Geotechnical Investigation, Cape Spear Access Road, Cape Spear National Historic Site, NL

Prepared for:

Parks Canada
1869 Upper Water St.,
Suite AH201
Halifax, NS B3J 1S9

Prepared by:
Stantec Consulting Ltd.
141 Kelsey Drive
St. John's, NL A1B 0L2
Tel: (709) 576-1458
Fax: (709) 576-2126

Final Report

File No: 133347329

June 13, 2016

Table of Contents

1.0 INTRODUCTION

Acting on the request and authorization of Parks Canada (the Client), Stantec Consulting Ltd. (Stantec) has completed a geotechnical investigation in support of the construction of a proposed new paved access road to Cape Spear Lighthouse at the Cape Spear National Historic Site, Newfoundland and Labrador.

The purpose of this geotechnical investigation was to determine the subsurface conditions to facilitate design and construction of the proposed roadway structure. The scope of work completed for this project was in general accordance with Stantec's proposal dated March 9, 2016, and included the following:

- A geotechnical field subsurface investigation consisting of eleven (11) mechanically excavated test pits;
- Geotechnical laboratory testing on one (1) representative soil sample; and
- A geotechnical report presenting the findings of the field investigation, including test pit records and laboratory results. At design stage, Stantec can provide further comments and recommendations regarding site development and pavement design.

This factual report has been prepared specifically and solely for the proposed development described herein and contains all of the findings of this investigation.

2.0 SITE AND GEOLOGY

The proposed development is located at Cape Spear Lighthouse National Historic Site on Blackhead Road, Blackhead, Newfoundland and Labrador as shown on the attached Figure No. 01.

A gravel access road currently exists at the proposed site. The initial section (few hundred meters) of this road is paved. Cracks throughout the asphalt surface were observed at the time of site investigation. The ground surface is generally uneven and slopes upwards towards the Lighthouse (east of the intersection of access road and Blackhead road). Both sides of the existing access road are partially vegetated. Bedrock outcroppings are noted across the site.

Based on previous experience in the area and available geological literature, the natural subsurface conditions in the area are understood to consist of a veneer of till layer which contains sand with less than 20 percent silt and clay (diamicton matrices) extending to bedrock. Bedrock geology at the site is mapped as pebble conglomerate with red sandstone at top of the Skerries Bight member, Cuckold Formation, Signal Hill Group.

3.0 FIELD PROCEDURES

The field investigation was completed on May 24, 2016 and consisted of excavating eleven (11) test pits using a rubber-tired backhoe provided by Stantec. The approximate test pit locations are shown on the attached Figure No: 01: Test Pit Location Plan. Test pit locations were selected and established by Stantec in the field by using a handheld GPS unit with ± 5 m accuracy. Final test pit locations were staked by Stantec for future survey by the project's surveyor.

All test pits were excavated refusal on probable/inferred bedrock at depths ranging from 0.1 m to 1.8 m below the ground surface, except TP-03, which was terminated at 1.5 m depth due to presence of a probable abandoned underground utility. Upon completion, the test pits were backfilled with the excavated material and nominally compacted using the excavator bucket. Once Stantec has departed the site, it is the responsibility of the Owner to address any potential hazards due to settlement of backfilled materials.

The field work was conducted under the inspection of Stantec personnel who maintained detailed field records of the various soil strata and groundwater conditions encountered during the investigation. The soils were classified in general accordance with the procedures outlined in the attached explanatory key: Symbol and Terms Used on Borehole and Test Pit Records. Representative soil samples were obtained directly from the test pit walls or from the excavator bucket during the field investigation. All soil samples were stored in moisture proof containers and sent to our laboratory for storage and selected testing. Samples remaining after testing will be stored for a period of three (3) months at which time they will be discarded, unless instructions to the contrary are received.

4.0 LABORATORY TESTING

Laboratory testing consisting of soil gradations and moisture content determinations were performed on representative samples obtained from TP-01. The laboratory test results are presented in the attached Figure 1– Gradation Curves. Note that the samples tested for soil gradation excluded over-size materials larger than 75 mm (3 inches).

5.0 SUBSURFACE CONDITIONS

Subsurface conditions observed in the test pits are summarized in the subsections below and described in detail on the attached Test Pit Records along with an accompanying explanatory key: Symbols and Terms used on Borehole and Test Pit Records. Representative photographs of the excavated test pits and spoil piles are also attached.

In general, the subsurface conditions encountered at the proposed development area consisted of a surficial layer of organic soils overlying fill materials extending to bedrock.

5.1 Organic Soils

Surficial layers of organic soils including sod, rootmat and/or topsoil were encountered at all test pit locations. The combined thickness of the organic soils ranged from 0.1 m to 0.3 m. Grass, roots, rootlets, occasional gravel and asphalt were encountered within the organic layers.

A layer of black, peat/organic materials with strong organic odour was encountered at TP-01, TP-02 and TP-03 locations underlying the upper fill and/or gravel and sand layer. The thickness of the peat/organic materials ranged from 0.1 m to 0.2 m.

5.2 Asphalt

A layer of asphalt was encountered below the organic layer at TP-04 and in the organic layer at TP-02. The thickness of the asphalt was approximately 0.1 m.

5.3 Fill

Fill materials were encountered at all test pit locations. Based on our observations in the test pits, the composition of fill varied across the site.

Rockfill was encountered at TP-03 at a depth of 0.3 m and extended to 0.5 m below the existing ground surface. Based on our visual observations, the rockfill is described as 100 mm minus blasted rock with sand and gravel. In terms of relative density, based on direct inspection in the test pits and excavator performance, the rockfill can be generally classified as loose.

A layer of gravel and sand was encountered at TP-01 to TP-04 at depths ranged from 0.1 m to 0.5 m below the existing ground surface. The thickness was varied from 0.4 m to 0.7 m. Based on our visual observations, the materials can be described as brown to grey, gravel with sand and silt (GP-GM) with trace rootlets, tree debris, occasional to some cobbles and some to frequent boulders. Organic materials were observed throughout the layer. Slight to strong organic odour was encountered at the bottom of the layer. In terms of relative density, based on direct inspection in the test pit and excavator performance, this fill layer can be generally classified as loose to compact.

A 0.5 m and 0.2 m thick layer of sand and gravel was encountered at TP-03 and TP-09 at a depth of 1.0 m and 0.2 m respectively. Based on our visual observations, the materials can be described as brown to grey, sand with silt and gravel (SP-SM) to silty sand with gravel (SM) with occasional to some cobbles. Black organic soil materials and debris (e.g. glass, metal pieces etc.) were encountered at TP-09. In terms of relative density, based on direct inspection in the test pit and excavator performance, this fill layer can be generally classified as loose to compact.

5.4 Silty Sand with Gravel

A layer of sand was encountered underlying the surficial organic soils at TP-05 to TP-11 at depths ranging from 0.1 m to 0.3 m below the existing ground surface, except TP-09. A sand layer was also encountered at TP-01, TP-02 and TP-04 underlying the peat/organic materials and/or fill materials at depths ranging from 0.6 m to 1.0 m below the existing ground surface. The thickness of the layer ranged from 0.1 m to 0.9 m.

Based on visual field observations and laboratory testing, the materials are generally classified as a dark brown to reddish brown to black, silty sand with gravel (SM) to sand with silt and gravel (SP-SM) with trace to some rootlets, occasional to some cobbles, and occasional boulders. Gradation analyses conducted on one (1) representative sample provided 21.4% gravel, 62.2% sand and 16.4% fines (silt/clay). The moisture content of the samples was 13.0%. The result of the gradation analysis is shown on the attached Figure 1 – Gradation Curves.

In terms of relative density, based on direct inspection in the test pits and excavator performance, the layer is generally classified as loose to compact.

5.5 Inferred Bedrock

Inferred/probable bedrock was encountered at all test pit locations at depths ranging from 0.1 m to 1.8 m below ground surface except TP-03. Inferred/probable bedrock as noted herein has been inferred based on excavator refusal.

The inference of bedrock has limitations due to size of the excavation and the nature of visual assessments from surface. Refusal can also result from the presence of large boulders or dense cobble and boulder rich horizons within the till stratum. In order to confirm bedrock at the test pit locations, borehole drilling and a minimum of 3 m of bedrock core recovery is recommended.

5.6 Groundwater

At the time of the investigation, groundwater seepage was encountered at test pit locations, TP-01, TP-02, TP-03 and TP-05. Based on our observations during test pit excavations, slow to rapid water seepage was observed through fill and/or silty sand with gravel at depths ranging from 0.3 m to 1.5 m below the ground surface.

It should be noted that test pits were not left open for a sufficient length of time for water levels to stabilize. Furthermore, groundwater levels may fluctuate seasonally and in response to precipitation events. To determine the long-term groundwater conditions at the site, borehole drilling and installation of groundwater monitor wells or standpipes would be required.

6.0 CLOSURE

Use of this factual report is subject to the Statement of General Conditions, attached. It is the responsibility of Parks Canada who is identified as "the Client" within the Statement of General Conditions, and its agents to review the conditions and to notify Stantec should any of these not be satisfied. The Statement of General Conditions addresses the following: use of the report; basis of the report; standard of care; interpretation of site conditions; varying or unexpected site conditions; and planning, design, or construction.

Development or design plans and specifications should be reviewed by Stantec to confirm that this report addresses the project specifics and that the contents of this report have been properly interpreted. Site work relating to the recommendations included in this report should be carried out in the presence of a qualified geotechnical engineer; Stantec cannot be responsible for site work carried out without being present.

We trust this report meets your present requirements. However, additional comments and recommendations can be provided upon request. Should any additional information be required, please do not hesitate to contact our office at your convenience.

Sincerely,
STANTEC CONSULTING LTD

[redacted]

[redacted]

[redacted]

ATTACHMENTS

Statement of General Conditions
Symbols and Terms Used on Borehole and Test Pit Records
Test Pit Records
Test Pit Photographs
Figure 1 – Gradation Curves
Figure No: 01: Test Pit Location Plan

STATEMENT OF GENERAL CONDITIONS

USE OF THIS REPORT: This report has been prepared for the sole benefit of the Client or its agent and may not be used by any third party without the express written consent of Stantec Consulting Ltd. and the Client. Any use which a third party makes of this report is the responsibility of such third party.

BASIS OF THE REPORT: The information, opinions, and/or recommendations made in this report are in accordance with Stantec Consulting Ltd.'s present understanding of the site specific project as described by the Client. The applicability of these is restricted to the site conditions encountered at the time of the investigation or study. If the proposed site specific project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Stantec Consulting Ltd. is requested by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

STANDARD OF CARE: Preparation of this report, and all associated work, was carried out in accordance with the normally accepted standard of care in the state or province of execution for the specific professional service provided to the Client. No other warranty is made.

INTERPRETATION OF SITE CONDITIONS: Soil, rock, or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec Consulting Ltd. at the time of the work and at the specific testing and/or sampling locations. Classifications and statements of condition have been made in accordance with normally accepted practices which are judgmental in nature; no specific description should be considered exact, but rather reflective of the anticipated material behavior. Extrapolation of in situ conditions can only be made to some limited extent beyond the sampling or test points. The extent depends on variability of the soil, rock and groundwater conditions as influenced by geological processes, construction activity, and site use.

VARYING OR UNEXPECTED CONDITIONS: Should any site or subsurface conditions be encountered that are different from those described in this report or encountered at the test locations, Stantec Consulting Ltd. must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Stantec Consulting Ltd. will not be responsible to any party for damages incurred as a result of failing to notify Stantec Consulting Ltd. that differing site or sub-surface conditions are present upon becoming aware of such conditions.

PLANNING, DESIGN, OR CONSTRUCTION: Development or design plans and specifications should be reviewed by Stantec Consulting Ltd., sufficiently ahead of initiating the next project stage (property acquisition, tender, construction, etc.), to confirm that this report completely addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site work relating to the recommendations included in this report should only be carried out in the presence of a qualified geotechnical engineer; Stantec Consulting Ltd. cannot be responsible for site work carried out without being present.

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Rootmat	- vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mixture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

Desiccated	- having visible signs of weathering by oxidization 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 successions of different soil types, e.g. silt and sand
Layer	- > 75 mm in thickness
Seam	- 2 mm to 75 mm in thickness
Parting	- < 2 mm in thickness

Terminology describing soil types:
The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4th Edition are used. The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):
Terminology describing materials outside the USCS, (e.g. particles larger than 75 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 20%

Terminology describing compactness of cohesionless soils:
The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on page 3. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Terminology describing consistency of cohesive soils:
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, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

Consistency	Undrained Shear Strength		Approximate SPT 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

ROCK DESCRIPTION

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	*Very Poor Quality*
25-50	*Poor Quality*
50-75	*Fair Quality*
75-90	*Good Quality*
90-100	*Excellent Quality*

Alternate (Colloquial) Rock Mass Quality	
Very Severely Fractured	*Crushed*
Severely Fractured	*Shattered or Very Blocky*
Fractured	*Blocky*
Moderately Jointed	*Sound*
Intact	*Very Sound*

RQD (Rock Quality Designation) denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. RQD is determined in accordance with ASTM D6032.

SCR (Solid Core Recovery) denotes the percentage of solid core (cylindrical) retrieved from a borehole of any orientation. All pieces of solid (cylindrical) core are summed and divided by the total length of the core run (It excludes all portions of core pieces that are not fully cylindrical as well as crushed or rubble zones).

Fracture Index (FI) is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of natural occurring fractures.

Terminology describing rock with respect to discontinuity and bedding spacing:

Spacing (mm)	Discontinuities	Bedding
>6000	*Extremely Wide*	-
2000-6000	*Very Wide*	*Very Thick*
600-2000	*Wide*	*Thick*
200-600	*Moderate*	*Medium*
60-200	*Close*	*Thin*
20-60	*Very Close*	*Very Thin*
<20	*Extremely Close*	*Laminated*
<6	-	*Thinly Laminated*

Terminology describing rock strength:

Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	<1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

Terminology describing rock weathering:

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

STRATA PLOT

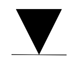
Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.

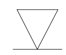
Boulders Cobbles Gravel	Sand	Silt	Clay	Organics	Asphalt	Concrete	Fill	Igneous Bedrock	Meta-morphic Bedrock	Sedi-mentary Bedrock

SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT


measured in standpipe, piezometer, or well


inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

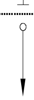
Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-Values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N-values corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to 'A' size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_U	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

TEST PIT RECORD

Stantec

CLIENT: Parks Canada
PROJECT: Geotechnical Investigation - Cape Spear Access Road
LOCATION: Cape Spear National Historic Site, Cape Spear, NL
DATES (mm-dd-yy): DUG 5-24-16
WATER LEVEL 1.52m
TEST PIT No. TP-01
PROJECT No. 133347329
DATUM N/A

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES OTHER TESTS	UNDRAINED SHEAR STRENGTH - kPa ★ (20, 40, 60, 80) / WATER CONTENT & ATTERBERG LIMITS Wp W WL (10–80)
0		SOD/ROOTMAT						
		Loose, brown, GRAVEL with sand and silt (GP-GM); occasional to some cobbles, some to frequent boulders: FILL - trace rootlets - medium organic odour observed at the bottom of the layer			BS	1		
		ROOTMAT/PEAT						
1		Loose to compact, brown, silty SAND with gravel (SM); some cobbles, occasional boulders - trace rootlets at top of layer		∇ (1.52 m)	BS	2		W ≈ 13
		End of Test Pit Slow water seepage observed at 1.52 m depth. Backhoe refusal on inferred bedrock.						
2								

TEST PIT RECORD

Stantec

CLIENT: Parks Canada
PROJECT: Geotechnical Investigation - Cape Spear Access Road
LOCATION: Cape Spear National Historic Site, Cape Spear, NL
DATES (mm-dd-yy): DUG 5-24-16
WATER LEVEL: 0.31m
TEST PIT No.: TP-02
PROJECT No.: 133347329
DATUM: N/A

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: OTHER TESTS	UNDRAINED SHEAR STRENGTH - kPa ★ (20, 40, 60, 80); WATER CONTENT & ATTERBERG LIMITS W_P W W_L (10, 20, 30, 40, 50, 60, 70, 80)
0		SOD						
		ASPHALT						
		ROOTMAT/TOPSOIL						
		Loose, brown to grey, GRAVEL with silt and sand (GP-GM); occasional cobbles: FILL - with organics, tree debris		▽				
		ROOTMAT/PEAT						
1		Loose, brown to reddish brown, silty SAND with gravel (SM); occasional cobbles - trace rootlets at top of layer						
2		End of Test Pit Moderate to rapid water seepage observed at 0.31 m depth. Backhoe refusal on inferred bedrock.						

TEST PIT RECORD

Stantec

CLIENT Parks Canada
PROJECT Geotechnical Investigation - Cape Spear Access Road
LOCATION Cape Spear National Historic Site, Cape Spear, NL
DATES (mm-dd-yy): DUG 5-24-16
WATER LEVEL 1.52m

TEST PIT No. TP-03
PROJECT No. 133347329
DATUM N/A

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: OTHER TESTS
0		SOD/ROOTMAT					
		ROCK FILL - 4 inch minus with sand and gravel					
		Loose to compact, brown to grey, GRAVEL with sand and silt (GP-GM); occasional to some cobbles: FILL - trace rootlets					
		ROOTMAT/PEAT					
1		Compact, grey, SAND with silt and gravel (SP-SM); occasional to some cobbles: FILL - wood debris with creosote encountered at 1.37 m depth		∇			
		End of Test Pit Slow water seepage observed at 1.52 m depth. Test pit terminated due to probable abandoned underground utility.					
2							

UNDRAINED SHEAR STRENGTH - kPa ★ (20, 40, 60, 80)

WATER CONTENT & ATTERBERG LIMITS (W_P, W, W_L) (10, 20, 30, 40, 50, 60, 70, 80)

TEST PIT RECORD

Stantec

CLIENT	Parks Canada
PROJECT	Geotechnical Investigation - Cape Spear Access Road
LOCATION	Cape Spear National Historic Site, Cape Spear, NL
DATES (mm-dd-yy): DUG	5-24-16
WATER LEVEL	N/A
TEST PIT No.	TP-04
PROJECT No.	133347329
DATUM	N/A

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: OTHER TESTS	UNDRAINED SHEAR STRENGTH - kPa ★ (20, 40, 60, 80) / WATER CONTENT & ATTERBERG LIMITS W_P W W_L (10, 20, 30, 40, 50, 60, 70, 80)
0		ROOTMAT/SOD - tree debris						
		ASPHALT						
		Loose, brown, GRAVEL with silt and sand (GP-GM); some cobbles: FILL - with rootlets, tree debris, pieces of asphalt and rock						
		Loose, black to dark brown, SAND with silt and gravel (SP-SM); occasional to some cobbles - with rootlets and organics at top of layer						
1								
		End of Test Pit No water seepage observed. Backhoe refusal on inferred bedrock.						
2								

Stantec

TEST PIT RECORD

CLIENT: Parks Canada
PROJECT: Geotechnical Investigation - Cape Spear Access Road
LOCATION: Cape Spear National Historic Site, Cape Spear, NL
DATES (mm-dd-yy): DUG 5-24-16
WATER LEVEL: 0.38m

TEST PIT No.: TP-05
PROJECT No.: 133347329
DATUM: N/A

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: OTHER TESTS	UNDRAINED SHEAR STRENGTH - kPa ★ (20, 40, 60, 80) / WATER CONTENT & ATTERBERG LIMITS W_P W W_L (10–80)
0		ROCK FILL - with sod/rootlets on the top						
		ROOTMAT/TOPSOIL						
		Loose, brown, silty SAND with gravel (SM) to SAND with silt and gravel (SP-SM); occasional to some cobbles - some rootlets, organics - fractured rock piece encountered		∇	BS	1		
		End of Test Pit Slow water seepage observed at 0.38 m depth. Backhoe refusal on inferred bedrock.						
1								
2								

Stantec

TEST PIT RECORD

CLIENT Parks Canada
PROJECT Geotechnical Investigation - Cape Spear Access Road
LOCATION Cape Spear National Historic Site, Cape Spear, NL
DATES (mm-dd-yy): DUG 5-24-16 WATER LEVEL N/A

TEST PIT No. TP-06
PROJECT No. 133347329
DATUM N/A

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES OTHER TESTS	UNDRAINED SHEAR STRENGTH - kPa ★ (20, 40, 60, 80) / WATER CONTENT & ATTERBERG LIMITS W_P W W_L (10, 20, 30, 40, 50, 60, 70, 80)
0		SOD/ROOTMAT						
		Loose, brown, silty SAND with gravel (SM) to SAND with silt and gravel (SP-SM); some cobbles - some rootlets, organics - fractured rock piece encountered			BS	1		
		End of Test Pit No water seepage observed. Backhoe refusal on inferred bedrock.						
1								
2								

TEST PIT RECORD

Stantec

CLIENT	Parks Canada	TEST PIT No.	TP-07
PROJECT	Geotechnical Investigation - Cape Spear Access Road	PROJECT No.	133347329
LOCATION	Cape Spear National Historic Site, Cape Spear, NL		
DATES (mm-dd-yy): DUG	5-24-16 WATER LEVEL N/A	DATUM	N/A

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES OTHER TESTS	UNDRAINED SHEAR STRENGTH - kPa ★ (20, 40, 60, 80) / WATER CONTENT & ATTERBERG LIMITS W_P W W_L (10, 20, 30, 40, 50, 60, 70, 80)
0		SOD/ROOTMAT						
		Loose, black to brown, silty SAND with gravel (SM) - trace organics, rootlets						
		End of Test Pit No water seepage observed. Backhoe refusal on inferred bedrock.						
1								
2								

TEST PIT RECORD

Stantec

CLIENT	Parks Canada	TEST PIT No.	TP-08
PROJECT	Geotechnical Investigation - Cape Spear Access Road	PROJECT No.	133347329
LOCATION	Cape Spear National Historic Site, Cape Spear, NL		
DATES (mm-dd-yy): DUG	5-24-16	WATER LEVEL N/A	DATUM N/A

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: OTHER TESTS
0		SOD/ROOTMAT					
		Loose, black, silty SAND with gravel (SM) - organic material observed throughout the layer					
		End of Test Pit No water seepage observed. Backhoe refusal on inferred bedrock.					
1							
2							

UNDRAINED SHEAR STRENGTH - kPa ★ (20, 40, 60, 80)

WATER CONTENT & ATTERBERG LIMITS W_P W W_L (10, 20, 30, 40, 50, 60, 70, 80)

TEST PIT RECORD

Stantec

CLIENT: Parks Canada
PROJECT: Geotechnical Investigation - Cape Spear Access Road
LOCATION: Cape Spear National Historic Site, Cape Spear, NL
DATES (mm-dd-yy): DUG 5-24-16
WATER LEVEL: N/A

TEST PIT No.: TP-09
PROJECT No.: 133347329
DATUM: N/A

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: OTHER TESTS	UNDRAINED SHEAR STRENGTH - kPa ★ (20, 40, 60, 80); WATER CONTENT & ATTERBERG LIMITS W_P W W_L (10, 20, 30, 40, 50, 60, 70, 80)
0		SOD/ROOTMAT						
		Loose, brown, SAND with silt and gravel (SP-SM) to silty SAND with gravel (SM); occasional cobbles: FILL - black organics observed throughout the layer - debris (e.g. glass, metal pieces, felt) encountered						
		End of Test Pit No water seepage observed. Backhoe refusal in inferred bedrock.						
1								
2								

TEST PIT RECORD

Stantec

CLIENT: Parks Canada
PROJECT: Geotechnical Investigation - Cape Spear Access Road
LOCATION: Cape Spear National Historic Site, Cape Spear, NL
DATES (mm-dd-yy): DUG 5-24-16
WATER LEVEL: N/A

TEST PIT No.: TP-10
PROJECT No.: 133347329
DATUM: N/A

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	OTHER TESTS
0		SOD/ROOTMAT					
		Loose, brown,silty SAND with gravel (SM) to SAND with silt and gravel (SP-SM) - trace rootlets, organics			BS	1	
		End of test pit No water seepage observed Backhoe refusal on inferred bedrock					
1							
2							

UNDRAINED SHEAR STRENGTH - kPa ★ (20, 40, 60, 80)

WATER CONTENT & ATTERBERG LIMITS W_P W W_L (10, 20, 30, 40, 50, 60, 70, 80)

TEST PIT RECORD

Stantec

CLIENT Parks Canada
PROJECT Geotechnical Investigation - Cape Spear Access Road
LOCATION Cape Spear National Historic Site, Cape Spear, NL
DATES (mm-dd-yy): DUG 5-24-16 WATER LEVEL N/A

TEST PIT No. TP-11
PROJECT No. 133347329
DATUM N/A

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: OTHER TESTS	UNDRAINED SHEAR STRENGTH - kPa ★ (20, 40, 60, 80); WATER CONTENT & ATTERBERG LIMITS W_P W W_L (10–80)
0		SOD/ROOTMAT						
		Loose, black to brown, silty SAND with gravel (SM); occasional cobbles - organic material observed throughout the layer - a sand seam encountered at 0.42 m depth						
		End of Test Pit No water seepage observed. Backhoe refusal on inferred bedrock.						
1								
2								

Test Pit TP-01

Test Pit TP-01 Spoil Pile

Test Pit TP-02

Test Pit TP-02 Spoil pile

Test Pit TP-03

Test Pit TP-03 Spoil Pile

Test Pit TP-04

Test Pit TP-04 Spoil Pile

Test Pit TP-05

Test Pit TP-05 Spoil Pile

Test Pit TP-06

Test Pit TP-06 Spoil pile

Test Pit TP-07

Test Pit TP-07 Spoil Pile

Test Pit TP-08

Test Pit TP-08 Spoil Pile

Test Pit TP-09

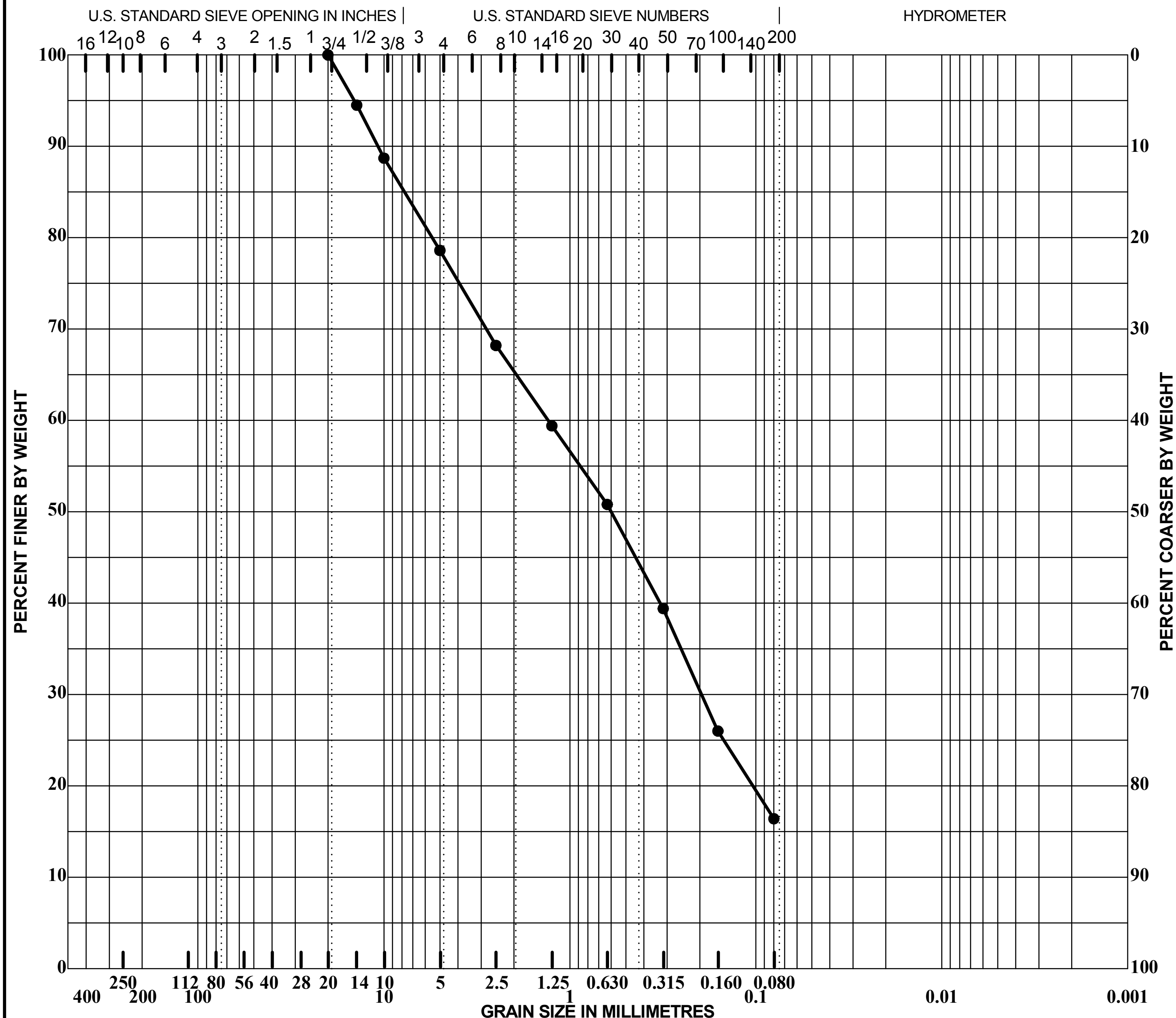
Test Pit TP-09 Spoil Pile

Test Pit TP-10

Test Pit TP-10 Spoil Pile

Test Pit TP-11

Test Pit TP-11 Spoil Pile



COBBLE	GRAVEL		SAND			SILT and CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (m)	Description	W%	W_L	W_P	I_P
●	TP-01 BS02	1.76	Silty SAND with gravel (SM)	13.0			

	Sample	Depth (m)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	TP-01 BS02	1.76	20.00	1.31	0.196		21.4	62.2	16.4	

REMARKS:

Stantec

Client:	**Parks Canada**
Project:	**Geotechnical Investigation - Cape Spear Access Road**
Project No.:	**133347329**
Location:	**Cape Spear National Historic Site, Cape Spear, NL**

FIGURE 1

GRADATION CURVES

V:\01333\ACTIVE\133347244 - CAPE SPEAR\DESIGN\DRAWING\CIVIL\C3D\MODEL_FILES\Testpit_Drawing.dwg
2016/06/13 9:32 AM By: Benson, Amanda

Stantec

141 Kelsey Drive
St. John's NL
www.stantec.com

Legend

– TEST PIT LOCATION

Notes

16.06.13
133347244

Client/Project
PARKS CANADA
GEOTECHNICAL INVESTIGATION - CAPE SPEAR ACCESS ROAD

Figure No.
01

Title
TEST PIT LOCATION PLAN

Memo

To:	[redacted]	From:	[redacted]
	Stantec Consulting Ltd. 141 Kelsey Drive St. John's, NL A1B 0L2		Stantec Consulting Ltd. 141 Kelsey Drive St. John's, NL A1B 0L2
File:	133347329	Date:	June 27, 2016

Reference: Design Recommendations for Pavement Structures/Areas, Cape Spear National Historic Site, Blackhead Road, NL

This memorandum provides comments and recommendations regarding site development and pavement structure of the proposed access road to Cape Spear Lighthouse at Cape Spear National Historic Site, Newfoundland and Labrador. At the time of issuing this report, it is understood that a new unpaved access road is planned to be constructed for the site. Recommendations are based on a geotechnical investigation performed by Stantec in May, 2016.

Site Preparation

Subgrade preparation should involve the excavation of materials identified in the geotechnical report as SOD, ROOTMAT, TOPSOIL and ASPHALT. Excavated areas should be proof rolled and, if required, built to the desired grade with an approved structural fill as described below. The geotechnical investigation revealed areas with shallow bedrock. If the surface elevation of the proposed road is to be within 1.0 m of bedrock, the bedrock should be overbroken to a minimum of 300 mm and compacted or excavated and replaced with approved structural fill.

The predominant subgrade material is silty sand with gravel (SM) to gravel with silt and sand (GP-GM) with fines contents (silts / clays) on the order of 16.4%. Typically, where the fines content of a soil is in excess of 12%, the soil may tend to soften and become unsuitable and difficult to work when it becomes wetter than its optimum moisture content and is disturbed. In addition, silty soils that have been successfully compacted and approved, may require removal if they subsequently become wet and softened from water infiltration, precipitation or freezing.

Excavations may encounter groundwater seepage and/or surface water runoffs during site preparation earthworks that will be important to control. All water seepage should be controlled using appropriate measures, such as open drainage ditching.

Temporary and Permanent Slopes

Temporary slopes comprised of a well-graded gravel (GW) or processed rockfill material should be no steeper than 1 horizontal to 1 vertical (1H:1V). For predominately sandy materials such as a pit run sand and gravel or silty sand with gravel (SM), the slope should be no steeper than 1.5 horizontal to 1 vertical (1.5H:1V).

Final, permanent slopes should be no steeper than 2.0 horizontal to 1.0 vertical (2.0H:1.0V). The materials should be placed and compacted as described below. Erosion control and protection of slopes is recommended.

Additional slope flattening or mitigation may be required to maintain the stability of temporary slopes. All temporary excavations and slopes should be periodically inspected for evidence of instability and movement by experienced geotechnical personnel. The contractor and/or designer should review with Stantec the construction excavation slopes and fill placement geometry plans that would be implemented at the construction phase for the proposed development when they become available.

Structural Fill

Structural fill should consist of a well-graded, free-draining granular material such as pit run sand and gravel or processed blasted rockfill. The maximum particle size should not exceed 150 mm.

Site excavated fill materials may be suitable for re-use as structural fill provided the moisture content is maintained within 1 to 2 percent below its optimum value and are free of deleterious materials (i.e. organics). If consideration is given to reusing the in-situ soils, the above noted concerns regarding handling and placement of these materials under wet and freezing conditions must be considered.

Structural fill should be placed in horizontal lifts and compacted to the specifications outlined in Table 1: Recommended Structural Fill Compaction Requirements. In addition to the compaction requirements presented in Table 1, visual approval of all structural fill during placement is recommended. The lift thickness used during fill placement should be compatible with the compaction equipment and material type to ensure the required density throughout. Due to the particle size distribution of coarser grained soils (e.g., rockfill), verification of the field density by visual inspection during proof rolling by geotechnical personnel will be required. As a general guide, structural fill should be placed in 300 to 400 mm lifts and compacted with a 10 tonne vibratory roller.

Table 1: Recommended Structural Fill Compaction Requirements

Structural Fill Application	Minimum Compaction Requirements Percent of Standard Proctor (ASTM D698) Maximum Dry Density, %
Roadway Areas	98

Roadway Structures/Areas

Site preparation and structural fill placement should be completed in accordance with the previous Sections to achieve the required road elevation. The strength of the pavement has been evaluated using the approach provided in the *AASHTO 1993 Guide for the Design of Pavement Structures*. The pavement design has been carried out using the following design parameters and recommendations for pavement structure are presented below in Table 2.

Design Parameters	**Design Values**
Design Life	20 years
Design ESAL's (equivalent axle load of 18,000 lbs)	20,000
Reliability	75 percent
Subgrade Resilient Modulus (M_R)	30 MPa
Drainage coefficient	1.0

Table 2: Recommendations for Pavement Structure

Materials	Standard Traffic Loading
Class A Gravel	150 mm
Granular Subbase (Class B)	200 mm
Biaxial Geogrid (BX1200) or equivalent	Placed between subgrade and subbase

Materials types and placement specifications conforming to the Newfoundland Department of Transportation Engineering Specifications or equivalent will be suitable for this application. A biaxial BX1200 type or equivalent geogrid is recommended to place between the subgrade and subbase materials to provide the additional stability of the unpaved roadway structure and prevent erosion. It is recommended that a review of our pavement structure be completed once other details, such as design life and maintenance protocol are finalized. Proper surface and subgrade drainage is recommended to ensure that the recommended pavement structure will perform satisfactorily.

Pavement Construction

Pavement should be constructed following the steps mentioned below:

- Excavate to required grade;
- Scarify and compact subgrade, or overbreak and compact bedrock;
- Proof roll subgrade, excavate and replace unsuitable material;

- If required to achieve design elevations, place and compact approved fill material to 98% standard proctor maximum dry density;
- Install geogrid according to the manufacturer's specifications; and
- Place and compact Granular B and Granular A to 100% standard proctor maximum dry density.