Construction Specifications for ESD Practices

Appendix B.4

B.4.A Green Roof Specifications

1. Material Specifications

Because there is significant variation in green roof assemblies and methods, providing comprehensive specifications is not feasible. Material specifications for green roofs will vary based on each roofing system and specific information should be obtained from the appropriate manufacturer or retailer. The following information and specifications, which include acceptable materials for generic applications, is not exclusive or limiting.

2. Planting Media

Planting media should be a soil-like mixture with an organic content of 15% or less. The grain size distribution is necessary for to attain proper moisture content, permeability, nutrient management and non-capillary porosity, and soil structure. Grain size guidelines vary for single and dual media green roof assemblies.

The planting media shall be tested and meet the following criteria:

- Non-Capillary Pore Space at Field Capacity, 0.333 bar (TMECC 03.01, A) — ≥ 15% (volume)
- Moisture Content at Field Capacity (TMECC 03.01, A) — ≥ 12% (volume)
- Maximum Media Water Retention (FLL) — ≥ 30% (volume)
- Alkalinity, $CaCO_3$ equivalents (MSA) — ≤ 2.5%
- Total Organic Matter by Wet Combustion (MSA) — ≤ 3–15% (dry wt.)
- pH (RCSTP) — 6.5 – 8.0
- Soluble Salts (DTPA saturated media extraction – RCSTP) — ≤ 6 mmhos/cm
- Cation Exchange Capacity (MSA) — ≥ 10 meq/100 g
- Saturated Hydraulic Conductivity (FLL):
  - Single Media Assemblies — ≥ 0.05 in/min
  - Dual Media Assemblies — ≥ 0.30 in/min

- Mineral Fraction Grain Size Distribution (ASTM D422):

	Single Media	Dual Media
Clay Fraction (2 micron)	0	0
% Passing #200 Sieve	≤ 5%	5 – 15%
% Passing # 60 Sieve	≤ 10%	10 – 25%
% Passing #18 Sieve	5 – 50%	20 – 50%
% Passing ⅛ inch Sieve	20 – 70%	55 – 90%
% Passing ⅜ inch Sieve	75 – 100%	90 – 100%

3. Green Roof Layers

Root Barriers – should be thermoplastic membranes with minimum thickness of 30 mils. Membranes certified for use as root barriers are recommended. However, only FLL currently offers a recognized certification test. Many FLL-certified materials are locally available.

Granular Drainage Media – should be a non-carbonate mineral aggregate meeting the following specifications:

- Saturated Hydraulic Conductivity ≥ 25 inches/minute
- Total Organic Matter (by wet combustion) ≤ 1%
- Abrasion Resistance (ASTM C131-96) ≤ 25% loss
- Soundness (ASTM C88 or T103 or T103-91) ≤ 5% loss
- Porosity (ASTM C29) ≥ 25%
- Alkalinity, CaCO3 equivalents (MSA) ≤ 1%
- Grain Size Distribution (ASTM C136)
  - Percent Passing #18 Sieve ≤1%
  - Percent Passing ¼ inch Sieve ≤ 30%
  - Percent Passing 3/8 inch Sieve ≤ 80%

Separation Fabric – should be a lightweight, non-woven geotextile that is easily penetrated by roots while providing a durable separation between drainage and growth media layers. Separation fabrics should meet the following:

- Unit Weight (ASTM D3776) ≤ 4.25 ounces per square yard
- Grab Tensile Strength (ASTM D4632) ≤ 90 lbs.
- Mullen Burst Strength (ASTM D4632) ≥ 135 lbs/inch
- Permittivity (ASTM D4491) ≥ 2 sec-1

B.4.B Specifications for Permeable Pavements & Reinforced Turf

These specifications include information on acceptable materials for typical applications and are not exclusive or limiting. The designer is responsible for developing detailed specifications for individual projects and specific conditions.

1. Pervious Concrete Specifications

Design Thickness - Pervious concrete applications shall be designed so that the thickness of the concrete slab shall support the traffic and vehicle types that will be carried. Applications may be designed using either standard pavement procedures (e.g., AASHTO, ACI 325.9R, ACI 330R) or using structural values derived from flexible pavement design procedures.

Mix & Installation – Traditional Portland cements (ASTM C 150, C 1157) may be used in pervious concrete applications. Phosphorus admixtures may also be used. Materials should be tested (e.g., trial batching) prior to construction so that critical properties (e.g., settling time, rate of strength development, porosity, permeability) can be determined.

Aggregate – Pervious concrete contains a limited fine aggregate content. Commonly used gradations include ASTM C 33 No. 67 (¾ in. to No. 4), No. 8 (⅜ in. to No. 16) and No. 89 (⅜ in. to No. 50) sieves. Single-sized aggregate (up to 1 inch) may also be used.

Water Content – Water-to-cement ratios between 0.27 and 0.30 are used routinely with proper inclusion of chemical admixtures. Water quality should meet ACI 30a. As a general rule, potable water should be used although recycled concrete production water meetingASTM C 94 or AASHTO M 157 may also be used.

Admixtures – Chemical admixtures (e.g., retarders or hydration-stabilizers) are used to obtain special properties in pervious concrete. Use of admixtures should meet ASTM C 494 (chemical admixtures) and ASTM C 260 (air entraining admixtures) and closely follow manufacturer's recommendations.

Base Course – The base course shall be AASHTO No. 3 or 4 course aggregate with an assumed open pore space of 30% ($n = 0.30$).

2. Permeable Interlocking Concrete Pavements (PICP)

Paver Blocks – Blocks should be either 3⅛ in. or 4 in. thick, and meet ASTM C 936 or CSA A231.2 requirements. Applications should have 20% or more (40% preferred) of the surface area open. Installation should follow manufacturer's instructions, except that infill and base course materials and dimensions specified in this Appendix shall be followed.

Infill Materials and Leveling Course – Openings shall be filled with ASTM C-33 graded sand or sandy loam. PICP blocks shall be placed on a one-inch thick leveling course of ASTM C-33 sand.

Base Course - The base course shall be AASHTO No. 3 or 4 course aggregate with an assumed open pore space of 30% ($n = 0.30$).

3. Reinforced Turf

Reinforced Grass Pavement (RGP) – Whether used with grass or gravel, the RGP thickness shall be at least 1¾" thick with a load capacity capable of supporting the traffic and vehicle types that will be carried.

B.4.C Specifications for Micro-Bioretention. Rain Gardens, Landscape Infiltration & Infiltration Berms

1. Material Specifications

The allowable materials to be used in these practices are detailed in Table B.4.1.

2. Filtering Media or Planting Soil

The soil shall be a uniform mix, free of stones, stumps, roots or other similar objects larger than two inches. No other materials or substances shall be mixed or dumped within the micro-bioretention practice that may be harmful to plant growth, or prove a hindrance to the planting or maintenance operations. The planting soil shall be free of Bermuda grass, Quackgrass, Johnson grass, or other noxious weeds as specified under COMAR 15.08.01.05.

The planting soil shall be tested and shall meet the following criteria:

- Soil Component - Loamy Sand or Sandy Loam (USDA Soil Textural Classification)
- Organic Content - Minimum 10% by dry weight (ASTM D 2974). In general, this can be met with a mixture of loamy sand (60%-65%) and compost (35% to 40%) or sandy loam (30%), coarse sand (30%), and compost (40%).
- Clay Content - Media shall have a clay content of less than 5%.
- pH Range – Should be between 5.5 - 7.0. Amendments (e.g., lime, iron sulfate plus sulfur) may be mixed into the soil to increase or decrease pH.

There shall be at least one soil test per project. Each test shall consist of both the standard soil test for pH, and additional tests of organic matter, and soluble salts. A textural analysis is required from the site stockpiled topsoil. If topsoil is imported, then a texture analysis shall be performed for each location where the topsoil was excavated.

3. Compaction

It is very important to minimize compaction of both the base of bioretention practices and the required backfill. When possible, use excavation hoes to remove original soil. If practices are

excavated using a loader, the contractor should use wide track or marsh track equipment, or light equipment with turf type tires. Use of equipment with narrow tracks or narrow tires, rubber tires with large lugs, or high-pressure tires will cause excessive compaction resulting in reduced infiltration rates and is not acceptable. Compaction will significantly contribute to design failure.

Compaction can be alleviated at the base of the bioretention facility by using a primary tilling operation such as a chisel plow, ripper, or subsoiler. These tilling operations are to refracture the soil profile through the 12 inch compaction zone. Substitute methods must be approved by the engineer. Rototillers typically do not till deep enough to reduce the effects of compaction from heavy equipment.

Rototill 2 to 3 inches of sand into the base of the bioretention facility before backfilling the optional sand layer. Pump any ponded water before preparing (rototilling) base.

When backfilling the topsoil over the sand layer, first place 3 to 4 inches of topsoil over the sand, then rototill the sand/topsoil to create a gradation zone. Backfill the remainder of the topsoil to final grade.

When backfilling the bioretention facility, place soil in lifts 12" to 18". Do not use heavy equipment within the bioretention basin. Heavy equipment can be used around the perimeter of the basin to supply soils and sand. Grade bioretention materials with light equipment such as a compact loader or a dozer/loader with marsh tracks.

4. Plant Material

Recommended plant material for micro-bioretention practices can be found in Appendix A, Section A.2.3.

5. Plant Installation

Compost is a better organic material source, is less likely to float, and should be placed in the invert and other low areas. Mulch should be placed in surrounding to a uniform thickness of 2" to 3". Shredded or chipped hardwood mulch is the only accepted mulch. Pine mulch and wood chips will float and move to the perimeter of the bioretention area during a storm event and are not acceptable. Shredded mulch must be well aged (6 to 12 months) for acceptance.

Rootstock of the plant material shall be kept moist during transport and on-site storage. The plant root ball should be planted so $1/8^{th}$ of the ball is above final grade surface. The diameter of the planting pit shall be at least six inches larger than the diameter of the planting ball. Set and maintain the plant straight during the entire planting process. Thoroughly water ground bed cover after installation.

Trees shall be braced using 2" by 2" stakes only as necessary and for the first growing season only. Stakes are to be equally spaced on the outside of the tree ball.

Grasses and legume seed should be drilled into the soil to a depth of at least one inch. Grass and legume plugs shall be planted following the non-grass ground cover planting specifications.

The topsoil specifications provide enough organic material to adequately supply nutrients from natural cycling. The primary function of the bioretention structure is to improve water quality. Adding fertilizers defeats, or at a minimum, impedes this goal. Only add fertilizer if wood chips or mulch are used to amend the soil. Rototill urea fertilizer at a rate of 2 pounds per 1000 square feet.

6. Underdrains

Underdrains should meet the following criteria:

- Pipe- Should be 4" to 6" diameter, slotted or perforated rigid plastic pipe (ASTMF 758, Type PS 28, or AASHTO-M-278) in a gravel layer. The preferred material is slotted, 4" rigid pipe (e.g., PVC or HDPE).
- Perforations - If perforated pipe is used, perforations should be ⅜" diameter located 6" on center with a minimum of four holes per row. Pipe shall be wrapped with a ¼" (No. 4 or 4x4) galvanized hardware cloth.
- Gravel – The gravel layer (No. 57 stone preferred) shall be at least 3" thick above and below the underdrain.
- The main collector pipe shall be at a minimum 0.5% slope.
- A rigid, non-perforated observation well must be provided (one per every 1,0000 square feet) to provide a clean-out port and monitor performance of the filter.
- A 4" layer of pea gravel (⅛" to ⅜" stone) shall be located between the filter media and underdrain to prevent migration of fines into the underdrain. This layer may be considered part of the filter bed when bed thickness exceeds 24".

The main collector pipe for underdrain systems shall be constructed at a minimum slope of 0.5%. Observation wells and/or clean-out pipes must be provided (one minimum per every 1000 square feet of surface area).

7. Miscellaneous

These practices may not be constructed until all contributing drainage area has been stabilized

Table B.4.1 Materials Specifications for Micro-Bioretention, Rain Gardens & Landscape Infiltration-			
Material	**Specification**	**Size**	**Notes**
Plantings	see Appendix A, Table A.4	n/a	plantings are site-specific
Planting soil [2' to 4' deep]	loamy sand (60 - 65%) & compost (35 – 40%) or sandy loam (30%), coarse sand (30%) & compost (40%)	n/a	USDA soil types loamy sand or sandy loam; clay content < 5%
Organic content	Min. 10% by dry weight (ASTM D 2974)		
Mulch	shredded hardwood		aged 6 months, minimum**;** no pine or wood chips
Pea gravel diaphragm	pea gravel: ASTM-D-448	NO. 8 OR NO. 9 (1/8" TO 3/8")	
Curtain drain	ornamental stone: washed cobbles	stone: 2" to 5"	
Geotextile		n/a	PE Type 1 nonwoven
Gravel (underdrains and infiltration berms)	AASHTO M-43	NO. 57 OR NO. 6 AGGREGATE (3/8" to 3/4")	
Underdrain piping	F 758, Type PS 28 or AASHTO M-278	4" to 6" rigid schedule 40 PVC or SDR35	Slotted or perforated pipe; 3/8" perf. @ 6" on center, 4 holes per row; minimum of 3" of gravel over pipes; not necessary underneath pipes. Perforated pipe shall be wrapped with ¼-inch galvanized hardware cloth
Poured in place concrete (if required)	MSHA Mix No. 3; f'_c = 3500 psi @ 28 days, normal weight, air-entrained; reinforcing to meet ASTM-615-60	n/a	on-site testing of poured-in-place concrete required: 28 day strength and slump test; all concrete design (cast-in-place or pre-cast) *not using previously approved State or local standards* requires design drawings sealed and approved by a professional structural engineer licensed in the State of Maryland - design to include meeting ACI Code 350.R/89; vertical loading [H-10 or H-20]; allowable horizontal loading (based on soil pressures); and analysis of potential cracking
Sand	AASHTO-M-6 or ASTM-C-33	0.02" to 0.04"	Sand substitutions such as Diabase and Graystone (**AASHTO)** #10 are not acceptable. No calcium carbonated or dolomitic sand substitutions are acceptable. No "rock dust" can be used for sand.