Appendix A

Geotechnical Report

Englobe
Soils Materials Environment

SNC Lavalin Inc.

Geotechnical Investigation
Neil's Brook Bridge
Cabot Trail, Cape Breton Highlands
National Park, Nova Scotia

Final Report

Date: December 14, 2015
Ref. N°: 20335

Englobe

SNC Lavalin Inc.

Geotechnical Investigation
Neil's Brook Bridge, Cabot Trail
Cape Breton Highlands
National Park, Nova Scotia

Final Report | 20335

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REVISION AND PUBLICATION REGISTER		
Revision N°	**Date**	**Modification And/Or Publication Details**
0	2015-08-07	Draft Report
1	2015-12-14	Final Report

1 INTRODUCTION

Englobe Corp. at the request of SNC Lavalin Inc., has carried out a geotechnical investigation at the site of a proposed bridge replacement identified as Neil's Brook Bridge near Neil's Harbour, Nova Scotia. The purpose of the work was to assess the subsurface conditions at select areas of the site and to make recommendations for the design and costing of earthworks and foundations.

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

2 SITE AND PROJECT DESCRIPTION

It is understood that Park Canada proposes to replace the existing bridge structure on the Cabot Trail in the Cape Breton Highland National Park near Neil's Harbour, Nova Scotia. Detail design drawings are not available; however, the foundation for the structure will likely be supported on either concrete spread footings or driven steel 'H' or pipe piles. It is understood that current best practice for bridge design is to utilize either fully integral or semi-integral abutments as a measure to reduce maintenance costs during the life span of the bridge. Current information regarding design indicates the bridge will have a single span supported on integral or semi-integral abutments with approach slabs at each end.

3 INVESTIGATION PROCEDURE

The fieldwork for the investigation was carried out from July 2 to 4, 2015, when six (6) boreholes were drilled and three (3) test pits were dug at the locations shown on the enclosed Figure 1. The boreholes investigation was carried out using a CME-55 track-mounted auger drill rig supplied by Logan Geotech of Stewiacke, Nova Scotia. The test pits were dug using a tracked excavator supplied by Cape Smokey Trucking and Excavating Ltd.

The investigation was carried out by qualified field engineering personnel who logged the subsurface conditions. The boreholes were advanced using continuous flyte augers and casing rod with field sampling and testing performed in the open borehole. Standard Penetration Tests (SPT) were carried out at regular intervals in the boreholes to obtain soil blow counts (i.e. N-values) using a 50-mm O.D. split spoon sampler. Disturbed soil samples were obtained from the boreholes using conventional techniques. Bedrock was drilled and sampled using NQ-sized (i.e. 50 mm dia.) coring equipment.

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

4 SUBSURFACE CONDITIONS

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

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

The subsurface conditions encountered at the borehole and test pit locations were found to be similar. In general fill deposits were encountered overlying undisturbed site-native sand and gravel and bedrock. The following paragraphs further describe the subsurface conditions at the site.

Table 4-1. Summary of Subsurface Conditions at Boreholes and Test Pits.

BOREHOLE / TEST PIT NUMBER	NORTHING (metres)	EASTING (metres)	DEPTH TO SAND AND GRAVEL (metres)	DEPTH TO BEDROCK (metres)	DEPTH OF BOREHOLE (metres)
BH 1	5186262.500	4589083.125	4.6	-	10.82
BH 2	5186279.097	4589157.634	2.4	-	4.57
BH 3	5186246.661	4589075.513	-	2.6	7.62
BH 4	5186266.646	4589113.201	1.3	1.3	1.37
BH 5	5186244.685	4589052.424	0.2	1.2	3.20
BH 6	5186243.094	4589133.780	0.2	1.3	4.65
TP 1	5186256.891	4589114.293	0.3	0.6	1.13
TP 2a	5186257.205	4589082.986	-	-	3.05
TP 2b	5186251.845	4589083.015	-	-	2.44

4.1 Asphalt Pavement, Gravels and/or Topsoil

A layer of asphalt pavement was encountered at the surface of boreholes BH 1 and BH 4. The asphalt pavement was approximately 100 mm in thickness. Gravel was encountered at the surface of borehole BH 2 and was approximately 150 mm in thickness. Topsoil was encountered at the surface of boreholes BH 3, BH 5 and BH 6 and test pit TP 1. The topsoil layer can be described as dark brown silty sand and was loose and moist.

4.2 Fill

Fill was encountered at boreholes BH 1, BH 2, BH 3, BH 4 and test pits TP 2a and TP 2b. The fill can generally be described as sand and gravel to gravelly sand containing occasional to some cobbles. The fill was moist and brown to gray and/or pink in colour. Standard penetration N-values for the fill deposits at the boreholes ranged from 2 to 52 blows per 300 mm penetration, indicating a loose to very dense material. The higher N-values recorded are due mainly to gravel and cobble content in the fill interfering with the test and not necessarily representative of *insitu* relative density. The fill was proven to a total depth of 4.6 metres at borehole BH 1.

Laboratory gradation testing of a select fill sample indicated a material with 22 percent gravel, 61 percent sand and a fines (i.e. silt and clay sizes) content of 7 percent. Moisture content testing of a select fill sample provided a value of 5.9 percent.

4.3 Sand and Gravel

At all borehole locations (except BH 3) and at test pit TP 1, a sand and gravel deposit was encountered beneath the fill or topsoil layers. These typically compact soils are described on the Borehole and Test Pit Logs in Appendix 2 as having trace to some silt and clay with occasional cobbles and boulders. Observations of the *insitu* deposits indicated that the material was to pink to brown in colour and its moisture content was described as moist. Standard penetration N-values for the sand and gravel deposit at the boreholes ranged from 4 to 45 blows per 300 mm penetration, indicating a loose to very dense material. The sand and gravel was proven to a total depth of 10.82 metres below the existing ground surface at borehole BH 1.

Laboratory gradation testing of select sand and gravel samples indicated a material with 35 to 45 percent gravel, 36 to 59 percent sand and a fines (i.e. silt and clay sizes) content of 6 to 19 percent. Moisture content testing of select sand and gravel samples provided values of 4 and 13 percent.

4.4 Bedrock

Geologic mapping of the proposed development area indicates that the site is underlain by granite and granodiorite bedrock.

Bedrock was core-drilled in boreholes BH 3, BH 5 and BH 6, at depths ranging from 1.17 to 2.6 metres. Examination of bedrock core samples indicates that the site is underlain by granite and granodiorite bedrock.

The bedrock has been observed to be moderately to highly fractured, medium strong and gray to pink in colour. The Rock Quality Designation (RQD) values of core samples ranged from 0% to 50% indicating a very poor to poor quality rock. Unconfined Compressive Strength on "intact" cores indicated strengths ranging from 16.2 MPa to 40.7 MPa which classified the bedrock as poor (R2) to medium strong (R3) in strength.

4.5 Groundwater

Since wash boing and casing was used to advance the boreholes through the coarse alluvial deposits, it was not possible to make groundwater observations during the field investigation through open-hole measurement at the borehole locations. The groundwater level is expected to be influenced by the water level in adjacent stream; thus it is expected that the groundwater level at the site should be encountered at approximately 5.6 metres.

5 DISCUSSION AND RECOMMENDATIONS FOR DESIGN

5.1 Site Development – General

In the following paragraphs, a discussion of site development is presented in light of the observed subsurface conditions. Currently, detailed design information is not available; however, the bridge will likely be a single span using integral or semi-integral abutments supported on either concrete spread footings or driven steel 'H' or pipe piles.

For reporting, it has been necessary to make some assumptions regarding the extent of development, particularly, the type of structure, site grades, construction methodology, etc. As a result, some of the recommendations outlined below are of a preliminary nature and can only be confirmed as specific designs are presented for the site.

It is understood that current best practice for bridge design is to utilize either fully integral or semi-integral abutments as a measure to reduce maintenance costs during the life span of the bridge. The use of fully or semi-integral abutments at this site supported on driven piles presents some additional design considerations due to the presence of shallow bedrock. Typically, for fully-integral abutments, a single row of piles is driven to suitable bearing stratum and allowances for thermal movement in the superstructure is carried by the "flexibility" of the piles. At this site, pile size to satisfy the structural load capacity may not be long enough to satisfy thermal movement. However, to increase pile length and to allow adequate flexing for integral abutment design, bedrock removal or pre-boring into the bedrock would be required. Pile penetration into the granite bedrock by driving is expected to be minimal. Should pre-boring be chosen, backfill should consist of sand. Encasing the pile through the embankment fill with a corrugated metal or PVC pipe may be required in order to provide sufficient pile movement.

5.2 Site Preparation, Excavation and Earthworks

To prepare the immediate bridge area to receive shallow foundations, it will be necessary to remove all organic soils, fill materials, and wet / loose soils from beneath foundation bearing areas. This material should be subexcavated to the level of competent soil (i.e. material noted on the Borehole Logs as “Site-Native Sand and Gravel Deposit or Bedrock”). This excavation will vary depending on final bridge location(s) and design grades. At the boreholes located in proximity to the proposed bridge abutments, this is expected to range from 0.6 metres to 4.6 metres. This excavation may extend below the water table in some areas, so inflow of groundwater into the excavation should be anticipated. All work will require diversion of the water flow from the brook utilizing cofferdams, diversion piping and pumps of suitable capacity so that bridge foundation installation work can be carried out in the dry.

Following this initial subexcavation, a general proof-rolling of the exposed subgrade (with vibratory compaction equipment) is recommended to identify any loose or soft areas. Any such areas identified should be subexcavated and replaced with an approved fill. Importation of an approved structural fill may be utilized for this purpose.

Excavations in the site-native sand and gravel deposits are expected to remain temporarily stable at side slopes of 1:1 (horizontal to vertical), while long-term stability can be achieved at 3:1.

For pile foundations, only nominal earthworks will be necessary to ready the site for construction. Subexcavation of unsuitable soils is not required – only removal of materials that would impede installation of piles and regrading of the site is anticipated. Some minor earthworks may be necessary to temporarily support pile cap concrete.

5.3 Spread Footings

After removal of all unsuitable soil, if loose/wet soil conditions are encountered at proposed design grades, further subexcavation followed by placement of a properly prepared engineered fill may be required. Structural fill materials may consist of varied material types, subject to approval, which can be compacted to the required density. Structural fill should consist of a well-graded rockfill or, if conditions require, clear rockfill. The material should have a maximum particle size of 200 mm and a nominal "fines" content (i.e. minus 0.08 mm size). Fill should be placed in lifts not exceeding 300 mm thickness and should be compacted to the equivalent of 100 percent of the materials standard Proctor maximum dry density or equivalent for rockfill. Water and loose/soft soils should be removed from excavations, and bearing stratum approved prior to fill placement. It is strongly recommended that an approved clean rockfill be used for the bottom lift(s) (i.e. 1 metres thickness), due to expected wet conditions. Placement of alternative structural fill materials can be utilized upon approval from the geotechnical engineer. Geotechnical inspection and certification of engineered fill material placement is recommended.

For design of foundations by Limit States Design, the factored soil bearing resistance (using a bearing resistance factor of 0.5) of footings with a minimum width of 0.6 metres and at a minimum depth of 1.2 metres are as follows:

Table 5-1. Limit States Design Parameters.

LIMIT STATES DESIGN PARAMETER	ALLUVAIL DEPOSIT / STRUCTURAL FILL	COMPETENT BEDROCK
Factored Geotechnical Bearing Resistance at Ultimate Limit States (ULS)	300 kPa	500 kPa
Geotechnical Resistance at Serviceability Limit States (SLS)	200 kPa	300 kPa

The serviceability limit states are based on a maximum allowable settlement of 25 mm. Unfactored loads should be used with the SLS bearing pressures in accordance with the 2010 National Building Code of Canada (NBCC).

5.4 Pile Foundations

Piled foundations maybe considered as a foundation design for support of the bridge abutments. Driven steel piles may be either traditional pipe piles or ‘H’ type piles. These piles may be driven to practical refusal within the bedrock encountered at depths of between 1.3 and 2.6 metres below existing grade at the bridge structure.

Load carrying capacity for either the pipe or ‘H’ type steel piles for two typical end bearing piles on bedrock are given below. The pile type and size chosen for design will be influenced by several factors such as the structural loads carried by the foundation, the availability of the pile type/size and the pile driving equipment.

The pile capacities given below are based on the proposed pile size and anticipated site conditions. Final pile capacities are a function of pile size, penetration depth, resistance criteria, site grading requirements, etc. For preliminary design of piles driven to a suitable depth end-bearing in the bedrock, the calculated ULS load capacity (with applied resistance factor of 0.4) is as follows:

Pile Type	ULS Capacity
HP 360 x 152 'H' Pile	1400 kN
355 x 12.7 Pipe Pile (open-ended)	1200 kN

Steel piles should have a minimum wall thickness of 12 mm and the tip protected with a driving shoe. For steel piles, a pile driving hammer capable of delivering energy of 252 Joules/cm^2 to 315 Joules/cm^2 of steel cross-section is recommended. The pile hammer shall deliver a rated energy of not less than 33,895 kN-m. Piles should be re-tapped no sooner than 24 hours after achieving the refusal criteria and sufficiently driven to re-establish the refusal criteria. Additional subsequent re-taps should be conducted as necessary.

Piles should be spaced no closer than 3 times the pile diameter (measured centre-to-centre). Strict control of pile location and verticality should be exercised to ensure accurate pile spacing and prevent eccentric and non-vertical loading of piles and groups.

Quality control inspection during piling operations is recommended to ensure proper seating of piles and that driving criteria has been met. A quality assurance-testing program for piles is recommended and should include Pile Driving Analyzer (PDA) monitoring to confirm load capacities.

Driving records should be kept throughout the pile installation period. Information to be recorded should include, pile dimensions, hammer type, rated energy, ram weight, anvil weight and driving resistance.

5.5 Re-use of On-site Materials and Backfilling

Select portions of the alluvial deposits and fill maybe considered suitable for reuse at the site as common material or, in some applications, as engineered fill. Any organic soils, and loose/wet soils are not suitable to reuse for engineered fill, these may be reused at the site in general site grading and landscaping (i.e. in non-settlement sensitive areas). The reuse of on-site materials will be contingent to a large extent on the condition of the materials after excavation, handling and stockpiling.

To qualify as engineered wall backfill, all boulders, debris and deleterious inclusions should be removed. Wall backfill should be placed in lifts not exceeding 250 mm thickness and compacted in-place to 95 percent standard Proctor maximum dry density.

5.6 Seismic Response

The effect of site conditions on seismic response should be considered in the design of foundations. Based on the subsurface soil conditions encountered in the boreholes, the site on the west side of the structure (area of BH 1, BH 3, BH 5, TP2A and TP 2B) may be considered as Class C for seismic site response (CHBDC 2014 Table 4.1). The site on the east side of the structure (area of BH 2, BH 4, BH 6 and TP 1) may be considered as Class B for seismic site response.

5.7 Interpreted Soil Design Parameters

Soil parameters recommended for use in design are outlined in the following table. The parameters indicated have been summarized from laboratory and field testing and from known empirical correlations. The values indicated are provided as a guide and their specific use in design should be confirmed with the geotechnical engineer.

Table 5-2. Interpreted Soil Design Parameters

PARAMETER	SITE-NATIVE SAND AND GRAVEL DEPOSITS
Bulk Unit Weight, kN/m^3	21
Moisture Content, %	11
Effective Unit Weight, kN/m^3	11

PARAMETER	SITE-NATIVE SAND AND GRAVEL DEPOSITS
Soil Cohesion (C_u), kN/m^3	0
Effective Angle of Internal Friction	32˚
Active Earth Pressure Coeff.(K_a)	0.31
Passive Earth Pressure Coeff.(K_p)	3.3

5.8 De-watering

All work will require diversion of the water flow from the brook around the construction site utilizing pumps of suitable capacity (i.e. minimum 150 mm diameter) so that foundation installation work can be carried out in the dry. The rate of infiltration into the foundation excavations is expected to be moderate to high and can be controlled by conventional dewatering techniques consisting of 75 to 100 mm diameter portable pumps and grading of excavations to sump locations. Water pumped from excavations is expected to contain "fines" and will require care in disposal. Provision for proper site drainage in accordance with applicable municipal, provincial, and federal environmental requirements should be made at the construction stage. The use of coffer dams or sheet piling may be necessary where excavations encroach on the watercourse boundary(s).

5.9 Erosion and Sediment Control Guidelines

Nova Scotia Environment has published a set of guidelines dealing with environmental protection, specifically, erosion and sedimentation control. The document is of a general nature, however, presents proven methods for lessening the impact of soil erosion on downstream receptors. The Guidelines should be adopted for construction.

6 COMMENTS ON CONSTRUCTION

The following comments on specific construction aspects of the project are provided for the guidance of designers. The contractor undertaking the work should make their own interpretation of the factual information provided in this report as it affects their construction procedures and scheduling.

The in situ soils are subject to loosening and softening in the presence of water. Construction methods and scheduling should reflect this. If construction takes place in the winter months care must be taken not to allow freezing of subsoil. Any fill or native soil that freezes must be sub excavated and replaced.

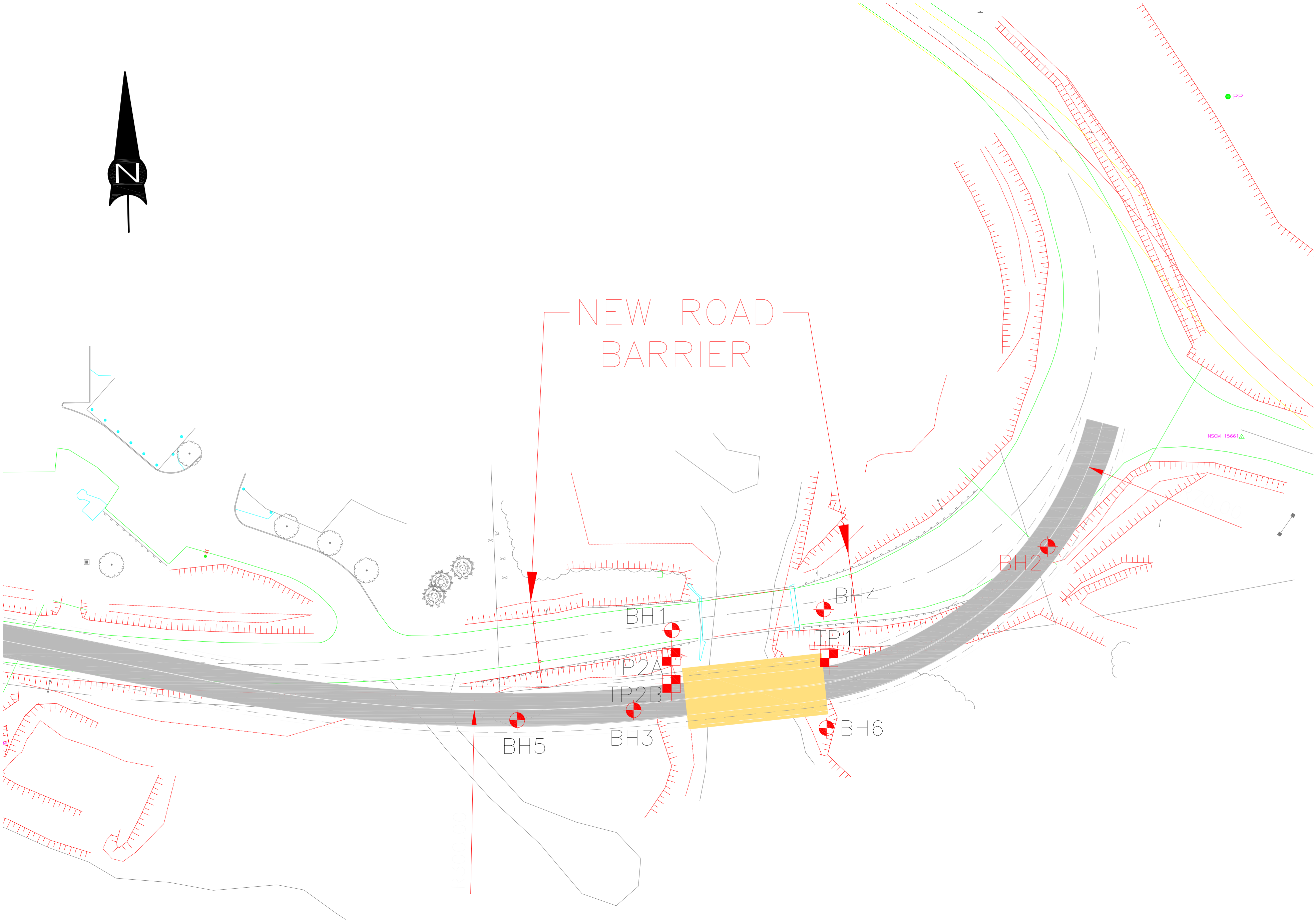
In periods of inclement weather or during extended work delays, foundation excavations within the site native soils should be protected by a working mat of lean concrete placed over the bearing soil immediately following excavation and preparation of the foundation contact area. Alternatively, a

150 mm thick compacted granular layer (e.g. Type II gravel) can be constructed at the founding level. It may be also necessary to insulate the founding strata during periods of subzero temperatures.

Geotechnical inspection and testing by qualified personnel is recommended during earthworks construction.

7 CLOSURE

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



LEGEND:

BH1 - Borehole Location

TP1 - Test Pit Location

Englobe

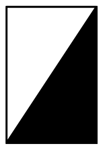
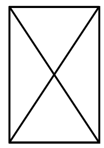
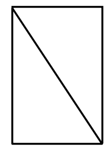
Site Sketch Showing Test Locations
Neil's Brook Bridge Replacement
Cape Breton Highlands National Park, NS

DATE: July 2015	SCALE: 1:1000	DRAWN BY: JJ	CKD BY: TKM	JOB No. 20335	FIGURE 1

Appendix 1 Explanation of Terms and Symbols

SOIL SAMPLES

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

 undisturbed  disturbed  not recovered

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

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

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

OTHER TESTS

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

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

* The results of these tests usually are reported separately

SYMBOLS AND TERMS USED ON THE BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

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

Terminology describing soil structure:

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

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

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

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

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

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

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

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

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

FILL TILL BEDROCK

1. All sieve sizes mentioned on this chart are U.S. Standard, ASTM E11.

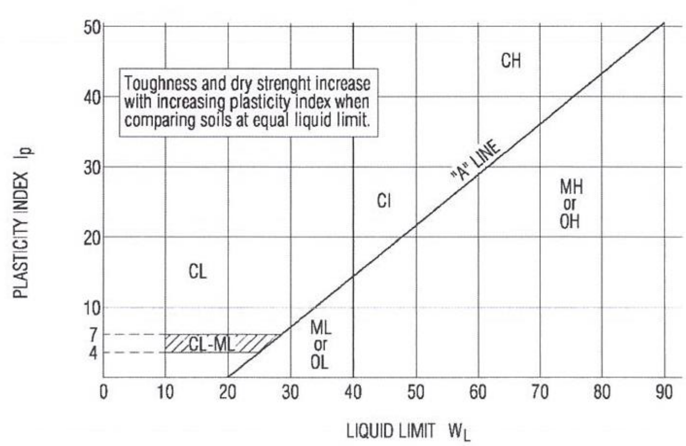
2. Boundary classifications possessing characteristics of two groups are given combined group symbols eg GW-GC is a well-graded gravel-sand mixture wtih clay binder between 5% and 12%.

3. Soil fractions and limiting textural boundaries are in accordance with the Unified Soil Classification System, except that an inorganic clay of medium plasticity (CI) is recognized.

4. The following adjectives may be employed to define percentage ranges by weight of minor components:

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

PLASTICITY CHART



Englobe

Appendix 2 Borehole Logs

BOREHOLE LOG

PROJECT: Geotechnical Investigation - Neil's Brook Bridge, CBHNP, NS

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
LL	TKM	7/3/15	20335	BH 1

CASING RESISTANCE blows/300mm

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

DATUM: Ground Surface Elevation provided by SNC Lavalin

SURFACE ELEVATION 6.32 meters

DRILL TYPE: Drill Rig

OTHER TESTS

DEPTH (ft)	DEPTH (m)	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE TYPE	PENE. RESIST.
0				Asphalt Pavement (100 mm)		
0–15.5				FILL : sand and gravel, trace silt, very loose to very dense, moist, brown.		
2					SS	N=52
4	1				SS	N=15
6					SS	N=13
8	2				SS	N=8
10	3			Sand mixed with organic soil from 2.59 to 3.20 metres.	SS	N=2
12					SS	N=5
14	4				SS	N=5
15.5				PEAT : silty sand, loose, wet, dark brown.		
16	5			SAND AND GRAVEL : trace of silt, loose to dense, moist, pink to brown.	SS	N=15
19	6				SS	N=5

PLATE 1

Englobe

BOREHOLE LOG

PROJECT
Geotechnical Investigation -
Neil's Brook Bridge, CBHNP, NS

LOGGED/DWN. LL | CKD. TKM | DATE OF INVEST. 7/3/15 | JOB NO. 20335 | HOLE NO. BH 1

CASING RESISTANCE blows/300mm

WC % wp- □ w- ● wl- △

10 20 30 40 50

DRILL TYPE: Drill Rig

DATUM Ground Surface Elevation provided by SNC Lavalin

SURFACE ELEVATION 6.32 meters

DEPTH (ft)	DEPTH (m)	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	COND.	TYPE	PENE. RESIST.	OTHER TESTS
						SS	N=14	
22								
23	7							
24						SS	N=26	
25								
26	8					SS	N=25	Sieve
27								
28								
29	9					SS	N=30	
30								
31						SS	N=16	
32								
33	10							
34						SS	N=46	
35								
36	11			End of Borehole at 10.82 metres in Sand and Gravel.				
37								
38								
39	12							
40								
41								

BOREHOLE LOG

Englobe

PROJECT: Geotechnical Investigation - Neil's Brook Bridge, CBHNP, NS

LOGGED/DWN. LL | CKD. TKM | DATE OF INVEST. 7/3/15 | JOB NO. 20335 | HOLE NO. BH 2

DRILL TYPE: Drill Rig

CASING RESISTANCE blows/300mm

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

DATUM: Ground Surface Elevation provided by SNC Lavalin

SURFACE ELEVATION 8.41 meters

DEPTH (ft)	SOIL DESCRIPTION	TYPE	PENE. RESIST.	OTHER TESTS
0–0.5	GRAVEL : sandy, trace silt, loose, dry and gray.			
0.5–8	FILL : sand some silt and gravel, compact, moist, brown.			
0–2		SS	N=12	
3–5		SS	N=27	
8–15	SAND AND GRAVEL: some silt, occasional cobbles, compact to dense, moist to wet, reddish brown.			
8–10		SS	N=38	
10–12		SS	N=29	Sieve
13–15		SS	N=44	
15	End of Borehole at 4.57 metres in Sand and Gravel.			

BOREHOLE LOG

PROJECT: Geotechnical Investigation - Neil's Brook Bridge, CBHNP, NS

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
LL	TKM	7/4/15	20335	BH 3

CASING RESISTANCE blows/300mm

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

DATUM: Ground Surface Elevation provided by SNC Lavalin

SURFACE ELEVATION 2.88 meters

DRILL TYPE: Drill Rig

DEPTH (ft)	DEPTH (m)	SOIL DESCRIPTION	TYPE	PENE. RESIST.	OTHER TESTS
0–2		TOPSOIL : silty sand, loose, moist, dark brown.	SS	N=8	TCR - Total Core Recovery RQD - Rock Quality Designation UCS - Unconfined Compressive Strength
2–8.5	1, 2	FILL : sand and gravel, occasional cobble, loose to compact, moist, brown.	SS	N=7	
			RC		
			SS	N=11	
8.5–21	3, 4, 5, 6	BEDROCK : Granite and Orthogneiss, poor to excellent quality, gray and pink.	RC		TCR = 67% RQD = 42%
			RC		TCR = 74% RQD = 38% UCS = 37.7 MPa
			RC		TCR = 99% RQD = 63%

BOREHOLE LOG

Englobe	**BOREHOLE LOG**
	PROJECT Geotechnical Investigation - Neil's Brook Bridge, CBHNP, NS

LOGGED/DWN.	LL	CKD.	TKM	DATE OF INVEST.	7/4/15	JOB NO.	20335	HOLE NO.	BH 3

CASING RESISTANCE blows/300mm

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

DATUM Ground Surface Elevation provided by SNC Lavalin

SURFACE ELEVATION 2.88 meters

DRILL TYPE: Drill Rig

DEPTH ft	DEPTH m	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	COND.	TYPE	PENE. RESIST.	OTHER TESTS
22								
23	7					RC		TCR = 100% RQD = 92%
24								
25				End of Borehole at 7.62 metres in Bedrock.				
26	8							
27								
28								
29	9							
30								
31								
32								
33	10							
34								
35								
36	11							
37								
38								
39	12							
40								
41								

BOREHOLE LOG

Englobe

PROJECT: Geotechnical Investigation - Neil's Brook Bridge, CBHNP, NS

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
LL	TKM	7/3/15	20335	BH 4

DRILL TYPE: Drill Rig

CASING RESISTANCE blows/300mm

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

DATUM: Ground Surface Elevation provided by SNC Lavalin

SURFACE ELEVATION 6.73 meters

SOIL DESCRIPTION	COND.	TYPE	PENE. RESIST.	OTHER TESTS
Asphalt Pavement (100 mm)				
FILL : gravelly and silty sand, compact, moist, light brown.		SS	N=17	Sieve
		SS	50/125	
SAND AND GRAVEL : trace of silt, compact to dense, moist, pink to brown.				
Practical refusal of augers at 1.37 metres depth on possible bedrock or large boulders.				

DEPTH: ft 1–20; m 1–6

PLATE 6

BOREHOLE LOG

PROJECT: Geotechnical Investigation - Neil's Brook Bridge, CBHNP, NS

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
LL	TKM	7/4/15	20335	BH 5

CASING RESISTANCE blows/300mm

WC % wp- □ w- ● wl- △

10 20 30 40 50

DATUM: Ground Surface Elevation provided by SNC Lavalin

SURFACE ELEVATION 5.18 meters

DRILL TYPE: Drill Rig

SOIL DESCRIPTION	SOIL SAMPLE TYPE	PENE. RESIST.	OTHER TESTS
TOPSOIL : silty sand, loose, moist, dark brown.			TCR - Total Core Recovery RQD - Rock Quality Designation UCS - Unconfined Compressive Strength
SAND AND GRAVEL : trace of silt, compact, moist, brown.	SS	N=21	
BEDROCK : Granite and Orthogneiss, poor to good quality, gray and pink.	RC		TCR = 58% RQD = 48%
	RC		TCR = 100% RQD = 76% UCS = 16.2 MPa
End of Borehole at 3.20 metres in Bedrock.			

DEPTH (ft): 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

DEPTH (m): 1 2 3 4 5 6

PLATE 7

BOREHOLE LOG

PROJECT
Geotechnical Investigation -
Neil's Brook Bridge, CBHNP, NS

LOGGED/DWN. LL	CKD. TKM	DATE OF INVEST. 7/3/15	JOB NO. 20335	HOLE NO. BH 6

CASING RESISTANCE blows/300mm

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

DATUM Ground Surface Elevation provided by SNC Lavalin

SURFACE ELEVATION 5.90 meters

DRILL TYPE: Drill Rig

DEPTH (ft)	DEPTH (m)	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	COND.	TYPE	PENE. RESIST.	OTHER TESTS
0–4.5	0–1.4			TOPSOIL : silty sand, loose, moist, dark brown. SAND AND GRAVEL : trace of silt, loose, moist, brown.		SS	N=4	TCR - Total Core Recovery RQD - Rock Quality Designation UCS - Unconfined Compressive Strength
						RC		TCR = 31% RQD = 18% UCS = 40.7 MPa
				BEDROCK : Granite and Orthogneiss, highly fractured and weathered, poor quality, pink.		RC		TCR = 40% RQD = 0%
						RC		TCR = 90% RQD = 26%
	4.65			End of Borehole at 4.65 metres in Bedrock.				

Depth scale: ft 1–20; m 1–6

PLATE 8

TEST PIT LOG

PROJECT: Geotechnical Investigation - Neil's Brook Bridge, CBHNP, NS

LOGGED/DWN. LL	CKD. TKM	DATE OF INVEST. 7/3/15	JOB NO. 20335	TEST PIT TP 1

BACKHOE TYPE: Excavator

DATUM: Ground Surface Elevation provided by SNC Lavalin

SURFACE ELEVATION 6.53 meters

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

DEPTH (m)	SOIL DESCRIPTION	OTHER TESTS
0.00–0.25	TOPSOIL : silty sand, loose, moist, dark brown.	
0.25–0.50	SAND AND GRAVEL, some silt, loose, moist, brown.	Sieve
0.50–0.90	BEDROCK : Granite, highly fractured and weathered, poor quality, pink.	
	End of Test Pit at 4.65 metres in Bedrock. Test Pit dry upon completion.	

Columns: DEPTH (ft, m); MODIFIED USCS; SOIL SYMBOL; SOIL DESCRIPTION; SOIL SAMPLE (COND., TYPE, POCKET PENE.); OTHER TESTS

Depth scale: ft 1–20; m 1–6

TEST PIT LOG

PROJECT	Geotechnical Investigation - Neil's Brook Bridge, CBHNP, NS
LOGGED/DWN.	LL
CKD.	TKM
DATE OF INVEST.	7/3/15
JOB NO.	20335
TEST PIT	TP 2a
BACKHOE TYPE	Excavator
DATUM	Ground Surface Elevation provided by SNC Lavalin
SURFACE ELEVATION	5.40 meters

WC % (wp- □ w- ● wl- △) 10 20 30 40 50	DEPTH ft	DEPTH m	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	COND.	TYPE	POCKET PENE.	OTHER TESTS
	0–10.8	0–3.3			FILL : sand and gravel, trace silt, cobble and small boulders, very loose to loose, dry to moist, brown.				
		3.3			End of Test pit at 3.3 metres in Fill.				
					Test pit dry upon completion.				

Depth scale: ft 1–20; m 1–6

TEST PIT LOG

Englobe

PROJECT: Geotechnical Investigation - Neil's Brook Bridge, CBHNP, NS

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	TEST PIT
LL	TKM	7/3/15	20335	TP 2b

BACKHOE TYPE: Excavator

DATUM: Ground Surface Elevation provided by SNC Lavalin

SURFACE ELEVATION 5.40 meters

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

DEPTH (ft)	DEPTH (m)	MODIFIED USCS	SOIL SYMBOL	SOIL DESCRIPTION	COND.	TYPE	POCKET PENE.	OTHER TESTS
0–8	0–2.44		Fill (hatched)	FILL : sand and gravel, trace silt, cobble and small boulders, very loose to loose, dry to moist, brown.				
8	2.44			End of Test pit at 2.44 metres in Fill. Test pit dry upon completion.				

PLATE 11

Appendix 3 Laboratory Test Results

TABLE 3-1: SUMMARY OF LABORATORY DATA
Geotechnical Investigation
Neil's Brook Bridge
Englobe Project No. 20335

Borehole No.	Sample No.	Depth (m)	Description	Moisture Content (%)	Particle Size Distribution Gravel (%)	Sand (%)	Fines (silts and clays) (%)	UCS (MPa)
BH 1	12	7.6 - 8.2	Sand and gravel, trace silt and clay	13.0	35	59	6	
BH 2	3+4	2.4 - 3.7	Sand and gravel, some silt and clay	11	36	53	11	
BH 3	6	4.4 - 5.5	Granite					37.7
BH 4	1	0.3 - 0.9	Fill	5.9	22	61	17	
BH 5	3	2.7 - 2.9	Orthogneiss					16.2
BH 6	2	1.3 - 1.5	Orthogneiss					40.7
TP 1	1	0.3 - 0.6	Sand and gravel, some silt and clay	4	45	36	19	

MARITIME TESTING

METRIC SIEVE ANALYSIS REPORT

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

Client:

SNC Lavalin Inc.
65 Beech Hill Road, Suite 2
Antigonish, Nova Scotia
B2G 2P9

Attn: Todd Barkhouse
PHONE (902) 863-1220 **FAX:** (902) 863-3225

Our Project No: 20335
Client Contract No.:
Client PO.:
CC:

Project: Geotechnical Investigation - Neil's Brook Bridge, CBHNP, Nova Scotia
Source: BH 1
Sample No: SA 12
Location: 7.6 - 8.2 m
Date Sampled: 07-Jul-15
Sampled by: LL
Date Received:
Date Tested: 22-Jul-15

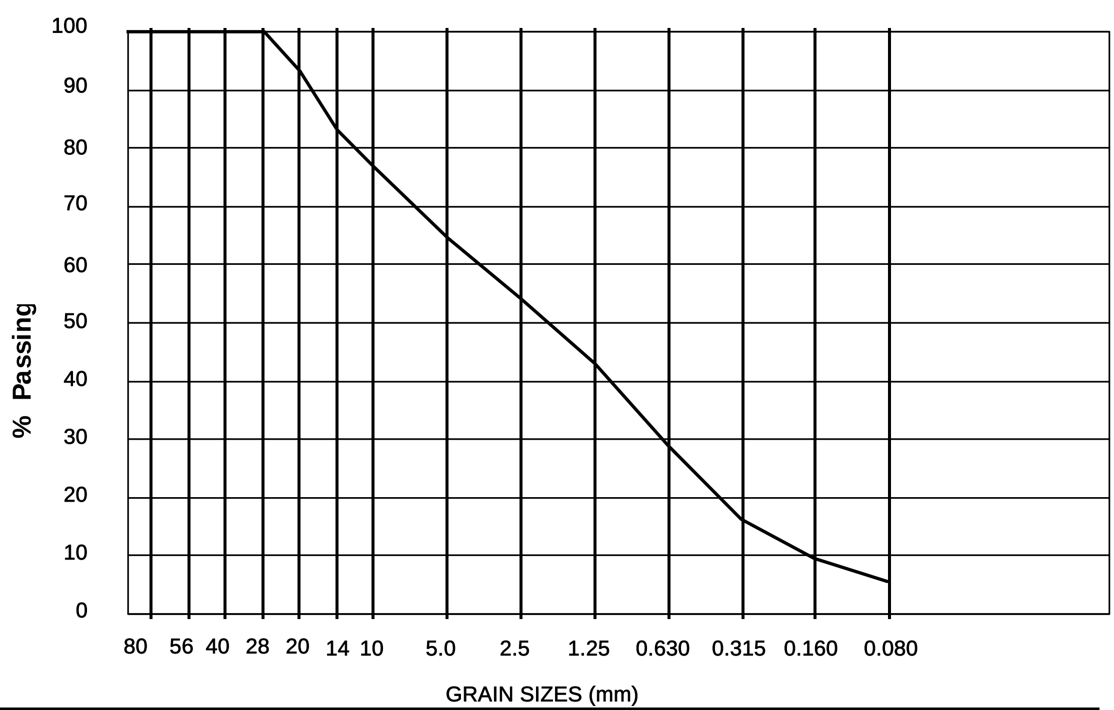
PHYSICAL PROPERTY TESTS

Soil Type	Sand and Gravel	**Liquid Limit**		**Flat and Elongated Particles, %**	
Gravel, %	35	**Plastic Limit**		**Coarse Spec. Gravity**	
Sand, %	59	**Plasticity Index**		**Fractured Faces, %**	
Silt and Clay, %	6	**Coarse Absorption, %**		**Petrographic No.**	
Moisture Cont., %	13	**Fine Absorption, %**		**Max. Dry Density, (kg/m3)**	
Abrasion Loss, %		**Micro Deval Loss, %**		**Optimum Moisture, %**	

Sieve Size (mm)	Percent Passing	Spec. Band
112		
80		
56		
40		
28	100	
20	93	
14	83	
10	77	
5.0	65	
2.5	54	
1.25	43	
0.630	29	
0.315	16	
0.160	9	
0.080	5.7	

GRAIN SIZE CURVE

Spec Band
NO SPEC



Comments:

Record No: 9246 MTL Tech: RMC/CM PER

CERTIFIED LABORATORY FOR TESTING CONCRETE

pm KM

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

METRIC SIEVE ANALYSIS REPORT

Client:

SNC Lavalin Inc.
65 Beech Hill Road, Suite 2
Antigonish, Nova Scotia
B2G 2P9

Our Project No: 20335

Client Contract No.:

Client PO.:

CC:

Attn: Todd Barkhouse

PHONE (902) 863-1220 **FAX:** (902) 863-3225

Project: Geotechnical Investigation - Neil's Brook Bridge, CBHNP, Nova Scotia

Source: BH 2

Sampled by: LL

Sample No: SA3&4

Date Sampled: 07-Jul-15

Date Received:

Location: 2.4 - 3.7 m

Date Tested: 22-Jul-15

PHYSICAL PROPERTY TESTS

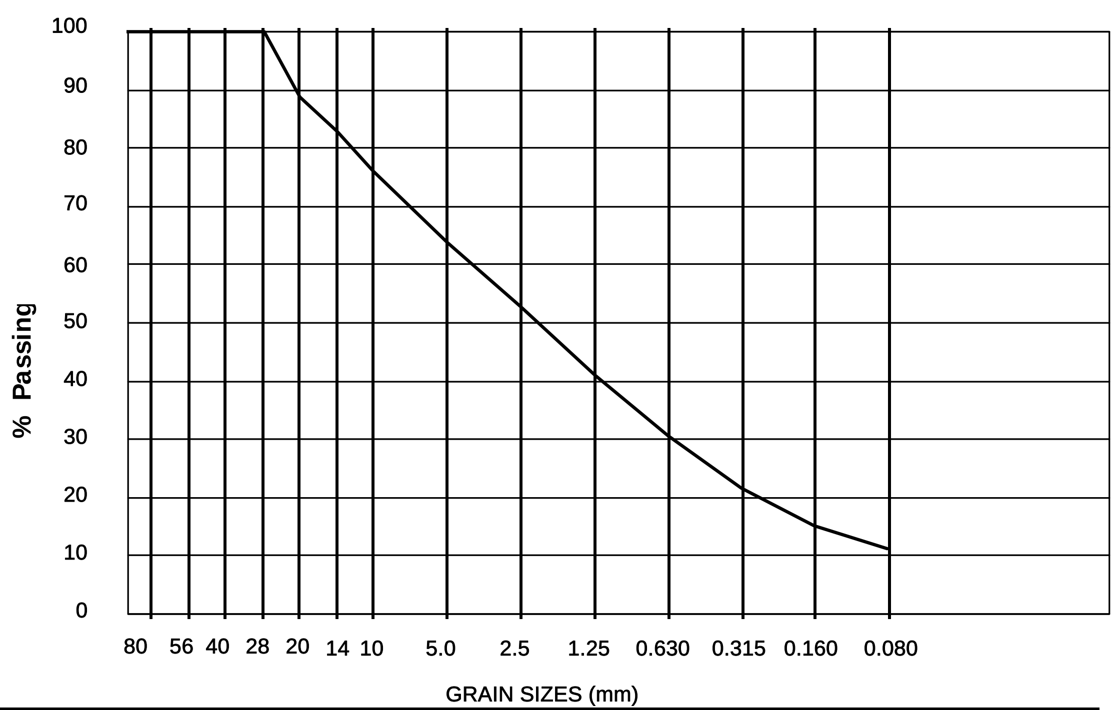
Soil Type	Sand and Gravel	**Liquid Limit**		**Flat and Elongated Particles, %**	
Gravel, %	36	**Plastic Limit**		**Coarse Spec. Gravity**	
Sand, %	53	**Plasticity Index**		**Fractured Faces, %**	
Silt and Clay, %	11	**Coarse Absorption, %**		**Petrographic No.**	
Moisture Cont., %	11	**Fine Absorption, %**		**Max. Dry Density, (kg/m3)**	
Abrasion Loss, %		**Micro Deval Loss, %**		**Optimum Moisture, %**	

Spec Band

NO SPEC

Sieve Size (mm)	Percent Passing	Spec. Band
112		
80		
56		
40		
28	100	
20	89	
14	83	
10	76	
5.0	64	
2.5	53	
1.25	41	
0.630	31	
0.315	22	
0.160	15	
0.080	11.2	

GRAIN SIZE CURVE



Comments:

Record No: 9247 MTL Tech: MM PER

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METRIC SIEVE ANALYSIS REPORT

Client:
SNC Lavalin Inc.
65 Beech Hill Road, Suite 2
Antigonish, Nova Scotia
B2G 2P9

Attn: Todd Barkhouse
PHONE (902) 863-1220 **FAX:** (902) 863-3225

Our Project No: 20335
Client Contract No.:
Client PO.:
CC:

Project: Geotechnical Investigation - Neil's Brook Bridge, CBHNP, Nova Scotia
Source: BH 4
Sample No: SA1
Location: 0.3 - 0.9 m
Date Sampled: 07-Jul-15
Sampled by: LL
Date Received:
Date Tested: 22-Jul-15

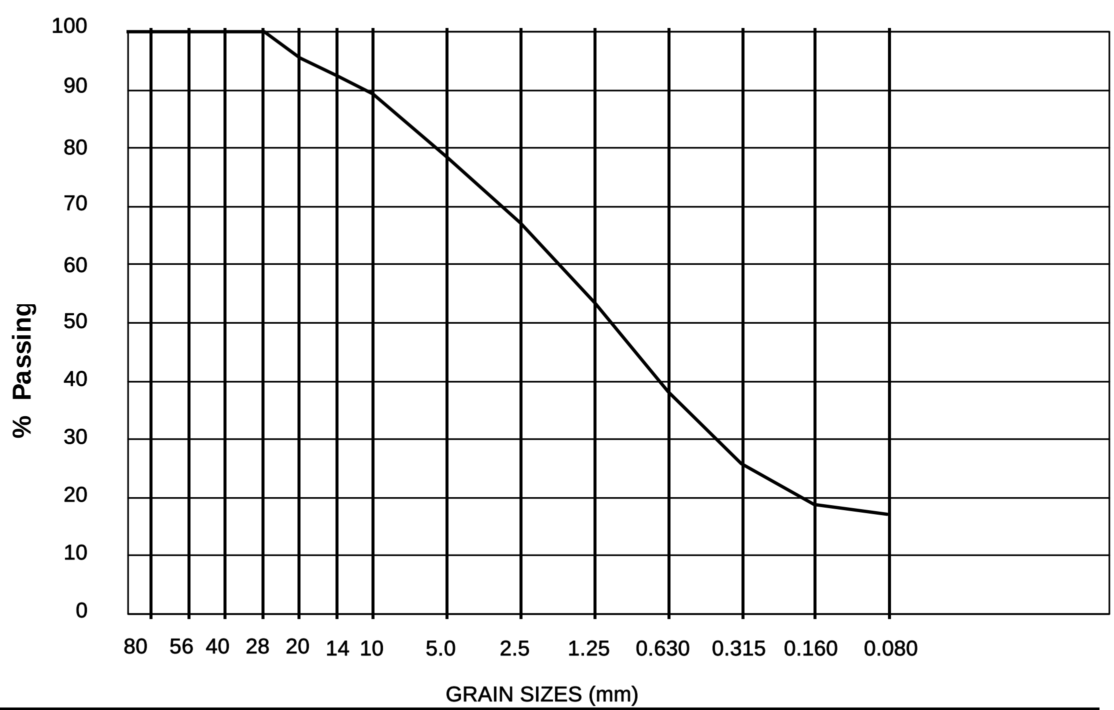
PHYSICAL PROPERTY TESTS

Soil Type	Fill	**Liquid Limit**		**Flat and Elongated Particles, %**	
Gravel, %	22	**Plastic Limit**		**Coarse Spec. Gravity**	
Sand, %	61	**Plasticity Index**		**Fractured Faces, %**	
Silt and Clay, %	17	**Coarse Absorption, %**		**Petrographic No.**	
Moisture Cont., %	5.9	**Fine Absorption, %**		**Max. Dry Density, (kg/m3)**	
Abrasion Loss, %		**Micro Deval Loss, %**		**Optimum Moisture, %**	

Spec Band
NO SPEC

Sieve Size (mm)	Percent Passing	Spec. Band
112		
80		
56		
40		
28	100	
20	96	
14	92	
10	89	
5.0	78	
2.5	67	
1.25	53	
0.630	38	
0.315	26	
0.160	19	
0.080	17.1	

GRAIN SIZE CURVE



Comments:

Record No: 9248 MTL Tech: MM/CM PER

CERTIFIED LABORATORY FOR TESTING CONCRETE

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METRIC SIEVE ANALYSIS REPORT

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

Client:

SNC Lavalin Inc.
65 Beech Hill Road, Suite 2
Antigonish, Nova Scotia
B2G 2P9

Our Project No: 20335

Client Contract No.:

Client PO.:

CC:

Attn: Todd Barkhouse

PHONE (902) 863-1220 **FAX:** (902) 863-3225

Project: Geotechnical Investigation - Neil's Brook Bridge, CBHNP, Nova Scotia

Source: TP 1

Sampled by: LL

Sample No: SA1

Date Sampled: 07-Jul-15

Date Received:

Location: 0.3 - 0.6 m

Date Tested: 21-Jul-15

PHYSICAL PROPERTY TESTS

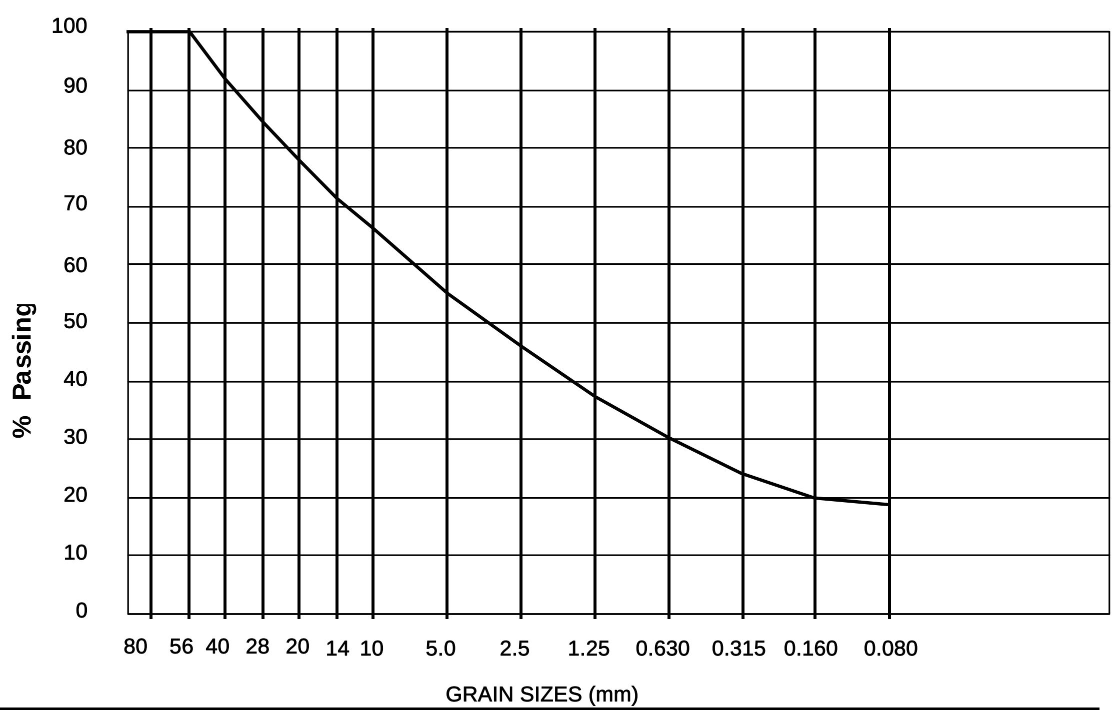
Soil Type	Sand and Gravel	**Liquid Limit**		**Flat and Elongated Particles, %**	
Gravel, %	45	**Plastic Limit**		**Coarse Spec. Gravity**	
Sand, %	36	**Plasticity Index**		**Fractured Faces, %**	
Silt and Clay, %	19	**Coarse Absorption, %**		**Petrographic No.**	
Moisture Cont., %	4	**Fine Absorption, %**		**Max. Dry Density, (kg/m3)**	
Abrasion Loss, %		**Micro Deval Loss, %**		**Optimum Moisture, %**	

Sieve Size (mm)	Percent Passing	Spec. Band
112		
80		
56	100	
40	92	
28	84	
20	78	
14	71	
10	66	
5.0	55	
2.5	46	
1.25	37	
0.630	30	
0.315	24	
0.160	20	
0.080	18.9	

GRAIN SIZE CURVE

Spec Band

NO SPEC



Comments:

Record No: 9249 MTL Tech: MM/CH PER

CERTIFIED LABORATORY FOR TESTING CONCRETE

Reporting of these test results constitutes a testing service only. Engineering interpretation or evaluation of test results is provided only on request.

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