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Chapter 1 - Introduction

1.1 Purpose of this Volume

Best Management Practices (BMPs) are schedules of activities, prohibitions of practices, maintenance procedures, managerial practices, or structural features that prevent or reduce adverse impacts to waters of Washington State. As described in Volume I of this stormwater manual, BMPs for long-term management of stormwater at developed sites can be divided into three main categories:

- BMPs addressing the amount and timing of stormwater flows;
- BMPs addressing prevention of pollution from potential sources; and
- BMPs addressing treatment of runoff to remove sediment and other pollutants.

This volume of the stormwater manual focuses on the third category, treatment of runoff to remove sediment and other pollutants at developed sites. The purpose of this volume is to provide guidance for selection, design and maintenance of permanent runoff treatment facilities.

BMPs for controlling stormwater flows and pollutant sources are presented in Volumes III and IV, respectively.

1.2 Content and Organization of this Volume

Volume V of the stormwater manual contains 12 chapters. Chapter 1 serves as an introduction and summarizes available options for treatment of stormwater. Chapter 2 outlines a step-by-step process for selecting treatment facilities for new development and redevelopment projects. Chapter 3 presents treatment facility “menus” that are used in applying the step-by-step process presented in Chapter 2. These menus cover different treatment needs that are associated with different sites. Chapter 4 discusses general requirements for treatment facilities. Chapter 5 presents information regarding on-site stormwater management BMPs for pollution-generating impervious surfaces (PGIS). These BMPs are intended to infiltrate, disperse, or contain runoff on site, as well as to provide treatment. Chapters 6 through 11 provide detailed information regarding specific types of treatment identified in the menus. Chapter 12 other BMPs for which the Washington State Department of Ecology has approved specific uses.

The appendices to this volume contain more detailed information on selected topics described in the various chapters.

1.3 How to Use this Volume

This volume contains information necessary to design, construct, and maintain BMPs for stormwater treatment. This information shall be used in conjunction with engineering standards and specifications set forth in Snohomish County EDDS.
1.4 Runoff Treatment Facilities

1.4.1 General Considerations

Runoff treatment facilities are designed to remove pollutants contained in stormwater runoff. The pollutants of concern include sand, silt, and other suspended solids; metals such as copper, lead, and zinc; nutrients (e.g., nitrogen and phosphorus); certain bacteria and viruses; and organics such as petroleum hydrocarbons and pesticides. Methods of pollutant removal include sedimentation/settling, filtration, plant uptake, ion exchange, adsorption, and bacterial decomposition. Floatable pollutants such as oil, debris, and scum can be removed with separator structures.

1.4.2 Maintenance

Maintenance requirements for drainage facilities are set forth in SCC 7.53.140 and Volume V, Chapter 4.6 of this manual.

1.4.3 Treatment Methods

Methods used for runoff treatment facilities and common terms used in runoff treatment are discussed below:

- **Wetpools.** Wetpools provide runoff treatment by allowing settling of particulates during quiescent conditions (sedimentation), by biological uptake, and by vegetative filtration. Wetpools may be single-purpose facilities, providing only runoff treatment, or they may be combined with a detention pond or vault to also provide flow control. If combined, the wetpool facility can often be stacked under the detention facility with little further loss of development area.

- **Biofiltration.** Biofiltration uses vegetation in conjunction with slow and shallow-depth flow for runoff treatment. As runoff passes through the vegetation, pollutants are removed through the combined effects of filtration, infiltration, and settling. These effects are aided by the reduction of the velocity of stormwater as it passes through the biofilter. Biofiltration facilities include swales that are designed to convey and treat concentrated runoff at shallow depths and slow velocities, and filter strips that are broad areas of vegetation for treating sheet flow runoff.

- **Oil/Water Separation.** Oil/water separators remove oil floating on the top of the water. There are two general types of separators - the American Petroleum Institute (API) separators and coalescing plate (CP) separators. Both use gravity to remove floating and dispersed oil. API separators, or baffle separators, are generally composed of three chambers separated by baffles. The efficiency of these separators is dependent on detention time in the center, or detention chamber, and on droplet size. CP separators use a series of parallel plates, which improve separation efficiency by providing more surface area, thus reducing the space needed for the separator. Oil/water separators must be located off-line from the primary conveyance/detention system, bypassing flows greater than the water quality design flow. Other devices/facilities that may be used for removal of oil include catch basin inserts and linear sand filters. Oil control devices/facilities should always be placed upstream of other treatment facilities and as close to the source of oil generation as possible.
- **Pretreatment.** Presettling basins are often used to remove sediment from runoff prior to discharge into other treatment facilities. Basic treatment facilities, listed in Step 6 – Figure 5.1, can also be used to provide pretreatment. Pretreatment often must be provided for filtration and infiltration facilities to protect them from clogging or to protect ground water. Appropriate pretreatment devices include a presettling basin, wet pond/vault, biofilter, constructed wetland, or oil/water separator.

- **Infiltration.** Infiltration refers to the use of the filtration, adsorption, and biological decomposition properties of soils to remove pollutants. Infiltration can provide multiple benefits including pollutant removal, peak flow control, ground water recharge, and flood control. However, one condition that can limit the use of infiltration is the potential adverse impact on ground water quality. To adequately address the protection of ground water when evaluating infiltration it is important to understand the difference between soils that are suitable for runoff treatment and soils only suitable for flow control. Sufficient organic content and sorption capacity to remove pollutants must be present for soils to provide runoff treatment. Examples are silty and sandy loams. Coarser soils, such as gravelly sands, can provide flow control but are not suitable for providing runoff treatment. The use of coarser soils to provide flow control for runoff from pollutant generating surfaces must always be preceded by treatment to protect ground water quality. Thus, there will be instances when soils are suitable for treatment but not flow control, and vice versa.

- **Filtration.** Filtration refers to the use of various media such as sand, perlite, zeolite, and carbon, to remove low levels of total suspended solids (TSS). Specific media such as activated carbon or zeolite can remove hydrocarbons and soluble metals.

- **Bioretention.** Bioretention facilities are essentially infiltration basins with two special features: First, the infiltration basin is overexcavated and partially refilled with a special bioretention soil mix that functions as a granular filtration medium to provide stormwater treatment. Second, specific vegetation is planted to maintain the soil's ability to adsorb pollutants and infiltrate water, and to absorb and degrade pollutants captured by the soil. A bioretention facility can be used as a combination flow control / treatment system, or can be designed with an underdrain, which reduces or eliminates the flow control function. Bioretention facilities constructed according to the requirements of this manual provide enhanced treatment. Design and construction information for bioretention facilities is set forth in Volume III, Chapter 3.3.12.
See Volume I, Chapter 4 for the treatment facility selection process.
Chapter 3 - Treatment Facility Menus

See Volume I, Chapter 4 for the treatment facility selection menus.
Chapter 4 - General Requirements for Stormwater Facilities

4.1 Design Volume and Flow

4.1.1 Water Quality Design Storm Volume

The water quality design storm volume is defined in SCC 30.63A.530 as the volume of runoff predicted from a 24-hour storm with a 6-month return frequency, or, alternatively, the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model.

Wetpool facilities are sized based upon use of the NRCS (formerly known as SCS) curve number equations in Volume III, Chapter 2 for the 6-month, 24-hour storm. Treatment facilities sized by this simple runoff volume-based approach are the same size whether they precede detention, follow detention, or are integral with the detention facility (i.e., a combined detention and wetpool facility).

Unless amended to reflect local precipitation statistics, the 6-month, 24-hour precipitation amount may be assumed to be 72 percent of the 2-year, 24-hour amount. Precipitation estimates of the 6-month and 2-year, 24-hour storms for certain towns and cities are listed in Volume I, Appendix I-B. For other areas, interpolating between isopluvials for the 2-year, 24-hour precipitation and multiplying by 72% yields the appropriate storm size. Isopluvials for 2-year, 24-hour amounts for Western Washington are reprinted in Volume III.

4.1.2 Water Quality Design Flow Rate

The water quality design flow rate is defined in SCC 30.63A.540 for treatment systems downstream of detention facilities as the full 2-year release rate from the detention facility.

The water quality design flow rate is defined in SCC 30.63A.540 for treatment systems upstream of detention facilities, or for projects in which detention is not required, as the flow rate at or below which 91% of the runoff volume, as estimated by an approved continuous runoff model, will be treated. All BMPs except wetpool-types shall use the 15-minute time series from an approved continuous runoff model.

Design criteria for treatment facilities are assigned to achieve the applicable performance goal at the water quality design flow rate (e.g., 80 percent TSS removal).

For treatment facilities not preceded by an equalization or storage basin, and when runoff flow rates exceed the water quality design flow rate, the treatment facility should continue to receive and treat the water quality design flow rate to the applicable treatment performance goal. Only the higher incremental portion of flow rates are bypassed around a treatment facility. Snohomish County encourages design of systems that engage a bypass at higher flow rates provided the reduction in pollutant loading exceeds that achieved with bypass at the water quality design flow rate.
Treatment facilities preceded by an equalization or storage basin may identify a lower water quality design flow rate provided that at least 91 percent of the estimated runoff volume in the time series of an approved continuous runoff model is treated to the applicable performance goals (e.g., 80 percent TSS removal at the water quality design flow rate and 80 percent TSS removal on an annual average basis).

Runoff flow rates in excess of the water quality design flow rate can be routed through the facility provided a net pollutant reduction is maintained, and the applicable annual average performance goal is likely to be met.

Treatment facilities that are located downstream of detention facilities shall only be designed as on-line facilities.

4.1.3 Flows Requiring Treatment

Runoff from pollution-generating impervious or pervious surfaces must be treated. Pollution-generating impervious surfaces (PGIS) are those impervious surfaces considered to be a significant source of pollutants in stormwater runoff. PGIS are defined in SCC 30.91P.255 as those impervious surfaces considered to be a significant source of pollutants in stormwater runoff. Such surfaces include those which are regularly subject to: vehicular use, industrial activities, or storage of erodible or leachable materials, wastes, or chemicals, and which receive direct rainfall or the run-on or blow-in of rainfall. Erodible or leachable materials, wastes, or chemicals are those substances which, when exposed to rainfall, measurably alter the physical or chemical characteristics of the rainfall runoff and are PGIS. Examples include, but are not limited to, erodible soils that are stockpiled, uncovered process wastes, manure, fertilizers, oily substances, ashes, kiln dust, and garbage dumpster leakage. Metal roofs are also considered PGIS unless they are coated with an inert, non-leachable material such as baked-on enamel coating. The following surfaces are considered regularly-used by motor vehicles: roads, unvegetated road shoulders, bike lanes within the traveled lane of a roadway, driveways, parking lots, unfenced fire lanes, vehicular equipment storage yards, and airport runways. A surface, whether paved or not, shall be considered subject to vehicular use if it is regularly used by motor vehicles. The following surfaces are not considered to be regularly-used surfaces by motor vehicles: paved bicycle pathways separated from and not subject to drainage from roads for motor vehicles, fenced fire lanes, and infrequently used maintenance access roads.

Pollution-generating pervious surfaces (PGPS) are defined in SCC 30.91P.256 as any non-impervious surface subject to the use of pesticides and fertilizers or loss of soil. Typical PGPS include lawns, landscaped areas, golf courses, parks, cemeteries, and sports fields.

Summary of Areas Needing Treatment

- All runoff from pollution-generating impervious surfaces is to be treated through the water quality facilities specified in Chapter 2 and Chapter 3.
- Lawns and landscaped areas specified are pervious but also generate run-off into street drainage systems. In those cases the runoff from the pervious areas must be estimated and added to the runoff from impervious areas to size treatment facilities.
• Runoff from backyards can drain into native vegetation in areas designated as open space or buffers. In these cases, the area in native vegetation may be used to provide the requisite water quality treatment, provided it meets the requirements in Chapter 5 under the “Cleared Area Dispersion BMPs,” of BMP T5.30 Full Dispersion.

• Drainage from impervious surfaces that are not pollution-generating need not be treated and may bypass runoff treatment, if it is not mingled with runoff from pollution-generating surfaces.

• Roof runoff is still subject to flow control per Minimum Requirement #7. Note that metal roofs are considered pollution generating unless they are coated with an inert non-leachable material.

• Drainage from areas in native vegetation should not be mixed with untreated runoff from streets and driveways, if possible. It is best to infiltrate or disperse this relatively clean runoff to maximize recharge to shallow ground water, wetlands, and streams.

• If runoff from non-pollution generating surfaces reaches a runoff treatment BMP, flows from those areas must be included in the sizing calculations for the facility. Once runoff from non-pollution generating areas is mixed with runoff from pollution-generating areas, it cannot be separated before treatment.

4.2 Sequence of Facilities

Volume I, Chapter 4 contains requirements for determining the type of treatment system needed for a project. Many of the treatment options are combinations of treatment facilities in which the sequence of facilities is prescribed. In general, all treatment facilities may be installed upstream of detention facilities. However, not all treatment facilities can function effectively if located downstream of detention facilities. Those facilities that treat unconcentrated flows, such as filter strips and narrow-area biofilters, are usually not practical downstream of detention facilities. Other types of treatment facilities present special problems that must be considered before placement downstream is advisable.

For instance, prolonged flows discharged by a detention facility that is designed to meet the flow duration standard of SCC 30.63A.550 may interfere with proper functioning of basic biofiltration swales and sand filters. Grasses typically specified in the basic biofiltration swale design will not survive. A wet biofilter design would be a better choice.

Prolonged flows in sand filters may cause the sand to become anoxic and release phosphorus previously captured within the filter. To prevent long periods of sand saturation, adjustments may be necessary after the sand filter is in operation to bypass some areas of the filter. This bypassing will allow them to drain completely. It may also be possible to employ a different type of facility that is less sensitive to prolonged flows.

Oil control facilities must be located upstream of treatment facilities and as close to the source of oil-generating activity as possible. They should also be located upstream of detention facilities, if possible.
Table 5.1 summarizes placement considerations of treatment facilities in relation to detention.

<table>
<thead>
<tr>
<th>Water Quality Facility</th>
<th>Preceding Detention</th>
<th>Following Detention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic biofiltration swale</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>Wet biofiltration swale</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>Filter strip</td>
<td>OK</td>
<td>No—must be installed before flows concentrate.</td>
</tr>
<tr>
<td>Basic or large wetpond</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>Basic or large combined detention and wetpond</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Wet vault</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>Basic or large sand filter or sand filter vault</td>
<td>OK, but presetting and control of floatables needed</td>
<td>OK—sand filters downstream of detention facilities may require field adjustments if prolonged flows cause sand saturation and interfere with phosphorus removal.</td>
</tr>
<tr>
<td>Stormwater treatment wetland/pond</td>
<td>OK</td>
<td>OK</td>
</tr>
</tbody>
</table>

4.3 Setbacks, Slopes, and Embankments

4.3.1 Setbacks

Setbacks for drainage facilities shall be provided in accordance with the requirements of SCC 30.63A.710.

4.3.2 Berms

Berms shall be constructed in accordance with Snohomish County EDDS.

4.4 Facility Liners

Liners are intended to reduce the likelihood that pollutants in stormwater will reach ground water when runoff treatment facilities are constructed. In addition to groundwater protection considerations, some facility types require permanent water for proper functioning. An example is the first cell of a wetpond.
Treatment liners amend the soil with materials that treat stormwater before it reaches more freely draining soils. They have slow rates of infiltration, generally less than 2.4 inches per hour (1.7 x 10^{-3} cm/s), but not as slow as low permeability liners. Treatment liners may use in-place native soils or imported soils.

Low permeability liners reduce infiltration to a very slow rate, generally less than 0.02 inches per hour (1.4 x 10^{-5} cm/s). These types of liners should be used for industrial or commercial sites with a potential for high pollutant loading in the stormwater runoff. Low permeability liners may be fashioned from compacted till, clay, geomembrane, or concrete. Till liners are preferred because of their general resilience and ease of maintenance.

The appropriate liner for a facility shall be selected in accordance with the information below.

4.4.1 General Design Criteria

Liners shall be evenly placed over the bottom and/or sides of the treatment area of the facility. Areas above the treatment volume that are required to pass flows greater than the water quality treatment flow (or volume) need not be lined. However, the lining must be extended to the top of the interior side slope and anchored if it cannot be permanently secured by other means.

Materials and methods shall conform to Snohomish county EDDS.
Table 5.2 shows requirements for the type of liner to be used with various runoff treatment facilities.

<table>
<thead>
<tr>
<th>WQ Facility</th>
<th>Area to be Lined</th>
<th>Type of Liner Recommended</th>
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</thead>
<tbody>
<tr>
<td>Presettling basin</td>
<td>Bottom and sides</td>
<td>Low permeability liner or Treatment liner (If the basin will intercept the seasonal high ground water table, a treatment liner is recommended.)</td>
</tr>
<tr>
<td>Wetpond</td>
<td>First cell: bottom and sides to WQ design water surface</td>
<td>Low permeability liner or Treatment liner (If the wet pond will intercept the seasonal high ground water table, a treatment liner is recommended.)</td>
</tr>
<tr>
<td></td>
<td>Second cell: bottom and sides to WQ design water surface</td>
<td>Treatment liner</td>
</tr>
<tr>
<td>Combined detention/WQ facility</td>
<td>First cell: bottom and sides to WQ design water surface</td>
<td>Low permeability liner or Treatment liner (If the facility will intercept the seasonal high ground water table a treatment liner is recommended.)</td>
</tr>
<tr>
<td></td>
<td>Second cell: bottom and sides to WQ design water surface</td>
<td>Treatment liner</td>
</tr>
<tr>
<td>Stormwater wetland</td>
<td>Bottom and sides, both cells</td>
<td>Low permeability liner (If the facility will intercept the seasonal high ground water table, a treatment liner is recommended.)</td>
</tr>
<tr>
<td>Sand filtration basin</td>
<td>Basin sides only</td>
<td>Treatment liner</td>
</tr>
<tr>
<td>Sand filter vault</td>
<td>Not applicable</td>
<td>No liner needed</td>
</tr>
<tr>
<td>Linear sand filter</td>
<td>Not applicable if in vault</td>
<td>No liner needed</td>
</tr>
<tr>
<td></td>
<td>Bottom and sides of presettling cell if not in vault</td>
<td>Low permeability or treatment liner</td>
</tr>
<tr>
<td>Media filter (in vault)</td>
<td>Not applicable</td>
<td>No liner needed</td>
</tr>
<tr>
<td>Wet vault</td>
<td>Not applicable</td>
<td>No liner needed</td>
</tr>
</tbody>
</table>

### 4.4.2 Design Criteria for Treatment Liners

- Treatment liners shall consist of two feet of soil with a minimum organic content of 5% AND a minimum cation exchange capacity (CEC) of 5 milliequivalents/100 grams.
- One sample per 1,000 square feet of facility area shall be tested. Each sample shall be a composite of subsamples taken throughout the depth of the treatment layer (usually two to six feet below the expected facility invert).

• Cation exchange capacity (CEC) shall be tested using USEPA Method 9081, Cation Exchange Capacity of Soils (Sodium Acetate).

• Certification by a soils testing laboratory that imported soil meets the organic content and CEC criteria above shall be provided to Snohomish County.

• Animal manures used in treatment soil layers must be sterilized because of potential for bacterial contamination of the groundwater.

• If a treatment liner will be below the seasonal high water level, the pollutant removal performance of the liner must be evaluated by a geotechnical or groundwater specialist and found to be as protective as if the liner were above the level of the groundwater.

• If the soil in the liner is not the native soil or the soil has very low permeability, the side walls must be lined with at least 18 inches of treatment soil to prevent untreated seepage.

4.4.3  Design Criteria for Low Permeability Liner Options

This section presents the design criteria for each of the following four low permeability liner options: compacted till liners, clay liners, geomembrane liners, and concrete liners.

General

• Where grass must be planted over a low permeability liner per the facility design, a minimum of 6 inches of good topsoil or compost-amended native soil (2 inches compost tilled into 6 inches of native till soil) must be placed over the liner in the area to be planted. Twelve inches of cover is preferred.

• A low permeability liner shall not be used if seasonal high groundwater is likely to contact the liner, unless liner buoyancy is evaluated by a geotechnical engineer and addressed in the design as stipulated by that engineer.

• Where grass must be planted over a low permeability liner per the facility design, a minimum of 6 inches of topsoil or compost-amended soil shall be placed over the liner in the area to be planted.

Compacted Till Liners.

• Soils for compacted till liners shall meet the following size gradation.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Minimum Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 inch</td>
<td>100%</td>
</tr>
<tr>
<td>4 inch</td>
<td>90%</td>
</tr>
<tr>
<td>#4</td>
<td>70% - 100%</td>
</tr>
<tr>
<td>#200</td>
<td>20%</td>
</tr>
</tbody>
</table>

• Soil should be placed in 6-inch lifts.
- Soil shall be compacted to 95% minimum dry density, modified proctor method (ASTM D-1557).
- Liner thickness shall be a minimum of 18 inches after compaction.
- A different depth and density sufficient to retard the infiltration rate to $2.4 \times 10^{-5}$ inches per minute ($1 \times 10^{-6}$ cm/s) may also be used.

**Clay Liners.**
- Clay shall be compacted to 95% minimum dry density, modified proctor method (ASTM D-1557).
- Clay liner thickness after compaction shall be a minimum of 12 inches.
- A different depth and density sufficient to retard the infiltration rate to $2.4 \times 10^{-5}$ inches per minute ($1 \times 10^{-6}$ cm/s) may also be used.
- The slope of clay liners must be restricted to 3H: 1V for all areas requiring soil cover; otherwise, the soil layer must be stabilized by another method so that soil slippage into the facility does not occur. Any alternative soil stabilization method must take maintenance access into consideration.

**Geomembrane Liners**
- Geomembrane liners shall be ultraviolet (UV) light resistant and have a minimum thickness of 30 mils. A thickness of 40 mils shall be used in areas of maintenance access or where heavy machinery must be operated over the membrane.
- Geomembranes shall be bedded according to the manufacturer’s recommendations.
- Geomembrane liners shall be installed so that they can be covered with 12 inches of top dressing forming the bottom and sides of the facility. Top dressing shall consist of 6 inches of crushed rock covered with 6 inches of native soil. The rock layer is to mark the location of the liner for future maintenance operations. As an alternative to crushed rock, 12 inches of native soil may be used if orange plastic “safety fencing” or another highly-visible, continuous marker is embedded 6 inches above the membrane.
- Geomembrane liners shall not be used on slopes steeper than 5H:1V to prevent the top dressing material from slipping. Textured liners may be used on slopes up to 3H:1V upon recommendation by a geotechnical engineer that the top dressing will be stable for all site conditions, including maintenance.

**Concrete Liners.**
- Portland cement liners are allowed irrespective of facility size, and shotcrete may be used on slopes.
- Specifications must be developed by a professional engineer who certifies the liner against cracking or losing water retention ability under expected conditions of operation, including facility maintenance operations.
- Asphalt concrete may not be used for liners due to its permeability to many organic pollutants.
• If grass is to be grown over a concrete liner, slopes must be no steeper than 5H: IV to prevent the top dressing material from slipping.

4.5 Hydraulic Structures

4.5.1 Flow Splitter Designs

Many water quality (WQ) facilities can be designed as flow-through or on-line systems with flows above the WQ design flow or volume simply passing through the facility at a lower pollutant removal efficiency. However, it is sometimes desirable to restrict flows to WQ treatment facilities and bypass the remaining higher flows around them through off-line facilities. This can be accomplished by splitting flows in excess of the WQ design flow upstream of the facility and diverting higher flows to a bypass pipe or channel. The bypass typically enters a detention pond or the downstream receiving drainage system, depending on flow control requirements. In most cases, it is a designer’s choice whether WQ facilities are designed as on-line or off-line; an exception is oil/water separators, which must be designed off-line.

A crucial factor in designing flow splitters is to ensure that low flows are delivered to the treatment facility up to the WQ design flow rate. Above this rate, additional flows are diverted to the bypass system with minimal increase in head at the flow splitter structure to avoid surcharging the WQ facility under high flow conditions.

Flow splitters are typically manholes or vaults with concrete baffles. In place of baffles, the splitter mechanism may be a half tee section with a solid top and an orifice in the bottom of the tee section. A full tee option may also be used as described below in the “General Design Criteria.” Standard details for flow splitters are shown in EDDS Standard Drawings 5-250A and 5-250B.

General Design Criteria

• A flow splitter must be designed to deliver the WQ design flow rate specified in this volume to the WQ treatment facility. For the basic size sand filter, which is sized based on volume, use the WQ design flow rate to design the splitter. For the large sand filter, use the 2-year flow rate or the flow rate that corresponds with treating 95 percent of the runoff volume of a long-term time series predicted by an approved continuous runoff model.

• The top of the weir must be located at the water surface for the design flow. Remaining flows enter the bypass line. Flows modeled using a continuous simulation model should use 15-minute time steps, if available. Otherwise use 1-hour time steps.

• The maximum head must be minimized for flow in excess of the WQ design flow. Specifically, flow to the WQ facility at the 100-year water surface must not increase the design WQ flow by more than 10%.

• As an alternative to using a solid top plate in EDDS Standard Drawing 5-270C, a full tee section may be used with the top of the tee at the 100-year water surface. This alternative would route emergency overflows (if the overflow pipe were plugged) through the WQ facility rather than back up from the manhole.
- Special applications, such as roads, may require the use of a modified flow splitter. The baffle wall may be fitted with a notch and adjustable weir plate to proportion runoff volumes other than high flows.

- For ponding facilities, back water effects must be included in designing the height of the standpipe in the manhole.

**Materials**

- Materials shall be in accordance with Snohomish County EDDS.

- The splitter baffle may be installed in a Type 2 manhole or vault.

- The baffle wall must be made of reinforced concrete or another suitable material resistant to corrosion, and have a minimum 4-inch thickness. The minimum clearance between the top of the baffle wall and the bottom of the manhole cover must be 4 feet; otherwise, dual access points should be provided.

- Materials shall conform to Snohomish County EDDS.
4.5.2 Flow Spreading Options

Flow spreaders function to uniformly spread flows across the inflow portion of water quality facilities (e.g., sand filter, biofiltration swale, or filter strip). There are two flow spreader options presented in this section:

- Option 1 – Concrete sump box
- Option 2 – Interrupted curb

Option 1 can be used for spreading flows that are concentrated or unconcentrated.

Option 2 shall be used only for flows that are already unconcentrated and enter a filter strip or continuous inflow biofiltration swale.

General Design Criteria

- See Snohomish County EDDS Chapter 5.
- Where flow enters the flow spreader through a pipe, it is recommended that the pipe be submerged to the extent practical to dissipate energy as much as possible.
- For higher inflows (greater than 5 cfs for the 100-yr storm), a Type 1 catch basin should be positioned in the spreader and the inflow pipe should enter the catch basin with flows exiting through the top grate. The top of the grate should be lower than the level spreader plate, or if a notched spreader is used, lower than the bottom of the v-notches.

Option 1 -- Concrete Sump Box (See Figure 5.2)

- The wall of the downstream side of a rectangular concrete sump box must extend a minimum of 2 inches above the treatment bed. This serves as a weir to spread the flows uniformly across the bed.
- The downstream wall of a sump box must have “wing walls” at both ends. Side walls and returns must be slightly higher than the weir so that erosion of the side slope is minimized.
- Concrete for a sump box can be either cast-in-place or precast, but the bottom of the sump must be reinforced with wire mesh for cast-in-place sumps.
- Sump boxes must be placed over bases that consists of 4 inches of crushed rock, 5/8-inch minus to help assure the sump remains level.

Option 2 -- Interrupted Curb (No Figure)

Interrupted curbs are sections of curb placed to have gaps spaced at regular intervals along the total width (or length, depending on facility) of the treatment area. At a minimum, gaps must be every 6 feet to allow distribution of flows into the treatment facility before they become too concentrated. The opening must be a minimum of 11 inches. As a general rule, no opening should discharge more than 10 percent of the overall flow entering the facility.
Figure 5.2 – Flow Spreader Option B: Concrete Sump Box

Example of a concrete sump flow spreader used with a biofiltration swale (may be used with other WQ facilities).

Note: Extend sides into slope. Height of side wall and wing walls must be sufficient to handle the 100-year flow or the highest flow entering the facility.
4.5.3 Outfall Systems

Properly designed outfalls are critical to reducing the chance of adverse impacts as the result of concentrated discharges from pipe systems and culverts, both onsite and downstream. Outfall systems include rock splash pads, flow dispersal trenches, gabion or other energy dissipaters, and tightline systems. A tightline system is typically a continuous length of pipe used to convey flows down a steep or sensitive slope with appropriate energy dissipation at the discharge end.

General Design Criteria

Provided below are general design criteria for both Outfall Features and Tightline Systems.

Outfall Features

At a minimum, all outfalls must be provided with a rock splash pad (See EDDS Standard Drawing 5-060) except as specified below:

- The flow dispersion systems shown in EDDS Standard Drawings 5-070 through 5-085 should only be used when both criteria below are met:
  1. An outfall is necessary to disperse concentrated flows across uplands where no conveyance system exists and the natural (existing) discharge is unconcentrated; and
  2. The 100-year peak discharge rate is less than or equal to 0.5 cfs.

- For freshwater outfalls with a design velocity greater than 10 fps, a gabion dissipater or engineered energy dissipater may be required. See Snohomish County EDDS Chapter 5 for engineering design information and details for energy dissipation.

- Tightline systems may be needed to prevent aggravation or creation of a downstream erosion problem.

- In marine waters, rock splash pads and gabion structures are not recommended due to corrosion and destruction of the structure, particularly in high energy environments. Diffuser Tee structures (see EDDS Standard Drawing 5-085, are also not generally recommended in or above the intertidal zone. They may be acceptable in low bank or rock shoreline locations. Stilling basins or bubble-up structures are acceptable. Generally, tightlines trenched to extreme low water or dissipation of the discharge energy above the ordinary high water line are preferred. Outfalls below extreme low water may still need an energy dissipation device (e.g., a tee structure) to prevent nearby erosion.

- Energy dissipation requirements are set forth in Snohomish County EDDS, including stilling basins, drop pools, hydraulic jump basins, baffled aprons, and bucket aprons, are required for outfalls with design velocity greater than 20 fps. These should be designed using published or commonly known techniques found in such references as Hydraulic Design of Energy Dissipaters for Culverts and Channels, published by the Federal Highway Administration of the United States Department of Transportation; Open Channel Flow, by V.T. Chow; Hydraulic Design of Stillling Basins and Energy Dissipaters, EM 25, Bureau of Reclamation (1978); and other publications, such as those prepared by the Natural Resource Conservation Service.
• Alternate mechanisms may be used, such as bubble-up structures that eventually drain and structures fitted with reinforced concrete posts. If any alternate mechanisms are to be considered, they should be designed using sound hydraulic principles and consideration of ease of construction and maintenance.

• Mechanisms that reduce velocity prior to discharge from an outfall are encouraged. Some of these are drop manholes and rapid expansion into pipes of much larger size. Other discharge end features may be used to dissipate the discharge energy. An example of an end feature is the use of a Diffuser Tee with holes in the front half, as shown in EDDS Standard Drawing 5-085.

Note: stormwater outfalls submerged in a marine environment can be subject to plugging due to biological growth and shifting debris and sediments. Therefore, unless intensive maintenance is regularly performed, they may not meet their designed function.

• New pipe outfalls can provide an opportunity for low-cost fish habitat improvements. For example, an alcove of low-velocity water can be created by constructing the pipe outfall and associated energy dissipater back from the stream edge and digging a channel, over-widened to the upstream side, from the outfall to the stream (as shown in Figure 5.3). Overwintering juvenile and migrating adult salmonids may use the alcove as shelter during high flows. Potential habitat improvements should be discussed with the Washington Department of Fish and Wildlife biologist prior to inclusion in design.

• Bank stabilization, bioengineering and habitat features may be required for disturbed areas.

• Outfall structures should be located where they minimize impacts to fish, shellfish, and their habitats.

• One caution to note is that the in-stream sample gabion mattress energy dissipater may not be acceptable within the ordinary high water mark of fish-bearing waters or where gabions will be subject to abrasion from upstream channel sediments. A four-sided gabion basket located outside the ordinary high water mark should be considered for these applications.

**Tightline Systems**

• Outfall tightlines may be installed in trenches with standard bedding on slopes up to 20%. In order to minimize disturbance to slopes greater than 20%, it is recommended that tightlines be placed at grade with proper pipe anchorage and support.

• Except as indicated above, tightlines or conveyances that traverse the marine intertidal zone and connect to outfalls must be buried to a depth sufficient to avoid exposure of the line during storm events or future changes in beach elevation. If non-native material is used to bed the tightline, such material shall be covered with at least 3 feet of native bed material or equivalent.

• High density polyethylene pipe (HDPP) tightlines must be designed to address the material limitations, particularly thermal expansion and contraction and pressure design, as specified by the manufacturer. The coefficient of thermal expansion and contraction for solid wall polyethylene pipe (SWPE) is on the order of 0.001 inch per foot per Fahrenheit degree. Sliding sleeve connections must be used to address this thermal expansion and contraction.
These sleeve connections consist of a section of the appropriate length of the next larger size diameter of pipe into which the outfall pipe is fitted. These sleeve connections must be located as close to the discharge end of the outfall system as is practical.

- Due to the ability of HDPP tightlines to transmit flows of very high energy, special consideration for energy dissipation must be made. See EDDS Chapter 5 for energy dissipation requirements.
Figure 5.3 – Fish Habitat Improvement at New Outfalls
4.6 Maintenance Standards for Drainage Facilities and Catch Basins

4.6.1 Purpose
The purpose of this chapter is to set forth maintenance standards for different components of drainage facilities and catch basins. These standards match specific facility components and features with approved uniform maintenance procedures.

The facility-specific maintenance standards contained in this section are intended to be conditions for determining if maintenance actions are required, as identified through inspection. The following definitions apply to maintenance described in this chapter.

"Drainage facility" means a stormwater flow control or treatment facility described in Table 5.3 of this chapter.

"Catch basin" means a catch basin or manhole of a type described in Snohomish County EDDS.

“Maintenance” for this chapter shall be used to mean regular maintenance, repair or replacement actions. The maintenance standards are not intended to be measures of a facility's required condition at all times between inspections. In other words, if these conditions are exceeded at any time between inspections and/or maintenance, this does not automatically constitute a violation of these standards.

4.6.2 Applicability
This chapter applies to drainage facilities identified in Table 5.3 of this chapter that are owned or operated by Snohomish County, catch basins owned or operated by the County, and such drainage facilities and catch basins owned by other entities.

4.6.3 Enforcement
Snohomish County Code (SCC) 7.53.140 requires any owner or operator of a drainage facility described in this chapter to maintain the facility in accordance with the standards set forth in this chapter.

4.6.4 Tracking Maintenance and Repair Costs
SCC 7.53.140 requires property owners to keep records of their maintenance actions for their drainage facilities. In addition, Snohomish County requests that owners and operators of drainage facilities track the cost of maintenance and repairs and provide these costs to the County. This request is not a regulatory requirement. The information will be used by the County to estimate general maintenance and repair cost information and to provide that information to members of the public who may need to perform such work and estimate costs. The County does not intend to provide cost information that can be traced to a specific facility.
4.6.5 Drainage Facility Maintenance Schedule

A) Maintenance actions to be completed within thirty days of the date of notice

1) When a County-initiated inspection of a flow control structure finds that the hydraulic function of the structure is significantly impaired, the owner or operator shall have thirty days from the date of the notice issued by the County in which to complete maintenance actions required by the notice.

2) If, after thirty days, the required maintenance actions have not been completed, the owner or operator will be in violation of County code and will be subject to enforcement action by the County. In such cases, the County may, at its option, perform the necessary maintenance actions, in which case the owner or operator will be charged for all costs the County incurs for performing these maintenance actions.

B) Maintenance of catch basins to be completed within six months of the date of notice

Note - this section applies to catch basins associated with a stormwater conveyance system, and excludes catch basins or manholes that function directly as part of drainage facilities as described above, for example, a catch basin containing a flow control structure for a detention facility. Catch basins that function directly as part of those drainage facilities shall be considered to be part of those facilities.

1) In addition to the requirements of section 4.6.5A, when a County-initiated inspection of a catch basin identifies one or more conditions listed in Table 5.3 for which maintenance is needed, and for which the necessary maintenance actions are estimated to cost less than $25,000, the owner or operator has six months from the date of the notice issued by the County in which to complete maintenance actions required by the notice.

2) The owner or operator is responsible for obtaining all required permits and permissions before starting work.

3) If, after six months from the date of the notice, the required maintenance actions have not been completed, the owner or operator will be subject to enforcement action by the County. In such cases, the County may, at its option, perform the necessary maintenance actions, in which case the owner or operator will be charged for all costs the County incurs for performing these maintenance actions.

4) With the exception of work described in 4.6.5A and 4.6.5E, maintenance actions may not be allowed during the period from October 1 to April 30 in order to ensure that downstream property and stream corridors will not be subject to flooding, habitat degradation, or pollutant contamination as a result of these actions.

5) Depending on the scope of work and seasonal conditions, the County reserves the right to require the owner or operator to complete necessary maintenance actions in the first year during the period from May 1 to September 30.
C) Maintenance actions to be completed within one year of the date of notice

1) In addition to the requirements of section 4.6.5A, when a County-initiated inspection of a drainage facility identifies one or more conditions for any component listed in Table 5.3 for which maintenance is needed, and for which the necessary maintenance actions are estimated to cost less than $25,000, the owner or operator has one year from the date of the notice issued by the County in which to complete maintenance actions required by the notice. If maintenance of a flow control structure is required under section 4.6.5A, the cost of those maintenance actions shall be considered part of the total maintenance cost for the entire drainage facility.

2) The owner or operator is responsible for obtaining all required permits and permissions before starting work.

3) If, after one year from the date of the notice, the required maintenance actions have not been completed, the owner or operator will be subject to enforcement action by the County. In such cases, the County may, at its option, perform the necessary maintenance actions, in which case the owner or operator will be charged for all costs the County incurs for performing these maintenance actions.

4) With the exception of work described in 4.6.5A and 4.6.5E, maintenance actions may not be allowed the period from October 1 to April 30 in order to ensure that downstream property and stream corridors will not be subject to flooding, habitat degradation, or pollutant contamination as a result of these actions.

5) Depending on the scope of work and seasonal conditions, the County reserves the right to require the owner or operator to complete necessary maintenance actions in the first year during the period from May 1 to September 30.

D) Maintenance actions to be completed within two years of the date of notice

1) In addition to the requirements of section 4.6.5A, when a County-initiated inspection of a drainage facility identifies one or more conditions for any component listed in Table 5.3 for which maintenance is needed, and for which the necessary maintenance actions are estimated to cost $25,000 or more, the owner or operator has two years from the date of the notice issued by the County in which to complete maintenance actions required by the notice as well as any other actions needed to produce the expected results in Table 5.3. If maintenance of a flow control structure is required under section 4.6.5A, the cost of those maintenance actions shall considered part of the total maintenance cost for the entire drainage facility.

2) The owner or operator shall be responsible for acquiring all needed permits and permissions before commencing work.

3) If, after two years from the date of the notice, the required maintenance actions have not been completed, the owner or operator will be subject to enforcement action by the County. In such cases, the County may, at its option, perform the necessary maintenance actions, in which case the owner or operator will be charged for all costs the County incurs for performing these maintenance actions.

4) With the exception of work described in 4.6.5A and 4.6.5E, maintenance actions may not be allowed the period from October 1 to April 30 in order to ensure that downstream
property and stream corridors will not be subject to flooding, habitat degradation, or pollutant contamination as a result of these actions.

5) Depending on the scope of work and seasonal conditions, the County reserves the right to require the owner or operator to complete necessary maintenance actions in the first year during the period from May 1 to September 30.

6) In order for the owner or operator of the drainage facility to receive two (2) years to perform the necessary maintenance actions, he/she must provide the County with a good faith estimate or bid for the total cost of these maintenance actions no later than the 60th day after the date of the notice.

E) Emergency orders

1) In addition to any requirements described above, and in accordance with the provisions of Chapter 30.85 SCC, if the County determines that a condition exists at a drainage facility that endangers public or private property, creates an immediate hazard, creates a violation of critical areas provisions or surface water protection, or threatens the health and safety of the occupants of any premises or members of the public, the County may issue an emergency order. Upon issuance of an emergency order, the owner or operator of the drainage facility shall remedy the condition immediately.

4.6.5 Maintenance Standards - Use Table 5.3
## Table 5.3 – Maintenance Standards

### No. 1 – Detention Ponds

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Conditions When Maintenance Is Needed</th>
<th>Results Expected When Maintenance Is Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Trash &amp; Debris</td>
<td>Function of facility is impaired by or likely to be impaired by trash and debris.</td>
<td>Trash and debris is removed.</td>
</tr>
<tr>
<td>Vegetation</td>
<td>Function of facility is impaired by vegetation.</td>
<td>Vegetation is removed or managed to restore proper function of facility.</td>
<td>Use of herbicides shall be in accordance with an Integrated Pest Management Plan.</td>
</tr>
<tr>
<td>Contaminants and Pollution</td>
<td>Any evidence of oil, gasoline, contaminants or other pollutants</td>
<td>Contaminants or pollutants are removed</td>
<td></td>
</tr>
<tr>
<td>Beaver Dams</td>
<td>Dam results in change or function of the facility.</td>
<td>Facility is returned to design function.</td>
<td>Note: Coordinate trapping of beavers and removal of dams with appropriate permitting agencies.</td>
</tr>
<tr>
<td>Insects</td>
<td>When insects such as wasps and hornets interfere with maintenance activities.</td>
<td>Insects are destroyed or removed from site. Use of pesticides shall be in accordance with an Integrated Pest Management Plan</td>
<td></td>
</tr>
<tr>
<td>Tree Growth and Hazard Trees</td>
<td>Function of facility is impaired by trees. Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove Hazard trees (i.e., dead, diseased, or dying trees) need to be identified Note: A certified Arborist may be needed to determine health of trees or removal requirements.</td>
<td>Trees are removed or managed to restore proper function of facility. Trees do not hinder maintenance activities. Hazard trees are identified and those that pose an imminent danger are removed.</td>
<td></td>
</tr>
<tr>
<td>Erosion</td>
<td>Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.</td>
<td>Slopes are stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.</td>
<td></td>
</tr>
<tr>
<td>General</td>
<td>Liner is visible and has more than three 1/4-inch holes in it.</td>
<td>Liner is repaired or replaced. Liner is fully covered.</td>
<td></td>
</tr>
<tr>
<td>Berms</td>
<td>Liner (If Applicable)</td>
<td>Liner is repaired or replaced. Liner is fully covered.</td>
<td></td>
</tr>
<tr>
<td>Settling</td>
<td>Any part of a berm which has settled at least 4 inches lower than the design elevation.</td>
<td>Berm is repaired and restored to the design elevation.</td>
<td></td>
</tr>
</tbody>
</table>
### No. 1 – Detention Ponds

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Conditions When Maintenance Is Needed</th>
<th>Results Expected When Maintenance Is Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Erosion</td>
<td>Any erosion observed on a compacted structural berm embankment.</td>
<td>Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Note: A licensed civil engineer may be needed to inspect, evaluate and recommend a repair plan.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Piping</td>
<td>Discernable water flow through a compacted structural berm. Ongoing erosion with potential for erosion to continue. Tree growth on a compacted structural berm over 4 feet in height may lead to piping through the berm which could lead to failure of the berm. Evidence of rodent holes in berm, and/or water piping through berm via rodent holes Note: A geotechnical engineer may be needed to inspect and evaluate condition and recommend repair of condition.</td>
<td>Piping eliminated. Erosion potential resolved.</td>
</tr>
<tr>
<td>Storage Area</td>
<td>Sediment</td>
<td>Accumulated sediment that exceeds 10% of the designed pond depth unless otherwise specified or affects inletting or outletting condition of the facility.</td>
<td>Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.</td>
</tr>
<tr>
<td>Emergency Overflow/ Spillway</td>
<td>Tree Growth</td>
<td>Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping.</td>
<td>Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. Note: A licensed civil engineer may be needed to determine proper berm/spillway restoration.</td>
</tr>
<tr>
<td></td>
<td>Rock Armoring</td>
<td>Rock layer on subgrade is less than 1.0 feet deep and/or subgrade is exposed</td>
<td>Rocks and pad depth are restored to a minimum depth of 1.0 feet.</td>
</tr>
<tr>
<td></td>
<td>Erosion</td>
<td>Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.</td>
<td>Slopes are stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.</td>
</tr>
</tbody>
</table>

**NOTE:** The above maintenance standards also apply to naturally-occurring closed depressions used to meet the flow control requirements set forth in SCC 30.63A.550 through SCC 30.63A.570.
### No. 2 – Infiltration Facilities

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Conditions When Maintenance Is Needed</th>
<th>Results Expected When Maintenance Is Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Trash &amp; Debris</td>
<td>Function of facility is impaired by or likely to be impaired by trash and debris.</td>
<td>Trash and debris is removed.</td>
</tr>
<tr>
<td></td>
<td>Vegetation</td>
<td>Function of facility is impaired by vegetation.</td>
<td>Vegetation is removed or managed to restore proper function of facility. Use of herbicides shall be in accordance with an Integrated Pest Management Plan.</td>
</tr>
<tr>
<td>Contaminants and Pollution</td>
<td>Any evidence of oil, gasoline, contaminants or other pollutants</td>
<td></td>
<td>Contaminants or pollutants are removed</td>
</tr>
<tr>
<td>Erosion</td>
<td>Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion</td>
<td>Slopes are stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.</td>
<td></td>
</tr>
<tr>
<td>Storage Area</td>
<td>Sediment</td>
<td>Water ponding in infiltration pond after rainfall ceases and appropriate time allowed for infiltration.   (A percolation test pit or test of facility indicates facility is only working at 90% of its designed capabilities. If two inches or more sediment is present, remove).</td>
<td>Sediment is removed and/or facility is cleaned so that infiltration system works according to design.</td>
</tr>
<tr>
<td>Filter Bags (if applicable)</td>
<td>Sediment and Debris</td>
<td>Sediment and debris fill bag more than 1/2 full.</td>
<td>Filter bag is replaced or system is redesigned.</td>
</tr>
<tr>
<td>Rock Filters</td>
<td>Sediment and Debris</td>
<td>By visual inspection, little or no water flows through filter during heavy rain storms.</td>
<td>Gravel in rock filter is replaced.</td>
</tr>
<tr>
<td>Side Slopes of Pond</td>
<td>Erosion</td>
<td>See &quot;Detention Ponds&quot; (No. 1).</td>
<td>See &quot;Detention Ponds&quot; (No. 1).</td>
</tr>
<tr>
<td>Berms</td>
<td>Settling</td>
<td>Any part of a berm which has settled at least 4 inches lower than the design elevation.</td>
<td>Berm is repaired and restored to the design elevation.</td>
</tr>
<tr>
<td></td>
<td>Erosion</td>
<td>Any erosion observed on a compacted structural berm embankment.</td>
<td>Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Note: A licensed civil engineer may be needed to inspect, evaluate and recommend a repair plan.</td>
<td></td>
</tr>
</tbody>
</table>
## No. 2 – Infiltration Facilities

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Conditions When Maintenance Is Needed</th>
<th>Results Expected When Maintenance Is Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Piping</td>
<td>Discernable water flow through a compacted structural berm. Ongoing erosion with potential for erosion to continue. Tree growth on a compacted structural berm over 4 feet in height may lead to piping through the berm which could lead to failure of the berm. Evidence of rodent holes in berm, and/or water piping through berm via rodent holes Note: A geotechnical engineer may be needed to inspect and evaluate condition and recommend repair of condition.</td>
<td>Piping eliminated. Erosion potential resolved.</td>
</tr>
<tr>
<td>Emergency Overflow Spillway</td>
<td>Tree Growth</td>
<td>Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping.</td>
<td>Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. Note: A licensed civil engineer may be needed to determine proper berm/spillway restoration.</td>
</tr>
<tr>
<td>Rock Armoring</td>
<td>Rock layer on subgrade is less than 1.0 feet deep and/or subgrade is exposed</td>
<td>Rocks and pad depth are restored to a minimum depth of 1.0 feet.</td>
<td></td>
</tr>
<tr>
<td>Erosion</td>
<td>Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.</td>
<td>Slopes are stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.</td>
<td></td>
</tr>
<tr>
<td>Pre-settling Ponds and Vaults</td>
<td>Facility or sump filled with Sediment and/or debris</td>
<td>The settling area or sump contains sediment/debris up to a depth of either 6 inches or the sedimentation design depth.</td>
<td>Sediment/debris is removed.</td>
</tr>
<tr>
<td>Maintenance Component</td>
<td>Defect</td>
<td>Conditions When Maintenance is Needed</td>
<td>Results Expected When Maintenance is Performed</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------</td>
<td>---------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Storage Area</td>
<td>Plugged Air Vents</td>
<td>One-half of the cross section of a vent is blocked at any point or the vent is damaged.</td>
<td>Vents open and functioning.</td>
</tr>
<tr>
<td></td>
<td>Debris and Sediment</td>
<td>The average sediment depth measured at multiple locations exceeds 10% of the detention pipe diameter (or the depth of the storage area) or the sediment depth measured at any single point exceeds 15% of the pipe diameter. (Example: The sediment depth in a 60-inch diameter detention pipe is measured at three locations. The sediment would need to be removed if the average depth of the three measurements is at least 6 inches or if the depth of any single measurement is at least 9 inches.)</td>
<td>All sediment, debris, and organic matter removed from storage area.</td>
</tr>
<tr>
<td>Joints Between Tank/Pipe Section</td>
<td>Any openings or voids at section joint allowing material to seep into or water to leak out of facility. Note: This may need an engineering analysis to assess the structural stability.</td>
<td>All joints between tank/pipe sections are sealed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tank or Pipe Bent Out of Shape</td>
<td>Any part of tank/pipe is bent out of shape more than 10% of its design shape. Note: This may need an engineering analysis to assess the structural stability.</td>
<td>Tank/pipe section is repaired or replaced to design.</td>
</tr>
<tr>
<td></td>
<td>Tank/Pipe Material</td>
<td>Any visible holes or cracks wider than a quarter of an inch or evidence of material seeping into or water leaking out of pipe wall, or qualified maintenance or inspection personnel determine that tank/pipe is not structurally sound.</td>
<td>Tank/pipe is repaired or replaced to design specifications and is structurally sound.</td>
</tr>
<tr>
<td>Access Hole</td>
<td>Cover Not in Place</td>
<td>Cover is missing or only partially in place. Any open manhole requires maintenance.</td>
<td>Manhole is closed.</td>
</tr>
<tr>
<td></td>
<td>Locking Mechanism Not Working</td>
<td>Locking mechanism cannot be opened or lock bolts cannot be removed by one maintenance person with proper hand tools.</td>
<td>Mechanism or lock bolts open with proper hand tools.</td>
</tr>
<tr>
<td></td>
<td>Cover Difficult to Remove</td>
<td>One maintenance person cannot remove lid after applying normal lifting pressure with proper hand tools. Intent is to keep cover from sealing off access to maintenance.</td>
<td>Cover can be removed and reinstalled by one maintenance person with proper hand tools.</td>
</tr>
<tr>
<td></td>
<td>Ladder Rungs Unsafe</td>
<td>Ladder is unsafe due to missing rungs, cracked/broken rungs, misalignment, rungs not securely attached to structure wall, rust, or cracks.</td>
<td>Ladder meets design standards and allows maintenance person safe access.</td>
</tr>
<tr>
<td>Catch Basins</td>
<td>See “Catch Basins” (No. 5)</td>
<td>See “Catch Basins” (No. 5).</td>
<td>See “Catch Basins” (No. 5).</td>
</tr>
<tr>
<td>Standpipe, Cleanout Gate, Orifice Plate</td>
<td>Obstructions, Damaged, or Missing</td>
<td>See “Control Structure/Flow Restrictors” (No. 4)</td>
<td>See “Control Structure/Flow Restrictors” (No. 4)</td>
</tr>
</tbody>
</table>
### No. 4 – Control Structure/Flow Restrictors

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Condition When Maintenance is Needed</th>
<th>Results Expected When Maintenance is Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standpipe</td>
<td>Obstructions</td>
<td>Any material blocking (or having the potential of blocking) the pipe overflow.</td>
<td>Pipe is free of all obstructions and works as designed.</td>
</tr>
<tr>
<td></td>
<td>Structural Damage</td>
<td>Structure is not securely attached to manhole wall.</td>
<td>Structure is securely attached to wall and outlet pipe.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Structure is not in upright position (allow up to 10% from plumb).</td>
<td>Structure is in correct position.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Connections to outlet pipe are not watertight and show signs of rust.</td>
<td>Connections to outlet pipe are watertight; structure repaired or replaced and works as designed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Any holes other than designed holes in the structure.</td>
<td>Structure has no holes other than designed holes.</td>
</tr>
<tr>
<td>Cleanout Gate</td>
<td>Damaged or Missing</td>
<td>Cleanout gate is not watertight or is missing.</td>
<td>Gate is watertight and works as designed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gate cannot be moved up and down by one maintenance person.</td>
<td>Gate moves up and down easily and is watertight.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chain/rod leading to gate is missing or damaged.</td>
<td>Chain is in place and works as designed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gate is rusted over 50% of its surface area.</td>
<td>Gate is repaired or replaced to meet design standards.</td>
</tr>
<tr>
<td>Orifice Plate</td>
<td>Damaged or Missing</td>
<td>Control device is not working properly due to missing, out of place, or bent orifice plate.</td>
<td>Plate is in place and works as designed.</td>
</tr>
<tr>
<td></td>
<td>Obstructions</td>
<td>Any trash, debris, sediment, or vegetation blocking the plate.</td>
<td>Plate is free of all obstructions and works as designed.</td>
</tr>
<tr>
<td>Overflow Pipe</td>
<td>Obstructions</td>
<td>Any trash or debris blocking (or having the potential of blocking) the overflow pipe.</td>
<td>Pipe is free of all obstructions and works as designed.</td>
</tr>
<tr>
<td>Access Hole</td>
<td>Cover Not in Place</td>
<td>Cover is missing or only partially in place. Any open manhole requires maintenance.</td>
<td>Manhole is closed.</td>
</tr>
<tr>
<td></td>
<td>Locking Mechanism Not Working</td>
<td>Locking mechanism cannot be opened or lock bolts cannot be removed by one maintenance person with proper hand tools.</td>
<td>Mechanism or lock bolts open with proper hand tools.</td>
</tr>
<tr>
<td></td>
<td>Cover Difficult to Remove</td>
<td>One maintenance person cannot remove lid after applying normal lifting pressure with proper hand tools.</td>
<td>Cover can be removed and reinstalled by one maintenance person with proper hand tools.</td>
</tr>
<tr>
<td></td>
<td>Ladder Rungs Unsafe</td>
<td>Ladder is unsafe due to missing rungs, cracked/broken rungs, misalignment, rungs not securely attached to structure wall, rust, or cracks.</td>
<td>Ladder meets design standards and allows maintenance person safe access.</td>
</tr>
</tbody>
</table>
No. 4 – Control Structure/Flow Restrictors

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Condition When Maintenance is Needed</th>
<th>Results Expected When Maintenance is Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catch Basin</td>
<td>See “Catch Basins” (No. 5).</td>
<td>See “Catch Basins” (No. 5).</td>
<td>See “Catch Basins” (No. 5).</td>
</tr>
<tr>
<td>Sediment &amp; Debris</td>
<td>Sediment, trash, vegetation, and/or other debris material exceeds 25% of the catch basin sump depth or is 1 foot below the orifice plate.</td>
<td>Control structure orifice is not blocked. All sediment and debris removed.</td>
<td></td>
</tr>
</tbody>
</table>
### No. 5 – Catch Basins

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Conditions When Maintenance is Needed</th>
<th>Results Expected When Maintenance is performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Sediment &amp; Debris</td>
<td>Sediment, trash, and/or other debris material is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.</td>
<td>No sediment or debris is located immediately in front of catch basin or on grate opening.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sediment, trash, and/or other debris material (located in the catch basin) exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe.</td>
<td>No sediment or debris is in the catch basin.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sediment, trash, and/or other debris material located in any inlet or outlet pipe is blocking more than 1/3 of its height.</td>
<td>Inlet and outlet pipes are free of sediment and debris.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dead animals or vegetation that impair catch basin function or that could generate odors that could cause complaints or dangerous gases (e.g., methane).</td>
<td>No dead animals or vegetation are present within the catch basin.</td>
</tr>
<tr>
<td>Structure Damage to Frame and/or Top Slab</td>
<td>Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch (Intent is to make sure no material is seeping into the catch basin).</td>
<td>Top slab is free of holes and cracks. No water and/or soil is seeping into the catch basin</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached</td>
<td>Frame is sitting flush on the riser rings or top slab and firmly attached</td>
</tr>
<tr>
<td>Fractures or Cracks in Basin Walls/ Bottom</td>
<td>Cracks wider than 1/2 inch or evidence of soil particles entering the structure through the cracks, or qualified maintenance or inspection personnel determine that the vault is not structurally sound.</td>
<td>Catch basin is replaced or repaired to design standards.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.</td>
<td>Pipe is regrouted and secure at wall.</td>
</tr>
<tr>
<td>Settlement/ Misalignment</td>
<td>Settlement of misalignment of the catch basin causes a safety, function, or design problem.</td>
<td>Catch basin is replaced or repaired to design standards.</td>
<td></td>
</tr>
<tr>
<td>Contaminants and Pollution</td>
<td>Any evidence of oil, gasoline, contaminants or other pollutants Note: Coordinate removal/cleanup with local and/or state water quality response agency.</td>
<td>Contaminants or pollutants are removed.</td>
<td></td>
</tr>
<tr>
<td>Access Hole Cover</td>
<td>Cover Not in Place</td>
<td>Cover is missing or only partially in place. Any open catch basin requires maintenance.</td>
<td>Catch basin cover is fully in place</td>
</tr>
<tr>
<td></td>
<td>Locking Mechanism Not Working</td>
<td>Locking mechanism cannot be opened or lock bolts cannot be removed by one maintenance person with proper hand tools.</td>
<td>Mechanism or lock bolts open with proper hand tools.</td>
</tr>
<tr>
<td></td>
<td>Cover Difficult to Remove</td>
<td>One maintenance person cannot remove lid after applying normal lifting pressure with proper hand tools. Intent is keep cover from sealing off access to maintenance.</td>
<td>Cover can be removed and reinstalled by one maintenance person with proper hand tools.</td>
</tr>
</tbody>
</table>
No. 5 – Catch Basins

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Conditions When Maintenance is Needed</th>
<th>Results Expected When Maintenance is performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ladder</td>
<td>Ladder Rungs Unsafe</td>
<td>Ladder is unsafe due to missing rungs, cracked/broken rungs, rungs not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.</td>
<td>Ladder meets design standards and allows maintenance person safe access.</td>
</tr>
<tr>
<td>Metal Grates (If Applicable)</td>
<td>Trash and Debris</td>
<td>Trash and debris that is blocking more than 20% of grate surface inletting capacity.</td>
<td>Grate free of trash and debris.</td>
</tr>
<tr>
<td></td>
<td>Damaged or Missing.</td>
<td>Grate missing or broken member(s) of the grate.</td>
<td>Grate is in place and meets design standards.</td>
</tr>
</tbody>
</table>

No. 6 – Debris Barriers (e.g., Trash Racks)

<table>
<thead>
<tr>
<th>Maintenance Components</th>
<th>Defect</th>
<th>Condition When Maintenance is Needed</th>
<th>Results Expected When Maintenance is Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Trash and Debris</td>
<td>Trash or debris that is plugging more than 20% of the openings in the barrier.</td>
<td>Barrier cleared to design flow capacity.</td>
</tr>
<tr>
<td>Metal</td>
<td>Damaged/ Missing Bars.</td>
<td>Bars are bent out of shape more than 3 inches.</td>
<td>Bars in place with no bends more than 3/4 inch.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bars are missing or entire barrier missing.</td>
<td>Bars in place according to design.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bars are loose and rust is causing 50% deterioration to any part of barrier.</td>
<td>Barrier replaced or repaired to design standards.</td>
</tr>
<tr>
<td>Inlet/Outlet Pipe</td>
<td>Debris barrier missing or not attached to pipe</td>
<td></td>
<td>Barrier firmly attached to pipe.</td>
</tr>
</tbody>
</table>
### No. 7 – Energy Dissipaters

<table>
<thead>
<tr>
<th>Maintenance Components</th>
<th>Defect</th>
<th>Conditions When Maintenance is Needed</th>
<th>Results Expected When Maintenance is Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rock Pad</td>
<td>Missing or Moved Rock</td>
<td>Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil where pad was originally installed.</td>
<td>Rock pad replaced to design standards.</td>
</tr>
<tr>
<td></td>
<td>Erosion</td>
<td>Soil erosion in or adjacent to rock pad.</td>
<td>Rock pad replaced to design standards.</td>
</tr>
<tr>
<td>Rock Gabion Structures</td>
<td>Wire basket matrix deteriorated or broken</td>
<td>Deterioration determined to be near to breaking. Broken wire results in hole large enough to allow rocks to protrude out of basket</td>
<td>Rewire area of concern or replace basket and/or rocks as necessary.</td>
</tr>
<tr>
<td></td>
<td>Wire basket misaligned</td>
<td>Baskets have shifted and no longer providing full energy dissipations or may be prone to tipping or collapse</td>
<td>Realign or relocate as necessary to meet design intent.</td>
</tr>
<tr>
<td>Dispersion Trench</td>
<td>Perforated Pipe Plugged with Sediment</td>
<td>Accumulated sediment that exceeds 20% of the design depth or over 1/3 of perforations in pipe are plugged.</td>
<td>Pipe cleaned/flushed so that it matches design.</td>
</tr>
<tr>
<td></td>
<td>Not Discharging Water Properly</td>
<td>Water is discharging at a few concentrated points along the top of the trench rather than flowing uniformly along the entire length of trench lip.</td>
<td>Trench redesigned or rebuilt to standards.</td>
</tr>
<tr>
<td></td>
<td>“Distributor” Catch Basin Overflows</td>
<td>Water is observed or reported to be flowing out of top of basin during any storm less than the design storm.</td>
<td>Facility rebuilt or redesigned to standards.</td>
</tr>
<tr>
<td></td>
<td>Receiving Area Over-Saturated</td>
<td>Water in receiving area is causing or has potential of causing landslide problems.</td>
<td>No danger of landslides.</td>
</tr>
<tr>
<td>Catch Basins</td>
<td>Other Defects</td>
<td>See “Catch Basins” (No. 5).</td>
<td>See “Catch Basins” (No. 5).</td>
</tr>
</tbody>
</table>
### No. 8 – Typical Biofiltration Swales

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect or Problem</th>
<th>Condition When Maintenance is Needed</th>
<th>Recommended Maintenance to Correct Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Sediment Accumulation on Grass</td>
<td>Sediment depth exceeds 2 inches.</td>
<td>Remove sediment deposits on grass treatment area of the swale. When finished, swale should be level from side to side and drain freely toward outlet. There should be no areas of standing water once inflow has ceased. Reseed any bare spots as needed in loosened, fertile soil.</td>
</tr>
<tr>
<td></td>
<td>Standing Water</td>
<td>When water stands in the swale between storms and does not drain freely.</td>
<td>Any of the following may apply: remove sediment or trash blockages, improve grade from head to foot of swale, remove clogged check dams, add underdrains or convert to a wet biofiltration swale.</td>
</tr>
<tr>
<td>Flow spreader</td>
<td></td>
<td>Flow spreader uneven or clogged so that flows are not uniformly distributed through entire swale width.</td>
<td>Level the spreader and clean so that flows are spread evenly over entire swale width.</td>
</tr>
<tr>
<td>Constant Baseflow</td>
<td></td>
<td>When small quantities of water continually flow through the swale, even when it has been dry for weeks and an eroded, muddy channel has formed in the swale bottom.</td>
<td>Add a low-flow pea-gravel drain the length of the swale or by-pass the baseflow around the swale.</td>
</tr>
<tr>
<td>Poor Vegetation Coverage</td>
<td>When grass is sparse or bare or eroded patches occur in more than 10% of the swale bottom.</td>
<td>Determine why grass growth is poor and correct that condition. Replant with plugs of grass from the upper slope: plant in the swale bottom at 8-inch intervals. Or reseed into loosened, fertile soil.</td>
<td></td>
</tr>
<tr>
<td>Vegetation</td>
<td>When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.</td>
<td>Mow vegetation or remove nuisance vegetation so that flow not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings.</td>
<td></td>
</tr>
<tr>
<td>Excessive Shading</td>
<td>Grass growth is poor because sunlight does not reach swale.</td>
<td>If possible, trim back overhanging limbs and remove brushy vegetation on adjacent slopes. In addition, reseed bare spots with shade tolerant grass seed mix and/or replant with plugs of slough sedge or other sedges.</td>
<td></td>
</tr>
<tr>
<td>Inlet/Outlet</td>
<td>Inlet/outlet areas clogged with sediment and/or debris.</td>
<td>Remove material so that there is no clogging or blockage in the inlet and outlet area.</td>
<td></td>
</tr>
<tr>
<td>Trash and Debris Accumulation</td>
<td>Trash and debris accumulated in the bio-swale.</td>
<td>Remove trash and debris from swale.</td>
<td></td>
</tr>
<tr>
<td>Erosion/Scouring</td>
<td>Eroded or scoured swale bottom due to flow channelization, or higher flows.</td>
<td>For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. If bare areas are large, generally greater than 12 inches wide, the swale should be regraded and reseeded. For smaller bare areas, overseed when bare spots are evident, or take plugs of grass from the upper slope and plant in the swale bottom at 8-inch intervals.</td>
<td></td>
</tr>
</tbody>
</table>
### No. 9 – Wet Biofiltration Swales

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect or Problem</th>
<th>Condition When Maintenance is Needed</th>
<th>Recommended Maintenance to Correct Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Sediment Accumulation</td>
<td>Sediment depth exceeds 2 inches in 10% of the swale treatment area.</td>
<td>Remove sediment deposits in treatment area.</td>
</tr>
<tr>
<td></td>
<td>Water Depth</td>
<td>Water not retained to a depth of about 4 inches during the wet season.</td>
<td>Build up or repair outlet berm so that water is retained in the wet swale.</td>
</tr>
<tr>
<td></td>
<td>Wetland Vegetation</td>
<td>Vegetation becomes sparse and does not provide adequate filtration, OR vegetation is crowded out by very dense clumps of cattail, which do not allow water to flow through the clumps.</td>
<td>Determine cause of lack of vigor of vegetation and correct. Replant as needed with wetland plants. For excessive cattail growth, cut cattail shoots back and compost offsite. Note: normally wetland vegetation does not need to be harvested unless die-back is causing oxygen depletion in downstream waters.</td>
</tr>
<tr>
<td></td>
<td>Inlet/Outlet</td>
<td>Inlet/outlet area clogged with sediment and/or debris.</td>
<td>Remove clogging or blockage in the inlet and outlet areas.</td>
</tr>
<tr>
<td></td>
<td>Erosion/Scouring</td>
<td>Swale has eroded or scoured due to flow channelization, or higher flows.</td>
<td>Check design flows to assure swale is large enough to handle flows. Bypass excess flows or enlarge swale. Replant eroded areas with fibrous-rooted plants such as Juncus effusus (soft rush) in wet areas or snowberry (Symphoricarpos albus) in dryer areas.</td>
</tr>
</tbody>
</table>

### No. 10 – Filter Strips

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect or Problem</th>
<th>Condition When Maintenance is Needed</th>
<th>Recommended Maintenance to Correct Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Sediment Accumulation on Grass</td>
<td>Sediment depth exceeds 2 inches.</td>
<td>Remove sediment deposits, re-level so slope is even and flows pass evenly through strip. Reseed any bare spots as needed in loosened, fertile soil.</td>
</tr>
<tr>
<td></td>
<td>Vegetation</td>
<td>When the grass becomes excessively tall (greater than 10 inches); when nuisance weeds and/or other vegetation starts to take over.</td>
<td>Mow grass, control nuisance vegetation, such that flow is not impeded. Grass should be mowed to a height between 3-4 inches.</td>
</tr>
<tr>
<td></td>
<td>Erosion/Scouring</td>
<td>Eroded or scoured areas due to flow channelization, or higher flows.</td>
<td>For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the filter strip should be regraded and reseeded. For smaller bare areas, overseed when bare spots are evident.</td>
</tr>
<tr>
<td></td>
<td>Flow spreader</td>
<td>Flow spreader uneven or clogged so that flows are not uniformly distributed through entire filter width.</td>
<td>Level the spreader and clean so that flows are spread evenly over entire filter width.</td>
</tr>
</tbody>
</table>
## No. 11 – Wetponds

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Condition When Maintenance is Needed</th>
<th>Results Expected When Maintenance is Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Water level</td>
<td>First cell is empty, doesn't hold water.</td>
<td>Line the first cell to maintain water per the original design. Although the second cell may drain, the first cell must remain full to control turbulence of the incoming flow and reduce sediment resuspension.</td>
</tr>
<tr>
<td></td>
<td>Inlet/Outlet Pipe</td>
<td>Inlet/Outlet pipe clogged with sediment and/or debris material.</td>
<td>No clogging or blockage in the inlet and outlet piping.</td>
</tr>
<tr>
<td></td>
<td>Sediment Accumulation</td>
<td>Sediment accumulations in pond bottom that exceeds the depth of sediment zone plus 6 inches, usually in the first cell.</td>
<td>Sediment removed from pond bottom.</td>
</tr>
<tr>
<td></td>
<td>in Pond Bottom</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil Sheen on Water</td>
<td>Prevalent and visible oil sheen.</td>
<td>Oil removed from water using oil-absorbent pads or vactor truck. Source of oil located and corrected. If chronic low levels of oil persist, plant wetland plants such as Juncus effusus (soft rush) which can uptake small concentrations of oil.</td>
</tr>
<tr>
<td></td>
<td>Erosion</td>
<td>Erosion of the pond’s side slopes and/or scouring of the pond bottom that exceeds 6 inches, or where continued erosion is prevalent.</td>
<td>Slopes stabilized using proper erosion control measures and repair methods.</td>
</tr>
<tr>
<td>Berms</td>
<td>Settling</td>
<td>Any part of a berm which has settled at least 4 inches lower than the design elevation.</td>
<td>Berm is repaired and restored to the design elevation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If settlement is apparent, measure berm to determine amount of settlement.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Settling can be an indication of more severe problems with the berm or outlet works. Note: A licensed civil engineer may be needed to determine the cause of the settlement.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Internal Berm</td>
<td>Berm dividing cells should be level.</td>
<td>Berm surface is leveled so that water flows evenly over entire length of berm.</td>
</tr>
<tr>
<td></td>
<td>Erosion</td>
<td>Any erosion observed on a compacted structural berm embankment.</td>
<td>Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Note: A licensed civil engineer may be needed to inspect, evaluate and recommend a repair plan.</td>
<td></td>
</tr>
<tr>
<td>Maintenance Component</td>
<td>Defect</td>
<td>Condition When Maintenance is Needed</td>
<td>Results Expected When Maintenance is Performed</td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------</td>
<td>--------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Piping</td>
<td>Discernable water flow through a compacted structural berm. Ongoing erosion with potential for erosion to continue. Tree growth on a compacted structural berm over 4 feet in height may lead to piping through the berm which could lead to failure of the berm. Evidence of rodent holes in berm, and/or water piping through berm via rodent holes Note: A geotechnical engineer may be needed to inspect and evaluate condition and recommend repair of condition.</td>
<td>Piping eliminated. Erosion potential resolved.</td>
</tr>
<tr>
<td>Emergency Overflow/Spillway</td>
<td>Tree Growth</td>
<td>Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping.</td>
<td>Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. Note: A licensed civil engineer may be needed to determine proper berm/spillway restoration.</td>
</tr>
<tr>
<td>Rock Armoring</td>
<td>Rock layer on subgrade is less than 1.0 feet deep and/or subgrade is exposed</td>
<td>Rocks and pad depth are restored to a minimum depth of 1.0 feet.</td>
<td></td>
</tr>
<tr>
<td>Erosion</td>
<td>Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.</td>
<td>Slopes are stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.</td>
<td></td>
</tr>
<tr>
<td>Maintenance Component</td>
<td>Defect</td>
<td>Condition When Maintenance is Needed</td>
<td>Results Expected When Maintenance is Performed</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------</td>
<td>-------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>General</td>
<td>Trash/Debris Accumulation</td>
<td>Trash and debris accumulated in vault, pipe or inlet/outlet (includes floatables and non-floatables).</td>
<td>Remove trash and debris from vault.</td>
</tr>
<tr>
<td></td>
<td>Sediment Accumulation</td>
<td>Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6 inches.</td>
<td>Remove sediment from vault.</td>
</tr>
<tr>
<td></td>
<td>Damaged Pipes</td>
<td>Inlet/outlet piping damaged or broken and in need of repair.</td>
<td>Pipe repaired and/or replaced.</td>
</tr>
<tr>
<td></td>
<td>Access Hole Cover</td>
<td>One maintenance person cannot remove lid after applying normal lifting pressure with proper hand tools.</td>
<td>Cover can be removed and reinstalled by one maintenance person with proper hand tools.</td>
</tr>
<tr>
<td></td>
<td>Ventilation</td>
<td>Ventilation area blocked or plugged.</td>
<td>Blocking material removed or cleared from ventilation area. Specified % of the vault surface area provides ventilation to the vault interior (see design specifications).</td>
</tr>
<tr>
<td></td>
<td>Vault Structure Damage - Cracks in Walls Bottom, Damage to Frame and/or Top Slab</td>
<td>Cracks wider than 1/2 inch or evidence of soil particles entering the structure through the cracks, or qualified maintenance or inspection personnel determine that the vault is not structurally sound.</td>
<td>Vault replaced or repairs made so that vault meets design specifications and is structurally sound.</td>
</tr>
<tr>
<td></td>
<td>Baffles</td>
<td>Baffles corroding, cracking, warping and/or showing signs of failure as determined by qualified maintenance or inspection personnel.</td>
<td>Baffles repaired or replaced to specifications.</td>
</tr>
<tr>
<td></td>
<td>Access Ladder Damage</td>
<td>Ladder is corroded or deteriorated, not functioning properly, not attached to structure wall, missing rungs, has cracked/broken rungs and/or is misaligned. Confined space warning sign missing.</td>
<td>Ladder replaced or repaired to specifications, and allows maintenance person safe access. Replace sign warning of confined space entry requirements. Ladder and entry notification complies with OSHA standards.</td>
</tr>
</tbody>
</table>
### No. 13 – Sand Filters (above ground/open)

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Condition When Maintenance is Needed</th>
<th>Results Expected When Maintenance is Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above Ground</td>
<td>Sediment Accumulation on top layer</td>
<td>Sediment depth exceeds 1/2 inch.</td>
<td>No sediment deposit on top layer of sand filter that would impede permeability of the filter section.</td>
</tr>
<tr>
<td></td>
<td>Trash and Debris Accumulations</td>
<td>Trash and debris accumulated on sand filter bed.</td>
<td>Trash and debris removed from sand filter bed.</td>
</tr>
<tr>
<td></td>
<td>Sediment/Debris in Clean-Outs</td>
<td>When the clean-outs become fully or partially plugged with sediment and/or debris.</td>
<td>Sediment removed from clean-outs.</td>
</tr>
<tr>
<td></td>
<td>Sand Filter Media</td>
<td>Drawdown of water through the sand filter media takes longer than 24 hours, and/or flow through the overflow pipes occurs frequently.</td>
<td>Top several inches of sand are scraped. May require replacement of entire sand filter depth depending on extent of plugging (a sieve analysis is helpful to determine if the lower sand has too high a proportion of fine material).</td>
</tr>
<tr>
<td></td>
<td>Prolonged Flows</td>
<td>Sand is saturated for prolonged periods of time (several weeks) and does not dry out between storms due to continuous base flow or prolonged flows from detention facilities.</td>
<td>Low, continuous flows are limited to a small portion of the facility by using a low wooden divider or slightly depressed sand surface.</td>
</tr>
<tr>
<td></td>
<td>Short Circuiting</td>
<td>When flows become concentrated over one section of the sand filter rather than dispersed.</td>
<td>Flow and percolation of water through sand filter is uniform and dispersed across the entire filter area.</td>
</tr>
<tr>
<td></td>
<td>Erosion Damage to Slopes</td>
<td>Erosion over 2 inches deep where cause of damage is prevalent or potential for continued erosion is evident.</td>
<td>Slopes stabilized using proper erosion control measures.</td>
</tr>
<tr>
<td></td>
<td>Rock Pad Missing or Out of Place</td>
<td>Soil beneath the rock is visible.</td>
<td>Rock pad replaced or rebuilt to design specifications.</td>
</tr>
<tr>
<td></td>
<td>Flow Spreader</td>
<td>Flow spreader uneven or clogged so that flows are not uniformly distributed across sand filter.</td>
<td>Spreader leveled and cleaned so that flows are spread evenly over sand filter.</td>
</tr>
<tr>
<td></td>
<td>Damaged Pipes</td>
<td>Any part of the piping that is crushed or deformed more than 20% or any other failure to the piping.</td>
<td>Pipe repaired or replaced.</td>
</tr>
<tr>
<td>Maintenance Component</td>
<td>Defect</td>
<td>Condition When Maintenance is Needed</td>
<td>Results Expected When Maintenance is Performed</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>Below Ground Vault</td>
<td>Sediment Accumulation on Sand Media Section</td>
<td>Sediment depth exceeds 1/2 inch.</td>
<td>No sediment deposits on sand filter section that would impede permeability of the filter section.</td>
</tr>
<tr>
<td></td>
<td>Sediment Accumulation in Presettling Portion of Vault</td>
<td>Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6 inches.</td>
<td>No sediment deposits in first chamber of vault.</td>
</tr>
<tr>
<td></td>
<td>Trash/Debris Accumulation</td>
<td>Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.</td>
<td>Trash and debris removed from vault and inlet/outlet piping.</td>
</tr>
<tr>
<td></td>
<td>Sediment/Debris in Drain Pipes/Cleanouts</td>
<td>Sediment, trash, and/or other debris material located in any inlet, outlet, or cleanout pipe is blocking more than 1/3 of its height.</td>
<td>Sediment and debris removed.</td>
</tr>
<tr>
<td></td>
<td>Short Circuiting</td>
<td>When seepage/flow occurs along the vault walls and corners. Sand eroding near inflow area.</td>
<td>Sand filter media section re-laid and compacted along perimeter of vault to form a semi-seal. Erosion protection added to dissipate force of incoming flow and curtail erosion.</td>
</tr>
<tr>
<td></td>
<td>Damaged Pipes</td>
<td>Inlet or outlet piping damaged or broken and in need of repair.</td>
<td>Pipe repaired and/or replaced.</td>
</tr>
<tr>
<td></td>
<td>Access Hole Cover Damaged/Not Working</td>
<td>One maintenance person cannot remove lid after applying normal lifting pressure with proper hand tools.</td>
<td>Cover can be removed and reinstalled by one maintenance person with proper hand tools.</td>
</tr>
<tr>
<td></td>
<td>Ventilation</td>
<td>Ventilation area blocked or plugged</td>
<td>Blocking material removed or cleared from ventilation area. Specified % of the vault surface area provides ventilation to the vault interior (see design specifications).</td>
</tr>
<tr>
<td></td>
<td>Vault Structure Damaged; Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab</td>
<td>Cracks wider than 1/2 inch or evidence of soil particles entering the structure through the cracks, or qualified maintenance or inspection personnel determine that the vault is not structurally sound.</td>
<td>Vault replaced or repairs made so that vault meets design specifications and is structurally sound.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cracks wider than 1/2 inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.</td>
<td>Vault repaired so that no cracks exist wider than 1/4 inch at the joint of the inlet/outlet pipe.</td>
</tr>
<tr>
<td></td>
<td>Baffles/Internal walls</td>
<td>Baffles or walls corroding, cracking, warping and/or showing signs of failure as determined by qualified maintenance or inspection personnel.</td>
<td>Baffles repaired or replaced to specifications.</td>
</tr>
<tr>
<td></td>
<td>Access Ladder Damaged</td>
<td>Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, has cracked/broken rungs, and/or is misaligned.</td>
<td>Ladder replaced or repaired to specifications, and allows maintenance person safe access.</td>
</tr>
</tbody>
</table>
## No. 15 – Stormfilter™

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Condition When Maintenance is Needed</th>
<th>Results Expected When Maintenance is Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below Ground Vault</td>
<td>Sediment Accumulation on Media.</td>
<td>Sediment depth exceeds 1/4 inch.</td>
<td>No sediment deposits which would impede permeability of the compost media.</td>
</tr>
<tr>
<td></td>
<td>Sediment Accumulation in Vault</td>
<td>Sediment depth exceeds 6 inches in first chamber.</td>
<td>No sediment deposits in vault bottom of first chamber.</td>
</tr>
<tr>
<td></td>
<td>Trash/Debris Accumulation</td>
<td>Trash and debris accumulated on compost filter bed.</td>
<td>Trash and debris removed from the compost filter bed.</td>
</tr>
<tr>
<td></td>
<td>Sediment/Debris in Drain Pipes/Cleanouts</td>
<td>Sediment, trash, and/or other debris material located in any inlet, outlet, or cleanout pipe is blocking more than 1/3 of its height.</td>
<td>Sediment and debris removed.</td>
</tr>
<tr>
<td>Damaged Pipes</td>
<td>Any part of the pipes that are crushed or damaged due to corrosion and/or settlement.</td>
<td>Pipe repaired and/or replaced.</td>
<td></td>
</tr>
<tr>
<td>Access Hole Cover</td>
<td>Damaged/Not Working</td>
<td>One maintenance person cannot remove lid after applying normal lifting pressure with proper hand tools.</td>
<td>Cover can be removed and reinstalled by one maintenance person with proper hand tools.</td>
</tr>
<tr>
<td>Vault Structure</td>
<td>Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab</td>
<td>Cracks wider than 1/2 inch or evidence of soil particles entering the structure through the cracks, or qualified maintenance or inspection personnel determine that the vault is not structurally sound.</td>
<td>Vault replaced or repairs made so that vault meets design specifications and is structurally sound.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cracks wider than 1/2 inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.</td>
<td>Vault repaired so that no cracks exist wider than 1/4 inch at the joint of the inlet/outlet pipe.</td>
</tr>
<tr>
<td>Baffles</td>
<td>Baffles corroding, cracking warping, and/or showing signs of failure as determined by qualified maintenance or inspection personnel.</td>
<td>Baffles repaired or replaced to specifications.</td>
<td></td>
</tr>
<tr>
<td>Access Ladder</td>
<td>Damaged</td>
<td>Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, has cracked/broken rungs, and/or is misaligned.</td>
<td>Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.</td>
</tr>
<tr>
<td>Below Ground Cartridge Type</td>
<td>Media clogged</td>
<td>Drawdown of water through the media takes longer than 1 hour, and/or overflow occurs frequently.</td>
<td>Media cartridges replaced.</td>
</tr>
</tbody>
</table>

Check manufacturer’s operation and maintenance manual for complete maintenance instructions.
## No. 16 – API Baffle Oil/Water Separators

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Condition When Maintenance is Needed</th>
<th>Results Expected When Maintenance is Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Discharged Water Not Clean</td>
<td>Water discharged from facility has obvious signs of poor water quality.</td>
<td>Treated stormwater discharged from vault should be clear without thick visible sheen.</td>
</tr>
<tr>
<td></td>
<td>Sediment Accumulation</td>
<td>Sediment depth in bottom of vault exceeds 6 inches in depth.</td>
<td>No sediment deposits on vault bottom that would impede flow through the vault and reduce separation efficiency.</td>
</tr>
<tr>
<td></td>
<td>Trash and Debris Accumulation</td>
<td>Trash and debris accumulation in vault, or pipe inlet/outlet, floatables and non-floatables.</td>
<td>Trash and debris removed from vault, and inlet/outlet piping.</td>
</tr>
<tr>
<td></td>
<td>Oil Accumulation</td>
<td>Oil accumulations that exceed 1 inch, at the surface of the water.</td>
<td>Extract oil from vault by vactoring. Disposal in accordance with state and local regulations.</td>
</tr>
<tr>
<td></td>
<td>Damaged Pipes</td>
<td>Inlet or outlet pipes damaged or broken and in need of repair.</td>
<td>Pipes repaired or replaced.</td>
</tr>
<tr>
<td>Access Hole Cover</td>
<td>Damaged/Not Working</td>
<td>One maintenance person cannot remove lid after applying normal lifting pressure with proper hand tools.</td>
<td>Cover can be removed and reinstalled by one maintenance person with proper hand tools.</td>
</tr>
<tr>
<td>Vault Structure Damage</td>
<td>Includes</td>
<td>Cracks wider than 1/2 inch or evidence of soil particles entering the structure through the cracks, or qualified maintenance or inspection personnel determine that the vault is not structurally sound.</td>
<td>Vault replaced or repairs made so that vault meets design specifications and is structurally sound.</td>
</tr>
<tr>
<td></td>
<td>Cracks in Walls Bottom</td>
<td>Cracks wider than 1/2 inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.</td>
<td>Vault repaired so that no cracks exist wider than 1/4 inch at the joint of the inlet/outlet pipe.</td>
</tr>
<tr>
<td></td>
<td>Damage to Frame and/or Top Slab</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baffles</td>
<td></td>
<td>Baffles corroding, cracking, warping and/or showing signs of failure as determined by qualified maintenance or inspection personnel.</td>
<td>Baffles repaired or replaced to specifications.</td>
</tr>
<tr>
<td>Access Ladder Damage</td>
<td></td>
<td>Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, has cracked/broken rungs, and/or is misaligned.</td>
<td>Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.</td>
</tr>
</tbody>
</table>
## No. 17 – Coalescing Plate Oil/Water Separators

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Condition When Maintenance is Needed</th>
<th>Results Expected When Maintenance is Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Discharged Water Not Clean</td>
<td>Water discharged from facility has obvious signs of poor water quality.</td>
<td>Treated stormwater discharged from vault should be clear with no thick visible sheen.</td>
</tr>
<tr>
<td>Sediment Accumulation</td>
<td></td>
<td>Sediment depth in bottom of vault exceeds 6 inches in depth and/or visible signs of sediment on plates.</td>
<td>No sediment deposits on vault bottom and plate media, which would impede flow through the vault and reduce separation efficiency.</td>
</tr>
<tr>
<td>Trash and Debris Accumulation</td>
<td></td>
<td>Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.</td>
<td>Trash and debris removed from vault, and inlet/outlet piping.</td>
</tr>
<tr>
<td>Oil Accumulation</td>
<td></td>
<td>Oil accumulation that exceeds 1 inch at the water surface.</td>
<td>Oil is extracted from vault using vactoring methods. Coalescing plates are cleaned by thoroughly rinsing and flushing. Should be no visible oil depth on water.</td>
</tr>
<tr>
<td>Damaged Coalescing Plates</td>
<td></td>
<td>Plate media broken, deformed, cracked and/or showing signs of failure.</td>
<td>A portion of the media pack or the entire plate pack is replaced depending on severity of failure.</td>
</tr>
<tr>
<td>Damaged Pipes</td>
<td></td>
<td>Inlet or outlet pipes damaged or broken and in need of repair.</td>
<td>Pipes repaired and or replaced.</td>
</tr>
<tr>
<td>Baffles</td>
<td></td>
<td>Baffles corroding, cracking, warping and/or showing signs of failure as determined by qualified maintenance or inspection person.</td>
<td>Baffles repaired or replaced to specifications.</td>
</tr>
<tr>
<td>Vault Structure Damage - Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab</td>
<td></td>
<td>Cracks wider than 1/2 inch or evidence of soil particles entering the structure through the cracks, or qualified maintenance or inspection personnel determine that the vault is not structurally sound.</td>
<td>Vault replaced or repairs made so that vault meets design specifications and is structurally sound.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cracks wider than 1/2 inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.</td>
<td>Vault repaired so that no cracks exist wider than 1/4 inch at the joint of the inlet/outlet pipe.</td>
</tr>
<tr>
<td>Access Hole Cover</td>
<td>Damaged/Not Working</td>
<td>One maintenance person cannot remove lid after applying normal lifting pressure with proper hand tools.</td>
<td>Cover can be removed and reinstalled by one maintenance person with proper hand tools.</td>
</tr>
<tr>
<td>Access Ladder</td>
<td>Damaged</td>
<td>Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, has cracked/broken rungs, and/or is misaligned.</td>
<td>Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.</td>
</tr>
</tbody>
</table>
### No. 18 – Catchbasin Inserts

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Conditions When Maintenance is Needed</th>
<th>Results Expected When Maintenance is Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Sediment Accumulation</td>
<td>When sediment forms a cap over the insert media of the insert and/or unit.</td>
<td>No sediment cap on the insert media and its unit.</td>
</tr>
<tr>
<td></td>
<td>Trash and Debris Accumulation</td>
<td>Trash and debris accumulates on insert unit creating a blockage/restriction.</td>
<td>Trash and debris removed from insert unit. Runoff freely flows into catch basin.</td>
</tr>
<tr>
<td></td>
<td>Media Insert Not Removing Oil</td>
<td>Effluent water from media insert has a visible sheen.</td>
<td>Effluent water from media insert is free of oils and has no visible sheen.</td>
</tr>
<tr>
<td></td>
<td>Media Insert Water Saturated</td>
<td>Catch basin insert is saturated with water and no longer has the capacity to absorb.</td>
<td>Remove and replace media insert.</td>
</tr>
<tr>
<td></td>
<td>Media Insert-Oil Saturated</td>
<td>Media oil saturated due to petroleum spill that drains into catch basin.</td>
<td>Remove and replace media insert.</td>
</tr>
<tr>
<td></td>
<td>Media Insert Use Beyond Normal Product Life</td>
<td>Media has been used beyond the typical average life of media insert product.</td>
<td>Remove and replace media at regular intervals, depending on insert product.</td>
</tr>
</tbody>
</table>
### No. 19 – Bioretention Facilities

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Condition When Maintenance is Needed</th>
<th>Maintenance Action and Expected Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above Ground</td>
<td>Sediment accumulation</td>
<td>Sediment depth on bioretention bed exceeds 1/2 inch.</td>
<td>Remove sediment so that permeability is not impeded.</td>
</tr>
<tr>
<td></td>
<td>Trash or debris</td>
<td>Trash and debris accumulated on filter bed.</td>
<td>Remove trash and debris from filter bed.</td>
</tr>
<tr>
<td></td>
<td>sediment accumulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sediment or</td>
<td>Flow through overflow structure blocked so that standing pool depth is above design depth.</td>
<td>Remove sediment and debris from overflow structure.</td>
</tr>
<tr>
<td></td>
<td>debris in</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>overflow structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excessive</td>
<td>Drawdown time</td>
<td>Drawdown of water through the bioretention bed takes longer than 24 hours, or flow through the overflow</td>
<td>Remove and replace mulch or bioretention soil mix to restore permeability and/or clean underdrain.</td>
</tr>
<tr>
<td></td>
<td>drawdown time</td>
<td>pipes occurs frequently.</td>
<td></td>
</tr>
<tr>
<td>Short-circuiting</td>
<td>Water does not pond evenly over</td>
<td></td>
<td>Remove and replace mulch or bioretention soil mix to restore uniform pool depth.</td>
</tr>
<tr>
<td></td>
<td>bioretention bed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erosion or</td>
<td>Erosion or damaged areas over 2</td>
<td></td>
<td>Repair or stabilize slopes.</td>
</tr>
<tr>
<td></td>
<td>inches deep where cause of damage is</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>prevalent or potential for continued</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>erosion is evident.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy dissipaters at</td>
<td>Visible soil, missing rock, or other</td>
<td></td>
<td>Replace or rebuild energy dissipaters to design specifications.</td>
</tr>
<tr>
<td></td>
<td>inlet or overflow are</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>damaged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bioretention</td>
<td>Plants are damaged, diseased, or</td>
<td></td>
<td>Replace plants with healthy ones selected appropriately for the location in the facility.</td>
</tr>
<tr>
<td></td>
<td>dead</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weeds or</td>
<td>Weeds or invasive plants growing in</td>
<td></td>
<td>Remove weeds and invasive plants, replace with bioretention plants or cover affected areas with mulch, as appropriate.</td>
</tr>
<tr>
<td></td>
<td>bioretention facility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drainage System Feature</td>
<td>Potential Defect</td>
<td>Conditions When Maintenance Is Needed</td>
<td>Results Expected When Maintenance Is Performed Or Not Needed</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------------------------</td>
<td>--------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>General</td>
<td>Sediment Accumulation</td>
<td>Sediment depth is within 12 through 18 inches of dry weather water surface elevation.</td>
<td>Accumulated sediment should be removed.</td>
</tr>
<tr>
<td></td>
<td>Trash and Debris Accumulation</td>
<td>Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.</td>
<td>Trash and debris removed from vault, and inlet/outlet piping.</td>
</tr>
<tr>
<td></td>
<td>Oil Accumulation</td>
<td>Oil accumulation that exceeds 1-inch at the water surface.</td>
<td>Oil is extracted from vault using vactoring methods. Coalescing plates are cleaned by thoroughly rinsing and flushing. Should be no visible oil depth on water.</td>
</tr>
</tbody>
</table>

See Wet Vaults (No. 12)

Check manufacturer’s operation and maintenance manual for complete maintenance instructions.
### No. 21 - Conveyance Storm Pipes

<table>
<thead>
<tr>
<th>Drainage System Feature</th>
<th>Potential Defect</th>
<th>Conditions When Maintenance Is Needed</th>
<th>Results Expected When Maintenance Is Performed Or Not Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Obstructions, Including Roots</td>
<td>Root enters or deforms pipe, reducing flow.</td>
<td>Use mechanical methods to remove root if possible. Use of chemicals to remove roots shall be done in accordance with an Integrated Pest Management plan. If necessary, remove the vegetation over the line.</td>
</tr>
<tr>
<td></td>
<td>Pipe Dented or Broken</td>
<td>Inlet/outlet piping damaged or broken and in need of repair.</td>
<td>Pipe repaired and/or replaced.</td>
</tr>
<tr>
<td></td>
<td>Pipe Rusted or Deteriorated</td>
<td>Any part of the piping that is crushed or deformed more than 20% or any other failure to the piping.</td>
<td>Pipe repaired and/or replaced.</td>
</tr>
<tr>
<td></td>
<td>Sediment &amp; Debris</td>
<td>Sediment depth is greater than 20% of pipe diameter.</td>
<td>Install upstream debris traps (where applicable) then clean pipe and remove material.</td>
</tr>
<tr>
<td></td>
<td>Debris barrier or Trash Rack Missing</td>
<td>A debris barrier or trash rack that had been installed on the end of a drainage pipe is missing</td>
<td>Debris barrier or trash rack is replaced.</td>
</tr>
<tr>
<td></td>
<td>Joint/Seal Problems</td>
<td>The joint between pipe sections is separated and/or the seal at the joint is cracked or broken.</td>
<td>The joint and/or seal is repaired so that joint is not separated and is properly sealed.</td>
</tr>
</tbody>
</table>
### No. 22 - Facility Discharge Points

<table>
<thead>
<tr>
<th>Drainage System Feature</th>
<th>Potential Defect</th>
<th>Conditions When Maintenance Is Needed</th>
<th>Results Expected When Maintenance Is Performed Or Not Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inspection of Discharge Water for Obvious Signs of Poor Water Quality.</td>
<td>Sheen, obvious oil or other contaminants present.</td>
<td>Identify and eliminate pollution source AND report discharge to Snohomish County Surface Water Management Division. Effluent discharge from facility should be clear.</td>
</tr>
<tr>
<td></td>
<td>Receiving Area Saturated</td>
<td>Water in receiving area is causing substrate to become saturated and unstable.</td>
<td>Receiving area sound.</td>
</tr>
<tr>
<td>General</td>
<td>Rock Pad - Missing or Moved Rock</td>
<td>Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil where pad was originally installed.</td>
<td>Rock pad replaced to design standards.</td>
</tr>
<tr>
<td></td>
<td>Rock Pad - Erosion</td>
<td>Soil erosion in or adjacent to rock pad.</td>
<td>Rock pad replaced to design standards.</td>
</tr>
<tr>
<td></td>
<td>Obstructions, Including Roots</td>
<td>Roots or debris enters pipe or deforms pipe, reducing flow</td>
<td>Use mechanical methods to remove root if possible. Use of chemicals to remove roots shall be done in accordance with Integrated Pest Management plan. If necessary, remove the vegetation over the line.</td>
</tr>
<tr>
<td></td>
<td>Pipe Rusted or Deteriorated</td>
<td>Any part of the pipe that is broken, crushed or deformed more than 20% or any other failure to the piping</td>
<td>Pipe repaired or replaced.</td>
</tr>
</tbody>
</table>
### No. 23 – Access Gates

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Condition When Maintenance is Needed</th>
<th>Maintenance Action and Expected Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Damaged or missing components</td>
<td>Gate and/or locking mechanism condition is such that access is impeded.</td>
<td>Gate and locking mechanism are fully functional for access purposes.</td>
</tr>
<tr>
<td></td>
<td>Damaged or missing components</td>
<td>Broken or missing hinges such that gate cannot be easily opened and closed by a maintenance person.</td>
<td>Hinges intact and lubed. Gate is working freely.</td>
</tr>
<tr>
<td></td>
<td>Damaged or missing components</td>
<td>Gate is out of plumb more than 6 inches and more than 1 foot out of design alignment.</td>
<td>Gate is aligned and vertical (plumb).</td>
</tr>
<tr>
<td></td>
<td>Damaged or missing components</td>
<td>Missing stretcher bands, and ties.</td>
<td>Stretcher bar, bands, and ties in place.</td>
</tr>
</tbody>
</table>
## No. 24 – Access Roads

<table>
<thead>
<tr>
<th>Maintenance Component</th>
<th>Defect</th>
<th>Condition When Maintenance is Needed</th>
<th>Maintenance Action and Expected Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Road Surface</td>
<td>Condition of road surface may lead to erosion of the facility or limit access.</td>
<td>Road repaired.</td>
</tr>
<tr>
<td></td>
<td>Erosion of Ground Surface</td>
<td>Noticeable rills are seen in landscaped areas.</td>
<td>Causes of erosion are identified and steps taken to slow down/spread out the water. Eroded areas are filled, contoured, and seeded. If needed, regrade affected areas.</td>
</tr>
<tr>
<td></td>
<td>Vegetation</td>
<td>Function of road is impaired by vegetation</td>
<td>Vegetation is removed or managed to restore proper function of facility. Use of herbicides shall be in accordance with an Integrated Pest Management Plan.</td>
</tr>
<tr>
<td></td>
<td>Tree Growth</td>
<td>Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove.</td>
<td>Trees do not hinder maintenance activities.</td>
</tr>
<tr>
<td></td>
<td>Trees or shrubs that have fallen over road.</td>
<td></td>
<td>Fallen trees or shrubs removed from road.</td>
</tr>
</tbody>
</table>
Chapter 5 - On-Site Stormwater Management

This chapter presents the methods for design and implementation of on-site stormwater management best management practices (BMPs) required by SCC 30.63A.525. Implementation of the dispersion BMPs (T5.11 and T5.12), and Post-Construction Soil Quality and Depth (BMP T5.13), is required by SCC 30.63A.525 to the maximum extent feasible. Other BMPs in this chapter are not specifically required by Snohomish County code but can assist in reducing stormwater runoff and pollution from developed sites.

The on-site dispersion BMPs in this chapter are intended to receive runoff from pollution-generating impervious surfaces at single-family residential properties. Infiltration and dispersion BMPs intended for non-pollution-generating surfaces at these properties are described in Chapter 3, Volume III of this Manual. Because the BMPs in this chapter are intended to provide both flow control (via infiltration or attenuation) and stormwater treatment, the feasibility of their use is determined on the basis of soil, groundwater, and site characteristics related not only to infiltration capacity but also to pollution removal capacity.

Developers should note that some stormwater infiltration systems may be regulated by the Washington State Department of Ecology as Class V injection wells under Washington State's Underground Injection Control (UIC) program, set forth in Chapter 173-218 WAC. Generally speaking, Class V injection wells are wells or trenches that are deeper than they are wide, or which contain perforated pipe. Snohomish County does not implement or enforce the state UIC regulations.


Selection of Dispersion BMPs for pollution-generating impervious surfaces (PGIS) to meet Snohomish County code requirements.

The three dispersion BMPs in this chapter are Concentrated Flow Dispersion (BMP T5.11), Sheet Flow Dispersion (BMP T5.12), and Full Dispersion (BMP T5.30). As noted above, Snohomish County code requires implementation of the BMPs T5.11 and T5.12 to the maximum extent feasible. Both of these BMPs involve dispersing flow through a minimum length flow path some combination of native vegetation and area with soil amended to meet the requirements of BMP T5.13. The minimum flow path length is based on the specific method of dispersion. Use of these BMPs may allow the PGIS to be modeled as "landscaped area" in WWHM.

Runoff from PGIS on individual single-family residential lots must be dispersed using one or both of these BMPs if they can be designed for the site according to the design criteria and constraints set forth for the BMPs, and if the minimum depth from the bottom of the dispersion pad or trench to seasonal high water table, hardpan, or other low permeability layer is:

- 3 feet or more for threshold discharge areas of 10,000 square feet or less of pollution-generating impervious surface (PGIS);
• 5 feet or more for threshold discharge areas of greater than 10,000 square feet of PGIS;
• 5 feet or more in areas designated as high aquifer sensitive areas on Snohomish County’s Aquifer Recharge/Wellhead Protection map dated October 1, 2007;
• 10 feet from the base of any mining activity or regional infiltration pond.

If the design and groundwater criteria set forth above are not met, dispersion of runoff from PGIS is not feasible and must not be used. In such cases, runoff from driveways and other PGIS must be conveyed to an appropriately-designed treatment system.
5.3.1 Dispersion BMPs for Pollution-Generating Impervious Surfaces (PGIS)

BMP T5.11 Concentrated Flow Dispersion

Applications and Limitations

Concentrated flow dispersion can be used in any situation where flow can be dispersed through native vegetation or developed vegetated areas with soil amended to meet the requirements of BMP T5.13 - Post-Construction Soil Quality and Depth.

Design criteria for Concentrated Flow Dispersion

Figure 5.4 shows concentrated flow dispersion using a splash block or gravel pad, and also shows the use of a dispersion trench. In the splash block / gravel pad option, shown at the "uphill" end of each driveway in the figure, runoff is concentrated by a berm or slotted drain and discharged onto a splash block or gravel pad. In the dispersion trench option, shown at the "downhill" end of each driveway in the figure, runoff is concentrated by a berm or slotted drain to a dispersion trench.

a) Concentrated flow dispersion using a dispersion trench

- A minimum 25-foot flow path is required between the discharge point of the dispersion trench and any property line, structure, steep slope, stream, lake, wetland, lake, or other impervious surface.

- Dispersion trenches may only be used for concentrated flow dispersion if the native soil on site has the following characteristics:
  - The cation exchange capacity of the native soil is a minimum of 5 milliequivalents / 100 grams dry soil, as measured by USEPA Method 9081, Cation Exchange Capacity of Soils (Sodium Acetate).
  - The organic content of the native soil is 1 per cent or greater, as measured by ASTM D2974 – 07 - Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils.

  If these soil criteria cannot be met, this BMP can only be implemented by splash blocks or gravel pads.

- A maximum of 700 square feet of impervious area may drain to each dispersion trench.

- No erosion or flooding of downstream properties may result.

- Proposals to discharge runoff toward landslide hazard areas, above slopes greater than 20%, or above erosion hazard areas must be evaluated by a geotechnical engineer or licensed geologist and approved by Snohomish County.

- For sites with septic systems, discharges from a dispersion trench must be downgradient of the drainfield primary and reserve areas. This requirement may be waived by
Snohomish County if site topography clearly prohibits flows from intersecting the drainfield.

**Hydrologic modeling credit for concentrated flow dispersion using a dispersion trench**

Where a dispersion trench is used to implement BMP T5.11 and the runoff from the dispersion trench is discharged into an undisturbed native landscape area or an area that meets BMP T5.13, and the vegetated flow path is at least 25 feet, the impervious area may be modeled as landscaped area. This is done in the WWHM by entering the impervious area into the "landscaped area" field.

b) Concentrated flow dispersion using a splash block or gravel pad

- A minimum 50-foot flow path is required between the discharge point of the splash block or gravel pad and any property line, structure, steep slope, stream, lake, wetland, lake, or other impervious surface.
- Splash blocks or gravel pads must be placed on top of soil amended according to the criteria of BMP T5.13.
- A maximum of 700 square feet of impervious area may drain to each splash block or gravel pad.
- No erosion or flooding of downstream properties may result.
- Proposals to discharge runoff toward landslide hazard areas, above slopes greater than 20%, or above erosion hazard areas must be evaluated by a geotechnical engineer or licensed geologist and approved by Snohomish County.
- For sites with septic systems, discharges from a splash block or gravel pad must be downgradient of the drainfield primary and reserve areas. This requirement may be waived by Snohomish County if site topography clearly prohibits flows from intersecting the drainfield.

**Hydrologic modeling credit for concentrated flow dispersion using a splash block or gravel pad**

Where a splash block or gravel pad is used to implement BMP T5.11 and the runoff from the splash block or gravel pad is discharged into an undisturbed native landscape area or an area that meets BMP T5.13, and the vegetated flow path is at least 50 feet, the impervious area may be modeled as landscaped area. This is done in the WWHM by entering the impervious area into the "landscaped area" field.
Figure 5.4 – Typical Concentrated Flow Dispersion for Steep Driveways
BMP T5.12 Sheet Flow Dispersion

Applications and Limitations

Sheet flow dispersion from pollution-generating impervious surfaces can be used in areas with a slope of 15% or less where flow can be dispersed through native vegetation or developed vegetated areas with soil amended to meet the requirements of BMP T5.13 - Post-Construction Soil Quality and Depth. For areas with slopes greater than 15%, dispersion if feasible must be achieved by using BMP T5.11, Concentrated Flow Dispersion.

Design criteria for Sheet Flow Dispersion

Figure 5.5 shows sheet flow dispersion using a dispersion trench, and also shows sheet flow from pavement discharged through a "transition zone." The dispersion trench option, shown in the upper drawing in the figure, is identical to that used in BMP T5.11 - Concentrated Flow Dispersion. The transition zone option, shown in the lower drawing in the figure, involves direct discharge of sheet flow from the PGIS through a two-foot wide strip constructed of one of several materials.

a) Sheet flow dispersion using a dispersion trench

The design criteria and hydrologic modeling credit are the same as those set forth for a dispersion trench in BMP T5.11 - Concentrated Flow Dispersion.

b) Sheet flow dispersion using a transition zone

- Sheet flow from the PGIS shall be discharged into a two-foot-wide transition zone between the edge of the pollution-generating impervious surface and the downslope vegetation. The transition zone shall consist of an extension of pavement subgrade material, modular pavement, or drain rock.

- The transition zone material must be placed on top of soil amended according to the criteria of BMP T5.13.

- For up to 20 feet of sheet flow path on the PGIS, a minimum 10-foot flow path is required between the edge of the transition zone and any property line, structure, steep slope, stream, lake, wetland, lake, or other impervious surface. An additional 5 feet of flow path must be added for each addition 20 feet of width or fraction thereof.

- For up to 150 feet of sheet flow path on contributing cleared area (i.e., bare soil, non-native landscaping, lawn, and/or pasture), a minimum 25-foot flow path with a maximum 8% slope is required between the edge of the transition zone and any property line, structure, steep slope, stream, lake, wetland, lake, or other impervious surface. If the slope of the area receiving the flow is greater than 8%, the 25-foot flowpath length must be increased 1.5 feet for each percent increase in slope above 8%.
Proposals to discharge runoff toward landslide hazard areas, above slopes greater than 20%, or above erosion hazard areas must be evaluated by a geotechnical engineer or licensed geologist and approved by Snohomish County.

For sites with septic systems, discharges generated by the use of BMP T5.12 must be downgradient of the drainfield primary and reserve areas. This requirement may be waived by Snohomish County if site topography clearly prohibits flows from intersecting the drainfield.

*Hydrologic modeling credit for concentrated flow dispersion using a splash block or gravel pad*

Where a transition zone is used to implement BMP T5.12 and the runoff from the transition zone is discharged into an undisturbed native landscape area or an area that meets BMP T5.13, and the vegetated flow path meets the criteria described above, the impervious area may be modeled as landscaped area. This is done in the WWHM by entering the impervious area into the "landscaped area" field.
Figure 5.5 – Sheet Flow Dispersion for Driveways
5.3.2  Post-Construction Soil Quality

SCC 30.63A.525 requires the use of BMP T5.13 - Post-Construction Soil Quality and Depth on all development sites.
BMP T5.13 Post-Construction Soil Quality and Depth

**Purpose and Definition**

Naturally occurring (undisturbed) soil and vegetation provide important stormwater functions including: water infiltration; nutrient, sediment, and pollutant adsorption; sediment and pollutant biofiltration; water interflow storage and transmission; and pollutant decomposition. These functions are largely lost when development strips away native soil and vegetation and replaces it with minimal topsoil and sod. Not only are these important stormwater functions lost, but such landscapes themselves become pollution-generating pervious surfaces due to increased use of pesticides, fertilizers and other landscaping and household/industrial chemicals, the concentration of pet wastes, and pollutants that accompany roadside litter.

Establishing soil quality and depth regains greater stormwater functions in the post development landscape, provides increased treatment of pollutants and sediments that result from development and habitation, and minimizes the need for some landscaping chemicals, thus reducing pollution through prevention.

**Applications and Limitations**

Establishing a minimum soil quality and depth is not the same as preservation of naturally occurring soil and vegetation. However, establishing a minimum soil quality and depth will provide improved on-site management of stormwater flow and water quality.

Soil organic matter can be attained through numerous materials such as compost, composted woody material, biosolids, and forest product residuals. It is important that the materials used to meet the soil quality and depth BMP be appropriate and beneficial to the plant cover to be established. Likewise, it is important that imported topsoils improve soil conditions and do not have an excessive percent of clay fines.

**Design Guidelines**

- **Soil retention.** The duff layer and native topsoil should be retained in an undisturbed state to the maximum extent practicable. In any areas requiring grading remove and stockpile the duff layer and topsoil on site in a designated, controlled area, not adjacent to public resources and critical areas, to be reapplied to other portions of the site where feasible.

- **Soil quality.** All areas subject to clearing and grading that have not been covered by impervious surface, incorporated into a drainage facility or engineered as structural fill or slope shall, at project completion, demonstrate the following:

  1. A topsoil layer with a minimum organic matter content of ten percent dry weight in planting beds, and 5% organic matter content (based on a loss-on-ignition test) in turf areas, and a pH from 6.0 to 8.0 or matching the pH of the original undisturbed soil. The topsoil layer shall have a minimum depth of eight inches except where tree roots limit the depth of incorporation of amendments needed to meet the criteria. Subsoils below the topsoil layer should be scarified at least 4 inches with some incorporation of the upper material to avoid stratified layers, where feasible.

  2. Planting beds must be mulched with 2 inches of organic material
3. Quality of compost and other materials used to meet the organic content requirements:
   a. The organic content for “pre-approved” amendment rates can be met only using compost that meets the definition of “composted materials” in WAC 173-350-220. This code is available online at: http://www.ecy.wa.gov/programs/swfa/facilities/350.html.

   Compost used in bioretention areas should be stable, mature and derived from yard debris, wood waste, or other organic materials that meet the intent of the organic soil amendment specification. Biosolids and manure composts can be higher in bio-available phosphorus than compost derived from yard or plant waste and therefore are not allowed in bioretention areas due to the possibility of exporting bio-available phosphorus in effluent.

   The compost must also have an organic matter content of 35% to 65%, and a carbon to nitrogen ratio below 25:1.

   The carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.

   b. Calculated amendment rates may be met through use of composted materials as defined above; or other organic materials amended to meet the carbon to nitrogen ratio requirements, and meeting the contaminant standards of Grade A Compost. The resulting soil should be conducive to the type of vegetation to be established.

   • Implementation Options: The soil quality design guidelines listed above can be met by using one of the methods listed below.

     1. Leave undisturbed native vegetation and soil, and protect from compaction during construction.

     2. Amend disturbed soil according to the following procedures:

        b. Scarify subsoil to a depth of one foot

        c. In planting beds, place three inches of compost and till in to an eight-inch depth.

        d. In turf areas, place two inches of compost and till in to an eight-inch depth.

        e. Apply two to four inches of arborist wood chip, coarse bark mulch, or compost mulch to planting beds after final planting.

   Alternatively, disturbed soil can be amended on a site-customized manner so that it meets the soil quality criteria set forth above, as determined by a licensed engineer, geologist, landscape architect, or other person as approved by Snohomish County.

3. Stockpile existing topsoil during grading, and replace it prior to planting. Stockpiled topsoil must be amended if needed to meet the organic matter and depth requirements by following the procedures in method (2) above.

4. Import topsoil mix of sufficient organic content and depth to meet the organic matter and depth requirements.
More than one method may be used on different portions of the same site. Soil that already meets the depth and organic matter quality standards, and is not compacted, does not need to be amended.

**Maintenance**

- Soil quality and depth should be established toward the end of construction and once established, should be protected from compaction, such as from large machinery use, and from erosion.
- Soil should be planted and mulched after installation.
- Plant debris or its equivalent should be left on the soil surface to replenish organic matter.

**Flow Reduction Credits**

Flow reduction credits can be taken in runoff modeling when BMP T5.13 is used as part of a dispersion design under the conditions described in:

- BMP T5.11 Concentrated Flow Dispersion
- BMP T5.12 Sheet Flow Dispersion
- Chapter III, Appendix III-C, Section 7.5: Reverse Slope Sidewalks
- Chapter III, Appendix III-C, Section 7.2.4: Road projects
- Non-pollution-generating impervious surface dispersion BMPs in Chapter 3, Volume III.
5.3.2 Site Design BMPs

BMP T5.20 Preserving Natural Vegetation

NOTE: BMP T5.20 is not required by Chapters 30.63A or 30.63B SCC. It contains nonregulatory guidance regarding general practices for site design and maintenance.

Purpose and Definition

Preserving natural vegetation on-site to the maximum extent practicable will minimize the impacts of development on stormwater runoff. Preferably 65 percent or more of the development site should be protected for the purposes of retaining or enhancing existing forest cover and preserving wetlands and stream corridors.

Applications and Limitations

New development often takes place on tracts of forested land. In fact, building sites are often selected because of the presence of mature trees. However, unless sufficient care is taken and planning done, in the interval between buying the property and completing construction much of this resource is likely to be destroyed. The property owner is ultimately responsible for protecting as many trees as possible, with their understory and groundcover. This responsibility is usually exercised by agents, the planners, designers and contractors. It takes 20 to 30 years for newly planted trees to provide the benefits for which trees are so highly valued.

Forest and native growth areas allow rainwater to naturally percolate into the soil, recharging ground water for summer stream flows and reducing surface water runoff that creates erosion and flooding. Conifers can hold up to about 50 percent of all rain that falls during a storm. Twenty to 30 percent of this rain may never reach the ground but evaporates or is taken up by the tree. Forested and native growth areas also may be effective as stormwater buffers around smaller developments.

On lots that are one acre or greater, preservation of 65 percent or more of the site in natural vegetation will allow the use of full dispersion techniques presented in BMP T5.30. Sites that can fully disperse are not required to provide runoff treatment or flow control facilities.

Design Guidelines

- The preserved area should be situated to minimize the clearing of existing forest cover, to maximize the preservation of wetlands, and to buffer stream corridors.
- The preserved area should be placed in a separate tract or protected through recorded easements for individual lots.
- If feasible, the preserved area should be located downslope from the building sites, since flow control and water quality are enhanced by flow dispersion through duff, undisturbed soils, and native vegetation.
- The preserved area should be shown on all property maps and should be clearly marked during clearing and construction on the site.
**Maintenance**

- Vegetation and trees should not be removed from the natural growth retention area, except for approved timber harvest activities and the removal of dangerous and diseased trees.
BMP T5.21 Better Site Design

NOTE: BMP T5.21 is not required by Chapters 30.63A or 30.63B SCC. It contains nonregulatory guidance regarding general practices for site design and maintenance.

Purpose and Definition

Fundamental hydrological concepts and stormwater management concepts can be applied at the site design phase that are:

- more integrated with natural topography,
- reinforce the hydrologic cycle,
- more aesthetically pleasing, and
- often less expensive to build.

A few site planning principles help to locate development on the least sensitive portions of a site and accommodate residential land use while mitigating its impact on stormwater quality.

Design Guidelines

- **Define Development Envelope and Protected Areas** - The first step in site planning is to define the development envelope. This is done by identifying protected areas, setbacks, easements and other site features, and by consulting applicable local standards and requirements. Site features to be protected may include important existing trees, steep slopes, erosive soils, riparian areas, or wetlands.

  By keeping the development envelope compact, environmental impacts can be minimized, construction costs can be reduced, and many of the site’s most attractive landscape features can be retained. In some cases, economics or other factors may not allow avoidance of all sensitive areas. In these cases, care can be taken to mitigate the impacts of development through site work and other landscape treatments.

- **Minimize Directly Connected Impervious Areas** - Impervious areas directly connected to the storm drain system are the greatest contributors to urban nonpoint source pollution. Any impervious surface that drains into a catch basin or other conveyance structure is a “directly connected impervious surface.” As stormwater runoff flows across parking lots, roadways, and other paved areas, the oil, sediment, metals, and other pollutants are collected and concentrated. If this runoff is collected by a drainage structure and carried directly along impervious gutters or in sealed underground pipes, it has no opportunity for filtering by plant material or infiltration into the soil. It also increases in velocity and amount, causing increased peak-flows in the winter and decreased base-flows in the summer.

  A basic site design principle for stormwater management is to minimize these directly connected impervious areas. This can be done by limiting overall impervious land coverage or by infiltrating and/or dispersing runoff from these impervious areas.
Maximize Permeability - Within the development envelope, many opportunities are available to maximize the permeability of new construction. These include minimizing impervious areas, paving with permeable materials, clustering buildings, and reducing the land coverage of buildings by smaller footprints. All of these strategies make more land available for infiltration and dispersion through natural vegetation.

Clustered driveways, small visitor parking bays and other strategies can also minimize the impact of transportation-related surfaces while still providing adequate access.

Once site coverage is minimized through clustering and careful planning, pavement surfaces can be selected for permeability. A patio of brick-on-sand, for example, is more permeable than a large concrete slab. Engineered soil/landscape systems are permeable ground covers suitable for a wide variety of uses. Permeable/porous pavements can be used in place of traditional concrete or asphalt pavements in many low traffic applications.

Maximizing permeability at every possible opportunity requires the integration of many small strategies. These strategies will be reflected at all levels of a project, from site planning to materials selection. In addition to the environmental and aesthetic benefits, a high-permeability site plan may allow the reduction or elimination of expensive runoff underground conveyance systems, flow control and treatment facilities, yielding significant savings in development costs.

Build Narrower Streets - More than any other single element, street design has a powerful impact on stormwater quantity and quality. In residential development, streets and other transportation-related structures typically can comprise between 60 and 70 percent of the total impervious area, and, unlike rooftops, streets are almost always directly connected to the stormwater conveyance system.

The combination of large, directly connected impervious areas, together with the pollutants generated by automobiles, makes the street network a principal contributor to stormwater pollution in residential areas.

Street design is usually mandated by local municipal standards. These standards have been developed to facilitate efficient automobile traffic and maximize parking. Most require large impervious land coverage. In recent years, new street standards have been gaining acceptance that meet the access requirements of local residential streets while reducing impervious land coverage. These standards generally create a new class of street that is narrower than the current local street standard, called an "access" street. An access street is intended only to provide access to a limited number of residences.

Because street design is the greatest factor in a residential development’s impact on stormwater quality, it is important that designers, municipalities and developers employ street standards that reduce impervious land coverage.

Maximize Choices for Mobility - Given the costs of automobile use, both in land area consumed and pollutants generated, maximizing choices for mobility is a basic principle
for environmentally responsible site design. By designing residential developments to promote alternatives to automobile use, a primary source of stormwater pollution can be mitigated.

Bicycle lanes and paths, secure bicycle parking at community centers and shops, direct, safe pedestrian connections, and transit facilities are all site-planning elements that maximize choices for mobility.

- **Use Drainage as a Design Element** - Unlike conveyance storm drain systems that hide water beneath the surface and work independently of surface topography, a drainage system for stormwater infiltration or dispersion can work with natural land forms and land uses to become a major design element of a site plan.

By applying stormwater management techniques early in the site plan development, the drainage system can suggest pathway alignments, optimum locations for parks and play areas, and potential building sites. In this way, the drainage system helps to generate urban form, giving the development an integral, more aesthetically pleasing relationship to the natural features of the site. Not only does the integrated site plan complement the land, it can also save on development costs by minimizing earthwork and expensive drainage features.
5.3.3 Other Practices

BMP T5.30 Full Dispersion

Purpose and Definition
This BMP allows for "fully dispersing" runoff from impervious surfaces and cleared areas of development sites that protect at least 65% of the site (or a threshold discharge area on the site) in a forest or native condition.

Applications and Limitations

- Rural single family residential developments should use these dispersion BMPs wherever possible to minimize effective impervious surface to less than 10% of the development site.

- Other types of development that retain 65% of the site (or a threshold discharge area on the site) in a forested or native condition may also use these BMPs to avoid triggering the flow control facility requirement.

- The preserved area should be situated to minimize the clearing of existing forest cover, to maximize the preservation of wetlands (though the wetland area and any streams and lakes do not count toward the 65% forest or native condition area), and to buffer stream corridors.

- The preserved area should be placed in a separate tract or protected through recorded easements for individual lots.

- The preserved area should be shown on all property maps and should be clearly marked during clearing and construction on the site.

- All trees within the preserved area at the time of permit application shall be retained, aside from approved timber harvest activities and the removal of dangerous or diseased trees.

- The preserved area may be used for passive recreation and related facilities, including pedestrian and bicycle trails, nature viewing areas, fishing and camping areas, and other similar activities that do not require permanent structures, provided that cleared areas and areas of compacted soil associated with these areas and facilities do not exceed eight percent of the preserved area.

Design Criteria

- Infiltration and dispersion of runoff from non-pollution-generating surfaces

Non-pollution-generating impervious surfaces (NPGIS) that comply with the downspout infiltration requirements in Volume III, Chapter 3, are considered to be "fully dispersed" (i.e., zero percent effective imperviousness). All other NPGIS are considered to be "fully dispersed" (i.e., at or approaching zero percent effective imperviousness) only if they are within a threshold discharge area that is or will be more than 65% forested (or
native vegetative cover) and less than 10% impervious (total), AND if they comply with the NPGIS dispersion requirements of Chapter 3.1.2, Volume III, and have vegetated flow paths through native vegetation exceeding 100 feet.

- **Driveway Dispersion**

  Driveway surfaces are considered to be "fully dispersed" if they are within a threshold discharge area that is or will be more than 65% forested (or native vegetative cover) and less than 10% impervious (total), AND if they comply with the driveway dispersion BMPs – BMP 5.11 and BMP T5.12 - and have flow paths through native vegetation exceeding 100 feet. This also holds true for any driveway surfaces that comply with the roadway dispersion BMPs described below.

- **Roadway Dispersion**

  Roadway surfaces are considered to be "fully dispersed" if they are within a threshold discharge area that is or will be more than 65% forested (or native vegetative cover) and less than 10% impervious (total), AND if they comply with the following dispersion requirements:

  1. Roadway runoff dispersion is allowed only on rural neighborhood collectors and local access streets. To the extent feasible, driveways should be dispersed to the same standards as roadways to ensure adequate water quality protection of downstream resources.

  2. The road section shall be designed to minimize collection and concentration of roadway runoff. Sheet flow over roadway fill slopes (i.e., where roadway subgrade is above adjacent right-of-way) should be used wherever possible to avoid concentration.

  3. When it is necessary to collect and concentrate runoff from the roadway and adjacent upstream areas (e.g., in a ditch on a cut slope), concentrated flows shall be incrementally discharged from the ditch via cross culverts or at the ends of cut sections. These incremental discharges of newly concentrated flows shall not exceed 0.5 cfs at any one discharge point from a ditch for the 100-year runoff event. Where flows at a particular ditch discharge point were already concentrated under existing site conditions (e.g., in a natural channel that crosses the roadway alignment), the 0.5-cfs limit would be in addition to the existing concentrated peak flows.

  4. Ditch discharge points with up to 0.2 cfs discharge for the peak 100-year flow shall use rock pads or dispersion trenches to disperse flows. Ditch discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow shall use only dispersion trenches to disperse flows.

  5. Dispersion trenches shall be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end, shall be aligned perpendicular to the flowpath, and shall be minimum 2 feet by 2 feet in section, 50 feet in length, filled with ¾-inch to 1½-inch washed rock, and provided with a level notched grade board (see EDDS Standard drawing 5-080A). Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between up to 4 trenches. Dispersion trenches shall have a minimum spacing of 50 feet.
6. After being dispersed with rock pads or trenches, flows from ditch discharge points must traverse a minimum of 100 feet of undisturbed native vegetation before leaving the project site, or entering an existing onsite channel carrying existing concentrated flows across the road alignment.

Note: In order to provide the 100-foot flowpath length to an existing channel, some roadway runoff may unavoidably enter the channel undispersed. Also note that water quality treatment may be waived for roadway runoff dispersed through 100 feet of undisturbed native vegetation.

7. Flowpaths from adjacent discharge points must not intersect within the 100-foot flowpath lengths, and dispersed flow from a discharge point must not be intercepted by another discharge point. To enhance the flow control and water quality effects of dispersion, the flowpath shall not exceed 15% slope, and shall be located within designated open space.

Note: Runoff may be conveyed to an area meeting these flowpath criteria.

8. Ditch discharge points shall be located a minimum of 100 feet upgradient of steep slopes (i.e., slopes steeper than 40%), wetlands, and streams.

9. Where Snohomish County determines there is a potential for significant adverse impacts downstream (e.g., erosive steep slopes or existing downstream drainage problems), dispersion of roadway runoff may not be allowed, or other measures may be required.

- **Cleared Area Dispersion**

  The runoff from cleared areas that are comprised of bare soil, non-native landscaping, lawn, and/or pasture is considered to be "fully dispersed" if it is dispersed through at least 25 feet of native vegetation in accordance with the following criteria:

  1. The contributing flowpath of cleared area being dispersed must be no more than 150 feet, AND
  2. Slopes within the 25-foot minimum flowpath through native vegetation should be no steeper than 8%. If this criterion cannot be met due to site constraints, the 25-foot flowpath length must be increased 1.5 feet for each percent increase in slope above 8%.
Chapter 6 - Pretreatment

6.1 Purpose

This chapter presents the methods that may be used to provide pretreatment prior to basic or enhanced runoff treatment facilities. Pretreatment must be provided in the following applications:

- for sand and media filtration and infiltration BMPs to protect them from excessive siltation and debris
- where the basic treatment facility or the receiving water may be adversely affected by non-targeted pollutants (e.g., oil), or may be overwhelmed by a heavy load of targeted pollutants (e.g., suspended solids).

6.2 Application

Presettling basins are a typical pretreatment BMP used to remove suspended solids. All of the basic runoff treatment facilities may also be used for pretreatment to reduce suspended solids. Catchbasin inserts may be appropriate in some circumstances to provide oil or TSS control, depending on the type of insert. Some of the manufactured storm drain structures presented in Chapter 12 may also be used for pretreatment for oil or TSS reduction.

A detention pond sized to meet the flow control standard in Volume I may also be used to provide pretreatment for suspended solids removal.

6.3 Best Management Practices (BMPs) for Pretreatment

This Chapter has only one BMP - BMP T6.10 for presettling basins. As noted in Chapter 6.2, there are other BMPs that may also meet the requirements for pretreatment for specific projects.

BMP T6.10 Presettling Basin

Purpose and Definition

A Presettling Basin provides pretreatment of runoff in order to remove suspended solids, which can impact other runoff treatment BMPs.

Application and Limitations

Runoff treated by a Presettling Basin may not be discharged directly to a receiving water; it must be further treated by a basic or enhanced runoff treatment BMP.

Design Criteria

See Chapter 5 Snohomish County EDDS.

Setbacks

Setbacks shall be in accordance with SCC 30.63A.710 and other applicable regulations of the state or Snohomish Health District.
Chapter 7 - Infiltration and Bioinfiltration Treatment Facilities

7.1 Purpose
A stormwater infiltration treatment facility is an impoundment; typically a basin, trench, or bioinfiltration swale whose underlying soil removes pollutants from stormwater. The infiltration BMPs described in this chapter include:

BMP T7.10 Infiltration basins
BMP T7.20 Infiltration trenches
BMP T7.30 Bioinfiltration swales

Infiltration treatment soils must contain sufficient organic matter and/or clays to sorb, decompose, and/or filter stormwater pollutants. Pollutant/soil contact time, soil sorptive capacity, and soil aerobic conditions are important design considerations.

Information regarding site criteria, infiltration rates, site suitability, and design details for infiltration treatment BMPs is set forth in Volume III, Chapter 3. Design details regarding BMP T7.30, Bioinfiltration swales, is retained in this chapter since that BMP serves only an infiltration treatment function.

7.2 Application
Infiltration treatment systems are typically installed:

- As off-line systems, or on-line for small drainages
- As a polishing treatment for street/highway runoff after pretreatment for TSS and oil
- As part of a treatment train
- As retrofits at sites with limited land areas, such as residential lots, commercial areas, parking lots, and open space areas.
- With appropriate pretreatment for oil and silt control to prevent clogging. Appropriate pretreatment devices include a pre-settling basin, wet pond/vault, biofilter, constructed wetland, media filter, and oil/water separator.

An infiltration basin is preferred, where applicable, and where a trench or bioinfiltration swale cannot be sufficiently maintained.

7.3 General Considerations
See Volume III, Chapter 3.3.
7.4 Best Management Practices (BMPs) for Infiltration and Bioinfiltration Treatment

The three BMPs discussed below are recognized currently as effective treatment techniques using infiltration and bioinfiltration. Specific BMPs shall be selected in accordance with Volume I, Chapter 4.

BMP T7.10 Infiltration Basins
See Volume III, Chapter 3.

BMP T7.20 Infiltration Trenches
See section 3.3.11, Chapter 3, Volume III.

BMP T7.30 Bioinfiltration Swale

Description
Bioinfiltration swales combine grassy vegetation and soils to remove stormwater pollutants by percolation into the ground. Their pollutant removal mechanisms include filtration, soil sorption, and uptake by vegetative root zones.

In general, bioinfiltration swales are used for treating stormwater runoff from roofs, roads and parking lots. Runoff volumes greater than water quality design volume are typically overflowed to the subsurface through an appropriate conveyance facility such as a dry well, or an overflow channel to surface water. Overflows that are directed to a surface water must meet the requirements of SCC 30.63A.550 through SCC 30.63A.570.

Additional Design Criteria Specific for Bioinfiltration Swales

- Pretreatment is required.
- The space available for ponding water within a Bioinfiltration swale can be sized by either:
  - Completely retaining the water quality design volume, i.e., the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model (or, the runoff volume from a 6-month 24-hour storm). No reduction in volume is taken for any infiltration. Under this option, the overflow to a dry well or to a surface water must be above the elevation corresponding to the water quality design volume.
  - Using the same design sizing procedures outlined in Chapter 3 of Volume III for infiltration facilities designed as treatment facilities.
- Drawdown time for the water quality design volume: 48 hours max. See Site Suitability Criterion (SSC 4) in Section 3.3.7, Chapter 3, Volume III.
- Swale bottom: flat with a longitudinal slope less than 1%.
• The maximum ponded level: 6 inches.
• Treatment soil to be at least 18 inches thick with a CEC of at least 5 meq/100 gm dry soil, organic content of at least 1%, and sufficient target pollutant loading capacity.
• The treatment zone depth of 6 inches or more should contain sufficient organics and texture to ensure good growth of the vegetation.
• The treatment soil infiltration rate should not exceed 1-inch per hour for a treatment zone depth of 6 inches relying on the root zone to enhance pollutant removal. The Site Suitability Criteria in Section 3.3.7 of Chapter 3, Volume III must also be applied, if a design soil depth of 18 inches is used then a maximum infiltration rate of 2.4 inches per hour is applicable.
• Use native or adapted grass.
• If the Stormwater Site Plan identifies pollutants that could cause a violation of Ecology's ground water quality Standards (Chapter 173-200 WAC), appropriate mitigation measures must be required to ensure groundwater standards will not be violated.
Chapter 8 - Sand Filtration Treatment Facilities and Bioretention Facilities used for Treatment Only

This chapter presents criteria for the design, construction and maintenance of runoff treatment sand filters including basin, vault, and linear filters. Two Best Management Practices (BMPs) are discussed in this Chapter:

BMP T8.10 Sand Filter Vault
BMP T8.20 Linear Sand Filter

NOTE: Bioretention systems provide enhanced treatment if they are sized according to the criteria used for basic sand filters (i.e., treating 91% of the total runoff volume predicted by WWHM or an approved equivalent model). Design and construction criteria for bioretention systems are set forth in Volume III, Chapter 3.

8.1 Purpose
Sand filters can provide basic treatment or other treatment in accordance with the requirements of Volume I, Chapter 4.

8.2 Description
A typical sand filtration system consists of a pretreatment system, flow spreader(s), a sand bed, and the underdrain piping. The sand filter bed includes a geotextile fabric between the sand bed and the bottom underdrain system.

An impermeable liner under the facility may also be needed if the filtered runoff requires additional treatment to remove soluble ground water pollutants, or in cases where additional ground water protection was mandated. The variations of a sand filter include a basic or large sand filter, sand filter with level spreader, sand filter vault, and linear sand filter. Figures 5.6 through 5.11 and EDDS Standard Drawings 5-300A and 5-300B provide information on various sand filter configurations.
Figure 5.6 – Sand Filtration Basin Preceded by Presettling Basin
Figure 5.7 – Sand Filter with Pretreatment Cell
Figure 5.8 – Sand Filter with Pretreatment Cell (Section)
Figure 5.9 – Sand Filter with Level Spreader
Figure 5.10 Sand Filter with Level Spreader (Sections)
Figure 5.11 – Example Isolation/Diversion Structure
8.3 [RESERVED]

8.4 Applications and Limitations

See Chapter 5-13 of Snohomish County EDDS.

8.5 [RESERVED]

8.6 Design Criteria

Objective: To capture and treat the Water Quality Design Storm volume which is 91% of the total runoff volume (95% for large sand filter) as predicted by Western Washington Hydrology Model (WWHM) (or an approved, equivalent continuous runoff model). Only 9% of the total runoff volume (5% for large sand filter) would bypass or overflow from the sand filter facility. Off-line sand filters can be located either upstream or downstream of detention facilities. On-line sand filters should only be located downstream of detention to prevent exposure of the sand filter surface to high flow rates that could cause loss of media and previously removed pollutants.

Basic Sand Filter:

A summary of the basic sand filter design requirements are given below. For off-line facilities, a flow splitter should be designed to route the water quality design flow rate to the sand filter.

On-line sand filters must NOT be placed upstream of a detention facility. This is to prevent exposure of the sand filter surface to high flow rates that could cause loss of media and previously removed pollutants.

On-line sand filters placed downstream of a detention facility must be sized using a continuous runoff model (WWHM or an approved equivalent model) to filter 91% of the runoff volume.

Off-line sand filters placed upstream of a detention facility must have a flow splitter designed to send all flows at or below the 15-minute water quality flow rate, as predicted by WWHM, to the sand filter. The sand filter must be sized to filter all the runoff sent to it (no overflows from the treatment facility should occur). Note that WWHM2 allows any bypasses and the runoff filtered through the sand to be directed to the downstream detention facility.

Off-line sand filters placed downstream of a detention facility must have a flow splitter designed to send all flows at or below the 2-year flow frequency from the detention pond, as predicted by WWHM, to the treatment facility. The treatment facility must be sized to filter all the runoff sent to it (no overflows from the treatment facility should occur).

Large Sand Filter: For a summary of the large sand filter design requirements follow the requirements for the basic sand filter except, for the percent runoff filtered, use 95% instead of 91%.

Note: An overflow should be included in the design of the basic and large sand filter pond. The overflow height should be at the maximum hydraulic head of the pond above the sand bed.
**Underdrains**

Underdrains for sand filters include the following configurations:

- a central collector pipe with lateral feeder pipes;
- a geotextile drain strip in an 8-inch gravel backfill or drain rock bed;
- longitudinal pipes in an 8-inch gravel backfill or drain rock with a collector pipe at the outlet end.

**Design Criteria:**

Engineering standards and specifications for sand filters and other granular media filters are set forth in Section 5-13 of Snohomish County EDDS.

**Sand specification**

The sand in a filter must consist of a medium sand meeting the size gradation (by weight) given in Table 5.4 below. The contractor must obtain a grain size analysis from the supplier to certify that the No. 100 and No. 200 sieve requirements are met. Note: 2008 WSDOT Standard Specifications, Section 9-03.13 Standard Backfill for Sand Drains, does not meet this specification and shall not be used for sand filters.

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**8.7 [Reserved]**

**8.8 Maintenance**

Maintenance requirements for drainage facilities are set forth in Chapter 7.53.140 SCC and Volume V, Chapter 4.6 of this manual. The following information is offered as non-regulatory recommendations.

- Accumulated silt and debris on top of the sand filter should be removed when their depth exceeds 1/2-inch. The silt should be scraped off during dry periods with steel rakes or other devices. Once sediment is removed, the design permeability of the filtration media can typically be restored by then striating the surface layer of the media. Finer sediments that have penetrated deeper into the filtration media can reduce the permeability to unacceptable levels, necessitating replacement of some or all of the sand.
• Sand replacement frequency is not well established and will depend on suspended solids levels entering the filter (the effectiveness of the pretreatment BMP can be a significant factor).

• Frequent overflow into the spillway or overflow structure or slow drawdown are indicators of plugging problems. The sand filter basin and the presettling basin should empty in 24 hours following a storm event, depending on the basin depth. If the hydraulic conductivity drops to one (1) inch per hour corrective action is needed, e.g.:
  - Scraping the top layer of fine-grain sediment accumulation (mid-winter scraping is suggested)
  - Removal of thatch
  - Aerating the filter surface
  - Tilling the filter surface (late-summer rototilling is suggested)
  - Replacing the top 4 inches of sand.
  - Inspecting geotextiles for clogging

• Rapid drawdown in the sand bed (greater than 12 inches per hour) indicates short-circuiting of the filter. Inspect the cleanouts on the underdrain pipes and along the base of the embankment for leakage.

• Drawdown tests for the sand bed could be conducted, as needed, during the wet season. These tests can be conducted by allowing the filter to fill (or partially fill) during a storm event, then measuring the decline in water level over a 4-8 hour period. An inlet and an underdrain outlet valve would be necessary to conduct such a test.

• Formation of rills and gullies on the surface of the filter indicates improper function of the inlet flow spreader, or poor sand compaction. Check for accumulation of debris on or in the flow spreader and refill rills and gullies with sand.

• Avoid driving heavy equipment on the filter basin to prevent compaction and rut formation.
BMP T8.10  Sand Filter Vault

Description:

A sand filter vault is similar to an open sand filter except that the sand layer and underdrains are installed below grade in a vault. It consists of presettling and sand filtration cells. See EDDS Standard Drawings 5-300A and 5-300B.

Applications and Limitations

- Use where space limitations preclude above ground facilities
- Not suitable where high water table and heavy sediment loads are expected
- An elevation difference of 4 feet between inlet and outlet is needed

Design Criteria

Engineering standards and specifications for sand filter vaults and other granular media filter vaults are set forth in Section 5-17 of Snohomish County EDDS.
BMP T8.20  Linear Sand Filter

Description:

Linear sand filters are typically long, shallow, two-celled, rectangular vaults. The first cell is designed for settling coarse particles, and the second cell contains the sand bed. Stormwater flows into the second cell via a weir section that also functions as a flow spreader. See EDDS Standard Drawings 5-300A and 5-300B.

Application and Limitations

- Applicable in long narrow spaces such as the perimeter of a paved surface.
- As a part of a treatment train as downstream of a filter strip, upstream of an infiltration system, or upstream of a wet pond or a biofilter for oil control.
- To treat small drainages (less than 2 acres of impervious area).
- To treat runoff from high-use sites for TSS and oil/grease removal, if applicable.

Design Criteria

Engineering standards and specifications for sand filter vaults and other granular media filter vaults are set forth in Section 5-17 of Snohomish County EDDS. Additional design criteria are set forth below:

- The two cells should be divided by a divider wall that is level and extends a minimum of 12 inches above the sand bed.
- Stormwater may enter the sediment cell by sheet flow or a piped inlet.
- The width of the sand cell must be 1-foot minimum to 15 feet maximum.
- The sand cell filter bed must be a minimum of 12 inches deep and have an 8-inch layer of drain rock with perforated drainpipe beneath the sand layer.
- The drainpipe set in the drain rock layer must be 6-inch diameter minimum and be wrapped in geotextile and sloped a minimum of 0.5 percent.
- Maximum sand cell filter bed ponding depth: 1 foot.
- Set sediment cell with as follows:

<table>
<thead>
<tr>
<th>Sand filter width W (inches)</th>
<th>12 to 24</th>
<th>24 to 48</th>
<th>48 to 72</th>
<th>72 +</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sediment cell width (inches)</td>
<td>12</td>
<td>18</td>
<td>24</td>
<td>W / 3</td>
</tr>
</tbody>
</table>
Chapter 9 - Biofiltration Treatment Facilities

This Chapter addresses five Best Management Practices (BMPs) that are classified as biofiltration treatment facilities:

Biofilters are vegetated treatment systems (typically grass) that remove pollutants by means of sedimentation, filtration, soil sorption, and/or plant uptake. They are typically configured as swales or flat filter strips.

9.1 Purpose

Biofiltration facilities, used by themselves, provide basic treatment. They can be used in combination with other treatment facilities in systems that provide additional treatment, in accordance with the requirements of Volume I, Chapter 4.

9.2 Applications

A biofilter can be used as a basic treatment BMP for contaminated stormwater runoff from roadways, driveways, parking lots, and highly impervious ultra-urban areas or as the first stage of a treatment train. In cases where hydrocarbons, high TSS, or debris would be present in the runoff, such as high-use sites, a pretreatment system for those components would be necessary. Off-line location is preferred to avoid flattening vegetation and the erosive effects of high flows. Biofilters should be considered in retrofit situations where appropriate.

9.3 Site Suitability

The following factors must be considered for determining site suitability:

- Target pollutants are amenable to biofilter treatment
- Accessibility for Operation and Maintenance
- Suitable growth environment; (soil, etc.) for the vegetation
- Adequate siting for a pre-treatment facility if high petroleum hydrocarbon levels (oil/grease) or high TSS loads could impair treatment capacity or efficiency
- If the biofilter can be impacted by snowmelts and ice, refer to Caraco and Claytor for additional design criteria (USEPA, 1997).


9.4 Best Management Practices

This Chapter presents the following Biofiltration Treatment BMPs:

BMP T9.10 – Basic Biofiltration Swale
BMP T9.20 - Wet Biofiltration Swale
BMP T9.30 – Continuous Inflow Biofiltration Swale
BMP T9.40 – Basic Filter Strip & Compost-Amended Filter Strip
BMP T9.50 – Narrow Area Filter Strip
BMP T9.10  Basic Biofiltration Swale

Description:

Biofiltration swales are typically shaped as a trapezoid or a parabola as shown in Figure 5.12.

Limitations:

Data suggest that the performance of biofiltration swales is highly variable from storm to storm. It is therefore recommended that treatment methods providing more consistent performance, such as sand filters and wet ponds, be considered first. Swales downstream of devices of equal or greater effectiveness can convey runoff but should not be expected to offer a treatment benefit.

Design Criteria:

- Design criteria are specified in Table 5.5. A 9-minute hydraulic residence time is used at a multiple of the peak 15 minute water quality design flow rate (Q) as defined in SCC 30.63A.540.
• Check the hydraulic capacity/stability for inflows greater than design flows. Bypass high flows, or control release rates into the biofilter, if necessary.

• Install level spreaders (min. 1-inch gravel) at the head and every 50 feet in swales of ≥4 feet width. Include sediment cleanouts (weir, settling basin, or equivalent) at the head of the biofilter as needed.

• Use energy dissipaters (riprap) for increased downslopes.

**Guidance for Bypassing Off-line Facilities:**

Most biofiltration swales are currently designed to be on-line facilities. However, an off-line design is possible. Swales designed in an off-line mode should not engage a bypass until the flow rate exceeds a value determined by multiplying Q, the off-line water quality design flow rate predicted by the WWHM, by the ratio determined in Figure 5.18. This modified design flow rate is an estimate of the design flow rate determined by using SBUH procedures. Ecology’s intent is to maintain recent biofiltration sizing recommendations (9 minutes detention at the peak design flow rate estimated by SBUH for a 6-month, 24-hour storm with a Type 1A rainfall distribution) until more definitive information is collected concerning bioswale performance. The only advantage of designing a swale to be off-line is that the stability check, which may make the swale larger, is not necessary.

**Sizing Procedure for Biofiltration Swales**

This guide provides biofilter swale design procedures in full detail, along with examples.

**Preliminary Steps (P)**

**P-1** Determine the Water Quality design flow rate (Q) in 15-minute time-steps using the WWHM. Use the correct flow rate, off-line or on-line, for your design situation.

**P-2** Establish the longitudinal slope of the proposed biofilter.

**P-3** Select a vegetation cover suitable for the site. Refer to Tables 5.7, 5.8, and 5.9 to select vegetation for western Washington.

**Design Calculations for Biofiltration Swale**

There are a number of ways of applying the design procedure introduced by Chow (Chow, 1959). These variations depend on the order in which steps are performed, what constants are established at the beginning of the process and which ones are calculated, and what values are assigned to the variables selected initially.

The procedure recommended here is an adaptation appropriate for biofiltration applications of the type being installed in the Puget Sound region. This procedure reverses Chow’s order, designing first for capacity and then for stability. The capacity analysis emphasizes the promotion of biofiltration, rather than transporting flow with the greatest possible hydraulic efficiency. Therefore, it is based on criteria that promote sedimentation, filtration, and other pollutant removal mechanisms. Because these criteria include a lower maximum velocity than permitted for stability, the biofilter dimensions usually do not have to be modified after a stability check.
Design Steps (D):

D-1. Select the type of vegetation, and design depth of flow (based on frequency of mowing and type of vegetation).

D-2. Select a value of Manning’s n (See Table 5.5)

### Table 5.5 – Biofiltration Swale and Vegetated Filter Strip Sizing Criteria

<table>
<thead>
<tr>
<th>Design parameter</th>
<th>BMP T 9.10-Biofiltration swale</th>
<th>BMP T 9.40-Filter strip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal Slope</td>
<td>0.015 - 0.025¹</td>
<td>0.01 - 0.15</td>
</tr>
<tr>
<td>Maximum velocity</td>
<td>1 ft / sec (@ K multiplied by the WQ design flow rate ; for stability, 3 ft/sec max.)</td>
<td>0.5 ft / sec</td>
</tr>
<tr>
<td>Maximum water depth²</td>
<td>2”- if mowed frequently; 4” if mowed infrequently</td>
<td>1-inch max.</td>
</tr>
<tr>
<td>Manning coefficient (22)</td>
<td>(0.2 – 0.3)²(0.24 if mowed infrequently)</td>
<td>0.35 (0.45 if compost-amended, and mowed to maintain grass height ≤ 4”)</td>
</tr>
<tr>
<td>Bed width (bottom)</td>
<td>(2 - 10 ft)²</td>
<td>---</td>
</tr>
<tr>
<td>Freeboard height</td>
<td>0.5 ft</td>
<td>---</td>
</tr>
<tr>
<td>Minimum hydraulic residence time at Water Quality Design Flow Rate</td>
<td>9 minutes (18 minutes for continuous inflow)</td>
<td>9 minutes</td>
</tr>
<tr>
<td>Minimum length</td>
<td>100 ft</td>
<td>Sufficient to achieve hydraulic residence time in the filter strip</td>
</tr>
<tr>
<td>Maximum sideslope</td>
<td>3 H : 1 V</td>
<td>Inlet edge ≥ 1” lower than contributing paved area</td>
</tr>
<tr>
<td>Max. tributary drainage flowpath</td>
<td>---</td>
<td>150 feet</td>
</tr>
<tr>
<td>Max. longitudinal slope of contributing area</td>
<td>---</td>
<td>0.05 (steeper than 0.05 need upslope flow spreading and energy dissipation)</td>
</tr>
<tr>
<td>Max. lateral slope of contributing area</td>
<td>---</td>
<td>0.02 (at the edge of the strip inlet)</td>
</tr>
</tbody>
</table>

1. For swales, if the slope is less than 1.5% install an underdrain using a perforated pipe, or equivalent. Amend the soil if necessary to allow effective percolation of water to the underdrain. Install the low-flow drain 6” deep in the soil. Slopes greater than 2.5% need steps made of concrete blocks or poured in place retaining walls with rock filled sumps at the downstream side. Underdrains can be made of 6 inch Schedule 40 PVC perforated pipe with 6” of drain gravel on the pipe. The gravel and pipe must be enclosed by geotextile fabric. (See Figures 5.13 and 5.14)

2. Below the design water depth install an erosion control blanket, at least 4” of topsoil, and the selected biofiltration mix. Above the water line use a straw mulch or sod.

3. This range of Manning’s n can be used in the equation; b = Qn/1.49y(1.67) s(0.5) – Zy with wider bottom width b, and lower depth, y, at the same flow. This provides the designer with the option of varying the bottom width of the swale depending on space limitations. Designing at the higher n within this range at the same flow decreases the hydraulic design depth, thus placing the pollutants in closer contact with the vegetation and the soil.

4. For swale widths up to 16 feet the cross-section can be divided with a berm (concrete, plastic, compacted earthfill) using a flow spreader at the inlet (Figure 5.15)
Figure 5.13 – Biofiltration Swale Underdrain Detail

Figure 5.14 – Biofiltration Swale Low-Flow Drain Detail
Figure 5.15 – Swale Dividing Berm

D-3. Select swale shape—typically trapezoidal or parabolic.

D-4. Use Manning's equation and first approximations relating hydraulic radius and dimensions for the selected swale shape to obtain a working value of a biofilter width dimension:

\[
Q = \frac{1.49AR^{0.67}s^{0.5}}{n} \tag{1}
\]

\[
A_{\text{rectangle}} = Ty \tag{2}
\]

\[
R_{\text{rectangle}} = \frac{Ty}{T+2y} \tag{3}
\]
Where:

\[ Q = \text{Water Quality Design flow rate in 15-minute time steps based on WWHM, (ft}^3/\text{s, cfs)} \]
\[ n = \text{Manning's n (dimensionless)} \]
\[ s = \text{Longitudinal slope as a ratio of vertical rise/horizontal run (dimensionless)} \]
\[ A = \text{Cross-sectional area (ft}^2) \]
\[ R = \text{Hydraulic radius (ft)} \]
\[ T = \text{top width of trapezoid or width of a rectangle (ft)} \]
\[ y = \text{depth of flow (ft)} \]
\[ b = \text{bottom width of trapezoid (ft)} \]

If equations 2 and 3 are substituted into equation 1 and solved for T, complex equations result that are difficult to solve manually. However, approximate solutions can be found by recognizing that T>>y and Z^2>>1, and that certain terms are nearly negligible. The approximation solutions for rectangular and trapezoidal shapes are:

\[ R_{\text{rectangle}} \approx y, \quad R_{\text{trapezoid}} \approx y, \quad R_{\text{parabolic}} \approx 0.67y, \quad R_{\text{v}} \approx 0.5y \]

Substitute \( R_{\text{trapezoid}} \) and \( A_{\text{trapezoid}} = by+zy^2 \) into Equation 1, and solve for the bottom width b (trapezoidal swale):

\[ b \approx \frac{2.5Qn}{1.49y^{1.67} s^{0.5}} - Zy \]

For a trapezoid, select a side slope Z of at least 3. Compute b and then top width T, where T = b + 2yZ. (Note: Adjustment factor of 2.5 accounts for the differential between Water Quality design flow rate and the SBUH design flow. This equation is used to estimate an initial cross-sectional area. It does not affect the overall biofiltration swale size.)

If b for a swale is greater than 10 ft, either investigate how Q can be reduced, divide the flow by installing a low berm, or arbitrarily set b = 10 ft and continue with the analysis. For other swale shapes refer to Fig. 9.5.
Figure 5.16 – Geometric Formulas for Common Swale Shapes

Source: Livingston, et al, 1984
D-5. Compute A:

\[ A_{\text{rectangle}} = Ty \quad \text{or} \quad A_{\text{trapezoid}} = by + Zy^2 \]

\[ A_{\text{filter strip}} = Ty \]

D-6. Compute the flow velocity at design flow rate:

\[ V = \frac{Q}{A} \]

\( K \) = A ratio of the peak 10-minute flow predicted by SBUH to the water quality design flow rate estimated using the WWHM. The value of \( K \) is determined from Figure 5.17 for on-line facilities, or Figure 5.18 for off-line facilities.

If \( V > 1.0 \text{ ft/sec} \) (or \( V > 0.5 \text{ ft/sec} \) for a filter strip), repeat steps D-1 to D-6 until the condition is met. A velocity greater than 1.0 ft/sec was found to flatten grasses, thus reducing filtration. A velocity lower than this maximum value will allow a 9-minute hydraulic residence time criterion in a shorter biofilter. If the value of \( V \) suggests that a longer biofilter will be needed than space permits, investigate how \( Q \) can be reduced (e.g., use of low impact development BMP’s), or increase \( y \) and/or \( T \) (up to the allowable maximum values) and repeat the analysis.

D-7. Compute the swale length (L, ft)

\[ L = Vt \quad (60 \text{ sec/min}) \]

Where: \( t \) = hydraulic residence time (min)

Use \( t = 9 \) minutes for this calculation (use \( t = 18 \) minutes for a continuous inflow biofiltration swale). If a biofilter length is greater than the space permits, follow the advice in step D-6.

If a length less than 100 feet results from this analysis, increase it to 100 feet, the minimum allowed. In this case, it may be possible to save some space in width and still meet all criteria. This possibility can be checked by computing \( V \) in the 100 ft biofilter for \( t = 9 \) minutes, recalculating \( A \) (if \( V < 1.0 \text{ ft/sec} \)) and recalculating \( T \).

D-8. If there is still not sufficient space for the biofilter, Snohomish County and the project proponent should consider the following solutions (listed in order of preference):

1) Divide the site drainage to flow to multiple biofilters.

2) Use infiltration to provide lower discharge rates to the biofilter (only if the Site Suitability Criteria in Chapter 3, Volume III are met).

3) Increase vegetation height and design depth of flow (note: the design must ensure that vegetation remains standing during design flow).
4) Reduce the developed surface area to gain space for biofiltration.
5) Increase the longitudinal slope.
6) Increase the side slopes.
7) Nest the biofilter within or around another BMP.

**Check for Stability (Minimizing Erosion)**

The stability check must be performed for the combination of highest expected flow and least vegetation coverage and height. A check is not required for biofiltration swales that are located "off-line" from the primary conveyance/detention system, Maintain the same units as in the biofiltration capacity analysis.

**SC-1.** Perform the stability check for the 100-year, return frequency flow using 15-minute time steps using an approved continuous runoff model. Until WWHM peak flow rates in 15-minute time steps are available the designer can use the WWHM 100-yr. hourly peak flows times an adjustment factor of 1.6 to approximate peak flows in 15-minute time steps.

**SC-2.** Estimate the vegetation coverage ("good" or "fair") and height on the first occasion that the biofilter will receive flow, or whenever the coverage and height will be least. Avoid flow introduction during the vegetation establishment period by timing planting or bypassing.

**SC-3.** Estimate the degree of retardance from Table 5.6. When uncertain, be conservative by selecting a relatively low degree.

The maximum permissible velocity for erosion prevention (Vmax) is 3 feet per second.

**Stability Check Steps (SC)**

<table>
<thead>
<tr>
<th>Coverage</th>
<th>Average Grass Height (inches)</th>
<th>Degree of Retardance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>&lt;2</td>
<td>E. Very Low</td>
</tr>
<tr>
<td></td>
<td>2-6</td>
<td>D. Low</td>
</tr>
<tr>
<td></td>
<td>6-10</td>
<td>C. Moderate</td>
</tr>
<tr>
<td></td>
<td>11-24</td>
<td>B. High</td>
</tr>
<tr>
<td></td>
<td>&gt;30</td>
<td>A. Very High</td>
</tr>
<tr>
<td>Fair</td>
<td>&lt;2</td>
<td>E. Very Low</td>
</tr>
<tr>
<td></td>
<td>2-6</td>
<td>D. Low</td>
</tr>
<tr>
<td></td>
<td>6-10</td>
<td>D. Low</td>
</tr>
<tr>
<td></td>
<td>11-24</td>
<td>C. Moderate</td>
</tr>
<tr>
<td></td>
<td>&gt;30</td>
<td>B. High</td>
</tr>
</tbody>
</table>

See Chow (1959). In addition, Chow recommended selection of retardance C for a grass-legume mixture 6-8 inches high and D for a mixture 4-5 inches high. No retardance recommendations have appeared for emergent wetland species. Therefore, judgment must be used. Since these species generally grow less densely than grasses, using a "fair" coverage would be a reasonable approach.

**SC-4.** Select a trial Manning's n for the high flow condition. The minimum value for poor vegetation cover and low height (possibly, knocked from the vertical by high flow) is 0.033. A good initial choice under these conditions is 0.04.
Figure 5.19 – Relationship of Manning’s n with VR for Various Degrees of Flow Retardance

**SC-5.** Refer to Figure 5.19 to obtain a first approximation for VR of 3 feet/second.

**SC-6.** Compute hydraulic radius, R, from VR in Figure 5.19 and a Vmax

**SC-7.** Use Manning’s equation to solve for the actual VR.

**SC-8.** Compare the actual VR from step SC-7 and first approximation from step SC-5. If they do not agree within 5 percent, repeat steps SC-4 to SC-8 until acceptable agreement is reached. If n<0.033 is needed to get agreement, set n = 0.033, repeat step SC-7, and then proceed to step SC-9.

**SC-9.** Compute the actual V for the final design conditions:

Check to be sure V < V_{max} of 3 feet/second.

**SC-10.** Compute the required swale cross-sectional area, A, for stability:

**SC-11.** Compare the A, computed in step SC-10 of the stability analysis, with the A from the biofiltration capacity analysis (step D-5).
If less area is required for stability than is provided for capacity, the capacity design is acceptable. If not, use A from step SC-10 of the stability analysis and recalculate channel dimensions.

**SC-12.** Calculate the depth of flow at the stability check design flow rate condition for the final dimensions and use A from step SC-10.

**SC-13.** Compare the depth from step SC-12 to the depth used in the biofiltration capacity design (Step D-1). Use the larger of the two and add 0.5 ft. of freeboard to obtain the total depth ($y_t$) of the swale. Calculate the top width for the full depth using the appropriate equation.

**SC-14.** Recalculate the hydraulic radius: (use b from Step D-4 calculated previously for biofiltration capacity, or Step SC-11, as appropriate, and $y_t$ = total depth from Step SC-13)

**SC-15.** Make a final check for capacity based on the stability check design storm (this check will ensure that capacity is adequate if the largest expected event coincides with the greatest retardance). Use Equation 1, a Manning’s n selected in step D-2, and the calculated channel dimensions, including freeboard, to compute the flow capacity of the channel under these conditions. Use R from step SC-14, above, and $A = b(y_t) + Z(y_t)^2$ using b from Step D-4, D-15, or SC-11 as appropriate.

If the flow capacity is less than the stability check design storm flow rate, increase the channel cross-sectional area as needed for this conveyance. Specify the new channel dimensions.

**Completion Step (CO)**

**CO.** Review all of the criteria and guidelines for biofilter planning, design, installation, and operation above and specify all of the appropriate features for the application.
Example of Design Calculations for Biofiltration Swales

Preliminary Steps

P-1. Assume that the WWHM based Water Quality Design Flow Rate in 15 minute time-steps, Q, is 0.2 cfs. Assume an on-line facility.

P-2. Assume the slope (s) is 2 percent.

P-3. Assume the vegetation will be a grass-legume mixture and it will be infrequently mowed.

Design for Biofiltration Swale Capacity

D-1. Set winter grass height at 5" and the design flow depth (y) at 3 inches.

D-2. Use n = 0.20 to \( n_2 = 0.30 \)

D-3. Base the design on a trapezoidal shape, with a side slope \( Z = 3 \).

D-4a. Calculate the bottom width, b;

Where:

\[
\begin{align*}
n & = 0.20 \\
y & = 0.25 \text{ ft} \\
Q & = 0.2 \text{ cfs} \\
s & = 0.02 \\
Z & = 3
\end{align*}
\]

\[
b \approx \frac{2.5Qn}{1.49y^{1.67}s^{0.5}} - Zy
\]

At \( n_2; b_2 = 6.5 \text{ feet} \)

D-4b. Calculate the top width (T)

\[
T = b + 2yZ = 4.0 + [2(0.25)(3)] = 5.5 \text{ feet}
\]

D-5. Calculate the cross-sectional area (A)

\[
A = by + Zy^2 = (4.0)(0.25) + (3)(0.25^2) = 1.19 \text{ ft}^2
\]

D-6. Calculate the flow velocity (V)

\[
V = K\frac{Q}{A} = 0.17 \text{ ft/sec}
\]

for \( K = 1 \). Actual K is determined per Figure 5.17

0.17 < 1.0 ft/sec \( \therefore \) OK
D-7 Calculate the Length (L)

\[ L = Vt (60 \text{ sec/min}) \]
\[ = 0.17 \times (9)(60) \]

For \( t = 9 \text{ min} \), \( L = 92 \text{ ft. at n} \); expand to a minimum of 100 foot length per design criterion
At \( n_2 \), \( L = 100 \text{ ft.} \)

Note: Where \( b \) is less than the maximum value, it may be possible to reduce \( L \) by increasing \( b \). In this case, because \( L \) is determined by the requirement for a minimum length of 100 feet, it is not possible.

**Check for Channel Stability**

SC-1. Base the check on passing the 100-year, return frequency flow (15 minute time steps) through a swale with a mixture of Kentucky bluegrass and tall fescue on loose erodible soil. Until WWHM peak flow rates in 15-minute time steps are available the designer can use the WWHM 100-yr. hourly peak flows times an adjustment factor of 1.6 to approximate peak flows in 15-minute time steps. Assume that the adjusted peak \( Q \) is 1.92 cfs.

SC-2. Base the check on a grass height of 3 inches with "fair" coverage (lowest mowed height and least cover, assuming flow bypasses or does not occur during grass establishment).

SC-3. From Table 5.6, Degree of Retardance = D (low)
Set \( V_{\text{max}} = 3 \text{ ft/sec} \)

SC-4. Select trial Manning’s \( n = 0.04 \)

SC-5. From Figure 5.19, \( VR_{\text{approx}} = 3 \text{ ft}^2/\text{s} \)

SC-6. Calculate \( R \)

\[ R = \frac{VR_{\text{approx}}}{V_{\text{max}}} = 1.0 \text{ ft} \]

SC-7. Calculate \( VR_{\text{actual}} \)

\[ VR_{\text{actual}} = \frac{1.49}{n} R^{1.67} s^{0.5} = 5.25 \text{ ft}^2/\text{sec} \]

SC-8. \( VR_{\text{actual}} \) from step SC-7 > \( VR_{\text{approx}} \) from step SC-5 by > 5%.
Select new trial \( n = 0.0475 \)
Figure 5.19: \( VR_{\text{approx}} = 1.7 \text{ ft}^2/\text{s} \)
R = 0.57 ft.
VR_{actual} = 1.73 \text{ ft}^2/\text{s} \text{ (within 5\% of } VR_{appx} = 1.7) 

**SC-9.** Calculate V

\[
V = \frac{VR_{actual}}{R} = \frac{1.73}{0.57} = 3 \text{ ft/sec}
\]

V = 3 ft/sec ≤ 3 ft/sec, V\text{max} :; OK

**SC-10.** Calculate Stability Area

\[
A_{\text{Stability}} = \frac{Q}{V} = \frac{1.92}{3} = 0.64 \text{ ft}^2
\]

**SC-11.** Stability Check

A_{\text{Stability}} = 0.64 \text{ ft}^2 \text{ is less than } A_{\text{Capacity}} \text{ from step D-5 (} A_{\text{Capacity}} = 1.19 \text{ ft}^2). ;; OK

If A_{\text{Stability}} > A_{\text{Capacity}}, it will be necessary to select new trial sizes for width and flow depth (based on space and other considerations), recalculate A_{\text{Capacity}}, and repeat steps SC-10 and SC-11.

**SC-12.** Calculate depth of flow at the stability design flow rate condition using the quadratic equation solution:

\[
y = \frac{-b \pm \sqrt{b^2 - 4Z(-A)}}{2Z}
\]

For b = 4, y = 0.14 ft (positive root)

**SC-13.** Use the greater value of y from SC-12 or that assumed in D-1. In this case, the greater depth is 0.25-foot, which was the basis for the biofiltration capacity design. Add 0.5 feet freeboard to that depth.

Total channel depth = 0.75 ft
Top Width = b + 2yZ
= 4 + (2)(0.75)(3)
= 8.5 ft

**SC-14.** Recalculate hydraulic radius and flow rate

For b = 4 ft, y = 0.75 ft
Z = 3, s = 0.02, n = 0.2
A = by + Zy^2 = 4.68 \text{ ft}^2
R = \{by + Zy^2\}/\{b + 2y(Z^2 + 1)^{0.5}\} = 0.53 \text{ ft.}
SC-15. Calculate Flow Capacity at Greatest Resistance

\[
Q = \frac{1.49AR^{0.67}s^{0.5}}{n} = 3.2 \text{ cfs}
\]

\(Q = 3.2 \text{ cfs} > 1.92 \text{ cfs} ; \text{ OK}
\]

Completion Step

CO-1. Assume 100 feet of swale length is available.

The final channel dimensions are:

- Bottom width, \(b = 4\) feet
- Channel depth = 0.75 feet
- Top width = \(b + 2yz = 8.5\) feet

No check dams are needed for a 2% slope.

Soil Criteria

- The following top soil mix at least 8-inch deep:
  - Sandy loam 60-90 %
  - Clay 0-10 %
  - Composted organic matter, 10-30 %
    (excluding animal waste, toxics)

- Use compost amended soil where practicable
- Till to at least 8-inch depth
- For longitudinal slopes of < 2 percent use more sand to obtain more infiltration
- If ground water contamination is a concern, seal the bed with clay or a geomembrane liner

Vegetation Criteria

- See Tables 5.7, 5.8 and 5.9 for recommended grasses, wetland plants, and groundcovers.
- Select fine, turf-forming, water-resistant grasses where vegetative growth and moisture will be adequate for growth.
- Irrigate if moisture is insufficient during dry weather season.
- Use sod with low clay content and where needed to initiate adequate vegetative growth. Preferably sod should be laid to a minimum of one-foot vertical depth above the swale bottom.
- Consider sun/shade conditions for adequate vegetative growth and avoid prolonged shading of any portion not planted with shade tolerant vegetation.
- Stabilize soil areas upslope of the biofilter to prevent erosion
- Fertilizing a biofilter should be avoided if at all possible in any application where nutrient control is an objective. Test the soil for nitrogen, phosphorus, and potassium and consult with a landscape professional about the need for fertilizer in relation to soil nutrition and vegetation requirements. If use of a fertilizer cannot be avoided, use a slow-release fertilizer formulation in the least amount needed.

**Recommended grasses (see Tables 5.7 and 5.8 below)**

<table>
<thead>
<tr>
<th>Mix 1</th>
<th>Mix 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>75-80 percent</td>
<td>60-70 percent</td>
</tr>
<tr>
<td>tall or meadow fescue</td>
<td>tall fescue</td>
</tr>
<tr>
<td>10-15 percent</td>
<td>10-15 percent</td>
</tr>
<tr>
<td>seaside/colonial bentgrass</td>
<td>seaside/colonial bentgrass</td>
</tr>
<tr>
<td>5-10 percent</td>
<td>10-15 percent</td>
</tr>
<tr>
<td>Redtop</td>
<td>meadow foxtail</td>
</tr>
<tr>
<td>6-10 percent</td>
<td>6-10 percent</td>
</tr>
<tr>
<td>alsike clover</td>
<td>alsike clover</td>
</tr>
<tr>
<td>1-5 percent</td>
<td>1-5 percent</td>
</tr>
<tr>
<td>marshfield big trefoil</td>
<td>marshfield big trefoil</td>
</tr>
<tr>
<td>1-6 percent</td>
<td>1-6 percent</td>
</tr>
<tr>
<td>Redtop</td>
<td>Redtop</td>
</tr>
</tbody>
</table>

**Table 5.7 – Grass Seed Mixes Suitable for Biofiltration Swale Treatment Areas**

Note: all percentages are by weight. * based on Briargreen, Inc.
Table 5.8 – Groundcovers And Grasses Suitable for the Upper Side Slopes of a Biofiltration Swale in Western Washington

<table>
<thead>
<tr>
<th>Groundcovers</th>
<th>Grasses (drought-tolerant, minimum mowing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>kinnikinnick*</td>
<td>Arctostaphylos uva-ursi</td>
</tr>
<tr>
<td>Epimedium</td>
<td>Epimedium grandiflorum</td>
</tr>
<tr>
<td>creeping forget-me-not</td>
<td>Omphalodes verna</td>
</tr>
<tr>
<td></td>
<td>Euonymus lanceolata</td>
</tr>
<tr>
<td>yellow-root</td>
<td>Xanthorrhiza simplissima</td>
</tr>
<tr>
<td></td>
<td>Genista</td>
</tr>
<tr>
<td>white lawn clover</td>
<td>Trifolium repens</td>
</tr>
<tr>
<td>white sweet clover*</td>
<td>Melilotus alba</td>
</tr>
<tr>
<td>strawberry*</td>
<td>Rubus calycinoides</td>
</tr>
<tr>
<td>broadleaf lupine*</td>
<td>Fragaria chiloensis</td>
</tr>
<tr>
<td></td>
<td>Lupinus latifolius</td>
</tr>
</tbody>
</table>

**Construction Criteria**

The biofiltration swale should not be put into operation until areas of exposed soil in the contributing drainage catchment have been sufficiently stabilized. Deposition of eroded soils can impede the growth of grass in the swale and reduce swale treatment effectiveness. Thus, effective erosion and sediment control measures should remain in place until the swale vegetation is established (see Volume II for erosion and sediment control BMPs). Avoid compaction during construction. Grade biofilters to attain uniform longitudinal and lateral slopes.

**Maintenance**

Maintenance requirements for drainage facilities are set forth in Chapter 7.53.140 SCC and Volume V, Chapter 4.6 of this manual.
BMP T9.20  Wet Biofiltration Swale

Description

A *wet biofiltration swale* is a variation of a basic biofiltration swale for use where the longitudinal slope is slight, water tables are high, or continuous low base flow is likely to result in saturated soil conditions. Where saturation exceeds about 2 weeks, typical grasses will die. Thus, vegetation specifically adapted to saturated soil conditions is needed. Different vegetation in turn requires modification of several of the design parameters for the basic biofiltration swale.

Performance Objectives

Wet biofiltration swales provide basic treatment if used by themselves, and can be used in combination with other systems to provide additional treatment, in accordance with the requirements of Volume I, Chapter 4.

Applications/Limitations

Wet biofiltration swales are applied where a basic biofiltration swale is desired but not allowed or advisable because one or more of the following conditions exist:

- The swale is on till soils and is downstream of a detention pond providing flow control.
- Saturated soil conditions are likely because of seeps or base flows on the site.
- Longitudinal slopes are slight (generally less than 2 percent).

Design Criteria

Use the same design approach as for basic biofiltration swales except to add the following:

**Adjust for extended wet season flow.** If the swale will be downstream of a detention pond providing flow control, multiply the treatment area (bottom width times length) of the swale by 2, and readjust the swale length, if desired. Maintain a 5:1 length to width ratio.

**Intent:** An increase in the treatment area of swales following detention ponds is required because of the differences in vegetation established in a constant flow environment. Flows following detention are much more prolonged. These prolonged flows result in more stream-like conditions than are typical for other wet biofilter situations. Since vegetation growing in streams is often less dense, this increase in treatment area is needed to ensure that equivalent pollutant removal is achieved during extended flow events.

**Swale Geometry:** Same as specified for basic biofiltration swales except for the following modifications:

**Criterion 1:** The bottom width may be increased to 25 feet maximum, but a minimum length-to-width ratio of 5:1 must be provided. No longitudinal dividing berm is needed. *Note: The minimum swale length is still 100 feet.*
**Criterion 2:** If longitudinal slopes are greater than 2 percent, the wet swale must be stepped so that the slope within the stepped sections averages 2 percent. Steps may be made of concrete block or poured in place concrete retaining walls with rock filled sumps at the downstream side, log check dams, or short riprap sections. No underdrain or low-flow drain is required.

**High-Flow Bypass:** A high-flow bypass (i.e., an off-line design) is required for flows greater than the off-line water quality design flow that has been increased by the ratio indicated in Figure 5.18. The bypass is necessary to protect wetland vegetation from damage. Unlike grass, wetland vegetation will not quickly regain an upright attitude after being laid down by high flows. New growth, usually from the base of the plant, often taking several weeks, is required to regain its upright form. The bypass may be an open channel parallel to the wet biofiltration swale. **Water Depth and Base Flow:** Same as for basic biofiltration swales except the design water depth shall be 4 inches for all wetland vegetation selections, and no underdrains or low-flow drains are required.

**Flow Velocity, Energy Dissipation, and Flow Spreading:** Same as for basic biofiltration swales except no flow spreader is needed.

**Access:** Same as for basic biofiltration swales except access is only required to the inflow and the outflow of the swale; access along the length of the swale is not required. Also, wheel strips may not be used for access in the swale.

**Intent:** An access road is not required along the length of a wet swale because of infrequent access needs. Frequent mowing or harvesting is not desirable. In addition, wetland plants are fairly resilient to sediment-induced changes in water depth, so the need for access should be infrequent.

**Soil Amendment:** Same as for basic biofiltration swales.

**Planting Requirements:** Same as for basic biofiltration swales except for the following modifications:

1. A list of acceptable plants and recommended spacing is shown in Table 5.9. In general, it is best to plant several species to increase the likelihood that at least some of the selected species will find growing conditions favorable.

2. A wetland seed mix may be applied by hydroseeding, but if coverage is poor, planting of rootstock or nursery stock is required. Poor coverage is considered to be more than 30 percent bare area through the upper 2/3 of the swale after four weeks.

**Recommended Design Features:** Same as for basic biofiltration swales

**Construction Considerations:** Same as for basic biofiltration swales

**Maintenance Considerations:**

Maintenance requirements for drainage facilities are set forth in Chapter 7.53.140 SCC and Volume V, Chapter 4.6 of this manual.
Table 5.9 – Recommended Plants for Wet Biofiltration Swale

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Spacing (on center)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shortawn foxtail</td>
<td>Alopecurus aequalis</td>
<td>seed</td>
</tr>
<tr>
<td>Water foxtail</td>
<td>Alopecurus geniculatus</td>
<td>seed</td>
</tr>
<tr>
<td>Spike rush</td>
<td>Eleocharis spp.</td>
<td>4 inches</td>
</tr>
<tr>
<td>Slough sedge*</td>
<td>Carex obnupta</td>
<td>6 inches or seed</td>
</tr>
<tr>
<td>Sawbeak sedge</td>
<td>Carex stipata</td>
<td>6 inches</td>
</tr>
<tr>
<td>Sedge</td>
<td>Carex spp.</td>
<td>6 inches</td>
</tr>
<tr>
<td>Western managrass</td>
<td>Glyceria occidentalis</td>
<td>seed</td>
</tr>
<tr>
<td>Velvetgrass</td>
<td>Holcus mollis</td>
<td>seed</td>
</tr>
<tr>
<td>Slender rush</td>
<td>Juncus tenuis</td>
<td>6 inches</td>
</tr>
<tr>
<td>Watercress*</td>
<td>Rorippa nasturtium-aquaticum</td>
<td>12 inches</td>
</tr>
<tr>
<td>Water parsley*</td>
<td>Oenanthe sarmentosa</td>
<td>6 inches</td>
</tr>
<tr>
<td>Hardstem bulrush</td>
<td>Scirpus acutus</td>
<td>6 inches</td>
</tr>
<tr>
<td>Small-fruited bulrush</td>
<td>Scirpus microcarpus</td>
<td>12 inches</td>
</tr>
</tbody>
</table>

* Good choices for swales with significant periods of flow, such as those downstream of a detention facility.

Note: Cattail (Typha latifolia) is not appropriate for most wet swales because of its very dense and clumping growth habit which prevents water from filtering through the clump.
BMP T9.30  Continuous Inflow Biofiltration Swale

Description

In situations where water enters a biofiltration swale continuously along the side slope rather than discretely at the head, a different design approach—the continuous inflow biofiltration swale—is needed. The basic swale design is modified by increasing swale length to achieve an equivalent average residence time.

Applications

A continuous inflow biofiltration swale is to be used when inflows are not concentrated, such as locations along the shoulder of a road without curbs. This design may also be used where frequent, small point flows enter a swale, such as through curb inlet ports spaced at intervals along a road, or from a parking lot with frequent curb cuts. In general, no inlet port should carry more than about 10 percent of the flow.

A continuous inflow swale is not appropriate for a situation in which significant lateral flows enter a swale at some point downstream from the head of the swale. In this situation, the swale width and length must be recalculated from the point of confluence to the discharge point in order to provide adequate treatment for the increased flows.

Design Criteria

Same as specified for basic biofiltration swale except for the following:

- The design flow for continuous inflow swales must include runoff from the pervious side slopes draining to the swale along the entire swale length. Therefore, they must be on-line facilities.
- If only a single design flow is used, the flow rate at the outlet should be used. The goal is to achieve an average residence time through the swale of 9 minutes as calculated using the on-line water quality design flow rate multiplied by the ratio, K, in Figure 5.17. Assuming an even distribution of inflow into the side of the swale double the hydraulic residence time to a minimum of 18 minutes.
- For continuous inflow biofiltration swales, interior side slopes above the WQ design treatment elevation shall be planted in grass. A typical lawn seed mix or the biofiltration seed mixes are acceptable. Landscape plants or groundcovers other than grass may not be used anywhere between the runoff inflow elevation and the bottom of the swale. Intent: The use of grass on interior side slopes reduces the chance of soil erosion and transfer of pollutants from landscape areas to the biofiltration treatment area.
BMP T9.40 Basic Filter Strip

Description:
A basic filter strip is flat with no side slopes (Figure 5.20). Contaminated stormwater is distributed as sheet flow across the inlet width of a biofilter strip.
Applications/Limitations:
The basic filter strip is typically used on-line and adjacent and parallel to a paved area such as parking lots, driveways, and roadways. Where a filter strip area is compost-amended to a minimum of 10% organic content in accordance with BMP T5.13; with hydroseeded grass maintained at 95% density and a 4-inch length by mowing and periodic re-seeding (possible landscaping with herbaceous shrubs), the filter strip serves as an Enhanced Treatment option.

Design Criteria for Filter strips:

- Use the Design Criteria specified in Table 5.5
- Filter strips should only receive sheet flow.
- Use curb cuts ≥ 12-inch wide and 1-inch above the filter strip inlet.

Calculate the design flow depth using Manning’s equation as follows:

\[ KQ = (1.49A R^{0.67}s^{0.5})/n \]

Substituting for AR:

\[ KQ = (1.49Ty^{1.67}s^{0.5})/n \]

Where:

- \( Ty = A_{\text{rectangle, ft}^2} \)
- \( y \approx R_{\text{rectangle, design depth of flow, ft. (1 inch maximum)}} \)
- \( Q = \text{peak Water Quality design flow rate based on WWHM, ft}^3/\text{sec} \) (See Appendix I-B, Volume I)
- \( K = \text{The ratio determined by using Figure 5.17} \)
- \( n = \text{Manning’s roughness coefficient} \)
- \( s = \text{Longitudinal slope of filter strip parallel to direction of flow} \)
- \( T = \text{Width of filter strip perpendicular to the direction of flow, ft.} \)
- \( A = \text{Filter strip inlet cross-sectional flow area (rectangular), ft}^2 \)
- \( R = \text{hydraulic radius, ft.} \)

Rearranging for \( y \):

\[ y = \left[ \frac{KQn}{1.49Ts^{0.5}} \right]^{0.6} \]

\( y \) must not exceed 1 inch

Note: As in swale design an adjustment factor of \( K \) accounts for the differential between the WWHM Water Quality design flow rate and the SBUH design flow

Calculate the design flow velocity \( V \), ft./sec., through the filter strip:
$V = \frac{KQ}{T_y}$

$V$ must not exceed 0.5 ft./sec

Calculate required length, ft., of the filter strip at the minimum hydraulic residence time, $t$, of 9 minutes:

$L = tv = 540V$
BMP T9.50 Narrow Area Filter Strip

Description:

This section describes a filter strip design for impervious areas with flowpaths of 30 feet or less that can drain along their widest dimension to grassy areas.

Applications/Limitations:

A narrow area filter strip could be used at roadways with limited right-of-way, or for narrow parking strips, the narrow strip. If space is available to use the basic filter strip design, that design should be used in preference to the narrow filter strip.

The treatment objectives, applications and limitations, design criteria, materials specifications, and construction and maintenance requirements set forth in the basic filter strip design apply to narrow filter strip applications.

Design Criteria:

Design criteria for narrow area filter strips are the same as specified for basic filter strips. The sizing of a narrow area filter strip is based on the length of flowpath draining to the filter strip and the longitudinal slope of the filter strip itself (parallel to the flowpath).

Step 1: Determine the length of the flowpath from the upstream to the downstream edge of the impervious area draining sheet flow to the filter strip. Normally this is the same as the width of the paved area, but if the site is sloped, the flow path may be longer than the width of the impervious area.

Step 2: Calculate the longitudinal slope of the filter strip (along the direction of unconcentrated flow), averaged over the total width of the filter strip. The minimum sizing slope is 2 percent. If the slope is less than 2 percent, use 2 percent for sizing purposes. The maximum allowable filter strip slope is 20 percent. If the slope exceeds 20 percent, the filter strip must be stepped down the slope so that the treatment areas between drop sections do not have a longitudinal slope greater than 20 percent. Drop sections must be provided with erosion protection at the base and flow spreaders to re-spread flows. Vertical drops along the slope must not exceed 12 inches in height. If this is not possible, a different treatment facility must be selected.

Step 3: Select the appropriate filter strip length for the flowpath length and filter strip longitudinal slope (Steps 1 and 2 above) from the graph in Figure 5.21. The filter strip must be designed to provide this minimum length L along the entire stretch of pavement draining into it.

To use the graph: Find the length of the flowpath on one of the curves (interpolate between curves as necessary). Move along the curve to the point where the design longitudinal slope of the filter strip (x-axis) is directly below. Read the filter strip length on the y-axis which corresponds to the intersection point.
Note: minimum allowable filter strip length is 4 feet

Figure 5.21 – Filter Strip Lengths for Narrow Right-of-Way
Chapter 10 - Wetpool Facilities

10.1 Purpose

This chapter presents the methods, criteria, and details for analysis and design of wetponds, wetvaults, and stormwater wetlands. These facilities have as a common element a permanent pool of water - the wetpool. Each of the wetpool facilities can be combined with a detention or flow control pond in a combined facility. Included are the following specific facility designs:

- BMP T10.10 - Wetponds - Basic and Large
- BMP T10.20 - Wetvaults
- BMP T10.30 - Stormwater Wetlands
- BMP T10.40 - Combined Detention and Wetpool Facilities

10.2 Application

The wetpool facility designs described for the BMPs in this Chapter will achieve the performance objectives cited in Chapter 3 of this volume for specific treatment menus.

10.3 Best Management Practices (BMPs) for Wetpool Facilities

The BMPs discussed below are currently recognized as effective treatment techniques using wetpool facilities. The specific BMPs that are selected should be coordinated with the Treatment Facility Menus discussed in Chapter 3.

BMP T10.10 Wetponds - Basic and Large

Purpose and Definition

A wetpond is a constructed stormwater pond that retains a permanent pool of water ("wetpool") at least during the wet season. The volume of the wetpool is related to the effectiveness of the pond in settling particulate pollutants. As an option, a shallow marsh area can be created within the permanent pool volume to provide additional treatment for nutrient removal. Peak flow control can be provided in the "live storage" area above the permanent pool. See EDDS Standard Drawings 5-240A and 5-240B for design information.

The following design, construction, and operation and maintenance criteria cover two wetpond applications - the basic wetpond and the large wetpond. Large wetponds are designed for higher levels of pollutant removal.
**Applications and Limitations**

A wetpond requires a larger area than a biofiltration swale or a sand filter, but it can be integrated to the contours of a site fairly easily. In till soils, the wetpond may hold a permanent pool of water. In more porous soils, wetponds may still be used, but water seepage from unlined cells could result in a dry pond, particularly in the summer months. Lining the first cell with a low permeability liner is one way to deal with this situation. As long as the first cell retains a permanent pool of water, this situation will not reduce the pond’s effectiveness.

Wetponds work best when the water already in the pond is moved out en masse by incoming flows, a phenomenon called "plug flow." Because treatment works on this displacement principle, the wetpool storage of wetponds may be provided below the groundwater level without interfering unduly with treatment effectiveness. However, if combined with a detention function, the live storage must be above the seasonal high groundwater level.

Wetponds may be single-purpose facilities, providing only runoff treatment, or they may be combined with a detention pond to also provide flow control. If combined, the wetpond can often be stacked under the detention pond with little further loss of development area. See BMP T10.40 for a description of combined detention and wetpool facilities.

**Design Criteria**

Engineering standards and specifications set forth in Chapter 5-10 of Snohomish County EDDS shall apply to Wetponds.

The primary design factor that determines a wetpond's treatment efficiency is the volume of the wetpool. The larger the wetpool volume, the greater the potential for pollutant removal. For a basic wetpond, the wetpool volume provided shall be equal to or greater than the total volume of runoff from the water quality design storm - the 6-month, 24-hour storm event. Alternatively, the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model.

A large wetpond requires a wetpool volume at least 1.5 times larger than the total volume of runoff from the 6-month, 24-hour storm event. Also important are the avoidance of short-circuiting and the promotion of plug flow. **Plug flow** describes the hypothetical condition of stormwater moving through the pond as a unit, displacing the "old" water in the pond with incoming flows. To prevent short-circuiting, water is forced to flow, to the extent practical, to all potentially available flow routes, avoiding "dead zones" and maximizing the time water stays in the pond during the active part of a storm.

Design features that encourage plug flow and avoid dead zones are:

- Dissipating energy at the inlet.
- Providing a large length-to-width ratio.
- Providing a broad surface for water exchange using a berm designed as a broad-crested weir to divide the wetpond into two cells rather than a constricted area such as a pipe.
- Maximizing the flowpath between inlet and outlet, including the vertical path, also enhances treatment by increasing residence time.
Sizing Procedure

Procedures for determining a wetpond's dimensions and volume are outlined below.

Step 1: Identify required wetpool volume using the SCS (now known as NRCS) curve number equations presented in Volume III, Chapter 2, Section 2.3.2. A basic wetpond requires a volume equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, use the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model. A large wetpond requires a volume at least 1.5 times the total volume of runoff from the 6-month, 24-hour storm event, or 1.5 times the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model.

Step 2: Determine wetpool dimensions. Determine the wetpool dimensions satisfying the design criteria outlined below and set forth in EDDS Standard Drawings 5-240A and 5-240B. A simple way to check the volume of each wetpool cell is to use the following equation:

\[ V = \frac{h(A_1 + A_2)}{2} \]

where
- \( V \) = wetpool volume (cf)
- \( h \) = wetpool average depth (ft)
- \( A_1 \) = water quality design surface area of wetpool (sf)
- \( A_2 \) = bottom area of wetpool (sf)

Step 3: Design pond outlet pipe and determine primary overflow water surface. The pond outlet pipe shall be placed on a reverse grade from the pond's wetpool to the outlet structure. Use the following procedure to design the pond outlet pipe and determine the primary overflow water surface elevation:

a) Use the nomographs in Figures 5.22 and 5.23 to select a trial size for the pond outlet pipe sufficient to pass the on-line WQ design flow, \( Q_{wq} \), indicated by WWHM or other approved continuous runoff model.

b) Use Figure 5.25 to determine the critical depth \( d_c \) at the outflow end of the pipe for \( Q_{wq} \).

c) Use Figure 5.26 to determine the flow area \( A_c \) at critical depth.

d) Calculate the flow velocity at critical depth using continuity equation (\( V_c = \frac{Q_{wq}}{A_c} \)).

e) Calculate the velocity head \( V_H \) (\( V_H = \frac{V_c^2}{2g} \), where \( g \) is the gravitational constant, 32.2 feet per second).

f) Determine the primary overflow water surface elevation by adding the velocity head and critical depth to the invert elevation at the outflow end of the pond outlet pipe (i.e., overflow water surface elevation = outflow invert + \( d_c + V_H \)).

g) Adjust outlet pipe diameter as needed and repeat Steps (a) through (e).

Step 4: Determine wetpond dimensions. See EDDS Standard Drawings 5-240A and 5-240B.
Wetpool Geometry

- The wetpool shall be divided into two cells separated by a baffle or berm. The first cell shall contain between 25 to 35 percent of the total wetpool volume. The baffle or berm volume shall not count as part of the total wetpool volume. The term baffle means a vertical divider placed across the entire width of the pond, stopping short of the bottom. A berm is a vertical divider typically built up from the bottom, or if in a vault, connects all the way to the bottom.

**Intent:** The full-length berm or baffle promotes plug flow and enhances quiescence and laminar flow through as much of the entire water volume as possible. Alternative methods to the full-length berm or baffle that provide equivalent flow characteristics may be approved on a case-by-case basis by the Snohomish County.

- Sediment storage shall be provided in the first cell. The sediment storage shall have a minimum depth of 1 foot. A fixed sediment depth monitor should be installed in the first cell to gauge sediment accumulation unless an alternative gauging method is proposed.

- The minimum depth of the first cell shall be 4 feet, exclusive of sediment storage requirements. The depth of the first cell may be greater than the depth of the second cell.

- The maximum depth of each cell shall not exceed 8 feet (exclusive of sediment storage in the first cell). Pool depths of 3 feet or shallower (second cell) shall be planted with emergent wetland vegetation (see Vegetation).

- Inlets and outlets shall be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet shall be at least 3:1. The flowpath length is defined as the distance from the inlet to the outlet, as measured at mid-depth. The width at mid-depth can be found as follows: width = (average top width + average bottom width)/2.

- Wetponds with wetpool volumes less than or equal to 4,000 cubic feet may be single celled (i.e., no baffle or berm is required). However, it is especially important in this case that the flow path length be maximized. The ratio of flow path length to width shall be at least 4:1 in single celled wetponds, but should preferably be 5:1.

- All inlets shall enter the first cell. If there are multiple inlets, the length-to-width ratio shall be based on the average flowpath length for all inlets.

- The first cell may be lined in accordance with the liner requirements contained in Section 4.4 and Snohomish County EDDS.

Berms, Baffles, and Slopes

Berms, baffles, and slopes shall conform to standards and specifications set forth in Chapter 5-10 of Snohomish County EDDS.

- A berm or baffle shall extend across the full width of the wetpool, and tie into the wetpond side slopes. The geotechnical analysis, if required, shall address situations in which one of the two cells is empty while the other remains full of water.
- The top of the berm may extend to the WQ design water surface or be 1-foot below the WQ design water surface.
- The interior berm or baffle may be a retaining wall provided that the design is prepared and stamped by a licensed civil engineer. If a baffle or retaining wall is used, it should be submerged one foot below the design water surface to discourage access by pedestrians.

**Inlet and Outlet**

Inlet and outlet structures shall conform to standards and specifications set forth in Chapter 5-10 of Snohomish County EDDS.

See EDDS Standard Drawings 5-240A and 5-240B.

The inlet to the wetpond shall be submerged with the inlet pipe invert a minimum of two feet from the pond bottom (not including sediment storage). The top of the inlet pipe should be submerged at least 1-foot, if possible.

- A sump is not required in the outlet structure for a wetpond that does not provide detention storage.
- The pond outlet pipe (as opposed to the manhole or type 2 catch basin outlet pipe) shall be back-sloped or have a turn-down elbow, and extend 1 foot below the WQ design water surface.
- The pond outlet pipe shall be sized, at a minimum, to pass the on-line WQ design flow.
- The overflow criteria for wetponds designed to provide only treatment are as follows:
  a) The requirement for primary overflow is satisfied by either the grated inlet to the outlet structure or by a birdcage above the pond outlet structure.
  b) The bottom of the grate opening in the outlet structure shall be set at or above the height needed to pass the WQ design flow through the pond outlet pipe. *Note: The grate invert elevation sets the overflow water surface elevation.*
  c) The grated opening should be sized to pass the 100-year design flow. The capacity of the outlet system should be sized to pass the peak flow for the conveyance requirements.

**Access and Setbacks**

- Setbacks shall be in accordance with SCC 30.63A.710.
- Access shall be provided in accordance with Chapter 30.63A SCC and Chapter 5-10 of Snohomish County EDDS.

**Vegetation**

Vegetation requirements set forth in Chapter 5-10 of Snohomish County EDDS shall apply to wetponds, unless in conflict with the following requirements, in which case the following requirements will take precedence.
• Large wetponds intended for phosphorus control should not be planted within the cells, as the plants will release phosphorus in the winter when they die off.

• If the second cell of a basic wetpond is 3 feet or shallower, the bottom area shall be planted with emergent wetland vegetation. See Table 5.10 for recommended emergent wetland plant species for wetponds. Intent: Planting of shallow pond areas helps to stabilize settled sediment and prevent resuspension.

• Cattails (Typha latifolia) are not recommended because they tend to crowd out other species and will typically establish themselves anyway.

• If the wetpond discharges to a phosphorus-sensitive lake or wetland, shrubs that form a dense cover should be planted on slopes above the WQ design water surface on at least three sides. For banks that are berms, no planting is allowed if the berm is regulated by dam safety requirements. The purpose of planting is to discourage waterfowl use of the pond and to provide shading. Some suitable trees and shrubs include vine maple (Acer circinatum), wild cherry (Prunus emarginata), red osier dogwood (Cornus stolonifera), California myrtle (Myrica californica), Indian plum (Oemleria cerasiformis), and Pacific yew (Taxus brevifolia) as well as numerous ornamental species.

• Evergreen or columnar deciduous trees along the west and south sides of ponds are recommended to reduce thermal heating, except that no trees or shrubs may be planted on berms meeting the criteria of dams regulated for safety. In addition to shade, trees and shrubs also discourage waterfowl use and the attendant phosphorus enrichment problems they cause. Trees should be set back so that the branches will not extend over the pond.

**Maintenance**

Maintenance requirements for drainage facilities are set forth in Chapter 7.53.140 SCC and Volume V, Chapter 4.6 of this manual.

<table>
<thead>
<tr>
<th>Table 5.10 – Emergent Wetland Plant Species Recommended for Wetponds</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Species</strong></td>
</tr>
<tr>
<td>Agrostis exarata(1)</td>
</tr>
<tr>
<td>Carex stipata</td>
</tr>
<tr>
<td>Eleocharis palustris</td>
</tr>
<tr>
<td>Glyceria occidentalis</td>
</tr>
<tr>
<td>Juncus tenuis</td>
</tr>
<tr>
<td>Oenanthe sarmentosa</td>
</tr>
<tr>
<td>Scirpus atrocinctus (formerly S. cyperinus)</td>
</tr>
<tr>
<td>Scirpus microcarpus</td>
</tr>
<tr>
<td>Sagittaria latifolia</td>
</tr>
</tbody>
</table>

**INUNDATION 1 TO 2 FEET**

| Agrostis exarata(1) | Spike bent grass | Prairie to coast | |
### INUNDATION 1 TO 3 FEET

<table>
<thead>
<tr>
<th>Species</th>
<th>Type</th>
<th>Habitat</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alisma plantago-aquatica</td>
<td>Water plantain</td>
<td>Margins of ponds, wet meadows</td>
<td></td>
</tr>
<tr>
<td>Eleocharis palustris</td>
<td>Spike rush</td>
<td>Marshes, pond margins</td>
<td></td>
</tr>
<tr>
<td>Glyceria occidentalis</td>
<td>Western managrass</td>
<td>Wet meadows, pastures, wetland margins</td>
<td></td>
</tr>
<tr>
<td>Juncus effusus</td>
<td>Soft rush</td>
<td>Shallow standing water, saturated soils</td>
<td></td>
</tr>
<tr>
<td>Scirpus microcarpus</td>
<td>Small-fruited bulrush</td>
<td>Wet ground to 18 inches depth</td>
<td>18 inches</td>
</tr>
<tr>
<td>Sparganium emmersum</td>
<td>Bur reed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### INUNDATION GREATER THAN 3 FEET

<table>
<thead>
<tr>
<th>Species</th>
<th>Type</th>
<th>Habitat</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carex obnupta</td>
<td>Slough sedge</td>
<td>Wet ground or standing water</td>
<td>1.5 to 3 feet</td>
</tr>
<tr>
<td>Beckmania syzigachne&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>Western sloughgrass</td>
<td>Wet prairie to pond margins</td>
<td></td>
</tr>
<tr>
<td>Scirpus acutus&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>Hardstem bulrush</td>
<td>Single tall stems, not clumping</td>
<td>to 3 feet</td>
</tr>
<tr>
<td>Scirpus validus&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>Softstem bulrush</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuphar polysepalum</td>
<td>Spatterdock</td>
<td>Deep water</td>
<td>3 to 7.5 feet</td>
</tr>
<tr>
<td>Nymphaea odorata&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>White waterlily</td>
<td>Shallow to deep ponds</td>
<td>to 6 feet</td>
</tr>
</tbody>
</table>

**Notes:**

- <sup>(1)</sup> Non-native species. *Beckmania syzigachne* is native to Oregon. Native species are preferred.
- <sup>(2)</sup> *Scirpus* tubers must be planted shallower for establishment, and protected from foraging waterfowl until established. Emerging aerial stems should project above water surface to allow oxygen transport to the roots.

**Primary sources:**
Figure 5.22 – Headwater Depth for Smooth Interior Pipe Culverts with Inlet Control
Figure 5.23 – Headwater Depth for Corrugated Pipe Culverts with Inlet Control
Figure 5.24 – Critical Depth of Flow for Circular Culverts

Note: For all cross-sectional shapes, $d_c$ can be calculated by trial and error knowing that the quantity ($Q^2T/gA^3$) = 1.0 at critical depth.

**EXAMPLE**

$D = 66$ inches, $Q = 100$ cfs  
$d_c/D$ - Ratio = 0.50  
$d_c = (0.50)(66$ inches$) = 33$ inches $\sqrt(12$ inches/ft$)  
$d_c = 2.75$ feet
Figure 5.25 – Circular Channel Ratios
BMP T10.20 Wet vaults

Purpose and Definition
A wet vault is an underground structure similar in appearance to a detention vault, except that a wet vault has a permanent pool of water (wetpool) which dissipates energy and improves the settling of particulate pollutants. See EDDS Standard Drawing 5-280. Being underground, the wet vault lacks the biological pollutant removal mechanisms, such as algae uptake, present in surface wet ponds.

Applications and Limitations
A wet vault can be used to provide basic treatment in certain applications or can be used as part of a treatment train. If oil control is required for a project, a wet vault may be combined with an API oil/water separator.

Design Criteria
Engineering standards and specifications set forth in Section 5-15 of Snohomish County EDDS shall apply to wet vaults, provided that specific geometry criteria set forth below related to treatment performance shall also apply.

Sizing Procedure
The sizing procedure for a wet vault is identical to the sizing procedure for a wet pond. The wet pool volume for the wet vault shall be equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, the 91st percentile, 24-hour runoff volume estimated by an approved continuous runoff model may be used.
Wetpool Geometry

Same as specified for wetponds (see BMP T10.10) except for the following two modifications:

- The sediment storage in the first cell shall be an average of 1 foot. Because of the v-shaped bottom, the depth of sediment storage needed above the bottom of the side wall is roughly proportional to vault width according to the schedule below:

<table>
<thead>
<tr>
<th>Vault Width</th>
<th>Sediment Depth (from bottom of side wall)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15'</td>
<td>10&quot;</td>
</tr>
<tr>
<td>20'</td>
<td>9&quot;</td>
</tr>
<tr>
<td>40'</td>
<td>6&quot;</td>
</tr>
<tr>
<td>60'</td>
<td>4&quot;</td>
</tr>
</tbody>
</table>

- The second cell shall be a minimum of 3 feet deep since planting cannot be used to prevent resuspension of sediment in shallow water as it can in open ponds.

Vault Structure

- The vault shall be separated into two cells by a wall or a removable baffle. If a wall is used, a 5-foot by 10-foot removable maintenance access must be provided for both cells. If a removable baffle is used, the following criteria apply:
  - The baffle shall extend from a minimum of 1 foot above the WQ design water surface to a minimum of 1 foot below the invert elevation of the inlet pipe.
  - The lowest point of the baffle shall be a minimum of 2 feet from the bottom of the vault, and greater if feasible.
- If the vault is less than 2,000 cubic feet (inside dimensions), or if the length-to-width ratio of the vault pool is 5:1 or greater, the baffle or wall may be omitted and the vault may be one-celled.
- The two cells of a wetvault shall not be divided into additional subcells by internal walls. If internal structural support is needed, use post and pier construction be used to support the vault lid rather than walls. Any walls used within cells must be positioned so as to lengthen, rather than divide, the flowpath.
- The bottom of the first cell shall be sloped toward the access opening. Slope shall be between 0.5 percent (minimum) and 2 percent (maximum). The second cell may be level (longitudinally) sloped toward the outlet, with a high point between the first and second cells. Sloping the second cell towards the access opening for the first cell is also acceptable.
- The vault bottom shall slope laterally a minimum of 5 percent from each side towards the center, forming a broad "v" to facilitate sediment removal. Note: More than one "v" may be used to minimize vault depth.
- Exception: Snohomish County may allow the vault bottom to be flat if removable panels are provided over the entire vault. Removable panels should be at grade, have stainless steel lifting eyes, and weigh no more than 5 tons per panel.
• The highest point of a vault bottom must be at least 6 inches below the outlet pipe invert elevation to provide for sediment storage over the entire bottom.

• Wetvaults may be constructed using arch culvert sections provided the top area at the WQ design water surface is, at a minimum, equal to that of a vault with vertical walls designed with an average depth of 6 feet.

**Inlet and Outlet**

• The inlet pipe to the wetvault shall be submerged with the inlet pipe invert a minimum of 3 feet from the vault bottom. The top of the inlet pipe shall be submerged at least 1-foot.

• Unless designed as an off-line facility, the capacity of the outlet pipe and available head above the outlet pipe shall be designed to convey the 100-year design flow for developed site conditions without overtopping the vault. The available head above the outlet pipe must be a minimum of 6 inches.

• The outlet pipe shall be back-sloped or have tee section, the lower arm of which should extend 1 foot below the WQ design water surface to provide for trapping of oils and floatables in the vault.

• Snohomish County may require a bypass/shutoff valve to enable the vault to be taken offline for maintenance.

**Access Requirements**

The requirements set forth in Section 5-15 of Snohomish County EDDS shall apply to wetvaults, with the following additional requirement:

• A minimum of 50 square feet of grate shall be provided over the second cell. For vaults in which the surface area of the second cell is greater than 1,250 square feet, 4 percent of the top shall be grated. This requirement may be met by one grate or by many smaller grates distributed over the second cell area. Note: a grated access door can be used to meet this requirement.

**Access Roads, Right of Way, and Setbacks**

The requirements set forth in Section 5-15 of Snohomish County EDDS shall apply to wetvaults.

**Maintenance**

Maintenance requirements for drainage facilities are set forth in Chapter 7.53.140 SCC and Volume V, Chapter 4.6 of this manual.
BMP T10.30 Stormwater Treatment Wetlands

Purpose and Definition

In land development situations, wetlands are usually constructed for two main reasons: to replace or mitigate impacts when natural wetlands are filled or impacted by development (mitigation wetlands), and to treat stormwater runoff (stormwater treatment wetlands). Stormwater treatment wetlands are shallow man-made ponds that are designed to treat stormwater through the biological processes associated with emergent aquatic plants (see the stormwater wetland details in Figure 5.26 and Figure 5.27).

Wetlands created to mitigate disturbance impacts, such as filling, may not also be used as stormwater treatment facilities. This is because of the different, incompatible functions of the two kinds of wetlands. Mitigation wetlands are intended to function as full replacement habitat for fish and wildlife, providing the same functions and harboring the same species diversity and biotic richness as the wetlands they replace. Stormwater treatment wetlands are used to capture and transform pollutants, just as wetponds are, and over time pollutants will concentrate in the sediment. This is not a healthy environment for aquatic life. Stormwater treatment wetlands are used to capture pollutants in a managed environment so that they will not reach natural wetlands and other ecologically important habitats. In addition, vegetation must occasionally be harvested and sediment dredged in stormwater treatment wetlands, further interfering with use for wildlife habitat.

In general, stormwater wetlands perform well to remove sediment, metals, and pollutants that bind to humic or organic acids. Phosphorus removal in stormwater wetlands is highly variable.

Applications and Limitations

This stormwater wetland design occupies about the same surface area as wetponds, but has the potential to be better integrated aesthetically into a site because of the abundance of emergent aquatic vegetation. The most critical factor for a successful design is the provision of an adequate supply of water for most of the year. Careful planning is needed to be sure sufficient water will be retained to sustain good wetland plant growth. Since water depths are shallower than in wetponds, water loss by evaporation is an important concern. Stormwater wetlands are a good WQ facility choice in areas with high winter groundwater levels.
**Design Criteria**

When used for stormwater treatment, stormwater wetlands employ some of the same design features as wetponds. However, instead of gravity settling being the dominant treatment process, pollutant removal mediated by aquatic vegetation and the microbiological community associated with that vegetation becomes the dominant treatment process. Thus when designing wetlands, water volume is not the dominant design criteria. Rather, factors which affect plant vigor and biomass are the primary concerns.

**Sizing Procedure**

**Step 1:** The volume of a basic wetpond is used as a template for sizing the stormwater wetland. The design volume is the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, the 91st percentile, 24-hour runoff volume estimated by an approved continuous runoff model may be used.

**Step 2:** Calculate the surface area of the stormwater wetland. The surface area of the wetland shall be the same as the top area of a wetpond sized for the same site conditions. Calculate the surface area of the stormwater wetland by using the volume from Step 1 and dividing by the average water depth (use 3 feet).

**Step 3:** Determine the surface area of the first cell of the stormwater wetland. Use the volume determined from Criterion 2 under "Wetland Geometry", and the actual depth of the first cell.

**Step 4:** Determine the surface area of the wetland cell. Subtract the surface area of the first cell (Step 3) from the total surface area (Step 2).

**Step 5:** Determine water depth distribution in the second cell. Decide if the top of the dividing berm will be at the surface or submerged (designer's choice). Adjust the distribution of water depths in the second cell according to Criterion 8 under "Wetland Geometry" below. Note: This will result in a facility that holds less volume than that determined in Step 1 above. This is acceptable.

**Intent:** The surface area of the stormwater wetland is set to be roughly equivalent to that of a wetpond designed for the same site so as not to discourage use of this option.

**Step 6:** Choose plants. See Table 5.9 for a list of plants recommended for wetpond water depth zones, or consult a wetland scientist.

**Wetland Geometry**

1. Stormwater wetlands shall consist of two cells, a presettling cell and a wetland cell.
2. The presettling cell shall contain approximately 33 percent of the wetpool volume calculated in Step 1 above.
3. The depth of the presettling cell shall be between 4 feet (minimum) and 8 feet (maximum), excluding sediment storage.
4. One-foot of sediment storage shall be provided in the presettling cell.
5. The wetland cell shall have an average water depth of about 1.5 feet (plus or minus 3 inches).

6. The "berm" separating the two cells shall be shaped such that its downstream side gradually slopes to form the second shallow wetland cell (see the section view in Figure 5.27). Alternatively, the second cell may be graded naturalistically from the top of the dividing berm (see Criterion 8 below).

7. The top of berm shall be either at the WQ design water surface or submerged 1-foot below the WQ design water surface, as with wetponds. Berm standards and specifications set forth in 5-10 of Snohomish County EDDS apply.

8. Two examples are provided for grading the bottom of the wetland cell. One example is a shallow, evenly graded slope from the upstream to the downstream edge of the wetland cell (see Figure 5.26). The second example is a "naturalistic" alternative, with the specified range of depths intermixed throughout the second cell (see Figure 5.27). A distribution of depths shall be provided in the wetland cell depending on whether the dividing berm is at the water surface or submerged (see Table 5.11 below). The maximum depth is 2.5 feet in either configuration. Other configurations within the wetland geometry constraints listed above may be approved by Snohomish County.

<table>
<thead>
<tr>
<th>Table 5.11 – Distribution of Depths in Wetland Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dividing Berm at WQ Design Water Surface</td>
</tr>
<tr>
<td>Depth Range (feet)</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>0.1 to 1</td>
</tr>
<tr>
<td>1 to 2</td>
</tr>
<tr>
<td>2 to 2.5</td>
</tr>
</tbody>
</table>
Figure 5.26 – Stormwater Wetland – Option One
Figure 5.27 – Stormwater Wetland — Option Two
Lining Requirements

The following hydrologic conditions in the wetland shall be met.

1. The second cell must retain water for at least 10 months of the year.
2. The first cell must retain at least three feet of water year-round.

A liner may be needed to achieve these conditions. Liners shall meet the requirements set forth in Chapter 4.4 of this volume. If a liner is needed, either a treatment liner or a low permeability liner may be used, provided the conditions are met. The need for a liner shall be determined by conducting a hydrologic analysis using a complete precipitation record and accounting for evapotranspiration losses and soil characteristics.

If a low permeability liner is used, a minimum of 18 inches of native soil amended with good topsoil or compost (one part compost mixed with 3 parts native soil) must be placed over the liner. For geomembrane liners, a soil depth of 3 feet is recommended to prevent damage to the liner during planting. Hydric soils are not required.

Inlet and Outlet

See inlet and outlet requirements for Wetponds, BMP T10.10. All materials and engineering standards and specifications set forth in Snohomish County EDDS shall apply.

Access and Setbacks

- Setbacks shall be provided in accordance with SCC 30.63A.710.
- Access shall be provided in accordance with Chapter 30.63A SCC and Chapter 5-10 Snohomish County EDDS.

Vegetation

The wetland cell shall be planted with emergent wetland plants following the recommendations given in Table 5.10 or the recommendations of a wetland specialist. Note: Cattails (Typha latifolia) are not recommended. They tend to escape to natural wetlands and crowd out other species. In addition, the shoots die back each fall and will result in oxygen depletion in the wetpool unless they are removed.

Construction Criteria

- Construction and maintenance considerations are the same as for wetponds.
- Construction of the naturalistic alternative (Option 2) can be easily done by first excavating the entire area to the 1.5-foot average depth. Then soil subsequently excavated to form deeper areas can be deposited to raise other areas until the distribution of depths indicated in the design is achieved.
**Maintenance**

Maintenance requirements for wetponds shall apply to stormwater treatment wetlands. Maintenance requirements for drainage facilities are set forth in SCC 7.53.140 and Volume V, Chapter 4.6 of this manual.
BMP T10.40 Combined Detention and Wetpool Facilities

Purpose and Definition

Combined detention and WQ wetpool facilities have the appearance of a detention facility but contain a permanent pool of water as well. The following design procedures, requirements, and recommendations cover differences in the design of the stand-alone WQ facility when combined with detention storage. The following combined facilities are addressed:

- Detention/wetpond (basic and large)
- Detention/wetvault
- Detention/stormwater wetland.

There are two sizes of the combined wetpond, a basic and a large, but only a basic size for the combined wetvault and combined stormwater wetland. The facility sizes (basic and large) are related to the pollutant removal goals. See Chapter 3 for more information about treatment performance goals.

Applications and Limitations

Combined detention and water quality facilities are very efficient for sites that also have detention requirements. The water quality facility may often be placed beneath the detention facility without increasing the facility surface area. However, the fluctuating water surface of the live storage will create unique challenges for plant growth and for aesthetics alike.

The basis for pollutant removal in combined facilities is the same as in the stand-alone WQ facilities. However, in the combined facility, the detention function creates fluctuating water levels and added turbulence. For simplicity, the positive effect of the extra live storage volume and the negative effect of increased turbulence are assumed to balance, and are thus ignored when sizing the wetpool volume. For the combined detention/stormwater wetland, criteria that limit the extent of water level fluctuation are specified to better ensure survival of the wetland plants.

Unlike the wetpool volume, the live storage component of the facility should be provided above the seasonal high water table.

Combined Detention and Wetpond (Basic and Large)

Typical design details and concepts for a combined detention and wetpond are shown in Figures 5.28 and 5.29. The detention portion of the facility shall meet the design criteria and sizing procedures set forth in Volume 3.

Sizing Procedure

The sizing procedure for combined detention and wetponds are identical to those outlined for wetponds and for detention facilities. The wetpool volume for a combined facility shall be equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, the 91st percentile, 24-hour runoff volume estimated by an approved continuous runoff model may be used to size the wetpool. Follow the standard procedure specified in Volume III to size the detention portion of the pond.
Detention and Wetpool Geometry

- The wetpool and sediment storage volumes shall not be included in the required detention volume.

- The "Wetpool Geometry" criteria for wetponds (see BMP T10.10) shall apply with the following modifications/clarifications:

Criterion 1: The permanent pool may be made shallower to take up most of the pond bottom, or deeper and positioned to take up only a limited portion of the bottom. Note, however, that having the first wetpool cell at the inlet allows for more efficient sediment management than if the cell is moved away from the inlet. Wetpond criteria governing water depth must, however, still be met.

Intent: This flexibility in positioning cells is provided to allow for multiple use options, such as volleyball courts in live storage areas in the drier months.

Criterion 2: The minimum sediment storage depth in the first cell is 1-foot. The 6 inches of sediment storage required for detention ponds does not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with the detention sediment storage requirement.

Berms, Baffles, and Slopes

See Wetponds, BMP T10.10. Engineering standards and specifications set forth in Chapter 5-10 Snohomish County EDDS shall apply.
Figure 5.28 – Combined Detention and Wetpond
Figure 5.29 – Combined Detention and Wetpond (Continued)
Figure 5.30 – Alternative Configurations of Detention and Wetpool Areas
Inlet and Outlet
The "Inlet and Outlet" criteria for wetponds shall apply with the following modifications:

- A sump must be provided in the outlet structure of combined ponds.
- The detention flow restrictor and its outlet pipe shall be designed according to the requirements for detention ponds (see Volume III).

Access and Setbacks
Same as for wetponds.

Planting Requirements
Same as for wetponds.

Combined Detention and Wetvault
The sizing procedure for combined detention and wetvaults is identical to those outlined for wetvaults and for detention facilities. The wetvault volume for a combined facility shall be equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, the 91st percentile, 24-hour runoff volume estimated by an approved continuous runoff model may be used to size the wetpool portion of vault. Follow the standard procedure specified in Volume 3 to size the detention portion of the vault.

The design criteria for detention vaults and wetvaults must both be met, except for the following modifications or clarifications:

- The minimum sediment storage depth in the first cell shall average 1-foot. The 6 inches of sediment storage required for detention vaults does not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with detention vault sediment storage requirements.

- The oil retaining baffle shall extend a minimum of 2 feet below the WQ design water surface.

Intent: The greater depth of the baffle in relation to the WQ design water surface compensates for the greater water level fluctuations experienced in the combined vault. The greater depth is deemed prudent to better ensure that separated oils remain within the vault, even during storm events.

Note: If a vault is used for detention as well as water quality control, the facility may not be modified to function as a baffle oil/water separator as allowed for wetvaults in BMP T10.20. This is because the added pool fluctuation in the combined vault does not allow for the quiescent conditions needed for oil separation.

Combined Detention and Stormwater Wetland
The sizing procedure for combined detention and stormwater wetlands is identical to those outlined for stormwater wetlands and for detention facilities. Follow the procedure specified in BMP T10.30 to determine the stormwater wetland size. Follow the standard procedure specified in Volume III to size the detention portion of the wetland.
The design criteria for detention ponds and stormwater wetlands must both be met, except for the following modifications or clarifications:

- The "Wetland Geometry" criteria for stormwater wetlands (see BMP T10.30) are modified as follows:
  - The minimum sediment storage depth in the first cell is 1-foot. The 6 inches of sediment storage required for detention ponds does not need to be added to this, nor does the 6 inches of sediment storage in the second cell of detention ponds need to be added.

**Intent:** Since emergent plants are limited to shallower water depths, the deeper water created before sediments accumulate is considered detrimental to robust emergent growth. Therefore, sediment storage is confined to the first cell which functions as a presettling cell.

The "Inlet and Outlet" criteria for wetponds shall apply with the following modifications:

- A sump must be provided in the outlet structure of combined facilities.
- The detention flow restrictor and its outlet pipe shall be designed according to the requirements for detention ponds (see Volume III).

The "Planting Requirements" for stormwater wetlands are modified to use the following plants which are better adapted to water level fluctuations:

- Scirpus acutus (hardstem bulrush) 2 - 6’ depth
- Scirpus microcarpus (small-fruited bulrush) 1 - 2.5’ depth
- Sparganium emersum (burreed) 1 - 2’ depth
- Sparganium eurycarpum (burreed) 1 - 2’ depth
- Veronica sp. (marsh speedwell) 0 - 1’ depth

In addition, the shrub Spirea douglasii (Douglas spirea) may be used in combined facilities.

**Water Level Fluctuation Restrictions:** The difference between the WQ design water surface and the maximum water surface associated with the 2-year runoff shall not be greater than 3 feet. If this restriction cannot be met, the size of the stormwater wetland must be increased. The additional area may be placed in the first cell, second cell, or both. If placed in the second cell, the additional area need not be planted with wetland vegetation or counted in calculating the average depth.

**Intent:** This criterion is designed to dampen the most extreme water level fluctuations expected in combined facilities to better ensure that fluctuation-tolerant wetland plants will be able to survive in the facility. It is not intended to protect native wetland plant communities and is not to be applied to natural wetlands.
Chapter 11 - Oil and Water Separators

This chapter provides a discussion of oil and water separators, including their application and design criteria. BMPs are described for baffle type and coalescing plate separators.

11.1 Purpose of Oil and Water Separators

To remove oil and other water-insoluble hydrocarbons, and settleable solids from stormwater runoff.

11.2 Description

Oil and water separators are typically the American Petroleum Institute (API) (also called baffle type) (American Petroleum Institute, 1990) or the coalescing plate (CP) type using a gravity mechanism for separation. See EDDS Standard Drawings 5-310 and 5-315. Oil removal separators typically consist of three bays; forebay, separator section, and the afterbay. The CP separators need considerably less space for separation of the floating oil due to the shorter travel distances between parallel plates. A spill control (SC) separator (Figure 5.31) is a simple catchbasin with a T-inlet for temporarily trapping small volumes of oil. The spill control separator is included here for comparison only and is not designed for, or to be used for treatment purposes.
Figure 5.31 – Spill Control Separator (not for oil treatment)
11.3 Performance Objectives

Oil and water separators should be designed to remove oil and TPH down to 15 mg/L at any time and 10 mg/L on a 24-hr average, and produce a discharge that does not cause an ongoing or recurring visible sheen in the stormwater discharge, or in the receiving water. (See also Chapter 3 of this volume).

11.4 Applications/Limitations

The following are potential applications of oil and water separators where free oil is expected to be present at treatable high concentrations and sediment will not overwhelm the separator. For low concentrations of oil, other treatments may be more applicable. These include sand filters and emerging technologies.

- Commercial and industrial areas including petroleum storage yards, vehicle maintenance facilities, manufacturing areas, airports, utility areas (water, electric, gas), and fueling stations.

- Facilities that would require oil control BMPs under the high-use site threshold described in Chapter 2 including parking lots at convenience stores, fast food restaurants, grocery stores, shopping malls, discount warehouse stores, banks, truck fleets, auto and truck dealerships, and delivery services.

- Without intense maintenance oil/water separators may not be sufficiently effective in achieving oil and TPH removal down to required levels.

- Pretreatment should be considered if the level of TSS in the inlet flow would cause clogging or otherwise impair the long-term efficiency of the separator.

- For inflows from small drainage areas (fueling stations, maintenance shops, etc.) a coalescing plate (CP) type separator is typically considered, due to space limitations. However, if plugging of the plates is likely, then a new design basis for the baffle type API separator may be considered on an experimental basis.

11.5 Site Suitability

Consider the following site characteristics:

- Sufficient land area
- Adequate TSS control or pretreatment capability
- Compliance with environmental objectives
- Adequate influent flow attenuation and/or bypass capability
- Sufficient access for operation and maintenance (O & M)
11.6 Design Criteria-General Considerations

NOTE: Engineering standards and specifications for oil / water separators are set forth in Chapter 5-19 of Snohomish County EDDS.

The following are design criteria applicable to API and CP oil/water separators:

- If practicable, determine oil/grease (or TPH) and TSS concentrations, lowest temperature, pH; and empirical oil rise rates in the runoff, and the viscosity, and specific gravity of the oil. Also determine whether the oil is emulsified or dissolved. Do not use oil/water separators for the removal of dissolved or emulsified oils such as coolants, soluble lubricants, glycols, and alcohols.

- Locate the separator off-line and bypass the incremental portion of flows that exceed the off-line 15-minute, water quality design flow rate multiplied by the ratio indicated in Figure 5.18. If it is necessary to locate the separator on-line, try to minimize the size of the area needing oil control, and use the on-line water quality design flow rate multiplied by the ratio indicated in Figure 5.17.

- Use only impervious conveyances for oil contaminated stormwater.

- Specify appropriate performance tests after installation and shakedown, and/or certification by a professional engineer that the separator is functioning in accordance with design objectives. Expeditious corrective actions must be taken if it is determined the separator is not achieving acceptable performance levels.

- Add pretreatment for TSS that could cause clogging of the CP separator, or otherwise impair the long-term effectiveness of the separator.

Criteria for Separator Bays:

- Multiply the size of the separator bay determined for the water quality design flow rate by the correction factor ratio indicated in Figure 5.18 of this volume (assuming an off-line facility.

- To collect floatables and settleable solids, design the surface area of the forebay at \( \geq 20 \text{ ft}^2 \) per 10,000 \( \text{ft}^2 \) of area draining to the separator. The length of the forebay should be 1/3-1/2 of the length of the entire separator. Include roughing screens for the forebay or upstream of the separator to remove debris, if needed. Screen openings should be about 3/4 inch.

- Include a submerged inlet pipe with a turn-down elbow in the first bay at least two feet from the bottom. The outlet pipe should be a Tee, sized to pass the design peak flow and placed at least 12 inches below the water surface.

- Include a shutoff mechanism at the separator outlet pipe.
- Use absorbents and/or skimmers in the afterbay as needed.

**Criteria for Baffles:**

- Oil retaining baffles (top baffles) should be located at least at 1/4 of the total separator length from the outlet and should extend down at least 50% of the water depth and at least 1 ft. from the separator bottom.

- Baffle height to water depth ratios should be 0.85 for top baffles and 0.15 for bottom baffles.

**11.7 Oil and Water Separator BMPs**

Two BMPs are described in this section. BMP T11.10 for baffle type separators, and BMP T11.11 for coalescing plate separators.
**BMP T11.10 API (Baffle type) Separator Bay**

**Design Criteria**

The criteria for small drainages is based on \( V_h \), \( V_t \), residence time, width, depth, and length considerations. As a correction factor API's turbulence criteria is applied to increase the length.

For drainage areas less than two acres, use the design hydraulic horizontal velocity, \( V_h \), for the design \( V_h/V_t \) ratio rather than the API minimum of \( V_h/V_t = 15 \).

The following is the sizing procedure using modified API criteria:

- Determine the oil rise rate, \( V_t \), in cm/sec, using Stokes Law, or empirical determination, or 0.033 ft./min for 60 \( \mu \) oil. The application of Stokes’ Law to site-based oil droplet sizes and densities, or empirical rise rate determinations recognizes the need to consider actual site conditions. In those cases the design basis would not be the 60 micron droplet size and the 0.033 ft/min. rise rate.

- Stokes Law equation for rise rate, \( V_t \) (cm/sec):
  
  \[ V_t = \frac{g(\rho_w - \rho_o)(d^2)}{18\mu_w} \]

Where:

- \( V_t \) = the rise rate of the oil droplet (cm/s or ft/sec)
- \( g \) = acceleration due to gravity (cm/s² or ft/s²)
- \( \rho_w \) = density of water at the design temperature (g/cm³ or lbm/ft³)
- \( \rho_o \) = density of oil at the design temperature (g/cm³ or lbm/ft³)
- \( d \) = oil droplet diameter (cm or ft)
- \( \mu_w \) = absolute viscosity of the water (g/cm-s or lbm/ft-s)

Use

- oil particle size diameter, \( D = 60 \) microns (0.006 cm)
- \( \rho_w = 0.999 \) gm/cc. at 32°C F
- \( \rho_o \): Select conservatively high oil density. For example, if diesel oil @ \( \rho_o = 0.85 \) gm/cc and motor oil @ \( \rho_o = 0.90 \) can be present then use \( \rho_o = 0.90 \) gm/cc
- \( \mu_w = 0.017921 \) poise, gm/cm-sec. at \( T_w = 32 \) °F

Use the following separator dimension criteria:

- Separator water depth, \( d \geq 3 \leq 8 \) feet (to minimize turbulence)
- Separator width, 6-20 feet
- Depth/width (d/w) of 0.3-0.5

**For Stormwater Inflow from Drainages under 2 Acres:**

1. Determine \( V_t \) and select depth and width of the separator section based on above criteria.
2. Calculate the minimum residence time ($t_m$) of the separator at depth $d$:

\[ t_m = \frac{d}{V_t} \]

3. Calculate the horizontal velocity of the bulk fluid, $V_h$, vertical cross-sectional area, $A_v$, and actual design $V_h/V_t$:

\[ V_h = \frac{Q}{d w} = \frac{Q}{A_v} \quad (V_h \text{ maximum at } < 2.0 \text{ ft/min.}) \]

$Q = (k)$ the ratio indicated in Figure 5.18 for the site location multiplied by the 15-minute Water Quality design flow rate in ft\(^3\)/min, at minimum residence time, $t_m$

At $V_h/V_t$ determine $F$, turbulence and short-circuiting factor (see Appendix V-C) API $F$ factors range from 1.28-1.74.

4. Calculate the minimum length of the separator section, $l(s)$, using:

\[ l(s) = F q t_m / w d = F (V_h / V_t) d \]

\[ l(t) = l(f) + l(s) + l(a) \]

\[ l(t) = l(t)/3 + l(s) + l(t)/4 \]

Where:

\[ l(t) = \text{total length of 3 bays = “L” in EDDS Standard Drawing 5-310} \]

\[ l(f) = \text{length of forebay} \]

\[ l(a) = \text{length of afterbay} \]

5. Calculate $V = l(s) w d = F q t_m$, and $A_h = w l(s)$

$V = \text{minimum hydraulic design volume}$

$A_h = \text{minimum horizontal area of the separator}$

**For Stormwater Inflow from Drainages > 2 Acres:** Use $V_h = 15 \ V_t$ and $d = (Q/2V_h)^{1/2}$ (with $d/w = 0.5$) and repeat above calculations 3-5.
BMP T11.11 Coalescing Plate (CP) Separator Bay

Design Criteria

Calculate the projected (horizontal) surface area of plates needed using the following equation:

\[ A_h = \frac{Q}{V_t} = \frac{[Q]}{[.00386 \times ((S_w - S_o)/(\mu_w))]} \]

Where

- \( A_h \) = horizontal surface area of the plates (ft²)
- \( V_t \) = rise rate of the oil droplet (ft/min)
- \( Q \) = design flowrate (ft³/min)
- \( S_w \) = specific gravity of water at the design temperature
- \( S_o \) = specific gravity of oil at the design temperature
- \( \mu_w \) = absolute viscosity of the water (poise)

The above equation is based on an oil droplet diameter of 60 microns

- Plate spacing should be a minimum of 3/4 in (perpendicular distance between plates).
- Select a plate angle between 45° to 60° from the horizontal.
- Locate plate pack at least 6 inches from the bottom of the separator for sediment storage
- Add 12 inches minimum head space from the top of the plate pack and the bottom of the vault cover.
- Design inlet flow distribution and baffles in the separator bay to minimize turbulence, short-circuiting, and channeling of the inflow especially through and around the plate packs of the CP separator. The Reynolds Number through the separator bay should be <500 (laminar flow).
- Include forebay for floatables and afterbay for collection of effluent
- The sediment-retaining baffle must be upstream of the plate pack at a minimum height of 18 in.
- Design plates for ease of removal, and cleaning with high-pressure rinse or equivalent.

Maintenance

Maintenance requirements for drainage facilities are set forth in SCC 7.53.140 and Volume V, Chapter 4.6 of this manual.
Chapter 12 - Other BMPs and Technologies Approved by the Washington State Department of Ecology

This chapter identifies other systems and technologies to which the Washington State Department of Ecology (Ecology) has assigned use designations, or has determined to be equivalent to BMPs in this manual.

Ecology has assigned Use Level Designations (ULDs) to systems and technologies evaluated according to the Technical Assessment Protocol - Ecology (TAPE) and the Chemical Technical Assessment Protocol (CTAPE). These protocols were developed to allow Ecology to determine whether a system or technology meets the performance criteria for BMPs in the 2005 Ecology Stormwater Management Manual for Western Washington. Information about the TAPE and the CTAPE is available at:


The three ULDs used by Ecology are General Statewide Use Level Designation (GULD), Conditional Use Level Designation (CULD), and Pilot Use Level Designation (PULD). Snohomish County will allow use of systems and technologies with a GULD without a code modification, provided that they are designed and constructed in accordance with the information presented on Ecology's website. Systems and technologies with CULDs or PULDs may only be used in Snohomish County with approval through the code modification process.

Table 5.12 lists the systems and technologies for which Ecology had assigned ULDs or equivalence designations as of the date of adoption of this manual. With the exception of the Media Filter Drain designed by the Washington State Department of Transportation, all of the systems and technologies listed are private commercial products. Their inclusion in this manual does not represent endorsement of any kind by Snohomish County.
Table 5.12  Washington State Department of Ecology Use Level Designations or Equivalence Designations

General Use Level Designation (GULD)

<table>
<thead>
<tr>
<th>System</th>
<th>Basic</th>
<th>Enhanced</th>
<th>Phosphorus</th>
<th>Oil</th>
<th>Pretreatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>StormFilter - zeolite/perlite/granular activated carbon media</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDS Media Filtration System - perlite</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSDOT Media Filter Drain</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td></td>
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<tr>
<td>Filterra</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>CDS System</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Vortechs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>AquaSwirl</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>AquaFilter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Downstream Defender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X (sediment only)</td>
</tr>
<tr>
<td>Stormceptor</td>
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<td></td>
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<td>X</td>
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Conditional Use Level Designation (CULD)

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<th>System</th>
<th>Basic</th>
<th>Enhanced</th>
<th>Phosphorus</th>
<th>Oil</th>
<th>Pretreatment</th>
</tr>
</thead>
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<tr>
<td>Filterra</td>
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<td></td>
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<td>BayFilter</td>
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<tr>
<td>BaySeparator</td>
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Pilot Use Level Designation (PULD)

<table>
<thead>
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<th>System</th>
<th>Basic</th>
<th>Enhanced</th>
<th>Phosphorus</th>
<th>Oil</th>
<th>Pretreatment</th>
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</thead>
<tbody>
<tr>
<td>EcoStorm Plus</td>
<td>X</td>
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<tr>
<td>FloGard Perk Filter</td>
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<tr>
<td>Up-Flo Filterq</td>
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<td></td>
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<tr>
<td>Jellyfish</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AquaFilter - coarse perlite</td>
<td>X</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>AquaFilter - AquaBlend C media</td>
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## Construction Stormwater Runoff Treatment

### General Use Level Designation (GULD)

<table>
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<tr>
<th>System</th>
<th>100% on-site infiltration</th>
<th>Batch treatment discharge to surface water</th>
<th>Flow-through treatment discharge to surface water</th>
</tr>
</thead>
<tbody>
<tr>
<td>StormKlear Chitosan Enhanced Sand Filtration (CESF)</td>
<td>X</td>
<td>X</td>
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<tr>
<td>FlocClear CESF</td>
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<td>X</td>
<td></td>
</tr>
<tr>
<td>ChitoVan CESF</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>StormKlear LiquiFloc CESF</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

### Conditional Use Level Designation (CULD)

<table>
<thead>
<tr>
<th>System</th>
<th>100% on-site infiltration</th>
<th>Batch treatment discharge to surface water</th>
<th>Flow-through treatment discharge to surface water</th>
</tr>
</thead>
<tbody>
<tr>
<td>FlocClear CESF</td>
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<td></td>
<td>X</td>
</tr>
<tr>
<td>StormKlear LiquiFloc CESF</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Electrocoagulation Subtractive Technology</td>
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</table>

### Technologies determined by Ecology as equivalent to existing technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Equivalent to</th>
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</thead>
<tbody>
<tr>
<td>Silva Cell</td>
<td>Bioretention facility</td>
</tr>
<tr>
<td>EarthGuard® Fiber Matrix</td>
<td>BMP C120 - Temporary and Permanent Seeding</td>
</tr>
<tr>
<td>Erosion Eel</td>
<td>BMP C235 - Straw Wattles</td>
</tr>
<tr>
<td>ClimaCover All Weather Protective System</td>
<td>Sand Bags as referenced in BMP C123 - Plastic Covering</td>
</tr>
<tr>
<td>Track Clean™ Construction Entrance Plates</td>
<td>BMP C105 - Stabilized Construction Entrance</td>
</tr>
<tr>
<td>Filtrexx®</td>
<td>BMP C233 - Silt Fence</td>
</tr>
<tr>
<td>SiltSoxx®</td>
<td>BMP C220 - Storm Drain Inlet Protection</td>
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<tr>
<td>CheckSoxx®</td>
<td>BMP C207 - Storm Check Dams</td>
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<tr>
<td>Delta Lok</td>
<td>SWPPP Element 6 - Slope Protection</td>
</tr>
</tbody>
</table>
Volume V References


Appendix V-A Basic Treatment Receiving Waters

1. All salt waterbodies

2. **Rivers** | **Upstream Point for Exemption**
---|---
Skykomish | Beckler River
Snohomish | Snoqualmie River
Snoqualmie | Middle and North Fork Confluence
Stillaguamish | North and South Fork Confluence
North Fork Stillaguamish | Boulder River
South Fork Stillaguamish | Canyon Creek
Suiattle | Darrington

3. **Lakes** | **County**
---|---
[No lakes in Snohomish County]
Appendix V-B (Also published as Appendix III-D)
Procedure for Conducting a Pilot Infiltration Test

The Pilot Infiltration Test (PIT) consists of a relatively large-scale infiltration test to better approximate infiltration rates for design of stormwater infiltration facilities. The PIT reduces some of the scale errors associated with relatively small-scale double ring infiltrometer or “stove-pipe” infiltration tests.

**Infiltration Test**

- Excavate the test pit to the depth of the bottom of the proposed infiltration facility. Lay back the slopes sufficiently to avoid caving and erosion during the test.

- The horizontal surface area of the bottom of the test pit should be approximately 100 square feet. For small drainages and where water availability is a problem smaller areas may be considered as determined by the site professional.

- Accurately document the size and geometry of the test pit.

- Install a vertical measuring rod (minimum 5-ft. long) marked in half-inch increments in the center of the pit bottom.

- Use a rigid 6-inch diameter pipe with a splash plate on the bottom to convey water to the pit and reduce side-wall erosion or excessive disturbance of the pond bottom. Excessive erosion and bottom disturbance will result in clogging of the infiltration receptor and yield lower than actual infiltration rates.

- Add water to the pit at a rate that will maintain a water level between 3 and 4 feet above the bottom of the pit. A rotameter can be used to measure the flow rate into the pit.

  *Note:* A water level of 3 to 4 feet provides for easier measurement and flow stabilization control. However, the depth should not exceed the proposed maximum depth of water expected in the completed facility.

Every 15-30 min, record the cumulative volume and instantaneous flow rate in gallons per minute necessary to maintain the water level at the same point (between 3 and 4 feet) on the measuring rod.

Add water to the pit until one hour after the flow rate into the pit has stabilized (constant flow rate) while maintaining the same pond water level. (usually 17 hours)

After the flow rate has stabilized, turn off the water and record the rate of infiltration in inches per hour from the measuring rod data, until the pit is empty.

**Data Analysis**

Calculate and record the infiltration rate in inches per hour in 30 minutes or one-hour increments until one hour after the flow has stabilized.

*Note:* Use statistical/trend analysis to obtain the hourly flow rate when the flow stabilizes. This would be the lowest hourly flow rate.
Apply appropriate correction factors for site heterogeneity, anticipated level of maintenance and treatment to determine the site-specific design infiltration rate (Volume III, Tables 3.6 and 3.7).

**Example**

The area of the bottom of the test pit is 8.5-ft. by 11.5-ft.

Water flow rate was measured and recorded at intervals ranging from 15 to 30 minutes throughout the test. Between 400 minutes and 1,000 minutes the flow rate stabilized between 10 and 12.5 gallons per minute or 600 to 750 gallons per hour, or an average of \((9.8 + 12.3) / 2 = 11.1\) inches per hour.

Applying a correction factor of 5.5 for gravelly sand in table 6.3 the design long-term infiltration rate becomes 2 inches per hour, anticipating adequate maintenance and pre-treatment.
Appendix V-C  Turbulence and Short-Circuiting Factor

Figure D.1 – Recommended Values of $F$ for Various Values of $v_h/V_t$

<table>
<thead>
<tr>
<th>$v_h/V_t$</th>
<th>Turbulence Factor ($F_t$)</th>
<th>$F = 1.2(F_t)$</th>
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</thead>
<tbody>
<tr>
<td>20</td>
<td>1.45</td>
<td>1.74</td>
</tr>
<tr>
<td>15</td>
<td>1.37</td>
<td>1.64</td>
</tr>
<tr>
<td>10</td>
<td>1.27</td>
<td>1.52</td>
</tr>
<tr>
<td>6</td>
<td>1.14</td>
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<tr>
<td>3</td>
<td>1.07</td>
<td>1.28</td>
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