Tree Filter

Stormwater BMP Type

Pretreatment BMP	☐
Infiltration BMP	☐
Filtering BMP	■
Stormwater Pond BMP	☐
Stormwater Wetland BMP	☐
Water Quality Conveyance BMP	☐
Stormwater Reuse BMP	☐
Proprietary BMP	☐
Other BMPs and Accessories	☐

Stormwater Management Suitability

Retention*	■
Treatment	■
Pretreatment	☐
Peak Runoff Attenuation	☐

*Exfiltration systems only

Pollutant Removal

Sediment*	**High**
Phosphorus	**Moderate**
Nitrogen	**Moderate**
Bacteria	**Moderate**

*Includes sediment-bound pollutants and floatables (with pretreatment)

Implementation

Capital Cost	**High**
Maintenance Burden	**Medium**
Land Requirement	**Low**

Description

Tree filters are compact bioretention systems consisting of an open-bottomed chamber with one or more trees and filled with engineered soil media. Tree filters collect, temporarily store, and filter stormwater runoff through the engineered soil media, and the tree provides pollutant uptake. Tree filters are particularly well suited to urban or built-out areas where they can easily fit into small footprints and/or work as retrofits. Tree filters often work in tandem with existing stormwater networks allowing less frequent, high-intensity storm events to bypass the system.

Tree filters consist of three main parts: the tree, soil media, and chamber. The chamber is typically filled with engineered soil media that is designed for rapid infiltration. The system is planted with non-invasive trees or shrubs. The top of the chamber typically has a tree grate to protect the base of the tree, soil, and root system, as well as for pedestrian safety. The grate also serves to keep trash and debris from entering the top of the chamber. Most of the stormwater enters the system through a curb cut under the grate. Within the chamber there is typically storage for ponded stormwater runoff above the soil media. The engineered soil media filters the stormwater runoff as it flows downward through the system. The filtered runoff is collected in an underdrain and returned to the storm drainage system or infiltrates into the underlying soil. Tree filters provide pollutant removal via filtration, infiltration, pollutant uptake, and adsorption.

Advantages

- Applicable to small drainage areas and narrow right-of-way areas where space is limited.

- Ideal for stormwater retrofits and highly developed sites.
- Requires less space than other forms of bioretention.
- Can provide stormwater retention, runoff volume reduction, and groundwater recharge if designed for infiltration.
- Can provide aesthetic benefits by enhancing the streetscape like standard street trees.
- Provides other non-stormwater benefits of trees including cleaner air, reduction of heat island effect, carbon sequestration, reduced noise pollution, reduced pavement maintenance needs, and cooler cars in shaded parking lots.
- Available with pre-cast concrete or proprietary (i.e., manufactured) designs or non-proprietary designs for reduced cost.

Limitations

- Limited to smaller drainage areas.
- Frequent maintenance required.
- Should not be used in areas of heavy sediment loads (i.e., unstabilized construction sites).
- Generally, less cost-effective than other stormwater infiltration systems in terms of cost per cubic foot of runoff treated due to cost of bioretention soil media and subsurface structural components.

Siting Considerations

- **Drainage Area:** The maximum contributing drainage area for one individual tree filter is between 0.25 and 0.5 acre. Larger drainage areas can be managed with the use of multiple tree filters; however, there may be more cost-effective solutions for larger drainage areas.

- **Soils:** Tree filters that return filtered runoff to the conveyance system and do not infiltrate into the ground can be used in almost any soil type. Tree filters that rely on infiltration should be used only when the soil infiltration characteristics are appropriate (see Chapter 10 for design guidance for stormwater infiltration systems).

- **Land Use:** Tree filters are suitable in ultra-urban settings where space is limited as well as residential and suburban areas. Potential locations include medians, streetscapes (e.g., between the curb and sidewalk), roadway shoulders, and along shared-use paths. Locate where the structural integrity of the roadbed material will not be compromised and where snow storage will not occur atop the tree filter.

- **Water Table and Bedrock:** For tree filters designed for infiltration (unlined systems), meet the minimum required vertical separation distances from the top and bottom of the filtering system to the seasonal high groundwater table (SHGT) and bedrock, as described in Chapter 10.

- **Horizontal Setbacks:** For bioretention systems designed for infiltration (unlined systems), meet the minimum horizontal setback distances in Chapter 10.

Soil Evaluation

- Conduct an evaluation of the soil characteristics and subsurface conditions at the location of the proposed system including soil type, depth to the seasonal high groundwater table, depth to bedrock, and soil infiltration rate. Refer to Chapter 10 for soil evaluation guidance.

Design Recommendations

General Considerations

This section addresses three types of tree filter designs (Table 13-7. Tree Filter Design Types

Type of System	Underdrain Type	Infiltration or Filtration Design?	Suitable for Retention?	Suitable for Treatment?	General Conditions for Use
Tree Filter with Underdrain Partial Infiltration System	Raised Underdrain	Infiltration and Filtration (partial infiltration)	Yes (infiltration volume only)	Yes	All HSG Soil types Underdrain required for HSG C and D Soils
Tree Filter with Underdrain and Liner Flow-Through System	Underdrain and Impermeable Liner	Filtration Only	No	Yes	Land Uses with Higher Potential Pollutant Loads Contaminated sites Where required vertical separation to SHGT cannot be met Sites with unacceptable setback distances for infiltration
Tree Filter Without Underdrain Infiltration System	No Underdrain	Infiltration and Filtration (Full infiltration)	Yes	Yes	HSG A and B Soils

):

- **Tree Filter with Underdrain (Partial Infiltration System):** Tree filters are commonly designed with an underdrain to account for potential infiltration failure due to clogging, groundwater mounding, or periods of excessive rainfall. Underdrained systems can be used with any soil type or soil infiltration rate. The underdrain should be raised above the bottom of the system to maximize infiltration and enhance nitrogen removal. Underdrained systems (without a liner) are suitable for providing stormwater retention, although only the infiltrated volume (not the volume discharged via the underdrain) can be credited toward the Standard 1 retention requirement.

- **Tree Filter with Underdrain and Liner (Flow-Through System):** An underdrain and impermeable liner are required for use with Land Uses with Higher Potential Pollutant Loads (LUHPPLs) (see Chapter 10), in locations where contaminated soils exist, where the required vertical separation to SHGT cannot be met, or in locations with unacceptable horizontal setbacks for infiltration. Such systems are suitable for providing treatment but do not provide retention credit.

- **Tree Filter with No Underdrain (Infiltration System):** Tree filters can be designed to fully infiltrate into the native soil without an underdrain. Such systems, also called "treewells," are best suited for use with Hydrologic Soil Group (HSG) A and B soils. Tree filters can have higher relative construction costs than other surface infiltration systems presented in this Manual (infiltration basins and trenches) due to the cost of the engineered bioretention soil, plantings, subsurface structural components, etc. Infiltration tree filters (tree wells) can be designed without pre-cast or proprietary concrete chambers at reduced construction cost.

Table 13-4. Tree Filter Design Types

Type of System	Underdrain Type	Infiltration or Filtration Design?	Suitable for Retention?	Suitable for Treatment?	General Conditions for Use
Tree Filter with Underdrain Partial Infiltration System	Raised Underdrain	Infiltration and Filtration (partial infiltration)	Yes (infiltration volume only)	Yes	All HSG Soil types Underdrain required for HSG C and D Soils
Tree Filter with Underdrain and Liner Flow-Through System	Underdrain and Impermeable Liner	Filtration Only	No	Yes	Land Uses with Higher Potential Pollutant Loads Contaminated sites Where required vertical separation to SHGT cannot be met Sites with unacceptable setback distances for infiltration
Tree Filter Without Underdrain Infiltration System	No Underdrain	Infiltration and Filtration (Full infiltration)	Yes	Yes	HSG A and B Soils

Pretreatment

- Commonly incorporate pretreatment measures at locations where runoff enters the tree filter in accordance with the Pretreatment BMPs section of this Manual.

- Acceptable pretreatment measures include interior concrete sediment collection chambers and exterior deep sump hooded catch basins.

- Interior Concrete Sediment Collection Chambers
  - Should be designed to overflow directly into the tree filter via a level overflow weir wall.
    - Elevation of overflow weir wall should be sufficiently lower than gutter line to at least pass the applicable Water Quality Volume (WQV) or Water Quality Flow (WQF) below the elevation of the gutter line.
  - Should be equipped with a cover or with an overall tree filter grate.
  - Minimum depth: 4 feet from top of overflow weir wall.
  - Minimum bottom surface area: 6 square feet with no individual dimension (length or width) less than 2 feet.
  - Provide two 2-inch diameter seep holes (the lowest being 2 feet above interior bottom of collection chamber) along the weir wall.

- Deep Sump Hooded Catch Basin
  - Typically requires the tree filter surface to be at least 24 inches below the top of curb/sidewalk due to the depth of the catch basin outlet pipe.
  - If constructing a new catch basin, use a square catch basin structure, which should directly abut the tree filter. The width of the outlet should extend the full inside width of the catch basin structure. Outlet opening height should be sufficient to convey the applicable WQV or WQF but should not be less than 4 inches.
  - Minimum sump depth: 4 feet
  - If utilizing an existing round deep sump hooded catch basin structure, runoff can be conveyed to the tree filter via a pipe (see deep sump hooded catch basin design in the Pretreatment BMPs section of this Manual).

Sizing and Dimensions

- Tree Filter Bed (Bottom) Area
  - Tree filters should be designed by either the Static or Dynamic Methods as described in Chapter 10.
  - Tree filters should completely drain in 48 hours or less after the end of the design storm as described in Chapter 10.
  - For unlined systems, the design infiltration rate used for system sizing and drain time analysis should be equal to 50% of the slowest observed field infiltration rate of the underlying soils or 0.5 inches per hour (1.0 feet per day) for the bioretention soil media, whichever value is lower.

- For lined systems, use the coefficient of permeability of the bioretention soil media (0.5 inches per hour or 1.0 feet per day or) in the drain time analysis.
- Multiple tree filters can be combined to meet water quality goals.

- Bioretention Soil Depth
  - Engineered bioretention soil media should have a depth of 24 to 48 inches ,or as necessary to accommodate the required sizing, vegetation species and root establishment/growth, and subsurface conditions. The volume should be adequate to ensure root systems and thereby the tree will be viable and able to grow.
  - Bioretention systems with trees should have a minimum soil depth of 30 inches.
  - Soil depth may be limited by the requirement to maintain adequate separation to groundwater and bedrock as specified in Chapter 10.

- Ponding Depth
  - Maximum for water quality storm: 6 inches
  - Maximum for overflow events: 9 inches (preferred) to 12 inches (absolute maximum)

- Freeboard Depth
  - Minimum freeboard depth: 3 to 6 inches
  - As measured from the elevation of the maximum ponding depth to the facility's overflow elevation or to the invert of the inlet to the facility, whichever is lower.

- Bottom Width
  - Minimum: 5 feet

- Bottom Slope
  - Design bottom of tree filter to be level.

- Concrete Tree Filter Chamber
  - Should be a minimum of 18 inches deep below top of curb/sidewalk and should be designed to support adjacent structures.

Inlet

- Design the inlet in accordance with the Inlet and Outlet Controls section of this Manual.

- Runoff can be introduced via a curb cut or drop inlet. Runoff can be introduced via a pipe from an upstream structure such as a catch basin, although this option is limited as it requires either a shallow upstream structure and/or deeper tree filter .

- Design the bioretention system in an off-line configuration to the extent feasible if runoff is delivered by a storm drain pipe or is along the main storm conveyance system.

- Depth between inlet and top of engineered soil media should be 2 inches or less and should be designed to minimize erosion within the tree filter.

Outlet & Overflow

- Tree filters designed off-line are typically sized to handle only the Water Quality Volume.
    - If the tree filter is designed to infiltrate and meets the infiltration criteria, an outlet is not required. Once the system has reached its capacity (i.e., once the system is full), additional flow will bypass the tree filter. The designer should confirm that the bypassed flow is managed downstream and does not worsen flooding.

- Tree filters designed in an on-line configuration must have an outlet sized to convey the 10-year, 24-hour storm event, at a minimum.
    - Design the outlet in accordance with the Inlet and Outlet Controls section of this Manual.
    - Outlets are typically an overflow riser that discharges to a storm drainage system.
    - Outlets must be designed such that stormwater does not overflow from the tree filter onto adjacent roadway surfaces.

- If used, underdrains can connect to a downstream drainage system or daylight at an approved discharge point.

Underdrain System

- Use an underdrain system when a proposed tree filter meets one or more of the following conditions:
    - Is in native soil that has an infiltration rate less than 0.3 inch per hour (HSG C and D soils)
    - Does not meet vertical separation distance to SHGT or bedrock (Chapter 10) and should be lined
    - Does not meet minimum horizontal setback distances (Chapter 10) and should be lined
    - Is within a Land Use with Higher Potential Pollutant Loads (LUHPPL) (Chapter 10) or area of contaminated soils and should be lined.

- An underdrain is also recommended, but not required, for other tree filter installations to account for potential infiltration failure due to clogging, groundwater mounding, or periods of excessive rainfall.

- Minimum underdrain pipe diameter: 4 inches

- Minimum underdrain pipe slope: 0.5%

- Use two layers of gravel with the underdrain system. Both layers of gravel should be located below and extend across the entire bottom of the tree filter chamber. The upper gravel layer should consist of 3 inches of pea gravel, and the lower layer should consist of a 12-inch thick gravel sump.

- For unlined systems, install the perforated underdrain pipe at the top of the 12-inch gravel sump. For systems that are lined with an impermeable liner to prevent infiltration, install the underdrain pipe at the bottom of the 12-inch gravel sump so the system can drain completely between storm events.

- If the tree filter is designed without an underdrain, pea gravel and gravel sump are optional.

- Lay underdrain such that perforations are on the bottom of the pipe.

- Use solid (non-perforated) pipe sections and watertight joints outside the BMP.

- If an underdrain is used, place non-woven filter fabric above the pea gravel (below the bioretention soil layer) for a distance of 1 to 2 feet on both sides of the underdrain. Filter fabric should not be placed across the entire width of the chamber. If gravel storage/underdrain layers extend below the concrete chamber, place filter fabric along sidewalls of excavation below the chamber.

- Other considerations when designing/installing underdrains:

    - Provide a marking stake and an animal guard for underdrains that daylight at grade.

- Include a minimum of one observation well/cleanout for each underdrain.

    - Cleanouts should be at least 4 inches in diameter, be nonperforated, and extend to the surface. Cap cleanouts with a watertight removable cap. The cleanout should be highly visible at the ground surface or below the grate when the grate is removed.

Materials

- Surface Cover
    - If a tree filter grate is used, no surface cover is required over the bioretention soil media.
    - If a tree filter grate is not used, a minimum 3-inch thick layer of river stone may be used on top of the bioretention soil media.
    - Mulch may be used directly around the base of the tree, but mulch should NOT be used to cover the entire surface of the tree filter.
    - If mulch is used, use 2 to 4 inches of shredded hardwood bark mulch, aged for 6 months minimum.

- Vegetation
  - Select tree/shrub species with guidance provided in Appendix F of this Manual. Use of native species is recommended.
  - Location of tree filter and species should be selected to avoid obstruction of sight lines.

- Engineered Bioretention Soil Media
  - The engineered bioretention soil media in tree filters systems is designed to filter/treat runoff and to provide sufficient organic material to support plan establishment and growth.
  - The engineered bioretention soil media should be a homogeneous soil mix of (by volume):
    - 60–85% Sand
    - 15–25% Topsoil
    - 3–8% Organic Matter
  - **Sand** should be washed concrete sand (ASTM C33 or AASHTO M-6) or coarse washed sand that meets the gradation schedule as shown in State of Connecticut Department of Transportation Standard Specifications, Section M.01 (Aggregates), Table M.01.04-1 for Fine Aggregate Gradations.
  - **Topsoil** should contain 5–20% organic material, have a pH range of 5.5 to 7.0, and be a sandy loam, loamy sand, or loam per USDA soil texture with less than 5% clay content. Topsoil that meets the State of Connecticut Department of Transportation Standard Specifications, Section M.13.01 (Roadside Development) for Topsoil may also be used, except it should contain less than 5% clay.
  - **Organic matter** should consist of one of the following materials
    - 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.
    - Wood Derivatives: Shredded wood, wood chips, ground bark, or wood waste; of uniform texture and free of stones, sticks, soil, or toxic materials.
  - Compost shall NOT be used as organic matter since the use of compost in bioretention soil media can result in nutrient export from the system.
  - Soil amendments such as zerovalent iron and/or drinking water treatment residuals (alum) may be used to further enhance phosphorus sorption.
  - Bioretention soil mix should have a pH of 5.2 to 7.0 and meet the particle size distribution defined in Table 13-8.

Table 13-5. Acceptable Particle Size Distribution of Final Bioretention Soil Mix

Media Type	Sieve #	Size (inches)	Size (mm)	% Passing
Coarse Sand	4	0.187	4.76	100
Medium Sand	10	0.079	2.00	95
Fine Sand	40	0.017	0.42	40-15
Silt	200	0.003	0.075	10-20
Clay	<200	Pan	Pan	0-5

- Bioretention soil mix should NOT contain any of the following materials: stones, clods, roots, clay lumps, and pockets of coarse sand exceeding 0.187 inches (4.76 mm) in any dimension; plants, sod, 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 any other extraneous materials that are harmful to plant growth.

- Pea Gravel
  - Should consist of 3/8" AASHTO No. 8 stone. Pea gravel should be clean (washed and free from dirt and debris) and rounded in shape.

- Gravel Sump
  - Should consist of 3/4" AASHTO No. 5 stone. Gravel should be clean (washed and free from dirt and debris), crushed, and angular.

- Filter Fabric
  - Use non-woven filter fabric that complies with State of Connecticut Department of Transportation Standard Specifications, Section M.08.01.19 (Drainage – Geotextiles).

- Poured-in-place Concrete
  - If used, should be an appropriate class of concrete based on the application and conform to State of Connecticut Department of Transportation Standard Specifications, Section 6.01 (Concrete for Structures).

- Underdrain (perforated and non-perforated pipe sections)
  - Polyethylene or polyvinyl pipe.

- Liner
  - If used, should consist of a 30 mil (minimum) HDPE or PVC liner, or one of the alternative liner systems described in Chapter 10 with the approval of the review authority.

Other Considerations

- If tree filter is located adjacent to a sidewalk or in an area subject to high pedestrian traffic, consider the use of curb around the perimeter of the tree filter, or the use of a grate over the tree filter to reduce trip hazard and prevent pet waste and trampling.
    - If height from top of tree filter media to sidewalk elevation is greater than 12 inches, use a grate.

- Where existing sidewalks are modified to incorporate tree filters, the sidewalk should comply with meet accessibility requirements.
    - Grates can be used over tree filters to meet sidewalk width accessibility requirements.

- If designing a lined system in a location where SHGT is located at or above the bottom of the liner or closed bottom of the system, complete a buoyancy analysis to ensure buoyancy of the system will not be an issue.

- For lined systems within LUHPPLs, a shutoff valve can be installed on the underdrain outlet to capture and contain accidental spills or releases that reach the bioretention system.

- Roadway stability can be a design issue when installing tree filters along roadways. It may be necessary to provide a vertical impermeable barrier to keep water from saturating the road's sub-base. The barrier should be capable of supporting H-20 loads.

Winter Operations

- Tree filters should not be used as dedicated snow storage areas. To the extent feasible, locate and design the system to avoid snow storage areas and potential damage from snow plowing activities. If unavoidable, use grates and tree protection barriers to minimize potential damage to the system. Refer to Chapter 7 for general design considerations related to winter operations.

Construction Recommendations

- The designing qualified professional should develop a detailed, site-specific construction sequence.

- The designing qualified professional should inspect the installation during the following stages of construction, at a minimum:
    - After excavation of the system and installation of the concrete chamber
    - After placement of gravel layer
    - After placement of underdrain before covering by the pea gravel layer
    - After placement of bioretention soil media
    - After installation of bypass, outlet/overflow, and inlet controls
    - After tree has been installed

- The designing qualified professional should provide an as-built plan of the completed system along with a certification that the system was designed in accordance with the guidance contained in this Manual and other local or state requirements and that the system was installed in accordance with the approved plans.

- The bioretention soil mix should be tested prior to placement according to the specifications in this section (at least one test per bioretention system). The designing qualified professional should certify that the bioretention soil mix meets the specifications in the previous section based on soil testing results.

- The entire contributing drainage area should be completely stabilized prior to directing any flow to the bioretention system. Adequate vegetative cover must be established over any pervious area adjacent or contributing to the system before runoff can be accepted.

- Erosion and sediment controls should be in place during construction in accordance with the Connecticut Guidelines for Soil Erosion and Sediment Control and the Soil Erosion and Sediment Control (SESC) Plan developed for the project.

- During clearing and grading of the site, measures should be taken to avoid soil compaction at the location of the proposed tree filter.

- The system should be fenced off during the construction period to prevent disturbance of the soils.

- The system should be excavated to the dimensions and elevations shown on the plans. The method of excavation should avoid compaction of the bottom of the system. Excavation equipment should not be allowed within the limits of the system.

- The gravel, pea gravel, and bioretention soil media should be placed in the excavation by a hydraulic excavator located outside the limits of the system and then hand-raked to the desired elevation.

- Place the bioretention soil in 6 to 12-inch lifts. The bioretention soil needs to settle before planting. Lightly tamp or spray the surface of the bioretention soil with water until saturated. The elevation of the bioretention soil can be a couple of inches higher at installation than the design elevation in anticipation of settling. Bring bioretention soil levels back to the design elevation if necessary.

- Install tree or shrub(s) in the tree filter. Water tree/shrubs thoroughly immediately after planting and as necessary until fully established. The bioretention soil mix provides enough organic material to adequately supply nutrients from natural cycling.

Maintenance Needs

- Tree filters should be designed with easy access to all components of the system for maintenance purposes. Refer to Chapter 7 for general design considerations to reduce and facilitate system maintenance.

- Detailed inspection and maintenance requirements, inspection and maintenance schedules, and those parties responsible for maintenance should be identified on the plans and in the Stormwater Management Plan.

- Maintenance should be detailed in a legally binding maintenance agreement.

- Maintenance activities such as sediment removal and repairs should be performed with rakes and light-weight equipment rather than heavy construction equipment to avoid compaction of the bioretention soil media and underlying soils. Heavy equipment may be used for sediment removal and other maintenance activities if the equipment is positioned outside the limits of the system. Heavy construction equipment should not be allowed within the limits of the system for maintenance purposes.

Recommended Maintenance Activities

- Inspect after major storms (1 inch or more of precipitation) in the first few months following construction.

- Inspect tree filter annually.

- Refer to Appendix B for maintenance inspection checklists, including items to focus on during the inspections.

- Remove trash and organic debris (leaves) in the Spring and Fall.

- Remove sediment from the sediment chamber or other pretreatment area when it accumulates to a depth of more than 12 inches or 50% of the design depth. Clean outlet of sediment forebay or other pretreatment measures when drawdown time exceeds 36 hours after the end of a storm event.

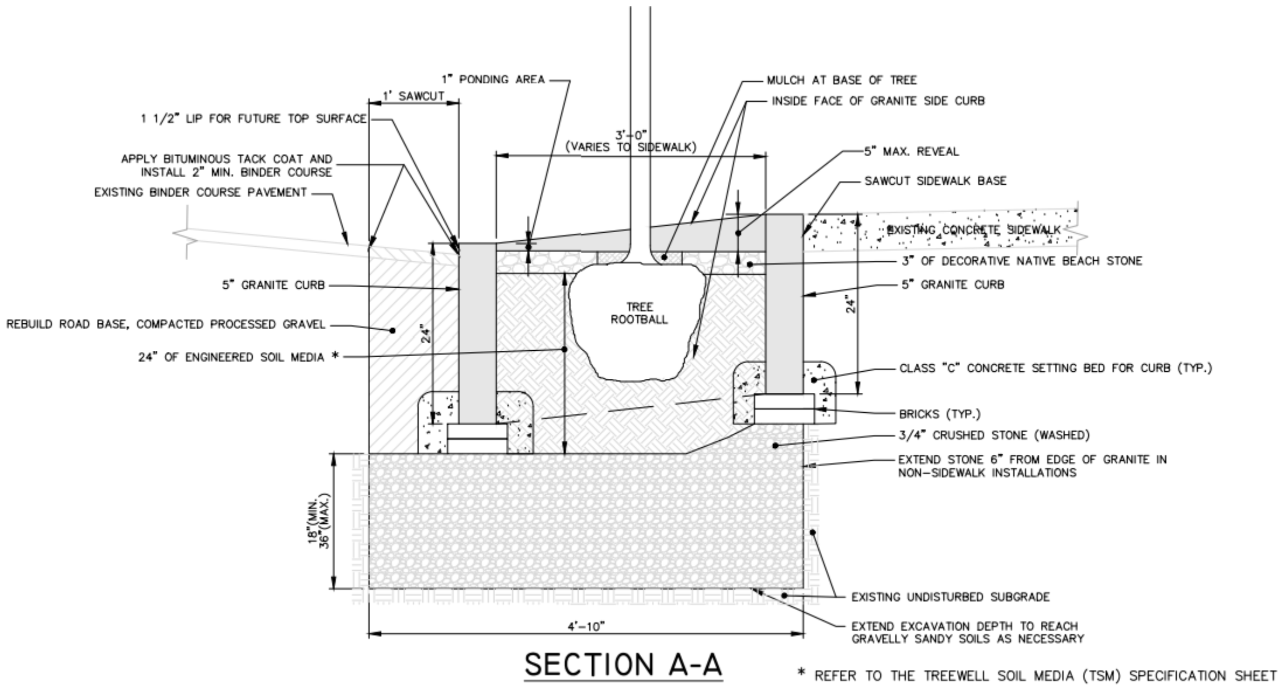
- Remove accumulated sediment from the tree filter when the sediment accumulation exceeds 1 inch or when drawdown time exceeds 48 hours after the end of a storm event, indicating that the soil media is clogged. Replace with fresh bioretention soil media that conforms to the specifications in this section.

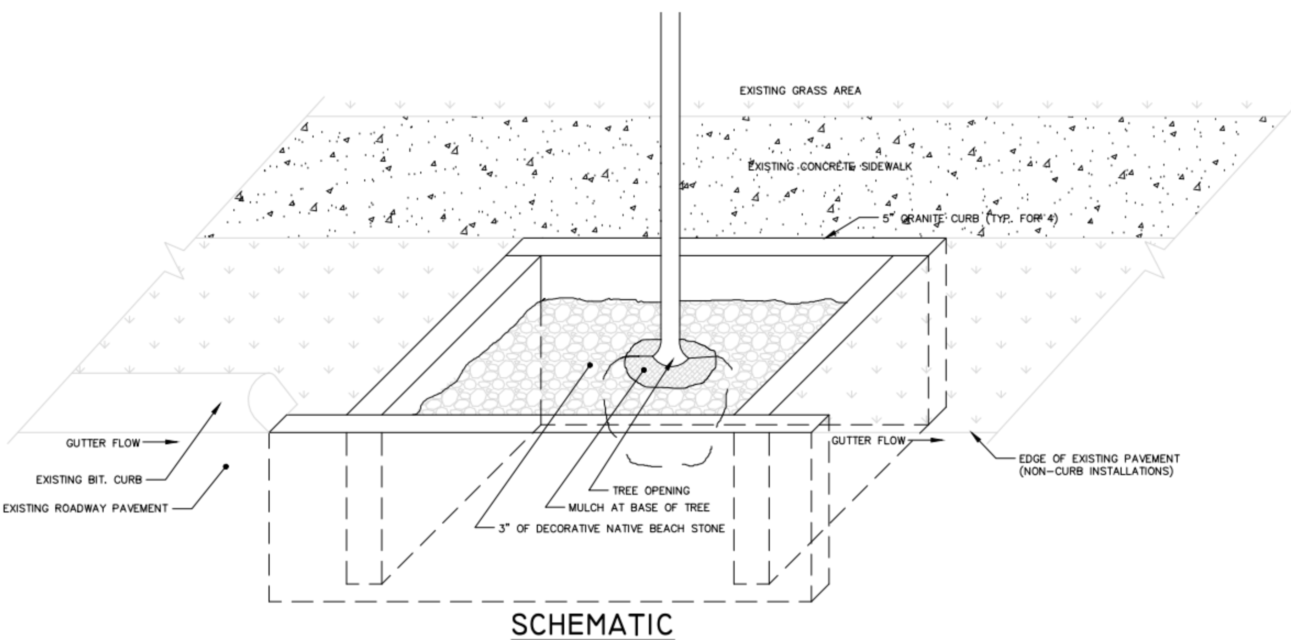
- Tree filters require seasonal landscape maintenance, including:
  - Watering trees and shrubs as necessary during first growing season
  - Watering as necessary during dry periods
  - Treating diseased trees and shrubs as necessary
  - Inspection of soil and repairing eroded areas around the tree filter

- Removal of litter and debris from the tree filter surface and/or grate

Figure 13-19. Tree Filter with Underdrain Schematic

Figure 13-20. Tree Filter without Underdrain (Treewell) Schematic





Source: Niantic Treewell Design, Town of East Lyme Engineering Department.