AGENCY OF TRANSPORTATION **OFFICE MEMORANDUM**

To: Adam Goudreau, P.E., Structures Project Manager

END CEE

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

Date: September 12, 2023

Subject: Rockingham IM 091-1(81) Geotechnical Data Report

1.0 INTRODUCTION

As requested, we have completed our subsurface investigation of the proposed culvert replacement the Rockingham IM 091-1(81) project. The subject project consists of replacement of Bridge 24-3 carrying I91 over the Little Commissary Brook in the town of Rockingham. Contained herein are the results of our field sampling and testing, laboratory analysis of soil samples, and design parameter recommendations for use in the design of the proposed replacement structure, as determined using the 2020 AASHTO LRFD Bridge Design Specifications.

2.0 FIELD INVESTIGATION

Two field investigations were conducted as part of this project. An initial subsurface investigation was conducted between December 8, 2022, and February 8, 2023, by the VTrans Drill Unit. This subsurface investigation included advancing four standard penetration (SPT) borings. B-101, B-103, and B-104 were advanced along the proposed footprint of the culvert and B-102 was advanced approximately 45 feet south of the proposed culvert to profile the subsurface material for potential support of excavation.

A second investigation was conducted between June 26 and June 27, 2023 by GEODesign, Inc. and New England Boring Contractors (NEBC). This subsurface investigation included the advancement of two additional borings, B-201 and B-202, to better profile bedrock in the median of the interstate in the footprint of the culvert. A summary of the final location of each boring and corresponding ground surface elevation can be found in Table 2.1. The values for Northings and Easting are based on the Vermont State Plan Grid Coordinate System NAD 83 and were located by the Geotechnical Engineering Section's Trimble Geoexplorer 600 handheld GPS with a sub-meter accuracy. Elevations for the borings are based on the North American Vertical Datum, NAVD88 and were the survey file x19a190sv.dgn dated November 2022. The locations and elevations for the borings should be considered accurate only to the degree implied by the method used to determine them.

Table 2.1 *Boring Locations and Elevations*

Boring No.	Station	Offset (ft)	Northing (ft)	Easting (ft)	Approximate Ground Surface Elevation (ft)
B-101	2+41	-3.6	261653.9	1652548.1	566.6
B-102	3+17	51.5	261575.3	1652600.4	560.0
B-103	2+99	-3.1	261632.9	1652602.5	562.1
B-104	3+58	-3.1	261612.1	1652657.4	563.0
B-201	2+78	-5.9	261643.0	1652583.6	564.3
B-202	3+15	6.0	261618.6	1652614.4	563.4

The borings were performed in general accordance with AASHTO T206, *Standard Method of Test for Penetration Test and Split-Barrel Sampling of Soils.* During drilling operations for borings B-101, B-102, B-103, and B-104 split spoon samples and standard penetration tests (SPT) were taken at a 5-foot interval until a depth of 40 feet (ft) below ground surface (bgs), and then continuously to a depth of 50 ft bgs and finally at 5 ft intervals to 80 ft bgs or bedrock. For B-201, the boring was advanced to bedrock without sampling. In B-202, the boring was advanced to a depth of 65 ft bgs with no samples. When bedrock was encountered, two continuous 5 ft bedrock cores were taken to confirm the presence of bedrock. Bedrock was encountered in borings B-101, B-103, and B-201 at depths of 70, 48, and 49.5 ft bgs, respectively. A layer of weathered bedrock was noted in B-103 and B-201 above bedrock.

Soil samples were visually identified in the field and SPT blow counts were recorded on the boring logs when applicable. Soil samples were preserved and returned to the VTrans Construction and Materials Bureau Laboratory for testing and further evaluation. Upon completion of the laboratory testing, the borings logs were revised to reflect the results of the laboratory classification analysis. The attached boring logs display the types of soil strata encountered and include the laboratory test data, SPT data, and any pertinent observations made by the boring crew.

Details of the bedrock coring were recorded on the boring logs when applicable. Cores were then placed in core boxes and returned to the VTrans Construction and Materials Bureau Laboratory for further evaluation and testing, where applicable. The boring logs were revised to reflect the classification and description of the bedrock cores. It should be noted that bedrock cores were attempted in B-102 starting at a depth of 61.5 ft bgs. Coring resulted in no recovery of bedrock to a depth of 80 ft bgs. Based on observations from the field staff, no core recovery could be from a layer of weathered and poor-quality bedrock.

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 outside diameter (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. The number of blows required to drive the sampler each 6-inch increment is recorded, and the Standard Penetration Resistance (N-Value) is calculated as the sum of the blows over the second and third 6-inch intervals. The SPT N-value is commonly used with established correlations to estimate several 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 hammers on its drill rigs. A CME 55 Track rig was used for the borings, completed by the Agency with a hammer energy correction factor of 1.52. The borings completed by NEBC were drilled with a Mobile B-53 track rig with an energy correction factor of 0.85. These values, included on the boring logs, should be used in calculations to estimate soil parameters.

Geotechnical laboratory tests were performed on select representative samples to assist with soil classification and evaluate engineering properties of the soil. Grain size analyses were performed on select soil samples in accordance with AASHTO T 88, *Standard Method of Test for Particle Size Analysis of Soils*. Results from this testing can be found on the attached boring logs.

A detailed description of the recovered 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 the laboratory data, field testing, 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 on the logs.

4.1 Boring B-101

The ground surface elevation at B-101 was approximately 566.6 ft. Groundwater was measured before drilling on January 27, 2023, at a depth of 18.0 ft, corresponding to an approximate elevation of 548.6 ft. Bedrock was encountered at a depth of 70.0 ft bgs, corresponding to an approximate elevation of 496.6 ft.

Approximate Elevation (ft)	Soil Profile
566.6 – 566.0 ft	Asphalt pavement
566.0 – 549.1 ft	Very Dense GRAVEL and Sand, trace Silt
549.1 – 528.1 ft	Medium Dense SILT and Sand, little Gravel
528.1 – 496.6 ft	Very Dense SAND and Gravel, some Silt
< 496.6 ft	Bedrock

4.2 Boring B-102

The ground surface elevation at B-102 was approximately 560.0 ft. Groundwater was measured before drilling on December 15, 2022, at a depth of 21.7 ft bgs, corresponding to an approximate groundwater elevation of 538.3 ft. No bedrock was recovered to a depth of 80 ft bgs. Cores were attempted beginning at a depth of 61.5 ft bgs on what was assumed to be weathered bedrock.

Approximate Elevation (ft)	Soil Profile
560.0 – 542.5 ft	Medium Dense GRAVEL and Sand, little silt
542.5 – 518.0 ft	Dense SAND and Silt, some Gravel
518.0 – 498.5 ft	Very Dense SAND and Gravel, little Silt
< 498.5 ft	Very Dense No Recovery, assumed Weathered Bedrock

4.3 Boring B-103

The ground surface elevation at B-103 was approximately 562.1 ft. Groundwater was measured before drilling on December 9 and 13, 2022 at a depth of 37.5 ft bgs, corresponding to an approximate ground elevation of 524.6 ft. Bedrock was encountered at a depth of 48.0 ft bgs, corresponding to an approximate elevation of 514.1 ft.

Approximate Elevation (ft)	Soil Profile
562.1 – 549.6 ft	Medium Dense SAND and Gravel
549.6 – 528.6 ft	Medium Dense SILT and Sand, little Gravel
528.6 – 514.1 ft	Very Dense GRAVEL and Sand, trace Silt
< 514.1 ft	Bedrock

4.4 Boring B-104

The ground surface elevation at B-104 was approximately 563.0 ft. Groundwater was measured before drilling on February 7, 2023 at a depth of 28.8 ft bgs, corresponding to an approximate ground elevation of 534.2 ft. Bedrock was not encountered to a depth of 80.4 ft bgs.

Approximate Elevation (ft)	Soil Profile
563.0 – 562.4 ft	Asphalt pavement
562.4 – 539.5 ft	Dense GRAVEL and Sand, little Silt
539.5 – 517.0 ft	Medium Dense SILT and Sand, little Gravel
517.0 – 503.0 ft	Very Dense SAND and Gravel, some Silt
503.0 – 483.0 ft	Very Dense GRAVEL and Sand, little Silt

4.5 Borings B-201 B-202

For the supplementary borings completed by NEBC, the ground surface elevations at B-201 and B-202 were approximately 564.3 ft and 563.4, respectively. Groundwater was not measured during drilling operations as these were only left open for a short time. No soil samples were taken in either boring. Bedrock was encountered in B-201 at a depth of 49.5 ft bgs corresponding to an approximate elevation of 514.8 ft. Bedrock was not encountered in B-202 to a depth of 64 ft bgs corresponding to a depth of 499.4 ft.

4.7 Design Parameters

Engineering properties assigned to the in-situ materials are shown in Table 4.7.1. These values should be used when designing the substructure units. It is recommended that values of K_o be used for calculating earth pressures where the structure is not allowed to deflect longitudinally, away from or into the retained soil mass. Values for K_a should be utilized for an active earth pressure condition where the structure is moving away from the soil mass and K_p where the structure is moving toward the soil mass. The design earth pressure coefficients are based on horizontal surfaces (non-sloping backfill) and a vertical wall face.A summary of the rock core findings are listed in Table 4.7.2 as well as available in the attached boring logs. Information from the cores indicated PHYLLITE to be the main rock type in the recovered samples. The bedrock had rock mass ratings (RMR) of 31 across the borings, indicating poor rock.

Table 4.7.1: Engineering Properties of In-Situ Materials

Soil Description	M. Dense to V Dense GRAVEL and Sand, trace Silt	M Dense to Dense SILT and Sand, some Gravel	V Dense SAND and Gravel, little Silt
Unit Weight, γ (lbs/ft^3):	125	110	135
Internal Friction Angle, ° (degrees):	36	32	38
Coefficient of Friction, f			
- mass concrete cast against soil:	0.57	0.33	0.50
- soil against precast/formed concrete:	0.35	0.31	0.34
Active Earth Pressure Coef., K_a:	0.26	0.31	0.24
Passive Earth Pressure Coef., K_p:	3.85	3.26	4.20
At-Rest Earth Pressure Coefficient, K_o:	0.41	0.47	0.38

Table 4.7.2 Rock Core Sample Results B-101, B-103

Rock Type	Core Size	RQD (%)	Dip (Deg)	Hardness	Weathering	RMR	Competency
Phyllite	BX	0-10	75-90	Soft-Medium Hard	Moderately Weathered	31	Poor Rock

5.0 RECOMMENDATIONS

Bedrock was encountered in Borings B-101, B-103, and B-201, along the proposed footprint of the box culvert. Based on the approximate elevation of bedrock, it appears to slope upward from the southbound shoulder to the median, flatten out to the center of the median, and then steeply drop off below the northbound barrel. Based on these subsurface conditions and the proposed box profile, the bottom of the box will likely sit at or above the bedrock as profiled by the median borings, B-103 and B-201. The box may sit in the layer of weathered bedrock.

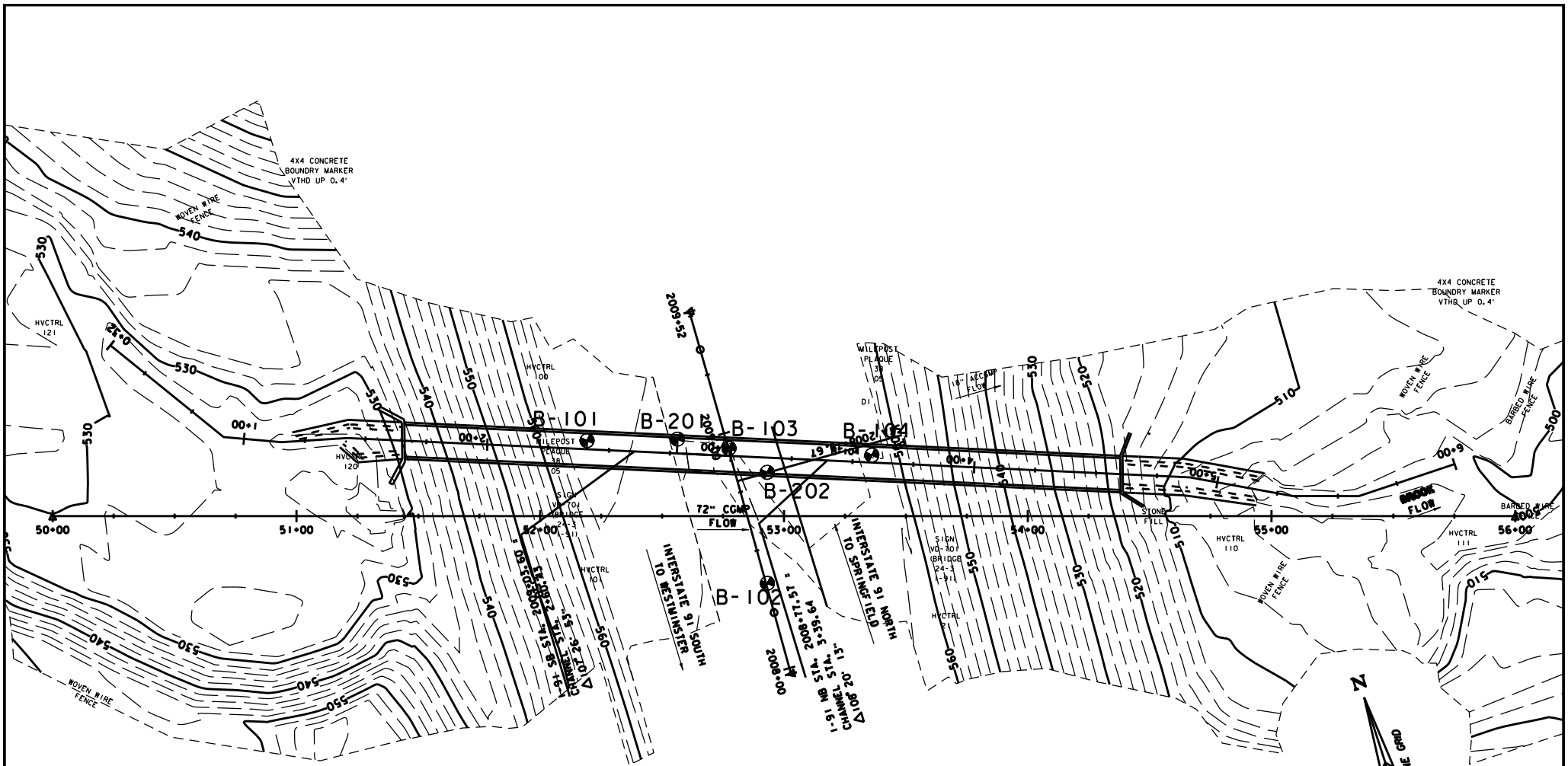
The competent rock recovered in the rock cores was classified as soft to medium hard and slightly to moderately weathered. This along with the low RQD values and presence of fractures throughout the cores indicate the material can likely be removed by a contractor without specialized equipment or the need for blasting. Where bedrock was not encountered or was encountered below the bottom of box, the bearing soils are described as a mixture of very dense sand and gravel and should have no issue supporting the replacement structure. Broken rock and refusal conditions were encountered throughout the borings and may impact the use of sheet piles to retain the site during installation of the box.

6.0 CONCLUSION

We are happy to provide design recommendations once information is available to do so. If you have any questions or would like to discuss this report, please contact the Geotechnical Engineering Section. Computer generated boring logs are attached and available in the *M:\Projects\19a190\MaterialsResearch* folder.

Attachments: Boring Layout (1 Page)
Boring Logs (13 Pages)

cc: Electronic Read File/MG
Project File/CEE
END



BORING CHART

HOLE NO.	STA.	OFFSET	NORTHING	EASTING	GROUND ELEVATION	ELEV. TLOB
B-101	2+41	-3.6	261653.9	1652548.1	566.6	496.6
B-102	3+17	51.5	261575.3	1652600.4	560.0	----
B-103	2+99	-3.1	261632.9	1652602.5	562.1	514.0
B-104	3+58	-3.1	261612.1	1652657.4	563.0	----
B-201	2+78	-5.9	261643.0	1652583.6	564.3	514.8
B-202	3+15	6.0	261618.6	1652614.4	563.4	----

BORING LAYOUT

SCALE 1" = 20'-0"

20 0 20

BENCHMARK
VT HIGHWAY DISK
ELEV=548.63

SIGN VD-701 (BRIDGE 24-2 1-91)

CHAIN LINK FENCE

MILEPOST 38 00

HVCTRL 20

PROJECT NAME: ROCKINGHAM	
PROJECT NUMBER: IM 091-1(81)	
FILE NAME: i90r90/si90r90border.dgn	PLOT DATE: ssssDATEsss
PROJECT LEADER: N.WARK	DRAWN BY: D.D.BEARD
DESIGNED BY: ------	CHECKED BY: ------
EXISTING CONDITIONS LAYOUT	SHEET sS#s OF sT#s

STATE OF VERMONT
AGENCY OF TRANSPORTATION
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BORING LOG

Rockingham
IM 091-1(81)
I91

Boring No.: **B-101**
Page No.: 1 of 2
Pin No.: 19a190
Checked By: END

Boring Crew: McGinley, Monette, Arles, Zottola
Date Started: 1/24/23 Date Finished: 1/31/23
VTSPG NAD83: N 261653.90 ft E 1652548.10 ft
Station: 2+41.00 Offset: -3.60
Ground Elevation: 566.6 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	3 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	CME 55 TRACK	C_E = 1.52

Groundwater Observations

Date	Depth (ft)	Notes
01/27/23	18.0	WT before drilling
01/31/23	40.5	WT 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:, Asphalt 0-0.55', Rollercone cleanout 4.2-5.0'								
5		Visual Description:, GRAVEL, trace Sand, Rock, gry, MTD, Rec. = 1.2 ft, Rollercone cleanout 9.0-10.0'				21-22-16-16 (38)				
10		A-1-a, Lab Classification: GRAVEL and Sand, trace Silt, gry-brn, MTD, Rec. = 1.2 ft, Broken rock was within sample.				9-14-34-20 (48)	10.5	52.6	37.1	10.3
15		Visual Description:, Broken Rock, little Sand, gry, MTD, Rec. = 0.4 ft, Rollercone cleanout 19.0-20.0'				12-12-12-25 (24)				
20		Visual Description:, Fine SAND, little Silt, gry-brn, Moist, Rec. = 0.9 ft				6-8-8-5 (16)				
25		Visual Description:, SAND, some Gravel, some Silt, brn, Moist, Rec. = 0.2 ft				6-3-2-3 (5)				
30		Visual Description:, Fine SAND and Silt, some Gravel, brn, Moist, Rec. = 0.8 ft				5-3-3-7 (6)				
35		A-4, Lab Classification: SILT and Sand, little Gravel, brn, MTW, Rec. = 1.3 ft				3-2-7-15 (9)	15.0	12.9	35.5	51.6
40		Visual Description:, SAND, some Gravel, trace Silt, brn, Moist, Rec. = 0.7 ft				32-39-36-33 (75)				
		Visual Description:, Broken Rock, Rec. = 0.3 ft, Refusal at 42.6'. 10 blows/no movement.				48-R@1" (R)				
		Field Note:, No recovery, Refusal at 44.1'. 10 blows/no movement.				R@1"				

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.

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BORING LOG

Rockingham
IM 091-1(81)
I91

Boring No.: **B-101**
Page No.: 2 of 2
Pin No.: 19a190
Checked By: END

Boring Crew: McGinley, Monette, Arles, Zottola
Date Started: 1/24/23 Date Finished: 1/31/23
VTSPG NAD83: N 261653.90 ft E 1652548.10 ft
Station: 2+41.00 Offset: -3.60
Ground Elevation: 566.6 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	3 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	CME 55 TRACK	C_E = 1.52

Groundwater Observations

Date	Depth (ft)	Notes
01/27/23	18.0	WT before drilling
01/31/23	40.5	WT 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 %
		NXDC cleanout. Large stone from 44-45'				(R)				
		A-1-b, Lab Classification: SAND, some Gravel, some Silt, brn, MTW, Rec. = 1.8 ft				14-21-21-40 (42)	15.4	28.9	48.0	23.1
		Visual Description:, SAND and Silt, brn, MTW, Rec. = 0.3 ft, Refusal at 48.4'. 50 blows/0.5'				R@5" (R)				
50		Visual Description:, SAND and Silt, some Gravel, brn, MTW, Rec. = 0.3 ft, Refusal at 50.3'. 50 blows/0.5'				R@3" (R)				
55		Visual Description:, SAND and Silt, some Gravel and Broken Rock., brn, MTW, Rec. = 0.8 ft, Refusal at 55.8'. 50 blowes/0.5'				44-R@4" (R)				
60		A-1-b, Lab Classification: SAND and Gravel, little Silt, brn, MTW, Rec. = 0.7 ft				21-R@5" (R)	15.4	39.5	41.2	19.3
65		Visual Description:, Coarse to fine SAND, trace Silt, gry, Moist, Rec. = 1.7 ft, Refusal at 66.2'. 100 blows. Rollercone cleanout 66.2-70'				29-48-R@2" (R)				
70		70.0 ft - 75.0 ft, Gray, Sulfidic PHYLLITE, Run is highly shattered and fragmented. Weathered surfaces are rust and faintly yellow stained. Soft, Moderately weathered, Poor rock, BX, RMR = 31	R-1 (85-90)	20 (0)	5 3 4 5 4	Top of Bedrock @ 70.0 ft				
75		75.0 ft - 80.0 ft, Gray, Sulfidic PHYLLITE, Run is highly shattered and fragmented. Weathered surfaces are faintly yellow stained and brown stained. Few rust splotches on fresher surfaces. Soft, Moderately weathered, Poor rock, BX, RMR = 31	(90)	40 (0)	4 2 3 2 3					
80		Hole stopped @ 80.0 ft								
		Remarks: Moved boring into shoulder from embankment.								
85										

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
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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.

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BORING LOG

Rockingham
IM 091-1(81)
I91

Boring No.: **B-102**
Page No.: 1 of 2
Pin No.: 19a190
Checked By: END

Boring Crew: McGinley, Monette, Arles, Glow
Date Started: 12/12/22 Date Finished: 12/22/22
VTSPG NAD83: N 261575.30 ft E 1652600.40 ft
Station: 3+17.00 Offset: 51.50
Ground Elevation: 560.0 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	3 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	CME 55 TRACK	C_E = 1.52

Groundwater Observations

Date	Depth (ft)	Notes
12/14/22	22.2	WT before drilling
12/15/22	21.7	WT before drilling
12/20/23	22.3	WT before drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		0.0 ft - 5.0 ft, Rollercone cleanout 4.2-5.0'					
5		A-1-b, Lab Classification: GRAVEL and Sand, little Silt, blk/gry, Moist, Rec. = 1.0 ft, Rollercone cleanout 9.5'-10.0'	14-12-14-25 (26)	9.4	45.7	41.2	13.1
10		Visual Description:, Poorly graded SAND, some Gravel, trace Silt., gry, Moist, Rec. = 0.2 ft, Rollercone cleanout 14.6'-15.0'	12-8-9-8 (17)				
15		Visual Description:, SAND, some Silt, trace Gravel. Broken Rock was within sample, brn/gry, MTW, Rec. = 1.2 ft, Rollercone cleanout 19.2'-20.0'	11-10-8-7 (18)				
20		Visual Description:, Poorly graded SILT, some Sand, trace Gravel., brn/gry, Moist, Rec. = 1.4 ft	4-5-6-11 (11)				
25		Field Note:, No recovery, Rollercone cleanout 29.5'-30.0'	9-10-8-6 (18)				
30		A-4, Lab Classification: SAND and Silt, some Gravel, brn, Moist, Rec. = 1.3 ft, Rollercone cleanout 34.5'-35.0'	4-7-5-6 (12)	12.7	22.3	41.1	36.6
35		Visual Description:, Poorly graded SILT and Sand, some Gravel., brn, Moist, Rec. = 1.2 ft, Rollercone cleanout 39.4'-40.0'	9-10-12-12 (22)				
40		Visual Description:, Poorly graded SILT with some Sand. Wood was within sample., gry, Moist, Rec. = 0.3 ft, Refusal at 40.9'. 10 blows no movement.	12-R@3" (R)				
		Visual Description:, Well graded SAND and Silt, some Gravel. Broken Rock and wood within sample, gry, Moist, Rec. = 0.3 ft	15-28-21-8 (49)				
		A-1-a, Lab Classification: GRAVEL, some Sand, trace Silt, brn/gry, Moist, Rec. = 0.7 ft	8-13-	10.7	68.4	22.8	8.8

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.

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BORING LOG

Rockingham
IM 091-1(81)
I91

Boring No.: **B-102**
Page No.: 2 of 2
Pin No.: 19a190
Checked By: END

Boring Crew: McGinley, Monette, Arles, Glow
Date Started: 12/12/22 Date Finished: 12/22/22
VTSPG NAD83: N 261575.30 ft E 1652600.40 ft
Station: 3+17.00 Offset: 51.50
Ground Elevation: 560.0 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	3 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	CME 55 TRACK	C_E = 1.52

Groundwater Observations

Date	Depth (ft)	Notes
12/14/22	22.2	WT before drilling
12/15/22	21.7	WT before drilling
12/20/23	22.3	WT before drilling

Depth (ft)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
	Visual Description:, Poorly graded SAND, little Silt, trace Gravel., gry, Moist, Rec. = 1.1 ft, Refusal at 46.8' 50 blows/0.5'. Rollercone cleanout 47.5'-48.0'	15-13 (28) 24-R@4" (R)				
	A-1-b, Lab Classification: SAND and Gravel, little Silt, brn/gry, Moist, Rec. = 0.9 ft, Refusal at 49.0' 50 blows/0.5'. Rollercone cleanout 49.7'-50.0'	30-R@6" (R)	11.6	40.0	42.1	17.9
50	Visual Description:, Well graded SAND and Gravel., gry, Moist, Rec. = 0.1 ft, Refusal at 50.8'. 10 blows no movement.	31-R@2" (R)				
55	Field Note:, No recovery, Refusal at 55.0'. 10 blows no movement.	R@0" (R)				
60	Field Note:, No recovery, Refusal at 60.2' 50 blows/0.5'.	R@2" (R)				
	Field Note:, Attempted BX core 61.5'-66.5'. No recovery					
65	Field Note:, Attempted BX core 66.5'-70.0'. No recovery					
70	Field Note:, No recovery, Refusal at 70.0'. 10 blows no movement.	R@0" (R)				
	Field Note:, Attempted BX core 70.0'-75.0'. No recovery					
75	Field Note:, No recovery, Refusal at 75.1'. 50 blows/0.5"	R@1" (R)				
	Field Note:, Attempted BX core 75.0'-80.0'. No recovery					
80	Field Note:, No recovery, Refusal at 80.0'. 10 blows no movement. Hole stopped @ 80.0 ft	R@0" (R)				
85						

Remarks:
Attempted a BX core from 66.5'. Core barrel would not advance past 70'. Pulled core barrel from casing. Outer core barrel separated from inner core barrel.

Notes:
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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.

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

BORING LOG

Rockingham
IM 091-1(81)
I91

Boring No.: **B-103**
Page No.: 1 of 2
Pin No.: 19a190
Checked By: END

Boring Crew: McGinley, Monette, Zottola
Date Started: 12/08/22 Date Finished: 12/13/22
VTSPG NAD83: N 261632.90 ft E 1652602.50 ft
Station: 2+99.00 Offset: -3.10
Ground Elevation: 562.1 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	3 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	CME 55 TRACK	C_F = 1.52

Groundwater Observations

Date	Depth (ft)	Notes
12/09/22	37.5	WT before drilling
12/13/22	37.5	WT 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 %
5		A-1-b, Lab Classification: SAND and Gravel, little Silt, gry, Moist, Rec. = 1.2 ft, Lost water return at 2'. Rollercone cleanout 2.0-5.0'				8-6-5-14 (11)	11.5	39.3	43.5	17.2
10		Visual Description:, Broken Rock with some coarse Sand, gry, Moist, Rec. = 1.3 ft				10-10-14-23 (24)				
15		Visual Description:, SILT and Sand, brn, Moist, Rec. = 0.9 ft, Rollercone cleanout 19.4-20.0'				5-3-6-7 (9)				
20		A-4, Lab Classification: SILT and Sand, little Gravel, brn, Moist, Rec. = 1.2 ft				6-3-5-5 (8)	16.5	12.9	38.4	48.7
25		Visual Description:, SILT and Sand, brn, Moist, Rec. = 0.7 ft				5-7-8-5 (15)				
30		Visual Description:, SILT and Sand, trace Gravel, brn, Moist, Rec. = 0.9 ft				7-7-6-6 (13)				
35		A-1-b, Lab Classification: GRAVEL and Sand, little Silt, gry, Moist, Rec. = 0.2 ft				11-7-17-32 (24)	13.7	47.7	36.5	15.8
40		A-1-b, Lab Classification: GRAVEL, some Sand, some Silt, gry, Moist, Rec. = 1.2 ft, Refusal at 41.7'. 100 blows				12-15-36-R@2" (51) R@5" (R)	13.8	48.1	28.3	23.6
		Visual Description:, Broken Rock, trace Sand and Silt, gry, Moist, Rec. = 0.4 ft, Refusal at 42.4'. 50 blows/0.5'								
		Visual Description:, Broken Rock, some Silt and Sand, Dk/gry, Moist, Rec.				30-				

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.

2010 COPY ROCKINGHAM IM 091.GPJ VERMONT AOT.GDT 9/12/23

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

BORING LOG

Rockingham
IM 091-1(81)
I91

Boring No.: **B-103**
Page No.: 2 of 2
Pin No.: 19a190
Checked By: END

Boring Crew: McGinley, Monette, Zottola
Date Started: 12/08/22 Date Finished: 12/13/22
VTSPG NAD83: N 261632.90 ft E 1652602.50 ft
Station: 2+99.00 Offset: -3.10
Ground Elevation: 562.1 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	3 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	CME 55 TRACK	C_F = 1.52

Groundwater Observations

Date	Depth (ft)	Notes
12/09/22	37.5	WT before drilling
12/13/22	37.5	WT 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 %
		= 0.9 ft, Refusal at 44.9'. 50 blows/0.5'				R@5" (R) R@1" (R)				
		Visual Description:, Broken Rock, Dk/gry, Moist, Rec. = 0.1 ft, Refusal at 46.1'. 10 blows/no movement								
		A-1-b, Lab Classification: GRAVEL and Sand, little Silt, Dk/gry, Moist, Rec. = 0.1 ft, Refusal at 48.2'. 10 blows no movement.	R-1 (85-90)	36 (0)	2 4 6 5 13	R@3" (R)	10.3	48.9	35.3	15.8
50		48.2 ft - 53.2 ft, Gray, Sulfidic PHYLLITE, Run is highly shattered and fragmented. Orange staining along weathered surfaces. Soft, Moderately weathered, Poor rock, BX, RMR = 31								
55		53.2 ft - 58.2 ft, Gray, Sulfidic PHYLLITE, Run is moderately shattered. Vertical fractures are open and rust/orange stained. Medium hard, Moderately weathered, Poor rock, BX, RMR = 31	R-2 (90)	60 (10)	3 3 10 3 5					
60		58.2 ft - 63.2 ft, Gray, Sulfidic PHYLLITE, Run is highly shattered. Vertical fractures are open and rust/orange stained. Soft, Moderately weathered, Poor rock, BX, RMR = 31	R-3 (75-90)	48 (0)	5 3 1 4 3					
		Hole stopped @ 63.2 ft								
65										
		Remarks: 1. Hole collapsed at 28.8'. 2. Top of Bedrock @ 48.0 ft.								
70										
75										
80										
85										

Notes:
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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.

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

BORING LOG

Rockingham
IM 091-1(81)
I91

Boring No.: **B-104**
Page No.: 1 of 2
Pin No.: 19a190
Checked By: END

Boring Crew: McGinley, Monette, Zottola
Date Started: 2/06/23 Date Finished: 2/08/23
VTSPG NAD83: N 261612.10 ft E 1652657.40 ft
Station: 3+58.00 Offset: -3.10
Ground Elevation: 563.0 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	3 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	CME 55 TRACK	C_E = 1.52

Groundwater Observations

Date	Depth (ft)	Notes
02/07/23	28.8	WT before drilling
02/08/23	22.4	WT after drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Field Note:, Asphalt 0-0.55', Rollercone cleanout 4.0-5.0'					
5		Visual Description:, Broken Rock, Dk/brn, Moist, Rec. = 0.2 ft, Rock in end of sampler. BXDC cleanout 8.8'-11.0'.	26-34-20-15 (54)				
10		A-1-b, Lab Classification: GRAVEL and Sand, little Silt, gry, Moist, Rec. = 1.0 ft, Broken Rock. BXDC cleanout 13.0-15.0'	12-15-15-16 (30)	8.1	48.8	39.7	11.5
15		Visual Description:, Broken Rock, gry, Moist, Rec. = 1.0 ft, Advanced casing to 20'	10-10-8-10 (18)				
20		Visual Description:, Broken Rock and Sand, brn, MTW, Rec. = 0.3 ft	16-12-10-6 (22)				
25		A-4, Lab Classification: SILT and Sand, little Gravel, brn, Moist, Rec. = 1.0 ft	9-6-6-6 (12)	13.1	17.0	35.5	47.5
30		Visual Description:, SILT, little Sand, trace Gravel, brn, MTW, Rec. = 0.4 ft	4-2-4-7 (6)				
35		Visual Description:, SILT, little Sand, some Broken Rock, brn, MTW, Rec. = 0.7 ft	4-3-5-8 (8)				
40		A-4, Lab Classification: SILT, some Sand, some Gravel, brn, MTW, Rec. = 1.1 ft	15-7-5-5 (12)	20.4	23.1	31.2	45.7
		Visual Description:, SILT, some Sand, trace Gravel and Broken Rock, brn, Moist, Rec. = 1.5 ft	5-10-12-19 (22)				
		Visual Description:, SILT and Sand, brn, Moist, Rec. = 1.3 ft	21-21-				

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

BORING LOG

Rockingham
IM 091-1(81)
I91

Boring No.: **B-104**
Page No.: 2 of 2
Pin No.: 19a190
Checked By: END

Boring Crew: McGinley, Monette, Zottola
Date Started: 2/06/23 Date Finished: 2/08/23
VTSPG NAD83: N 261612.10 ft E 1652657.40 ft
Station: 3+58.00 Offset: -3.10
Ground Elevation: 563.0 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	3 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	CME 55 TRACK	C_E = 1.52

Groundwater Observations

Date	Depth (ft)	Notes
02/07/23	28.8	WT before drilling
02/08/23	22.4	WT after drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		A-1-b, Lab Classification: SAND and Gravel, some Silt, brn, Moist, Rec. = 1.4 ft	18-25 (39)	11.8	36.6	40.4	23.0
		Visual Description:, SILT, some Sand, some Gravel and Broken Rock, brn, MTW, Rec. = 0.9 ft, Refusal at 49.4'. 100 blows	26-27-21-31 (48)				
50		Visual Description:, SILT, some Sand, some Gravel and Broken Rock, brn, MTW, Rec. = 1.3 ft, Refusal at 51.9'. 100 blows	22-40-R@5" (R)				
			18-25-31-R@5" (56)				
55		Field Note:, No recovery, Refusal at 55.4'. 50 blows/0.5'. Casing would not advance beyond 57'	R@5" (R)				
		Field Note:, No recovery, Attempted BX core 57'-62'					
60							
65		A-1-a, Lab Classification: GRAVEL, some Sand, little Silt, brn/gry, MTW, Rec. = 0.3 ft, Refusal at 65.3' 50 blows/0.5'.	R@3" (R)	9.2	51.7	33.7	14.6
70		Field Note:, No recovery, Refusal at 70.4'. 50 blows/0.5'.	R@5" (R)				
75		Field Note:, No recovery, Refusal at 75.0' 10 blows no movement.	R@0" (R)				
80		A-1-b, Lab Classification: SAND and Gravel, Some Silt, brn/gry, Moist, Rec. = 0.4 ft, Refusal at 80.4'. 50 blows/0.5'.	R@5" (R)	14.5	38.2	50.0	11.8
		Hole stopped @ 80.4 ft					
85		Remarks: 1. Moved boring into shoulder from embankment. 2. Hole Collapsed at 26.7'. 3. Casing advanced very slowly from 9.5'-10.0'.					

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

BORING LOG

Rockingham
IM 091-1(81)
I91

Boring No.: **B-201**
Page No.: 1 of 2
Pin No.: 19A190
Checked By: JAG

Boring Crew: B. Thompson, NEBC, J. Cassara, GEODesign
Date Started: 6/26/23 Date Finished: 6/26/23
VTSPG NAD83: N 261643.00 ft E 1652583.60 ft
Station: 2+78.00 Offset: -5.9
Ground Elevation: 564.3 ft

	Casing	Sampler
Type:	FJ	SS
I.D.:	4 in	1.38 in
Hammer Wt:	300	140 lb.
Hammer Fall:	30 in.	30 in.
Hammer/Rod Type:		Safety
Rig: Mobile B-53 Track		C_e = 0.85

Groundwater Observations		
Date	Depth (ft)	Notes
		See Remarks

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 %
		Topsoil								
		Possible Fill								
5										
10										
15										
20										
25										
30										

Notes:

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

BORING LOG

Rockingham
IM 091-1(81)
I91

Boring No.: **B-201**
Page No.: 2 of 2
Pin No.: 19A190
Checked By: JAG

Boring Crew: B. Thompson, NEBC, J. Cassara, GEODesign
Date Started: 6/26/23 Date Finished: 6/26/23
VTSPG NAD83: N 261643.00 ft E 1652583.60 ft,
Station: 2+78.00 Offset: -5.9
Ground Elevation: 564.3 ft

	Casing	Sampler
Type:	FJ	SS
I.D.:	4 in	1.38 in
Hammer Wt:	300	140 lb.
Hammer Fall:	30 in.	30 in.
Hammer/Rod Type:		Safety
Rig: Mobile B-53 Track		C_e = 0.85

Groundwater Observations

Date	Depth (ft)	Notes
		See Remarks

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 %
40		Possible Glacial Till								
45		Possible Weathered Bedrock								
50		49.5 ft to 54.5 ft, Gray, soft to moderately hard, fresh to slightly weathered along fracture surfaces, shattered to very closely jointed, very poor quality PHYLLITE. Fracturing 60-75 degrees from horizontal. Silt/clay infill observed on one fracture. NQ2	C1	30 (0)	2					
					3.25					
					3					
					3.5					
					3.5					
55		54.5 ft to 59.5 ft, Gray, soft to moderately hard, fresh to slightly weathered along fracture surfaces, very closely to closely jointed, very poor quality PHYLLITE. Fracturing typ. 60-75 degrees from horizontal and near vertical. NQ2	C2	100 (22)	3.5					
					4					
					3					
					3.75					
					2.5					
60		Hole stopped @ 59.5 ft Borehole Terminated in Bedrock								
65										

Remarks:
1) Ground surface elevation estimated from topographic base plan provided by VTrans.
2) Wash and drive drilling methods used to advance borehole. Groundwater observations were not recorded.
3) Grayish-brown wash water observed 0-5' deep, with dark reddish gray rock chips.
4) Gray wash water observed 5-15' deep, with small piece of wood noted.
5) Brown wash water observed below 15' deep, with smaller rock chips. Became siltier at 28' deep (silt balls observed).
6) Increased drilling resistance about 27.5' deep. Wash water sandier. Rock chips observed at 29' deep.
7) Olive gray to light brown wash water observed below 35' deep, with small piece of wood noted.
8) Increased drilling resistance at 39.5'. Rig chatter observed 40-42' deep.
9) White rock chips observed 45.5' deep, gray rock chips observed 46.5' deep.

Notes:

STATE OF VERMONT
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CONSTRUCTION AND MATERIALS
BUREAU CENTRAL LABORATORY

BORING LOG

Rockingham
IM 091-1(81)
I91

Boring No.: **B-202**
Page No.: 1 of 3
Pin No.: 19A190
Checked By: JAG

Boring Crew: B. Thompson, NEBC, J. Cassara, GEODesign
Date Started: 6/27/23 Date Finished: 6/27/23
VTSPG NAD83: N 261618.60 ft E 1652614.40 ft
Station: 3+15.00 Offset: 6.0
Ground Elevation: 563.4 ft

	Casing	Sampler
Type:	FJ	SS
I.D.:	4 in	1.38 in
Hammer Wt:	300	140 lb.
Hammer Fall:	30 in.	30 in.
Hammer/Rod Type:		Safety
Rig: Mobile B-53 Track		C_E = 0.85

Groundwater Observations		
Date	Depth (ft)	Notes
		See Remarks

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Topsoil					
		Possible Fill					
5							
10							
15							
20							
25							
30							

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 of groundwater may occur due to other factors than those present at the time measurements were made.

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

BORING LOG

Rockingham
IM 091-1(81)
I91

Boring No.: **B-202**
Page No.: 2 of 3
Pin No.: 19A190
Checked By: JAG

Boring Crew: B. Thompson, NEBC, J. Cassara, GEODesign
Date Started: 6/27/23 Date Finished: 6/27/23
VTSPG NAD83: N 261618.60 ft E 1652614.40 ft
Station: 3+15.00 Offset: 6.0
Ground Elevation: 563.4 ft

	Casing	Sampler
Type:	FJ	SS
I.D.:	4 in	1.38 in
Hammer Wt:	300	140 lb.
Hammer Fall:	30 in.	30 in.
Hammer/Rod Type:		Safety
Rig: Mobile B-53 Track		C_E = 0.85

Groundwater Observations		
Date	Depth (ft)	Notes
		See Remarks

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
40		Rec. = 0.7 ft	3-4/2"				
45							
50		Possible Glacial Till (with Cobbles/Boulders)					
55							
60		Rec. = 1.8 ft	37-68-127-134/4"				
65		Hole stopped @ 64.0 ft Borehole Terminated with No Refusal					

Remarks:
1) Ground surface elevation estimated from topographic base plan provided by VTrans.
2) Wash and drive drilling methods used to advance borehole. Groundwater observations were not recorded.
3) Installed 4" ID casing to 5' deep. Advanced open hole to 49' deep. Telescoped 3" ID casing to 49.5' deep (spun to 47', hammered to 49.5').

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

BORING LOG

Rockingham
IM 091-1(81)
I91

Boring No.: **B-202**
Page No.: 3 of 3
Pin No.: 19A190
Checked By: JAG

Boring Crew: B. Thompson, NEBC, J. Cassara, GEODesign
Date Started: 6/27/23 Date Finished: 6/27/23
VTSPG NAD83: N 261618.60 ft E 1652614.40 ft
Station: 3+15.00 Offset: 6.0
Ground Elevation: 563.4 ft

	Casing	Sampler
Type:	FJ	SS
I.D.:	4 in	1.38 in
Hammer Wt:	300	140 lb.
Hammer Fall:	30 in.	30 in.
Hammer/Rod Type:		Safety
Rig: Mobile B-53 Track		C_E = 0.85

Groundwater Observations		
Date	Depth (ft)	Notes
		See Remarks

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
75		4) Grayish brown wash water observed 0-13.5' deep (with phyllite rock chips). Brown wash water typically observed below 13.5' deep (appears siltier with silt balls observed). 5) Wood splinters observed in wash water 35-40' deep. 6) Inferred steel at 42' deep due to drilling resistance and filings observed in wash water. Wash water lost upon initial contact (+/- 150 gals), during driving 3" ID casing through the steel (+/- 75 gals), and flushing out casing. SS sample attempted 42-43' to punch through steel. 7) Increased drilling resistance observed 49-54' deep through possible cobbles/boulder or dense glacial till. Reduced resistance below 54' with smoother advance. 8) Little to no water return 55-60' deep (sand and rock chips observed in wash). 9) Attempted SS sample 59-61' deep, then advanced borehole to 64' deep using roller bit. Attempted final SS sample but noted borehole collapse at +/- 54' deep.					
80							
85							
90							
95							
100							

Notes:
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3. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.