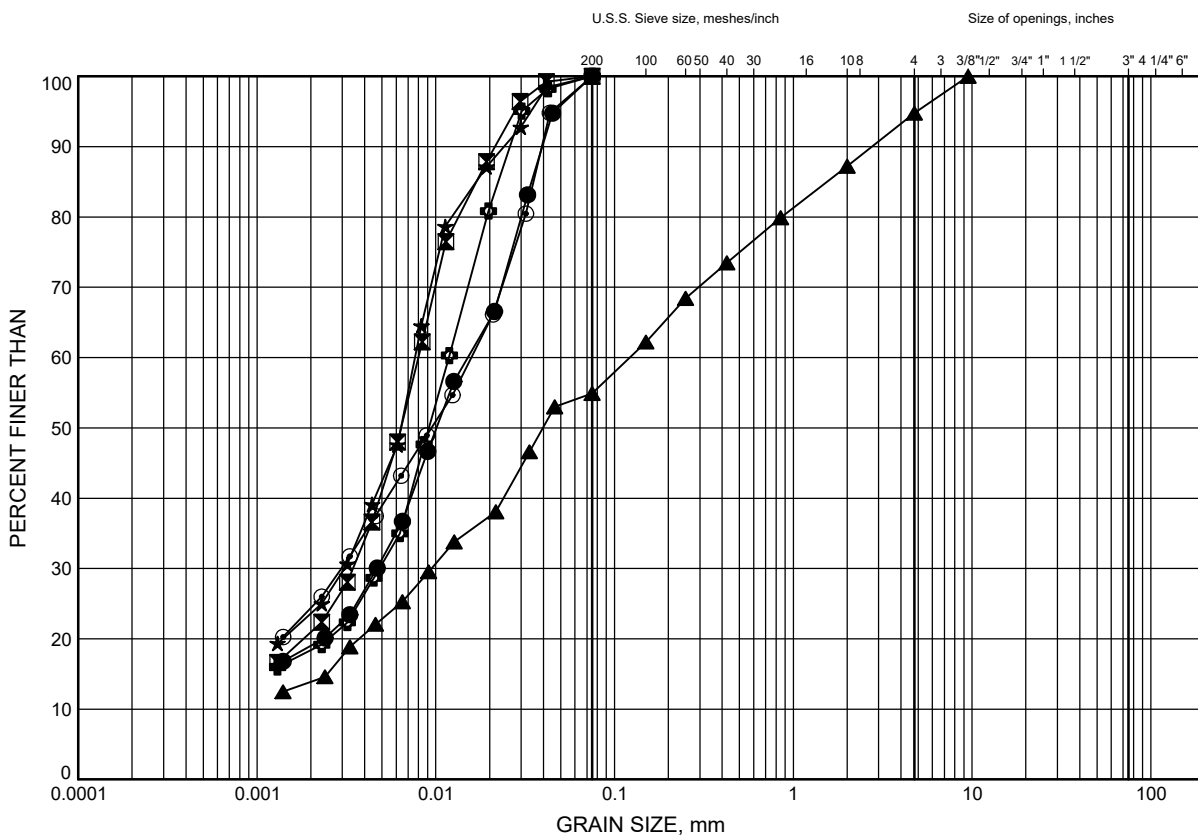


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# GRAIN SIZE DISTRIBUTION

FIGURE B4

## Lower Cohesive TILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WR 17-02	21.6	176.9
⊠	WR 17-03	18.6	175.1
▲	WR 17-04	35.5	159.2
★	WR 17-05	23.2	170.5
⊙	WR 17-05	26.2	167.5
⊕	WR 17-06	24.7	172.8

Date August 2017

W.P.



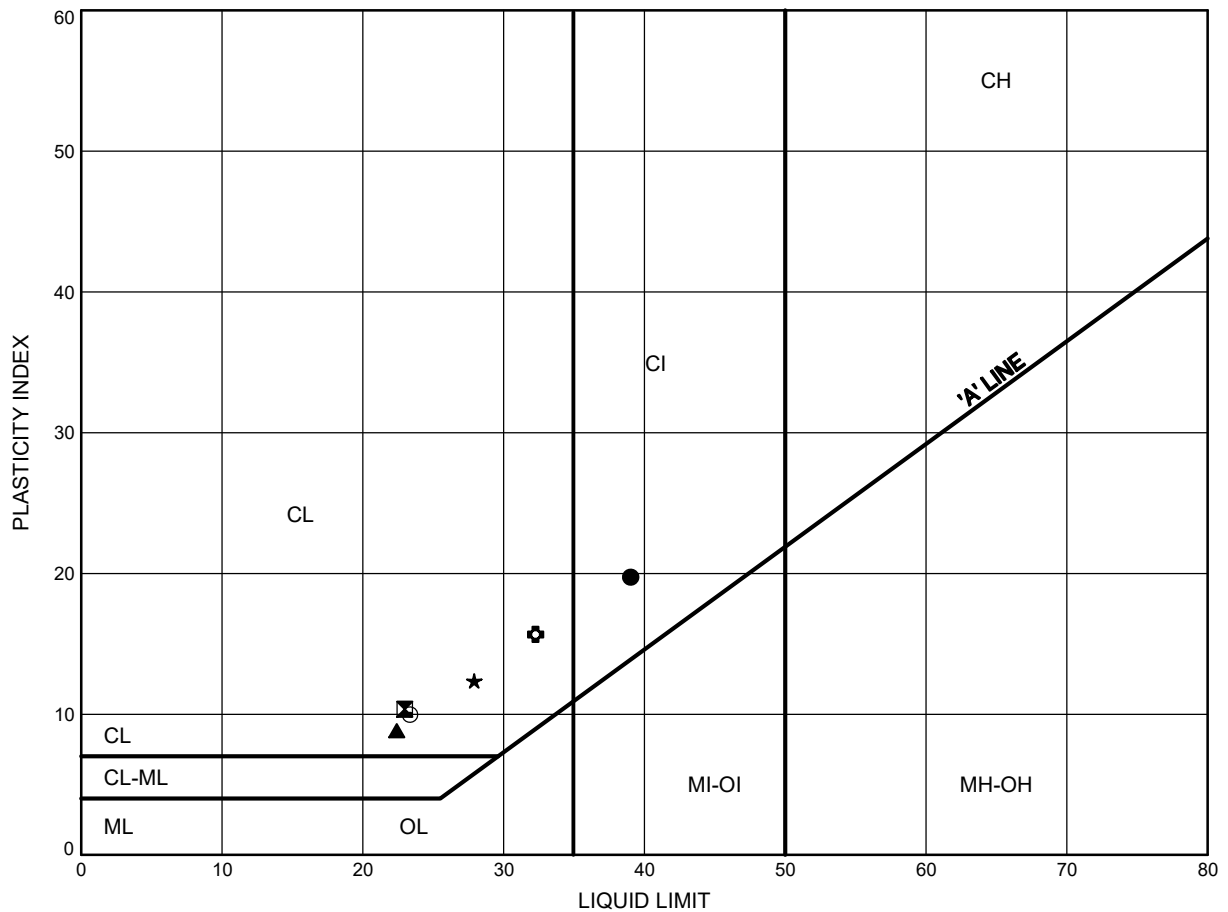
Prep'd AN

Chkd. ME

# ATTERBERG LIMITS TEST RESULTS

FIGURE B5

## Upper Cohesive TILL



### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WR 17-01	1.8	198.0
⊠	WR 17-01	7.9	191.9
▲	WR 17-01	9.4	190.4
★	WR 17-02	5.1	193.4
⊙	WR 17-02	9.4	189.1
⊕	WR 17-03	2.6	191.1

Date August 2017  
W.P. ....

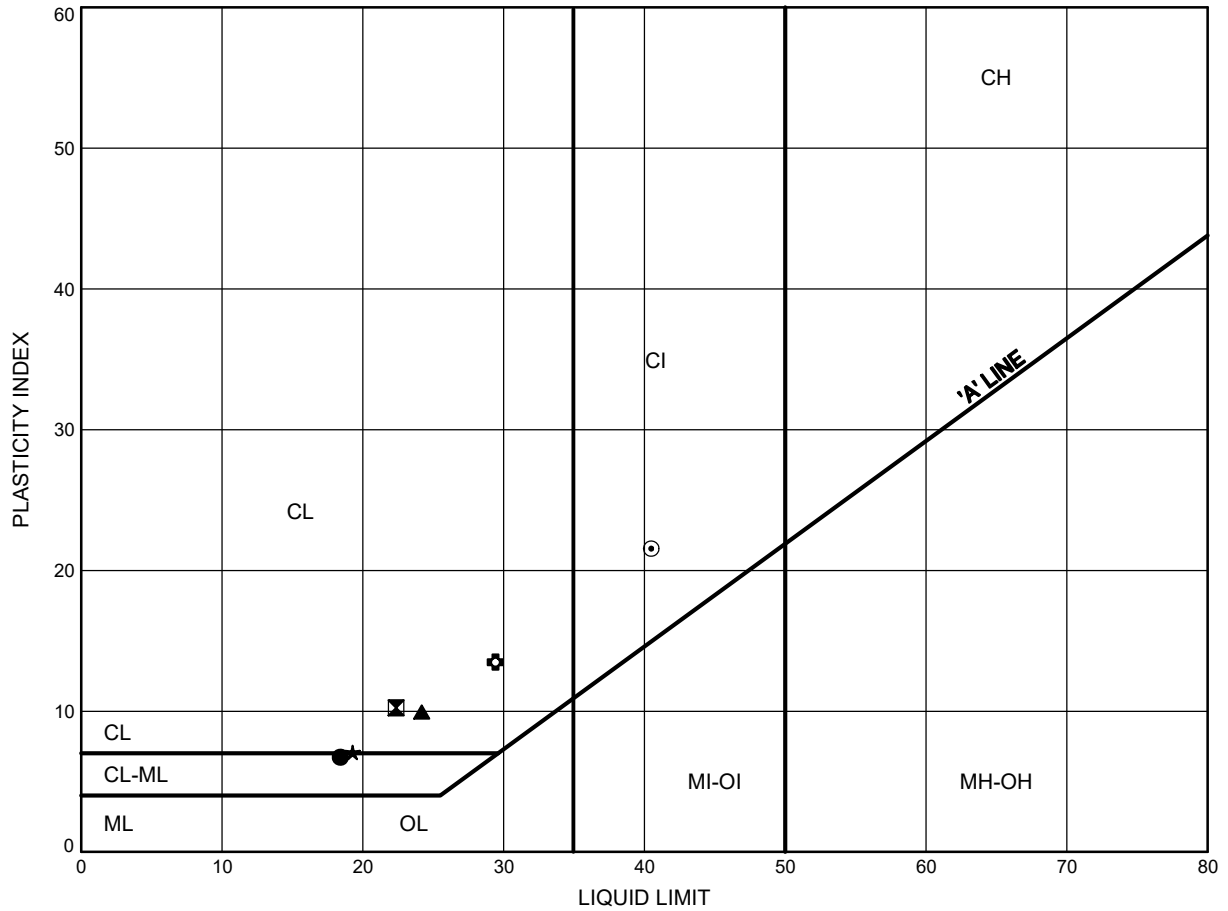


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Chkd. ME

# ATTERBERG LIMITS TEST RESULTS

FIGURE B6

## Upper Cohesive TILL



### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WR 17-03	4.9	188.8
⊠	WR 17-04	9.4	185.3
▲	WR 17-05	3.4	190.3
★	WR 17-05	4.9	188.8
⊙	WR 17-06	1.8	195.7
⊕	WR 17-06	7.9	189.6

Date August 2017  
W.P. ....

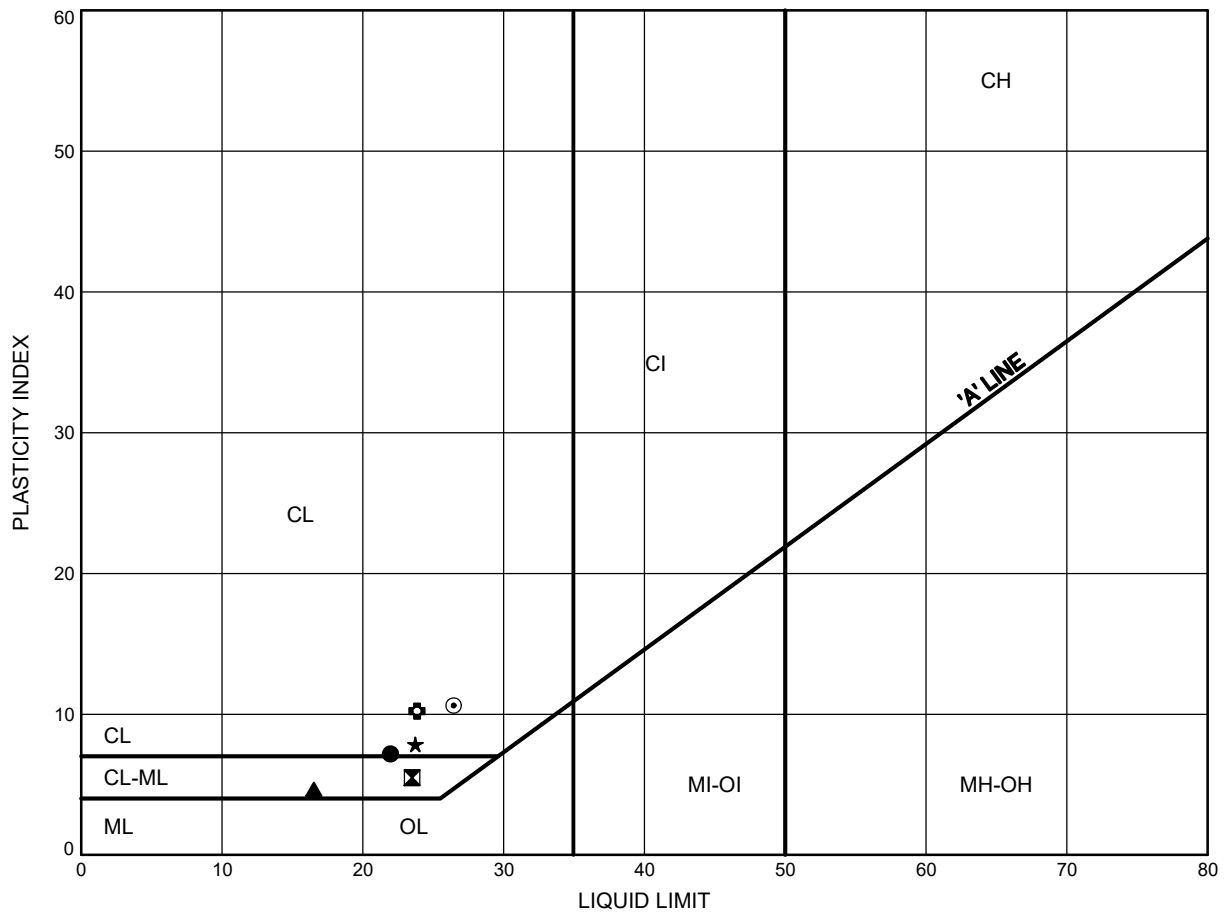


Prep'd AN  
Chkd. ME

# ATTERBERG LIMITS TEST RESULTS

FIGURE B7

## Lower Cohesive TILL



### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WR 17-02	21.6	176.9
⊠	WR 17-03	18.6	175.1
▲	WR 17-04	35.5	159.2
★	WR 17-05	17.1	176.6
⊙	WR 17-05	35.4	158.3
⊕	WR 17-06	12.5	185.0

Date August 2017  
W.P. ....



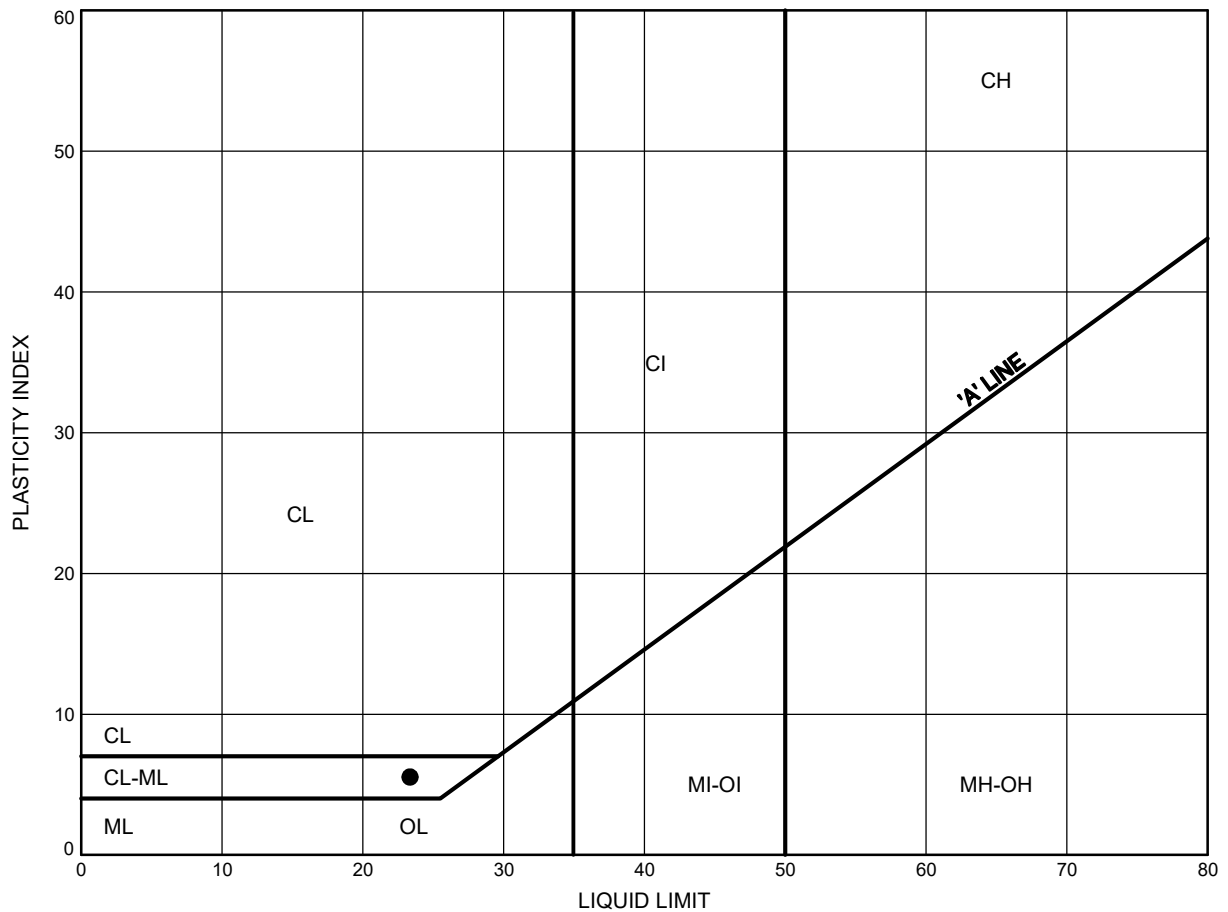
Prep'd AN  
Chkd. ME



# ATTERBERG LIMITS TEST RESULTS

FIGURE B8

## Lower Cohesive TILL



### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WR 17-06	24.7	172.8

Date August 2017  
W.P. ....

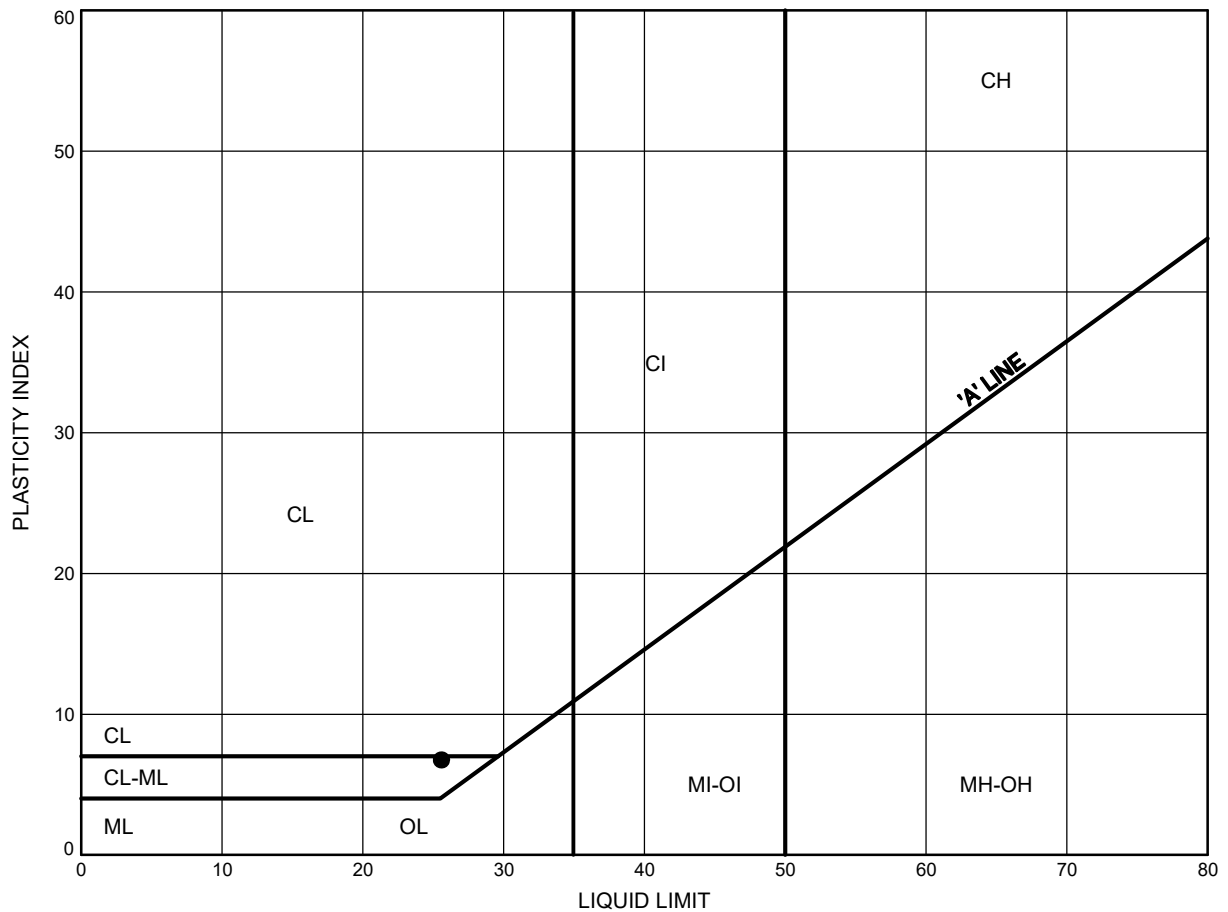


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# ATTERBERG LIMITS TEST RESULTS

FIGURE B9

SILT, Trace Clay to Clayey



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WR 17-04	20.1	174.6

Date August 2017  
W.P. ....



Prep'd AN  
Chkd. ME

## 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.  
CA14596-JUL17  
Corrosivity (Soil)

Sample ID	Unit	WR 17-06, SS2 (2'6"-4'6")	WR 17-02, SS5 (10- 12')	WR 17-03, SS3 (5-7')	WR 17-05, SS4 (7'6"- 9'6")
Sample Date/Time		05-Jul-17	10-Jul-17	12-Jul-17	16-Jun-17
Moisture	%	14.9	18.6	15.40	17.50
pH	no unit	8.62	8.66	8.66	8.28
Corrosivity Index	none	4.0	4.0	4.0	2.0
Soil Redox Potential	mV	303	277	282	284
Sulphide	%	<0.02	<0.02	<0.02	<0.02
Chloride	µg/g	2	3.0	33.0	200.0
Sulphate	µg/g	3.9	5	14	200
Conductivity	uS/cm	68	95	106	367
Resistivity (calculated)	Ohms.cm	14700	10500	9430	2720

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

## Appendix C

### Record of Borehole Sheets and Laboratory Test Results – Previous Investigations

# RECORD OF BOREHOLE No WRB-1 1 of 2 METRIC

G.W.P. \_\_\_\_\_ LOCATION \_\_\_\_\_ Coords: 4 852 913.9 N; 292 423.8 E ORIGINATED BY F.P.  
DIST Central HWY 427 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.K.  
DATUM Geodetic DATE December 7 and 8, 2015 CHECKED BY A.V.

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	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					
200.0	Ground Surface					20 40 60 80 100							
0.0	CLAYEY SILT containing wood fragments		1	SS	14								
199.4	Stiff												
0.6	Dark brown												
	Moist												
	CLAYEY SILT to SILTY CLAY, trace to some sand, trace gravel		2	SS	46								
	Very stiff to hard		3	SS	32								1 7 47 45
	Brown becoming grey below a depth of 3.8m												
	Moist to wet												
	(TILL)		4	SS	33								
			5	SS	26								
			6	SS	16								
			7	SS	22								
			8	SS	15								3 11 51 35
			9	SS	17								
			10	SS	54								
			11	SS	38								First groundwater strike at 10.2m
			</										

# RECORD OF BOREHOLE No WRB-1 2 of 2 METRIC

G.W.P. \_\_\_\_\_ LOCATION \_\_\_\_\_ Coords: 4 852 913.9 N; 292 423.8 E ORIGINATED BY F.P.  
DIST Central HWY 427 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.K.  
DATUM Geodetic DATE December 7 and 8, 2015 CHECKED BY A.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	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						
185.0							20 40 60 80 100	20 40 60 80 100	10 20 30				
			14	SS	102								0 4 72 24
183.8													
182.2	SILTY SAND, trace clay Dense to very dense Grey Wet		15	SS	97								0 57 37 6
			16	SS	65								
			17	SS	35								
176.7													
173.3	Switched to Dynamic Cone Penetration Test												
172.5													
172.5	End of Dynamic Cone Penetration Test												
	▽ Water level noted during drilling												
	Note:  1. Groundwater was not encountered inside the borehole upon completion of drilling.												

**RECORD OF BOREHOLE No WRB-2**

1 of 2

**METRIC**

G.W.P. \_\_\_\_\_ LOCATION \_\_\_\_\_ Coords: 4 853 092.1 N; 292 431.7 E ORIGINATED BY F.P.  
DIST Central HWY 427 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.K.  
DATUM Geodetic DATE December 01, 2015 CHECKED BY A.V.

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						
195.0	Ground Surface						20 40 60 80 100	20 40 60 80 100	10 20 30					
0.0	CLAYEY SILT containing rootlets and topsoil		1	SS	11									
	Stiff Dark brown Moist		2	SS	11									
193.6	CLAYEY SILT, with sand, trace gravel		3	SS	14									
1.4	Stiff to hard Brown becoming grey below a depth of 3.8m Moist to wet  (TILL)		4	SS	16									1 10 45 44
			5	SS	22									
			6	SS	58									
			7	SS	53									
			8	SS	84									1 14 72 13
			9	SS	50/10cm									
			10	SS	50/10cm									5 25 47 23
			11	SS	50/15cm									
			12	SS	36									
181.8	SAND, with silt		13	SS	78									0 71 24 5
13.2	Very dense Grey Wet													
180.8	Switched to Dynamic Cone Penetration Test													
14.2														

ON MTO\_NEW LOGO HWY 427 15TF013A-REV.GPJ ON\_MOT.GDT 14/01/2016 4:21:15 PM

Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No WRB-2	2 of 2	METRIC
-----------------------------	--------	--------

G.W.P.	LOCATION	Coords: 4 853 092.1 N; 292 431.7 E	ORIGINATED BY	F.P.
DIST Central	HWY 427	BOREHOLE TYPE	Continuous Flight Hollow Stem Augers	COMPILED BY
DATUM Geodetic	DATE	December 01, 2015	CHECKED BY	A.V.

[illegible]



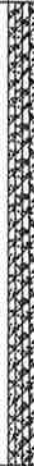



<b>PROJECT</b> 06-1111-012		<b>RECORD OF BOREHOLE No S19</b>		1 OF 1 <b>METRIC</b>	
<b>W.O.</b> 06-20012		<b>LOCATION</b> N 4852973.6; E 292419.3		<b>ORIGINATED BY</b> DD	
<b>DIST</b> Central HWY 427		<b>BOREHOLE TYPE</b> 200 mm Outside Diameter Hollow Stem Augers		<b>COMPILED BY</b> VA	
<b>DATUM</b> Geodetic		<b>DATE</b> March 2, 2009		<b>CHECKED BY</b> SMW	

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
193.8	GROUND SURFACE													
193.8	TOPSOIL		1	SS	11									
	CLAYEY SILT with sand, trace gravel (TILL) containing rootlets and topsoil to a depth of 0.6 m		2	SS	4									
	Firm to hard													
	Dark brown to grey		3	SS	19									
	Moist		4	SS	13									
	Containing oxidation zones between depths of 1.5 m and 2.1 m		5	SS	33									
			6	SS	04/0.1									
			7	SS	104									
	Augers grinding at a depth of 4.9 m													
			8	SS	112									
	Augers grinding at a depth of 7.0 m													
			9	SS	10/0.1									
185.9	END OF BOREHOLE													
7.9	NOTES:													
	1. Water level in open borehole at a depth of 6.1 m below ground surface (Elev. 187.7 m) upon completion of drilling.													
	2. An additional borehole was drilled adjacent to Borehole S19; See Record of Borehole S19A for details.													
	3. Borehole backfilled with bentonite.													

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

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



PROJECT 06-1111-012		RECORD OF BOREHOLE No S19A		2 OF 3 METRIC										
W.O. 05-20012		LOCATION N 4652973.6 :E 292417.3		ORIGINATED BY CR										
DIST Central HWY 427		BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers		COMPILED BY VA										
DATUM Geodetic		DATE March 10, 2009		CHECKED BY SMM <i>SMM</i>										
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 (%)		
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES						SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	
— CONTINUED FROM PREVIOUS PAGE —														
173.8 20.0	CLAYEY SILT, some sand, trace gravel (TILL) Very dense Grey Moist to wet  Wet below a depth of 17.1 m		3	SS	66							5 10 68 17		
170.6 23.2	SILT, trace clay, containing sand seams Compact Grey Wet		5	SS	18							0 0 92 8		
167.9 25.9	SANDY SILT, trace clay Compact Grey Wet		6	SS	24									
167.9 25.9	SAND and SILT, trace to some gravel, trace clay, containing cobbles and boulders (TILL) Very dense Grey Wet		7	SS	100							10 37 48 5		
164														

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

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



PROJECT		RECORD OF BOREHOLE No S19A				3 OF 3 METRIC									
W.O.		LOCATION		ORIGINATED BY											
DIST		BOREHOLE TYPE		COMPILED BY											
DATUM		DATE		CHECKED BY											
06-1111-012		N 4652973.6; E 292417.3		CR											
05-20012		200 mm Outside Diameter Hollow Stem Augers		VA											
Central HWY 427		March 10, 2009		SMM											
Geodetic															
SOIL PROFILE		SAMPLES		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa		WATER CONTENT (%)		γ		GR SA SI CL	
— CONTINUED FROM PREVIOUS PAGE —								20 40 60 80 100		10 20 30					
162.9	SAND and SILT, trace to some gravel, trace clay, containing cobbles and boulders (TILL) Very dense Grey Wet		8	SS	194		163	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x REMOULDED		W <sub>p</sub> — W — W <sub>L</sub>					
30.9	END OF BOREHOLE														
NOTES:															
1. Water level in open borehole at a depth of 2.1 m below ground surface (Elev. 191.7 m) upon completion of drilling.															
2. Borehole backfilled with bentonite.															

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

PROJECT 06-1111-012				RECORD OF BOREHOLE No S20				1 OF 1 METRIC					
W.O. 05-20012				LOCATION N 4852984.8 :E 292457.6				ORIGINATED BY DD					
DIST Central HWY 427				BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers				COMPILED BY VA					
DATUM Geodetic				DATE March 3, 2009				CHECKED BY SMM <i>SM</i>					
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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED
193.9	GROUND SURFACE					20	40	60	80	100			
8.9	TOPSOIL												
	CLAYEY SILT with sand, trace gravel (TILL) containing rootlets and oxidation zones to a depth of 1.4 m		1	SS	10								
	Firm to hard		2	SS	5								
	Dark brown to grey		3	SS	14								
	Moist to wet		4	SS	9								
	Becoming grey below a depth of 2.3 m		5	SS	21								
			6	SS	40								
			7	SS	102								
			8	SS	118								
			9	SS	00/0.1								
186.0	END OF BOREHOLE												
8.0	NOTES:												
	1. Water level in open borehole at a depth of 6.1 m below ground surface (Elev. 187.8 m) upon completion of drilling.												
	2. Borehole backfilled with bentonite.												

MIS-MTO 001 06-1111-012 GPJ GAL-MISS.GDT 85/09 SAC/DD

+ 3, × 3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE



PROJECT 06-1111-012			RECORD OF BOREHOLE No S21			1 OF 3 METRIC											
W.O. 05-20012			LOCATION N 4853030.3 :E 292401.0			ORIGINATED BY DD											
DIST Central HWY 427			BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers			COMPILED BY VA											
DATUM Geodetic			DATE March 4 & 5, 2009			CHECKED BY SMM											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)	γ	GR SA SI CL				
194.0	GROUND SURFACE																
0.1	TOPSOIL		1	SS	31												
	CLAYEY SILT, some sand, trace gravel (TILL) containing rootlets, topsoil and oxidation zones to a depth of 2.1 m Firm to hard Dark brown to grey Moist		2	SS	6		193										
			3	SS	4		192										
			4	SS	15		191										
			5	SS	19		190										
			6	SS	00/0.20		189										
			7	SS	81		188										
	Containing cobbles between depths of 6.1 m and 6.5 m		8	SS	00/0.20		187										
			9	SS	00/0.20		186										
			10	SS	102		185										
183.8							184										
10.2	Silty SAND, trace clay Very dense Grey Wet		11	SS	60		183										
182.3							182										
11.7	SAND and SILT, trace clay Dense Grey Moist to wet below a depth of 12.5 m		12	SS	32		181										
			13	SS	39		180										

Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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





PROJECT 06-1111-012		RECORD OF BOREHOLE No S21				3 OF 3 METRIC							
W.O. 05-20012		LOCATION N 4853030.3; E 292401.0				ORIGINATED BY DD							
DIST Central HWY 427		BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers				COMPILED BY VA							
DATUM Geodetic		DATE March 4 & 5, 2009				CHECKED BY SMM							
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					
	— CONTINUED FROM PREVIOUS PAGE —						20 40 60 80 100						
	Dynamic Cone Penetration Test (DCPT) below a depth of 25.9 m						○ UNCONFINED + FIELD VANE						
							● QUICK TRIAXIAL × REMOULDED						
							20 40 60 80 100						
163.5													
163.2	SAND and SILT, some gravel, trace clay, containing cobbles (TILL)		21	SS	50/0.15								
30.8	Very dense Grey Wet												
	END OF BOREHOLE												
	NOTES:												
	1. Water level in open borehole at a depth of 6.1 m below ground surface (Elev. 187.9 m) upon completion of drilling.												
	2. A Dynamic Cone Penetration Test was carried out between depths of 25.9 m and 30.5 m.												
	3. Borehole backfilled with bentonite.												
	* SPT "N" value affected by sample disturbance due to groundwater inflow to the borehole.												

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





PROJECT 06-1111-012				RECORD OF BOREHOLE No S22				1 OF 2 METRIC						
W.O. 05-20012				LOCATION N 4853048.3 E 292442.8				ORIGINATED BY DD						
DIST Central HWY 427				BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers				COMPILED BY VA						
DATUM Geodetic				DATE March 6, 2009				CHECKED BY SMT						
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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
193.7	GROUND SURFACE													
0.9	TOPSOIL		1	SS	10									
	CLAYEY SILT, some to with sand, trace gravel (TLL) containing rootlets and topsoil to a depth of 0.6 m		2	SS	10									
	Stiff to hard		3	SS	19									
	Brown to grey		4	SS	21									
	Moist		5	SS	59									
			6	SS	37									
			7	SS	61									
			8	SS	79									
186.5	SAND and SILT, trace gravel, trace clay (TLL)		9	SS	04/0.15									
7.2	Very dense		10	SS	00/0.22									
	Grey													
	Moist to wet below a depth of 7.6 m													
183.3	Silty SAND, trace clay		11	SS	84									
10.4	Very dense													
	Grey													
	Wet													
182.0	SAND and SILT, trace clay		12	SS	37									
11.7	Dense													
	Grey													
	Wet													
178.9			13	SS	31									
14.8														

Continued Next Page

+ 3, x 3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

PROJECT 06-1111-012				RECORD OF BOREHOLE No S22				2 OF 2 METRIC				
W.O. 05-20012				LOCATION N 4853048.3 :E 292442.8				ORIGINATED BY DD				
DIST Central HWY 427				BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers				COMPILED BY VA				
DATUM Geodetic				DATE March 6, 2009				CHECKED BY SMW				
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					
	--- CONTINUED FROM PREVIOUS PAGE ---											
176.3	SILT, trace sand, trace to some clay Very stiff Grey Wet		14	SS	29							
17.4	END OF BOREHOLE		15	SS	28							0 1 88 11
172.4	Dynamic Cone Penetration Test (DCPT) below a depth of 18.3 m											
21.3	END OF DCPT Refusal to Further DCPT Penetration											
	NOTES:											
	1. Water level in open borehole at a depth of 6.0 m below ground surface (Elev. 187.7 m) upon completion of drilling.											
	2. A Dynamic Cone Penetration Test was carried out between depths of 18.3 m and 21.3 m.											
	3. Borehole backfilled with bentonite.											

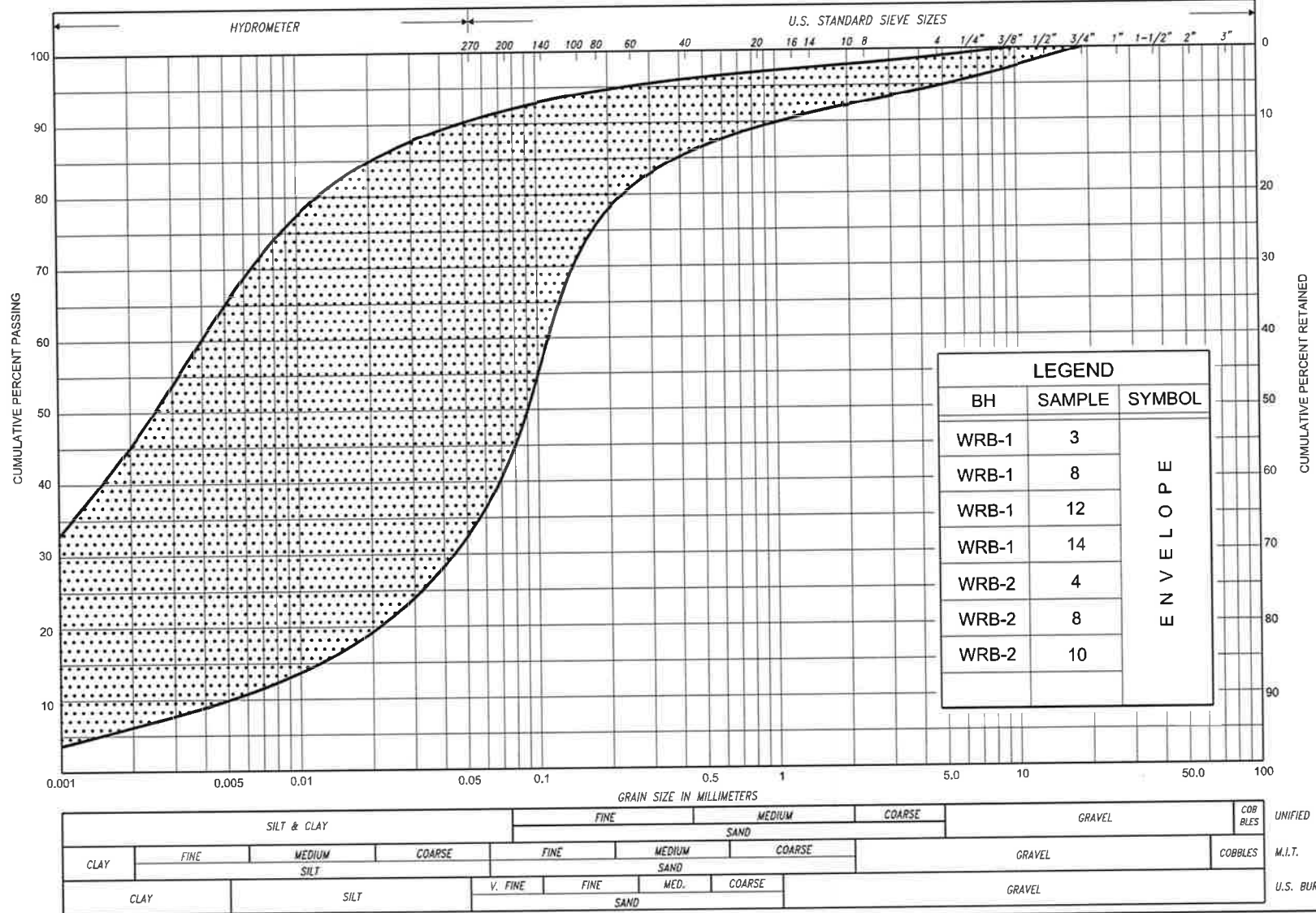
<b>PROJECT</b> 06-1111-012		<b>RECORD OF BOREHOLE No S23</b>		1 OF 1 <b>METRIC</b>
<b>W.O.</b> 05-20012	<b>LOCATION</b> N 4853058.0 :E 292390.6	<b>ORIGINATED BY</b> CR		
<b>DIST</b> Central <b>HWY</b> 427	<b>BOREHOLE TYPE</b> 200 mm Outside Diameter Hollow Stem Augers	<b>COMPILED BY</b> VA		
<b>DATUM</b> Geodetic	<b>DATE</b> March 9, 2009	<b>CHECKED BY</b> SMW		

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
197.2 0.0	GROUND SURFACE															
196.5 0.7	Silty sand, some gravel, trace clay, containing debris, wood, brick and concrete fragments and rootlets (FILL) Compact Brown Moist to wet		1	SS	20											
195.8 1.4	Clay, some sand, some gravel, containing debris, brick and concrete fragments (FILL) Very stiff Mottled brown and grey Moist		2	SS	20											
	CLAYEY SILT, trace to some sand, trace gravel (TILL), containing cobbles containing oxidation zones to a depth of 3.7 m Very stiff to hard Brown becoming grey below a depth of 3.7 m Moist		3	SS	26											
			4	SS	42											
			5	SS	43											
			6	SS	78											
			7	SS	24											
			8	SS	17											
			9	SS	88/0.25											
			10	SS	50/0.10											
	Wet below a depth of 9.1 m		11	SS	00/0.1											
186.4 10.8	END OF BOREHOLE															
NOTES:  1. A 50 mm diameter monitoring well was installed at a depth of 10.7 m (Elev. 186.5 m).  Water level measurements:  Date            Depth    Elev. On Completion 8.5 m    185.7 m April 24, 2009    3.8 m    193.4 m May 21, 2009    3.8 m    193.4 m June 15, 2009    4.0 m    193.2 m July 09, 2009    4.1 m    193.1 m																

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

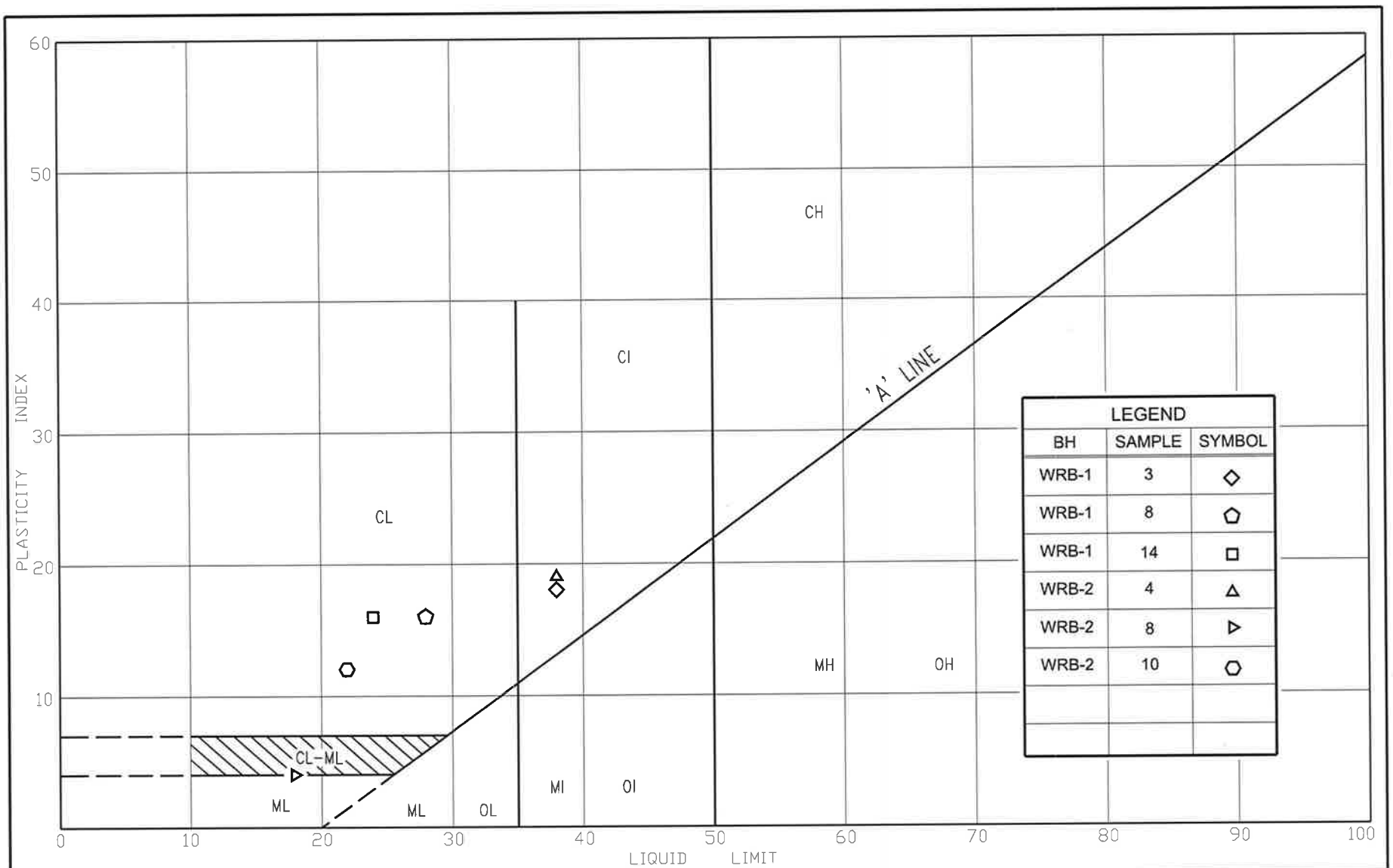
PROJECT 06-1111-012				RECORD OF BOREHOLE No S24				1 OF 1 METRIC							
W.O. 05-20012				LOCATION N 4852954.8 E 292466.5				ORIGINATED BY DD							
DIST Central HWY 427				BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers				COMPILED BY VA							
DATUM Geodetic				DATE March 3, 2009				CHECKED BY SMM							
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							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED			WATER CONTENT (%)				
								20 40 60 80 100 20 40 60 80 100			10 20 30 10 20 30				
199.2	GROUND SURFACE														
199.0	TOPSOIL														
	SILTY CLAY, some sand, trace gravel, (TILL) containing rootlets to a depth of 0.6 m		1	SS	14		199								
	Stiff to very stiff		2	SS	22		198								2 13 49 36
	Brown to grey		3	SS	28										
	Moist		4	SS	26		197								
			5	SS	26		196								
195.5	CLAYEY SILT some to with sand, trace gravel, containing cobbles below a depth of 9.8 m (TILL)		6	SS	13		195								
3.7	Stiff to hard		7	SS	17		194								
	Grey		8	SS	18		193								
	Moist to wet		9	SS	20		192								
			10	SS	113		191								
	Auger grinding at a depth of 9.8 m						190								
							189								
	Wet below a depth of 10.7 m		11	SS	11/0.2		188								5 32 50 13
							187								
186.6	END OF BOREHOLE		12	SS	113										
12.7	NOTES:														
1. Water level in open borehole at a depth of 8.0 m below ground surface (Elev. 191.2 m) upon completion of drilling. 2. Borehole backfilled with bentonite.															

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 9/5/09 SAC/DD



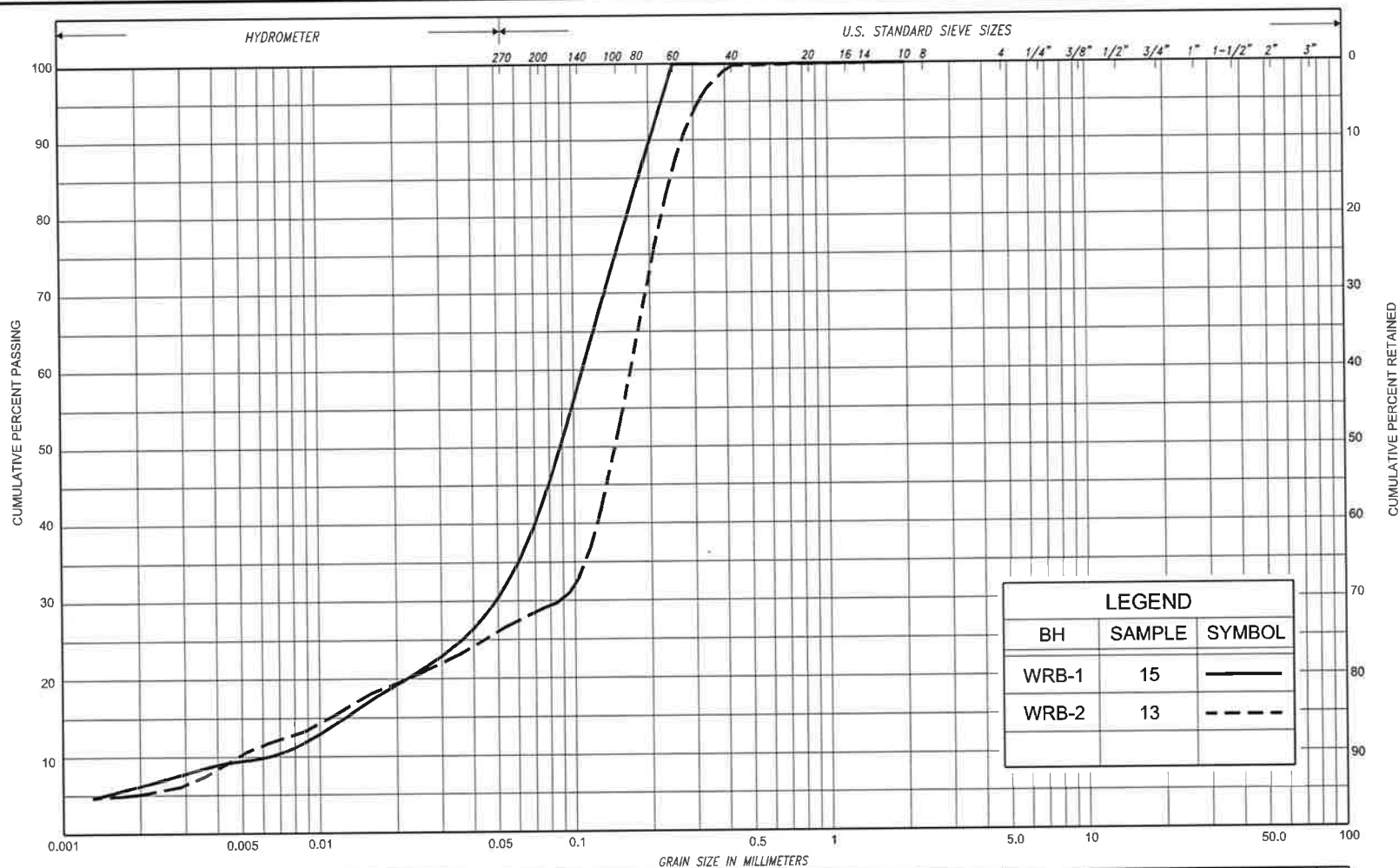
# GRAIN SIZE DISTRIBUTION CLAYEY SILT to SILTY CLAY (TILL)

FIG No. F-1  
HWY: 427  
G.W.P. No.



**PLASTICITY CHART**  
CLAYEY SILT to SILTY CLAY (TILL)

FIG No. F-2  
HWY: 427  
G.W.P. No.



SILT & CLAY				FINE			MEDIUM		COARSE	GRAVEL		COB BLES	UNIFIED
							SAND						
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	SAND			GRAVEL		COB BLES	M.I.T.
CLAY		SILT		V. FINE	FINE	MED.	COARSE	SAND		GRAVEL			U.S. BUREAU



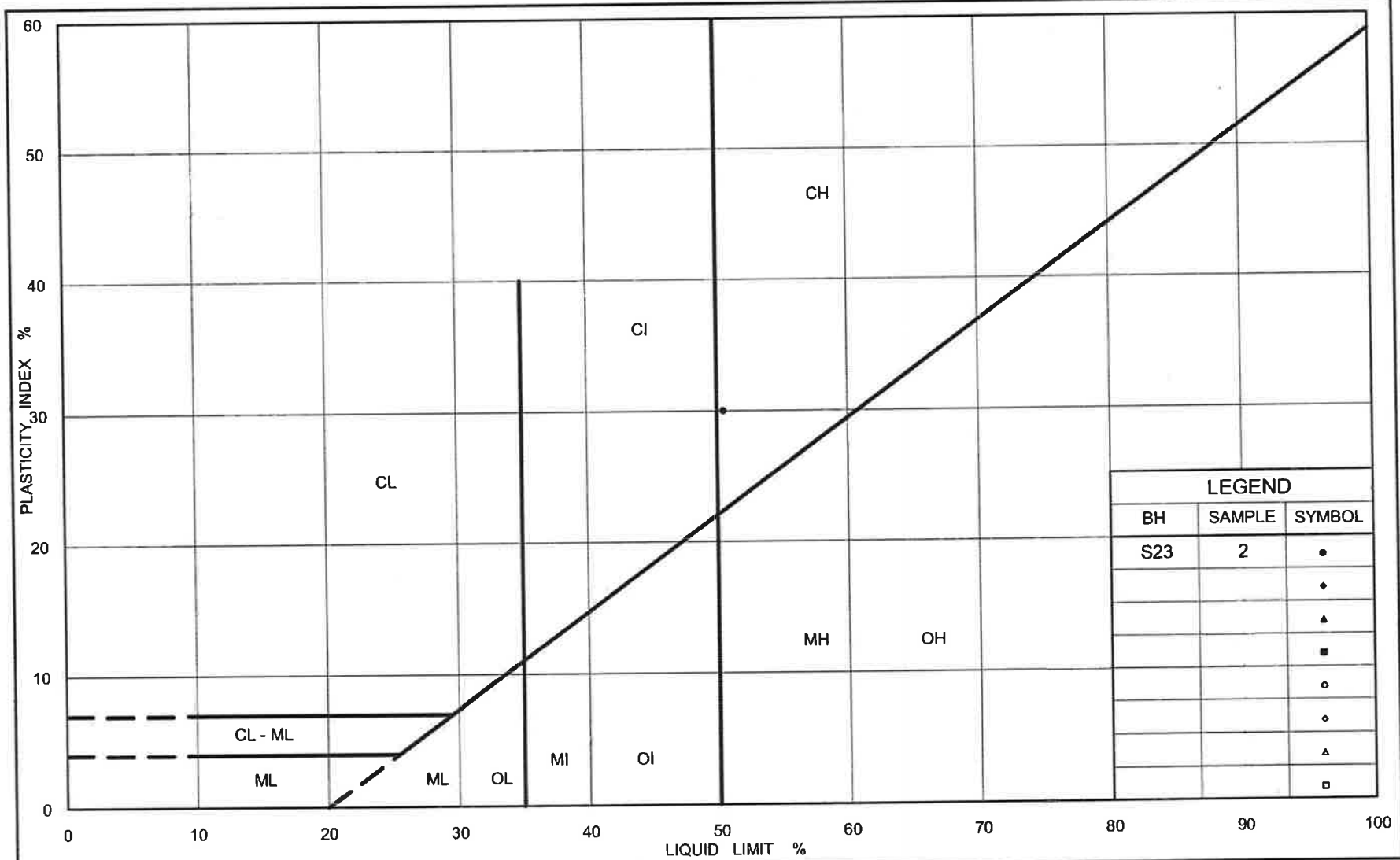
## GRAIN SIZE DISTRIBUTION

SILT, with sand to SILTY SAND

FIG No. F-3

HWY: 427

G.W.P. No.



Ministry of Transportation

Ontario

# PLASTICITY CHART Clay Fill

Figure No. B1

Project No. 06-1111-012-4

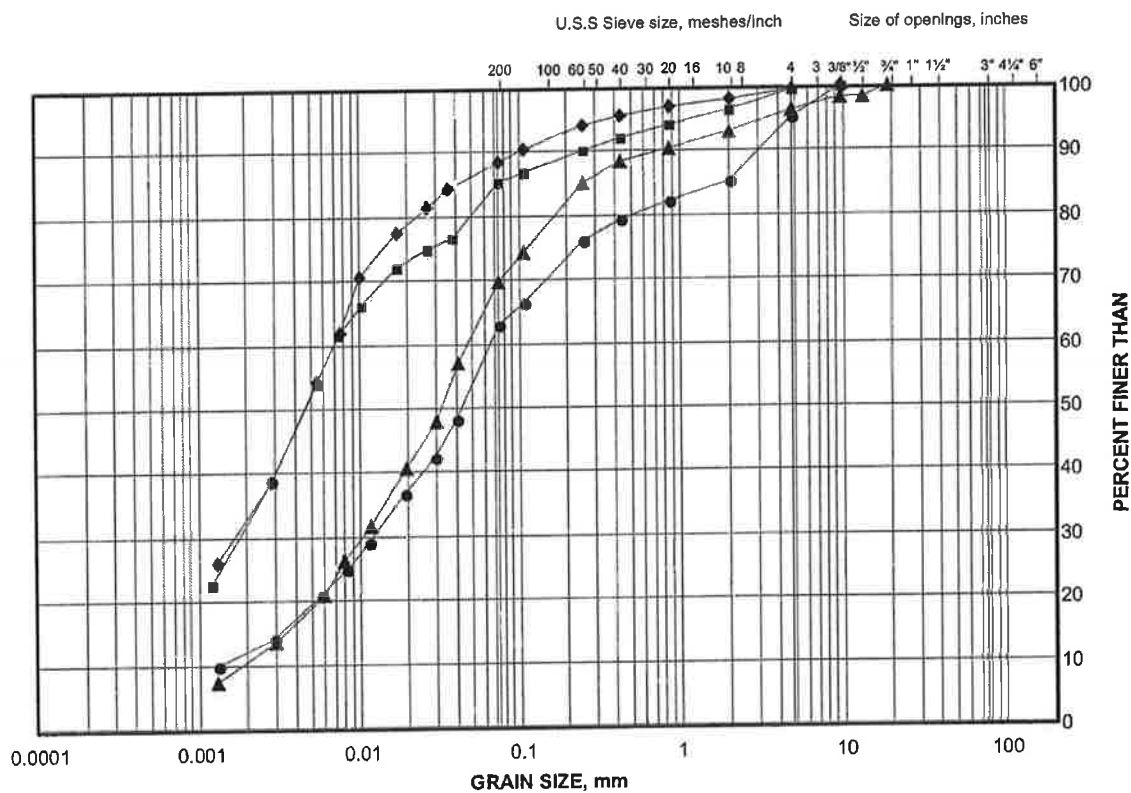
Checked By: *SM*



# GRAIN SIZE DISTRIBUTION TEST RESULTS

Upper Clayey Silt to Silty Clay Till

FIGURE B2-A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S24	11	188.3
■	S22	4	191.1
◆	S23	6	188.2
▲	S20	7	189.1

Project Number: 06-1111-012-4

Checked By: *sm*

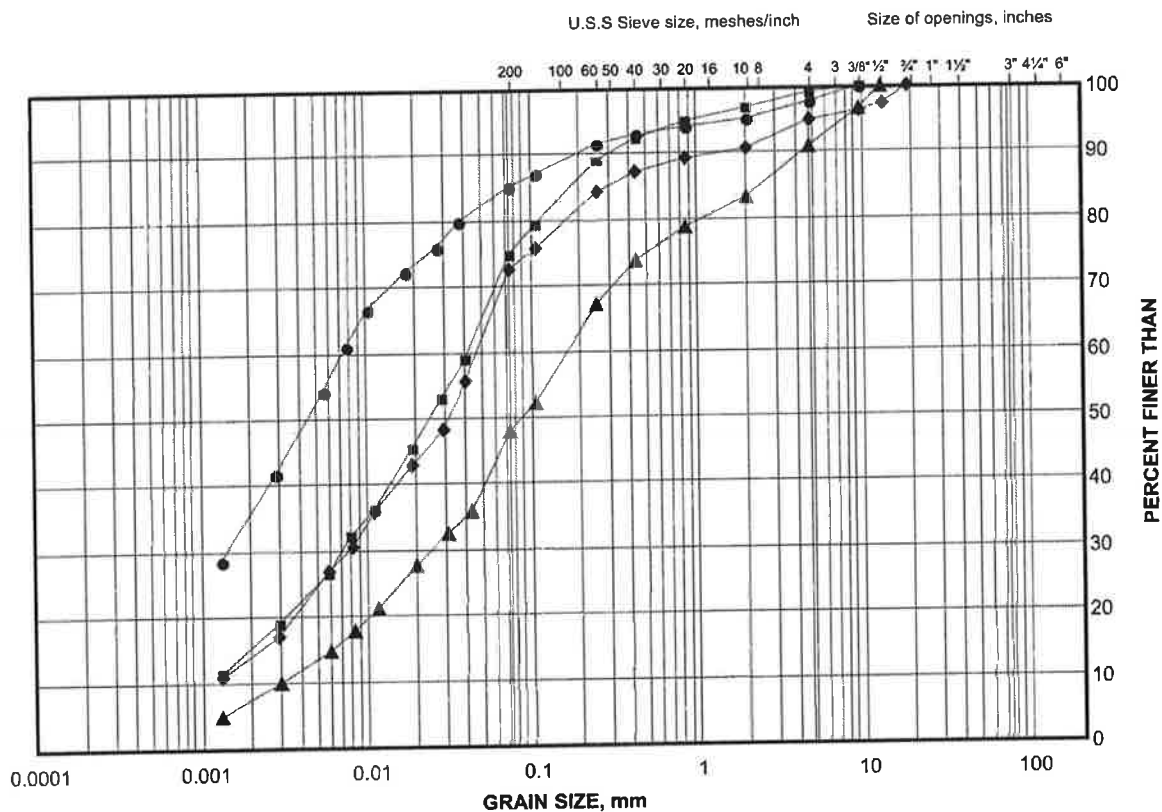
Golder Associates

Date: 04-Aug-09

# GRAIN SIZE DISTRIBUTION TEST RESULTS

Upper Clayey Silt to Silty Clay Till

FIGURE B2-B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

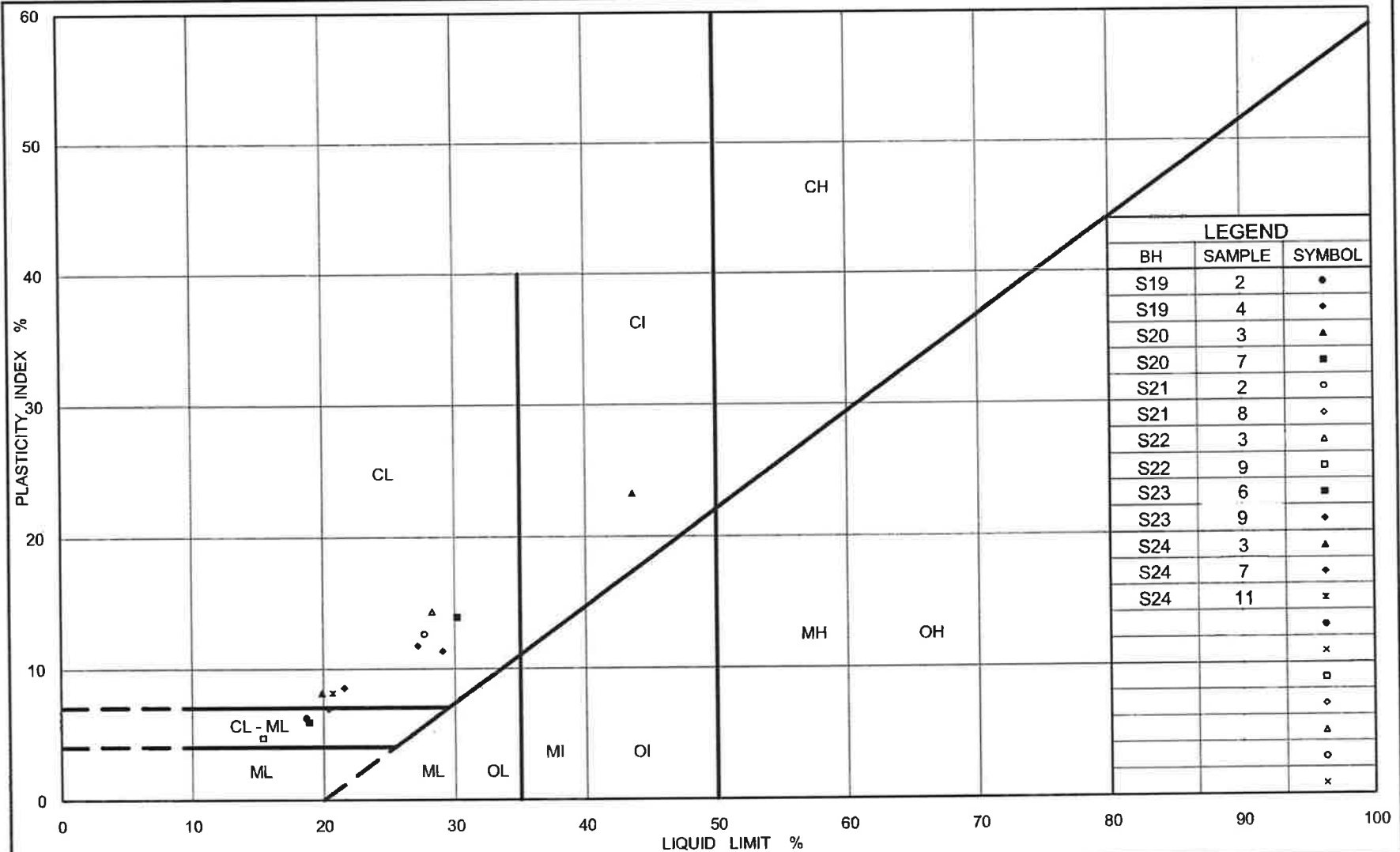
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S24	2	198.1
■	S19	8	187.5
◆	S21	8	187.9
▲	S22	9	186.0

Project Number: 06-1111-012-4

Checked By: *SM*

Golder Associates

Date: 04-Aug-09



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## PLASTICITY CHART

### Upper Clayey Silt to Silty Clay Till

Figure No. B3

Project No. 06-1111-012-4

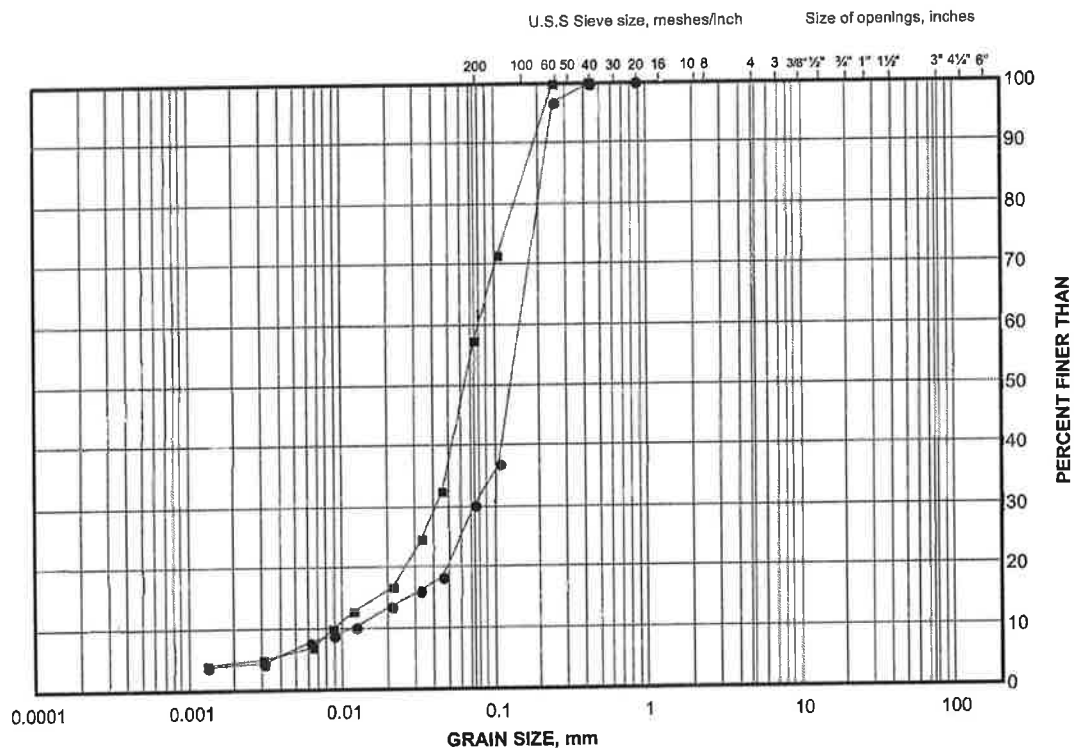
Checked By:

*SM*

# GRAIN SIZE DISTRIBUTION TEST RESULTS

Silty Sand to Sand and Silt

FIGURE B4



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S21	11	183.0
■	S22	12	181.2

Project Number: 06-1111-012-4

Checked By: *SM*

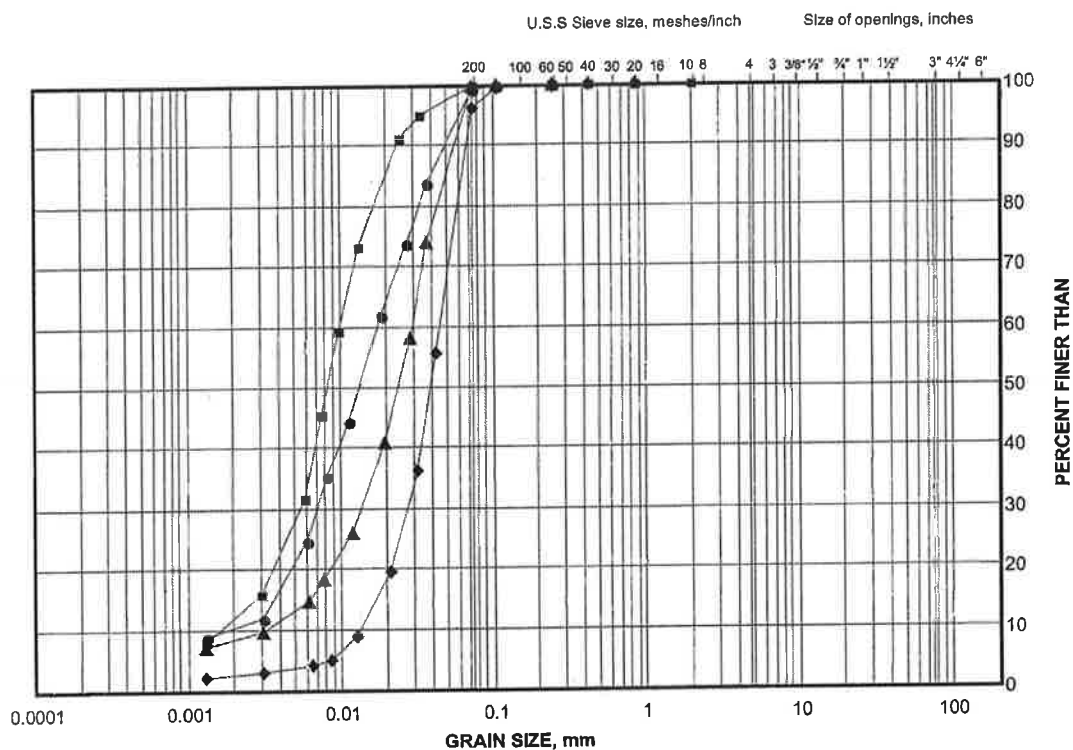
Golder Associates

Date: 29-May-09

# GRAIN SIZE DISTRIBUTION TEST RESULTS

Silt

FIGURE B5



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

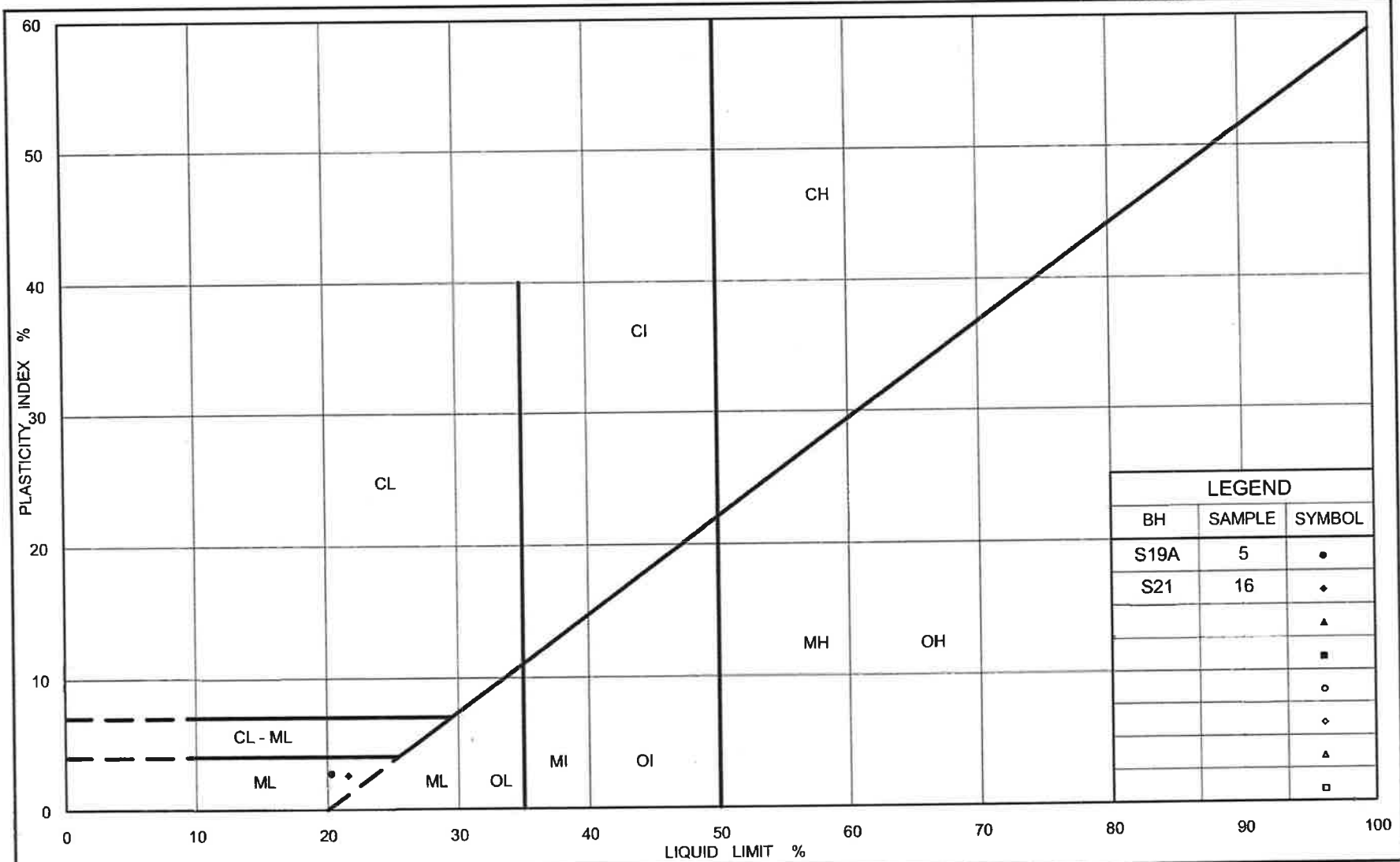
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S22	15	176.6
■	S21	17	174.0
◆	S21	20	169.3
▲	S19A	5	172.2

Project Number: 06-1111-012-4

Checked By: sm

Golder Associates

Date: 29-May-09



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# PLASTICITY CHART Silt

Figure No. B6

Project No. 06-1111-012-4

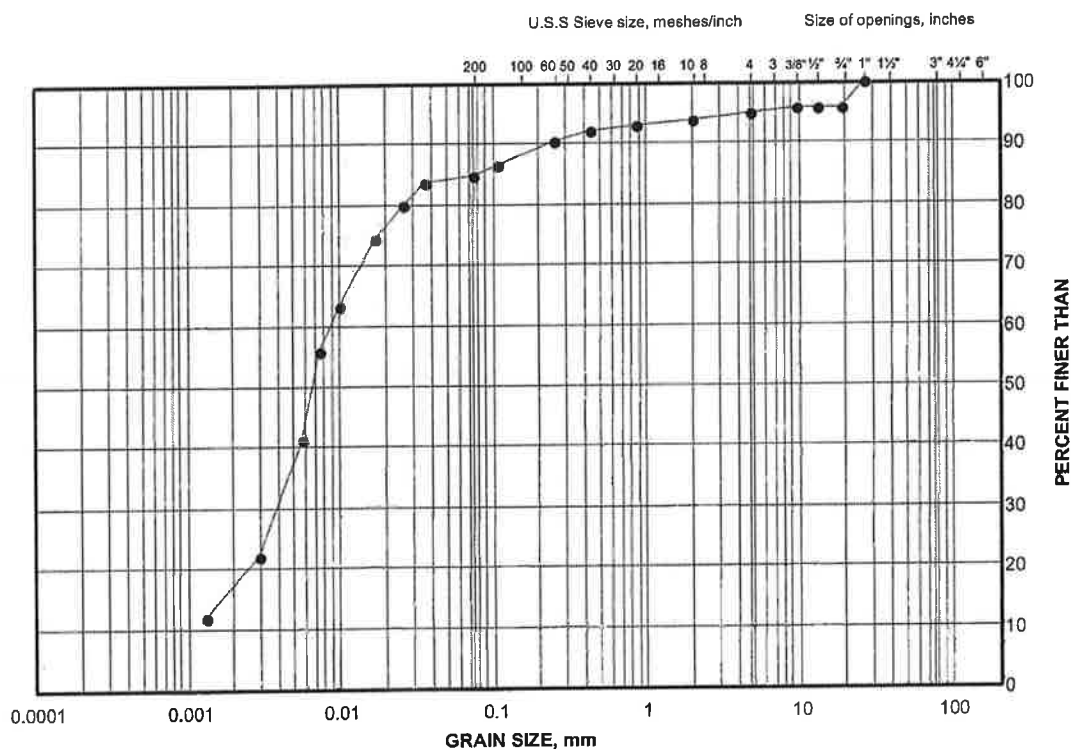
Checked By:

STM

# GRAIN SIZE DISTRIBUTION TEST RESULT

Clayey Silt Till (Lower Cohesive Till)

FIGURE B7



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

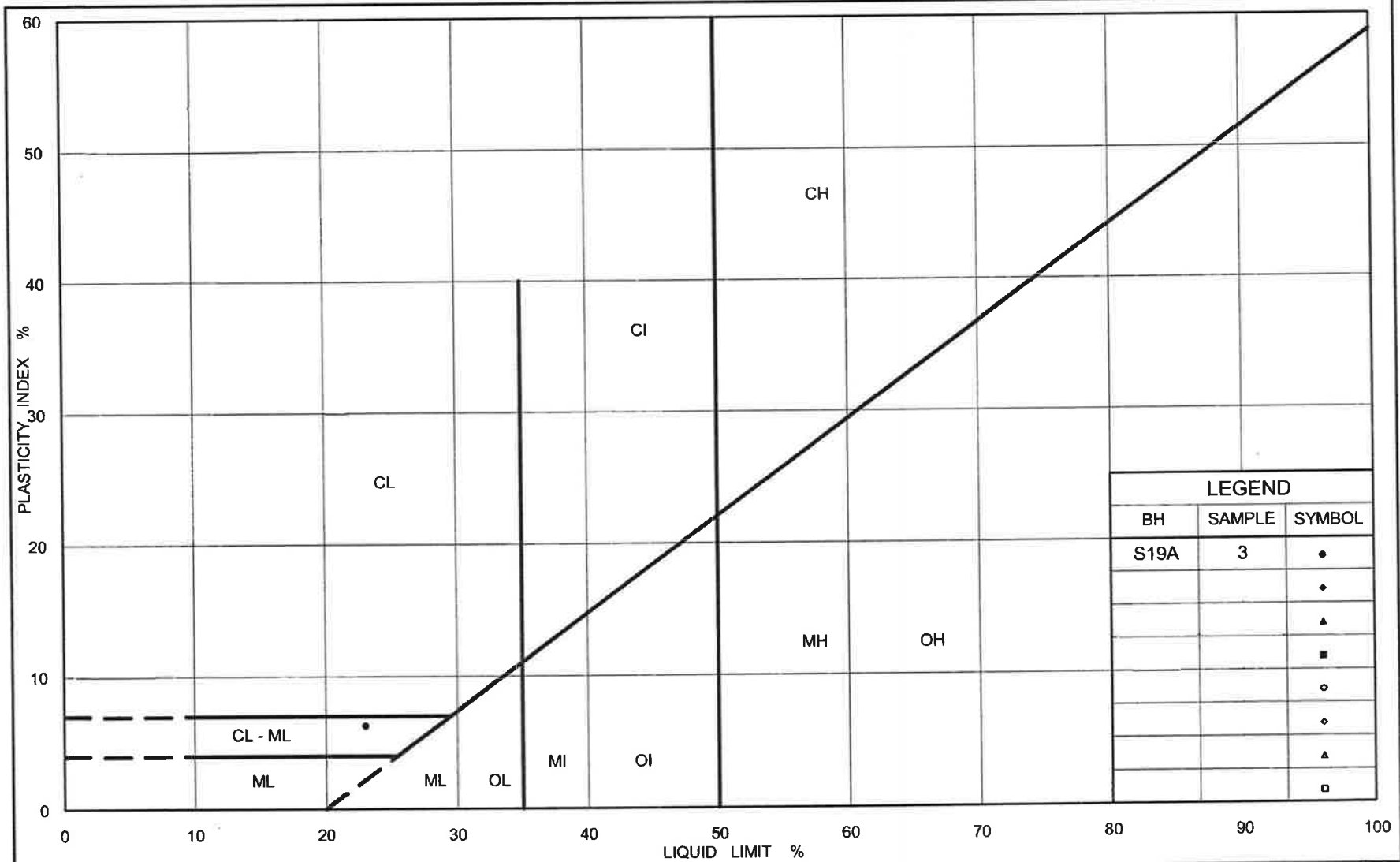
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	S19A	3	178.3

Project Number: 06-1111-012-4

Checked By: 8m

Golder Associates

Date: 29-May-09



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Ontario

# PLASTICITY CHART Clayey Silt Till (Lower Cohesive Till)

Figure No. B8

Project No. 06-1111-012-4

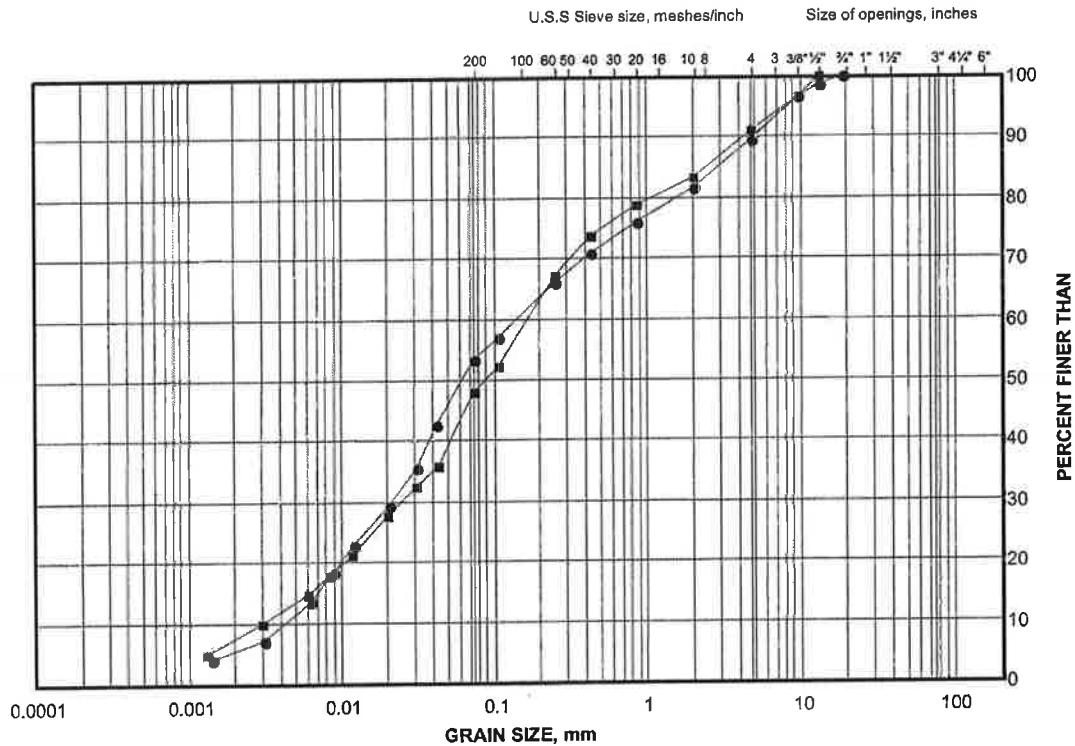
Checked By: *SM*



# GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand and Silt Till

FIGURE B9



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

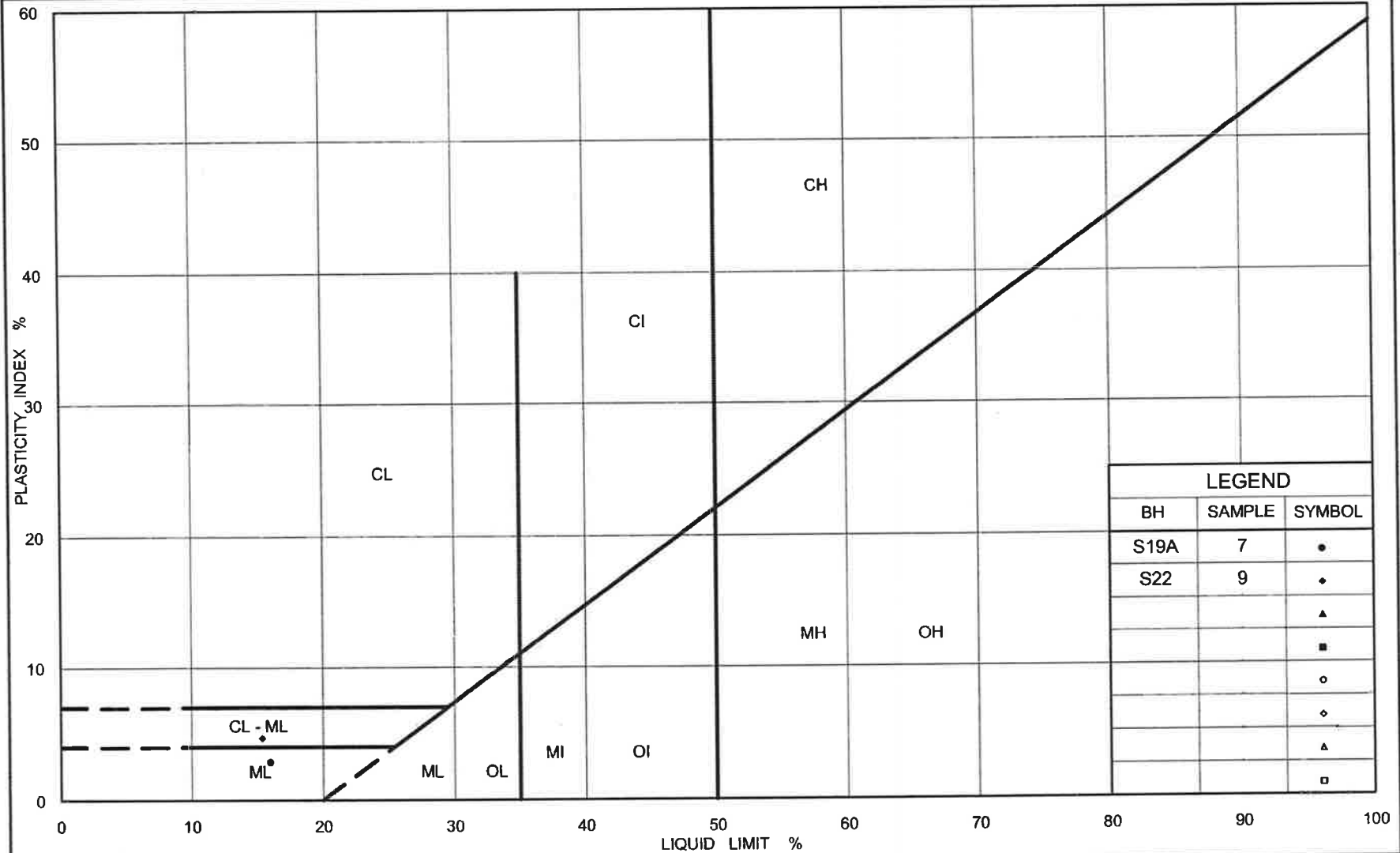
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S19A	7	166.1
■	S22	9	186.0

Project Number: 06-1111-012-4

Checked By: SM

**Golder Associates**

Date: 29-May-09



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# PLASTICITY CHART Sand and Silt Till

Figure No. B10

Project No. 06-1111-012-4

Checked By:

SM

## Appendix D

### Borehole Locations and Soil Strata Drawings








**THURBER** ENGINEERING LTD.



## KEYPLAN

## LEGEND

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

NO	ELEVATION	NORTHING	EASTING
S19	193.8	4 852 973.6	292 419.3
S19A	193.8	4 852 973.6	292 417.3
S20	193.9	4 852 984.8	292 457.6
S21	194.0	4 853 030.3	292 401.0
S22	193.7	4 853 048.3	292 442.8
S23	197.2	4 853 058.0	292 390.6
S24	199.2	4 852 954.8	292 466.5
WR17-01	199.8	4 852 916.1	292 436.3
WR17-02	198.5	4 852 937.5	292 429.1
WR17-03	193.7	4 852 992.5	292 415.0
WR17-04	194.7	4 853 081.4	292 428.4
WR17-05	193.7	4 853 022.2	292 459.5
WR17-06	197.5	4 852 972.0	292 465.3
WRB-1	200.0	4 852 913.9	292 423.8
WRB-2	195.0	4 853 092.1	292 431.7

-NOTES-

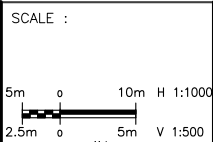
- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

**GEOCRES No.**



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A	19/08/27	100% SUBMISSION TO CA				AN	KS
NO.	DATE	REVISIONS				BY	CHK.
						LEAD.	PRO.
						MAN.	MAN.



CONSULTANT	DESIGNED	M. MEHDI	MM	19/08/27
	DRAWN	A. NOOR	AN	19/08/27
	CHECKED	K. SHI	KS	19/08/27
	APPROVED LEAD ENGINEER	J. LEE	JL	19/08/27
	APPROVED PROJ. MANAGER	J. LEE	JL	19/08/27
		NAME (PRINT)	INIT.	DATE



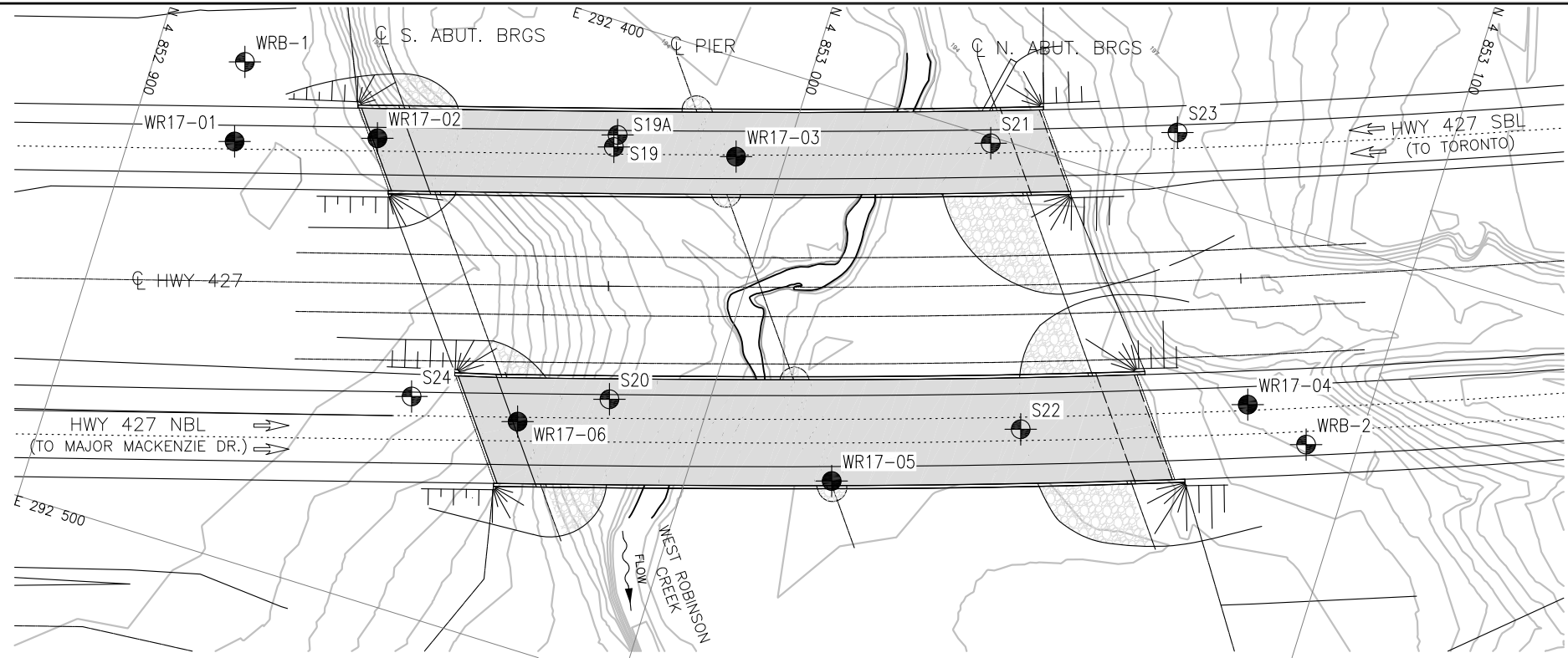
TITLE
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HWY 427 EXPANSION  
HIGHWAY 427 NBL OVER  
WEST ROBINSON CREEK

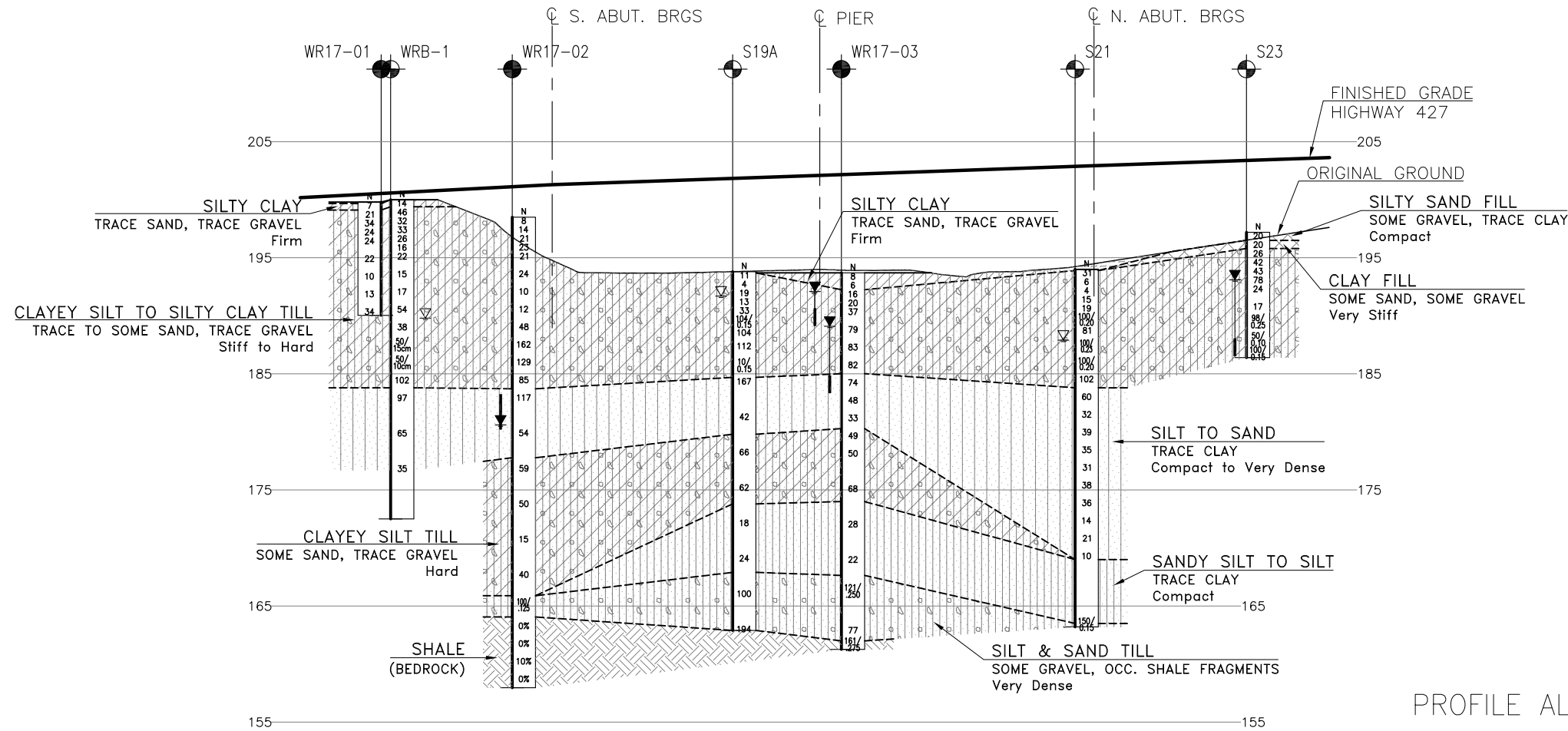
## BOREHOLE LOCATIONS AND SOIL STRATA

PROJECT ID.	STAGE IDENTIFIER	DESIGN PACKAGE NUMBER	DISCIPLINE	STRUCTURE NUMBER	DOCUMENT TYPE	DRAWING NUMBER	REVISION NUMBER
H427-D	H	3A	STR	B16A	DWG	501	A





PLAN



PROFILE ALONG C HWY 427 SBL

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



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
W	Water Level
↓	Head Artesian Water
⊕	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
S19	193.8	4 852 973.6	292 419.3
S19A	193.8	4 852 973.6	292 417.3
S20	193.9	4 852 984.8	292 457.6
S21	194.0	4 853 030.3	292 401.0
S22	193.7	4 853 048.3	292 442.8
S23	197.2	4 853 058.0	292 390.6
S24	199.2	4 852 954.8	292 466.5
WR17-01	199.8	4 852 916.1	292 436.3
WR17-02	198.5	4 852 937.5	292 429.1
WR17-03	193.7	4 852 992.5	292 415.0
WR17-04	194.7	4 853 081.4	292 428.4
WR17-05	193.7	4 853 022.2	292 459.5
WR17-06	197.5	4 852 972.0	292 465.3
WRB-1	200.0	4 852 913.9	292 423.8
WRB-2	195.0	4 853 092.1	292 431.7

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. Surface details and features are for conceptual illustration.

GEOCRES No.

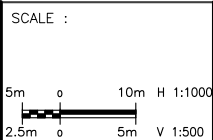
HWY 427 EXPANSION  
HIGHWAY 427 SBL OVER  
WEST ROBINSON CREEK

BOREHOLE LOCATIONS AND SOIL STRATA

PROJECT ID.	STAGE IDENTIFIER	DESIGN PACKAGE NUMBER	DISCIPLINE	STRUCTURE NUMBER	DOCUMENT TYPE	DRAWING NUMBER	REVISION NUMBER
H427-D	H	3A	STR	B16B	DWG	601	A

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NO.	DATE	REVISIONS	BY	CHK	APP	PROJ. MGR.
A	19/08/27	100% SUBMISSION TO CA	AN	KS	JL	JL



DESIGNED	M. MEHDI	MM	19/08/27
DRAWN	A. NOOR	AN	19/08/27
CHECKED	K. SHI	KS	19/08/27
APPROVED LEAD ENGINEER	J. LEE	JL	19/08/27
APPROVED PROJ. MANAGER	J. LEE	JL	19/08/27
NAME (PRINT)	INIT.	DATE	



PROJECT ID.	STAGE IDENTIFIER	DESIGN PACKAGE NUMBER	DISCIPLINE	STRUCTURE NUMBER	DOCUMENT TYPE	DRAWING NUMBER	REVISION NUMBER
H427-D	H	3A	STR	B16B	DWG	601	A

## Appendix E

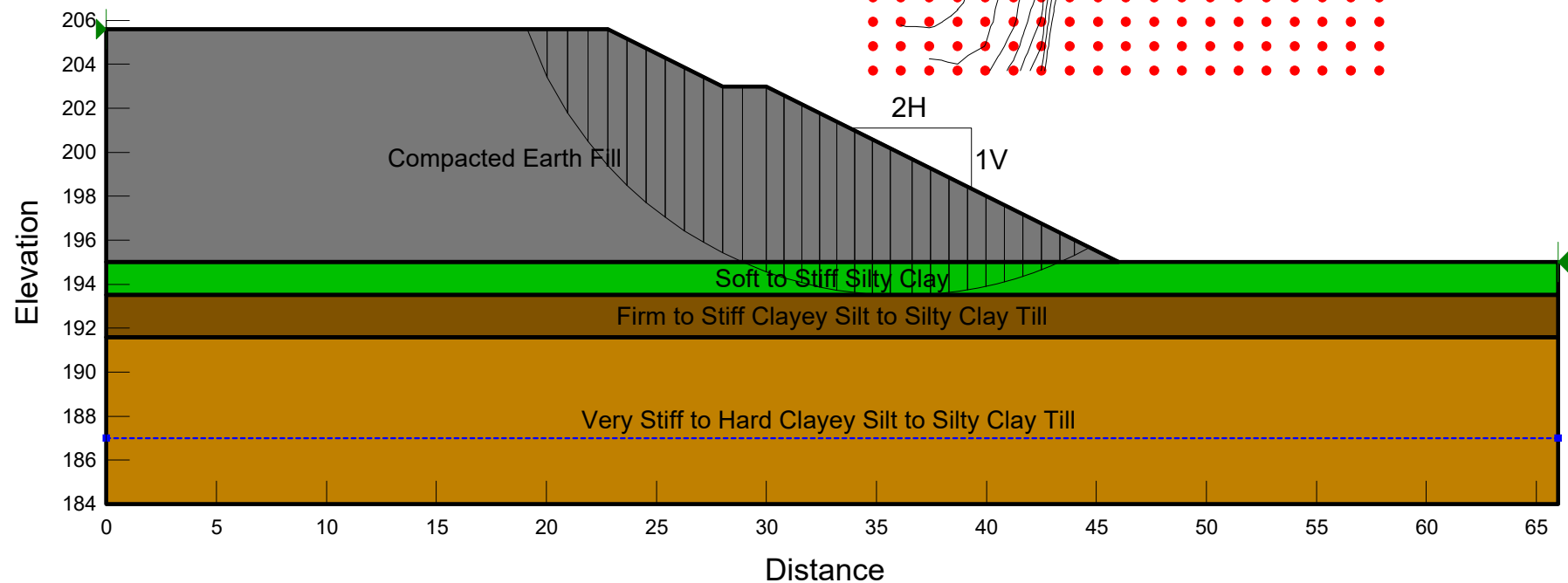
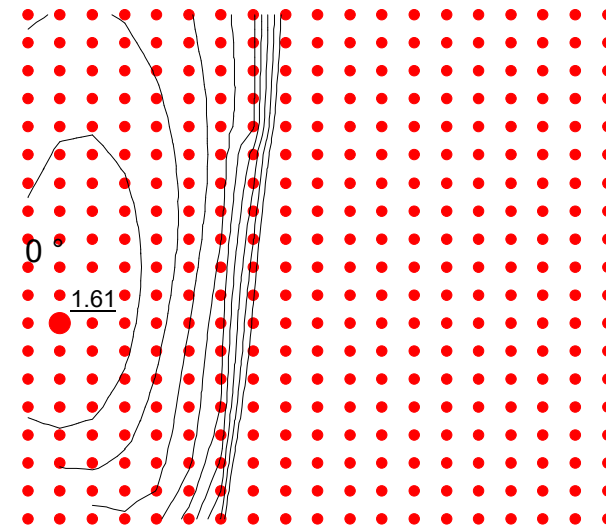
### Stability Analysis Output for Approach Embankments

**FIGURE E1**

# **CRITICAL EMBANKMENT SECTION (STA. 15+600)** **SHORT-TERM CONDITION**

Compacted Earth Fill	20 kN/m <sup>3</sup>	0 kPa	30 °
Soft to Stiff Silty Clay	18 kN/m <sup>3</sup>	50 kPa	0 °
Firm to Stiff Clayey Silt to Silty Clay Till	20 kN/m <sup>3</sup>	100 kPa	0 °
Very Stiff to Hard Clayey Silt to Silty Clay Till	21 kN/m <sup>3</sup>	200 kPa	0 °

Method: Morgenstern-Price, Half Sine  
 Minimum Slip Surface Depth: 1 m  
 Seismic: 0



**FIGURE E2**

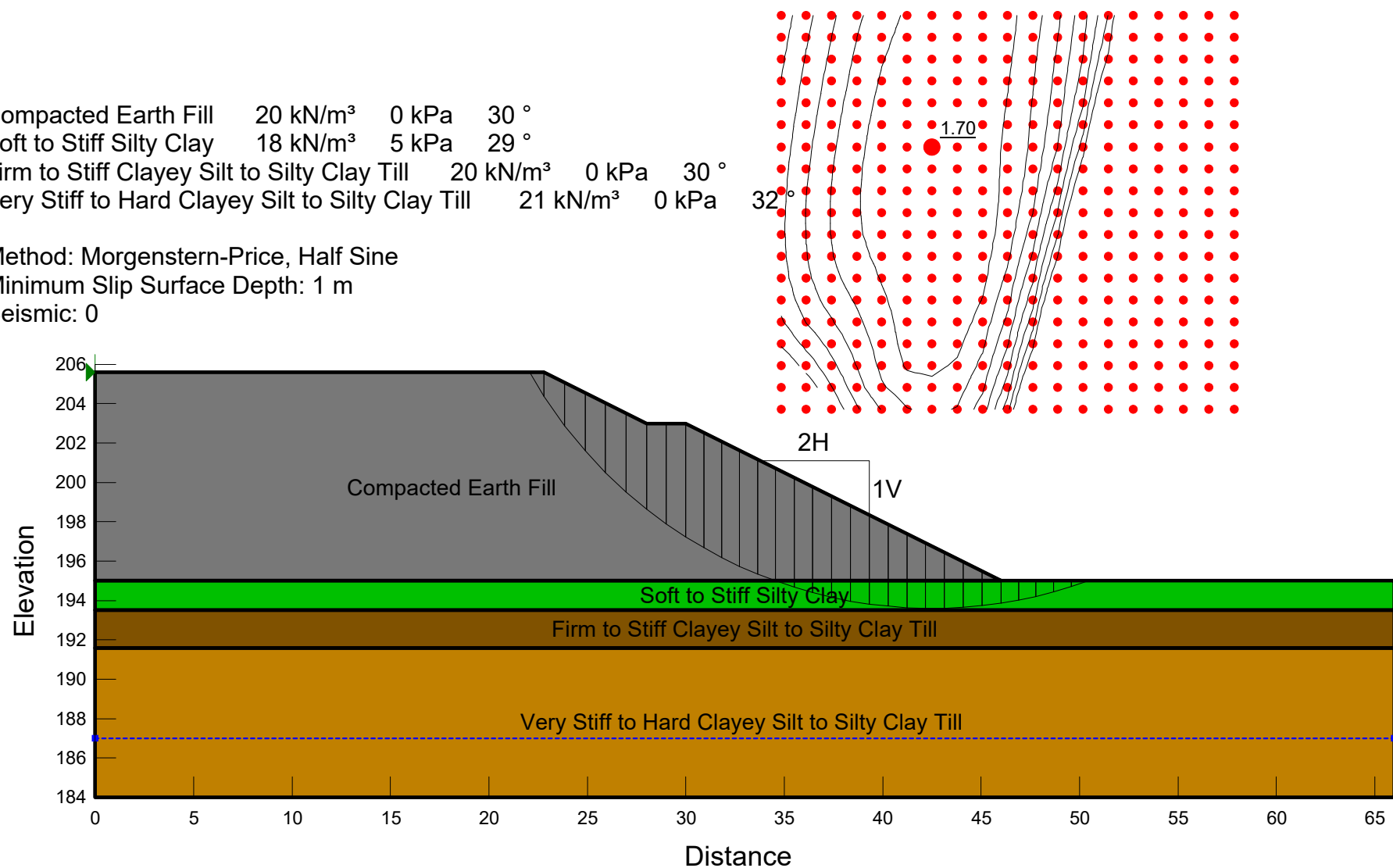
# **CRITICAL EMBANKMENT SECTION (STA. 15+600)** **LONG-TERM CONDITION**

Compacted Earth Fill	20 kN/m <sup>3</sup>	0 kPa	30 °
Soft to Stiff Silty Clay	18 kN/m <sup>3</sup>	5 kPa	29 °
Firm to Stiff Clayey Silt to Silty Clay Till	20 kN/m <sup>3</sup>	0 kPa	30 °
Very Stiff to Hard Clayey Silt to Silty Clay Till	21 kN/m <sup>3</sup>	0 kPa	32 °

Method: Morgenstern-Price, Half Sine

Minimum Slip Surface Depth: 1 m

Seismic: 0



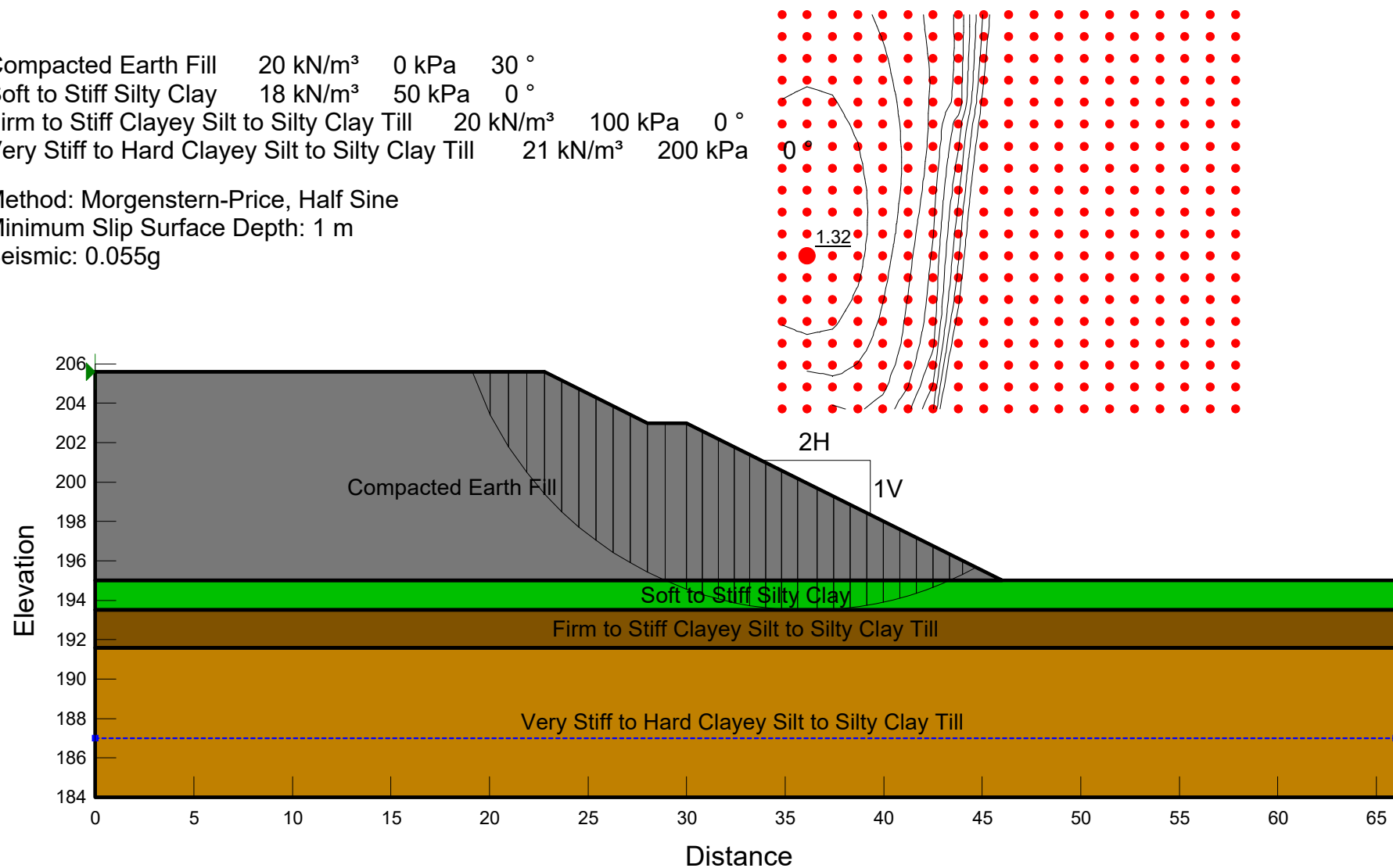


**FIGURE E3**

# **CRITICAL EMBANKMENT SECTION (STA. 15+600)** **SEISMIC CONDITION**

Compacted Earth Fill	20 kN/m <sup>3</sup>	0 kPa	30 °
Soft to Stiff Silty Clay	18 kN/m <sup>3</sup>	50 kPa	0 °
Firm to Stiff Clayey Silt to Silty Clay Till	20 kN/m <sup>3</sup>	100 kPa	0 °
Very Stiff to Hard Clayey Silt to Silty Clay Till	21 kN/m <sup>3</sup>	200 kPa	0 °

Method: Morgenstern-Price, Half Sine  
 Minimum Slip Surface Depth: 1 m  
 Seismic: 0.055g



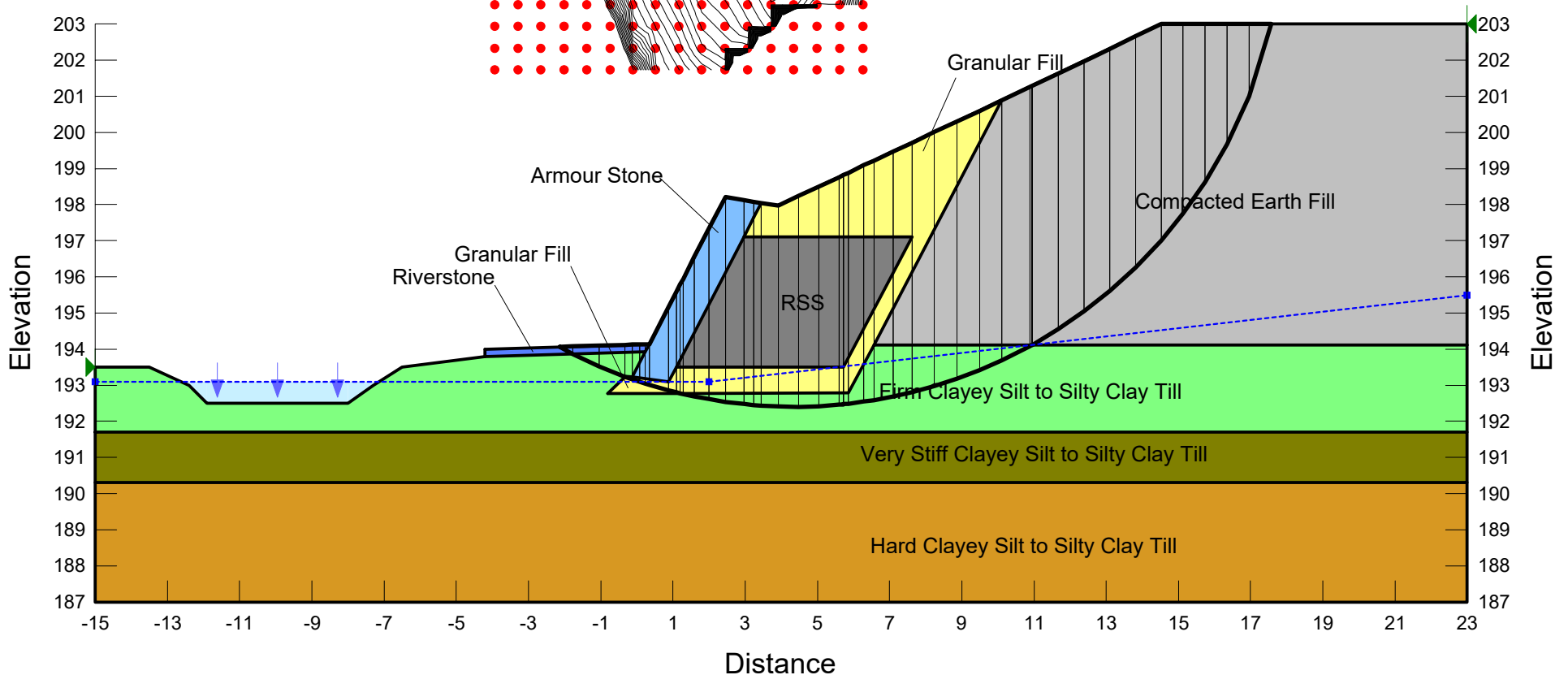
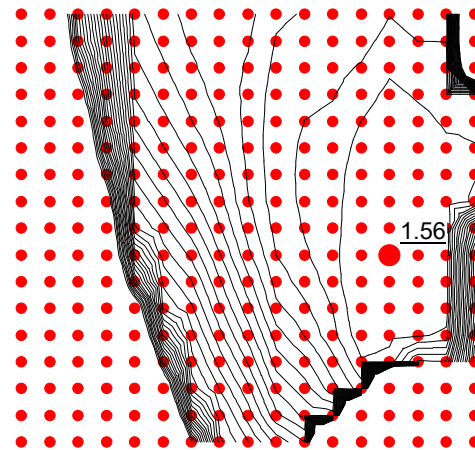
# CRITICAL WALL SECTION WEST ROBINSON CREEK ARMOUR STONE WALL SHORT-TERM CONDITION (NWL)

FIGURE E4

File Name: West Robinson Bridge Armour Stone Wall - TSA\_2.gsz  
Last Edited By: Geoff Lay  
Date: 4/18/2018

Method: Morgenstern-Price  
Minimum Slip Surface Depth: 1 m  
Seismic: 0

Granular Fill	21 kN/m <sup>3</sup>	0 kPa	35 °
RSS	22 kN/m <sup>3</sup>	200 kPa	34 °
Armour Stone	24 kN/m <sup>3</sup>	1,000 kPa	0 °
Riverstone	19 kN/m <sup>3</sup>	0 kPa	38 °
Firm Clayey Silt to Silty Clay Till	18 kN/m <sup>3</sup>	50 kPa	0 °
Very Stiff Clayey Silt to Silty Clay Till	21 kN/m <sup>3</sup>	100 kPa	0 °
Hard Clayey Silt to Silty Clay Till	22 kN/m <sup>3</sup>	200 kPa	0 °
Compacted Earth Fill	20 kN/m <sup>3</sup>	0 kPa	30 °



# CRITICAL WALL SECTION WEST ROBINSON CREEK ARMOUR STONE WALL LONG-TERM CONDITION (NWL)

FIGURE E5

File Name: West Robinson Bridge Armour Stone Wall - ESA\_2.gsz

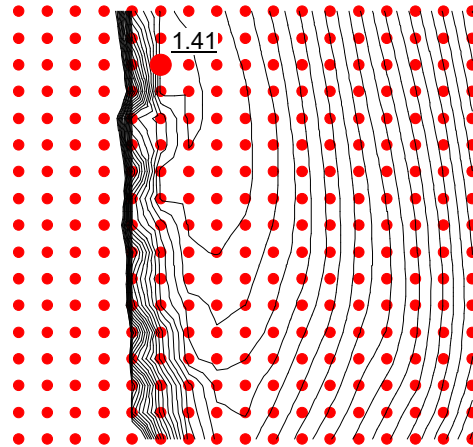
Last Edited By: Geoff Lay

Date: 4/18/2018

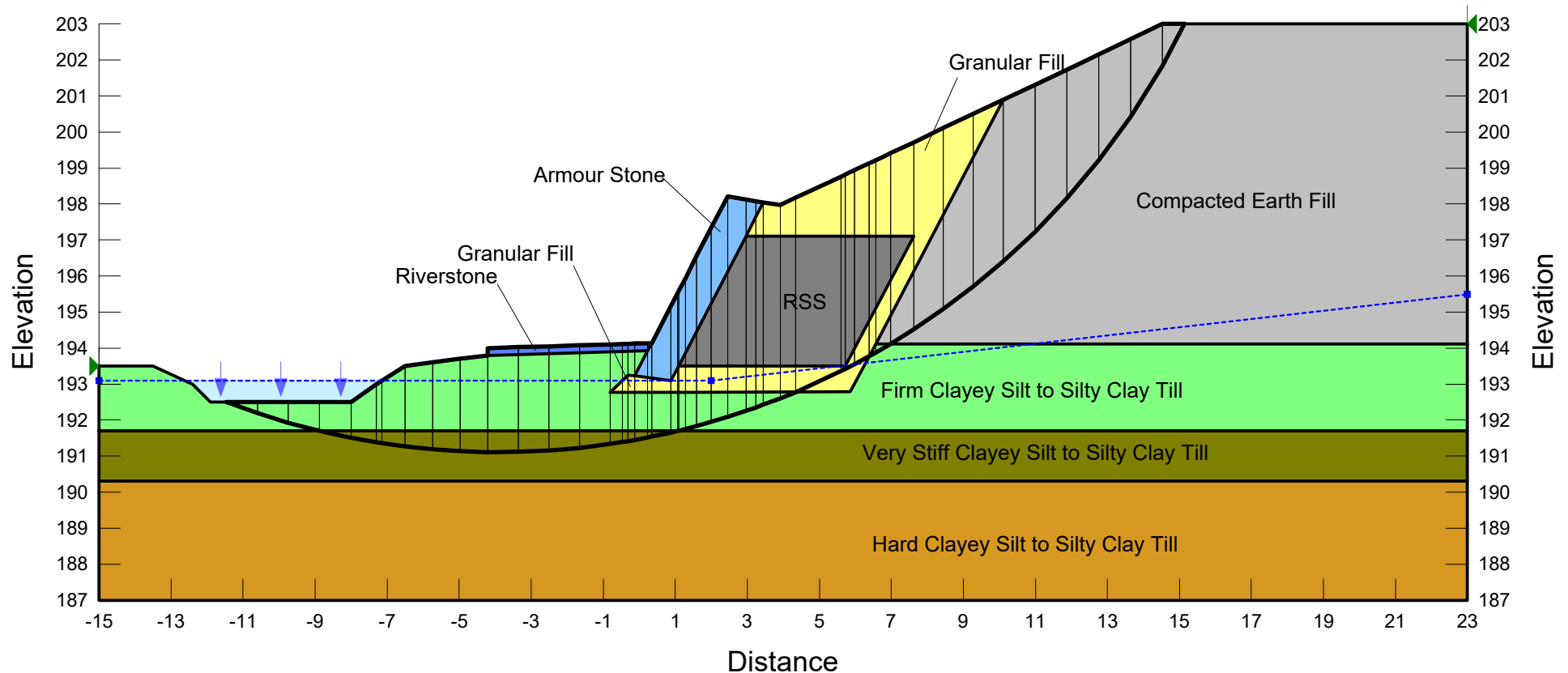
Method: Morgenstern-Price

Minimum Slip Surface Depth: 1 m

Seismic: 0



Granular Fill	21 kN/m <sup>3</sup>	0 kPa	35 °
RSS	22 kN/m <sup>3</sup>	200 kPa	34 °
Armour Stone	24 kN/m <sup>3</sup>	1,000 kPa	0 °
Riverstone	19 kN/m <sup>3</sup>	0 kPa	38 °
Firm Clayey Silt to Silty Clay Till	18 kN/m <sup>3</sup>	5 kPa	29 °
Very Stiff Clayey Silt to Silty Clay Till	21 kN/m <sup>3</sup>	0 kPa	32 °
Hard Clayey Silt to Silty Clay Till	22 kN/m <sup>3</sup>	0 kPa	34 °
Compacted Earth Fill	20 kN/m <sup>3</sup>	0 kPa	30 °



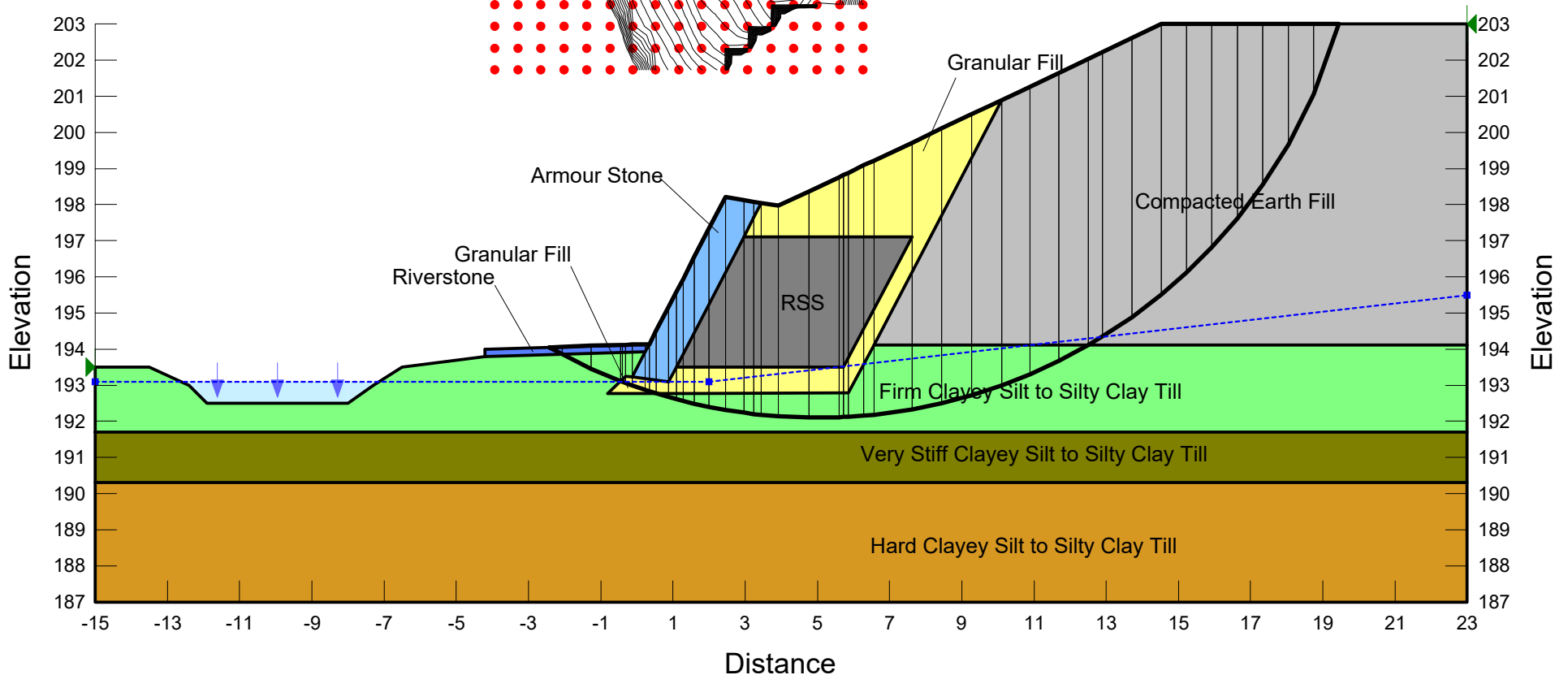
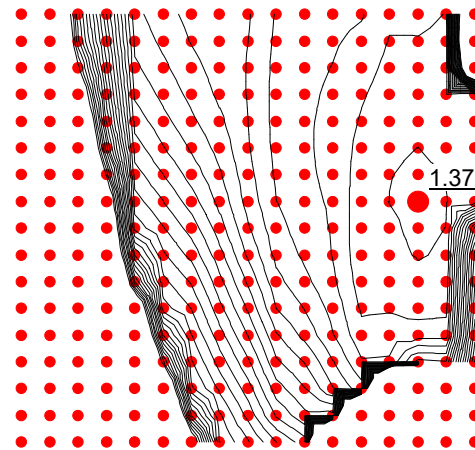
# CRITICAL WALL SECTION WEST ROBINSON CREEK ARMOUR STONE WALL SEISMIC CONDITION (NWL)

FIGURE E6

File Name: West Robinson Bridge Armour Stone Wall - TSA (Seismic).gsz  
Last Edited By: Geoff Lay  
Date: 4/18/2018

Method: Morgenstern-Price  
Minimum Slip Surface Depth: 1 m  
Seismic: 0.055g

Granular Fill	21 kN/m <sup>3</sup>	0 kPa	35 °
RSS	22 kN/m <sup>3</sup>	200 kPa	34 °
Armour Stone	24 kN/m <sup>3</sup>	1,000 kPa	0 °
Riverstone	19 kN/m <sup>3</sup>	0 kPa	38 °
Firm Clayey Silt to Silty Clay Till	18 kN/m <sup>3</sup>	50 kPa	0 °
Very Stiff Clayey Silt to Silty Clay Till	21 kN/m <sup>3</sup>	100 kPa	0 °
Hard Clayey Silt to Silty Clay Till	22 kN/m <sup>3</sup>	200 kPa	0 °
Compacted Earth Fill	20 kN/m <sup>3</sup>	0 kPa	30 °



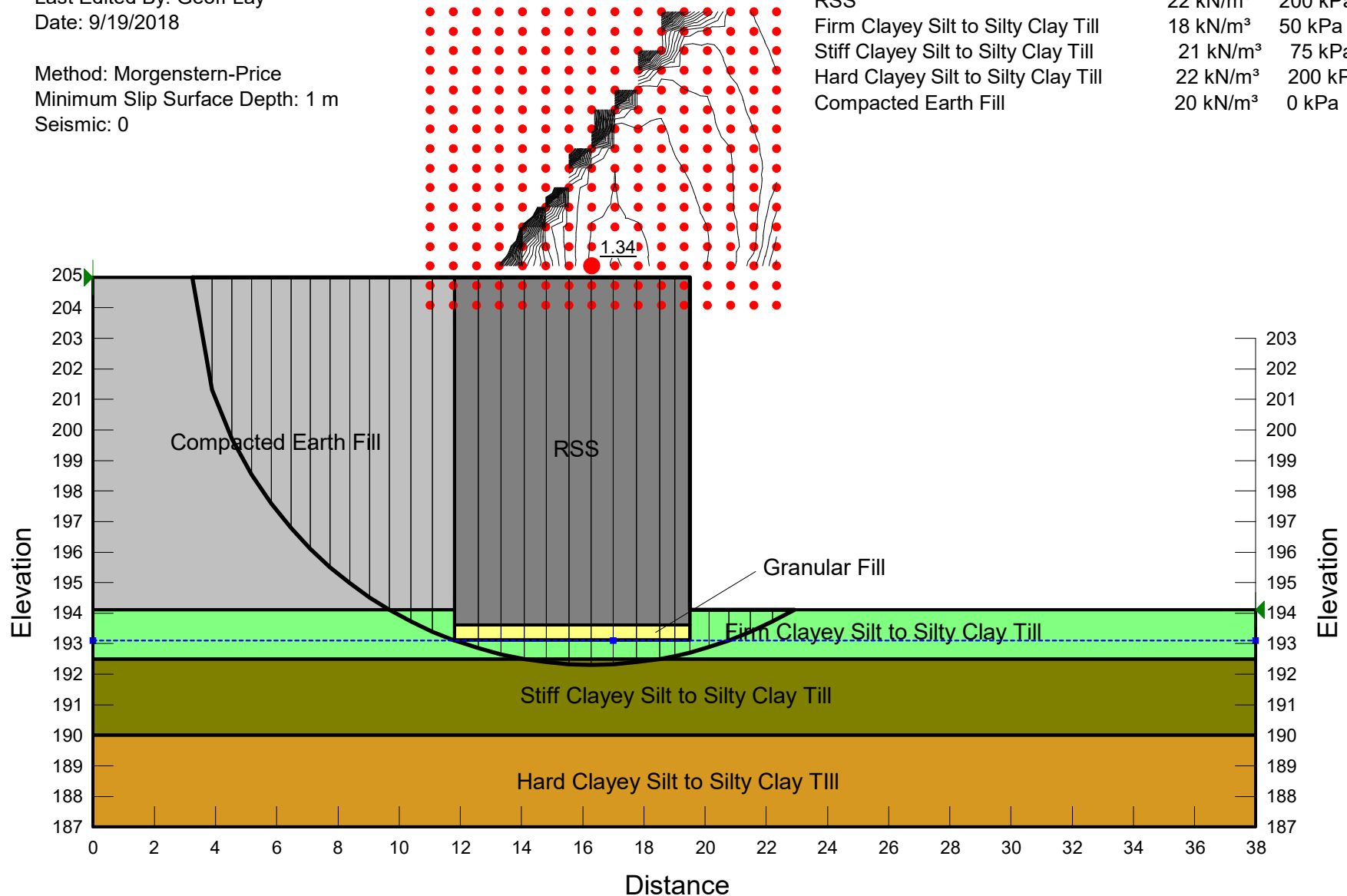
# CRITICAL WALL SECTION WEST ROBINSON CREEK RSS WALL SHORT-TERM CONDITION (NWL)

FIGURE E7

File Name: West Robinson Bridge RSS Wall - TSA.gsz  
Last Edited By: Geoff Lay  
Date: 9/19/2018

Method: Morgenstern-Price  
Minimum Slip Surface Depth: 1 m  
Seismic: 0

Granular Fill	21 kN/m <sup>3</sup>	0 kPa	35 °
RSS	22 kN/m <sup>3</sup>	200 kPa	34 °
Firm Clayey Silt to Silty Clay Till	18 kN/m <sup>3</sup>	50 kPa	0 °
Stiff Clayey Silt to Silty Clay Till	21 kN/m <sup>3</sup>	75 kPa	0 °
Hard Clayey Silt to Silty Clay Till	22 kN/m <sup>3</sup>	200 kPa	0 °
Compacted Earth Fill	20 kN/m <sup>3</sup>	0 kPa	30 °



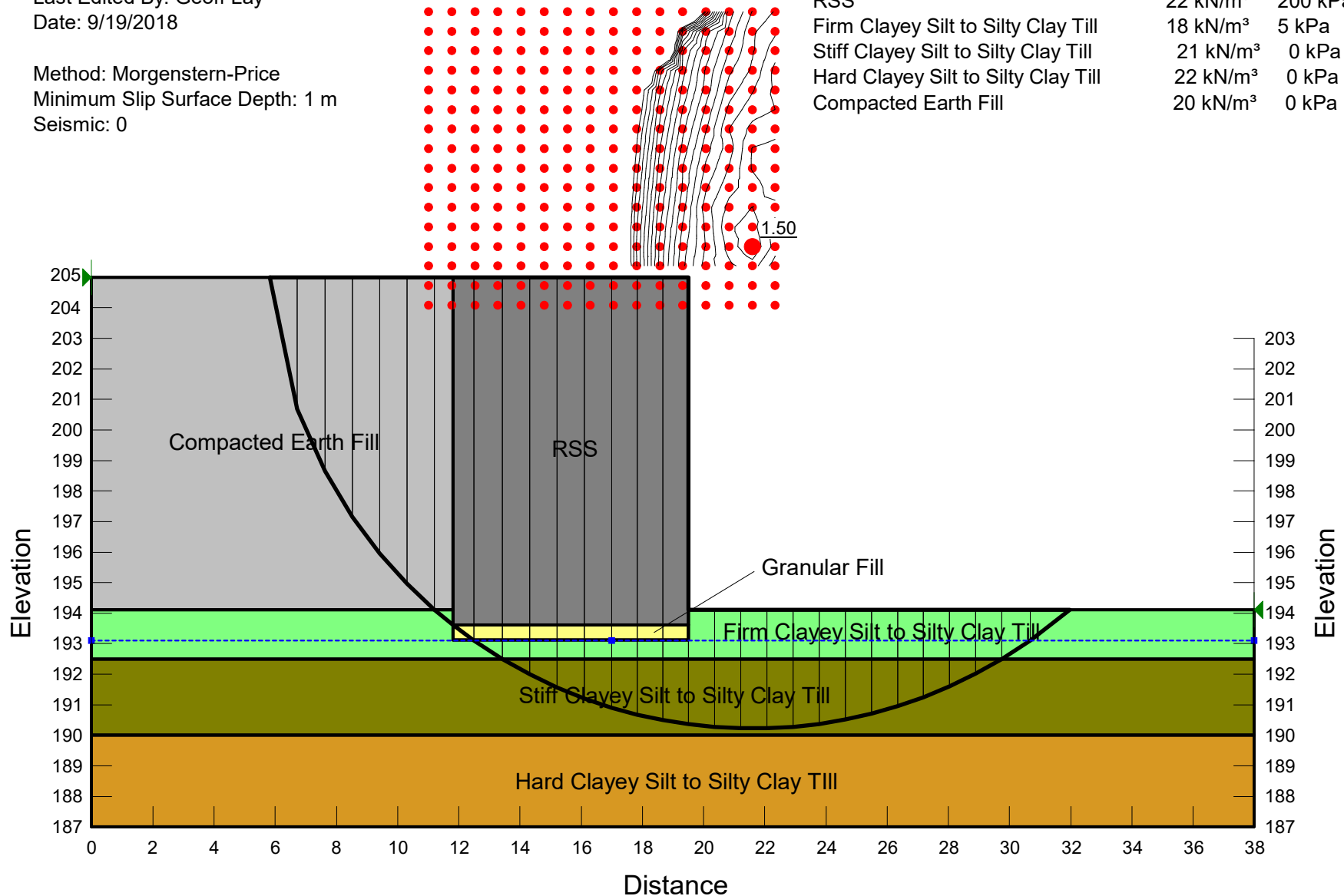
# CRITICAL WALL SECTION WEST ROBINSON CREEK RSS WALL LONG-TERM CONDITION (NWL)

FIGURE E8

File Name: West Robinson Bridge RSS Wall - ESA.gsz  
Last Edited By: Geoff Lay  
Date: 9/19/2018

Method: Morgenstern-Price  
Minimum Slip Surface Depth: 1 m  
Seismic: 0

Granular Fill	21 kN/m <sup>3</sup>	0 kPa	35 °
RSS	22 kN/m <sup>3</sup>	200 kPa	34 °
Firm Clayey Silt to Silty Clay Till	18 kN/m <sup>3</sup>	5 kPa	29 °
Stiff Clayey Silt to Silty Clay Till	21 kN/m <sup>3</sup>	0 kPa	30 °
Hard Clayey Silt to Silty Clay Till	22 kN/m <sup>3</sup>	0 kPa	34 °
Compacted Earth Fill	20 kN/m <sup>3</sup>	0 kPa	30 °



# CRITICAL WALL SECTION WEST ROBINSON CREEK RSS WALL SEISMIC CONDITION (NWL)

FIGURE E9

File Name: West Robinson Bridge RSS Wall - TSA (Seismic).gsz

Last Edited By: Geoff Lay

Date: 9/19/2018

Method: Morgenstern-Price

Minimum Slip Surface Depth: 1 m

Seismic: 0.055g

Granular Fill

RSS

Firm Clayey Silt to Silty Clay Till

Stiff Clayey Silt to Silty Clay Till

Hard Clayey Silt to Silty Clay Till

Compacted Earth Fill

21 kN/m <sup>3</sup>	0 kPa	35 °
22 kN/m <sup>3</sup>	200 kPa	34 °
18 kN/m <sup>3</sup>	50 kPa	0 °
21 kN/m <sup>3</sup>	75 kPa	0 °
22 kN/m <sup>3</sup>	200 kPa	0 °
20 kN/m <sup>3</sup>	0 kPa	30 °

