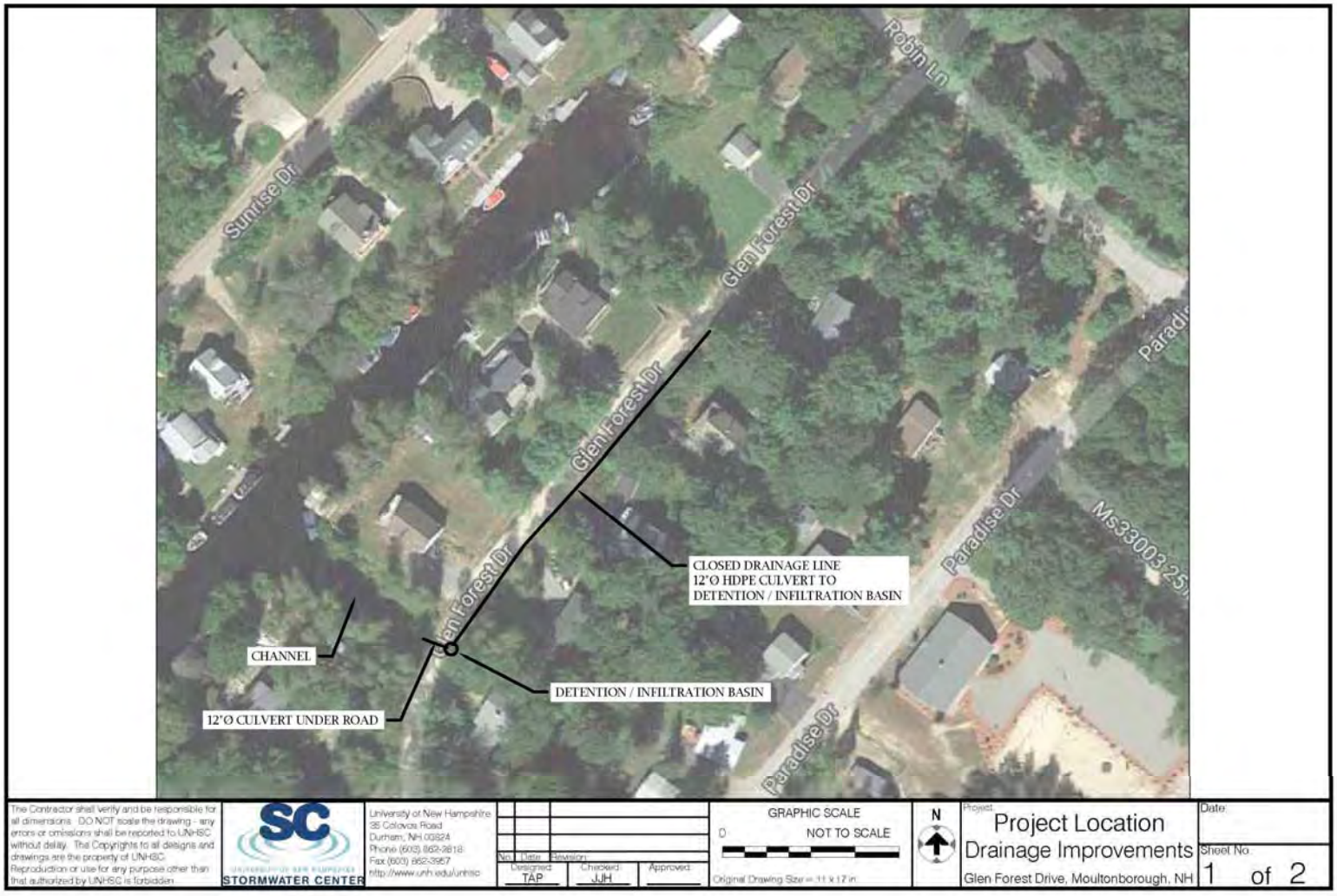
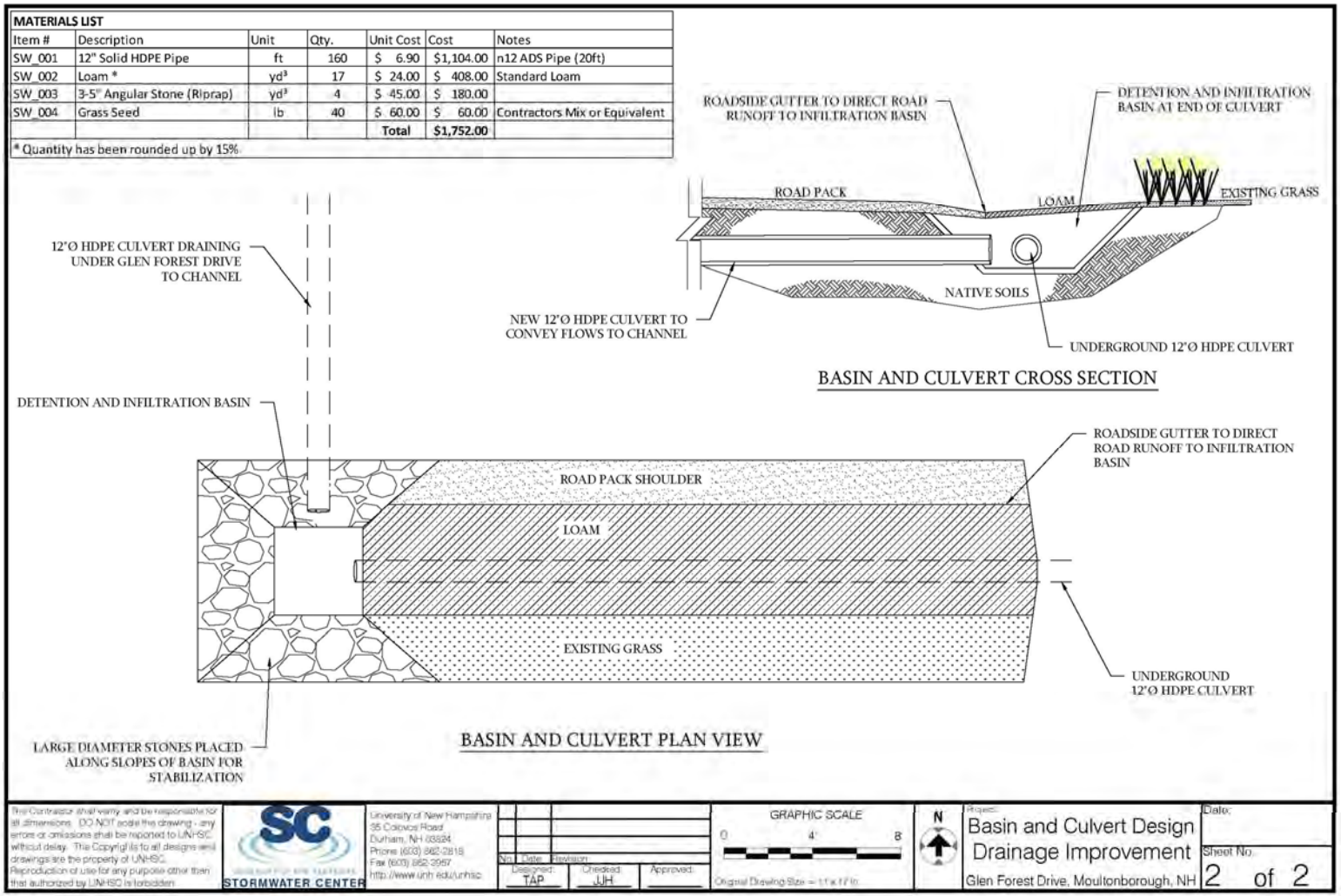
APPENDIX E: UNHSC DESIGNS FOR BMP SITES

Site 1-23: Glen Forest Drive, Balmoral, Moultonborough, NH



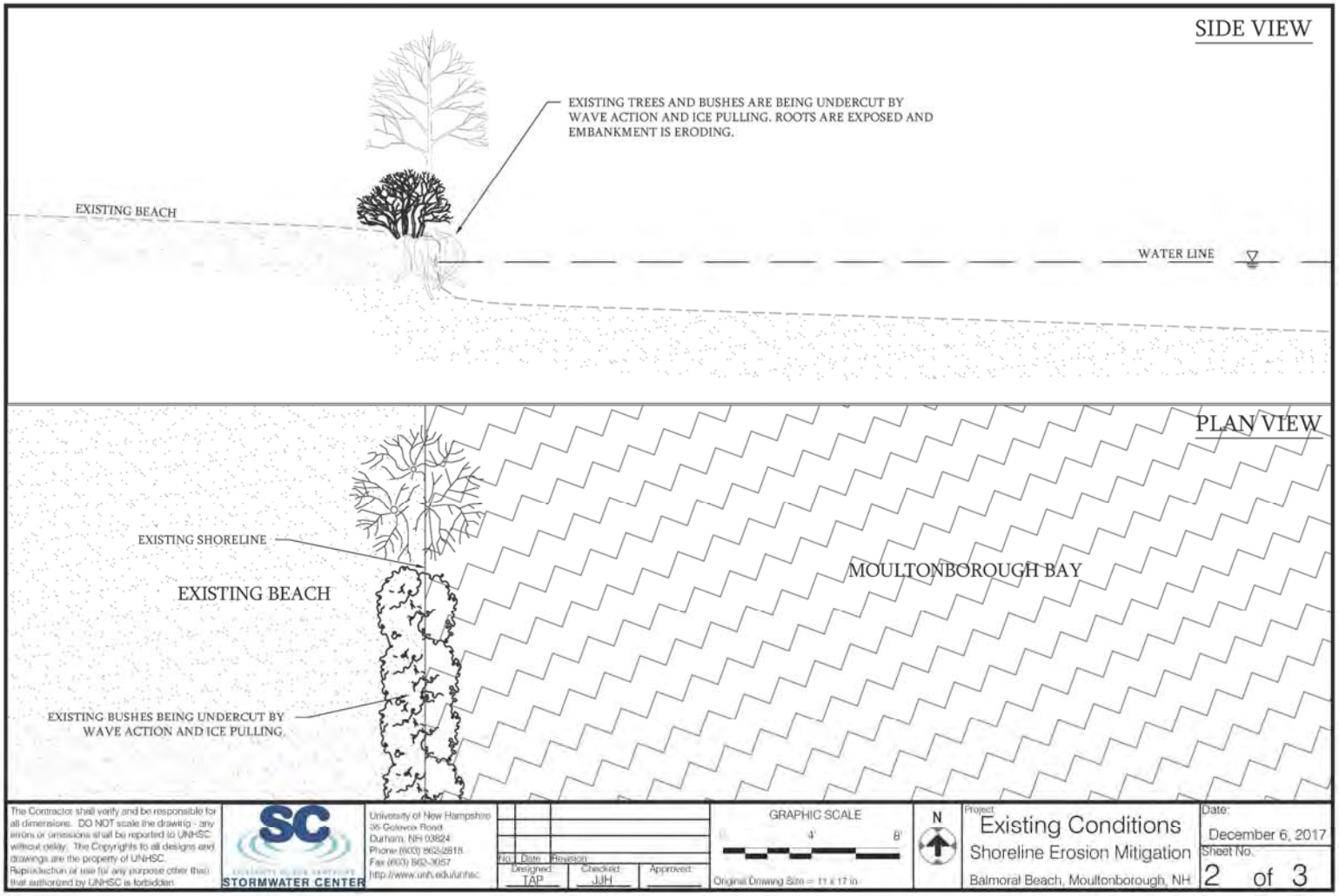


MATERIALS LIST

Item #	Description	Unit	Qty.	Unit Cost	Cost	Notes
SW_001	12" Solid HDPE Pipe	ft	160	$ 6.90	$1,104.00	n12 ADS Pipe (20ft)
SW_002	Loam *	yd^3	17	$ 24.00	$ 408.00	Standard Loam
SW_003	3-5" Angular Stone (Riprap)	yd^3	4	$ 45.00	$ 180.00	
SW_004	Grass Seed	lb	40	$ 60.00	$ 60.00	Contractors Mix or Equivalent
				Total	$1,752.00	

* Quantity has been rounded up by 15%

Site 2-05: Balmoral Beach, Balmoral, Moultonborough, NH


SIDE VIEW
EXISTING TREES AND BUSHES ARE BEING UNDERCUT BY WAVE ACTION AND ICE PULLING. ROOTS ARE EXPOSED AND EMBANKMENT IS ERODING.
EXISTING BEACH
WATER LINE
PLAN VIEW
EXISTING SHORELINE
EXISTING BEACH
MOULTONBOROUGH BAY
EXISTING BUSHES BEING UNDERCUT BY WAVE ACTION AND ICE PULLING.
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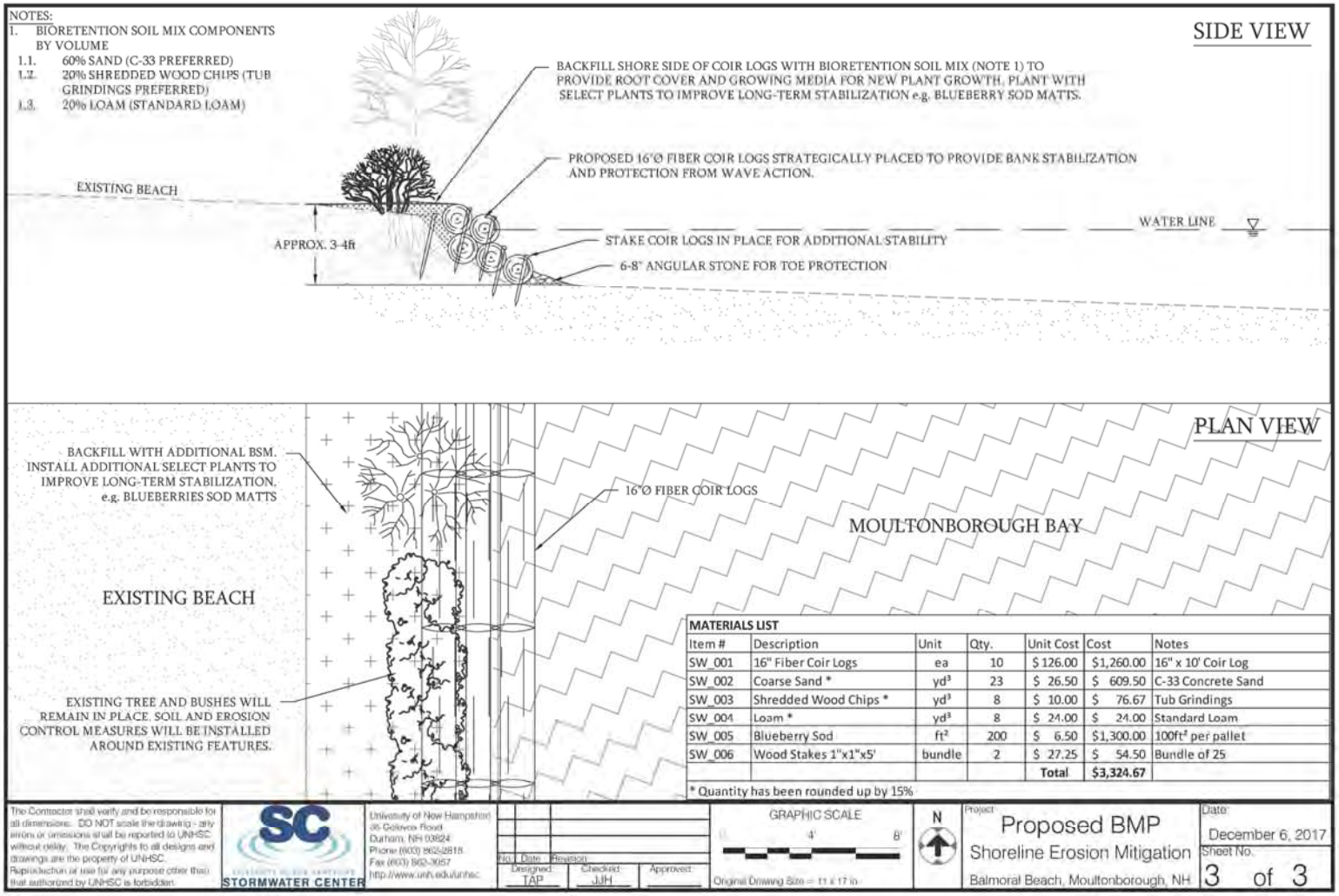
No. Date Revision
Designed: TAP
Checked: JJH
Approved:
GRAPHIC SCALE
0 4' 8'
Original Drawing Size = 11 x 17 in.
N
Project:
Existing Conditions
Shoreline Erosion Mitigation
Balmoral Beach, Moultonborough, NH
Date:
December 6, 2017
Sheet No.
2 of 3


NOTES:
1. BIORETENTION SOIL MIX COMPONENTS BY VOLUME
1.1. 60% SAND (C-33 PREFERRED)
1.2. 20% SHREDDED WOOD CHIPS (TUB GRINDINGS PREFERRED)
1.3. 20% LOAM (STANDARD LOAM)
SIDE VIEW
BACKFILL SHORE SIDE OF COIR LOGS WITH BIORETENTION SOIL MIX (NOTE 1) TO PROVIDE ROOT COVER AND GROWING MEDIA FOR NEW PLANT GROWTH. PLANT WITH SELECT PLANTS TO IMPROVE LONG-TERM STABILIZATION e.g. BLUEBERRY SOD MATTS.
PROPOSED 16"Ø FIBER COIR LOGS STRATEGICALLY PLACED TO PROVIDE BANK STABILIZATION AND PROTECTION FROM WAVE ACTION.
EXISTING BEACH
APPROX. 3-4ft
WATER LINE
STAKE COIR LOGS IN PLACE FOR ADDITIONAL STABILITY
6-8" ANGULAR STONE FOR TOE PROTECTION
PLAN VIEW
BACKFILL WITH ADDITIONAL BSM. INSTALL ADDITIONAL SELECT PLANTS TO IMPROVE LONG-TERM STABILIZATION. e.g. BLUEBERRIES SOD MATTS
16"Ø FIBER COIR LOGS
MOULTONBOROUGH BAY
EXISTING BEACH
EXISTING TREE AND BUSHES WILL REMAIN IN PLACE. SOIL AND EROSION CONTROL MEASURES WILL BE INSTALLED AROUND EXISTING FEATURES.
MATERIALS LIST
Item # | Description | Unit | Qty. | Unit Cost | Cost | Notes
SW_001 | 16" Fiber Coir Logs | ea | 10 | $ 126.00 | $1,260.00 | 16" x 10' Coir Log
SW_002 | Coarse Sand * | yd³ | 23 | $ 26.50 | $ 609.50 | C-33 Concrete Sand
SW_003 | Shredded Wood Chips * | yd³ | 8 | $ 10.00 | $ 76.67 | Tub Grindings
SW_004 | Loam * | yd³ | 8 | $ 24.00 | $ 24.00 | Standard Loam
SW_005 | Blueberry Sod | ft² | 200 | $ 6.50 | $1,300.00 | 100ft² per pallet
SW_006 | Wood Stakes 1"x1"x5' | bundle | 2 | $ 27.25 | $ 54.50 | Bundle of 25
Total $3,324.67
* Quantity has been rounded up by 15%
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N
Project
Proposed BMP
Shoreline Erosion Mitigation
Balmoral Beach, Moultonborough, NH
Date
December 6, 2017
Sheet No.
3 of 3

Recommended BMPs – States Landing Beach Area Improvements

Moultonborough Bay Watershed Plan - Recommended BMPs – States Landing Beach

Project: Moultonborough Bay Watershed Plan - Recommended BMPs

Project Objectives:

Working in collaboration with FB Environmental, the University of New Hampshire Stormwater Center (UNHSC) was tasked with providing Green Infrastructure design recommendations for the States Landing redevelopment project.

Documents:

For these recommendations the concept design entitled States Landing Beach Area Improvement Project Conceptual Plan produced by G2+1 LLC and dated March 25, 2016 was used.

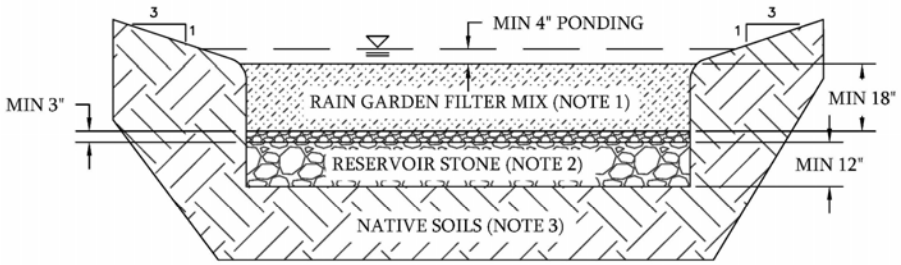
Comments:

Overall, the concept design is detailed and well developed with its selection and siting of green infrastructure stormwater controls (raingardens and bioswales). UNHSC recommendations for system detail including system cross-sections, materials specification, sizing and pollutant load reduction potential are included here to assist with system design. Vegetation is not specified and can be selected based on the towns aesthetic needs. At minimum the systems should be densely vegetated with a grass (rye, fescue) mix.

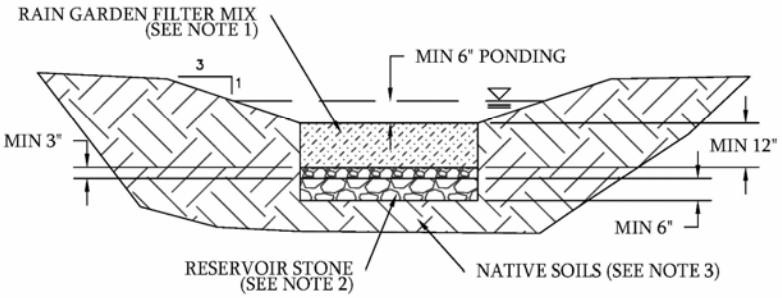
Contents:

NOTES

1. RAIN GARDEN FILTER MIX IS COMPRISED OF THE FOLLOWING MATERIALS MIXED BY VOLUME
   - 1.1. 60% COARSE SAND (ASTM C-33)
   - 1.2. 20% STANDARD LOAM
   - 1.3. 20% SHREDDED WOOD CHIPS (TUB GRINDINGS)
2. RESERVOIR STONE SHALL BE ⅜" STONE OR LARGER. STONE GREATER THAN OR EQUAL TO ¾" SHALL HAVE A 3" LAYER OF ⅜" STONE SEPARATING THE FILTER MIX AND RESERVOIR STONE.
3. DO NOT COMPACT NATIVE SOILS AT THE BOTTOM OF EXCAVATION
4. DO NOT USE ANY TEXTILE FABRICS WITHIN VERTICAL CROSS SECTION OF SYSTEM.
5. SURFACE SHALL BE DENSELY VEGETATED TO PREVENT EROSION. VEGETATION TYPE SHALL BE IN ACCORDANCE WITH PREFERRED MAINTENANCE PRACTICES.



TYPICAL RAIN GARDEN CROSS-SECTION



TYPICAL TREATMENT SWALE CROSS-SECTION

STORMWATER CENTER

GRAPHIC SCALE 0 3' 6'

No.	Date	Revision

Designed: TAP | Checked: JJH | Approved: TPB

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Project: Typical Cross-Sections
States Landing Beach
Moultonborough, NH

Date: December 7, 2017

Sheet No. 1 of 1

1

SOIL PREPARATION (PERFORMANCE SPECIFICATION) for Bioretention Systems

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes soil media for the bioretention systems and rain gardens specified according to performance requirements of the mixes. In general, the media is suitable for a variety of plant species however, careful consideration of system hydrology and solar radiation should be included in plant selection.

1.2 ALLOWANCES

A. Preconstruction and field quality-control testing are part of testing and inspecting allowance.

1.3 DEFINITIONS

A. Bioretention Soil Mix (BSM): Existing, on-site soil; imported soil; or manufactured soil that has been modified as specified with soil amendments. A soil mixture best for media filtration.

B. Cation exchange capacity (CEC): a measure of the soil's ability to hold positively charged ions.

C. Organic Matter: The total organic materials in soil and the soil biomass; also called "humus" or "soil organic matter."

D. Subgrade: Surface and/or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill above which a bioretention system is constructed.

1.4 PREINSTALLATION MEETINGS

A. Pre-installation Conference: Conduct conference at **the Project site prior to commencement of construction activities**

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include recommendations for application and use.
2. Include test data substantiating that products comply with requirements.
3. Include sieve analyses for aggregate materials.
4. Material Certificates: For each type of imported soil, soil amendment and/or fertilizer, before delivery to the site, according to the following:
   a. Manufacturer's qualified testing agency's certified analysis of standard products.
   b. Analysis of nonstandard materials, by a qualified testing agency.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For each testing agency.

B. Preconstruction Test Reports: For preconstruction soil analyses specified in "Preconstruction Testing" Article.

C. Field quality-control reports.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.

1. Laboratories: Subject to compliance with requirements.

1.8 TESTING REQUIREMENTS

A. General: Perform tests on soil samples according to requirements in this article.

B. Physical Testing:

1. Soil samples must be obtained during the soil characterization field analysis and classified according to ASTM D2487 (Standard Practice for Classification of Soils for Engineering Purposes [Unified Soil Classification System]) and ASTM D2488 (Standard Practice for Description and Identification of Soils [Visual-Manual Procedure]).
2. Soil samples must undergo laboratory particle size analysis according to ASTM D422 (Standard Test Method for Particle-Size Analysis of Soils).

C. Chemical Testing:

1. Cation Exchange Capacity (CEC): Analysis by sodium saturation at pH 7

D. Fertility Testing: Soil fertility analysis according to standard laboratory protocols including the following:

1. Percentage of organic matter.
2. CEC, calcium percent of CEC, and magnesium percent of CEC.
3. Soil reaction (acidity/alkalinity pH value).
4. Nitrogen ppm.
5. Phosphorous ppm.
6. Copper ppm.

E. Organic-Matter Content: Using ASTM D 2974-00 Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils. Analysis using loss-by-ignition method.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.

3. Do not move or handle materials when they are wet or frozen.

PART 2 - PRODUCTS

2.1 SOIL MEDIA SPECIFIED ACCORDING TO PERFORMANCE REQUIREMENTS
Particle Size Distribution according to ASTM D422 (Standard Test Method for Particle-Size Analysis of Soils).

1. Particle Size Distribution by Separates:
   a. Exclude any material > 4.76 mm - 0%
   b. Very Coarse Sand/Gravel: Gravel (2.0 to 4.76 mm) 5% maximum (percent by dry weight).
   c. Sand (0.42 to 2.0 mm) 60 - 85% (percent by dry weight).
   d. Silt (0.075 to 0.42 mm) 20% maximum (percent by dry weight).
   e. Clay (less than 0.075mm) 5% maximum (percent by dry weight).

Table 1: Acceptable particle size distribution of final bioretention soil mix

Sieve #	Sieve Size in (mm)	% Passing
4	0.187 (4.76)	100
10	0.079 (2)	95
40	0.017 (0.42)	40 - 15
200	0.003 (0.075)	10 - 20
<200	Pan	0 - 5

2. Fragment Size Distribution:
   a. Sticks and Roots: should be minimized and preferably limited to nothing larger than 4.76 mm
   b. Debris and Other Foreign Materials: should be minimized

3. Percentage of Organic Matter: Minimum 3 percent by volume and maximum 8 percent by volume.
4. Soil Reaction: pH of 6 to 7.
5. CEC of Total Soil: Minimum 10 meq/100 mL at pH of 7.0.
6. Basis-of-Design Product: Subject to compliance with requirements indicated on Drawings
7. Basic Properties: Manufactured soil **SHALL NOT** contain the following:
   a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, asphalt, bricks, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, solid waste, and other extraneous materials that are harmful to plant growth.
   b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of 5 percent by dry weight of the manufactured soil.
   c. Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding 0.187 inches (4.76 mm) in any dimension.

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2.2 ACCEPTABLE ORGANIC SOIL AMENDMENTS

A. No compost should be used in the planting mix unless specified by the engineer.

B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture with 100 percent passing through a 1/2-inch (13-mm) sieve, a pH of 3.4 to 4.8.

C. Wood Derivatives: Shredded wood, wood chips, ground bark, or wood waste; of uniform texture and free of stones, sticks, soil, or toxic materials.

D. Media amendments such as zero-valent iron and/or drinking water treatment residuals (alum) to enhance phosphorus sorption as specified by the engineer.

PART 3 - EXECUTION

3.1 GENERAL

A. Place soil media according to requirements in other Specification Sections.

B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, asphalt/concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, solid waste, or acid has been deposited in planting soil.

C. Proceed with placement only after unsatisfactory conditions have been corrected.

D. Compaction: Compact each blended lift of soil media to 75 percent of maximum Standard Proctor density according to ASTM D 698

E. Finish Grading: Grade soil media to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections:

1. Compaction: Test planting-soil compaction after placing each lift and at completion using a densitometer or soil-compaction meter calibrated to a reference test value based on laboratory testing according to ASTM D 698.
2. Retain "Performance Testing" Subparagraph below if required; revise to suit Project.
3. Performance Testing: For each amended soil media type, demonstrating compliance with specified performance requirements. Perform testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.

C. Soil media will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Label each sample and test report with the date, location keyed to a site plan or other location system, visible conditions when and where sample was taken, and sampling depth.

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3.3 PROTECTION

A. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Vehicle traffic.
4. Foot traffic.
5. Erection of sheds or structures.
6. Impoundment of water.
7. Excavation or other digging unless otherwise indicated.

B. If soil media or subgrade is over compacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the soil media and contamination; restore the subgrade as directed by Engineer and replace contaminated soil media with new soil media.

3.4 CLEANING

A. Protect areas adjacent to soil media preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.

B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.

1. Dispose of excess subsoil and unsuitable materials on-site where directed by Owner.

6

Biofiltration Factsheet

Biofiltration is a practice that provides temporary storage of runoff for filtering through an engineered soil media. The storage capacity is typically made of void spaces in the filter media and temporary ponding at the surface of the practice. Once the runoff has passed through the filter media it is collected by an under-drain pipe for discharge. The performance curve for this control practice assumes zero infiltration. If a filtration system has subsurface soils that are suitable for infiltration, then user should use either the performance curves for the infiltration trench or the infiltration basin depending on the predominance of storage volume made up by free standing storage or void space storage. Depending on the design of the manufactured or packaged bio-filter systems such as tree box filters may be suitable for using the bio-filtration performance results. Design specifications for biofiltration systems are provided in the most recent version of *The New Hampshire Stormwater Manual, Volume 2: Post-Construction Best Management Practices Selection and Design.*

Sample Design

Profile view of a Tree Box Filter. The underdrain makes the system one example of a biofiltration system.

Examples images from the *New Hampshire Stormwater Manual, Volume 2*, p. 116

Pollutant Export Rate by Land Use[1]

Source Category by Land Use	Land Surface Cover	P Load Export Rate[1] (lbs./acre/year)	N Load Export Rate[2] (lbs./acre/year)
Commercial (COM) and Industrial (IND)	Directly connected impervious	1.78	15
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.32	14.1
Medium-Density Residential (MDR)	Directly connected impervious	1.96	14.1
Low-Density Residential (LDR) - "Rural"	Directly connected impervious	1.52	14.1

[1] From NH Small MS4 General Permit, Appendix F

General Equations

Physical Storage Capacity: Depth of Runoff * Drainage Area
Cost: Physical Storage Capacity * Cost Index * Adjustment Factor
Yearly Pollutant Removal: Pollutant Load Export Rate * Drainage Area * Efficiency

Cost

Infiltration Trench System	Materials and Installation Cost ($/ft³) (2010)[2]	Design Cost ($/ft³) (2010)	Materials and Installation Cost ($/ft³) (2017)[3]	Design Cost ($/ft³) (2017)
Rural	10	3.5	12.3	4.31
Mixed	20	7	24.6	8.62
Urban	30	10.5	36.9	12.93

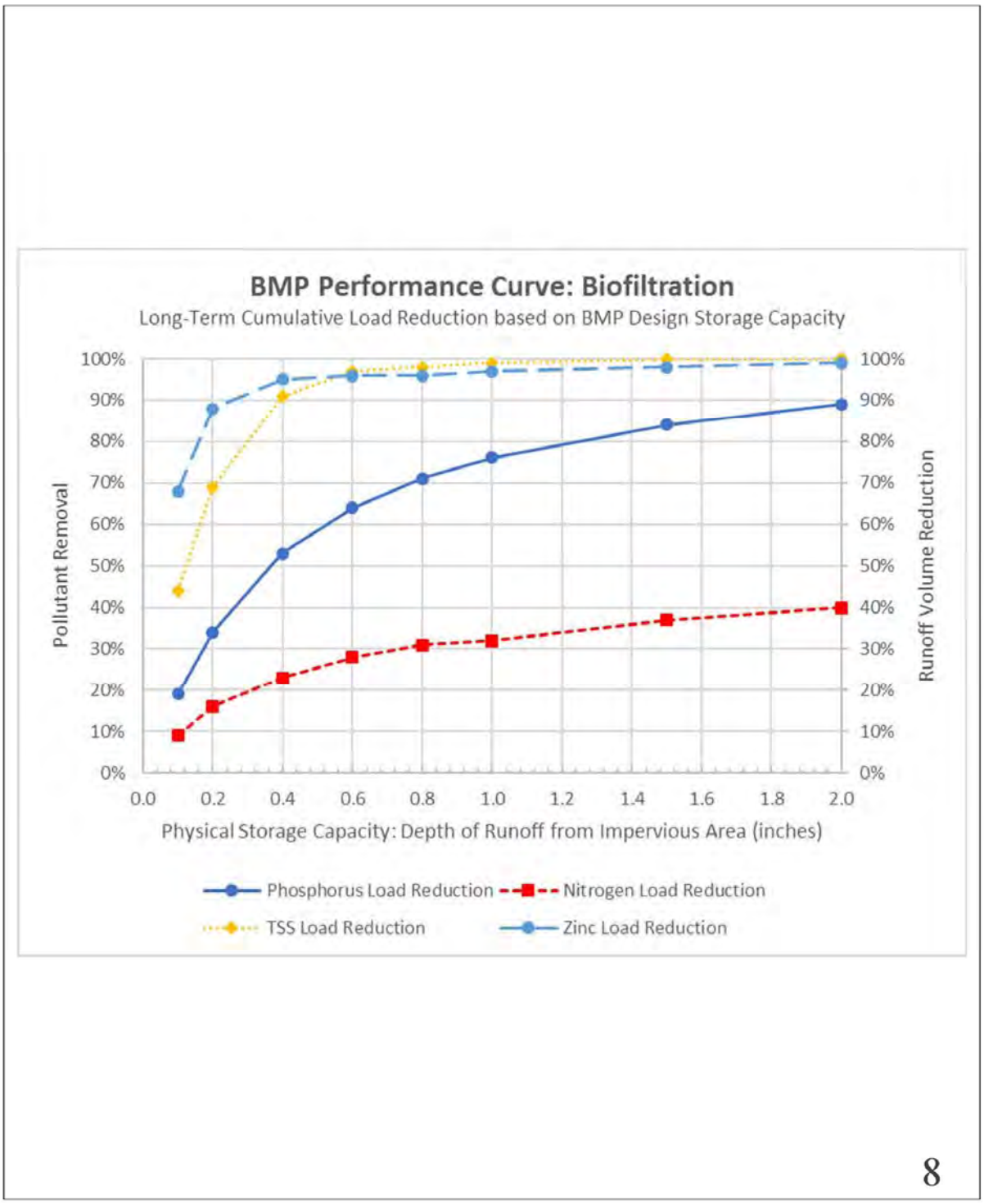
[2] From UNHSC Cost Estimates; converted from 2004 to 2010 dollars using U.S. Department of Labor (USDOL) (2012). Bureau of Labor Statistics consumer price index inflation calculator. http://www.bls.gov/data/inflation_calculator.htm

[3] Converted from 2010 costs using ENR Cost Index

Prepared By:
University of New Hampshire
Stormwater Center
Durham, NH
www.unh.edu/unhsc
August 2017

7

BMP Performance Curve for Biofiltration



Regular Inspection and Maintenance Guidance for Bioretention Systems / Tree Filters

Maintenance of bioretention systems and tree filters can typically be performed as part of standard landscaping. Regular inspection and maintenance is critical to the effective operation of bioretention systems and tree filters to insure they remain clear of leaves and debris and free draining. This page provides guidance on maintenance activities that are typically required for these systems, along with the suggested frequency for each activity. Individual systems may have more, or less frequent maintenance needs depending on a variety of factors including but not limited to: the occurrence of large storm events, overly wet or dry periods, regional hydrologic conditions, and the upstream land use.

ACTIVITIES

The most common maintenance activity is the removal of sediment and organic debris from the system and bypass structures. Visual inspections are routine for system maintenance. This includes looking for standing water, accumulated leaves, holes in the soil media, signs of plant distress, and debris and sediment accumulation in the system. Vegetation coverage is integral to the performance of the system, including infiltration rate and nutrient uptake. Vegetation care is important to system productivity and health.

ACTIVITY	FREQUENCY
CLOGGING AND SYSTEM PERFORMANCE	
A record should be kept of the time to drain for the system completely after a storm event. The system should drain completely within 72 hours.	After every major storm in the first few months, then annually at minimum.
Check to insure the filter surface remains well draining after storm events. **Remedy**: If filter bed is clogged, draining poorly, or standing water covers more than 50% of the surface 48 hours after a precipitation event, then remove top few inches of discolored material. Till, or rake remaining material as needed.	
Check inlets and outlets for leaves and debris. **Remedy**: Rake in and around the system to clear it of debris. Also, clear the inlet and overflow if obstructed.	Quarterly initially, annually as a minimum thereafter.
Check for animal burrows and short-circuiting in the system. **Remedy:** Soil erosion from short circuiting or animal boroughs should be repaired when they occur. The holes should be filled and lightly compacted	
Inspect inlets and outlets to ensure good condition and no evidence of deterioration. Check to see if high-flow bypass is functioning. **Remedy:** Repair or replace any damaged structural parts, inlets, outlets, sidewalls.	
VEGETATION	
Check for robust vegetation coverage throughout the system and dead or dying plants. **Remedy:** Vegetation should cover > 75% of the system and should be cared for as needed.	Annually or as needed

Last Revised 02/2017

9

CHECKLIST FOR INSPECTION OF BIORETENTION SYSTEM / TREE FILTERS

Location:
Inspector:
Date:
Time:
Site Conditions:
Days Since Last Rain Event:

Inspection Items	Satisfactory (S) or Unsatisfactory (U)	Comments/Corrective Action
1. Initial Inspection After Planting and Mulching		
Plants are stable, roots not exposed	S U	
Surface is at design level, no evidence of preferential flow/shoving	S U	
Inlet and outlet/bypass are functional	S U	
2. Debris Cleanup (1 time/year minimum, Spring/Fall)		
Litter, leaves, and dead vegetation removed from the system	S U	
Prune/mow vegetation	S U	
3. Standing Water (1 time/year and/or after large storm events)		
No evidence of standing water after 24-48 hours since rainfall	S U	
4. Vegetation Condition and Coverage		
Vegetation condition good with good coverage (typically > 75%)	S U	
5. Other Issues		
Note any additional issues not previously covered.	S U	
Corrective Action Needed		**Due Date**
1.		
2.		
3.		
Inspector Signature		**Date**

Last Revised 02/2017

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