APPENDIX A

GEOTECHNICAL REPORTS

GEOTECHNICAL INVESTIGATION - Corney Brook Road Realignment Cabot Trail, Highlands National Park, Cape Breton, Nova Scotia

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1.0 INTRODUCTION

Stantec Consulting Ltd. (Stantec), acting at the request of Mr. Jeff MacKinnon of Crandall Engineering Ltd., has carried out a geological/geotechnical assessment of the rock mass near Corney Brook in the Cape Breton Highlands National Park. The purpose of the work was to further assess the rock mass and to provide recommendations to facilitate detailed design of the proposed realignment in this area.

Previous work was carried out at this site by Stantec and consisted of the following projects:

- Geotechnical Investigation and Design of Stabilization measures for a section of the downslope cliff face which was undergoing a large scale slope failure. Work consisted of analyzing the slope, designing a soldier pile wall, replacing a section of steel Bin wall with concrete "TWALL", and removing unstable material in a large wedge on the upslope side of the road.
- Investigation and design of additional stabilization measures at and near the above noted site consisting of rock bolting a large wedge and constructing a concrete wall below the existing soldier pile wall.
- Options analysis addressing ongoing stability issues related to the rock mass at Corney Brook which recommended moving the road away from the existing cliff face.

The investigation for this project consisted of a review of existing data compiled from the previous work noted above, along with additional geological mapping of the rock face and collection of samples to determine the acid producing potential of the rock to be excavated in order to realign the road.

This report presents a summary of the data compiled from the previous work and provides recommendations related to design and construction of the new road.

2.0 SITE DESCRIPTION

The site is located approximately 9 km from the Cheticamp Park Boundary along the Cabot Trail in the Highlands National Park. The Cabot Trail in this area is constructed a large rock cut with a steep cliff to the ocean on the coastal side.

The down slope rock cliff is currently about 70 m above sea level at the toe of the cliff. The up slope rock cuts are up to 15 m high. The top of the upslope is treed and the overburden is relatively thin (less than 2 m) based on observation along the top of the rock cut.

3.0 INVESTIGATION PROCEDURES

As noted previously, data collected from previous investigations/assessments were compiled along with additional field investigations done specifically for this project. The field investigations consisted of obtaining the orientation of the various geological features within the rock mass relevant to the design of the rock cut.

A software package "ShapeMetrix^{3D}" was utilized to collect detailed orientations of the main features affecting the stability of the rock cut which is the intersection of the bedding/cleavage and another dominant joint set. The model provides the orientation of the intersection of these two planes which has been used to recommend stable slope angles. The system, ShapeMetrix^{3D}, produces a 3D model for the rock slope that is then used to define slope geometry and derive geological structure orientations, which are input to subsequent stability analyses and remedial design. The system can accurately map 100% of the rock face in a timely and safe manner with minimal disruption to the transportation corridor. The resulting 3D model can be used to produce profiles, drawings and images of the site and can be shared with VTrans, contractors and other parties for planning and remedial work.

4.0 SITE CONDITIONS

During the site work carried out in 2013, 5 boreholes and 1 test pit were put down along the down slope edge of the existing roadway. The boreholes and test pit records along with the site location plan are provided in Appendix A and summarized below.

Fine grained metasedimentary bedrock was encountered in the test pit and all five boreholes at depths ranging from 0.5 to 3.7 m below grade. In TP1, BH2, BH3 and BH5 the bedrock surface was composed of a layer of highly weathered metasiltstone ranging in thickness from approximately 0.7 to 0.9 m.

Underlying the highly weathered bedrock surface the rock mass quality generally ranged from very severely fractured to moderately jointed and was slightly weathered on discontinuity surfaces. In BH1 to BH4 layers of highly weathered and severely fractured bedrock were encountered at depths ranging from 1.8 m to 8.5 m, with thicknesses ranging from 0.2 to 1.0 m. During coring in BH2 and BH5 a loss of the return wash water occurred at 4.8 m and 6.5 m respectively, this could have been caused by larger discontinuities and/or fractured sections.

Bedrock at the site has undergone low grade metamorphism and tectonic events, which give it the distinct structure apparent in the road cuts where a well-developed foliation creates layers of rock which are oriented sub-parallel to the cliff face. These layers are either the original bedding planes or transposed compositional layering, which occurs from metamorphism, which causes realignment of the original rock fabric. These planes dip steeply toward the west and the steepness creates unstable faces which create surfaces that extend from the base of the cliff up to the road level. The surface of these planes is continuous, relatively wavy and smooth. A second joint set strikes toward the northwest and dips steeply toward the southwest. Where this joint intersects the bedding planes, large wedges form (see photo). The line of intersection of these wedges is steeply dipping and creates unstable masses of rock.

The bedrock at the site has also been subjected to tectonic stresses and examination of the rock core shows significant evidence of micro-fractures throughout the core. Many of these micro-fractures show differential movements and fractures are healed often with calcite creating a relatively weak “sugar cube” like structure. This micro-fracture affects the overall rock mass properties.

Bedrock Structural Properties

Axial point load strength index testing was completed on 32 samples of bedrock core and yielded an inferred Q_U average of 74 MPa. The rock strength test results are provided in Appendix A.

Additional site specific modeling was carried out on the main structural features that form the large wedge failure using "ShapeMetrix^{3D}". As noted previously the main structural features controlling the stability of the rock mass are the intersection of the bedding/foliation and another dominant joint as shown in the previous photo. The modeling indicates the intersection of these joints creates a line that tips toward the road at an angle of approximately 55° from the horizontal. Stability of sliding plans and wedges have been assessed based on the following parameters:

Effective cohesion:	0 kPa
Effective Friction Angle:	30°
Total Unit Weight:	26 kN/m3

The Rock Mass Rating System utilizes a variety of the properties of the rock to develop an overall rating that can be used for various engineering correlations such as strength parameters, elastic modulus, rippability etc. The properties that comprise the system consist of the following:

- Point Load Index or Unconfined compressive strength
- Rock Quality Designation (RQD)
- Joint Spacing
- Joint Condition
- Groundwater
- Joint Orientations

To address the stability of the rock mass based on a failure through a combination of intact rock and discontinuities we have used the strength parameters based on the rating system. The boreholes and observations of the existing rock cut were used as inputs to the rating system and based on this exercise the following parameters have been used to analyse this type of stability problem:

Effective Cohesion:	250 kPa
Effective Friction Angle:	30°
Total Unit Weight:	26 kN/m^3

Acid Producing Potential

Twenty-five grab samples were obtained along the exposed rock cut to determine the acid producing potential of the bedrock. This work was carried out to ensure disposal of the excavated material was done in an acceptable manner. Testing was carried out at the Minerals Engineering Centre at Dalhousie University. The following table presents the results of this testing.

Sample	Wt.% S			Kg H2S04/t		
	Total	As Sulphate	Sulphide	Acid Producing Potential	Acid Consuming Potential	pH
Cabot Trail Sample 01	0.011			0.33		
Cabot Trail Sample 02	0.046			1.39		
Cabot Trail Sample 03	0.047			1.45		
Cabot Trail Sample 04	0.222			6.79		
Cabot Trail Sample 05	0.122			3.73		
Cabot Trail Sample 06	0.224			6.85		
Cabot Trail Sample 07	0.028			0.86		
Cabot Trail Sample 08	0.016			0.49		
Cabot Trail Sample 09	0.988	0.041	0.947	28.97	8.28	6.85
Cabot Trail Sample 10	0.021			0.63		
Cabot Trail Sample 11	0.051			1.55		
Cabot Trail Sample 12	0.012			0.37		
Cabot Trail Sample 13	0.025			0.78		
Cabot Trail Sample 14	0.022			0.66		
Cabot Trail Sample 15	0.019			0.58		
Cabot Trail Sample 16	0.060			1.84		
Cabot Trail Sample 17	0.021			0.63		
Cabot Trail Sample 18	<0.001			<0.03		
Cabot Trail Sample 19	0.063			1.93		
Cabot Trail Sample 20	0.018			0.56		
Cabot Trail Sample 21	0.049			1.50		
Cabot Trail Sample 22	0.022			0.67		
Cabot Trail Sample 23	0.328	0.010	0.318	9.73	6.11	7.30
Cabot Trail Sample 24	0.028			0.85		
Cabot Trail Sample 25	0.111			3.41		
Cabot Trail Sample 25-DUI	0.107			3.26		

5.0 DISCUSSION

5.1 GENERAL

Based on the review of existing data and the current investigation and assessment, the following sections provide recommendations for various aspects of the detailed design.

5.2 SLOPES

As previously noted, the intersection of bedding/ foliation and another major joint set creates a series of unstable wedges and the intersections of the wedges have a dip of approximately 55° from the horizontal toward the roadway, therefore it is recommended that this angle be used in the design of the final slope angle.

The final slope should be constructed by pre-shearing the rock at this orientation or if possible excavating to this angle. Care must be exercised to prevent over-steepening portions of the slope which will potentially undermine wedges. The bedding dips steeper than the wedge intersections and following bedding planes will over-steepen the slope. If the slope is cut steeper than the 55° there is a risk of a large wedge failure similar to the layer wedges that would have been removed during the existing road construction. As the rock excavation proceeds, loose material should be scaled from the cut face.

A stability analysis was carried out considering a failure through the rock mass for the cut slope above the road having a height of 30 m and cut at an angle of 55° as recommended. A safety factor of greater than 2 was obtained. In addition, we carried out an analysis of the entire upper slope and lower slope having a total height of approximately 100 m and obtained a safety factor of 1.3 which is considered to be the low end of acceptable safety factors for this type of infrastructure.

The overburden at the top of the slope should be cut no steeper than 2H:1V and any loose cobbles and boulders should be removed from the face. A 1 m wide bench at the top of the cut would reduce the amount of material rolling down the cut from the overburden.

5.3 EXCAVATION AND DISPOSAL

We have evaluated the excavatability of the rock based on information from the present investigation. The boreholes suggest that the near surface rock is very severely fractured and could be excavated with large equipment. Deeper in the rock cut the joint spacing and Rock Quality Designation increases. This along with a strength indicated to be in the order of 50 to 100 MPa suggests that the bulk of the material would have to be removed by a combination of ripping and blasting. Ripping is not expected to be suitable for all of the excavation work and may be quite limited in its effectiveness and blasting is likely to be a more efficient means of rock removal of the scale required for this project.

Sampling and testing for the acid generating potential was carried out in general accordance with the Provincial Sulphide Bearing Material Disposal Regulations. In this guideline a sulphide sulphur content of greater than 0.4% is considered potentially acid generating, the overall average of all samples has to exceed 0.4% and the number of samples exceeding 0.4% has to be greater than 50%. Based on the results of the testing carried out for this project, the material is not considered potential acid generating and would not require special disposal techniques related to this. Confirmation sampling should be carried out during construction.

The material is very fissile and has a tendency to break down as it is handled and because of this can be used for general fill but not a source of aggregate type material for gravels or armore stone.

5.4 ROCK FALL CATCHMENT

Much of the recent rock fall design research has been conducted by the Oregon Department of Transportation – Research Group and their research has been published by the U.S. Federal Highway Administration (FHWA) "Rock Fall Catchment Area Design Guide", November 2001.

This guide provides a series of charts which indicate the percentages of material which falls from the slope and is contained within a ditch with a variety of geometries. We have attached a series of charts in Appendix B for various slope heights based on a slope angle close to the 55° previously recommended in this report.

Selection of the appropriate width of catchment for the Corney Brook site has to consider the type of material that will be falling from the slope, the risk to traffic and the cost associated with wide ditches which results in large volumes of rock removal.

On the charts is a column labelled "Impact" and we recommend that as a minimum the ditch should ensure that 99% of the material falling from the slope impacts within the ditch and not on the road; this would require a ditch width in the order of 5-6 m for the highest slopes. Once the falling rock impacts in the ditch, it will roll toward the road and additional catchment width is required to contain a high percentage of rock within the ditch. The type of rock we anticipate to have falling in the ditch would be flat slabs that will tend to slide down the slope face with little capacity to roll due to their shape. As a minimum it is recommended that the ditches be designed for 85-90% catchment. Consideration could be given to designing to ensure impact happens within the ditch with a barrier constructed at the edge of the ditch to prevent rolling material from getting on the roadway. This would reduce overall cost significantly but has implications with maintenance requirements (snow removal).

6.0 CLOSURE

Use of this report is subject to the Statement of General Conditions provided in Appendix A. It is the responsibility of the Public Works and Government Services Canada who is identified as "the Client" within the Statement of General Consitions, and its agents to review the conditions and to notify Stantec Consulting Ltd. Should any of these be not 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

This report was prepared by Greg MacNeill, P.Eng. and reviewed by Dan McQuinn, P.Eng. Should you have any questions, please do not hesitate to call us at 902-468-7777.

Yours very truly,

STANTEC CONSULTING LTD.

S. Greg MacNeill, P.Eng.

Dan McQuinn, P.Eng.

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APPENDIX A

Statement of General Conditions
Symbols and Terms Used on Borehole and Test Pit Records
Borehole Records
Drawing No. 1, Borehole and 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.

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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.

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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

Stantec

BOREHOLE RECORD

BH1

CLIENT PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PROJECT No. 121615619
LOCATION HIGHLANDS NATIONAL PARK, CAPE BRETON, NOVA SCOTIA
BH SIZE HW/HQ
DATES: BORING 2013/01/10 to 2013/01/11 WATER LEVEL
DATUM ASSUMED

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR-RQD %	OTHER TESTS
0	100.30								
	100.07	ASPHALT							
	99.44	FILL: reddish brown sand with silt and gravel			SS	1	250	75/175mm	
1		Very severely fractured to fractured medium grey METASEDIMENTARY BEDROCK -weathered staining at fractures -highly weathered sections			HQ	2	92%	22%	
2					HQ	3	100%	0%	
3					HQ	4	100%	47%	
4					HQ	5	100%	72%	Ip
5					HQ	6	100%	64%	Ip
6					HQ	7	100%	35%	
7					HQ	8	100%	30%	
8					HQ	9	100%	16%	Ip
9		-highly weathered and very severely fractured from (8.5m to 9.1m)			HQ	10	100%	0%	
10					HQ	11	100%	26%	Ip

UNDRAINED SHEAR STRENGTH - kPa: 20 40 60 80

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

App'd________ Jan 31 2013 13:50:59

MBH 1/31/13

Stantec BOREHOLE RECORD BH1

CLIENT PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PROJECT No. 121615619
LOCATION HIGHLANDS NATIONAL PARK, CAPE BRETON, NOVA SCOTIA
BH SIZE HW/HQ
DATES: BORING 2013/01/10 to 2013/01/11
WATER LEVEL
DATUM ASSUMED

DEPTH(m)	ELEVATION(m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY (mm)	SAMPLES: N-VALUE OR-RQD %	OTHER TESTS
10	89.63	METASEDIMENTARY BEDROCK; Continued							
		End of Borehole -Slope Indicator Installed							
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

UNDRAINED SHEAR STRENGTH - kPa: 20 40 60 80

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

App'd__________ Jan 31 2013 13:50:59

MBH 1/31/13

Stantec

BOREHOLE RECORD

BH2

CLIENT PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PROJECT No. 121615619
LOCATION HIGHLANDS NATIONAL PARK, CAPE BRETON, NOVA SCOTIA
BH SIZE HW/HQ
DATES: BORING 2013/01/12
WATER LEVEL
DATUM ASSUMED

DEPTH(m)	ELEVATION(m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR-RQD %	OTHER TESTS
0	100.15	Previous Test Pit Zone TP1							
1	98.93	Very severely fractured to moderately jointed medium grey METASEDIMENTARY BEDROCK -weathered staining at fractures -highly weathered sections			HQ	1	77%	0%	
2					HQ	2	80%	13%	
3–4					HQ	3	100%	45%	
5		-loss return of wash water while drilling from (4.8m to 6.5m)			HQ	4	100%	52%	Ip
6–7		-moderately weathered and very severely fractured from (5.8m to 6.4m)			HQ	5	82%	53%	
8					HQ	6	100%	73%	Ip
9–10					HQ	7	100%	83%	Ip

UNDRAINED SHEAR STRENGTH - kPa: 20, 40, 60, 80

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

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MBH 1/31/13

Stantec

BOREHOLE RECORD

BH2

CLIENT PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

PROJECT No. 121615619

LOCATION HIGHLANDS NATIONAL PARK, CAPE BRETON, NOVA SCOTIA

BH SIZE HW/HQ

DATES: BORING 2013/01/12

WATER LEVEL

DATUM ASSUMED

DEPTH(m)	ELEVATION(m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR-RQD %	OTHER TESTS
10		METASEDIMENTARY BEDROCK; Continued							
					HQ	8	100%	70%	
11									
					HQ	9	100%	25%	
12	87.96				HQ	10	100%	30%	
		End of Borehole -Slope Indicator Installed							
13									
14									
15									
16									
17									
18									
19									
20									

UNDRAINED SHEAR STRENGTH - kPa

20 40 60 80

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

App'd________ Jan 31 2013 13:51:4

MBH 1/31/13

Stantec

BOREHOLE RECORD

BH3

CLIENT PUBLIC WORKS AND GOVERNMENT SERVICES CANADA — PROJECT No. 121615619

LOCATION HIGHLANDS NATIONAL PARK, CAPE BRETON, NOVA SCOTIA — BH SIZE HW/HQ

DATES: BORING 2013/01/13 — WATER LEVEL 2013/01/21 — DATUM ASSUMED

DEPTH(m)	ELEVATION(m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR-RQD %	OTHER TESTS
0	99.64	FILL: reddish brown sand with silt and gravel			SS	1	400	34	
	99.03	Highly weathered medium grey METASEDIMENTARY BEDROCK							
	98.12	Very severely fractured to moderately jointed medium grey METASEDIMENTARY BEDROCK -weathered staining at fractures -highly weathered sections			HQ	2	73%	0%	
					HQ	3	71%	0%	
					HQ	4	90%	0%	
					HQ	5	100%	38%	
					HQ	6	100%	40%	
		-Highly weathered and very severely fractured from (1.8m to 2.4m) and (7.7m to 7.9m)			HQ	7	100%	64%	Ip
				▼	HQ	8	93%	78%	Ip
9	90.60	End of Borehole -50 mm pvc monitoring well installed							

UNDRAINED SHEAR STRENGTH - kPa: 20 40 60 80

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

App'd________ Jan 31 2013 13:51:5

MBH 1/31/13

Stantec BOREHOLE RECORD BH4

CLIENT: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
PROJECT No. 121615619

LOCATION: HIGHLANDS NATIONAL PARK, CAPE BRETON, NOVA SCOTIA
BH SIZE: HW/HQ

DATES: BORING 2013/01/14 WATER LEVEL 2013/01/21
DATUM: ASSUMED

DEPTH(m)	ELEVATION(m)	SOIL DESCRIPTION	TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR-RQD %	OTHER TESTS
0	100.50	FILL: reddish brown sand with silt and gravel	SS	1	300	12	
			SS	2	200	5	S
			SS	3	50	7	
			SS	4	150	8	
2.90	97.60	Very severely fractured to fractured medium grey METASEDIMENTARY BEDROCK -weathered staining at fractures -highly weathered sections	SS	5	100	67/200mm	
			HQ	6	76%	17%	
			HQ	7	100%	48%	
			HQ	8	100%	27%	Ip
		-highly weathered and very severely fractured from (6.1m to 7.1m)	HQ	9	79%	0%	
			HQ	10	100%	65%	
7.77	92.73	End of Borehole -50 mm pvc monitoring well installed					

UNDRAINED SHEAR STRENGTH - kPa: 20, 40, 60, 80

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

App'd__________ Jan 31 2013 13:51:6

Stantec

BOREHOLE RECORD

BH5

CLIENT: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
LOCATION: HIGHLANDS NATIONAL PARK, CAPE BRETON, NOVA SCOTIA
DATES: BORING 2013/01/14
WATER LEVEL:

PROJECT No. 121615619
BH SIZE: HW/HQ
DATUM: ASSUMED

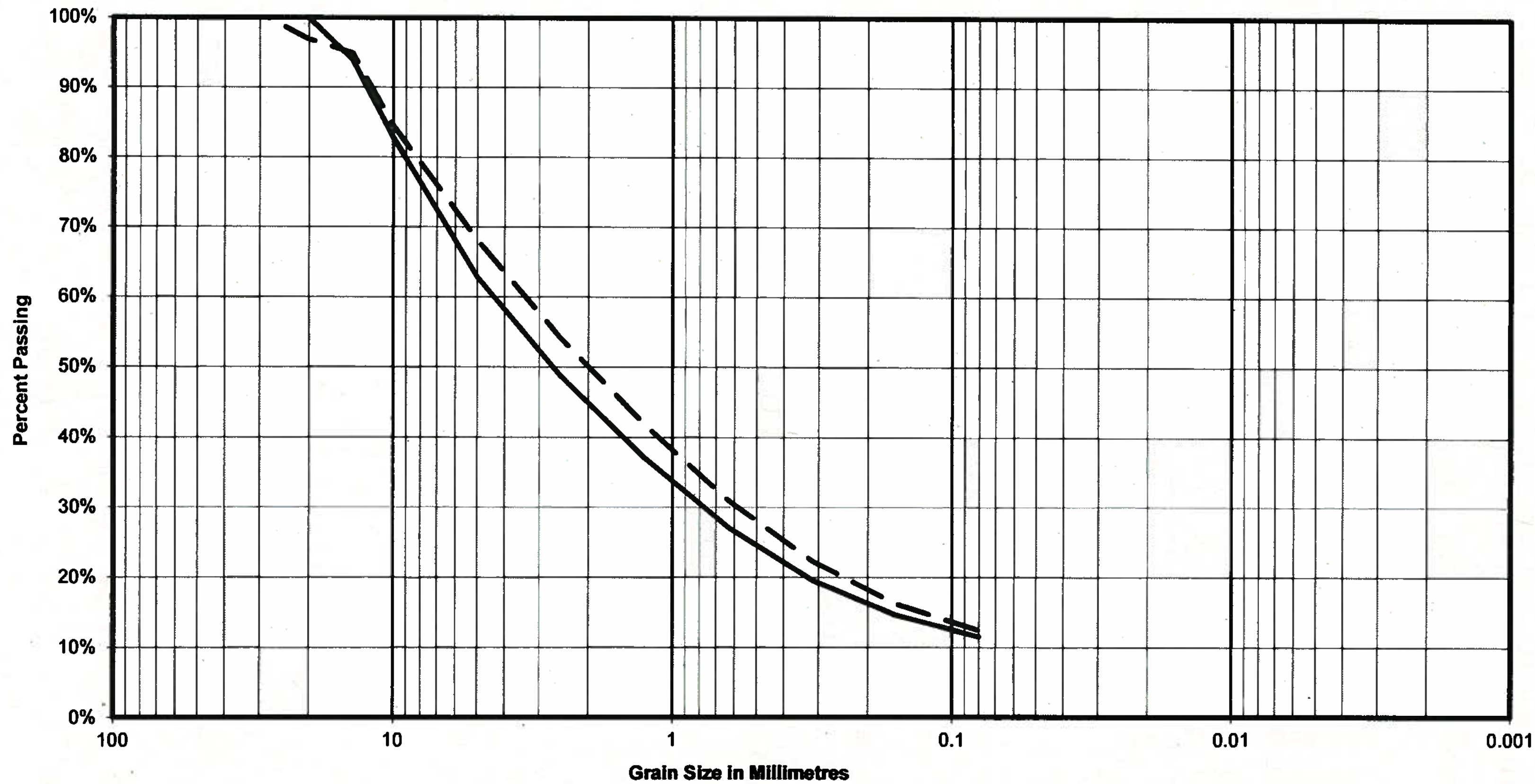
DEPTH(m)	ELEVATION(m)	SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR-RQD %	OTHER TESTS
0	101.30	FILL: reddish brown sand with silt and gravel	SS	1	350	13	
			SS	2	250	7	
			SS	3	0	6	
			SS	4	200	5	S
			SS	5	0	6	
	97.64	Highly weathered medium grey METASEDIMENTARY BEDROCK	SS	6	350	41	
	96.88	Very severely fractured to fractured medium grey METASEDIMENTARY BEDROCK -weathered staining at fractures -lost return of wash water during drilling from (6.1m to 6.7m)	HQ	7	66%	0%	
			HQ	8	93%	22%	
			HQ	9	100%	0%	
			HQ	10	100%	63%	Ip
	93.68	End of Borehole					

UNDRAINED SHEAR STRENGTH - kPa: 20, 40, 60, 80
WATER CONTENT & ATTERBERG LIMITS (W_P, W, W_L)
DYNAMIC PENETRATION TEST, BLOWS/0.3m ★
STANDARD PENETRATION TEST, BLOWS/0.3m ●
10 20 30 40 50 60 70 80 90

App'd________ Jan 31 2013 13:51:7

MBH 1/31/13

Approved:



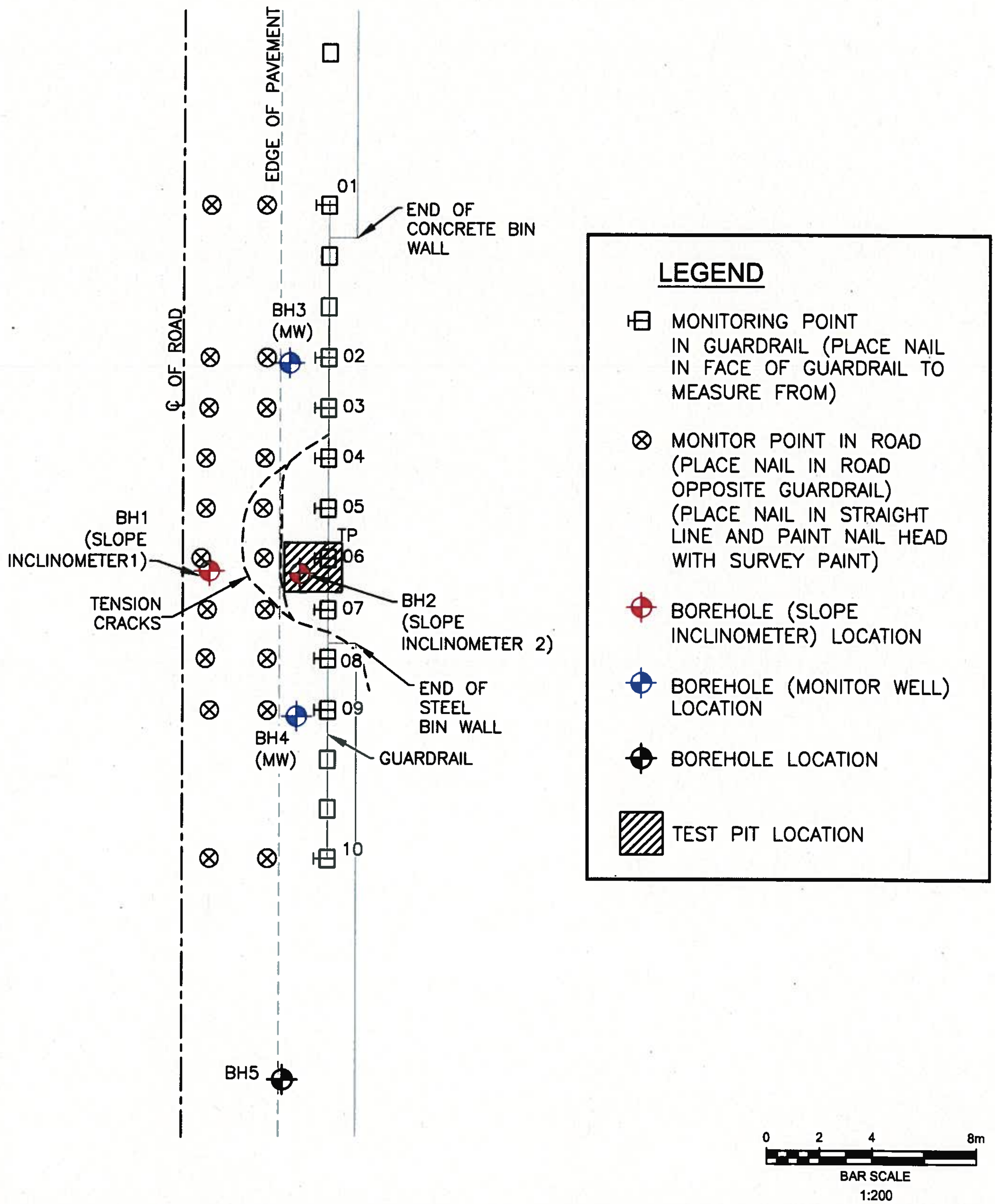
	Gravel		Sand			Silt and Clay
	Coarse	Fine	Coarse	Medium	Fine	

Unified Soil Classification System ASTM D 2487/2488

Curve	BOREHOLE/TESTPIT	SAMPLE	DEPTH (ft)	Soil Fractions			Soil Description
				Gravel	Sand	Silt/Clay	
———	BH5	SS 4	2.2 to 2.8 m	37%	51%	12%	Sand with silt and gravel
— — ·	BH4	SS 2	0.9 to 1.5 m	32%	56%	12%	Sand with silt and gravel

Job No.: 121615619

Stantec



NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

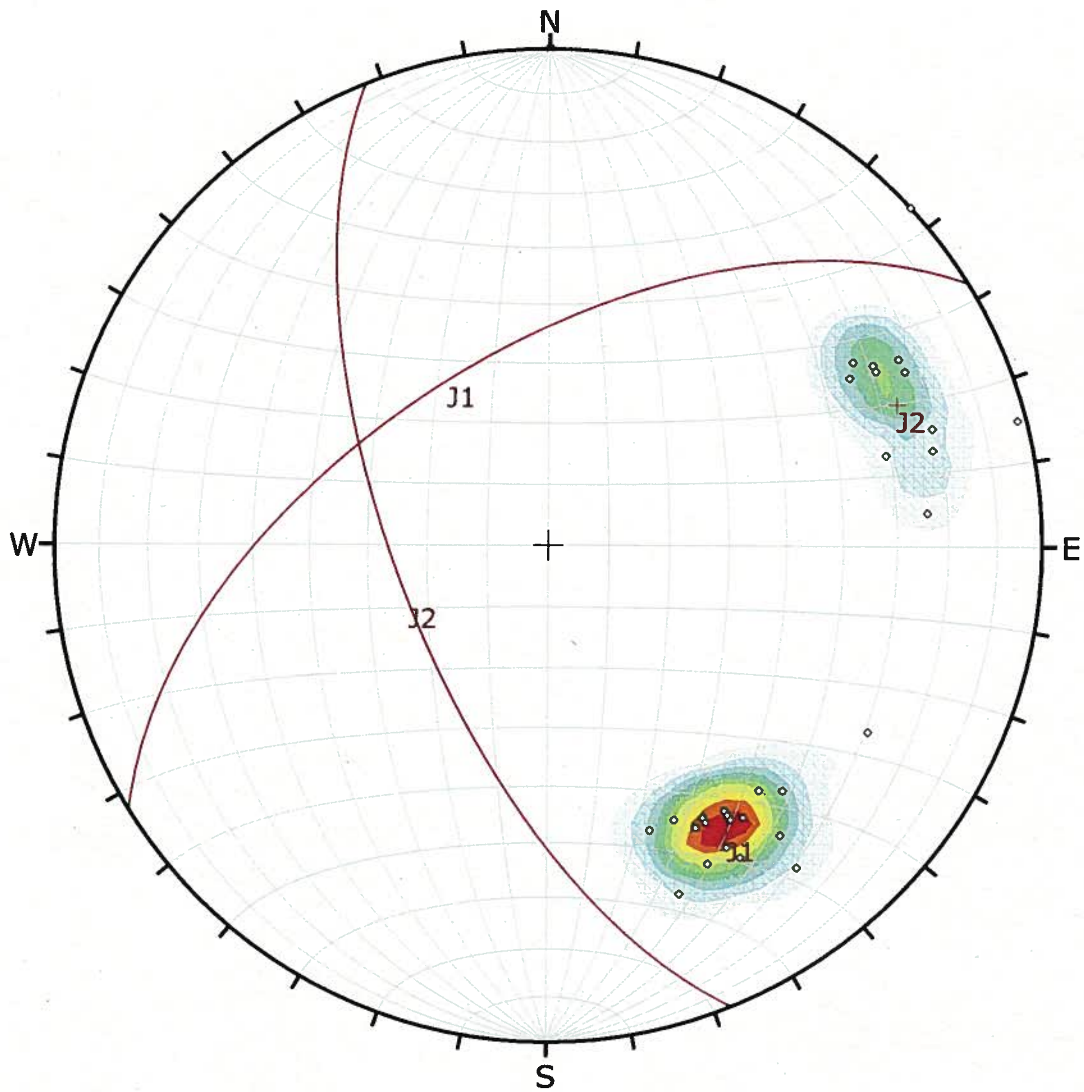
PLAN VIEW OF TENSION CRACK, MONITORING POINTS, BOREHOLE, MONITOR WELL AND TEST PIT LOCATIONS CORNEY BROOK SLOPE MONITORING CAPE BRETON HIGHLANDS NATIONAL PARK, NOVA SCOTIA	Job No.: 121615619	Dwg. No.: 1	Stantec
	Scale: 1:200		
	Date: 2013/01/17		
	Dwn. By: SJT		
Client: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA	App'd By:		

T:\1216XXX\121615619 corney brook\121615619-01.dwg PRINTED: Jan 17, 2013

APPENDIX B

Structural Mapping Data (ShapeMetrix^{3D})

Rock Catchment Design Charts



Symbol	Feature
◇	Pole Vectors

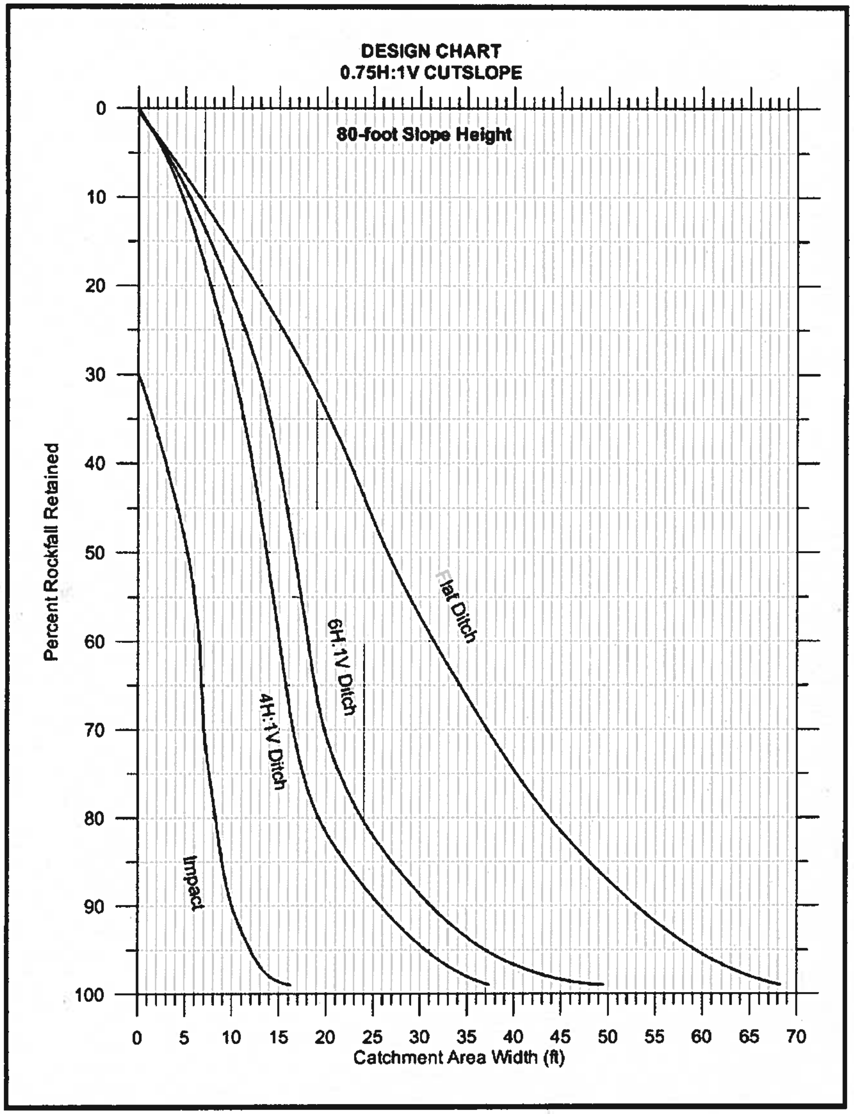
Color	Density Concentrations
	0.00 - 3.60
	3.60 - 7.20
	7.20 - 10.80
	10.80 - 14.40
	14.40 - 18.00
	18.00 - 21.60
	21.60 - 25.20
	25.20 - 28.80
	28.80 - 32.40
	32.40 - 36.00
Maximum Density	35.65%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

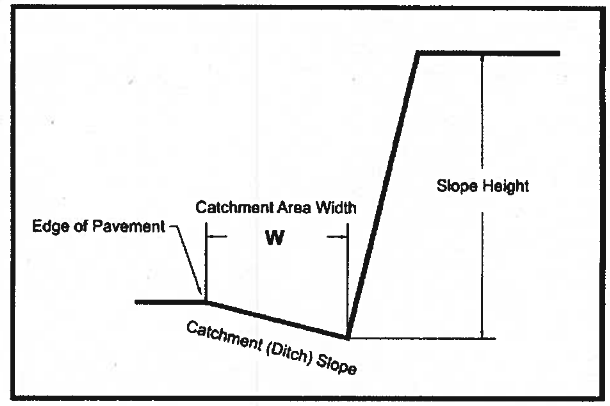
Plot Mode	Pole Vectors
Vector Count	30 (30 Entries)
Hemisphere	Lower
Projection	Equal Area

Stantec

Project	Corney Brook Slope Assessment, Cabot Trail		
Analysis Description	Structural Mapping Data (ShapeMetrix)		
Drawn By	JN/MCM	*Company*	Stantec Consulting Ltd.
Date	6/30/2015, 12:58:57 PM	*File Name*	Corney Brook Structure - Shapemetrix.dip

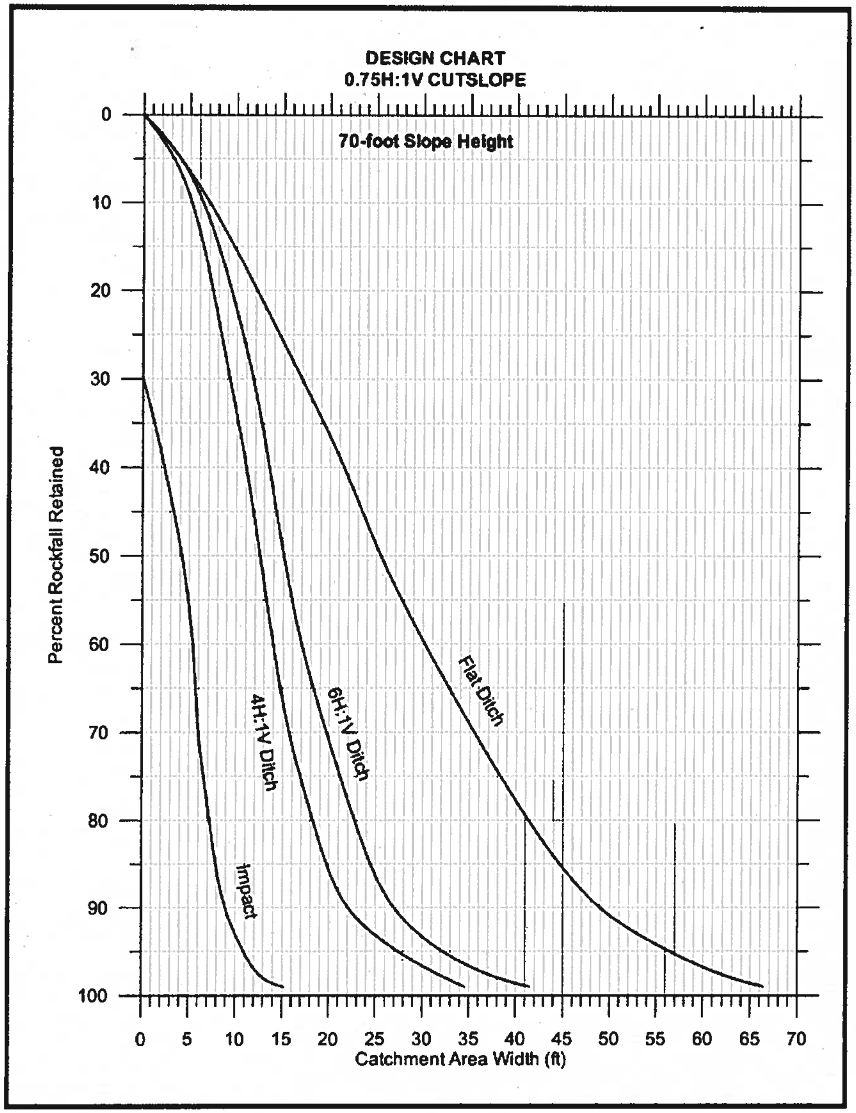
DIPS 6.016

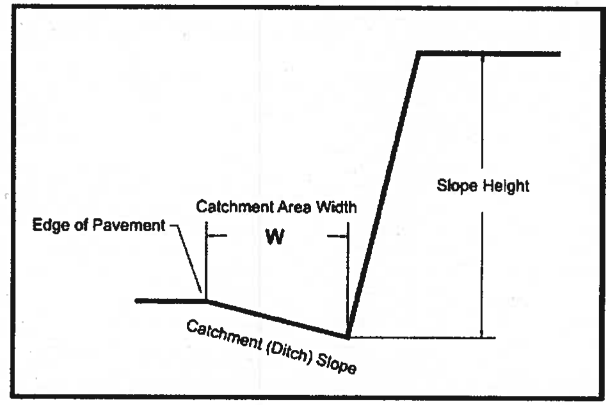




Quick Reference - 80-Ft Slope Catchment Area Width - **W**				
Percent Rockfall Retained	Impact	Catchment Area Slope		
		4H:1V	6H:1V	Flat
	W (ft)	**W** (ft)	**W** (ft)	**W** (ft)
50%	5	14	17	27
75%	8	18	22	40
80%	8	19	24	44
85%	9	22	27	48
90%	10	26	31	53
95%	12	31	37	59
99%	16	37	50	68

Figure 5.20: Design chart for 80-foot high 0.75H:1V cutslopes

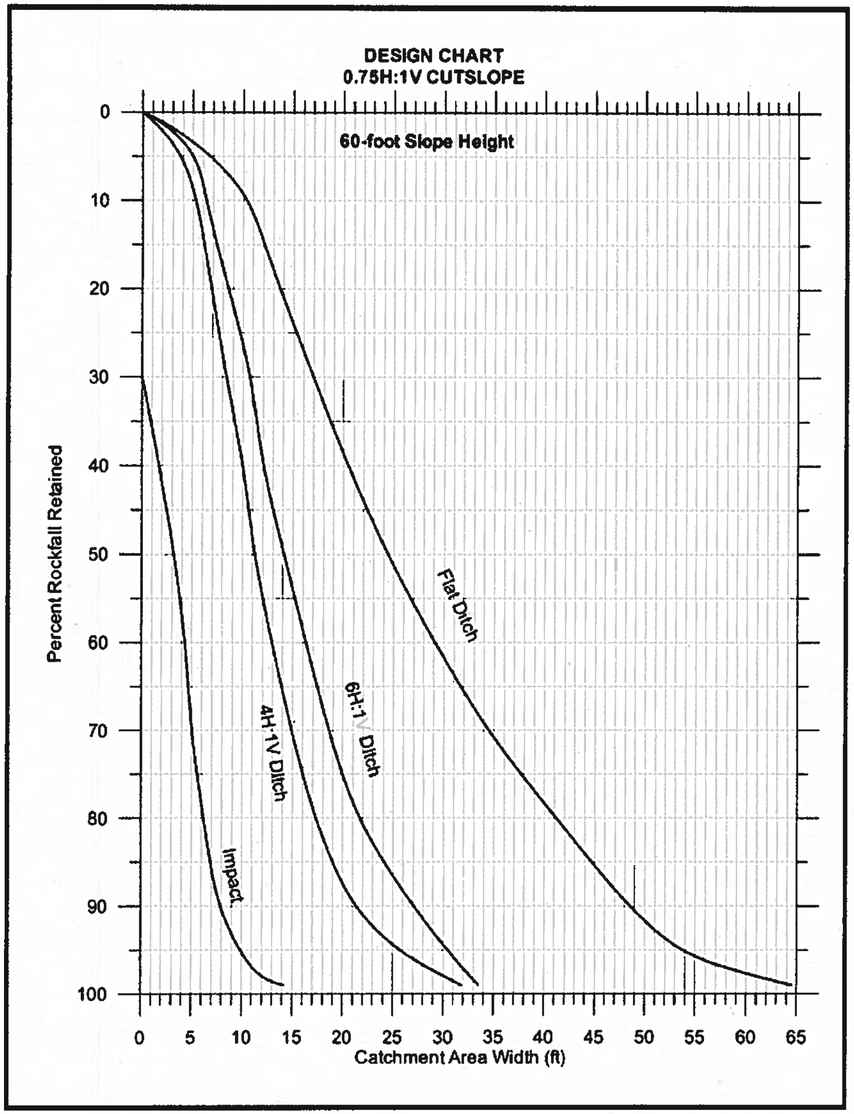


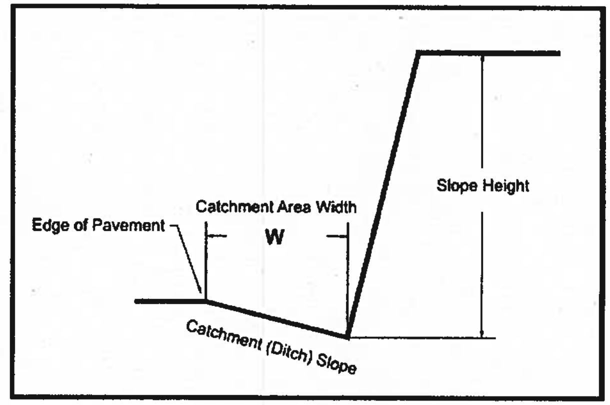


Quick Reference - 70-Ft Slope
Catchment Area Width - W

Percent Rockfall Retained	Impact	Catchment Area Slope		
		4H:1V	6H:1V	Flat
	W (ft)	W (ft)	W (ft)	W (ft)
50%	4	13	15	25
75%	7	17	21	38
80%	7	18	23	41
85%	8	20	24	45
90%	9	22	27	49
95%	11	28	32	57
99%	15	35	42	66

Figure 5.19: Design chart for 70-foot high 0.75H:1V cutslopes

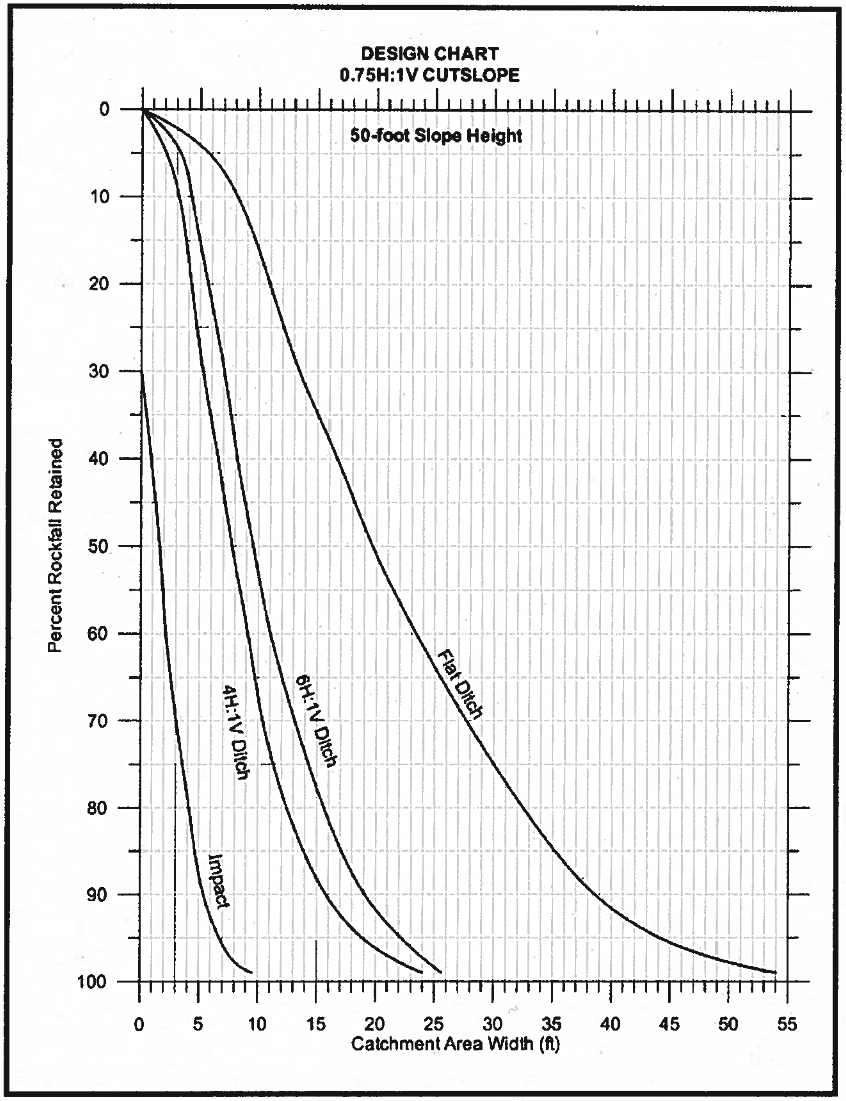


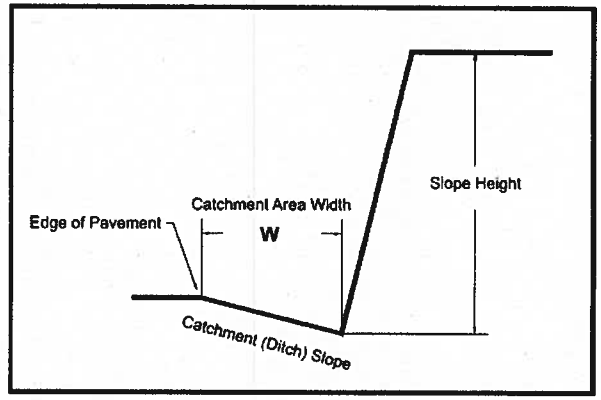


Quick Reference - 60-Ft Slope
Catchment Area Width - **W**

Percent Rockfall Retained	Impact	Catchment Area Slope		
		4H:1V	6H:1V	Flat
	W (ft)	W (ft)	W (ft)	W (ft)
50%	3	11	14	24
75%	6	16	20	38
80%	6	17	22	41
85%	7	19	24	45
90%	8	21	27	49
95%	10	26	30	54
99%	14	32	34	65

Figure 5.18: Design chart for 60-foot high 0.75H:1V cutslopes

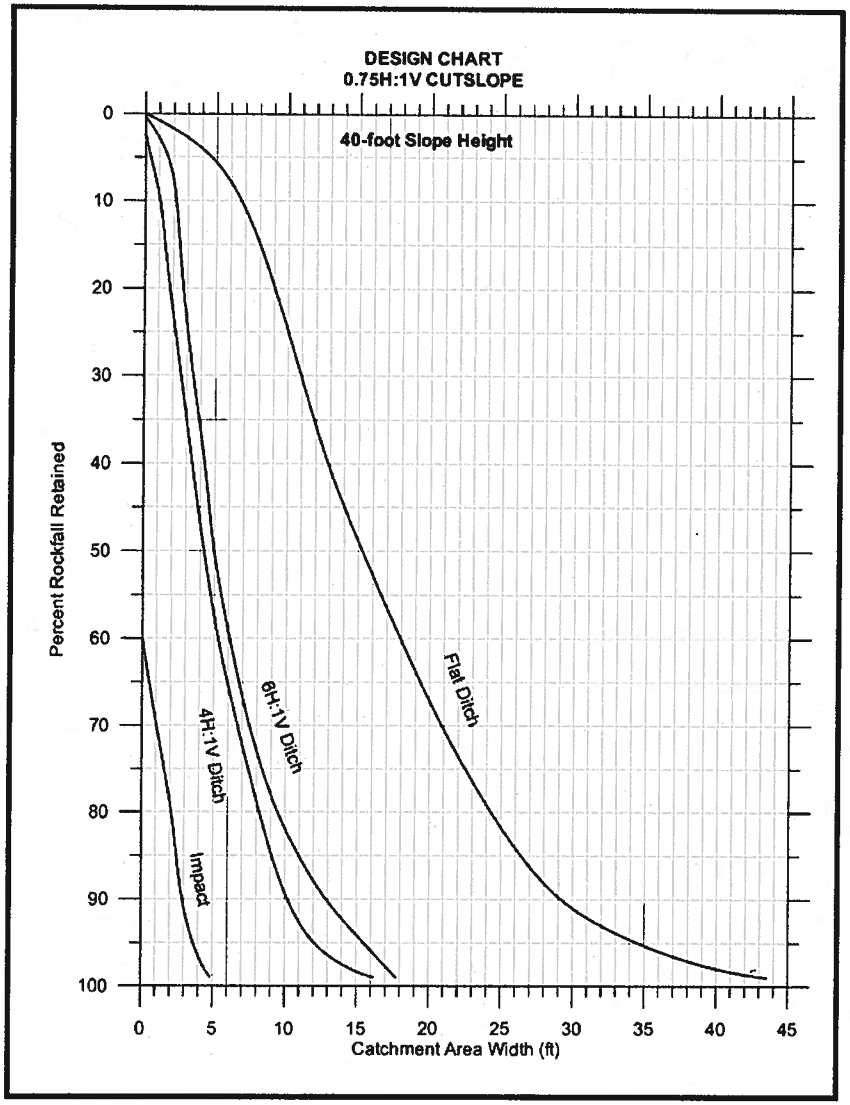


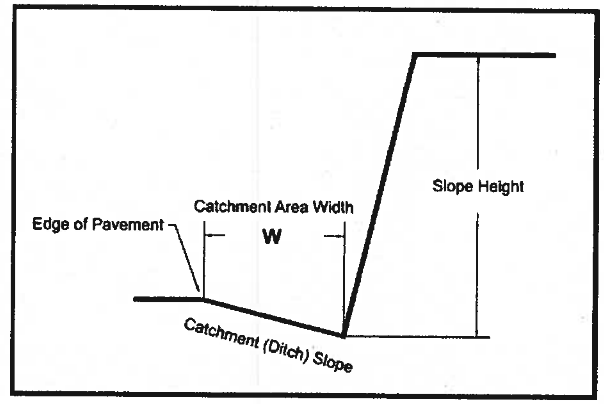


Quick Reference - 50-Ft Slope
Catchment Area Width - W

Percent Rockfall Retained	Impact	Catchment Area Slope		
		4H:1V	6H:1V	Flat
	W (ft)	W (ft)	W (ft)	W (ft)
50%	2	8	10	20
75%	4	11	14	30
80%	4	12	16	33
85%	5	14	17	35
90%	5	16	19	39
95%	7	19	22	44
99%	10	24	26	54

Figure 5.17: Design chart for 50-foot high 0.75H:1V cutslopes





Quick Reference - 40-Ft Slope Catchment Area Width - **W**				
Percent Rockfall Retained	Impact	Catchment Area Slope		
		4H:1V	6H:1V	Flat
	W (ft)	W (ft)	W (ft)	W (ft)
50%	0	4	5	15
75%	2	7	8	23
80%	2	8	9	24
85%	2	9	11	26
90%	3	10	13	29
95%	4	12	15	35
99%	5	16	18	44

Figure 5.16: Design chart for 40-foot high 0.75H:1V cutslopes

GEOTECHNICAL INVESTIGATION REPORT, PROPOSED CULVERT REPLACEMENT, CAPE BRETON HIGHLANDS NATIONAL PARK OF CANADA, CAPE BRETON, NOVA SCOTIA

Project No. 121618417

Prepared for:
Crandall Engineering Ltd.
1077 boul. St. George Boulevard,
Suite 400
Moncton NB E1E 4C9

Prepared by:
Stantec Consulting Ltd.
207 - 201 Churchill Drive
Membertou NS B1S 0H1

July 31, 2015

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LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

Stantec Consulting Ltd. (Stantec) has been retained by Crandall Engineering Ltd. (Crandall) to carry out a geotechnical investigation for the proposed replacement of the Corney Brook culvert which is located at approximately 10.2 kilometers from the Cape Breton Highlands National Park of Canada entrance in Cheticamp, Nova Scotia. It is understood that the new culvert will be constructed near the location of the existing culvert and with a similar road alignment.

The purpose of the investigation was to obtain soil, bedrock, and groundwater information near the footprint of the proposed culvert replacement and to provide recommendations for site preparation and design parameters for use in foundation design.

This report has been prepared specifically and solely for the proposed development described herein. It contains a summary of our findings, and includes geotechnical engineering recommendations to assist with design of the culvert replacement.

2.0 WORK PLAN

Our geotechnical field investigation was out carried from May 30 to June 1, 2015 in general accordance to the work plan outlined in our proposal, dated: April 7, 2015. At the request of Crandall, some additions were made to the work plan. The final work plan for the geotechnical investigation included the following:

- A field investigation consisting of three boreholes drilled and terminated into bedrock.
- Supervision during drilling of the boreholes including the classifications of soils and bedrock.
- Standard geotechnical laboratory classification testing on soil and bedrock samples obtained from the field investigation.
- Preparation of this geotechnical report including our findings, recommendations for design of site preparation and foundations.

3.0 SITE DESCRIPTION AND GEOLOGY

The existing culvert is located along the Cabot Trail at approximately 10.2 kilometers from the Cape Breton Highland National Park of Canada entrance in Cheticamp, Nova Scotia. Corney Brook flows approximately in a south to north direction, through the culvert that crosses the Cabot Trail, and down into the Gulf of St. Lawrence.

The existing structure is a reinforced concrete box culvert with approximate dimensions of 4.3 metres wide by 1.8 metres high and 22.0 metres long. A two lane, 7.4 metre wide, roadway

(Cabot Trail) runs in a north-south direction over the culvert. The top of culvert is buried approximately eight metres below the existing surface of the roadway. Corrugated steel bin retaining/head walls are located above and to the sides of the culvert, extending up to near finished grade of the roadway. Some amour stone is present immediately adjacent to the outside of the box culvert and steel bin retaining/head walls. Based on available information, the invert elevation of the existing culvert is approximately 4.4 metres.

Geological mapping indicates that the principal native overburden soil consists of nonfluvial valley fill (colluvial deposit) consisting of mainly muddy debris emplaced by solifluction of upslope glacial tills and weathered rock, directly overlying metamorphosed sedimentary bedrock from the Silurian age of the Jumping Book Metamorphic Suite and consisting of siltstone, sandstone, conglomerate, wacke, arkose and minor ryolite. From the current borehole investigation, the principal overburden soils consisted of cohesionless granular materials.

4.0 INVESTIGATION PROCEDURES

4.1 GENERAL

The geotechnical investigation consisted of drilling three boreholes. Coordinates and ground elevations at each borehole location, along with a scaled borehole location plan, were provided by Crandall. Two boreholes were originally planned but an additional borehole was added to assess approximate bedrock elevation near the existing culvert. The field borehole drilling program was conducted between May 30 and June 1, 2015. Samples of the soil and bedrock were recovered and classified. Detailed logs of the soils and bedrock conditions encountered, and the sampling and testing carried out are given on the Borehole Records in the Appendix B.

4.2 BOREHOLES

Boreholes BH1 and BH3 were drilled approximately 12.5 and 14.6 metres from the outside edge of wall of the existing culvert in each of the south and north bound lanes of the roadway, respectively. Borehole BH2 was in the south bound lane next to the existing culvert, at approximately 1.8 metres from the outside edge of wall of the existing culvert. All boreholes were drilled using a track mounted drill rig equipped for geotechnical sampling and in situ testing. The depths of the boreholes ranged from 11.6 to 12.7 metres below existing ground surface. The boreholes were logged by Stantec personnel. Each borehole was advanced using HW size casing. Soil samples were taken using conventional 50 mm split-spoon samplers while performing Standard Penetration Tests. The Standard Penetration Test (N-value) is the number of blows required to drive a 50 millimetre outer diameter, split-spoon sampler 300 millimetres into the soil using a standard fall height and mass. N-values can be used as an indication of relative density, and can also be used to estimate other soil parameters.

Bedrock was cored in the boreholes using HQ size core barrel. The Rock Quality Designation (RQD) and recovery of the samples were measured and recorded. RQD is the ratio of the sum of the core recovered greater than 100 millimetre in length divided by the total core drilled, expressed as a percentage.

4.3 SURVEY

Borehole locations and elevations were surveyed by Crandall; elevations are referenced to Geodetic Datum. Borehole Locations are shown on Drawing No. 1 in the Appendix B.

4.4 LABORATORY TESTING

All soil and rock samples were taken to our Dartmouth laboratory for final visual assessment and classification testing. Laboratory testing was conducted on selected soil samples and included moisture contents and grain size analyses. In addition, unconfined compressive strengths and point load index tests were performed on bedrock core samples. The results of the laboratory testing performed are shown on the Borehole Records or separate figures in Appendix B.

Soil descriptions given in the borehole logs have been determined using ASTM D2487 and D2488, Standard Practice for Classification of Soils for Engineering Purposes and Standard Practice for Description and Identification of Soils.

5.0 SOIL, BEDROCK AND GROUNDWATER CONDITIONS

The subsurface conditions encountered in the boreholes are described in detail on the Borehole Records in the Appendix B.

In summary, the subsurface conditions at the boreholes were generally similar throughout, comprising of a surficial layer of asphalt pavement underlain by a homogeneous layer of fill, overlying a native deposit of granular material, followed by bedrock at depths between 9.1 and 9.2 metres below existing ground surface. Corresponding bedrock surface elevations varied between approximately 3.2 to 3.7 metres. The fill is likely a combination of imported gravels and local borrow material consisting of silty sand with gravel, containing occasional cobbles and boulders. The native deposit consists of well graded gravel with silt and sand, containing some cobbles and boulders. The relative density of the native material ranges from loose to compact. The bedrock comprised of metamorphosed sedimentary bedrock consisting of siltstone, sandstone and conglomerate.

A summary of the various soil and bedrock strata encountered at the borehole locations are provided in the Table 1 below and subsequent subsections.

Table 1 Summary of Borehole Findings

Borehole No.	Ground Surface Elevation (m)	ASPHALT Thickness (m)	FILL Thickness (m)	Native Deposit			BEDROCK		Groundwater Level (m)
				Depth to Surface	Elev.	Thickness	Depth to Surface	Elev.	
BH1	12.8	0.2	3.9	4.1	8.6	5.0	9.1	3.7	8.2
BH2	12.4	0.2	8.9	-	-	0	9.2	3.2	-
BH3	12.6	0.2	4.5	4.6	7.9	4.5	9.2	3.4	-

5.1 ASPHALT

A 200 millimetre thick surficial layer of asphalt was encountered in all borehole locations.

5.2 FILL

Fill, consisting of brown and grey silty sand with gravel, occasional cobbles and boulders was encountered directly below the asphalt in all borehole locations. The thickness of the fill layer ranged from 3.9 to 8.9 metres.

Grain size analyses were conducted on three samples of the fill, which consisted of the gravel, sand, and silt/clay particle size distributions as shown in the Table 2 below. Also shown are the natural moisture contents of the samples:

Table 2 Grain Size Distribution Results and Natural Moisture Contents of FILL

Borehole No.	Sample No.	Sample Depth (m)	ASTM Soil Classification[1]	Percent Material Composition, by Particle Size			Natural Moisture Content %
				Gravel	Sand	Silt/Clay[2]	
BH1	SS2	1.2	silty SAND (SM) with gravel	25	53	23	5.5
BH2	SS4	2.5	silty SAND (SM) with gravel	39	45	16	4.9
BH3	SS5	3.2	silty SAND (SM) with gravel	27	51	22	8.7

(1) ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
(2) The percent of silt and clay-sized particles are reported collectively as the percent fines.

5.3 WELL GRADED GRAVEL (GW-GM) WITH SILT AND SAND

A native deposit of well graded gravel with silt and sand was encountered below the fill layer in boreholes BH1 and BH3. Some cobbles and boulders were encountered throughout this native deposit.

Based on the measured N-values from standard penetration testing, the native deposit had a loose to compact relative density.

Grain size analyses were conducted on two samples of the native deposit, which consisted of the gravel, sand, and silt/clay particle size distributions as shown in the Table 3 below. Also shown are the natural moisture contents of the samples:

Table 3 Grain Size Distribution Results and Natural Moisture Contents of Native Granular Deposit

Borehole No.	Sample No.	Sample Depth (m)	ASTM Soil Classification[1]	Percent Material Composition, by Particle Size			Natural Moisture Content %
				Gravel	Sand	Silt/Clay[2]	
BH1	SS13	8.4	well graded GRAVEL (GW-GM) with silt and sand	55	35	10	9.3
BH3	SS12	9.0	well graded GRAVEL (GW-GM) with silt and sand	47	42	11	11.7

(1) ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
(2) The percent of silt and clay-sized particles are reported collectively as the percent fines.

5.4 BEDROCK

Bedrock was encountered at all borehole locations. The bedrock composition generally comprised of metamorphosed siltstone, sandstone and conglomerate. RQD measured on the recovered rock core varied from 0 to 48 percent indicating the rock varies from very poor to poor quality. The results of unconfined compressive strength (UCS) testing and inferred unconfined compressive strength from point load index tests performed on samples of bedrock core varied from 27 to 110 MPa. The results are summarized in the following Table 4.

Table 4 Summary of Rock Core Unconfined Compressive Strength

Borehole No.	Elevation (m)	Qu (MPa)	Rock Type
1	2.9	72	Conglomerate
1	2.6	110(1)	Conglomerate
2	0.6	48(1)	Siltstone
2	0.0	28	Siltstone
3	1.9	27(1)	Sandstone

Note: 1.) Qu inferred from point load tests.

5.5 GROUNDWATER LEVEL

Groundwater levels are anticipated to be similar to the water level in Corney Brook, and can be influenced by precipitation events and seasonal changes.

6.0 DISCUSSION ON FINDINGS AND ASSESSMENT

6.1 GENERAL

We understand that the new culvert is proposed near the same location as the existing culvert with a similar road alignment. It is further understood that the new culvert will either be a precast concrete culvert or corrugated steel structure. The new culvert will be wider than the existing culvert with an approximate width of eight metres and length of 20 metres or more. The height is currently unknown.

To accommodate construction and traffic flow a temporary road and culvert are to be placed west of the existing culvert. Mass excavation will be undertaken to expose and demolish the existing culvert. Consideration for managing temporary excavation slopes, water control, and sedimentation and erosion control will be required.

After completion of culvert construction, backfilling will be required to re-establish design road elevations and alignment. Retaining walls at the each end of the new culvert are anticipated for support of backfill and will likely consist of a mechanical stabilized earth retaining wall system or equivalent.

At the borehole locations, asphalt overlies an existing fill layer followed by a natural deposit of granular material over bedrock. The bedrock surfaces were encountered at depths of approximately 9.1 metres (bedrock elev. 3.7 m) to 9.2 metres (bedrock elev. 3.2 m) below existing ground surfaces.

Based on the findings at the borehole locations approximate surface elevations (3.7 m, 3.4 m and 3.2 m) and the anticipated design concept of the new culvert having similar invert elevations as the existing culvert (approximate elevation of 4.4 m) for the culvert replacement, the foundation of the new structure is anticipated to be founded on bedrock. Strip footing foundations founded on bedrock would be suitable for support of the new culvert. The following subsections provide geotechnical recommendations for design of site preparation and foundations.

6.2 SITE PREPARATION AND EXCAVATIONS

The depths of excavation required will depend on design elevation of proposed strip footings. However, it is anticipated that footing design elevations will place the new strip footings on bedrock and below water levels of Corney Brook.

Site preparation should include removal of surficial asphalt, fill, and the native deposit of well graded gravel with silt and sand down to clean intact bedrock.

Removal of fill and excavation through native overburden soils for grading purposes and or footing foundations may be undertaken using conventional earth moving equipment. Excavation into bedrock is anticipated and some bedrock may be removed by excavating or ripping but likely will require a hydraulic breaker or blasting.

The bearing surface of the bedrock may become disturbed and uneven during removal. Therefore, in order to achieve a uniform surface for concrete placement and maintain a proper working surface, breaking of bedrock irregularities and or use of a mud mat will be required.

6.3 SOIL PARAMETERS

The following soil parameters in Table 5 below may be used for design provided the materials are incorporated into the work as described in the following sections, where applicable.

Table 5 Soil Parameters

Parameter	Material	
	Imported Rock Fill(1)	Compacted Reworked Natural Granular Deposit(2)
Total Unit Weight (kN/m^3)	22	21
Submerged Unit Weight(3) (kN/m^3)	12	11
Effective Angle of Internal Friction (°)	36	35
Coefficient of Earth Pressure At Rest(4)	0.41	0.43
Active Earth Pressure Coefficient(4)	0.26	0.27
Passive Earth Pressure Coefficient(4)	3.85	3.69
Friction Factor, Soil/Concrete	0.5	0.5
Friction Angle, Soil/Concrete (°)	22	22
Friction Factor, Soil/Steel	0.4	0.4
Friction Angle, Soil/Steel (°)	22	22

NOTES:
(1) Rock fill gradation and compaction requirements outlined in Section 6.6.
(2) Reworked natural granular deposit and compaction requirements outlined in Section 6.6.
(3) For uplift design, the groundwater table should be assumed at the ground surface and therefore, submerged unit weights should be used.
(4) Coefficients of earth pressure assume a frictionless wall with a vertical back face and a horizontal back slope.

6.4 WATER CONTROL

Based on recent borehole findings and anticipated footing elevations, control of brook water flow and levels will be required during excavations, construction of proposed structures (footings, culvert and retaining walls) and placement of backfill.

In general, the brook water flow and levels can be controlled using diversion methods, dam and pump, and or cofferdams. Construction of steel sheet pile (SSP) cofferdams for this site may not be practical as it will be difficult to drive SSP wall sections passed the cobbles and boulders that are present within the layers of existing fill and native granular deposit. Also, as noted previously, bedrock is anticipated to be present at footing elevation.

If construction of cofferdams is chosen as the method of water flow and level control, heavy sheet pile section could be used to minimize the potential damage to the SSP sections. Base heave/piping must be considered inside the cofferdam. Softening of the cofferdam base could be prevented by providing a tremie poured concrete plug at the base of the excavation.

6.5 SHALLOW FOUNDATIONS

Once the site has been prepared as outlined above, strip footings would be suitable for proposed foundations. Based on the findings at the borehole locations, it is anticipated that foundations would be constructed on bedrock.

Spread footings placed on cleaned intact bedrock would be suitable for the foundations. The factored bearing resistance at Ultimate Limit States (ULS) was calculated in accordance with the Canadian Highway Bridge Design Code (CHBDC) Clause 6.6.2. Spread footings can be designed using a factored ULS bearing resistance of 1,000 kPa and includes a bearing resistance factor of 0.5 for shallow foundations. The geotechnical bearing resistance for the serviceability limit state (SLS) would be negligible.

It is understood that the area around the footings along the outside of the culvert walls will fundamentally have sufficient soil coverage for frost protection. However, the inside area of the footings (i.e. invert side of the culvert) could be subjected to frost penetration due to the anticipated footing and bedrock elevations. Therefore, it is assumed that the culvert design will take into consideration frost protection by either ensuring the footings are always submerged below brook water level or footings are embedded 1. 2 meters below final culvert floor elevation.

A minimum footing embedment depth, as per the manufacture specifications, should be considered in the design for confinement and scour protection.

It is recommended that bearing surfaces be reviewed by competent geotechnical personnel at the time of construction to ensure the condition of the bearing surface is acceptable.

6.6 FILL AND COMPACTION REQUIREMENTS

Culvert and retaining wall backfill, along with general subgrade fill, should be in accordance with the selected culvert manufacturer requirements and NSTIR Standard Specifications.

The culvert and retaining wall manufacturers will generally require granular materials within a specified backfill zone of the structure. Imported granular material such as well graded sand and gravel meeting the requirement of Nova Scotia Transportation Infrastructure and Renewal (NSTIR) standard specifications for their gradations of gravel borrow, fill against structure (FAS), and type 1 and type 2 gravels are commonly used for these applications. However, the specific material to be used should be specified by the manufacturer and/or designer.

Granular backfill in the immediate area of the structural elements should be compacted to the greater of 95 percent standard Proctor density or the manufactures requirements. The material should be placed in lift thicknesses compatible with the compaction equipment used to obtain the required compaction throughout. Compaction immediately adjacent the structural elements should be accomplished with relatively thin fill lifts and light compaction equipment to prevent over stressing of the elements.

General subgrade fills beyond the specified granular backfill zones of the structural elements, could generally comprise of NSTIR Borrow material. Excavate inorganic existing site fill and native gravel that is maintained at a suitable moisture content to achieve specified compaction and with over-sized particles removed should generally be suitable for re-use as borrow material. However, materials excavated from below water or that become saturated from rainfall/runoff or other means may render the materials unsuitable.

General subgrade fills should also be placed in lift thickness compatible with the compaction equipment used to ensure that the required density is achieved over the entire lift. The fill should be compacted to at least 95 percent standard Proctor density, with the exception of the upper 300 millimeters below road subgrade level, which should be compacted to at least 98 percent.

NSTIR Type 2 and Type 1 pavement gravels should be compacted to 100 percent standard Proctor density.

6.7 EROSION AND SEDIMENTATION CONTROL

The control of erosion and sedimentation should satisfy regulatory requirements. As a minimum, the following generic measures are recommended for both temporary and permanent site conditions:

- The contractor should contain all sediment-contaminated water on the site.
- Natural vegetation should be left undisturbed where possible.
- For permanent applications, spread mulch or vegetate disturbed soil surfaces immediately.
- Leave existing vegetative cover in place for erosion control until just prior to excavation or site grading.
- Place all excavated material which is intended for reuse as soon as possible and compact. Remove all excavated material not intended for reuse directly off-site. Excavated material that cannot be immediately reused should be placed in a compacted stockpile completely surrounded at the toe by silt fence. Stockpiles should be covered with tarps as necessary to prevent infiltration and erosion in wet weather.
- Sediment fences should be incorporated and maintained to intercept sediment-contaminated water and reduce runoff velocity.

6.8 SITE EFFECTS – SEISMIC RESPONSE

Based on the findings at the borehole locations, anticipated conditions following site preparation as described above and Clause 4.1.8.4 of the National Building Code of Canada (NBCC, 2005), the site classification for seismic site response is B.

6.9 COLD WEATHER CONSTRUCTION

If construction is carried out during cold weather conditions, it should be noted that all earthworks performed during freezing weather are suspect and special measures are required. Guidelines for cold weather construction can be provided upon request.

7.0 CLOSURE

Use of this report is subject to the Statement of General Conditions provided in Appendix A. It is the responsibility of Crandall Engineering Ltd., who is identified as "the Client" within the Statement of General Conditions, and its agents to review the conditions and to notify Stantec Consulting Ltd. 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
- Planning, design or construction

This report was prepared by Shaun M. Walker, P.Eng. and reviewed by Brian T. Grace, P.Eng. We trust that the information contained in this report is adequate for your present purposes. If you have any questions about the contents of the report or if we can be of any other assistance please contact us at your convenience.

Yours very truly,

STANTEC CONSULTING LTD.

Shaun M. Walker, P.Eng.
Associate, Geotechnical Engineer

Brian T. Grace, P.Eng.
Principal, Geotechnical Engineer

APPENDIX A

Statement of General Conditions
Symbols and Terms Used on Borehole and Test Pit Records
Borehole Records BH1 to BH3
Grain Size Distribution Analyses
Drawing No. 1, Borehole 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

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BOREHOLE RECORD

NORTHING: 5176678
EASTING: 658518

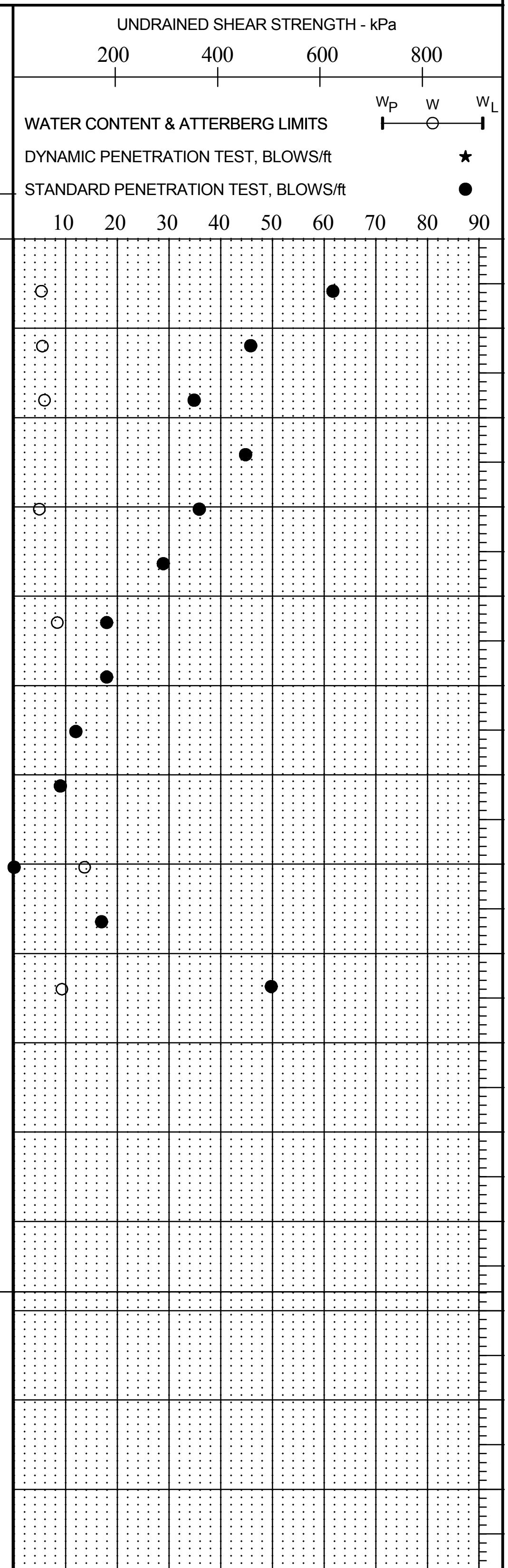
BH1

CLIENT: CRANDALL ENGINEERING LTD.
PROJECT No. 121618417

LOCATION: Corney Brook Culvert Replacement, CBHNP, NS
BH SIZE: HW

DATES: BORING 2015/06/01
WATER LEVEL 8.2 m on 2015/06/02
DATUM: GEODETIC

DEPTH(m)	ELEVATION(m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR-RQD %	OTHER TESTS
0	12.80								
	12.52	ASPHALT							
		FILL: brown and grey silty sand with gravel - occassional cobbles and boulders			SS	1	350	62	
1					SS	2	350	46	S
2					SS	3	325	35	
					SS	4	300	45	
3					SS	5	325	36	
					SS	6	300	29	
4	8.63	Loose to compact brown well graded gravel (GW-GM) with silty and sand - some cobbles and boulders			SS	7	150	18	
5					SS	8	0	18	
					SS	9	0	12	
6					SS	10	50	9	
7					SS	11	250	0	
					SS	12	50	17	
8				▼	SS	13	200	50	S
9	3.68	Poor quality grey CONGLOMERATE - moderately weathered			HQ	14	100%	38%	
10					HQ	15	97%	48%	Ip Qu
11	1.01				HQ	16	100%	46%	
12		End of borehole at 11.8 metres below existing ground surface. Plastic standpipe installed for monitoring of static groundwater level.							
13									
14									
15									



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Stantec

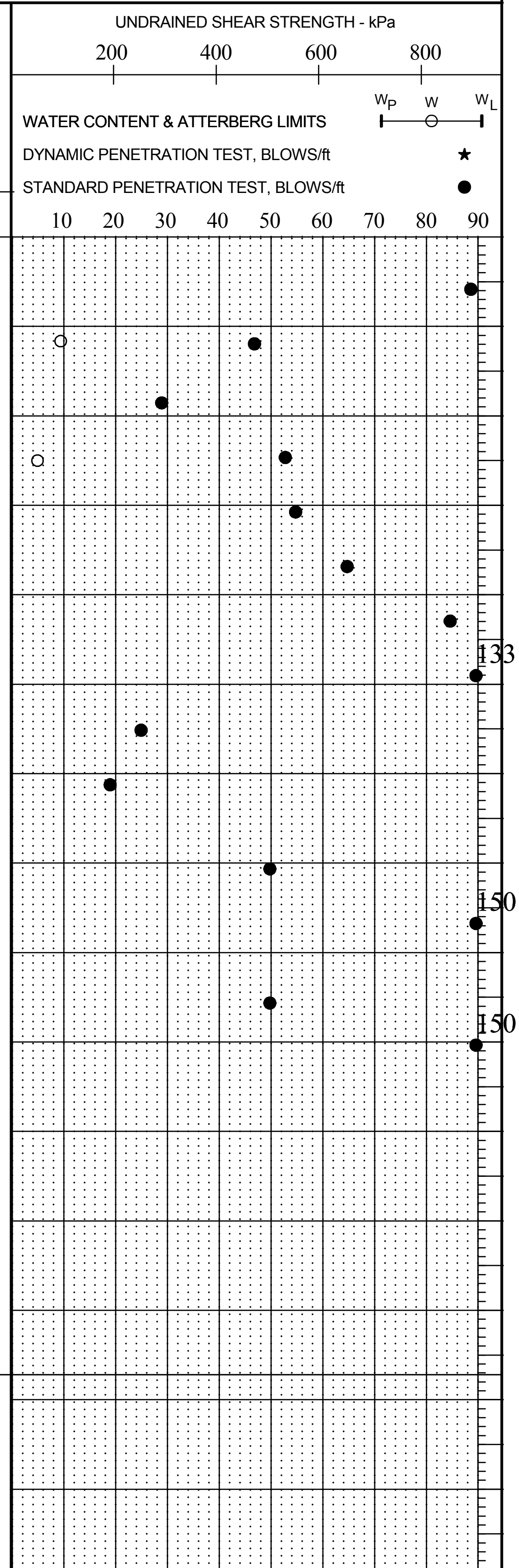
BOREHOLE RECORD

NORTHING: 5176694
EASTING: 658528

BH2

CLIENT: CRANDALL ENGINEERING LTD.
PROJECT No. 121618417
LOCATION: Corney Brook Culvert Replacement, CBHNP, NS
BH SIZE: HW
DATES: BORING 2015/05/31
WATER LEVEL: No Standpipe Installed
DATUM: GEODETIC

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY (mm)	SAMPLES: N-VALUE OR-RQD %	OTHER TESTS
0	12.41						
	12.13	ASPHALT					
		FILL: brown and grey silty sand with gravel - occassional cobbles and boulders	SS	1	375	89	
			SS	2	300	47	
			SS	3	325	29	
			SS	4	400	53	S
			SS	5	325	55	
			SS	6	350	65	
			SS	7	250	85	
			SS	8	50	133	
			SS	9	50	25	
			SS	10	125	19	
			SS	11	50	50	
			SS	12	50	150	
			SS	13	50	50	
			SS	14	50	150	
	3.21	Very poor to poor quality grey SILTSTONE - slightly weathered - joints with silt infilling	HQ	15	100%	0	
			HQ	16	56%	0	
			HQ	17	92%	28%	Ip
	-0.32		HQ	18	100%	33%	Qu
		End of borehole at approximately 12.7 metres below existing ground surface.					



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Stantec

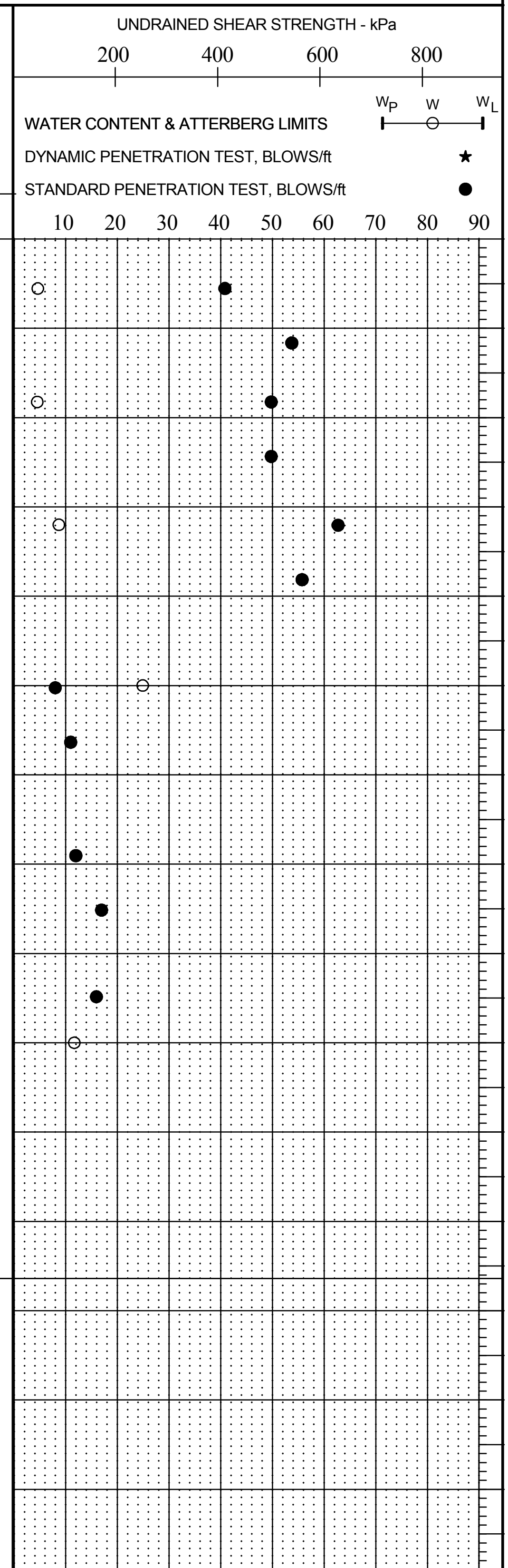
BOREHOLE RECORD

NORTHING: 5176702
EASTING: 658538

BH3

CLIENT: CRANDALL ENGINEERING LTD.
PROJECT No.: 121618417
LOCATION: Corney Brook Culvert Replacement, CBHNP, NS
BH SIZE: HW
DATES: BORING 2015/05/30
WATER LEVEL: No Standpipe Installed
DATUM: GEODETIC

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR-RQD %	OTHER TESTS
0	12.57						
	12.32	ASPAHLT					
		FILL: brown and grey silty sand with gravel - occassional cobbles and boulders	SS	1	500	41	
			SS	2	375	54	
			SS	3	400	50	
			SS	4	375	50	
			SS	5	325	63	S
			SS	6	325	56	
	7.87	Loose to compact brown well graded gravel (GW-GM) with silty and sand - some cobbles and boulders	SS	7	150	8	
			SS	8	100	11	
			SS	9	150	12	
			SS	10	50	17	
			SS	11	0	16	
			SS	12	150	50/100 mm	
	3.37	Poor quality grey SANDSTONE - slightly weathered - joints with silt infill	HQ	13	100%	32%	S Ip
			HQ	14	89%	40%	
	0.93	End of borehole at approximately 11.6 metres below existing ground surface.					



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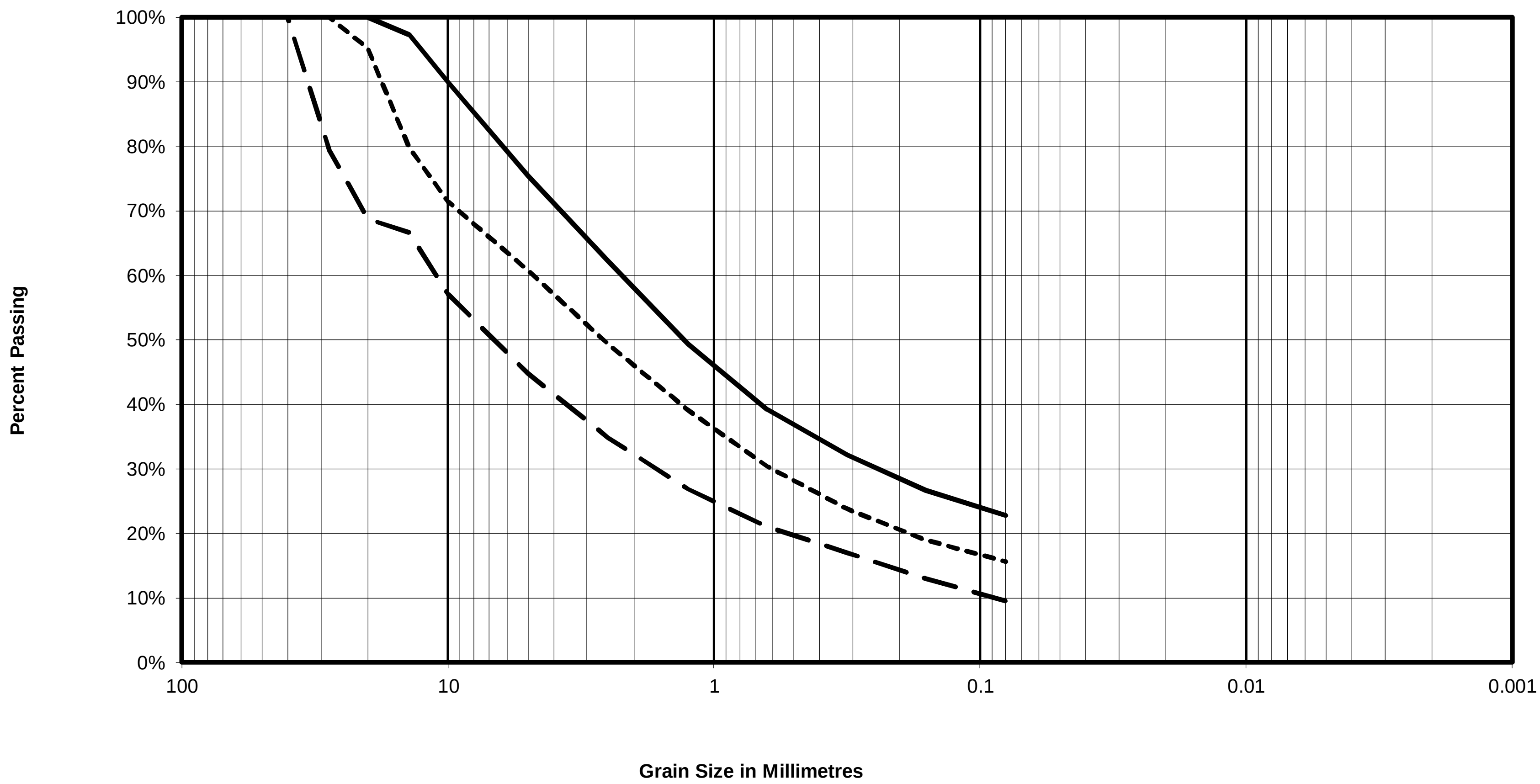
Approved: SW



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Unified Soil Classification System ASTM D 2487/2488

Curve	BOREHOLE/TESTPIT	SAMPLE	DEPTH (m)	Soil Fractions			Soil Description
				Gravel	Sand	Silt/Clay	
———	BH 1	SS 2	1.2	25%	53%	23%	silty SAND (SM) with gravel
— — ·	BH 1	SS 13	8.4	55%	35%	10%	well graded GRAVEL (GW-GM) with silt and sand
- - - -	BH 2	SS 4	2.5	39%	45%	16%	silty SAND (SM) with gravel

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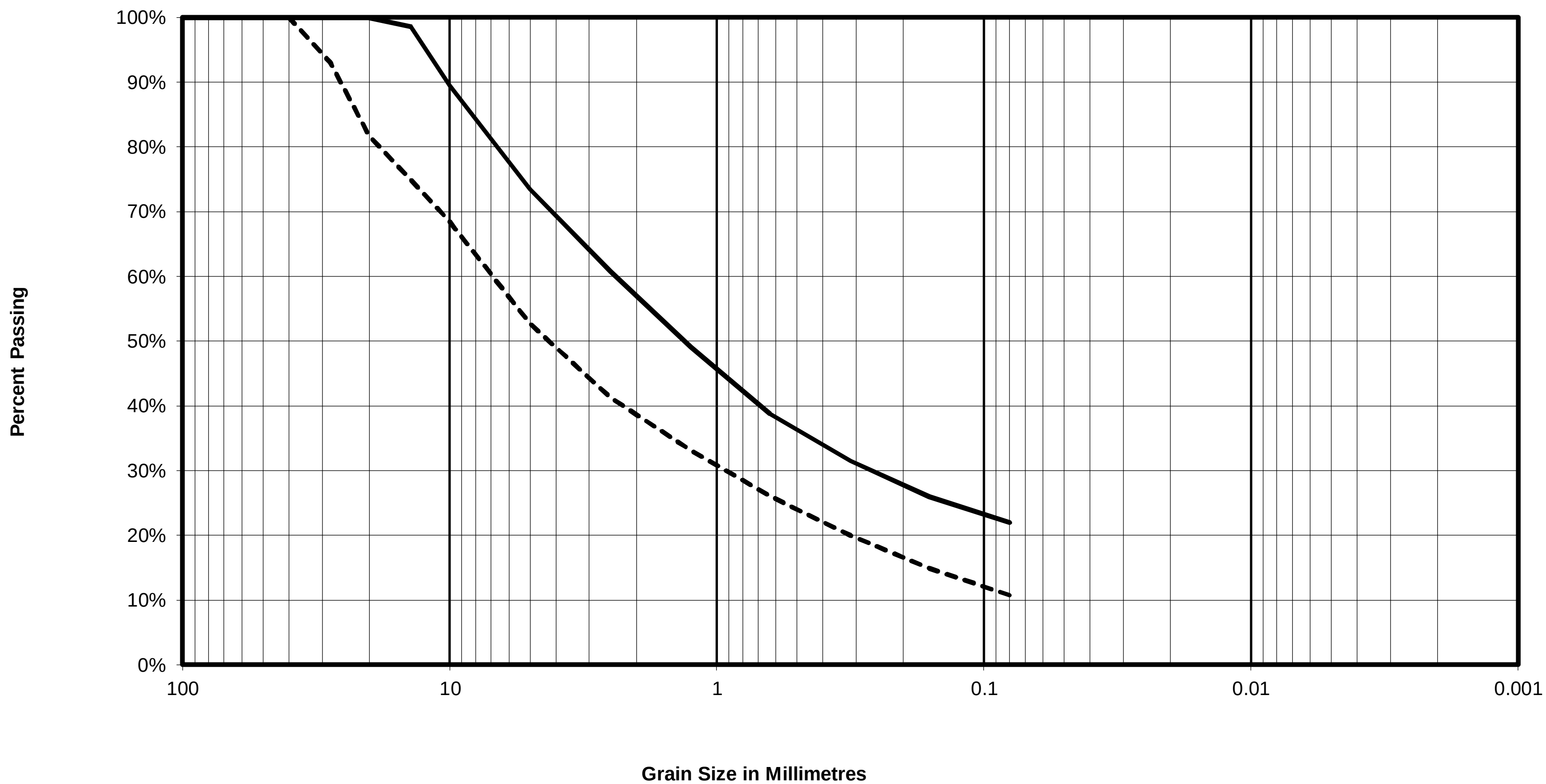
Job No.: 121618417

Approved: SW



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Unified Soil Classification System ASTM D 2487/2488

Curve	BOREHOLE/TESTPIT	SAMPLE	DEPTH (m)	Soil Fractions			Soil Description
				Gravel	Sand	Silt/Clay	
———	BH 3	SS 5	3.2	27%	51%	22%	silty SAND (SM) with gravel
- - - -	BH 3	SS 12	9.0	47%	42%	11%	well graded GRAVEL (GW-GM) with silt and sand

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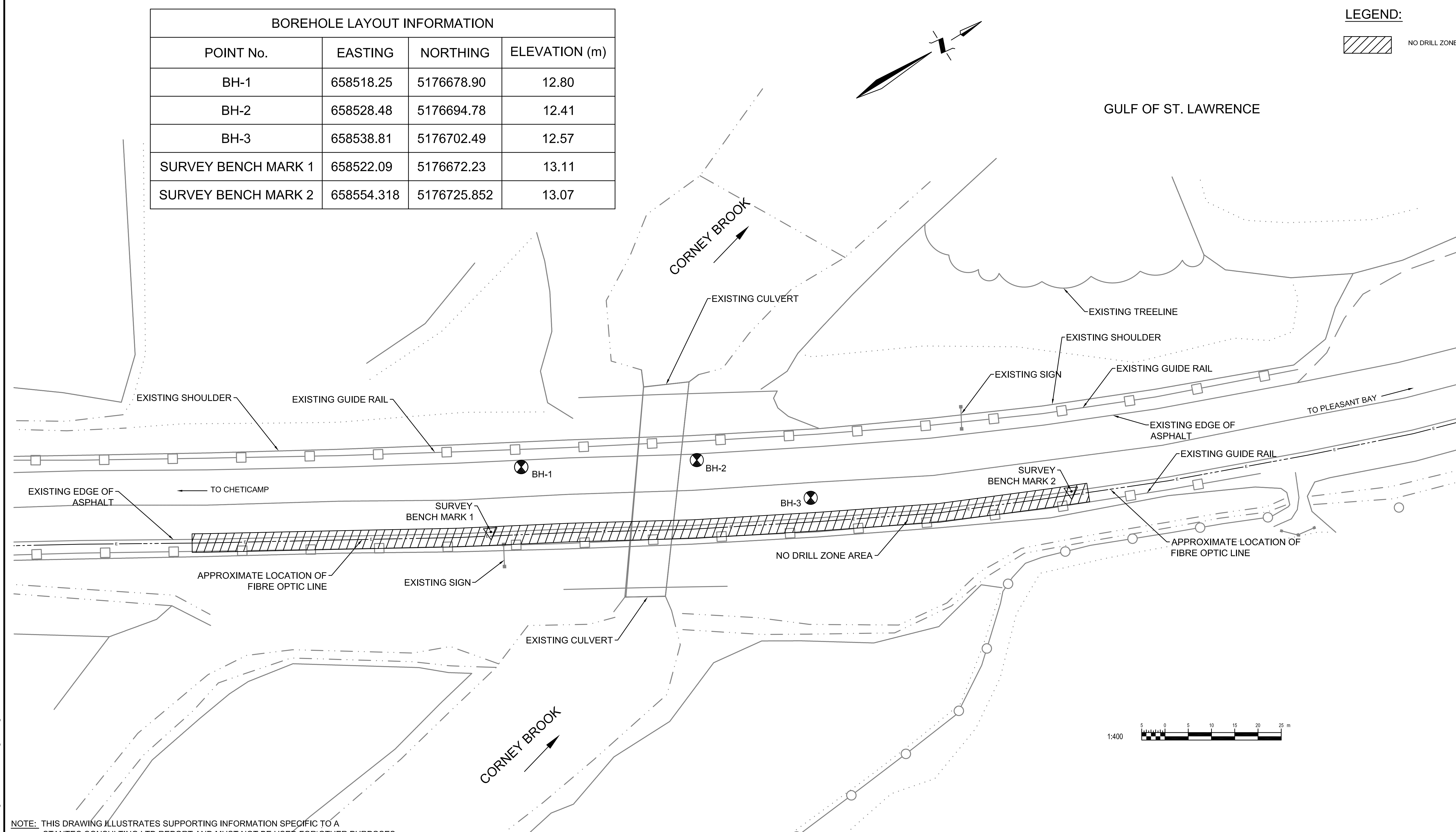
Job No.: 121618417

BOREHOLE LAYOUT INFORMATION			
POINT No.	EASTING	NORTHING	ELEVATION (m)
BH-1	658518.25	5176678.90	12.80
BH-2	658528.48	5176694.78	12.41
BH-3	658538.81	5176702.49	12.57
SURVEY BENCH MARK 1	658522.09	5176672.23	13.11
SURVEY BENCH MARK 2	658554.318	5176725.852	13.07



NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

BASE DRAWING FROM CRANDALL ENGINEERING DWG 14122-6P-C100 DATED MAY 21, 2015

CRANDALL ENGINEERING LTD

CORNEY BROOK CULVERT REPLACEMENT

CAPE BRETON HIGHLANDS NATIONAL PARK, N.S.

BOREHOLE LOCATION PLAN

Job No.:	121618417
Scale:	1:400
Date:	2015/07/29
Dwn. By:	BDP
App'd By:	SW

Dwg. No.: 1

Stantec

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