



## **FINAL REPORT**

### **FOUNDATION INVESTIGATION AND DESIGN REPORT New Material Storage Facility at Powassan Patrol Yard, ON**

**Agreement No. 5015-E-0007  
Assignment No. 10  
Geocres No. 31L-220**

**Prepared for:**  
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# Ministry of Transportation

## Northeastern Region – Geotechnical Section

### Foundation Investigation and Design Report

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Assignment No. 10

Geocres No. 31L-220

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# 1 FOUNDATION INVESTIGATION REPORT

## 1.1 Introduction

This report presents the results of a geotechnical investigation carried out by EXP Services Inc. (EXP) for the proposed new material (including winter sand/salt) storage facility at the Powassan Patrol Yard, located on Highway 11, approximately 1.3 km north of Highway 534 interchange, Municipality of Powassan, Northeastern Ontario. The work was undertaken under Agreement # 5015-E-0007, Assignment No. 10. The terms of reference (TOR) were as presented in the Ministry of Transportation (MTO) email received on March 12, 2019.

The purpose of this investigation is to establish existing subsurface conditions at the proposed location of the patrol yard structure within construction limits defined by MTO. The site-specific geotechnical investigation consisted of field investigation including visual inspection, drilling, soil sampling, and laboratory testing. Factual results of the investigation and laboratory testing are included in this report. The report has been prepared specifically and solely for the project described in the report.

## 1.2 Site Description and Geological Setting

### 1.2.1 Site Description

The Powassan Patrol Yard is located on Highway 11, about 35 km south of North Bay and approximately 1.3 km north of the Highway 534 interchange (see Key Map on Drawing 1, Appendix B). The site is bound by Highway 11 to the east, a farm to the north, and by mature trees to the south and west.

A paved roadway lead from the site entrance on Highway 11 to the two existing sand domes and salt sheds, a steel frame canopy and 5-bay garages/office. The existing sand domes are located approximately 80 m west of the entrance gate. The proposed new storage facility will be located at the location of the existing domes and extended toward the south.

The topography of the site is considered relatively flat (~Elev. 266 m) . The ground surface of Powassan patrol yard is paved around all the existing buildings. Photographs of the site are included in Appendix A.

### 1.2.2 Geological Setting

According to the Ministry of Northern Development and Mines Map 2556, Quarternary Geology of Ontario, Southern Sheet, the site is generally glaciolacustrine deposits consisting of sand, gravelly sand and gravel, nearshore and beach deposits. According to the Ministry of Northern Development and Mines Map 2544, Bedrock Geology of Ontario, Southern Sheet, the bedrock at the site consists of Felsic igneous rocks consisting of tonalite, granodiorite, monzonite, granite, syenite and derived gneisses.

## 1.3 Available Documents of Previous Investigations

The available reports of previous investigations for Powassan Patrol Yard in the MTO GEOCREs library are:

*Geocres No. 31L-05: "Foundation Investigation Report, D.H.O Patrol Yard at Powassan" prepared by Foundations Section, Materials & Research Division, September 28, 1962.*

*Geocres No. 31L-74: "Foundation Investigation and Design Report, Sand/Salt Storage Structure, Powassan Patrol Yard" prepared by Acres International, January 30, 2001.*

The details of four boreholes completed by Acres International (Acres) for Powassan Patrol Yard in 2001 are outlined in Table 1.1 and the borehole locations are shown on Drawings in Appendix B. For the ground elevations mentioned in Table 1.1 the BM with elevation 265.992 m was used as noted in Acres' report. The borehole logs are included in Appendix G. As can be seen, the previous boreholes were drilled north of existing domes. BH-1 and BH-2 are the closest boreholes to the currently drilled boreholes BH19-P-1 and BH19-P-2.

Table 1.1. Summary of boreholes completed by Acres International

BH #	MTM NAD83 Northing	MTM NAD83 Easting	Ground Elevation (m)	Borehole Depth (m)
BH-1	5105939	314801	266.07	8.23
BH-2	5105939	314762	266.26	6.70
BH-3	5105979	314763	267.71	14.32
BH-4	5105978	314802	266.22	7.0

## 1.4 Investigation Procedures

### 1.4.1 Fieldwork

The field investigation was performed between April 15 and 16, 2019. The field program consisted of drilling four (4) sampled boreholes (BH19-P-1 to BH19-P-4). The boreholes were strategically located at the patrol yard to provide the subsurface information for the design of the proposed material storage facility. The borehole locations are shown on Drawing 1 in Appendix B.

The borehole locations (referenced to the MTM NAD83 coordinate system) and their ground surface elevations were surveyed by EXP personnel, with reference to the benchmark (BM) established on cut

cross in northeast face of concrete foundation. The elevation of the BM was considered 265.992 m based on the drawing provided with TOR. The BM location is shown on Drawing 1, in Appendix B.

The boreholes were advanced using a truck mounted CME-55 drill rig, equipped with a hollow stem augers. All borehole drilling and sampling operations were performed by a specialist drilling contractor, Landcore Drilling Services. The locations, elevations and depths of boreholes are shown below in Table 1.2.

*Table 1.2. Locations, elevations and depths of boreholes completed by EXP Services Inc.*

BH #	Location	MTM NAD83 Northing	MTM NAD83 Easting	Ground Elevation (m)	Borehole Depth (m)
BH19-P-1	NW of the existing domes	5105931.1	314775.1	266.3	10.7
BH19-P-2	NE of existing domes	5105935.3	314821.2	266.3	15.9
BH19-P-3	SW corner of the patrol yard	5105860.9	314748.4	266.3	16.6
BH19-P-4	SE corner of the patrol yard	5105872.1	314828.0	266.5	15.9

During the drilling of the boreholes, soil samples were obtained using a 51 mm outside diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D 1586), at intervals shown on the attached borehole logs (Appendix C). The original field (uncorrected) SPT “N” values were recorded on the borehole logs as recommended in the Canadian Foundation Engineering Manual (CFEM pg. 40) and used to provide an assessment of in-situ consistency of cohesive soils or relative density of non-cohesive soils. The water supply from the site, Powassan Patrol Yard, was used for soil sampling.

Upon completion of the drilling operations, groundwater level measurements were carried out in the open holes. The groundwater levels encountered in the boreholes are shown on the borehole logs and presented below in Table 1.7. The boreholes were decommissioned by bentonite/cement mixtures in accordance with the Ministry of the Environment Regulation 903, as amended by Regulation 128/03 (the well regulation under the Ontario Water Resources Act).

The fieldwork was supervised by a member of EXP’s engineering staff who directed the drilling and sampling operation, logged borehole data in accordance with MTO and/or ASTM standards for soils classification, and retrieved soil samples for subsequent laboratory testing and identification.

All the recovered soil samples were placed in labelled moisture-proof bags and returned to EXP’s Sudbury and Brampton laboratory for additional visual, textual and olfactory examination, and sampling for laboratory testing.

### 1.4.2 Laboratory Testing

All samples returned to the laboratory were subjected to visual examination and classification. The laboratory testing program included the determination of natural moisture content, particle size distribution and Atterberg Limits tests for approximately 25% of the collected soil samples. In addition, Soil chemical (Corrosivity and Contamination) package tests were performed on two soil samples. All the laboratory tests were carried out in accordance with MTO and/or ASTM standards as appropriate.

The laboratory test results are provided on the attached borehole log sheets in Appendix C. The results of the grain size analyses are presented graphically in Appendix D.

## 1.5 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are presented on the borehole log sheets in Appendix C. Laboratory test results are provided in Appendix D. The “Explanation of Terms Used in Report” preceding the borehole logs in Appendix C forms an integral part of and should be read in conjunction with this report.

A borehole location plan and stratigraphic section along the proposed material storage facility are provided in Appendix B. It should be noted that the stratigraphic boundaries indicated on the borehole logs and stratigraphic section are inferred from non-continuous sampling, observations of drilling progress and results of Standard Penetration Tests. These boundaries typically represent transitions from one soil type to another and should not be regarded as exact planes of geological change. Further, subsurface conditions may vary between and beyond the borehole locations.

In general, the stratigraphic sequence at the proposed structure site consists of top sand and gravel fill, underlain by sand and silt/ silt to clayey silt, underlain by sand. A summary of the soil and groundwater conditions encountered in the boreholes is provided below. The soil conditions at the north side of the site encountered at this investigation are consistent to the reported soil conditions in the previous investigation.

### 1.5.1 Pavement Structure

Asphaltic concrete was encountered at the surface of boreholes BH19-P-1 and BH19-P-2 and ranged in thickness from approximately 75 mm to 100 mm. Asphalt thicknesses may further vary beyond the borehole locations.

Sand and gravel fill was encountered below the Asphaltic concrete on boreholes BH19-P-1 and BH19-P-2, and ranged in thickness from approximately 75 mm to 100 mm; and at the surface of boreholes BH19-P-3 and BH19-P-4. The total thickness of this layer in all the boreholes is 0.2 m.



### 1.5.2 Sand and Silt

A sand and silt layer was encountered below the pavement structure for borehole BH19-P-1. The approximate elevations of the surface and base of the layer and the thickness of layer as encountered in borehole is summarized in Table 1.3 below:

Table 1.3. Summary of sand and silt layer

Borehole	Elevation (m)		Layer Surface Depth (m)	Layer Thickness (m)
	Top	Bottom		
BH19-P-1	266.1	264	0.2	2.1

This layer consists of fine to medium grained sand and silt with trace gravel, trace silt. The material is brown in color, and moist to wet. The SPT "N" values within this layer ranged between 13 and 32 blows per 300 mm penetration, corresponding to compact to dense compactness condition.

Laboratory testing performed on selected samples consisted of moisture content and grain size distribution tests. The test results are as follows:

Moisture Content:

- 10% to 20%

Grain Size Distribution:

- 0% to 14% gravel;
- 49% to 75% sand;
- 50% silt; and
- 1% clay

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The result of grain size distribution tests performed is also provided on Figure 1, in Appendix D.

### 1.5.3 Silt to Clayey Silt

A layer of silt to clayey silt was encountered below sand and gravel fill in boreholes BH19-P-3 and BH19-P-4. The approximate elevations of the surface and base of the deposit and the thickness of deposit as encountered in boreholes are summarized in Table 1.4 below:

Table 1.4. Summary of silt to clayey silt layer

Borehole	Elevation (m)		Layer Surface Depth (m)	Layer Thickness (m)
	Top	Bottom		
BH19-P-3	266.1	264.2	0.2	1.9
BH19-P-4	266.3	262.0	0.2	4.3

The composition of this layer is silt and clayey silt, with some sand, trace gravel, and trace to some organics. The material is brown/grey with orange molting, and moist to wet. The SPT “N” values within this layer ranged between 6 and 17 blows per 300 mm penetration, suggesting firm to very stiff consistency.

Laboratory testing performed on selected sample consisted of moisture content, grain size distribution and Atterberg Limit tests. The test results are as follow:

Moisture Content:

- 16% to 23%

Grain Size Distribution:

- 3% to 4% gravel;
- 17% to 25% sand;
- 55% to 62% silt; and
- 17% clay

Atterberg limits:

- Liquid Limit: 18%
- Plastic Limit: 22%
- Plasticity Index: 4%

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The result of the grain size distribution test and Atterberg Limit tests are also provided on Figures 2 and 5, respectively, in Appendix D.

#### 1.5.4 Sand

A layer of native sand was encountered in boreholes BH19-P-1, BH19-P-2 and BH19-P-4; below sand and silt layer in borehole BH19-P-1, below pavement structure in borehole BH19-P-2 and below the silt to sandy silt in boreholes BH19-P-4, and these boreholes were terminated within this layer. The approximate elevations of the surface and base of the deposit and the thickness of deposit as encountered in boreholes are summarized in Table 1.5 below:

Table 1.5. Summary of sand layer

Borehole	Elevation (m)		Layer Surface Depth (m)	Layer Thickness (m)
	Top	Bottom		
BH19-P-1	264.0	255.6	2.3	8.4
BH19-P-2	266.1	250.4	0.2	15.7
BH19-P-4	262.0	250.6	4.5	12.6

The composition of this layer is fine to medium grained sand, with trace to some gravel, trace to some silt and trace clay. The material is brown in color with orange molting, and moist to wet. The SPT "N" values within this layer were between 7 and 75 blows per 300 mm penetration, suggesting loose to very dense, but generally compact to very dense compactness condition.

Laboratory testing performed on selected sample consisted of moisture content and grain size distribution tests. The test results are as follow:

Moisture Content:

- 1% to 19%

Grain Size Distribution:

- 0% to 21% gravel;
- 56% to 98% sand;
- 1% to 22% silt; and
- 2% to 3% clay

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The result of grain size distribution tests is also provided on Figure 3, in Appendix D.

### 1.5.5 Silty Sand

A layer of native silty sand was encountered in borehole BH19-P-3 below the silt to clayey silt, was extended deeper with Dynamic Cone Penetration Test (DCPT) until DCPT refusal (100 blows per 300 mm penetration) and is terminated within this layer. The approximate elevations of the surface and base of the deposit and the thickness of deposit as encountered in boreholes are summarized in Table 1.6 below:

Table 1.6. Summary of silty sand layer

Borehole	Elevation (m)		Layer Surface Depth (m)	Layer Thickness (m)
	Top	Bottom		
BH19-P-3	264.2	249.7	2.1	14.5

The composition of this layer is fine grained sand, with trace gravel and trace clay. The material is brown in color with orange molting, and moist to wet. The SPT “N” values within this layer were between 9 and 39 blows per 300 mm penetration, suggesting loose to dense compactness condition.

Laboratory testing performed on selected sample consisted of moisture content and grain size distribution tests. The test results are as follow:

Moisture Content:

- 3% to 19%

Grain Size Distribution:

- 0% to 1% gravel;
- 61% to 72% sand;
- 27% to 35% silt; and
- 0% to 3% clay

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The result of grain size distribution tests is also provided on Figure 4, in Appendix D.

## 1.6 Groundwater Conditions

Information regarding groundwater levels at the site was obtained by measuring water levels in the open holes of all the boreholes after completion of drilling. The groundwater levels measured in the boreholes are shown on Table 1.7 and on the borehole logs. Water levels measured in open boreholes might not be stabilized due to the relatively short period of observation.

Table 1.7 Groundwater data

Borehole	Date of Drilling	Ground surface Elevation (m)	Groundwater Elevation (m)	Groundwater Depth (m)
BH19-P-1	4/16/2019	266.3	Dry in open hole	
BH19-P-2	4/16/2019	266.3	Dry in open hole	
BH19-P-3	4/15/2019	266.3	Dry in open hole	
BH19-P-4	4/15/2019	266.35	Dry in open hole	

During investigation, upon completion of borehole drilling, the unstabilized groundwater level was not encountered in all the boreholes within the sand and silt to clayey silt deposits, but seasonal variations in the water tables should be expected. However, the moist to wet condition of sand and silt to clayey silt samples from the upper few meters, suggest the presence of perched water locally.

## 1.7 Chemical Analyses

One (1) soil sample was selected for chemical analyses, and were sent via courier, in a secure cooler under chain of custody, to AGAT Laboratories., a CALA-certified and accredited laboratory in Mississauga, Ontario.

The sample SS3 from borehole BH19-P-2 was analyzed for corrosivity chemical analysis. The analytical results are summarized in Table 1.8 below and are presented in Appendix D.

Table 1.8. Corrosivity chemical analysis

Sample Identification	pH (unitless)	Soluble Chloride (ppm)	Soluble Sulphate (ppm)	Resistivity (ohm-cm)	Conductivity (mS/cm)	Redox Potential (mV)
BH19-P-2-SS3 Sand	6.86	7470	157	75	13.4	247 to 259

## 1.8 Environmental Analyses

In addition to corrosivity testing, one (1) sample of native sand material from BH19-P-1 (SS2) was analyzed for metals and general inorganics parameters and BTEX/ Petroleum Hydrocarbons (PHCs) – (F1-F4). The analytical results (Certificate of Analysis) are compiled in Appendix D.

## 2 DISCUSSIONS AND ENGINEERING RECOMMENATIONS

### 2.1 General

This section of the report provides geotechnical design recommendations for the proposed Patrol Yard material storage structure at the Powassan Patrol Yard, located in the Municipality of Powassan, Northeastern Ontario. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the previous and current investigations at the site and presented in **Part I-Foundation Investigation Report**. The interpretation and recommendations provided are intended solely to permit designers to assess foundation alternatives and design the proposed structure. Comments on construction are only provided to highlight issues that could affect the design. Contractors bidding on the works should make their own assessments of the factual data and how it might affect construction means and methods, scheduling and the like.

Based on information included in the TOR and correspondence with MTO, it is understood that the existing two sand dome storage structures (approximately 31 m in diameter each) at the MTO Powassan Patrol Yard will be replaced by the new storage structure having a footprint of 18.3 m by 54.9 m. However, at the time of writing this report the exact location of the new structure was not defined, but it is assumed that it is going to be located on the location shown in Drawing 1 in Appendix B. It is further assumed, based on design drawings of the similar structure provided by MTO, that a building will have a maximum height of about 11.0 m to the bottom of the trusses (underside of roof truss) and it will be encompassed with a 2.5 m high, cast-in-place concrete foundation walls around the perimeter. The building can then be erected with either steel or timber framing, at a height to accommodate indoor loading and delivery of road sand/salt. The existing ground surface at the structure location is around Elev. 266.4, and it is assumed that finished top of floor will be at that elevation to tie-in to the adjacent exterior paved areas.

This report addresses the geotechnical design of the foundation for the proposed structure by providing geotechnical design parameters at the Ultimate Limit State (ULS) and Serviceability Limit States (SLS) as well as other geotechnical parameters that may be required in accordance with the latest edition of the *Canadian Highway Bridge Design Code (CHBDC)* (CAN/CSA-S6-14), the *Guideline for Professional Engineers Providing Geotechnical Engineering Service* (1992), the *Canadian Foundation Engineering Manual (CFEM)* (2006), the *provisions in the TOR* and good practice. It also provides discussion about the structure foundation type, stability and settlement analyses, frost protection, construction considerations and dewatering during construction, as requested in the TOR from the MTO email dated March 18, 2019.

As further requested in the TOR, the settlement and stability analyses were completed for a scenario in which the new structure would be loaded to its full allowable capacity. This scenario consists of sand/salt stacked to the maximum allowable height of the concrete walls with a stockpile area covering the entire footprint of the building. The angle of repose for sand/salt was assumed to be 33°.

## 2.2 Geotechnical Design Considerations for Foundations

At the north side of the site, the subsurface condition below the pavement structure generally consist of a layer of compact to very dense sand, while at the south side the pavement structure is underlain by a layer of firm to very stiff silt to clayey silt followed by a layer of compact to dense sand. The bedrock was not encountered within the explored depth of maximum 16.6 m. No groundwater was encountered during drilling.

### 2.2.1 Foundations of New Storage Structure

Based on the subsurface conditions at this site and given that bedrock or very dense material was not encountered within the borehole termination depth (i.e. 16.6 m below the ground surface), deep foundations are not considered to be practical foundation option since the founding strata within which deep foundation elements such as H-piles or caissons will be terminated provides low axial resistances. Therefore, we recommend that the new sand/salt storage structure be supported on shallow foundations comprised of spread footings founded on/within the native compact sand and/or stiff silt to clayey silt deposits, or on free draining engineered fill, such as Granular 'A' or Granular 'B', Type I or Type II (OPSS.PROV 1010), over native sand deposit, as discussed in the following sections.

Given the subsurface conditions at the site the impact on settlement at the foundations of the structure will be influenced by the operating/stockpiling practices. It is our understanding that the structure will accommodate stockpiles of sand/salt at strategic locations within the structure. Based on the information mentioned in Section 2.1, the maximum loading condition is likely to be salt stockpiled to at least the level of the concrete wall over the full footprint. Mounding in the center at the angle of repose material of 33% beyond the height of the concrete wall is also a possibility.

These types of structures generally have service lives of about 20 years. Typically, in settings of poor soil conditions, the approach would be to mitigate potential distress for a shallow foundation supported on it rather than employ expensive deep foundations for building support. Mitigation to create stable foundation soils can include preloading of the footprint area before construction, structure support on engineered fill and/or stockpiling constrains in order to enhance serviceability.

#### 2.2.1.1 Footing Elevation

Based on the results of the geotechnical investigation and a requirement for adequate protection against frost penetration in the project area (i.e. a minimum 2.0 m below the lowest surrounding area, see Section 2.2.5), the following founding elevations of strip/spread footings are recommended:

**Table 2.2 Recommendations for footing elevation**

Soil at Founding Level	Foundation Elevation (m)	Depth Below Existing Grade
Native compact sand and/or stiff silt to clayey silt	264.3	~2.0 m
1.7 m thick engineered fill over native sand and/or silt to clayey silt	264.3	~2.0 m (requires excavation up to Elev. 262.6 m)

### 2.2.1.2 Geotechnical Resistances

In the context of the CHBDC, a satisfactory foundation design would require, in terms of Limit States Design, the factored geotechnical resistance of its foundation to withstand and not exceed the imposed Ultimate Limit State loads - (ULS) Design Approach, and its ability to deform acceptably under the Service Limit State loads - (SLS) Design Approach. These associated loads are typically known as unfactored and factored loads, respectively. Therefore, strip/spread footings placed on the properly prepared subgrade at the design elevation given in Table 2.2, should be designed based on the factored resistances at ULS and geotechnical reactions at SLS for 25 mm of settlement given in Table 2.3 below. The footing width of 2.1 m is assumed. Settlement of the footings under the loading from the stockpile inside the structure which will occur after its construction is considered and discussed in Section 2.6.2. In determining the settlement characteristics of the proposed building (tolerable total and differential settlement), the unfactored loads are required to be provided by the Structural or Design Engineer. The ULS and SLS consequence factor of 1.0 and degree of site understanding of 0.9 were applied in accordance with Tables 6.1 and 6.2 in the CHBDC S6-14, respectively.

**Table 2.3 Factored geotechnical resistances for a 2.1 m wide footing**

Soil at Founding Level	Width of Footing (m)	Factored Ultimate Geotechnical Resistance (kPa)	Factored Serviceability Geotechnical Resistance* (kPa) (for 25 mm settlement)
Native compact sand	2.1	300	200
Native stiff silt to clayey silt over compact sand	2.1	200	150



1.7 m thick engineered fill over native sand	2.1	450	300
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*Note: \* Factored serviceability geotechnical resistance values can be review, if higher settlement is tolerable*

Since the ULS resistance and the settlement depend on the footing size and depth of embedment, the geotechnical resistances given in Table 2.3 should be reviewed if the selected footing width or founding elevations differ from those given in the table. Similarly, if an inclined load is applied instead of a vertical load, which is used in these calculations, the values given in Table 2.3 should be reviewed to consider those inclinations.

Prior to placing footings, the exposed native subgrade should be inspected according with OPSS 902 and SP 109S12. A Qualified Geotechnical Engineer should check that the design foundation elevation is achieved and all unsuitable soils including fill and organics should be removed.

### 2.2.1.3 Resistance to Lateral Loads

Resistance to lateral forces/sliding resistance between the subgrade and concrete should be calculated in accordance with Section 6.7.5 of the CHBDC. The unfactored values of the coefficient of friction,  $\tan \delta$ , between the base of cast-in-place concrete footing and the native silty clay/ clayey silt subgrade soils below the frost level are presented in Table 2.4.

*Table 2.4 Recommendations for coefficient of friction*

Interface	Coefficient of Friction, $\tan \delta$
Cast-in-place concrete and native compact sand/stiff silt to clayey silt	0.45
Cast-in-place concrete and engineered fill	0.6

A factor of 0.8 should be applied in calculation of the horizontal resistance in accordance with CHBDC.

In a case of the unbalanced lateral earth pressures caused by sand/salt stockpiles being piled against the perimeter walls, these walls should be designed based on the following geotechnical parameters assuming a triangular lateral earth pressure distribution:

- Unit weight of sand/salt stockpile material = 20 kN/m<sup>3</sup>
- Friction angle of sand/salt stockpile material= 33°
- Lateral earth pressure coefficient ( $K_o$ ) = 0.5

#### 2.2.1.4 Frost Protection

According to Ontario Provincial Standard Drawing (OPSD – 3090.100), the frost depth in the Powassan area is about 2.0 m. Consequently, all footings exposed to seasonal freezing conditions should be protected from frost action by at least 2.0 m of soil cover or equivalent insulation.

### 2.3 Earthquake Considerations

Recommendations for the geotechnical aspects to determine the earthquake loading are presented below.

#### Subsoil Conditions:

The subsoil and groundwater information at this site have been examined in relation to Section 4.1.8.4 A of the Ontario Building Code (OBC, 2012). The subsoil generally consists of dominantly compact sand at the north side of the site, while a layer of stiff silt to clayey silt over compact sand is dominant at the south side of the site. The reported N-values for the soil below 3 m of the founding level ranged from 7 to 30 blows for 300 mm of penetration, with an average value being around 16 blows per 300 mm of penetration.

#### Corrected N-Values $N_{60}$ :

The Average Standard Penetration Resistance shown in Table 4.1.8.4.A. Site Classification for Seismic Site Response in OBC 2012 refers to  $N_{60}$  which is defined as “Average Standard Penetration Resistance for the top 30 m, corrected to a rod energy efficiency of 60% of the theoretical maximum”. It should be noted that the drillers in the Powassan area do not have their rod energy efficiencies measured and therefore, computed  $N_{60}$  values are not available for this site. In our opinion, the reported N-values could be considered as an approximate equivalent to the normalized  $N_{60}$  values as noted in the OBC 2012 for establishing the site classification.

#### Depth of Boreholes:

Table 4.1.8.4.A. Site Classification for Seismic Site Response in OBC 2012 indicated that the average properties in the top 30 m are to be used to determine the site classification. The four (4) boreholes advanced for building construction at this site were between 10.7 m and 16.6 m deep. The total overburden thickness was between 10.7 m and 16.6 m at the tested locations and depths. The bedrock was not encountered within explored depths.

#### Site Classification:

Based on the above assumptions and interpretations, and the soil conditions, the Site Class for this site is estimated to be Class “D” as per Table 4.1.8.4.A, Site Classification for Seismic Site Response, OBC 2012. The values of the Spectral Response acceleration for different periods and the Peak Ground Acceleration (PGA) for the Powassan area can be obtained from the National Building Code of Canada (2010).

These parameters should be reviewed by a Structural Engineer.

## 2.4 Liquefaction Considerations

Based on soils and groundwater condition encountered at the site, no liquefaction is expected due to the ground motion from an earthquake having 10% probability of exceedance in a 50-year period.

## 2.5 Perimeter Wall and Floor Construction

The perimeter wall of the proposed structures may be constructed as a cantilever retaining wall with an extended heel toward the inside of the structure and founded on native soils or engineered fill. Structural steel bars should be provided in the footings and in the walls.

The concrete and/or asphalt floor slabs supported on the existing granular fill or on engineered fill could be designed inside the structure. Based on available information, the floor slab/ asphalt surface elevation will be around 266.4 m. Below the floor, the sub-floor drainage system should be placed and compacted as described later in this section. The asphalt pavement structure will need to be designed by a pavement engineer. The concrete floor slab has to be design by a structural engineer specialist as well. However, it is recommended that for the concrete floor slab the final lift of granular fill beneath the floor slabs should consist of a minimum thickness of 200 mm of OPSS Granular A material, uniformly compacted to 100% of SPMDD. For this condition, a modulus of subgrade reaction  $k_v$  of 50 MPa/m may be assumed for preliminary assessment purposes. For design purposes, the value provided above needs to be modified to account for size effects as per standard design methods as outlined in CFEM 2006. The concrete floor slabs should be structurally separate from the foundation walls and columns and saw-cut control joints should be provided at regular intervals along column lines to minimize shrinkage cracking and allow for normal differential settlement of the floor slabs. Considering that the floor will be covered by sand/salt stockpile during cold weather, a frost protection is not considered necessary.

The construction of spread footing and subgrade for the floor may be carried out in accordance with the following recommendations:

Prior to construction, all obviously unsuitable material should be fully removed from the entire underfooting and underfloor area (see Section 2.7). Following rough grading, the exposed subgrade should be proof-rolled with a roller under the full-time supervision of a qualified geotechnical personnel. Any soft spots detected during proof-rolling should be sub-excavated and replaced with Granular A or Granular B, Type I or Type II materials compacted to at least 98 % of the Standard Proctor Maximum Dry Density (SPMDD). The prepared subgrade should be covered with at least 200 mm thick layer of Granular A compacted to not less than 100% of the material's SPMDD, crowned slightly in the central area.

Around the perimeter of the building the ground surface should be sloped on a positive grade away from the structure to promote surface water run-off and reduce groundwater infiltration adjacent to the foundations. Permanent perimeter drains are not required if the interior base is set at least 200 mm above the exterior grade and the grade is sloped away from the structure. However, a permanent subfloor drainage system may be required to collect salt-bearing water. To minimize contamination into

the native soils and subsequently into the groundwater, a barrier such as a compacted low-permeability clay liner or geomembrane usually should be installed below a salt storage area. In practice, the use of geomembrane shows advantage over the compacted clay liner in terms of improved performance of the barrier. The geomembrane should be installed on a minimum 75 mm thick sand layer (OPSS PROV 1004 or OPSS PROV 1002) and covered with a 300 mm thick layer of sand fill on top of the geomembrane to protect it from the overlying pavement structure. At this particular site, the presence of layer of natural stiff silty clay could be considered as a natural barrier system for contaminant transport.

## 2.6 Stability and Settlement Analyses

### 2.6.1 Stability

To assess the global stability of the material storage facilities and to check that a minimum Factor of Safety of 1.3 will be achieved for the maximum height winter sand/salt stockpiles, a series of slope stability analyses were performed. The static slope stability analyses were performed using the Morgenstern-Price method developed based on limit equilibrium. The SLOPE/W computer program developed by GeoSlope International was employed for computation.

Stability assessments were performed for the proposed new structure assuming that the maximum sand/salt stockpile height could be 8.7 m having side slopes of 1.5H:1V as shown on in Appendix E. The stratigraphy and groundwater condition at the site were developed based on the results of the geotechnical investigation presented in Part I - Foundation Investigation Report.

Given the above, effective stress analyses for a long-term stability assessment and total stress analysis for a short-term stability assessment was performed taking into consideration the subsoil conditions encountered directly beneath and adjacent the proposed structures.

Tabulated below in Table 2.7 are the soil parameters used for the stability analyses. The soil parameters were generally estimated based on the results of field and laboratory investigation.

Table 2.7 Soil properties used in stability analyses

Material Type	Effective Stress Parameters			Total Stress Parameters		
	$\phi$ (degree s)	c (kPa)	$\gamma$ (kN/m <sup>3</sup> )	$\phi$ (degrees)	c (kPa)	$\gamma$ (kN/m <sup>3</sup> )
Engineered Fill	32	0	21	32	0	21
Firm to Very Stiff Silt to Clayey Silt	26	0	18	26	65	18
Compact to Very Dense Sand	31	0	20	31	0	20

Stockpile Material (Winter sand/ salt)	33	0	20	33	0	20
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The graphical results of these analyses can be seen in Appendix E. As shown on figures in Appendix E, the results of stability analyses for an approximately 8.7 m high winter sand/salt stockpile (in the center, with the side slopes of 1.5H:1V) restrained with concrete walls on both sides in the building suggest that the factor of safety greater of 1.3 can be obtained for a deep-seated failure surface.

## 2.6.2 Settlement

To evaluate the maximum settlement and differential settlement values below the material (including winter sand/salt) stockpile loadings in the proposed storage building, a 3D computer program; Settle3D (Rocscience) was employed. The properties for the encountered soil layers used in the settlement model are evaluated based on the results of the SPT as per CHBDC. The parameters are listed in Table 2.8.

Table 2.8 Soil properties used in settlement analyses

Material Type	$\gamma$ (kN/m <sup>3</sup> )	E (MPa)	C <sub>c</sub>	C <sub>r</sub>	P <sub>c</sub> (kPa)	e <sub>0</sub>	C <sub>v</sub>
Engineered Fill	21	50	-	-	-	-	-
Compact Sand and Silt	20	30	-	-	-	-	-
Firm to Very Stiff Silt to Clayey Silt	18	-	0.13	0.015	295	0.5	0.002
Compact to Very Dense Sand	20	45	-	-	-	-	-

The geometry of the stockpiles was assumed based on its maximum allowable capacity which is a maximum height of approximately 11 m at the center and 2.5 m along the sides at the wall. The proposed structure will be 18.3 m by 54.9 m . The model is illustrated on Figure F1 included in Appendix F.

The results of the settlement analyses are plotted on Figures F1 to F4 (Appendix F). The estimated settlements under the stockpile at the center and at the edges of the stockpile (i.e. location of footings) are presented in Table 2.9.

**Table 2.9 Results of settlement analyses**

Foundation Soil Type	Estimated Settlement (mm)			
	Elastic		Consolidation	
	Edge	Centre	Edge	Centre
Compact Sand (North Side)	15	40	-	-
Firm to Very Stiff Silt to Clayey Silt (South Side)	12	30	8	18

The calculated settlements are anticipated to occur immediately after the stockpile loadings are applied or within a period of one month. However, the loadings and consequent consolidation settlement would occur after the footings have been constructed. Therefore, the footings for these structures should be designed under the full allowable stockpile loadings. The geometries of stockpiles under the full allowable loadings including their maximum heights are recommended above. If the proposed storage building will lie within the footprint of existing building, the post construction settlement within the existing stockpile area is expected to be less than estimated above. In this case the differential settlement between the existing stockpile area and new areas not previously loaded, exists. Therefore, it is recommended to preload the portion of proposed storage building within the virgin area, south side (i.e. outside of the existing structure footprint). It is also recommended that the designer include detailed procedures in the contract drawings and note.

If the virgin footprint area (south side) is preloaded by a gravel/sand stockpile prior of construction, the post-construction settlement/differential settlement can be reduced. The settlement analysis for a 5 m height of the stockpile preloading was performed and the results are presented in Table 2.10 and attached Figure F5, Appendix F. The results show that the total settlement of approximately 31 mm at the center could be achieved by placing the 5 m high stockpile, respectively. The total settlement of approximately 9 mm can be produced at the proposed location of the storage footings. Therefore, these analyses demonstrate that preloading can significantly reduce the post construction settlement. It is anticipated that these predicted total settlements will take place as the load is applied or within a time period of about 30 days.

**Table 2.10 Results of settlement analyses for preloading the virgin footprint area**

Height of Stockpile Preloading (m)	Estimated Settlement at Centre (mm)	Estimated Settlement at Location of Proposed Footing (mm)
5	31	~9

Assuming preloading of the virgin areas for a period of one month is undertaken there should be no significant settlement issues at this site. Some monitoring of the preloading and perimeter walls after construction is indicated to confirm expectation.

## **2.7 Site Preparation and Engineered Fill Construction**

As mentioned previously, the areas within the limits of the buildings should be stripped and cleared of asphalt, surface vegetation, topsoil and debris prior to construction. Any soils containing excessive organics or loose/disturbed materials are not suitable for the subgrade of building foundations, floor slabs or engineered fill. Therefore, areas with those soils should be excavated and replaced with engineered fill comprised of Granular A or Granular B, Type I or Type II.

Engineered fill could be placed after stripping all topsoil, organic matter, fill and other compressible, weak and deleterious materials within an area extending at least 1.0 meters beyond the outside edge of the founding level of any footings. After stripping, the entire area should be heavily proof-rolled inspected and approved by a Geotechnical Engineer. Engineered fill should be placed in accordance with OPSS 501 and SP105S22. The fill material should be placed in thin layers not exceeding approximately 300 mm when loose. Oversize particles larger than 120 mm should be discarded, and each fill layer should be uniformly compacted with heavy compactors, suitable for the type of fill used. The engineered fill below the footing and floor slab should be compacted to 100% of its SPMDD, while within outside/exterior paved areas, the fill should be compacted to 98% of its SPMDD.

Full-time geotechnical inspection and quality control (by means of frequent field density and laboratory testing) should be provided by the Geotechnical Engineer. Every lift should be evaluated by a sufficient number of tests to ensure that the level of compaction is constantly achieved, and the compaction procedure is applied.

## **2.8 Excavation and Groundwater Control**

The groundwater level at the site was not recorded, however some perched water could be encountered within the upper few meters. Therefore, it is possible that some groundwater enters into the excavation at the site. Considering that the soils encountered at the bottom of the excavation and within potential excavation depths could be silt to clayey silt, it is assessed that these soils are susceptible to disturbance from groundwater and mobilized equipment. Therefore, the groundwater level needs to be controlled to at least 0.5 m below the excavation level to avoid disturbance, and any groundwater seepage should be removed from the excavation prior to placement of granular backfill in dry. In general, where the excavation base is within 0.5 m of the prevailing groundwater level at the time of construction, it is anticipated that control of seepage can be accomplished by using properly filtered sumps, and/or filtered drains placed along the base the excavation. Surface water should be directed away of the excavation.

All excavations should be carried out in accordance with the latest version of the Occupational Health and Safety Act. For the act, the existing materials are considered as Type 3 soils above the groundwater table and Type 4 soils below the groundwater table. Temporary excavations (i.e. those that



are open only for a short period) above the groundwater table may be made with side slopes not steeper than about 1H:1V, while the temporary slopes below the groundwater table, if any, must be formed at 3H:1V unless a suitable dewatering system is installed to lower the water level below the base of the excavation.

Qualified geotechnical personnel should be on-site during the foundation installation and for fill material placement, to verify the design assumptions, and to verify the design recommendations.

## 2.9 Corrosion Protection

As stated above, one soil sample was selected for analyses of pH, water soluble sulphate, chloride concentrations, resistivity, conductivity and oxidation-reduction potential. The testing was completed to determine the potential for degradation of the concrete in the presence of soluble sulphate and the potential for corrosion of exposed steel used in foundations and buried infrastructure. The analysis results are summarized in summarized in Section 1.6 of this report and detailed results are included in Appendix D.

The chemical data presented in Section 1.6 indicates very low resistivity of the tested soil, which indicates a very high potential for corrosion of buried metallic elements (MTO Gravity Pipe Design Guidelines, Page 25). The maximum chloride content reported is 7470 ppm ( $\mu\text{g/g}$ ) which indicates a potential for additional corrosion. The soil pH was about 6.86 which is within what is considered the normal range for soil pH of 5.0 to 9.0. Based on these results it appears that there is a need for coatings and corrosion protection systems for buried steel objects.

The maximum water-soluble sulphate content of the soils tested is 157 ppm ( $\mu\text{g/g}$ ), i.e. 0.0157% which is less than 0.10%. It indicates low potential to corrode normal Portland cement concrete. Therefore, no particular precautions are required to provide protection against sulphate attack such as special cements or mixtures.

## 2.10 Environmental Consideration

One (1) sample of native sand from BH19-P-2 (SS 2) was analyzed for metals and general inorganics parameters, as well as, for BTEX/ Petroleum Hydrocarbons (PHCs) – (F1-F4) in accordance with land use criteria listed in the Ministry of the Environment standards (Ontario Regulation 153). The analytical results (Certificate of Analysis) are compiled in Appendix D.

The results were compared with soil criteria in Table 2 (Potable Groundwater Condition) and Table 3 (Non-Potable Groundwater Condition) of Ontario Regulation 153, and the conclusion was that the soil sample met all property use standards in Table 2 and Table 3.



July 26, 2019

### 3 CLOSURE

The recommendations made in this report are in accordance with our present understanding of the project and are provided solely for the team responsible for the design of the works described herein.

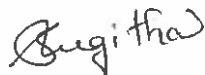
We recommend that we be retained to review our recommendations as the design nears completion to ensure that the final design is in agreement with the assumptions on which our recommendations are based and that our recommendations have been interpreted as intended. If not accorded this review, EXP will assume no responsibility for the interpretation and use of the recommendations in this report.

A subsurface investigation is a limited sampling of a site; the subsurface conditions have been established only at the test hole locations. Should conditions at the site be encountered which differ from those reported at the test locations, we require that we be notified immediately in order to assess this additional information and our recommendations, as appropriate. It may then be necessary to perform additional investigation and analysis.

Contractors bidding on or undertaking any proposed work at this site should, relative to the subsurface conditions, decide on their own investigations, if deemed necessary, as well as their own interpretations of the factual results provided herein, so they may draw their own conclusions as to how the subsurface conditions may affect them.

This Foundation Investigation and Design Report has been prepared by Sugitha Anandakumar, M.Eng., EIT and Silvana Micic, Ph.D., P.Eng., and reviewed by TaeChul Kim, M.E.Sc., P.Eng. and Stan E. Gonsalves, M.Eng., P.Eng., MTO Designated Foundation Contact. The field investigation was conducted by Phillips Laframboise.


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MTO Designated Foundation Contact



Encl.

## 4 LIMITATIONS AND USE OF REPORT

### BASIS OF REPORT

This report ("Report") is based on site conditions known or inferred by the geotechnical investigation undertaken as of the date of the Report. Should changes occur which potentially impact the geotechnical condition of the site, or if construction is implemented more than one year following the date of the Report, the recommendations of EXP may require re-evaluation.

The Report is provided solely for the guidance of design engineers and on the assumption that the design will be in accordance with applicable codes and standards. Any changes in the design features which potentially impact the geotechnical analyses or issues concerning the geotechnical aspects of applicable codes and standards will necessitate a review of the design by EXP. Additional field work and reporting may also be required.

Where applicable, recommended field services are the minimum necessary to ascertain that construction is being carried out in general conformity with building code guidelines, generally accepted practices and EXP's recommendations. Any reduction in the level of services recommended will result in EXP providing qualified opinions regarding the adequacy of the work. EXP can assist design professionals or contractors retained by the Client to review applicable plans, drawings, and specifications as they relate to the Report or to conduct field reviews during construction.

Contractors contemplating work on the site are responsible for conducting an independent investigation and interpretation of the borehole results contained in the Report. The number of boreholes necessary to determine the localized underground conditions as they impact construction costs, techniques, sequencing, equipment and scheduling may be greater than those carried out for the purpose of the Report.

Classification and identification of soils, rocks, geological units, contaminant materials, building envelopment assessments, and engineering estimates are based on investigations performed in accordance with the standard of care set out below and require the exercise of judgment. As a result, even comprehensive sampling and testing programs implemented with the appropriate equipment by Experienced personnel may fail to locate some conditions. All investigations or building envelope descriptions involve an inherent risk that some conditions will not be detected. All documents or records summarizing investigations are based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated. Some conditions are subject to change over time. The Report presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, these should be disclosed to EXP to allow for additional or special investigations to be undertaken not otherwise within the scope of investigation conducted for the purpose of the Report.

### RELIANCE ON INFORMATION PROVIDED

The evaluation and conclusions contained in the Report are based on conditions in evidence at the time of site inspections and information provided to EXP by the Client and others. The Report has been prepared for the specific site, development, building, design or building assessment objectives and purpose as communicated by the Client. EXP has relied in good faith upon such representations,

information and instructions and accepts no responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of any misstatements, omissions, misrepresentation or fraudulent acts of persons providing information. Unless specifically stated otherwise, the applicability and reliability of the findings, recommendations, suggestions or opinions Expressed in the Report are only valid to the extent that there has been no material alteration to or variation from any of the information provided to EXP.

## **STANDARD OF CARE**

The Report has been prepared in a manner consistent with the degree of care and skill exercised by engineering consultants currently practicing under similar circumstances and locale. No other warranty, Expressed or implied, is made. Unless specifically stated otherwise, the Report does not contain environmental consulting advice.

## **COMPLETE REPORT**

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment form part of the Report. This material includes, but is not limited to, the terms of reference given to EXP by its client ("Client"), communications between EXP and the Client, other reports, proposals or documents prepared by EXP for the Client in connection with the site described in the Report. In order to properly understand the suggestions, recommendations and opinions Expressed in the Report, reference must be made to the Report in its entirety. EXP is not responsible for use by any party of portions of the Report.

## **USE OF REPORT**

The information and opinions Expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. No other party may use or rely upon the Report in whole or in part without the written consent of EXP. Any use of the Report, or any portion of the Report, by a third party are the sole responsibility of such third party. EXP is not responsible for damages suffered by any third party resulting from unauthorised use of the Report.

## **REPORT FORMAT**

Where EXP has submitted both electronic file and a hard copy of the Report, or any document forming part of the Report, only the signed and sealed hard copy shall be the original documents for record and working purposes. In the event of a dispute or discrepancy, the hard copy shall govern. Electronic files transmitted by EXP have utilize specific software and hardware systems. EXP makes no representation about the compatibility of these files with the Client's current or future software and hardware systems. Regardless of format, the documents described herein are EXP's instruments of professional service and shall not be altered without the written consent of EXP.

## **Appendix A – Photographs**



Photo 1. Powassan Patrol Yard - Existing steel frame canopy and salt dome; Drilling borehole BH19-D-1, facing northeast



Photo 2. Powassan Patrol Yard - Existing steel frame canopy; Drilling borehole BH19-D-2, facing northwest



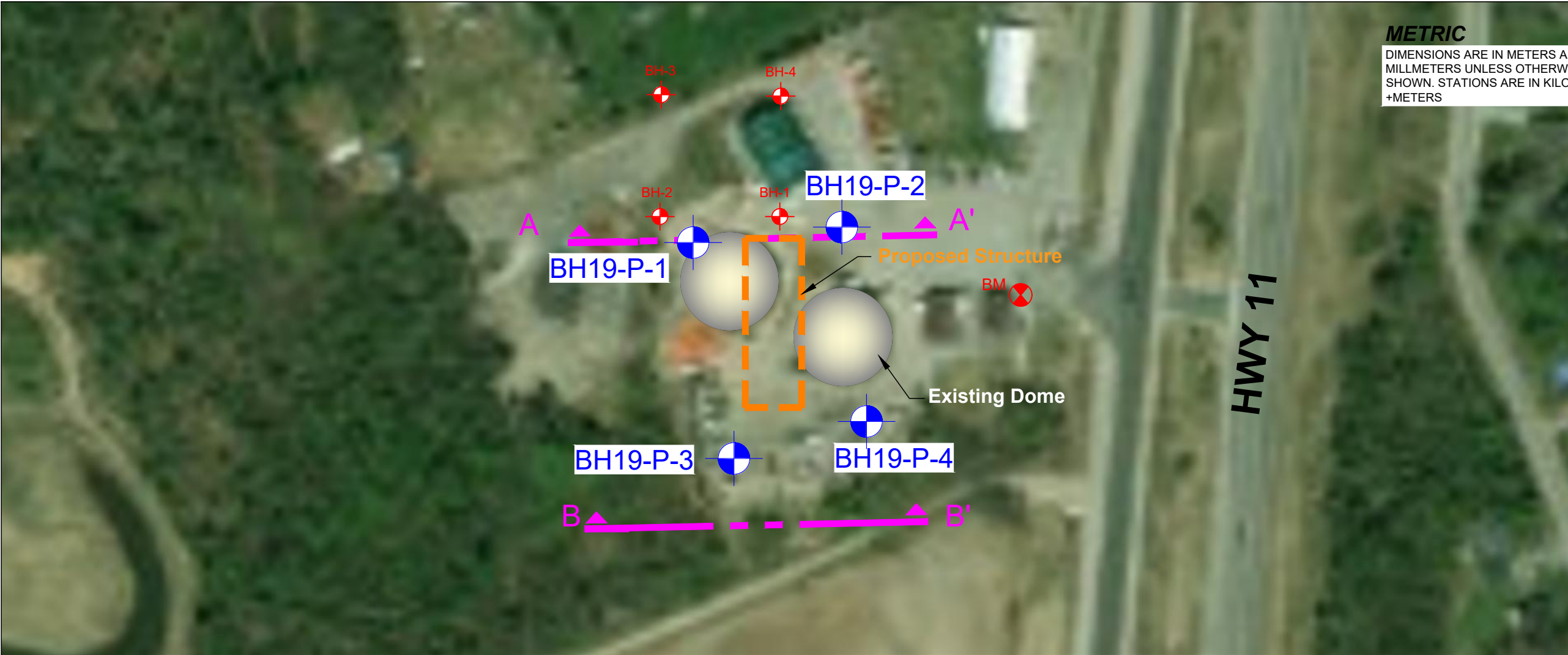


Photo 3. Powassan Patrol Yard - Drilling borehole BH19-D-3, facing southeast



Photo 4. Powassan Patrol Yard - Drilling borehole BH19-D-4, facing northeast

## **Appendix B – Drawings**



**METRIC**  
DIMENSIONS ARE IN METERS AND/OR  
MILLIMETERS UNLESS OTHERWISE  
SHOWN. STATIONS ARE IN KILOMETERS  
+METERS

CONT. No. 5015-E-0007 GWP No. - Assignment No. 10	
Various Patrol Yards, Sudbury and North Bay Areas PATROL YARD AT POWASSAN ON HWY 11 BOREHOLE LOCATION PLAN AND SOIL STRATA	SHEET 1

exp.	exp Services Inc.
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KEY PLAN
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LEGEND
Borehole Location
Existing Borehole Location
Standard Penetration Test (Blows/0.3 m)
Groundwater level measured in open hole
Bench Mark Location (Elev. 267.537m)

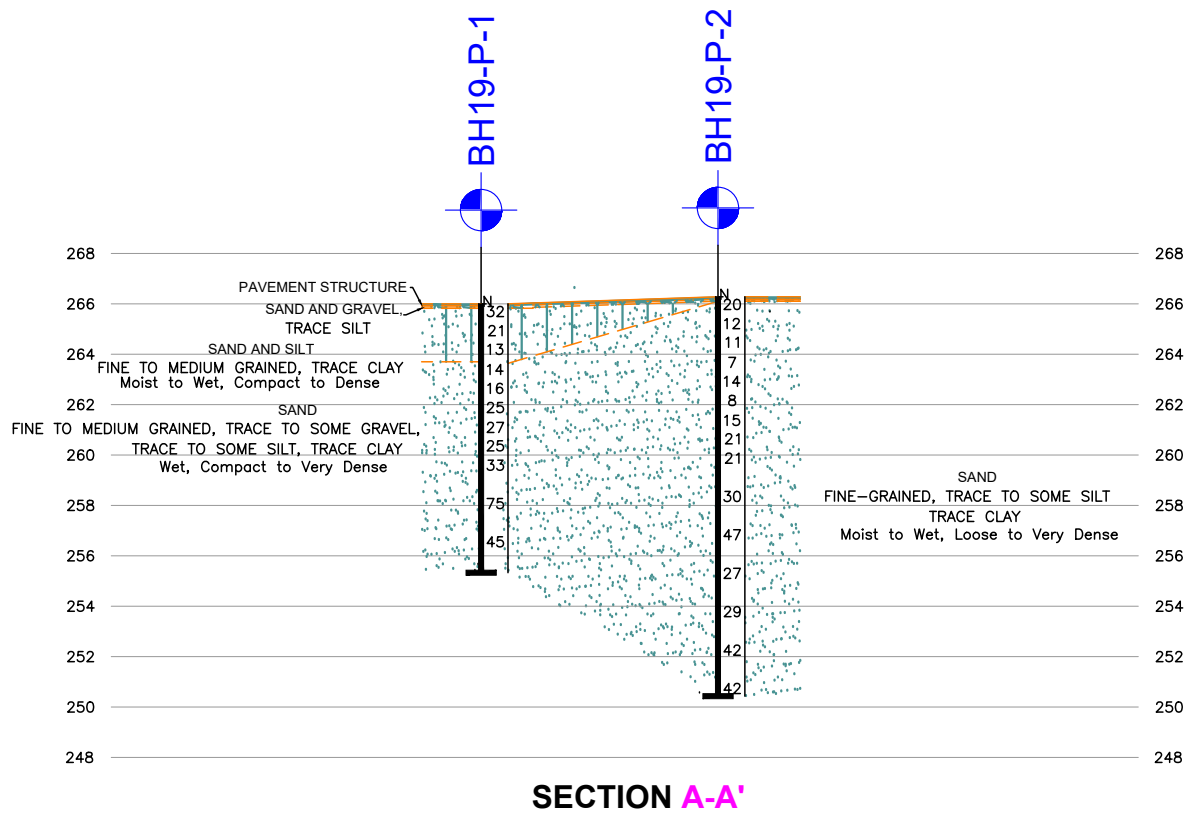
SOIL STRATA SYMBOLS
PAVEMENT STRUCTURE
SAND AND GRAVEL
SAND
SILTY SAND
FILL
SAND
SILT TO CLAYEY SILT

BH No.	ELEV.	MTM CO-ORDINATES (ZONE ON-10)	
		NORTHING	EASTING
BH19-P-1	266.3	5105931.1	314775.1
BH19-P-2	266.3	5105935.3	314821.2
BH19-P-3	266.3	5105860.9	314784.8
BH19-P-4	266.5	5105872.1	314828.0

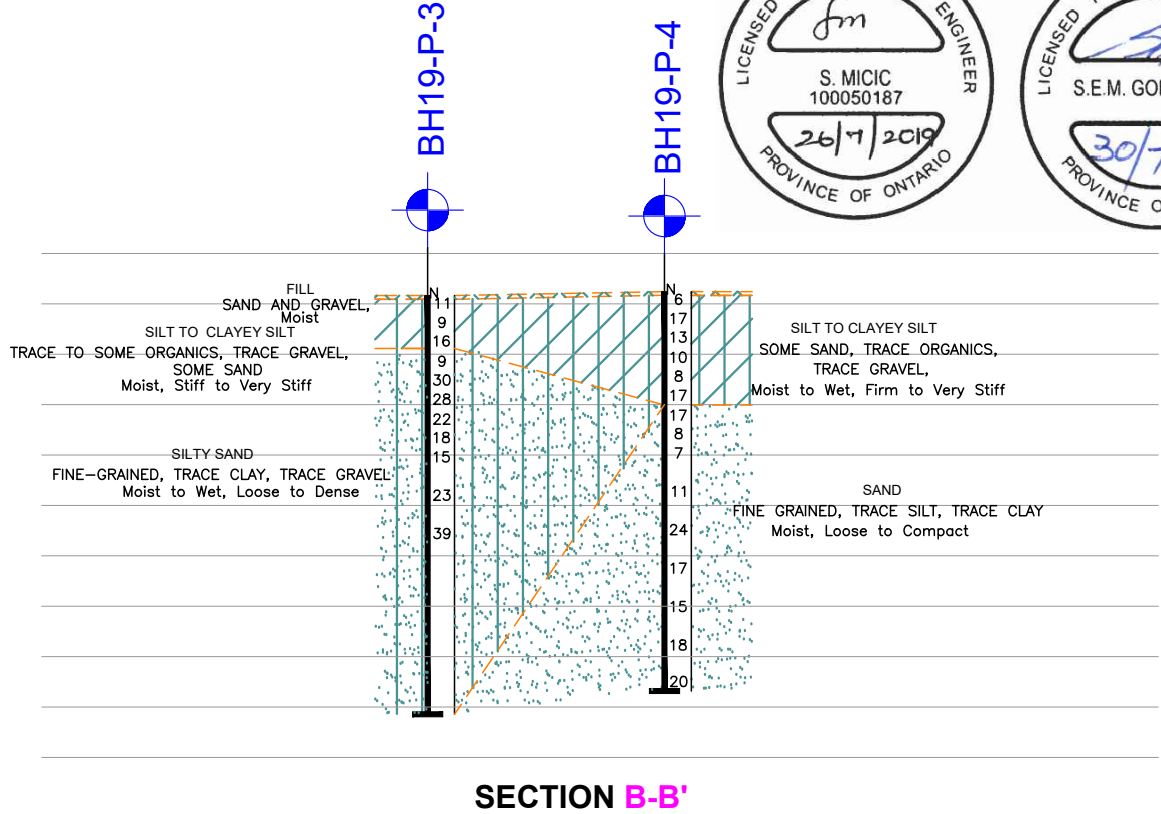
NOTES
This drawing is for subsurface information only. The proposed structure details/ works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents
The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.
SCALE: HOR 0 5 30 m VERT 0 1 6 m

	SM	SUBMISSION FOR MTO REVIEW
DATE	BY	DESCRIPTION
		GEOCRES NO. 311-220
		PROJECT NO. ADM-00233185-K0
SUBM'D SH	CHECKED SM	DATE Jul. 26, 19
DRAWN SH	CHECKED SM	APPROVED SG DWG. 1

PLAN



SECTION A-A'



SECTION B-B'





## **Appendix C – Borehole Logs**

# Explanation of Terms Used on Borehole Records

## SOIL DESCRIPTION

Terminology describing common soil genesis:

*Topsoil:* mixture of soil and humus capable of supporting good vegetative growth.

*Peat:* fibrous fragments of visible and invisible decayed organic matter.

*Fill:* where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc.; none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

*Till:* the term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Terminology describing soil structure:

*Desiccated:* having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.

*Stratified:* alternating layers of varying material or color with the layers greater than 6 mm thick.

*Laminated:* alternating layers of varying material or color with the layers less than 6 mm thick.

*Fissured:* material breaks along plane of fracture.

*Varved:* composed of regular alternating layers of silt and clay.

*Slickensided:* fracture planes appear polished or glossy, sometimes striated.

*Blocky:* cohesive soil that can be broken down into small angular lumps which resist further breakdown.

*Lensed:* inclusion of small pockets of different soil, such as small lenses of sand scattered through a mass of clay; not thickness.

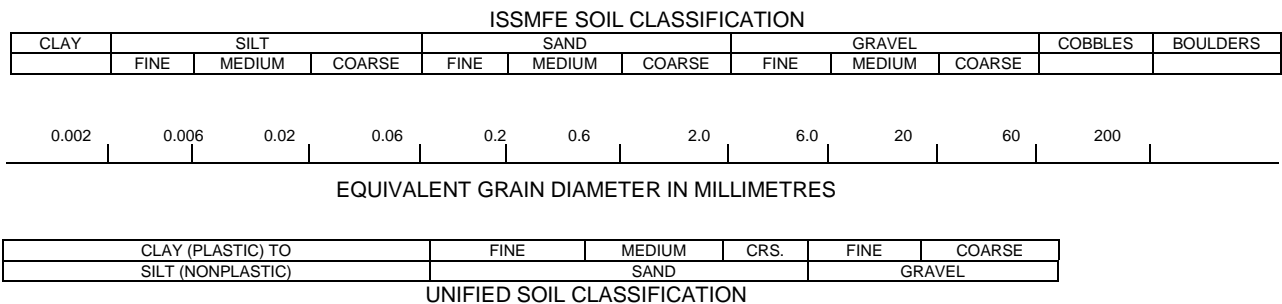
*Seam:* a thin, confined layer of soil having different particle size, texture, or color from materials above and below.

*Homogeneous:* same color and appearance throughout.

*Well Graded:* having wide range in grain sized and substantial amounts of all predominantly on grain size.

*Uniformly Graded:* predominantly on grain size.

All soil sample descriptions included in this report follow generally the ASTM D2487-11 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) with some modification to reflect current MTO practices. The system divides soils into three major categories: (1) coarse grained, (2) fine-grained, and (3) highly organic. The soil is then subdivided based on either gradation or plasticity characteristics. The system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification. The classification excludes particles larger than 76 mm. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually in accordance with ASTM D2488-09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems. Others may use different classification systems; one such system is the ISSMFE Soil Classification.



Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present and as described below in accordance with Canadian Foundation Engineering Manual (CFEM):

Table a: Percent or Proportion of Soil

	Criteria
Trace	1% - 10%
Some	10% - 20%
Little	20% - 35%
Some	>35% and main fraction

The standard terminology to describe cohesionless soils includes the compactness as determined by the Standard Penetration Test 'N' value:

Table b: Apparent Density of Cohesionless Soil

	'N' Value (blows/0.3 m)
Very Loose	N<5
Loose	5≤N<10
Compact	10≤N<30
Dense	30≤N<50
Very Dense	50≤N

The standard terminology to describe cohesive soils includes consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests or similar field and laboratory analysis, Standard Penetration Test 'N' values can also be used to provide an approximate indication of the consistency and shear strength of fine grained, cohesive soils:

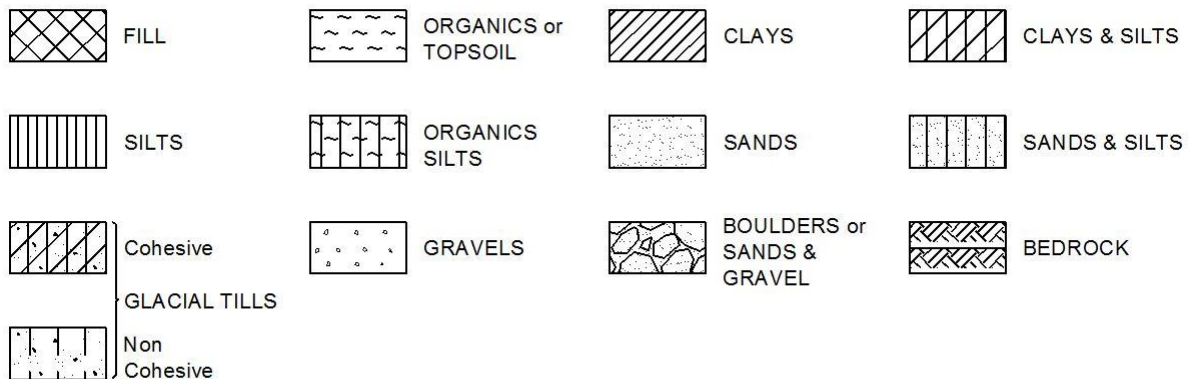
Table c: Consistency of Cohesive Soil

Consistency	Vane Shear Measurement (kPa)	'N' Value
Very Soft	<12.5	<2
Soft	12.5-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

Note: 'N' Value - The Standard Penetration Test records the number of blows of a 140 pound (64kg) hammer falling 30 inches (760mm), required to drive a 2 inch (50.8mm) O.D. split spoon sampler 1 foot (305mm). For split spoon samples where full penetration is not achieved, the number of blows is reported over the sampler penetration in meters (e.g. 50/0.15).

## STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



## WATER LEVEL MEASUREMENT



Open Borehole or Test Pit



Monitoring Well, Piezometer or Standpipe

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

SS	Split spoon sample (obtained from the Standard Penetration Test)
WS	Wash sample
BS	Bulk sample
TW	Thin wall sample or Shelby tube
PS	Piston sample
AS	Auger sample
VT	Vane test
GS	Grab sample
HQ, NQ, etc.	Rock core samples obtained with the use of standard size diamond drilling bits

### STRESS AND STRAIN

$u_w$	kPa	Pore water pressure
$r_u$	1	Pore pressure ratio
$\sigma$	kPa	Total normal stress
$\sigma'$	kPa	Effective normal stress
$\tau$	kPa	Shear stress
$\sigma_1, \sigma_2, \sigma_3$	kPa	Principal stresses
$\varepsilon$	%	Linear strain
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	Principal strains
E	kPa	Modulus of linear deformation
G	kPa	Modulus of shear deformation
$\mu$	1	Coefficient of friction

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	Coefficient of volume change
$c_c$	1	Compression index
$c_s$	1	Swelling index
$c_r$	1	Recompression index
$c_v$	m <sup>2</sup> /s	Coefficient of consolidation
H	m	Drainage path
$T_v$	1	Time factor
U	%	Degree of consolidation
$\sigma'_{v0}$	kPa	Effective overburden pressure
$\sigma'_p$	kPa	Preconsolidation pressure
$\tau_f$	kPa	Shear strength
$c'$	kPa	Effective cohesion intercept
$\phi'$	—°	Effective angle of internal friction
$c_u$	kPa	Apparent cohesion intercept
$\phi_u$	—°	Apparent angle of internal friction
$\tau_R$	kPa	Residual shear strength
$\tau_r$	kPa	Remoulded shear strength
$S_t$	1	Sensitivity = $c_u/\tau_r$

### PHYSICAL PROPERTIES OF SOIL

$P_s$	kg/m <sup>3</sup>	Density of solid particles
$\gamma_s$	kN/m <sup>3</sup>	Unit weight of solid particles
$\rho_w$	kg/m <sup>3</sup>	Density of water
$\gamma_w$	kN/m <sup>3</sup>	Unit weight of water
$\rho$	kg/m <sup>3</sup>	Density of soil
$\gamma$	kN/m <sup>3</sup>	Unit weight of soil
$\rho_d$	kg/m <sup>3</sup>	Density of dry soil
$\gamma_d$	kN/m <sup>3</sup>	Unit weight of dry soil
$\rho_{sat}$	kg/m <sup>3</sup>	Density of saturated soil
$\gamma_{sat}$	kN/m <sup>3</sup>	Unit weight of saturated soil
$\rho'$	kg/m <sup>3</sup>	Density of submerged soil
$\gamma'$	kN/m <sup>3</sup>	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 = $(W_L - W_P)$
$I_L$	%	Liquidity index = $(W - W_P)/I_p$
$I_C$	%	Consistency index = $(W_L - W)/I_p$
$e_{max}$	1, %	Void ratio in loosest state
$e_{min}$	1, %	Void ratio in densest state
$I_D$	1	Density index = $(e_{max} - e)/(e_{max} - e_{min})$
D	mm	Grain diameter
$D_n$	mm	N percent - diameter
$C_u$	1	Uniformity coefficient
h	m	Hydraulic head or potential
q	m <sup>3</sup> /s	Rate of discharge
v	m/s	Discharge velocity
i	1	Hydraulic gradient
k	m/s	Hydraulic conductivity
j	kN/m <sup>3</sup>	Seepage force

## 1 OF 1

METRIC

W.P.	LOCATION			Powassan Patrol Yard, Quebec Drive, Powassan ON, MTM ON10		ORIGINATED BY	PL				
DIST	Parry Sound	HWY	Quebec Drive	BOREHOLE TYPE		CME 55, Hollow stem auger drill	COMPILED BY	LC			
DATUM	Geodetic			DATE	2019.04.16 - 2019.04.16	LATITUDE	46.093095	LONGITUDE	79.370998	CHECKED BY	SM

[illegible]

ONTARIO MTO POWASSAN BH LOGS V1.GPJ ONTARIO MTO.GDT 7/25/19

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

Brampton, Ontario

## RECORD OF BOREHOLE No 19-P-2

1 OF 2

METRIC

W.P. \_\_\_\_\_ LOCATION Powassan Patrol Yard, Quebec Drive, Powassan ON, MTM ON10 ORIGINATED BY PL  
 DIST Parry Sound HWY Quebec Drive BOREHOLE TYPE CME 55, Hollow stem auger drill COMPILED BY LC  
 DATUM Geodetic DATE 2019.04.16 - 2019.04.16 LATITUDE 46.093132 LONGITUDE 79.370402 CHECKED BY SM

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 (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL P. PENETROMETER		W <sub>P</sub> W                      W <sub>L</sub> WATER CONTENT (%)				GR	SA	SI	CL
266.3	Ground Surface																
266.0	PAVEMENT STRUCTURE 100 mm		1	SS	20	266									12	77	(11)
266.1	asphaltic concrete		2	SS	12	265											
266.2	- over 75 mm sand and gravel, trace silt		3	SS	11	264											
0.2	SAND fine-grained, trace to some silt, trace clay, brown, moist to wet, loose to very dense		4	SS	7	263											
			5	SS	14	262											
			6	SS	8	261											
			7	SS	15	260											
			8	SS	21	259											
			9	SS	21	258											
			10	SS	30	257											
			11	SS	47	256											
		12	SS	27	255												

Continued Next Page

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

ONTARIO MTO POWASSAN BH LOGS V1.GPJ ONTARIO MTO.GDT 7/25/19

## 2 OF 2

METRIC

W.P.	LOCATION				Powassan Patrol Yard, Quebec Drive, Powassan ON, MTM ON10		ORIGINATED BY	PL	
DIST	Parry Sound	HWY	Quebec Drive	BOREHOLE TYPE		CME 55, Hollow stem auger drill		COMPILED BY	LC
DATUM	Geodetic			DATE	2019.04.16 - 2019.04.16	LATITUDE	46.093132	LONGITUDE	79.370402
					CHECKED BY	SM			

[illegible]

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



Brampton, Ontario

## RECORD OF BOREHOLE No 19-P-3

1 OF 2

METRIC

W.P. \_\_\_\_\_ LOCATION Powassan Patrol Yard, Quebec Drive, Powassan ON, MTM ON10 ORIGINATED BY PL  
 DIST Parry Sound HWY Quebec Drive BOREHOLE TYPE CME 55, Hollow stem auger drill COMPILED BY LC  
 DATUM Geodetic DATE 2019.04.15 - 2019.04.16 LATITUDE 46.092463 LONGITUDE 79.371345 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	W <sub>p</sub> W W <sub>L</sub>	W <sub>p</sub> W W <sub>L</sub>		
266.3	Ground Surface													
266.0	<b>FILL</b> sand and gravel, brown, moist													
0.2	<b>SILT TO CLAYEY SILT</b> trace to some organics, trace gravel, some sand, brown/grey, moist, stiff to very stiff		1	SS	11		266							
			2	SS	9									
			3	SS	16		265							
264.2	<b>SILTY SAND</b> fine-grained, trace gravel, trace clay, orange mottling throughout, brown, moist to wet, loose to dense		4	SS	9		264							1 61 35 3
2.1			5	SS	30		263							0 69 31 0
			6	SS	28		262							
			7	SS	22		261							
			8	SS	18		260							
			9	SS	15		259							
			10	SS	23		258							
			11	SS	39		257							0 72 27 1
							256							
							255							

Continued Next Page

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

ONTARIO MTO POWASSAN BH LOGS V1.GPJ ONTARIO MTO.GDT 7/25/19

Brampton, Ontario

# RECORD OF BOREHOLE No 19-P-3

2 OF 2

METRIC

W.P. \_\_\_\_\_ LOCATION Powassan Patrol Yard, Quebec Drive, Powassan ON, MTM ON10 ORIGINATED BY PL  
 DIST Parry Sound HWY Quebec Drive BOREHOLE TYPE CME 55, Hollow stem auger drill COMPILED BY LC  
 DATUM Geodetic DATE 2019.04.15 - 2019.04.16 LATITUDE 46.092463 LONGITUDE 79.371345 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	20 40 60	GR SA SI CL		
249.7	<b>SILTY SAND</b> fine-grained, trace gravel, trace clay, orange mottling throughout, brown, moist to wet, loose to dense ( <i>continued</i> )						254							
253														
252														
251														
250														
16.6	<b>End of borehole at 16.62 m depth.</b>  Notes: 1. No groundwater was encountered upon completion of drilling.													

Brampton, Ontario

# RECORD OF BOREHOLE No 19-P-4

1 OF 2

METRIC

W.P. \_\_\_\_\_ LOCATION Powassan Patrol Yard, Quebec Drive, Powassan ON, MTM ON10 ORIGINATED BY PL  
 DIST Parry Sound HWY Quebec Drive BOREHOLE TYPE CME 55, Hollow stem auger drill COMPILED BY LC  
 DATUM Geodetic DATE 2019.04.15 - 2019.04.15 LATITUDE 46.092563 LONGITUDE 79.370315 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ  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 X P. PENETROMETER										
266.5	Ground Surface							20	40	60	80	100		20	40	60		
266.0	<b>FILL</b> sand and gravel, brown, moist		1	SS	6		266							○				
0.2	<b>SILT TO CLAYEY SILT</b> orange molting, trace organics, trace gravel, some sand, brown/grey, moist to wet, firm to very stiff		2	SS	17		265							○				
			3	SS	13		264							○				
			4	SS	10		263							○				
			5	SS	8		262							○				
			6	SS	17		261							○				
			7	SS	17		260							○				
262.0	<b>SAND</b> fine-grained, trace silt, trace clay, brown, moist, loose to compact		8	SS	8		259							○				
4.5			9	SS	7		258							○				
			10	SS	11		257							○				
			11	SS	24		256							○				
			12	SS	17		255							○				

Continued Next Page

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

ONTARIO MTO POWASSAN BH LOGS V1.GPJ ONTARIO MTO.GDT 7/25/19

Brampton, Ontario

2 OF 2

## METRIC

W.P.	LOCATION			Powassan Patrol Yard, Quebec Drive, Powassan ON, MTM ON10	ORIGINATED BY	PL	
DIST	Parry Sound	HWY	Quebec Drive	BOREHOLE TYPE	CME 55, Hollow stem auger drill	COMPILED BY	LC
DATUM	Geodetic	DATE	2019.04.15 - 2019.04.15	LATITUDE	46.092563	LONGITUDE	79.370315
				CHECKED BY	SM		

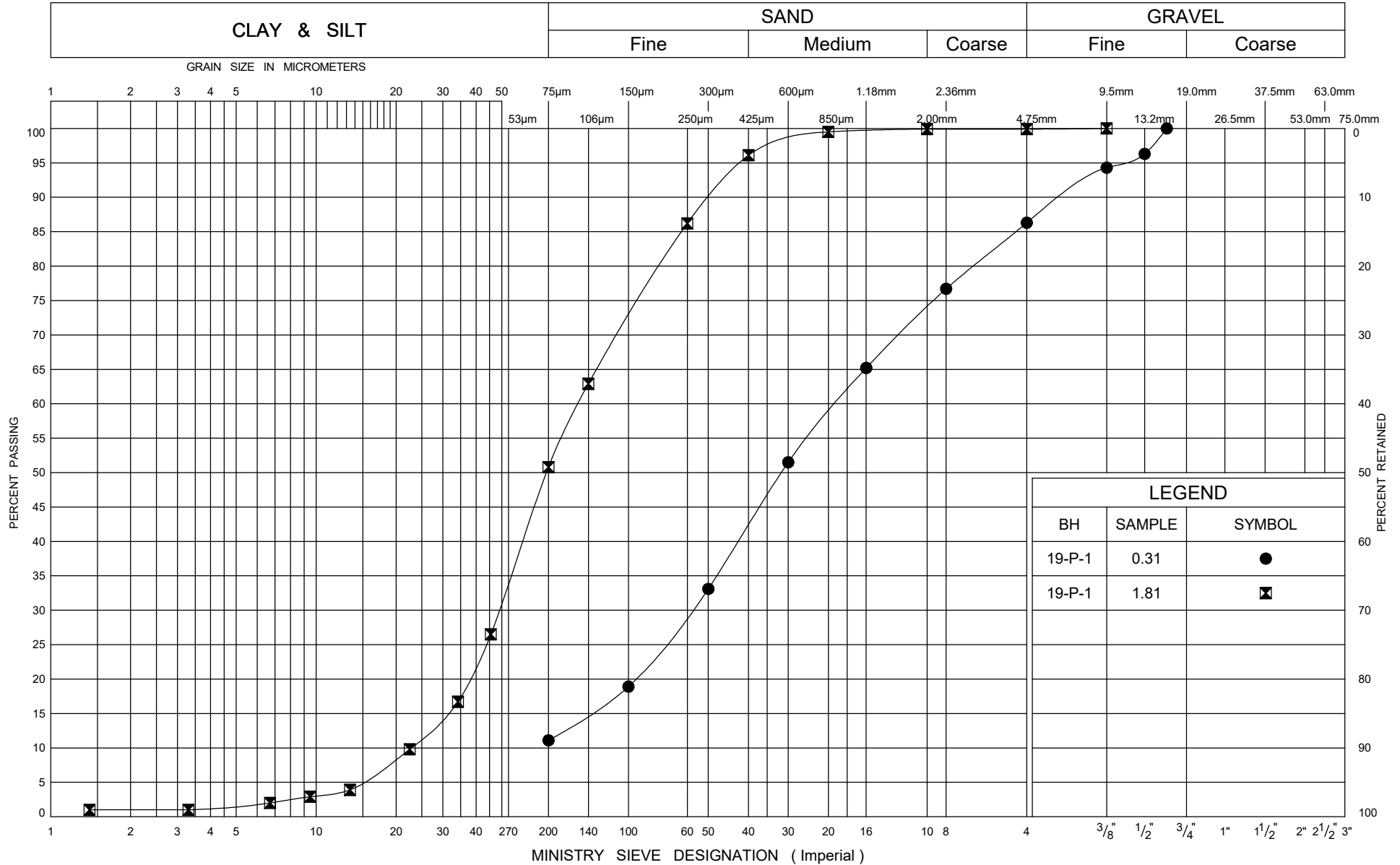
[illegible]

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

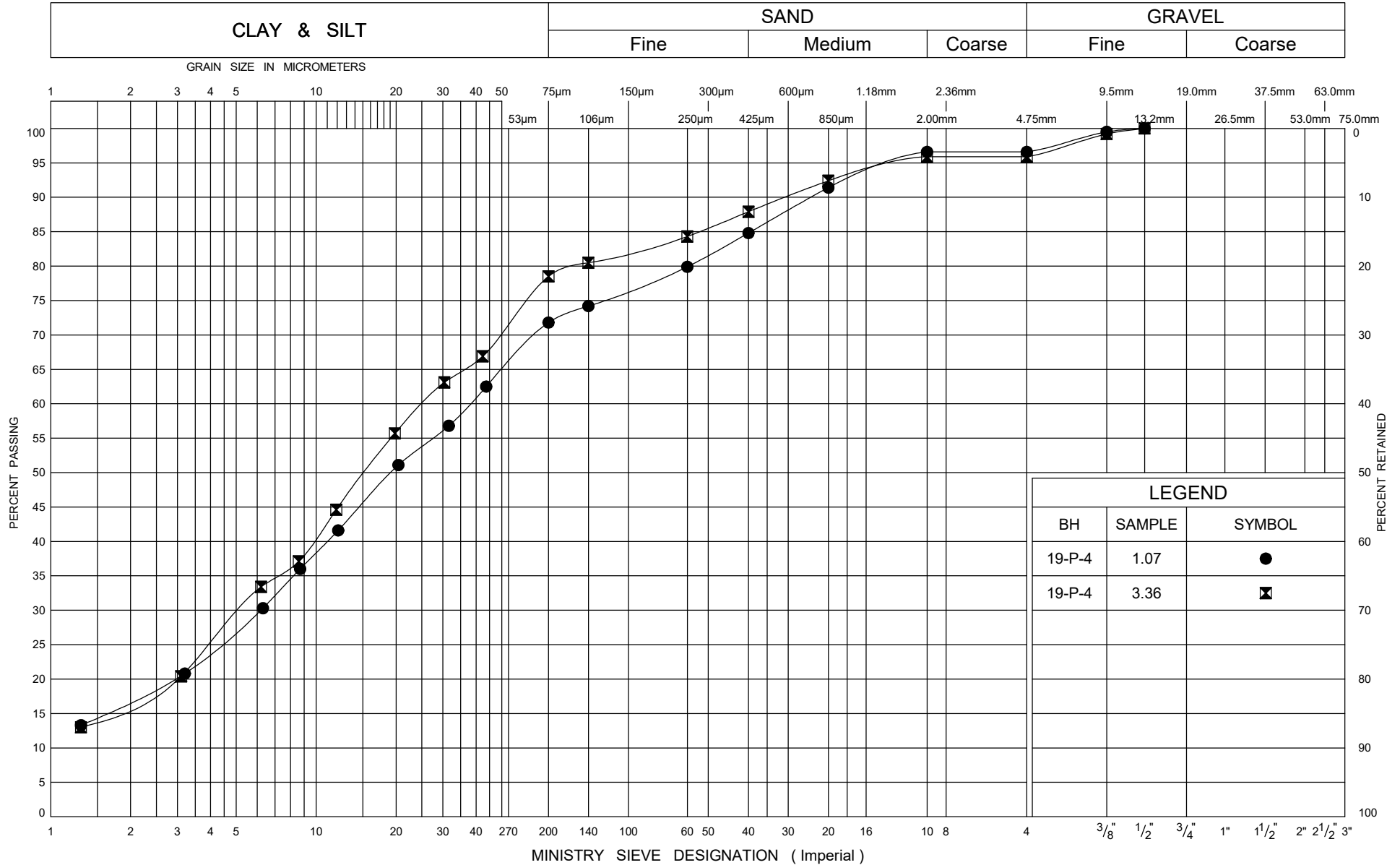
ONTARIO MTO POWASSAN BH LOGS V1.GPJ ONTARIO MTO GDT 7/25/19

## **Appendix D – Laboratory Data**

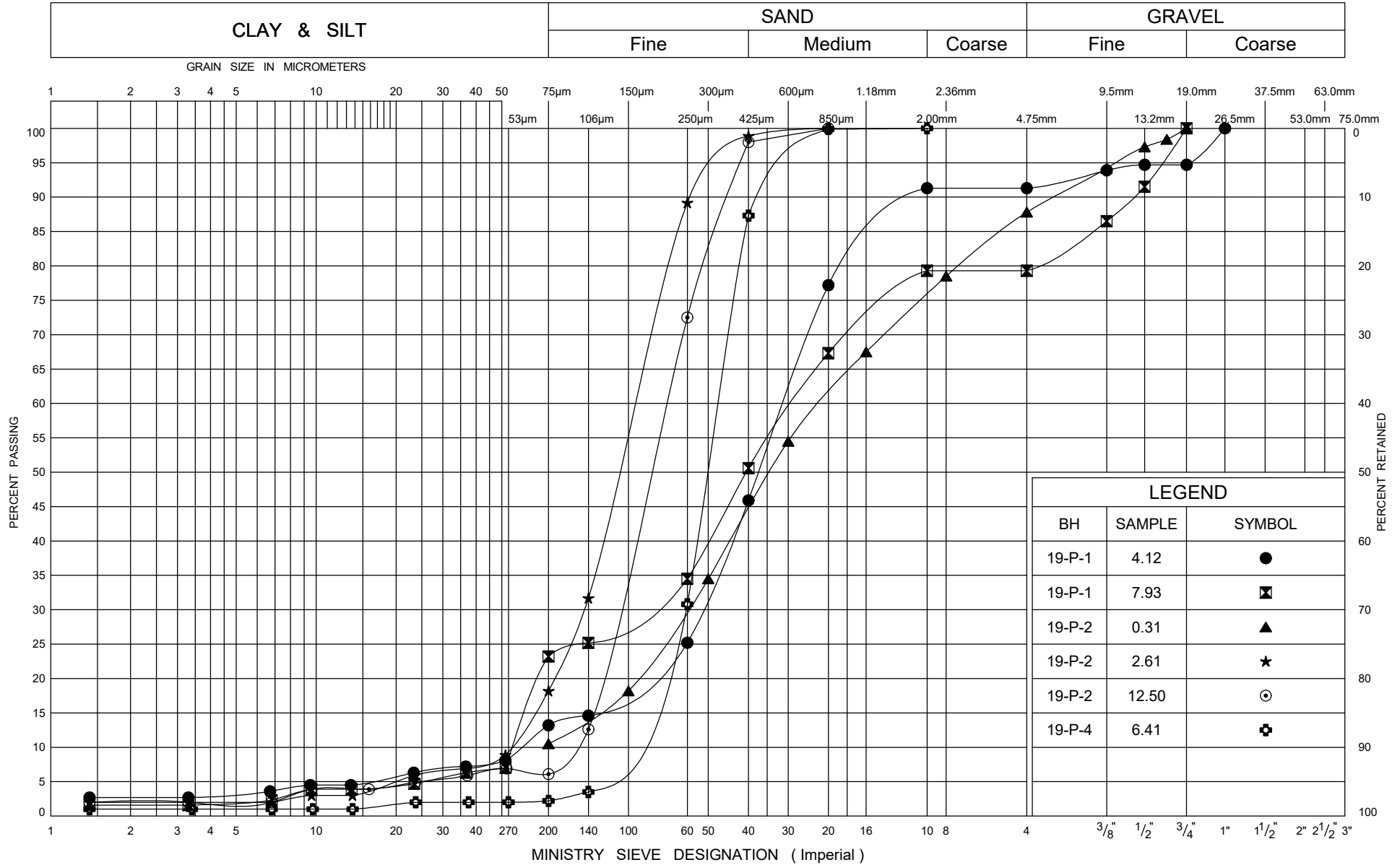
# UNIFIED SOIL CLASSIFICATION SYSTEM



# UNIFIED SOIL CLASSIFICATION SYSTEM

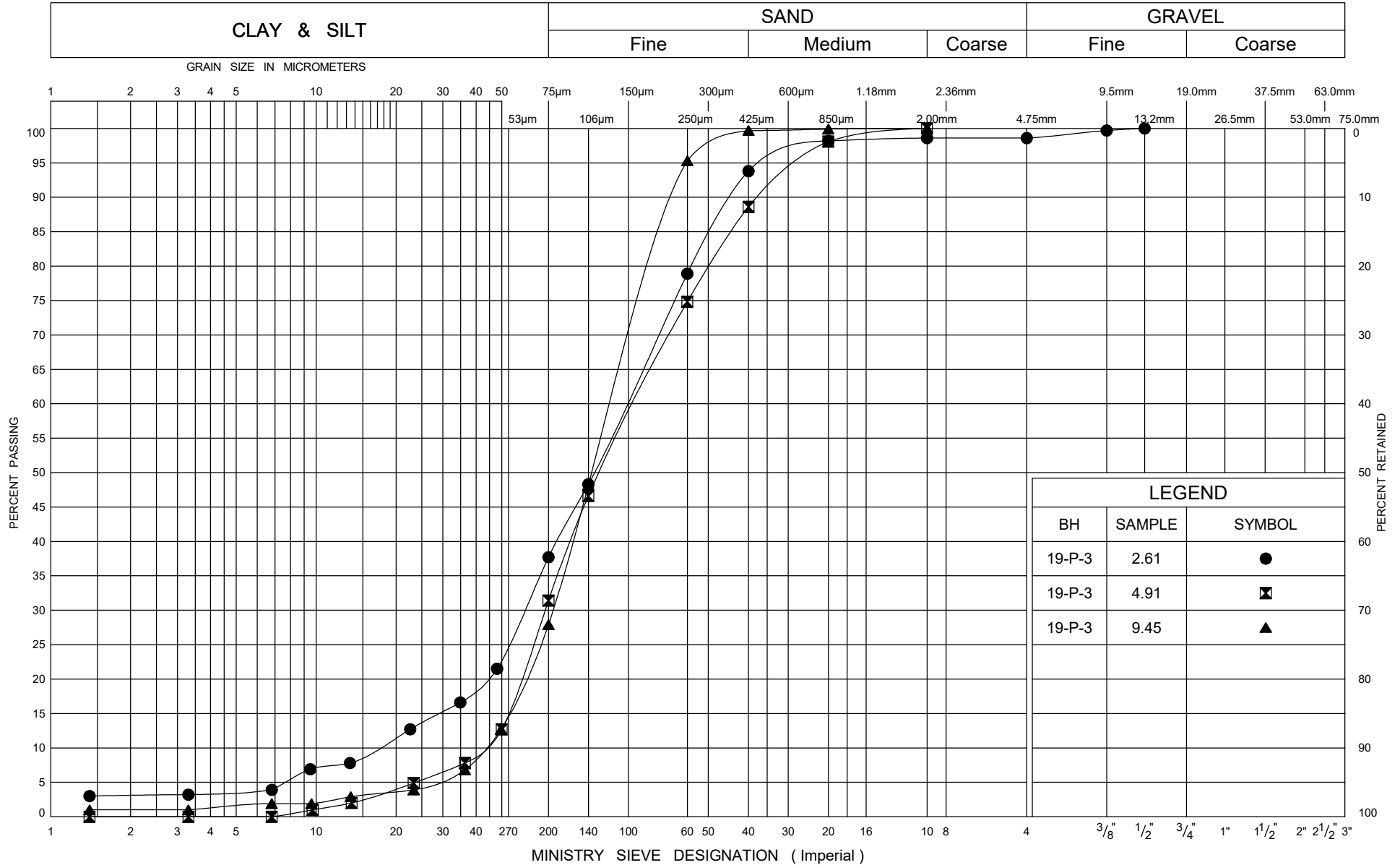


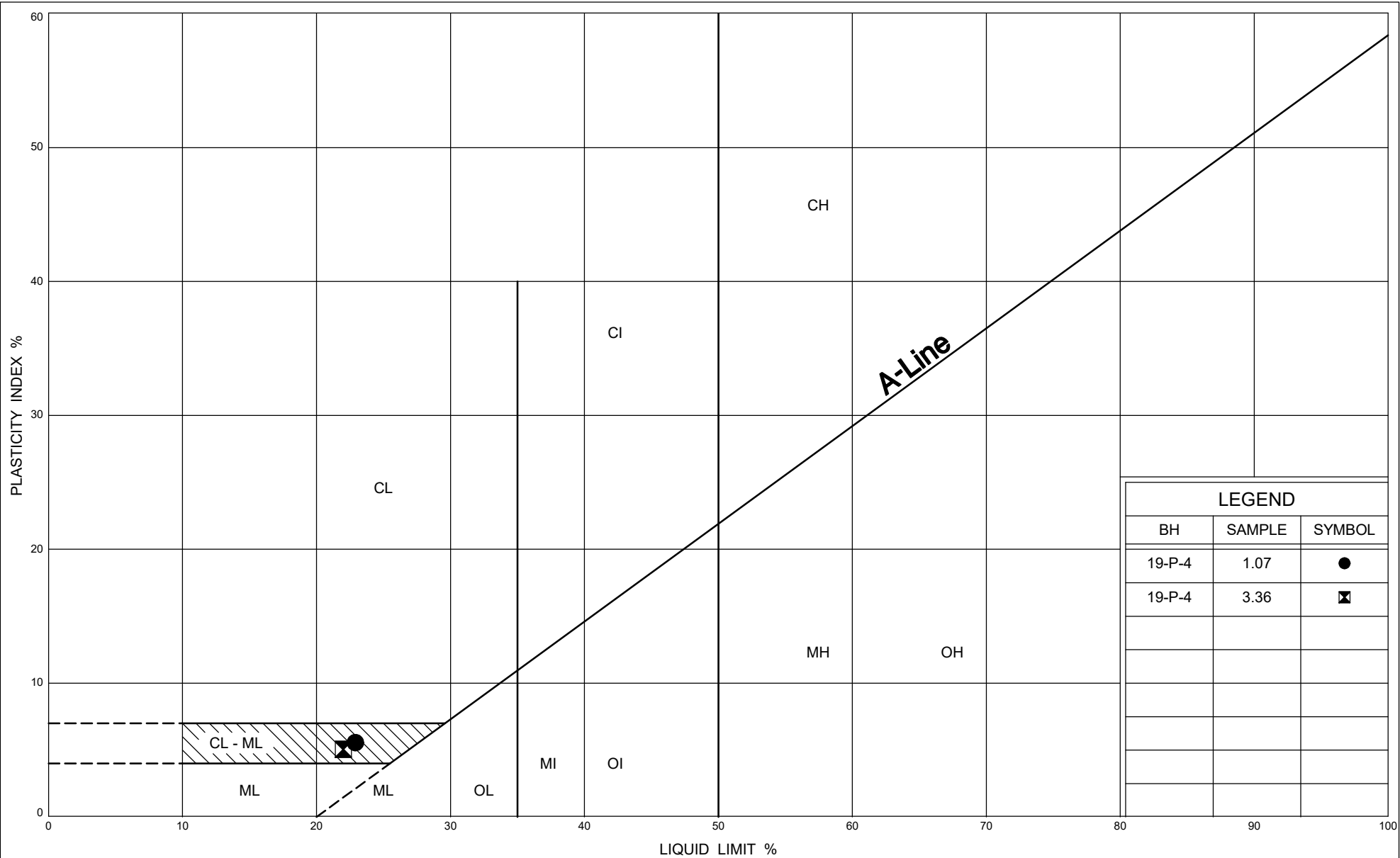
# UNIFIED SOIL CLASSIFICATION SYSTEM





# UNIFIED SOIL CLASSIFICATION SYSTEM





CLIENT NAME: EXP. SERVICES INC.  
885 REGENT ST  
SUDBURY, ON P3E5M4  
(705) 674-9681

ATTENTION TO: Ian MacMillan

PROJECT: ADM-00233185-K0

AGAT WORK ORDER: 19U464857

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Supervisor

TRACE ORGANICS REVIEWED BY: Pinkal Patel, Report Reviewer

DATE REPORTED: May 15, 2019

PAGES (INCLUDING COVER): 10

VERSION\*: 2

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

**\*NOTES**

VERSION 2: Partial report for sample "19-H-1-SS2" issued May 14, 2019.

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



## Certificate of Analysis

AGAT WORK ORDER: 19U464857

PROJECT: ADM-00233185-K0

5835 COOPERS AVENUE  
MISSISSAUGA, ONTARIO  
CANADA L4Z 1Y2  
TEL (905)712-5100  
FAX (905)712-5122  
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

SAMPLING SITE:

ATTENTION TO: Ian MacMillan

SAMPLED BY:

### Corrosivity Package

DATE RECEIVED: 2019-05-08

DATE REPORTED: 2019-06-15

		SAMPLE DESCRIPTION:		19-D-2-SS4	19-PS-2-SS3	19-G-1-SS3	19-P-2-SS3	
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	
		DATE SAMPLED:		2019-05-08	2019-05-08	2019-05-08	2019-05-08	
Parameter	Unit	G / S	RDL	182124	182125	182126	RDL	182127
Sulfide (S2-)	%		0.05	<0.05	<0.05	<0.05	0.05	<0.05
Chloride (2:1)	µg/g		2	8	160	6	40	7470
Sulphate (2:1)	µg/g		2	26	15	14	40	157
pH (2:1)	pH Units		NA	6.04	6.26	6.83	NA	6.86
Electrical Conductivity (2:1)	mS/cm		0.005	0.040	0.368	0.053	0.005	13.4
Redox Potential 1	mV		5	204	142	233	5	255
Redox Potential 2	mV		5	228	179	245	5	247
Redox Potential 3	mV		5	214	181	249	5	259
Resistivity (2:1)	ohm.cm		1	25000	2720	18900	1	75

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

182124-182126 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.

\*Sulphide analyzed at AGAT 5623 McAdam

PI note: Redox Potential is not an accredited parameter.

Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.

182127 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.

\*Sulphide analyzed at AGAT 5623 McAdam

PI note: Redox Potential is not an accredited parameter.

Elevated RDL indicates the degree of sample dilution prior to the analysis in order to keep analytes within the calibration range of the instrument and to reduce matrix interference.

Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.

Analysis performed at AGAT Toronto (unless marked by \*)

Certified By:

*Anamjot Bhela*  




## Certificate of Analysis

AGAT WORK ORDER: 19U464857

PROJECT: ADM-00233185-K0

5835 COOPERS AVENUE  
MISSISSAUGA, ONTARIO  
CANADA L4Z 1Y2  
TEL (905)712-5100  
FAX (905)712-5122  
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Ian MacMillan

SAMPLING SITE:

SAMPLED BY:

### O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2019-05-08

DATE REPORTED: 2019-05-13

		SAMPLE DESCRIPTION:		19-G-1-SS2	19-PS-1-SS2	19-P-1-SS2	19-D-2-SS2
		SAMPLE TYPE:		Soil	Soil	Soil	Soil
		DATE SAMPLED:		2019-05-08	2019-05-08	2019-05-08	2019-05-08
Parameter	Unit	G / S	RDL	182119	182121	182122	182123
Antimony	µg/g		0.8	<0.8	<0.8	<0.8	<0.8
Arsenic	µg/g		1	<1	1	<1	<1
Barium	µg/g		2	35	32	40	27
Beryllium	µg/g		0.5	<0.5	<0.5	<0.5	<0.5
Boron	µg/g		5	<5	<5	<5	<5
Boron (Hot Water Soluble)	µg/g		0.10	<0.10	<0.10	<0.10	<0.10
Cadmium	µg/g		0.5	<0.5	<0.5	<0.5	<0.5
Chromium	µg/g		2	8	14	8	9
Cobalt	µg/g		0.5	3.2	4.9	1.9	4.5
Copper	µg/g		1	12	28	4	10
Lead	µg/g		1	4	2	1	1
Molybdenum	µg/g		0.5	<0.5	<0.5	<0.5	<0.5
Nickel	µg/g		1	6	10	4	6
Selenium	µg/g		0.4	0.6	<0.4	0.7	<0.4
Silver	µg/g		0.2	<0.2	<0.2	<0.2	<0.2
Thallium	µg/g		0.4	<0.4	<0.4	<0.4	<0.4
Uranium	µg/g		0.5	<0.5	<0.5	0.6	<0.5
Vanadium	µg/g		1	19	36	10	26
Zinc	µg/g		5	22	21	11	16
Chromium VI	µg/g		0.2	<0.2	<0.2	<0.2	<0.2
Cyanide	µg/g		0.040	<0.040	<0.040	<0.040	<0.040
Mercury	µg/g		0.10	<0.10	<0.10	<0.10	<0.10
Electrical Conductivity	mS/cm		0.005	0.099	5.02	0.137	0.052
Sodium Adsorption Ratio	NA		NA	1.30	50.5	5.73	0.438
pH, 2:1 CaCl2 Extraction	pH Units		NA	5.59	5.81	7.18	5.12

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

182119-182123 EC was determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio. SAR is a calculated parameter.

Analysis performed at AGAT Toronto (unless marked by \*)

Certified By:





## Certificate of Analysis

AGAT WORK ORDER: 19U464857

PROJECT: ADM-00233185-K0

5835 COOPERS AVENUE  
MISSISSAUGA, ONTARIO  
CANADA L4Z 1Y2  
TEL (905)712-5100  
FAX (905)712-5122  
<http://www.agatlabs.com>

CLIENT NAME: EXP. SERVICES INC.

ATTENTION TO: Ian MacMillan

SAMPLING SITE:

SAMPLED BY:

### O. Reg. 153(511) - PHCs F1 - F4 (Soil)

DATE RECEIVED: 2019-05-08

DATE REPORTED: 2019-05-13

		SAMPLE DESCRIPTION:		19-G-1-SS2	19-H-1-SS2	19-PS-1-SS2	19-P-1-SS2	19-D-2-SS2
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		2019-05-08	2019-05-08	2019-05-08	2019-05-08	2019-05-08
Parameter	Unit	G / S	RDL	182119	182120	182121	182122	182123
Benzene	µg/g		0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Toluene	µg/g		0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ethylbenzene	µg/g		0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Xylene Mixture	µg/g		0.05	<0.05	<0.05	<0.05	<0.05	<0.05
F1 (C6 to C10)	µg/g		5	<5	<5	<5	<5	<5
F1 (C6 to C10) minus BTEX	µg/g		5	<5	<5	<5	<5	<5
F2 (C10 to C16)	µg/g		10	<10	<10	<10	<10	<10
F3 (C16 to C34)	µg/g		50	<50	<50	<50	<50	<50
F4 (C34 to C50)	µg/g		50	<50	<50	<50	<50	<50
Gravimetric Heavy Hydrocarbons	µg/g		50	NA	NA	NA	NA	NA
Moisture Content	%		0.1	12.7	25.6	12.2	11.7	12.8
Surrogate	Unit	Acceptable Limits						
Terphenyl	%		60-140	112	96	87	120	100

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

182119-182123

Results are based on sample dry weight.  
The C6-C10 fraction is calculated using Toluene response factor.  
Xylenes is a calculated parameter. The calculated value is the sum of m&p-Xylene and o-Xylene.  
C6-C10 (F1 minus BTEX) is a calculated parameter. The calculated value is F1 minus BTEX.  
The C10 - C16, C16 - C34, and C34 - C50 fractions are calculated using the average response factor for n-C10, n-C16, and n-C34.  
Gravimetric Heavy Hydrocarbons are not included in the Total C16-C50 and are only determined if the chromatogram of the C34 - C50 hydrocarbons indicates that hydrocarbons >C50 are present.  
The chromatogram has returned to baseline by the retention time of nC50.  
Total C6 - C50 results are corrected for BTEX contribution.  
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.  
nC6 and nC10 response factors are within 30% of Toluene response factor.  
nC10, nC16 and nC34 response factors are within 10% of their average.  
C50 response factor is within 70% of nC10 + nC16 + nC34 average.  
Linearity is within 15%.  
Extraction and holding times were met for this sample.  
Fractions 1-4 are quantified with the contribution of PAHs. Under Ontario Regulation 153, results are considered valid without determining the PAH contribution if not requested by the client.  
Quality Control Data is available upon request.

Analysis performed at AGAT Toronto (unless marked by \*)

Certified By:

*Jinkal Patel*

## Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 19U464857

PROJECT: ADM-00233185-K0

ATTENTION TO: Ian MacMillan

SAMPLING SITE:

SAMPLED BY:

Soil Analysis															
RPT Date:			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

### O. Reg. 153(511) - Metals & Inorganics (Soil)

Antimony	182264		<0.8	<0.8	NA	< 0.8	91%	70%	130%	95%	80%	120%	94%	70%	130%
Arsenic	182264		3	3	NA	< 1	101%	70%	130%	94%	80%	120%	98%	70%	130%
Barium	182264		109	110	0.9%	< 2	105%	70%	130%	100%	80%	120%	116%	70%	130%
Beryllium	182264		<0.5	<0.5	NA	< 0.5	99%	70%	130%	98%	80%	120%	76%	70%	130%
Boron	182264		7	7	NA	< 5	101%	70%	130%	104%	80%	120%	76%	70%	130%
Boron (Hot Water Soluble)	182264		0.31	0.33	NA	< 0.10	113%	60%	140%	100%	70%	130%	102%	60%	140%
Cadmium	182264		<0.5	<0.5	NA	< 0.5	99%	70%	130%	101%	80%	120%	99%	70%	130%
Chromium	182264		30	31	3.3%	< 2	103%	70%	130%	102%	80%	120%	112%	70%	130%
Cobalt	182264		10.0	10.3	3.0%	< 0.5	105%	70%	130%	105%	80%	120%	103%	70%	130%
Copper	182264		20	20	0.0%	< 1	95%	70%	130%	101%	80%	120%	97%	70%	130%
Lead	182264		9	9	0.0%	< 1	105%	70%	130%	104%	80%	120%	100%	70%	130%
Molybdenum	182264		<0.5	<0.5	NA	< 0.5	108%	70%	130%	100%	80%	120%	98%	70%	130%
Nickel	182264		25	25	0.0%	< 1	103%	70%	130%	108%	80%	120%	110%	70%	130%
Selenium	182264		0.5	0.5	NA	< 0.4	103%	70%	130%	92%	80%	120%	96%	70%	130%
Silver	182264		<0.2	<0.2	NA	< 0.2	99%	70%	130%	99%	80%	120%	95%	70%	130%
Thallium	182264		<0.4	<0.4	NA	< 0.4	101%	70%	130%	113%	80%	120%	107%	70%	130%
Uranium	182264		0.5	0.5	NA	< 0.5	112%	70%	130%	116%	80%	120%	121%	70%	130%
Vanadium	182264		41	43	4.8%	< 1	103%	70%	130%	112%	80%	120%	111%	70%	130%
Zinc	182264		52	52	0.0%	< 5	93%	70%	130%	102%	80%	120%	103%	70%	130%
Chromium VI	182119	182119	<0.2	<0.2	NA	< 0.2	108%	70%	130%	100%	80%	120%	102%	70%	130%
Cyanide	182122	182122	<0.040	<0.040	NA	< 0.040	98%	70%	130%	99%	80%	120%	104%	70%	130%
Mercury	182264		<0.10	<0.10	NA	< 0.10	127%	70%	130%	109%	80%	120%	110%	70%	130%
Electrical Conductivity	182119	182119	0.099	0.108	8.7%	< 0.005	109%	90%	110%	NA			NA		
Sodium Adsorption Ratio	182119	182119	1.30	1.38	6.0%	NA	NA			NA			NA		
pH, 2:1 CaCl2 Extraction	182119	182119	5.59	5.61	0.4%	NA	100%	80%	120%	NA			NA		

Comments: NA signifies Not Applicable.

Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

### Corrosivity Package

Sulfide (S2-)	182124	182124	< 0.05	< 0.05	NA	< 0.05	100%	80%	120%						
Chloride (2:1)	178497		10	9	NA	< 2	93%	80%	120%	89%	80%	120%	89%	70%	130%
Sulphate (2:1)	178497		10	9	NA	< 2	92%	80%	120%	93%	80%	120%	97%	70%	130%
pH (2:1)	182124	182124	6.04	6.01	0.5%	NA	99%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	182119	182119	0.099	0.108	8.7%	< 0.005	109%	90%	110%	NA			NA		
Redox Potential 1	1					< 5	100%	70%	130%		70%	130%		70%	130%

## Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 19U464857

PROJECT: ADM-00233185-K0

ATTENTION TO: Ian MacMillan

SAMPLING SITE:

SAMPLED BY:

### Soil Analysis (Continued)

RPT Date:			DUPLICATE			Method Blank	REFERENCE MATERIAL		METHOD BLANK SPIKE		MATRIX SPIKE	
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper

Comments: NA signifies Not Applicable.

Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL

Certified By:








## Quality Assurance

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 19U464857

PROJECT: ADM-00233185-K0

ATTENTION TO: Ian MacMillan

SAMPLING SITE:

SAMPLED BY:

### Trace Organics Analysis

RPT Date:			DUPLICATE			Method Blank	REFERENCE MATERIAL		METHOD BLANK SPIKE			MATRIX SPIKE			
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

O. Reg. 153(511) - PHCs F1 - F4 (Soil)

Benzene	174969		< 0.02	< 0.02	NA	< 0.02	90%	60%	130%	85%	60%	130%	89%	60%	130%
Toluene	174969		< 0.05	< 0.05	NA	< 0.05	88%	60%	130%	89%	60%	130%	86%	60%	130%
Ethylbenzene	174969		< 0.05	< 0.05	NA	< 0.05	101%	60%	130%	87%	60%	130%	79%	60%	130%
Xylene Mixture	174969		< 0.05	< 0.05	NA	< 0.05	97%	60%	130%	81%	60%	130%	82%	60%	130%
F1 (C6 to C10)	174969		< 5	< 5	NA	< 5	96%	60%	130%	86%	85%	115%	80%	70%	130%
F2 (C10 to C16)	173534		< 10	< 10	NA	< 10	100%	60%	130%	95%	80%	120%	70%	70%	130%
F3 (C16 to C34)	173534		< 50	< 50	NA	< 50	104%	60%	130%	98%	80%	120%	76%	70%	130%
F4 (C34 to C50)	173534		< 50	< 50	NA	< 50	95%	60%	130%	87%	80%	120%	116%	70%	130%

Comments: When the average of the sample and duplicate results is less than 5x the RDL, the Relative Percent Difference (RPD) will be indicated as Not Applicable (NA).

Certified By:

*Jinkal Patel*

## Method Summary

CLIENT NAME: EXP. SERVICES INC.

PROJECT: ADM-00233185-K0

SAMPLING SITE:

AGAT WORK ORDER: 19U464857

ATTENTION TO: Ian MacMillan

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Sulfide (S2-)	MIN-200-12025	ASTM E1915-09	GRAVIMETRIC
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Redox Potential 1	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Resistivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Antimony	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Arsenic	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Barium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Beryllium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron (Hot Water Soluble)	MET-93-6104	EPA SW 846 6010C; MSA, Part 3, Ch.21	ICP/OES
Cadmium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Cobalt	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Copper	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Lead	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Molybdenum	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Nickel	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Selenium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Silver	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Thallium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Uranium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Vanadium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Zinc	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium VI	INOR-93-6029	SM 3500 B; MSA Part 3, Ch. 25	SPECTROPHOTOMETER
Cyanide	INOR-93-6052	MOE CN-3015 & E 3009 A;SM 4500 CN	TECHNICON AUTO ANALYZER
Mercury	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Electrical Conductivity	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Sodium Adsorption Ratio	INOR-93-6007	McKeague 4.12 & 3.26 & EPA SW-846 6010C	ICP/OES
pH, 2:1 CaCl2 Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER

## Method Summary

CLIENT NAME: EXP. SERVICES INC.

AGAT WORK ORDER: 19U464857

PROJECT: ADM-00233185-K0

ATTENTION TO: Ian MacMillan

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Trace Organics Analysis			
Benzene	VOL-91-5009	EPA SW-846 5035 & 8260D	P&T GC/MS
Toluene	VOL-91-5009	EPA SW-846 5035 & 8260D	P&T GC/MS
Ethylbenzene	VOL-91-5009	EPA SW-846 5035 & 8260D	P&T GC/MS
Xylene Mixture	VOL-91-5009	EPA SW-846 5035 & 8260D	P&T GC/MS
F1 (C6 to C10)	VOL-91-5009	CCME Tier 1 Method	P&T GC/FID
F1 (C6 to C10) minus BTEX	VOL-91-5009	CCME Tier 1 Method	P&T GC/FID
F2 (C10 to C16)	VOL-91-5009	CCME Tier 1 Method	GC/FID
F3 (C16 to C34)	VOL-91-5009	CCME Tier 1 Method	GC/FID
F4 (C34 to C50)	VOL-91-5009	CCME Tier 1 Method	GC/FID
Gravimetric Heavy Hydrocarbons	VOL-91-5009	CCME Tier 1 Method	BALANCE
Moisture Content	VOL-91-5009	CCME Tier 1 Method	BALANCE
Terphenyl	VOL-91-5009		GC/FID



## Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

### Report Information:

Company: exp  
Contact: Ian Macmillan @ exp.com  
Address: Sudbury  
Phone: \_\_\_\_\_ Fax: \_\_\_\_\_  
Reports to be sent to: Ian Macmillan @ exp.com  
1. Email: \_\_\_\_\_  
2. Email: \_\_\_\_\_

### Project Information:

Project: ADM-00233185-KO  
Site Location: MTO  
Sampled By: PL  
AGAT Quote #: SOA PO: \_\_\_\_\_  
Please note: If quotation number is not provided, client will be billed full price for analysis.

### Invoice Information:

Company: \_\_\_\_\_  
Contact: \_\_\_\_\_  
Address: \_\_\_\_\_  
Email: \_\_\_\_\_  
Bill To Same: Yes ☒ No ☐

### Regulatory Requirements:

(Please check all applicable boxes)

☐ Regulation 153/04

Table Indicate One

☐ Ind/Corn

☐ Res/Park

☐ Agriculture

Soil Texture (Check One)

☐ Coarse

☐ Fine

☐ Sewer Use

☐ Sanitary

☐ Storm

Region Indicate One

☐ MISA

☐ Regulation 558

☐ CCME

☐ Prov. Water Quality  
Objectives (PWQO)

☐ Other

Indicate One

Is this submission for a  
Record of Site Condition?

☐ Yes ☒ No

Report Guideline on  
Certificate of Analysis

☐ Yes ☒ No

### Sample Matrix Legend

B Biota  
GW Ground Water  
O Oil  
P Paint  
S Soil  
SD Sediment  
SW Surface Water

Field Filtered - Metals, Hg, CrVI

### 0. Reg 153

Metals and Inorganics

☐ All Metals ☐ 153 Metals (excl. Hydrides)

☐ Hydride Metals ☐ 153 Metals (incl. Hydrides)

ORPs: ☐ B-HWS ☐ Cl- ☐ CN

☐ C\* ☐ EC ☐ FOC ☐ Hg

☐ pH ☐ SAR

Full Metals Scan

Regulation/Custom Metals

Nutrients: ☐ TP ☐ NH<sub>3</sub> ☐ TKN

☐ NO<sub>3</sub> ☐ NO<sub>2</sub> ☐ NO<sub>2</sub>+NO<sub>3</sub>

Volatiles: ☐ VOC ☒ BTEX ☐ THM

PHCs F1 - F4

ABNs

PAHs

PCBs: ☐ Total ☐ Aroclors

Organochlorine Pesticides

TCLP: ☐ M&I ☐ VOCs ☐ ABNs ☐ B(a)P ☐ PCBs

Sewer Use

Corrosivity

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Y / N	Metals and Inorganics	0. Reg 153	Volatiles	PHCs F1 - F4	ABNs	PAHs	PCBs: Total Aroclors	Organochlorine Pesticides	TCLP: M&I VOCs ABNs B(a)P PCBs	Sewer Use	Corrosivity
19-G-1-SS2	May 8/19		5	S	No rush		✓		✓								
19-H-1-SS2			2		Rush 2 day - no M&I		✓		✓								
19-PS-1-SS2			5		No rush		✓		✓								
19-P-1-SS2							✓		✓								
19-D-2-SS2							✓		✓								
19-D-2-SS4																	
19-PS-2-SS3																	
19-G-1-SS3																	
19-P-2-SS3																	

Samples Relinquished By (Print Name and Sign):

Samples Relinquished By (Print Name and Sign):

Samples Relinquished By (Print Name and Sign):

Date

Date

Date

Time

Time

Time

Samples Received By (Print Name and Sign):

Samples Received By (Print Name and Sign):

Samples Received By (Print Name and Sign):

Date

Date

Date

Time

Time

Time

Page 1 of 1

No: T 087566

## **Appendix E – Results of Stability Analyses**

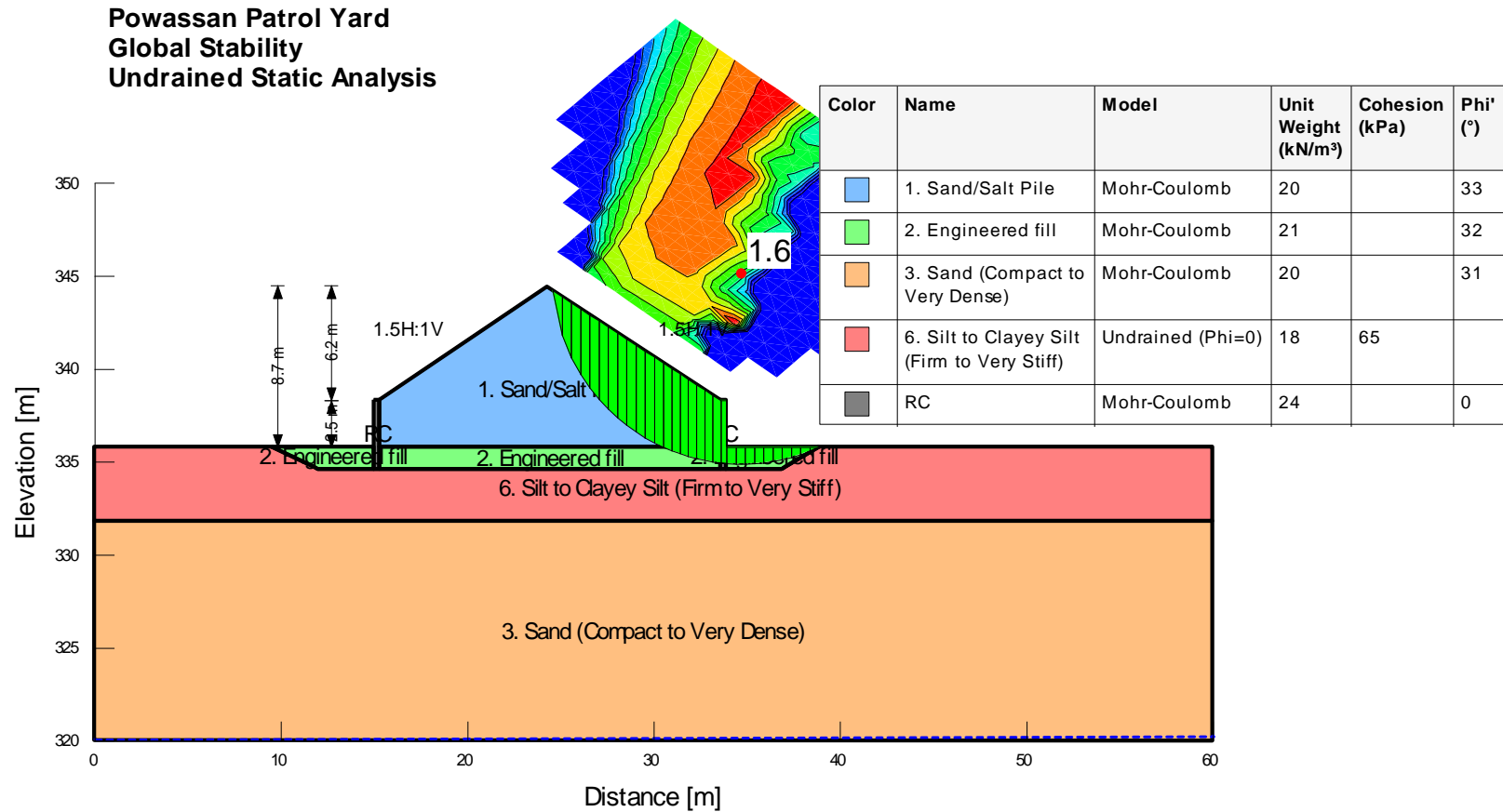


Figure E1. Global stability for Powassan Patrol Yard – Undrained static analysis

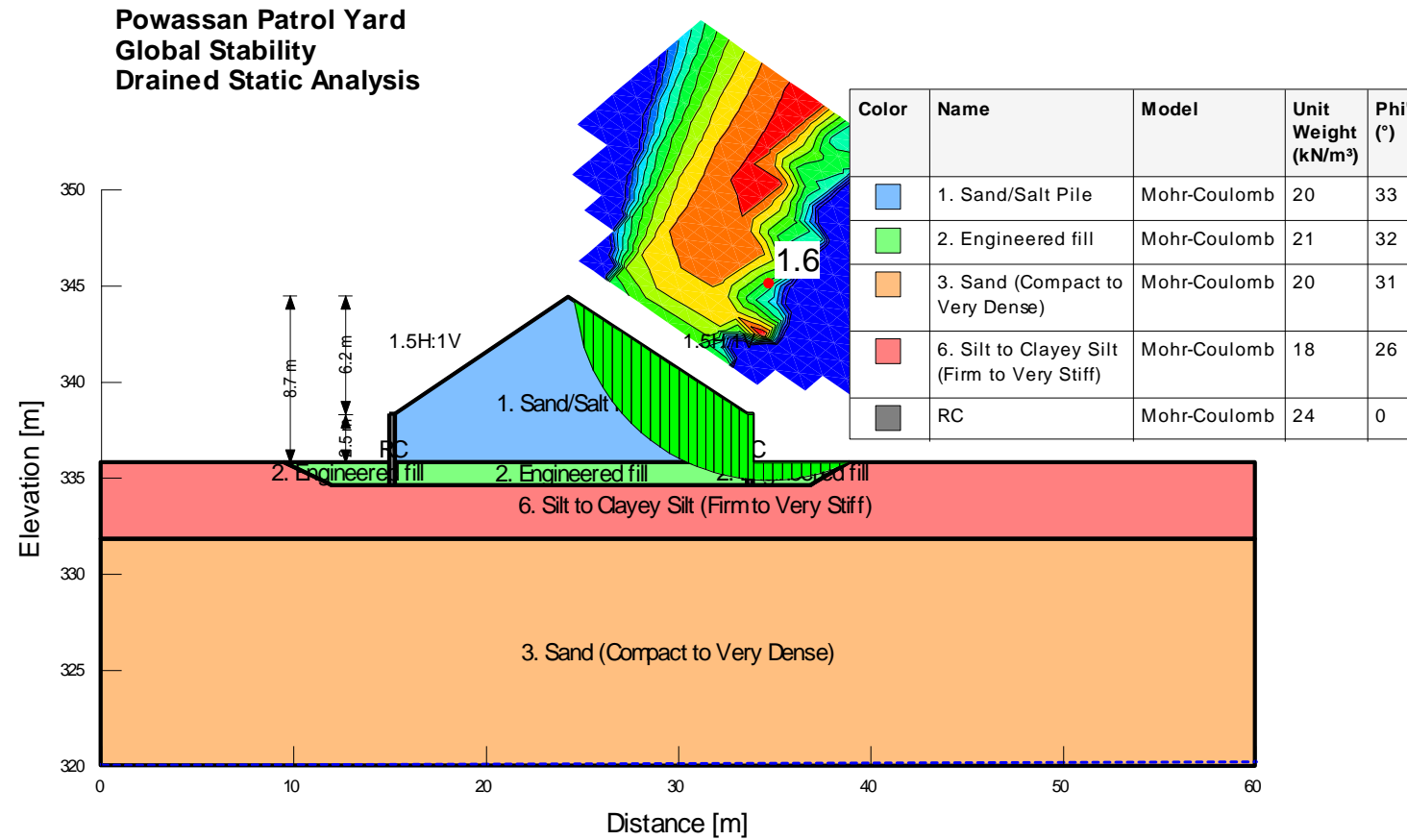


Figure E2. Global stability for Powassan Patrol Yard – Drained static analysis

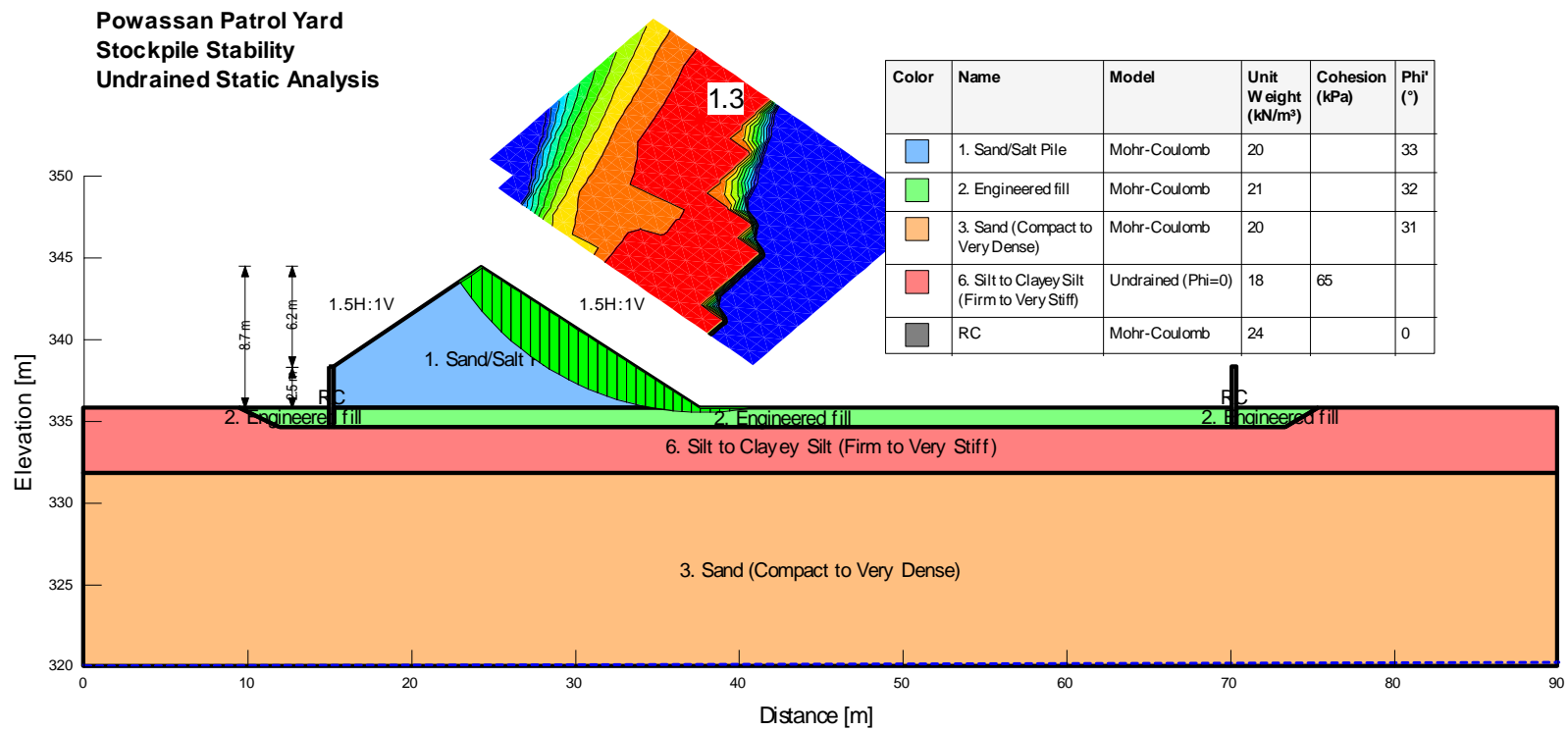


Figure E3. Stockpile stability for Powassan Patrol Yard – Undrained static analysis



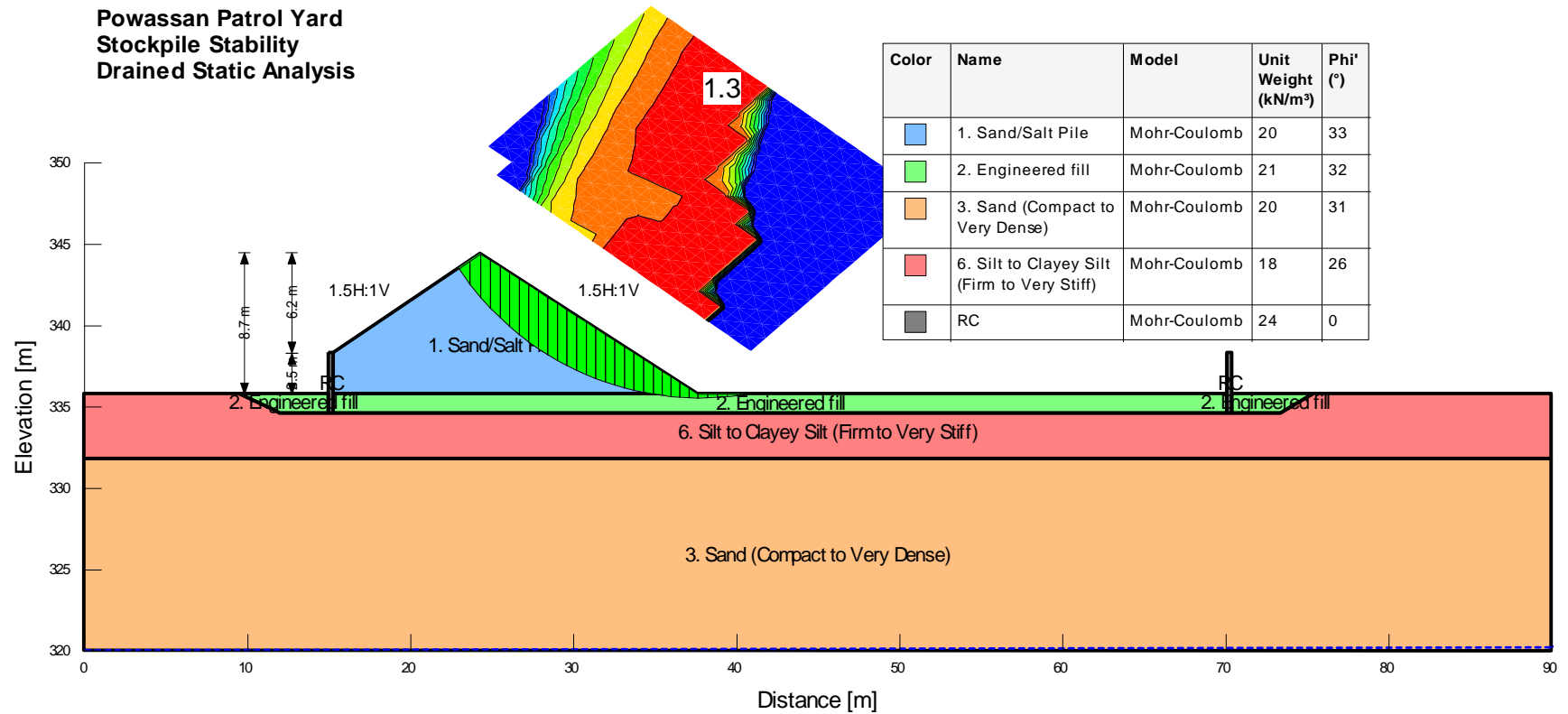
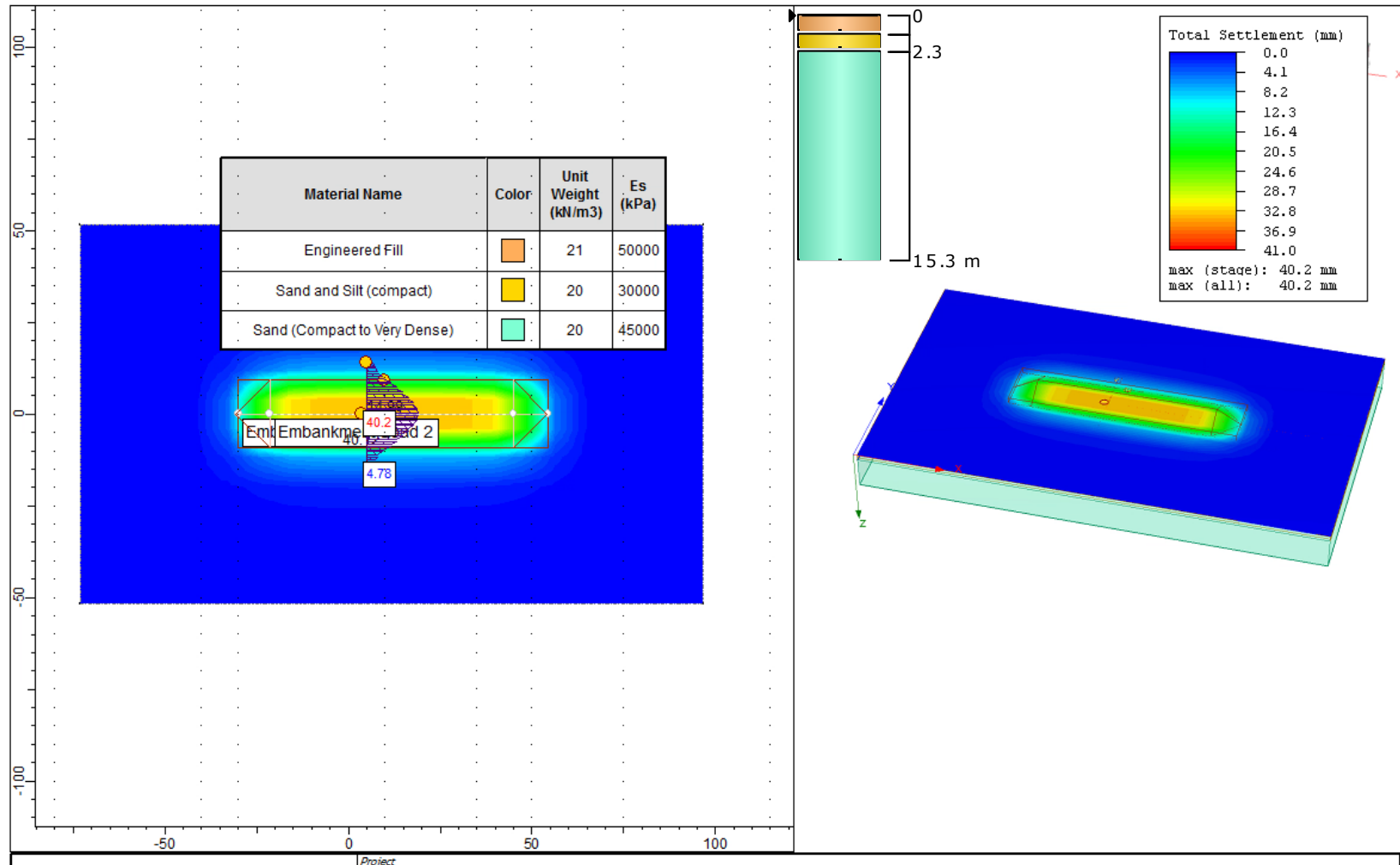


Figure E4. Stockpile stability for Powassan Patrol Yard – Drained static analysis

## **Appendix F – Results of Settlement Analyses**



Project: FIDR for Powassan Patrol Yard

Analysis Description: Full loading (North Side) – Total Settlement

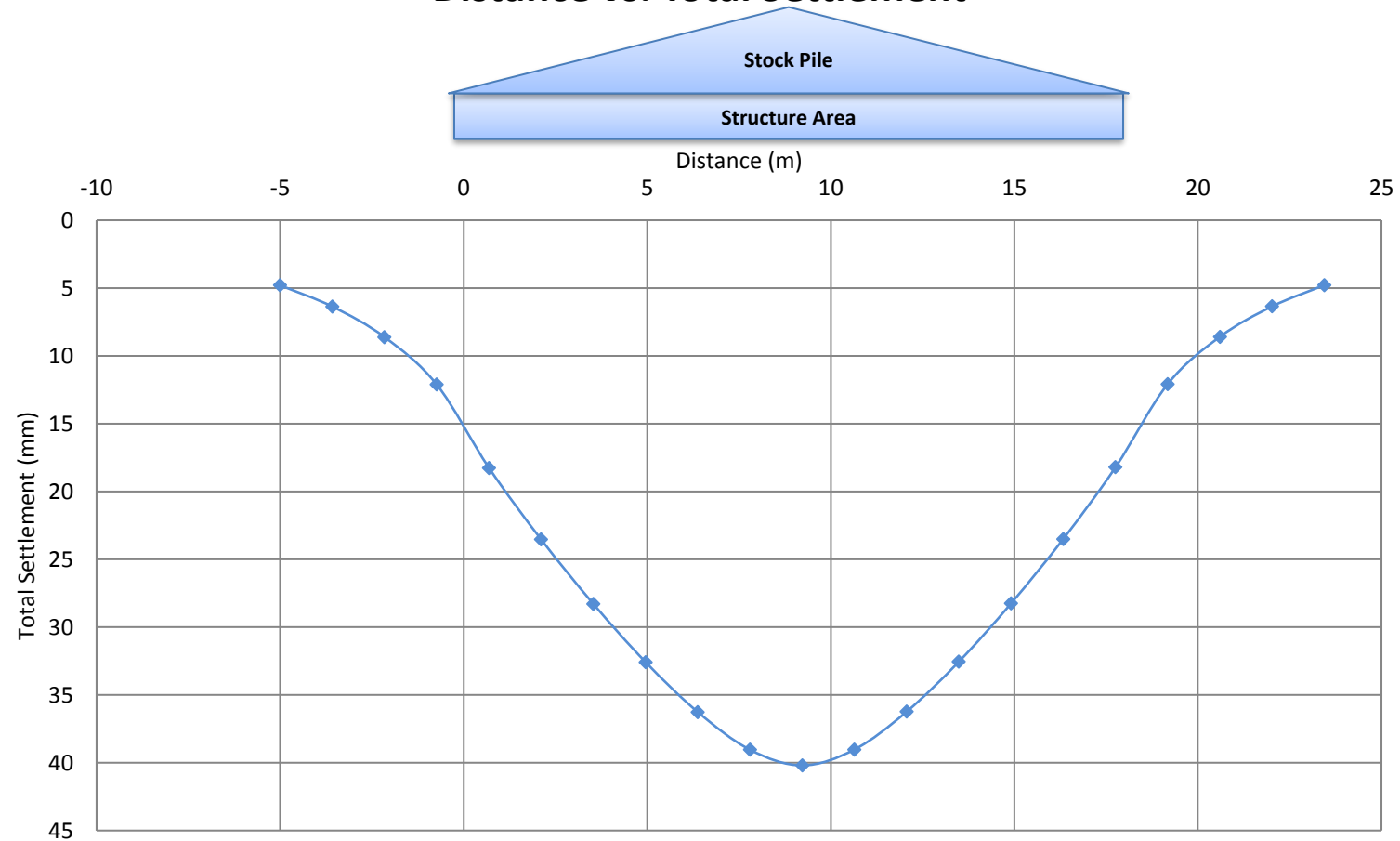
Figure No: F1

Company: exp Services Inc.

Date: June, 2019

File Name: Settlement Analysis – Assignment 10

## Distance vs. Total Settlement



*Project:* FIDR for Powassan Patrol Yard

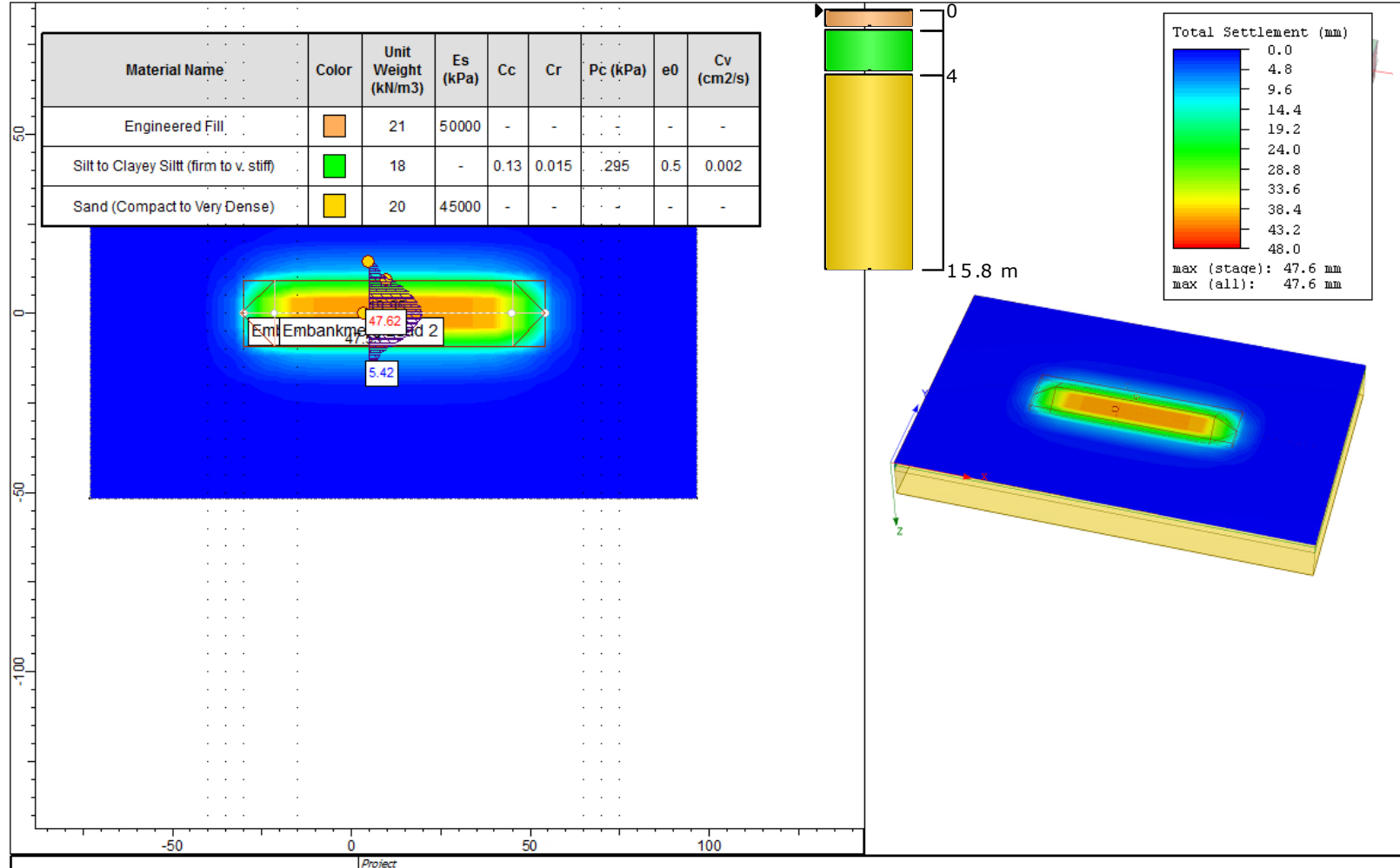
*Analysis Description:* Full loading (North Side) – **Total Settlement**

*Figure No:* F2

*Company:* **exp** Services Inc.

*Date:* June, 2019

*File Name:* Settlement Analysis – Assignment 10



Project: FIDR for Powassan Patrol Yard

Analysis Description: Full Loading on (South Side) – Total Settlement

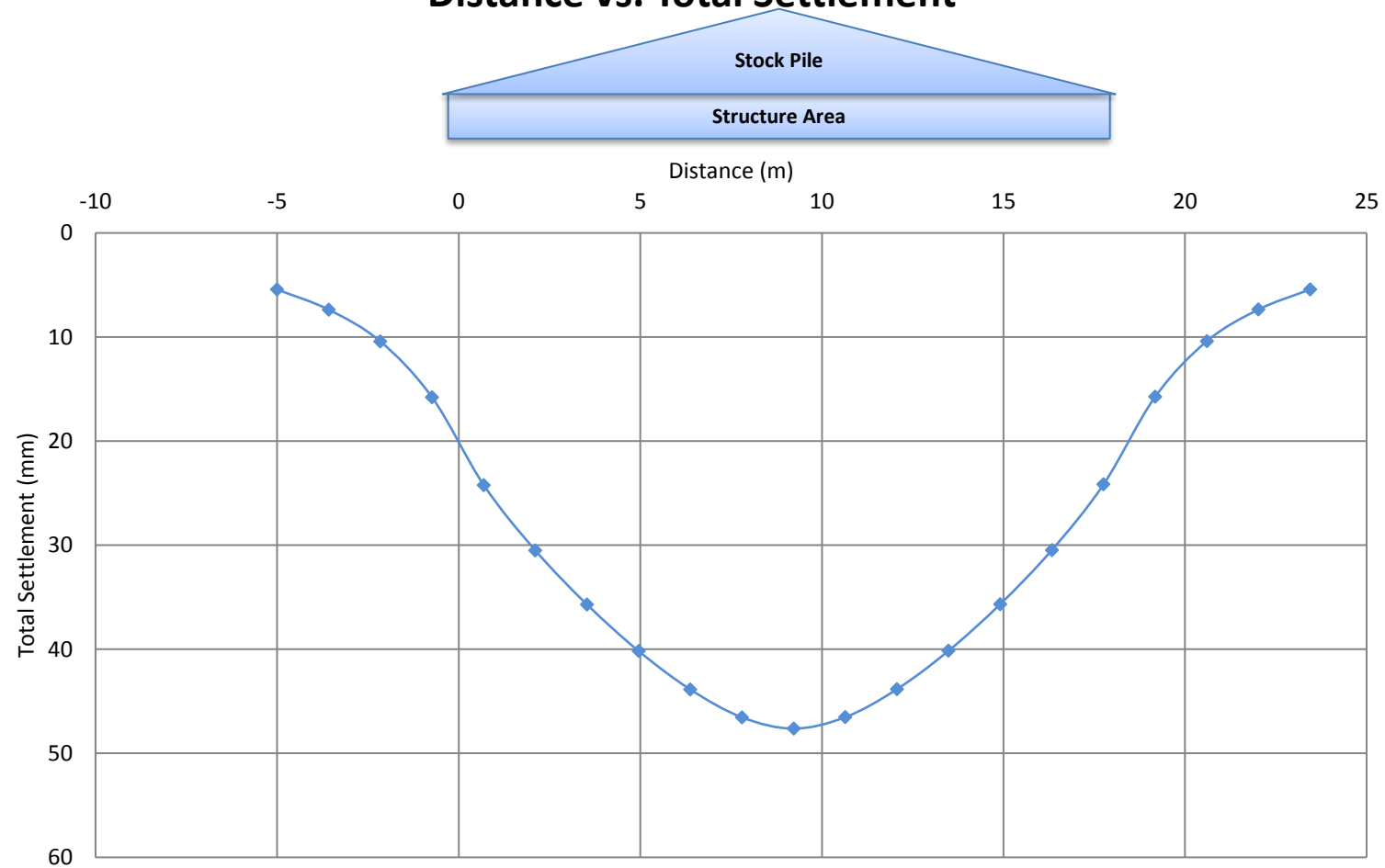
Figure No: F3

Company: exp Services Inc.

Date: May, 2019

File Name: Settlement Analysis – Assignment 10

## Distance vs. Total Settlement



*Project:* FIDR for Powassan Patrol Yard

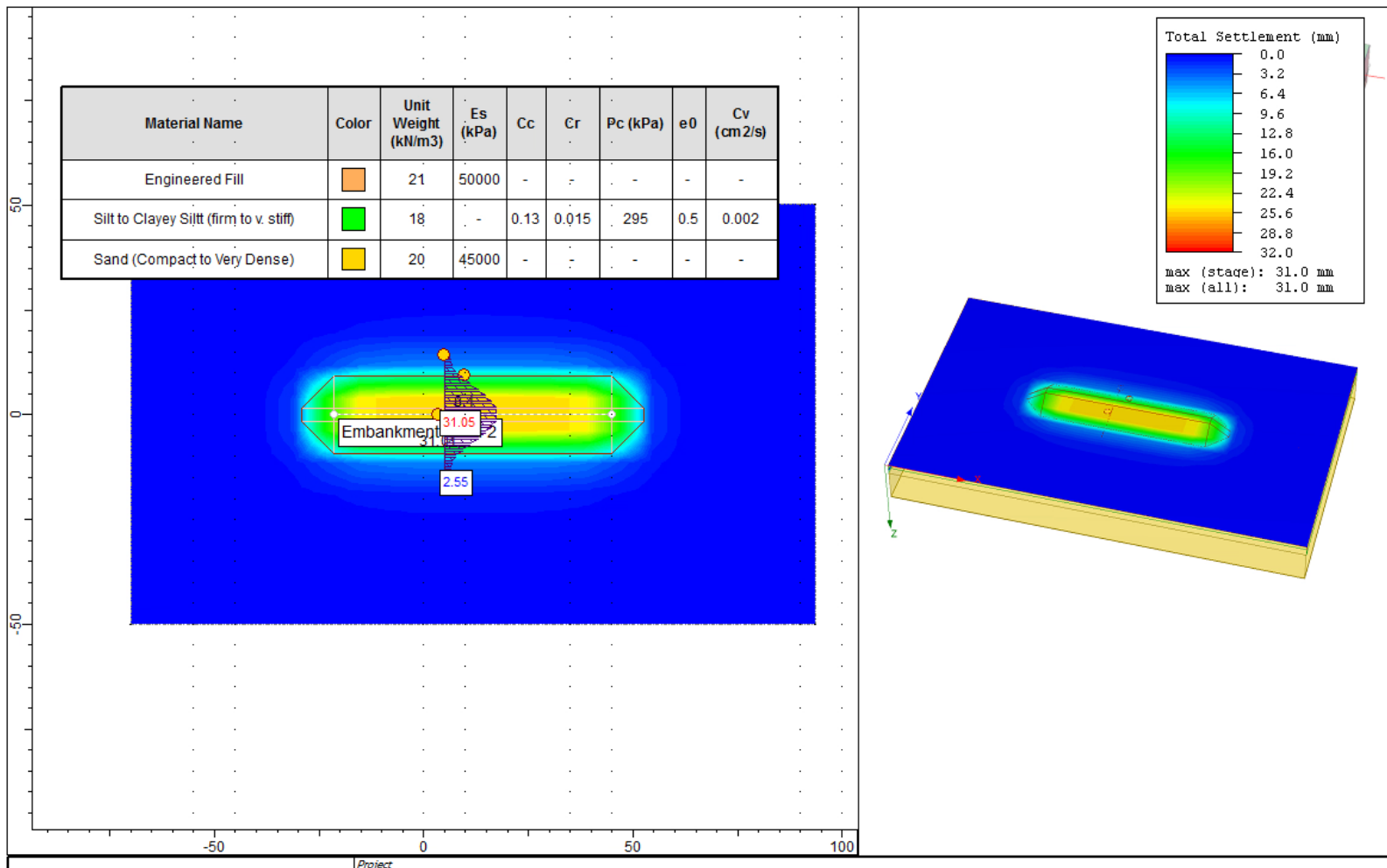
*Analysis Description:* Full Loading on (South Side) – **Total Settlement**

*Figure No:* F4

*Company:* **exp** Services Inc.

*Date:* June, 2019

*File Name:* Settlement Analysis – Assignment 10



Project: FIDR for Powassan Patrol Yard

Analysis Description: Preloading 5 m (South Side) – **Total Settlement**

Figure No: F5

Company: **exp** Services Inc.

Date: June, 2019

File Name: Settlement Analysis – Assignment 10

## **Appendix G – Records of Borehole from Previous Investigation**



## 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 (RQD), 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

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL


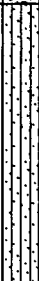
$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
$H$	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
$U$	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_r$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	$e$	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	$n$	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	$w$	1, %	WATER CONTENT	$D$	mm	GRAIN DIAMETER
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	$h$	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	$q$	m <sup>3</sup> /s	RATE OF DISCHARGE
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	$v$	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL				$i$	1	HYDRAULIC GRADIENT

## METRIC

WP 3 Sand / Salt Structures LOCATION Powassan Patrol Yard ORIGINATED BY R.S  
DIST Northern Region HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY R.S  
DATUM Geodetic DATE Sept. 20, 2000 CHECKED BY LF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	STANDARD PENETRATION TEST (N) VALUE		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		UNIT WEIGHT kN/m3	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 <sub>N</sub> W <sub>L</sub>				WATER CONTENT(%) 20 40 60
								✱ FIELD VANE	● LAB VANE					
								◆ POCKET PEN.	○ CONE PENETRATION					
266.07 0.00	Fill, gravelly sand, brown, compact and moist.		1	SS	15		266.0	●					No freestanding water in borehole at end of drilling	
265.47 .60				2	SS		16	265.0	●					
				3	SS		17	264.0	●					
				4	SS		15	263.0	●					
263.02 3.05	Sand,(SP), reddish brown, compact, moist.	5		SS	14		262.0	●						
		6	SS	22	261.0		●							
		7	SS	20	260.0		●							
260.89 5.18		Silty sand (SM), grayish brown, compact to dense, moist.	8	SS	22		259.0	●						
	9		SS	27	258.0		●							
	10		SS	43										
257.84 8.23			11	SS	37									
								END OF BOREHOLE						

# RECORD OF BOREHOLE No 2

METRIC

WP 3 Sand / Salt Structures LOCATION Powassan Patrol Yard ORIGINATED BY R.S  
 DIST Northern Region HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY R.S  
 DATUM Geodetic DATE Sept 20 2000 CHECKED BY J.F

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	STANDARD PENETRATION TEST (N) VALUE		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT 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 (%)					
								FIELD VANE POCKET PEN.	LAB VANE CONE PENETRATION	W <sub>P</sub>	W <sub>N</sub>	W <sub>L</sub>			
266.26 0.00 265.96 .3	Fill, gravelly sand, brown, compact and moist.													Wet condition of soil from 1.52 to 2.28m possibly perched water.  0 40 60 0	
	Silty sand (SM), grayish brown, loose to compact, moist to wet.		2	SS	8										
264.14 2.12	Sand,(SP), reddish brown, compact, moist.													No freestanding water in borehole at end of drilling  1 45 50 4	
			3	SS	20										
			4	SS	28										
			5	SS	33										
259.56 6.70							END OF BOREHOLE								



# RECORD OF BOREHOLE No 3

METRIC






W P 3 Sand / Salt Structures LOCATION Powassan Patrol Yard ORIGINATED BY B.S  
 DIST Northern Region HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY B.S  
 DATUM Geodetic DATE Sept 20, 2000 CHECKED BY J.F

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	STANDARD PENETRATION TEST (N) VALUE		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT			UNIT WEIGHT kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N' VALUES			20 40 60 80 100	25 50 75 100 125	W <sub>p</sub> W <sub>N</sub> W <sub>L</sub>	20 40 60			
253.99 14.32			10	SS	73		254.0							
							END OF BOREHOLE							

# RECORD OF BOREHOLE No4

METRIC

W P 3 Sand / Salt Structures LOCATION Powassan Patrol Yard ORIGINATED BY R.S  
 DIST Northern Region HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY R.S  
 DATUM Geodetic DATE Sept. 20, 2000 CHECKED BY LF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	STANDARD PENETRATION TEST (N) VALUE		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH (kPa)							WATER CONTENT(%)		
							✕ FIELD VANE      ✕ LAB VANE ✧ POCKET PEN.      ○ CONE PENETRATION					W <sub>p</sub> W <sub>N</sub> W <sub>L</sub>					
							20   40   60   80   100 25   50   75   100   125					20   40   60					
266.22																	
266.14 .08	Fill, gravelly sand, brown, compact and moist.		1	SS	2		266.0	•							Wet condition of soil from 2.13 to 3.65m possibly perched water.		
								265.0									
					2	SS	11		264.0	•							
	Silty sand with trace of clay (SM-ML), grayish brown, loose to compact, moist.		3	SS	13		263.0	•						"N" values not reliable, pushing something but still recovering small samples. Samples 5 to 8.			
								262.0									
					4	SS	11		261.0								
263.33 2.89	Silty sand (SM) with occassional cobble or boulder. Grayish brown, loose to compact, moist to wet.						260.0							No freestanding water in borehole at end of drilling			
								259.0									
					5	SS			258.0	•							
	Sand,(SP), reddish brown, compact, moist.		6	SS										END OF BOREHOLE			
					7	SS											
			8	SS													
					9	SS	26										
259.22 7.0																	
257.99 8.23																	