LVM Maritime Testing

Geotechnical, Materials and Environmental Engineering

SNC Lavalin Inc.

Geotechnical Investigation
Bedford Institute of Oceanography Second Access Road, Dartmouth, Nova Scotia

Final Report

Date: April 25, 2016
Ref. N°: 20127

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Final Report | 20127

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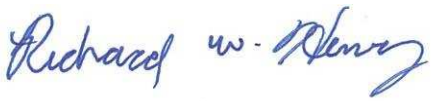

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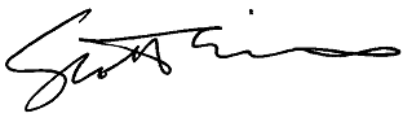

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Property and Confidentiality

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0	2015-03-31	Draft Report
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1 INTRODUCTION

At the request of SNC Lavalin Inc., LVM - Maritime Testing (LVM-MTL), a division of EnGlobe Corp., has carried out a geotechnical investigation for the construction of a second access road and upgrading to existing roads at the Bedford Institute of Oceanography, in Dartmouth, Nova Scotia. The purpose of the work was to assess the subsurface conditions at select areas of the proposed and existing roads and to make recommendations for design and costing of earthworks and roadway construction.

This report presents the observations and engineering recommendations associated with the geotechnical investigation of the site. Included herein are the factual results of the field investigation including discussion of field procedures, subsurface conditions, laboratory analysis and recommendations for site development.

2 SITE AND PROJECT DESCRIPTION

Fire Authorities have recommended to Department of Fisheries that a second access road to Bedford Institute of Oceanography be developed to provide more reliable access/egress to/from the campus in the event of an emergency evacuation. Preliminary work completed to date indicates that the most reliable and cost effective access would be through Wallace Heights. In addition to the new access, the existing roads, Baffin Boulevard and Hudson Way, will be upgraded as necessary to a standard that is acceptable to the Halifax Regional Municipality (HRM) and Halifax Water so that when the work is complete the roads can be conveyed to HRM. To determine the existing subsurface conditions along the existing roads to input into the design and costing of the upgrades, a proposal for a geotechnical investigation has been requested.

3 INVESTIGATION PROCEDURE

The fieldwork for the investigation was carried out from March 17 to 24, 2015, when twelve (12) boreholes were drilled and two (2) test pits were excavated at the approximate locations shown on the enclosed Figure 1. The boreholes were drilled using a truck-mounted auger drill rig supplied by Logan Geotech of Stewiacke, NS. The excavator was supplied to the project by a local earthworks contractor.

The site investigation was carried out by qualified geotechnical engineering personnel who located the test pits and boreholes in the field and logged the subsurface conditions. The test locations were predetermined by the client in advance of the investigation. The boreholes were advanced using continuous flyte augers with field sampling and testing performed in the open borehole. Standard Penetration Tests (SPT) were carried out at regular intervals in all boreholes to obtain soil blow counts (i.e. N-values) using a 50-mm O.D. split spoon sampler. Disturbed soil samples were obtained from the boreholes using conventional techniques. Grab samples were obtained from the test pits.

Following field sampling and visual description, overburden samples were placed in waterproof sample bags and transported to our Dartmouth laboratory for further examination and scheduling for geotechnical index testing.

4 SUBSURFACE CONDITIONS

An explanation of terms and symbols used in the report is provided in Appendix 1. A summary of the encountered geologic conditions is provided on the Borehole and Test Pit Logs in Appendix 2. Laboratory Testing results are provided in Appendix 3.

It should be noted that the stratigraphic boundaries on the Borehole and Test Pit Logs typically represent a transition of one soil type to another and do not necessarily indicate an exact plane of geologic change. Subsurface conditions may vary between and beyond the Borehole locations.

In summary, the soil conditions encountered at the boreholes and test pits were similar and consisted of asphalt pavement and fill deposits or rootmat/topsoil overlying glacial till and inferred bedrock. Practical refusal of the drill augers, split spoon sampler or excavator bucket was encountered at all borehole and test pit locations except for boreholes BH 8 and BH 9, indicating bedrock or a large boulder. Practical refusal was encountered at depths ranging from 1.2 metres to 2.7 metres at the borehole and test pit locations. The following paragraphs and table further describe the subsurface conditions at the site.

Table 1 Summary of Subsurface Conditions

BOREHOLE / TEST PIT NUMBER	ASPHALT PAVEMENT THICKNESS (MM)	ROADWAY GRAVEL THICKNESS (MM)	DEPTH TO TILL (METRES)	DEPTH TO BEDROCK (METRES) [1.]
BH 1	101	356	--	1.8
BH 2	140	775	2.1	2.2
BH 3	114	190	--	1.2
BH 4	127	177	--	1.4
BH 5	168	290	--	2.0
BH 6	102	509	--	1.4
BH 7	102	814	--	2.7
BH 8	102	357	1.1	--
BH 9	102	357	1.8	--
BH 10	102	357	--	1.8

BOREHOLE / TEST PIT NUMBER	ASPHALT PAVEMENT THICKNESS (MM)	ROADWAY GRAVEL THICKNESS (MM)	DEPTH TO TILL (METRES)	DEPTH TO BEDROCK (METRES) [1.]
BH 11	89	722	2.0	2.4
BH 12	127	329	2.1	2.7
TP 13	--	--	0.5	1.4
TP 14	--	--	0.5	2.0

1. Practical refusal to advance augers or split spoon refusal on large boulder or inferred bedrock.

4.1 Asphalt Pavement and Roadway Gravel

Asphalt pavement was encountered at the surface of all boreholes at a thickness ranging from 89 mm to 168 mm. Roadway gravel underlying the asphalt pavement ranged in thickness from 177 mm to 814 mm. At most of the borehole locations, several distinct layers of asphalt were noted indicating the roadway(s) had been resurfaced. Although the boundary between the roadway gravels and underlying fill was distinctly identified, it was not possible in the boreholes to identify distinct gravel types (i.e., Type 1 or Type 2).

4.2 Fill

Fill deposits have been encountered in all boreholes below the roadway gravels. The fill generally consisted of gravelly sand, trace to some silt and some cobbles. Trace organics were evident in the fill at BH 4. The fill varied from greyish brown to grey brown in colour and its moisture content can be described as dry to moist. Standard penetration N-values for the fill at the boreholes ranged from 15 to 73 blows per 300 mm penetration, indicating a loose to dense material. The high N-values recorded in the fill deposit may be attributed to the gravel and cobble content and generally not representative of the *insitu* relative density. The fill was proven for a total depth of 2.6 metres at BH 7.

Laboratory gradation testing of a select fill sample indicated a material with 33 percent sand, 43 percent gravel, and a fines (i.e. silt and clay sizes) content of 24 percent. Moisture content testing of a select fill sample indicated 5.5 percent.

4.3 Organic Soils

Rootmat/Topsoil was encountered at the surface of both test pits. The rootmat/topsoil was approximately 500 mm in thickness at both test pits. A thin layer of topsoil was encountered below fill deposits at BH 2 and BH 7. The topsoil was approximately 40 mm in thickness on average.

4.4 Till (Site-Native Glacial Soil)

Till deposits have been encountered at boreholes and test pits BH 2, BH 8, BH 9, BH 11, BH 12, TP 13 and TP 14 below the fill deposits or rootmat/topsoil. The till consisted of gravelly sand, trace to some

silt with occasional to some cobbles and small boulders. The till was typically grey to grey-brown in colour and its moisture content can be described as moist. Standard penetration N-values for the till at the boreholes ranged from 34 to 69 blows per 300 mm penetration, indicating a dense material. The high N-values recorded in the fill deposit may be attributed to the gravel and cobble content and generally not representative of the *insitu* relative density. The till was proven for a total depth of 3.1 metres at BH 8.

Laboratory gradation testing of a select till sample indicated a material with 49 percent sand, 30 percent gravel, and a fines (i.e. silt and clay sizes) content of 21 percent. Moisture content testing of a select till sample indicated 7.0 percent.

4.5 Bedrock

Geologic mapping of the proposed development area indicates that the site is underlain by the Goldenville formation that comprises mainly of Greywacke (quartzite). During the investigation, Quartzite bedrock was inferred at all borehole locations, except BH 8 and BH 9, by refusal to advance the drill auger or split spoon refusal. Bedrock was inferred at both test pits locations by refusal to advance the excavator bucket. Bedrock was encountered either below the glacial till or fill deposits at total depths ranging from 1.2 to 2.7 metres at the boreholes and test pits. Diamond core drilling of bedrock was not conducted at the site.

4.6 Groundwater

Groundwater observations were made during the field investigation through open-hole measurement at the borehole locations. A summary of the accumulated groundwater information is provided on the Borehole Logs in Appendix 2.

During the current investigation, groundwater was encountered at borehole BH 1, BH 7 and BH 11 at depths ranging from 1.2 metres to 2.4 metres below the existing ground surface. Perched groundwater can be expected during construction. Seasonal fluctuations in groundwater levels can be expected.

5 DISCUSSION AND RECOMMENDATIONS FOR DESIGN

5.1 Site Development – General

Fire Authorities have recommended to Department of Fisheries that a second access road to Bedford Institute of Oceanography be developed to provide more reliable access/egress to/from the campus in the event of an emergency evacuation. Preliminary work completed to date indicates that the most reliable and cost effective access would be through Wallace Heights. In addition to the new access, the existing roads, Baffin Boulevard and Hudson Way, will be upgraded as necessary to a standard that is acceptable to the Halifax Regional Municipality (HRM) and Halifax Water so that when the work is complete the roads can be conveyed to HRM.

5.2 Flexible Pavement Design

Extension of Hudson Way to Princess Margaret Boulevard.

The construction of the extension will likely involve conventional site preparation and earthworks construction practices and is expected to impact nominally on the existing environment(s). Care in site preparation, including installation, maintenance and evaluation of all environmental control measures would be required.

Roadway preparation would first require removal of vegetation and organic soils (i.e. site grubbing). This work should be limited to the Line of Disturbance (i.e. right-of-way) defined for the project. In general, maintaining vegetation on designated undisturbed areas is essential and will minimize the potential for soil loss through erosion.

In conjunction with grubbing, storm water control should be established. This typically consists of placing temporary roadway culverts, ditching and installation of control mechanisms that will regulate surface water flow across the site and roadway subgrade areas. If required, installation of culverts should be carried out in accordance with the Transportation and Public Works Environmental Practice Specification governing culvert installation.

Following initial activities, roadway subgrade preparation will be required. The extent of this will be directly linked to the final roadway design. Use of on-site soils for fill purposes is discussed below.

At the current stage, detailed roadway design has not been carried out. Depending on final design elevations, the roadway subgrade will most likely be constructed of rockfill or site till. In keeping with Halifax Regional Municipality's "Municipal Design Guidelines 2013", section 4.4.1.5, the site soils can be classified as granular till. Consistent with Standard Detail, 16 m Urban Minor Collector, LVM-MTL recommends the following roadway cross section.

Hudson Way Extension (16 m Urban Minor Collector, Granular Till Subgrade)	50 mm – Type C Asphalt Pavement 75 mm – Type B Asphalt Pavement 150 mm – Type 1 Gravel 400 mm – Type 2 Gravel
Hudson Way Extension (16 m Urban Minor Collector, Rockfill Subgrade)	50 mm – Type C Asphalt Pavement 75 mm – Type B Asphalt Pavement 150 mm – Type 1 Gravel 300 mm – Type 2 Gravel

Minimum compaction (pavement) – 92.5 % Theoretical Maximum Density (ASTM D2041)
Minimum compaction (granular(s)) – 100 % Standard Proctor Maximum Dry Density

* All pavement structure materials to meet HRM Specifications.

5.3 Evaluation of the Existing Roadways

Based on measurements taken in the boreholes, the asphalt pavement thickness on Baffin Boulevard ranged from 101 mm to 168 mm with an average thickness of 125 mm, and the layer identified as roadway gravels ranged from 177 mm to 775 mm with an average thickness of 383 mm. For Hudson Way, the asphalt thickness ranged from 89 mm to 127 mm with an average thickness of 104 mm, and the roadway gravels ranged from 329 mm to 814 mm with an average thickness of 489 mm. Based on the HRM road classification of Urban Minor Collector and assuming a granular till subgrade, the average asphalt thickness is satisfied for Baffin Boulevard but not Hudson Way, and the average roadway gravel thickness is not satisfied for either Baffin Boulevard or Hudson Way.

Although the asphalt thickness and roadway gravels do not satisfy HRM specification, consideration must be given to the past usage and existing condition of the two roads. Baffin Boulevard is the main roadway to BIO and all transport trucks taking supplies and equipment to the ships and facilities travel along this road. Hudson Way is mostly used by automobiles for employing accessing the BIO facility and parking lot areas. Based on visual observations made during the borehole program, both Baffin Boulevard and Hudson Way appear to be performing satisfactory with only localized areas exhibiting deterioration and no areas suggested major subgrade failures or drainage issues. It is understood that only minor changes are proposed to the horizontal and vertical alignments to Baffin Boulevard and Hudson Way other than constructing a new intersection where the roads meet. It is our opinion that complete reconstruction of these roadways in order to satisfy the HRM specifications for asphalt and gravel thicknesses is not necessary but that an asphalt overlay in conjunction with milling and localized reconstruction be adequate for the roads to perform satisfactorily over their expected lifespan. It is recommended that once snow melts and the ground thaws that a detailed surface evaluation of the asphalt pavement be conducted so that detailed recommendations can be provided for measures to upgrade the existing roadways to performance levels for the intended usage.

5.4 Re-use of On-site Materials and Backfilling

The insitu soils (i.e. glacial till or blasted bedrock) are generally suitable for re-use as structural fill. The reuse of on-site materials will be contingent to a large extent on the condition of the materials after excavation, handling and stockpiling. The organic soils or wet soils are not acceptable for use as structural fill. These soils should only be used in non-settlement sensitive areas of the site.

To qualify as subgrade fill, all boulders, debris and deleterious inclusions should be removed. Structural fill should be placed in lifts not exceeding 300 mm in thickness and compacted in-place to 95 percent standard Proctor maximum dry density. A higher level of compaction (i.e. 98 percent) is recommended for structural fill within the upper 0.3 metres of finished subgrade.

5.5 Dewatering

During earthworks, water may be expected to enter excavations during precipitation events, as surface runoff or as seepage from within the soil strata. The rate of infiltration into shallow excavations is expected to be moderate and can be controlled by conventional dewatering techniques consisting of 75 to 100 mm diameter portable pumps and grading of excavations to sump locations. The rate of

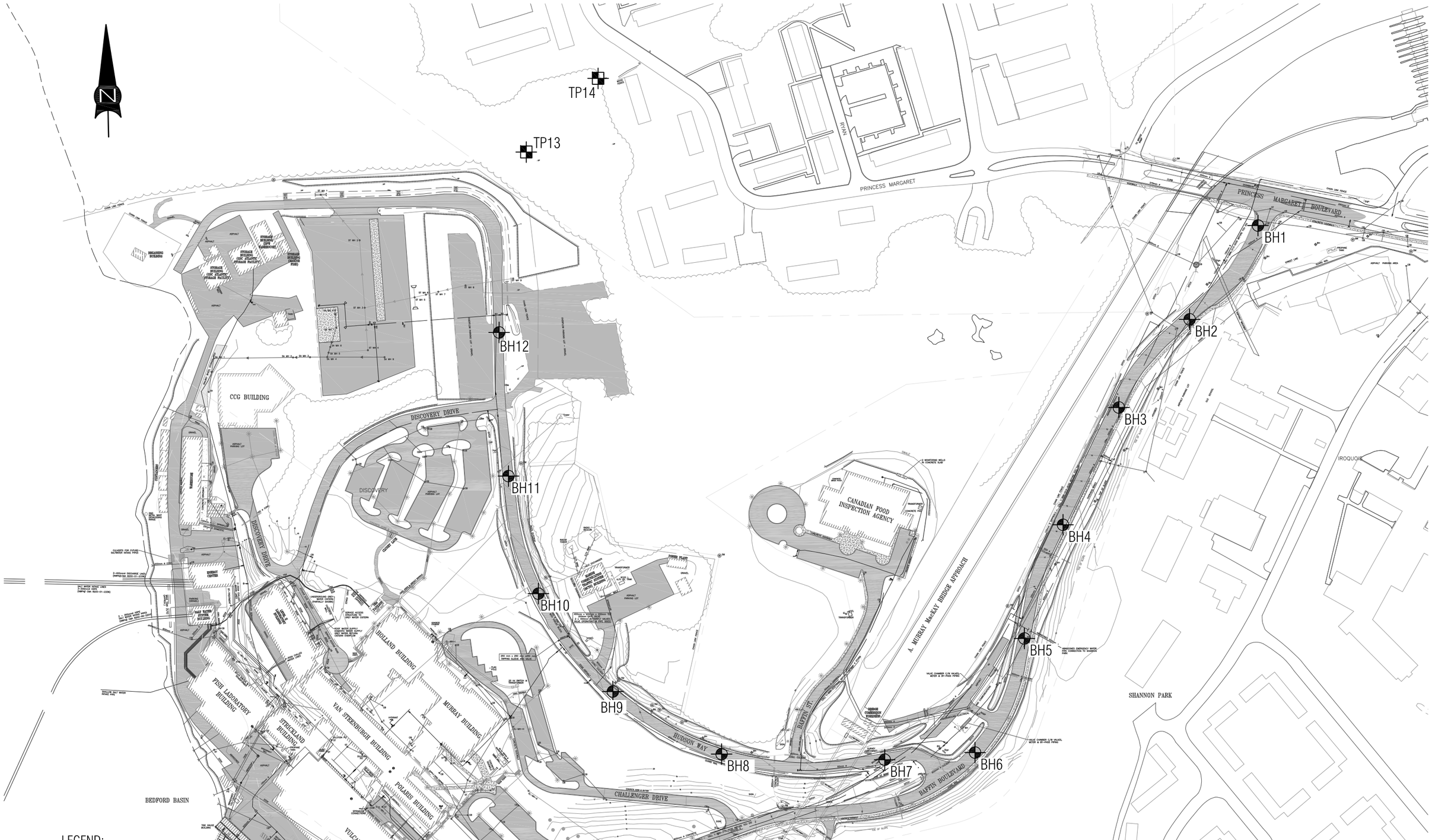
infiltration into deeper excavations is expected to be moderate to high, subject to seasonal/weather conditions, and may require several larger pumps. Water pumped from excavations is expected to contain “fines” and will require care in disposal. Provision for proper site drainage in accordance with applicable municipal, provincial, and federal environmental requirements should be made at the design and construction stage.

5.6 Underground Services

The installation of the sanitary and storm sewer lines should be prepared in accordance with the current HRM Standard Specifications for Municipal Services Systems. Generally, the standard requires the sanitary sewer services be bedded in free draining granular material (e.g. NSTIR Type 1 gravel) for a minimum thickness of 150 mm below the pipe and 300 mm above the pipe. The bedding should be compacted in-place to 95 percent standard Proctor maximum dry density. The remainder of the service trench can be backfilled with select on-site or imported materials to a minimum 95 percent standard Proctor maximum dry density and the upper 300 mm to subgrade to 98 percent. The reuse of on-site materials will be contingent to a large extent on the condition of the materials after excavation, handling and stockpiling. Services should be placed a minimum of 1.5 metres below finished grade for frost protection unless permanent insulation is provided.

6 CLOSURE

The geotechnical investigation undertaken has involved random sampling of site conditions. Should any conditions be encountered during constructions that are contrary to those reported herein, we request immediate notification so that reassessment can be undertaken.



LEGEND:

TP13 - Approximate Test Pit Location

BH1 - Approximate Borehole Location

Ref: Existing Condition Site Plan of BIO Second Access Road, Dartmouth, NS, Dated February 2015, Project No. R.073592.001, Provided By Client.

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Site Plan Showing Approximate Test Locations BIO Second Access Road, Dartmouth, NS

DATE: March 2015	SCALE: NTS	DRAWN BY: JJ	CKD BY: TKM	JOB No. 20127	FIGURE 1

Appendix 1 Explanation of Terms and Symbols

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SYMBOLS AND TERMS USED ON THE BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Behavioural properties (i.e. plasticity, permeability) take precedence over particle gradation in describing soils.

Terminology describing soil structure:

Desiccated	- having visible signs of weathering by oxidation of clay minerals, shrinkage cracks etc.
Fissured	- having cracks, and hence a blocky structure
Varved	-composed of regular alternating layers of silt and clay
Stratified	- composed of alternating layers or different soil types, e.g. silt and sand or silt and clay
Well Graded	- having wide range in grain sizes and substantial amounts of all intermediate particle sizes
Uniformly Graded	- predominantly of one grain size.

Terminology used for describing soil strata based upon the proportion of individual particle size present:

Trace, or occasional	Less than 10%
Some	10-20%
Adjective (e.g. silty or sandy)	20-35%
And (e.g. silt and sand)	35-50%

The standard terminology to describe cohesionless soils includes the relative density, as determined by laboratory test or by the Standard Penetration Test 'N' - value: the number of blows of 140 pound (64 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil.

Relative Density	'N' Value	Relative Density %
Very loose	<4	<15
Loose	4-10	15-35
Compact	10-30	35-65
Dense	30-50	65-85
Very Dense	>50	>85

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression test, or occasionally by standard penetration tests.

Consistency	Undrained Shear Strength		'N' Value
	Kips/sq.ft.	kPa	
Very Soft	<0.25	<12.5	<2
Soft	0.25-0.5	12.5-25	2-4
Firm	0.5-1.0	25-50	4-8
Stiff	1.0-2.0	50-100	8-15
Very Stiff	2.0-4.0	100-200	15-30
Hard	>4.0	>200	>30

SOIL CLASSIFICATION SYSTEM (MODIFIED U.S.C.)

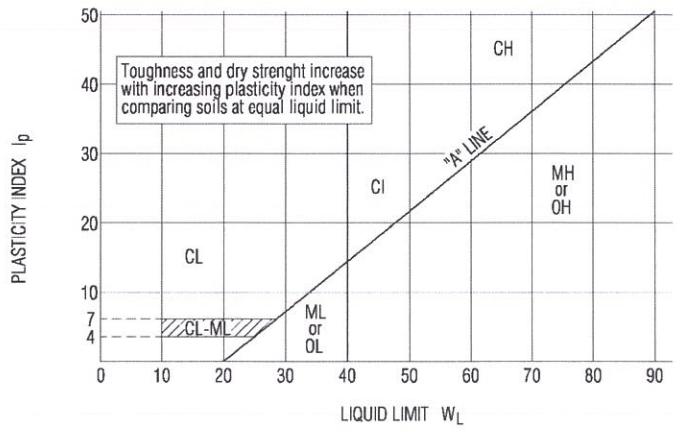
MAJOR DIVISION			GROUP SYMBOL	GRAPHIC SYMBOL	COLOR CODE	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
HIGHLY ORGANIC SOILS			Pt		ORANGE	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE	
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN NO. 200 SIEVE SIZE)	GRAVELS MORE THAN HALF COARSE FRACTION LARGER THAN NO.4 SIEVE SIZE	CLEAN GRAVELS	GW		RED	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, <5% FINES	$Cu = \frac{D_{60}}{D_{10}} > 4$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			GP		RED	POORLY-GRADED GRAVELS, AND GRAVEL-SAND MIXTURES, <5% FINES	NOT MEETING ALL ABOVE REQUIRMENTS	
		DIRTY GRAVELS	GM		YELLOW	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES >12% FINES	ATTERBERG LIMITS BELOW "A" LINE OR $I_p < 4$	
			GC		YELLOW	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES >12% FINES	ATTERBERG LIMITS ABOVE "A" LINE OR $I_p > 7$	
	SANDS MORE THAN HALF COARSE FRACTION SMALLER THAN NO.4 SIEVE SIZE	CLEAN SANDS	SW		RED	WELL-GRADED SANDS, GRAVELLY SANDS, <5% FINES	$Cu = \frac{D_{60}}{D_{10}} > 6$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			SP		RED	POORLY-GRADED SANDS, OR GRAVELLY SANDS, <5% FINES	NOT MEETING ALL ABOVE REQUIRMENTS	
		DIRTY SANDS	SM		YELLOW	SILTY SANDS, SAND-SILT MIXTURES >12% FINES	ATTERBERG LIMITS BELOW "A" LINE OR $I_p < 4$	
			SC		YELLOW	CLAYEY SANDS, SAND-CLAY MIXTURES >12% FINES	ATTERBERG LIMITS ABOVE "A" LINE OR $I_p > 7$	
FINE - GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES NO.200 SIEVE SIZE)	SILTS BELOW "A" LINE ON PLASTICITY CHART; NEGLIGIBLE ORGANIC CONTENT		ML		GREEN	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	$W_L < 50$	SEE CHART BELOW
			MH		BLUE	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS	$W_L > 50$	
	CLAYS ABOVE "A" LINE ON PLASTICITY CHART; NEGLIGIBLE ORGANIC CONTENT		CL		GREEN	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS	$W_L < 30$	
			CI		GREEN-BLUE	INORGANIC CLAYS OF MEDIUM PLASTICITY SILTY CLAYS	$W_L > 30, < 50$	
			CH		BLUE	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	$W_L > 50$	
	ORGANIC SILTS & ORGANIC CLAYS BELOW "A" LINE ON PLASTICITY CHART		OL		GREEN	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	$W_L < 50$	
			OH		BLUE	ORGANIC CLAYS OF HIGH PLASTICITY	$W_L > 50$	

FILL TILL BEDROCK

1. All sieve sizes mentioned on this chart are U.S. Standard, ASTM E11.
2. Boundary classifications possessing characteristics of two groups are given combined group symbols eg GW-GC is a well-graded gravel-sand mixture wtih clay binder between 5% and 12%.
3. Soil fractions and limiting textural boundaries are in accordance with the Unified Soil Classification System, except that an inorganic clay of medium plasticity (CI) is recognized.
4. The following adjectives may be employed to define percentage ranges by weight of minor components:

and	50 - 36%
gravelly, sandy, silty, clayey, ect.	35 - 21%
some	20 - 11%
trace	10 - 1%

PLASTICITY CHART



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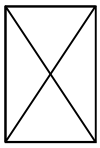
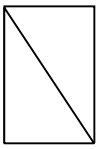
SOIL SAMPLES

CONDITION – This column graphically indicates the depth and condition of the sample:

 undisturbed  disturbed  not recovered

TYPE – The type of sample is indicated in this column as follows:

A auger sample
B block sample
C rock core, or frozen soil core
D drive sample
G grab sample
SS split spoon
P Pitcher tube sample
U tube sample (usually thin-walled)
W wash or air return sample
O other (see report text)

PENETRATION RESISTANCE – Unless otherwise noted this column refers to the number of blows (N) of a 140 pound (63.5 kg) hammer freely dropping 30 inches (0.76 m) required to drive a 2 inch (50.8 mm) O.D. open-end sampler 0.5 feet (0.15 m) to 1.5 feet (0.45 m) into the soil, or until 100 blows have been applied, in which case, the penetration is stated. This is the standard penetration test referred to in ASTM D 1586.

OTHER TESTS

In this column are tabulated results of other laboratory tests as indicated by the following symbols:

*C	Consolidation test
Fines	Percentage by weight smaller than #200 sieve
D_R	Relative density (formerly specific gravity)
k	Permeability coefficient
*MA	Mechanical grain size analysis and hydrometer test (if appropiate)
pp	Pocket pentrometer strength
*q	Triaxial compression test
q_U	Unconfined compressive strength
*SB	Shearbox test
SO_4	Concentration of water-soluble sulphate
*ST	Swelling test
TV	Torvane shear strength
VS	Vane Shear Strength (undistrubed-remolded)
ε_f	Unit strain at failure
γ	Unit weight of soil or rock
γ_d	Dry unit weight of soil or rock
ρ	Density of soil or rock
ρ_d	Dry density of soil or rock

* The results of these tests usually are reported separately

Appendix 2 Borehole and Test Pit Logs

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BOREHOLE LOG

PROJECT
Geotechnical Investigation - Bedford Institute of Oceanography Second Access Road

LOGGED/DWN. LL / RH | CKD. KM | DATE OF INVEST. 3/17/15 | JOB NO. 20127 | HOLE NO. BH 1

DRILL TYPE: Drill Rig

CASING RESISTANCE blows/300mm

WC % wp- □ w- ● wl- △
10 20 30 40 50

DEPTH ft	DEPTH m	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	COND.	SOIL SAMPLE TYPE	SOIL SAMPLE PENE. RESIST.	OTHER TESTS
				DATUM Topographical Survey Plan Provided by SNC Lavalin SURFACE ELEVATION 5.50 meters				
0		GP		Asphalt Pavement, 101 mm thick.				
0		GP		Roadway gravels, compact to dense, dry, greyish brown.				
1				FILL: gravelly sand, trace to some silt, some cobbles, compact to dense, moist, grey to brown.		SS	50/150	50 blows for 150 mm.
3	1					G		
5						SS	50/150	50 blows for 150 mm.
6				Large Boulder or Inferred Bedrock				
7	2			End of Borehole at 1.8 metres. Practical refusal on large boulder or bedrock.				
				Groundwater encountered in Borehole at 1.2 metres below ground surface.				
10	3							
13	4							
16	5							

PLATE 1

LVM | MARITIME TESTING

BOREHOLE LOG

PROJECT
Geotechnical Investigation - Bedford Institute of Oceanography Second Access Road

LOGGED/DWN. LL / RH	CKD. KM	DATE OF INVEST. 3/17/15	JOB NO. 20127	HOLE NO. BH 2

CASING RESISTANCE blows/300mm

WC % wp- □ w- ● wl- △ (10 20 30 40 50)

DEPTH ft / m

MODIFIED USCS

SOIL SYMBOL

DATUM Topographical Survey Plan Provided by SNC Lavalin

SURFACE ELEVATION 7.50 meters

DEPTH ft	DEPTH m	MODIFIED USCS	SOIL DESCRIPTION	SOIL SAMPLE COND.	SOIL SAMPLE TYPE	SOIL SAMPLE PENE. RESIST.	OTHER TESTS
			Asphalt Pavement, 140 mm thick.				
1		GP	Roadway gravels, dense to very dense, dry, greyish brown.				
2					SS	N=64	
3	1		FILL: gravelly sand, trace to some silt, some cobbles, compact to dense, moist, grey to brown.				
4					SS	N=35	
5							
6					SS	N=15	
7	2		Topsoil		SS	50/150	50 blows for 150 mm.
			TILL: gravelly sand, some silt and gravel, occasional cobbles, compact to dense, moist, brown.				
8			Large Boulder or Inferred Bedrock				
9			End of Borehole at 2.2 metres. Practical refusal on large boulder or bedrock.				
10	3		Borehole dry at completion.				
11							
12							
13	4						
14							
15							
16	5						

DRILL TYPE: Drill Rig

OTHER TESTS

PLATE 2

LVM | MARITIME TESTING

BOREHOLE LOG

PROJECT
Geotechnical Investigation - Bedford Institute of Oceanography Second Access Road

LOGGED/DWN. LL / RH	CKD. KM	DATE OF INVEST. 3/17/15	JOB NO. 20127	HOLE NO. BH 3

CASING RESISTANCE blows/300mm

WC % wp- □ w- ● wl- △
10 20 30 40 50

DEPTH ft m

MODIFIED USCS

SOIL SYMBOL

SOIL DESCRIPTION

DATUM Topographical Survey Plan Provided by SNC Lavalin

SURFACE ELEVATION 11.10 meters

SOIL SAMPLE: COND. | TYPE | PENE. RESIST.

DRILL TYPE: Drill Rig

OTHER TESTS

ft	m	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	COND.	TYPE	PENE. RESIST.
				Asphalt Pavement, 114 mm thick.			
		GP		Roadway gravels, dense, dry, greyish brown.			
1				FILL: gravelly sand, trace to some silt, some cobbles, compact to dense, moist, grey to brown.		SS	N=73
2	1						
3							
4				Large Boulder or Inferred Bedrock			
5				End of Borehole at 1.2 metres. Practical refusal on large boulder or bedrock.			
6				Borehole dry at completion.			
7	2						
8							
9							
10	3						
11							
12							
13	4						
14							
15							
16	5						

PLATE 3

LVM | MARITIME TESTING

BOREHOLE LOG

PROJECT
Geotechnical Investigation - Bedford Institute of Oceanography Second Access Road

LOGGED/DWN. LL / RH | CKD. KM | DATE OF INVEST. 3/17/15 | JOB NO. 20127 | HOLE NO. BH 4

CASING RESISTANCE blows/300mm

WC % wp- □ w- ● wl- △
10 20 30 40 50

DEPTH ft m

MODIFIED USCS | SOIL SYMBOL

SOIL DESCRIPTION

DATUM Topographical Survey Plan Provided by SNC Lavalin

SURFACE ELEVATION 15.70 meters

SOIL SAMPLE: COND. | TYPE | PENE. RESIST.

DRILL TYPE: Drill Rig

OTHER TESTS

ft	m	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	COND.	TYPE	PENE. RESIST.	OTHER TESTS
				Asphalt Pavement, 127 mm thick.				
		GP		Roadway gravels, dense, dry, greyish brown.				
1				FILL: gravelly sand, trace to some silt, some cobbles, compact to dense, moist, grey to brown.		SS	N=54	
3	1					SS	50/150	50 blows for 150 mm.
5				Large Boulder or Inferred Bedrock				
6				End of Borehole at 1.4 metres. Practical refusal on large boulder or bedrock.				
				Borehole dry at completion.				
7	2							
10	3							
13	4							
16	5							

PLATE 4

LVM | MARITIME TESTING

BOREHOLE LOG

PROJECT
Geotechnical Investigation - Bedford Institute of Oceanography Second Access Road

LOGGED/DWN. LL / RH | CKD. KM | DATE OF INVEST. 3/17/15 | JOB NO. 20127 | HOLE NO. BH 5

DRILL TYPE: Drill Rig

CASING RESISTANCE blows/300mm

WC % wp- □ w- ● wl- △
10 20 30 40 50

DEPTH ft	DEPTH m	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	COND.	SOIL SAMPLE TYPE	SOIL SAMPLE PENE. RESIST.	OTHER TESTS
				DATUM Topographical Survey Plan Provided by SNC Lavalin SURFACE ELEVATION 19.00 meters				
				Asphalt Pavement, 168 mm thick.				
1		GP		Roadway gravels, compact, dry, greyish brown.				
2				FILL: gravelly sand, trace to some silt, some cobbles, compact to dense, moist, grey to brown.		SS	50/150	50 blows for 150 mm.
3	1							
4						G		
5								
6						SS	50/150	50 blows for 150 mm.
7	2			Large Boulder or Inferred Bedrock				
8				End of Borehole at 2.0 metres. Practical refusal on large boulder or bedrock.				
9				Borehole dry at completion.				
10	3							
11								
12								
13	4							
14								
15								
16	5							

PLATE 5

LVM | MARITIME TESTING

BOREHOLE LOG

PROJECT
Geotechnical Investigation - Bedford Institute of Oceanography Second Access Road

LOGGED/DWN. LL / RH | CKD. KM | DATE OF INVEST. 3/17/15 | JOB NO. 20127 | HOLE NO. BH 6

CASING RESISTANCE blows/300mm

WC % wp- □ w- ● wl- △
10 20 30 40 50

DEPTH ft m

MODIFIED USCS | SOIL SYMBOL

SOIL DESCRIPTION

DATUM Topographical Survey Plan Provided by SNC Lavalin

SURFACE ELEVATION 19.80 meters

SOIL SAMPLE: COND. | TYPE | PENE. RESIST.

DRILL TYPE: Drill Rig

OTHER TESTS

ft	m	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	COND.	TYPE	PENE. RESIST.	OTHER TESTS
				Asphalt Pavement, 102 mm thick.				
0		GP		Roadway gravels, compact, dry, greyish brown.				
1								
2				FILL: gravelly sand, trace to some silt, some cobbles, compact to dense, moist, grey to brown.		SS	N=39	
3	1					SS	50/150	50 blows for 150 mm.
4								
5				Large Boulder or Inferred Bedrock				
6				End of Borehole at 1.4 metres. Practical refusal on large boulder or bedrock.				
				Borehole dry at completion.				
7	2							
8								
9								
10	3							
11								
12								
13	4							
14								
15								
16	5							

PLATE 6

LVM | MARITIME TESTING

BOREHOLE LOG

PROJECT
Geotechnical Investigation - Bedford Institute of Oceanography Second Access Road

LOGGED/DWN. LL / RH | CKD. KM | DATE OF INVEST. 3/17/15 | JOB NO. 20127 | HOLE NO. BH7

DRILL TYPE: Drill Rig

CASING RESISTANCE blows/300mm

WC % wp- □ w- ● wl- △
10 20 30 40 50

DATUM Topographical Survey Plan Provided by SNC Lavalin

SURFACE ELEVATION 20.70 meters

DEPTH ft	DEPTH m	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	COND.	SOIL SAMPLE TYPE	SOIL SAMPLE PENE. RESIST.	OTHER TESTS
				Asphalt Pavement, 102 mm thick.				
		GP		Roadway gravels, compact to dense, dry, greyish brown.		SS	50/150	50 blows for 150 mm.
1								
2								
3	1			FILL: gravelly sand, trace to some silt, some cobbles, compact to dense, moist, grey to brown.		G		
4								
5								
6	2					SS	N=53	
7								
8						SS	N=43	
9				Topsoil				
				Large Boulder or Inferred bedrock				
10	3			End of Borehole at 2.7 metres. Practical refusal on large boulder or bedrock				
11				Groundwater encountered in Borehole at 2.4 metres below ground surface.				
12								
13	4							
14								
15								
16	5							

PLATE 7

LVM | MARITIME TESTING

BOREHOLE LOG

PROJECT
Geotechnical Investigation - Bedford Institute of Oceanography Second Access Road

LOGGED/DWN. LL / RH | CKD. KM | DATE OF INVEST. 3/17/15 | JOB NO. 20127 | HOLE NO. BH8

DRILL TYPE: Drill Rig

OTHER TESTS

CASING RESISTANCE blows/300mm

WC % wp- □ w- ● wl- △
10 20 30 40 50

DATUM Topographical Survey Plan Provided by SNC Lavalin

SURFACE ELEVATION 23.00 meters

DEPTH ft	DEPTH m	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE COND.	SOIL SAMPLE TYPE	SOIL SAMPLE PENE. RESIST.
0				Asphalt Pavement, 102 mm thick.			
1		GP		Roadway gravels, compact, dry, greyish brown.			
2				FILL: gravelly sand, trace to some silt, some cobbles, compact to dense, moist, grey to brown.		SS	N=50
3	1						
4				TILL: gravelly sand, trace to some silt, occasional to some cobbles and small boulders, dense, moist, grey.		SS	N=69
5							
6	2					G	
7							
8							
9							
10	3			End of Borehole at 3.0 metres in till.			
11				Borehole dry at completion.			
12							
13	4						
14							
15							
16	5						

PLATE 8

LVM | MARITIME TESTING

BOREHOLE LOG

PROJECT
Geotechnical Investigation - Bedford Institute of Oceanography Second Access Road

LOGGED/DWN. LL / RH | CKD. KM | DATE OF INVEST. 3/17/15 | JOB NO. 20127 | HOLE NO. BH9

CASING RESISTANCE blows/300mm

WC % wp- □ w- ● wl- △
10 20 30 40 50

DEPTH ft m

MODIFIED USCS | SOIL SYMBOL

SOIL DESCRIPTION

DATUM Topographical Survey Plan Provided by SNC Lavalin

SURFACE ELEVATION 25.70 meters

SOIL SAMPLE: COND. | TYPE | PENE. RESIST.

DRILL TYPE: Drill Rig

OTHER TESTS

ft	m	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	COND.	TYPE	PENE. RESIST.
				Asphalt Pavement, 102 mm thick.			
1		GP		Roadway gravels, compact to dense, dry, greyish brown.			
2				FILL: gravelly sand, trace to some silt, some cobbles, compact to dense, moist, brown.		SS	N=52
3	1						
4						SS	N=42
5							
6				TILL: gravelly sand, trace to some silt, occasional to some cobbles and small boulders, dense, moist, brown to grey.		SS	N=36
7	2						
8						SS	N=34
9							
10	3			End of Borehole at 2.7 metres in till. Borehole dry at completion.			
11							
12							
13	4						
14							
15							
16	5						

PLATE 9

LVM | MARITIME TESTING

BOREHOLE LOG

PROJECT
Geotechnical Investigation - Bedford Institute of Oceanography Second Access Road

LOGGED/DWN. LL / RH | CKD. KM | DATE OF INVEST. 3/17/15 | JOB NO. 20127 | HOLE NO. BH10

CASING RESISTANCE blows/300mm

WC % wp- □ w- ● wl- △
10 20 30 40 50

DEPTH ft m

MODIFIED USCS | SOIL SYMBOL

SOIL DESCRIPTION

DATUM Topographical Survey Plan Provided by SNC Lavalin

SURFACE ELEVATION 26.00 meters

SOIL SAMPLE: COND. | TYPE | PENE. RESIST.

DRILL TYPE: Drill Rig

OTHER TESTS

ft	m	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	COND.	TYPE	PENE. RESIST.	OTHER TESTS
0				Asphalt Pavement, 102 mm thick.				
0		GP		Roadway gravels, compact to dense, dry, greyish brown.				
1				FILL: gravelly sand, trace to some silt, some cobbles, compact to dense, moist, grey to brown.		SS	50/150	50 blows for 150 mm.
3	1					G		
5						SS	50/150	50 blows for 150 mm.
6				Large Boulder or Inferred Bedrock				
7	2			End of Borehole at 1.8 metres. Practical refusal on large boulder or bedrock.				
				Borehole dry at completion.				
10	3							
13	4							
16	5							

PLATE 10

LVM | MARITIME TESTING

BOREHOLE LOG

PROJECT
Geotechnical Investigation - Bedford Institute of Oceanography Second Access Road

LOGGED/DWN. LL / RH | CKD. KM | DATE OF INVEST. 3/17/15 | JOB NO. 20127 | HOLE NO. BH11

CASING RESISTANCE blows/300mm

WC % wp- □ w- ● wl- △
10 20 30 40 50

DEPTH ft m

MODIFIED USCS | SOIL SYMBOL

SOIL DESCRIPTION

DATUM Topographical Survey Plan Provided by SNC Lavalin

SURFACE ELEVATION 25.50 meters

SOIL SAMPLE: COND. | TYPE | PENE. RESIST.

DRILL TYPE: Drill Rig

OTHER TESTS

ft	m	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	COND.	TYPE	PENE. RESIST.	OTHER TESTS
				Asphalt Pavement, 89 mm thick.				
0		GP		Roadway gravels, dense, dry, greyish brown.		SS	N=38	
3	1			FILL: gravelly sand, trace to some silt, some cobbles, compact to dense, moist, grey to brown.		SS	50/150	50 blows for 150 mm.
7	2			TILL: gravelly sand, trace to some silt, occasional to some cobbles and small boulders, dense, moist, brown to grey.		SS	N=57	
8				Large Boulder or Inferred Bedrock				
				End of Borehole at 2.4 metres. Practical refusal on large boulder or bedrock.				
				Groundwater encountered in Borehole at 1.7 metres below ground surface.				
10	3							
13	4							
16	5							

PLATE 11

LVM | MARITIME TESTING

BOREHOLE LOG

PROJECT
Geotechnical Investigation - Bedford Institute of Oceanography Second Access Road

LOGGED/DWN. LL / RH | CKD. KM | DATE OF INVEST. 3/17/15 | JOB NO. 20127 | HOLE NO. BH12

CASING RESISTANCE blows/300mm

WC % wp- □ w- ● wl- △
10 20 30 40 50

DEPTH ft m

MODIFIED USCS | SOIL SYMBOL

SOIL DESCRIPTION

DATUM Topographical Survey Plan Provided by SNC Lavalin

SURFACE ELEVATION 24.70 meters

SOIL SAMPLE: COND. | TYPE | PENE. RESIST.

DRILL TYPE: Drill Rig

OTHER TESTS

ft	m	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	COND.	TYPE	PENE. RESIST.	OTHER TESTS
0				Asphalt Pavement, 127 mm thick.				
0		GP		Roadway gravels, compact, dry, greyish brown.				
1				FILL: gravelly sand, trace to some silt, some cobbles, compact to dense, moist, grey to brown.		SS	50/150	50 blows for 150 mm.
3	1					G		
5						SS	N=39	
6	2							
7				TILL: gravelly sand, trace to some silt, occasional to some cobbles and small boulders, dense, moist, brown to grey.		SS	N=36	
9				Large Boulder or Inferred Bedrock				
10	3			End of Borehole at 2.7 metres. Practical refusal on large boulder or bedrock Borehole dry at completion.				
13	4							
16	5							

PLATE 12

LVM | MARITIME TESTING

TEST PIT LOG

PROJECT
Geotechnical Investigation - Bedford Institute of Oceanography Second Access Road

LOGGED/DWN. RH	CKD. KM	DATE OF INVEST. 3/24/15	JOB NO. 20127	TEST PIT TP 13

WC % wp- □ w- ● wl- △ (10 20 30 40 50)

DEPTH ft / m

MODIFIED USCS | SOIL SYMBOL

SOIL DESCRIPTION

DATUM Topographical Survey Plan Provided by SNC Lavalin

SURFACE ELEVATION 0.00 meters

SOIL SAMPLE: COND. | TYPE | POCKET PENE.

BACKHOE TYPE: Drill Rig

OTHER TESTS

ft	m	SOIL SYMBOL	SOIL DESCRIPTION	COND.	TYPE	POCKET PENE.
0	0		Rootmat/Topsoil			
1						
2			TILL: gravelly sand, some cobbles and small boulders, trace to some silt, compact to dense, moist, brown to grey.		G	
3	1					
4						
5			Large Boulder or Inferred Bedrock.			
			End of Test Pit at 1.4 metres. Practical refusal on large boulder or bedrock.			
6			Test Pit dry at completion.			
7	2					
8						
9						
10	3					
11						
12						
13	4					
14						
15						
16	5					

PLATE 13

LVM | MARITIME TESTING

BOREHOLE LOG

PROJECT
Geotechnical Investigation - Bedford Institute of Oceanography Second Access Road

LOGGED/DWN. LL / RH	CKD. KM	DATE OF INVEST. 3/17/15	JOB NO. 20127	HOLE NO. TP 14

CASING RESISTANCE blows/300mm

WC % wp- □ w- ● wl- △ (10 20 30 40 50)

DEPTH ft / m

MODIFIED USCS

SOIL SYMBOL

SOIL DESCRIPTION

DATUM Topographical Survey Plan Provided by SNC Lavalin

SURFACE ELEVATION 0.00 meters

SOIL SAMPLE: COND. | TYPE | PENE. RESIST.

DRILL TYPE: Drill Rig

OTHER TESTS

ft	m	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION
0	0			Rootmat/Topsoil
1				
2				TILL: gravelly sand, some cobbles and small boulders, trace to some silt, compact to dense, moist, brown to grey.
3	1			
4				
5				
6				
6.5	2			Large Boulder or Inferred Bedrock.
7				End of Test Pit at 2.0 metres. Practical refusal on large boulder or bedrock.
8				Test Pit dry at completion.
9				
10	3			
11				
12				
13	4			
14				
15				
16				
	5			

PLATE 14

Appendix 3 Laboratory Test Results

LVM Maritime Testing

LVM MARITIME TESTING

METRIC SIEVE ANALYSIS REPORT

97 TROOP AVE., DARTMOUTH, N.S. B3B 2A7 - TEL (902) 468-6486 FAX 468-4919

Client:

SNC Lavalin Inc. (Maritimes)
Suite 200, Park Lane Terraces
5657 Spring Garden Road
Halifax, NS B3J 3R4

Attn: Bernadette Landry
PHONE (902) 492-4544 **FAX:**

Our Project No: 20127

Client Contract No.:
Client PO.:
CC:

Project: Geotechnical Investigation - BIO Access Road, Dartmouth, Nova Scotia
Source: BH 7
Sample No: 3
Location: 1.5 - 2.1 m
Date Sampled: 23-Mar-15
Sampled by: LL/RH
Date Received: 23-Mar-15
Date Tested: 25-Mar-15

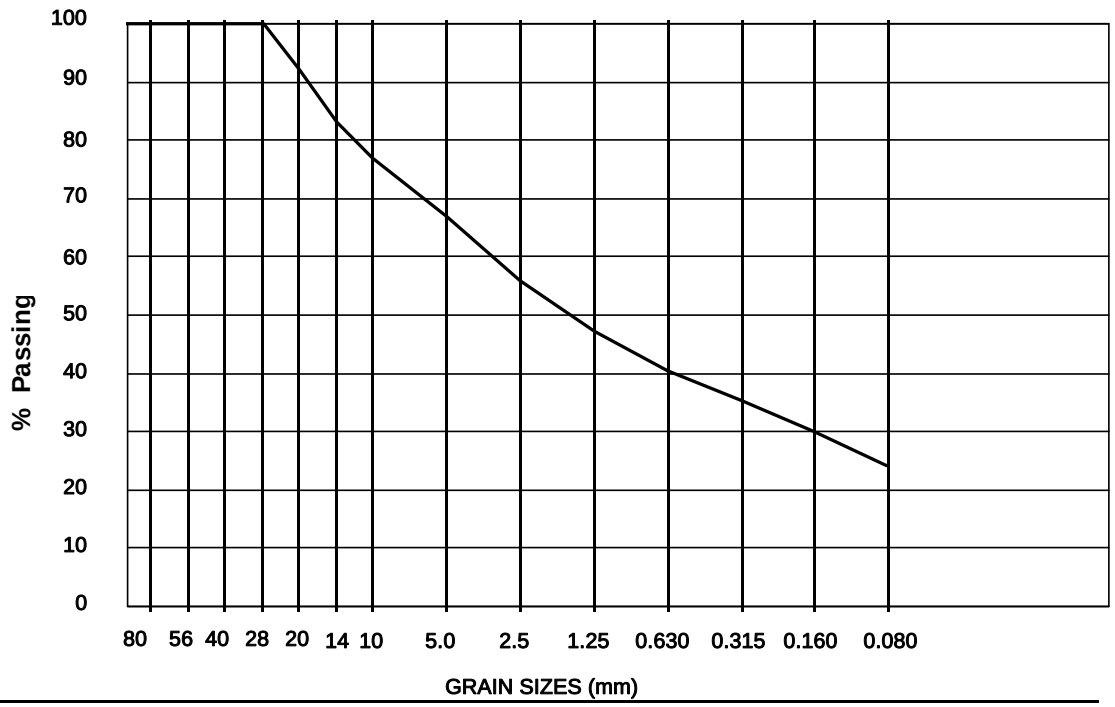
PHYSICAL PROPERTY TESTS

Soil Type	Fill	**Liquid Limit**		**Flat and Elongated Particles, %**	
Gravel, %	33	**Plastic Limit**		**Coarse Spec. Gravity**	
Sand, %	43	**Plasticity Index**		**Fractured Faces, %**	
Silt and Clay, %	24	**Coarse Absorption, %**		**Petrographic No.**	
Moisture Cont., %	5.5	**Fine Absorption, %**		**Max. Dry Density, (kg/m3)**	
Abrasion Loss, %		**Micro Deval Loss, %**		**Optimum Moisture, %**	

Sieve Size (mm)	Percent Passing	Spec. Band
112		
80		
56		
40		
28	100	
20	92	
14	83	
10	77	
5.0	67	
2.5	56	
1.25	47	
0.630	40	
0.315	35	
0.160	30	
0.080	24.1	

GRAIN SIZE CURVE

Spec Band
NO SPEC



Comments:

Record No: 9038 **MTL Tech:** LB **PER**

CERTIFIED LABORATORY FOR TESTING CONCRETE

pm KM

LVM MARITIME TESTING

METRIC SIEVE ANALYSIS REPORT

97 TROOP AVE., DARTMOUTH, N.S. B3B 2A7 - TEL (902) 468-6486 FAX 468-4919

Client:

SNC Lavalin Inc. (Maritimes)
Suite 200, Park Lane Terraces
5657 Spring Garden Road
Halifax, NS B3J 3R4

Attn: Bernadette Landry
PHONE (902) 492-4544 **FAX:**

Our Project No: 20127

Client Contract No.:
Client PO.:
CC:

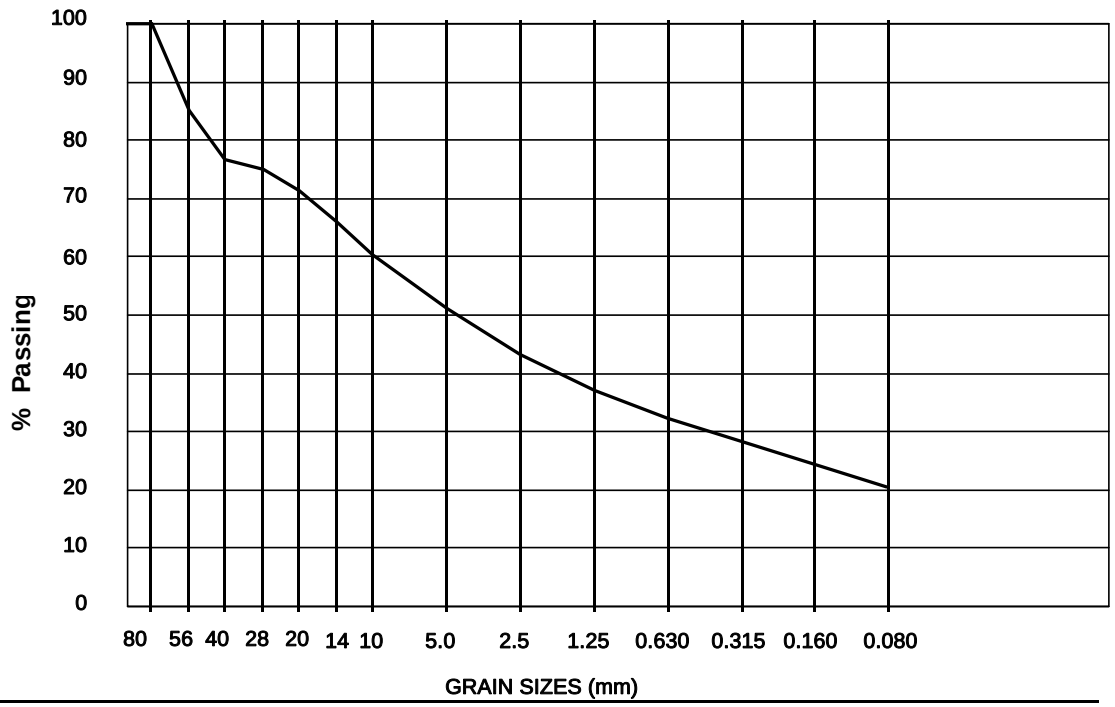
Project: Geotechnical Investigation - BIO Access Road, Dartmouth, Nova Scotia
Source: TP 14
Sample No: 1
Location: 0.6 - 1.2 m
Date Sampled: 23-Mar-15
Sampled by: LL/RH
Date Received: 23-Mar-15
Date Tested: 25-Mar-15

PHYSICAL PROPERTY TESTS					
Soil Type	Till	**Liquid Limit**		**Flat and Elongated Particles, %**	
Gravel, %	49	**Plastic Limit**		**Coarse Spec. Gravity**	
Sand, %	30	**Plasticity Index**		**Fractured Faces, %**	
Silt and Clay, %	21	**Coarse Absorption, %**		**Petrographic No.**	
Moisture Cont., %	7	**Fine Absorption, %**		**Max. Dry Density, (kg/m3)**	
Abrasion Loss, %		**Micro Deval Loss, %**		**Optimum Moisture, %**	

Sieve Size (mm)	Percent Passing	Spec. Band
112		
80	100	
56	85	
40	77	
28	75	
20	71	
14	66	
10	61	
5.0	51	
2.5	43	
1.25	37	
0.630	32	
0.315	28	
0.160	25	
0.080	20.6	

GRAIN SIZE CURVE

Spec Band
NO SPEC



Comments:

Record No: 9037 **MTL Tech:** LB **PER**

CERTIFIED LABORATORY FOR TESTING CONCRETE

pm KM