1.4.5 Temporary Structural Practices

F. **Mulch Socks.** *(See Specifications manual item 648S-1 and Standard Specifications manual item 648S for details)*

1. **Description.**

A mulch sock is mulch material encased in mesh to form a tube/roll. A technique used to intercept sheet flow and pond runoff, allowing sediment to fall out of suspension, and often filtering sediment as well. Mulch socks provide an environmentally-sensitive and cost-effective alternative to sediment fence.

2. **Material.**

Mulching material can be manufactured on or off the project site. It consists primarily of organic material, separated at the point of generation, and may include: shredded bark, stump grindings, or composted bark.

The mulch shall have the following composition:

- Use untreated wood chips produced from a 3 (three) inch minus screening process (equivalent to TxDOT Item 161, Compost, Section 1.6.2.B, Wood Chip requirements).
- Large portions of silts, clays, or fine sands are not acceptable in the mix.
- The pH should fall between 5.5 and 8.5.
- The organic matter content is $\geq 25\%$, dry weight basis.

Mulch material must be free of refuse, physical contaminants, and material toxic to plant growth. It is not acceptable for the mulch material to contain ground construction debris, biosolids, or manure.

Sock material will be 100% biodegradable, photodegradable, or recyclable such as burlap, twine, UV photodegradable plastic, polyester, or any other acceptable material. The material mesh opening should be equal to or less than 3/8 inch (10 mm) and the material tensile strength should be equal to or greater than 44 psi (3.09 kg/cm²) or 202 psi (14.2 kg/cm²).

Prior to placement, a representative sample of the mulching material must be accepted by the project engineer or his/her designee and by the city inspector.

3. **Installation.**

- Use 12 or 18 inch diameter mulch socks for all sediment control applications. The 18 inch diameter sock material has proven to be the most consistent for all sediment control applications (TxDOT, April 2006).
• Mulch socks should be used at the base of slopes no steeper than 2:1 and should not exceed the maximum spacing criteria provide in Table 1.4.5.F.1 for a given slope category. The spacing criteria are based on the maximum drainage area, in square feet, above a 100 feet wide section of mulch sock.

• Place mulch socks at a 5’ or greater distance away from the toe of slopes to maximize space available for sediment deposition.

• When placed on level contours sheet flow of water should be perpendicular to the mulch sock at impact and un-concentrated.

• Install mulch socks using rebar stakes with a minimum 3/8 inch diameter and a minimum length of 48-inches, wood stakes with a minimum dimensions of 1 inch by 2 inch and a minimum length of 48 inches, or earth anchors placed behind the mulch sock on 4-foot centers. Drive the stakes in the ground to a minimum depth of 24-inches leaving less than 12-inches of post above the exposed mulch socks. It is preferable to cut the post flush with the top of the mulch sock.

• In order to prevent the movement or floating of the mulch log during rain events or construction operations, install stakes on the front side placed on 4-foot centers.

• In order to prevent water flowing around the ends of mulch socks, point the ends upslope to place them at a higher elevation.

• In order to prevent water flowing between the gaps between the joints of adjacent ends of mulch socks lap the ends of adjacent mulch socks a minimum of 12 inches. Never stack mulch socks on top of one another.

• Mulch socks can be placed around the perimeter of affected areas, if the area is flat or the perimeter is on contour. Socks should be placed using ‘smiles’ and j-hooks (see section 1.4.5.G., Silt Fence for proper placement and J hook details.)

• Do not place socks where they cannot pond water.

• For steeper slopes, an additional sock can be constructed on the top of the slope and within the slope area as determined by specific field conditions. Multiple socks are recommended on steeper slopes.

• Do not use mulch socks in areas of concentrated flow, as they are intended to control sheet flow only.

4. Where mulch socks are not allowed as a sediment control:

• On slopes with groundwater seepage;

• In concentrated flow situations or in runoff channels;

• On slopes equal to or steeper than 2:1;

• At the bottom of steep perimeter slopes exceeding 100 feet in length (large up-gradient watershed);

• Below culvert outlet aprons, and
• Around catch basins and closed storm system outlets.

• Within a stormwater control structure.

5. Inspection and Maintenance

• Inspect mulch socks after installation for gaps under the mulch socks and for gaps between the joints of adjacent ends of mulch socks.

• Inspect every 7-days and within 24-hours of a rainfall event of 0.5-inches or greater event and replace or repair if necessary.

• Sediment retained by the sock shall be removed when it has reached 1/3 of the exposed height of the sock. Alternatively, the sediment and sock can be stabilized with vegetation at the end of construction.

• Mulch socks can be vegetated or unvegetated. Vegetated mulch socks can be left in place. The vegetation grows into the slope, further anchoring the filter sock. Unvegetated filter socks are often cut open when the project is completed, and the mulch is spread around the site as soil amendment. The mulch should be spread out into the landscape to a depth that will not prevent seed germination and encourage effective revegetation of the site.

References:

1. Demars, Long, and Ives (2001), Performance Specifications for Wood Waste Materials As An Erosion Control Mulch And As A Filter Berm, NETCR 25

2. City of Austin, Mabel Davis Park Site Remediation, Standard Technical Specifications, Compost/Mulch Filter Berm - Section 02273 (2004), Volume 2


Table 1.4.5.F.1 Mulch Socks and Maximum Slope Lengths for 12” and 18” Sock Diameters.

<table>
<thead>
<tr>
<th>Slope</th>
<th>Max. Slope Length Between 18 in. Dia. Sock (ft)</th>
<th>Max. Drainage Area (sf) per 100 ft of Sock</th>
</tr>
</thead>
<tbody>
<tr>
<td>100:1-50:1</td>
<td>100</td>
<td>10000</td>
</tr>
<tr>
<td>50:1–30:1</td>
<td>75</td>
<td>7500</td>
</tr>
<tr>
<td>30:1–25:1</td>
<td>65</td>
<td>6500</td>
</tr>
<tr>
<td>25:1–20:1</td>
<td>50</td>
<td>4800</td>
</tr>
<tr>
<td>Slope</td>
<td>Max. Slope Length Between 12 in. Dia. Sock (ft)</td>
<td>Max. Drainage Area (sf) per 100 ft of Sock</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>100:1-50:1</td>
<td>100</td>
<td>6000</td>
</tr>
<tr>
<td>50:1-30:1</td>
<td>40</td>
<td>4000</td>
</tr>
<tr>
<td>30:1-25:1</td>
<td>30</td>
<td>3000</td>
</tr>
<tr>
<td>35:25:1-20:1</td>
<td>25</td>
<td>2600</td>
</tr>
<tr>
<td>20:1:10:1</td>
<td>15</td>
<td>1300</td>
</tr>
<tr>
<td>10:1-5:1</td>
<td>10</td>
<td>1000</td>
</tr>
<tr>
<td>5:1-2:1</td>
<td>5</td>
<td>500</td>
</tr>
</tbody>
</table>

Figure 1.4.5.F  Typical Mulch Sock Detail

**Remove existing figure**
Add new figure
TYPICAL MULCH SOCK INSTALLATION

Note: Install mulch sock along a level contour

Install mulch sock near slope where it transitions into a steeper slope

See Table 1.4.5.F.1 for spacing requirements

Place additional mulch material to fill seam between the sock and the ground

Water flow

Mulch material

Stake

24"
1.4.7 Vegetative Practices

A. Temporary Vegetative Stabilization of Disturbed Areas.

1. Description.

Stabilize soil in disturbed areas with temporary vegetation. Refer to ECM Section 1.4.5.A. – Mulching for other temporary stabilization options.

2. Purpose.

To stabilize the soil; to reduce damages from sediment and runoff to downstream areas; improve wildlife habitat; enhance natural beauty.


Use vegetation to temporarily stabilize the soil on disturbed, graded or cleared areas prior to establishment of permanent vegetation.

4. Design Criteria.

Prior to vegetative establishment, install needed erosion control practices, such as diversions, grade stabilization structures, berms, dikes, level spreaders, and sediment basins. Final grading and shaping has usually not been completed for temporary stabilization.

5. Fertilizer.

For temporary vegetative establishment, fertilizer may be applied if a soil test indicates the need for additional nutrients. For more information, refer to Standard Specification 606S. Fertilizer apply slow release fertilizer with an analysis of 15-15-15 at the rate of .5 pounds of nitrogen per 1,000 square feet once at planting and once during the period of establishment. Approval from the Planning and Development Review Department must be obtained if a higher rate of fertilizer is proposed. The timing of the fertilization shall correspond with the installation of vegetation. In order to avoid the conveyance of nutrients off-site, the timing of fertilization shall not occur when rainfall is expected or during slow plant growth or dormancy (i.e., during the cool season for warm-season plants). Chemical fertilizer may not be applied in the Critical Water Quality Zone.


Prepare a suitable seed bed which allows good seed-to-soil contact and soil conditions that are conducive to vegetative growth. Do not disturb the soil within the critical root zone of existing trees. See section 1.4.8.B. or information regarding the protection of trees in construction areas. Areas of compacted soil shall be loosened to a depth of at least two (24) inches by plowing, discing, raking or other acceptable means before seeding. In areas where no topsoil exists, or where topsoil is needed for vegetative establishment, the subgrade shall be loosened by discing or by scarifying to a depth of at least two (2) inches prior to placement to permit bonding of the topsoil to the subsoil. Placement of topsoil shall not occur in such a manner or location such that stormwater runoff is likely to transport the material downstream (e.g. over bedrock in an area of concentrated flow). All disturbed areas to be revegetated are required to
place have a minimum of six (6) inches of topsoil. Topsoil, when used, shall meet the definition of topsoil as defined in standard specification 601S.3.A Salvaging and Placing Topsoil. Topsoil salvaged from the existing site may often be used, but it should meet the same standards as set forth in these standards.

7. Seeding.

If seeding is to be conducted during the cool season (September 15 to March 1) plant select species noted as “cool season cover crop” from the Tables in Standard Specification 604S and/or 609S. Warm season seeding (March 2 to September 14) shall follow standard specification 604S (seeding for erosion control) and 609S (native grassland seeding and planting for restoration). If seeding is to be conducted during the warm season (March 2 to September 14) use one of the following options (whichever is applicable):

- Native Seeding: Green Sprangletop (Leptochloa dubia) at the rate of 4 lbs. per acre.
- Non-native Seeding: Comply with one of the options described in 604S.5 using Bermuda grass.

Apply seed uniformly with broadcast method, a seed spreader, drill, cultipacker seeder or hydroseeder (slurry includes seed, fertilizer and binder – see item 8). Length of seed germination is dependent on weather, soil moisture, species type and other variables. For native seed it can range from two to five weeks. If inadequate germination is evidenced, reseeding shall be required.

8. Protection of Seed Bed with Hydromulch or Soil Retention Blanket.

Newly-installed temporary vegetation must be protected by hydromulch or soil retention blanket (refer to Standard Specification 605S Soil Retention Blanket) immediately after seeding. Protection of the seed bed shall occur in a manner that will allow seed germination and that encourages effective vegetative growth. Hydromulching, when used, shall comply with the requirements of Table 1.4.7-A: Hydromulching for Temporary Vegetative Stabilization. The following hydromulch requirements are in accordance with the Erosion Control Technology Council (ECTC). The ECTC has set its mission to be the recognized industry authority in the development of standards, testing, and installation techniques for rolled erosion control products (RECPs), hydraulic erosion control products (HECPs) and sediment retention fiber rolls (SRFRs). ECTC promotes the use of RECPs, HECPs and SRFRs through education and industry leadership, and assists specifying agencies, engineers, designers and other interested individuals and organizations in the proper application of products and establishment of testing standards.

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Longevity</th>
<th>Typical Applications</th>
<th>Application Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% or any blend of wood, cellulose, straw, and/or cotton plant material (except no mulch shall)</td>
<td>70% or greater Wood/Straw 30% or less Paper or Natural Fibers</td>
<td>0-3 months</td>
<td>Moderate slopes; from flat to 3:1</td>
<td>1500 to 2000 lbs per acre</td>
</tr>
</tbody>
</table>
a. Hydraulic Mulch. Hydraulically-applied material(s) containing defibrated paper, wood and/or natural fibers that may or may not contain tackifiers used to facilitate revegetation establishment on mild slopes and designed to be functional for up to 3 months. Refer to Table 1.4.7-B for mulch properties and to Standard Specification 604S – Seeding for additional mulch requirements.

Table 1.4.7-B: Properties of Hydraulic Mulch

<table>
<thead>
<tr>
<th>Property (Test Method)</th>
<th>Required Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content %</td>
<td>12.0% ±3.0% (max.)</td>
</tr>
<tr>
<td>Organic matter %</td>
<td>90% ±1% Oven Dry Basis (min.)</td>
</tr>
<tr>
<td>Tacking Agent</td>
<td>0% or greater</td>
</tr>
<tr>
<td>Water holding capacity</td>
<td>500% or greater</td>
</tr>
</tbody>
</table>

9. Watering
Seed germination will be expected within 1 week of sowing. Supplemental watering is may be required to germinate seed and maintain growth. Seedlings shall be watered daily, or more often as necessary to ensure growth and to ensure that the vegetative cover stabilizes the soil as required. Depending on the weather and constituents of a seed mix, new plantings may require daily watering for the first week or longer after sowing to ensure germination, with reduced irrigation post-germination to ensure growth, plant health and vigor. Irrigation shall occur at rates and frequencies determined by a licensed irrigator or other qualified professional, and as allowed by the Austin Water Utility and the current water restrictions and water conservation initiatives. Significant rainfall (on-site rainfall of half-inch or greater) may allow the postponement of watering until the next scheduled irrigation.

B. Permanent Vegetative Stabilization of Disturbed Areas.
1. Description.
Permanent vegetative stabilization may comprise the installation of planting vegetation such as sod and bunch grasses, forbs, shrubs, and/or sod trees on critical disturbed areas. Permanent vegetative stabilization for disturbed areas may be achieved either by means of seeding or by sodding. When seeded, newly-installed permanent vegetation must be protected by hydromulch or soil retention blanket (refer to Standard Specification 605S Soil Retention Blanket).
2. Purpose.
To stabilize the soil, to reduce damages from sediment and runoff to downstream areas, improve wildlife habitat, enhance natural beauty.
Disturbed, graded or cleared areas which are subject to erosion and where a permanent, long-lived vegetative cover is needed.
4. Design Criteria.
• Standard Specifications
For areas that are seeded refer to Standard Specification 604S – Seeding for Erosion Control or 609S – Native Grassland Seeding and Planting for Restoration for Erosion Control (whichever is applicable). For areas that are sodded refer to Standard Specification 602S – Sodding for Erosion Control.

- Site Preparation.
- Install needed erosion control practices, such as interceptor dikes, berms and spreaders, contour ripping, erosion stops, channel liners and sediment basins.
- Grade as needed and feasible to permit the use of conventional equipment for seed bed preparation, seeding, mulch applications, anchoring and maintenance.

5. Bed Preparation.

Prepare a suitable bed which allows good contact between the soil and the seed or sod (whichever is used).

Areas of compacted soil shall be loosened by plowing, discing, raking or other acceptable means to a depth of six (6) inches or greater prior to seeding or sodding.

In areas where no topsoil exists, or where topsoil is needed for vegetative establishment, the subgrade shall be loosened by discing or by scarifying to a depth of at least two (2) inches prior to placement of six (6) inches of topsoil to permit bonding of the topsoil to the subsoil.

All disturbed areas to be revegetated are required to place a minimum of six (6) inches of topsoil. Topsoil, when used, shall meet the definition of topsoil as defined in standard specification 601S.3A Salvaging and Placing Topsoil.

Topsoil salvaged from the existing site may often be used, but it should meet the same standards as set forth in these standards. Placement of topsoil shall not occur in such a manner or location such that stormwater runoff is likely to transport the material downstream (e.g. over bedrock in an area of concentrated flow).

6. Fertilizer.

For permanent vegetative establishment, fertilizer may be applied if a soil test indicates the need for additional nutrients. For more information, refer to Standard Specification 606S, Fertilizer. Apply fertilizer with an analysis of 15-15-15 at a rate of .5 pounds of nitrogen per 1,000 square feet. Approval from the Planning and Development Review Department must be obtained if a different type or rate of fertilizer is proposed. The timing of the fertilization shall correspond with the installation of vegetation. In order to avoid the conveyance of nutrients off-site, the timing shall not occur when rainfall is imminent, or during slow plant growth or dormancy (i.e., during the cool season for warm-season plants). Chemical fertilizer may not be applied in the Critical Water Quality Zone.

7. Seeding.

Select the appropriate species in the tables provided in Standard specification 604S and/or 609S. All seeding work must conform to these specifications.

8. Protection of Seed Bed with Hydromulch or Soil Retention Blanket.

When seeded, newly-installed permanent vegetation must be protected by hydromulch or soil retention blanket (refer to Standard Specification 605S Soil Retention Blanket) immediately after seeding. Protection of the seed bed shall occur in a manner that will allow seed germination and that encourages effective vegetative growth. Hydromulching, when used, shall comply with the requirements of Table 1.4.7-C: Hydromulching for Permanent Vegetative Stabilization. The following hydromulch requirements are in accordance with the Erosion Control Technology Council (ECTC). The ECTC has set its mission to be the recognized industry authority in the development of standards, testing, and installation techniques for rolled erosion control products (RECPs), hydraulic erosion control products (HECPs) and sediment retention fiber rolls (SRFRs). ECTC promotes the use of RECPs, HECPs and SRFRs through education and industry leadership, and assists specifying agencies, engineers, designers and other interested individuals and organizations in the proper application of products and establishment of testing standards.
Table 1.4.7-C: Hydromulching for Permanent Vegetative Stabilization

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Longevity</th>
<th>Typical Applications</th>
<th>Application Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonded Fiber Matrix (BFM)</td>
<td>80% Organic defibrated fibers 10% Tackifier</td>
<td>6 months</td>
<td>On slopes up to 2:1 and erosive soil conditions</td>
<td>2500 to 4000 lbs per acre (see manufacturers recommendations)</td>
</tr>
<tr>
<td>Fiber Reinforced Matrix (FRM)</td>
<td>65% Organic defibrated fibers 25% Reinforcing Fibers or less 10% Tackifier</td>
<td>Up to 12 months</td>
<td>On slopes up to 1:1 and erosive soil conditions</td>
<td>3000 to 4500 lbs per acre (see manufacturers recommendations)</td>
</tr>
</tbody>
</table>

a. Bonded Fiber Matrix (BFM): Bonded Fiber Matrix shall consist of organic defibrated fibers and cross-linked hydro-colloidal tackifiers. Refer to Table 1.4.7-D for mulch properties and to Standard Specification 604S – Seeding for additional mulch requirements.

Table 1.4.7-D: Properties of Bonded Fiber Matrix

<table>
<thead>
<tr>
<th>Property (Test Method)</th>
<th>Required Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content %</td>
<td>12% ±3.0% (max.)</td>
</tr>
<tr>
<td>Organic matter %</td>
<td>75% ±3% Oven Dry Basis (min.)</td>
</tr>
<tr>
<td>Cross-linked Hydro-colloidal Tackifiers</td>
<td>10.0% ±1%</td>
</tr>
<tr>
<td>Water holding capacity</td>
<td>500% or greater</td>
</tr>
<tr>
<td>Mass per unit area (ASTM D6566)</td>
<td>10.0 oz/square yard (min.)</td>
</tr>
<tr>
<td>Thickness (ASTM D6525)</td>
<td>0.12 inch (min.)</td>
</tr>
<tr>
<td>Ground Cover (ASTM D6567)</td>
<td>97% (min.)</td>
</tr>
<tr>
<td>Functional Longevity</td>
<td>6 months (min.)</td>
</tr>
<tr>
<td>% Effectiveness</td>
<td>90% (min.)</td>
</tr>
<tr>
<td>Cure time</td>
<td>24 hours</td>
</tr>
<tr>
<td>Vegetative Establishment (ASTM D7322)</td>
<td>400%</td>
</tr>
</tbody>
</table>

b. Fiber Reinforced Matrix (FRM). Fiber Reinforced Matrix shall consist of organic defibrated fibers produced from grinding clean, whole wood chips, crimped interlocking fibers, cross-linked insoluble hydro-colloidal tackifiers and reinforcing natural and/or synthetic fibers. Refer to Table 1.4.7-E for mulch properties and to Standard Specification 604S – Seeding for additional mulch requirements.

Table 1.4.7-E: Properties of Fiber Reinforced Matrix
<table>
<thead>
<tr>
<th>Property (Test Method)</th>
<th>Required Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content %</td>
<td>12% ±3.0% (max.)</td>
</tr>
<tr>
<td>Organic matter % - organic fiber</td>
<td>65% ±3.5% Oven Dry Basis (min.)</td>
</tr>
<tr>
<td>Organic matter % - reinforcing fibers</td>
<td>25% or less</td>
</tr>
<tr>
<td>Cross-linked Hydro-colloidal Tackifiers</td>
<td>10.0% ±1%</td>
</tr>
<tr>
<td>Water holding capacity</td>
<td>500% or greater</td>
</tr>
<tr>
<td>Mass per unit area (ASTM D6566)</td>
<td>11.0 oz/square yard (min.)</td>
</tr>
<tr>
<td>Thickness (ASTM D6525)</td>
<td>0.16 inch (min.)</td>
</tr>
<tr>
<td>Ground Cover (ASTM D6567)</td>
<td>97 % (min.)</td>
</tr>
<tr>
<td>Functional Longevity</td>
<td>12 months (min.)</td>
</tr>
<tr>
<td>% Effectiveness</td>
<td>99% (min.)</td>
</tr>
<tr>
<td>Cure time</td>
<td>24 hours</td>
</tr>
<tr>
<td>Vegetative Establishment (ASTM D7322)</td>
<td>500%</td>
</tr>
</tbody>
</table>

   Sodding is an acceptable practice for permanent vegetative stabilization. Installation of sod shall comply with practices described in Standard Specification 602S – Sodding. Sod placed on slopes greater than 3:1 must be staked using biodegradable landscape staples.

10. Rooted Plants.
    Installation of rooted plants – including bare root, live root, and container-grown plants, – in conjunction with other methods, is an acceptable means of achieving permanent vegetative stabilization. Installation of rooted plants shall comply with practices described in Standard Specification 608S – Planting.

1140. Irrigation.
    Supply new seedlings and/or sod with adequate water for growth until the plants are firmly established. Provide watering as required in the Standard Specifications. Water according to the schedule described below, or to replace moisture loss per evapotranspiration (ET), whichever is greater. Significant rainfall (on-site rainfall of ½” or greater) may allow the postponement of watering until the next scheduled irrigation. Supplemental watering is may be required to germinate seed and maintain growth of rooted plants. Depending on the weather and constituents of a seed mix, new plantings may require daily watering for the first week or longer after sowing to ensure germination, with reduced irrigation post-germination to ensure growth, plant health and vigor. Irrigation shall occur at rates and frequencies determined by a licensed irrigator or other qualified professional, and as allowed by the Austin Water Utility and the current water restrictions and water conservation initiatives. Significant rainfall (on-site rainfall of half-inch or greater) may allow the postponement of watering until the next scheduled irrigation.

**Table 1.4.7-F: Watering Schedule**

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Irrigation</th>
<th>Frequency</th>
</tr>
</thead>
</table>

08/01/2014
Maintenance is a vital factor in providing an adequate vegetative erosion control cover. Monitoring, watering, mulching and weeding shall be required during the period of establishment to ensure planting success. Maintenance practices shall comply with construction methods and plant establishment requirements described in Standard Specifications 604S, 608S, and 609S.

a. Reseeding - Inspect all seeded areas for failures and reseed as necessary per 609S.

b. Replanting – Failure of rooted plant requires replacement per Standard Specification 608S.

c. Weeding: Anticipate weed problems prior to planting desired plants and eradicate control weeds as necessary to curb competition and enable proposed vegetation to thrive ensure a weed-free site. Weed types and amounts are dependent on weather, season, soil quality, and site conditions. Refer to Standard Specifications 602, 604, 608 and 609 for weed lists and treatment methods. Refer to Standard Specifications 608 604 and 609 for weed lists. Treatment methods shall be tailored for each situation, and should follow current City of Austin Integrated Pest Management (IPM) guidelines and Invasive Species Management Plan.

Table 1.4.7-G: Weeding Schedule

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Weed Treatment</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior-to-planting</td>
<td>Eradicate all weeds</td>
<td>2x or as necessary</td>
</tr>
<tr>
<td>At sowing/planting</td>
<td>Spot-treat &amp; hand-pull</td>
<td>As necessary</td>
</tr>
<tr>
<td>Next 30 days</td>
<td>Spot-treat &amp; hand-pull</td>
<td>1x/week</td>
</tr>
<tr>
<td>Until Final Completion</td>
<td>Eradicate all weeds</td>
<td>As necessary</td>
</tr>
</tbody>
</table>

C. Stabilization of Disturbed Areas with Trees, Perennials, Grasses and Shrubs.

1. Description.

   Planting rooted vegetation, such as trees, perennials, grasses and shrubs, on disturbed areas.

2. Purpose.

   To stabilize area, to reduce damages from sediment and runoff to downstream areas, to enhance natural beauty.

Graded or cleared areas subject to erosion where a permanent, long-lived diverse vegetative cover is desired.

4. Design Criteria.
Preference should be given to plants that are suitable for erosion control and that establish easily on difficult sites.

An excellent tabulation of vegetation types suited for various soil types and locations is provided in Appendix F—Descriptive Categories of Tree Species of this manual.

5. Planting Time.
Ideal planting times are fall and early spring. This allows for the plant to become established during periods of moderate temperatures and potentially adequate moisture.

Soil preparation of rooted plants shall comply with practices described in Standard Specification 608S—Planting.

7. Irrigation.
Supply rooted plants with adequate water for growth until the plants are firmly established. Provide temporary irrigation as required in the Standard Specifications. Irrigate according to the schedule described below, or to replace moisture loss per evapotranspiration (ET), whichever is greater. Significant rainfall (on-site rainfall of ½” or greater) may allow the postponement of watering until the next scheduled irrigation.

Table 1.4.7-I: Irrigation Schedule

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Irrigation Amount</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>At Installation</td>
<td>Minimum 2”</td>
<td>Min. 2x or 3x/day</td>
</tr>
<tr>
<td>Next 30-days</td>
<td>Min. 2” or replace ET</td>
<td>Min. 1x or 2x/day</td>
</tr>
<tr>
<td>Until Final Completion</td>
<td>Min. 2.5” or replace ET</td>
<td>As necessary</td>
</tr>
</tbody>
</table>

8. Maintenance.
— a. Monitoring, watering, mulching and weeding shall be required during the period of establishment to ensure planting success. Maintenance practices shall comply with construction methods and plant establishment requirements described in Standard Specification 608S—Planting.
— b. Weeding: Anticipate weed problems prior to planting desired plants and eradicate weeds as necessary to ensure a weed-free site. Weed types and amounts are dependent on weather, season, soil quality, and site conditions. Refer to Standard Specification 608 for weed lists and treatment methods.

Table 1.4.7-J: Weeding Schedule

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Weed Treatment</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior-to-planting</td>
<td>Eradicate all weeds</td>
<td>2x or as necessary</td>
</tr>
<tr>
<td>At sowing/planting</td>
<td>Spot treat &amp; hand-pull</td>
<td>As necessary</td>
</tr>
<tr>
<td>Next 30 days</td>
<td>Spot-treat &amp; hand-pull</td>
<td>1x/week</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Until Final Completion</td>
<td>Eradicate all weeds</td>
<td>As necessary</td>
</tr>
</tbody>
</table>
1.6.1 Introduction

This document provides guidelines for both the design of stormwater controls to enhance water quality and for the long-term maintenance of these facilities. These guidelines should be followed in order to provide protection for the water resources in the Austin area and to minimize time and effort in obtaining project review and approval. It is recognized that not all sites will permit ponds to be designed strictly according to these guidelines and that innovative designs are possible. However, such deviations from these guidelines must be approved by the Director of the Watershed Protection and Development Review Department (WPDR) pursuant to § 25-8-151 of the Land Development Code (Innovative Management Practices).

Stormwater can have significant impact on the water quality of Austin's creeks and the Colorado River. To minimize the effect of non-point source pollutants in stormwater, best management practice (BMP) water quality controls—stormwater control measures (SCMs, or controls)—are required to serve development. These water quality controls are designed to improve water quality by removing suspended particulate matter and associated constituents such as bacteria, nutrients and metals.

The City of Austin has two water quality zones: the Barton Springs Zone (BSZ), shown in Figure 1.6.1.A, and outside the Barton Springs Zone. Outside the Barton Springs Zone, sedimentation/filtration basin effluent quality is the water quality standard for new development; sedimentation/filtration basins are the standard water quality control for new development (which is not required to meet a non-degradation standard) and are discussed in detail in Section 1.6.5. If using controls other than sedimentation/filtration basins outside the Barton Springs Zone, site runoff shall have an average annual pollutant load equal to or less than the effluent load of a sedimentation/filtration system that treats the required water quality volume. Inside the Barton Springs Zone, site runoff shall cause no net increase in average annual pollutant load compared to existing conditions per requirements in LDC 25-8 514. Refer to Section 1.6.9 for demonstrating compliance within the Barton Springs Zone. Note that all developments must also comply with State of Texas regulations, such as those applicable to the Edwards Aquifer zone.

Add New Figure 1.6.1.A
Applicants are encouraged to contact the WPDR staff prior to submitting plans proposing innovative practices. Minimum design guidelines for several alternatives are outlined in Section 1.6.7.

Figures 1-46 and 1-47 in Appendix V of this manual illustrate water quality design options for suburban and water supply suburban watersheds, and water supply rural watersheds.
1.6.2 General Design Guidelines

The following section discusses general design parameters which most stormwater control measures, including water quality controls, have in common. These parameters include the volume of run-off which is to be treated, a method to isolate this volume, and liner requirements.

A. Capture Volume or Water Quality Volume. The primary control strategy for water quality basins is to capture and isolate at least a minimum volume of stormwater runoff for treatment, and to release the treated volume in forty-eight (48) hours or as specified. The minimum volume is the first one-half (0.5) inch of runoff plus an additional one-tenth (0.1) inch for each ten (10) percent increase of impervious cover over twenty (20) percent within the drainage area to the control. This depth of runoff from the contributing drainage area to the control is and will be referred to as the Capture Volume (LDC 25-8-213(B)), also known as the “Water Quality Volume.” The water quality volume must consist of runoff from all impervious surfaces such as roadways, parking areas and roof tops, and all developed pervious areas. Water quality treatment is not required for runoff from lands left in their natural state, e.g., greenbelts and open spaces. Runoff from these areas must be routed around the water quality basin or it must be included in the water quality volume. Off-site contributing drainage should be routed around the water quality basin except in cases where runoff from at least 10 acres of untreated, off-site area can be treated. In urban watersheds developments that treat off-site areas may be eligible for cost recovery and/or cost participation, per Section 1.9.2. The minimum water quality volume for a control that treats off-site runoff will be that required for the on-site area, and at least 0.15-inch for the contributing drainage area; larger volumes will, in general, increase the City’s level of cost recovery and/or cost participation.

If this is not done, off-site contributing areas must be included in the water quality volume or a hydrologic study must be presented which indicates insignificant mixing with the on-site water quality volume. A separate case from the above is a commercial subdivision. Since development on individual lots in commercial subdivisions will incorporate water quality controls, the water quality volume for roadways in commercial subdivisions may be based on only the likely contributing drainage area of the roadway after the lots are developed.

That is, contributing drainage to roadways from the individual lots does not have to be included in the water quality volume for a commercial subdivision provided that the total drainage area contributing to the roadway pond does not exceed fifty (50) acres. Section 1.6.10 includes example calculations for determining water quality volumes.

Because travel time from distant contributing areas reduces the effectiveness of the water quality controls in capturing all of the water quality volume, a maximum contributing drainage area of fifty (50) acres per water quality control basin is recommended.

B. Water Quality Volume Diversion Structures. Off-line water quality controls are often required to have a diversion structure or splitter box which will capture and isolate the water quality volume. A typical approach for achieving isolation capture of the water quality volume is to construct an isolation/diversion weir in the stormwater channel such that the height of the weir equals the elevation of the water quality volume in the pond. When runoff in excess of the water quality volume enters the stormwater channel it will spill over the isolation/diversion weir with minimal mixing with the already isolated captured water quality volume. The splitter design must be capable of passing the peak flow rate of a twenty-five (25) year storm into the water quality pond, and pass the peak flow rate of the one-hundred (100) year design storm past the basin.
without overtopping the pond walls. As an alternative the design engineer can size the diversion structure for the flowrate on the twenty-five (25) year inflow hydrograph that will fill the pond; a hydraulic and hydrologic analysis must be provided that conforms with accepted procedures, as defined in the Drainage Criteria Manual. The maximum velocity entering the water quality basin shall not exceed 2 ft/sec.

Figures 1-48 through 1-50 in Appendix V of this manual presents examples of these structures.

1. Off-line stormwater control measures may be required to have a diversion structure or splitter box which will capture the water quality volume. A typical approach for achieving capture of the water quality volume is to construct a diversion weir in the stormwater channel. For stormwater control measures that require a diversion structure the following minimum design standards must be provided:

   a) The height of the diversion weir must be equal to or greater than the surface elevation of the water quality volume in the stormwater control measure.

   b) The diversion structure must be capable of passing the peak flow rate of the twenty-five (25) year storm into the stormwater control measure.

   c) The maximum velocity entering the water quality basin shall not exceed two (2) feet per second.

   d) When runoff in excess of the water quality volume enters the stormwater channel it will spill over the diversion weir. The diversion weir must be designed to pass the peak flow rate of the one-hundred (100) year design storm past the stormwater control measure with a head over the diversion weir of no more than one foot.

   e) The water quality pond design shall allow enough freeboard to pass the design flow rate for the 100 year storm over the splitter/diversion structure without overtopping of any side walls of the pond, plus an additional 5% of the total fill height or three inches, whichever is greater, to allow for construction irregularities and long term soil settling.

   f) As an alternative the design engineer can size the diversion structure for the flowrate of the twenty-five (25) year inflow hydrograph that will fill the pond; a hydraulic and hydrologic analysis must be provided that conforms with accepted procedures, as defined in the Drainage Criteria Manual.

Figures 1-48 through 1-50 in Appendix V of this manual presents examples of these structures.

2. Stormwater control measures that propose to stack the detention volume above the water quality volume must comply with the following criteria.

Stormwater control measures that may be allowed to stack detention above the water quality volume are as follows:

   • Partial sedimentation with sand filtration or biofiltration controls
• Full sedimentation with sand filtration or biofiltration controls
• Retention Irrigation controls that are not subject to compliance with the SOS ordinance.
• Rainwater Harvesting controls
• Rain Gardens
• Porous Pavement

The following minimum design criteria must be provided:

a) The velocity of the flows entering the stormwater control measure for the developed 100 year peak flow must not exceed two feet per second

b) Velocity breaks and energy dissipation should be incorporated into the design to reduce erosive impacts on the stormwater control measure and to protect the medium (sand or biofiltration) from washing out or eroding.

c) Detention pond and stormwater control measure wall elevations must meet the minimum freeboard requirements provided in the City of Austin - Drainage Criteria Manual.

C. Basin Liners. All wet ponds require an impermeable liner. Impermeable liners are also required for water quality basins located over the Edwards Aquifer Recharge Zone and in areas where there is surface runoff to groundwater conductivity. Impermeable liners may be clay, concrete, geosynthetic clay liner (GCL), geomembrane, or other approved liner, depending on the application. The analysis and design should entail a comprehensive review of the site specific conditions to determine the most appropriate type of liner for the site, and should include a stability assessment of the pond side slope. The guidelines below must be used for the design of liners for wet ponds, sedimentation basins, filtration basins, and retention ponds as applicable. The criteria in item 1 is applicable to any size basin or pond, while the criteria in item 2 may be applied to sedimentation basins, filtration basins and retention ponds that are less than 1,000 square feet in area. When required for sedimentation/filtration basins, the liner must underlie both the sedimentation basin and filtration basin and any gabion wall areas.

1. Wet Ponds, Sedimentation Basins, Filtration Basins, and Retention Ponds
There are a number of important engineering design and construction considerations for wet pond liners and other basin liners. A geotechnical engineer must be involved in all aspects of the liner design. All liner studies, plans, details, specifications and other related documents must be sealed by a geotechnical engineer. Careful attention must be paid to each of the following areas:

• Liner subgrade - A stable subgrade is very important in the construction of the pond or basin. Careful evaluation must be conducted to ensure the liner will be placed on a suitable base. If any voids are encountered, proper geotechnical analysis must be performed to ensure that the integrity of the liner can be maintained. Proof rolling must be conducted as necessary to determine the suitability of the subgrade, and any suspect areas must be reworked and recompacted, or the weak soils removed and replaced with suitable
fill material. The subgrade for geomembrane or GCL must be smooth and contain no particles greater than 0.375 inch diameter.

• **Liner characteristics** - at least three types of liners can be considered, including a clay liner of appropriate thickness and permeability, a geomembrane liner, and GCL. Alternative liner designs may also be considered.

  o **If geomembrane** is used, it must have a minimum thickness of thirty (30) mils and be ultraviolet resistant. Use of a geomembrane also requires that a suitable geotextile fabric be placed on the top and bottom of the membrane for puncture protection if any particles greater than 0.375 inch are present in the cover soil or subgrade surface, respectively. The geotextile material must have a minimum unit weight of 8 oz./sq. yd., a minimum puncture strength of 125 lbs., a minimum Mullen Burst Strength of 400 psi, and a minimum tensile strength of 200 lbs. The designer must demonstrate the liner's impermeability, and the method of liner protection to be used during maintenance and sediment removal operations. Equivalent methods for protection of the geomembrane liner will be considered by the Watershed Protection and Development Review Department on a case by case basis. Equivalency will be judged on the basis of ability to protect the geomembrane from puncture, tearing and abrasion. Figure 1-56 in Appendix V of this manual illustrates this placement. Individuals installing geomembrane liners must be trained and/or certified by the liner manufacturer. Figure 1-56B and 1-56C in Appendix V of this manual presents examples of illustrate acceptable geomembrane liner end details for use on concrete walls, stacked stone walls, and earthen embankments.

  o **If a clay** liner is used, it must be designed for the site-specific conditions by a geotechnical engineer, and must have a minimum thickness of twelve (12) inches or greater. Coefficient of permeability must be 1x10^-7 cm/sec or less. Other parameters must be as follows: plasticity index of not less than 15; liquid limit of not less than 30; and at least 30% clay particles passing the No. 200 sieve, with a maximum particle size of 1 inch. Soil must be processed to reduce clod size as much as possible prior to compaction and compaction of the lifts must be done using footed rollers. Clay compaction must be no less than 95% of Standard Proctor Density at or above optimum moisture content or 90% of Modified Proctor Density at a moisture content between 1% dry and 3% wet of optimum. Soil sampling and testing must be conducted on the borrow source and installed liner samples as applicable. Liner material verification sampling and testing should occur at frequencies which must be in accordance with the QA/QC plan. In-situ materials may be used if it can be demonstrated that all required liner parameters will be met. If the clay liner is to be overlain by a drainage layer, a suitable geotextile fabric must be placed on the surface of the liner prior to placement of the drainage layer to prevent plugging of the drain by the clay liner. Detail 661-5 of the City of Austin Standards Manual Figure 1-56A in Appendix V of this manual illustrates this placement.

  o **Geomembrane or GCL** liner placement over excavated rock requires installation of protective material to prevent damage to the liner. Examples of protective material include spray-on fiberglass, additional clay liner material, or placement of a geosynthetic fabric.
An alternative liner design may be approved by the Director of the Watershed Protection and Development Review Department if it can be demonstrated by the responsible party that the liner is at least equivalent to or exceeds the above requirements.

- **Handling of liner penetrations** - Liner penetrations are one of the areas of the pond or basin that are most susceptible to leakage. It is critical that the design and construction of these areas pay special attention to liner continuity around these interface points. Detailed analysis must be performed related to the handling of all areas of liner penetrations such as pipe inlet and outlet structures, headwalls, and areas where concrete access ramps, maintenance and pump pads interface with the liner. Penetrations for wet ponds should be placed to minimize the hydraulic head over the penetration. Consideration must be given to the need for special applications such as anti-seep collars, gaskets, clay or bentonite plugs, special backfill and compaction, and other measures to prevent leakage around all these areas. Intake pipes should be doubled-walled or lined below the elevation of the water quality volume or permanent pool elevation.

- **Protecting the liner from erosion** - The integrity of the liner, particularly a clay liner, can be severely compromised by any erosion that may occur at the surface of the liner. The design must provide appropriate mechanisms to prevent erosion of the liner at all areas, including the inlet structure and the separation berm between the forebay and main pool of wet ponds. Additionally, the liner must be continuous under wet pond separation berms to minimize the potential for leakage at the equalization/interbasin pipe.

- **Protecting the liner against damage and loss of moisture** - It is imperative that the clay liner be kept moist during construction and prior to the time the basin is filled. Otherwise, cracks can develop in the clay, particularly during the hotter months of the year, thereby rendering it susceptible to leakage. For wet ponds, provisions must be included in the construction documents that require the contractor to protect the liner against loss of moisture until the basin is completely filled. For all ponds, damage to unprotected clay, GCL, or geomembrane liners can also occur due to passage of equipment during construction or during future sediment removal and maintenance operations. To minimize the possibility of damage and drying, all liner designs should include a protective soil layer over the liner with a minimum thickness of 12 inches for clay liners, and 24 inches for GCL and geomembrane (the 24-inch thickness can be reduced for liners which are never to undergo traffic by heavy equipment or are otherwise protected from heavy equipment). The protective cover layer includes 4-inches of topsoil per City of Austin Landscape criteria.

- **Liner Plans and Specifications** - The engineer must prepare the necessary plans and specifications to provide the contractor clear direction for the construction of the liner and all related components. Construction details must be included for all linen cross-sections, penetrations, and any other areas requiring special attention and/or guidance to ensure proper construction. A scale drawing of the area to be lined, including a grid established across the base and side slopes of the pond or basin with target elevations shown, must also be prepared by the engineer. This grid will provide a basis for verification of liner thickness during construction and will be used for the purpose of recording elevation data prior to placement of the initial lift and following placement of the final lift. All required testing, standards, procedures, and material properties must be spelled out in detail in the documents. Parties who are responsible for any surveying, sampling, testing and other verification requirements must be identified in the documents.
• **Groundwater Control** - Liners constructed below groundwater will require dewatering as necessary to allow construction of the liner. To prevent damage to the liner due to uplift pressures after termination of dewatering or during future maintenance, the liner must include placement of sufficient soil ballast or additional thickness of clay liner to resist any uplift pressures. *Alternative designs to relieve liner uplift pressure (French drain, etc.) will be considered and must be approved by the Watershed Protection Development Review Department.*

• **Construction Quality Assurance/Quality Control Plan** - A construction Quality Assurance/Quality Control (QA/QC) Plan must be prepared by the engineer for the purpose of providing a basis for all construction/installation and testing of the liner system during the liner construction process. The QA/QC plan must be approved by the City prior to liner construction.

  o For clay liners, the QA/QC plan must include, but not be limited to, the following items: **recordkeeping documents**, including daily construction reports, inspection and test data sheets, non-conformance and corrective measure reports, design and specification changes, and all other documentation accumulated by inspection personnel during construction; **pre-construction soil sampling, testing and documentation protocol**, including the type of information to be documented for each sample, and the test procedures to be used; **protocol during construction**, including the monitoring of the subgrade, as well as material placement (including items such as density testing and moisture content, lift thickness and bonding, processing of soil and reduction of clods, footed compaction equipment, and number of passes of compaction equipment), sampling and testing procedures, frequencies and other requirements; Also, the handling of any liner perforations as a result of various types of testing must be addressed along with guidance on how to address any deficiencies that may be discovered, including corrective measures to be taken.

  o For geomembrane and GCL liners, the QA/QC plan must include, but not be limited to, the following items: **geomembrane/GCL manufacturing and delivery data requirements**, including raw materials properties, roll and production quality assurance and control data requirements, along with transportation, handling and storage requirements, and conformance testing; **installer qualifications requirements; installation requirements**, including surface preparation, system anchorage, geomembrane/GCL placement (including, but not limited to panel identification, placement and installation schedule), seaming information (including, as applicable to geomembrane or GCL, seam layout, preparation, equipment, weather conditions, trial welds, general procedures, non-destructive testing and destructive testing), identification of defects and repair procedures, and geomembrane/GCL acceptance procedures.

**Soils and Liner Evaluation Report (SLER), Geosynthetic Clay Liner Evaluation Report (GCLER), or Geomembrane Liner Evaluation Report (GLER)** - All liner construction and QA/QC activities must be under the supervision of an independent licensed engineer with experience in geotechnical engineering. *The engineer or his representative must be on site during all significant liner construction activities, including but not limited to:*

  1. At the beginning of liner construction to inspect subgrade acceptability;
2. During the processing of clay liner material for placement to ensure adequate moisture conditioning and particle size reduction;
3. During placement of clay liner lifts to ensure 6 inch maximum lift depth is not exceeded and compaction is sufficient;
4. During all geomembrane installation;
5. During clay and geomembrane liner testing;
6. Prior to placement of successive clay lifts to verify acceptability of prior lift surface;
7. During construction of penetrations and any other construction that will affect the integrity of the liner (access ramps, pump pads, etc.)
8. During placement of protective soil layer.

- **Water Level Monitoring for liner integrity verification in wet ponds** - After the filling and installation of aquatic vegetation in a wet pond, the water level of the permanent pool shall be measured monitored for a minimum of eight weeks. The engineer shall specify the method and frequency of monitoring, and the responsible party for conducting water level monitoring. The engineer shall perform a water balance, as specified in 1.6.6.C. 5, to determine that the water loss does not exceed anticipated losses from calculated liner leakage, evaporation, plant transpiration and discharge. All monitoring data and calculations must be documented and submitted to the City of Austin for review.

2. Sedimentation Basins, Filtration Basins and Retention Ponds less than 1,000 square feet in area.

Concrete liners may be used for sedimentation basins, filtration basins and retention ponds less than one-thousand (1,000) square feet in area. Concrete must be five (5) inch thick Class A or better as defined in the City of Austin Standard Specifications and must be reinforced by steel wire mesh. The steel wire mesh must be six (6) gauge wire or larger and six (6) inch by six (6) inch mesh or smaller. An Ordinary Surface Finish (as specified in Item 410.25 of the City of Austin Standard Specifications) is required. When the underlying soil is clay or has an unconfined compressive strength of one-quarter (0.25) ton per square foot or less, the concrete must have a minimum six (6) inch compacted aggregate base consisting of coarse sand and river stone, crushed stone or equivalent with diameter of three-quarters (0.75) to one (1) inch. Where visible, the concrete must be inspected annually and all cracks must be sealed.

**D. Short-Circuiting and Dead Storage.** All water quality controls shall be designed to minimize short-circuiting (flow reaching the outlet structure before utilizing the entire water quality volume and/or surface area) and dead storage (areas within the basin which are by-passed by the flow regime and are, therefore, ineffective in the treatment process). Irregular shapes shall be avoided, or shall use baffles or other measures to achieve adequate hydraulic efficiency. Inlet and outlet structures shall be located at extreme ends of the basin. Pilot channels are discouraged in water quality ponds due to the creation of short-circuiting and standing water problems.
Due to topographic constraints, a pilot channel installed in a water quality pond must be filled with appropriately-sized rocks to prevent short-circuiting, standing water problems, and shall have a flow spreader installed at the upstream end of the channel.

For sedimentation basins, sediment chambers, and filtration basins, the inflow shall be discharged into the basin uniformly across the basin width (see Figure 1-48, Appendix V). Ideally, the inlet (isolation/diversion) structure should be designed to provide this uniform flow distribution; if not, a flow spreader is required in the basin to distribute flows. Use the flow spreader design criteria shown in Figure 1.6.5.A, Full Sedimentation/Filtration Riser Pipe Outlet System and Determining Location of Flow Spreader in Filtration Basin or the reinforced vegetated hedgerow shown in Figure 1.6.7.C.2, Partial Sedimentation/Biofiltration pond.

See Figure 1.6.2.D for preferred configurations for different BMPs stormwater control measures (note: some figures are shown as rectangular shapes for simplicity; designs are not required to have straight edges).
Figure 1.6.2.D  Water Quality Control Configurations (adapted from Persson, Somes, Wong. Hydraulics Efficiency of Constructed Wetlands and Ponds, 1999)
1.6.3 Maintenance and Construction Requirements

B. Maintenance Requirements—Design and Construction.

12. For water quality treatment systems that utilize vegetation (vegetated sedimentation basin or sediment chamber, retention/irrigation, vegetative filter strip, biofiltration, rainwater harvesting, non-required vegetation, rain garden) a minimum of 95% of the vegetation shall be alive and viable. No bare areas greater than 10 square feet may exist. For ponds these performance requirements apply to the entire pond area including the pond bottom, side slopes, and areas adjacent to the pond.

*******

C. Major Maintenance Requirements.


Vegetation Maintenance.

— Once vegetation is established, biofiltration systems should require less maintenance than sand filtration systems because the vegetation protects the filtration media from surface crusting and sediment clogging. Plant roots also provide a pathway for water to permeate down into the media, thus further enhancing the hydraulic performance of the system. Unless damaged by unusual sediment loads, high flows, or vandalism, the biofiltration media should be left undisturbed and allowed to age naturally.

A. Performance Requirements

Performance Requirements—

A minimum of 95% of the vegetation shall be alive and viable for one year following installation. No bare areas greater than 10 square feet may exist. These performance requirements apply to the entire pond including the pond bottom, side slopes, and areas adjacent to the pond.

B. Maintenance Considerations in Design

Landscape Maintenance.

A lack of maintenance considerations in the design of a landscape commonly results in a site that is more maintenance intensive (i.e., costly) than necessary and/or appropriate for its purpose, and one that requires the routine use of practices that are undesirable (e.g., extensive pesticide use, intensive pruning of plants that grow too large for the spaces they occupy). It is important that the designer include maintenance considerations and IPM throughout the planning and design phase of a biofiltration project. To the extent possible, these criteria are designed to minimize the potential for pests and the amount of maintenance required for the biofiltration pond. Landscapes should be designed to allow for the access and aid the maneuverability of maintenance equipment (e.g., if areas of the pond are designed to be mown, acute angles should be avoided in turf areas; wide angles, gentle, sweeping curves, and straight lines are easier to mow).

C. Mowing and/or Trimming

A. Mowing and/or Trimming.

Mowing and/or trimming of vegetation is allowable with certain restrictions. Vegetation that is mowed
or cut shall be removed.

1. Tall Herbaceous and Medium Herbaceous Plants.

Trimming activities must not impinge on the growing tips (basal crown) of the bunchgrasses. Cutting these grasses below the basal crown will severely stress and possibly kill them. These plants shall be cut no lower than 18" from the ground. The annual physical removal of all woody weeds from the filtration basin is required.

2. Short Herbaceous Plants.

Sod-forming grasses may be mown or trimmed to an appropriate height. These plants shall not be scalped; cut no lower than four (4) inches from the ground.

D. Integrated Pest Management (IPM)

An integrated pest management (IPM) plan and associated restrictive covenant is required for a biofiltration pond. IPM is a continuous system of controlling pests (weeds, diseases, insects or others) in which pests are identified, action thresholds are considered, all possible control options are evaluated and selected control(s) are implemented. Control options—which include biological, cultural, manual, mechanical and chemical methods—are used to prevent or remedy unacceptable pest activity or damage. Choice of control option(s) is based on effectiveness, environmental impact, site characteristics, worker/public health and safety, and economics. The goal of an IPM system is to manage pests and the environment to balance benefits of control, costs, public health and environmental quality. IPM takes advantage of all appropriate pest management options.

1. Weed Management.

Preventing the introduction of weeds is the most practical and cost-effective method for their management. Do not allow bare soil to be present, design it out of the system. Prevention programs include such techniques as limiting weed seed dispersal, minimizing soil disturbance, and properly managing desirable vegetation. Remove weeds early in their growth stage, before they set seed. (One year of seeds is equal to seven years of weeds) Allow the desired vegetation to out-compete the weeds.

a. Mulch: Control weeds by blocking light and air space.

   i. Bark mulch, the traditional material for minimizing weeds in ornamental landscapes, is not recommended because it will tend to float or otherwise be washed out of the system. The innovative use of non-traditional mulches will be required when ornamental beds are used in biofiltration facilities. Gravel is permitted to cover the soil surface both in the sediment basin and the filter basin.

   ii. Gravel or crushed recycled glass equivalent in size to gravel may be used to cover the soil surface in biofiltration.

   iii. Weed fabric is not permitted in biofiltration due to the potential for clogging of the pores.

b. Cultivation: Cultivating cuts the weed roots below the soil to reduce root carbohydrates. May be done by hand tools only; using cultivating machines is not acceptable. Repeat cultivation at 2-3 week intervals during the growing season. Keep hoes sharp and in good condition to reduce the effort needed. Any bare areas must be re-seeded.

c. Organic herbicides: Be aware that organic herbicides must be used with caution and can
be dangerous in concentrated form. Personal protective equipment must be used: rubber gloves, long
pants, eye protection. The use of organic herbicides is restricted to the following products:

i. Acetic acid (20% vinegar) is effective on small annuals.

ii. Essential oils: Includes cinnamon, clove, summer savory and thyme must be used at the
appropriate concentration. Effective on a limited number of species.


Biofiltration ponds shall not become breeding places for mosquitoes. Meet the drainage requirements
established per 1.6.7 (C). Once the pond has drained, remaining incidental standing water must not be
present for longer than four days (96 hours) thereafter.


In addition to water quality treatment, biofiltration ponds offer additional benefits such as providing
food and habitat for wildlife. Pets may also be attracted to them. However, activities by animals within a
pond shall not interfere with pond functions and design objectives. Digging or burrowing by animals in
the filtration basin is particularly troublesome. There is the potential for certain animals to become a pest
of biofiltration ponds in the Austin area. Evaluate the potential for problems due to animal activity in the
proposed pond site. Where the potential exists for problematic activity, fencing or similar exclusionary
method shall be provided.

E. Irrigation

C. Irrigation. Irrigation will be necessary to establish the vegetative community immediately after
completion of the planting and during the first 3-6 months after planting. Thereafter irrigation needs
should be minimal and a permanent irrigation system may not be necessary. If a permanent irrigation
system is proposed, the design must address both stormwater management and plant health needs. In
particular, overwatering is unacceptable as it will negatively impact the hydraulic performance and
pollutant removal capabilities of the biofiltration system. The following minimum criteria will apply for
permanent irrigation systems:

• Soil water moisture sensors must be installed at appropriate depths and locations in the biofiltration
  basin.

• No irrigation during periods when rainfall is occurring.

• No irrigation is to commence until the soil moisture content of the filtration media is ≤ 25% of the
  Available Water Capacity (AWC). For plants native or adapted to arid and semi-arid conditions, no
  irrigation should commence until the soil moisture content is ≤ Wilting Point (WP), or 0% AWC.

• Irrigation will cease once the soil moisture content is ≤ 75% AWC; 50% for plants native or adapted
to arid and semi-arid conditions.

• The designer shall It is required that the designer conduct a water balance to aid in the design, using a
time step of one day or less.

F. Routine Maintenance

D. Maintenance. Once vegetation is established, biofiltration systems should require less maintenance
than sand filtration systems because the vegetation protects the filtration media from surface crusting and
sediment clogging. Plant roots also provide a pathway for water to permeate down into the media, thus
further enhancing the hydraulic performance of the system. Unless damaged by unusual sediment loads, high flows, or vandalism, the biofiltration media should be left undisturbed and allowed to age naturally.

Once vegetation is established, biofiltration systems should require less maintenance than sand filtration systems because the vegetation protects the filtration media from surface crusting and sediment clogging. Plant roots also provide a pathway for water to permeate down into the media, thus further enhancing the hydraulic performance of the system. Unless damaged by unusual sediment loads, high flows, or vandalism, the biofiltration media should be left undisturbed and allowed to age naturally, and biofiltration pond vegetation shall be managed so that a dense, healthy vegetative cover is preserved. The following maintenance items should be performed depending on frequency and time of year:

— Water Plants as necessary during the first growing season and during dry periods. Irrigation will be necessary to establish the vegetative community during the first 3-6 months after planting has been completed and by hand immediately after completion of the project.

Biweekly during first growing season: Inspect vegetation. Biweekly inspection of vegetation during first growing season until 95% vegetative cover is established.

Monthly: Monthly Check for accumulated sediments, remove as needed.

Quarterly: Remove debris and accumulated sediment; replace soil media in void areas caused by settlement; repair eroded areas; remulch by hand any void areas.

Quarterly removal of debris, sediment accumulation, and soil media should be replaced in void areas caused by settlement, and repair eroded areas. Remulch any void areas by hand whenever needed.

Semi-annually: Remove and replace dead or diseased vegetation that is considered beyond treatment (see planting specifications); treat all diseased trees and shrubs mechanically or by hand depending on the insect or disease infestation.

— Six months remove and replace dead and diseased vegetation. Removal and replacement of all dead and diseased vegetation considered beyond treatment (see planting specifications).—

— Treat all diseased trees and shrubs mechanically or by hand depends on insect or disease infestation.

Late winter: trim bunch grasses; mow turf grasses; harvest other types of vegetation according to recommendations in the planting specifications. Adhere to Section 1.6.3.C.6.A Mowing and/or Trimming.

— Late Winter harvesting involving trimming of bunchgrass (trim to minimum 18" or higher), and mowing of turf grasses (minimum 3" high). For other types vegetation see recommendations in the planting specifications.

Spring: Remove previous mulch layer and apply new mulch layer by hand (option) once every two to three years.

— Spring remove previous mulch layer before applying new layer (optional) by hand once every two to three years in the Spring.

When 48 hour drawdown time is exceeded or significant decrease in drawdown time is observed: Evaluate bed soil and underdrain system, take appropriate measures to return to design drawdown time.

— Any time 48 hour drawdown time is exceeded or significant decrease in drawdown time is observed, evaluate bed soil, underdrain system and appropriate measures should be taken. Biofiltration pond vegetation shall be managed so that a dense, healthy vegetative cover is preserved. Once established,
native grasses shall be maintained without fertilizers and limited use of organic herbicides. A recorded
restrictive covenant and cover sheet notes will establish the requirements for the implementation and
ongoing maintenance of an approved Integrated Pest Management Plan (IPM).

**Signage.**

- Delineate the boundaries of the biofiltration area as minimal mow maintenance, no fertilizers, and
limited use of organic herbicides application is allowed.

**Sequence of Construction.**

**G. Sequence of Construction**

The following sequence of construction shall be used for all development using the biofiltration design
criteria. The applicant is encouraged to provide any Additional details appropriate for the particular
development.

1. Erosion controls and tree protection are to be installed as indicated on the approved site plan.

2. Contact the Watershed Protection and Development Review Department to schedule a
preconstruction coordination meeting to be held on site. During the pre-construction meeting the
biofiltration certification requirements will be reviewed.

3. Erosion controls will be revised, if needed, to comply with Inspectors' directives, and revised
construction schedule relative to the water quality plan requirements and the erosion plan.

4. Rough-cut all required or necessary ponds. Either the permanent outlet structure or a temporary
outlet must be constructed prior to development of any embankment or excavation that leads to ponding
conditions. The outlet system must consist of a low-level outlet and an emergency overflow meeting the
requirements of the Drainage Criteria Manual (Section 8.3) and/or the Environmental Criteria Manual
(section 1.4.2.K) as required. The outlet system shall be protected from erosion and shall be maintained
throughout the course of construction until final restoration is achieved.

5. Temporary controls to be inspected and maintained weekly and prior to anticipated rainfall events,
and after rainfall events, as needed.

6. Schedule a mid-construction conference with the City Inspector to coordinate changes in the
construction schedule and evaluate effectiveness of the erosion control plan after possible construction
alterations to the site. The biofiltration media must be delivered to, or mixed at, the site prior to the
mid-construction conference. The media must be certified as meeting the required specifications by the
project Engineer, or his/her designee, and approved by the City Inspector. The media must be stored
on-site separate from other materials, and covered to prevent erosion of the mixture by rainfall and
runoff. The media must have a prominent tag affixed that reads "BIOFILTRATION MEDIA FOR
WATER QUALITY POND."

7. Complete construction and stabilize all areas draining to the biofiltration basin. Permanent controls
will be cleaned out and filter media will be installed after stabilization of the site. Pre-soak the in-place
biofiltration media and add additional media as needed until the 18" design depth is achieved. Provide
plant material tags for the vegetation to the City Inspector prior to planting. The project Engineer must be
present during installation of the biofiltration media and plantings, and approve the installation.

8. Complete permanent erosion control and site restoration. Remove temporary
erosion/sedimentation controls and tree protection. Restore any areas disturbed during removal of
erosion/sedimentation controls.


H. Other Items

--- Other items:

a. All requirements in 1.6.3.C.1. apply except as noted above.

b. Signage shall be used to delineate the boundaries of the biofiltration area that are maintained with minimal mowing, no fertilizers, and limited use of organic herbicides.

b. Vegetative cover must be at least 95%, with no unvegetated area exceeding ten (10) square feet, and no evidence of erosion.

c. The minimum vegetation height shall be three (3) inches for turfgrasses and eighteen (18) inches for bunchgrasses. Vegetation that is mowed or cut shall be removed.

d. An approved Integrated Pest Management (IPM) Plan is required.

*****

8. Porous Pavement for Pedestrian Use (Section 1.6.7.E).

   General Maintenance

   • a. Verify that the porous pavement receives no off-site runoff.

   b. Verify that the porous pavement is protected from vehicular traffic.

   • e. Prior to final acceptance it must be demonstrated that the saturated hydraulic conductivity of any portion of the porous pavement is at least 20 inches/hour or, if the system is saturated, the entire water quality volume infiltrates into the subgrade within 2448 hours.

   Use the following testing methods to verify:

   • For porous concrete and porous asphalt use ASTM C1701

   • For open-jointed block pavement, permeable interlocking concrete pavement (PICP) or concrete grid pavement (CGP) use ASTM C1781

--- Construction.

--- Subgrade Preparation. Since porous pavement is an infiltration practice it is imperative that the permeability of the underlying native soils be preserved. It is important to protect the subgrade from overcompaction, accumulation of fines, excessive construction equipment traffic, and surface ponding. No grading should take place during wet soil conditions to minimize sealing of the soil surface. In situations
where the subgrade has been over compacted or the permeability has been diminished scarification should take place to a depth sufficient to match the naturally occurring in-situ state, typically scarification should be a minimum of three (3) to twelve (12) inches in depth. Any accumulation of debris, fines, or sediment that has occurred during subgrade preparation should be removed prior to starting the gravel bed installation.

—Gravel Bed Preparation. Immediately upon completion of the subgrade preparation and after acceptance of the subgrade work by the Watershed Protection and Development Review inspector the placement of the one half (0.5) to one and one half (1.5) inch diameter washed, rounded, river gravel, can begin. Any accumulation of debris, fines, or sediment that has occurred during the placement of the gravel bed installation should be removed.

—Observation Ports. Observation ports are required in order to determine if the system is infiltrating properly. Each observation port should be a perforated PVC pipe, 4-6" diameter, with threaded endcap, flush with top of gravel layer, and protected from vandalism (e.g., cover endcap with porous pavement cutout). Observation ports are to placed in representative locations at a minimum spacing of one port per 5,000 square feet of porous pavement area, with a least one port per contiguous pavement section.

—Porous Pavement Installation. Contractor installation qualifications require that the contractor provide to the Watershed Protection and Development Review Department inspector at the preliminary construction meeting a statement attesting to qualifications and demonstrating experience with the following porous pavement procedures and tests:

—• A minimum of two (2) completed projects with addresses

—• Measuring unit weight acceptance data

—• Conducting in-situ pavement tests including void content and unit weight

—• Preparing product samples

If the installing contractor and pavement producer do not have sufficient experience with porous pavement systems, the installing contractor shall retain an experienced consultant to monitor production, handling, and placement operations at the contractor's expense.

Construction and Post construction Maintenance

• When installing porous concrete, floating and troweling are not used, as those may close the surface pores.

• Do not seal or repave with non-porous materials.

• No piling of dirt, sand, gravel, or landscape material without covering the pavement first with a durable cover to protect the integrity of the pervious surface.

• All landscape cover must be graded to prevent washing and or floating of such materials onto or through the pervious surface. No off-site flows allowed onto the porous pavement area.
• All chemical spills inclusive but not limited to petrochemicals, hydrocarbons, pesticides, and herbicides should be reported to the owner so they can prevent uncontrolled migration.

• Chemical migration control may require flushing, and/or the introduction of microbiological organisms to neutralize any impacts to the soil or water.

Monthly:

• Ensure that paving area is clean of debris, ensure that paving dewater between storms, and ensure that the area is clean of sediments.

Semi-annually:

• Ensure that the porous pavement is protected from landscape clogging due to runoff from landscape areas, rooftops, and other areas that may significantly reduce the long-term permeability by diverting flows away. It is recommended that the pervious surface be power-washed and surface vacuumed semi-annually in order to flush out silt or other contaminants that may reduce the long-term permeability. It is recommended that this frequency be increased for areas where overhanging vegetation, excessive dirt, and pollutants are frequent.

Annually:

• To ensure that the entire water quality volume infiltrates into the subgrade within 48 hours the pervious surface should be vacuumed to restore the open permeable pores and lift the sediment or other contaminants out that may reduce the long-term permeability.
  
  o It is recommended that this frequency be increased for areas where overhanging vegetation, excessive dirt, and pollutants are frequent.

• Inspect the surface for deterioration. As necessary, repair or and repair and/or replace porous pavement or, for open-jointed block pavement or permeable interlocking concrete pavement replenish aggregate within the joints as necessary.

Signage.

– Signs should be posted in landscape areas and/or at entrances to the property as reminders of an ecologically sensitive pavement structure and that certain guidelines must be adhered to.

– Sequence of Construction.

– The following sequence of construction shall be used for all development using the porous pavement design criteria. The applicant is encouraged to provide any additional details appropriate for the particular development.

  1. Erosion controls and tree protection are to be installed as indicated on the approved site plan.

  2. Contact the Watershed Protection and Development Review Department to schedule a preconstruction coordination meeting to be held on site.
3. Contractor installation letter attesting to qualifications and demonstrating experience with porous pavemen t systems must be provided to the inspector at the preliminary construction meeting.

4. Erosion controls will be revised, if needed, to comply with Inspectors' directives, and revised construction schedule relative to the water quality plan requirements and the erosion plan.

5. Rough-cut all required or necessary ponds. Either the permanent outlet structure or a temporary outlet must be constructed prior to development of any embankment or excavation that leads to ponding conditions. The outlet system must consist of a low-level outlet and an emergency overflow meeting the requirements of the Drainage Criteria Manual (Section 8.3) and/or the Environmental Criteria Manual (section 1.4.25.K) as required. The outlet system shall be protected from erosion and shall be maintained throughout the course of construction until final restoration is achieved.

6. Temporary controls to be inspected and maintained weekly and prior to anticipated rainfall events, and after rainfall events, as needed.

7. Schedule a mid-construction conference with the City Inspector to coordinate changes in the construction schedule and evaluate effectiveness of the erosion control plan after possible construction alterations to the site.

8. Contact Watershed Protection and Development Review Department 48 hours prior to schedule inspection of sub-grade prior to placement of the gravel bed and porous pavement installation. The removal of fines, scarification of over compacted subgrade bed, and restoration of the naturally occurring in-situ state should occur prior to placement of the gravel bed and installation of the porous pavement. Conduct permeability test to verify that the system functions as designed, i.e., apply ³ 12.5 gallons/sq.ft. of water within 5 minutes to at least three representative areas; if any runoff occurs the system is not acceptable.


10. Upon completion of the proposed site improvements the engineer shall provide an Engineer's concurrence letter certifying in writing that the proposed facilities were constructed in conformance with the approved plans.
1.6.5. Design Guidelines for Sedimentation/Filtration Systems

A. Full Sedimentation with Filtration


The sand bed filtration system consists of the inlet structure/flow spreader, sand bed, underdrain piping and basin liner.

- **Inlet Structure/Flow Spreader.** The inlet structure should spread the flow uniformly across the surface of the filter media. See Section 1.6.2.D for acceptable geometry and configuration. See Figure 1.6.5.A below for flow spreader design guidance. A rock flow spreader is recommended. The rocks directly in the flow path of the riser pipe discharge must be sized appropriately to prevent scour and erosion; models such as the US Army Corp of Engineers "Channel Pro" can be used, or other acceptable procedure. For proper riprap sizing follow the design criteria located in ECM Section 1.4.6.D, Stone Riprap. For expected maximum velocities in the range of 5-8 fps the following gradation is recommended for uncontained rocks; contained rock systems (e.g. wire mesh, gabion) are also acceptable and must be sized appropriately:

- **D15** 6 to 7.9 inches
- **D50** 8.8 to 10 inches
- **D100** 11.1 to 15 inches

**Figure 1.6.5.A. Full Sedimentation/Filtration Riser Pipe Outlet System and Determining Location of Flow Spreader in Filtration Basin.**
Determination of Dimension X, or maximum pipe discharge travel distance:

- Given known riser pipe diameter \( d \), calculate cross-sectional area \( A_o = \pi d^2/4 \text{ (ft}^2\text{)} \)

- Calculate maximum riser pipe discharge \( Q \) (cfs) using orifice equation

- Calculate maximum discharge velocity \( v = Q/A_o \text{ (ft/sec)} \)

- Calculate "fall time" for flow trajectory \( t = \sqrt{\frac{2 \cdot (B + A)}{g}} \)

- \( t \) is in seconds

- \( B = \) Recommended \( \geq 2" \) differential between bottom of sedimentation basin and top of filter

- \( A = \) pipe radius including thickness + any gap between riser pipe and pond bottom (ft)

- \( g = \) gravitational acceleration = 32.2 ft/sec\(^2\)

- Calculate \( X \geq 1 + v \cdot t \) (ft)

1 ft is added for margin of safety

- **Basin Geometry.** See 1.6.2.D for criteria.

- **Sand Bed.** The sand bed for city-maintained filtration basins must be built to the "Sand Bed with Gravel Layer" configuration below unless topographic constraints make this design unfeasible. Unfeasible is considered: assuming (for the purposes of this selection process only) a maximum ponding depth of three feet in the sedimentation basin, if it is not feasible to obtain an outlet for the drainage from the filtration basin within one-hundred (100) feet of the crest of the filtration embankment, then the "trench design" may be used. For ponds not maintained by the city, the sand bed may be a choice of one of the two configurations given below.

Note: Sand bed depths are final, compacted depths. Consolidation effects must be taken into account. Pre-soaking of media is recommended to induce consolidation so that the correct amount of makeup material can be determined. To pre-soak apply 5-10 gallons of water per sq. ft. of filtration bed, within 1 hour.

- **Sand Bed with Gravel Layer** (Figures 1-56 and 1-56A in Appendix V of this manual Details 661-1 and 661-2 in the City of Austin Standards Manual).

The top layer is to be a minimum of eighteen (18) inches of 0.02-0.04 inch diameter sand which corresponds with ASTM C-33 concrete sand (smaller sand size is not acceptable). Under the sand shall be a layer of one-half (0.5) to one and one-half (1.5) inch diameter washed, rounded, river gravel which provides three (3) inches to five (5) inches of cover over the top of the underdrain lateral pipes. Clean, screened, crushed recycled glass no smaller than 3/8 inch is also acceptable. The sand and gravel must be separated by a layer of geotextile fabric meeting the specifications shown in Table 1.6.5.A-1, Geotextile Fabric Requirements.
The top layer shall be twelve (12) to eighteen (18) inches of 0.02-0.04 inch diameter sand which corresponds with ASTM C-33 concrete sand (smaller sand size is not acceptable). Laterals shall be placed in trenches with a covering of one-half (0.5) to one and one-half (1.5) inch diameter washed, rounded river gravel which provides three (3) inches to five (5) inches of cover over the top of the underdrain lateral pipes and geotextile fabric. The geotextile fabric is needed to prevent the filter media from infiltrating into the lateral piping. The geotextile fabric specifications are shown in Table 1.6.5.A-1, Geotextile Fabric Requirements.

Table 1.6.5.A-1 Geotextile Fabric Requirements

<table>
<thead>
<tr>
<th>Property</th>
<th>Test method</th>
<th>ASTM Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabric Weight</td>
<td>D 3776</td>
<td>≥ 3.0 ounces/square yard</td>
</tr>
<tr>
<td>Ultraviolet (UV) Radiation Stability</td>
<td>D 4355</td>
<td>70% strength retained min., After 500 hours in xenon arc device</td>
</tr>
<tr>
<td>Mullen Burst Strength</td>
<td>D 3786</td>
<td>≥ 120 pound per square inch</td>
</tr>
<tr>
<td>Water Flow Rate</td>
<td>D 4491</td>
<td>≥ 275 gallons/minute/square feet</td>
</tr>
</tbody>
</table>

- **Biofiltration Medium Bed** (Figure 1-56D in Appendix V of this manual, Detail 661-3 in the City of Austin Standards Manual).

For Biofiltration Media Bed specifications refer to Section 1.6.7.C.4.B.

- **Underdrain Piping**. The underdrain piping consists of the main collector pipe(s) and perforated lateral branch pipes. The piping should be reinforced to withstand the weight of the overburden. Internal diameters of lateral branch pipes should be six (6) inches or greater and perforations should be three-eighths (3/8) inch. All piping is to be schedule 40 polyvinyl chloride (PVC) or greater strength. The maximum spacing for the laterals should be ten (10) feet between laterals and five (5) feet from a wall or side. Lesser spacings are acceptable. The maximum spacing between rows of perforations should not exceed six (6) inches. The minimum grade of piping shall be one-eighth (1/8) inch per foot (one (1) percent slope). Access for cleaning all underdrain piping is needed. Cleanouts with a removable PVC cap are required within fifty (50) feet of every portion of lateral, at collector drain lines, and at every bend. In order to minimize damage to these cleanouts due to maintenance equipment, vandalism, and mowing set the top of the cleanout flush with the top of the sand bed. At least one lateral must be accessible for cleaning when the pond is full. The full pond cleanout should extend above the water quality elevation and/or be located outside of the water quality volume ponding area. In order to minimize vandalism or other types of damage to this full pond cleanout the use of exposed piping shall be avoided or minimized.

- **Basin Liner**. If an impermeable liner is required it shall meet the specifications given in Section 1.6.2(C). If an impermeable liner is not required then a geotextile fabric liner shall be installed which meets the specifications listed in Section 1.6.2(C).

- **Outfall**. The surface discharge from the underdrain pipe shall be non-erosive. Where feasible the underdrain pipe should discharge to a gravel trench in order to diffuse the flow and promote infiltration.
and recharge. See Figure 1-52 in Appendix V. If a gravel trench is not feasible other options are shown
in the City of Austin Standards 508S-16 through 20.

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B. Partial Sedimentation/Filtration.

1. Basin Surface Areas and Volume. A filtration rate of 0.0312 gallons per minute per square
foot has been selected for design criteria (six (6) feet per day or two (2) million gallons per acre per day).
This filtration rate is based on a Darcy's Law coefficient of permeability of two (2) feet per day, an average
hydraulic head of three (3) feet and a sand bed depth of 18 inches. This filtration rate is less than that
assumed for the filtration basin in the full sedimentation/filtration system due to higher sediment loading
and consequent clogging of the filter media. Section A above contains an explanation of how the filtration
rate and coefficient of permeability were determined. References 80, 96 and 98 provide additional
information.

Note: The top surface of the sand filter bed must be horizontal, i.e., no grade is allowable.

The following equation gives the minimum surface area required for the filtration basin:

\[ Af = \frac{WQV}{(4+1.33*H)} \]

where "Af" is the required surface area of the media in square feet and "WQV" is the water quality volume
in cubic feet as defined in section 1.6.2A, and H is the maximum ponding depth above the filtration media
in feet.

The combined volume of the sediment chamber and filtration basin exclusive of the gabion volume must
be equal to the water quality volume, i.e., \( V_s + V_f = \text{water quality volume} \) where "Vs" is the sediment
chamber volume and "Vf" is the filtration basin volume.

The volume of the sediment chamber, "V_s", shall be a minimum of 20 percent of the water quality
volume. If a splitter box/diversion structure is required, see Section 1.6.2.B, for minimum design
standards. The water quality pond design shall allow enough freeboard to pass the design flow rate for the
100 year storm over the splitter/diversion structure without overtopping of any side walls of the pond, plus
an additional 5% of the total fill height or three inches, whichever is greater, to allow for construction-
irregularities and long term soil settling. The design shall ensure that under no circumstances does the
sediment chamber allow water to return to the isolation/diversion structure, i.e., isolation of the water-
quality volume must be ensured

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C. Pollutant Treatment Efficiency (Efficiency Ratio) Values for Sand Filtration Systems.
Treatment efficiency or Efficiency Ratio (a term now recommended by USEPA) is the percent reduction in pollutant concentration. For filtration systems designed in accordance with the guidelines in this section, the following pollutant Efficiency Ratio values are to be assumed:
These values are based on a report titled "Removal Efficiencies of Stormwater Control Structures" dated May 1990 by the Environmental Resource Management Division of the WPDR, and do not account for bypass flows. These values will be updated as more data becomes available. For estimating pollutant loading for runoff, the data in Section 1.6.9.3 should be used.

C. Pollutant Effluent Concentration Values for Sand Filtration Systems

For sedimentation/filtration systems designed in accordance with the guidelines in this section, the pollutant effluent concentrations shall be assumed to be equal to the concentrations listed below in Table 1.6.5.C.1. These concentrations shall also be used for load calculations that demonstrate that alternative controls perform equal to or better than sedimentation/filtration systems.

Table 1.6.5.C.1: Effluent event mean pollutant concentrations for sand filtration systems for Austin, Texas


<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Unit</th>
<th>Effluent Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>mg/L</td>
<td>22.4</td>
</tr>
<tr>
<td>EC</td>
<td>CFU/100 mL</td>
<td>4895</td>
</tr>
<tr>
<td>Pb</td>
<td>mg/L</td>
<td>0.00574</td>
</tr>
<tr>
<td>TN</td>
<td>mg/L</td>
<td>1.07</td>
</tr>
<tr>
<td>TP</td>
<td>mg/L</td>
<td>0.099</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>20.62</td>
</tr>
<tr>
<td>Zn</td>
<td>mg/L</td>
<td>0.0230</td>
</tr>
</tbody>
</table>
1.6.6 Design Guidelines for Wet Ponds

A. Capture Volume  Wet ponds in general are designed to have three stages with three corresponding volumes, which are intended to meet the water quality and detention requirements. The first two stages, permanent pool and extended detention, are required for all ponds and function primarily as a water quality control. The second stage may also serve as a streambank erosion prevention measure. The third stage, flood control detention, serves as a flood control measure and is optional to the design of the wet pond. The permanent pool and extended detention volume shall be designed for the entire drainage area contributing to the control for which water quality controls are not already provided. Offsite areas, which are currently undeveloped, may be assumed undeveloped in the design. The primary reason to require extended detention for all of the developed drainage areas, which have not provided detention, is to prevent pond washout caused by high flow-through rates.

1. Permanent Pool  - The permanent pool, the lowest stage of the pond, is designed to hold and treat a volume of runoff between storm events through quiescent settling and biological uptake. The permanent pool should remain nearly full at all times to provide a source of water for wetland plants which are used for biological uptake and to minimize turbulence within the pond during storm events which may result in resuspension of sediment. During storm events, the pond is designed to flush out the treated water and replace it with “new” runoff. The minimum surface area of the permanent pool must be greater than ½ acre (21,780 square feet).

The effluent concentration removal efficiency of wet ponds is directly related to the time the runoff is held in the pond. The longer the runoff is held in the pond, the more settling and biological uptake that can occur. Based upon national and local monitoring data, a hydraulic residence time of two weeks would provide an equivalent level of water quality treatment as sedimentation/filtration. Therefore, the permanent pool volume should be as large as the amount of runoff produced in a two-week period. To ensure that the pollutant removal removal efficiency can be achieved during the “rainy” season, the rainfall data used is based upon the statistics for the average wettest month. In addition, the volume should be increased to account for losses associated with 15 years of sediment build-up. When the drainage area to the pond contains only uplands, an increase of volume by five percent is acceptable to account for this loss. If the pond is located where it may receive streambed loads, a more detailed analysis will be required to account for storage losses.

The wettest mean monthly storm, which generates runoff in the Austin area, produces 0.72 inches of rainfall and occurs every 5.45 days. The amount of runoff from 0.72 inches of rainfall can be estimated by multiplying the rainfall depth by the annual runoff-rainfall ratio, \( R_v \), runoff coefficient found in Table 1-9 of Section 1.6.9, and the rainfall depth. To achieve the fourteen-day minimum residence time an adjustment coefficient is determined by dividing the desired residence time by the storm reoccurrence interval (5.45 days). Then the runoff depth, reoccurrence coefficient, loss factor, and drainage area are multiplied to determine a volume. The permanent pool volume may be calculated using the following equation:

\[
V = (RT/RI) \times WMMS \times R_v \times Rf \times Ls \times DA \times 1'/12"
\]

where “\( V \)” is the permanent pool volume (ac-ft), “\( RT \)” is the desired hydraulic residence time (14 days), “\( RI \)” is the reoccurrence interval for the wettest mean monthly storm (5.45 days), “\( WMMS \)” is the wettest mean monthly storm depth (0.72”), “\( R_v \)” is the runoff-rainfall ratio “\( Rf \)” is the annual runoff coefficient (Table 1-9 of Section 1.6.9), “\( Ls \)” is the storage loss coefficient, and “\( DA \)” is the drainage area (ac). By replacing the variables with local values and simplifying, the equation for permanent pool volume for ponds receiving upland runoff is:

\[
V = 0.162 \times R_v \times Rf \times DA
\]
1.6.7 Green Storm Water Quality Infrastructure

1.6.7.4 Infiltration Rate Evaluation

An evaluation of infiltration rate is necessary to determine if infiltration is feasible and to establish design infiltration rates for several of the innovative water quality controls described in Section 1.6.7.

There are three basic steps for evaluating infiltration rate:
1. Desktop study (i.e., soil survey maps or existing geotechnical information)
2. Field sampling (i.e., soil depth verification and textural analysis)
3. In-situ testing (i.e., more rigorous in-situ infiltration or percolation testing)

The design infiltration rate shall be established by applying a minimum factor of safety of 2 to the estimated or measured infiltration rate. A higher factor of safety may be used at the discretion of the design engineer to take into variability associated with assessment methods, soil texture, soil uniformity, influent sediment loads, and compaction during construction.

Table 1.6.7-1 identifies the minimum required steps for establishing the infiltration rate for each applicable water quality control. Although not required, results from in-situ testing may be used to establish infiltration rate for any applicable control.

Table 1.6.7-1. Minimum required steps for establishing infiltration rate.

<table>
<thead>
<tr>
<th>Water Quality Control</th>
<th>Desktop Study</th>
<th>Field Sampling</th>
<th>In-situ Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retention/Irrigation System</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Vegetative Filter Strip</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Rainwater Harvesting覆</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Porous Pavement for Pedestrian Use</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Rain Garden - Full Infiltration</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Rain Garden - Partial Infiltration</td>
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Note 1: Infiltration evaluation is not required for rainwater harvesting when the system is designed for beneficial reuse (i.e., when capacity for WQV is restored by pumping water to a separate tank).

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A. Retention/Irrigation Systems.

2. Minimum Design Criteria for the Retention Basin. Information on water quality volume, diversion structures, and lining requirements can be found in the Environmental Criteria Manual Section 1.6.2, General Design Guidelines. In addition, applicable requirements of Section 1.6.3, Maintenance and Construction Requirements must be incorporated in the design.

   a. Retention Basin Volume. The basin must be of sufficient size to capture and hold the required capture volume. Retention basins are designed to capture and hold the water quality volume routed to them via diversion structures. All structural elements & piping below the Water Quality elevation shall be watertight. For development in the Barton Springs Zone, refer to Section 1.6.9.3E of this manual for the required capture volume.

   b. One-Hundred Year Storm. A bypass capable of conveying the 100-year storm around the basin must be provided.

   c. Lining. Retention basins shall be lined as required by State of Texas regulations, such as within the Edwards Aquifer recharge zone. A liner will be required for a retention basin if the basin is located in the Edwards Aquifer recharge zone in accordance with Section 1 of the ECM. The liner must be designed in accordance with Environmental Criteria Manual Section 1.6.2C., Basin Liners. All retention basins are subject to 1.6.3.C.4, Maintenance and Construction Requirements.

   d. Erosion Prevention. The inlets to the retention basin must be designed to prevent erosion of the soil and liner. Rock rip-rap or other erosion prevention systems must be placed at the basin inlet to reduce velocities to less than three feet per second.

   e. Access Ramp. A maintenance access ramp, as described in Environmental Criteria Manual Section 1.6.3, is required for all facilities.


   h. Soil. The irrigation area must contain a minimum of 12 inches of native or enhanced soil with the appropriate permeability rates. A minimum of 12 inches of soil, with the identified permeability rates, must be present in the irrigation area. A soils report must be provided and must include at a minimum a soils map verifying soil types in the irrigation area, permeability rates, soil depths, percent of coarse fragments gravel size (2.0 mm diameter) and larger, found on the soil surface and in the subsurface soils, depth of roots, locations of borings or trenches, photographs of exposed soils, location and type of soil enhancement performed, soils testing results, etc. A site visit may be conducted by the city to confirm soil conditions, including when representative trenches have been opened or borings are being conducted. City staff must be given at least 72 hours notice of when borings or trenches are to be backfilled.

   If soil is enhanced, topsoil or amended topsoil shall meet the requirements of Standard Specification 601S, Salvaging and Placing Topsoil. The condition, type, structure, and quality of the soil shall be conducive to infiltration and to plant growth. If alternative methods of amending soil can be demonstrated to increase the infiltration capacity by at least a factor of three, these methods may be used with approval from the Director of the WPD.
1.6.7 Green Storm Water Quality Infrastructure

B. Vegetative Filter Strips.

2. General Design Guidelines. Filter strips must be sized correctly, have the proper slope, utilize sheet flow, have appropriate soil type and thickness, and have appropriate vegetation of the proper density. Filter strips are typically designed by grading the site to promote overland flow of runoff to a vegetated area. Level spreaders are required at the upstream end of the filter strip if the length of the contributing drainage area (in the direction of flow) exceeds 72 feet. The maximum length of the contributing drainage area shall not exceed 150 feet. Level spreaders or other measures for preventing flow from becoming concentrated should be spaced throughout the length of the filter strip at intervals of no more than 25 feet. For rooftop impervious cover disconnects the downspouts must be at least 10 feet away from the nearest impervious surface to discourage "re-connections". The VFS shall not receive runoff until after the contributing drainage area has been stabilized to prevent erosion and sedimentation.

Filter strips can be classified as either natural or engineered. In general, natural filter strips utilize existing vegetated areas whereas engineered filter strips are constructed features. Engineered vegetative filter strips differ from natural vegetative filters in that they are specifically designed and constructed to maximize the water quality benefits of this practice, particularly in areas where adequate buffers do not exist naturally or cannot be preserved. Filter strips should have a minimum slope of 1%. Engineered filter strips should be constructed to maintain a constant slope that does not exceed 10%. Where existing vegetated areas are to be used ("natural" VFS) the average slope of the VFS should not exceed 10%, with no portion exceeding 15%.

It should also be noted that vegetative filter strips cannot be used to provide detention of erosive flow (2-year control per ECM 1.6.8) or flood flows. Additionally, vegetative filter strips are not recommended for use within the Barton Springs Zone.

C. Biofiltration

1. Introduction. Biofiltration devices are a type of stormwater control measure (SCM) water quality control best management practice (BMP) that uses the chemical, biological, and physical properties of plants, microbes, and soils to remove pollutants from stormwater runoff. Biofiltration can be a critical component of an integrated Low Impact Development (LID) strategy, or can be employed by itself—Biofiltration systems can provide equivalent treatment to a standard sedimentation/filtration system, but are not acceptable as a primary method for controlling non-point source pollution in watersheds within the Barton Springs Zone or Barton Springs Contributing Zone.

A biofiltration system is an enhanced filtration device that typically utilizes more than one treatment mechanisms for removing pollutants from stormwater runoff. A sedimentation basin is required as a first step in the SCM BMP, to provide pre-treatment of runoff in order to protect the biofiltration medium from becoming clogged prematurely by sediment loads. Then, flows are directed through a biofiltration medium which removes pollutants. A defining characteristic of the biofiltration SCM BMP is a
community of plants and microorganisms that is rooted in the filter medium and that can provide more treatment of runoff, directly and by uptake from the filter medium. As well as enhancing removal of pollutants, the plant community tends to sustain the permeability of the biofiltration medium for longer periods of time without maintenance. It is the existence of this biological community that differentiates a biofiltration SCM BMP from a typical sand filter, which is otherwise comparable in design and performance.

There are several hydraulic features or components that combine to make the biofiltration system work effectively. There is commonly a splitter box or comparable diversion structure at the flow entrance to provide some control over flows admitted to the device. There is also a flow spreading structure to ensure flows do not concentrate and potentially channelize the filter medium. There is a sedimentation chamber to capture coarse sediments, and in some cases (described below) a separator element. The biofiltration filtration chamber typically must have an underdrain piping system beneath it, with native or adapted vegetation rooted in the medium and selected for tolerance to ponding and dry soil conditions. Finally, there is an outlet structure from the SCM BMP at the point of discharge.

For biofiltration ponds to work effectively, maximum velocities into the sedimentation chamber must not be exceeded. This requirement tends to limit the size and amount of impervious cover that is practical for treatment using this kind of device. Biofiltration ponds are relatively low maintenance once native plantings are well established. These devices should be restricted from any use that may negatively affect the function of the biofiltration pond (e.g. pet use, application of herbicides and pesticides, excessive mowing, etc.). To ensure this, an approved and recorded Integrated Pest Management plan will be required for the drainage area up to and including the pond area. See section 1.6.3 for maintenance, irrigation, and sequence of construction requirements.

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4. Biofiltration Basin Details

B. Biofiltration Bed with Underdrain

The biofiltration medium bed for biofiltration basins must be built to the Biofiltration Bed configuration illustrated in Figure 1.6.7.C-3 (for details see Figure 1-56D in Appendix V of this manual Detail 661-3 in the City of Austin Standards Manual). The biofiltration medium layer is to be a minimum of eighteen (18) inches meeting the specifications stated in Section 4A above. Other materials or substances that may be harmful to plant growth, or prove a hindrance to the planting or maintenance operations shall not be mixed or dumped within the biofiltration area. Note: Required biofiltration medium bed depths should be interpreted as final consolidated values rather than as initially placed. Under the biofiltration medium shall be an underdrain system that consists of one-half (0.5) to one and one-half (1.5) inch diameter washed, rounded, river gravel surrounding 6 inch Schedule 40 PVC underdrain lateral pipes. The maximum spacing for the laterals should be ten (10) feet between laterals and five (5) feet from a wall or side. The minimum thickness of the gravel envelope is 3 inches. The soil medium and gravel layer must be separated by a filter material. The filter material may be a gravel separation lens consisting of 3/4 - 1/4-inch washed, rounded, river gravel (no limestone) 2 to 3 inches in thickness or a layer of geotextile fabric meeting the specifications shown in Table 1.6.5.A-1, Geotextile Fabric Requirements. To avoid compaction of the biofiltration medium and promote filtration heavy equipment shall not be allowed in biofiltration area after the biofiltration medium has been placed.
Figure 1.6.7.C-3: Biofiltration medium bed with underdrain system.

Access must be provided for cleaning all underdrain piping. Cleanouts with a removable PVC cap are required within fifty (50) feet of every portion of lateral, at collector drain lines, and at every bend. In order to minimize damage to these cleanouts due to maintenance equipment, vandalism, and mowing, the top of the cleanout should be set flush with the top of the biofiltration medium bed or ground surface from 08/01/2014.
which it emerges. It is recommended that cleanouts be located outside of the water quality volume ponding area and above the water quality volume elevation when feasible to reduce short circuiting caused by loss or damage to the cleanout caps. At least one lateral must be accessible for cleaning when the pond is full. The full pond cleanout must extend above the water quality elevation and/or be located outside of the water quality volume ponding area. In order to minimize vandalism or other types of damage the use of exposed piping shall be avoided or minimized.

Note: The top surface of the biofiltration medium bed must be horizontal.

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1.6.7 Green Storm Water Quality Infrastructure

1.6.7.D. Rainwater Harvesting

1. Introduction. Rooftops can generate large volumes of runoff which, when discharged to paved surfaces and landscaped areas, can generate large pollutant loads. Rainwater harvesting systems can capture this runoff before it is discharged, thus preventing pollution while also putting the captured water to beneficial use, such as landscape irrigation or cooling water. The amount of runoff captured will depend on the size (water quality volume) and drawdown time of the rainwater harvesting system. The systems can also control the peak flow rate for the 2-year storm. See section 1.6.8 of the Environmental Criteria Manual (ECM) if specifically designed for this purpose. Rainwater harvesting systems can provide equivalent treatment to a standard sedimentation/filtration system and may be used within the Barton Springs Zone if the design achieves the non-degradation load requirements detailed in Section 1.6.9, but only the irrigation design (Option B) described below will meet retention irrigation system standards and therefore can be used as a primary method for controlling non-point source pollution in watersheds within the Barton Springs Zone or Barton Springs Contributing Zone. Rainwater Harvesting systems will only be permitted for commercial developments.

In an effort to promote water conservation, the State of Texas offers financial incentives and tax exemptions to offset the equipment costs. Additionally, the Water Conservation staff of the City of Austin Water Utility Department is available to provide input on how to achieve cost efficient design and equipment selection that will also help reduce water and wastewater costs.

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3. Design Options.

A typical configuration for a rainwater harvesting system is shown in Figure 1.6.7.D-2. To receive water quality credit, rainwater harvesting systems must be designed so that captured runoff is held for at least 12 hours after rainfall has ceased, then either gravity-drained to a vegetated area sized large enough to infiltrate all the water (Option A), or used to irrigate the vegetated area (Option B). The latter design is similar to a retention/irrigation system and ECM section 1.6.7(A) should be referenced for guidance. The vegetated area can also serve as a vegetated filter strip for flows that by-pass the rainwater harvesting system.
Because the required drawdown time is no more than five (5) days, these systems generally cannot be used to meet water conservation-oriented landscape irrigation needs (e.g., 5-day watering schedule). However, the portion of the system capacity that is recovered during the 5-day (maximum) drawdown period may be eligible for water quality credit. For example, water in the system may be pumped to a separate tank for subsequent beneficial reuse such as landscape irrigation during dry conditions. Or, a portion of the tank may be designated as water quality volume that empties within 5 days and the remaining portion of the tank is reserved for beneficial reuse. The amount of water harvested for beneficial reuse should be evaluated so that it may be usefully deployed over the service area to which it is directed. The annual capture and annual use (for irrigation, etc.) for the device should balance, and if they do not the annual use becomes the limiting capture quantity.

Figure 1.6.7.D-2. Typical configuration for a rainwater harvesting system.

Alternatively, and with approval from the Director, the system may be designed to empty or partially empty prior to the next forecasted rain event using an advanced real-time controller.

**Option A - Captured Runoff Gravity-Drained to a Vegetated Area for Infiltration**

The water quality volume must be provided by the system designer, with the drawdown time set to a maximum of 120 hours. The designer must demonstrate that the vegetated area is sufficiently large to infiltrate the entire water quality volume within 120 hours (see Figure 1.6.7.D-3 below).

The average "treatment" rate of the rainwater harvesting system is:

\[ Q_{\text{avg}} = \frac{WQV}{DDT} \]

Where:

- \( Q_{\text{avg}} \) is the treatment rate
· WQV is the water quality volume
· DDT is the drawdown time, which is set to a maximum of 120 hours

It is reasonable to assume saturated conditions, and the infiltration rate of the vegetated area can be calculated as:

\[ Q_{\text{veg}} = k \times i \times A \]

Where:
· \( k \) = soil hydraulic conductivity
· \( i \) = hydraulic gradient, and
· \( A \) = infiltration (vegetated) area.

Figure 1.6.7.D-3. Design Option A with captured runoff discharged to a vegetated area for infiltration.

As minimal ponding of water over the vegetated area is expected, the hydraulic gradient can be assumed equal to 1, thus:

\[ Q_{\text{veg}} = k \times A \]
To be conservative, design the vegetated area for the maximum flowrate discharged from the rainwater harvesting system. A reasonable assumption is to assume a value twice $Q_{avg}$, and to also assume a lag time (LT) between the time runoff ends and when the rainwater harvesting system begins discharging:

$$Q_p = \frac{2 \cdot WQV}{(DDT - LT)}$$

Setting the peak flow rate discharged from the rainwater harvesting system equal to the vegetated area infiltration rate, and solving for $A$:

$$A = \frac{2 \cdot WQV}{k \cdot (DDT - LT)}$$

Where

- $A$ = minimum required infiltration (vegetated) area in ft$^2$
- $WQV$ = water quality volume in ft$^3$
- $K$ = hydraulic conductivity in ft/hour
- $DDT$ = drawdown time in hours
- $LT$ = lag time in hours

A design infiltration rate (i.e., hydraulic conductivity) for the site must be established through desktop study and field sampling as described in Section 1.6.7.4. The lag time LT should be set to a minimum of 12 hours.

To be eligible for water quality credit the vegetated area also must meet the following criteria:

- The length (dimension in direction of flow) of the vegetative area should be at least 15 feet.
- The average slope of the vegetative area must be between 1% and 10%, with no portion exceeding 15%.
- The hydraulic loading rate should not exceed 0.05 cfs per ft. width for the maximum flowrate applied to the vegetated area (see below for procedure to calculate peak flowrate). Higher hydraulic loading rates are allowed but will reduce water quality credit. In this case, a maximum allowable rate of 0.15 cfs per ft. width is allowed.
- The soil depth should be a minimum of twelve (12) inches.
- The vegetated area should have dense vegetative cover (minimum 95% coverage as measured at the base of the vegetation). The use of native grasses is strongly recommended due to their resource efficiency and their ability to enhance soil infiltration. In the case of natural wooded areas where 95% vegetative cover is not present, a minimum of four inches of leaf litter or mulch must be in place.
- An irrigation plan is required.

**Option B - Captured Runoff Used to Irrigate Vegetated Area**
A typical design configuration in which captured runoff is used to irrigate a vegetated area is shown in Figure 1.6.7.D-4 below. The water quality volume must be provided by the system designer, with the drawdown time set to a maximum of 120 hours. The system should be designed according to the retention/irrigation criteria in section 1.6.7.A of the Environmental Criteria.

Rainwater systems are considered auxiliary water sources by the Austin Water Utility. When a rainwater harvesting system meets the definition of Auxiliary Water per the City of Austin - Utility Criteria Manual (UCM) then the design of this system must comply with the backflow protection requirements established in Section 2.3.4 of the UCM, Backflow Prevention Rules and Regulations Pertaining to Sites With Both City Potable Water and Auxiliary Water.

Figure 1.6.7.D-4. Design Option B with captured runoff used to irrigate a vegetated area.
1.6.7.E Porous Pavement

---1. Introduction. Porous Pavement describes a system comprising a load-bearing, durable concrete surface together with an underlying layered structure that temporarily stores water prior to infiltration. Porous Pavement is a water quality control best management practice (BMP) using the storage within the underlying structure or sub-base to provide ground water recharge and to reduce pollutants in stormwater runoff. Unlike traditional pavement, porous pavement contains little or no "fine" materials; instead, it contains voids that encourage infiltration. Porous pavement consists of an open-graded coarse aggregate, bonded together by asphalt cement, with sufficient interconnected voids to make it highly permeable to water. When proposing the use of this material be sure to provide highly detailed specifications and ensure that an experienced contractor is used to minimize potential problems.

---Porous pavement for vehicular use is not allowed as a water quality control and will not receive credit against water quality volume calculations. If porous pavement is proposed for non-pedestrian use in the recharge zone of a Drinking Water Protection Watershed or in the Barton Springs Recharge or Contributing Zone then a liner is required underneath the porous pavement structure and the runoff from this structure must drain to an approved Water Quality control.

---Porous pavement for pedestrian use is not acceptable as a water quality control and will not receive credit against water quality volume calculations within the Barton Springs Recharge or Contributing Zone.

---Porous pavement is not allowed under stormwater hot spots or areas where land use or activities generate highly contaminated runoff. Hot spot runoff frequently contains pollutant concentrations exceeding those typically found in stormwater. Hot spots include commercial nurseries, auto salvage facilities, hazardous materials generators (if containers are exposed to rainfall), vehicle fueling and maintenance areas, and vehicle and equipment washing dry or steam cleaning facilities, food production/distribution loading dock and trash compactor areas (Note: Some of these land uses/activities may have additional discharge restrictions under Chapter 6-5, Article 5 (Discharges into Storm Sewers or Watercourses) of the City Code). Since porous pavement is an infiltration practice, it should not be applied at stormwater hot spots due to the potential for ground water contamination.

---Porous pavement adjacent to buildings, roadways, and other structures may require an impermeable barrier to prevent possible damage to these structures due to infiltration. The requirement for impermeable barriers will be at the discretion of the design engineer.

---2. Water Quality Credit and Design Guidelines.

---For water quality credit purposes, porous pavement area that meets the following criteria can be deducted from the drainage area used for sizing the water quality control; however it is not eligible for impervious cover credit unless allowed under § 25-8-63 of the Land Development Code:

---• Porous pavement hydraulic conductivity > 20 in/hr.
---• Subgrade saturated hydraulic conductivity > 0.20 in/hr.
---• Gravel layer below porous pavement thickness ≥ 3 inches with effective porosity ≥ 0.30.
---• COA walkways standard sidewalk dimensions used (i.e., no over-sized walkways that may encourage vehicular use).
---• No off-site runoff
---• No irrigation
---• Depth to water table ≥ 3 feet
---• Depth to bedrock ≥ 12".
---• Industrial vacuuming or pressure washing every six months.
---See Figure 1.6.7.E-1 for typical cross-section.
---See Section 1.6.3 for requirements related to construction, maintenance, signage, and sequence of construction.
Figure 1.6.7.E-1. Typical cross-section for porous pavement.

3. Example

A 5 acre commercial site with 50% impervious cover (2.5 impervious acres) is required to implement on-site water quality controls. The development proposes to use 0.5 acres (of the 2.5 impervious acres) of porous pavement for pedestrian walkways. Determine the water quality credit for this system.

Without the porous pavement, the water quality volume required is 0.80", or 14,520 ft$^3$.

Assuming the above criteria is met, the porous pavement deducts 0.5-acre from the site impervious cover, thus the site behaves as if it is 4.5 acres with 2.0 impervious acres, or 44.4% impervious cover. This reduces the required water quality volume from 0.80" to 0.744" and the drainage area is also reduced from 5 acres to 4.5 acres. The required water quality volume with porous pavement is thus 12,161 ft$^3$, or about a 6% reduction.

4. References:


1. Description.

Porous pavement describes a system comprising a limited capacity load-bearing, durable surface together with an underlying layered structure that temporarily stores water prior to infiltration and releases the temporarily stored water by infiltration into the underlying permeable subgrade.

Porous pavement can qualify for Water Quality credit if designed using the storage within the underlying structure or sub-base to infiltrate stormwater and provide ground water recharge to reduce pollutants in stormwater runoff. When proposing the use of a porous pavement system highly...
detailed specifications and details must be provided and an experienced contractor shall be selected, to minimize potential problems.

A. The types of porous pavement systems that are acceptable for both pedestrian and vehicular traffic are as follows:

1. **Open-jointed block pavement, permeable interlocking concrete pavement (PICP) or concrete grid pavement (CGP):** These systems consist of high strength concrete units that are separated by open or stone-filled joints that allow stormwater to infiltrate. The concrete units are laid on an open graded, single-sized granular base. See Figure 1.6.7.E-1 for a typical cross section.

2. **Porous asphalt (PA):** This system consists of regular bituminous asphalt in which the fines have been screened and reduced, creating void spaces and making it permeable. See Figure 1.6.7.E-2 for a typical cross section. Permeable friction course (PFC) is a porous asphalt overlay placed over an impervious cover surface and is not eligible for water quality credit.

B. The type of porous pavement system that is acceptable for pedestrian use only is as follows:

1. **Porous concrete pavement:** This system is monolithically poured concrete produced by binding aggregate particles with a mortar created with water and cement as specified by the manufacturer. Minimal sand content results in large voids and high pavement porosity, typically between 15 and 25%. This high porosity and the weaker cement bond result in less strength compared to conventional concrete. See Figure 1.6.7.E-3 for a typical cross section.

2. **Site Selection.**

   **Land Use –** Porous pavement should be limited to pedestrian areas, areas with low vehicular traffic volumes, smaller axle loads and low speeds such as, parking stalls, smaller parking lots, overflow parking areas of larger parking lots and other areas with little or no traffic. Permeable surfaces are currently not considered suitable for roads with heavy traffic or high speeds due to the risks associated with failure, the safety implications of ponding, and disruption arising from reconstruction.

   **Off Site Flows –** Run-on from drainage area(s) outside of the porous pavement area is not allowed.

   **Hot Spots –** Porous pavement systems depend upon infiltration into the underlying permeable subgrade. Due to the potential for groundwater contamination, porous pavement shall not be allowed under stormwater hot spots or in areas where land use or activities generate highly contaminated runoff or yield high sediment loads. Hot spot runoff frequently contains pollutant concentrations exceeding those typically observed in stormwater. Hot spots include, but are not limited to, commercial nurseries, auto salvage facilities, hazardous materials generators (where containers are exposed to rainfall), vehicle fueling and maintenance areas, and vehicle and equipment washing dry or steam cleaning facilities, food production/distribution loading dock and trash compactor areas (Note:
Some of these land uses/activities may have additional discharge restrictions under Chapter 6-5, Article 5 (Discharges into Storm Sewers or Watercourses) of the City Code.

Barton Spring Zone - Porous pavement is not acceptable as a water quality control and will not receive credit against water quality volume calculations.

Geotechnical Evaluation – A major factor for most design decisions is related to the existing soil conditions. It shall be necessary to obtain geotechnical/soils and subsurface information prior to the design of a porous pavement system. The following information must be collected and submitted for review by the City of Austin for consideration of porous pavement systems:

1. Soil Conditions - Subgrade saturated hydraulic conductivity must be greater than or equal to 0.20 in/hr.
   - For sites with a consistent soil type, a minimum of one soil permeability test must be taken per 5,000 square feet of planned porous surface area. The determination of the infiltration rate must follow the criteria established in ECM Section 1.6.7.4, Infiltration Rate Evaluation.
   - Testing must be performed prior to the start of construction and prior to the placement of the base or gravel layer on the native soil to verify that design saturated hydraulic conductivity values are present. The Environmental inspector must be contacted 48 hours prior to these tests being performed so they can be present during the test and/or evaluate and approve the results.

2. Water Table – The depth to water table is greater than or equal to twelve (12) inches.

3. Bedrock – The depth to bedrock is greater than or equal to twelve (12) inches.

Setback Requirement - If a porous pavement system is proposed near a structure or a street. Then an additional geotechnical evaluation shall be undertaken to identify potential impacts and to establish minimum distances between the system and the structure.

Impermeable Barrier - Porous pavement adjacent to buildings, roadways, and other structures may require the installation of an impermeable barrier to prevent possible damage to these structures due to infiltration. The requirement for impermeable barriers may be at the discretion of the design engineer. The Public Works Director or designated representative shall review any decisions on impermeable barrier(s) within City ROW and easements.
Slopes - The use of porous pavement system shall be restricted to gentle slopes up to a 20 to 1 grade (5%). On steeper slopes the potential for water seepage out of the pavement surface limits effectiveness.


The designer must select the appropriate material properties, the appropriate pavement thickness, underlying layers, material types, and other characteristics needed to meet the anticipated traffic loads and hydrological requirements simultaneously.

For water quality credit purposes, a porous pavement area that meets the criteria can be deducted from the drainage area used for sizing the water quality control; however it is not eligible for impervious cover credit unless allowed under § 25-8-63 of the Land Development Code (i.e. multi-use trails, fire lanes, etc).

The following criteria must be met when designing a porous pavement system:

A. The gravel layer below porous pavement must have a minimum thickness greater than or equal to five (5) inches with an assumed effective porosity less than or equal to 0.30 to account for reduced volume due to sediment. The gravel layer must be an open graded (single size) aggregate, with little or no fines. Examples of standard open graded gravel materials that allow for storage and conveyance of storm water are those that meet C-33 ASTM Nos. 8, 9, 57, and 67.

B. For open-jointed block pavement, permeable interlocking concrete pavement (PICP) or concrete grid pavement (CGP):

- It is recommended that the joints be filled with a durable, angular, porous, open-graded, aggregate that promotes rapid infiltration, and meeting C-33 ASTM No. 8 or 9 aggregate requirements.

- In order to preserve the porosity and permeability of the pavement fine-graded sands or aggregates, such as concrete sand, soil and mortar sand, are not allowed.
Figure 1.6.7-E.1 Typical cross section for Open-jointed block pavement, Permeable Interlocking Concrete Pavement or Concrete Grid Pavement.
Figure 1.6.7.E-2 Typical cross-section for Porous Asphalt.
4. **Site Plan or Subdivision Construction Plan Requirements.**

The following information must be included in the Site or Subdivision Construction plan sheet(s):

A. The standard sequence of construction must be modified to include the following special requirements:

1. Pre-Construction - Contractor installation qualifications require that the contractor provide to the Environmental Inspector at the preliminary construction meeting a statement attesting to qualifications and demonstrating experience. Contractors must prove specialized competence by presenting a copy of current certification from an authoritative porous pavement industry association.

Acceptable porous pavement industry associations include the following:

- For open-jointed block pavement, permeable interlocking concrete pavement, or concrete grid pavement: Interlocking Concrete Pavement Institute, Brick Industry Association, National Concrete Masonry Association
- For porous asphalt: Texas or National Asphalt Pavement Associations
• For porous concrete pavement: Texas or National Ready Mixed Concrete Associations, or
• American Society of Civil Engineers

2. Saturated hydraulic conductivity testing must take place twice:
   a. Prior to construction, and
   b. Prior to placement of the gravel bed

3. The Environmental inspector must be contacted 48 hours prior to the placement of the gravel bed saturated hydraulic conductivity test being performed and test results must be provided to the inspector documenting that the design saturated hydraulic conductivity has been met.

B. The construction and post –construction/inspection notes below (Sections 1.6.7.E. 5 & 6) must be included on the stormwater control measure plan sheet.

5. Construction.

Proper construction of permeable pavement systems requires measures to preserve natural infiltration rates prior to placement of the pavement, as well as measures to protect the system from the time that pavement construction is complete to the end of site construction. The following recommendations apply to all permeable pavement systems:

A. General
   1. Keep mud and sediment-laden runoff away from the pavement area.
   2. Temporarily divert runoff or install sediment control measures as necessary to reduce the amount of sediment run-on to the pavement.
   3. Cover surfaces with a heavy impermeable membrane when construction activities threaten to deposit sediment onto the pavement area.
   4. Low ground pressure (LGP) track equipment should be used within the pavement area to limit over-compacting the subgrade. Wheel loads such as, passenger cars and pick-up trucks should not be allowed on the pavement area during construction.

B. Subgrade Preparation. Since porous pavement is an infiltration practice it is imperative that the permeability of the underlying native soils be preserved. The following recommendations apply to all permeable pavement systems:
   1. It is important to protect the subgrade from over compaction, accumulation of fines, excessive construction equipment traffic, and surface ponding. Any accumulation of debris, fines, or
sediment that has occurred during subgrade preparation should be removed prior to starting the gravel bed installation.

2. **No grading should take place during wet soil conditions to minimize sealing of the soil surface.**

3. In situations where the subgrade has been over compacted or the permeability has been diminished scarification should take place to a depth sufficient to match the naturally occurring in-situ state. Typically scarification should be a minimum of four (4) to six (6) inches in depth.

C. **Gravel Bed Preparation.** The gravel bed should consist of clean, crushed gravel, free of mud, clay, vegetation or other debris, conforming to ASTM C 33 for stone quality. Size gradation shall conform to ASTM C-33 No. 57 or No. 67 as described in City of Austin Standard Specification 510.2.(a), Pipe Bedding Stone.

   **Placement of the gravel bed can occur once:**

   1. The design saturated hydraulic conductivity of the subgrade has been verified using the criteria stated in ECM Section 1.6.7.4.

   2. The City of Austin Environmental inspector has approved the gravel bed preparation.

   3. Any accumulation of debris, fines, or sediment that has occurred during the placement of the gravel bed installation has been removed.

D. **Porous Pavement Installation.** Contractor installation qualifications require that the contractor provide to the City of Austin Environmental inspector, at the preliminary construction meeting, a statement attesting to qualifications and demonstrating experience with the following porous pavement procedures and tests:

   **For all types of porous pavement systems:**

   1. Contractors must prove specialized competence by presenting current certification from an authoritative industry association. (See ECM section 1.6.7.E.4.A.1 for examples of acceptable industry associations)

   2. Provide the addresses for a minimum of three (3) completed projects with similar geologic and climate conditions as the proposed site.

   **For porous concrete and porous asphalt systems provide additional information regarding the procedures that will be followed to meet the following:**

   - Measuring unit weight acceptance data
   - Conducting in-situ pavement tests including void content and unit weight
• Preparing product samples

If the installing contractor and pavement producer do not have sufficient experience with porous pavement systems, the installing contractor shall retain an experienced consultant to monitor production, handling, and placement operations at the contractor's expense.

6. **Post Construction / Inspection.**

The porous pavement saturated hydraulic conductivity must be greater than or equal to 20 in/hr.

Use the following testing methods to verify the surface saturated hydraulic conductivity:

- For porous concrete and porous asphalt use ASTM C1701
- For open-jointed block pavement, permeable interlocking concrete pavement (PICP) or concrete grid pavement (CGP) use ASTM C1781

All inspection, infiltration testing, and maintenance activities shall be documented and made available to City of Austin inspection staff upon request.

7. **Flood Mitigation.**

For porous pavement systems complying with the flood detention requirements of the Drainage Criteria Manual the following criteria will apply:

- Monitoring ports will be required
- Must provide an annual 3\textsuperscript{rd} party inspection as required for Subsurface Ponds (see ECM Section 1.6.2.E)
- The storage volume must be increased to account for losses due to sediment build up. Since no run on is allowed on the porous pavement system a minimal increase in volume of fifteen percent (15\%) is required.

8. **Maintenance.**

See Section 1.6.3.C.8 for requirements related to maintenance

9. **Example.**

A 5 acre commercial site with 50\% impervious cover (2.5 impervious acres) is required to implement on-site water quality controls. The development proposes to use 0.5 acres (of the 2.5 impervious acres) of porous asphalt for parking spaces. Determine the water quality credit for this system.
Without the porous pavement, the water quality volume required is 0.80", or 14,520 ft³. See ECM Section 1.6.2.A, Capture Volume or Water Quality Volume, for this base formula.

Assuming the above criteria is met, the use of porous pavement would allow the design engineer to deduct 0.5-acre from the drainage area to the site storm water control measure, and thus the site behaves as if it is 4.5 acres with 2.0 impervious acres, or 44.4% impervious cover. This reduces the required water quality volume from 0.80" to 0.744" and the drainage area is also reduced from 5 acres to 4.5 acres. The required water quality volume with porous pavement is thus 12,161 ft³, or about a 6% reduction.

10. References.


1.6.7.H. Rain Garden.

2. Site Selection.

Rain gardens can be used in new developments or as a retrofit within an existing site. Unlike conventional centralized stormwater management systems, multiple rain gardens may be dispersed across a development, and incorporated into the landscape, providing aesthetic as well as ecological benefits. Rain gardens allow for all or a portion of the water quality volume (WQV) to be treated within landscaped areas, and therefore may reduce landscape irrigation requirements by making use of stormwater runoff. Rain gardens are especially suited for small sites and are typically installed in locations such as parking lot islands, site perimeter areas, and other landscape areas.

![Diagram of a rain garden with detention areas.](image)

Figure 1.6.7.H-1. Multiple rain gardens may be dispersed across a development, and incorporated into the landscape, providing aesthetic as well as ecological benefits.

The following site characteristics must be considered when designing a rain garden.

Land Use - The use of rain gardens as a water quality control is limited to Commercial, Multi-Family, Civic Uses, and Public Right of Way developments only, and single family residential. The restrictions on use for single family residential are as follows:

1. Rain Garden must be located in a dedicated common area or within a drainage easement that is accessible by standard maintenance equipment from the right of way.

2. A minimum of four (4) single family lots must be treated by the rain garden.

3. No rain gardens are to be located in backyards or fenced in yards.

4. Not allowed in the Barton Spring Zone per the Edwards Aquifer Protection Program rules.
5. The City of Austin will provide functional maintenance. Homeowners may add additional native landscaping and provide more frequent care.

Full infiltration and partial infiltration rain gardens are not allowed in areas where land use or activities generate highly contaminated runoff due to the potential for ground water contamination. These areas include commercial nurseries, auto recycle facilities, hazardous materials generators (if containers are exposed to rainfall), industrial process areas, gas stations, food production/distribution loading dock and trash compactor areas, vehicle fueling and maintenance areas, and vehicle and equipment washing and steam or dry cleaning facilities.

Drainage Area - Rain gardens are restricted to a contributing drainage area not to exceed two acres and a ponding depth not to exceed 12 inches.

Barton Springs Zone - At this time, an unlined rain garden is not acceptable as a primary method for controlling non-point source pollution in watersheds within the Barton Springs Recharge Zone and Contributing Barton Springs Zone. If a rain garden is proposed for use in the Barton Springs Recharge or Contributing Zone, then a liner is required and the discharge from this facility must be managed to comply with the Save Our Springs ordinance.

Setbacks - Rain gardens must be designed to prevent adverse impacts to building foundations, basements, wellheads, and roadways from the infiltration of water.

Slopes - Rain gardens should not be located on slopes exceeding 15 percent.

Soil conditions - When siting a full or partial infiltration rain garden, appropriate soil conditions must be present. The depth to an impermeable layer must be at least 12 inches below the bottom of the rain garden. For full infiltration rain gardens, the underlying native soil must have a design infiltration rate that will draw down the full ponded depth in less than 48 hours. For example, for a 12 inch maximum ponding depth, the design infiltration rate must be at least 0.25 inches per hour. For a 6 inch maximum ponding depth, the design infiltration rate must be at least 0.13 inches per hour. For a 3 inch maximum ponding depth, the minimum design infiltration rate is 0.06 inches per hour. The design infiltration rate is based on applying at least a factor of safety of two (2) to the measured steady state saturated infiltration rate (i.e., the design infiltration rate is equal to one half of the measured infiltration rate). A higher factor of safety may be used at the discretion of the design engineer to take into variability associated with assessment methods, soil texture, soil uniformity, influent sediment loads, and compaction during construction. For full infiltration systems the infiltration rate of the soil subgrade below the growing medium of the rain garden must be determined using in-situ testing as described in ECM Section 1.6.7.4. If a range of values are measured then the geometric mean should be used.

Water Table - Full and partial infiltration rain gardens are not allowed in locations where the depth from the bottom of the growing medium to the highest known groundwater table is less than 12 inches.

Bedrock - Full and partial infiltration rain gardens are not allowed in locations where depth from the bottom of the growing medium to bedrock is less than 12 inches. In cases with bedrock less
than 3 feet from the bottom of the growing media, soil testing should be conducted in-situ to account for the effect of this limiting horizon.

Groundwater and Soil Contamination - Full and partial infiltration rain gardens are not allowed in locations where infiltration would cause or contribute to mobilization or movement of contamination in soil or groundwater or would interfere with operations to remediate groundwater contamination. If filtration rain gardens are proposed under these conditions, the potential for incidental infiltration should be evaluated to determine whether an impermeable liner must be used.

6. Underdrain System.

- Full Infiltration Rain Garden - A full infiltration rain garden does not have an underdrain system and does not require a geotextile under the growing medium.

- Partial Infiltration and Full Filtration Rain Garden - The underdrain for a partial infiltration and full filtration rain garden consists of gravel-surrounded perforated pipes as illustrated in Figure 1.6.7.H-6 (for details see Figure 1.5.6D in Appendix V of this manual and Detail 661-3 in the City of Austin Standards Manual).

![Figure 1.6.7.H-6. Underdrain design for partial infiltration and full filtration rain gardens.](image_url)

The underdrain piping must comply with the criteria located in ECM section 1.6.7.C.4.B, Biofiltration Basin Details. For partial infiltration systems with raised outlets, the pipe does not require a slope.

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For full filtration designs, if an impermeable liner is required it shall meet the specifications given in Section 1.6.2.C. A geotextile (or gravel separation lens) is not required at the bottom of unlined rain gardens.