NORTHEAST INC
Environmental Engineering
Geotechnical Engineering
Water Resources
Hydrogeology

October 5, 2011
Project No. 4707

Board of Selectmen
c/o: Dina Cutting, Administrative Assistant
Town of Lyme
Office of the Selectmen
P. O. Box 126
Lyme, N. H. 03768

RE: Report of Performing Design Phase
Geotechnical Engineering Services
River Road Riverbank Failure Area
Lyme, New Hampshire

Dear Board of Selectmen:

Submitted is the HTE Northeast, Inc. (HTE) analysis of the Connecticut riverbank failure located along a 1,000'± section of River Road in the northwest part of Lyme, New Hampshire. This work was performed in accordance with HTE Proposal No. 9372.1 dated August 8, 2011. This report is subject to the Limitations in Appendix A.

I) Introduction

It is HTE's understanding that substantial river bank slope failures occurred on or about April 30 to May 1, 2011 along the west side of River Road where it is adjacent to the Connecticut River. The slope failures occurred in several areas over a 1,000± feet distance for a portion of River Road just south of North Thetford Road On June 22nd, the undersigned observed that portions of the southbound (west) lane of River Road were in danger of further failure being imminent.

It is understood that the flood level rose to within a few feet of the road level (the grade of River Road varies from about EL 398± to EL 400±), and that the river level receded relatively quickly. The failure occurred in the interior (and straight) portion of an obtuse bend (southeast, the south, then southwest flow) in the river.

It is understood that consideration is being given to re-constructing the affected portion of River Road along a new alignment that would be shifted to the east of the current alignment. The establishment of this new alignment would be based on constructing permanent stable new slopes along the adjacent Connecticut River shoreline to the west.

Holden Engineering & Surveying, Inc. (Holden) obtained topographic survey information of the failure area, including topographic data for the easterly 50'± of the river (at normal level), and also 50'± east of the present road, such that accurate cross-sections of slope failure areas could be developed for use

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in our work. The area has a preliminary surficial geologic mapping as stratified sand & silt outwash, often overlying varved clays. The subsurface explorations performed for this study indicates that the pertinent soil stratigraphy consists of loose to medium dense non-cohesive fine sand/silt alluvium overlying dense granular ice-contact deposits. The presence of varved deposits was not in evidence. Bedrock was not encountered to the depths explored.

Based on our observations, chronology of events, and results of subsurface explorations presented subsequently, it appears that the failed riverbank section of concern was been caused by the following general conditions:

1) Long term erosion and undermining of the riverbank due to flow action. Erosion and undermining alone are responsible for depletion of the alluvium riverbank along the east side of the Connecticut River in the area of concern. The frequent raising and lowering of the water level by downstream dam management (Wilder Dam), over time, is a contributing factor. As the soil mass is slowly removed from the bottom of the slope, the overall stability is reduced by the decrease in resisting forces until such time that the slope or a portion of the slope either sloughs or rotates to a more stable condition classical rotational type failure surface). This situation repeats itself over a long period of time being exacerbated during floods.

2) Existence of water in the riverbank soils. The high groundwater levels within the slope cross section at the time of the flood increased the driving forces thus tending to destabilize or reduce overall stability, particularly as the flood receded. The saturation of the relatively slow-draining alluvial soils resulted in an unbalanced hydrostatic condition in the slope. Surface runoff from the east is not considered to have been a significant factor in the riverbank failure. Wave action is not considered to have been a factor in the riverbank failure.

It is anticipated that the failure of the subject riverbank was a result of both of these phenomenon in concert. It can be anticipated that future long term riverbank instability will occur, as evidenced by the steepness of the post-flood riverbank and the 'tension cracks' still present along portions of the west side of River Road. Remedial actions will need to consider reconstruction of the affected riverbank and contiguous upstream and downstream sections to a stable configuration (in-part to reduce groundwater impacts), including appropriate riverbank slope surface protection.

It should be noted that the current riverbank configuration is considered unstable and we do not recommend re-opening of the road until a stable re-construction is implemented.

II) Subsurface Explorations

HTE observed the drilling of four test borings, designated as HTE-1 to HTE-4 at approximate stations Sta 18+75±, 16+75±, 14+45± and 13+00± along River Road, per the Holden survey. The explorations were performed in general accordance with ASTM D 1452 by New Hampshire Boring, Inc. (NHB), of

Derry, N. H., on August 15 and 16, 2011. The logs of the test borings and observation wells, prepared by HTE, are attached as Appendix B. The approximate as-drilled exploration locations are shown on the project plans developed by Holden.

The test boring was drilled using standard dive & wash test boring drilling techniques to depths ranging from 31'± to 41'±. Standard Penetration Tests (SPTs) were performed in each test boring in general accordance with ASTM D 1586. The SPT consists of driving a 1-3/8 inch I.D. split spoon sampler with a 140 pound hammer falling 30 inches. The blows for each 6 inches of penetration are recorded for a total of 18 to 24 inches. The sum of the blows required to drive the sampler from 6 inches to 18 inches penetration is referred to as the Standard Penetration Resistance, or N-value, which is an index measure of in-situ soil density or consistency.

In addition to the split spoon samples obtained at 5' depth increments, selected additional split-spoon samples were obtained at anticipated general slip-circle depths. The test borings were performed under the observation of a HTE geotechnical engineer. Soil samples from the test borings were classified in the field by HTE in general accordance with the Burmister Soil Classification System.

Groundwater level measurement observation wells were installed in borings HTE-1 and HTE-3.

III) Subsurface Conditions

Based on the results of HTE's test boring observations, the existing overburden soils encountered in the test boring consist generally of loose to medium dense natural fine sand and silt alluvial deposits, underlain at least locally at boring HTE- 3, by dense granular ice-contact deposits at a depth of about 34½'± and continuing to the termination depth of 41'. A more detailed discussion of soil conditions encountered is outlined below. The non-cohesive alluvial deposits were encountered in each test boring to below depths considered of importance for this study. Significant clay deposits were noted not to be present.

IV) Slope Stability Analyses – Stone Slope Configuration Initial Option

Based on the results of the test boring program, the survey data provided by Holden and HTE's observations, cross sections of the subject Connecticut River riverbank were developed by Holden (refer to separate Holden plan set). Using the cross sectional slope geometry (1.5 horizontal to 1 vertical – 1.5H:1V slope), and the soil and rock fill parameters determined from literature review, slope stability analyses were performed to assess existing slope conditions with regard to potential slope failure. The analyses were performed using GSLOPE, a slope modeling software package, developed by Mitre Software Corporation. The GSLOPE program utilizes Bishop's Modified Method of limit equilibrium slope stability analysis.

HTE considered the following in-situ index property average values:

Silty Sand In-Situ Moist Density (γ_m): 120 pounds per cubic foot (pcf)

Silty Sand Effective Friction Angle (ϕ): 32°

HTE considered the following Bank-run Gravel index property average values:

Bank-run Gravel In-Situ Moist Density (γ_m): 125 pounds per cubic foot (pcf)
Bank-run Gravel Effective Friction Angle (ϕ): 34°

HTE considered the following Class A Stone Fill index property average values:

Class A Stone In-Situ Moist Density (γ_m): 140 pounds per cubic foot (pcf)
Class A Stone Effective Friction Angle (ϕ): 34°

HTE considered the following Class C Rip-Rap index property average values:

Class C Rip-Rap In-Situ Moist Density (γ_m): 135 pounds per cubic foot (pcf)
Class C Rip-Rap Effective Friction Angle (ϕ): 34°

Stability analyses were performed, in order to investigate a proposed stone slope concept for permanent riverbank/slope stabilization. The intent of these analyses was to determine the slope and materials necessary to achieve a minimum factor of safety against failure of 1.5 for a 10-year flood event (EL 386.5). Analyses were performed for minimum 4' thickness rock slope configuration with a slope of no steeper than 1.5H:1V. This configuration considers that the failed soil mass is removed. Analytical results indicate that a factor of safety of approximately 1.5 can be achieved by utilizing more-dense NHDOT Class A Stone Fill for the lower portion and less dense Class C Rip-Rap for construction of the upper portion.

The use of NHDOT Bank-run Gravel is considered for the balance of the necessary replacement backfill, beneath the stone/rock fills, for the construction phase excavation, assuming a cut-back slope of no steeper than 2H:1V. All new soil backfill, to beneath roadway subgrade, should be compacted to at least 93% of the optimum dry density per ASTM D-1557. Re-use of the native silty sand for backfill is not recommended.

Copies of the stability analysis results for the proposed stone slope, showing the existing/proposed slope profiles, input material properties and resultant minimum factors of safety, are attached as Appendix C.

V) Slope Stability Analyses – Alternate Stone/Soil Slope Configuration

Based on September 2011 discussions with the Town of Lyme, Holden developed an alternate stone/soil slope configuration, with a 3H:1V slope. Based on the results of the test boring program, the survey data provided by Holden and HTE's observations, cross sections of the subject Connecticut River riverbank were developed by Holden (refer to separate October 2011 Holden plan set). Using the cross sectional slope geometry (3H:1V slope), and the soil and rock fill parameters determined from

literature review, slope stability analyses were performed to assess existing slope conditions with regard to potential slope failure. The analyses were performed using GSLOPE, a slope modeling software package, developed by Mitre Software Corporation. The GSLOPE program utilizes Bishop's Modified Method of limit equilibrium slope stability analysis.

HTE considered the following in-situ index property average values:

Silty Sand In-Situ Moist Density (γ_m):	120 pounds per cubic foot (pcf)
Silty Sand Effective Friction Angle (ϕ):	32°

HTE considered the following Bank-run Gravel index property average values:

Bank-run Gravel In-Situ Moist Density (γ_m):	125 pounds per cubic foot (pcf)
Bank-run Gravel Effective Friction Angle (ϕ):	34°

HTE considered the following Class A Stone Fill index property average values:

Class A Stone In-Situ Moist Density (γ_m):	140 pounds per cubic foot (pcf)
Class A Stone Effective Friction Angle (ϕ):	34°

Stability analyses were performed, in order to investigate a proposed stone/soil slope concept for permanent riverbank/slope stabilization. The intent of these analyses was to determine the slope and materials necessary to achieve a minimum factor of safety against failure of 1.5 for a 10-year flood event (EL 386.5). Analyses were performed for minimum 3' thickness Class A Stone toe slope configuration to 1' above the 10-year flood level, and with soil above, with a slope of no steeper than 3H:1V. This configuration also considers that the failed soil mass is removed. Analytical results indicate that a factor of safety of approximately 1.5 can be achieved by utilizing more-dense NHDOT Class A Stone for the toe section, with in-place soil cut to a 3H:1V slope (with topsoil cover) for construction of the upper portion.

The use of NHDOT Bank-run Gravel is considered for the balance of the necessary replacement backfill, beneath the stone/rock fills, for the construction phase excavation, assuming a cut-back slope of no steeper than 2H:1V. All new soil backfill, to beneath roadway subgrade, should be compacted to at least 93% of the optimum dry density per ASTM D-1557. Re-use of the native silty sand for backfill is not recommended.

Copies of the stability analysis results for the proposed stone slope, showing the existing/proposed slope profiles, input material properties and resultant minimum factors of safety, are attached as Appendix D (pending).

VI) Other Components

The new stone slope or stone/soil slope section should be underlain by a course of heavy-grade non-woven geotextile. The geotextile should be non-woven heavy grade product meeting the requirements of NHDOT 593.411, and should be installed per the Section 593 requirements for 'permanent erosion control'. Further, for the 1.5H:1V stone slope configuration, the Class C Rip-Rap course for the stone slope option should be underlain by a 1' thickness of NHDOT Class C Stone.

Specifically related to the 3H:1V stone/soil slope configuration, the installation of Envirogrid™ (or similar) cellular units for topsoil surface stabilization between 1' above the 10-year and to 1' above the 50-year flood level (EL 390.75±) is recommended (this is depicted on the updated Holden cross-section).

VII) Recommended Typical Sections

As one alternative, a recommended typical 1.5H:1V stone slope cross-section for the riverbank re-construction, as prepared by Holden, is attached. It is our opinion that proper re-construction of the subject riverbank area with the depicted material configuration and underlying Bank-run Gravel replacement fill for excavation cut will have a factor of safety of greater than 1 relative to the flood event of May 2011.
As a second alternative, a recommended typical 3H:1V stone/soil slope cross-section for the riverbank re-construction, as prepared by Holden, is also attached. It is our opinion that proper re-construction of the subject riverbank area with the depicted Class A stone (toe section) and upper soil material configuration at excavation cut will have a factor of safety of greater than 1 relative to the flood event of May 2011.

VIII) Construction Considerations

For construction of either alternative, it is recommended: 1) that the work be conducted in 100'± wide sections, with complete section construction to at least the 50-year flood level over this width, prior to advancing to the next section; 2) that work on a new section should not be initiated unless the two week advance forecast is favorable; 3) that about 100 cu. yds of NHDOT Class C Stone be kept available at the site for temporary slope stabilization as necessary and 4) that a HTE geotechnical engineer observe the construction of the first re-construction section, in order to be able to comment on the progress of the method chosen for implementation.

IX) Closing

HTE trusts that this submittal will meet your current requirements for assistance to Holden Engineering & Surveying, Inc. with final design of slope stabilization. Please do not hesitate to contact this office should you have any questions.

Very truly yours,

HTE NORTHEAST, INC.

Roger B. Keilig, PE, PG
Sr. Project Manager

Cc: Peter Holden, Holden Engineering & Surveying, Inc.

Attachments: Table 1 – Summary of Explorations
Typical Reconstruction Cross-Section: Stone Slope
Typical Reconstruction Cross-Section: Stone/Soil Slope
Appendix A – Limitations
Appendix B – Test Boring Logs
Appendix C – Stability Analysis Calculations – Stone Slope
Appendix D – Stability Analysis Calculations – Stone/Soil Slope

NORTHEAST INC

APPENDIX A
LIMITATIONS ON WORK PRODUCT

Site Observations

1. The analyses and recommendations submitted in this report are based in part upon the data obtained from limited subsurface observations. The nature and extent of subsurface variations may not become evident until construction. If variations then appear evident, it will be necessary to reevaluate the recommendations of this report.

2. The generalized soil profile described in the text is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized and have been developed by interpretations of limited observations (no engineering subsurface samples were obtained; actual soil and bedrock transitions are probably more erratic.

3. Water level readings have been made under conditions stated. These data have been reviewed and interpretations have been made in the text of this report. However, it must be noted that fluctuations in the level of groundwater may occur due to variations in rainfall, temperature and other factors occurring since the time observations were made.

4. In the event that any changes in the proposed general project development are planned (e.g., floor slab on grade elevations, column and wall loads, building footprint size and location, etc.), the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report modified or verified in writing by HTE Northeast, Inc. It is recommended that this firm be provided the opportunity to review the final design plans and specifications in order to verify that earthwork and foundation recommendations have been properly interpreted and implemented.

Construction

5. It is also recommended that this firm be provided the opportunity to perform the recommended construction phase monitoring services to verify that the intent of our recommendations is being properly implemented in the field during construction. The recommendations given in this report shall not be considered valid unless we are given the opportunity to perform in this capacity.

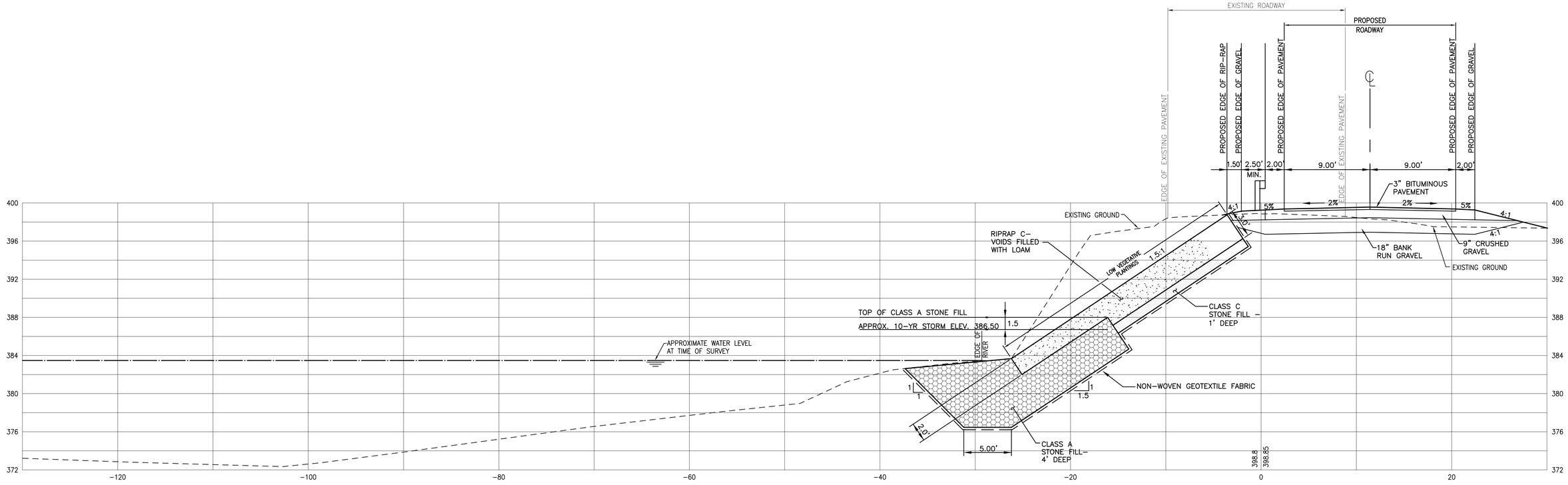
Topographic Data

6. This report is based on topographic data developed by Holden Engineering & Surveying, Inc.

Use of Report

7. This Geotechnical Engineering Report has been prepared for the exclusive use of Town of Lyme and for use by Holden Engineering & Surveying, Inc., in reference to the Proposed River Road Riverbank Re-construction project located at River Road (between N. Thetford Road and E. Thetford Road) in Lyme, NH and is intended to be in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied is made.

8. This soil and foundation engineering report has been prepared for this project by HTE Northeast, Inc. This report is for design purposes only and is not sufficient to prepare an accurate bid. Contractors wishing a copy of the report may secure it only with the authorization of the owner and then with the understanding that its scope is limited to design considerations only.



TYPICAL SECTION RIVER BANK STABILIZATION

1"=5' H
1"=5' V

CLASS A STONE FILL SHALL BE IRREGULAR IN SHAPE WITH APPROXIMATELY 50 PERCENT OF THE MASS HAVING A MINIMUM OF VOLUME OF 12 FT^3 (0.3m^3), APPROXIMATELY 30 PERCENT OF THE MASS RANGING BETWEEN 3 AND 12 FT^3 (0.08 AND 0.3m^3), APPROXIMATELY 10 PERCENT OF THE MASS RANGING BETWEEN 1 AND 3 FT^3 (0.03 AND 0.08 m^3), AND THE REMAINDER OF THE MASS COMPOSED OF SPALLS.

CLASS C STONE FILL SHALL CONSIST OF CLEAN, DURABLE FRAGMENTS OF LEDGE ROCK OF UNIFORM QUALITY, REASONABLY FREE FROM THIN OR ELONGATED PIECES. THE STONE SHALL BE MADE FROM ROCK WHICH IS FREE FROM TOP SOIL AND OTHER ORGANIC MATERIAL. THE STONE SHALLBE GRADED AS FOLLOWS:

SIEVE SIZE		PERCENTAGE BY WEIGHT PASSING
12 INCH	(300 mm)	100
4 INCH	(100mm)	50-90
1-1/2 INCH	(37.5mm)	0-30
3/4 INCH	(19.0mm)	0-10

RIPRAP C:
SEVENTY-FIVE PERCENT OF THE STONES SHALL HAVE A MINIMUM VOLUME OF 12 ft^3.

HTE FILE 4707
REPORT ATTACHMENT
1.5H:1V STONE SLOPE
SEPTEMBER 2011

HOLDEN TRANSPORTATION ENGINEERING

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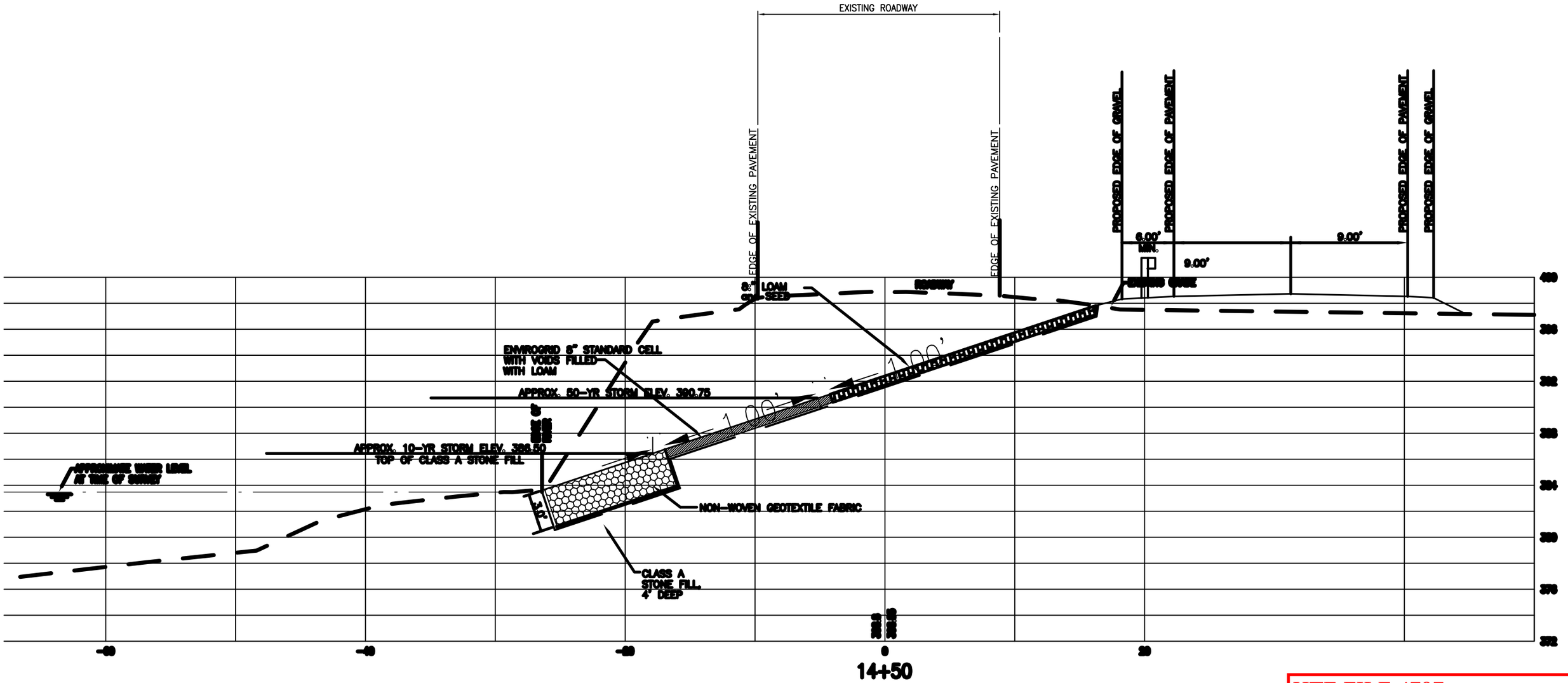
TYPICAL SECTION - RIVER BANK STABILIZATION AND ROADWAY
RIVER ROAD - CONNECTICUT RIVER BANK EROSION
LYME, NH

Revisions Date:	Description	Dr. By	Chk. By

Book | Page

Date: 08-24-11
Scale: 1"=5'
Dr. By: DS Ck By: BT
Job No. 1170009
Sheet no 1 of 2

XBASE



RIVER BANK STABILIZATION SECTION – OPTION NO. 2

HTE FILE 4707
REPORT ATTACHMENT
3H:1V STONE/SOIL SLOPE
OCTOBER 2011

HTE NORTHEAST INC

TABLE 1
SUMMARY OF SUBSURFACE EXPLORATIONS
RIVER ROAD STREAMBANK FAILURE
LYME, NEW HAMPSHIRE
PROJECT NO. 4707

TEST BORING DESIGNATION	GROUND SURFACE ELEVATION	BOTTOM OF FILL	BOTTOM OF ALLUVIUM	BOTTOM OF ICE-CONTACT DEPOSIT	BOTTOM OF EXPLORATION DEPTH	OBSERVED GROUNDWATER LEVELS DURING DRILLING OPERATIONS
		DEPTH (FT)	DEPTH (FT)	DEPTH (FT)	DEPTH (FT)	DEPTH (FT)
HTE-1	398.5 ±	±2	>36 ±	>36 ±	36 ±	15 ±
HTE-2	398 ±	±1	>31 ±	>31 ±	31 ±	N.M. ±
HTE-3	399 ±	±2	34.5 ±	>41 ±	41 ±	15 ±
HTE-4	400 ±	±1	>36 ±	>36 ±	36 ±	N.M. ±

Notes:

1) Borings HTE-1 to 4 were performed on August 15 and 16, 2011 by N. H. Boring, Inc. under HTE observation.

2) Groundwater levels were NOT measured during WASH BORING exploration advancement and therefore are not indicative of stabilized groundwater conditions. Groundwater depths for 08/23/11 for HTE-1 and 3 are shown.

3) Approx. locations of borings: HTE-1 at Sta 18+75; HTE-2 at Sta 16+75; HTE-3 at Sta 14+45; HTE-4 at Sta 13+00.

V:\4000\47\4707.Table 1.1

TEST BORING LOG

HTE NORTHEAST INC
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PROJECT:	**River Road Failure Investigation**	**BORING NO.:** **HTE-1**	**SHEET:** 1 of 2
LOCATION:	Lyme, New Hampshire	**CONTRACTOR:**	New Hampshire Boring, Inc
PROJ. NO:	4707	**FOREMAN:**	Roger Burn
CLIENT:	Holden Engineering & Surveying	**INSPECTOR:**	Erich Adler
DATE:	August 15, 2011	**GROUND SURFACE ELEVATION:**	398.5±

EQUIPMENT:	AUGER	CASING	SAMPLER	COREBRL.	GROUNDWATER OBSERVATIONS			
TYPE		HW	SS		ELAPSED TIME (HR)	175		
SIZE ID (IN)		4	1⅜		CASING AT (FT)	well		
HAMMER WT (LB)		300	140		DEPTH (FT)	15		
HAMMER FALL (IN)		24	30		☐ NO GROUNDWATER ENCOUNTERED			

☐ FIELD TESTING
☐ LABORATORY TESTING
☒ MONITORING WELL INSTALLED
☐ PID SCREENING
☐

Depth (FT)	SAMPLE NUMBER	RECOVERY (IN)	BLOWS PER 6"	STRATUM SYMBOL	SOIL AND ROCK CLASSIFICATION-DESCRIPTION BURMISTER SYSTEM (SOIL) U.S. CORPS OF ENGINEERS SYSTEM (ROCK)	STRATUM CHANGE DESCRIPTION	PID (PPM)
	S1	11	15		Asphalt	0.33	
1			17		Dense olive-brown poorly-graded coarse to fine SAND, trace fine Gravel, trace Silt, no structure, no odor, moist.		
			13				
2			14				
3							
4							
	S2	12	6		Medium dense olive-brown fine SAND and Silt, no structure, no odor, moist.	**ALLUVIUM**	
5			6				
			5				
6			5				
7							
8							
9							
	S3	8	6		Medium dense, similar to above.	**ALLUVIUM**	
10			5				
			5				
11			6				
12							
13							
14						14	
	S4	9	9		Medium dense brown poorly-graded coarse to fine SAND, trace Gravel, no structure, no odor, wet.		
15			10				
			9				
16			10			**ALLUVIUM**	
17							
18							
19						19	
	S5	9	9		Medium dense olive-brown SILT, some fine Sand, no structure, no odor, wet.		
20			9				
			9				
21			9			**ALLUVIUM**	
22							

Notes:
1) TYPE OF RIG: Diedrich D-50: Truck Mounted
2) HAMMER/HOIST TYPE: Safety / Cathead
3) 2" Monitoring well installed at 30' bgs.
4) Sta. 18+73, 1LT.

FILE: :\4000\47\4707 Lyme\Boring Logs\[4707BORINGLOG.xls]HTE 3 (

COHESIONLESS SOILS	COHESIVE SOILS	SAMPLE TYPE	PROPORTIONS
N = 0 - 4 = VERY LOOSE	N = 0 -2 = VERY SOFT	C = ROCK CORE	trace = 0% - 10%
4-10 = LOOSE	1 - 4 = SOFT	S = SPLIT SPOON	little = 10% - 20%
10-30 = MEDIUM	3 - 8 = MEDIUM	UP = UNDISTURBED PISTON	some = 20% - 35%
30-50 = DENSE	7 -15 = STIFF	UT = UNDISTURBED THINWALL	and = 35% - 50%
50 + = VERY DENSE	30 + = HARD		

TEST BORING LOG

NORTHEAST INC
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PROJECT:	**River Road Failure Investigation**	**BORING NO.:** **HTE-1**	**SHEET:** 2 of 2
LOCATION:	**Lyme, New Hampshire**	**CONTRACTOR:**	New Hampshire Boring, Inc
PROJ. NO:	4707	**FOREMAN:**	Roger Burn
CLIENT:	Holden Engineering & Surveying	**INSPECTOR:**	Erich Adler
DATE:	8/15/2011	**GROUND SURFACE ELEVATION:**	

EQUIPMENT:	**AUGER**	**CASING**	**SAMPLER**	**COREBRL.**	**GROUNDWATER OBSERVATIONS**				
TYPE		HW	SS		ELAPSED TIME (HR)	175			☐ FIELD TESTING
SIZE ID (IN)		4	1⅜		CASING AT (FT)	well			☐ LABORATORY TESTING
HAMMER WT (LB)		300	140		DEPTH (FT)	15			☒ MONITORING WELL INSTALLED
HAMMER FALL (IN)		24	30		☐ **NO GROUNDWATER ENCOUNTERED**				☐ PID SCREENING

Depth (FT)	SAMPLE NUMBER	RECOVERY (IN)	BLOWS PER 6"	STRATUM SYMBOL	SOIL AND ROCK CLASSIFICATION-DESCRIPTION BURMISTER SYSTEM (SOIL) U.S. CORPS OF ENGINEERS SYSTEM (ROCK)	STRATUM CHANGE DESCRIPTION	PID (PPM)
23							
24	S6	11	11		Medium dense olive-brown fine SAND, little to trace Silt, no structure, no odor, wet.	**ALLUVIUM**	
25			7				
			8				
26			8				
27							
28							
29							
30	S7	17	5		Loose olive-brown SILT and fine Sand, no structure, no odor, wet.		
			3				
31			2				
32			3				
33							
34							
35	S8	14	10		Dense olive-brown fine SAND, trace medium Sand, trace Silt, no structure, no odor, wet.	**ALLUVIUM**	
36			14				
			16				
			15				
37					Bottom of Exploration at 36'	36'	
38							
39							
40							
41							
42							
43							
44							

Notes:

1) TYPE OF RIG: Diedrich D-50: Truck Mounted
2) HAMMER/HOIST TYPE: Safety / Cathead
3) 2" Monitoring well installed at 30' bgs.

FILE: :\4000\47\4707 Lyme\Boring Logs\[4707BORINGLOG.xls]HTE 3 (

COHESIONLESS SOILS	**COHESIVE SOILS**	**SAMPLE TYPE**	**PROPORTIONS**
N = 0 - 4 = VERY LOOSE	N = 0 -2 = VERY SOFT	C = ROCK CORE	trace = 0% - 10%
4-10 = LOOSE	1 - 4 = SOFT	S = SPLIT SPOON	little = 10% - 20%
10-30 = MEDIUM	3 - 8 = MEDIUM	UP = UNDISTURBED PISTON	some = 20% - 35%
30-50 = DENSE	7 -15 = STIFF	UT = UNDISTURBED THINWALL	and = 35% - 50%
50 + = VERY DENSE	30 + = HARD		

TEST BORING LOG

HTE NORTHEAST INC
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Bedford, New Hampshire 03110
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PROJECT:	**River Road Failure Investigation**	**BORING NO.:** **HTE-2**	**SHEET:** 1 of 2
LOCATION:	Lyme, New Hampshire	**CONTRACTOR:**	New Hampshire Boring, Inc
PROJ. NO:	4707	**FOREMAN:**	Roger Burn
CLIENT:	Holden Engineering & Surveying	**INSPECTOR:**	Erich Adler
DATE:	August 16, 2011	**GROUND SURFACE ELEVATION:**	398±

EQUIPMENT:	**AUGER**	**CASING**	**SAMPLER**	**COREBRL.**	**GROUNDWATER OBSERVATIONS**				
TYPE		HW	SS		ELAPSED TIME (HR)				☐ FIELD TESTING
SIZE ID (IN)		4	1⅜		CASING AT (FT)				☐ LABORATORY TESTING
HAMMER WT (LB)		300	140		DEPTH (FT)				☐ MONITORING WELL INSTALLED
HAMMER FALL (IN)		24	30		☐ **NO GROUNDWATER ENCOUNTERED**				☐ PID SCREENING

Depth (FT)	SAMPLE NUMBER	RECOVERY (IN)	BLOWS PER 6"	STRATUM SYMBOL	SOIL AND ROCK CLASSIFICATION-DESCRIPTION BURMISTER SYSTEM (SOIL) U.S. CORPS OF ENGINEERS SYSTEM (ROCK)	STRATUM CHANGE DESCRIPTION	PID (PPM)
	S1	8			Asphalt	0.33	
1			5		Loose Olive-grey medium to fine SAND, little Gravel, trace Silt, no		
			5		structure, no odor, moist.		
2			4				
			5				
3							
4	S2	13	7		Medium dense brown fine SAND, some Silt, layered, no odor, moist.	**ALLUVIUM**	
			8				
5			6				
			8				
6							
7							
8							
9	S3	11	4		Loose brown fine SAND and Silt, no structure, no odor, moist.		
			3				
10			5				
			4				
11							
12							
13							
14	S4	12	5				
			5		Medium dense poorly-graded medium to fine SAND, little Gravel,	**ALLUVIUM**	
15			7		trace Silt, no structure, no odor, wet.		
			10				
16	S5	20	14		Medium dense brown poorly-graded coarse to fine SAND, little		
			12		Gravel, trace Silt, no structure, no odor, wet.		
17			10				
			11				
18							
19	S6	10	8		Medium dense, similar to above.	19.5	
			4		Medium dense olive-brown SILT, little fine Sand, varved, no odor, wet.		
20			7				
			5				
21	S7	24	8		Medium dense, similar to above.		
			6				
22			11				
			14				

Notes:

1) TYPE OF RIG: Diedrich D-50: Truck Mounted
2) HAMMER/HOIST TYPE: Safety / Cathead

4) Sta. 16+75, 3LT.

FILE: :\4000\47\4707 Lyme\Boring Logs\[4707BORINGLOG.xls]HTE 3 (

COHESIONLESS SOILS	**COHESIVE SOILS**	**SAMPLE TYPE**	**PROPORTIONS**
N = 0 - 4 = VERY LOOSE	N = 0 -2 = VERY SOFT	C = ROCK CORE	trace = 0% - 10%
4-10 = LOOSE	1 - 4 = SOFT	S = SPLIT SPOON	little = 10% - 20%
10-30 = MEDIUM	3 - 8 = MEDIUM	UP = UNDISTURBED PISTON	some = 20% - 35%
30-50 = DENSE	7 -15 = STIFF	UT = UNDISTURBED THINWALL	and = 35% - 50%
50 + = VERY DENSE	30 + = HARD		

TEST BORING LOG

HTE NORTHEAST INC
2 Cote Lane, Suite 1
Bedford, New Hampshire 03110
(603) 668-1654

PROJECT:	**River Road Failure Investigation**	**BORING NO.:** **HTE-2**	**SHEET:** 2 of 2
LOCATION:	**Lyme, New Hampshire**	**CONTRACTOR:**	New Hampshire Boring, Inc
PROJ. NO:	4707	**FOREMAN:**	Roger Burn
CLIENT:	Holden Engineering & Surveying	**INSPECTOR:**	Erich Adler
DATE:	8/16/2011	**GROUND SURFACE ELEVATION:**	

EQUIPMENT:	**AUGER**	**CASING**	**SAMPLER**	**COREBRL.**	**GROUNDWATER OBSERVATIONS**			
TYPE		HW	SS		ELAPSED TIME (HR)			
SIZE ID (IN)		4	1⅜		CASING AT (FT)			
HAMMER WT (LB)		300	140		DEPTH (FT)			
HAMMER FALL (IN)		24	30		☐ **NO GROUNDWATER ENCOUNTERED**			

☐ FIELD TESTING
☐ LABORATORY TESTING
☐ MONITORING WELL INSTALLED
☐ PID SCREENING

Depth (FT)	SAMPLE NUMBER	RECOVERY (IN)	BLOWS PER 6"	STRATUM SYMBOL	SOIL AND ROCK CLASSIFICATION-DESCRIPTION BURMISTER SYSTEM (SOIL) U.S. CORPS OF ENGINEERS SYSTEM (ROCK)	STRATUM CHANGE DESCRIPTION	PID (PPM)
24	S8	16	7 8 11 11		Medium dense olive-brown poorly-graded medium to fine SAND, trace Silt, oxidation layering, no odor, wet.	**ALLUVIUM**	
29	S9	14	9 10 12 13		Medium dense similar to above.	**ALLUVIUM**	
31					Bottom of Exploration at 31'	31'	

Notes:
1) TYPE OF RIG: Diedrich D-50: Truck Mounted
2) HAMMER/HOIST TYPE: Safety / Cathead

FILE: :\4000\47\4707 Lyme\Boring Logs\[4707BORINGLOG.xls]HTE 3 (

COHESIONLESS SOILS	COHESIVE SOILS	SAMPLE TYPE	PROPORTIONS
N = 0 - 4 = VERY LOOSE	N = 0 -2 = VERY SOFT	C = ROCK CORE	trace = 0% - 10%
4-10 = LOOSE	1 - 4 = SOFT	S = SPLIT SPOON	little = 10% - 20%
10-30 = MEDIUM	3 - 8 = MEDIUM	UP = UNDISTURBED PISTON	some = 20% - 35%
30-50 = DENSE	7 -15 = STIFF	UT = UNDISTURBED THINWALL	and = 35% - 50%
50 + = VERY DENSE	30 + = HARD		

TEST BORING LOG

NORTHEAST INC
2 Cote Lane, Suite 1
Bedford, New Hampshire 03110
(603) 668-1654

PROJECT:	**River Road Failure Investigation**	**BORING NO.:** **HTE-3**	**SHEET:** 1 of 2
LOCATION:	Lyme, New Hampshire	**CONTRACTOR:**	New Hampshire Boring, Inc
PROJ. NO:	4707	**FOREMAN:**	Roger Burn
CLIENT:	Holden Engineering & Surveying	**INSPECTOR:**	Erich Adler
DATE:	August 16, 2011	**GROUND SURFACE ELEVATION:**	399±

EQUIPMENT:	AUGER	CASING	SAMPLER	COREBRL.	GROUNDWATER OBSERVATIONS				
TYPE		HW	SS		ELAPSED TIME (HR)	175			☐ FIELD TESTING
SIZE ID (IN)		4	1⅜		CASING AT (FT)	well			☐ LABORATORY TESTING
HAMMER WT (LB)		300	140		DEPTH (FT)	15			☐ MONITORING WELL INSTALLED
HAMMER FALL (IN)		24	30		☐ NO GROUNDWATER ENCOUNTERED				☐ PID SCREENING

Depth (FT)	SAMPLE NUMBER	RECOVERY (IN)	BLOWS PER 6"	STRATUM SYMBOL	SOIL AND ROCK CLASSIFICATION-DESCRIPTION BURMISTER SYSTEM (SOIL) U.S. CORPS OF ENGINEERS SYSTEM (ROCK)	STRATUM CHANGE DESCRIPTION	PID (PPM)
					Asphalt	0.25	
1	S1	18	9 7		Medium Dense brown poorly-graded coarse to fine SAND and Gravel, trace Silt, no structure, no odor, moist.	**FILL**	
2			7 8		Medium dense brown fine SAND and Silt, layered, no odor, moist.	2	
3							
4	S2	12	7 5		Medium dense brown fine SAND and Silt, layered, no odor, moist.	**ALLUVIUM**	
5			5 5				
6							
7							
8							
9	S3	14	4 5		Medium dense brown fine SAND, some Silt, layered, no odor, moist.	**ALLUVIUM**	
10			6 5				
11	S4	12	4 4		Loose, similar to above.		
12			6 7				
13							
14						14	
14	S5	11	8 9		Medium dense brown poorly-graded medium to fine SAND, trace Silt, no structure, no odor, wet.		
15			11 11				
16	S6	16	10 10		Medium dense brown poorly-graded coarse to fine SAND, trace Silt, no structure, no odor, wet.	**ALLUVIUM**	
17			11 9				
18							
19						19	
19	S7	18	7 5		Medium dense olive-brown fine SAND and Silt, layered, no odor, wet.		
20			6 9				
21							
22							

Notes:

1) TYPE OF RIG: Diedrich D-50: Truck Mounted
2) HAMMER/HOIST TYPE: Safety / Cathead
3) 2" Monitoring well installed at 30' bgs.
4) Sta. 14+46, 2LT.

FILE: :\4000\47\4707 Lyme\Boring Logs\[4707BORINGLOG.xls]HTE 3 (

COHESIONLESS SOILS	COHESIVE SOILS	SAMPLE TYPE	PROPORTIONS
N = 0 - 4 = VERY LOOSE	N = 0 -2 = VERY SOFT	C = ROCK CORE	trace = 0% - 10%
4-10 = LOOSE	1 - 4 = SOFT	S = SPLIT SPOON	little = 10% - 20%
10-30 = MEDIUM	3 - 8 = MEDIUM	UP = UNDISTURBED PISTON	some = 20% - 35%
30-50 = DENSE	7 -15 = STIFF	UT = UNDISTURBED THINWALL	and = 35% - 50%
50 + = VERY DENSE	30 + = HARD		

TEST BORING LOG

HTL NORTHEAST INC
2 Cote Lane, Suite 1
Bedford, New Hampshire 03110
(603) 668-1654

PROJECT:	**River Road Failure Investigation**	**BORING NO.:** **HTE-3**	**SHEET:** 2 of 2
LOCATION:	**Lyme, New Hampshire**	**CONTRACTOR:**	New Hampshire Boring, Inc
PROJ. NO:	4707	**FOREMAN:**	Roger Burn
CLIENT:	Holden Engineering & Surveying	**INSPECTOR:**	Erich Adler
DATE:	8/16/2011	**GROUND SURFACE ELEVATION:**	

EQUIPMENT:	**AUGER**	**CASING**	**SAMPLER**	**COREBRL.**	**GROUNDWATER OBSERVATIONS**				
TYPE		HW	SS		ELAPSED TIME (HR)	175			☐ FIELD TESTING
SIZE ID (IN)		4	1⅜		CASING AT (FT)	well			☐ LABORATORY TESTING
HAMMER WT (LB)		300	140		DEPTH (FT)	15			☐ MONITORING WELL INSTALLED
HAMMER FALL (IN)		24	30		☐ NO GROUNDWATER ENCOUNTERED				☐ PID SCREENING

Depth (FT)	SAMPLE NUMBER	RECOVERY (IN)	BLOWS PER 6"	STRATUM SYMBOL	SOIL AND ROCK CLASSIFICATION-DESCRIPTION BURMISTER SYSTEM (SOIL) U.S. CORPS OF ENGINEERS SYSTEM (ROCK)	STRATUM CHANGE DESCRIPTION	PID (PPM)
23							
24	S8	18	7		Medium dense olive-brown fine SAND and Silt, layered, no odor, wet.	**ALLUVIUM**	
25			7				
26			10				
27			12				
28							
29							
30	S9	16	7		Medium dense olive-brown fine SAND and Silt, layered, no odor, wet.	**ALLUVIUM**	
31			6				
32			9				
33			13				
34							
35	S10	16	13		Dense olive-brown fine SAND and Silt, layered, no odor, wet.	34.5	
36			13		Dense grey poorly-graded fine SAND, trace Silt, no structure, no odor, wet.		
37			17			**GLACIO FLUVIAL DEPOSIT**	
38			17				
39							
40	S11	14	14		Dense grey poorly-graded fine SAND, trace Silt, no structure, no odor, wet.		
41			16				
42			20				
43			22				
44					Bottom of Exploration at 41'	41'	

Notes:

1) TYPE OF RIG: Diedrich D-50: Truck Mounted
2) HAMMER/HOIST TYPE: Safety / Cathead
3) 2" Monitoring well installed at 30' bgs.
4) Sta. 14+46, 2LT.

FILE: :\4000\47\4707 Lyme\Boring Logs\[4707BORINGLOG.xls]HTE 3 (

COHESIONLESS SOILS	COHESIVE SOILS	SAMPLE TYPE	PROPORTIONS
N = 0 - 4 = VERY LOOSE	N = 0 -2 = VERY SOFT	C = ROCK CORE	trace = 0% - 10%
4-10 = LOOSE	1 - 4 = SOFT	S = SPLIT SPOON	little = 10% - 20%
10-30 = MEDIUM	3 - 8 = MEDIUM	UP = UNDISTURBED PISTON	some = 20% - 35%
30-50 = DENSE	7 -15 = STIFF	UT = UNDISTURBED THINWALL	and = 35% - 50%
50 + = VERY DENSE	30 + = HARD		

TEST BORING LOG

NORTHEAST INC
2 Cote Lane, Suite 1
Bedford, New Hampshire 03110
(603) 668-1654

PROJECT:	**River Road Failure Investigation**	**BORING NO.:** **HTE-4**	**SHEET:** 1 of 2
LOCATION:	Lyme, New Hampshire	**CONTRACTOR:**	New Hampshire Boring, Inc
PROJ. NO:	4707	**FOREMAN:**	Roger Burn
CLIENT:	Holden Engineering & Surveying	**INSPECTOR:**	Erich Adler
DATE:	August 16, 2011	**GROUND SURFACE ELEVATION:**	400±

EQUIPMENT:	**AUGER**	**CASING**	**SAMPLER**	**COREBRL.**	**GROUNDWATER OBSERVATIONS**				
TYPE		HW	SS		ELAPSED TIME (HR)				☐ FIELD TESTING
SIZE ID (IN)		4	1⅜		CASING AT (FT)				☐ LABORATORY TESTING
HAMMER WT (LB)		300	140		DEPTH (FT)				☐ MONITORING WELL INSTALLED
HAMMER FALL (IN)		24	30		☐ **NO GROUNDWATER ENCOUNTERED**				☐ PID SCREENING

Depth (FT)	SAMPLE NUMBER	RECOVERY (IN)	BLOWS PER 6"	STRATUM SYMBOL	SOIL AND ROCK CLASSIFICATION-DESCRIPTION BURMISTER SYSTEM (SOIL) U.S. CORPS OF ENGINEERS SYSTEM (ROCK)	STRATUM CHANGE DESCRIPTION	PID (PPM)
	S1	19			Asphalt	0.25	
1			16		Medium dense light brown fine SAND, little Silt, no structure, no		
			6		odor, moist.		
2			5				
			3				
3							
4	S2	16	5		Loose olive-brown poorly-graded fine SAND, trace to little Silt, no	**ALLUVIUM**	
			5		structure, no odor, moist.		
5			4				
			5				
6							
7							
8							
9	S3	6	6		Loose olive-grey to olive-brown poorly-graded fine SAND, trace Silt,		
			4		no structure, no odor, moist.		
10			4				
			6				
11	S4	13	6		Medium dense olive-brown poorly-graded fine SAND, trace to little		
			6		Silt, no structure, no odor, moist.		
12			6				
			6				
13							
14	S5	12	6		Medium dense poorly-graded coarse to fine SAND, trace Silt, no	**ALLUVIUM**	
			7		structure, no odor, moist to wet.		
15			8				
			12				
16	S6	14	9		Medium dense, similar to above except wet.		
			10				
17			11				
			12				
18							
19	S7	9	10		Medium dense, similar to above.		
			10				
20			13				
			11				
21							
22							

Notes:

1) TYPE OF RIG: Diedrich D-50: Truck Mounted
2) HAMMER/HOIST TYPE: Safety / Cathead

4) Sta. 12+98, 5LT.

FILE: :\4000\47\4707 Lyme\Boring Logs\[4707BORINGLOG.xls]HTE 3 (

COHESIONLESS SOILS	**COHESIVE SOILS**	**SAMPLE TYPE**	**PROPORTIONS**
N = 0 - 4 = VERY LOOSE	N = 0 -2 = VERY SOFT	C = ROCK CORE	trace = 0% - 10%
4-10 = LOOSE	1 - 4 = SOFT	S = SPLIT SPOON	little = 10% - 20%
10-30 = MEDIUM	3 - 8 = MEDIUM	UP = UNDISTURBED PISTON	some = 20% - 35%
30-50 = DENSE	7 -15 = STIFF	UT = UNDISTURBED THINWALL	and = 35% - 50%
50 + = VERY DENSE	30 + = HARD		

TEST BORING LOG

NORTHEAST INC
2 Cote Lane, Suite 1
Bedford, New Hampshire 03110
(603) 668-1654

PROJECT:	**River Road Failure Investigation**	**BORING NO.:** **HTE-**	**SHEET:** 2 of 2
LOCATION:	**Lyme, New Hampshire**	**CONTRACTOR:**	New Hampshire Boring, Inc
PROJ. NO:	4707	**FOREMAN:**	Roger Burn
CLIENT:	Holden Engineering & Surveying	**INSPECTOR:**	Erich Adler
DATE:	8/16/2011	**GROUND SURFACE ELEVATION:**	

EQUIPMENT:	**AUGER**	**CASING**	**SAMPLER**	**COREBRL.**	**GROUNDWATER OBSERVATIONS**			
TYPE		HW	SS		ELAPSED TIME (HR)			
SIZE ID (IN)		4	1⅜		CASING AT (FT)			
HAMMER WT (LB)		300	140		DEPTH (FT)			
HAMMER FALL (IN)		24	30		☐ **NO GROUNDWATER ENCOUNTERED**			

☐ FIELD TESTING
☐ LABORATORY TESTING
☐ MONITORING WELL INSTALLED
☐ PID SCREENING

Depth (FT)	SAMPLE NUMBER	RECOVERY (IN)	BLOWS PER 6"	STRATUM SYMBOL	SOIL AND ROCK CLASSIFICATION-DESCRIPTION BURMISTER SYSTEM (SOIL) U.S. CORPS OF ENGINEERS SYSTEM (ROCK)	STRATUM CHANGE DESCRIPTION	PID (PPM)
23							
24	S8	11	6		Medium dense olive-brown SILT, some fine Sand, no structure, no odor, wet.	**ALLUVIUM**	
25			5				
26			9				
27			11				
28							
29	S9	16	8		Medium dense olive-brown medium to fine SAND, little Silt, no structrue, no odor, wet.	**ALLUVIUM**	
30			8				
31			8				
32			16		Bottom of Exploration at 31'	31'	
33							
34							
35							
36							
37							
38							
39							
40							
41							
42							
43							
44							

Notes:

1) TYPE OF RIG: Diedrich D-50: Truck Mounted
2) HAMMER/HOIST TYPE: Safety / Cathead

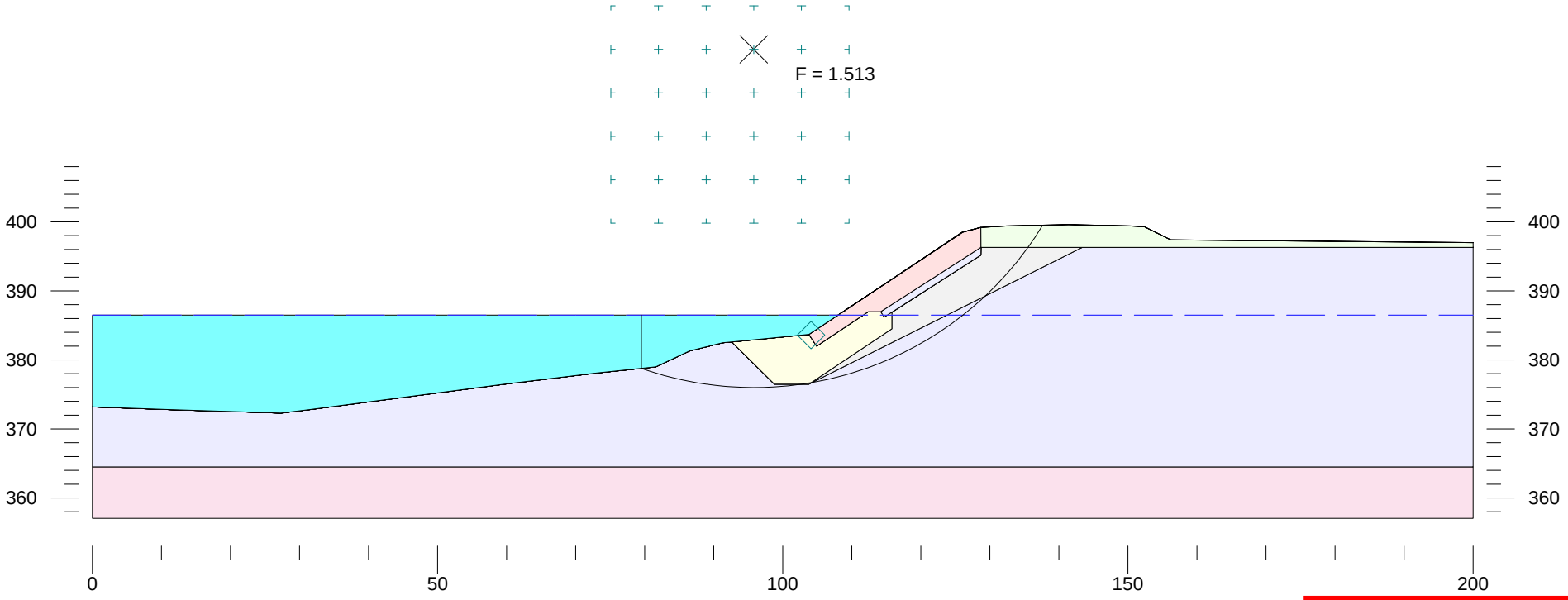
4) Sta. 12+98, 5LT.

FILE: :\4000\47\4707 Lyme\Boring Logs\[4707BORINGLOG.xls]HTE 3 (

COHESIONLESS SOILS	**COHESIVE SOILS**	**SAMPLE TYPE**	**PROPORTIONS**
N = 0 - 4 = VERY LOOSE	N = 0 -2 = VERY SOFT	C = ROCK CORE	trace = 0% - 10%
4-10 = LOOSE	1 - 4 = SOFT	S = SPLIT SPOON	little = 10% - 20%
10-30 = MEDIUM	3 - 8 = MEDIUM	UP = UNDISTURBED PISTON	some = 20% - 35%
30-50 = DENSE	7 -15 = STIFF	UT = UNDISTURBED THINWALL	and = 35% - 50%
50 + = VERY DENSE	30 + = HARD		

	Gamma	C	Phi	Piezo
	pcf	psf	deg	Surf.
Water	62.4	0	0	0
Road Fill	125	0	35	1
RipRap C	120	0	40	1
Class C Stone	135	0	45	1
Class A Stone	140	0	45	1
Fill	125	0	34	1
Silty Sand	120	0	32	1
Dense SAND	130	0	34	1

HTE Northeast, Inc. - Bedford NH
4707
River Road Slope Failures
September 2011
10 year flood level

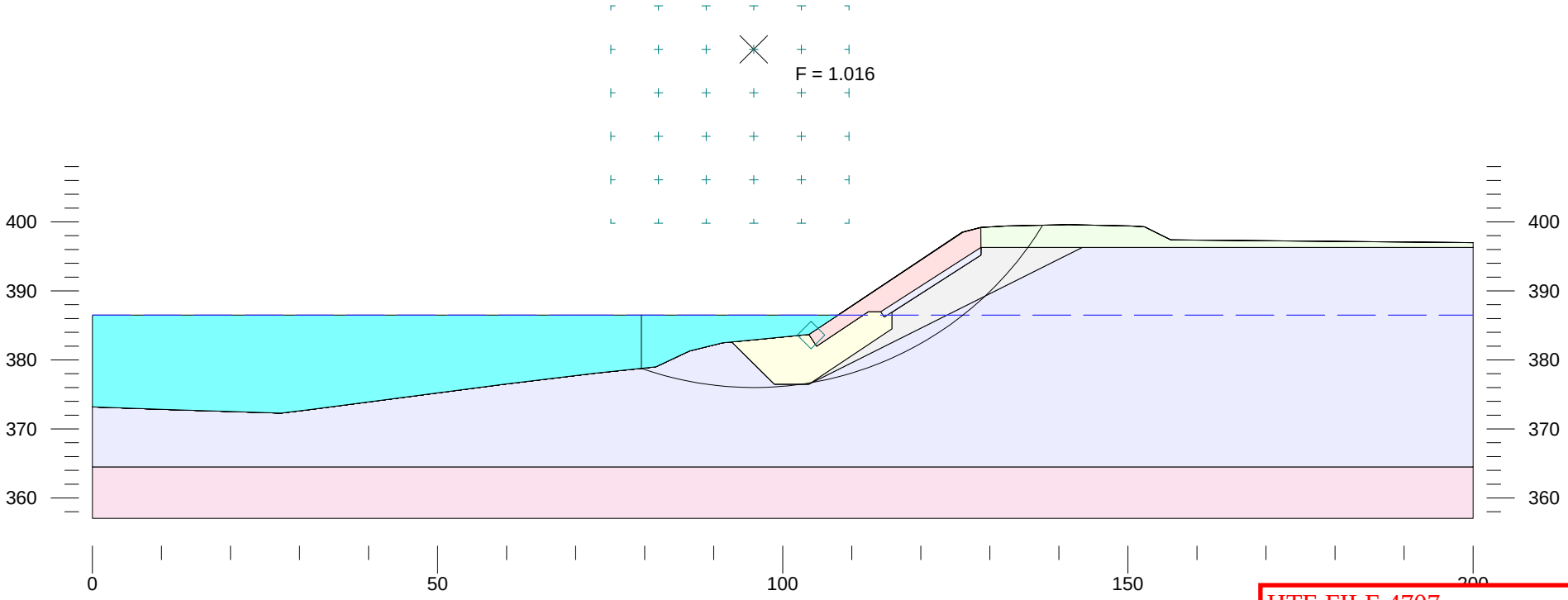


HTE FILE 4707
APPENDIX C.1
1.5H:1V STONE SLOPE
10-YEAR EVENT

	Gamma	C	Phi	Piezo
	pcf	psf	deg	Surf.
Water	62.4	0	0	0
Road Fill	125	0	35	1
RipRap C	120	0	40	1
Class C Stone	135	0	45	1
Class A Stone	140	0	45	1
Fill	125	0	34	1
Silty Sand	120	0	32	1
Dense SAND	130	0	34	1

Seismic coefficient = 0.14

HTE Northeast, Inc. - Bedford NH
4707
River Road Slope Failures
September 2011
10 year flood level



HTE FILE 4707
APPENDIX C.2
1.5H:1V STONE SLOPE
EARTHQUAKE