AGENCY OF TRANSPORTATION **OFFICE MEMORANDUM**

To: Carolyn Carlson, P.E., Structures Project Manager

END

From: Eric Denardo, Geotechnical Engineer via Callie Ewald, P.E., Geotechnical Engineering Manager

CEE

Date: October 11, 2016

Subject: Richford-Sutton BHF 0814(1) – Geotechnical Data Report

1.0 INTRODUCTION

We have completed our geotechnical investigation for the subject project located on VT Route 105A approximately 1.7 miles east of the intersection with VT Route 105 in Richford, Vermont crossing the Missisquoi River into Canada. Our investigation was only conducted on the southern abutment. Contained herein are the results from our subsurface investigation, geotechnical analysis, and calculated geotechnical soil parameters to be used in pile analyses and design.

2.0 FIELD INVESTIGATION

The field investigation was conducted between June 6, 2016 and June 9, 2016. Two standard penetration borings were drilled to determine the subsurface profile in order to aid in design and construction of the bridge foundation supported on piles. Boring locations were provided by Cory Burrall in the Geotechnical Services Request Form dated March 2, 2016. A summary of the location of each boring and corresponding ground surface elevation can be found in Table 2.1. The values for the Northings and Eastings are based on the Vermont State Plane Grid Coordinate System NAD 83, and were located by a handheld GPS. Elevations for the borings were then taken off a VTrans survey file. The locations and elevations of the borings should be considered accurate only to the degree implied by the method used to determine them. A boring location plan for the bridge is attached.

Table 2.1 Boring Locations

Boring Number	Station	Offset (ft)	Northing (ft)	Easting (ft)	Elevation (ft)
B-101	59+76.6	-7.35	915475.92	1617697.85	514.6
B-101A	59+66.6	-7.34	915467.77	1617704.14	514.3

The borings were performed in general accordance with AASHTO T206, *Standard Method of Test for Penetration Test and Split-Barrel Sampling of Soils.* During boring operations, for boring B-101, split spoon samples and standard penetration tests (SPT) were to be taken continuously to 20 feet, then at 5 foot intervals thereafter. During drilling operations, the drill casing encountered refusal at a depth of 27.3 feet. A 15 foot core was taken upon hitting refusal and results from this core indicated concrete, likely

the stem of the existing bridge abutment. As a result, the drill rig was moved 10 feet parallel to the roadway away from the abutment to where boring operations were continued as B-101A. In boring B-101A, the boring was advanced to a depth of 25 feet before sampling began. Split spoon samples and SPTs were taken at 5 foot intervals until bedrock was encountered at a depth of 70.1 feet. When bedrock was encountered, three BX rock cores were taken 15 feet into rock to collect five foot rock core runs to confirm the presence of bedrock. Mechanical difficulties with the drilling operations caused poor recovery in the second core run. For this reason, a third, five foot core run was performed.

3.0 FIELD AND LABORATORY TESTING

The standard penetration resistance of the in-situ soil is determined by the number of blows required to drive a 2 inch OD split barrel sampler into the soil with a 140 pound hammer dropped from a height of 30 inches, in accordance with procedures specified in AASHTO T206. During the standard penetration test (SPT), the sampler is driven for a total length of 2 feet, while counting the blows for each 6 inch increment. The SPT N-value, which is defined as the sum of the number of blows required to drive the sampler through the second and third increments, is commonly used with established correlations to estimate a number of soil parameters, particularly the shear strength and density of cohesionless soils. The N-values provided on the boring logs are raw values and have not been corrected for energy, borehole diameter, rod length, or overburden pressure. The VT Agency of Transportation has determined a hammer correction value, C_E, to account for the efficiency of the SPT hammer on the drill rig. For both borings a CME 45C Skid Rig was used, with a hammer energy correction factor of 1.42. This value, included on the boring logs, was used in calculations to determine soil parameters. Laboratory tests were conducted on all samples to evaluate grain size, moisture content, and percent finer than No. 200 sieve. Results from this testing can be found on the attached boring logs.

A detailed description of the rock cores is presented on the boring logs including run length, drill times, recovery, and Rock Quality Designation (RQD). Recovery is defined as the length of core obtained expressed as a percentage of the total length cored. In accordance with ASTM D6032, RQD is the total length of core pieces, 4 inches or greater in length, expressed as a percentage of the total length cored. RQD provides an indication of the integrity of the rock mass and relative extent of seams, jointing and bending planes. The Rock Mass Rating (RMR) is also included on the logs. RMR is AASHTO's (LRFD Bridge Design Specification) recommended method of classifying rock, and is based on five different parameters that all have relative ratings which combine to form the RMR. These parameters include rock strength, RQD, joint spacing, joint condition, and groundwater (AASHTO Section 10.4.6.4).

4.0 SOIL PROFILE

Review of laboratory data and boring logs revealed the following information pertaining to the soil strata. It should be noted that groundwater elevations are subject to change given the fact that boreholes were generally left open for a short period of time. Because groundwater elevations can fluctuate seasonally and are affected by temperature and

precipitation, groundwater may be encountered during construction when not previously noted in the logs.

B-101/B-101A (Abutment 1): The ground surface elevations at B-101 and B-101A were approximately 514.6 and 514.3 feet, respectively. Groundwater depths ranging from 19.5 feet to 21.6 feet below the ground surface were measured in both borings. Bedrock was encountered at a depth of 70.1 feet.

Depth (Below Ground Surface Elevation)	Soil Profile
0 – 0.85 feet	Asphalt
0.85 – 25 feet	Medium Dense Sandy Gravel
25 – 44 feet	Very Dense Sandy Gravel
44 – 70.1 feet	Loose to Medium Dense Silt
> 70.1 feet	Hard, Unweathered, Schist

5.0 DESIGN PARAMETERS

The following design parameters should be used in the pile analyses for Abutment 1. A groundwater elevation of 495 feet is recommended for design for the abutment. Tables 5.1 and 5.2 below show design parameters for the soil and bedrock respectively.

Table 5.1: Soil and Bedrock Design Parameters

Elevation (ft)	Soil Description	Unit Weight (pcf)	Friction Angle (º)	Poisson's Ratio	Subgrade Modulus (pci)	Shear Modulus (ksi)	Torsional Shear Stress / Ultimate Unit Skin Friction* (psf)
514 – 490	Sandy Gravel	120	35	0.30	90	1.80	690
490 – 471	Sandy Gravel	130	38	0.35	125	3.48	2164
471 – 445	Silt	115	32	0.33	20	1.46	1753
< 445	Rock	170	25	0.31	--	716	--

Table 5.2: Bedrock Design Parameters

Parameter	Values
Unconfined Compressive Strength (ksf)	720
Modulus of Elasticity (ksi)	1,875
Shear Modulus (ksi)	716

*Torsional shear stress and ultimate unit skin friction were calculated assuming an HP12x63 pile. According to the VTrans Integral Abutment Bridge Design Guidelines, an axial bearing failure of 736 kips can be used assuming an HP12X63 pile.

6.0 CONCLUSION

It is our understanding that piles are the preferred alternative for supporting this abutment. Cobbles and boulders were noted in Boring B-101A between 15 and 25 feet, with very dense drilling conditions from 25 feet to 45 feet. It is our opinion that piles will be able to be driven through the sandy gravel material below 25 feet, however an item for pre-drilling should be considered to penetrate through the cobbles and boulders noted above based on the final elevation of the pile cap.

Please feel free to contact us at (802) 828-2561 if you have any questions, or you would like to further discuss this report.

Attachments: Boring Location Plan (1 pages)
Boring Logs (3 pages)

cc: Cory Burrall
Electronic Read File/DJH
Project File/CEE
END

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SOIL CLASSIFICATION

AASHTO	
A1	Gravel and Sand
A3	Fine Sand
A2	Silty or Clayey Gravel and Sand
A4	Silty Soil - Low Compressibility
A5	Silty Soil - Highly Compressible
A6	Clayey Soil - Low Compressibility
A7	Clayey Soil - Highly Compressible

ROCK QUALITY DESIGNATION

R.Q.D. (%)	ROCK DESCRIPTION
<25	Very Poor
25 to 50	Poor
51 to 75	Fair
76 to 90	Good
>90	Excellent

SHEAR STRENGTH

UNDRAINED SHEAR STRENGTH IN P.S.F.	CONSISTENCY
<250	Very Soft
250-500	Soft
500-1000	Med. Stiff
1000-2000	Stiff
2000-4000	Very Stiff
>4000	Hard

CORRELATION GUIDE OF "N" TO DENSITY/CONSISTENCY

DENSITY (GRANULAR SOILS)		CONSISTENCY (COHESIVE SOILS)	
N	DESCRIPTIVE TERM	N	DESCRIPTIVE TERM
<5	Very Loose	<2	Very Soft
5-10	Loose	2-4	Soft
11-24	Med. Dense	5-8	Med. Stiff
25-50	Dense	9-15	Stiff
>50	Very Dense	16-30	Very Stiff
		31-60	Hard
		>60	Very Hard

COMMONLY USED SYMBOLS

▼	Water Elevation
⊗	Standard Penetration Boring
⊕	Auger Boring
⊙	Rod Sounding
S	Sample
N	Standard Penetration Test Blow Count Per Foot For: 2" O.D. Sampler 1 3/8" I.D. Sampler Hammer Weight Of 140 Lbs. Hammer Fall Of 30"
VS	Field Vane Shear Test
US	Undisturbed Soil Sample
B	Blast
DC	Diamond Core
MD	Mud Drill
WA	Wash Ahead
HSA	Hollow Stem Auger
AX	Core Size 1 1/8"
BX	Core Size 1 5/8"
NX	Core Size 2 1/8"
M	Double Tube Core Barrel Used
LL	Liquid Limit
PL	Plastic Limit
PI	Plasticity Index
NP	Non Plastic
w	Moisture Content (Dry Wgt. Basis)
D	Dry
M	Moist
MTW	Moist To Wet
W	Wet
Sat	Saturated
Bo	Boulder
Gr	Gravel
Sa	Sand
Si	Silt
Cl	Clay
HP	Hardpan
Le	Ledge
NLTD	No Ledge To Depth
CNPF	Can Not Penetrate Further
TLOB	Top of Ledge Or Boulder
NR	No Recovery
Rec.	Recovery
%Rec.	Percent Recovery
RQD	Rock Quality Designation
CBR	California Bearing Ratio
<	Less Than
>	Greater Than
R	Refusal (N > 100)
VTSPG	NAD83 - See Note 7

COLOR

blk	Black	pnk	Pink
bl	Blue	pu	Purple
brn	Brown	rd	Red
dk	Dark	tn	Tan
gry	Gray	wh	White
gn	Green	yel	Yellow
lt	Light	mltc	Multicolored
or	Orange		

DEFINITIONS (AASHTO)

BEDROCK (LEDGE) - Rock in its native location of indefinite thickness.

BOULDER - A rock fragment with an average dimension > 12 inches.

COBBLE - Rock fragments with an average dimension between 3 and 12 inches.

GRAVEL - Rounded particles of rock < 3" and > 0.0787" (#10 sieve).

SAND - Particles of rock < 0.0787" (#10 sieve) and > 0.0029" (#200 sieve).

SILT - Soil < 0.0029" (#200 sieve), non or slightly plastic and exhibits no strength when air-dried.

CLAY - Fine grained soil, exhibits plasticity when moist and considerable strength when air-dried.

VARVED - Alternate layers of silt and clay.

HARDPAN - Extremely dense soil, cemented layer, not softened when wet.

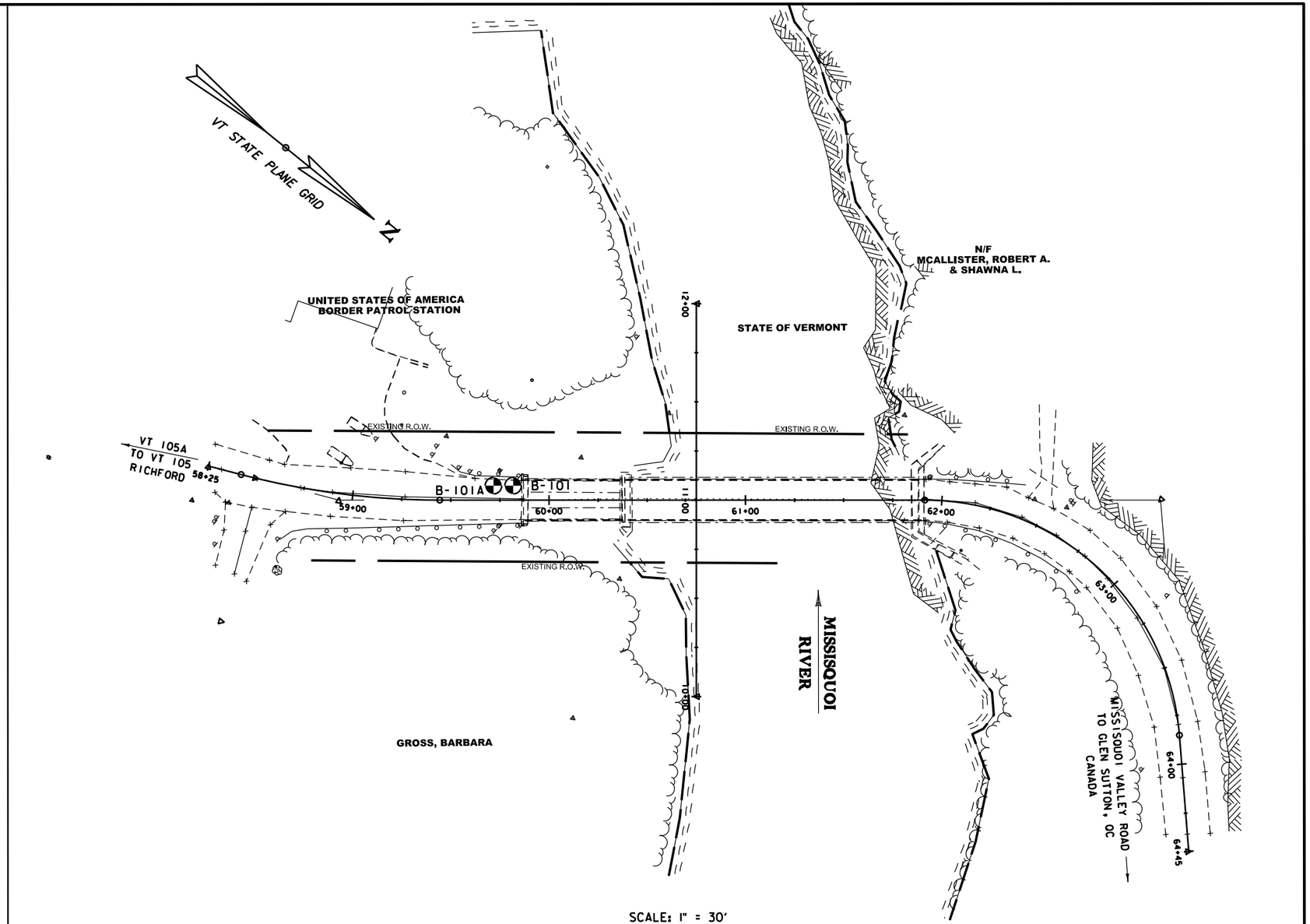
MUCK - Soft organic soil (containing > 10% organic material.

MOISTURE CONTENT - Weight of water divided by dry weight of soil.

FLOWING SAND - Granular soil so saturated (loose) that it flows into drill casing during extraction of wash rod.

STRIKE - Angle from magnetic north to line of intersection of bed with a horizontal plane.

DIP - Inclination of bed with a horizontal plane.



SCALE: 1" = 30'

GENERAL NOTES

1. The subsurface explorations shown herein were made between 6/6/16 and 6/9/16 by the Agency.
2. Soil and rock classifications, properties and descriptions are based on engineering interpretation from available subsurface information by the Agency and may not necessarily reflect actual variations in subsurface conditions that may be encountered between individual boring or sample locations.
3. Observed water levels and/or conditions indicated are as recorded at the time of exploration and may vary according to the prevailing rainfall, methods of exploration and other factors.
4. Engineering judgment was exercised in preparing the subsurface information presented herein. Analysis and interpretation of subsurface data was performed and interpreted for Agency design and estimating purposes. Presentation of the information in the Contract is intended to provide the Contractor access to the same data available to the Agency. The subsurface information is presented in good faith and is not intended as a substitute for personal investigation, independent interpretation, independent analysis or judgment by the Contractor.
5. Pictorial structure details shown on the boring plan layout or soils profile are for illustrative purposes only and may not accurately portray final contract details.
6. Terminology used on boring logs to describe the hardness, degree of weathering, and spacing of fractures, joints and other discontinuities in the bedrock is defined in the AASHTO Manual on Subsurface Investigations, 1988.
7. Northing and Easting coordinates are shown in Vermont State Plane Grid North American Datum 1983 in meters and survey feet.

BORING CHART

HOLE NO.	SURV. STATION	OFFSET	GROUND ELEV.	ELEV. TLOB
B-101	59+76.60	-7.35	514.6	N/A
B-101A	59+66.60	-7.34	514.3	444.2

PROJECT NAME: RICHFORD-SUTTON, PQ
PROJECT NUMBER: BHF 0814(I)

FILE NAME: s10c222bor.dgn
PROJECT LEADER: C. CARLSON
DESIGNED BY: C. BURRALL
BORING INFORMATION SHEET

PLOT DATE: $$$$DATE$$$
DRAWN BY: G. ROKES
CHECKED BY: C. BURRALL
SHEET $S"$ OF $T"$

STATE OF VERMONT
AGENCY OF TRANSPORTATION
CONSTRUCTION AND
MATERIALS BUREAU
CENTRAL LABORATORY

BORING LOG

Richford-Sutton
BHF 0814(1)
VT-105A Bridge #3

Boring No.: **B-101**
Page No.: 1 of 1
Pin No.: 10c222
Checked By: END

Boring Crew: Garrow, Judkins, Nieto
Date Started: 6/06/16 Date Finished: 6/07/16
VTSPG NAD83: N 915475.54 ft E 1617697.85 ft
Station: 59+76.6 Offset: -7.35
Ground Elevation: 514.6 ft

	Casing	Sampler
Type:	WB	SS
I.D.:	4 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	CME 45C SKID	C_E = 1.42

Groundwater Observations

Date	Depth (ft)	Notes
06/06/16	21.6	W.T. after drilling
06/07/16	21.5	W.T. before drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Asphalt Pavement, 0.0 ft - 0.85 ft					
		A-1-a, SaGr, Dk/brn, Moist, Rec. = 1.3 ft, Lab Note: Pieces of asphalt pavement were within sample	10-8-5-5 (13)	7.4	52.1	41.0	6.9
		A-1-b, GrSa, Dk/brn, Moist, Rec. = 0.7 ft	4-5-4-6 (9)	6.5	33.0	57.9	9.1
5		A-1-a, SaGr, gry, Moist, Rec. = 1.0 ft, Lab Note: Broken concrete was within sample	5-5-4-3 (9)	6.7	54.3	33.2	12.5
		A-1-a, SaGr, gry-brn, Moist, Rec. = 1.2 ft, Lab Note: Broken rock was within sample Field Note:, Cleaned out casing	5-24-9-9 (33)	3.0	65.2	28.0	6.8
10		A-1-b, GrSa, gry, MTW, Rec. = 0.3 ft, Lab Note: Broken rock was within sample Field Note:, Rollercone, Cleaned out casing	9-5-4-5 (9)	20.5	27.7	68.8	3.5
		A-1-a, SaGr, brn-gry, Moist, Rec. = 0.5 ft, Lab Note: Broken rock and pieces of broken concrete were within sample Field Note:, NXDC, Cleaned out casing, cobbles, stones and concrete	3-1-4-24 (5)	12.7	50.2	41.3	8.5
		A-1-a, Gr, gry, Moist, Rec. = 0.7 ft, Lab Note: A lot of pieces of broken concrete were within sample Field Note:, Cleaned out casing	17-9-6-7 (15)	12.8	87.2	10.9	1.9
15		A-1-a, SaGr, brn, Moist, Rec. = 0.5 ft, Lab Note: Pieces of broken concrete were within sample Field Note:, NXDC, Cleaned out casing, cobbles, stones and concrete	4-2-5-2 (7)	13.7	65.9	25.6	8.5
		A-1-a, Gr, gry, Moist, Rec. = 0.6 ft, Lab Note: A lot of broken rock and pieces of concrete were within sample Field Note:, NXDC, Cleaned out casing, cobbles and concrete	4-5-12-11 (17)	7.2	87.5	11.4	1.1
20		A-1-a, SaGr, gry, Moist, Rec. = 0.5 ft Field Note:, Cleaned out casing	11-14-6-4 (20)	12.3	76.4	22.3	1.3
		24.4 ft - 25.0 ft Field Note:, No Recovery Field Note:, NXDC, Cleaned out casing					
25		Field Note:, Cored concrete from 27.3 feet to 42.3 feet	4-7-18-9 (25)				
30							
35							
40							
		Hole stopped @ 42.3 ft					
45		Remarks: Hole Collapsed at 18.5 feet.					

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

BORING LOG 2 RICHFORD-SUTTON BHF0814(1).GPJ VERMONT AOT.GDT 10/7/16

STATE OF VERMONT
AGENCY OF TRANSPORTATION
CONSTRUCTION AND
MATERIALS BUREAU
CENTRAL LABORATORY

BORING LOG

Richford-Sutton
BHF 0814(1)
VT-105A Bridge #3

Boring No.: **B-101A**
Page No.: 1 of 2
Pin No.: 10c222
Checked By: END

Boring Crew: Nieto, Judkins, Coletti
Date Started: 6/07/16 Date Finished: 6/09/16
VTSPG NAD83: N 915467.77 ft E 1617704.14 ft
Station: 59+66.6 Offset: -7.34
Ground Elevation: 514.3 ft

	Casing	Sampler
Type:	WB	SS
I.D.:	4 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	CME 45C SKID	C_E = 1.42

Groundwater Observations

Date	Depth (ft)	Notes
06/09/16	19.5	W.T. before drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Run (Dip deg.)	Core Rec. % (RQD %)	Drill Rate minutes/ft	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Asphalt Pavement, 0.0 ft - 0.3 ft								
15		Field Note:, Cobbles								
20		Field Note:, Cobbles and boulder								
25		A-1-a, SaGr, gry-brn, Moist, Rec. = 1.2 ft, Lab Note: A lot of broken rock was within sample				13-27-20-27 (47)	10.0	60.1	29.5	10.4
		Field Note:, Cleaned out casing								
30		A-1-a, SaGr, gry-brn, Moist, Rec. = 0.8 ft, Lab Note: Broken rock was within sample				13-23-16-24 (39)	10.9	54.4	34.2	11.4
35		Field Note:, Cleaned out casing								
		A-1-a, Gr, gry, Moist, Rec. = 0.3 ft, Lab Note: A lot of broken rock was within sample				40-R@3.5" (R)	5.1	81.0	14.3	4.7
40		A-1-a, SaGr, gry, Moist, Rec. = 0.8 ft, Lab Note: A lot of broken rock was within sample				14-16-22-16 (38)	9.5	68.0	22.6	9.4
		Field Note:, BXDC, Cleaned out casing								

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

BORING LOG 2 RICHFORD-SUTTON BHF0814(1).GPJ VERMONT AOT.GDT 10/7/16

STATE OF VERMONT
AGENCY OF TRANSPORTATION
CONSTRUCTION AND
MATERIALS BUREAU
CENTRAL LABORATORY

BORING LOG

Richford-Sutton
BHF 0814(1)
VT-105A Bridge #3

Boring No.: **B-101A**
Page No.: 2 of 2
Pin No.: 10c222
Checked By: END

Boring Crew: Nieto, Judkins, Coletti
Date Started: 6/07/16 Date Finished: 6/09/16
VTSPG NAD83: N 915467.77 ft E 1617704.14 ft
Station: 59+66.6 Offset: -7.34
Ground Elevation: 514.3 ft

	Casing	Sampler
Type:	WB	SS
I.D.:	4 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	CME 45C SKID	C_E = 1.42

Groundwater Observations

Date	Depth (ft)	Notes
06/09/16	19.5	W.T. before drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Run (Dip deg.)	Core Rec. % (RQD %)	Drill Rate minutes/ft	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Field Note:, No Recovery				8-8-8-6 (16)				
50		Field Note:, BXDC, Cleaned out casing A-2-4, Sa, Dk/brn, Moist, Rec. = 0.9 ft				6-5-7-8 (12)	26.2	0.3	80.5	19.2
55		A-4, Si, gry, Moist, Rec. = 1.2 ft				2-4-5-4 (9)	28.9		9.1	90.9
60		Field Note:, BXDC, Cleaned out casing Field Note:, No Recovery				6-4-5-4 (9)				
65		Field Note:, BXDC, Cleaned out casing Field Note:, No Recovery				5-2-3-2 (5)				
70		Field Note:, No Recovery 70.1 ft - 75.1 ft, Gray, Graphitic biotite-muscovite-quartz-albite-pyrite Schist, Faint brown and rust staining along joints and pyrite inclusions. Hard, Unweathered, Fair rock, BX, RMR=49	1 (75)	90 (30)	7 4 4 4 4	R@Top of Bedrock @ 70.1 ft (R)				
75		75.1 ft - 80.1 ft, Gray, Graphitic biotite-muscovite-quartz-albite-pyrite Schist, Hard, Unweathered, Poor rock, BX, RMR=31, Low recovery due to mechanical difficulties during drilling	2 (75)	10 (0)	5 3 3 5 4					
80		80.1 ft - 85.1 ft, Gray, Graphitic biotite-muscovite-quartz-albite-pyrite gneissic Schist, Rust and brown staining along joints. Hard, Very slightly weathered, Fair rock, BX, RMR=43	3 (75-80)	84 (12)	6 5 5 5 5					
85		Hole stopped @ 85.1 ft								

Remarks:
Hole collapsed at 20.0 feet.

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

BORING LOG 2 RICHFORD-SUTTON BHF0814(1).GPJ VERMONT AOT.GDT 10/7/16