MTO Agreement No. 5011-E-0010
WO No. 2011-11041
Proposed Sand/Salt Storage Facility and Office/Garage
Missanabie Corners Patrol Yard
Foundation Investigation and Design Report

Geocres No. 41N-21

January 2013

Prepared for:
Ontario Ministry of Transportation
Northeastern Region
447 McKeown Avenue
North Bay, Ontario
CANADA P1B 9S9

Prepared by:
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Project No. 121-17876-00

GENIVAR

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January 15, 2013

Mr. Jean-Pierre Perron, P. Eng.
MTO Project Manager
Ontario Ministry of Transportation
Northeastern Region
447 McKeown Avenue
North Bay, Ontario P1B 9S9

Re: MTO Agreement No. 5011-E-0010 / WO No.: 2011-11041
Proposed Sand/Salt Storage Facility and Office/Garage – Missanabie Corners Patrol Yard
Foundation Investigation and Design Report (Geocres No. 41N-21)

Dear Mr. Perron:

We are pleased to submit our Foundation Investigation and Design Report for the proposed Sand/Salt Storage Facility and Office/Garage at the Ontario Ministry of Transportation Northeastern Region (MTO) Missanabie Corners Patrol Yard (formerly addressed as a Seabrook Patrol Yard) in the Township of Nadjiwon, Ontario. A borehole and laboratory testing program was conducted to assess soil and groundwater conditions at the site and provide recommendations for foundation design for the proposed structure.

This report presents the investigation methodology and findings, and our recommendations, and was completed in accordance with the Terms of Reference provided in MTO Agreement #5011-E-0010.

We trust that this report meets your current requirements. Please contact us if you have any questions.

Yours truly,
GENIVAR Inc.

J. Stephen Ash, P. Eng., P. Geo.
Director, Environment

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1. Introduction

GENIVAR Inc. (GENIVAR) was retained by the Ontario Ministry of Transportation Northeastern Region (MTO) to undertake a geotechnical investigation for the proposed construction of a sand/salt storage structure and office/garage at the Missanabie Corners Patrol Yard (formally addressed as a Seabrook Patrol Yard), located on Highway 651, approximately 300 m north of the Highway 651 / Highway 101 intersection, in the Township of Nadjiwon, Ontario. The purpose of the investigation was to assess subsurface conditions at the site and provide recommendations for foundation design at the designated structure location.

The geotechnical investigation was conducted in accordance with MTO Agreement #5011-E-0010. This Foundation Investigation and Design Report includes factual results of the geotechnical investigation carried out at the Missanabie Corners site, including the field and laboratory testing information, and geotechnical recommendations for foundation design and construction, including a discussion on foundation design alternatives.

2. Site Description and Regional Geology

2.1 Site Description

The Missanabie Patrol Yard (site) is located on the east side of Highway 651, approximately 300 m north of the Highway 651 / Highway 101 intersection in the Township of Nadjiwon, Ontario. The site layout is shown in Drawing 1 and colour photographs of the site are included in Appendix C.

This is a vacant site that is intended for development as an MTO Patrol Yard. Currently there is an approximately 50 m by 50 m graded, granular surface approximately 30 m east of the western property boundary, with access to Highway 651. The fill area generally slopes to the south and is surrounded by low lying bog lands with mixed deciduous and coniferous trees. There are small streams on the north and south side of the site. The surrounding properties are treed with no structures or residences observed within a few kilometres of the site.

Drawing 1 indicates the proposed location of the sand/salt structure as well as the office/garage. Bedrock is at the surface within and on the eastern side of the office/garage footprint.

2.2 Regional Geology

Map 5010 '*Northern Ontario Engineering Geology Terrain Study Data Base Map – Michipicoten'* published by the Ministry of Natural Resources (MNR) was referred to for information on the area soils and bedrock.

Based on the mapping information, the site is reportedly in an area characterized by glaciofluvial outwash landforms, which are well-drained deposits of sand and gravel occupying low areas within the bedrock terrain. Rock knobs occur to a lesser extent in this area. Relief is low and the topography is level to undulating with normally dry drainage conditions. Overburden cover is often shallow (less than 1 m thick) but may thicken to as much as 3 m in localized areas. The outwash sand and gravel deposits are underlain by Early Precambrian bedrock. Felsic igneous and metamorphic rocks, including granite, gneissic tonalite and mafic metavolcanics, are the dominant lithologies.

3. Historic Report Review

No historic geotechnical reports were available from the MTO Geocres Library for the Missanabie Corners Patrol yard or locations close to the yard. The regional geology information taken from the sources quoted in Section 2 indicate that the site likely has shallow sand and gravel overburden overlying Precambrian igneous and metamorphic bedrock.

4. Investigation Procedures

4.1 Subsurface Investigation

A borehole investigation was performed at the subject site between June 11 and June 13, 2012. The investigation consisted of advancing six (6) exploratory boreholes, designated as BH12-1 through BH12-6, commencing from existing ground level. Borehole locations are shown on Drawing 1 and were located at each of the four corners of the proposed sand/salt storage structure and at opposite corners of the proposed office/garage, as required in the Terms of Reference.

MTO minimum requirements for the borehole investigation outlined a maximum drilling depth of 10.0 m for the sand/salt structure boreholes and 5.0 m for the office/garage boreholes, unless refusal was encountered at shallower depth, or justification for deeper drilling was authorized by the MTO Project Manager. As well, two of the four boreholes for the sand/salt structure and both of the office/garage boreholes were to include rock cores to a minimum of 3.0 m depth below the rock surface, if bedrock was encountered within the shallow foundation zone.

In all six boreholes augering was terminated at 0.3 m to 1.5 m below ground surface on bedrock. Bedrock coring was completed within the sand/salt structure footprint at boreholes BH12-1 and BH12-3 to a depth of 10.4 m and 4.4 m, respectively. Within the office/garage footprint, coring was completed at boreholes BH12-5 and BH12-6 to a depth of 4.3 m and 9.8 m, respectively. The bedrock coring at BH12-1 and BH12-6 was extended to approximately 10 m below ground surface to allow for the installation of monitoring wells as part of a concurrent hydrogeological investigation for a new water supply.

The longitude and latitude of the individual borehole locations was obtained using a hand-held GPS unit in the WGS 84 reference system. These coordinates were subsequently converted to MTO standard coordinates (Northing and Easting). As the site is currently vacant, borehole elevations were surveyed to an assumed benchmark: a nail placed into a tree, marked with paint and a flag was assigned an elevation of 100 m. The borehole elevations were surveyed relative to this benchmark. Borehole elevations and coordinates are shown on Drawing 1, and are provided on the borehole logs included in Appendix A.

Drilling and soil sampling was completed using a truck-mounted drill rig operating under the supervision of an experienced GENIVAR soils technician. The boreholes were advanced to the soil sampling depths by means of continuous flight hollow stem augers. Standard Penetration Test (SPT) N values were recorded for the sampled intervals as the number of blows required to drive a split spoon sampler 305 mm into the soil, using a 63.5 kg drop hammer falling 750 mm (ASTM D1586 procedure). SPT N values are used in this report to assess consistency for cohesive soils and relative density for non-cohesive materials.

The sampled soil materials from discrete subsurface units were logged in the field using visual and tactile methods, and were then placed in labelled plastic bags for transport, future reference, possible laboratory testing, and storage. Soils for laboratory moisture content testing were placed in sealed laboratory jars for transport.

NQ-size coring equipment (47.6 mm diameter) was used to obtain bedrock core samples to depths noted above. Core recovery and rock quality index properties were determined by field inspection. Core samples were placed in labelled core boxes for transport, future reference and storage.

Groundwater conditions within the boreholes were observed during drilling, and prior to backfilling. In addition, two (2) groundwater monitoring wells were installed in boreholes BH12-1 and BH12-6 to measure static groundwater levels at the site. The monitoring wells were installed to meet Ontario Regulation (O. Reg.) 903 requirements, and consist of 51 mm (2 inch) outside diameter environmental grade PVC pipe, with a 1.5 m long No. 10 machine-slotted screen embedded within a sand pack. The sand pack was installed from the bottom of the monitoring well to a depth of approximately 0.3 m above the well screen. A bentonite seal was then placed between the top of the sand pack and the ground surface. The monitoring wells should be used as long term monitors for the site.

The remaining cored holes (BH12-3 and BH12-5) were backfilled with bentonite hole plug to the surface. The two (2) boreholes that were terminated on bedrock (BH12-2 and BH12-4) were backfilled with sand. The backfill material was compacted with the drill rig. As such, the boreholes are abandoned in accordance with O. Reg. 903 requirements, as amended. Table 4.1 below summarizes the borehole numbers and drilling depths and the surveyed elevations.

Table 4-1: Borehole Numbers, Drilling Depths and Elevations

Borehole No.	Drilling Depth Below Existing Ground Surface (mbgs) / Relative Elevation (m)	Monitoring Well	Comment
BH12-1	10.4 / 89.0	Monitoring well installed at 10.4 m depth	Cored into bedrock
BH12-2	0.5 / 98.6	-	
BH12-3	4.4 / 94.8	-	Cored into bedrock
BH12-4	1.2 / 98.1	-	
BH12-5	4.3 / 94.7	-	Cored into bedrock
BH12-6	9.8 / 89.3	Monitoring well installed at 9.8 m depth	Cored into bedrock

Note: Elevations are relative to cited temporary benchmark (Section 4.1).

4.2 Laboratory Testing

4.2.1 Soil Testing

The minimum number of laboratory tests was set at 25 percent of the samples, according to the MTO Terms of Reference. Low complexity soil tests were completed at GENIVAR's RAQ's certified laboratory in Peterborough. Laboratory testing results are presented on the borehole logs and in Appendix B.

Two (2) Particle Size Analyses (ASTM D422) and eight (8) Natural Moisture Content tests were completed for samples of the overburden material.

5. Subsurface Conditions

The subsurface conditions were explored at the six (6) borehole locations designated as BH12-1 to BH12-6. Borehole locations are shown on Drawing 1 and the subsurface stratigraphic profile for the site is shown on Drawing 2. Detailed borehole logs are provided in Appendix A, and laboratory test results are included in Appendix B.

5.1 Soil Profile Summary

All six (6) of the boreholes encountered a relatively thin layer of overburden overlying bedrock. The bedrock was cored at four (4) of the borehole locations to depths ranging from 4.3 m to 10.4 m below ground surface. Descriptions of the major subsurface units are provided in the following subsections.

5.1.1 Overburden

A 0.3 m to 1.5 m thick layer of overburden soil was encountered at each of the borehole locations. The overburden material consisted of brown sand and gravel to sand, some gravel with a trace to some silt extending to the depths (metres below ground surface, mbgs) and relative elevations shown below:

Borehole No.	Depth to Bottom of Overburden (Relative Elevation)
BH12-1	1.5 mbgs (97.9 m)
BH12-2	0.5 mbgs (98.6 m)
BH12-3	0.9 mbgs (98.3 m)
BH12-4	1.2 mbgs (98.1 m)
BH12-5	0.9 mbgs (98.1 m)
BH12-6	0.3 mbgs (98.7 m)

Laboratory particle size distribution analyses for two (2) samples of the overburden soil were completed, and results according to the Unified Soil Classification System (USCS) are summarized below, and shown on Figure B1 of Appendix B:

- Gravel (greater than 4.75 mm size) - 39 % to 43 %
- Sand (0.075 mm to 4.75 mm size) - 50 % to 59 %
- Silt and Clay (less than 0.075 mm size) - 2 % to 7 %

Standard Penetration Test results (N Values) in the overburden layer, where recorded, ranged between 19 and 30 blows per 305 mm of penetration, indicating compact relative density.

Laboratory determined moisture content of the overburden ranged from 2 % to 13 %, indicating moist material.

5.1.2 Bedrock

Boreholes BH12-1, BH12-3, BH12-5, and BH12-6 were cored and terminated in granitic gneiss bedrock. Boreholes BH12-3 and BH12-5 were terminated at 4.4 m and 4.3 m below ground surface, and boreholes BH12-1 and BH12-6 were terminated at depths of 10.4 m and 9.7 m, respectively. Monitoring wells were installed in BH12-1 and BH12-6. Rock core photographs are included in Appendix C.

A description of the bedrock is provided in Table 5-1. Total Core Recovery (TCR) ranged from 83 % to 100 %. Apart from the first core sample in borehole BH12-3, which encountered fractured material, Rock Quality Designation (RQD) values ranged from 69 % to 100 %, which is described as fair to excellent.

Table 5-1: Rock Core (RC) Description, RQD, and Recovery Data

BH	RC #	Depth (m)	TCR (%)	RQD (%)	Depth (m)	Description
12-1	1	1.52 – 2.13	83	69	1.52 – 10.41	GRANITIC GNEISS, pink, grey, black with brown oxidation layers, fine to medium grained, medium to strongly foliated at subhorizontal to 60º to core axis, hard, strong, slightly weathered.
	2	2.13 – 2.94	100	100		
	3	2.94 – 4.42	97	91		
	4	4.42 – 5.95	98	86		
	5	5.95 – 7.39	100	88		
	6	7.39 – 8.91	100	100		
	7	8.91 – 10.41	97	91		
12-3	1	0.91 – 1.42	100	0	0.91 – 4.40	GRANITIC GNEISS, pink, grey, black with brown oxidation layers, fine to medium grained, medium to strongly foliated at subhorizontal to 60º to core axis, hard, strong, slightly weathered
	2	1.42 – 2.95	100	76		
	3	2.95 – 4.40	100	87		
12-5	1	0.91 – 1.35	100	76	0.91 – 4.34	GRANITIC GNEISS, pink, grey, black with brown oxidation layers, fine to medium grained, medium to strongly foliated at subhorizontal to 60º to core axis, hard, strong, slightly weathered
	2	1.35 – 2.87	100	79		
	3	2.87 – 4.34	100	71		
12-6	1	0.38 – 1.37	100	94	0.38 – 9.65	GRANITIC GNEISS, pink, grey, black with brown oxidation layers, fine to medium grained, medium to strongly foliated at subhorizontal to 60º to core axis, hard, strong, slightly weathered
	2	1.37 – 2.87	100	89		
	3	2.87 – 4.40	98	86		
	4	4.40 – 5.87	100	90		
	5	5.87 – 7.42	100	75		
	6	7.42 – 8.89	100	100		
	7	8.89 – 9.65	100	94		

5.2 Groundwater Conditions

Groundwater conditions were observed in the open boreholes upon completion of drilling. The static water levels in the two monitoring wells (BH12-1 and BH12-6) were measured at two different times after drilling was completed. Results are summarized in Table 5-2.

Table 5-2: Summary of Groundwater Levels

Location	Measured Groundwater Depth mbgs (relative elevation, m)	Date Measured
BH12-1 (MW)	1.65 (97.75)	15 June 2012
	1.89 (97.51)	19 June 2012
BH12-2	no GW observed	12 June 2012
BH12-3	no GW observed	12 June 2012
BH12-4	no GW observed	12 June 2012
BH12-5	no GW observed	12 June 2012
BH12-6 (MW)	2.43 (96.63)	15 June 2012
	1.43 (97.63)	19 June 2012

Note: mbgs = metres below ground surface; MW = monitoring well, GW = groundwater

Based on the water level measurements and moisture condition of the inspected soil samples, the depth of shallow groundwater within the footprint of the proposed structures, at the time of the field investigation, was generally below 1.5 m below ground surface between elevations 97.5 m and 96.6 m.

It should be noted that groundwater levels may fluctuate seasonally and in response to climatic conditions, and perched groundwater conditions can potentially develop over the shallow bedrock.

6. Geotechnical Design Considerations

The proposed sand/salt storage structure will have a rectangular footprint of approximate dimensions 17.0 m × 24.0 m and the proposed garage/office structure will have a square footprint of approximate dimensions 9.8 m × 9.8 m. Foundation engineering guidelines presented in this section have been developed based on the soil and rock conditions investigated and described in Section 5, and in accordance with the most recent edition of the Canadian Highway Bridge Design Code (CHBDC) and the most recent edition of the Canadian Building Code in effect for MTO projects.

Four (4) boreholes (BH12-1 to BH12-4) were drilled to assess the subsurface conditions at the proposed sand/salt storage facility and two (2) boreholes (BH12-5 and BH12-6) were drilled to assess the subsurface conditions at the proposed garage/office structure. In general, the boreholes encountered a 0.3 m to 1.5 m thick layer of overburden soil comprised of brown sand and gravel to sand, some gravel with a trace to some silt, overlying granitic gneiss bedrock. The bedrock was sampled and assessed by coring to depths 10.4 m, 4.4 m, 4.3 and 9.7 m at boreholes BH12-1, BH12-3, BH12-5, and BH12-6, respectively. Rock Quality Designation (RQD) values ranged from 69 % to 100 % (fair to excellent), except for the first core interval at borehole BH12-3, which encountered several fractures.

Based on water level measurements and the moisture condition of the inspected soil samples, the depth of shallow groundwater within the footprint of the proposed structures, at the time of the field investigation, was generally below 1.5 m between elevations 97.5 m and 96.6 m.

6.1 “Red Flag” Conditions and NNSP’s

The presence of shallow bedrock at the Missanabie Corners site, at depths ranging from 0.3 m to 1.5 m below existing grade, may pose some challenges for construction of the foundation for the proposed sand/salt storage facility.

The following Non-Standard Special Provision (NSSP) is presented to address “Red Flag” conditions.

NSSP 1 The Contractor should be alerted of the subsurface conditions and that excavations for foundation installations will be within hard strength granitic gneiss bedrock.

6.2 Foundation Design

6.2.1 Shallow Foundation

Based on the results of this investigation, the proposed sand/salt storage facility and the garage/office structure can be supported on strip footings founded on the bedrock, with a recommended highest founding level between 1.0 m and 1.5 m below existing grade (relative elevation 98.0 m to 98.4 m), providing that permanent thermal insulation will be installed for frost protection. The other option is to lower the foundation level below 2.4 m depth (relative elevation 96.6 m to 97.0 m) for the frost protection purposes.

It should be noted that in between and beyond borehole locations, the bedrock surface and the depth to suitable bedrock may vary. In addition, the extent of the rock excavation will depend on the actual founding level. All loose, fractured, or highly weathered bedrock under the footing should be removed and replaced with concrete fill (20 MPa minimum strength).

The following geotechnical resistance can be used for the design of the strip footings with a minimum 0.9 m width, constructed directly on the bedrock:

- Factored Bearing Resistance at ULS, at 1.0 m depth= 2.5 MPa
- Factored Bearing Resistance at ULS, at 2.4 m depth= 5.0 MPa

Bearing Resistance at SLS will not govern the design.

A deeper foundation elevation for the strip footing will provide higher geotechnical resistance but we believe it is not required for the proposed storage facility. If concrete fill is required, allowable footing loadings should be restricted to 50 % of the compressive strength of the concrete.

All footing excavations and bearing surfaces must be inspected, evaluated, and approved by a Geologist or Geotechnical Engineer who is familiar with the findings of this investigation.

6.2.2 Deep Foundation

Based on the subsurface conditions at the site, and serviceability and reliability of the proposed building, the use of deep foundations is not recommended.

6.3 Frost Penetration Depth

The recommended design frost protection depth for the site area is 2.4 m (Source: OPSD 3090.100). Therefore, a permanent soil cover of about 2.4 m, or its thermal equivalent of high density insulation, is required for frost protection of foundations. In case of rockfill, only one-half of the rockfill thickness should be assumed to be effective in providing frost protection. A 50 mm thick layer of Polystyrene foam or insulating concrete forms (ICF's) with rigid foamboard applied at both inner and outer concrete forms of steel or plywood forms could be considered. Alternatively, Dow Chemical Styrofoam insulation applied to the foundation walls and extending at least 1.2 m outward from the walls may be used. Insulation should be applied according to manufacturer's specifications for required load ratings.

Any obvious cracks/joints at the surface of the excavated bedrock at the founding elevation should be grouted to prevent water penetration which may cause further cracking/jointing in the founding bedrock.

6.4 Resistance to Lateral Loads

Resistance to lateral forces/sliding between the concrete footings and clean bedrock surface should be calculated in accordance with Section 6.7.5 of the CHBDC. The ultimate angle of friction between the underside of the foundations and the clean, intact bedrock surface (or between concrete surface) can be taken as 32 degrees for design. The ultimate angle of friction can be increased to 35 degrees if the surface of the bedrock can be chiseled (i.e. roughened).

If additional horizontal resistance is required, or if the rock surface is not sufficiently level, dowelling or keying-in into the bedrock can be considered. Such measures would be required if the rock surface is smooth and/or inclined. The building foundation should be anchored to the underlying bedrock by dowels to resist overturning forces. For the strip footing, dowels consist of 15 M steel rebar should be provided with spacing at 750 mm centre to centre, with a minimum embedded depth of 500 mm into sound unfractured bedrock.

6.5 Backfill and Lateral Earth Pressure

Backfill behind foundation/retaining walls should consist of non-frost susceptible, free-draining backfill materials (i.e. Granular 'A' or Granular 'B' Type I or II, with no more than 10 % passing the 0.75 mm sieve as per requirement of OPSS 1010 and its Amendment No. 110S13) and the provision of drain pipes and weep holes to prevent hydrostatic pressure build-up against the walls.

Computation of earth pressures acting against walls should be in accordance with the CHBDC. For design purposes, the properties outlined in Table 6-1 can be assumed for backfill.

Table 6-1: Backfill Properties

Property	Compacted Granular 'A' or Granular 'B' Type II	Compacted Granular 'B' Type I
Angle of Internal Friction ϕ (unfactored)	35°	32°
Unit Weight γ	22 kN/m^3	21 kN/m^3
Coefficients of Lateral Earth Pressure		
K_a	0.27	0.31
K_b	0.35	0.41
K_o	0.43	0.47
K*	0.45	0.57

Notes:

- K_a is the coefficient of active earth pressure
- K_b is the backfill earth pressure coefficient for an unrestrained structure, including compaction effects
- K_o is the coefficient of earth pressure at rest
- K* is the earth pressure coefficient for a soil loading a fully restrained structure and includes compaction effects

Earth pressure coefficients are based on the assumption that the backfill behind the retaining structure is free-draining granular material and adequate drainage is provided.

Based on the observed subsurface conditions at the site, temporary shoring is likely not required to support excavations in rock. For information purposes, if shoring is required, it may be designed using the following expression:

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

where:

P = lateral earth pressure (kPa) acting at depth h
K = earth pressure coefficient
γ = unit weight of backfill (kN/m^3)
h = depth to point of interest in metres
q = equivalent value of surcharge on the ground surface in kPa

The coefficients of lateral earth pressure given in Table 6-2 may be used to design temporary shoring systems, based on the borehole results.

Table 6-2: Recommended Unfactored Parameters for Temporary Shoring Design

Soil Type	K_a	K_O	K_p	γ (kN/m^3)
Sand and Gravel\Sand some Gravel	0.33	0.5	3.0	19.0
Bedrock (below 1.0 m)	0.12	0.15	5.0	24.0

Notes:

- K_a - coefficient of active earth pressure
- K_o - coefficient of earth pressure at rest
- K_p - coefficient of passive earth pressure
- **γ** – unit weight

6.6 Floor Slab

An asphalt or poured concrete floor slab is recommended for the sand/salt storage building to provide a barrier to potential drainage/seepage from moist/wet material. The asphalt/concrete should be suitably thick for applied loads (equipment, material, etc.) and should be situated on OPSS Granular A base at least 150 mm thick and compacted to 100 % standard Proctor maximum dry density (ASTM D698).

The existing sand and gravel overburden materials are expected to provide an acceptable subgrade. Proof rolling under the direction of the Engineer is required for approval, prior to installing floor materials.

6.7 Seismic Design

The Ontario Building Code (OBC) specifies that the structure should be designed to withstand forces due to earthquakes. For the purpose of earthquake design the information relevant to the geotechnical conditions at this site is the 'Site Class'. Based on the explored soil properties and in accordance with Table 4.1.8.4.A of the Ontario Building Code (2006), it is recommended that Site Class 'A' (Hard Rock) be applied for structural design at this site.

Seismic information for the Missanabie Corners site is provided in the table below. Data from the 2005 National Building Code Seismic Hazard Calculation is provided in this table to be consistent with the 2006 Ontario Building Code.

Parameter	Missanabie Corners	Source
Site Class	A	2006 Ontario Building Code Table 4.1.8.4.A
$S_a(0.2)$	0.116	2005 National Building Code Seismic Hazard Calculation
$S_a(1.0)$	0.027	2005 National Building Code Seismic Hazard Calculation
F_a	0.7	2006 Ontario Building Code Table 4.1.8.4.B
F_v	0.5	2006 Ontario Building Code Table 4.1.8.4.C

Based on the subsurface condition at the site where bedrock was found at surface and shallow depth, dynamic and static liquefaction are not a concern at this site.

6.8 Dewatering and Drainage

The depth of shallow groundwater within the footprint of the proposed structures, at the time of the field investigation, was generally below 1.5 m. However, fluctuating groundwater levels and/or perched groundwater may occur at the site. If foundation excavations will extend to 2.4 m below existing ground surface then groundwater may be encountered during construction, and gravity drainage or pumping from filtered sumps located at the base of the excavations may be required to provide groundwater control. Surface water runoff should be directed away from the excavations at all times. Dewatering procedures should follow the requirements and specifications of OPSS 517 and groundwater control requirements should be planned accordingly by the Contractor prior to construction.

Depending on the construction and dewatering procedures to be used, the Contractor should obtain a Permit to Take Water (PTTW) under Section 34 of the Ontario Water Resources Act if pumping rates will exceed 50,000 L/day. It is unlikely that a PTTW will be required.

6.9 Excavations and General Construction Consideration

Construction excavations are required for foundations and utility services. Temporary excavations must be carried out in accordance with the latest edition of Ontario Regulation (O.Reg.) 213/91 of the Occupational Health and Safety Act (OHSA) as well as MTO specifications OPSS 539 – Protection Systems and OPSS 902 – Excavations and Backfilling to Structure. The sand and gravel to sand some gravel encountered at the site may be classified as Type 3 soil above the groundwater level or Type 4 soil below the groundwater level, in accordance with the OHSA.

Cut slopes in the bedrock should be no more than 1H:4V and, consistent with the OHSA, the walls of the rock excavation must be stripped of any loose rock or other material that could slide, fall, or roll upon workers. Type 3 soil excavations should be cut with 1H:1V or flatter side slopes. Type 4 soil excavations should be cut with 3H:1V or flatter side slopes. If the appropriate side slopes cannot be achieved, the excavations must be properly supported (shored). All excavation and grading procedures should follow the requirements and specifications of OPSS 206, as amended by SP 206S03, and management of excess material should follow the requirements of OPSS 180.

Excavation into the bedrock could be carried out using a hardened-tooth excavator, or drilling and hoe ramming techniques where relatively shallow depths of cut into bedrock are required. Line drilling and pre-shearing techniques will provide better control over the configuration of the founding surface. However, the rock excavation should be carried out so as not to induce excessive vibrations which could damage foundations and/or superstructures of the previously constructed buildings. For example, if rock blasting is to be implemented, this should be carried out under close supervision with vibration monitoring.

Regular inspections by qualified geotechnical engineering personnel must be conducted for any excavation in the bedrock to confirm that conditions are safe and consistent with the requirements of the OHSA.

It is recommended that sulfate resistant and chloride resistant concrete mixes should be used for all foundation construction at the site using Type HS cement as per Table 2 and 3 of CSA A23.1-09 and A23.2-09.

7. Miscellaneous Information

The following GENIVAR personnel and subcontractors responsible for completion of this geotechnical investigation are summarized in Table 7.1.

Table 7.1: Summary of Task Responsibilities and Personnel

Task	Name	Address	Phone
Buried Utility Locates	Peter Flowerday Central Cable Contractors	Wanapitae, ON	705-694-5256
Drilling	Kyle Gilmore Abraflex Drilling	Lively, ON	705-222-2272
Field Supervision	Dave Lembke, C.E.T., rcji GENIVAR Inc.	Peterborough, ON	705-743-6850
Project Coordinator	Jennifer Wales, P. Eng. and Beverly Leno, C.E.T., rcji GENIVAR Inc.	Peterborough, ON	705-743-6850
Laboratory Low Complexity	Kelly Whitney, C.E.T. GENIVAR Inc.	Peterborough, ON	705-743-6850
Laboratory Medium Complexity	Marijana Manojlovic, B.Sc. Golder Associates	Mississauga, ON	905-567-4444
Report Preparation	Raid Khamis, P. Eng., PMP. GENIVAR Inc.	Brampton, ON	905-799-8220
Report Review	Steve Ash, P. Eng., P. Geo. GENIVAR Inc.	Peterborough, ON	705-743-6850
RAQ's Key Contact	Jason Balsdon, M.A.Sc., P. Eng. GENIVAR Inc.	Newmarket, ON	905-853-3303

8. Closure

The data presented in this geotechnical report, and the quality thereof, is based on a scope of work authorized by the Client. While we believe the borehole information to be representative of site conditions, subsurface conditions between and beyond the test hole locations may vary. GENIVAR accepts no liability for use of or reliance on the report information by third parties, without express written consent.

Prepared by:
GENIVAR Inc.

Raid Khamis, P. Eng., PMP.
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Director, Environment

Reviewed by:

Jason Balsdon, M.A.Sc., P. Eng.
Director, Environment

Drawings

Drawing 1 – Borehole Location

Drawing 2 – Soil Strata

PLAN VIEW

SCALE 1:1500

10 0 10 20 m

NOTES:

1. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
2. COORDINATES AT BOREHOLE LOCATIONS WERE BY HANDHELD GPS.
3. BOREHOLE ELEVATIONS WERE SURVEYED RELATIVE TO A NAIL, PAINTED AND FLAGGED, IN A TREE (RELATIVE EL. 100.00 m).

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES

Agreement No.: 5011-E-0010

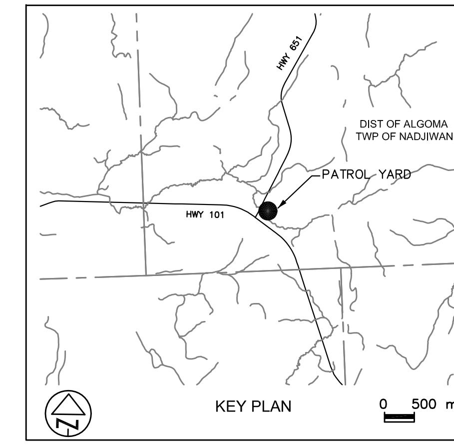
WO No.: 2011-11041

BOREHOLE LOCATION PLAN

PROPOSED SAND/SALT STORAGE FACILITY AND OFFICE / GARAGE
MISSANABIE CORNERS PATROL YARD
KING'S HIGHWAY 651

Client: MTO - Northeastern Region

DRAWING 1



LEGEND

- Borehole
- Benchmark

BH No	ELEVATION (Relative m)	COORDINATES (NAD 83 Zone16) NORTHING	EASTING
12–1	99.4	5314093.7	715225.3
12–2	99.1	5314074.4	715215.2
12–3	99.2	5314067.2	715228.5
12–4	99.3	5314087.1	715238.3
12–5	99.0	5314062.9	715236.7
12–6	99.1	5314066.4	715247.1

– NOTE –

THE ACTUAL SOIL STRATIFICATION HAS BEEN VERIFIED FROM DATA OBTAINED AT THE BOREHOLE LOCATIONS ONLY. THE INFERRED CONTACTS SHOWN ARE BASED ON GEOLOGICAL EVIDENCE AND THESE MAY VARY FROM THOSE SHOWN BETWEEN BORINGS.

LICENSED PROFESSIONAL ENGINEER
J. S. Ash
Jan 15/13
PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER
J. T. Balsdon
Jan 15/13
PROVINCE OF ONTARIO

SITE PLAN MAPPING REF. NO.:
MTO PLAN H–380–2, DECEMBER 1070.

PROJECT: 121–17876–00 111–11

GENIVAR

REVISIONS	DATE	BY	DESCRIPTION

GEOCRES No. 41N–21

HWY No 651			DIST ALGOMA
SUBM'D --	CHECKED JSA	DATE JANUARY 2013	SITE --
DRAWN PLB	CHECKED --	APPROVED --	DWG --

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES

Agreement No.: 5011-E-0010
WO No.: 2011-11041

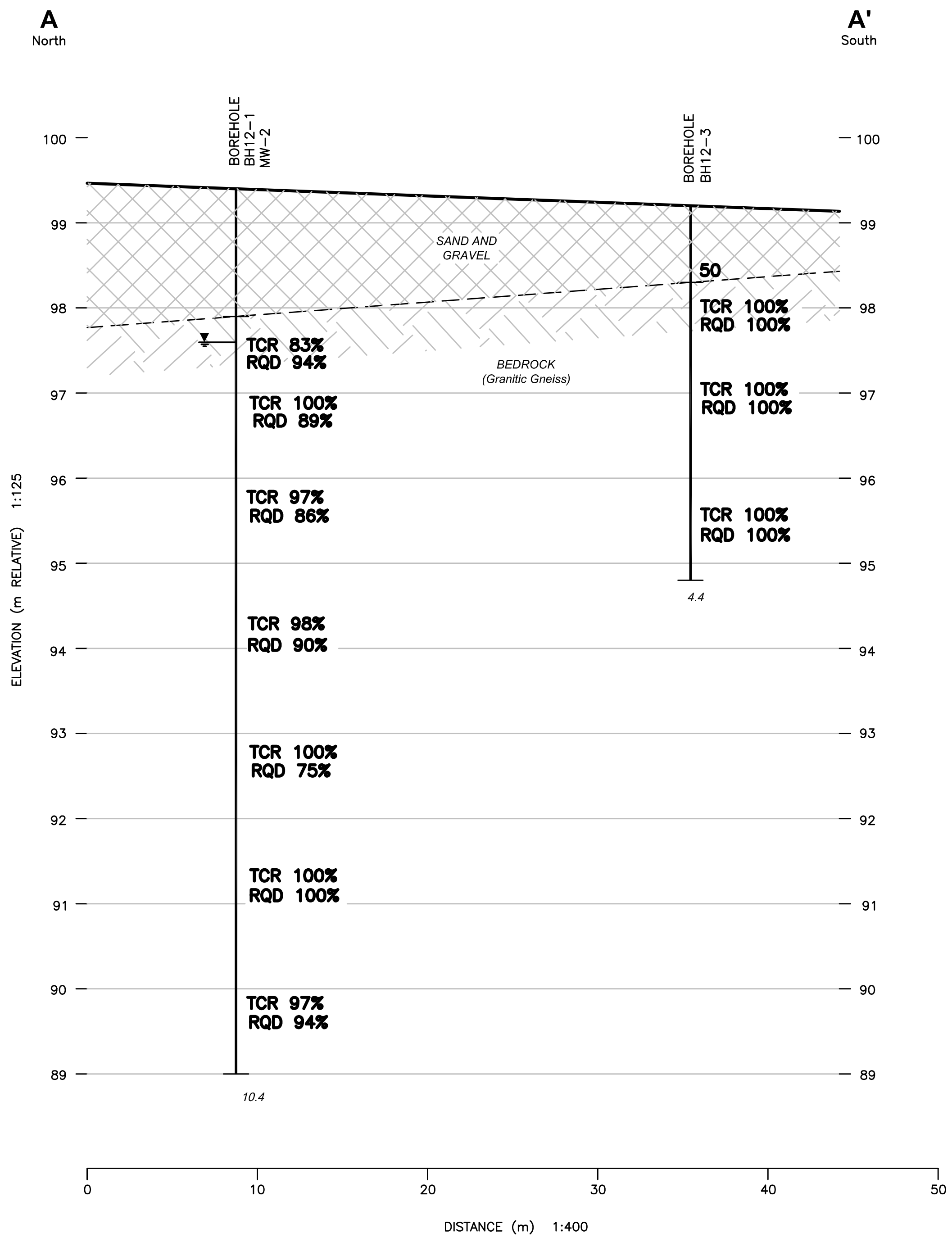
SOIL STRATA

PROPOSED SAND/SALT STORAGE FACILITY AND OFFICE / GARAGE
MISSANABIE CORNERS PATROL YARD
KING'S HIGHWAY 651

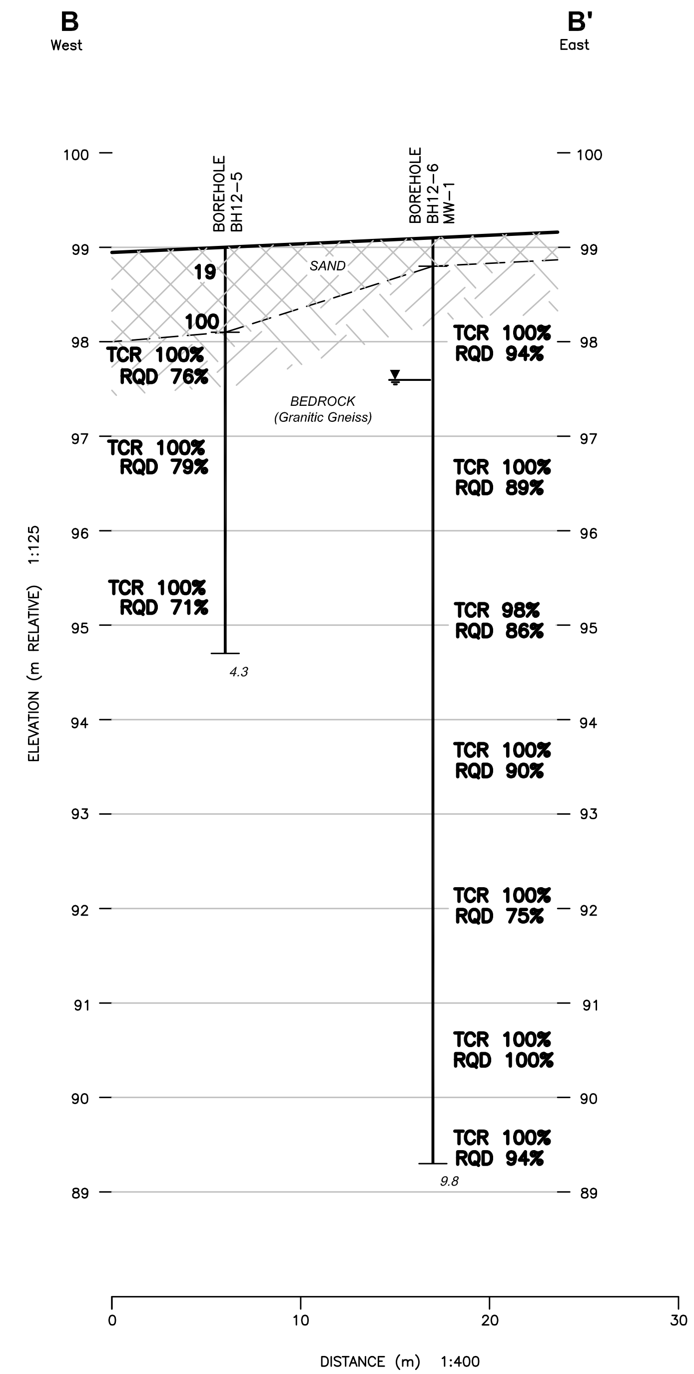
Client: MTO - Northeastern Region

DRAWING 2

CROSS SECTION A-A'



CROSS SECTION B-B'



LEGEND

19 Blows/0.3m (Std. Pen Test, 475 J / blow)

▼ Water Level At Time Of Investigation

BH No	ELEVATION (Relative m)	COORDINATES (NAD 83 Zone18) NORTHING	EASTING
12–1	99.4	5314093.7	715225.3
12–2	99.1	5314074.4	715215.2
12–3	99.2	5314067.2	715228.5
12–4	99.3	5314087.1	715238.3
12–5	99.0	5314062.9	715236.7
12–6	99.1	5314066.4	715247.1

– NOTE –

THE ACTUAL SOIL STRATIFICATION HAS BEEN VERIFIED FROM DATA OBTAINED AT THE BOREHOLE LOCATIONS ONLY. THE INFERRED CONTACTS SHOWN ARE BASED ON GEOLOGICAL EVIDENCE AND THESE MAY VARY FROM THOSE SHOWN BETWEEN BORINGS.

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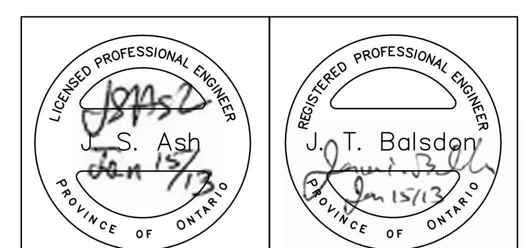
3. BOREHOLE ELEVATIONS WERE SURVEYED RELATIVE TO A NAIL, PAINTED AND FLAGGED, IN A TREE (RELATIVE EL. 100.00 m).

PROJECT: 121–17876–00 111–11

GENIVAR



REVISIONS DATE	BY	DESCRIPTION

GEOCRES No. 41N–21

HWY No 651			DIST ALGOMA
SUBM'D --	CHECKED JSA	DATE JANUARY 2013	SITE --
DRAWN PLB	CHECKED --	APPROVED --	DWG --

Appendix A

Borehole Explanation Forms

Borehole Logs

BOREHOLE LOG EXPLANATION FORM

This explanatory section provides the background to assist in the use of the borehole logs. Each of the headings used on the borehole log, is briefly explained.

DEPTH

This column gives the depth of interpreted geologic contacts in metres below ground surface.

STRATIGRAPHIC DESCRIPTION

This column gives a description of the soil based on a tactile examination of the samples and/or laboratory test results. Each stratum is described according to the following classification and terminology.

Soil Classification*		Terminology	Proportion
Clay	<0.002 mm		
Silt	0.002 to 0.06 mm	"trace" (e.g. trace sand)	<10%
Sand	0.06 to 2 mm	"some" (e.g. some sand)	10% - 20%
Gravel	2 to 60 mm	adjective (e.g. sandy)	20% - 35%
Cobbles	60 to 200 mm	"and" (e.g. and sand)	35% - 50%
Boulders	>200 mm	noun (e.g. sand)	>50%

* Extension of MIT Classification system unless otherwise noted.

The use of the geologic term "till" implies that both disseminated coarser grained (sand, gravel, cobbles or boulders) particles and finer grained (silt and clay) particles may occur within the described matrix.

The compactness of cohesionless soils and the consistency of cohesive soils are defined by the following:

COHESIONLESS SOIL		COHESIVE SOIL		
Compactness	Standard Penetration Resistance "N", Blows / 0.3 m	Consistency	Standard Penetration Resistance "N", Blows / 0.3 m	Undrained Shear Strength (cu) (kPa)
Very Loose	0 to 4	Very Soft	0 to 2	0 to 12
Loose	4 to 10	Soft	2 to 4	12 to 25
Compact	10 to 30	Firm	4 to 8	25 to 50
Dense	30 to 50	Stiff	8 to 15	50 to 100
Very Dense	Over 50	Very Stiff	15 to 30	100 to 200
		Hard	Over 30	Over 200

The moisture conditions of cohesionless and cohesive soils are defined as follows.

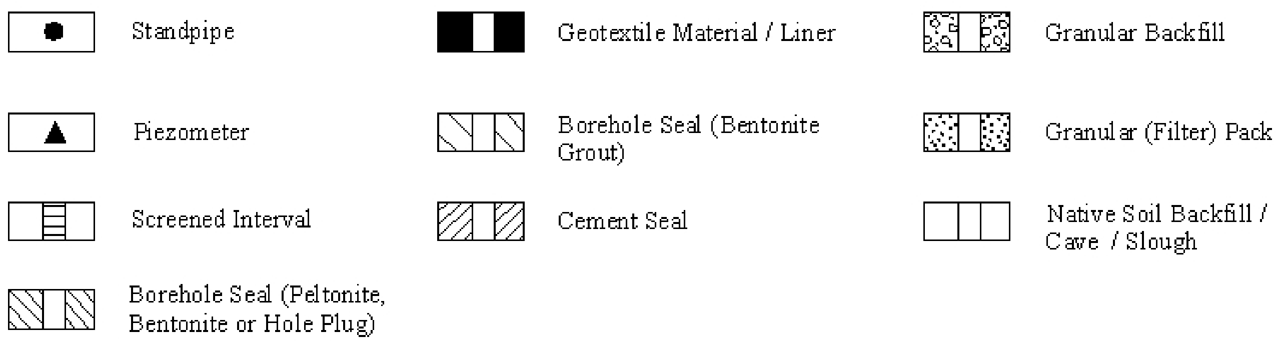
COHESIONLESS SOILS	COHESIVE SOILS		
Dry	DTPL	-	Drier Than Plastic Limit
Moist	APL	-	About Plastic Limit
Wet	WTPL	-	Wetter Than Plastic Limit
Saturated	MWTPL	-	Much Wetter Than Plastic Limit

STRATIGRAPHY

Symbols may be used to pictorially identify the interpreted stratigraphy of the soil and rock strata.

MONITOR DETAILS

This column shows the position and designation of standpipe and/or piezometer ground water monitors installed in the borehole. Also the water level may be shown for the date indicated.



Where monitors are placed in separate boreholes, these are shown individually in the "Monitor Details" column. Otherwise, monitors are in the same borehole. For further data regarding seals, screens, etc., the reader is referred to the summary of monitor details table.

SAMPLE

These columns describe the sample type and number, the "N" value, the water content, the percentage recovery, and Rock Quality Designation (RQD), of each sample obtained from the borehole where applicable. The information is recorded at the approximate depth at which the sample was obtained. The legend for sample type is explained below.

SS =	Split Spoon	GS =	Grab Sample
TW =	Thin Walled Shelby Tube	CS =	Channel Sample
AS =	Auger Flight Sample	WS =	Wash Sample
CC =	Continuous Core	RC =	Rock Core
PH =	TW Advanced Hydraulically		

$$\% \text{ Recovery} = \frac{\text{Length of Core Recovered Per Run}}{\text{Total Length of Run}} \times 100$$

Where rock drilling was carried out, the term RQD (Rock Quality Designation) is used. The RQD is an indirect measure of the number of fractures and soundness of the rock mass. It is obtained from the rock cores by summing the length of core recovered, counting only those pieces of sound core that are 100 mm or more in length. The RQD value is expressed as a percentage and is the ratio of the summed core lengths to the total length of core run. The classification based on the RQD value is given below.

RQD Classification	RQD (%)
Very poor quality	< 25
Poor quality	25 - 50
Fair quality	50 - 75
Good quality	75 - 90
Excellent quality	90 - 100

TEST DATA

The central section of the log provides graphs which are used to plot selected field and laboratory test results at the depth at which they were carried out. The plotting scales are shown at the head of the column.

Dynamic Penetration Resistance - The number of blows required to advance a 51 mm diameter, 60º steel cone fitted to the end of 45 mm OD drill rods, 0.3 m into the subsoil. The cone is driven with a 63.5 kg hammer over a fall of 750 mm.

Standard Penetration Resistance - Standard Penetration Test (SPT) "N" Value - The number of blows required to advance a 51 mm diameter standard split-spoon sampler 300 mm into the subsoil, driven by means of a 63.5 kg hammer falling freely a distance of 750 mm. In cases where the split spoon does not penetrate 300 mm, the number of blows over the distance of actual penetration in millimetres is shown as $\frac{xBlows}{mm}$

Water Content - The ratio of the mass of water to the mass of oven-dry solids in the soil expressed as a percentage.

W_P - Plastic Limit of a fine-grained soil expressed as a percentage as determined from the Atterberg Limit Test.

W_L - Liquid Limit of a fine-grained soil expressed as a percentage as determined from the Atterberg Limit Test.

REMARKS

The last column describes pertinent drilling details, field observations and/or provides an indication of other field or laboratory tests that were performed.

RECORD OF BOREHOLE No BH12-1

METRIC

LOCATION: MISSANABIE CORNERS PATROL YARD N 5 314 093.7 E 715 225.3 — ORIGINATED BY: DCL

BOREHOLE TYPE: CONTINUOUS FLIGHT HOLLOW STEM AUGERS WITH SPT, AND NQ CORING — COMPILED BY: DCL

DATUM: RELATIVE BENCHMARK — DATE: 6.13.12 - 6.13.12 — CHECKED BY: JSA

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	NATURAL MOISTURE CONTENT	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
99.4 / 0.0	**SAND AND GRAVEL:** SAND AND GRAVEL, TRACE SILT BROWN, MOIST	1	AS		o		39 59 (2)
97.9 / 1.5	**BEDROCK:** PINK, GREY, AND BLACK BANDED GRANITIC GNEISS, FINE-MEDIUM GRAINED, MODERATE TO STRONG FOLIATION, HARD, STRONG, SLIGHTLY WEATHERED	1	RC	TCR 83%			RQD = 69%
		2	RC	TCR 100%			RQD = 100%
		3	RC	TCR 97%			RQD = 91%
		4	RC	TCR 98%			RQD = 86%
		5	RC	TCR 100%			RQD = 88%
		6	RC	TCR 100%			RQD = 100%
		7	RC	TCR 97%			RQD = 91%
89.0 / 10.4	END OF BOREHOLE						

Elevation scale: 99, 98, 97, 96, 95, 94, 93, 92, 91, 90, 89

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%): 10 20 30

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

RECORD OF BOREHOLE No BH12-2

METRIC

LOCATION: MISSANABIE CORNERS PATROL YARD N 5 314 074.4 E 715 215.2 — ORIGINATED BY: DCL

BOREHOLE TYPE: CONTINUOUS FLIGHT HOLLOW STEM AUGERS WITH SPT, AND NQ CORING — COMPILED BY: DCL

DATUM: RELATIVE BENCHMARK — DATE: 6.12.12 - 6.12.12 — CHECKED BY: JSA

SOIL PROFILE: ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
99.1											
0.0	**GRAVELLY SAND:** GRAVELLY SAND, SOME SILT BROWN, COMPACT, MOIST		1	SS	30		99		o (approx. 11)		
98.6 / 0.5	END OF BOREHOLE										

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

RECORD OF BOREHOLE No BH12-3

METRIC

LOCATION: MISSANABIE CORNERS PATROL YARD N 5 314 067.2 E 715 228.5 — ORIGINATED BY: DCL

BOREHOLE TYPE: CONTINUOUS FLIGHT HOLLOW STEM AUGERS WITH SPT, AND NQ CORING — COMPILED BY: DCL

DATUM: RELATIVE BENCHMARK — DATE: 6.12.12 - 6.12.12 — CHECKED BY: JSA

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
99.2										
0.0	**SAND AND GRAVEL** SAND AND GRAVEL, TRACE SILT BROWN, MOIST		1	AS			99	~17		43 50 (7)
98.3			2	SS	50			~10		
0.9	**BEDROCK** PINK, GREY, AND BLACK BANDED GRANITIC GNEISS, FINE-MEDIUM GRAINED, MODERATE TO STRONG FOLIATION, HARD, STRONG, SLIGHTLY WEATHERED		1	RC	TCR 100%		98			RQD = 0%
			2	RC	TCR 100%		97			RQD = 76%
			3	RC	TCR 100%		96			RQD = 87%
94.8							95			
4.4	END OF BOREHOLE									

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 (%) 10 20 30

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

RECORD OF BOREHOLE No BH12-4

METRIC

LOCATION: MISSANABIE CORNERS PATROL YARD N 5 314 087.1 E 715 238.3 — ORIGINATED BY: DCL

BOREHOLE TYPE: CONTINUOUS FLIGHT HOLLOW STEM AUGERS WITH SPT, AND NQ CORING — COMPILED BY: DCL

DATUM: RELATIVE BENCHMARK — DATE: 6.12.12 - 6.12.12 — CHECKED BY: JSA

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
99.3 / 0.0	**GRAVELLY SAND:** GRAVELLY SAND, SOME SILT BROWN, MOIST		1	AS			99				
			2	SS	24						
98.1 / 1.2	END OF BOREHOLE										

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No BH12-5

METRIC

LOCATION: MISSANABIE CORNERS PATROL YARD N 5 314 062.9 E 715 236.7 — ORIGINATED BY: DCL

BOREHOLE TYPE: CONTINUOUS FLIGHT HOLLOW STEM AUGERS WITH SPT, AND NQ CORING — COMPILED BY: DCL

DATUM: RELATIVE BENCHMARK — DATE: 6.11.12 - 6.11.12 — CHECKED BY: JSA

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
99.0 / 0.0	**SAND:** FINE SAND, SOME GRAVEL BROWN, COMPACT, MOIST	1	SS	19			w ≈ 10		
		2	SS	100					
98.1 / 0.9	**BEDROCK:** PINK, GREY, AND BLACK BANDED GRANITIC GNEISS, FINE-MEDIUM GRAINED, MODERATE TO STRONG FOLIATION, HARD, STRONG, SLIGHTLY WEATHERED	1	RC	TCR 100%		98			RQD = 76%
		2	RC	TCR 100%		97			RQD = 79%
		3	RC	TCR 100%		96 / 95			RQD = 71%
94.6 / 4.3	END OF BOREHOLE								

Plot headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa — O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10, 20, 30.

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

RECORD OF BOREHOLE No BH12-6

METRIC

LOCATION: MISSANABIE CORNERS PATROL YARD N 5 314 066.4 E 715 247.1 — ORIGINATED BY: DCL

BOREHOLE TYPE: CONTINUOUS FLIGHT HOLLOW STEM AUGERS WITH SPT, AND NQ CORING — COMPILED BY: DCL

DATUM: RELATIVE BENCHMARK — DATE: 6.12.12 - 6.13.12 — CHECKED BY: JSA

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	NATURAL MOISTURE CONTENT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
99.1							
0.0	**SAND:** FINE SAND, SOME GRAVEL, BROWN, MOIST	1	AS			o	
98.7 / 0.4	**BEDROCK:** PINK, GREY, AND BLACK BANDED GRANITIC GNEISS, FINE-MEDIUM GRAINED, MODERATE TO STRONG FOLIATION, HARD, STRONG, SLIGHTLY WEATHERED	1	RC	TCR 100%	98		RQD = 94%
		2	RC	TCR 100%	97		RQD = 89%
		3	RC	TCR 98%	96, 95		RQD = 86%
		4	RC	TCR 100%	94		RQD = 90%
		5	RC	TCR 100%	93, 92		RQD = 75%
		6	RC	TCR 100%	91		RQD = 100%
		7	RC	TCR 100%	90		RQD = 94%
89.4 / 9.7	END OF BOREHOLE						

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10, 20, 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

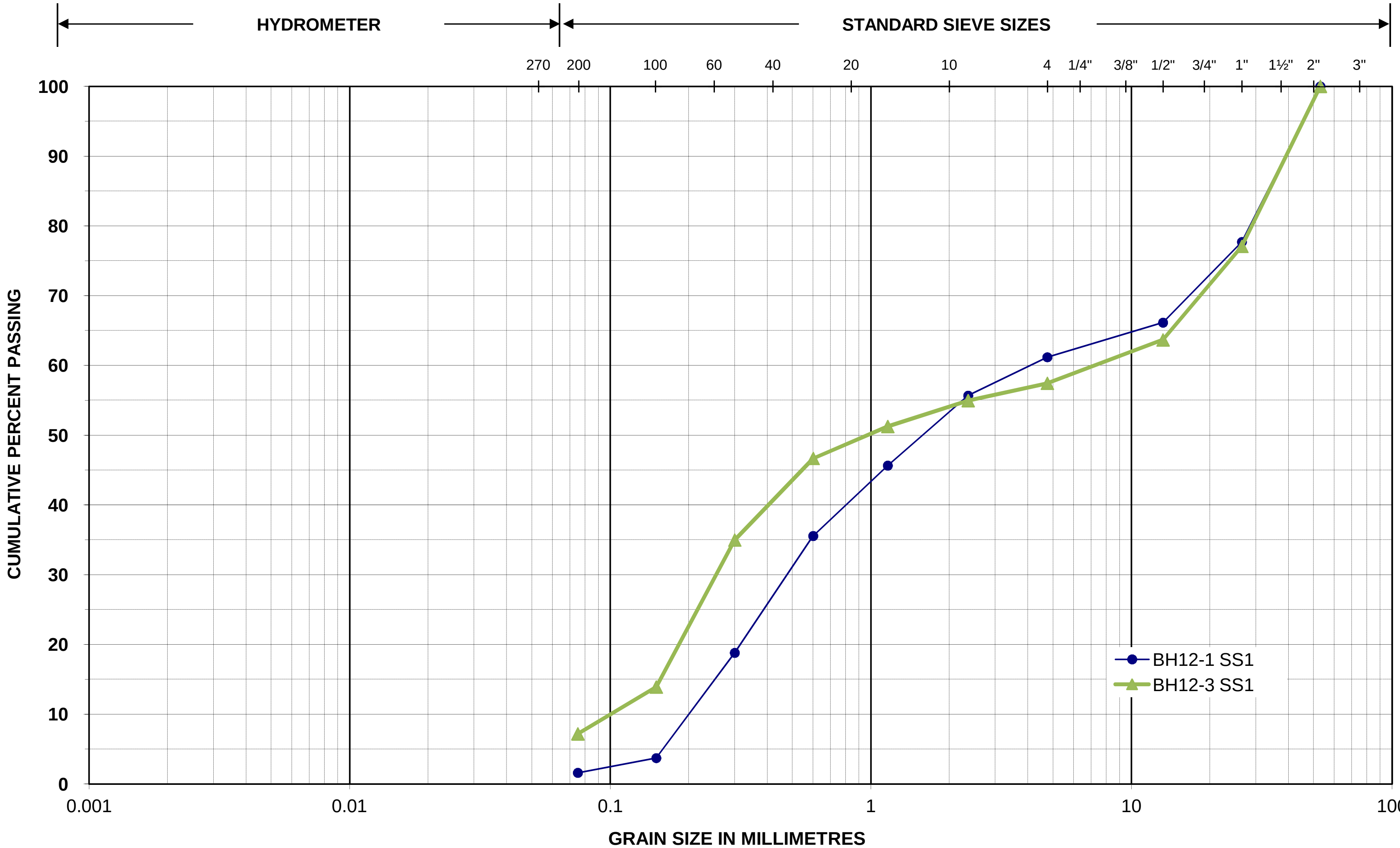
$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

Appendix B

Particle Size Distribution Analyses (Figure B1)

GENIVAR

PARTICLE SIZE DISTRIBUTION ASTM D422



Unified Classification System

SILT AND CLAY	SAND	GRAVEL

Project Name:	Missanabie Corners Patrol Yard	**Project No.:**	121-17876-00	**Figure No.:**	**B1**
Remarks	Sand and gravel, trace silt				

Appendix C

Site Photographs

Rock Core Photographs

MTO AGREEMENT #5011-E-0010
MISSANABIE CORNERS PATROL YARD

Photograph 1: Site access and granular pad. Looking southwest.

Photograph 2: Granular pad and surrounding forest. Looking northwest.

MTO AGREEMENT #5011-E-0010
MISSANABIE CORNERS PATROL YARD

Photograph 3: Granular pad. Looking south.

Photograph 4: Granular pad and drilling. Looking east.

Photograph 5: BH12-6 (MW1). Exposed bedrock. Looking south.

Photograph 6: BH12-1 (MW2). Looking north.

Photograph 1: BH12-1 Rock Core (1.52 m to 4.04 m).

Photograph 2: BH12-1 Rock Core (4.04 m to 8.92 m).

Photograph 3: BH12-1 Rock Core.

Photograph 4: BH12-1 Rock Core (8.92 m to 10.41 m).

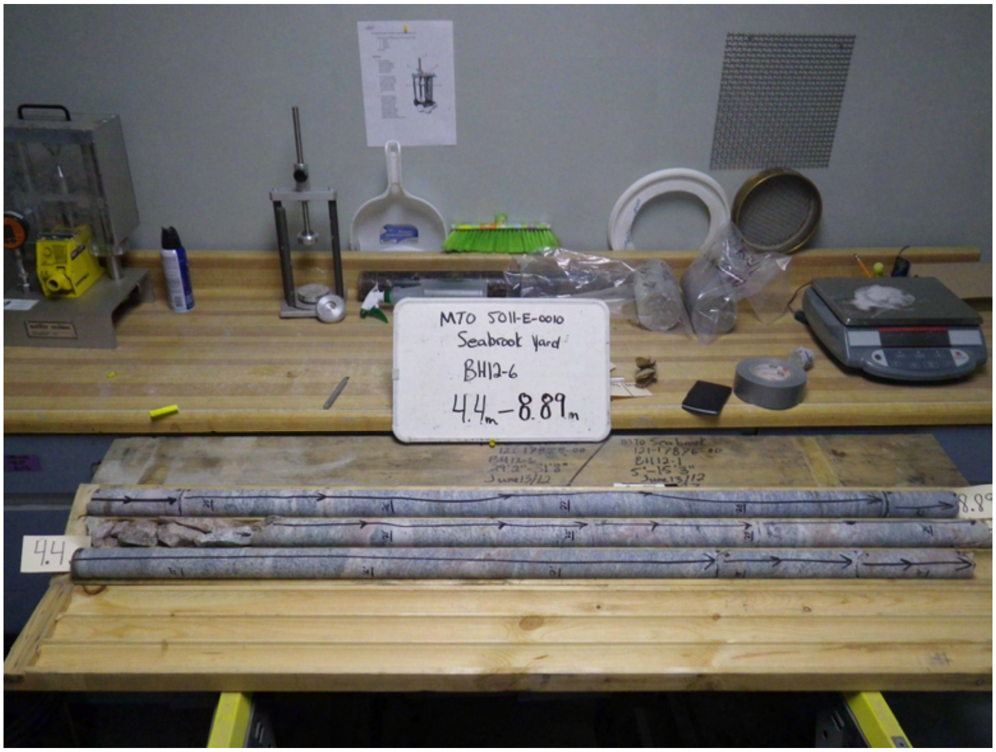
Photograph 5: BH12-3 Rock Core (0.91 m to 4.39 m).

Photograph 6: BH12-5 Rock Core (0.91 m to 4.34 m).

Photograph 7: BH12-6 Rock Core (0.38 m to 4.4 m).

Photograph 8: BH12-6 Rock Core.

MTO AGREEMENT #5011-E-0010
MISSANABIE CORNERS PATROL YARD – ROCK CORE



Photograph 9: BH12-6 Rock Core (4.4 m to 8.89 m).

Photograph 10: BH12-6 Rock Core (8.89 m to 9.65 m).