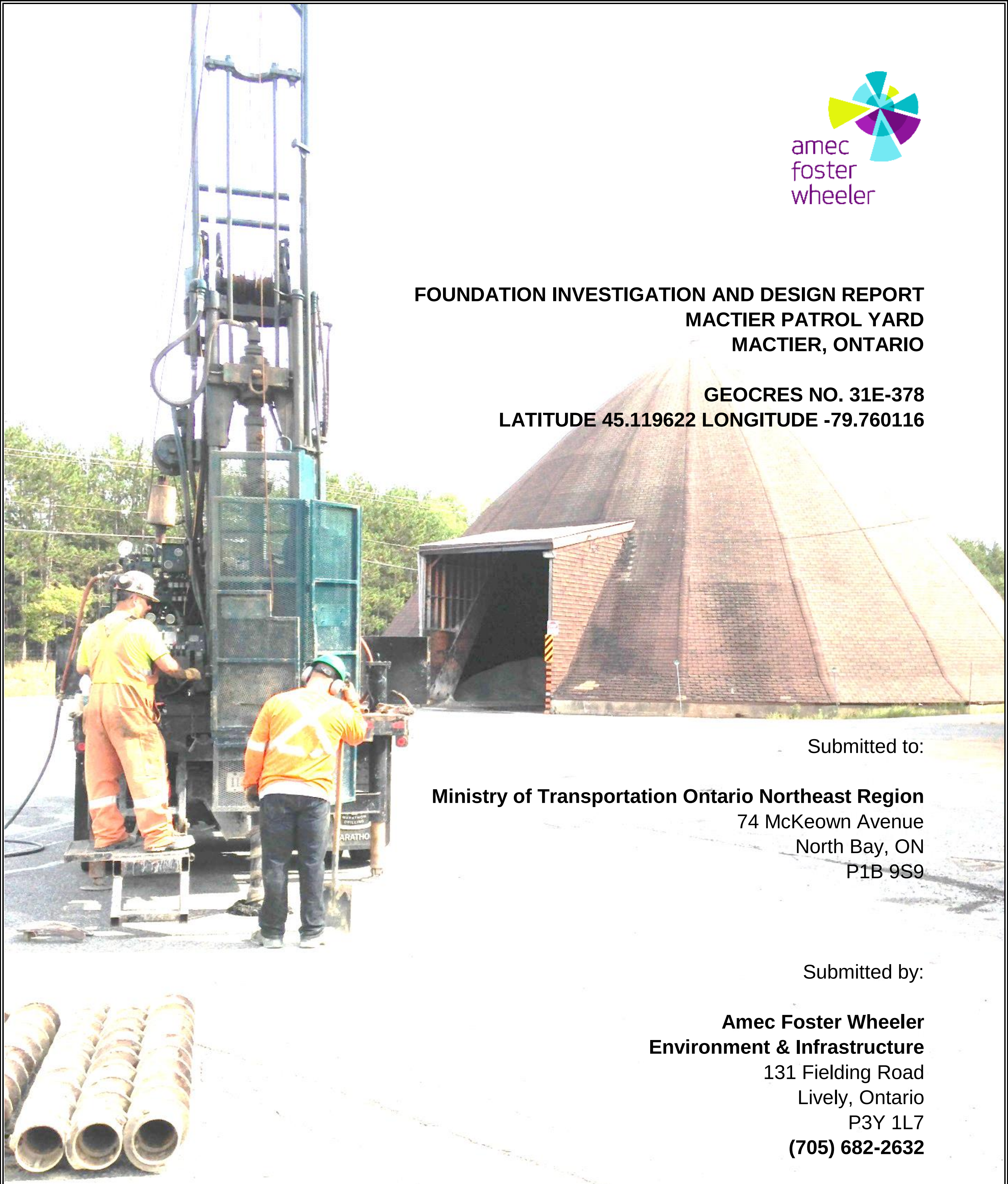

FOUNDATION INVESTIGATION AND DESIGN REPORT
MACTIER PATROL YARD
MACTIER, ONTARIO

GEOCRES NO. 31E-378
LATITUDE 45.119622 LONGITUDE -79.760116

Submitted to:

Ministry of Transportation Ontario Northeast Region
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February 07 2017
Amec Foster Wheeler Project No.: **TY163014**

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PART A

FOUNDATION INVESTIGATION REPORT
MACTIER PATROL YARD
MACTIER, ONTARIO

1.0 INTRODUCTION

1.1 Background

Amec Foster Wheeler Environment & Infrastructure (Amec Foster Wheeler) has been retained by The Ministry of Transportation Ontario, Northeast Region (MTO), for provision of foundation engineering services at six Patrol Yards as part of the Assignment No. 5015-E-0064.

This report addresses the results of the subsurface investigation carried out by Amec Foster Wheeler at the MTO MacTier Patrol Yard, located on the west side of Muskoka Road 11 (High Street) in MacTier, Ontario as shown on Drawing 1.

The terms of reference and scope of work for the foundation engineering services are outlined in MTO's Request for Quotation (RFQ), and associated Addendum and clarification responses for the Assignment.

The purpose of this investigation was to determine the subsurface and groundwater conditions as well as relevant soil properties within the subject site in order to provide recommendations for the foundation design aspects of the proposed development at the yard. Amec Foster Wheeler understands the MTO plans to construct a new sand/salt storage building structure at the MacTier Patrol Yard. This structure is to have an approximate area of 432 m^2 (18 m by 24 m), as shown on Drawing 1.

1.2 Site Description

The patrol yard is located in MacTier within the Township of Georgian Bay, Ontario. The entrance to the site is at the intersection of Muskoka Road 11 (High Street), and Curling Club Road approximately 4.4 km northeast of the intersection of Lake Joseph Road and Highway 69. The latitude and longitude coordinates for the site are Latitude 45.119622 and Longitude -79.760116.

At the time of the investigation, two salt/sand storage domes were located at the south portion of the Patrol Yard. One office/garage building was located to the north of the domes, adjacent to the site entrance. The remaining areas of the yard were generally vacant land, stockpile areas, and vehicle parking areas. Photographs of the site are included in Appendix A.

The proposed new structure is planned to be constructed between the most westerly sand/salt dome and the MTO office/garage as shown on Drawing 1.

1.3 Site Geology

The general surficial geology in the area of the site, can be characterized as coarse textured glaciolacustrine sand and gravel deposits with minor deposits of sands and silts overlying bedrock, according to Ministry of Northern Development and Mines (MNDM) "Surficial Geology" map, The bedrock in the area of the site can be described as Precambrian (Proterozoic): aged migmatitc rocks and gniesses of undetermined protolith according to MNDM "Geology Survey August 2003, 1:250,000 Bedrock Geology of Ontario" map. The area is located in the Grenville geological province.

2.0 INVESTIGATION PROGRAM

2.1 Soil Drilling Investigation

The fieldwork at the site was carried out on September 20 and 21, 2016, when five boreholes (BH16-01 to BH16-05) were advanced within the proposed maintenance structure footprint to depths between 3.6 m and 12.1 m below the existing ground surface.

The borehole locations (referenced to the MTM NAD83 Zone 10 northing and easting co-ordinate system), the ground surface elevations (referenced to Geodetic datum) and the drilled depths are summarized below and are shown on Drawing 1.

Table 1: MacTier Borehole Summary

Approximate Area	Borehole Designation	Location (MTM NAD83 Zone 10)		Ground Surface Elevation (m)	Borehole Depth[1] (m)
		Northing (m)	Easting (m)		
Northeast Corner	BH16-01	4,997,724	284,377	242.7	10.1
Southwest Corner	BH16-02	4,997,693	284,359	241.2	12.4
Northwest Corner	BH16-03	4,997,714	284,351	242.2	3.6
Centre	BH16-04	4,997,707	284,370.	242.0	12.1
Southeast Corner	BH16-05	4,997,703	284,385	241.7	11.3

1 – Depth includes depth of coring.

The ground surface elevation at the borehole locations were surveyed by Amec Foster Wheeler personnel. The existing footing of the MTO Garage with a known elevation of 242.870 m was used as a local benchmark. The borehole locations were also geo-referenced to MTM co-ordinates using a hand-held Global Positioning System (GPS) unit. The elevation and GPS co-ordinates can also be found on the Record of Borehole sheets.

The boreholes were advanced using hollow stem augers and conventional soil sampling methods under the supervision of an Amec Foster Wheeler technician, providing soils information along with relative soil density under the direction of the Amec Foster Wheeler project manager. Soil samples were collected at predetermined depth intervals in accordance with Standard Penetration Testing (SPT) procedures (ASTM D-1586) utilizing a mechanical hammer. Test results are recorded on the Record of Borehole sheets as 'N'-values. These values provide an indication of the various soil strata's condition with respect to compactness or consistency. The samples were placed in plastic bags and delivered to Amec Foster Wheeler's geotechnical laboratory in Sudbury for further examination and testing. One soil sample was submitted to AGAT Laboratories in Mississauga, Ontario, for analytical testing for pH, chlorides, sulphates and resistivity.

2.2 Laboratory Testing

In accordance with the TOR and Amec Foster Wheeler's proposal for this investigation, the following laboratory tests were conducted:

- Natural water content (41)
- Grain size distribution (11)
- Hydrometer (5)
- pH, chlorides, sulphates, resistivity (1)

The results of in-situ and laboratory tests are presented in the Record of Boreholes in Appendix B. The grain size distribution curves and plasticity chart, and the results of soil corrosivity tests are included in Appendix C

3.0 SUB-SURFACE CONDITIONS

A summary of the subsurface conditions encountered in the boreholes is presented below and the Record of Borehole sheets are included in Appendix B.

3.1 Asphalt

Surficial asphaltic concrete pavement was encountered in Boreholes BH16-01, BH16-04 and BH16-05. Asphalt was not present at Boreholes BH16-02 and BH16-03. The thickness of the asphalt was approximately 75 mm at the borehole locations.

3.2 Fill

An approximately 0.6 m thick layer of sand fill containing trace gravel was encountered below the asphalt in Boreholes BH16-01 and BH16-05. Sand fill was present at the ground surface at Boreholes BH16-02 and BH16-03. The fill thickness at these two boreholes was between 0.7m and 0.9 m. Measured SPT 'N' values within the fill ranged from 16 blows to 43 blows per 0.3 m of penetration, indicating a compact to dense compactness.

Laboratory testing on selected fill samples measured water contents ranging from 3% to 7% of the material's dry weight.

3.3 Sand

Sand was encountered below the asphalt in Borehole BH16-04 and underlying the fill in Boreholes BH16-01, BH16-02 and BH16-03. The sand consisted of trace gravel and trace to some silt. The deposit extended to depths ranging from 3.1 m to 7.6 m (Elevation 239.2 m to 233.6 m). The colour of the deposit changed with depth from orange/yellow sand, which was encountered in the first metre, to brownish grey sand with depth.

SPT 'N' values measured within the deposit ranged between 13 blows and 40 blows per 0.3 m of penetration, indicating a compact to dense compactness, predominantly compact to dense. The natural moisture content, as measured for collected split spoon samples recovered from the boreholes ranged from 3% to 21%.

Seven grain size distribution tests were completed on selected samples of the deposit, the results are as follows:

- Gravel (%): 0 to 5
- Sand (%): 81 to 95
- Silt and Clay Size (%): 3 to 19

The grain size distribution curves are presented in Appendix C.

3.4 Silty Sand

Silty sand was encountered below the fill in Borehole BH16-05. The silty sand consisted of trace gravel. The deposit extended to 7.6 m depth (Elevation 234.1).

SPT 'N' values measured within the deposit ranged between 8 blows and 45 blows per 0.3 m of penetration, indicating a loose to dense compactness, predominantly compact to dense. The natural moisture content, as measured for collected split spoon samples recovered from the boreholes ranged from 7% to 22%.

Two grain size distribution tests were completed on selected samples of the deposit, the results are as follows:

- Gravel (%): 0 to 1
- Sand (%): 61 to 69
- Silt and Clay Size (%): 30 to 39

The grain size distribution curves are presented in Appendix C.

3.5 Silty Sand (Till)

A layer of silty sand till, trace gravel was encountered below the sand in Boreholes BH-01 to BH-04. The layer ranged in thickness from 0.4 m to 3.3 m, extending to the termination depth of each of the four boreholes, where refusal to the drilling equipment on possible cobbles/boulders or bedrock was encountered. SPT 'N' values within the silty sand till ranged from 18 blows per 0.3 m of penetration to greater than 50 blows per 0.25 of penetration indicating a compact to very dense condition.

The natural moisture content, as measured for selected samples of the silty sand till ranged from 9% to 21%. One grain size distribution test was completed on a split spoon sample collected of the silty sand, the results are as follows:

- Gravel (%): 0
- Sand (%): 70
- Silt (%): 30

The grain size distribution curve is presented in Appendix C.

Three atterberg limits tests were attempted on the silty sand on the split spoon samples collected of the silty sand till and the results indicated that the fine portion of the silty sand till is non-plastic.

3.6 Sand (Till)

Sand till, some silt and some gravel was encountered below the silty sand in Borehole BH-05. The thickness of the sand till layer was 3.7 m, extending to the termination depth of the borehole, where refusal to the drilling equipment on possible cobbles/boulders or bedrock was encountered. SPT 'N' values within the sand till ranged from 17 blows to 61 blows per 0.3 m of penetration indicating a compact to very dense condition.

The natural moisture content, as measured for selected samples of the sand till ranged from 14% to 20%. One grain size distribution test was completed on a split spoon sample collected of the sand till, the results are as follows:

- Gravel (%): 11
- Sand (%): 77
- Silt (%): 12

The grain size distribution curve is presented in Appendix C.

3.7 Bedrock

Bedrock was inferred by auger refusal in Boreholes BH16-03 and BH16-05 and was confirmed by coring in Boreholes BH16-01, BH16-02, and BH16-04. The bedrock coring was extended to the borehole termination depths ranging from 10.1 m to 12.4 m below the existing ground surface (Elevation 232.6 m to 228.8 m). The bedrock is comprised of Precambrian (Proterozoic) aged migmatitc rocks and gneisses of the Central Gneiss Belt. The Total Core Recovery (TCR) ranged from 67% to 100% and the Solid Core Recovery (SCR) ranged from 25% to 100%. The Rock Quality Designation (RQD) varied between 0% and 100%, with RQD quality increasing with depth in all boreholes, indicating a rock mass quality of very poor' to excellent.

Photographs of the rock core are included in Appendix B.

3.8 Groundwater Conditions

Upon completion of drilling, groundwater was measured at a depth of between 3.9 m and 5.7 m below the existing grade. Coring was completed using drilling fluid in Boreholes BH16-01, BH16-02 and BH16-04. The use of the drilling fluid is expected to temporarily raise the groundwater level at the borehole locations where rock coring was carried out. The water level was measured twice in Borehole BH16-01, upon completion of drilling and several hours following completion. The water level was also measured twice in Borehole BH16-02, upon completion of drilling and the next morning upon arrival to site. The groundwater measurements are shown on the Record of Borehole sheets and are summarized below. In both boreholes, the water level dropped between 0.7 m and 0.8 m between the two water level measurements.

The groundwater at the site is expected to fluctuate seasonally and can be expected to be somewhat higher during the spring months and in response to major weather events.

Table 2: MacTier Groundwater Measurements

Approximate Area 1	Borehole Designation	Location (MTM NAD83 Zone 10)		Ground Surface Elevation (m)	Water Level Depth Below Ground Surface[1] (m)
		Northing (m)	Easting (m)		
Northeast Corner	BH16-01	4,997,724	284,377	242.7	3.9 and 4.7
Southwest Corner	BH16-02	4,997,693	284,359	241.2	4.0 and 4.7
Northwest Corner	BH16-03	4,997,714	284,351	242.2	N/A
Centre	BH16-04	4,997,707	284,370	242.0	4.7
Southeast Corner	BH16-05	4,997,703	284,385	241.7	5.7

1 – BH16-01 and 02 water level measurements were taken 2 times (once at borehole completion and once several hours later).

3.9 Analytical (Chemical) Test Results

Split spoon sample number 4 from BH16-04 was sent to an independent laboratory for analytical testing comprising pH, sulphate, resistivity and chloride determination and is presented in Appendix D.

4.0 CLOSURE

This Foundation Investigation Report was prepared by Nicholas Kicz, EIT, and reviewed by Mr. Mehdi Mostakhdemi, M.Sc., P.Eng. Mr. Ty Garde, M.Eng, P.Eng., a Designated MTO Foundations Contact for Amec Foster Wheeler, conducted an independent review of this report.

Respectfully submitted,

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PART B

FOUNDATION DESIGN REPORT
MACTIER PATROL YARD
MACTIER, ONTARIO

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 General

This section of the report provides foundation design recommendations for the proposed MTO Patrol Yard structure in MacTier and is based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigations at this site. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess/evaluate the design of the existing structure foundations.

It is understood that a new salt/storage maintenance structure is proposed for the site. The proposed structure is about 18 m wide and 24 m in long, with a concrete foundation wall, timber side walls, steel roof, and finished with an interior 50 mm asphalt floor and/or slab on grade. The proposed building will consist of a conventional building structure for storage of sand and salt, and will allow for inside loading and dumping.

Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

It is understood that the Foundation Investigation and Design Reports (FIDR) prepared for this assignment will be included in the design-build contract as a reference document. This FIDR is for planning purposes only and the Design/Build proponent shall satisfy themselves as to the sufficiency of the available information and supplement the information as needed to meet the requirements for detail design. The Design/Build proponent is solely responsible for selecting the appropriate foundation alternatives for the project and other aspects of the design and construction.

5.2 Site Preparation and Engineered Fill Construction

The areas within the limits of the proposed building should be stripped and cleared of surface vegetation, topsoil, and/or construction debris prior to construction. These materials are not suitable to support the building foundations, floor slabs, and/or any engineered fill and should be excavated and backfilled with engineered fill comprised of Granular A or Granular B Type II placed and compacted in accordance with OPSS 501 Construction Specification for Compacting, and SP 105S21 Amendment to OPSS 501 – Quality Control for Compaction, Method B.

Following stripping of the unsuitable surficial soils, the prepared subgrade should be heavily proof-rolled. The required extent of stripping of any loose granular soils, softened, upper portions of the native non-cohesive deposits will need to be determined based on the proofrolling and inspection.

Soils that are more than about 2 percent above their optimum water content for compaction or contain significant quantities of organics are not considered suitable for use as engineered fill. Following proof rolling and approval of the subgrade, engineer approved fill should be placed in maximum 300 mm thick loose lifts and uniformly compacted to at least 100 percent of the fill materials SPMDD. The final lift of engineered fill beneath conventionally loaded floor slabs should consist of a minimum thickness of 150 mm of Ontario Provincial Standard Specifications (OPSS) Granular A material, uniformly compacted to at least 100 percent of its Standard Proctor maximum dry density (SPMDD).

Care will be required to ensure that the prepared area extends far enough to encompass the limits of the engineered fill. The engineered fill limits are defined such that the fill extends to at least one metre beyond the outside edge of the founding level of any footing/pad or other settlement sensitive area and then downward and outward at a slope of one horizontal to one vertical.

It is emphasized that engineered fill employed during winter months should be carefully placed to ensure that any frozen material is removed prior to placement of additional lifts. Also, construction methods should be reviewed and designed to minimize any disturbance to the top of the approved fill pad(s), otherwise the materials can be disturbed and cause increase settlement of structures.

The final surface of the engineered fill should be protected as necessary from construction and foot traffic, and should be sloped to provide positive drainage for surface water during the construction period. If the engineered fill materials will be left exposed (i.e. uncovered) during periods of freezing weather, consideration should be given to placing an additional temporary soil cover above final subgrade to provide for frost protection.

Special care should be taken to ensure adequate compaction around columns and adjacent to foundation walls. Slab-on-grade floor systems should be structurally separate from the foundation walls and columns and sawcut control joints should be provided at regular intervals and along column lines to minimize shrinkage cracking and to allow for normal differential settlement of the floor slabs.

Where the ground floor slabs for the buildings are established at least 0.15 m above the level of the exterior final grade, no perimeter drainage at the footing level is required and the exterior foundation walls may be backfilled with materials free of existing fill, topsoil, organics and other deleterious materials carefully placed in lifts and compacted. The native soils are considered suitable for re-use as foundation wall backfill provided that these materials are free of organics, any boulders or cobbles greater than 150 mm in size are removed and that these materials are at suitable water content for compaction. Where the backfill against the exterior walls is to support settlement sensitive structures, such as concrete slabs, pavements or sidewalks, it should consist of fill approved by the geotechnical engineer and uniformly compacted to at least 100 percent of the materials' SPMDD inside the building and 98 percent SPMDD on the outside of the building.

5.3 Building and Perimeter Retaining Wall Foundation

Based on the subsurface conditions at this site, both shallow and deep foundation options have been considered for support of the building and perimeter retaining wall foundations. The bedrock surface appears to be sloping at the site with its highest elevation at about 238.6 m. Therefore, deep foundations may not be practical due to the shallow thickness of the overburden at some locations at the site.

A summary of the advantages and disadvantages associated with each option is provided below:

- **Spread footings and/or Slab on grade:** Spread footings are feasible due to presence of compact to dense sand at shallow depths at the site and are further discussed in the report.
- **Steel H-piles driven to found on the bedrock:** Driven steel H-piles are feasible for support of building foundations and perimeter wall foundations at this site. However, for lightly loaded piles on the west side of the site, where Borehole BH16-03 was advanced, the depth to the bedrock may not be enough to develop sufficient skin friction to resist the effects of the frost jacking. This option was not further discussed in this report.
- **Caissons founded in the bedrock:** Caissons founded in the bedrock are also feasible for support of building foundations and perimeter wall foundations at this site. However, for lightly loaded piles on the west side of the site, where Borehole BH16-03 was advanced, the depth to the bedrock may not be enough to develop sufficient skin friction to resist the effects of the frost jacking. Installation of caissons through sands would also require temporary liners to control the instability of the side walls and to control the groundwater seepage into the hole during construction. This option was not further discussed in this report.

The following sections provide recommendations for foundation design of the proposed building and its perimeter walls. Based on the subsurface conditions at the site and the above considerations, the preferred foundation design option from a geotechnical/foundations perspective is to support the proposed building and the perimeter retaining walls on shallow foundations (spread footings).

5.4 Shallow Foundations

5.4.1 Founding Elevations

Based on the borehole information, the anticipated loads from the proposed building foundations can utilize conventional spread footings founded on the undisturbed, native, compact to dense sand. The bearing soils are anticipated to consist mostly of compact sand.

For support of the proposed foundations, strip or spread footings should be founded below any fill and ideally below any loose near-surface soils, on compact to dense sand. The following maximum (highest) founding elevations are recommended for design of shallow foundations:

Table 3: Recommended Founding Elevations

Borehole Designation	Maximum (Highest) Founding Elevation (m)	Depth below Existing Grades (m)
BH16-01	241.1	1.6
BH16-02	239.6	1.6
BH16-03	240.6	1.6
BH16-04	240.4	1.6
BH16-05	240.1	1.6

The founding elevations given above will require excavation to a depth of 1.6 m below the existing grades to provide adequate frost protection, as discussed further in Section 4.6, below.

The footing subgrade should be inspected by a Quality Verification Engineer following excavation, in accordance with provincial standards to confirm that all existing fill, loosened sand or other unsuitable material have been removed. The founding soils will be susceptible to disturbance. If the concrete for the footings cannot be poured immediately after excavation and inspection, it is recommended that a concrete working slab be placed on the prepared subgrade within four hours of its inspection and approval.

5.4.2 Geotechnical Resistances/Reactions

Strip or spread footings placed on the properly prepared subgrade, at or below the design elevations given in the preceding section, should be designed based on the factored geotechnical resistances at Ultimate Limit States (ULS) and geotechnical reaction at Serviceability Limit States (SLS) given below assuming a "Typical" degree of understanding for both bearing and settlement in accordance with Table 6.2 – Geotechnical Resistance Factors, $Ø_{gu}$ and $Ø_{gs}$, for Ultimate and Serviceability Limit States, Respectively, and for Various Degrees of Site Understanding, from Section 6 – Foundations and Geotechnical Systems, of the Canadian Highway Bridge Design Code (CHBDC) 2014:

Table 4: Factored Geotechnical Resistances/Reactions

Founding Stratum	Footing Width (m)	Factored Geotechnical Resistance at ULS	Geotechnical Reaction at SLS[1]
Compact to dense sand	1 to 2	320 kPa	300 kPa

1 - For 25 mm of settlement

The geotechnical resistances should be reviewed if the selected footing width or founding elevation differs from those given above. In addition, these geotechnical resistances are provided for loads applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Section 6.10.4 of the CHBDC 2014.

A geotechnical engineer must inspect/approve the foundation base prior to placement of the granular fill (if required) or the structural concrete. This is necessary to confirm the founding conditions are consistent with the finding of this report, and to review the foundation construction procedures, etc.

5.4.3 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral loads (sliding resistance) between the base slab or concrete footings for the proposed structure and the subgrade should be calculated in accordance with Section 6.10.5 of the CHBDC 2014. A coefficient of friction (tan f') of 0.5 may be used in the sliding assessment between spread footings founded on compact sand. The above coefficient of friction is un-factored and a resistance factor of 0.8 should be applied in accordance with Table 6.2 of CHBDC 2014 based on the available subsurface conditions.

The factored horizontal geotechnical resistance, H_{ri} or H_{rs}, as follows:

$$H_{rs} = \psi\phi_{gu}(0.8A'c' + 0.8V\tan\varphi') > H_f$$

Where:

A' Effective contact area (m^2)

C' Nil

$\tan\varphi'$ Coefficient of internal friction for soil close to the underside of the spread/strip footing

V Unfactored vertical force (kN)

H_r Unfactored horizontal load (kN)

ψ Consequence factor (1.0)

ϕ_{gu} Geotechnical resistance factor (0.8)

5.4.4 Slab on Grade

It is understood that the floor of the new sand/salt storage building may be either an asphalt pavement or a concrete slab-on grade. The design of the asphalt pavement floor surface is outside of the scope of work for this assignment.

Slab-on-grade construction for a floor slab will be permissible at this site provided that organics, asphalt, fill materials and all other unsuitable soils be removed from the site. If the existing grade is to be raised, the subgrade should then be proofrolled prior to placing under floor fill. If contaminated or soft spongy areas are intercepted, they should be sub-excavated and replaced with compacted fill. All under floor fill should comprise clean, well graded, sand and gravel, compacted to 95% of the standard Proctor maximum dry density.

The modulus of vertical subgrade reaction (k_{vb}) is not a fundamental soil property, and the value changes with footing size. The current state of practise uses a standard reference vertical subgrade reaction k_{v1} associated with a 1 ft^2 plate (305 mm by 305 mm). For foundations on granular (non-cohesive), the modulus of vertical subgrade reaction can be estimated from the equations given below (CFEM, 2006).

$$k_{vb} = k_{v1}\left[\frac{b+0.3}{2b}\right]^2$$

where k_{vb} is the modulus of vertical subgrade reaction for actual foundation dimension, b (MPa/m);
k_{v1} is the modulus of vertical subgrade reaction for a 1 ft. x 1ft. plate (MPa/m);
b is the foundation width (m)

Based on the subsurface information a modulus of vertical subgrade reaction of 40 MPa/m maybe used for a 1 ft^2 plate for design purposes.

5.5 Sub-drainage

The effects of rain, snow, freezing temperatures, excessive drying and the ingress of water to the subgrade beneath the slab-on-grade should be prevented as much as possible. A sub-drainage system is not required, assuming there are no depressed sections in the building and the asphalt surface will be above the exterior grade.

5.6 Frost Protection

The frost depth in the project area is about 1.6 m according to Ontario Provincial Standard Drawing (OPSD) 3090.101 – Foundation Frost Penetration Depths for Southern Ontario. Therefore, all foundations exposed to seasonal freeze and thaw (external foundations and foundations in un-heated areas) should be provided with a minimum of 1.6 m of soil cover or equivalent thermal insulation for frost protection purposes. In addition, any bearing soil and fresh concrete should be protected from freezing during cold weather construction.

5.7 Excavation

Where space and construction activities permit the construction of unsupported open-cut excavations, these excavations should be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act (OHSA) for Construction Activities. Based on the OHSA classification system, the soils to be excavated on site would be classified as follow:

Fill Materials	Type 3
Sand above water Table	Type 3
Sand below water Table	Type 4

Shallow temporary unsupported excavations (i.e. those that are open for a relatively short time period) which are above the water table at the site should be made with side slopes no steeper than 1H:1V. Stockpiles of excavated materials and heavy construction equipment should be kept at least the same horizontal distance from the edge of excavation as the depth of the excavation to prevent local instabilities. Where groundwater is encountered the soil should be considered as Type 4, unless the soils are dewatered by positive methods. For Type 4 soils an excavation slope of 3H:1V, or flatter, is required from the base for excavations, in accordance with the OHSA.

5.8 Seismic Considerations

Section 4 of the CHBDC 2014 contains updated seismic analysis and design methodology. The CHBDC 2014 method uses a site classification system defined by the average soil/bedrock properties (e.g. shear wave velocity, Standard Penetration Test (SPT) resistance, undrained soil shear strength etc.) in the top 30 metres below the foundation level. There are 6 site classes from A to F, decreasing in ground stiffness from A, hard rock, to E, soft soil; with site class F used to denote other soils (e.g., sites underlain by thick peat deposits, high plastic clays, liquefiable soils, etc.). The site class is then used to obtain acceleration and velocity-based site coefficients F(PGA) and F(PGV), respectively, for the effects of site-specific soil conditions in design. The new approach of the CHBDC is generally in agreement with the Ontario Building Code (OBC) 2012, Part 4.

Based on the results of this investigation, a Site Class of D for “Stiff Soil” is recommended for seismic design purposes at this site as determined based on Section 4.4.3.2 of CHBDC 2014.

5.8.1 Seismic Analysis Coefficient

The Peak Ground Acceleration Ratio (PGA), Peak Ground Velocity (PGV), and the 5% damped spectral response acceleration values shall be determined for the 475-year, 975-year, and 2475-year return periods in accordance with Section 4.4.3.1of the CHBDC 2014.

The corresponding acceleration coefficients associated with return periods of 475 years, 975 years and 2475 years of ground motion for Site Class C at the project site are estimated and summarized in the following table:

Table 5: Seismic Parameters of Site

Return Period (Years)	Possibility of Exceedance	Coefficient of PGA	Coefficient of PGV	5% Damped Spectral Response Acceleration for a Period of 0.2 s, $S_a(0.2)$
475	10% in 50 years	0.027	0.027	0.050
975	5% in 50 years	0.041	0.042	0.073
2475	2% in 50 years	0.064	0.066	0.109

Note: Values obtained from the site Class C of Earthquakes Canada

5.8.2 Earthquake Induced Lateral Earth Pressures for Perimeter Retaining Walls

In accordance with Section 4.6.5 and C4.6.5 of the CHBDC 2014 and its Commentary (2014), for walls which do not allow lateral yielding, the horizontal seismic coefficient, k_h, used in the calculation of the seismic lateral earth pressure coefficient, is taken as equal to the seismic horizontal acceleration coefficient at zero wall movement. For structures which allow lateral yielding (i.e. the wing walls for this structure), k_h is taken as half of the seismic horizontal acceleration coefficient that corresponds to zero wall movement. The seismic vertical acceleration coefficient k_v in both cases should be ignored.

The granular backfill for the retaining wall may be placed either in a zone with width equal to at least 1.2 m behind the back of the wall stem (Case I) or within the wedge shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing (Case II).

The following seismic active pressure coefficients (K_{AE}) and seismic passive pressure coefficients (K_{PE}) for the two backfill cases (Case I to Case II) may be used in design for a return period of 2,475 years; these coefficients reflect the maximum K_{AE} and the minimum K_{PE} obtained using the k_h values as described above. It should be noted that these seismic earth pressure coefficients assume that the back of the wall is vertical; condition of the ground surface behind the wall is assumed to be flat. Where sloping backfill is present above the top of the wall, the lateral earth pressures under seismic loading conditions should be calculated by treating the weight of the backfill located above the top of the wall as a surcharge. Different values of K_{AE} and K_{PE} should be estimated separately for the conditions, if applicable.

Table 6: Lateral Earth Pressures

Seismic Active Pressure Coefficient (K_{AE})			
Wall Type	**Case I** (pressures are based on the existing overburden soil materials)	**Case II** (pressures are based on granular fill)	
		Granular A or Granular B, Type II	**Granular B, Type I**
Yielding Walls	0.35	0.27	0.30
Non-Yielding Walls	0.38	0.30	0.33
Seismic Passive Pressure Coefficient (K_{PE})			
Wall Type	**Case I**	**Case II**	
		Granular A or Granular B, Type II	**Granular B, Type I**
Yielding Walls	4.18	7.14	5.59
Non-Yielding Walls	4.04	6.92	5.38

5.9 Stability Assessment and Settlement Assessment in Sand/Salt Area

5.9.1 Stability Assessment

To assess the global stability of the storage structure and to check that the minimum factor of safety equal to 1.3 (based on a geotechnical resistance factor of 0.75 for temporary global stability and a degree of understanding of 0.75) will be achievable for the maximum height of the sand stockpile, a slope stability analysis was performed by modelling the scenario, which can be found in Appendix E.

The SLOPE/W computer program developed by GeoSlope international was employed for computation of the factor of safety, using the Morgensten-Price method to illustrate the static slope stability analysis, developed on the basis of limit equilibrium.

The stability was modelled both along the length, and the width of the proposed structure. Based on correspondence with the MTO Foundation staff and typical structural drawings provided to Amec Foster Wheeler by the MTO, the foundation walls were inputted as 3.7 m from ground surface upwards, with a 7.5 m high peak above the wall, providing an approximate angle of repose of 32 degrees. The stratigraphy and groundwater conditions were shown as found in the geotechnical borehole investigation completed for the site as presented in Part A of this report.

The MTO has stated that at this time there are no final plans for what the floor of the proposed structure will be, but it is known that it will either be a slab on grade, or asphalt layer. It is expected that the installed base floor will provide additional stability support for the system.

Table 8 below provides the soil parameters inputted into the stability model analysis to provide the given factor of safety. The soil parameters were generally estimated based on standard range values for soil types and the results of the field and laboratory results.

Table 7: Material Properties for Stability Model

Material Type	Unit Weight (kN/m^3)	Effective Cohesion, c' (kPa)	Internal Angle of Friction, (°)
Sand Pile	18	0	30
Compact to dense Sand & gravel (FILL)	20	0	32
Compact to dense sand to silty sand	20.5	0	32
Compact to very dense non-cohesive till	22	0	32
Engineered Fill	22	0	34

The results of the slope stability analysis, presented in Appendix E, indicate that the factor of safety against slope failure of the subgrade soils below the sand/salt storage pile, is greater than the minimum factor of safety of 1.3.

5.9.2 Settlement Assessment

Based on available information from the MTO and the results of the geotechnical borehole investigation, the sand pile will be placed on the storage building floor, which in turn will be supported by compact to dense fill overlaying native compact to dense sand to silty sand, and a layer of compact to very dense sand to silty sand till over the bedrock at the site.

The ground surface displacements (settlement) as a result of the placement of the sand stockpiles have been estimated using the commercially available computer program Settle-3D from Rocscience.

The contact pressure at the edge of the slab, based on a 3.7 m high wall is 70 kPa. The contact pressure in the centre of the slab is about 200 kPa. The average contact pressure is about 135 kPa has been assumed in the settlement analysis to include the weight of the full sand stockpile. This analysis assumes a sand volume of 3,240 m^3, a unit weight of 18 kN/m^3 for the sand, and a floor area of 432 m^2.

Based on our understanding of the subsurface conditions at the Site and the assumptions described above, the calculated total settlements of the subsoils under the sand pile are indicated in the following table.

Table 8: Settlement at Centre/Edge of Proposed Structure

Stage	Settlement at Centre of Proposed Structure (mm)	Settlement at Edge of Proposed Structure (mm)
After placement of sand pile	22	10

The estimated settlements presented in the above table are considered immediate and are not expected to occur over time as consolidation settlement is not anticipated at the site. We note that the settlement estimates outlined above are approximate only and that some variation in the actual settlements should be expected due to variations in the thickness and compressibility characteristics of the subsurface soils, flexibility/rigidity of the granular pad and uncertainties associated with estimation of soil deformation modulus. The actual settlements are expected to be lower than the values estimated above due to periodic fluctuations in volume (height) of the sand stockpile as well as higher unloading/reloading deformation modulus expected for the subsurface soils at the site. The rebound and settlements after the first loading is anticipated to be between on half and one third of the values presented above.

5.10 Analytical (Chemical) Test Results

Split spoon sample number 4 from BH16-04 was sent to an independent laboratory for analytical testing comprising pH, sulphate, resistivity and chloride determination and the test results are presented in Appendix D and summarized below.

Laboratory testing results for the sample indicates a pH of 7.2, chloride content of 46 µg/g, sulphate content of <2 µg/g and a resistivity value of 7,940 ohm-cm.

The concentration of water soluble sulphate within the soil sample tested does not exceed the limit of 0.1%, above which CSA A.23 recommends the use of sulphate resistant cement. Therefore, sulphate resistant concrete is not required.

Based on Table 3.2 of MTO Gravity Pipe Design Guidelines (GPDG) 2004, the soils have a very low corrosive potential. A more detailed review of these test results should be completed by a corrosion specialist.

6.0 CLOSURE

The Limitations of Report, as presented in Appendix F, forms an integral part of this report.

This Foundation Design Report was prepared by Nicholas Kicz, EIT, and reviewed by Mr. Mehdi Mostakhdemi, M.Sc., P.Eng. Mr. Ty Garde, M.Eng, P.Eng., a Designated MTO Foundations Contact for Amec Foster Wheeler, conducted an independent review of this report.

Respectfully submitted,

Amec Foster Wheeler Environment & Infrastructure,
a Division of Amec Foster Wheeler Americas Limited

Prepared by: :

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Designated MTO Foundations Contact

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

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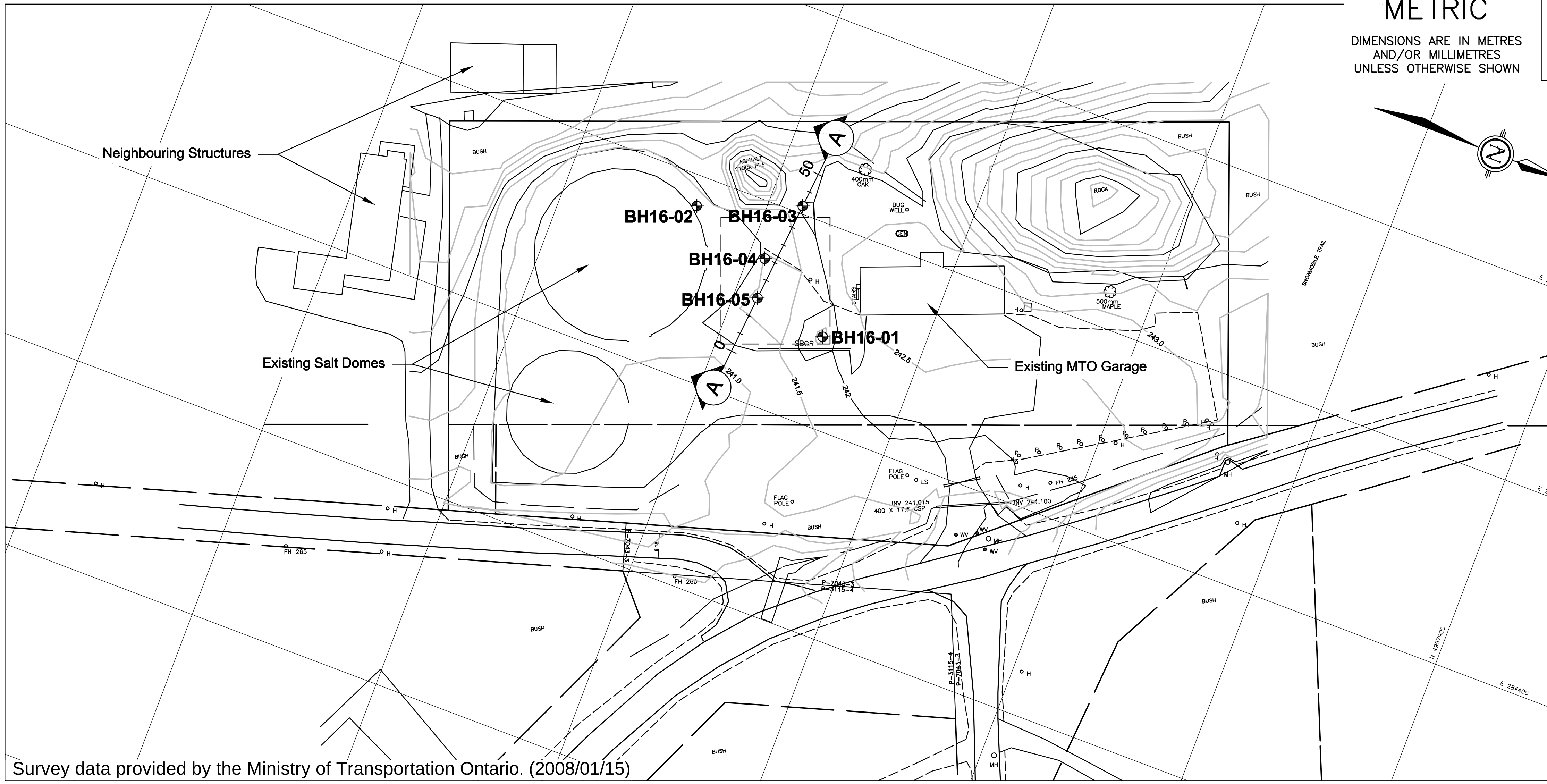
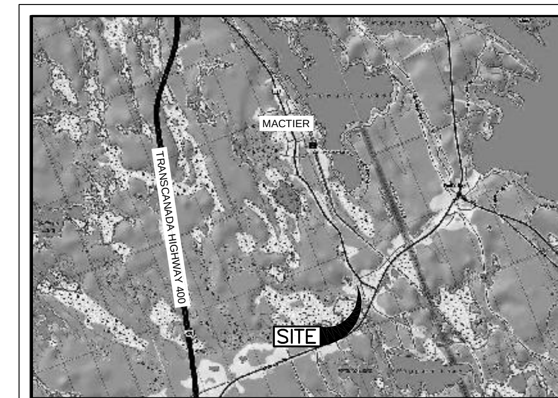
Foundation Investigation and Design
Assignment No. 5015–E–0064
MacTier Patrol Yard
MacTier, Ontario

PROPOSED STORAGE STRUCTURE
BOREHOLE LOCATION PLAN AND
SOIL STRATA SECTION

DRAWING 1

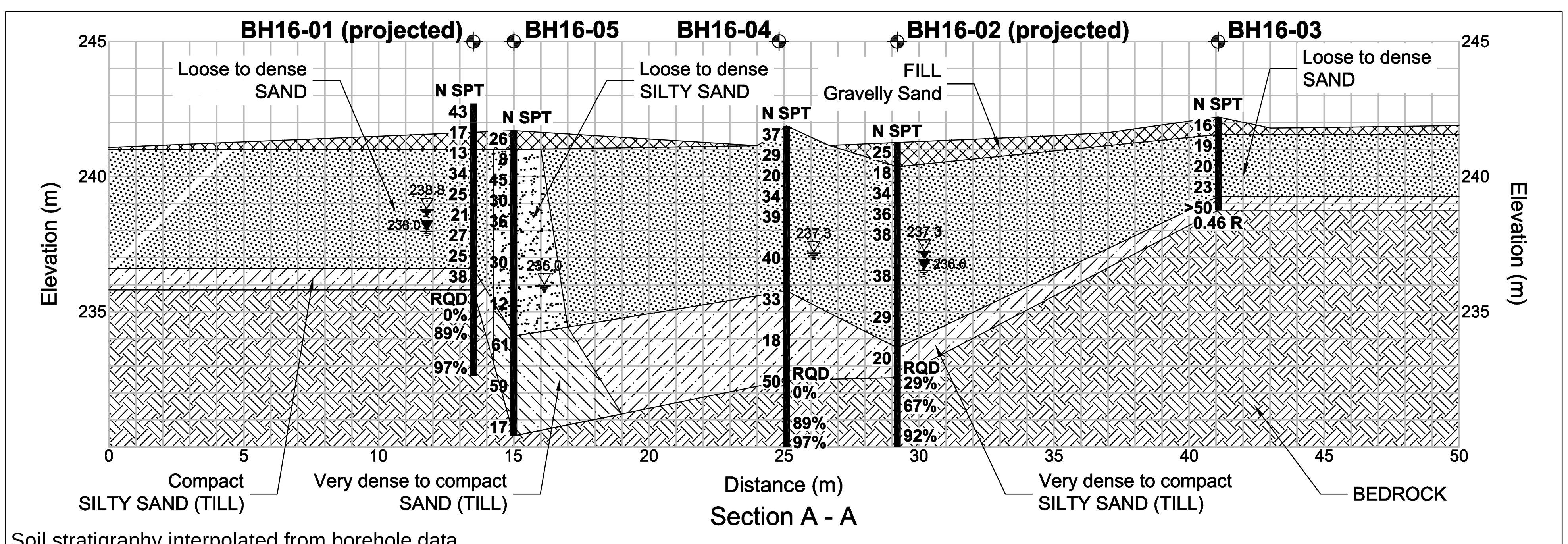


PLAN



KEY PLAN

0 0.5 1.0 1.5 2.0 2.5
Approximate Scale (km)



CENTERLINE PROFILE

LEGEND

- BOREHOLE LOCATION – 2016 INVESTIGATION
- N SPT STANDARD PENETRATION TEST VALUE
- 10 BLOWS/0.3m UNLESS OTHERWISE STATED (STD. PEN. TEST, 475 J/BLOW)
- REC RECOVERY
- R REFUSAL
- % ROCK QUALITY DESIGNATION (RQD)
- WATER LEVEL UPON COMPLETION OF DRILLING
- WATER LEVEL MEASURED SEVERAL HOURS AFTER COMPLETION
- EXISTING STRUCTURE
- PROPOSED STRUCTURE

NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING FOUNDATION DESIGN REPORT.
2. THE INTERPRETED STRATIGRAPHY REPRESENTS SIMPLIFIED SUBSURFACE CONDITIONS. THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN DEFINED AT BOREHOLE LOCATIONS ONLY. CONDITIONS BETWEEN BOREHOLE LOCATIONS COULD DIFFER FROM ILLUSTRATED CONDITIONS.
3. ELEVATIONS ARE REFERENCED TO GEODETIC DATUM.

NUMBER	ELEVATION	CO–ORDINATES (MTM, NAD 83 ZONE 10) NORTHING	EASTING
TESTHOLES BY OTHERS			
BH16–01	242.7	4997725	0284377
BH16–02	241.2	4997693	0284359
BH16–03	242.2	4997715	0284351
BH16–04	242.0	4997708	0284371
BH16–05	241.7	4997703	0284386

CENTER OF PROPOSED STRUCTURE
LATITUDE/LONGITUDE 45.119622, –79.760116

REGISTERED PROFESSIONAL ENGINEER
T. J. GARDE
Feb 7/17
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
M. MOSTAKHDEMI
100185447
Feb. 7/17
PROVINCE OF ONTARIO

0 20 40 60
Approximate Scale (m)

REVISIONS				
02/09/2017	1	NK	REVISED PER MTO COMMENTS	
DATE	REV.	BY	DESCRIPTION	
DESIGN NFK	CHK DMC	CODE	LOAD	
DRAWN MAT	CHK NFK	GEOCRES: 31E–378	DATE January 2017	

DOC: TY163014 – MACTIER

DATE PLOTTED: 2/9/2017 2:00:48 PM
FILE LOCATION: P:\projects\2016 Projects\Geotechnical\TY163014 MTO – Patrol Yards Eng\Drawings\TY163014 – Mactier.dwg

APPENDIX A

SITE PHOTOGRAPHS

Photo 1

View of drilling operations facing north. The southwest corner of the MTO garage is shown on the left hand side.

20 Sept 2016

Photo 2

View of drill over BH16-02. The larger dome is visible in the background

20 Sept 2016

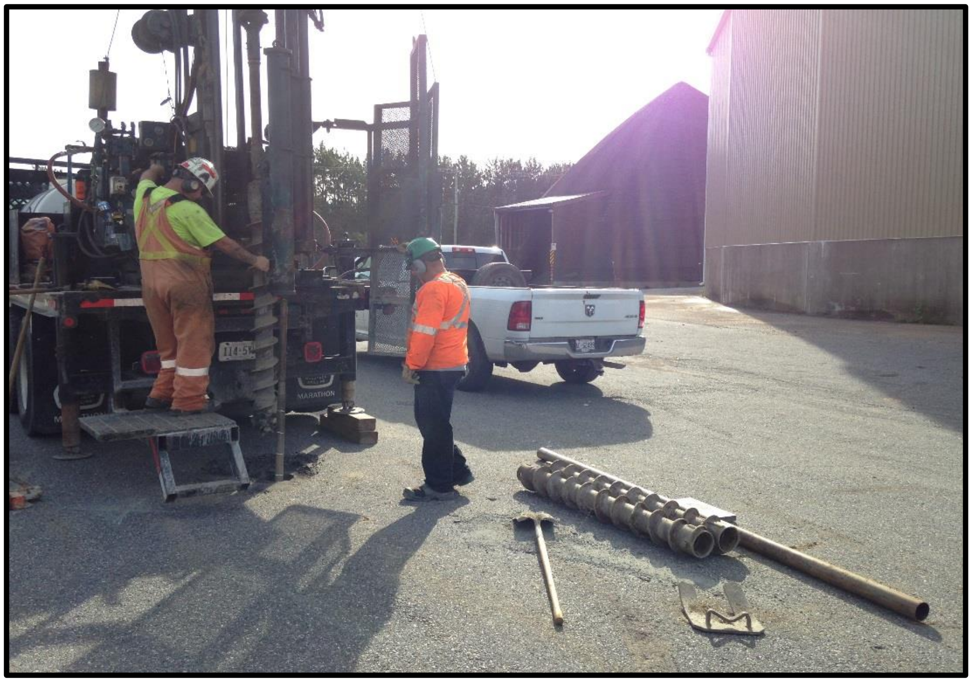


Photo 3

Drilling of borehole shown, with both domes shown in the background. Photo taken facing southeast

21 Sept 2016

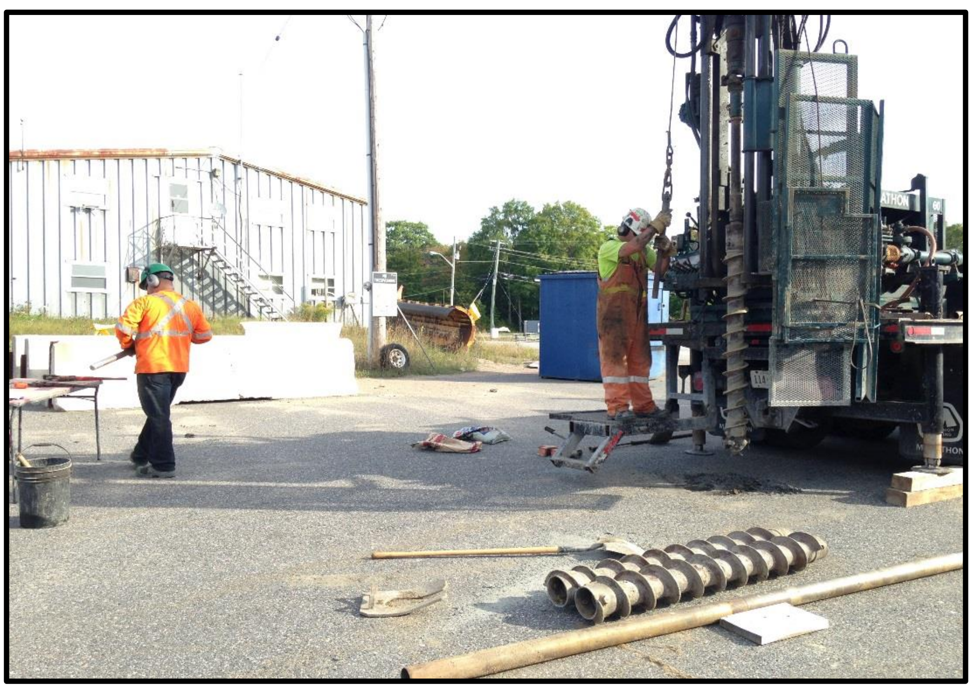


Photo 4

View of BH16-03 being drilled, with MTO Garage in the background. Photo taken facing northeast

20 Sept 2016

APPENDIX B

RECORD OF BOREHOLE NO. BH16-01 to BH 16-05

EXPLANATION OF BOREHOLE LOG

This form describes some of the information provided on the borehole logs, which is based primarily on examination of the recovered samples, and the results of the field and laboratory tests. Additional description of the soil/rock encountered is given in the accompanying geotechnical report.

GENERAL INFORMATION

Project details, borehole number, location coordinates and type of drilling equipment used are given at the top of the borehole log.

SOIL LITHOLOGY

Elevation and Depth

This column gives the elevation and depth of inferred geologic layers. The elevation is referred to the datum shown in the Description column.

Lithology Plot

This column presents a graphic depiction of the soil and rock stratigraphy encountered within the borehole.

Description

This column gives a description of the soil stratums, based on visual and tactile examination of the samples augmented with field and laboratory test results. Each stratum is described according to the *MTC Soil Classification Manual*.

The compactness condition of cohesionless soils (SPT) and the consistency of cohesive soils (undrained shear strength) are defined as follows *(Ref. MTC Soil Classification Manual)*:

Compactness of Cohesionless Soils	SPT N-Value*
Very loose	0 to 5
Loose	5 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

Consistency of Cohesive Soils	Undrained Shear Strength kPa
Very soft	0 to 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	Over 200

* For penetration of less than 0.3 m, N-values are indicated as the number of blows for the penetration achieved (e.g. 50/25: 50 blows for 25 centimeter penetration).

Soil Sampling

Sample types are abbreviated as follows:

SS Split Spoon	TW Thin Wall Open (Pushed)	RC Rock Core	GS Grab Sample
AS Auger Sample	TP Thin Wall Piston (Pushed)	WS Washed Sample	AR Air Return Sample

Additional information provided in this section includes sample numbering, sample recovery and numerical testing results.

Field and Laboratory Testing

Results of field testing (e.g., SPT, pocket penetrometer, and vane testing) and laboratory testing (e.g., natural moisture content, and limits) executed on the recovered samples are plotted in this section.

Instrumentation Installation

Instrumentation installations (monitoring wells, piezometers, inclinometers, etc.) are plotted in this section. Water levels, if measured during fieldwork, are also plotted. These water levels may or may not be representative of the static groundwater level depending on the nature of soil stratum where the piezometer tips are located, the time elapsed from installation to reading and other applicable factors.

Comments

This column is used to describe non-standard situations or notes of interest.

BEDROCK DESCRIPTION

STRENGTH CLASSIFICATION

Term (Grade)	Field Identification	Approximate Range of Uniaxial Compressive Strength (MPa)
Extremely Weak (R0)	Indented by thumbnail.	0.25 – 1.0
Very Weak (R1)	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife.	1.0 – 5.0
Weak (R2)	Can be peeled with a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer.	5.0 – 25
Medium Strong (R3)	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with a single firm blow of geological hammer.	25 – 50
Strong (R4)	Specimen requires more than one blow of geological hammer to fracture it.	50 – 100
Very Strong (R5)	Specimen requires many blows of geological hammer to fracture it.	100 – 250
Extremely Strong (R6)	Specimen can only be chipped with geological hammer.	>250

JOINT SPACING CLASSIFICATION

Term	Average Joint Spacing (m)
Extremely close	< 0.02
Very close	0.02 – 0.06
Close	0.06 – 0.20
Moderately close	0.20 – 0.6
Wide	0.6 – 2.0
Very wide	2.0 – 6.0
Extremely wide	> 6.0

ROCK QUALITY CLASSIFICATION

Rock Quality Designation, RQD (%)	Description of Rock Quality
0 – 25	Very Poor
25 – 50	Poor
50 – 75	Fair
75 – 90	Good
90 – 100	Excellent

Reference: Deere et al, 1967

WEATHERING CLASSIFICATION

Term (Grade)	Description
Fresh (W1)	No visible sign of rock material weathering; perhaps slight discoloration on major discontinuity surfaces.
Slightly Weathered (W2)	Discoloration indicates weathering of rock material on discontinuity surfaces. Less than 5 % of rock mass altered.
Moderately Weathered (W3)	Less than half of the rock material is decomposed and/or disintegrated into a soil. Fresh or discoloured rock is present either as a continuous framework or as core stones.
Highly Weathered (W4)	More than half of the rock material is decomposed and/or disintegrated into a soil. Fresh or discoloured rock is present either as a discontinuous framework or as core stones.
Completely Weathered (W5)	All rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil (W6)	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume but the soil has not been significantly transported.

Reference: Brown, 1981, “Suggested Methods for Rock Characterization Testing and Monitoring”. International Society for Rock Mechanics.

TERMINOLOGY

Rock Quality Designation (RQD) is defined as the percentage of intact core pieces longer than 100 mm (4 inches) to the total length of core. The core should be at least NW size (54.7 mm or 2.15 inches in diameter) and typically 5 ft (nominally 1.5 m) in length.

Solid Core Recovery (SCR) is defined as the percentage of intact cylindrical core pieces to the total length of core.

Total Core Recovery (TCR) is defined as the percentage of intact core pieces to the total length of core.

GROUNDWATER

▽ Groundwater level at completion of drilling.

▼ Groundwater level several hours after completion of drilling.

MTC SOIL CLASSIFICATION
Based on MTC Soil Classification Manual

MAJOR DIVISION				GROUP SYMBOL	TYPICAL DESCRIPTION	INFORMATION REQUIRED FOR DESCRIBING SOILS	LABORATORY CLASSIFICATION CRITERIA
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75µm)	GRAVELS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75mm	CLEAN GRAVELS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZE & SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICAL SIZE	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	GIVE TYPE, NAME, IF NECESSARY, INDICATE APPROX % OF SAND & GRAVEL ; MAX SIZE; ANGULARITY, SURFACE CONDITION, & HARDNESSOF THE COARSE GRAINS, LOCAL OR GEOLOGICAL NAME & OTHER PERTINENT DESCRECTIVE INFORMATION, & SYMBOL IN PARENTHESIS.	$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN 1 AND 3
			PREDOMINANTLY ONE SIZE OF A RANGE OF SIZES WITH STONE INTERMEDIATE SIZES MISSING	GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES		NOT MEETING ALL GRADATION REQUIREMENTS FOR GW
		GRAVEL WITH FINES (APPLICABLE AMOUNT OF FINES)	NON PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)	GM	SILTY GRAVELS, POORLY GRADED GRAVEL-SAND- SILT MIXTURES		ATTERBERG LIMITS BELOW A-LINE OR Ip LESS THAN 4
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)	GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE A- LINE WITH Ip GREATER THAN 7; ABOVE A-LINE WITH Ip BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS
	SANDS MORE THAN HALF THE COARSE FRACTION SMALLER THAN 4.75mm	CLEAN SANDS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZE & SUBSTANTIAL AMOUNT OF ALL INTERMEDIATE PARTICLE SIZES	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	FOR UNDISTURBED SOILS ADD INFORMATION ON STRATIFICATION, DEGREE OF COMPACTNESS, CEMENTATION, MOISTURE CONDITION & DRAINAGE CHARACTERISTICS	$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN 1 AND 3
			PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZE MISSING	SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES		NOT MEETING ALL GRADATION FOR SW
		SANDS WITH FINES (APPLICABLE AMOUNT OF FINES)	NON PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)	SM	SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES		ATTERBERG LIMITS BELOW A- LINE OR Ip LESS THAN 4
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)	SC	CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE A- LINE WITH Ip GREATER THAN 7; ABOVE A-LINE WITH Ip BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS

USE GRAIN SIZE CURVE IN IDENTIFYING THE FACTORS AS GIVEN UNDER FIELD IDENTIFICATION

DETERMINE PERCENTAGE OF GRAVEL & SAND FROM GRAIN SIZE CURVE. DEPENDING ON PERCENTAGE OF FINES (FRACTION SMALLER THAN 75 µm) COARSE GRAINED SOILS ARE CLASSIFIED AS FOLLOWS:

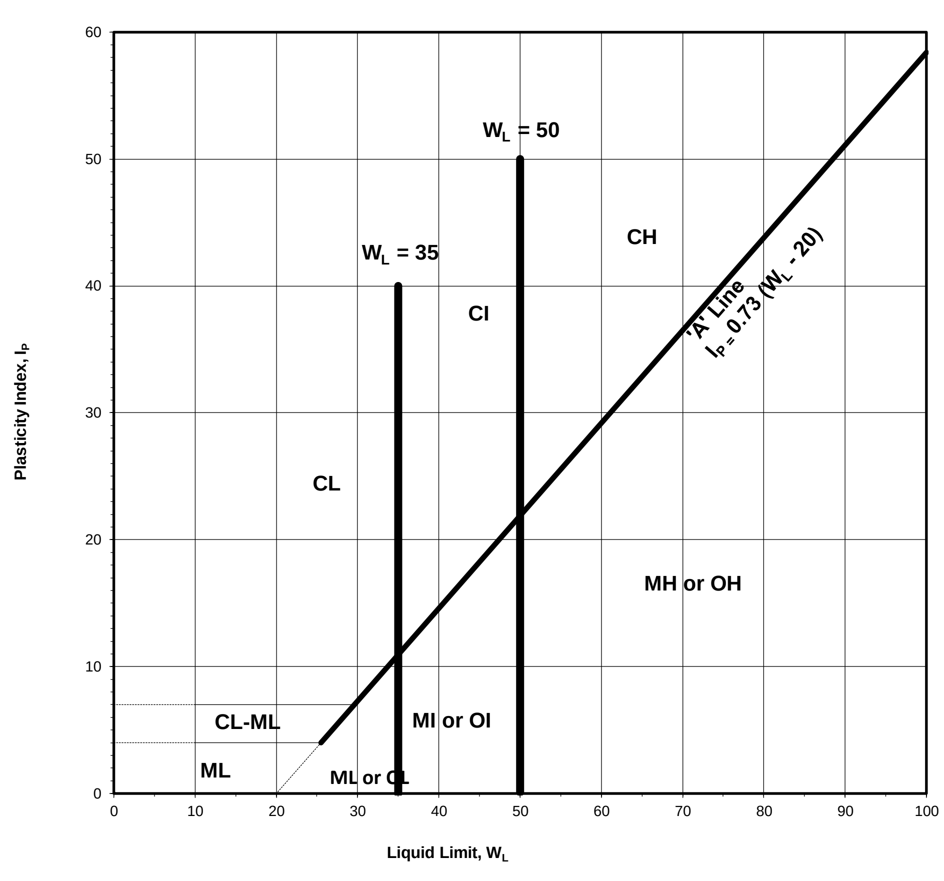
LESS THAN 5%	GW, GP, SW, SP
MORE THAN 12%	GM, GC, SM, SC
5% TO 12%	BORDER LINE CASES REQUIRE USE OF DUAL SYMBOL.

FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75µm) — IDENTIFICATION PROCEDURE ON FRACTION SMALLER THAN 425µm

		DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)	GROUP SYMBOL	TYPICAL DESCRIPTION	INFORMATION REQUIRED FOR DESCRIBING SOILS
SILT AND CLAYS	LIQUID LIMIT LESS THAN 35	NONE	QUICK	NONE	ML	INORGANIC SILTS & SANDY SILTS OR SLIGHTLY PLASTICITY, ROCK FLOUR	GIVE TYPE, NAME, IF NECESSARY, INDICATE DEGREE AND CHARACTER OF PLASTICITY, AMOUNT AND MAXIMUM SIZE OF COURSE GRAINS, COLOUR IN WET CONDITION, ODOUR, IF ANY, LOCAL OR GEOLOGIC NAME & OTHER PERTINENT DESCRIPTIVE INFORMATION & SYMBOL IN PARENTHESIS.
		MEDIUM TO HIGH	NONE TO VERY SLOW	MEDIUM	CL	SILTY CLAYS (INORGANIC), GRAVELLY CLAYS, SANDY CLAYS, LEAN CLAYS	
		SLIGHT TO MEDIUM	SLOW	SLIGHT	OL	ORGANIC SILT OF LOW PLASTICITY, ORGANIC SANDY SILTS	
	LIQUID LIMIT BETWEEN 35 AND 50	NONE TO SLIGHT	SLOW TO QUICK	SLIGHT	MI	INORGANIC COMPRESSIBLE FINE SANDY SILT WITH CLAY OF MEDIUM PLASTICIT, CLAYEY SILTS	
		HIGH	NONE	MEDIUM TO HIGH	CI	SILTY CLAYS (INORGANIC) OF MEDIUM PLASTICITY	
		SLIGHT TO MEDIUM	VERY SLOW	SLIGHT	OI	ORGANIC SILTY CLAYS OF MEDIUM PLASTICITY	FOR UNDISTURBED SOILS AND INFORMATION ON STRUCTURE, STRATIFICATION, CONSISTANCY IN UNDISTURBED AND REMOLDED STATES, MOISTURE & DRAINAGE CONDITION.
	LIQUID LIMIT GREATER THAN 50	SLIGHT TO MEDIUM	SLOW TO NONE	MEDIUM	MH	INORGANIC SILTS, HIGHLY COMPRESSIBLE MICACEOUS OR DIATOMECACOUS FINE SANDY SILTS, ELASTIC SILTS	
		HIGH TO VERY HIGH	NONE	HIGH	CH	CLAYS (INORGANIC) OF HIGH PLASTICITY, FAT CLAYS	
		MEDIUM TO HIGH	NONE TO VERY SLOW	SLIGHT TO MEDIUM	OH	ORGANIC CLAYS OF HIGH PLASTICITY	
HIGH ORGANIC SOILS		READILY IDENTIFIED BY COLOUR, ODOUR, SPONGY FEEL & FREQUENTLY BY FIBROUS TEXTURE			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS	

FRACTION		U.S STANDARD SIEVE SIZE		DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS	
		PASSING	RETAINED	PERCENT	DESCRIPTOR
GRAVEL	COARSE	75 mm	26.5 mm	Over 30	AND / WITH
	FINE	26.5 mm	4.75 mm	20-30	(ey) or (y)
SAND	COARSE	4.75 mm	2.00 mm	12-20	Some
	MEDIUM	2.00 mm	425 µm	5-12	Trace to some
	FINE	425 µm	75 µm	1-5	Trace
FINES (SILT OR CLAY BASED ON PLASTICITY)		75 µm			

OVERSIZED MATERIAL	
ROUNDED OR SUBROUNDED: COBBLES 75 mm TO 200 mm BOULDERS > 200 mm	NOT ROUNDED: ROCK FRAGMENTS > 75 mm ROCKS > 0.76 CUBIC METRE IN VOLUME



PLASTICITY CHART
FOR LABORATORY CLASSIFICATION OF FINE GRAINED SOILS

BOUNDARY CLASSIFICATION: BOUNDARY CLASSIFICATION: SOILS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE DESIGNATED BY COMBINATIONS OF GROUP SYMBOLS FOE EXAMPLE GW-GC WELL GRADED GRAVEL-SAND MIXTURE WITH CLAY BINDER

Amec Foster Wheeler Environment & Infrastructure,
a Division of Amec Foster Wheeler Americas Limited

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Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-01

G.W.P. 5015-E-0064 LOCATION 284377.343 E, 4997724.872 N ORIGINATED BY MAS

DIST ____ HWY ____ BOREHOLE TYPE Hollow Stem Augers COMPILED BY PW

DATUM MTM NAD 83 ZONE 10 DATE 20 September 2016 - 20 September 2016 CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - MacTier Patrol Yard, MacTier, Ontario JOB NO. TY163014

ELEV DEPTH (m)	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH (m)	ELEVATION (m)	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
242.7	NE Corner of Proposed Building								
242.6 0.1	75 mm ASPHALT								
	SAND trace gravel dense (FILL)	1	SS	43				8	
242.0 0.7	SAND compact to dense moist						242		
		2	SS	17		1		9	1 86 (13)
		3	SS	13			241	10	
						2			
		4	SS	34			240	12	
		5	SS	25		3		7	
					▽		239		
		6	SS	21		4		7	
					▼		238		
		7	SS	27		5		8	
		8	SS	25			237	17	0 86 (14)
236.6 6.1	SILTY SAND trace gravel dense (TILL)					6			
		9	SS	38			236	21	
235.8 6.9	BEDROCK								

Column legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; SOIL VAPOUR READING COV/TOV (ppm).

Continued Next Page

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

Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-01

G.W.P. 5015-E-0064 | LOCATION 284377.343 E, 4997724.872 N | ORIGINATED BY MAS

DIST ______ HWY ______ | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY PW

DATUM MTM NAD 83 ZONE 10 | DATE 20 September 2016 - 20 September 2016 | CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - MacTier Patrol Yard, MacTier, Ontario | JOB NO. TY163014

ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	SOIL VAPOUR READING COV/TOV (ppm)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	precambrian aged migmatite rocks and gneisses		10	RC								
235.5 7.2	TCR = 67% SCR = 25% RQD = 0% TCR = 98% SCR = 93% RQD = 89%		11	RC			8	235				
234.1 8.6	TCR = 100% SCR = 100% RQD = 97%		12	RC			9 10	234 233				
232.6 10.1	END OF BOREHOLE Notes: 1) Groundwater was encountered at a depth of 3.9 m at completion. 2) Groundwater was measured at a depth of 4.7 m at 5:00 pm on September 20, 2016 in open borehole. 3) Borehole was backfilled with bentonite and auger cuttings on completion.											

Legend: DCPT plot scale 20 40 60 80 100; Shear strength: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; scale 20 40 60 80 100. Water content: w_P — w — w_L; scale 20 40 60.

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

Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-02

G.W.P. 5015-E-0064 LOCATION 284359.106 E, 4997693.499 N ORIGINATED BY MAS

DIST ____ HWY ____ BOREHOLE TYPE Hollow Stem Augers COMPILED BY PW

DATUM MTM NAD 83 ZONE 10 DATE 20 September 2016 - 20 September 2016 CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - MacTier Patrol Yard, MacTier, Ontario JOB NO. TY163014

ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
241.2	SW Corner of Proposed Building									
0.0	SAND trace gravel compact (FILL)		1	SS	25			241	5	
240.3 0.9	SAND trace gravel dense to compact moist		2	SS	18		1	240	11	5 83 (12)
			3	SS	34		2	239	11	
			4	SS	36				12	
			5	SS	38		3	238	15	
						▽	4	237		
			6	SS	38	▼	5	236	19	0 91 (9)
			7	SS	29		6	235	20	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

SOIL VAPOUR READING COV/TOV (ppm)

Continued Next Page

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

Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-02

G.W.P. 5015-E-0064 LOCATION 284359.106 E, 4997693.499 N ORIGINATED BY MAS

DIST HWY BOREHOLE TYPE Hollow Stem Augers COMPILED BY PW

DATUM MTM NAD 83 ZONE 10 DATE 20 September 2016 - 20 September 2016 CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - MacTier Patrol Yard, MacTier, Ontario JOB NO. TY163014

ELEV / DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS
233.6 / 7.6	SILTY SAND, trace gravel, compact (TILL)	SS	8	20	13	
232.5 / 8.7	BEDROCK, precambrian aged migmatite rocks and gneisses. TCR = 90%, SCR = 38%, RQD = 29%	RC	9			
231.4 / 9.8	TCR = 100%, SCR = 100%, RQD = 67%	RC	10			
231.0 / 10.2	TCR = 92%, SCR = 92%, RQD = 92%	RC	11			
229.7 / 11.5	TCR = 100%, SCR = 100%, RQD = 100%	RC	12			
228.8 / 12.4	END OF BOREHOLE					

Notes:
1) Groundwater was encountered at a depth of 4.0 m at completion.
2) Groundwater was encountered at a depth of 4.7 m on September 21, 2016 in open borehole.
3) Borehole was backfilled with bentonite and auger cuttings on completion.

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20, 40, 60; SOIL VAPOUR READING COV/TOV (ppm); REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL; DEPTH m (8, 9, 10, 11, 12); ELEVATION m (234, 233, 232, 231, 230, 229); GROUND WATER CONDITIONS; STRAT PLOT.

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

RECORD OF BOREHOLE No. BH16-03

G.W.P. 5015-E-0064 | LOCATION 284351.193 E, 4997714.607 N | ORIGINATED BY MAS

DIST ______ HWY ______ | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY PW

DATUM MTM NAD 83 ZONE 10 | DATE 21 September 2016 - 21 September 2016 | CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - MacTier Patrol Yard, MacTier, Ontario | JOB NO. TY163014

ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
242.2	NW Corner of Proposed Building							
0.0	SAND trace gravel compact (FILL)		1	SS	16		7	
241.5 / 0.7	SAND trace silt compact		2	SS	19		8	
			3	SS	20		7	2 95 (3)
			4	SS	23		4	
239.2 / 3.1	SILTY SAND some gravel dense (TILL)		5	SS	50+ / 460mm		9	0 70 (30) Non Plastic
238.7 / 3.5	END OF BOREHOLE DUE TO REFUSAL ON PROBABLE BOULDERS / COBBLES OR BEDROCK							

Notes:
1) Borehole was backfilled with bentonite and auger cuttings on completion.

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (20, 40, 60); SOIL VAPOUR READING COV/TOV (ppm); DEPTH m (1, 2, 3); ELEVATION m (242, 241, 240, 239).

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

Ontario

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RECORD OF BOREHOLE No. BH16-04

G.W.P. 5015-E-0064	LOCATION 284370.768 E, 4997707.640 N		ORIGINATED BY MAS
DIST ___ HWY ___	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY PW
DATUM MTM NAD 83 ZONE 10	DATE 21 September 2016 - 21 September 2016		CHECKED BY TJG
PROJECT Foundation Investigation and Design Report - MacTier Patrol Yard, MacTier, Ontario			JOB NO. TY163014

SOIL PROFILE

ELEV / DEPTH (m)	DESCRIPTION	STRAT PLOT
242.0	Center of Proposed Building	
241.9 / 0.0	75 mm ASPHALT	
0.1	SAND, some silt, trace gravel, compact to dense, moist	
235.9 / 6.1	SILTY SAND, trace gravel, compact to dense (TILL)	

SAMPLES, GROUND WATER, WATER CONTENT AND REMARKS

NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	37		3	3 90 (7)
2	SS	29		3	
3	SS	20		12	
4	SS	34		9	
5	SS	39		13	
6	SS	40	▽ (approx. 4.6 m)	18	0 81 (19) Non Plastic
7	SS	33		19	

DEPTH (m) / ELEVATION (m): 1 / 241; 2 / 240; 3 / 239; 4 / 238; 5 / 237; 6 / 236

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

SOIL VAPOUR READING COV/TOV (ppm)

Continued Next Page

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

Ontario

amec foster wheeler

RECORD OF BOREHOLE No. BH16-04

G.W.P. 5015-E-0064 LOCATION 284370.768 E, 4997707.640 N ORIGINATED BY MAS

DIST HWY BOREHOLE TYPE Hollow Stem Augers COMPILED BY PW

DATUM MTM NAD 83 ZONE 10 DATE 21 September 2016 - 21 September 2016 CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - MacTier Patrol Yard, MacTier, Ontario JOB NO. TY163014

ELEV DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	DEPTH m	ELEVATION m	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		SS	8	18	8	234	19	
					9	233		
		SS	9	50			20	
232.6 / 9.4	BEDROCK precambrian aged migmatite rocks and gneisses TCR = 67% SCR = 25% RQD = 0%	RC	10		10	232		
231.7 / 10.3	TCR = 98% SCR = 93% RQD = 89%	RC	11		11	231		
230.2 / 11.8	TCR = 100% SCR = 100% RQD = 97%	RC	12		12	230		
229.9 / 12.1	END OF BOREHOLE							

Notes:
1) Groundwater was encountered at a depth of 4.7 m at completion.
2) Borehole was backfilled with bentonite and auger cuttings on completion.

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

Ontario

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RECORD OF BOREHOLE No. BH16-05

G.W.P. 5015-E-0064 LOCATION 284385.523 E, 4997703.490 N ORIGINATED BY MAS

DIST ___ HWY ___ BOREHOLE TYPE Hollow Stem Augers COMPILED BY PW

DATUM MTM NAD 83 ZONE 10 DATE 21 September 2016 - 21 September 2016 CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - MacTier Patrol Yard, MacTier, Ontario JOB NO. TY163014

ELEV DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH m	ELEVATION m	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
241.7	SE Corner of Proposed Building								
241.6 0.0	ASPHALT								
0.1	SAND trace gravel dense (FILL)	1	SS	26				4	
241.0 0.7	SILTY SAND loose to dense moist	2	SS	8		1	241	9	1 69 (30)
		3	SS	45		2	240	7	
		4	SS	30			239	9	
		5	SS	36		3	238	10	0 61 (39) Non Plastic
		6	SS	30		4, 5	237	20	
					∇		236		
		7	SS	12		6	235	22	

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L

SOIL VAPOUR READING COV/TOV (ppm)

Continued Next Page

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

Ontario

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RECORD OF BOREHOLE No. BH16-05

G.W.P. 5015-E-0064 LOCATION 284385.523 E, 4997703.490 N ORIGINATED BY MAS

DIST HWY BOREHOLE TYPE Hollow Stem Augers COMPILED BY PW

DATUM MTM NAD 83 ZONE 10 DATE 21 September 2016 - 21 September 2016 CHECKED BY TJG

PROJECT Foundation Investigation and Design Report - MacTier Patrol Yard, MacTier, Ontario JOB NO. TY163014

ELEV / DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" VALUES	DEPTH (m)	ELEVATION (m)	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
234.1 / 7.6	SAND, some silt, trace to some gravel, very dense to compact (TILL)	8	SS	61	8	234	17	
		9	SS	59	9	233	14	11 77 (12)
		10	SS	17	10, 11	232, 231	20	
230.4 / 11.3	END OF BOREHOLE DUE TO REFUSAL ON PROBABLE BOULDERS / COBBLES OR BEDROCK							

Notes:
1) Groundwater was encountered at a depth of 5.7 m at completion.
2) Borehole was backfilled with bentonite and auger cuttings on completion.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; SOIL VAPOUR READING COV/TOV (ppm)

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

Photo 5

Photo of rock cores from BH16-01

20 Sept 2016

Photo 6

Photo of rock core taken from BH16-04

21 Sept 2016

Photo 7

Photo of rock core taken from BH16-02

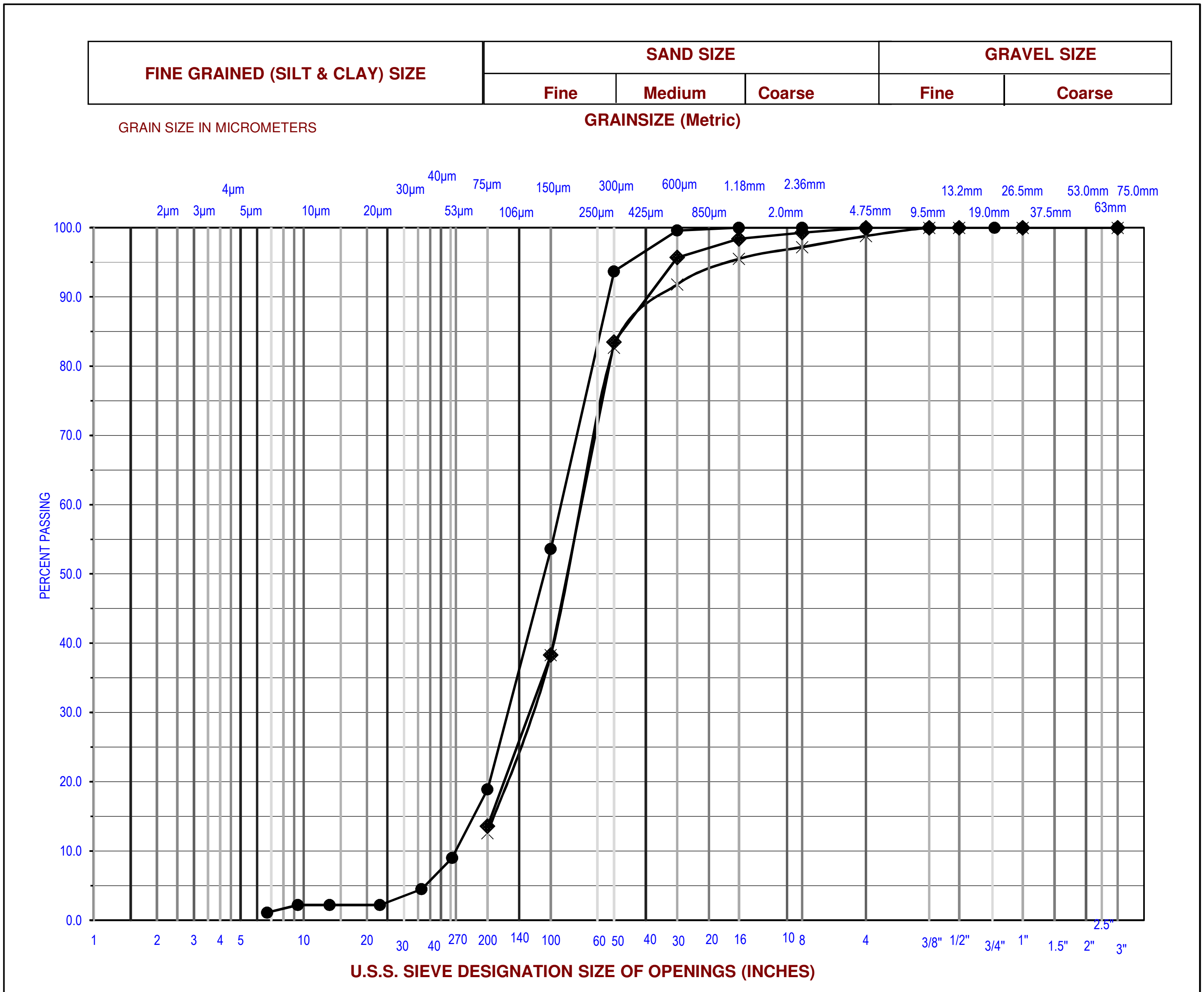
20 Sept 2016

APPENDIX C

LABORATORY TESTING RESULTS

FIGURE C1 - GRAIN SIZE DISTRIBUTION

SAND, some silt



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)	GRAVEL(%)	SAND (%)	SILT & CLAY(%)
X	16-01	SS2	241.7	1	86	13
◆	16-01	SS8	237.2	0	86	14
●	16-04	SS6	237.1	0	81	19

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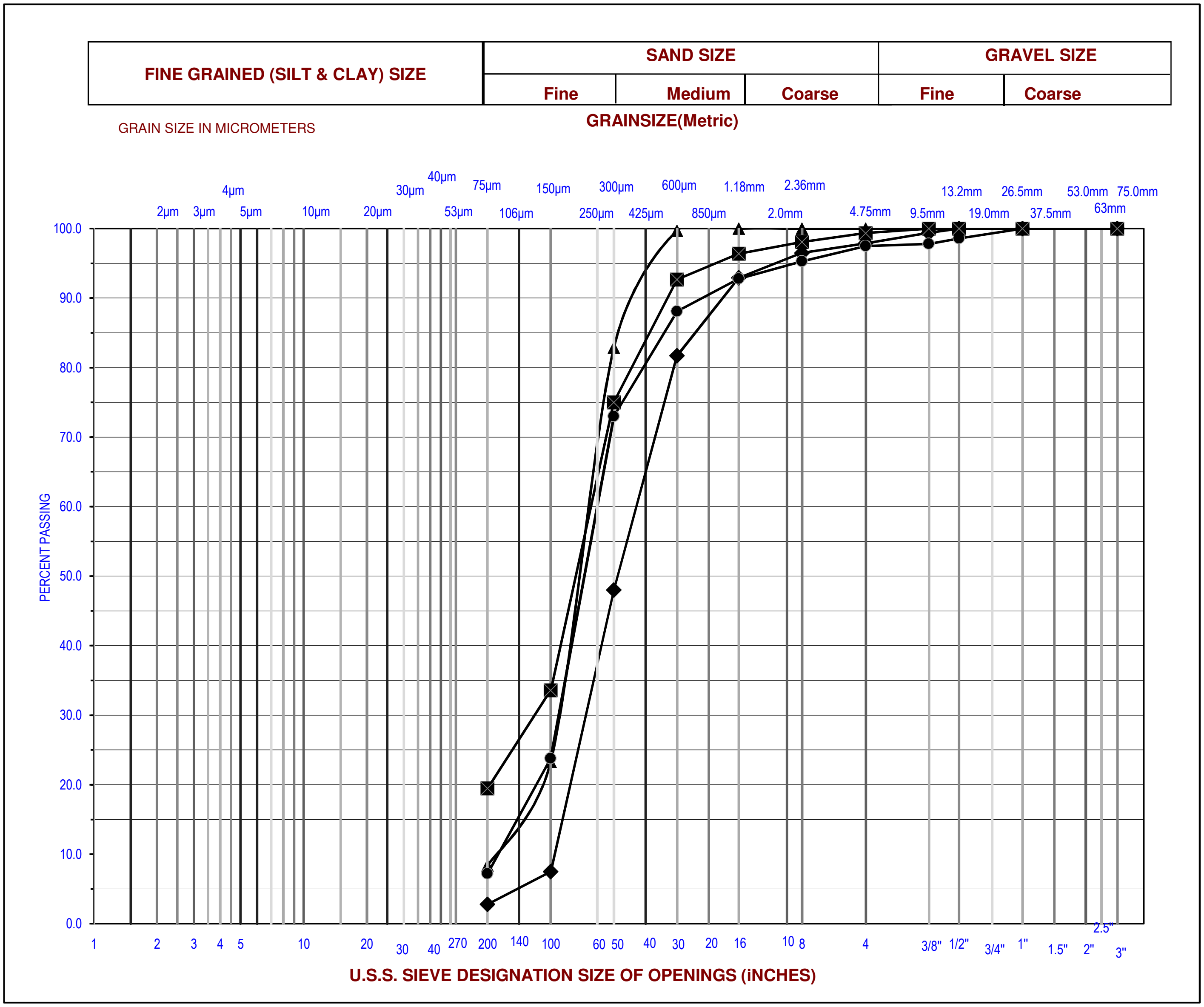
		Tested By:	**Reviewed By:**
		MMD	**TJG**

FIGURE C2 - GRAIN SIZE DISTRUBUTION

SAND, trace to some silt, trace gravel



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)	GRAVEL(%)	SAND (%)	SILT & CLAY (%)
X	16-02	SS6	236.3	0	91	9
◊	16-03	SS3	240.4	2	95	3
•	16-04	SS1	241.6	3	90	7
■	16-02	SS2	240.2	5	83	12

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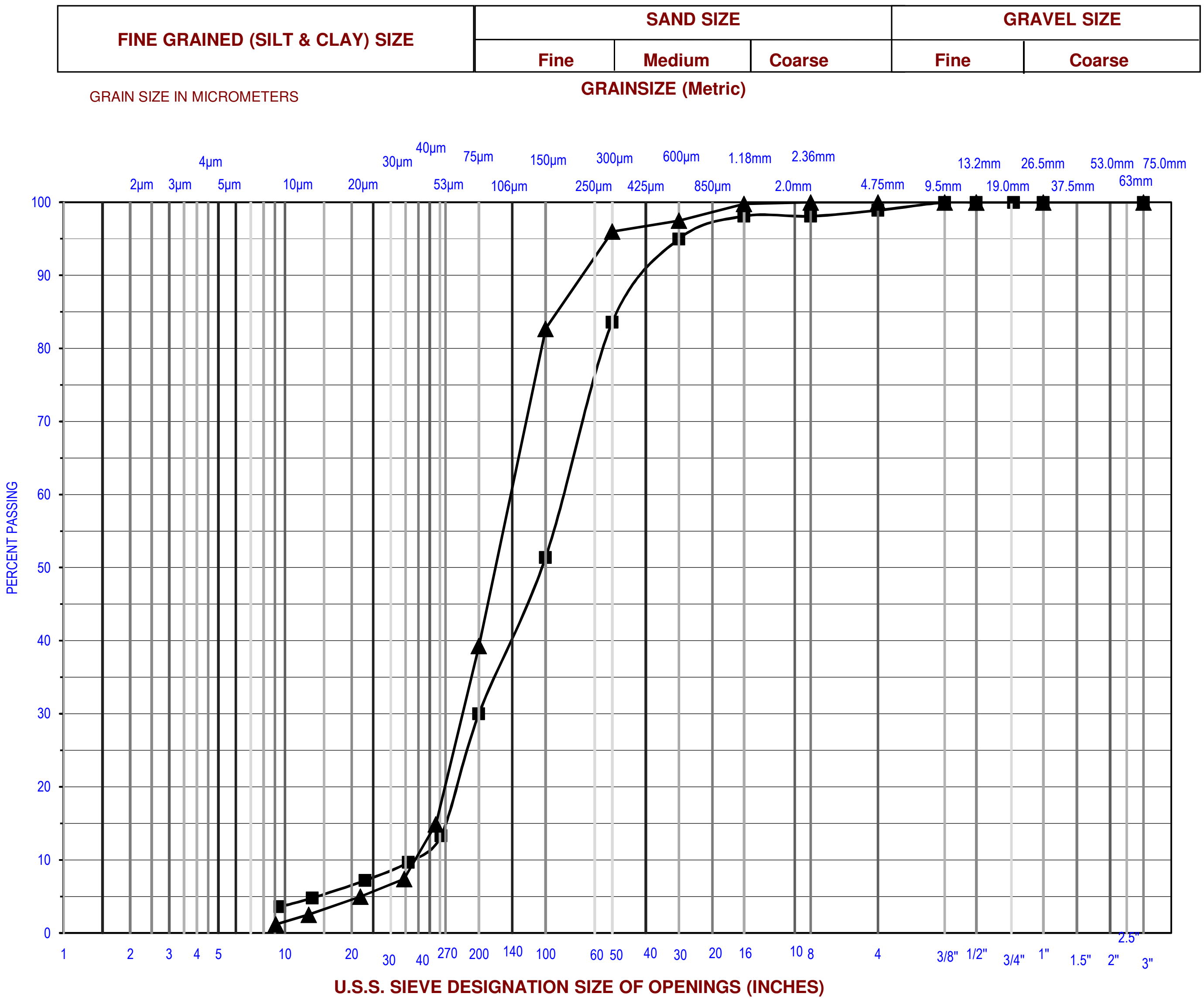
		Tested By:	**Reviewed By:**
		MMD	**TJG**

FIGURE C3 - GRAIN SIZE DISTRUBUTION

SILTY SAND



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)	GRAVEL(%)	SAND (%)	SILT & CLAY (%)
■	16-05	SS2	240.6	1	69	30
▲	16-05	SS5	238.4	0	61	39

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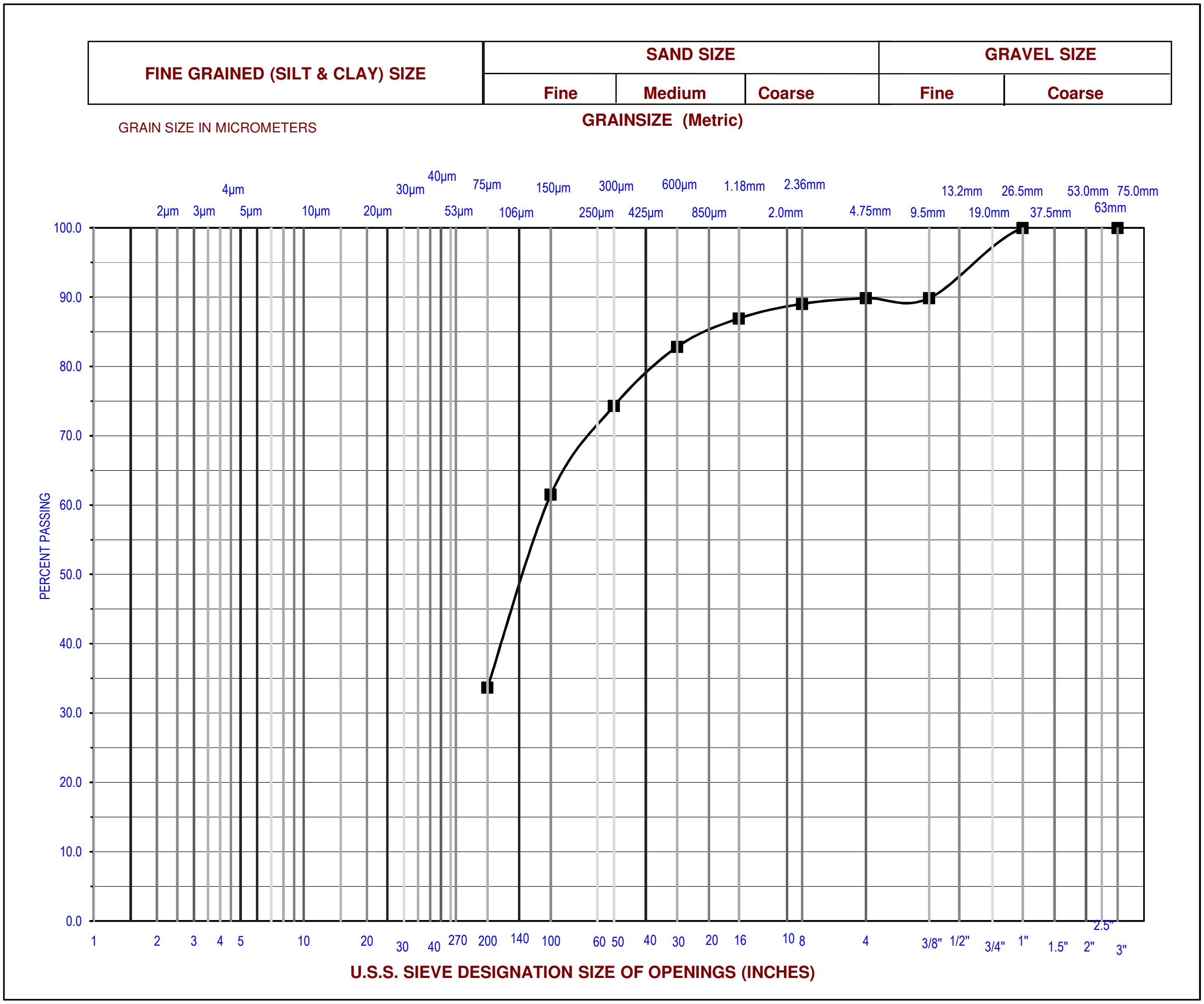
		Tested By:	**Reviewed By:**
		MMD	**TG**

FIGURE C4 - GRAIN SIZE DISTRUBUTION

SILTY SAND (TILL)



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)	GRAVEL(%)	SAND (%)	SILT & CLAY (%)
■	16-03	SS5	238.5	0	70	30

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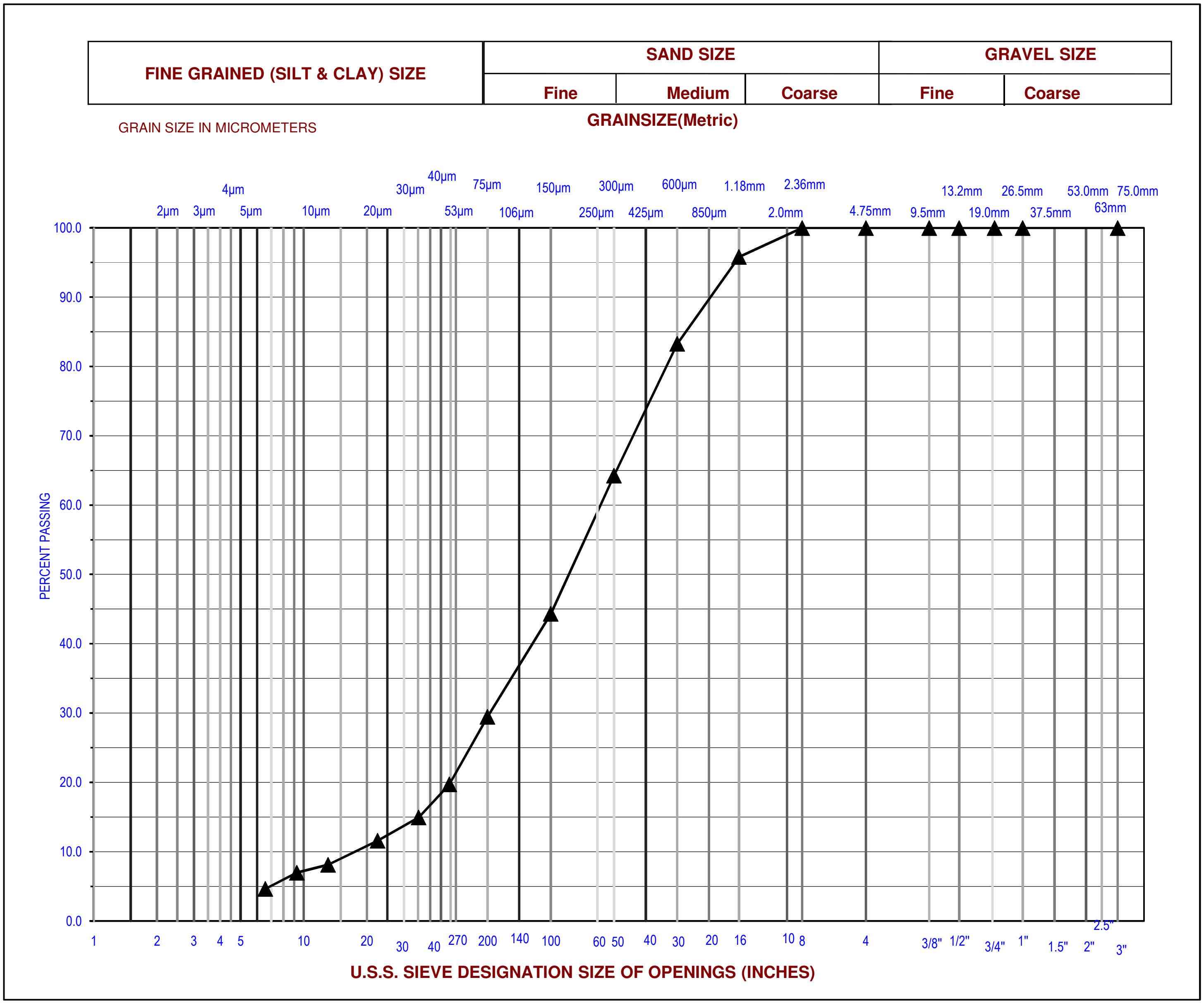
		Tested By:	**Reviewed By:**
		MMD	**TG**

FIGURE C5 - GRAIN SIZE DISTRUBUTION

SAND (TILL)



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)	GRAVEL(%)	SAND (%)	SILT & CLAY (%)
▲	16-05	SS9	232.3	11	77	12

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GRAIN SIZE DISTRIBUTION	Project No.:	TY163014
	Tested By:	Reviewed By:
	MMD	TJG

APPENDIX D

ANALYTICAL RESULTS

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

CLIENT NAME: AMEC FOSTER WHEELER ENVIRO&INFRASTR
131 FIELDING ROAD
LIVELY, ON P3Y1L7
(705) 682-2632

ATTENTION TO: David Brown

PROJECT: TY163014

AGAT WORK ORDER: 16U147324

SOIL ANALYSIS REVIEWED BY: Sofka Pehlyova, Senior Analyst

DATE REPORTED: Oct 18, 2016

PAGES (INCLUDING COVER): 5

VERSION*: 1

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

NOTES

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

AGAT Laboratories

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

Certificate of Analysis

AGAT WORK ORDER: 16U147324

PROJECT: TY163014

CLIENT NAME: AMEC FOSTER WHEELER ENVIRO&INFRASTR

ATTENTION TO: David Brown

SAMPLING SITE:

SAMPLED BY:

Inorganic Chemistry (Soil)

DATE RECEIVED: 2016-10-11

DATE REPORTED: 2016-10-18

			SAMPLE DESCRIPTION:	MacTier BH16-04 SS04
			SAMPLE TYPE:	Soil
			DATE SAMPLED:	9/21/2016
Parameter	**Unit**	**G / S**	**RDL**	**7919209**
Chloride (2:1)	µg/g		2	46
Sulphate (2:1)	µg/g		2	<2
pH (2:1)	pH Units		NA	7.22
Electrical Conductivity (2:1)	mS/cm		0.005	0.126
Resistivity (2:1)	ohm.cm		1	7940

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

7919209 EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil).

Certified By: Sofiea Pehlyora

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
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Quality Assurance

CLIENT NAME: AMEC FOSTER WHEELER ENVIRO&INFRASTR

AGAT WORK ORDER: 16U147324

PROJECT: TY163014

ATTENTION TO: David Brown

SAMPLING SITE:

SAMPLED BY:

Soil Analysis

RPT Date: Oct 18, 2016			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Inorganic Chemistry (Soil)															
Chloride (2:1)	7918090		3	3	NA	< 2	93%	80%	120%	98%	80%	120%	102%	70%	130%
Sulphate (2:1)	7918090		26	26	0.0%	< 2	94%	80%	120%	100%	80%	120%	102%	70%	130%
pH (2:1)	7918090		8.45	8.47	0.2%	NA	101%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	7919402		0.188	0.188	0.0%	< 0.005	99%	90%	110%	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.

Certified By: Sofia Pehlyova

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
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Method Summary

CLIENT NAME: AMEC FOSTER WHEELER ENVIRO&INFRASTR | **AGAT WORK ORDER: 16U147324**

PROJECT: TY163014 | **ATTENTION TO: David Brown**

SAMPLING SITE: | **SAMPLED BY:**

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
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
Resistivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION

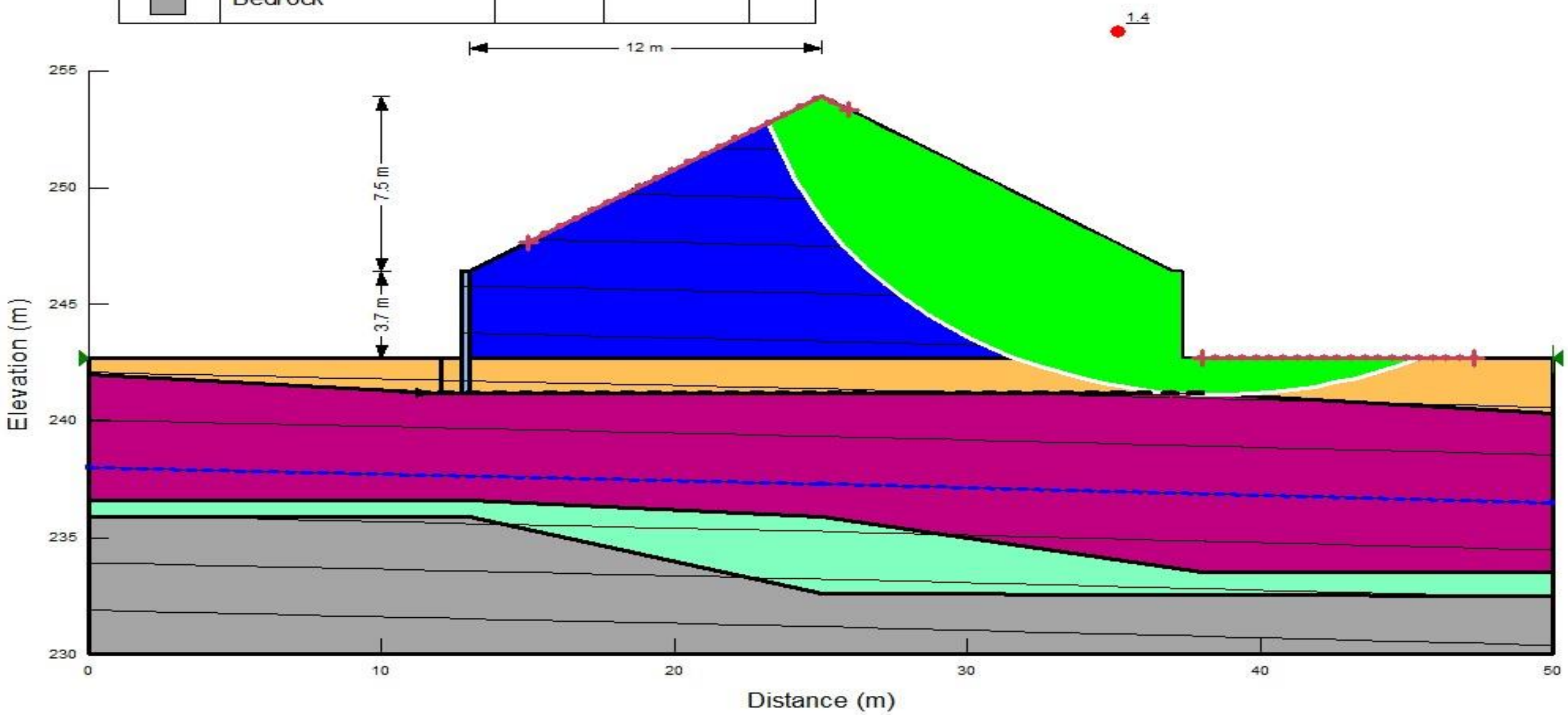
APPENDIX E

RESULTS OF STABILITY MODEL

Static Stability Model
MacTier Patrol Yard

Figure 1

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
Blue	Sand stockpile	18	0	30
Orange	Compact to dense sand and gravel fill	20	0	32
Magenta	Compact to dense sand to silty sand	20.5	0	32
Light green	Compact to very dense non-cohesive till	22	0	32
Light blue	Wall	24		
Grey	Bedrock			



Date: December 2016

Analysis by: NFK

Project Number: TY163014

Reviewed by: MM

APPENDIX F

LIMITATIONS OF REPORT

AMEC FOSTER WHEELER ENVIRONMENT & INFRASTRUCTURE

LIMITATIONS OF REPORT

The conclusions and recommendations given in this report are based on information determined at the borehole locations. The information contained herein in no way reflects on the environmental aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the geotechnical engineer be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in test holes.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of boreholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices. No other warranty is expressed or implied.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Amec Foster Wheeler accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.