Preliminary Foundation Investigation and Design Report

Proposed Embankment
Station 15+800 to 16+275 Township of Lahontan
Highway 17

GEOCRES No. 42D-45

Prepared for
MTO Northwestern Region

615 James Street South
Thunder Bay, ON
P7E 6P6

Prepared By:
TBT Engineering Limited

1918 Yonge Street
Thunder Bay, Ontario, P7E 6T9

December 19, 2016 Ref. No. 15-211

Table of Contents

APPENDICIES

Part A - FOUNDATION INVESTIGATION REPORT

1 Introduction

TBT Engineering Limited (TBTE) has been retained by the Ministry of Transportation Northwestern Region (MTO) to provide preliminary foundation investigation and design services for the proposed embankment for the proposed Highway 17 realignment at Hill 19 from Station15+800 to 16+275 in the Township of Lahontan. This preliminary investigation for a new embankment is one of several proposed alternative routes for Highway 17 through/around Hill 19. The preliminary foundation investigation was conducted to provide subsurface data for the development of the new proposed roadway.

This investigation consisted of 9 boreholes, and 2 Flat Plate Dilatometers (DMT) advanced within the proposed footprint of the embankment, laboratory testing and geotechnical analysis of the data. All borehole locations were determined through consultation with the MTO. This report (Part A) describes the subsurface conditions encountered during the investigation.

2 Site Description

The preliminary foundation investigation was conducted to investigate subsurface conditions at the embankment located from Station 15+800 to 16+275 (Lahontan). The embankment is located adjacent to Hill 19 and north of old abandoned highway. Hill 19 is predominately constituted from bedrock. A swamp/organic deposit is located at the base of the hill near Station 15+800 to approximately 16+050. Near Station 16+100 there is evidence of an old, embankment failure and / or rock stock pile. At this location, an MTO "Do Not Enter" sign is posted that identifies it as a quarry. The site is generally heavily treed.

The maximum embankment height is approximately 17 m.

Photo 2.1 – Near Station 16+050 along Centerline Looking Down Chainage

Photo 2.2 – Near Station 16+100 Looking East

2.1 Surficial Geology

Available surficial geology mapping (OGS NOEGTS Map 5092 – Schreiber) indicates the site is located in a glaciolacustrine delta terrain unit comprised of primary sand material with a silt secondary material with low relief. Based on the OGS NOEGTS manual the glaciolacustrine delta of Pays Plat Bay have been known to include varved clay. The site is bordered by bedrock knob terrain unit with high relief.

3 Investigation Procedures

A geotechnical site investigation was undertaken on August 10 to 18, 2016. The field investigation consisted of nine boreholes and two DMTs. The borehole locations and depths were determined through conversations with the MTO and are illustrated on the Borehole Location Plan found in Appendix A.

The borehole locations were identified in the field by TBTE personnel and service clearances were completed prior to mobilizing the drill rig to site. The boreholes were advanced using an all terrain mounted drill rig equipped hollow stem augers and a cat head used to carry out Standard Penetration Testing (SPT). Where augering through fill materials at Boreholes 7 and 9 was not possible casing was installed through the fill with an excavator to provide the drill rig access to the foundation soils. Soil samples were obtained at the boreholes from the auger flights and using a split spoon sampler as a part of the SPT. At Borehole 2 samples were obtain from a hand tool sampler and in-situ testing was conducted with a hand vane. Where cohesive soils were encountered relatively undisturbed thin walled tube samples were collected at select locations, and field shear vane tests were performed.

The flat plate dilatometer (DMT) consists of a blade shape probe which is pushed into the soil with minimal disturbance. At 200 mm intervals, the steel membrane within the blade is inflated laterally and the forces required to deform the soil are measured. The data obtained is interpreted based on published correlations to aide in the selection of engineering properties.

Borehole locations were surveyed by TBTE and were based on North American Datum 1983, MTM CSRS CBNV6-1997 Zone 14 and Canadian Geodetic Vertical Datum 1928:1978 adjustment (CGVD1928;78). Control was established from existing H&V sheets from the past Highway Engineering B&C Plans as provided by MTO. Multiple control points were used as derived from the H&V.

All boreholes were backfilled with a bentonite mixture following drilling.

4 Laboratory Testing

Samples which were obtained during the field investigation were subjected to routine laboratory testing. The routine testing included moisture content, and grain size analysis. The results of this testing are shown on the Borehole Logs (Appendix A and on the laboratory data reports Appendix B).

5 Subsurface Conditions

Details of the subsurface conditions are provided on the test hole logs (Appendix A), and on the Soil Strata Drawings (Appendix C).

The subsurface soils at this site typically consist of organic material and/or fill which overlies sand and clay. All boreholes extended to predetermined depths.

5.1 Organic Material

Organic material was encountered at the ground surface of Boreholes 1, 2, 3, and 5. The material ranges in thickness from 0.4 to 0.7 m. Based on two samples the natural moisture content of this material ranges from 168 to 251 %.

5.2 Fill

Fill was encountered at ground surface at Boreholes 4, 7, 8 and 9. The material ranges in thickness from 1.0 to 1.8 m. A single sample was selected for grain size distribution testing. The test result indicated a grain size distribution of 26 % gravel, 47 % sand, and 28 % silt/clay sized particles. The fill was comprised mainly of cobbles at Boreholes 7 and 9.

5.3 Sand - Upper

Silty sand with trace gravel, to sand with trace silt and trace gravel was encountered beneath the organic material at Boreholes 1, 2, 3, 5 and at ground surface at Borehole 6. The sand encountered at elevations ranging from 185.1 to 189.4 m and has a typical thicknesses ranging from 0.3 to 0.8 m with a thickness of 3.6 m at Borehole 6. Three samples were selected for grain size distribution testing. The test results indicated a grain size distribution of 0 to 8 % gravel, 66 to 88 % sand, and 5 to 33 % silt/clay sized particles. The material is loose to compact as indicated by “N” values ranging from 3 to 26 blows/0.3 m.

5.4 Varved Clay

Varved clay was encountered beneath the sand at Boreholes 1, 2, 3, 5, 6 and beneath the fill at Boreholes 4, 7, 8 and 9. Borehole 1, 2, and 3 were terminated within the clay stratum at depths ranging from 4.5 to 5.7 m. The clay was encountered at elevations ranging from 184.6 to 190.8 m with thicknesses ranging from 2.5 to 9.2 m. The clay has a varved structure with alternating layers varying in plasticity, silt content and colour (light and dark grey). Twelve samples were selected for grain size distribution testing. The test results indicated a grain size distribution of 0 to 2 % gravel, 1 to 34 % sand, and 66 to 99 % silt/clay sized particles.

Atterberg limit testing carried out on selected samples indicates the clay is generally of medium to high plasticity with the moisture contents approaching or exceeding the liquid limit. It is expected that the plasticity of the individual varves will vary.

Photo 5.1 – Thinned wall tube sample showing varved clay

Field shear vanes indicated that this material was in a very soft to stiff condition based on test results ranging from 8 to 60 kPa. Due to varved nature of the clay and the presence of varves with high silt content, it is expected that the field shear vane tests have likely overestimated the shear strength of the higher plastic varves. Subsequent laboratory shear vanes tests (using a small hand vane) were performed within tube samples indicate that the clay is in a very soft to firm condition with undrained shear strengths between 3 to 20 KPa. Interpretation of DMTs 7A and 8A indicate that the clay has a consistency generally ranging from very soft to stiff.

Undrained shear strength profiles versus depth were complied for the field vanes, lab vanes and undrained shear strength interpreted from DMT's. The undrained shear strength profiles are provided in Appendix D. The field vanes were adjusted using a correction factor of 0.8 for Plasticity Index (PI) as recommended by Bjerrum (1973). In addition, profiles of the estimated undrained shear strength were plotted for each borehole location assuming an undrained shear strength to effective overburden pressure ratio of 0.25 (Cu / P'o = 0.25).

Review of the profiles indicates that for Boreholes 1 to 6, the lower bound for the measured undrained shear strengths generally follow the predicted normally consolidated profile indicating normally consolidated condition with undrained shear strengths varying from less than 5 kPa to 25 kPa (increasing with depth). However, at Boreholes 7 to 8 as indicated by DMT 7A and 8A, the measured undrained shear strength generally exceed the normally consolidated profiles to depths of 8 m (BH 7 and DMT 7A), 6.5 m (BH 8 and DMT 8A).

Below a depth of 6.5 m at BH 8 and DMT 8A, the measured undrained shear strength drops to the normally consolidated levels. The over consolidated conditions may be a result of historical fill in the area of Boreholes 7 to 9. At Borehole 7 and DMT 7A, at a depth of approximately 3.5 m, the DMT Cu profile takes a sudden drop and a lab vane carried out at Borehole 7 drops to below the normally consolidated profile. This may be indicative of past shear movements at this location.

5.5 Silt

Silt with some sand was encountered at Boreholes 6 and 8 beneath the clay at depths between of 8.6 and 11.8 m. respectively. The silt was encountered at elevations of 178.1 and 180.8 m with thicknesses of 0.7 and 0.9 m, at Boreholes 8 and 6 respectively. A single sample was selected for grain size distribution testing. The test results indicated a grain size distribution of 0 % gravel, 21 % sand, and 79 % silt/clay sized particles. The material is very loose as indicated by “N” values of 1 and 4 blows/0.3 m.

5.6 Sand - Lower

Silty sand with trace to some gravel, was encountered beneath the clay at Boreholes 4 to 9. The sand was encountered at elevations ranging from 175.6 to 184.4, at depths between 8.2 and 12.1 m. All the boreholes terminated within this material. Eleven samples were selected for grain size distribution testing. The test results typically indicated a grain size distribution of 1 to 18 % gravel, 63 to 93 % sand, and 5 to 23 %

silt/clay sized particles, with three samples with gravel percentages of 24, 32 and 57 %. The material is loose to very dense as indicated by "N" values ranging from 7 to 63 blows/0.3 m.

5.7 Refusal

Auger refusal and/or "N" values of 100+ blows/0.3 m was encountered at Boreholes 4, 5, 8 and 9. The following table indicates the recorded refusal depths at each test hole. Refusals may be on cobbles, boulders, or bedrock. Refusal material was not sampled.

Table 5.1: Borehole Refusal

Borehole Number	Refusal Depth (m)	Refusal Elevation (m)	Refusal Type
4	12.5	177.2	Auger and SPT
5	14.4	171.2	Auger
8	20.8	169.1	Auger
9	10	178.3	Auger

5.8 Ground Water

The ground water levels were measured at 0.5 to 2.3 m from ground surface within 4 hours of completion of the boreholes. It should be noted that at Borehole 7 ground water was measured at a depth of 6.3 m upon completion. Due to the presence of low permeable soils ground water levels would not have stabilized during this time and water levels will vary from season to season and from the effects of heavy precipitation events.

6 Miscellaneous

Laboratory testing was carried out at the TBT Engineering laboratory in Thunder Bay. The drill equipment for this investigation was operated by TBT Engineering Limited. The field operations were supervised by Alan Finke. Laboratory testing was supervised by T. Fummerton C.E.T. This report was prepared by Steven Seller, P.Eng, and reviewed by W. Hurley, P.Eng (TBTE designated principal contact identified for MTO Foundation Engineering projects).

Part B - FOUNDATION DESIGN RECOMMENDATIONS

7 Introduction

TBT Engineering Limited (TBTE) has been retained by the Ministry of Transportation (MTO) to provide a preliminary foundation investigation and design services for the proposed embankment on the proposed Highway 17 realignment for Hill #19 from Stations 15+800 to 16+275 in the Township of Lahontan. The preliminary foundation investigation was conducted to provide subsurface data for the development of the new proposed roadway. It is understood that this embankment is one of several options for the realignment of Highway 17 at this location.

The foundation investigations as described in Part A, were carried out to investigate subsurface conditions at this site. The investigations consisted of nine boreholes, 2 DMTs, laboratory testing and geotechnical analysis of the data and references to sub-surface data obtained during the pavement design investigations. The Part A report describes the subsurface conditions encountered during the investigation.

The foundation soils at these sites typically consist of peat/organics or fill which overlie sand and very soft clay.

The purpose of this section of the report (Part B) is to provide preliminary embankment design recommendations. These are based on the conditions encountered at the borehole locations, TBTE's interpretation of the subsurface conditions at the site and analyses of embankment stability.

To adequately complete the embankment analysis, the area has been divided into two zones. The definition, including the rationale for these zones are provided below:

Zone1:

- Station 15+800 to 16+075
- Boreholes 1 through 6
- Normally consolidated clay soils
- Lower undrained shear strength profile than Zone 2 for undrained analysis
- Design ground water level was taken at ground surface.

Zone 2 :

- Station 16+076 to 16+275
- Boreholes 7 through 9, and DMTs 7A and 8A
- Area of posted quarry site.
- Area of reported embankment/stock pile slope instability
- Sharp drop in undrained shear strength profile indicates possible past slope instability
- Consideration of the use of residual strength properties for drained analysis Some over consolidation potentially caused by existing/past fill.
- Design ground water level was taken at the top of the clay surface

The detailed foundation investigation will be complex and exhaustive to adequately define the existing clay stratum beneath the proposed embankment. The detailed investigation will require a well-organized borehole/CPTU/DCPT plan, complex laboratory testing, and comprehensive engineering analysis. Based on this preliminary investigation it is anticipated that the construction of the embankment will be complex and have to incorporate multi stage construction with considerable delays between stages, the use of flanking berms, and potentially vertical drains and/or lightweight fills to reduce delays.

8 Embankment Analyses

8.1 Review of Embankment Options

Several options for the proposed embankment were reviewed from a foundations perspective and are presented in Table 8.1. Options reviewed address lightweight fills, staged construction, preloading, and removal of a portion of the clay material.

Table 8.1: Embankment Options

Option	Advantages	Disadvantages	Relative Cost
Lightweight Fill	Potential single stage construction.	Speciality construction methodology. Some preloading may still be required.	High
Staged Construction	Typical staged construction methodology.	Vertical drains will likely be required. Instrumentation will be required.	Moderate

		Delays in construction can be expected.	
Excavation of Clay	Typical construction methodology. Removes problematic soil.	Additional investigation of existing embankment. Vertical drains may required. Delays in construction may be required.	Moderate

8.2 Zone 1 - Geotechnical Assessment

Boreholes 1 to 3 were terminated within the clay foundation soils at a depth of 5 m. For this assessment, it has been assumed that the clay terminates at a depth of 10 m (based on findings at Borehole 5). The depth of clay should be investigated during detailed design.

Stability modeling was carried out using Slope/W software and limit equilibrium analysis using the Morgenstern-Price method.

The soil properties established for the embankment and foundation soils are presented in Table 8.1. The strength properties of the native soils have been based on published correlations with index tests. Typical strength properties have been selected for the various potential fill materials. The undrained shear strength of the clay was modelled to increase as a function of depth, z, based on the undrained shear strength profiles (Appendix D). The effective angle of internal friction for the foundation soils were estimated based on published correlations with index properties.

Table 8.2: Stability Analyses Soil Properties, Zone 1

Soil	Effective Stress Strength Properties		Total Stress Shear Strength, Cu (kPa)	Unit Weight γ (kN/m^3)
	Effective Angle of Internal Friction, φ' (degrees)	Effective Cohesion Intercept, C' (kPa)		
Rock Fill	40	0	-	18
Compacted Granular Fill	35	0	-	20
Organic material	28	0	-	11-12
Clay	24	0	4 + 1.7 z	18
Lower Sand and Gravel	31	0	-	19
Existing Fill	35	0	-	20
Upper Silty Sand	29	0	-	20

Compacted granular fill shall consist of OPSS Granular B, Type I, or III fill compacted in lifts to 95% of SPMDD.

Consolidation properties were selected based on published correlations with index testing (liquid limit and moisture content). The modified consolidation index (C'c = $Cc/(1+e_o)$) was estimated to vary between 0.16 and 0.34. The coefficient of consolidation (Cv) has been estimated at 3 m^2/yr for normally consolidated conditions.

8.2.1 Proposed Embankment Zone 1

Stability analyses have been completed to determine the preliminary configuration for the proposed embankment. The design is based on providing a minimum calculated factor of safety (FoS) of 1.3 with a uniformly distributed traffic load of 12 kPa. Seismic parameters for the stability models was not considered for this analysis. Each design scenario was carried out using both rock fill and compacted granular embankment fill. For this assessment it has been assumed that the organic soils will be stripped and removed prior to embankment construction.

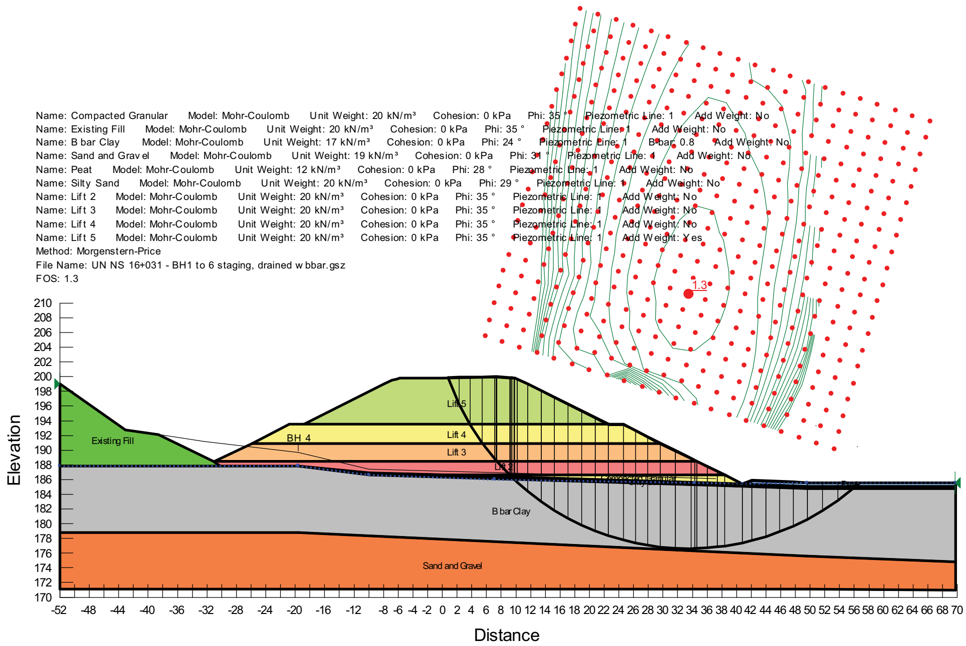
Based solely on long term drained conditions the final embankment configuration may consist of an embankment (up to 14 m in height) constructed with embankment slopes of 2H:1V using rock fill, or 2.5H:1V using compacted granular fill. However, the final configuration of the embankment will likely require flanking berms/flatter slopes and staged construction due to the low undrained shear strength of the clay foundation soils.

Based on total stress analyses (using undrained shear strengths for the clay foundation), the embankment could not be constructed in one stage without excessively flat slopes and a large flanking berm. Therefore staged construction would prove more practical. Staged construction analysis was completed using the following methodology:

1. Drained properties for the clay were used.
2. A pore water pressures response of bBar = 0.8 was applied to clay foundation soils.
3. Assumed near full dissipation of pore water pressure occurs between stage lifts.

This methodology for staged construction require approximately five stages of varying thicknesses to maintain a minimum factor of safety of 1.3 during construction. This approach works for both granular material and rock fill.

Figure 8.1: Short Term Stability Final Stage Compacted Granular



To construct the embankment in a single stage, excessively flat side slope (flatter than 9H:1V) and/or stepped flanking berms would be required. This is not considered practical given the excessive volume of fill required and property restrictions. Staged construction will be required to construct the proposed embankment. Detailed design will be required to optimize construction staging. The use of stepped flanking berms may also be considered to optimize staging requirements. The use of vertical drains will likely be required to expedite construction.

8.2.2 Settlement Performance, Zone 1

Settlement analysis has been completed to estimate settlements due to consolidation of the foundation soils for the proposed embankment. As per MTO Embankment Settlement Criteria (July 2, 2010), the design life established for settlement criteria for King's highways is 20 years following construction of the pavement structures. The settlement criteria over the design life for non-freeways on compressible soils is 200 mm total with a differential settlement rate of 100:1 as per Figure 1 of the above noted criteria.

The estimated settlements are based on the following assumptions:

- All highly compressible organic material is removed from beneath the embankments.
- The maximum embankment fill thickness is approximately 15 m (included up to 1 m of peat replacement).

Total settlements for the proposed embankment foundation soils have been estimated to be in the order of 1500 to 3000 mm. It is expected that this settlement will occur over a period of 15 years (assuming the clay is 10 m thick and underlain by permeable soils, relative to the clay). It should be noted that where rock fill is considered, additional long and short term settlements in the order of 150 to 300 mm may be realized.

The estimated settlements exceed the MTO settlement performance criteria, therefore site preloading will be required. The site preload may be considered in conjunction with the staged construction. The time required between stages and potential duration of preloads (which may be incorporated into the stage lifts) cannot be practically estimated without the consideration of vertical drains. Based on a vertical drain spacing in the order of 1 to 2 m the time between lifts of the stages would be measured in months. However, it is expected that without the consideration of vertical drains, the time between lifts of the stages would be measured in years.

8.3 Zone 2 - Geotechnical Assessment

Stability modeling was carried out using Slope/W software and limit equilibrium analysis using the Morgenstern-Price method.

The soil properties established for the embankment and foundation soils are presented below. Typical strength properties have been selected for the various potential fill materials. Note that undrained shear strength of the clay was modelled to increase as a function of depth, z, based on a conservative estimate of the undrained shear strength profiles (Appendix E). It should be noted that zones of higher undrained shear strengths were identified at Boreholes 7 to 9 and DMT's 7A and 8A likely due to past stock piling in this area (former quarry site). These test holes also indicate zones of low undrained shear strengths (approaching normally consolidated strengths). As details of the filling operations are unknown, it is likely that there are areas with extensive deposits of normally consolidated clays. As such, a normally consolidated undrained shear strength profile was considered for this assessment. The effective angle of internal friction for the foundation soils were estimated based on published correlations with index properties. Effective stress analysis was carried out using residual effective shear strength properties for the clay soils as there is a possibility of past slope instability in this area.

Table 8.2: Stability Analyses Soil Properties, Zone 2

Soil	Effective Stress Strength Properties		Total Stress Shear Strength, Cu (kPa)	Unit Weight γ (kN/m³)
	Effective Angle of Internal Friction, φ' (degrees)	Effective Cohesion Intercept, C' (kPa)		
Rock Fill	40	0	-	18
Compacted Granular Fill	35	0	-	20
Organic material	28	0	-	11-12
Clay	14 (residual)	0	8 + 1.8 z	18
Native Sand and Gravel	31	0	-	19
Existing Fill	35	0	-	20

Compacted granular fill shall consist of OPSS Granular B, Type II, or III fill compacted in lifts to 95% of SPMDD.

Consolidation properties were selected based on published correlations with index testing (liquid limit and moisture content). The modified consolidation index ($C'c = Cc/(1+e_o)$) was estimated to vary between 0.16 and 0.34. In areas were over consolidated clays were identified, the modified recompression index ($C'r = Cr/(1+e_o)$) was estimated to vary between 0.016 and 0.034. The coefficient of consolidation (Cv) has been estimated at 3 m^2/yr for normally consolidated conditions and 10 m^2/yr for over consolidated conditions.

8.3.1 Proposed Embankments, Zone 2

Stability analyses have been completed to determine the configuration for the proposed embankment. The design is based on providing a minimum calculated factor of safety (FoS) of 1.3 with a uniformly distributed traffic load of 12 kPa. Seismic parameters for the stability models was not considered for this analysis. Each design scenario was carried out using both rock fill and compacted granular embankment fill. For this assessment is was assumed that the existing rock fill will be left in place. Where granular fill is to be used over the existing rock fill, the rock fill surface shall be chinked.

Based on long term drained conditions, the final embankment configuration will likely require a flanking berm as provided below.

Table 8.3: Results of Drained Residual Stability Modelling, Flanking Berm, Zone 2

Embankment Material	Embankment Side Slopes (H:V)	Maximum Embankment Height (m)	Flanking Berm Dimensions			Minimum F.o.S.
			Width (m)	Height (m)	Slope (H:V)	
Rock fill	2:1	18.0	21	3.5	5:1	1.3
Compacted Granular	2:1	18.0	22	4	5:1	1.3

Figure 8.2: Long Term Stability, Residual Strength, Flanking Berm

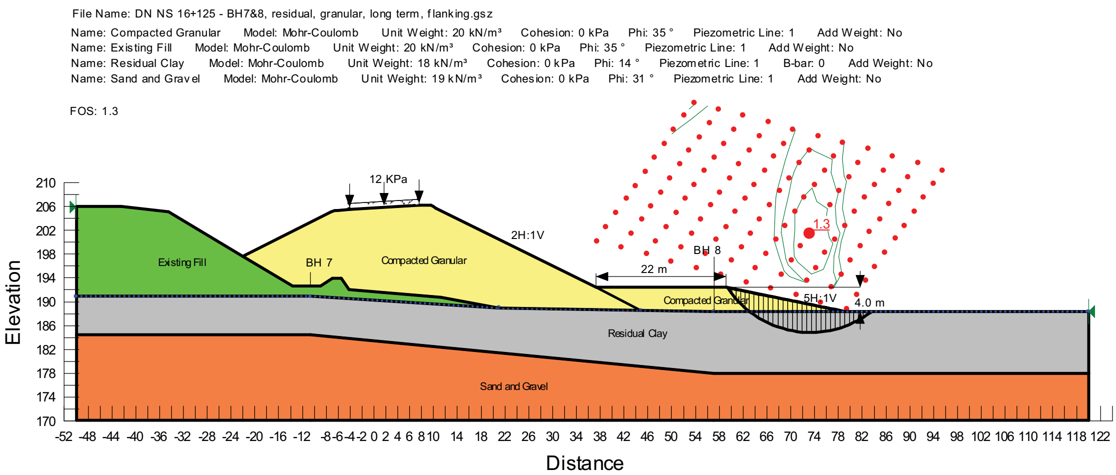
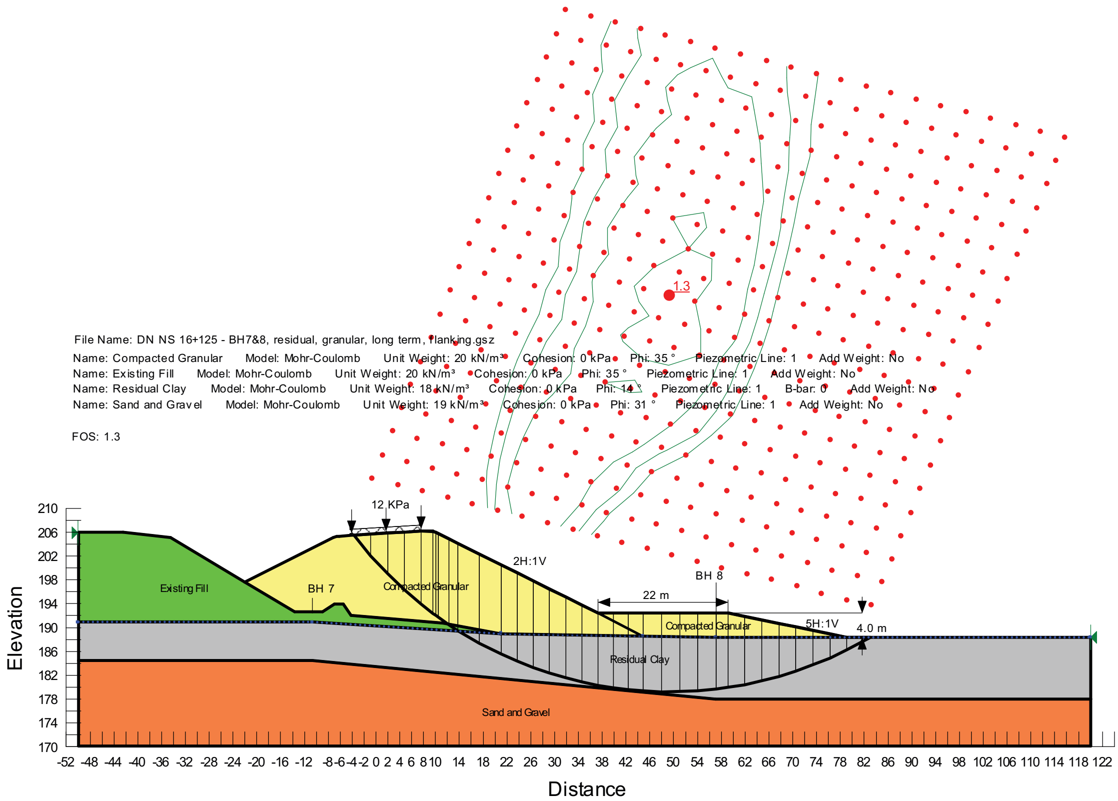


Figure 8.3: Long Term Stability, Residual Strength, Full Embankment



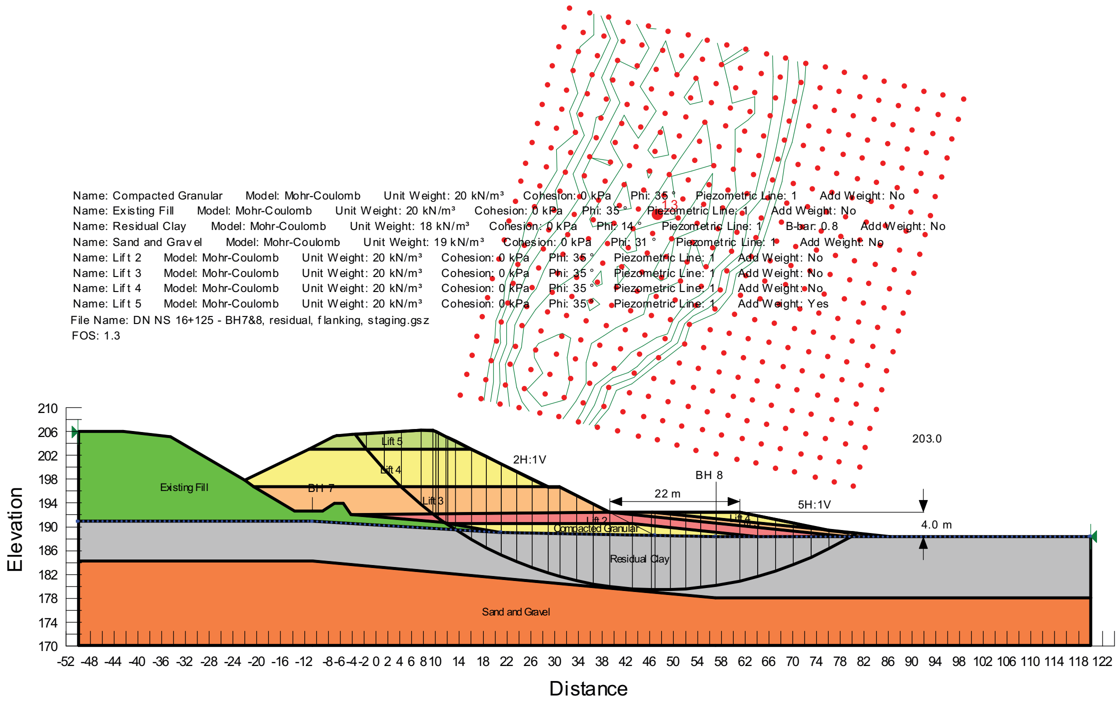
Based on the above assessment, property constraints should be considered as the length of flanking berm required may induce settlements beyond the limits of the flanking berms which could impact nearby infrastructure. The above also assumes residual strength properties for the clay foundation soils. A detailed investigation may be considered to assess the potential for slip surfaces within the clay foundation. It should be noted that undrained (total stress) analyses indicates larger flanking berms would be required to facilitate construction without staging as discussed below.

Based on total stress analyses (using undrained shear strengths for the clay foundation), the embankment could not be constructed in one stage without excessively flat slopes and large flanking berm would be required extending past the existing railway. Based on total stress analyses (using undrained shear strengths for the clay foundation), the embankment could not be constructed in one stage without excessively flat slopes and an excessively large flanking berm. Therefore staged construction would prove more practical. Staged construction analysis was completed using the following methodology:

1. Drained properties for the clay were used.
2. A pore water pressures response of bBar = 0.8 was applied to clay foundation soils.
3. Assumed near full dissipation of pore water pressure occurs between stage lifts.

This methodology for staged construction analysis indicates approximately five stages of varying thicknesses to maintain a minimum factor of safety of 1.3 during construction. This approach works for both granular material and rock fill.

Figure 8.4: Short Term Stability, Final Stage Compacted Granular



Staged construction will be required to construct the proposed embankment. Detailed design will be required to optimize construction staging. The use of stepped flanking berms may also be considered to optimize staging requirements. The use of vertical drains may also be required to expedite construction. Where vertical drains are considered, additional costs for installation through rock fill must also be considered.

8.3.2 Settlement Performance, Zone 2

Settlement analysis has been completed to estimate settlements due to consolidation of the foundation soils for the proposed embankment. As per MTO Embankment Settlement Criteria (July 2, 2010), the design life established for settlement criteria for King's highways is 20 years following construction of the pavement structures. The settlement criteria over the design life for non-freeways on compressible soils is 200 mm total with a differential settlement rate of 100:1 as per Figure 1 of the above noted criteria.

The estimated settlements are based on the following assumptions:

- The maximum embankment fill thickness is approximately 18 m.

Total settlements for the proposed embankment foundation soils have been estimated to be in the order of 600 to 2000 mm. Given the variability of clay thickness and zones of over consolidated clays within this area, settlements are expected to be highly differential. It is expected that this settlement will occur over a period of 1 to 15 years and will be highly dependent on the clay thickness and the degree of over consolidation. It should be noted that where rock fill is considered, additional long and short term settlements in the order of 200 to 350 mm may be realized.

The estimated settlements exceed the MTO settlement performance criteria, therefore site preloading will be required. The site preload may be considered in conjunction with the staged construction. The time required between stages and potential duration of preloads (which may be incorporated into the stage lifts) cannot be practically estimated without the consideration of vertical drains. Based on a vertical drain spacing in the order of 1 to 2 m the time between lifts of the stages would be measured in months. However, it is expected that without the consideration of vertical drains or further defining the properties of the variations in the clay, the time between lifts of the stages would be measured in years.

9 Recommendations for Detailed Design

The proposed location of the highway realignment traverses over a deposit of weak foundation soils, an old quarry site, and an area which reportedly was subject to an embankment/stock pile failure. With the soft ground that has been encountered and the unknown history of the site; extensive field investigations and laboratory testing is recommended for the detailed investigation. Construction of the embankment as envisioned will be complex.

The following considerations/investigation/testing methodologies are recommended for the detailed design:

- An assessment of property constraints for slope and flanking berm restrictions.
- The entire footprint should be investigated using MTO's methodology for soft ground/swamp investigations.
  - The prescribed DCPTs should be replaced with DMTs.
  - In situ dissipation testing (CPTU and/or DMT) to estimate horizontal dissipation rates for the design of vertical drains.
  - Investigation should extend to determine the full extent of the clay deposit in Zone 1.
  - Investigation should be designed to delineate the normally consolidated clay deposit in Zone 2.
- Additional borehole or DMT investigation may be required in Zone 2 to identify the potential of an existing failure surface through the clay soil.
- A monitored test fill may be considered to estimate porewater pressure response and in situ porewater pressure dissipation characteristics.
- Complex testing of the clay should be completed, further isolating and identifying the similar varves:
  - Consolidation testing should be completed for the clay in both zones.
  - Direct Shear testing (drained and undrained) should be completed to further develop the shear strength profile within both zones.
- Detailed analysis of the staged construction should be completed taking into account the potential use/effect of, but not be limited to:
  - Porewater pressure dissipation,
  - Potential shear strength gains,

  - Lightweight fills,
  - Vertical drains (including consideration of installation issues through rock fill)
  - Limited excavation and replacement of native clay soils
- A monitoring and instrumentation plan should be developed to aide in the implementation of the construction staging during construction.
- Detailed analysis of the settlement performance utilizing complex testing results and incorporating stage construction delays and potential lightweight fills should be completed. A monitored test fill may be considered to refine design parameters and analyses for staging (eg. to measure drainage characteristics of varved clays).
- Site preloading to meet MTO settlement performance criteria .
- Investigations through the existing embankment may be considered to assess the following:
  - Stability of the existing highway embankment should be considered if any material is removed from the toe of the existing embankment to facilitate the construction or investigation of the proposed embankment.
  - Where the existing embankment will be in service during construction of the new embankment, settlement performance of the existing embankment should be assessed.

- A program of DMT's may be considered to better identify zones of normally consolidated clays.

10 Limitations

Conclusions and recommendations presented in this preliminary report are based on the information determined at a limited number of test hole locations. These preliminary recommendations are made on the basis that additional investigations, testing and analyses will be carried out during detail design and are not to be used for construction. Subsurface and groundwater conditions between and beyond these locations may differ from those encountered. Conditions may become apparent during detailed design investigations or construction that were not detected and could not be anticipated at the time of the preliminary site investigation.

The comments given in this report on potential construction problems and possible methods of construction are intended only for the guidance of the designer.

Groundwater levels indicated are based on the information described within the report. The presence of all conditions that could affect the type and scope of dewatering procedures which may be considered cannot readily be determined from boreholes. These include local and seasonal fluctuations of the groundwater level, changes in soil conditions between test locations, thin and/or discontinuous layers of highly permeable soils, etc.

The information contained within this report in no way reflects any environmental aspect of the site or soil.

11 Closure

We trust the above addresses your project requirements at this time. Should you have any questions or comments, please do not hesitate the contact us at your convenience.

Yours truly,
For TBT ENGINEERING

Steven Seller, P.Eng
Project Engineer

Gordon Maki, P.Eng
Senior Engineer

Wayne Hurley, P.Eng.
Principal Contact for MTO Foundations

APPENDIX A
Borehole Logs

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R.Q.D.), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY $= \frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX $= w_L - w_P$
I_L	1	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
e_{max}	1,%	VOID RATIO IN LOOSEST STATE

e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 1

METRIC

W.P. 6120-15-00	LOCATION Station 15+838 o/s 3.0 Rt of Proposed C/L N:5415539; E:265280 MTM Zone:14		ORIGINATED BY AF
DIST NWR HWY 17	BOREHOLE TYPE Hollow Stem Auger		COMPILED BY LB
DATUM Geodetic	DATE 2016.08.18 - 2016.08.18	LATITUDE 48.8769247 LONGITUDE -87.5388275	CHECKED BY SS

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES – NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
186.6	Station 15+838 o/s 3.0 Rt of Proposed C/L					
0.0	ORGANIC - black					
186.2 / 0.4	SAND - some silt, brown, loose	1	AS			0 86 (14)
		2	SS	6		
185.4 / 1.2	CLAY - varved, some sand, grey, soft to very soft	3	SS	1		
		4	SS	1		0 12 (88)
		5	SS	1		
		6	SS	1		
181.2 / 5.4	End of Borehole @ 5.4 m.					

ELEVATION SCALE: 186, 185, 184, 183, 182

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

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

RECORD OF BOREHOLE No 2

METRIC

W.P. 6120-15-00 LOCATION Station 15+914 o/s 3.1 Rt of Proposed C/L N:5415465; E:265294 MTM Zone:14 ORIGINATED BY AF

DIST NWR HWY 17 BOREHOLE TYPE Hiller/ Pilcon COMPILED BY LB

DATUM Geodetic DATE 2016.08.18 - 2016.08.18 LATITUDE 48.8762601 LONGITUDE -87.5386295 CHECKED BY SS

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION (m)	NATURAL MOISTURE CONTENT w (%)	GR	SA	SI	CL
186.3	Station 15+914 o/s 3.1 Rt of Proposed C/L									
0.0	ORGANIC - black	1	GRAB							
185.7 / 0.6	SAND - Silty, brown/grey	2	GRAB							
185.3 / 1.0	CLAY - varved, some sand, grey, very soft	3	GRAB							
		4	GRAB				0	13	31	56
		5	GRAB							
181.8 / 4.5	End of Borehole @ 4.5 m.									

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL).

Elevation scale: 186, 185, 184, 183, 182

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

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 3

METRIC

W.P. 6120-15-00 LOCATION Station 15-972 o/s 0.7 Lt of Proposed C/L N:5415408; E:265302 MTM Zone:14 ORIGINATED BY AF

DIST NWR HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY LB

DATUM Geodetic DATE 2016.08.18 - 2016.08.18 LATITUDE 48.8757481 LONGITUDE -87.5385149 CHECKED BY SS

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
186.4	Station 15-972 o/s 0.7 Lt of Proposed C/L						
0.0	ORGANIC - black						
186.0 / 0.4	SAND - Silty, brown	1	AS			186	
185.7 / 0.7	CLAY - varved, trace sand, grey, soft	2	SS	2			
		3	SS	1		185	
		4	SS	1		184	
		5	SS	1		183	
						182	
		6	SS	1			0 1 10 89
						181	
180.7 / 5.7	End of Borehole @ 5.7 m.						

Plot headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 4

METRIC

W.P. 6120-15-00 LOCATION Station 16+044 o/s 19.6 Lt of Proposed C/L N:5415336; E:265323 MTM Zone:14 ORIGINATED BY AF

DIST NWR HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY LB

DATUM Geodetic DATE 2016.08.18 - 2016.08.18 LATITUDE 48.8751019 LONGITUDE -87.5382217 CHECKED BY SS

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
189.7	Station 16+044 o/s 19.6 Lt of Proposed C/L				
0.0	FILL - SAND - Gravelly, Silty, occasional cobbles, brown, compact	1	AS		
		2	SS	15	26 47 (28)
		3	AS		
187.9 / 1.8	----- - layers of organic matter CLAY - varved, some sand, trace gravel, grey, soft to firm	4	SS	18	
		5	SS	1	
		6	SS	1	
		7	TW		
		8	TW		
		9	SS	1	
		10	SS	1	0 12 (88)
	----- - very stiff				2 19 (79)
178.7 / 11.0	SAND - Gravelly, some silt, occasional cobbles, grey, compact to dense	11	SS	7	
177.2 / 12.5	End of Borehole @ 12.5 m. Auger Refusal.	12	SS	101	24 56 (19)

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (189 to 178); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³.

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

RECORD OF BOREHOLE No 5

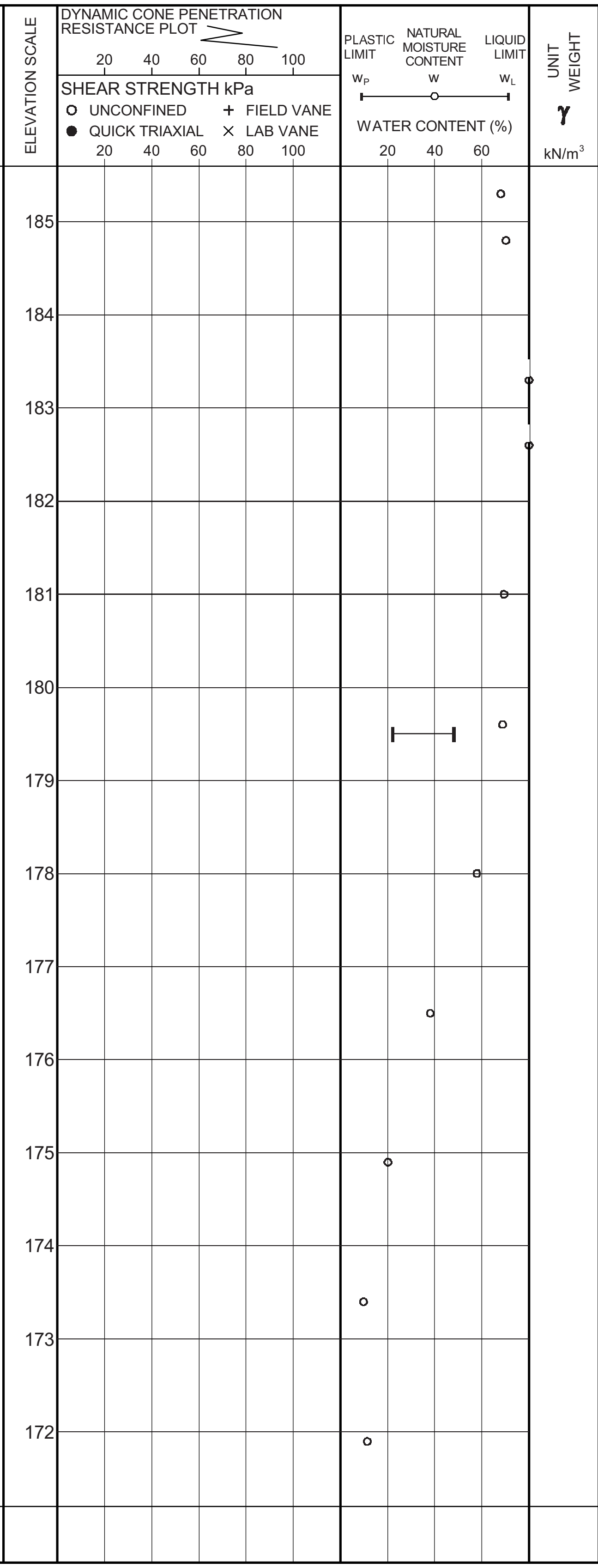
METRIC

W.P. 6120-15-00 | LOCATION Station 16+031 o/s 49.6 Rt of Proposed C/L N:5415347; E:265254 MTM Zone:14 | ORIGINATED BY AF

DIST NWR HWY 17 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY LB

DATUM Geodetic | DATE 2016.11.08 - 2016.11.08 | LATITUDE 48.8751964 | LONGITUDE -87.5391635 | CHECKED BY SS

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.6	Station 16+031 o/s 49.6 Rt of Proposed C/L				
0.0	PEAT - black	1	AS		
185.1 / 0.5	SAND - brown				
184.8 / 0.8	CLAY - varved, trace sand, grey, very soft to firm	2	SS	1	
		3	SS	1	
		4	SS	1	
		5	TW		
		6	TW		
		7	SS	1	0 1 17 83
		8	SS	1	
		9	TW		0 1 58 41
175.6 / 10.0	SAND - some silt, trace gravel, grey, loose to dense	10	SS	9	5 79 (17)
		11	SS	43	8 72 (20)
		12	SS	36	
171.2 / 14.4	End of Borehole @ 14.4 m. Auger Refusal.				



$+^3, \times^3$: Numbers refer to Sensitivity   O $^{3\%}$ STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 6

METRIC

W.P. 6120-15-00 LOCATION Station 16+074 o/s 4.2 Rt of Proposed C/L N:5415305; E:265301 MTM Zone:14 ORIGINATED BY AF

DIST NWR HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY LB

DATUM Geodetic DATE 2016.11.08 - 2016.11.08 LATITUDE 48.8748217 LONGITUDE -87.5385186 CHECKED BY SS

ELEV DEPTH	SOIL PROFILE DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
189.4	Station 16+074 o/s 4.2 Rt of Proposed C/L				
0.0	SAND - trace gravel, trace silt to Silty, occasional cobbles, brown/grey, very loose to compact	1	AS		
		2	SS	8	2 66 (33)
		3	SS	26	
		4	SS	12	8 88 (5)
		5	SS	3	
185.8 3.6	CLAY - varved, trace sand, grey, soft to firm				
		6	SS	1	0 1 26 74
		7	TW	1	
		8	SS	1	
180.8 8.6	SILT - some sand to Sandy, grey, very loose				
179.9 9.5	SAND - Silty, trace to some gravel, occasional cobbles, grey, loose to dense	9	SS	4	
		10	SS	31	15 63 (23)
		11	SS	7	
		12	SS	38	

Column headings: GROUND WATER CONDITIONS; ELEVATION SCALE (189 to 175); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 6

METRIC

W.P. 6120-15-00 LOCATION Station 16+074 o/s 4.2 Rt of Proposed C/L N:5415305; E:265301 MTM Zone:14 ORIGINATED BY AF

DIST NWR HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY LB

DATUM Geodetic DATE 2016.11.08 - 2016.11.08 LATITUDE 48.8748217 LONGITUDE -87.5385186 CHECKED BY SS

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
173.7	SAND - Silty, trace to some gravel, occasional cobbles, grey, loose to dense *(continued)*		13	SS	39		174		o		5 75 (20)
15.7	End of Borehole @ 15.7 m.										

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

ONTARIO MTO MOD 15-211 MTO PAYS PLAT.GPJ ONTARIO MTO.GDT 19/12/16

RECORD OF BOREHOLE No 7

METRIC

W.P. 6120-15-00 LOCATION Station 16+121 o/s 10.7 Lt of Proposed C/L N:5415260; E:265320 MTM Zone:14 ORIGINATED BY AF

DIST NWR HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY LB

DATUM Geodetic DATE 2016.08.17 - 2016.08.17 LATITUDE 48.8744183 LONGITUDE -87.5382553 CHECKED BY SS

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.6	Station 16+121 o/s 10.7 Lt of Proposed C/L				
0.0	FILL - Rockfill, Cobbles, Boulders				
190.8 / 1.8	CLAY - varved, trace sand, firm to stiff	1	SS	12	
		2	SS	4	
		3	TW		
		4	SS	1	
		5	SS	4	0 1 20 80
		6	SS	1	0 1 34 65
184.4 / 8.2	SAND & GRAVEL - trace to some gravel, silt to Silty, numerous cobbles, brown, compact to dense	7	SS	23	
		8	SS	33	
		9	SS	27	
		10	SS	44	18 78 (5)

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (192–178); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

Continued Next Page

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 7

METRIC

W.P. 6120-15-00 | LOCATION Station 16+121 o/s 10.7 Lt of Proposed C/L N:5415260; E:265320 MTM Zone:14 | ORIGINATED BY AF

DIST NWR HWY 17 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY LB

DATUM Geodetic | DATE 2016.08.17 - 2016.08.17 | LATITUDE 48.8744183 | LONGITUDE -87.5382553 | CHECKED BY SS

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND & GRAVEL - trace to some gravel, silt to Silty, numerous cobbles, brown, compact to dense *(continued)*		11	SS	41		177		~20 (w)		
176.9 / 15.7	End of Borehole @ 15.7 m.										

+³, ×³: Numbers refer to Sensitivity   O³% STRAIN AT FAILURE

RECORD OF BOREHOLE No 8

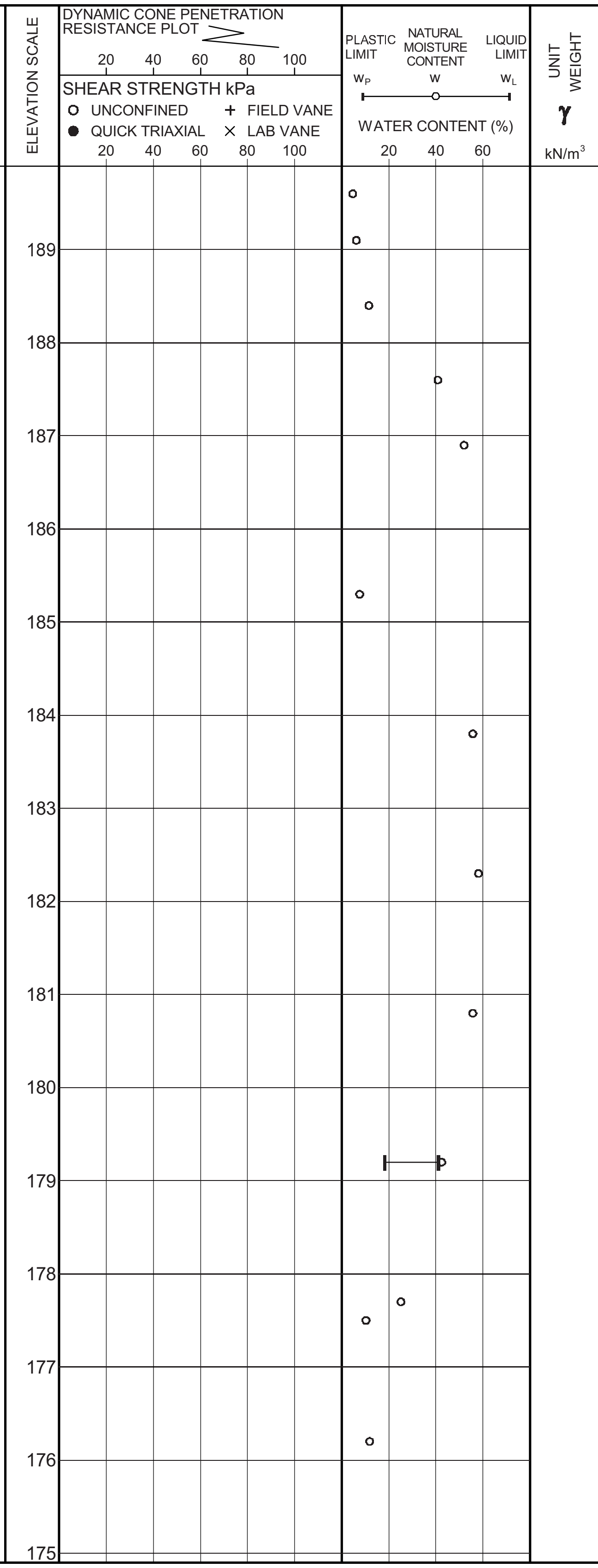
METRIC

W.P. 6120-15-00 LOCATION Station 16+111 o/s 57.1 Rt of Proposed C/L N:5415263; E:265251 MTM Zone:14 ORIGINATED BY AF

DIST NWR HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY LB

DATUM Geodetic DATE 2016.10.08 - 2016.10.08 LATITUDE 48.8744409 LONGITUDE -87.5391962 CHECKED BY SS

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
189.9	Station 16+111 o/s 57.1 Rt of Proposed C/L				
0.0	FILL - SAND & GRAVEL - numerous cobbles, brown, loose	1	AS		
		2	SS	9	
188.4 / 1.5	CLAY - varved, trace sand, grey, firm	3	SS	2	
		4	SS	1	
		5	SS	1	
185.9 / 4.0	SAND & GRAVEL - trace silt, occasional cobble, grey, compact	6	SS	14	57 38 (5)
184.6 / 5.3	CLAY - varved, trace sand to some sand, grey, soft to firm	7	SS	1	
		8	TW		
		9	TW		
		10	SS	1	0 34 (66)
178.1 / 11.8	SILT - Sandy, grey, very loose				0 21 (79)
177.4 / 12.5	SAND - trace to some gravel, trace to some silt, occasional cobbles, grey, compact to dense	11	SS	1	18 68 (14)
		12	SS	20	



Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity   O $^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 8

METRIC

W.P. 6120-15-00 | LOCATION Station 16+111 o/s 57.1 Rt of Proposed C/L N:5415263; E:265251 MTM Zone:14 | ORIGINATED BY AF

DIST NWR | HWY 17 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY LB

DATUM Geodetic | DATE 2016.10.08 - 2016.10.08 | LATITUDE 48.8744409 | LONGITUDE -87.5391962 | CHECKED BY SS

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	SAMPLE TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND - trace to some gravel, trace to some silt, occasional cobbles, grey, compact to dense *(continued)*		13	SS	26			
							174	
			14	SS	49		173	
							172	
			15	SS	63			1 93 (7)
							171	
							170	
			16	SS	29			
169.1 / 20.8	End of Borehole @ 20.8 m. Auger Refusal.							

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 9

METRIC

W.P.	6120-15-00	LOCATION	Station 16+143 o/s 18.9 Rt of Proposed C/L N:5415234; E:265293 MTM Zone:14	ORIGINATED BY	AF
DIST	NWR HWY 17	BOREHOLE TYPE	Hollow Stem Auger	COMPILED BY	LB
DATUM	Geodetic	DATE	2016.08.16 - 2016.08.16 LATITUDE 48.8741828 LONGITUDE -87.5386208	CHECKED BY	SS

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
188.3	Station 16+143 o/s 18.9 Rt of Proposed C/L
0.0	FILL - ROCKFILL
187.3 / 1.0	CLAY - grey, firm
184.7 / 3.6	SAND - trace gravel to Gravelly, trace silt, occasional cobbles, compact to dense - - - - - - numerous cobbles
178.3 / 10.0	End of Borehole @ 10.0 m. Auger Refusal.

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			0 1 21 77 (at elev. 187)
1	SS	1	
2	SS	1	
3	TW		
4	SS	14	
5	SS	39	32 60 (8)
6	SS	17	
7	SS	35	8 84 (8)
8	SS	101	

Column headings: GROUND WATER CONDITIONS; ELEVATION SCALE (188, 187, 186, 185, 184, 183, 182, 181, 180, 179); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

TBT ENGINEERING
CONSULTING GROUP

DMT 7A

Reference No.: **15-211**
Project: **HWY 11 Rossport to Caver's Hill**
Client: **MTO**

Ground Surface Elevation: 192.700 m
Water Table Depth: 5.3 m
Depth of DMT: 7.8 m

INPUT PARAMETERS

A	DMT A reading	bars
B	DMT B reading	bars
γ	Bulk Unit Weight	kN/m^3
Po	Effective overb. press.	kPa
U	Pore pressure	kPa
Id	Material Index	
Kd	Horizontal Stress Index	
Ed	Dilatometer Modulus	MPa
	Depth and Elevation	m

INTERPRETED GEOTECHNICAL PARAMETERS

γ	Bulk Unit Weight of Soil	kN/m^3
M	Constrained (oedometer) modulus	MPa
Ko	Coefficient of earth pressure insitu	
OCR	Overconsolidation ratio Pc/Po	
Pc	Preconsolidation pressure	kPa
q	Pc-Po	kPa
Cu	Undrained cohesion (cohesive)	kPa
Phi	Friction angle (cohesionless)	°
	Soil Description	

DEPTH	Elev.	A	B	A'	B'	γ	Po	U	Kd	Ed	M	Ko	OCR	Pc	q	Cu	Phi	Soil Description	
m	m	bars	bars	bars	bars	kN/m^3	kPa	kPa		MPa	MPa			kPa	kPa	kPa	degrees		
2.5	190.2	1.75	3	1.60	2.18	16.0	45	0	3.6	2.0	2.9	0.91	2.49	111	67	20		Silty CLAY	Soft
2.7	190.0	2.9	4.35	2.74	3.53	17.0	48	0	5.7	2.7	5.2	1.27	5.14	247	199	39		CLAY	Firm
2.9	189.8	3.15	4.85	2.98	4.03	17.0	51	0	5.8	3.6	7.1	1.29	5.26	270	219	43		Silty CLAY	Firm
3.1	189.6	3.55	5.15	3.39	4.33	17.0	55	0	6.2	3.3	6.6	1.34	5.81	318	263	49		CLAY	Firm
3.3	189.4	3.45	4.9	3.29	4.08	17.0	58	0	5.7	2.7	5.2	1.27	5.06	295	236	47		CLAY	Firm
3.5	189.2	2.95	4.35	2.80	3.53	17.0	62	0	4.5	2.5	4.3	1.08	3.59	221	159	38		CLAY	Firm
3.7	189.0	3.55	5	3.39	4.18	17.0	65	0	5.2	2.7	5.0	1.20	4.47	290	225	47		CLAY	Firm
3.9	188.8	3.6	5.1	3.44	4.28	17.0	68	0	5.0	2.9	5.2	1.17	4.21	288	220	48		CLAY	Firm
4.1	188.6	3.65	5.2	3.49	4.38	17.0	72	0	4.9	3.1	5.4	1.14	3.99	287	215	48		CLAY	Firm
4.3	188.4	3.80	5.45	3.63	4.63	17.0	75	0	4.8	3.5	6.1	1.13	3.96	298	222	50		CLAY	Firm
4.5	188.2	3.90	5.45	3.74	4.63	17.0	79	0	4.8	3.1	5.4	1.12	3.86	304	225	51		CLAY	Stiff
4.7	188.0	3.90	5.40	3.74	4.58	17.0	82	0	4.6	2.9	4.9	1.09	3.62	297	215	51		CLAY	Stiff
4.9	187.8	3.90	5.40	3.74	4.58	17.0	85	0	4.4	2.9	4.8	1.05	3.40	290	205	50		CLAY	Stiff
5.1	187.6	4.05	5.60	3.89	4.78	17.0	89	0	4.4	3.1	5.1	1.05	3.39	301	213	52		CLAY	Stiff
5.3	187.4	4.10	5.70	3.94	4.88	17.0	92	0	4.3	3.3	5.3	1.03	3.26	301	209	52		CLAY	Stiff
5.5	187.2	4.05	5.60	3.89	4.78	17.0	94	2	4.1	3.1	4.9	1.01	3.10	290	197	51		CLAY	Stiff
5.7	187.0	4.20	5.90	4.03	5.08	17.0	95	4	4.2	3.6	5.8	1.02	3.18	302	207	53		CLAY	Stiff
5.9	186.8	4.15	5.60	3.99	4.78	17.0	97	6	4.1	2.7	4.3	1.00	3.04	293	197	52		CLAY	Stiff
6.1	186.6	4.30	5.90	4.14	5.08	17.0	98	8	4.1	3.3	5.2	1.01	3.11	305	207	54		CLAY	Stiff
6.3	186.4	4.15	5.70	3.99	4.88	17.0	99	10	3.9	3.1	4.8	0.97	2.85	283	184	51		CLAY	Stiff
6.5	186.2	4.15	5.65	3.99	4.83	17.0	101	12	3.8	2.9	4.4	0.96	2.77	279	178	50		CLAY	Stiff
6.7	186.0	4.25	5.75	4.09	4.93	17.0	102	14	3.9	2.9	4.4	0.96	2.79	286	184	51		CLAY	Stiff
6.9	185.8	4.20	5.70	4.04	4.88	17.0	104	16	3.7	2.9	4.3	0.94	2.66	276	172	50		CLAY	Firm
7.1	185.6	4.15	5.55	4.00	4.73	17.0	105	18	3.6	2.5	3.7	0.92	2.54	267	161	49		CLAY	Firm
7.3	185.4	4.10	5.60	3.94	4.78	17.0	107	20	3.5	2.9	4.1	0.89	2.41	257	150	47		CLAY	Firm
7.5	185.2	3.85	5.25	3.70	4.43	17.0	108	22	3.2	2.5	3.4	0.83	2.10	227	119	43		CLAY	Firm
7.7	185.0	3.45	4.75	3.30	3.93	17.0	109	24	2.8	2.2	2.6	0.74	1.69	185	76	37		CLAY	Firm
7.8	184.9	2.70	4.05	2.55	3.23	16.0	112	25	2.1	2.4	2.1	0.56	1.05	117	5	26		CLAY	Firm

TBT ENGINEERING
CONSULTING GROUP

DMT 8A

Reference No.: **15-211**
Project: **HWY 11 Rossport to Caver's Hill**
Client: **MTO**

Ground Surface Elevation: 189.700 m
Water Table Depth: 2.5 m
Depth of DMT: 12.5 m

INPUT PARAMETERS

A	DMT A reading	bars
B	DMT B reading	bars
γ	Bulk Unit Weight	kN/m^3
Po	Effective overb. press.	kPa
U	Pore pressure	kPa
Id	Material Index	
Kd	Horizontal Stress Index	
Ed	Dilatometer Modulus	MPa
	Depth and Elevation	m

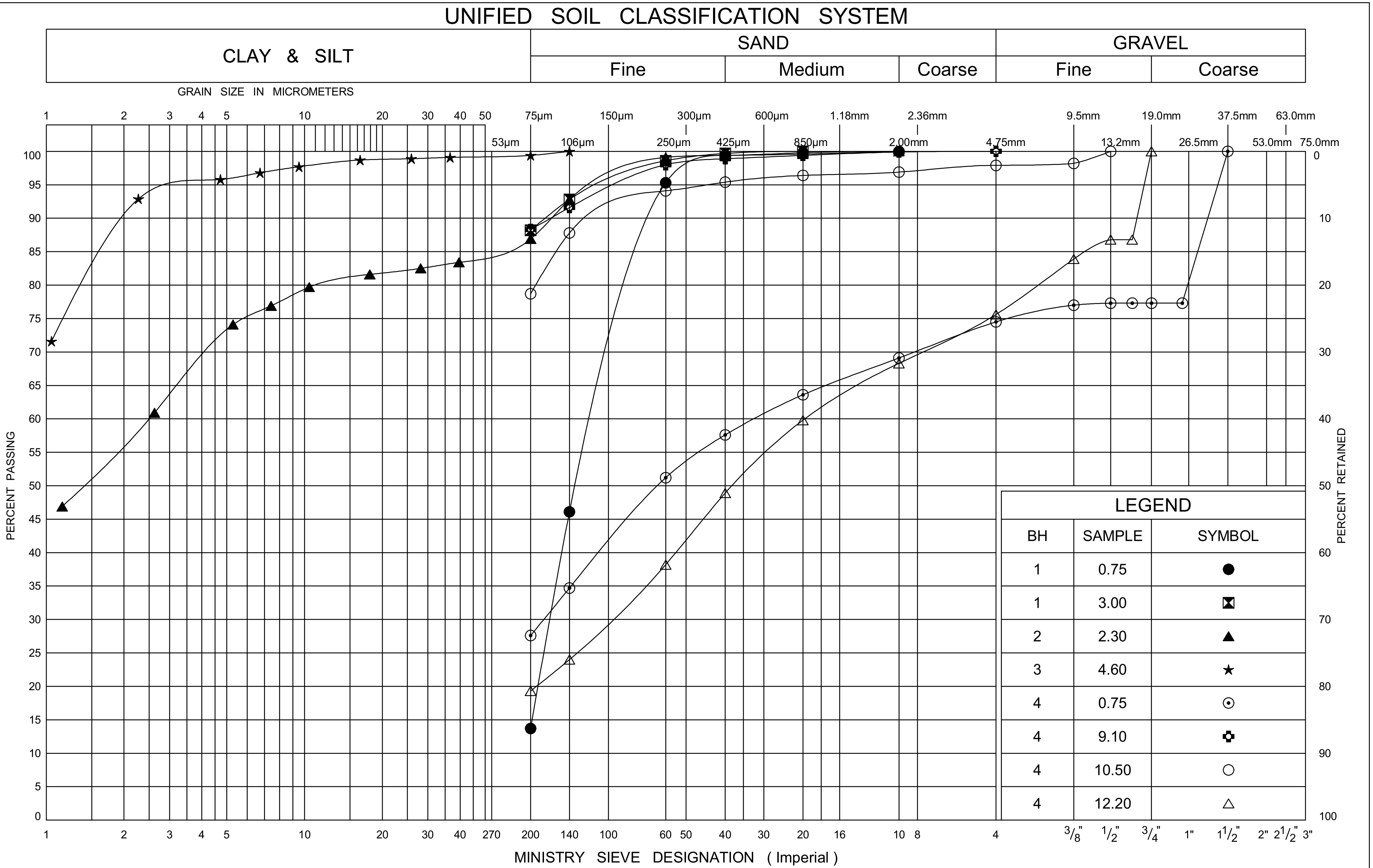
INTERPRETED GEOTECHNICAL PARAMETERS

γ	Bulk Unit Weight of Soil	kN/m^3
M	Constrained (oedometer) modulus	MPa
Ko	Coefficient of earth pressure insitu	
OCR	Overconsolidation ratio Pc/Po	
Pc	Preconsolidation pressure	kPa
q	Pc-Po	kPa
Cu	Undrained cohesion (cohesive)	kPa
Phi	Friction angle (cohesionless)	°
	Soil Description	

DEPTH	Elev.	A	B	A'	B'	γ	Po	U	Kd	Ed	M	Ko	OCR	Pc	q	Cu	Phi	Soil Description	
m	m	bars	bars	bars	bars	kN/m^3	kPa	kPa		MPa	MPa			kPa	kPa	kPa	degrees		
1.8	187.9	1.5	3.05	1.34	2.23	16.0	32	0	4.2	3.1	3.4	1.02	3.16	101	69	18		Clayey SILT	Soft
2.0	187.7	1.8	3.1	1.65	2.28	16.0	35	0	4.7	2.2	3.8	1.11	3.78	133	98	22		Silty CLAY	Soft
2.2	187.5	1.9	3.15	1.75	2.33	16.0	38	0	4.6	2.0	3.4	1.09	3.62	139	101	24		CLAY	Soft
2.4	187.3	2	3.3	1.85	2.48	16.0	42	0	4.4	2.2	3.6	1.07	3.48	145	103	25		CLAY	Soft
2.6	187.1	2.15	3.5	2.00	2.68	16.0	44	1	4.5	2.4	4.0	1.08	3.59	157	113	27		CLAY	Firm
2.8	186.9	2.1	3.45	1.95	2.63	16.0	45	3	4.3	2.4	3.8	1.03	3.25	146	101	25		Silty CLAY	Firm
3.0	186.7	2.05	3.35	1.90	2.53	16.0	46	5	4.0	2.2	3.4	0.99	2.95	136	90	24		CLAY	Soft
3.2	186.5	1.95	3.15	1.81	2.33	16.0	48	7	3.7	1.8	2.7	0.92	2.56	122	74	22		CLAY	Soft
3.4	186.3	0.65	2.8	0.46	1.98	17.0	49	9	0.8	5.3	4.5						29	SAND	Loose
3.6	186.1																	Refusal to	
3.8	185.9																	DMT	
4.0	185.7																	Used Augers	
4.2	185.5																	To Advance	
4.4	185.3																	Hole to	
4.6	185.1																	5.0 m	
4.8	184.9																		
5.0	184.7																		
5.3	184.4	3.00	4.90	2.82	4.08	17.0	61	27	4.2	4.4	7.0	1.02	3.15	192	131	34		Silty CLAY	Firm
5.5	184.2	2.75	4.20	2.59	3.38	16.0	62	29	3.7	2.7	4.0	0.93	2.61	162	100	29		CLAY	Firm
5.7	184.0	2.70	4.00	2.55	3.18	16.0	63	31	3.5	2.2	3.1	0.89	2.42	154	90	28		CLAY	Firm
5.9	183.8	2.70	4.00	2.55	3.18	16.0	65	33	3.4	2.2	3.1	0.87	2.32	150	85	28		CLAY	Firm
6.1	183.6	2.65	3.75	2.51	2.93	16.0	66	35	3.3	1.5	2.0	0.84	2.16	142	76	27		CLAY	Firm
6.3	183.4	2.60	3.80	2.46	2.98	16.0	67	37	3.1	1.8	2.4	0.81	1.98	133	66	26		CLAY	Firm
6.5	183.2	2.50	3.70	2.36	2.88	16.0	68	39	2.9	1.8	2.2	0.76	1.76	120	52	24		CLAY	Soft
6.7	183.0	2.45	3.65	2.31	2.83	16.0	70	41	2.7	1.8	2.1	0.72	1.61	112	43	22		CLAY	Soft
6.9	182.8	2.50	3.75	2.35	2.93	16.0	71	43	2.7	2.0	2.3	0.72	1.61	114	43	23		CLAY	Soft
7.1	182.6	2.60	3.90	2.45	3.08	16.0	72	45	2.8	2.2	2.6	0.73	1.66	120	48	24		CLAY	Soft
7.3	182.4	2.65	3.90	2.50	3.08	16.0	73	47	2.8	2.0	2.4	0.73	1.66	122	49	24		CLAY	Soft
7.5	182.2	2.80	4.00	2.66	3.18	16.0	75	49	2.9	1.8	2.2	0.76	1.79	133	59	26		CLAY	Firm
7.7	182.0	2.85	4.10	2.70	3.28	16.0	76	51	2.9	2.0	2.5	0.76	1.78	135	59	26		CLAY	Firm
7.9	181.8	2.90	4.15	2.75	3.33	16.0	77	53	2.9	2.0	2.4	0.76	1.77	136	59	27		CLAY	Firm
8.1	181.6	2.95	4.10	2.81	3.28	16.0	78	55	2.9	1.6	2.0	0.76	1.77	139	60	27		CLAY	Firm
8.3	181.4	3.00	4.15	2.86	3.33	16.0	80	57	2.9	1.6	2.0	0.76	1.76	140	61	28		CLAY	Firm
8.5	181.2	3.00	4.15	2.86	3.33	16.0	81	59	2.8	1.6	2.0	0.74	1.70	137	56	27		CLAY	Firm
8.7	181.0	2.95	4.15	2.81	3.33	16.0	82	61	2.7	1.8	2.1	0.71	1.58	129	47	26		CLAY	Firm
8.9	180.8	3.05	4.15	2.91	3.33	16.0	83	63	2.7	1.5	1.7	0.73	1.64	136	53	27		CLAY	Firm
9.1	180.6	3.05	4.15	2.91	3.33	16.0	85	65	2.7	1.5	1.7	0.71	1.58	133	49	27		CLAY	Firm
9.3	180.4	3.15	4.25	3.01	3.43	16.0	86	67	2.7	1.5	1.7	0.73	1.63	140	54	28		CLAY	Firm
9.5	180.2	3.20	4.35	3.06	3.53	16.0	87	69	2.7	1.6	1.9	0.72	1.62	141	54	28		CLAY	Firm
9.7	180.0	3.25	4.40	3.11	3.58	16.0	88	71	2.7	1.6	1.9	0.72	1.62	143	54	29		CLAY	Firm
9.9	179.8	3.30	4.45	3.16	3.63	16.0	89	73	2.7	1.6	1.9	0.72	1.61	144	55	29		CLAY	Firm
10.1	179.6	3.35	4.50	3.21	3.68	16.0	91	74	2.7	1.6	1.9	0.72	1.61	146	55	29		CLAY	Firm
10.3	179.4	3.40	4.55	3.26	3.73	16.0	92	76	2.7	1.6	1.9	0.72	1.61	148	56	30		CLAY	Firm
10.5	179.2	3.50	4.60	3.36	3.78	16.0	93	78	2.8	1.5	1.7	0.73	1.66	154	61	31		CLAY	Firm
10.7	179.0	3.55	4.70	3.41	3.88	16.0	94	80	2.8	1.6	1.9	0.73	1.65	156	61	31		CLAY	Firm
10.9	178.8	3.65	4.80	3.51	3.98	16.0	96	82	2.8	1.6	2.0	0.74	1.70	162	67	32		CLAY	Firm
11.1	178.6	3.65	4.80	3.51	3.98	16.0	97	84	2.7	1.6	1.9	0.73	1.64	159	62	32		CLAY	Firm
11.3	178.4	3.70	4.90	3.56	4.08	16.0	98	86	2.7	1.8	2.1	0.73	1.64	161	63	32		CLAY	Firm
11.5	178.2	3.50	4.65	3.36	3.83	16.0	99	88	2.5	1.6	1.8	0.67	1.41	140	41	29		CLAY	Firm
11.7	178.0	2.50	6.30	2.23	5.48	18.0	101	90	1.3	11.3	9.6						28	Silty SAND	Loose
11.9	177.8	3.25	5.05	3.08	4.23	17.0	102	92	2.1	4.0	3.6	0.57	1.08	111	8	24		Silty CLAY	Soft
12.1	177.6	2.30	5.75	2.04	4.93	18.0	104	94	1.1	10.0	8.5						27	Silty SAND	Loose
12.3	177.4	6.40	15.80	5.87	14.42	19.5	106	96	4.6	29.6	37.2						29	Sandy SILT	Compact
12.5	177.2	4.90	13.40	4.42	12.02	19.0	108	98	3.2	26.3	24.7						29	Silty SAND	Compact

APPENDIX B
Laboratory Test Data

78 12 M



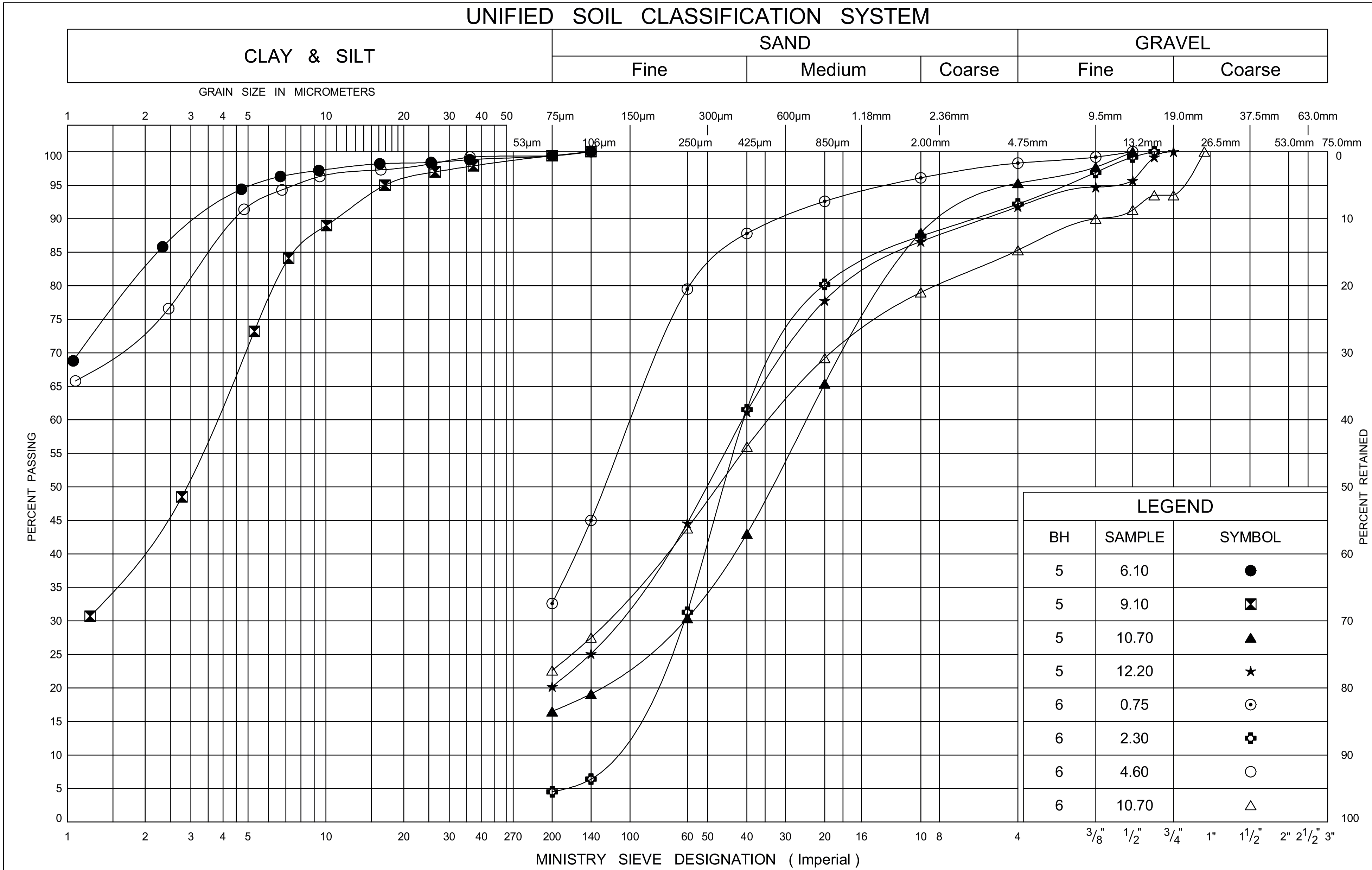
BH	SAMPLE	SYMBOL
1	0.75	●
1	3.00	⊠
2	2.30	▲
3	4.60	★
4	0.75	⊙
4	9.10	✿
4	10.50	○
4	12.20	△

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

FIG No

W P 6120-15-00



BH	SAMPLE	SYMBOL
5	6.10	●
5	9.10	⧗
5	10.70	▲
5	12.20	★
6	0.75	⊙
6	2.30	✿
6	4.60	○
6	10.70	△

Ministry of Transportation

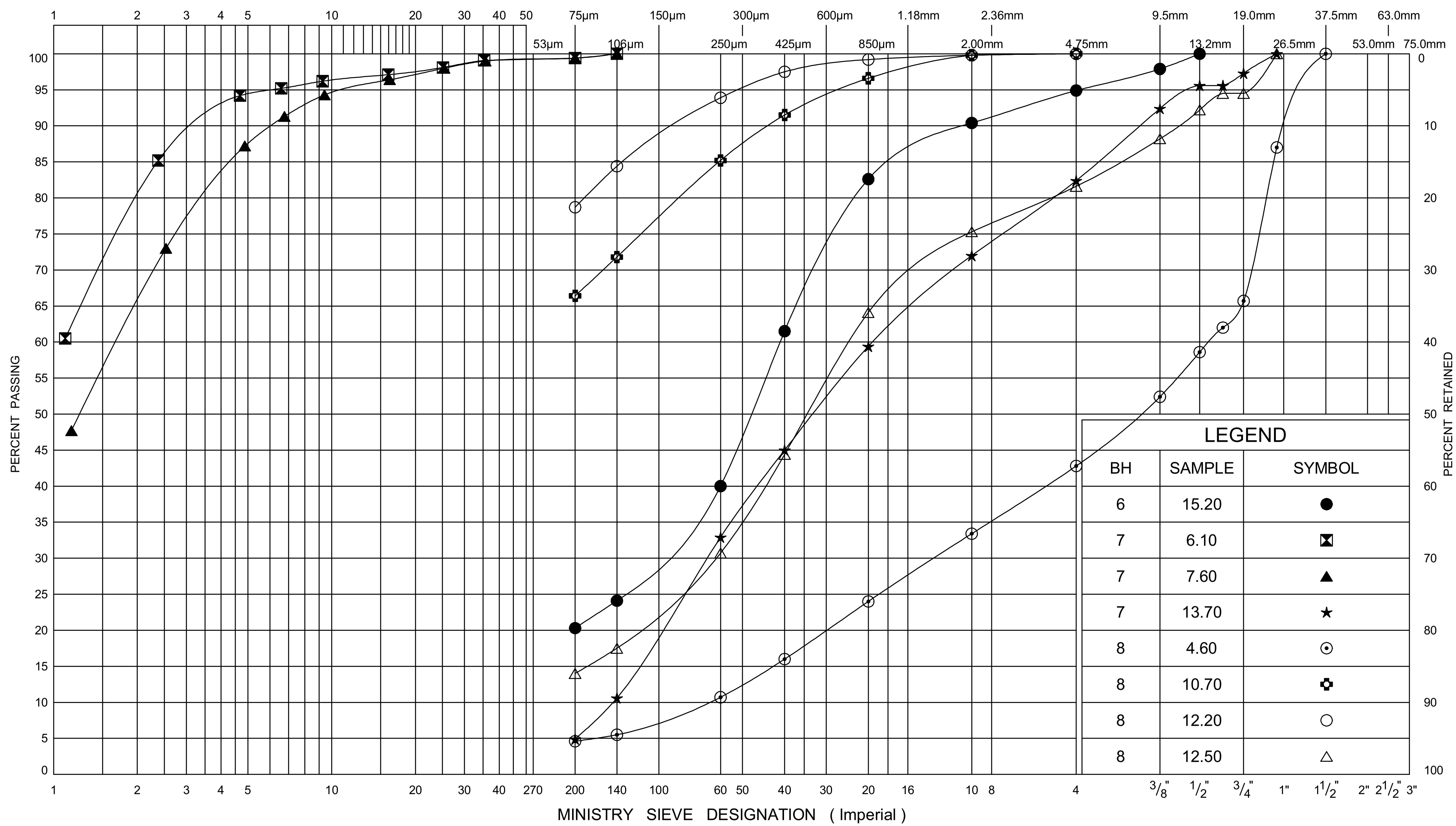
Ontario

GRAIN SIZE DISTRIBUTION

FIG No

W P 6120-15-00

78 12 M



BH	SAMPLE	SYMBOL
6	15.20	●
7	6.10	⧗
7	7.60	▲
7	13.70	★
8	4.60	⊙
8	10.70	✪
8	12.20	○
8	12.50	△

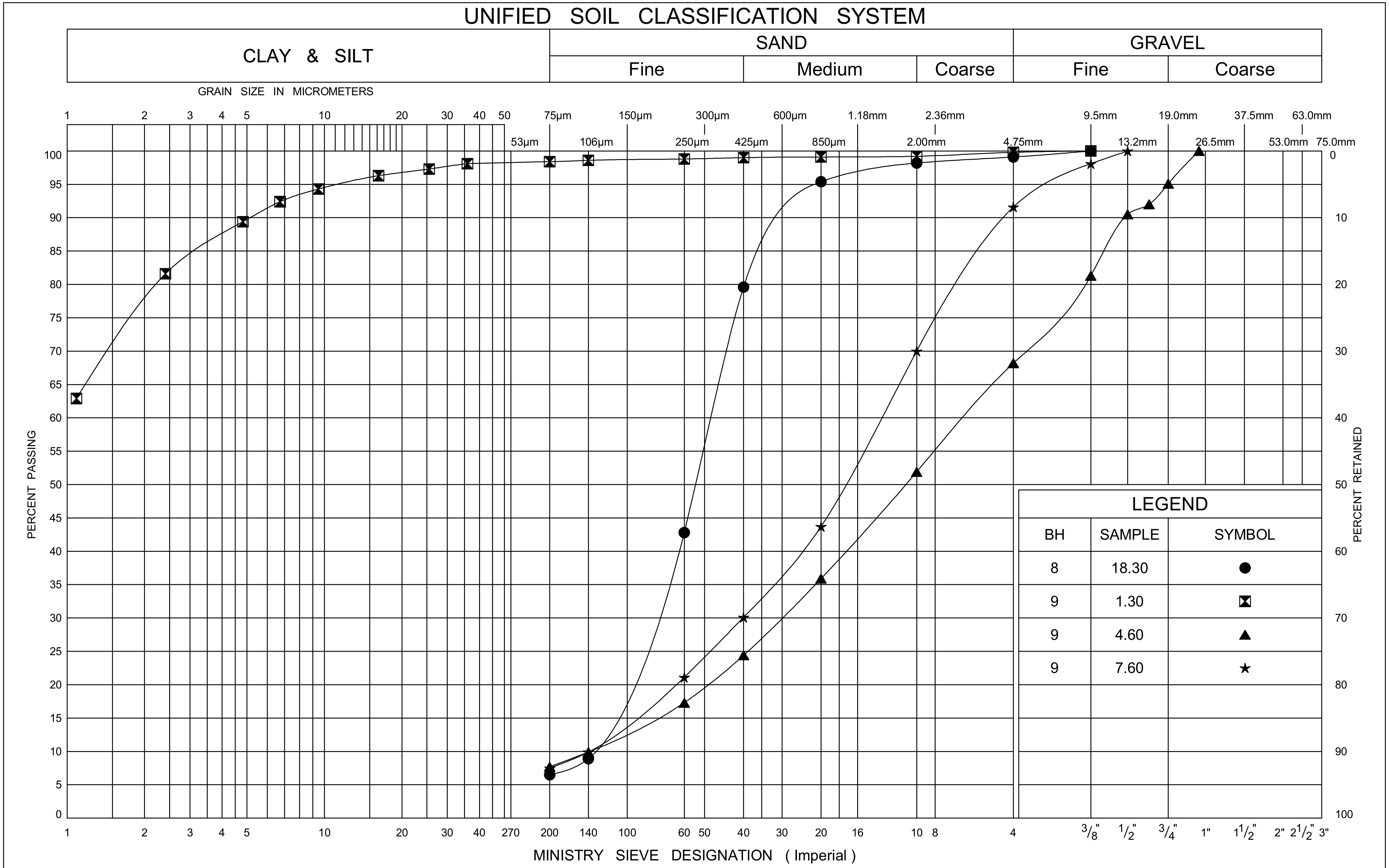
Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

FIG No
W P 6120-15-00

ONTARIO MOT GRAIN SIZE 15-211 MTO PAYS PLAT.GPJ ONTARIO MOT.GDT 9/28/16

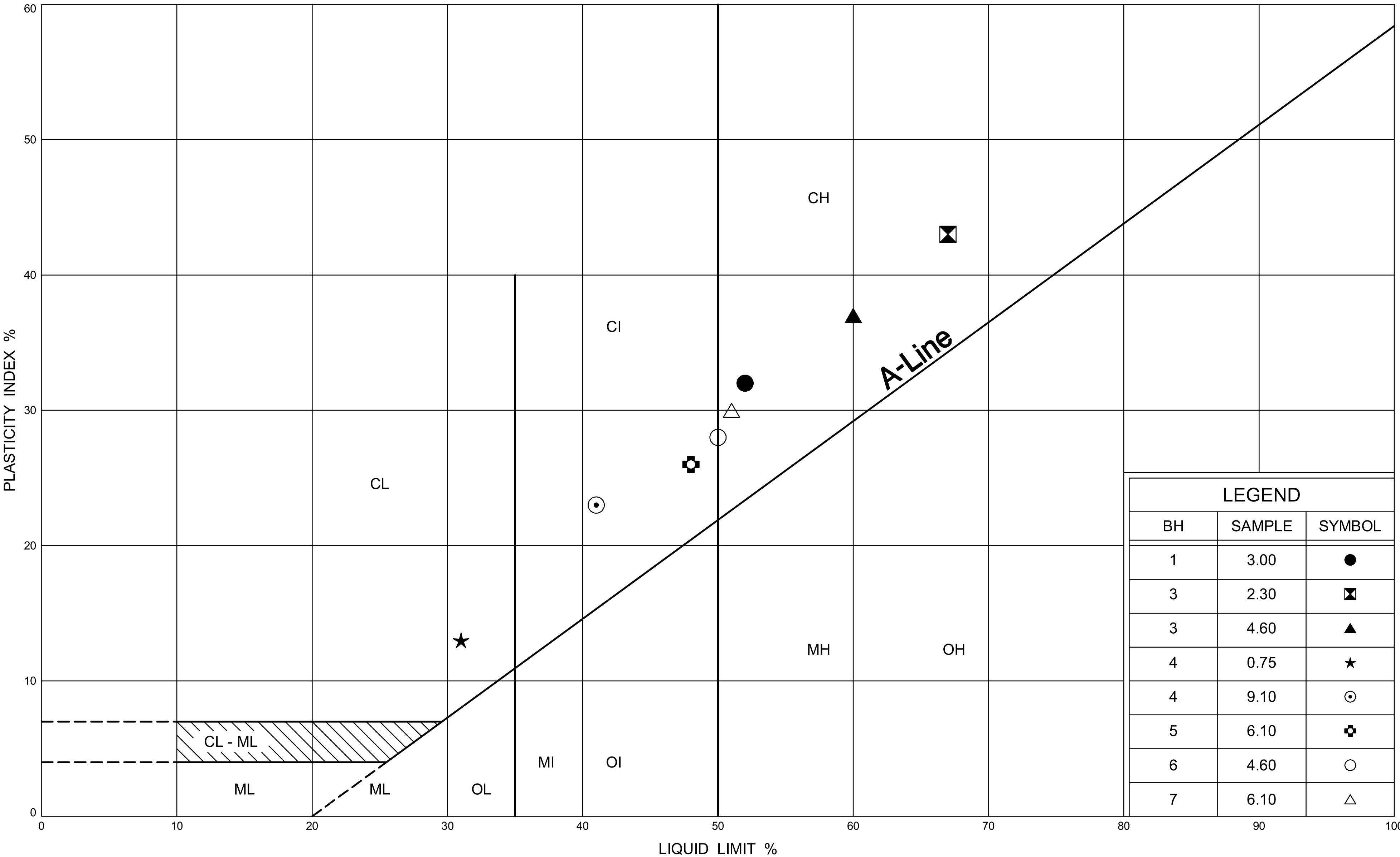
78 12 M



Ministry of Transportation Ontario	GRAIN SIZE DISTRIBUTION	FIG No W P 6120-15-00

ONTARIO MOT GRAIN SIZE 15-211 MTO PAYS PLAT.GPJ ONTARIO MOT.GDT 9/28/16

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
1	3.00	●
3	2.30	⧗
3	4.60	▲
4	0.75	★
4	9.10	⊙
5	6.10	✿
6	4.60	○
7	6.10	△

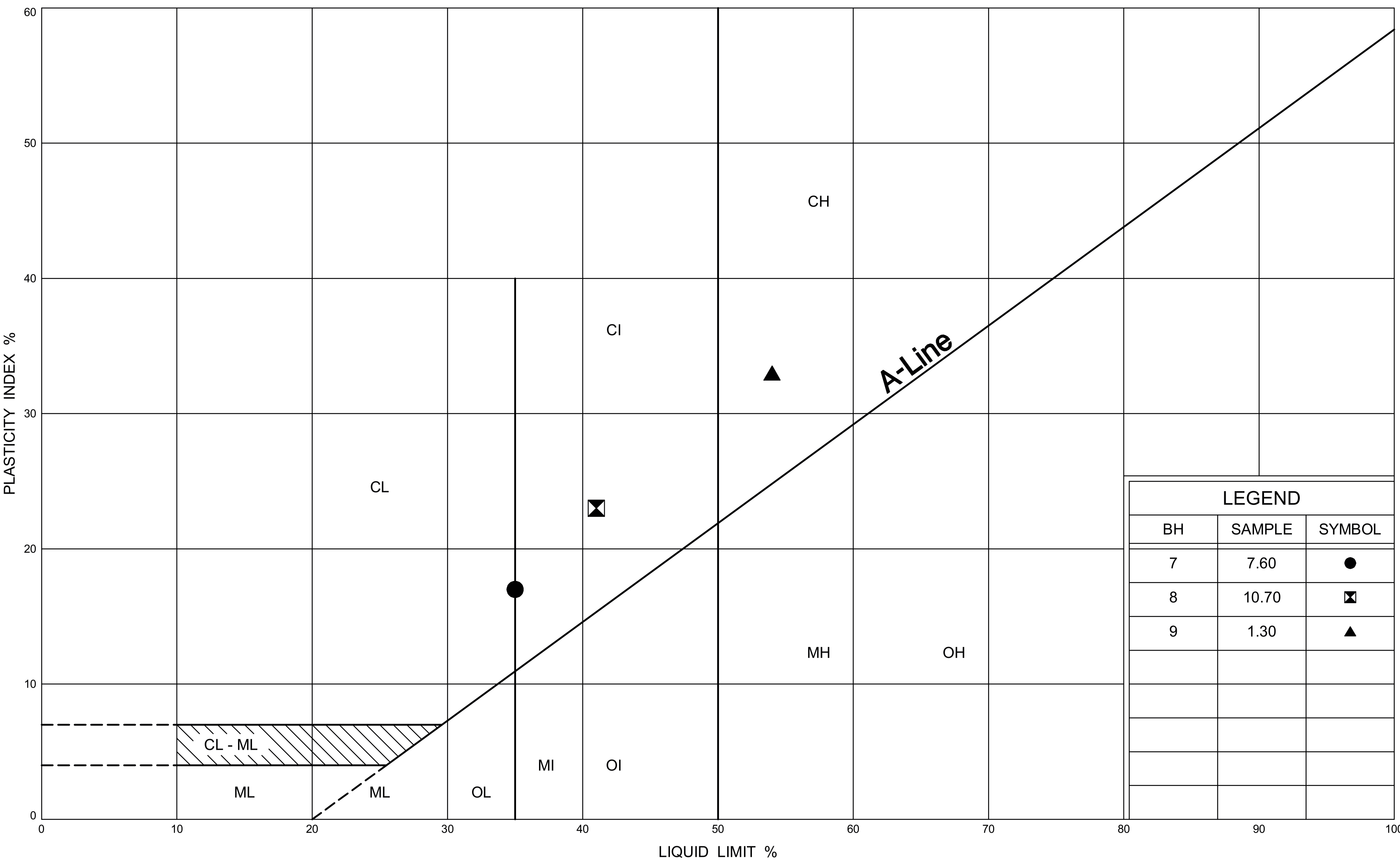
Ministry of Transportation
Ontario

PLASTICITY CHART

FIG No

W P 6120-15-00

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
7	7.60	●
8	10.70	⊠
9	1.30	▲

Ministry of Transportation
Ontario

PLASTICITY CHART

FIG No
W P 6120-15-00

ONTARIO MOT PLASTICITY CHART 15-211 MTO PAYS PLAT.GPJ ONTARIO MOT.GDT 9/28/16

APPENDIX C
Borehole Locations and Soil Strata Drawing

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

GeoCres	No. 42D-45
CONT	No. 2017-xx
WP	No. 6120-15-00

HILL #19 ALTERNATIVE 2-2
AT HWY 17
STRUCTURE REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

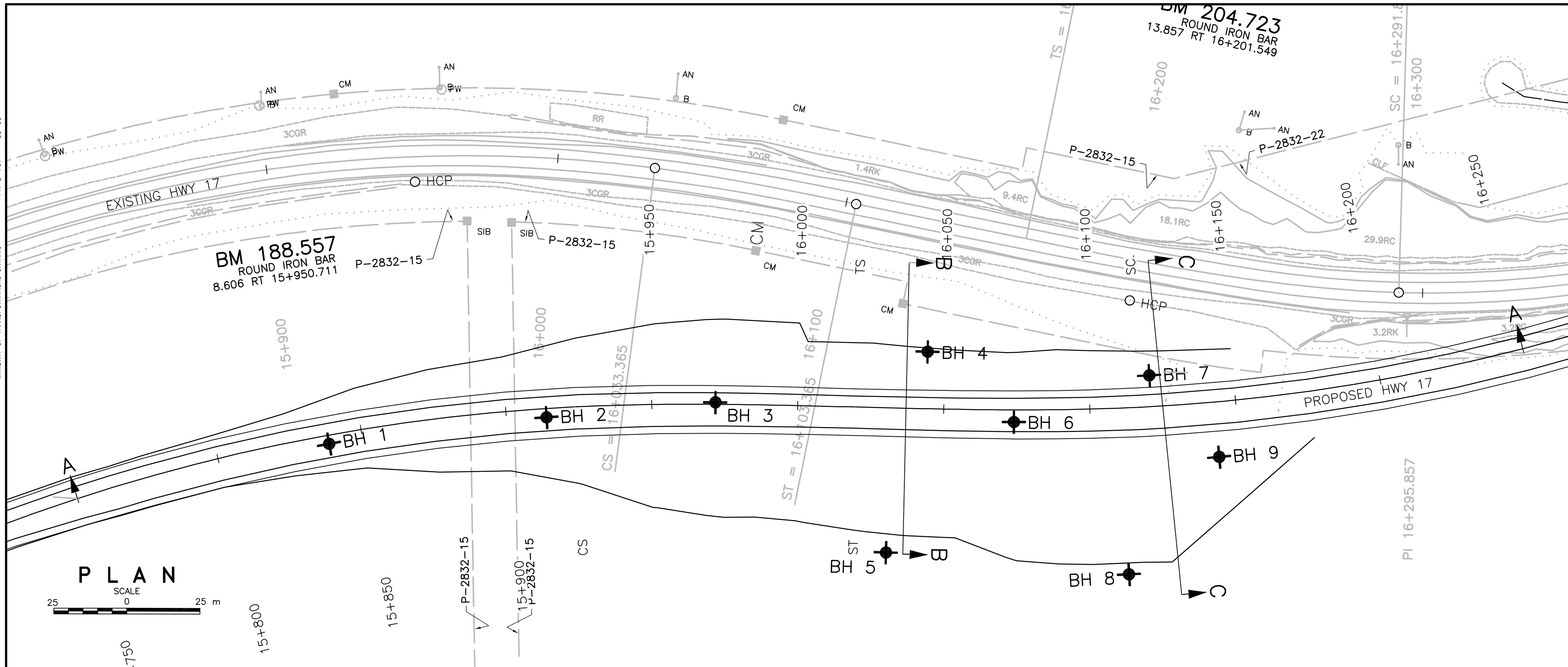
SHEET

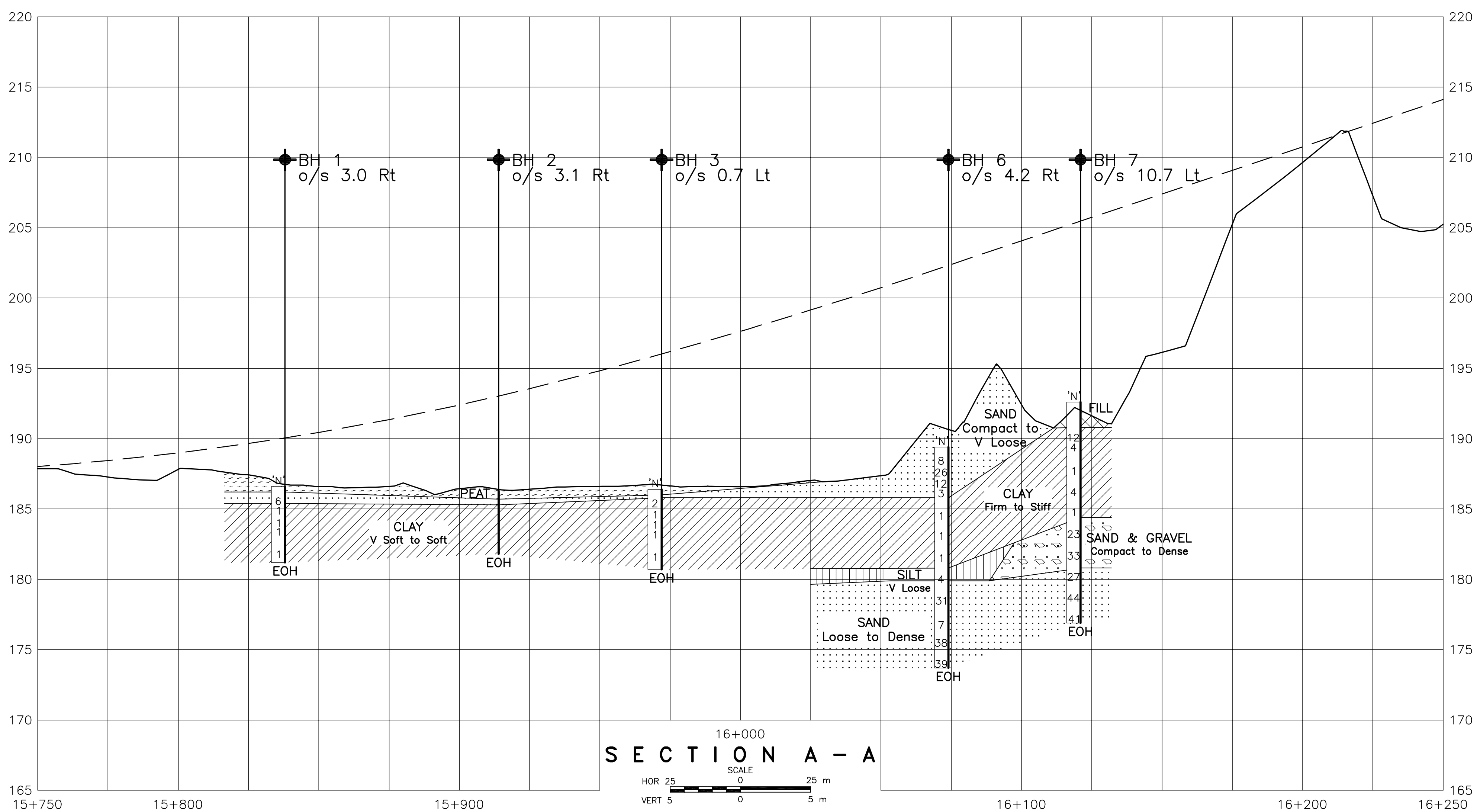
Ministry of Transportation
Northwestern Region
Structural Section

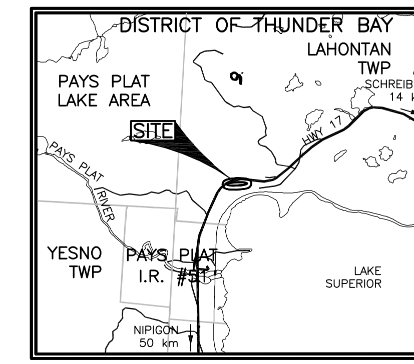
TBT ENGINEERING CONSULTING GROUP

LICENSED PROFESSIONAL ENGINEER
S.W.S. SELLER
100043505
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
W.P. HURLEY
21013503
19/12/2016
PROVINCE OF ONTARIO







KEY PLAN

2.0 km 0 2.0 km

SOIL STRATA SYMBOLS

PEAT
SAND
FILL
SAND & GRAVEL
SILT
CLAY

LEGEND

- BH — Borehole
- 'N' — Std Pen Test (Blows/0.3m)
- Water Level
- NFP — No Further Progress

No	ELEVATION	CO-ORDINATES (MTM) NORTH	EAST
1	186.6	14 5 415 539	265 280
2	186.3	14 5 415 465	265 294
3	186.4	14 5 415 408	265 302
4	189.7	14 5 415 336	265 323
5	185.6	14 5 415 347	265 254
6	189.4	14 5 415 305	265 301
7	192.6	14 5 415 260	265 320
8	189.9	14 5 415 263	265 251
9	188.3	14 5 415 234	26 5293

—NOTE—
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS		
20160930	TB	DRAFT
		DESCRIPTION

DESIGN	CHK	CODE XXXXX-XX	LOAD XX-XXX-XXX	DATE 20160917	
DRAWN TB	CHK SS	SITE XXX-XXX		DWG	1

Dec 19, 2016, 9:40am Login name: tblunden
Drawing Name: Y:\Projects\2015\15-211 MTO NWR Hwy 17 PDR Rossport\Foundations\Drawings\15-211 Foundation Final.dwg

MINISTRY OF TRANSPORTATION, ONTARIO PH-D-707 88-05

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

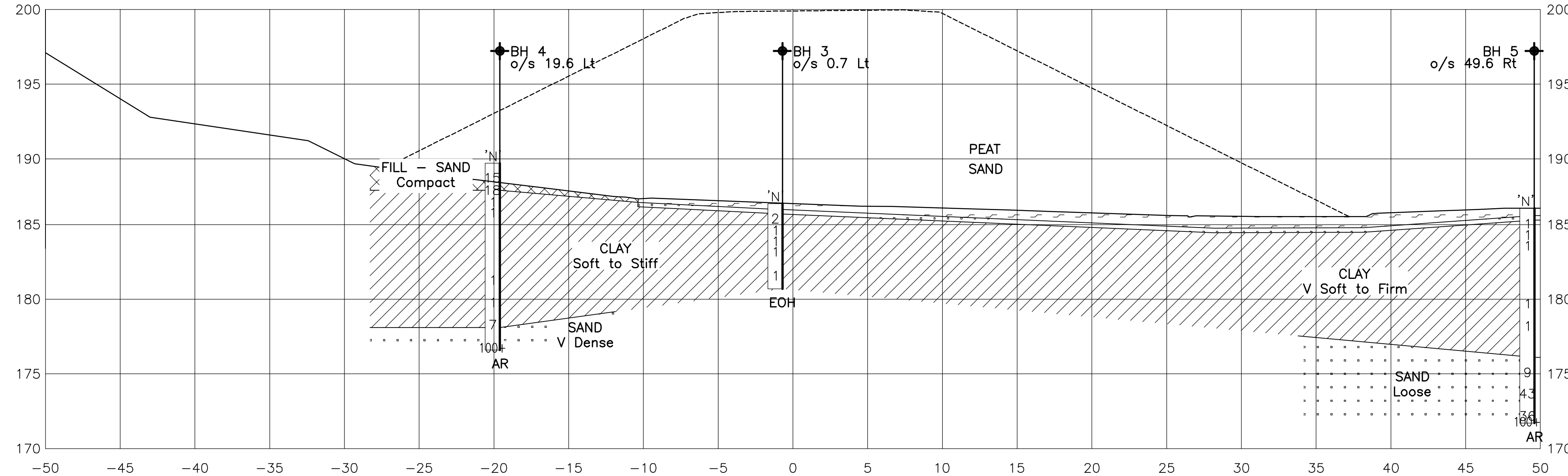
GeoCres No. 42D-45
CONT No. 2017-xx
WP No. 6120-15-00

HILL #19 ALTERNATIVE 2-2
AT HWY 17
STRUCTURE REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

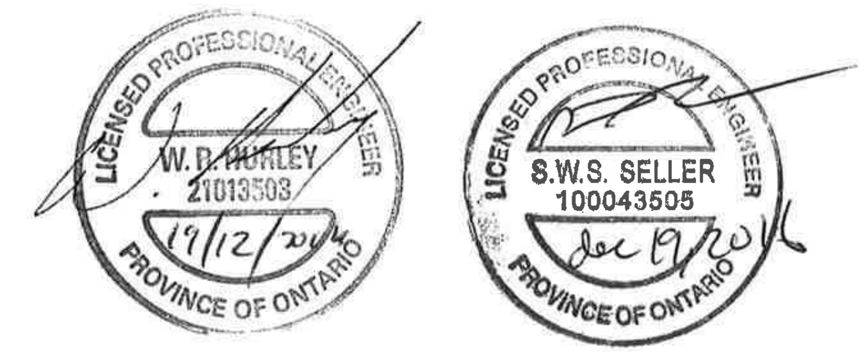
Ontario — Ministry of Transportation, Northwestern Region, Structural Section

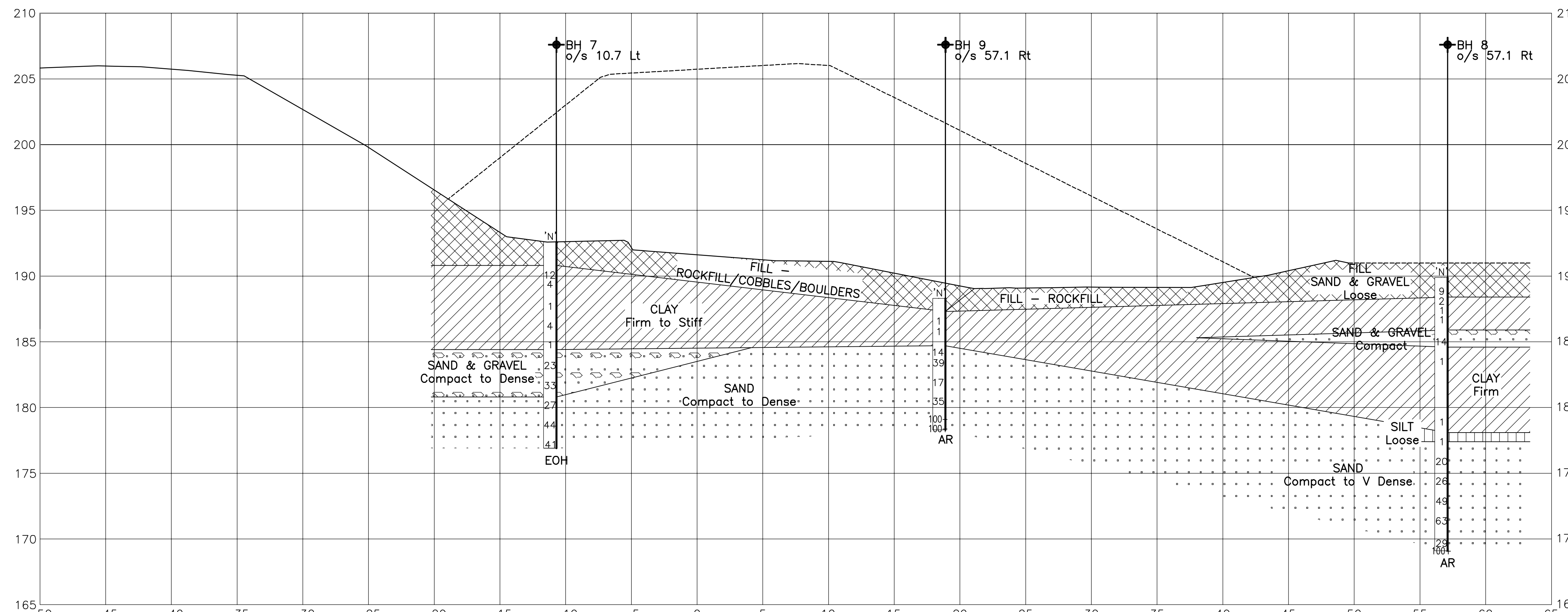
TBT ENGINEERING CONSULTING GROUP



SECTION B – B

SCALE 10 0 10 m





SECTION C – C

SCALE 10 0 10 m

REFERENCE DRAWING SUPPLIED BY

SOIL STRATA SYMBOLS

PEAT · SAND · FILL · SAND & GRAVEL · SILT · CLAY

LEGEND

- BH — Borehole
- 'N' — Std Pen Test (Blows/0.3m)
- ▼ — Water Level
- NFP — No Further Progress

No	ELEVATION	CO-ORDINATES (MTM) NORTH	EAST
1	186.6	14 5 415 539	265 280
2	186.3	14 5 415 465	265 294
3	186.4	14 5 415 408	265 302
4	189.7	14 5 415 336	265 323
5	185.6	14 5 415 347	265 254
6	189.4	14 5 415 305	265 301
7	192.6	14 5 415 260	265 320
8	189.9	14 5 415 263	265 251
9	188.3	14 5 415 234	26 5293

—NOTE—

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS

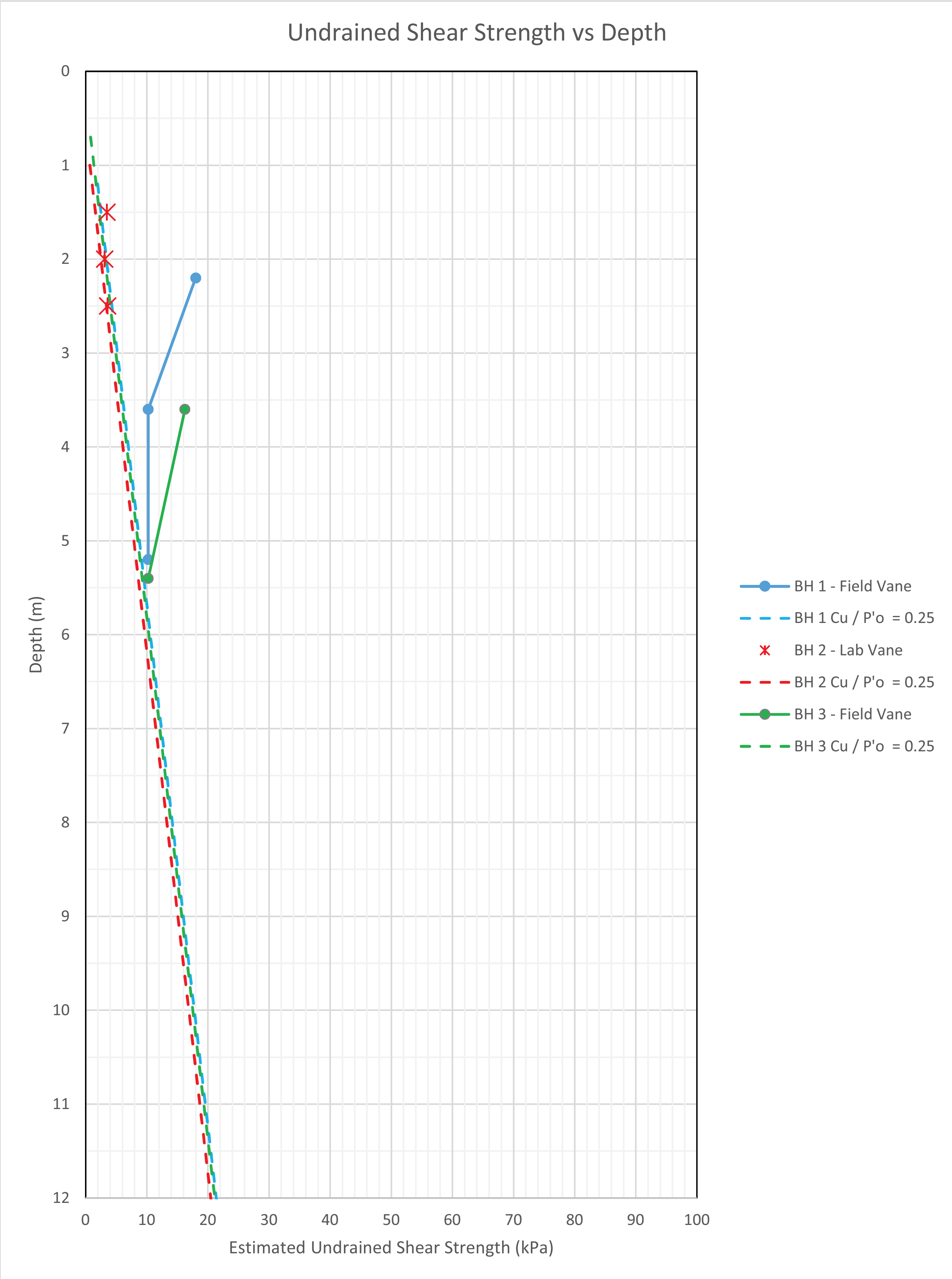
20160930	TB	DRAFT
		DESCRIPTION

DESIGN | CHK | CODE XXXXX–XX | LOAD XX–XXX–XXX | DATE 20160917
DRAWN TB | CHK SS | SITE XXX–XXX | | DWG 2

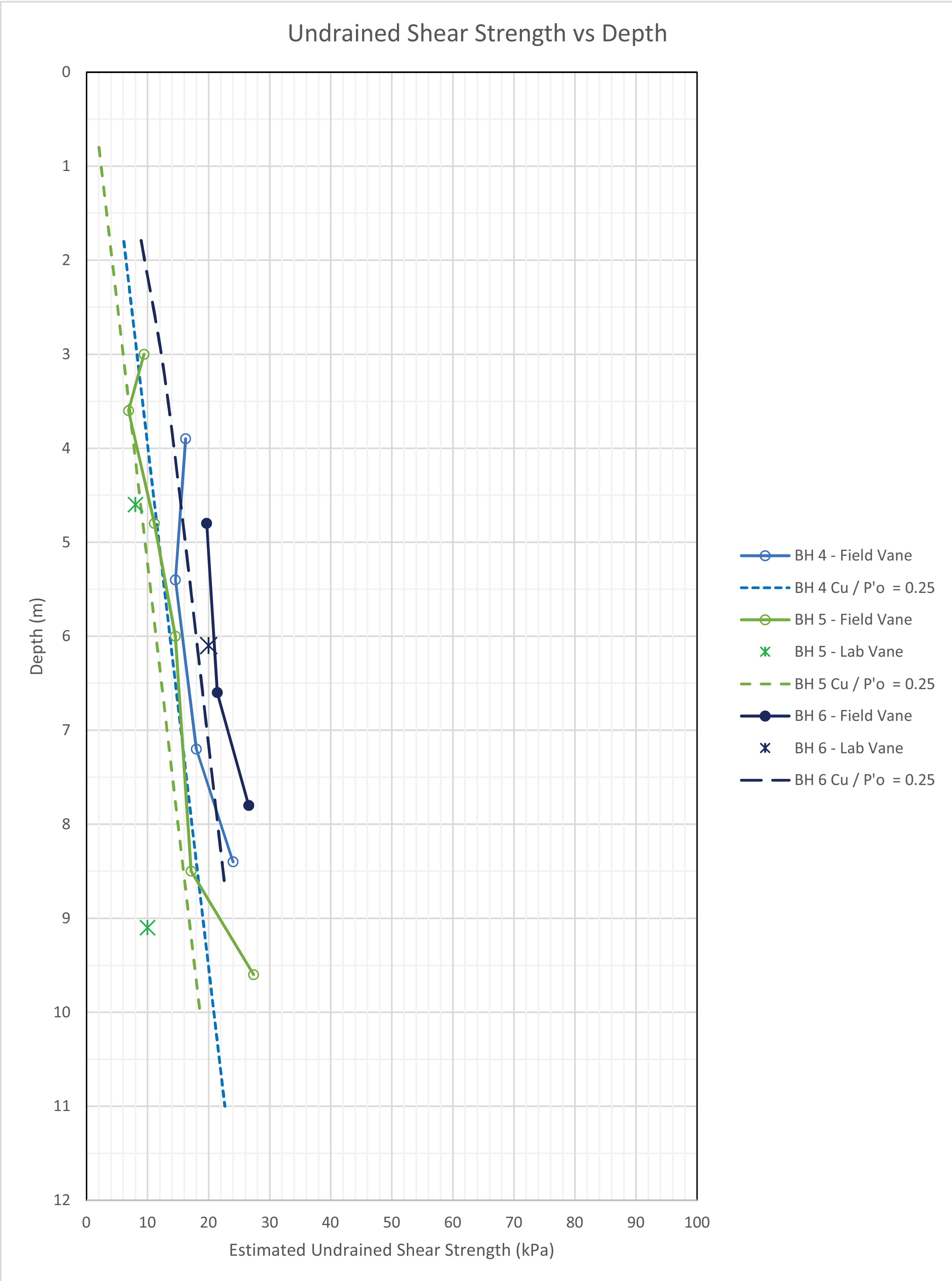
Dec 19, 2016, 9:40am Login name: tblunden
Drawing Name: Y:\Projects\2015\15-211 MTO NWR Hwy 17 PDR Rossport\Foundations\Drawings\15-211 Foundation Final.dwg

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

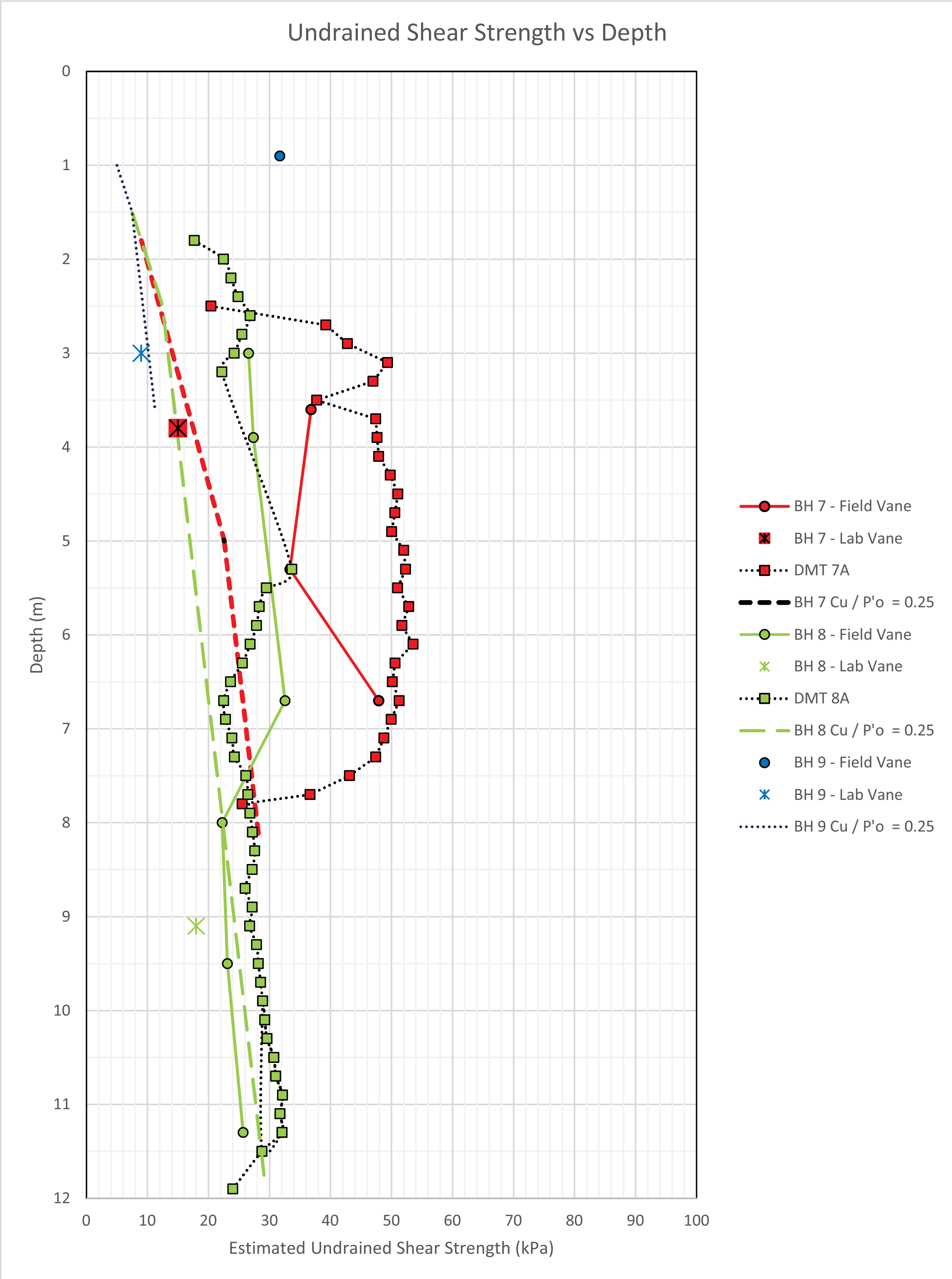
APPENDIX D
Undrained Shear Strength Profiles



Undrained Shear Strength vs Depth
Depth (m)
Estimated Undrained Shear Strength (kPa)
0
1
2
3
4
5
6
7
8
9
10
11
12
0 10 20 30 40 50 60 70 80 90 100
BH 1 - Field Vane
BH 1 Cu / P'o = 0.25
BH 2 - Lab Vane
BH 2 Cu / P'o = 0.25
BH 3 - Field Vane
BH 3 Cu / P'o = 0.25



Undrained Shear Strength vs Depth
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
0
10
20
30
40
50
60
70
80
90
100
Estimated Undrained Shear Strength (kPa)
BH 4 - Field Vane
BH 4 Cu / P'o = 0.25
BH 5 - Field Vane
BH 5 - Lab Vane
BH 5 Cu / P'o = 0.25
BH 6 - Field Vane
BH 6 - Lab Vane
BH 6 Cu / P'o = 0.25


Undrained Shear Strength vs Depth
Depth (m)
Estimated Undrained Shear Strength (kPa)
0
1
2
3
4
5
6
7
8
9
10
11
12
0
10
20
30
40
50
60
70
80
90
100
BH 7 - Field Vane
BH 7 - Lab Vane
DMT 7A
BH 7 Cu / P'o = 0.25
BH 8 - Field Vane
BH 8 - Lab Vane
DMT 8A
BH 8 Cu / P'o = 0.25
BH 9 - Field Vane
BH 9 - Lab Vane
BH 9 Cu / P'o = 0.25