AGENCY OF TRANSPORTATION **OFFICE MEMORANDUM**

To: Ken Upmal, P.E., Roadway Design Project Manager

END CEE

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

Date: January 13, 2016

Subject: Cabot-Danville FEGC-F 028-3(26) – Bridge No. 87 Integral Abutments

1.0 INTRODUCTION

We have completed our geotechnical investigation for the subject project located on US Route 2 near MM 2.9 in Cabot, Vermont crossing Molly's Brook. The proposed project includes the removal of the existing Bridge No. 87 and replacing it with a 44.8 foot single span NEXT Beam Bridge with associated roadway and channel work. A previous geotechnical report dated September 12, 2012 provided results from the initial subsurface investigation and recommendations for spread footings. Following review of preliminary plans and additional discussions with the Structures section, the substructure was changed from abutments supported on spread footings to integral abutments supported on piles. Contained herein are the results from our additional subsurface investigation, geotechnical analysis and recommendations for integral abutments supported on piles as determined using the 2014 AASHTO *LRFD Bridge Design Specifications.*

2.0 FIELD INVESTIGATION

The field investigation was conducted between November 16, 2015 and December 8, 2015. Three standard penetration borings were drilled to determine the subsurface profiles in order to aid in design and construction of the bridge foundations supported on piles. Boring locations were provided by Mike Cruz and Erik Atkins of Green International with the Geotechnical Services Request Form dated August 7, 2015. 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-205	14+69.4	-21.75	681931.00	1700535.32	1426.10
B-206	14+63.6	18.21	681890.21	1700537.16	1429.83
B-207	15+7.35	18.92	681895.49	1700580.40	1429.83

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-205, split spoon samples and standard penetration tests (SPT) were taken continuously to 25 feet, then at 5 foot intervals to 60 feet, and at 10 foot intervals to a depth of 95 feet. For boring B-206, samples and SPTs were taken continuously to 25 feet, then at 5 foot intervals to 50 feet, and 10 foot intervals to a depth of 100 feet. For boring B-207, samples and SPTs were taken continuously to 25 feet then at 5 foot intervals to 40 feet and 10 foot intervals to a depth of 100 feet. Bedrock was not encountered in any of the borings. 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 Construction and Materials Bureau Central Laboratory for testing and further evaluation. Upon completion of the laboratory testing, the boring logs were revised to reflect the results of the laboratory classification analysis.

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 boring B-205, a CME 45C Track Rig was used, with a hammer energy correction factor of 1.34. For borings B-206 and B-207, a CME 55 Track Rig was used with a hammer energy correction factor of 1.46. These values, included on the boring logs, were 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.

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-205 (Abutment 1): The ground surface elevation at B-205 was approximately 1426.1 feet. The groundwater was measured during drilling on November 12, 2015 at a depth of 6.4 feet below the ground surface. No bedrock was encountered to a depth of 95.4 feet. Thin layers of clay were found within the samples from 30 to 62 feet; however those samples tested non-plastic.

Depth (Below Ground Surface Elevation)	Soil Profile
0 – 8 feet	Loose Silty Sand
8 – 16 feet	Dense Sandy Gravelly Silt
16 – 22 feet	Very Dense Sandy Silty Gravel
22 – 58 feet	Dense Silt
58 – 95.4 feet	Very Dense Silt

B-206 (Abutment 1): The ground surface elevation at B-206 was approximately 1429.8 feet. The groundwater was measured before drilling on December 1, 2015 at a depth of 8.9 feet below the ground surface. No bedrock was encountered to a depth of 100.7 feet. Thin layers of clay were found within the samples from 30 to 72 feet; however those samples tested non-plastic.

Depth (Below Ground Surface Elevation)	Soil Profile
0 – 0.85 feet	Asphalt
1 – 17 feet	Dense Silty Gravelly Sand
17 – 25 feet	Dense Sandy Silt
25 – 75 feet	Dense Silt
75 – 100.7 feet	Very Dense Sandy Silt

B-207 (Abutment 2): The ground surface elevation at B-207 was approximately 1429.8 feet. The groundwater was measured before drilling on November 20, 2015 at a depth of 7.7 feet below the ground surface. No bedrock was encountered to a depth of 100.4 feet. Thin layers of clay were found within samples from 40 to 62 feet; however those samples tested non-plastic.

Depth (Below Ground Surface Elevation)	Soil Profile
0 – 0.94 feet	Asphalt
1 – 17 feet	Medium Dense Silty Sand
17 – 36 feet	Medium Dense Sandy Silt
36 – 76 feet	Dense Silt
76 – 100.4 feet	Very Dense Gravelly Sand/ Silty Sand

5.0 ANALYSIS

Developed by the Florida Bridge Software Institute, FB-Multipier, version 4.19.4, is a multi-aspect software that allows the user to analyze a bridge pier system in three dimensions. Its analysis factors in the subsurface strata, pile group including cap, and the structural capabilities of the pier system. For this integral abutment analysis, only the piles and cap were modeled.

5.1 Loads: Unfactored loads were provided by Mike Cruz and Erik Atkins of Green International in the Geotechnical Services Request Form dated August 7, 2015. The dead load (DC) provided did not include the weight of the pile cap so the weight of the pile cap was calculated and included in the analyses. The loads used can be found in Table 5.1. A total expected thermal movement of 0.13 inches/abutment was calculated based on the thermal expansion coefficient of the concrete NEXT Beams, the expected temperature range, and the length of the structure in accordance with AASHTO Section 3.12.2. A live load rotation of 0.01 radians per abutment was assumed for the analysis based on past projects of similar type and magnitude.

Table 5.1: Unfactored Loads

Type	Unfactored Loads/Abutment	Load Orientation
Dead Loads, DC	692.12 kips	Vertical
Wearing Loads, DW	37.63 kips	Vertical
Live Loads, LL	177.07 kips	Vertical

Our common practice, as outlined in the 2008 VTrans Integral Abutment Manual, is to apply vertical live and dead loading, as well as longitudinal effects from thermal deformations, brake forces, and rotation due to live loading. FB-Pier does not consider the longitudinal and transverse stiffness provided by the entire bridge structure; it models the abutment or pier standing alone. Due to this as well as guidance from other state's bridge manuals, it is assumed that all wind and braking forces are to be resisted by the stiffness of the frame that is not accounted for in design.

The loads provided in Table 5.1 were factored according to AASHTO LRFD Table 3.4.1-1. The governing Strength I load case resulted in a factored axial load of 1231 kips distributed over each abutment resulting in a maximum axial load equal to 246 kips per pile for a five pile layout.

5.2 Modeling: Due to the varying soil conditions on either side of the bridge, two soil profiles were developed and modeled in FB-Pier. Soil information from boring B-206 was used for Abutment 1 and soil information from B-207 was used for Abutment 2. The piles were analyzed for strength and service at both the non-scour and scour condition. A bottom of pile cap elevation of 1421 feet, provided in the revised preliminary plans dated July 2014, was used for both abutments in the analyses. Per general recommendations from the VTrans Hydraulics Section, a minimum scour depth of 6 feet below the thalweg was used in analyses which resulted in a scour elevation of 1412.8 feet.

The abutments were modeled as having a 9 foot high, 3.5 feet thick, and 50.25 feet long pile cap with 5 HP 12x63 piles spaced at 8.5 feet on center. All piles are assumed to be driven plumb and oriented for weak axis bending. Figure 5.1 below shows the pile layout for both abutments.

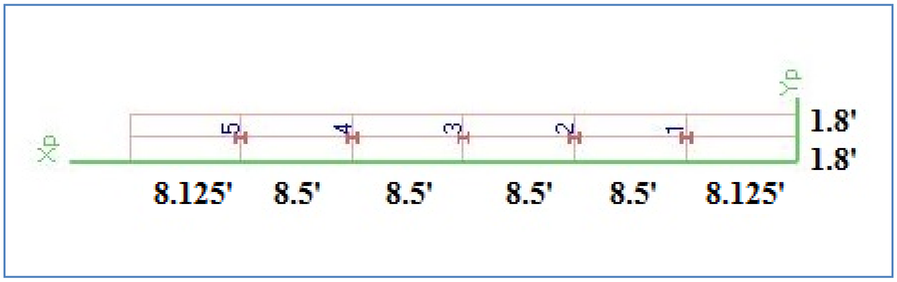


Figure 5.1: Abutment Pile Layout

6.0 RESULTS

6.1 Pile Stresses: Five HP 12x63 piles were modeled for both the non-scour and scour condition. The piles were checked for combined axial compression and flexure under both non-scour and scour conditions using the requirements of AASHTO LRFD 6.9.2.2. An FB-Pier analysis was performed by applying an axial load, lateral load and corresponding moment, a deflection, and a rotation at the top of each pile under AASHTO LRFD Strength Case I. The output from FB-Pier was used to calculate the factored structural and flexure pile resistance as well as the moment that would cause a plastic hinge in the pile, in accordance with VTrans 2008 Integral Abutment Bridge Design Guidelines. A plastic hinge consistently formed in the top segment of the pile in the analysis run with the non-scour soil condition. This occurred when the applied moment exceeded the plastic moment. An analysis was then performed to ensure that a plastic hinge would not form in the second segment of the pile, which would overstress the pile and cause the pile to fail. The second segment of the pile was considered to be between the two points of zero moment when a fixed head condition was modeled. FB-Pier outputs as well as calculated values are displayed below in Table 6.1 and 6.2, for Abutments No. 1 and No. 2 respectively, for an assumed 85 foot pile.

Table 6.1: FB-Pier Output for AASHTO Strength Case I –Abutment 1

Soil Condition	Max. Applied Moment (kip-ft)	Plastic Moment** (kip-ft)	2nd Pile Segment Interaction	Factored Lateral Load (kips)	Unbraced Length (feet)	Fixity* (feet)
Non-Scour	103.3	96.8	0.48	20.2	6	27
Scour	63.3	86.9	0.55	7.5	9	34

** Moment resulting in plastic hinge development. This moment becomes constant at pile head after pile begins to plastically deform.
* Measured from top of pile head

Table 6.2: FB-Pier Output for AASHTO Strength Case I –Abutment 2

Soil Condition	Max. Applied Moment (kip-ft)	Plastic Moment** (kip-ft)	2nd Pile Segment Interaction	Factored Lateral Load (kips)	Unbraced Length (feet)	Fixity* (feet)
Non-Scour	104.7	99.7	0.47	21.0	8	27
Scour	64.9	92.5	0.53	7.9	11	29

** Moment resulting in plastic hinge development. This moment becomes constant at pile head after pile begins to plastically deform.
* Measured from top of pile head

As shown in Tables 6.1 and 6.2, in the scour condition, the maximum applied moment is less than the plastic moment calculated; therefore a plastic hinge does not develop in the top segment of the pile during scour condition. The factored lateral load in this table is the load applied to the top of the pile to achieve the required deflection times a load factor of 1.2.

6.2 Axial Capacity Analysis: To aid in estimating pile lengths, the minimum length needed to resist the factored design load based on dynamic testing needed to be calculated. This is assuming the pile could achieve sufficient resistance primarily in skin friction as bedrock was not encountered in the borings. With a factored load of 246 kips, and a resistance factor, ϕ_{dyn} = 0.65, a nominal axial pile resistance of 378 kips is required.

Using the Nordlund method for cohesionless soils, unit skin friction values were calculated for each soil layer. Based on these values, the length of pile needed to resist the 378 kip load was calculated to be 65 feet, measured from the bottom of the pile cap. However, based on past experience with piles tending to run in similar soil conditions, we recommend pile lengths of 85 feet be used for estimating and plan preparation purposes.

The resistance factor of 0.65 requires a minimum of 2 dynamic tests performed per site condition, but no less than 2% of the production piles, during installation in accordance with Table 10.5.5.2.3-1 of the AASHTO LRFD code. No less than 1 test shall be performed at each abutment. The remaining piles should be calibrated by wave equation analysis.

6.3 Pile Cap Design: The backwall can be designed as a horizontal beam resisting lateral earth pressures. The lateral earth pressure is generated by the movement of the abutment either into (passive earth pressure) or away from (active earth pressure) the soil mass. Passive earth pressure conditions may govern during the warmer months as the structure expands. Similarly, an active earth pressure condition may control during the colder months of the year as the superstructure contracts.

Assuming distances of 7.6 feet and 8.3 feet from the bottom of the approach slab to the bottom of the pile cap for Abutments No. 1 and No. 2 respectively, and the abutment experiencing all of the lateral movement, then the full passive pressure condition would be met. This would produce a passive earth pressure coefficient larger than an active earth pressure coefficient. Therefore, it is conservative to design for the full passive pressure condition at the abutment.

Equation 1: $K_p = (1 + \sin\phi)/(1 - \sin\phi)$

Equation 2: $w_p = {}^{1}/_{2}\, \gamma\, H^2\, K_p$

The passive earth pressure per unit length of backwall can be calculated by inserting the value of K_p, computed in Equation 1, into Equation 2. The backfill unit weight is assumed to be equal to 135 pcf with an internal friction angle of 34 degrees. Based on these assumptions and Equations 1 and 2, the total passive earth pressure per unit length of the backwall is calculated to be equal to13.8k/ft and 16.4 k/ft for Abutments No. 1 and No. 2 respectively.

6.4 Downdrag Analysis: Negative skin friction, or downdrag, is considered when the relative settlement between the pile and soil equals or exceeds 0.4 inches according to AASHTO 3.11.8. The proposed roadway does not vary significantly in grade with the existing roadway and as a result will not require large amounts of fill. Therefore, neither settlement nor downdrag due to an additional roadway surcharge is expected.

6.5 Driving Resistances: Past experience suggests that the HP 12x63 piles analyzed in this report could be driven through the soils encountered by pile-driving equipment commonly used by contractors in the region. Section 10.7.8 of the AASHTO LRFD Bridge Design Specifications stipulates that the maximum tension and compression stresses allowed in the piles shall not exceed $\sigma = 0.9 * \phi_{da} * f_y$. ϕ_{da} as defined in AASHTO LRFD 6.5.4.2 as 1.0, resulting in a maximum induced stress in the pile of $0.9 * f_y$ or 45 ksi for grade 50 (50 ksi) piles. However, wave equation analyses only verify that the piles can be driven to a factored resistance; the program is not able to determine the location and size of boulders.

7.0 RECOMMENDATIONS

7.1 Integral Abutment Foundations: 5 HP 12x63 piles organized in a single row spaced at 8.5 feet center to center spacing will satisfy the requirements for design at both abutments. The piles are anticipated to be driven to a nominal axial resistance of 378 kips. The minimum required embedment for the piles is 28 feet below bottom of footing for both abutments. Pile lengths for estimating purposes should be assumed to be 85 feet below the bottom of footing for both abutments.

7.2 Construction Considerations:

7.2.1 Cofferdams/Temporary Earthwork Support: With the bottom of pile cap (Elevation 1421 ft) estimated to be located below ordinary high water (Elevation 1421.4 ft), cofferdams may be necessary. If required, the Contractor should be reminded that Section 208.07 of VTrans' *2011 Standard Specifications for Construction* indicates that "The Contractor shall prepare detailed plans and a schedule of operation for each cofferdam specified in the Contract. The design and structural details of the cofferdam shall be signed, stamped, and dated by a Professional Engineer (Structural or Civil)."

7.2.2 Construction Dewatering: Temporary construction dewatering may be required to construct the abutments. Temporary dewatering may also be necessary to limit disturbance to and maintain the integrity of the bearing surface. Temporary dewatering can likely be accomplished by open pumping from shallow sumps, temporary ditches, and trenches within and around the excavation limits. Sumps should be provided with filters suitable to prevent pumping of fine-grained soil particles. The water trapped by the temporary dewatering controls should be discharged to settling basins or an approved filter "sock" so that the fine particles suspended in the discharge have adequate time to "settle out" prior to discharge. All effluent, or discharge, should comply with all applicable permits and regulations.

7.2.3 Placement and Compaction of Soils: Fills should be placed systematically in horizontal layers not more than 12 inches in thickness, prior to compaction. Cobbles larger than 8 inches should be removed from the fill prior to placement. Compaction equipment should preferably consist of large, self-propelled vibratory rollers. Where hand-guided equipment, such as a small vibratory plate compactor, is used, the loose lift thickness shall not exceed 6 inches. Cobbles larger than 4 inches should be removed from the fill prior to placement.

Embankment fills should be compacted to a dry density of at least 95% of the maximum dry density determined in accordance with AASHTO T-99. The current specification calls for 90%, however we are in the process of revising it to be 95% as recommended above. Granular Backfill for Structures, or other select materials placed within the roadway base section shall be compacted to a dry density of 95% of the maximum dry density determined in accordance with AASHTO T-99.

7.2.4 Roadway/Embankment Design: No geotechnical problems are expected assuming standard Agency construction practices are utilized.

7.3 Design Parameters: Table 7.1 highlights the geotechnical design parameters of the foundation bearing soil as well as regularly specified aggregates. 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.

Table 7.1 Engineering Properties for Construction and In-Situ Materials

	703.01A - Granular Borrow	704.08 - Granular Backfill for Structures	B-206 In-Situ M. Dense SiGrSa	B-207 In-Situ Dense SiSa
Density (lb/ft^3):	130	135	115	120
Internal Friction Angle, φ (degrees)	32	34	35	36
Coefficient of Friction, f				
- concrete cast against soil:	0.50	0.55	0.45	0.40
- soil against formed concrete	0.40	0.45	0.31	0.31
Active Earth Pressure Coefficient, K_a:	0.31	0.28	0.27	0.26
Passive Earth Pressure Coefficient, K_p:	3.25	3.53	3.69	3.85
At-Rest Earth Pressure Coefficient, K_o:	0.47	0.44	0.43	0.41

8.0 CONCLUSION

If any further analysis is needed or you would like to discuss this report, please contact us at (802) 828-2561. Computer generated boring logs are attached and available in the *M:\Projects\78d347\MaterialsResearch* folder. FB-Pier input file are located in the *M:\Projects\78d347\MaterialsResearch\FB-Pier* folder:

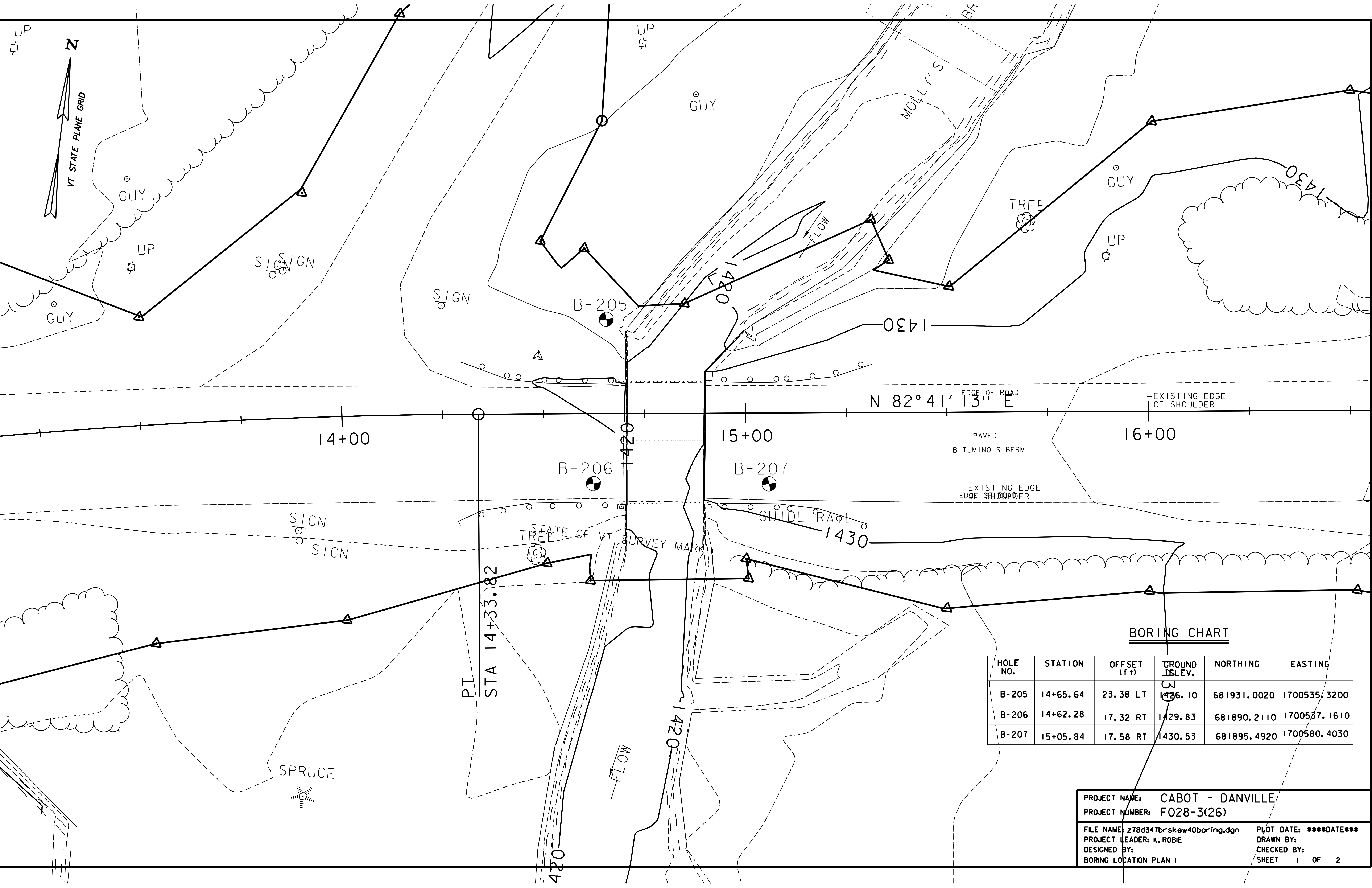
ABUT 1 STR I B-206.IN
ABUT 1 STR I B-206 Scour.IN
ABUT 1 SER I B-206.IN
ABUT 1 SER I B-206 Scour.IN

ABUT 2 STR I B-207.IN
ABUT 2 STR I B-207 Scour.IN
ABUT 2 SER I B-207.IN
ABUT 2 SER I B-207Scour.IN

Attachments: Boring Location Plan (1 pages)
Boring Logs (6 pages)

cc: Erik Atkins, Green International
Mike Cruz, Green International
Electronic Read File/DJH
Project File/CEE
END

Z:\Highways\ConstructionMaterials\GeotechEngineering\Projects\Cabot-Danville FEGC-F 028-3(26) C2\REPORTS\Cabot-Danville FEGC-F 028-3(26) Integral Abutments.docx



BORING CHART

HOLE NO.	STATION	OFFSET (ft)	GROUND ELEV.	NORTHING	EASTING
B-205	14+65.64	23.38 LT	1426.10	681931.0020	1700535.3200
B-206	14+62.28	17.32 RT	1429.83	681890.2110	1700537.1610
B-207	15+05.84	17.58 RT	1430.53	681895.4920	1700580.4030

PROJECT NAME: CABOT - DANVILLE
PROJECT NUMBER: F028-3(26)

FILE NAME: z78d347brskew40boring.dgn
PROJECT LEADER: K. ROBIE
DESIGNED BY:
BORING LOCATION PLAN 1

PLOT DATE: $$$$DATE$$$
DRAWN BY:
CHECKED BY:
SHEET 1 OF 2

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

BORING LOG

CABOT-DANVILLE
FEGC-F 028-3(26) C/2
US-2 BR-87

Boring No.:	**B-205**
Page No.:	1 of 2
Pin No.:	78d347
Checked By:	END

Boring Crew: JUDKINS, HOOK
Date Started: 11/16/15 Date Finished: 11/17/15
VTSPG NAD83: N 681931.00 ft E 1700535.32 ft
Station: 14+69.4 Offset: -21.75
Ground Elevation: 1426.1 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 TRACK	C_E = 1.34

Groundwater Observations

Date	Depth (ft)	Notes
11/12/15	6.4	W.T. During Drilling
11/13/15	7.9	W.T. During Drilling
11/17/15	7.2	W.T. During Drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		A-2-4, SiGrSa, Dk/gry, Moist, Rec. = 1.1 ft, Lab Note: Sticks and plant roots were within sample.	WH-1-1-3 (2)	14.7	21.0	58.1	20.9
		A-4, SiSa, Dk/gry, Moist, Rec. = 1.2 ft	WH-WH-1-1 (1)	25.4	0.1	57.7	42.2
		A-2-4, SiSa, Dk/gry, Moist, Rec. = 2.0 ft	1-2-1-1 (3)	32.8	0.5	69.9	29.6
		A-4, SiSa, brn-gry, Moist, Rec. = 1.1 ft, Lab Note: Small pieces of wood were within sample.	WH-1-7-4 (8)	26.5	13.5	50.7	35.8
		A-2-4, Sa, brn, Wet, Rec. = 1.0 ft, Lab Note: Broken rock and small pieces of wood were within sample.	5-6-8-6 (14)	45.6	15.4	69.3	15.3
10		A-4, SaGrSi, gry, Moist, Rec. = 0.5 ft	6-9-11-8 (20)	11.1	28.5	27.5	44.0
				44.9	17.2	63.6	19.2
		A-2-4, Sa, brn, Wet, Rec. = 1.0 ft		11.7	33.2	32.8	34.0
		Field Note:, Cleanout with NXDC	19-15-13-18 (28)	10.2	41.2	22.3	36.5
		A-2-4, SaGrSi, gry, Moist, Rec. = 0.5 ft, Lab Note: Broken rock was within sample.					
		A-4, SaSiGr, gry, Moist, Rec. = 0.7 ft, Lab Note: Broken rock was within sample. Field Note:, Cleanout with NXDC	9-4-8-5 (12)				
		Field Note:, No Recovery	12-26-32-20 (58)	10.7	46.2	20.8	33.0
		A-2-4, SaSiGr, gry, Moist, Rec. = 1.1 ft, Lab Note: Broken rock was within sample. Field Note:, Cleanout with NXDC	27-27-37-R@1" (64)	10.2	38.5	24.4	37.1
20		A-4, SaSiGr, gry, Moist, Rec. = 1.0 ft, Lab Note: Broken rock was within sample. A-4, SaGrSi, gry, Moist, Rec. = 1.5 ft, Lab Note: Broken rock was within sample.	14-17-20-24 (37)	10.7	35.8	22.2	42.0
		Field Note:, Cleanout with NXDC					
		A-4, Si, gry, Moist, Rec. = 1.6 ft Field Note:, Cleanout with NXDC	10-10-15-16 (25)	22.3	0.9	9.0	90.1
		A-4, Si, gry, Moist, Rec. = 1.7 ft	4-8-8-13 (16)	24.9	0.3	6.6	93.1
		Field Note:, Cleanout with roller cone					
30		A-4, Si, gry, Moist, Rec. = 1.5 ft, Lab Note: Sample tested non-plastic. Thin layers of clay were within sample.	5-9-11-16 (20)	32.2	0.1	1.1	98.8
		Field Note:, Cleanout with roller cone					
		A-4, Si, gry, Moist, Rec. = 1.6 ft, Lab Note: Sample tested non-plastic. Thin layers of clay were within sample.	6-12-14-22 (26)	29.1		1.6	98.4
40		Field Note:, Cleanout with roller cone					
		A-4, Si, gry, Moist, Rec. = 1.9 ft, Lab Note: Sample tested non-plastic. Thin layers of clay were within sample.	5-9-14-18 (23)	30.0		0.6	99.4
		Field Note:, Cleanout with roller cone					
		A-4, Si, gry, Moist, Rec. = 2.0 ft, Lab Note: Sample tested non-plastic. Thin layers of clay were within sample. Field Note:, Cleanout with NXDC	5-9-12-15 (21)	30.8	0.5	0.6	98.9
50		A-4, Si, gry, Moist, Rec. = 2.0 ft, Lab Note: Sample tested non-plastic. Thin layers of clay were within sample.	9-13-15-19	29.7		0.3	99.7

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.

STATE OF VERMONT AGENCY OF TRANSPORTATION CONSTRUCTION AND MATERIALS BUREAU CENTRAL LABORATORY	BORING LOG **CABOT-DANVILLE** **FEGC-F 028-3(26) C/2** **US-2 BR-87**	Boring No.: **B-205** Page No.: 2 of 2 Pin No.: 78d347 Checked By: END	

Boring Crew: JUDKINS, HOOK
Date Started: 11/16/15 Date Finished: 11/17/15
VTSPG NAD83: N 681931.00 ft E 1700535.32 ft
Station: 14+69.4 Offset: -21.75
Ground Elevation: 1426.1 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 TRACK	C_E = 1.34

Groundwater Observations

Date	Depth (ft)	Notes
11/12/15	6.4	W.T. During Drilling
11/13/15	7.9	W.T. During Drilling
11/17/15	7.2	W.T. During Drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
			(28)				
		Field Note:, Cleanout with roller cone					
		A-4, Si, gry, Moist, Rec. = 1.7 ft, Lab Note: Sample tested non-plastic. Thin layers of clay were within sample.	6-11-15-21 (26)	32.0	0.1	0.6	99.3
		Field Note:, Cleanout with roller cone					
60		A-4, Si, gry, Moist, Rec. = 0.8 ft, Lab Note: Sample tested non-plastic. Thin layers of clay were within sample.	8-R@3.5" (R)	23.6	6.9	5.9	87.2
		Field Note:, Cleanout with NXDC					
		Field Note:, No Recovery	R@0" (R)				
		Field Note:, Cleanout with NXDC					
70		Field Note:, No Recovery	R@3.5" (R)				
		Field Note:, Cleanout with NXDC					
		Field Note:, No Recovery	R@1" (R)				
		Field Note:, Cleanout with NXDC					
80		Field Note:, No Recovery	R@5" (R)				
		Field Note:, Cleanout with NXDC					
		Field Note:, No Recovery	R@0" (R)				
90		Field Note:, Cleanout with NXDC					
		Field Note:, No Recovery	R@2.5 (R)				
		Field Note:, Cleanout with NXDC					
		A-4, GrSiSa, gry, Moist, Rec. = 0.2 ft, Lab Note: Broken rock was within sample	R@5" (R)	9.2	24.8	32.0	43.2
		Hole stopped @ 95.4 ft					
100		Remarks: Hole Collapsed at 28.2 feet. 1.) Appears to be Si Sa with cobbles and boulders 65.0 feet to 95.0 feet. 2.) 30 feet of casing broke off and remains in the ground.					

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.

STATE OF VERMONT AGENCY OF TRANSPORTATION CONSTRUCTION AND MATERIALS BUREAU CENTRAL LABORATORY	BORING LOG **CABOT-DANVILLE** **FEGC-F 028-3(26) C/2** **US-2 BR-87**	Boring No.: **B-206** Page No.: 1 of 2 Pin No.: 78d347 Checked By: END

Boring Crew: NIETO, JUDKINS, GARROW

Date Started: 11/30/15 Date Finished: 12/08/15

VTSPG NAD83: N 681890.21 ft E 1700537.16 ft

Station: 14+63.6 Offset: 18.21

Ground Elevation: 1429.83 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 55 TRACK	C_E = 1.46

Groundwater Observations

Date	Depth (ft)	Notes
12/01/15	8.9	W.T. before drilling
12/07/15	10.1	W.T. before drilling
12/08/15	10.5	W.T. after drilling

Depth (ft)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
	Asphalt Pavement, 0.0 ft - 0.85 ft					
	A-1-b, SiGrSa, brn, Moist, Rec. = 1.2 ft	10-15-11-10 (26)	10.0	33.5	45.4	21.1
	A-2-4, SiGrSa, brn, Moist, Rec. = 1.1 ft	9-8-9-8 (17)	9.7	21.7	56.8	21.5
	A-2-4, SiSa, brn, Moist, Rec. = 1.1 ft	9-8-7-9 (15)	8.7	16.9	60.6	22.5
	A-2-4, SiGrSa, brn, Wet, Rec. = 0.4 ft	5-5-5-6 (10)	18.7	28.8	50.4	20.8
10	A-2-4, GrSa, brn, MTW, Rec. = 1.2 ft, Lab Note: Pieces of wood were within sample.	4-3-2-7 (5)	17.3	25.8	56.9	17.3
	A-1-b, SaGr, brn, Moist, Rec. = 0.6 ft, Lab Note: Broken rock was within sample.	39-20-R@ (R)	11.8	49.2	39.9	10.9
	Field Note:, Cleaned out casing					
	Field Note:, No Recovery	2-2-2-WH (4)				
	Field Note:, Cleaned out casing					
	Field Note:, No Recovery	2-5-5-4 (10)				
	Field Note:, Cleaned out casing					
	A-4, SaGrSi, gry, Moist, Rec. = 0.7 ft, Lab Note: Sample tested non-plastic. A small amount of clay was within sample.	4-5-16-50 (21)	10.6	35.5	28.2	36.3
20	Field Note:, Cleaned out casing					
	A-4, SaSi, gry, Moist, Rec. = 0.6 ft, Lab Note: Sample tested non-plastic.	17-9-4-5 (13)	16.7	6.3	26.5	67.2
	A-4, SaSi, gry, Moist, Rec. = 1.3 ft	7-9-13-15 (22)	13.9	10.5	25.2	64.3
	Field Note:, Cleaned out with NXDC					
	A-4, SaSi, gry, Moist, Rec. = 1.3 ft	17-17-17-13 (34)	12.6	18.1	24.5	57.4
	Field Note:, Cleaned out with NXDC					
	A-4, Si, gry, Moist, Rec. = 1.3 ft	12-9-10-13 (19)	20.0	9.0	12.2	78.8
30	Field Note:, Cleaned out with NXDC					
	A-4, Si, gry, Moist, Rec. = 1.4 ft, Lab Note: Sample tested non-plastic. A small amount of clay was within sample.	4-8-12-18 (20)	26.1	1.8	5.8	92.4
	Field Note:, Cleaned out with NXDC					
	A-4, Si, gry, Moist, Rec. = 1.8 ft, Lab Note: Sample tested non-plastic. A small amount of clay was within sample.	7-9-12-18 (21)	29.3	0.4	2.6	97.0
40	Field Note:, Cleaned out with NXDC					
	A-4, Si, gry, Moist, Rec. = 1.9 ft, Lab Note: Sample tested non-plastic. Thin layers of clay were within sample.	8-12-18-16 (30)	30.4		2.2	97.8
	Field Note:, Cleaned out with NXDC					
50	A-4, Si, gry, Moist, Rec. = 2.0 ft, Lab Note: Sample tested non-plastic. Thin layers of clay were within sample.	7-11-12-16 (23)	32.3	0.2	3.1	96.7

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.

VTrans Working to Get You There	STATE OF VERMONT AGENCY OF TRANSPORTATION CONSTRUCTION AND MATERIALS BUREAU CENTRAL LABORATORY	BORING LOG **CABOT-DANVILLE** **FEGC-F 028-3(26) C/2** **US-2 BR-87**	Boring No.: **B-206** Page No.: 2 of 2 Pin No.: 78d347 Checked By: END

Boring Crew: NIETO, JUDKINS, GARROW
Date Started: 11/30/15 Date Finished: 12/08/15
VTSPG NAD83: N 681890.21 ft E 1700537.16 ft
Station: 14+63.6 Offset: 18.21
Ground Elevation: 1429.83 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 55 TRACK	C_E = 1.46

Groundwater Observations

Date	Depth (ft)	Notes
12/01/15	8.9	W.T. before drilling
12/07/15	10.1	W.T. before drilling
12/08/15	10.5	W.T. after drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Field Note:, Cleaned out with NXDC					
60		A-4, Si, gry, Moist, Rec. = 2.0 ft, Lab Note: Sample tested non-plastic. Thin layers of clay were within sample.	6-10-14-17 (24)	30.7	0.2	1.8	98.0
		Field Note:, Cleaned out with NXDC					
70		A-4, Si, gry, Moist, Rec. = 2.0 ft, Lab Note: Sample tested non-plastic. Thin layers of clay were within sample.	7-16-26-34 (42)	27.3	0.3	5.9	93.8
80		A-1-b, SaGr, gry, Moist, Rec. = 0.3 ft, Lab Note: Broken rock was within sample.	R@3.5" (R)	14.1	50.4	34.4	15.2
		Field Note:, Cleaned out with NXDC					
90		Field Note:, No Recovery, Appears to be Si Sa	R@2.5" (R)				
100		A-4, SaSi, gry-Lt/brn, Moist, Rec. = 0.7 ft	48-R@2.5" (R)	40.3	16.1	41.8	42.1
		Hole stopped @ 100.7 ft					

Remarks:
Hole Collapsed at 30.2 feet.

Notes:
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STATE OF VERMONT AGENCY OF TRANSPORTATION CONSTRUCTION AND MATERIALS BUREAU CENTRAL LABORATORY	BORING LOG	
VTrans Working to Get You There, Vermont Agency of Transportation	**CABOT-DANVILLE** **FEGC-F 028-3(26) C/2** **US-2 BR-87**	Boring No.: **B-207** Page No.: 1 of 2 Pin No.: 78d347 Checked By: END

Boring Crew:	JUDKINS, HOOK
Date Started:	11/18/15
Date Finished:	11/20/15
VTSPG NAD83:	N 681895.49 ft E 1700580.40 ft
Station:	15+7.35
Offset:	18.92
Ground Elevation:	1429.83 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 55 TRACK	C_E = 1.46

Groundwater Observations

Date	Depth (ft)	Notes
11/19/15	8.1	W.T. during drilling
11/20/15	7.7	W.T. before drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %	LL %	PI %
		Asphalt Pavement, 0.0 ft - 0.94 ft							
		A-1-b, GrSa, brn, Moist, Rec. = 1.5 ft	7-10-10-9 (20)	8.7	37.6	46.2	16.2		
		A-2-4, SiGrSa, brn, Moist, Rec. = 1.0 ft	14-9-6-8 (15)	12.4	29.1	44.3	26.6		
		A-4, SaSi, brn, Moist, Rec. = 1.1 ft	6-2-3-2 (5)	28.1	5.7	44.8	49.5		
		A-2-4, SiSa, brn, Moist, Rec. = 1.3 ft	3-3-3-3 (6)	26.0	2.5	72.7	24.8		
10		A-4, SiSa, Dk/gry, Moist, Rec. = 2.0 ft, Lab Note: Wood fibers and pieces of wood were within sample.	3-2-3-2 (5)	38.9	1.8	57.3	40.9		
		A-2-4, SiSa, Dk/gry, Moist, Rec. = 1.3 ft, Lab Note: Wood fibers were within sample.	2-20-13-5 (33)	44.7	0.1	76.5	23.4		
		Field Note:, Clean out with NXDC							
		Field Note:, No Recovery	R@5" (R)						
		Field Note:, Clean out with NXDC							
		Field Note:, No Recovery	R@1" (R)						
		Field Note:, Clean out with NXDC							
		A-4, SaSi, gry, Moist, Rec. = 1.0 ft	12-5-6-5 (11)	14.1	14.8	20.6	64.6		
20		A-4, SaSi, gry, Moist, Rec. = 0.9 ft	4-6-4-4 (10)	16.8	11.7	22.0	66.3		
		Field Note:, Clean out with NXDC							
		Visual Description:, SaSi, gry, Moist, Rec. = 0.1 ft, Lab Note: Insufficient sample size for testing.	4-2-5-3 (7)	17.7					
		A-4, SaSi, gry, Moist, Rec. = 1.0 ft	5-2-2-3 (4)	16.9	13.6	24.4	62.0		
		A-4, SaSi, gry, Moist, Rec. = 0.8 ft	11-8-11-13 (19)	14.5	16.1	25.3	58.6		
		Field Note:, Clean out with roller cone							
30		Field Note:, No Recovery	22-25-21-21 (46)						
		Field Note:, Clean out with NXDC							
		Field Note:, No Recovery	13-20-21-21 (41)						
		Field Note:, Clean out with roller cone							
40		A-4, Si, gry, Moist, Rec. = 1.2 ft, Lab Note: Sample tested non-plastic. A thin clay layer was within sample.	6-10-14-20 (24)	29.4	0.1	3.8	96.1		
		Field Note:, Clean out with NXDC							
50		A-4, Si, gry, Moist, Rec. = 1.9 ft, Lab Note: Sample tested non-plastic. A thin clay layer was within sample.	7-9-11-12 (20)	30.9	0.5	4.7	94.8		

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

BORING LOG

CABOT-DANVILLE
FEGC-F 028-3(26) C/2
US-2 BR-87

Boring No.: **B-207**

Pin No.: 78d347
Checked By: END

Boring Crew: JUDKINS, HOOK
Date Started: 11/18/15 Date Finished: 11/20/15
VTSPG NAD83: N 681895.49 ft E 1700580.40 ft
Station: 15+7.35 Offset: 18.92
Ground Elevation: 1429.83 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 55 TRACK C_E = 1.46

Groundwater Observations

Date	Depth (ft)	Notes
11/19/15	8.1	W.T. during drilling
11/20/15	7.7	W.T. before drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %	LL %	PI %
		Field Note:, Clean out with roller cone							
60		A-4, Si, gry, Moist, Rec. = 1.8 ft, Lab Note: Sample tested non-plastic. A thin clay layer was within sample.	7-9-14-13 (23)	31.5		3.6	96.4		
		Field Note:, Clean out with NXDC							
70		A-4, ClSi, gry, Moist, Rec. = 1.9 ft	7-8-10-13 (18)	33.0	0.9	0.9	98.2	35	7
		Field Note:, Clean out with NXDC							
80		Field Note:, No Recovery	R@2.5" (R)						
		Field Note:, Clean out with NXDC							
90		A-1-b, GrSa, gry, Moist, Rec. = 0.6 ft, Lab Note: Broken rock was within sample.	12-R@5" (R)	13.7	38.5	49.3	12.2		
		Field Note:, Clean out with NXDC							
100		Field Note:, No Recovery, Appears to be Si Sa.	R@5" (R)						
		Hole stopped @ 100.4 ft							

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