DESIGNER NOTE: Green text corresponds to notes to the designer. Remove prior to use. Blue text denotes requirements for SFPUC-accepted assets.

DESIGNER NOTE: Replace “Engineer/Landscape Architect” with person in responsible charge for the project (e.g., Owner, Engineer, Landscape Architect).

1. general
   1. SUMMARY
      1. This section includes:
         1. Bioretention Soil Mix
         2. Aggregate Storage
         3. Composted Wood Mulch
         4. Streambed Cobbles [To be completed by designer.]
         5. Flow Channel Gravel [To be completed by designer.]
      2. Related Sections:
         1. Section 01 57 29 – Temporary Protection of Green Infrastructure Facilities

DESIGNER NOTE: The designer should list any additional specification sections which relate to the bioretention work (i.e., clean outs and underdrains, overflow structures, planting, temporary erosion control, utilities, irrigation, earthwork, other appurtenances, etc.).

* 1. Standards and Codes
     1. Reference Standards: This section incorporates by reference the latest versions of the following documents. These references are a part of this section as specified and modified.

|  |  |
| --- | --- |
| Reference | Title |
| Caltrans | Standard Specifications |
| San Francisco DPW | Engineering Standard Specifications |
| ASTM | Annual Book of ASTM Standards, American Society for Testing and Materials, Philadelphia, PA, 1997 or latest edition. |
| US Composting Council (USCC), | Seal of Testing Assurance (STA)  Compost Analysis Proficiency (CAP)  Test Method for The Examination of Composting and Compost (TMECC) |

* 1. Definitions
     1. Bioretention Soil Mix (BSM): A soil mix that has been specially blended and tested for use in bioretention facilities with the intent to meet the following objectives:
        1. Infiltrate runoff at a minimum rate of 5 inches per hour throughout the life of the facility, and
        2. By nature of its components be capable of the removal of certain suspended and dissolved stormwater pollutants, and
        3. Have sufficient moisture retention and other agronomic properties to support healthy vegetation.
  2. References

DESIGNER NOTE: Designer to provide references to all project specific documents (e.g., geotechnical report).

* 1. Submittals
     1. Pre-Installation Submittals: The Contractor shall submit to the Engineer/Landscape Architect the following a minimum of 20 calendar days (or as directed by the Engineer/Landscape Architect) prior to the construction of bioretention facilities. Submittals for all projects delivering Green Infrastructure assets for SFPUC acceptance are required to follow and include the SFPUC’s Bioretention Soil Mix Submittal Checklist (see <http://sfpuc.org/smr> under ‘SMR Documents’).
        1. BSM Submittals
           1. One (1) one-gallon sample of the BSM for visual inspection, or one (1) five-gallon sample of the BSM if sieve analysis is required.
           2. Source certificates for all BSM materials.
           3. Sieve analysis of BSM per ASTM D422 or Caltrans Test Method (CTM) C202 performed within two (2) months of product delivery to site.
           4. Certification from the soil supplier or an accredited testing agency that the BSM, including sand and compost components, conforms to all industry or technical society reference standards specified in Sections 2.01.A, 2.01.B, and 2.01C.
           5. A description of the equipment and methods used to mix the sand and compost to produce BSM.
           6. Organic content test results of the BSM, performed in accordance with Testing Methods for the Examination of Compost and Composting (TMECC) 05.07A, “Loss-On-Ignition Organic Matter Method.”
           7. Permeability test results for BSM per ASTM D2434 (Modified). See SFPUC Modified ASTM D2434 Procedures for required modifications to test.

DESIGNER NOTE: On larger projects, it may be appropriate to require that the above testing be performed on samples taken at the supplier’s yard from the stockpile to be used for the project; see designer note in Section 1.06.C.2.

* + - 1. Sand Submittals
         1. Sieve analysis of sand per ASTM D422 or CTM C202 performed within two (2) months of product delivery to site.

DESIGNER NOTE: Consider revising acceptable age of sieve tests depending on scale of project. On a larger project it may be appropriate to require testing on samples taken at the supplier’s yard from the stockpile to be used for the project; see designer note in Section 1.06.C.2.

* + - 1. Compost Submittals
         1. Quality analysis results for compost performed in accordance with Seal of Testing Assurance (STA) standards, as specified in Section 2.01.C, and performed within two (2) months of product delivery to site.
         2. Sieve analysis of compost per TMECC 02.02‑B performed within two (2) months of product delivery to site.
      2. Other Submittals
         1. Cut sheets of any media or soil admixes to enhance moisture retention properties, if used.
         2. Testing agency qualifications as specified in Section 1.06.B.

DESIGNER NOTE: Designer should include relevant submittal requirements for mulch and streambed gravel (e.g., sieve analysis), to ensure quality of delivered products.

* 1. Quality Control and Quality Assurance
     1. General: Test and inspect bioretention materials and operations as Work progresses as described in this section. Failure to detect defective Work or materials at any time will not prevent rejection if a defect is discovered after installation, nor shall it constitute final acceptance.
     2. Testing Agency Qualification:
        1. General: Agencies that perform testing on bioretention materials, including permeability testing, shall be accredited by STA (USCC), ASTM, AASHTO, Caltrans or other designated recognized standards organization. All certifications shall be current. Testing agency shall be capable of performing all tests to the designated and recognized standards specified and shall provide test results with an accompanying Manufacturer’s Certificate of Compliance. The following information shall be provided for all testing laboratories used:
           1. Name of lab(s) and contact person(s)
           2. Address(es) and phone number(s)
           3. Email address(es)
           4. Qualifications of laboratory and personnel including the date of current certification.
        2. Compost: Laboratory that performs testing shall be independent, enrolled in the US Composting Council’s (USCC) Compost Analysis Proficiency (CAP) program, and perform testing in accordance with USCC Test Method for The Examination of Composting and Compost (TMECC). The sample collection protocol can be obtained from the U.S. Composting Council, 4250 Veterans Memorial Highway, Suite 275, Holbrook, NY 11741, 631‑737‑4931, [www.compostingcouncil.org](http://www.compostingcouncil.org).
     3. Responsibilities of Contractor
        1. Submittals: Some of the tests required for this specification are unique, and BSM shall be considered a long-lead-time item. Under no circumstance shall failure to comply with all specification requirements be an excuse for a delay or for expedient substitution of unacceptable material(s). The requirements of Division 0 apply in their entirety.

Pre-Placement Conference: A mandatory pre-placement conference will take place, including at a minimum the Engineer/Landscape Architect, the Resident Engineer, the Owner/Client Representative, Installer, and general Contractor, to review schedule, products, soil testing, permeability testing, and installation. The Contractor shall notify the Engineer/Landscape Architect a minimum of 2 working days prior to conference.

DESIGNER NOTE: Pre-placement conference is mandatory for all projects within the public right-of-way, or on other public property, and is strongly recommended for privately-owned parcel projects.

* + - 1. Testing: All testing specified herein is the responsibility of the Contractor and shall be conducted by an independent testing agency, retained by the Contractor. The Owner reserves the right to conduct additional testing on all materials submitted, delivered, or in-place to ensure compliance with Specifications.

DESIGNER NOTE: Batch-specific test results and certifications shall be required for projects installing more than 100 cubic yards of BSM.

* 1. Delivery, Storage, and Handling
     1. Protect the BSM and mulch from contamination and all sources of additional moisture (e.g., rainfall, surface runoff, and other sources of moisture) at supplier site, during transport, and at the project site, until incorporated into the Work.
     2. The Contractor is required to coordinate delivery of BSM and aggregates with bioretention facility excavation and soil installation. A written schedule shall be submitted for review as part of the submittal package. In no case shall BSM be stockpiled onsite for more than 24 hours without prior written approval by the Engineer/Landscape Architect. If stockpiling onsite for any length of time, BSM stockpiles shall meet the following requirements:
        1. Locate stockpiles away from drainage courses, inlets, sewer cleanout vents, and concentrated stormwater flows
        2. Place stockpiles on geotextile fabric (or on steel road plates for longer-term and higher-volume stockpiles)
        3. Cover stockpiles with polyethylene plastic sheeting, tarps, or comparable material
        4. Contain eroded material from stockpiles (and prevent contamination from adjacent stockpiles) with temporary perimeter barrier (e.g., gravel bags, wattles, silt fence)
        5. For longer-term and higher-volume stockpiles, contain stockpiles using precast concrete blocks, jersey barrier or similar materials to prevent contamination from adjacent stockpiles and ground surfaces and to provide a backstop for re-handling operations

1. Products
   1. Bioretention Soil MIX (BSM)
      1. General: BSM shall be a well-blended mixture of sand and compost, shall have sufficient moisture retention to support healthy plant growth, and shall meet the following criteria:
         1. Mixture proportions: 30 to 40 percent Compost by volume and 60 to 70 percent Sand by volume

DESIGNER NOTE: Up to 15 percent of the sand fraction may be replaced with other media or soil admixtures (e.g., scoria, coconut coir, perlite, expanded shale, gypsum, vermiculite, pumice, biochar, and polymer-based and diatomaceous earth moisture retention admixtures) to enhance moisture retention capacity of soil, provided admixtures are low in fines (less than 5 percent passing the 200 sieve) and do not break down under normal handling and use. No topsoil, peat, silts, or uncured clays are permitted to be used as admixtures. Admixtures shall be free of sediments and other materials deleterious to plant growth.

* + - 1. Organic matter content: 4 to 8 percent as determined by TMECC 05.07‑A, Loss on Ignition Method.
      2. Extraneous materials: BSM shall be free of all roots, plants, weeds, sod, stones, clods, pockets of coarse sand, construction debris, or other extraneous materials harmful to plant growth.
      3. Permeability/Saturated Hydraulic Conductivity: 10 inches per hour (minimum) tested in accordance with ASTM D2434 (Modified). See SFPUC Modified ASTM D2434 Procedures for required modifications to test.

DESIGNER NOTE: 10-inch-per-hour minimum rate assumes a design rate of 5 inches per hour and a correction factor of 2 to account for reduction in performance from initially measured rates.

* + - 1. Acceptance of BSM quality and performance may be based on samples taken from stockpiles at supplier’s yard, submitted test results, and/or onsite and laboratory testing of installed material at the discretion of the Engineer/Landscape Architect. The point of acceptance will be determined in the field by the Engineer/Landscape Architect.

DESIGNER NOTE: Designer to consider non-compost based BSM specification if facility is serviced by an underdrain and if it is draining to phosphorus sensitive water body.

* + 1. Sand: Sand in the BSM shall conform to the requirements for Sand, Type [specify type from table below] specified herein, unless otherwise approved by the Engineer/Landscape Architect.

DESIGNER NOTE: Designer to specify sand type based on project specific requirements. Additionally, projects anticipating heavy sediment loads should incorporate pre-settling measures at the upstream end of the facility to allow for more efficient maintenance of facilities.

* + - 1. Sand shall be free of wood, waste, coating, or any other deleterious material.
      2. Sand material shall meet the following specifications for gradation.

| Sieve Size1 | Percent Passing by Weight2 |
| --- | --- |
| 3/8 inch | 100 | |
| No. 4 | 90 to 100 | |
| No. 8 | 70 to 100 | |
| No. 16 | 40 to 95 | |
| No. 30 | 15 to 70 | |
| No. 50 | 5 to 55 | |
| No. 100 | 0 to 15 | |
| No. 200 | 0 to 5 | |

1 Sieve provided in nominal size square openings or United States Standard Sieve Series sizes.

2 Sand conforming to ASTM C33 for Fine Aggregate satisfies the requirements of this specification for Sand.

* + - 1. All aggregate passing the No. 200 sieve shall be non-plastic.
      2. Acceptance of grading and quality of the sand may be based on samples taken from stockpiles at supplier’s yard or a submitted gradation report at the discretion of the Engineer/Landscape Architect. The point of acceptance will be determined in the field by the Engineer/Landscape Architect.
    1. Compost: Compost in the BSM shall be well decomposed, stable, weed free organic matter sourced from waste materials including yard debris, or wood wastes. Compost shall conform to California Code of Regulations Title 14, Division 7, Chapter 3.1 requirements, meet the PFRP (Process to Further Reduce Pathogens) standard to reduce weed seeds, pathogens, and deleterious materials under 14 CA Code of Regs §17868.3 (i.e., reaching the required minimum temperature of 55 degrees Celsius for the required length of time), be certified through the USCC Seal of Testing Assurance (STA) Program, and meet the criteria specified herein.
       1. Feedstocks: Feedstock materials shall be specified and include one or more of the following: landscape/yard trimmings, grass clippings, food scraps, and agricultural crop residues. Feedstock shall not include biosolids, manure, or post-consumer or post-industrial wood products.
       2. Organic Matter Content: 35 to 75 percent by dry weight tested in accordance with TMECC 05.07‑A (Loss on Ignition Organic Matter Method).
       3. Carbon to Nitrogen Ratio: C:N between 15:1 and 25:1 when tested in accordance with TMECC 05.02‑A.
       4. Maturity/Stability: shall have a dark brown color and a soil-like odor. Compost exhibiting a sour or putrid smell, containing recognizable grass or leaves, or is hot (120°F) upon delivery or rewetting is not acceptable. In addition, any one of the following is required to indicate stability:
          1. Specific Oxygen Uptake Rate (SOUR): 1.5 milligrams O2 per gram biodegradable volatile solids per hour (maximum) per TMECC 05.08‑A.
          2. Carbon Dioxide Evolution Rate: 8 milligrams CO2 per gram volatile solids per day per TMECC 05.08-B.
          3. Dewar Self Heating Test: 20°C temperature rise (maximum) per TMECC 05.08‑D (Class IV or V).
          4. Solvita®: Index value greater than 6 per TMECC 05.08‑E.
       5. Toxicity: Any one of the following measures is sufficient to indicate non-toxicity.
          1. Seed Germination: greater than 80 percent of control
          2. Vigor: greater than 80 percent of control per TMECC 05.05‑A.
          3. Ammonium < 500 ppm, dry basis
          4. Plant Trials > 80% of control
       6. Nutrient Content: provide analysis detailing nutrient content including N‑P‑K, Ca, Na, Mg, S, and B.
          1. Total Nitrogen: 0.9 percent (minimum).
          2. Boron: Total shall be < 80 ppm
       7. Salinity/Electrical Conductivity: less than 6.0 deciSiemen per meter (dS/m or mmhos/cm) per TMECC 04.10-A (1:5 Slurry Method, Mass Basis).
       8. pH: 6.0 to 8.5 per TMECC 04.11-A (1:5 Slurry pH).
       9. Gradation: Compost for BSM shall meet the following size gradation per TMECC 02.02-B (test shall be run on dry compost sample):

|  |  |  |
| --- | --- | --- |
| Sieve Size | Percent Passing by Weight | |
|  | Min | Max |
| 2 inch | 100 | - |
| 1 inch | 99 | 100 |
| 5/8 inch | 90 | 100 |
| 1/4 inch | 75 | 100 |

* + - 1. Bulk density: 500 to 1,100 dry pounds per cubic yard.
      2. Moisture content: 30 to 55 percent of dry solids.
      3. Inerts: compost shall be relatively free of inert ingredients, including glass, plastic, and paper, less than 1 percent by weight or volume per TMECC 03.08A.
      4. Weed seed/pathogen destruction: provide proof of process to further reduce pathogens (PFRP). For example, turned windrows must reach minimum 55°C for 15 days with at least 5 turnings during that period.
      5. Select Pathogens: Must meet a or b
         1. Salmonella: less than 3 Most Probable Number per 4 grams of total solids, dry weight per TMECC 07.02.
         2. Coliform Bacteria: fecal coliform less than 1,000 Most Probable Number per gram of total solids, dry weight per TMECC 07.01.
      6. Trace Contaminants Metals (lead, mercury, etc.): Product must meet US EPA, 40 CFR 503 regulations.
    1. Soil Admixtures: [Specify admixtures, if used]
  1. Aggregate Storage Layers

DESIGNER NOTE: Aggregate storage layer requirements are dependent on location of project (i.e., MS4 areas vs. combined sewer areas), site specific conditions (e.g., native soil infiltration rates, storage volume needs of project). The designer should update this specification based on the aggregate storage materials required for the project.

DESIGNER NOTE: Aggregate storage is optional in combined sewer areas for facilities without underdrains.

* + 1. Aggregate Storage shall consist of hard, durable, and clean, sand, gravel, or mechanically crushed stone, substantially free from adherent coatings. Materials shall be washed thoroughly to remove fines, organic matter, extraneous debris, or objectionable materials. Recycled materials are not permitted. The material shall be obtained only from a source(s) approved by the Engineer/Landscape Architect. Written requests for source approval shall be submitted to the Engineer/Landscape Architect not less than ten (10) working days prior to the intended use of the Material. Should the proposed source be one that the Engineer/Landscape Architect has no history of Material performance with, the Engineer/Landscape Architect reserves the right to take preliminary samples at the proposed source, and make preliminary tests, to first determine acceptability of the new source and then perform the applicable Material approval testing. Continued approval of a source is contingent upon the Materials from that source continuing to meet Contract requirements. Materials shall meet the Standard Specifications for grading and quality for use in the Work; however, allowable exceptions may be specified in the Contract.
    2. Aggregate storage shall be double washed at the source (on-site washing of aggregate is not allowed) and meet the following specifications for grading and quality.
       1. Aggregate gradation testing in accordance with ASTM C136 at least once per 500 cubic yards.

| Sieve1 | Percent Passing by Weight | | |
| --- | --- | --- | --- |
| Choking Course ASTM No. 9 (Modified)3 | Reservoir Course ASTM No. 7 (Modified)4 | Caltrans Class 2 Permeable Aggregate (MS4 Areas Only) |
| 1 inch | – | – | 100 |
| 3/4 inch | – | 100 | 90 to 100 |
| 1/2 inch | 100 | 90 to 100 | – |
| 3/8 inch | 100 | 40 to 70 | 40 to 100 |
| No. 4 | 85 to 100 | 0 to 15 | 25 to 40 |
| No. 8 | 10 to 40 | 0 to 5 | 18 to 33 |
| No. 16 | 0 to 10 | – | – |
| No. 30 | – | – | 5 to 15 |
| No. 50 | – | – | 0 to 7 |
| No. 2002 | 0 to 2 | 0 to 2 | 0 to 3 |

1 Sieve provided in nominal size square openings or United States Standard Sieve Series sizes.

2 Gradation modified from ASTM for portion passing the No. 200 sieve.

3 Materials likely to meet this specification are available locally as Graniterock 1/4” premium screenings (Wilson 1/4" x #10 Premium Screenings).

4 Materials likely to meet this specification are available locally as Graniterock 1/2” premium screenings (Wilson 1/2" x #4 Roofing Aggregate).

DESIGNER NOTE: Add strikethrough to aggregate(s) not proposed.

* + - 1. Crushed Particles: 90 percent (minimum) fractured faces tested in accordance with California Test 205. Do not use rounded river gravel.
      2. L.A. Abrasion: 40 percent (maximum) tested in accordance with ASTM C 131.
      3. Cleanness Value: 80 (minimum) tested in accordance with California Test 227 (Method of Test for Evaluating Cleanness of Coarse Aggregate).

DESIGNER NOTE: If the designer chooses to specify materials that differ from those provided herein, the designer should check their filter criteria to evaluate the likelihood of finer-graded material migration into underlying coarser graded materials or reduction in permeability relative to the underlying material. Refer to the SFPUC Aggregate Filter Criteria Guidance document for information on selecting appropriate alternate materials.

DESIGNER NOTE: Designer should verify that underdrain slot dimensions for project are compatible with aggregate gradation specified. Refer to the SFPUC Aggregate Filter Criteria Guidance document for information on selecting appropriate underdrain materials.

* 1. Composted Wood Mulch

DESIGNER NOTE: Designer to specify mulch requirements for bioretention facilities. Mulch may be composted wood mulch or rock mulch. Materials selected shall be sufficiently permeable to allow water to pass through at a rate equal to or greater than the underlying BSM.

DESIGNER NOTE: Composted wood mulch is required for SFPUC-accepted assets and is recommended for facilities in MS4 areas where the primary purpose of bioretention is treatment. Composted wood mulch supports plant health by providing beneficial nutrients through decomposition, and does not lead to soil moisture evaporation, which can happen when rock mulch is used in high temperature settings. Composted wood mulch shall be free of dyes, recycled dimensional lumber, and bark.

Composted Wood Mulch shall be stable, weed free organic matter sourced from waste materials including yard debris, wood wastes or other organic materials, not including biosolids or manure feedstock. Composted Wood Mulch shall be tested for and conform to all requirements of Section 2.01.C. Composted Wood Mulch shall also conform to California Code of Regulations Title 14, Division 7, Chapter 3.1 requirements, be certified through the USCC Seal of Testing Assurance (STA) Program, and meet the following:

* + 1. Feedstocks: Composted Wood Mulch shall be derived from plant debris with at least 90% consisting of clean (minimal trash) woody vegetation such as “Arbor Mulch” (i.e., tree trunks, branches, stumps, and brush). Up to 10% by volume may be derived from other clean source-separated feed stocks, such food scraps, and/or other woody materials.
    2. Composted Wood Mulch shall be screened to meet the following size gradation per TMECC 02.02-B (test shall be run on dry compost sample):

|  |  |  |
| --- | --- | --- |
| Sieve Size | Percent Passing by Weight | |
|  | Min | Max |
| 3 inch | 100 | - |
| 2 inch | 90 | - |
| 3/8 inch | 20 | 40 |

* + 1. No dyes or fiber mulch (aka “gorilla hair”) shall be used in the finished mulch product.
    2. A 5-gallon sample of the mulch product shall be submitted to the laboratory for testing, to provide enough fines from the product to complete the specific testing procedures.

DESIGNER NOTE: The above specification is based on the Caltrans specification for “Coarse Compost” with modifications for use in biotreatment systems and aligned with the Bay Area-wide recommended “Composted Wood Mulch Specification for Stormwater Biotreatment Areas”.

DESIGNER NOTE: Three inches of mulch within the bioretention limits is recommended for the purpose of capturing sediment, retaining moisture, preventing erosion, and minimizing weed growth in bioretention facilities. The specification of mulch above the bioretention limits (i.e., the transitional planting zone above ponding) is up to the designer.

* 1. Streambed cobbles

DESIGNER NOTE: This section intentionally left blank. Designer to specify cobble requirements, including gradation, for energy dissipation in bioretention facilities. Streambed Cobbles shall be sized to provide energy dissipation and to minimize erosion at facility inlets and outlets. The following text is a sample/template specification for cobbles within a bioretention facility:

Streambed Cobbles shall be clean, naturally occurring water rounded gravel material. Streambed Cobbles shall have a well-graded distribution of cobble sizes and conform to the following gradation:

|  |  |
| --- | --- |
| Approximate Size1 | Percent Passing by Weight |
| 4” | 99-100 |
| 3” | 70-90 |
| 2” |  |
| 1.5” | 20-30 |
| ¾” | 10 max. |

1 Approximate size can be determined by taking the average dimension of the three axes of the rock, Length, Width, and Thickness, by use of the following calculation: (Length + Width + Thickness)/3 = Approximate Size Length is the longest axis, width is the second longest axis, and thickness is the shortest axis.

The grading of the cobbles shall be determined by the Engineer/Landscape Architect by visual inspection of the load before it is delivered, or, if so ordered by the Engineer/Landscape Architect, by dumping individual loads on a flat surface and sorting and measuring the individual rocks contained in the load. Cobbles must be washed before placement.

* 1. Flow Channel Gravel

DESIGNER NOTE: This section intentionally left blank. Designer to specify gravel requirements, including gradation for erosion protection sized to remain stable during peak flow events and to minimize erosion along the flow lines of facilities. The following text is a sample/template specification for flow channel gravel within a bioretention facility:

“Flow channel gravel shall be crushed black basalt rock, uniform in quality, substantially free from wood, roots, bark, and other extraneous material, and conform to the following gradation: Flow channel gravel must be washed before placement.”

|  |  |
| --- | --- |
| Approximate Size1 | Percent Passing by Weight |
| 1.5” | 99-100 |
| ¾” | 5 max. |

1. Execution
   1. General
      1. Prevent runoff from adjacent pervious and impervious surfaces from entering the bioretention facility (e.g., gravel bag inlet curb cuts, stabilize adjacent areas, flow diversion) until authorization is given by the Engineer/Landscape Architect. Refer to SFPUC Specification Section 01 57 29 Temporary Protection of Green Infrastructure Facilities.
      2. Exclude equipment from bioretention facilities. No equipment shall operate within the facility once bioretention facility excavation has begun, including during and after excavation, backfilling, mulching, or planting.
      3. Prevent foreign materials and substances, such as silt laden run-off, construction debris, paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid from entering or being stored in the facility at any point during construction.
      4. Do not dump Materials or substances except the bioretention soil within the cell area.
   2. Grading
      1. The Contractor shall not start bioretention facility grading until all areas draining to the facility are stabilized and authorization has been given by the Engineer/Landscape Architect.
      2. Construct bioretention facility subgrade to +/- 3/4 inch of the grades and slopes specified on the Plans.
      3. Excavation within 6 inches of final native soil grade shall not be permitted if facility soils have standing water or have been subjected to more than 1/2 inch of precipitation within the previous 48 hours.

DESIGNER NOTE: Designer to remove for bioretention facilities on structure.

* 1. Subgrade Preparation and Protection
     1. Protect the bioretention excavation from over compaction and/or contamination.
        1. Areas which have been over compacted by equipment or vehicle traffic or by other means and which need to be ripped, over excavated, receive additional scarification, or other restorative means shall be done at the Contractor’s expense and at the direction of the Engineer/Landscape Architect.
        2. Excavated areas contaminated by sediment laden runoff prior to placement of BSM or Aggregate Storage material shall be remediated at the Contractor’s expense by removing the contaminated soil (top 3 inches minimum) and replacing with a suitable material, as determined by the Engineer/Landscape Architect.
     2. Remove all trash, debris, construction waste, cement dust and/or slurry, or any other materials that may impede infiltration into prepared subgrade.
     3. The subgrade shall be inspected and accepted by the Engineer/Landscape Architect prior to placement of any materials or final subgrade scarification.
     4. Scarify the surface of the subgrade to a minimum depth of 3 inches immediately prior to placement of BSM or aggregate storage material. Acceptable methods of scarification include use of excavator bucket teeth or a rototiller to loosen the surface of the subgrade.
     5. Place aggregate storage material, where shown on drawings with conveyor belt or with an excavator or loader from a height no higher than 6 feet unless otherwise approved by the Engineer/Landscape Architect (i.e., do not dump material directly from truck into cell).
     6. Aggregate Storage areas contaminated by sediment-laden runoff prior to placement of BSM shall be remediated at the Contractor’s expense by removing the contaminated aggregate storage material (top 3 inches minimum or as directed by the Engineer/Landscape Architect) and replacing with clean aggregate storage material per Section 2.03, to the lines and grades on the Plans.
     7. Aggregate Storage material shall be inspected and accepted for placement and finish grade by the Engineer/Landscape Architect prior to the installation of BSM. Any material that does not conform to this Specification shall be removed and replaced with acceptable material or remediated to the satisfaction of the Engineer/Landscape Architect, at the Contractor’s expense.

DESIGNER NOTE: Designer to customize (i.e. C,D&G) or remove (i.e. A,B&D) for bioretention facilities on structure or for lined bioretention. For lined bioretention facilities on grade, add the following language:

“Prior to placement of impermeable liner, the subgrade shall be prepared and contoured as necessary to provide a smooth surface, void of sharp rocks/debris. No void spaces shall be present between the liner and the subgrade. Geotextile fabric may be installed between the subgrade and the liner to protect the liner from sharp aggregate present in the subgrade. Engineer shall inspect/approve the prepared basin subgrade prior to the installation of any overlying geotextile material.”

* 1. Bioretention Soil Mix Placement
     1. The Contractor shall not place BSM until the Engineer/Landscape Architect has reviewed and confirmed the following:
        1. BSM delivery ticket(s): Delivery tickets shall show that the full delivered amount of BSM matches the product type, volume and manufacturer named in the submittals. Each delivered batch of BSM shall be accompanied by a certification letter from the supplier verifying that the material meets specifications and is supplied from the approved BSM stockpile.
        2. Visual match with submitted samples: Delivered product will be compared to the submitted 1-gallon sample, to verify that it matches the submitted sample. The Engineer/Landscape Architect may inspect any loads of BSM on delivery and stop placement if the soil does not appear to match the submittals; and require sampling and testing of the delivered soil to determine if the soil meets the requirements of Section 2.01 before authorizing soil placement.
        3. Inspection of the aggregate storage layer, underdrain, cleanout, and overflow structure installation, where included on the plans.

DESIGNER NOTE: On larger projects, it may be appropriate to require that the testing specified in Section 2.01 be performed on samples taken at the supplier’s yard from the stockpile to be used for the project; see designer note in Section 1.06.C.2.

* + 1. BSM placement, grading and consolidation shall not occur if there is standing water in the excavation or when the BSM is excessively wet, or has been subjected to more than 1/2 inch of precipitation within 48 hours prior to placement. Excessively wet is defined as being at or above 22 percent soil moisture by a General Tools & Instruments DSMM500 Precision Digital Soil Moisture Meter with Probe (or equivalent). A minimum of three readings with the soil moisture probe will be used to determine the average percent soil moisture reading per each truck load. There should be no visible free water in the material.
    2. The Contractor shall place BSM loosely in even lifts no deeper than 9 inches unless otherwise approved by the Engineer/Landscape Architect, with a conveyor belt or with an excavator or loader from a height no higher than 6 feet, unless otherwise approved by the Engineer/Landscape Architect (i.e., do not dump material directly from truck into cell). After each lift, rake the surface to a uniform grade, consolidate as specified below, and rake again to scarify before placing subsequent lifts or planting.
    3. Soil shall be placed upon a prepared subgrade in accordance with these Specifications and in conformity with the lines, grades, depth, and typical cross-section shown in the Drawings or as established by the Engineer/Landscape Architect.
    4. Excessively dry BSM may be lightly and uniformly moistened, as necessary, to facilitate placement and workability.
    5. Compact BSM using non-mechanical compaction methods (e.g., boot packing, hand tamping, or push type lawn roller) to 83 percent (+/- 2 percent) of the maximum dry density per modified Proctor test (ASTM D1557), or as directed by the Geotechnical Engineer. Determination of in-place density shall be made using a nuclear gauge per ASTM D6938. Moisture content determination shall be conducted on a soil sample taken at the location of the nuclear gage reading per ASTM D2216.

DESIGNER NOTE: BSM compaction target density will be updated as more data from installed projects becomes available on the optimal compaction to minimize settlement while maintaining the infiltration capacity of the media. Designers are encouraged to report field density measurements, observed infiltration rates (if available), and anecdotal field observations (e.g., soil appears well draining, settlement observed minimal).

* + 1. Grade BSM to a smooth, uniform surface plane with loose, uniformly fine texture. Rake, remove ridges, and fill depressions to meet finish grades.
    2. Final soil depth shall be measured and verified only after the soil has been compacted. If after consolidation, the soil is not within +/- 3/4 inch of the grades and slopes specified on the Plans, add material to bring it up to final grade and raked.
    3. The BSM shall be inspected and accepted for placement and finish grade by the Engineer/Landscape Architect prior to the installation of planting and mulch. Any BSM that does not conform to this Specification shall be remediated to the satisfaction of the Engineer/Landscape Architect, or removed and replaced with acceptable BSM, at the Contractor’s expense.
  1. Planting and Mulching
     1. Bioretention facilities shall be planted and mulched as shown on the Plans.
     2. Bioretention facilities shall not be planted or mulched when soils are excessively wet as defined in Section 3.04.
     3. Bioretention facility areas contaminated by sediment laden runoff prior to planting or placement of mulch shall be remediated at the Contractor’s expense by removing the contaminated BSM (top 3 inches minimum) and replacing with BSM per Section 2.01, to the lines and grades on the Plans.
     4. All mulch shall be inspected and accepted by the Engineer/Landscape Architect to ensure appropriate depth and material prior to facility commissioning (e.g., unblocking of inlets).
     5. At the conclusion of planting and mulching, the 90-day plant root-in period begins. During the 90-day plant root-in period the inlets shall be blocked to prevent runoff from adjacent pervious and impervious surfaces from entering the bioretention facility (e.g., gravel bag inlet curb cuts, stabilize adjacent areas, flow diversion) until authorization is given by the Engineer/Landscape Architect.

DESIGNER NOTE: Planting and mulching requirements shall be determined by the designer and included or referenced herein.

* 1. Flow Testing

DESIGNER NOTE: Flow testing is required for all Bioretention facilities receiving surface runoff located in the Public ROW or any stormwater facility to be owned or maintained by the City or a designated Agency/Authority. The following Flow Testing section is specific to Bioretention receiving gutter flow through a curb cut.

DESIGNER NOTE: Designer must customize the Flow Testing section to fit the unique conditions of the project. For example, fully customize section for piped inflow, pumped inflow, channel conveyance, weir distribution, etc.

* + 1. Inlets shall be constructed per the Plans and free from all obstructions prior to commencing flow testing.
    2. Initial testing shall take place immediately following the construction of curbs, walls, and/or inlet structures, and before the soil buffer layer is removed (see Section 01 57 29 Temp Protection of GI Facilities for information pertaining to the soil buffer layer).
    3. Final testing shall be conducted at the conclusion of the 90‑day plant root-in period. Protection and flow diversion measures installed to comply with Section 01 57 29 Temp Protection of GI Facilities shall be removed in their entirety prior to commencing flow testing.
    4. Prior to testing, broom sweep gutter and other impervious surfaces within the test area to remove sediments and other objectionable materials.
    5. The Engineer/Landscape Architect shall be present during the demonstration. The Contractor shall notify the Engineer/Landscape Architect a minimum of 2 working days prior to testing.
    6. The Contractor shall water test each facility to demonstrate that all inlet curb openings are capturing and diverting all water in the gutter to the facility, or diverting was per design intent. Testing shall include application of water from a hydrant or water truck per Section 00 73 73, Article 3.04 (Requirements for Using Water For Construction), at a minimum rate of 10 gallons per minute, into the gutter a minimum of 15 feet upstream of the inlet curb opening being tested. Each inlet shall be tested individually. If erosion occurs during final testing, restore soils, plants, and other affected materials.

DESIGNER NOTE: Designer should update water test and test flow rate for varied inlet types to reflect project-specific design, as needed.

* + 1. Engineer/Landscape Architect will identify deficiencies and required corrections, including but not limited to relocating misplaced plants, adjusting streambed gravel, adjusting mulch, adjusting inlets, splash aprons, and forebays, removing and replacing inlets, and removing debris.
    2. Once adjustments are made, the Contractor shall re-test to confirm all test-water flows into the facility from the gutter and correct any remaining deficiencies identified by Engineer/Landscape Architect.
    3. Inlets, outlets, and other bioretention facility appurtenances shall not be accepted until testing and any required correction and retesting is complete and accepted by the Engineer/Landscape Architect.

DESIGNER NOTE: The Owner may, at any time, conduct additional testing on all materials submitted, delivered, or in-place, to ensure compliance with the Specifications. Testing may include permeability testing per ASTM D2434 (Modified), density testing per ASTM D6938, etc., if the Engineer/Landscape Architect suspects the facility does not conform to these specifications (e.g., as evidenced by lower than anticipated infiltration capacity).

DESIGNER NOTE: Designer should consider adding a similar requirement to the Concrete Paving and Sanitary Sewerage Utilities sections of the Specifications, as needed.

END OF SECTION