AGENCY OF TRANSPORTATION **OFFICE MEMORANDUM**

To: Tina Bohl, Project Manager, Municipal Assistance Bureau

JAC CEE

From: Jace Curtis, Geotechnical Engineer via Callie Ewald, P.E., Geotechnical Engineering Manager

Date: April 10th, 2017

Subject: Colchester CMG PARK(47) – Retaining Wall Evaluation

1.0 INTRODUCTION

We have completed our geotechnical and geological investigation for the Colchester CMG PARK(47) project, located adjacent to US Route 7 at the intersection with Hercules Drive in the Town of Colchester, Vermont. This project includes the rehabilitation of the existing parking lot for use as a park-and-ride as well as installation of pedestrian facilities and landscape improvements. This report summarizes the boring and laboratory testing information from our subsurface investigation and contains foundation recommendations for a proposed retaining wall located from approximately Sta. 100+48 to Sta. 101+25 RT.

2.0 FIELD INVESTIGATION

The field investigation was conducted from February 17th, 2017 to February 22nd, 2017. Two standard penetration borings, two drilled probes, and three hand steel probes were completed to determine the subsurface profile to aid in the design and construction of a retaining wall foundation. A summary of the location of each boring/probe and corresponding ground surface elevation can be found in Table 2.1. Boring locations were determined based off plans sent by Scott Burbank of Vanasse Hangen Brustlin, Inc. (VHB) in an email dated January 25th, 2017. The borings were chosen to be drilled approximately at the turning points of the wall, to be completed at approximately equal distances along the footprint of the proposed retaining wall. This also allowed for a boring to be located at the tallest section of the wall. The locations of the drilled probes were chosen near the ends of the wall to aid in profiling the shallow bedrock. Based on the geometry and overhead obstructions, the probes were moved slightly to accommodate these obstructions and additional hand steel probes were conducted at the ends of proposed wall. 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 the existing survey file for the project. 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 is attached.

Table 2.1. Boring Locations

Boring	Type	Station (ft)	Offset (ft)	Northing (ft)	Easting (ft)	GSE (ft)*	TLOB (ft)*
B-101	SPT	100+62.1	32.0	733522.76	1463067.31	343.5	336.3
B-102	SPT	100+93.6	30.0	733560.10	1463090.91	341.2	333.2
P-101	HS	100+51.0	33.4	733511.70	1463055.82	344.5	336.1
P-101A	Probe	100+48.9	41.9	733502.84	1463057.90	345.4	338.6
P-102	HS	101+23.0	37.0	733597.59	1463106.15	339.5	331.8
P-102A	HS	101+32.1	35.5	733606.75	1463105.35	339.4	331.0
P-102B	Probe	101+17.8	28.5	733593.03	1463097.28	341.5	333.3

*Ground Surface Elevation (GSE), Top of Ledge or Boulder (TLOB)

The borings were performed in general accordance with AASHTO T206, *Standard Method of Test for Penetration Test and Split-Barrel Sampling of Soils.* During the boring operations, split spoon samples and standard penetration tests (SPT) were taken continuously to bedrock, approximately 7 to 8 feet below the ground surface. When bedrock was encountered, BX rock cores were taken 10 feet into bedrock to collect five foot core runs to confirm the presence of bedrock.

The drilled probes were conducted to determine additional depths to ledge or boulder. These were performed with a boulder buster attached to the bottom of the drill rod and then driven until refusal. In this scenario, a 15.25 inch long boulder buster weighing 10.3 pounds was attached to the bottom of the AW drill rod and used to break through the soil stratum until refusal was encountered, indicating top of ledge or boulder. The boulder buster was determined to be the fastest and easiest way to get down to a shallow hard stratum where soil samples were not needed. No soil samples were collected.

The hand steel probes were completed according to AASHTO's *1988 Manual on Subsurface Investigation*, Section 7.5.3.1, which states that exploratory probing can be defined when "small diameter, flush coupled, steel rods are pushed by hand to refusal in the underlying organic soil." The ¾ inch steel rods at this site were driven using a 10-pound sledge hammer. Exploratory probing is commonly used to determine depths to boulders or bedrock in areas with easily penetrable soil. No soil samples were collected.

Soil samples from the borings 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 rigs. A Diedrich 25 track rig was used for this project, however, because the Diedrich 25 track rig is brand new, a C_E value has not yet been determined for that hammer. As a result, a hammer energy correction factor of 1.3 is recommended for use in design for the Diedrich 25 track rig, based on a standard practice value for an automatic hammer. This value was used in soil parameter calculations. Laboratory tests were conducted on all samples to evaluate grain size, moisture content, percent finer than No. 200 sieve, and liquid and plastic limits when applicable.

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 preciously noted in the logs.

> **B-101:** The ground surface elevation at B-101 was approximately 343.5 feet. Groundwater was encountered after drilling operations on February 21st, 2017 at a depth of 2.0 feet below the ground surface corresponding to an approximate elevation of 341.5 feet.

Table 4.1. B-101 Soil Strata

Depth Below Ground Surface Elevation	Soil Profile
0 – 6 feet	Medium Dense Silty Sand
6 – 7.2 feet	Very Dense Sandy Gravel
> 7.2 feet	Moderately Hard Dolostone

B-102: For B-102, the ground surface elevation was approximately 341.2 feet. Groundwater was encountered after drilling operations on February 17^{th}, 2017 at a depth of 1.5 feet below the ground surface corresponding to an approximate elevation of 339.7 feet.

Table 4.2. B-102 Soil Strata

Depth Below Ground Surface Elevation	Soil Profile
0 – 2 feet	Loose Silty Sandy Gravel
2 – 6 feet	Medium Dense to Dense Sandy Silt
6 – 8 feet	Very Dense Silty Gravel
> 8 feet	Moderately Hard Dolostone

5.0 ANALYSIS

AASHTO's LRFD Bridge Design Specifications Manual (2014) was used as the reference for settlement and bearing resistance equations. Section 10.6.3.1.2 contains the equation used for bearing resistance. Neither depth factors nor load inclination factors were used in the analysis as they were not considered pertinent. Hough's Method, used to calculate settlement in normally consolidated cohesionless soils, can be found in Section 10.6.2.4.2.

We recommend the bottom of the retaining wall footings to be at least 4 feet below the ground surface based on frost susceptibility and bearing stratum at the site. However, an embedment value of 3 feet was used for the analysis because some wall systems use a stone or concrete leveling pad for additional embedment and foundation support. A wall length of 109 feet was assumed for analysis as determined from the preliminary plans dated December 5^{th}, 2016.

As per section 10.5.5.1 of the 2014 AASHTO LRFD Bridge Design Specifications, a resistance factor of 1.0 should be applied to the unfactored bearing resistance for use in service limit state design. Service limit state design includes, but is not limited to, settlement. Section 10.5.5.2.2 specifies that a resistance factor of 0.45 should be applied to the unfactored bearing resistance for use in strength limit state design for spread footings on rock and soil or prefabricated modular walls. Strength limit state design includes, but is not limited to, checks for bearing resistance, sliding and constructability. Potential for overturning is limited by controlling the location of the resultant of the reaction forces (eccentricity). Eccentricity, e, shall be limited as follows:

Foundations on soil: $|e| < b/3$
Foundations on rock: $|e| < 0.45b$

Eccentricity should be considered for settlement and bearing resistance design of spread footings by using effective footing widths based on AASHTO Section 10.6.1.3. All footing widths presented in this report are <u>effective</u> footing widths.

5.1 Bearing Resistance

Based on the profile in Borings B-101 and B-102, an assumed bottom of footing elevation located in the sandy silt stratum, as well as empirical relationships, it was determined the soil has a friction angle, $\phi = 37^{o}$ and density, $\gamma = 120$ lbs/ft^3. Figure 5.1 below displays the minimum effective footing width per maximum bearing resistance, factored due to LRFD strength limit. For footing widths of 2, 4, and 6 feet, the maximum bearing resistance is 8.8, 10.7, and 12.5 kips/ft^2 (ksf), respectively.

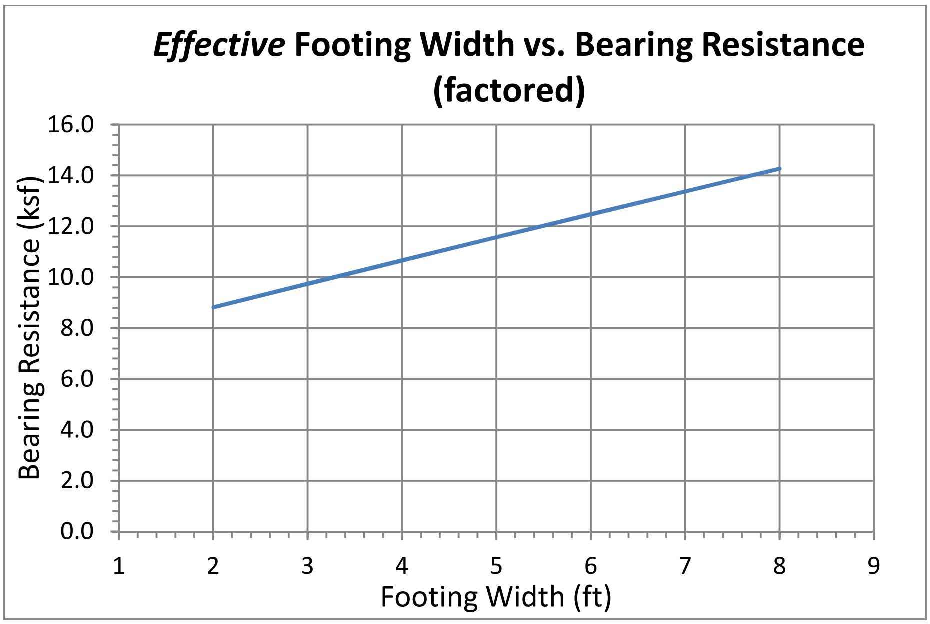


Figure 5.1. Factored Bearing Resistance. Load Resistance Factor, $\Phi = 0.45$

5.2 Settlement

Soil settlement values were calculated for various footing widths based on the nominal bearing pressure. Found in Figure 5.2 are the settlement values for bearing pressure ranging from 1.0 to 7.0 ksf. Due to the more granular nature of the soils at the footing elevation, settlement is expected to occur during or immediately after construction.

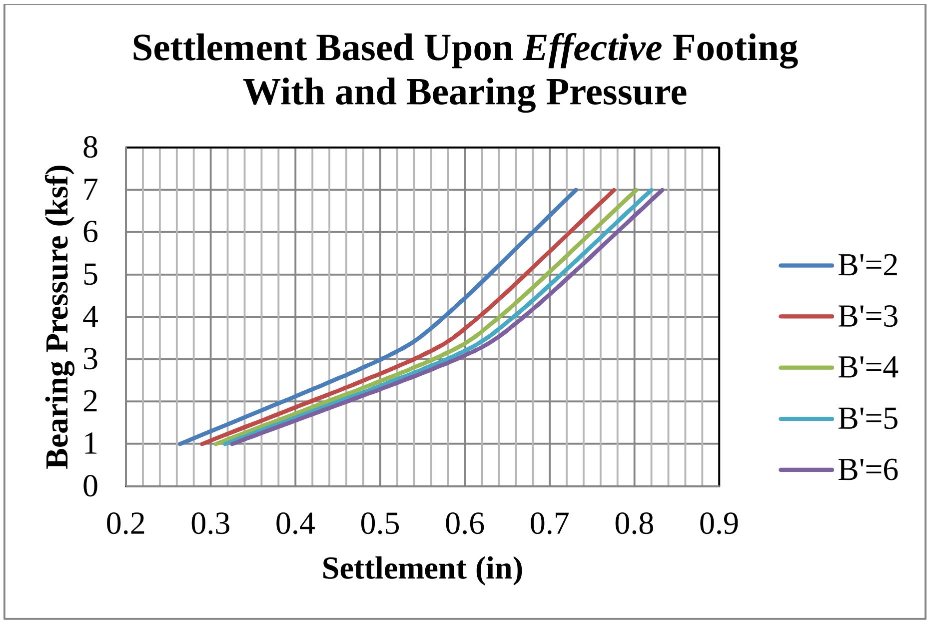


Figure 5.2. Settlement vs. Nominal Bearing Pressures

These calculations are based on the geometric and geotechnical assumptions outlined above. Sections 10.5.2 and 10.5.3 of AASHTO outline all design states relevant to spread footing design and the respective resistance factors. Eccentricity should be considered for settlement and bearing resistance design of spread footings by using effective footing widths based on AASHTO Section 10.6.1.3. Table 5.1 shows the appropriate resistance factors for various design states.

Table 5.1. Summary of Resistance Factors

Design State	Resistance Factor, Φ
Settlement	1.0
Bearing Resistance	0.45
Sliding	0.80

5.3 Global Stability

A global stability analysis was conducted to evaluate the overall stability of the soil slope and proposed retaining wall. Using Slide 6.0 developed by Rocscience, a slope stability analysis was performed which evaluated both compound and deep-seated failures for a 7 foot tall section of the wall. According to the VTrans Slope Stability Investigation and Evaluation Manual, GEI 14-01, the Spencer Method is recommended to be used for slope stability analyses of failure surfaces of any shape and a minimum factor of safety of 1.3 shall be used for slopes adjacent to but not directly supporting a structure. As a result, the Spencer Method produced a factor of safety against slope failure of greater than 1.3 (equivalent to a resistance factor of Φ = 0.75, which is AASHTO's recommended value for overall stability of a retaining wall that does not support or contain a structural element, Section 11.6.2.3). Because final plans have not yet been developed for the retaining wall, a detailed stability analysis should be considered to confirm whether or not reinforcement will be required. Figure 5.3 below shows an image of the proposed retaining wall with the groundwater table at 1.5 feet below the ground surface and the most critical failure surface using the Spencer Method with a factor of safety of 2.099.

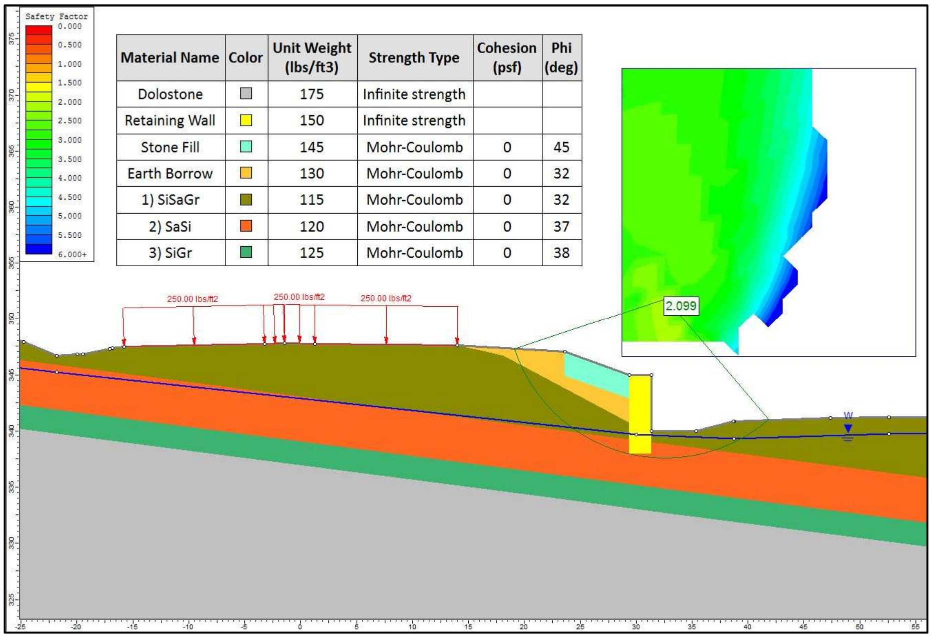


Figure 5.3. Retaining Wall Modeled at Station 101+00.

5.4 Retaining Wall Selection

A conceptual plan (end result) approach to retaining wall solicitation is recommended for all wall systems except conventional reinforced concrete walls and bin walls in which case detailed plans should be included in the bidding documents.

In accordance with the Agency standard practice, projects containing earth retaining structures (except conventionally reinforced concrete and bin walls) shall use a concept drawing approach, i.e. fully detained set of retaining wall plans will not be contained in the bidding documents. The design shall meet the requirements of the 2014 LRFD Bridge Design Specifications. The concept drawing, furnished in the bidding documents will contain the following geometric and design project specific information:

A. Geometric
   1. Beginning and end of wall stations.
   2. Elevations on top of wall at beginning and end of wall station as well as all profile break points
   3. Original and proposed ground line profiles in front of and behind the retaining wall.
   4. Cross sections at the retaining wall location at 24 foot intervals.
   5. Horizontal wall alignment
   6. Details of wall appurtenances such as traffic barriers, coping, fencing, drainage, location and configurations of signs and lighting including conduit locations.
   7. Right of way limits.

8. Construction sequence requirements if applicable, including traffic control, access, and stage construction sequences.
9. Elevation of highest permissible level for foundation construction. Location, depth and extent of any unsuitable material to be removed and replaced.
10. Quantities table showing estimated square feet of wall area, and quantity of appurtenances and traffic barriers.

B. Design

1. Shear strength and consolidation properties of foundation soils.
2. Shear strength and unit weight of select backfill.
3. Shear strength of random fill or in-situ soil behind the wall.
4. Required design life of the structure (example: permanent mechanically stabilized earth walls are commonly designed, based on corrosion, for minimum service live of 75 years).
5. Nominal bearing resistance for the foundation soil and minimum footing embedment depth.
6. Maximum tolerable total and differential settlement.
7. Magnitude, location and direction of external loads due to bridges, overhead signs and lights, traffic surcharge and rapid groundwater draw down.
8. Limits and requirements for drainage features beneath, behind, or through the retaining structure.
9. Backfill requirements for both within and behind the retaining structure. (Both material and placement requirements should be specified, i.e. gradation, plasticity index, electrochemical, soundness, maximum loose lift thickness, minimum density and allowable moisture content).
10. Special facing panel and module finishes or colors.

Geometric, geotechnical and structural considerations must be complementary for the conceptual plan to convey the desired end product to the bidders. In general, the specification should refer to the Agency's list of Approved Wall Systems in the link below. https://outside.vermont.gov/agency/vtrans/external/docs/construction/03GeotechEng/Engineering/MandRSoilAPPROVED_Retaining_Walls_8-2012_Final%20Engineering.pdf

6.0 RECOMMENDATIONS

6.1 Design Parameters

Based on the soil profiles above, laboratory testing, and the attached boring logs, the determined in-situ soil properties and common construction material properties can be found in Table 6.1. These values should be used when designing any structural units. It is recommended that the values of K_o be used for calculating earth pressure 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 6.1. Engineering Properties of In-Situ Soils and Construction Materials

	Retaining Wall Bearing Stratum	Common Construction Materials	
	M. Dense to Dense Sandy Silt (EL 339.2' – 335.2')	**703.01A – Granular Borrow**	**704.08 – Granular Backfill for Structures**
Unit Weight, γ (lb/ft^3)	120	130	140
Internal Friction Angle, ϕ (deg)	37	32	34
Coefficient of Friction, f			
-mass concrete cast against soil	0.33	0.45	0.55
-soil against precast/formed concrete	0.25	0.40	0.48
Active Earth Pressure Coefficient, K_a	0.25	0.31	0.28
Passive Earth Pressure Coefficient, K_p	4.02	3.26	3.53
At-Rest Earth Pressure Coefficient, K_o	0.40	0.47	0.44

If a non-horizontal ground surface behind the wall or structure is used in design, the following equations should be used to determine the active earth pressure coefficient, K_a (AASHTO LRFD Section 3.11.5.3).

$$k_a = \frac{\sin^2(\theta+\phi'_f)}{\Gamma[\sin^2\theta \sin(\theta-\delta)]} \qquad (3.11.5.3\text{-}1)$$

in which

$$\Gamma = [1 + \sqrt{\frac{\sin(\phi'_f+\delta)\sin(\phi'_f-\beta)}{\sin(\theta-\delta)\sin(\theta+\beta)}}]^2 \qquad (3.11.5.3\text{-}2)$$

Where:
δ = friction angle between fill and wall taken as specified in Table 3.11.5.3-1 (degrees)
β = angle of fill to the horizontal as shown in Figure 3.11.5.3-1 (degrees)
θ = angle of back face of wall to the horizontal as shown in Figure 3.11.5.3-1 (degrees)
ϕ'_f = effective angle of internal friction (degrees)

Refer to AASHTO LRFD Section 3.11.5.4 to determine the passive earth pressure coefficient, K_p for a non-horizontal ground surface.

6.2 Construction Considerations

6.2.1 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. Due to the sensitive nature of the slope, compaction equipment should preferable consist of hand-guided equipment, such as a small vibratory plate compactor.

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.

7.0 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 *Z:\Highways\CMB\GeotechEngineering\Projects\Colchester CMG PARK(47)\BORING LOGS* folder.

Enclosures: Boring Location Plan (1 page)
Boring Logs (2 pages)
Approximate Ledge Sections (1 page)

Cc: Electronic Read File/DJH
Project File/CEE
JAC

Z:\Highways\CMB\GeotechEngineering\Projects\Colchester CMG PARK(47)\REPORTS\Colchester CMG PARK(47) Retaining Wall Evaluation.docx

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

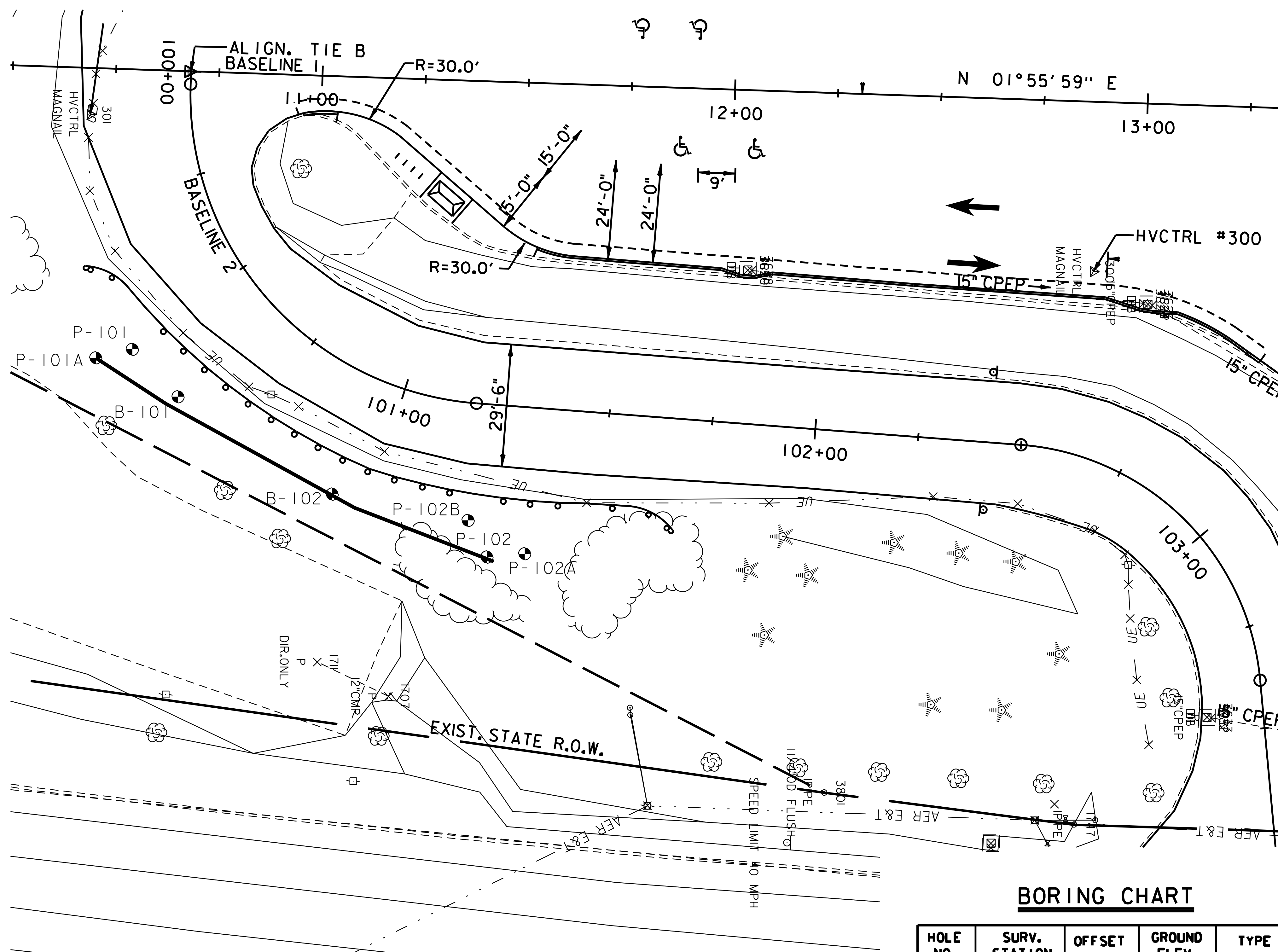
DENSITY (GRANULAR SOILS)		CONSISTENCY (COHESIVE SOILS)	
N	DESCRIPTIVE TERM	N	DESCRIPTIVE TERM
<5	Very Loose	<2	Very Soft
5-10	Loose	2-4	Soft
11-24	Med. Dense	5-8	Med. Stiff
25-50	Dense	9-15	Stiff
>50	Very Dense	16-30	Very Stiff
		31-60	Hard
		>60	Very Hard

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
ROD	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		



BORING CHART

HOLE NO.	SURV. STATION	OFFSET	GROUND ELEV.	TYPE
P-101A	100+48	41.9	345.4'	PROBE
P-101	100+51	33.8	344.5'	HAND STEEL PROBE
B-101	100+62	32.0	343.5'	SPT
B-102	100+94	30.0	341.2'	SPT
P-102B	101+18	28.5	341.5'	PROBE
P-102	101+23	37.0	339.5'	HAND STEEL PROBE
P-102A	101+32	35.5	339.4'	HAND STEEL PROBE

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.

GENERAL NOTES

1. The subsurface explorations shown herein were made by the Agency between 02/17/17, 02/21/17, and 02/22/17

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.

PROJECT NAME:	Colchester		
PROJECT NUMBER:	CMG PARK(47)		
FILE NAME:	z14c2070bormapJAC	PLOT DATE:	03/17/17
PROJECT LEADER:		DRAWN BY:	JAC
DESIGNED BY:		CHECKED BY:	
BORING INFORMATION SHEET		SHEET	1 OF 1

VTrans Working to Get You There — Vermont Agency of Transportation	STATE OF VERMONT AGENCY OF TRANSPORTATION CONSTRUCTION AND MATERIALS BUREAU CENTRAL LABORATORY	BORING LOG **Colchester** **CMGPARK(47)** **Park and Ride US-2, US-7**	Boring No.: **B-101** Page No.: 1 of 1 Pin No.: 14c207 Checked By: JAC

Boring Crew: Whitlock, Garrow, Warner
Date Started: 2/21/17 Date Finished: 2/21/17
VTSPG NAD83: N 733522.76 ft E 1463067.31 ft
Station: 100+62.11 Offset: 31.98
Ground Elevation: 343.5 ft

	Casing	Sampler
Type:	WB	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:	Diedrich D25	C_E = Unknown

Groundwater Observations

Date	Depth (ft)	Notes
02/21/17	2.0	W.T. after 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 %
		A-2-4, SiSa, brn, Dry, Rec. = 1.0 ft				2-2-3-4 (5)	19.1	18.8	50.6	30.6
2.5		A-4, SiSa, brn, Dry, Rec. = 1.0 ft				3-2-5-6 (7)	23.8	15.3	42.6	42.1
5.0		A-4, SiSa, brn, Dry, Rec. = 1.8 ft, Lab Note: Some clay was within sample. Sample tested non-plastic				6-8-9-15 (17)	24.2	11.8	29.8	58.4
		A-1-b, SaGr, brn, Moist, Rec. = 0.8 ft, Lab Note: Broken rock was within sample				10-12-R@2.5" (R)	16.1	56.6	25.0	18.4
7.5 / 10.0		7.2 ft - 12.2 ft, Blue-gray, Massive DOLOSTONE, with near vertical healed fractures. Vertical joint at 9.2 feet to 9.7 feet. Tan and orange staining along joints. Moderately hard, Slightly weathered, Fair rock, BX, RMR=52	1 (15-30)	100 (50)	4 4 5 5 5	Top of Bedrock @ 7.2 ft				
12.5 / 15.0		12.2 ft - 17.2 ft, Blue-gray, Massive DOLOSTONE, with few near vertical healed fractures. Vertical joint at 12.6 feet to 13.2 feet and 14.2 feet to 16.2 feet.. Moderately hard, Slightly weathered, Poor rock, BX, RMR=38	2 (10)	100 (22)	5 4 4 5 5					
17.5		Hole stopped @ 17.2 ft								

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	
VTrans Working to Get You There – Vermont Agency of Transportation	**Colchester** **CMGPARK(47)** **Park and Ride US-2, US-7**	Boring No.: **B-102** Page No.: 1 of 1 Pin No.: 14c207 Checked By: JAC

Boring Crew: Whitlock, Garrow, Warner
Date Started: 2/17/17 Date Finished: 2/17/17
VTSPG NAD83: N 733560.10 ft E 1463090.91 ft
Station: 100+93.56 Offset: 29.99
Ground Elevation: 341.2 ft

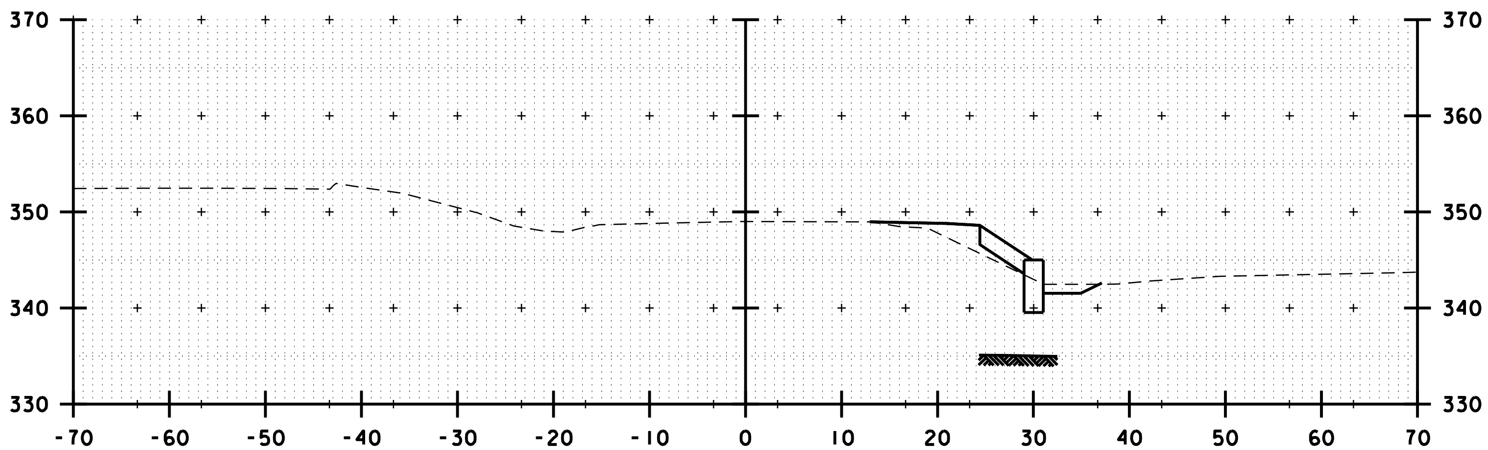
	Casing	Sampler
Type:	WB	SS
I.D.:	3 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	Diedrich D25	C_E = Unknown

Groundwater Observations

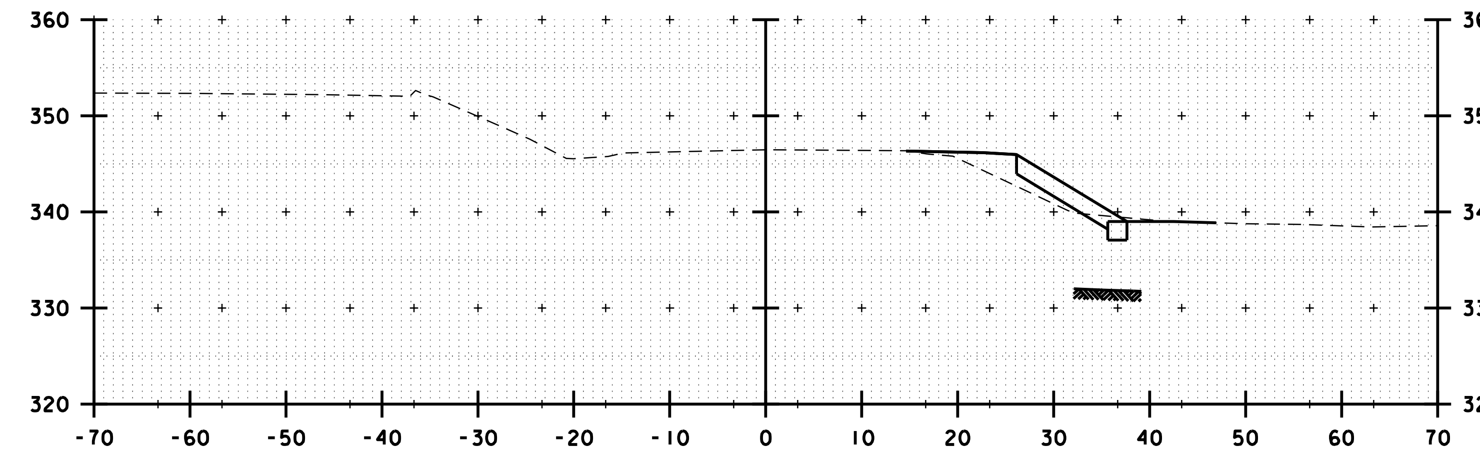
Date	Depth (ft)	Notes
02/17/17	1.5	W.T. after drilling

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 %
		A-1-b, SiSaGr, brn, Dry, Rec. = 0.9 ft, Lab Note: Decomposing plant material was within sample				2-2-2-4 (4)	17.8	43.2	36.7	20.1
2.5		A-4, SaSi, brn, Dry, Rec. = 1.5 ft, Lab Note: Some clay was within sample. Sample tested non-plastic				4-4-6-9 (10)	24.9	12.3	40.3	47.4
5.0		A-4, SaSi, brn, Dry, Rec. = 1.8 ft, Lab Note: Some clay was within sample. Sample tested non-plastic Field Note:, Cleaned out casing				6-9-12-20 (21)	19.0	19.4	33.4	47.2
7.5		A-2-4, SiGr, brn, Wet, Rec. = 0.8 ft, Lab Note: Broken rock was within sample				11-11-16-20 (27)	11.9	51.7	19.0	29.3
10.0, 12.5		8.0 ft - 13.0 ft, Blue-gray, Massive DOLOSTONE, with near vertical healed fractures. Rare pyrite along penetrative yellow and brown stained joints. Moderately hard, Moderately weathered, Fair rock, BX, RMR=48	1 (10)	100 (82)	4 5 4 5 5	Top of Bedrock @ 8.0 ft				
15.0, 17.5		13.0 ft - 18.0 ft, Gray, Massive DOLOSTONE, with radiating sub-horizontal and near vertical healed fractures. Tand and orange staining along joints. Moderately hard, Moderately weathered, Good rock, BX, RMR=61	2 (30)	94 (78)	5 4 5 8 5					
		Hole stopped @ 18.0 ft								

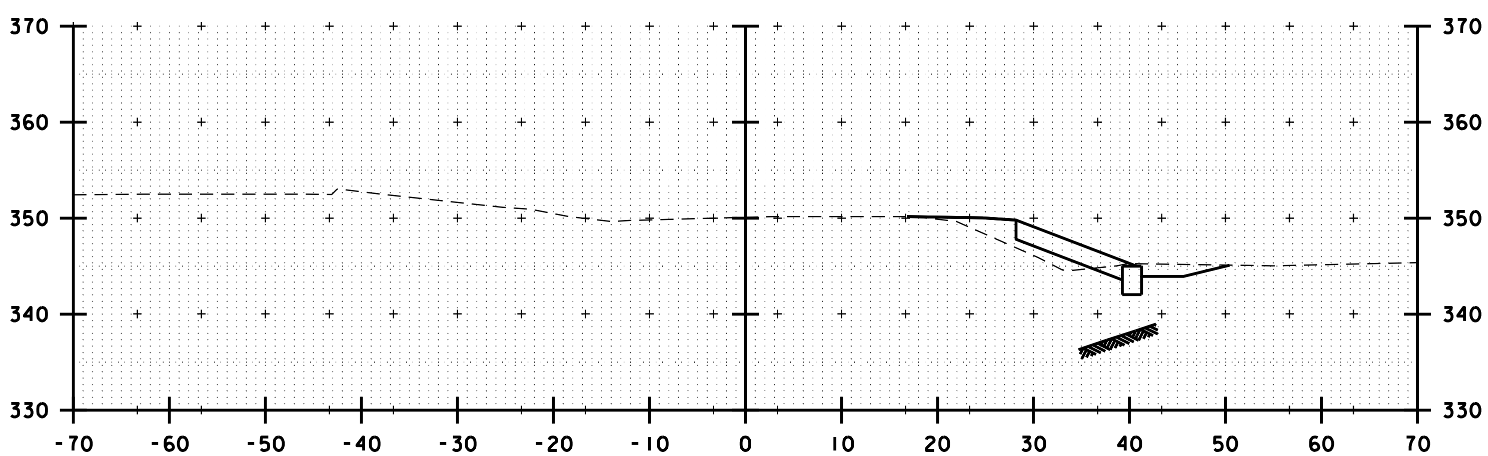
Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations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



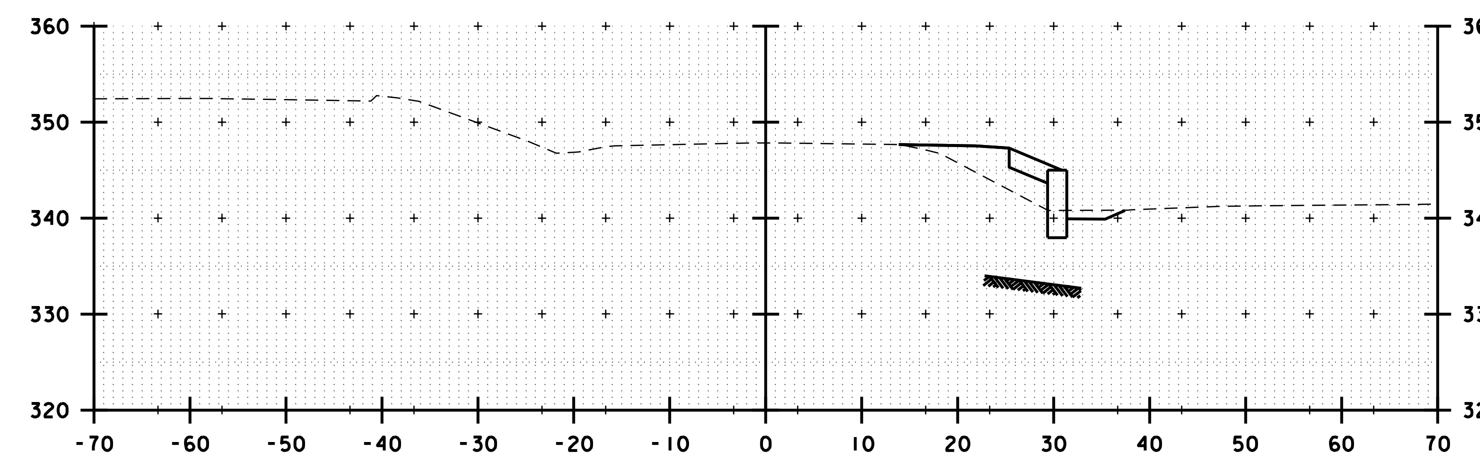
100+75



101+24



100+50



101+00

APPROXIMATE LEDGE DEPTH UNDER WALL

STA. 100+50 TO STA. 101+24

PROJECT NAME: Colchester	
PROJECT NUMBER: CMG PARK(47)	
FILE NAME: zl4c207nul_borings.dgn	PLOT DATE: 03/20/17
PROJECT LEADER: ------	DRAWN BY: JAC
DESIGNED BY: ------	CHECKED BY: ------
Approximate Ledge Depth	SHEET 1 OF 1