
Appendix A



June 09, 2016

HFX-00231668-A0 / 60.2

Mr. Vidya Limaye, PhD, P. Eng.
President, SHM Canada Consulting Limited (SHM)
255 Lacewood Drive, Suite 303
Halifax, NS B3M 4G2

Re: Bear Point Wharf Reconstruction
Summary of Geotechnical Investigation and Pile Recommendations

Dear Vidya,

Exp Services Inc. (**exp**) is pleased to provide SHM with this letter report, summarizing the results of the geotechnical investigation work performed for the proposed wharf reconstruction at Bear Point, NS. Previous documentation and geotechnical reports for historic work provided by SHM and PWGSC were reviewed, and it was agreed that further investigation was required in order to attain more information for pile design, particularly with respect to the bedrock underlying the site.

Methodology

A barge drill, provided by Lantech Drilling (Moncton NB), was used to carry out six boreholes around the existing wharf structure. The field work was supervised by an **exp** technician who logged the boreholes and collected representative soil and bedrock samples. A representative from GHD was on site to retrieve soils samples from several boreholes for environmental testing purposes.

Exp was responsible for service clearances to confirm that underground utilities were not present at the borehole locations. This is provided as general information only. Third parties should make their own inquiries with local authorities to confirm the presence or absence of utilities.

The borehole locations were selected to cover the area where the new wharf would be constructed and were advanced to depths ranging from approximately 5.1 m to 10.0 m below the harbour bottom. This corresponds to approximate elevations between -7.4 m and -12.5 m. The locations of the boreholes are shown on attached Figure 1, which is based on SHM drawing S2 of 6.

Subsurface Conditions

Subsurface conditions consisted of a very soft organic silt harbour bottom, overlying fractured granitic bedrock. Sandy glacial till deposits were described in historic reports but were not encountered in the current boreholes.

In general, the elevation of the bedrock in the current boreholes was similar to the elevations indicated in the 1952/1956 borings, although the overburden types and thicknesses were not consistent with the current investigation.

actions				due
2	ISSUED FOR REVIEW		FEB. 27 2016	
1	ISSUED FOR REVIEW		JAN. 19 2016	
0	ISSUED FOR REVIEW		DEC. 10 2015	

project	project
WHARF RECONSTRUCTION BEAR POINT WHARF SHELburnE COUNTY NOVA SCOTIA	

drawing design

assigned VL	concur
date	date
MM	desired
YY	
JAN. 26, 2016	
approved	approved
date	date
sender	Source/Location
WEGSC Project Manager	Administrateur de projet WEGSC
project number	no. du projet
R.076829.001	

drawing no. S2 OF 6 no. du dessin

F-0000/000-00 5.3.3485 Version 1

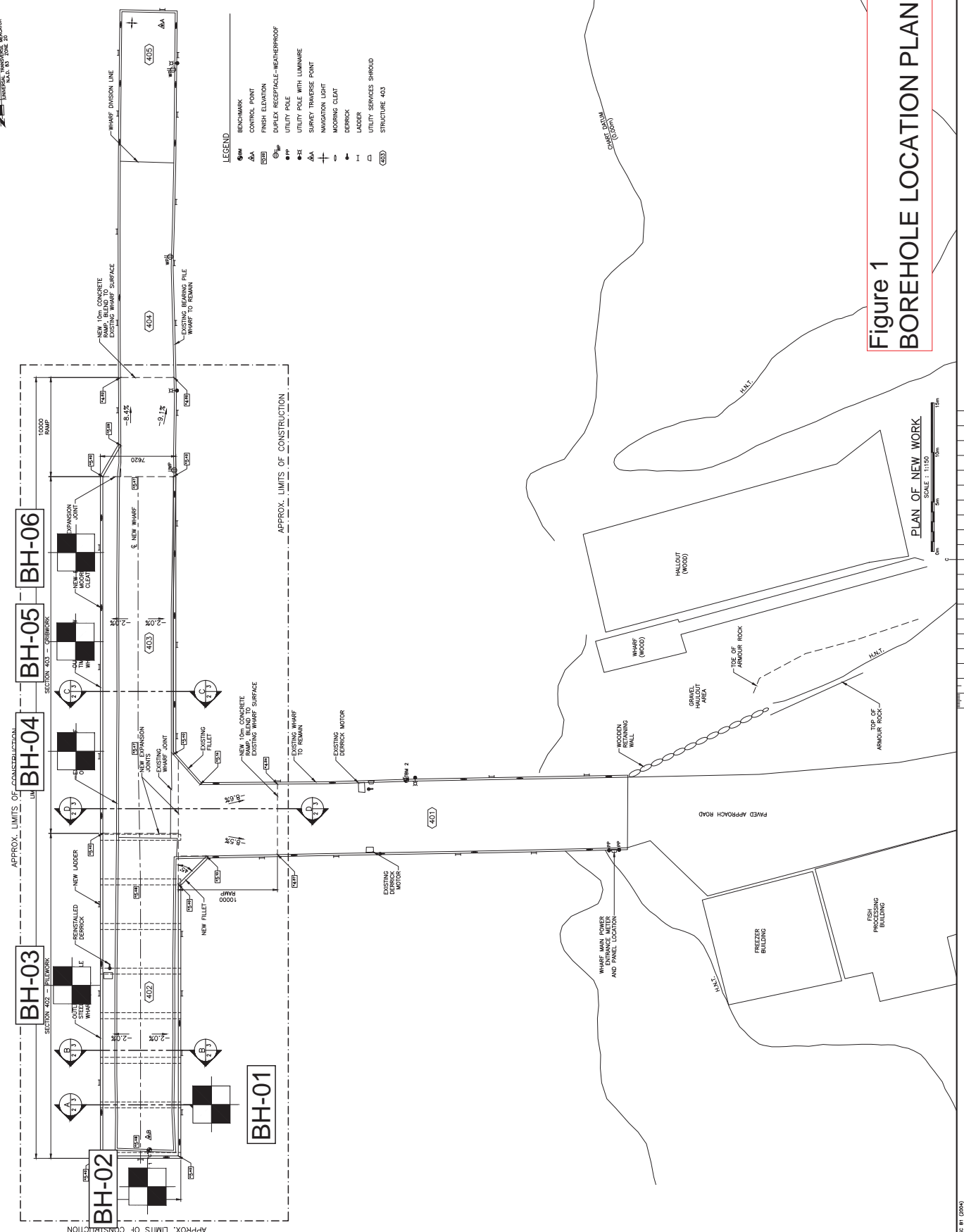


Figure 1
BOREHOLE LOCATION PLAN

Harbour Sediments

The Harbour sediments surrounding the wharf were classified under the United Soil Classification System (USCS) as very soft Silt with organics 'ML' to very soft organic Silt 'OL'. The deposit was saturated, black in colour and exhibited a strong organic odor.

Bedrock

The bedrock encountered at the site was Granodiorite near the surface which transitioned into Tonalite at depth. It was found to exhibit very poor to good quality, exhibited very close to close fracture spacing, with fractures predominantly oriented 45° to horizontal and occasional vertical fractures. UCS strength testing was performed on several intact sections of rock core, with results ranging from 70.0 MPa to 94.3 MPa, which would classify the rock strength as 'Strong'.

Although the parent rock strength is classified as 'Strong', the rock mass is highly fractured and the engineering behaviour of the unit will be dominated by the spacing and frequency of discontinuities in the highly fractured areas, rather than the rock strength.

Pile Recommendations

The following design recommendations and geotechnical parameters are based on experience at similar sites and from published values for the types of soil and bedrock encountered on this site. We have performed wave equation analyses using GRL WEAP® to determine the pile set criteria to achieve the design capacity. We understand that HP 360x174 H-Piles have been specified for the site, with a factored design load in axial compression of 575 kN per pile. Using a geotechnical resistance factor of 0.4, the factored ultimate geotechnical pile capacity is 1437.5 kN. We understand that the piles will be equipped with a protective driving shoe, which we endorse.

Preliminary capacity and pile set analyses were completed using the above information with the use of several standard diesel hammers that would be typical for the proposed works, ranging from a Delmag D12-32 to a D19-42. We have assumed pile penetration into fractured bedrock of approximately 2 m to 3 m to complete our analyses. Based on the results, we recommend a pile set of at least 10 blows per inch, for two consecutive sets. The minimum rated hammer energy should be 42.5 kJ (31.3 kip-feet). This corresponds to a rated energy of 200 J/cm² for the proposed HP360x174, which is relatively low for a driven steel H pile. A maximum rated energy of 350 J/cm² is recommended for pile installation. We do not anticipate a risk of excessive stress or damage to the piles during driving based on our analyses, at the recommended pile set and rated energy.

The final pile set criteria may be established on the basis of PDA measurements taken during pile installation. The PDA measurements would supersede the results of our wave equation analyses.

We anticipate that driven steel H-Piles may penetrate approximately 2 m to 3 m into the fractured bedrock on this site, but may stop short of this penetration where pile tips encounter more competent, massive bedrock sections. It should be noted that pile penetration depends on many factors which are not currently known and precise estimates are not possible.

It is recommended that piles are installed over their entire length by driving with diesel, gravity, air or hydraulic pile hammers. Installation by vibratory hammer is not recommended.

exp Services Inc.

*SHM Canada Consulting Limited
Bear Point Wharf Reconstruction, Nova Scotia
Project Number: **exp** HFX-00231668-A0
June 09, 2016*

Given the limited thickness of the very soft silt overburden, the use of a driving template, or similar means to control the pile location during driving, may be needed.

Closure

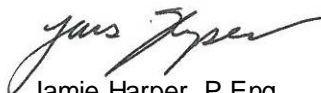
We trust this information meets your requirements. Please contact us if you have any questions, or require additional information.

Sincerely,



Brian Walker, P.Eng.
Senior Geotechnical Engineer

exp Services Inc.



Jamie Harper, P.Eng.
Geotechnical Engineer

exp Services Inc.



exp Services Inc.

*SHM Canada Consulting Limited
Bear Point Wharf Reconstruction, Nova Scotia
Project Number: **exp** HFX-00231668-A0
June 09, 2016*

Appendix A

Laboratory Test Results



Table 1- SUMMARY OF LABORATORY TEST RESULTS

CLIENT SHM Canada Consulting

LOCATION Bear Point Wharf, Bear Point, NS

PROJECT No. HFX-00231668-A0

TESTING:

Moisture Content:

1

Atterberg Limits:

0

Sieve Analysis:

1

Hydrometer Test:

0

UCS:

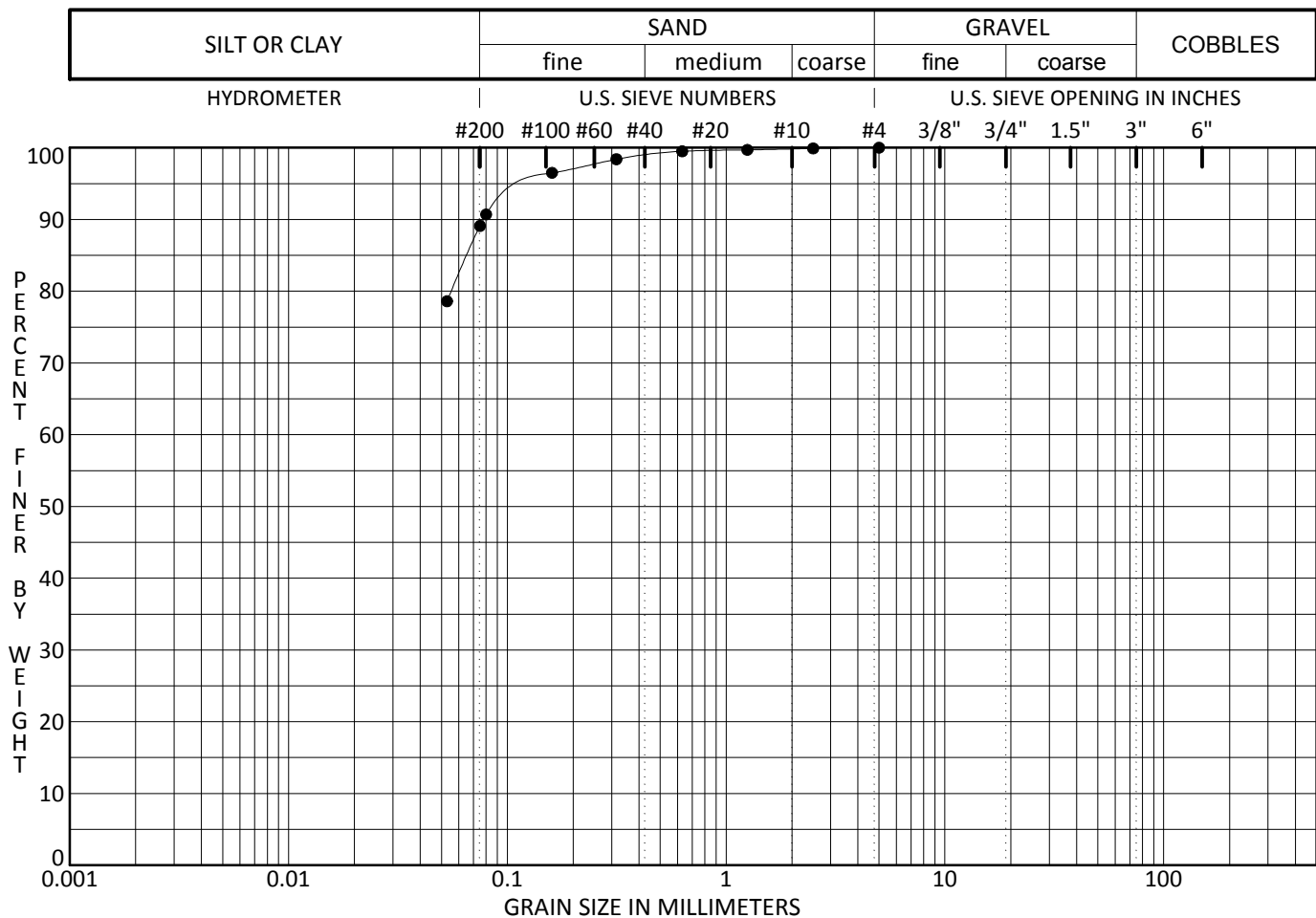
5

Soil Deposit	Borehole/Sample	Depth (m)	Water Content (%)	Atterberg Limits			Sieve Analysis			UCS (MPa)
				Liquid Limit	Plastic Limit	Plasticity Index	Gravel (%)	Sand (%)	Fines (%)	
Bedrock	BH-02/RC - 5	9.3								86.4
Bedrock	BH-02/RC - 8	14.0								77.5
Bedrock	BH-04/RC - 4	7.3								70.0
Bedrock	BH-05/RC - 3	6.0								88.8
Bedrock	BH-06/RC - 6	6.5								94.3
Silt	BH-01/SS - 2	4.6	70.5				0.0	10.9	89.1	



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GRAIN SIZE DISTRIBUTION



BH	SAMPLE	DEPTH(m)	Classification (USCS)	WC%	LL	PL	PI	Cc	Cu
BH-01	SS - 2	4.6	SILT ML	70.5					

BH	SAMPLE	DEPTH(m)	D60	D30	D10	%Gravel	%Sand	%Fines	Soil Deposit
BH-01	SS - 2	4.6				0.0	10.9	89.1	Silt



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CLIENT SHM Canada Consulting
LOCATION Bear Point Wharf, Bear Point, NS
PROJECT No. HFX-00231668-A0

exp Services Inc.

*SHM Canada Consulting Limited
Bear Point Wharf Reconstruction, Nova Scotia
Project Number: **exp** HFX-00231668-A0
June 09, 2016*

Appendix B

Descriptive Terms Used on Borehole Logs

Borehole Logs

Descriptive Terms - Borehole and Test Pit Logs

Soils	Grain Size	<div> <div>0.010.11.0101001000</div> <div>(mm)</div> </div>					
		<div> <div>Clay&Silt</div> <div>Sand</div> <div>Gravel</div> <div>Cobble</div> <div>Boulder</div> </div>					
		<div> <div>0.0750.4252.04.7676.4200</div> <div>(mm)</div> </div>					
Soils	Compactness (gravel, sand, tills)	N, Range	0 - 4	4 - 10	10 - 30	30 - 50	>50
		Density	V. Loose	Loose	Compact	Dense	V. Dense
Soils	Consistency (silt, clay)	S, kPa	< 12.5	12.5 - 25	25 - 50	50 - 100	100 - 200
		Consistency	V. Soft	Soft	Firm	Stiff	V. Stiff

Rock	Rock	RQD	Overall Quality			Fracture Spacing		
		0 - 25	Very Poor			< 50 mm Very Close		
		25 - 50	Poor			50 - 300 mm Close		
		50 - 75	Fair			0.3 - 1 m Moderate		
		75 - 90	Good			1 - 3 m Wide		
		90 - 100	Excellent			> 3 m Very Wide		
Rock	Rock	Comp. Str., MPa	0.25 - 1	1 - 5	5 - 25	25 - 50	50 - 100	100 - 250
		Description	Extremely Weak	Very Weak	Weak	Medium Strong	Strong	Very Strong
Rock	Rock							

Sample Types (location to scale on log)

SS	Split Spoon	B	Shovel (bulk)
T	Shelby Tube	H	Carved Block
P	Piston	V	In Situ Vane
F	Auger	NR	No Recovery
W	Wash		

Rock Cores: BQ (36.5mm), NQ (47.6mm), HQ (63.5mm)

Notation and Symbols

N	- N-value from standard penetration test; blows by 475 J drop hammer to advance std. 50mm O.D. split spoon sampler 0.3m	PL	- plastic limit, percent
RQD	- percent of core consisting of hard, sound pieces in excess of 100mm long (excluding machine breaks)	LL	- liquid limit, percent
Recovery	- sample recovery expressed as percent or length	▽	- groundwater level
S	- shear strength, kPa	▽	- seepage
Sr	- shear strength, remoulded		
Dd	- dry density, t/m ³		
W	- natural moisture content, percent		

SYMBOLS AND TERMS USED ON THE BOREHOLE AND TEST PIT RECORDS

Soil Description

Behavioral 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,
Fissured	Having cracks and, hence, a blocky structure
Varved	Composed of regular alternating layers of silt and clay
Stratified	Composed of alternating layers of different soil type, e.g., silt and sand
Well Graded	Having wide range in grain size and substantial amounts of all
Uniformly Graded	Predominantly of one grain size

Terminology used for describing soil strata based upon the proportion of individual particle sizes 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. splitspoon 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 in-situ vane tests, penetrometer tests, unconfined compression tests, or occasionally by standard penetration tests.

Undrained Shear Strength

Consistency	kips/sq. ft.	kPa	“N” Value
Very Soft	<0.25	<12.5	<2
Soft	0.25–.50	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



BOREHOLE RECORD

CLIENT SHM Canada Consulting

PROJECT No. HFX-00231668-A0

LOCATION Bear Point Wharf, Bear Point, NS

BOREHOLE No. BH-01

DATES of BORING May 17, 2016 WATER LEVEL _____

DATUM CVGD

DEPTH (m)	ELEV. (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					Undrained Shear Strength, kPa									
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	OTHER TESTS	20	40	60	80						
0	0.8	HARBOUR					mm			10	20	30	40	50	60	70	80	90	
1																			
2	-1.3	Harbour Sediments																	
3		SILT (ML), very soft, saturated, black. Strong Organic Odor.			SS	1	90	0											
4																			
5					SS	2	510	1	WC SVE										
6					SS	3	460	2											
7	-5.9	BEDROCK			SS	4	0	50 for 1"											
8		Grey Granodiorite transitioning to Tonalite with depth, strong, very poor to fair quality, very close to moderate fracture spacing, fractures oriented predominantly at 45 to 60 degrees to horizontal with some near vertical fractures.			RC	5	100%	0											
9	-7.6	End of Borehole @ 8.4 m Depth.			RC	6	78%	51											
10																			
11																			
12																			
13																			
14																			
15																			
16																			

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BOREHOLE RECORD

CLIENT SHM Canada Consulting

PROJECT No. HFX-00231668-A0

LOCATION Bear Point Wharf, Bear Point, NS

BOREHOLE No. BH-02

DATES of BORING May 17, 2016 WATER LEVEL _____

DATUM CVGD

DEPTH (m)	ELEV. (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					Undrained Shear Strength, kPa									
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	OTHER TESTS	20	40	60	80	Water Content & Atterberg Limits W_p W_L W_i					
0	2.4	HARBOUR					mm			10	20	30	40	50	60	70	80	90	
1																			
2																			
3																			
4																			
5	-2.5	Harbour Sediments																	
6		SILT (ML), very soft, saturated, black. Strong Organic Odor.			SS	1	0	0											
7	-4.9																		
8		BEDROCK			SS	2	0	50 for 1"											
9		Grey Granodiorite transitioning to Tonalite with depth, strong, very poor to good quality, very close to moderate fracture spacing, fractures oriented predominantly at 45 to 60 degrees to horizontal with some near vertical fractures.			RC	3	52%	51											
10		UCS = 86.4 MPa @ 9.3 m Depth.			RC	4	47%	80											
11					RC	5	50%	17	UCS										
12					RC	6	80%	73											
13					RC	7	100%	65											
14		UCS = 77.5 MPa @ 14.0 m Depth.			RC	8	100%	73	UCS										
15	-12.5	End of Borehole @ 14.9 m Depth.																	
16																			



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BOREHOLE RECORD

CLIENT SHM Canada Consulting

PROJECT No. HFX-00231668-A0

LOCATION Bear Point Wharf, Bear Point, NS

BOREHOLE No. BH-03

DATES of BORING May 18, 2016 WATER LEVEL _____

DATUM CVGD

DEPTH (m)	ELEV. (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					Undrained Shear Strength, kPa									
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	OTHER TESTS	20	40	60	80						
0	2.4	HARBOUR					mm			10	20	30	40	50	60	70	80	90	
1																			
2																			
3																			
4																			
5	-2.5	Harbour Sediments SILT (ML), very soft to very stiff, saturated, black. Strong Organic Odor.			SS	1	0	1											
6																			
7					SS	2	330	26											
8	-5.7	BEDROCK Grey Granodiorite transitioning to Tonalite with depth, strong, very poor to poor quality, very close to close fracture spacing, fractures oriented predominantly at 45 to 60 degrees to horizontal with some near vertical fractures.			SS	3	10	50 for 1"											
9					RC	4	20%	0											
10					RC	5	14%	0											
11	-8.2	End of Borehole @ 10.7 m Depth.			RC	6	44%	25											
12																			
13																			
14																			
15																			
16																			

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BOREHOLE RECORD

CLIENT SHM Canada ConsultingPROJECT No. HFX-00231668-A0LOCATION Bear Point Wharf, Bear Point, NSBOREHOLE No. BH-04DATES of BORING May 18, 2016 WATER LEVEL _____DATUM CVGD

DEPTH (m)	ELEV. (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					Undrained Shear Strength, kPa											
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	OTHER TESTS	20 40 60 80											
										Water Content & Atterberg Limits $\frac{W_p}{100} \frac{W_L}{100} \frac{W_i}{100}$ Dynamic Penetration Test, blows/0.3m ★ Standard Penetration Test, blows/0.3m ●											
0	1.8	HARBOUR					mm				10	20	30	40	50	60	70	80	90		
1																					
2																					
3																					
4																					
5	-2.8	Harbour Sediments SILT (ML), very soft, saturated, black. Strong Organic Odor.			SS	1	0	1		●											
					SS	2	50	1		●											
6	-4.3	BEDROCK Grey Granodiorite transitioning to Tonalite with depth, strong, very poor to fair quality, very close to close fracture spacing, fractures oriented predominantly at 45 to 60 degrees to horizontal with some near vertical fractures. UCS = 70.0 MPa @ 7.3 m Depth.			SS	3	0	50 for 1"													
7			RC	4	54%	51	UCS														
8			RC	5	19%	11															
9			RC	6	19%	12															
10			RC	7	48%	39															
11																					
12	-10.1	End of Borehole @ 11.9 m Depth.																			
13																					
14																					
15																					
16																					



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BOREHOLE RECORD

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PROJECT No. HFX-00231668-A0

LOCATION Bear Point Wharf, Bear Point, NS

BOREHOLE No. BH-05

DATES of BORING May 18, 2016 WATER LEVEL _____

DATUM CVGD

DEPTH (m)	ELEV. (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					Undrained Shear Strength, kPa									
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	OTHER TESTS	20	40	60	80						
0	0.8	HARBOUR					mm			10	20	30	40	50	60	70	80	90	
1																			
2																			
3																			
4	-2.6	Harbour Sediments			SS	1	0	1											
	-3.7	SILT (ML), very soft to hard, saturated, black. Strong Organic Odor.			SS	2	290	0-0-9-50 for 1"											
5		BEDROCK																	
		Grey Granodiorite transitioning to Tonalite with depth, strong, very poor to poor quality, very close to close fracture spacing, fractures oriented predominantly at 45 to 60 degrees to horizontal with some near vertical fractures.			RC	3	27%	27	UCS										
6		UCS = 88.8 MPa @ 6.0 m Depth.																	
7					RC	4	5%	0											
8																			
9					RC	5	43%	43											
10					RC	6	32%	23											
11	-9.6	End of Borehole @ 10.5 m Depth.																	
12																			
13																			
14																			
15																			
16																			



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BOREHOLE RECORD

CLIENT SHM Canada Consulting

PROJECT No. HFX-00231668-A0

LOCATION Bear Point Wharf, Bear Point, NS

BOREHOLE No. BH-06

DATES of BORING May 18, 2016 WATER LEVEL _____

DATUM CVGD

DEPTH (m)	ELEV. (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					Undrained Shear Strength, kPa									
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	OTHER TESTS	20	40	60	80						
0	1.1	HARBOUR					mm			10	20	30	40	50	60	70	80	90	
1																			
2																			
3																			
4	-2.3	Harbour Sediments SILT (ML), very soft to very stiff, saturated, black. Strong Organic Odor.			SS	1	10	1											
5					SS	2	40	1											
6	-4.2	Coarse Grained Granite Gravel, compact, saturated, grey.			SS	3	300	28											
7	-4.8	BEDROCK Grey Granodiorite transitioning to Tonalite with depth, strong, very poor to poor quality, very close to close fracture spacing, fractures oriented predominantly at 45 to 60 degrees to horizontal with some near vertical fractures. UCS = 94.3 MPa @ 6.5 m Depth.			SS	4	380	16											
8					SS	5	0	50 for 1"											
9					RC	6	43%	43	UCS										
10					RC	7	15%	0											
11	-7.4																		
12																			
13																			
14																			
15																			
16																			

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