3.8 Bioretention/Biofiltration Soil Media and Drainage Aggregates

Type of BMP	For Use with Bioretention, Biofiltration with Partial Infiltration, and Biofiltration with No Infiltration
Treatment Mechanisms	Biofiltration
Other Names	Engineered Soil Media

Description

Bioretention Soil Media (BSM) is a formulated soil mixture that filters pollutants from stormwater, retains moisture, and supports healthy vegetation. It is used in LID BMPs including Bioretention, Biofiltration with Partial Infiltration, and Biofiltration with No Infiltration. BSM consists of **60-80% sand, up to 20% topsoil, and 20% of an organic amendment**, by volume.

BSM must support healthy plant growth and should provide filtering of runoff. When used in Biofiltration BMPs that discharge filtered runoff to surface waters, BSM should be specially formulated to enhance filtering of runoff, reduce the risk of pollutant leaching from BSM, and limit the potential for clogging.

All areas within the Santa Margarita Region (SMR) of Riverside County drain to the Santa Margarita River and Santa Margarita Estuary, both of which are listed as impaired for nutrients under the approved 2010 303(d) list. Accordingly, **all BSM should be formulated to reduce the potential for nutrient leaching, especially when used in flow-through Biofiltration BMPs.** Where a BMP may discharge to a waterbody that is impaired for other pollutants, BSM should be formulated to reduce leaching of those pollutants as well.

The applicability of BSM testing requirements and other provisions of this Fact Sheet depend on the type of BMP and BMP design guidelines as shown in Table 1.

Table 1. Applicability of BSM Specification and Testing Requirements.

Testing Element	Bioretention (full infiltration)	Biofiltration (Partial and No Infiltration)
General Criteria and Composition	X	X
Basic Testing of Mixed BSM	X	X
Hydraulic Evaluation of Mixed BSM		X
Chemical Suitability of Mixed BSM		X
Sand for BSM	X[1]	X[1]
Topsoil for BSM	X[1]	X[1]
Organic Amendments for BSM	X	X
Mulch for BSM	X	X

[1] – Elements of these specifications may be waived by the local jurisdiction if testing of mixed BSM is acceptable.

General Criteria and Composition

- **BSM should consist of 60-80% sand, up to 20% topsoil, and 20% of an organic amendment, by volume.** Both mixed BSM and BSM components are subject to specific testing requirements depending on BMP type and design elements (see Table 1). To meet applicable requirements, suggested BSM component fractions and types are presented in Table 2. These are suggestions only; **acceptance of BSM depends on BSM and BSM component testing results.**
- Alternative BSM components and proportions may be used if they meet all applicable testing requirements. Acceptance of any such alternative BSM is subject to approval from the local jurisdiction.
- BSM should support the growth of hardy drought-tolerant native vegetation, which is typically adapted to thrive in limited nutrient environments. Excessive levels of nutrients in BSM can increase the presence of weeds and other undesirable vegetation and can cause export of nutrients from BSM. Accordingly, **all BSM should be evaluated according to the "Basic Whole Mixture Testing Requirements"** section.
- Sand, topsoil, and organic amendment components of BSM, and mulch are subject to requirements contained in sections of this Fact Sheet titled "Sand for BSM", "Topsoil for BSM", "Organic Amendments for BSM", and "Mulch for BSM", respectively. Specifications for sand and top soil can be waived at the discretion of the local jurisdiction if whole mix texting shows acceptable properties.
- To reduce the potential for nutrient leaching from BSM, it should be formulated according to the following guidelines (Also presented in Table 2).
    - For Bioretention BMPs, nutrient-sensitive compost may be used as the organic amendment according to requirements in the "Organic Amendments" section of this Fact Sheet.
    - **For Biofiltration BMPs, mixed BSM must meet requirements in the "Chemical Suitability for Mixed BSM" section of this Fact Sheet.** To meet these requirements, it is suggested that compost not be used as an organic amendment due to its potential to leach nutrients, even when carefully sourced to reduce such leaching. Instead, coconut coir pith, peat moss, or other alternative organic amendments are recommended. For guidance on these and other alternative organic amendments see the "Alternative Organic Amendments" subsection of this Fact Sheet.
- BSM should be formulated to support the long-term design flow rate of a given BMP.
    - For Biofiltration BMPs, BSM plays a critical role in BMP hydraulic performance and should be formulated depending on whether underdrain outlet controls are used. **BSM for Biofiltration BMPs should be evaluated according to the "Hydraulic Evaluation of Mixed BSM" section of this Fact Sheet.** Meeting these requirements may require that the fines content of sand or top soil be limited (see Table 2). Some sources of top soil and sand may not provide adequate permeability.
- BSM should always be **blended before it is delivered to the site** using a mechanical mixing method (e.g. drum mixer) to ensure uniform mixing. Using a loader to mix materials on site is typically not adequate for uniform mixing and is discouraged. If sand or topsoil components are sourced from the Project site, mixing may be conducted using loaders.

- **Testing samples of the mixed BSM that is delivered to the site is highly recommended,** especially for larger BMPs. Prior testing from a material manufacturer may be acceptable in place of project-specific data if it is not more than 6 months old and represents the actual mix proportions and components in the BSM delivered to the site.
- Procurement, handling, and placement of BSM should adhere to guidelines in the "Construction Guidelines" section of this Fact Sheet.

Table 2. Recommended BSM mixture component proportions and types to meet applicable requirements.

Component Type	Bioretention	Biofiltration (Partial and No Infiltration)	
		Without outlet control	With outlet control
Sand Type	Washed	Washed	Washed
Sand Fraction, by volume	60%	60-80%	80%
Topsoil Type	Sandy Loam or Loamy Sand	Sandy Loam or Loamy Sand	NA
Topsoil Fraction, by volume	20%	Up to 20%	0%
Organic Type	Nutrient-sensitive compost	Coconut coir pith, peat, or low nutrient compost	Coconut coir pith, peat, or low nutrient compost
Organic Fraction, by volume	20%	20%	20%

Basic Testing for Mixed BSM

Basic whole mixture testing should be conducted for any BSM used in stormwater BMPs. This should ideally be completed for actual mixed BSM that is used in site BMPs, but may be from a representative sample analysis not more than 6 months old. Sample(s) should be submitted to an agronomic laboratory for analysis of all parameters listed in this section. Laboratory analytical reports must document that mixed BSM conforms to the following requirements:

- pH: 6.0 – 8.5
- Salinity: 0.5 to 3.0 mmho/cm as electrical conductivity.
- Sodium absorption ratio: < 6.0
- Chloride: < 800 ppm
- Cation Exchange Capacity (CEC): > 10 meq/100 g.
- Organic Matter: 2 to 5% on a dry weight basis.
- Carbon:Nitrogen Ratio: 12 to 40; preferably 15 to 40.
- Sieve Fractions: Should adhere to the sieve fractions presented in Table 3 based on particle size analysis by ASTM Method D422 or similar.

Table 3. Sieve analysis requirements for mixed BSM

Textural Class (ASTM D422)	Size Range	Mass Fraction
Gravel	Larger than 2 mm	0 to 25 percent of total sample
Clay	Smaller than 0.005 mm	0 to 5 percent of non-gravel fraction

Hydraulic Testing of Mixed BSM

BSM that is used in Biofiltration BMPs plays a critical role in controlling flow through BMPs. BSM that flows too quickly can result in short contact times and poor hydraulics for pollutant removal. BSM that flows too slowly can limit surface infiltration rates below design assumptions, resulting in bypass during storms smaller than the design storm.

Hydraulic Testing Requirements: Samples of mixed BSM used in Biofiltration BMPs should be submitted for laboratory analysis of hydraulic conductivity. BSM samples used in this analysis should preferably be sourced from the actual BSM batch that will be used in a given BMP but analytical results from a representative sample not more than 6 months old may also be accepted. Analysis of hydraulic conductivity may be conducted according to one of the following methods:

- Permeability of Granular Soils: ASTM D2434, or,
- Analysis of hydraulic conductivity by USDA Handbook 30 method 34b, or similar approved laboratory method.

Hydraulic conductivity must be within the limits presented in Table 4 for BSM acceptance.

Table 4. Hydraulic suitability requirements for BSM.

BMP Hydraulic Regime	Maximum K_{sat} (in/hr)	Minimum K_{sat} (in/hr)
Biofiltration with Unrestricted Outlet (media control)	8	24
Biofiltration with Restricted Outlet (outlet control)	20	80
Bioretention	NA – Hydraulic Testing Not Required	

Chemical Suitability for Mixed BSM

To reduce the potential for pollutant leaching to surface waters, a sample of BSM used in Biofiltration BMPs should be submitted for laboratory analysis for pollutant leaching potential. The BSM sample should be from the actual batch of BSM that is used in the BMP or from a representative sample not more than 6 months old. This analysis should be performed according to the "Saturated Media Extract" methods (USDA Agricultural Handbook No. 60), which is commonly performed by agronomic laboratories.

Pollutant leaching test results for BSM should comply with limits for nitrate, phosphorus, and copper:

- Nitrate: < 3 mg/L
- Phosphorus: < 1 mg/L
- Copper: < 0.025 mg/L

Testing may be performed after laboratory rinsing of media with up to 15 pore volumes of water. Alternative organic amendments, may be needed to meet these criteria. The above pollutant leaching criteria may be waived at the discretion of the local jurisdiction.

Mulch for BSM

Bioretention and Biofiltration planting areas should generally be covered with 2 to 3 inches of well-aged, double or triple shredded mulch at the time of construction. An additional 1 to 2 inches of mulch should be added annually. Mulch should be non-floating to avoid clogging overflow structures. Inorganic mulches, such as rock, may be used.

Sand for BSM

The requirements in this section may be waived at the discretion of the local jurisdiction if criteria are met for applicable whole mix testing.

Sand should meet requirements for ASTM C33 "fine aggregate concrete sand." It may be sourced from commercial soil suppliers or from natural soil deposits (such as may be found on site). Sand should conform to the following requirements:

- Be free of any waste, wood, coatings (e.g. clay, stone dust, carbonate, etc.), or any other deleterious materials.
- Conform to the particle size distribution requirements for ATSM C33 "fine aggregate concrete sand" in Table 5 based on sieve size analysis by ASTM Method D422 or similar. This should be documented by laboratory analysis results for the actual sand that was used in the BSM, or a representative sample analysis not more than 6 months old.
- All aggregate passing the #200 sieve should be non-plastic.

Table 5. Sieve size fractions for ASTM C33 "fine aggregate concrete sand".

Sieve Size (ASTM D422)	Sieve Size (mm)	Percent Passing (by weight)	
		Minimum	Maximum
3/8 inch	9.5	100	100
#4	4.8	95	100
#8	2.4	80	100
#16	1.2	50	85
#30	0.60	25	60
#50	0.42	5	30
#100	0.15	0	10
#200	0.08	0	5

Topsoil for BSM

Topsoil can be an important part of BSM and can improve pollutant filtering, nutrient retention, and water holding. Because of these benefits, it is generally recommended as a component of BSM for Bioretention BMPs. However, topsoil (especially the fine fraction) can limit flow of water through BSM, so it may not be suitable for BSM.

If topsoil is used as a component of BSM it should be a sandy loam or loamy sand that is free of hazardous materials. It may be sourced from regional soil suppliers or from the project site, providing that it meets all requirements in this Section. Decomposed granite and derivatives of decomposed granite are not considered to be topsoil. All topsoil should meet the following requirements as confirmed by laboratory analytical reports from samples used in the mixed BSM, or from a representative sample analysis not more than 6 months old:

- Texture: Sandy loam or loamy sand according to the US Department of Agriculture Textural Classification System.

Sieve Fractions: Should adhere to the sieve fractions presented in Table 6 based on particle size analysis by ASTM Method D422 or similar. *Sieve analysis may be waived at the discretion of the local jurisdiction if permeability criteria are met for applicable whole mix testing.*

Table 6. Sieve analysis requirements for topsoil used in BSM

Textural Class (ASTM D422)	Size Range	Mass Fraction
Gravel	Larger than 2 mm	0 to 25 percent of total sample
Clay	Smaller than 0.005 mm	0 to 15 percent of non-gravel fraction

Organic Amendments for BSM

Organic amendments are a critical component of BSM to help filter pollutants from runoff, retain moisture, and support healthy vegetation. However, organic amendments, especially compost, can be a source of nutrients and other pollutants that can impact receiving waters.

Nutrient leaching from organic amendments is a particular concern for BSM that is used in Biofiltration BMPs which can discharge directly to surface waters. Accordingly, BSM used in Biofiltrations BMPs must conform to requirements contained in the "Chemical Suitability of Mixed BSM" section of this Fact Sheet. Alternative Organic Amendments are recommended to comply with chemical suitability requirements.

Bioretention BMPs discharge treated water to groundwater, so they pose less risk from nutrient export from BSM.

All organic amendments should conform to the requirements in either "Compost for BSM" or "Alternative Organic Amendments for BSM".

Compost for BSM

Compost should be a well-decomposed, stable, weed-free organic source derived from waste materials including yard debris, wood wastes, crop residues, or other organic materials. It should not be derived from biosolids. Compost should preferably be certified through the US Composting Council (USCC) Seal of Testing Assurance (STA) Program.

Compost should comply with the requirements in the list below. Given the stringent nature of these requirements, it is expected that not all composts will comply with the requirements. All requirements should be confirmed by laboratory analytical reports from samples of the compost used in the mixed BSM, or from a representative sample analysis not more than 6 months old.

- Feedstock: Compost feedstock should be specified. Compost should not be derived, in whole or in part, from biosolids.
- Source: Compost should be sourced from a facility that is permitted through CalRecycle. It should also preferably be sourced from a facility that is certified through the USCC STA program.
- Physical contaminants: Not to exceed 1% by dry weight.
- Organic Matter: 35% - 75% on a dry weight basis.
- pH: 6.0 – 8.5
- Salinity: < 10 mmho/cm as electrical conductivity
- Carbon:Nitrogen Ratio: 12:1 – 40:1. Ideal C:N ratio is greater than 15:1 to reduce the potential for nutrient leaching, especially when compost is intended to be used as the organic amendment of BSM in Biofiltration BMPs.
- Maturity/Stability: Shall conform to either:
    - Solvita Maturity Index: ≥ 5.5
    - CO_2 Evolution: < 2.5 mg CO_2-C per g compost organic matter per day or < 5 mg CO_2-C per g compost C per day, whichever unit is reported.
- Select pathogens: Shall pass US EPA Class A Standard, 40 CFR Section 503.32(a).
- Trace metals: Shall pass US EPA Class A Standard, 40 CFR Section 503.13.

Alternative Organic Amendments for BSM

Amendments used as a substitute for compost should provide comparable pollutant filtration, water holding, and support for vegetation. Coconut coir pith and peat are two alternative organic amendments that have been successfully used to replace compost in BSM. If either of these amendments is used, they should conform to the requirements under the headers below.

If other organic amendments are used a certified agronomist should certify that they would provide substantially equivalent pollutant filtration (i.e. nutrient retention and cation exchange capacity), water holding capacity, and would help to support healthy vegetation. Acceptance of any other organic amendment is subject to approval by the local jurisdiction.

<u>Coconut Coir Pith:</u>

If coconut coir pith is used as a component of BSM it should conform to the following requirements:

- Production Regime: Must be rinsed with freshwater to reduce potential salt water residues and screened to remove coarse fibers.
- Aging: Must be aged a minimum of 6 months.
- Salinity: < 2.0 mmho/cm as electrical conductivity.
- Total Carbon: > 35% on a dry weight basis.
- Total Nitrogen: < 1.5% on a dry weight basis.
- C:N Ratio: > 40.

Sphagnum Peat:

If sphagnum peat is used as a component of BSM is should conform to the following requirements:

- Salinity: < 3.0 mmho/cm as electrical conductivity.
- Total Carbon: > 35% on a dry weight basis.
- Total Nitrogen: < 1.5% on a dry weight basis.

Aggregate Materials for BSM Drainage Layers

Drainage of BSM requires the use of specific aggregate materials for filter course (aka choking layer) materials and for an underlying drainage and storage layer. Open graded ASTM No 57 stone (1/2" to 1-1/2" gravel) is used as the drain rock layer. ASTM No. 8 stone (1/4 to 1/2"pea gravel) is placed on top of this layer in a 3 inch lift. Choker sand is placed on top of the pea gravel in a 3-inch lift immediately below the BSM.

Rock and sand products used in BMP drainage should comply with size classifications in Table 7 and Table 8. All sand and stone products used in BSM drainage layers shall be clean and should preferably be washed.

Table 7. Particle size requirements for rock products.

Sieve Size	Percent Passing Sieves	
	AASHTO No. 57	ASTM No. 8
3 in	-	-
2.5 in	-	-
2 in	-	-
1.5 in	100	-
1 in	95 – 100	-
0.75 in	-	-
0.5 in	25 – 60	100
0.375 in	-	85 – 100
No. 4	10 max.	10 – 30
No. 8	5 max.	0 – 10
No. 16		0 – 5
No. 50		-

Table 8. Particle size requirements for choker sand

Sieve Size	Percent Passing Sieves
	Choker Sand - ASTM C33
0.375 in	100
No. 4	95 – 100
No. 8	80 – 100
No. 16	50 – 85
No. 30	25 – 60
No. 50	5 – 30
No. 100	0 – 10
No. 200	0 – 3

Delivery, Storage, and Handling

BSM and Aggregates should not be delivered or placed in frozen, wet, or muddy conditions. The Contractor should protect materials from absorbing excess water and form erosion at all times. The Contractor shall not store materials unprotected during large rainfall events (>0.25 inches). If water is introduced into material while it is stockpiled, the Contractor shall allow the material to drain to an acceptable level before it is placed.

BSM shall be thoroughly mixed prior to delivery using mechanical mixing methods such as a drum mixer. BSM shall be lightly compacted and placed in loose lifts approximately 12 inches thick to ensure reasonable settlements without excessive compaction. Compaction within the BSM area should not exceed 75 to 85% standard proctor within the designated depth of BSM. Machinery shall not be used in the BSM area to place BSM. A conveyor or spray system shall be used for placement in large facilities. Low ground pressure equipment may be authorized for large facilities at the discretion of the local jurisdiction.

Placement methods and BSM quantities shall account for approximately 10% volume loss due to compaction and settling. Planting methods and timing shall account for settling of media without exposing plant root systems.

The local jurisdiction may request up to three double ring infiltrometer tests (ASTM D3385) or approved alternative tests to confirm that placed materials meet applicable hydraulic suitability criteria. If the infiltration rate of placed material does not meet applicable criteria, the local jurisdiction may require replacement and/or decompaction of materials.

Quality Control and Acceptance

Acceptance of materials will be based on test results that are certified by the Contractor to be representative of the materials that are delivered to the site. Laboratory testing should ideally be conducted on stockpiled materials prior to delivery to the site. Testing results may be from previously sampled materials if they are not more than 6 months old and if the Contractor certifies that they are representative of the materials that are actually delivered to the site.