

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 14-B
KING COUNTY APPROVED
PUBLIC DOMAIN FACILITIES

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1. Bioretention Water Quality Facility

1.1 Overview

A Bioretention Water Quality Facility treats stormwater via percolation through one or more layers of specified media. Treated stormwater is infiltrated to native soil or is collected and discharged via an underdrain system. Approved media will support plant growth for desired aesthetics and erosion control

1.1.1 Configurations

Allowed configurations include depression (cell, pond); swale, and planter. Planter here refers to cells constructed with vertical wall (s). Section 6.2.3 of the SWDM contains applicable requirements re: walls, fencing, etc. Swale designs mean a narrow, linear cell that doubles as conveyance (e.g. online system) where overflows go through the facility rather than bypass it.

Swale designs must be designed so that the required design storm volume is completely infiltrated through media. Swale geometry and slope should be adjusted to maintain velocities for overflow storm so as not to damage channel /media.

1.1.2 Applications and Limitations

A bioretention water quality facility (BWQF) may be used in most residential, commercial, and industrial developments where *site* topography and drainage provide adequate hydraulic head.

Bioretention water quality facilities are designed to prevent water from backing up into the filter/media layer(s) (the underdrain system must drain freely). Therefore, a BWQF is more **difficult to install, and may not be suitable, in areas with high water tables** where groundwater could potentially flood the underdrain system.

Bioretention water quality facilities discharge must be by gravity, and must not rely on a pump system. If the pump fails, the media will become saturated, create anoxic conditions, and release pollutants. Pumped inflow is only allowed for privately maintained systems meeting the criteria in Section 4.2.3 of the SWDM.

A bioretention water quality facility should not be used during construction to control sediments unless the filter media/layers are replaced periodically during construction and after the *project site* is stabilized.

BWQF should comply with applicable requirements for sand filters in Section 6.2 of the SWDM “General Requirements for WQ Facilities”.

1.1.3 Approved Media Designs

Currently, 3 high performance soil media (HPBSM) BWQF designs are approved for use to meet requirements of Core Requirement 8 of the SWDM. These designs are referred to as Type 1, Type 2, and Type 3. Detailed descriptions for each are found under “Filter Composition” in the Design Criteria section of this reference.

1.1.4 Applications to SWDM WQ Treatment Menus

For meeting **basic treatment requirements**: Any of Type 1, Type 2, and Type 3 may be used.

For meeting **enhanced basic treatment** requirements, Any of Type 1, Type 2, and Type 3 may be used.

For meeting **sensitive lake treatment** requirements: Either Type 2 or Type 3 may be used.

1.2 Methods of Analysis

1.2.1 Overview

A bioretention water quality facility is designed with two parts: (1) a **temporary storage reservoir** to store runoff, and (2) a **filter bed** through which the stored runoff must percolate. Usually, the storage reservoir is simply placed directly above the filter, and the floor of the reservoir pond is the top of the filter bed. For this case, the storage volume also determines the hydraulic head over the filter surface, which increases the rate of flow through the filter media.

Bioretention water quality facilities shall be sized using an approved continuous runoff model such that a minimum of 91% of the average annual runoff volume will pass through the filter. Ponding depth of the storage reservoir shall be no greater than 1 foot.

Corrected (design) filtration rate for use in the approved model is set at 6 inches/hour for each of the 3 approved (Type 1, 2, and 3) HPBSM designs where presettling requirements per Section 6.5.1 of the SWDM are met. Where presettling is not feasible as determined by DLS-PD, a design filtration rate of 3 inches/hour shall be used.

1.2.2 Background

See Chapter 6, Section 6.5.2.1 “Methods of Analysis” for detailed background in filter design. Note that the filtration rate for use in approved model for BWQF designs is derived from an initial 12”/hour rate which is then modified by a factor of safety (FS) of 2 or 4 per “Guidance on using new high performance bioretention soil mixes” by Howie and Lubliner (ECY) dated May 2021/Publication 21-10-023. For systems that meet presettling requirements per Section 6.5.1, “General Requirements for Filtration Facilities, Presettling Requirement”, an FS of 2 is applied resulting in a design filtration rate of 6”/hour. For systems where compliance with presettling requirements is determined infeasible by DLS-PD, an FS of 4 is applied resulting in a design filtration rate of 3”/hour. BWQF designs used to comply with Core Requirement 8 must provide presettling per Section 6.5.1, unless determined infeasible by DLS-PD.

1.2.3 Modeled Routing Method

The modeled routing method allows the designer to optimize filter geometry and sizing to meet specific *site* conditions. The modeled method requires a trial and error solution using the approved model to route the developed inflow runoff time series through various filter configurations until the amount of runoff that passes through the filter media and is treated meets or exceeds the treatment objective defined for the facility. Refer to the approved model’s computer software reference manual for specific instructions on using the program. The general design process is described below.

Step 1: Determine treatment volume requirement. BWQF using HPBSM designs Type 1, 2, and 3 are each to be sized so that a minimum 91% of the average annual runoff volume will pass through the filter.

Step 2: Prepare the inflow time series. The developed inflow time series is prepared using the approved model as generally described in Chapter 3. Detailed instructions for preparing the time series can be found in the approved model's computer software reference manual. If the BWQF is upstream of detention, the time series is that of the developed *site*. If the BWQF is downstream of detention, the time series is the outflow time series leaving the detention facility. *Note: BWQF located downstream from detention facilities are smaller than those treating runoff before it is detained. Likewise, BWQF receiving flows from Level 2 detention facilities are smaller than those below Level 1 facilities.*

Step 3: Determine whether the BWQF will be on-line or off-line. For most WQ facilities, the designer may choose to design the facility as either on-line (all flow goes through the facility) or off-line (flows above the WQ design flow bypass the facility). An off-line BWQF has a high-flow bypass with an upstream flow splitter designed to bypass flows above the WQ design flow (see Section 6.2.5, p. 6-32, for more information on flow splitter design).

Note that the WQ design flow rate for the flow splitter is the rate required to pass the required WQ volume. For the BWQF, the rate is reported directly by the approved model (i.e., not modified in the manner for bioswales in Section 6.2.1); The BWQF uses the 91% runoff volume as the water quality design volume, corresponding to a 2-year return interval peak flow from the approved continuous model.

Step 4: Define BWQF filter modeling parameters. BWQF can be sized in WWHM using the sand filter element, or in MGS Flood using the infiltration pond element with the Sand Filter Data tab. Follow the guidance in the approved model's reference manual and apply the additional guidance below for the parameters required for the analysis:

- a) The surface area of the filter computed by the approved model using inputs of the bottom length and width of the infiltration pond (ft).
- b) Maximum water depth over filter: depth at which runoff begins to overflow the **BWQF** filter (1 foot maximum allowed)
- c) Permeable surfaces: bottom only.
- d) Riser and orifice information:
 - Riser head: same as the maximum water depth.
 - Number of orifices: zero. All runoff will either percolate through filter media or overflow the riser.
 - Top of riser: flat.
- e) Vertical infiltration: Assume a *design filtration rate* of 6 inches (presettling requirements met for facility) or 3 inches per hour (meeting presettling requirements for facility is determined infeasible by DLS-PD). Though the media will initially infiltrate at a much higher rate, that rate will slow as the filter accumulates sediment. When the filtration rate falls to design filtration rate, removal of sediment is necessary to maintain rates above the rate assumed for sizing purposes.

Step 5: Size the BWQF filter. Follow the facility sizing guidance in the approved model's reference manual to input the preliminary design configuration of the **BWQF** filter.

Step 6: Route the inflow time series through the BWQF filter and compare volumes. Compare the volume percentage passing through the filter with the percentage required for the

treatment volume (91%). The approved model calculates the routed volume percentage for the comparison.

- If the volume percentage of water passing through the filter exceeds the design treatment volume percentage, decrease the bottom area of the facility. Repeat this step until the desired performance is achieved.
- If the volume percentage of water passing through the filter is less than the design treatment volume percentage, increase the bottom area until the desired performance is achieved.

Step 7: Size the underdrain system. The underdrain system is sized to convey the peak filtered flows to the outlet. The **central collector pipe(s)** shall be sized to convey, at a minimum, the 2-year return frequency flow into the facility using the KCBW program's backwater analysis techniques described in Chapter 4.

To simplify the analysis, all flows for **BWQF** filters may be assumed to enter the collector pipe at the upstream end. Typically, the collector pipe will not be inlet controlled, so a simple square inlet type may be assumed. The full head of the facility may be utilized to convey flows through the pipe.

Feeder pipes may be sized using the design criteria in "Underdrain Systems" (p. 10) of the SWDM instead of analyzing the conveyance capacity as described above.

Strip drains must be analyzed for conveyance per manufacturer's specifications.

Intent: The underdrain must be able to remove standing water from beneath the filter media. If standing water remains, the media will remain saturated. This could cause reducing conditions in the media, allowing some pollutants to become mobile and be released from the filter to downstream receiving waters.

1.3 Design Criteria

1.3.1 General

BWQF should comply with applicable requirements for Sand Filters in Section 6.2 of the SWDM "General Requirements for WQ Facilities".

Allowed configurations include depression (cell, pond); swale, and planter. Planter here refers to cells constructed with vertical wall (s). Section 6.2.3 of the SWDM contains applicable requirements re: walls, fencing, etc. Swale designs mean a narrow, linear cell that doubles as conveyance (e.g. online system) where overflows go through the facility rather than bypass it.

Swale designs must be designed so that the required design storm volume is completely infiltrated through media. Swale geometry and slope should be adjusted to maintain velocities for overflow storm so as not to damage channel /media.

Applicable to all configurations: Non-under drained designs that receive runoff from impervious surfaces totaling 10,000 square feet or more; or, new pervious surfaces totaling $\frac{3}{4}$ acre or more, or a combination of impervious and pervious surfaces that results in a 0.15 cfs increase (using 15 minute time steps) or 0.1 cfs (using 1 hour time steps) in the 100 year peak flow when comparing predeveloped (historic) and developed conditions, shall also meet applicable requirements for infiltration facilities in Section 5.2, see additional guidance at the end of this section.

Additional requirements for swale designs include:

SWDM Section 5.2: 100 year overflow conveyance (if applicable); Protection from Upstream Erosion; Facility Construction Guidelines.

SWDM Section 6.3: Vegetated Flowpath Facility Designs: Access; Construction Considerations; Flow Velocity, Energy Dissipation, and Flow Spreading (#2, 3, 4 and 5)

Swale designs proposed for use along roads should follow applicable requirements from Section C.2.6.2:

The longitudinal slope of the BWQF swale shall be consistent with KCRDCS 7.02.A standards for grass-lined ditches which allow a maximum slope of 6%. Grades between 3% and 6% may require check dams to reduce potential erosion.

The BWQF swale shall meet the conveyance requirements described in Section 1.2.4.1 of the SWDM.

Flow entrance techniques for energy dissipation shall be utilized and may include where applicable: flow spreaders described in Section 6.2.6 of SWDM, gravel flow spreaders described in Section 6.3.4.2 of SWDM, rock pads for pipe flow entrances, and/or catch basins preceding bioretention where high sediment loads are anticipated. Other equivalent options may be considered. Consideration should be given as to whether the design details specified in Section 4.2.2 (Outfalls) are applicable to a given design.

Side slopes shall be per KCRDCS standards for roadside ditches.

Vegetation design for BWQFs in KC right of way shall be as approved by the King County Road Engineer.

1.3.2 BWQF Filter Geometry

1. **Any shape** filter bed may be used, including circular or free-form designs. *Note: The treatment process is governed by **vertical** flow, so short-circuiting is not a concern as it is in wetponds.*
2. **Filter depth** (*l*) and composition (**See filter composition below**). shall be as follows: See “Filter Composition” below.
3. **Depth of storage** over the filter media (*d*) shall be 1 foot maximum.

1.3.3 Pretreatment, Flow Spreading, and Energy Dissipation

1. See general presettling and pretreatment requirements for filtration facilities in Section 6.5.1 (p. 6-105). BWQF shall be considered sand filters for purposes of compliance with Section 6.5.1.
2. A **flow spreader** shall be installed at the inlet along one side of the filter to evenly distribute incoming runoff across the filter and prevent erosion of the filter surface. See Section 6.2.6 (p. 6-36) for details on flow spreaders.
 - a) **If the BWQF filter area is curved or an irregular shape**, a flow spreader shall be provided for a minimum of 20 percent of the filter perimeter.
 - b) If the **length-to-width ratio** of the filter is 2:1 or greater, a flow spreader must be located on the longer side and for a **minimum length** of 20 percent of the facility perimeter.

- c) In other situations, use good engineering judgment in positioning the spreader.
3. Erosion protection shall be provided along the first foot of the BWQF adjacent to the flow spreader. Geotextile meeting the specifications in WSDOT Standard Specifications, 9-33.2(1) Geotextile Properties / Table 1 / Moderate Survivability / Woven, and Table 2, Class A, weighted with sand bags at 15-foot intervals may be used. Quarry spalls may also be used.

1.3.4 Overflow and Bypass Structures

1. **On-line filters**¹ shall be equipped with **overflows** (primary, secondary, and emergency) in accordance with the design criteria for detention ponds (see Section 5.1.1.1, criteria for "Overflow" and "Emergency Overflow Spillway"). *Note: The primary overflow may be incorporated into the emergency spillway in cases where the spillway discharges into a downstream detention facility, or where overflows can be safely controlled and redirected into the downstream conveyance system.*
2. For off-line filters, the outlet structure for the BWQF filter must be designed to pass the 2-yr peak inflow rate, as determined using the approved model with 15-minute time steps calibrated to specific site conditions.

Intent: Overflow capacity is required for low-flow, high-volume storms which may exceed the storage capacity of the filter.

3. To the extent base flow conditions can be identified, **base flow** must be bypassed around the filter to keep the media from remaining saturated for extended periods of time.

1.3.5 Filter Composition

Type 1 HPBSM

18" thickness of HPBSM Primary Layer consisting of 70% sand, 20% coir, and 10% high carbon wood ash (biochar) by volume. 3" of Arborist's Woodchip Mulch (per Reference 11-C) shall be placed over the primary layer in the ponding area of the facility.

Type 2 HPBSM

18" thickness of HPBSM Primary layer plus 12" thickness of HPBSM Polishing Layer below it. HPBSM Polishing layer consists of 90% sand, 7.5% activated alumina, and 2.5% iron aggregate by volume. 3" of Arborist's Woodchip Mulch (per Reference 11-C) shall be placed over the primary layer in the ponding area of the facility.

Type 3 HPBSM

HPBSM Primary Layer plus 12" thickness of HPBSM Polishing Layer below it. 2" Compost Surface Layer is placed over the primary layer in the ponding area of the facility

1.3.6 Filter Specifications

Detailed specifications for the component media layers shall be per Reference 11-C. If the design includes compost (Type 3), the compost shall meet Specification 1 described in Reference 11-C.

¹ Whether a WQ facility is designed as on-line (all flow going through the facility) or off-line (high flows bypassing the facility) is a choice made by the designer. Section 6.2.5 (p. 6-29) contains information on flow splitters for WQ facilities.

When using the high performance bioretention designs with component media specifications described in Reference 11-C, pre-placement laboratory analysis for saturated hydraulic conductivity is not required. Verification of the mineral aggregate gradation is required, and media mix component ratios as placed must be certified and provided. All primary layer and polishing layer materials must meet Reference 11-C test specifications, and the test results must be provided.

1.3.7 Underdrain Systems

1. Several **underdrain systems** are acceptable:

- A central collector pipe with lateral feeder pipes in an 8-inch drain rock bed
- A central collector pipe with a geotextile drain strip in an 8-inch drain rock bed
- Longitudinal pipes in an 8-inch drain rock bed, with a collector pipe at the outlet end.

In smaller installations a single perforated pipe in 8 inches of drain rock may be adequate.

2. The **maximum perpendicular distance** between any two feeder pipes, or the edge of the filter and a feeder pipe, shall be 15 feet.

Intent: This spacing is required to prevent the underdrain system from backing up into the filter during the early life of the filter when high filtration rates exist.

3. All pipe shall be placed with a **minimum slope** of 0.5 %.
4. The **invert of the underdrain outlet** shall be above the seasonal high groundwater level. The *seasonal high groundwater level* is the highest elevation of groundwater observed.

Intent: The underdrain must be able to remove standing water from beneath the filter. If standing water remains, the filter will remain saturated. This could cause depletion of dissolved oxygen and reducing conditions in the filter, allowing some pollutants to become mobile and be released from the filter to downstream receiving waters.

5. **Cleanout** wyes with caps or junction boxes shall be provided at both ends of all collector pipes. Cleanouts shall extend to the surface of the filter.

- a. A valve box must be provided for access to the cleanouts.
- b. The cleanout assembly must be water-tight to prevent short circuiting of the filter.

Intent: Caps are required on cleanout wyes to prevent short-circuiting of water into the underdrain system when the pond fills with water.

6. If a **drain strip** is used for lateral drainage, the strip must be placed at the slope specified by the manufacturer but at least at 0.5%. All drain strip must extend to the central collector pipe. Drain strips installations must be analyzed for conveyance because manufactured products vary in the amount of flow they are designed to handle.
7. At least 8 inches of drain rock must be maintained over all underdrain piping or drain strip, and 6 inches must be maintained on either side to prevent damage by heavy equipment during maintenance.

*Note: If drain strip is used, it may be easier to install the central collector pipe in an 8-inch **trench** filled with drain rock, making the cover over the drain strip and the collector pipe the same thickness. In this case the pipe shall be wrapped with geotextile to prevent clogging. Use the same geotextile specification as given in WSDOT Standard*

Specifications, 9-33.2(1) Geotextile Properties / Table 1 / Moderate Survivability / Woven, and Table 2, Class A.

8. A **geotextile fabric** shall be used between the media/filter layer and the drain rock and be placed so that one inch of drain rock is above the fabric.

Intent: The position of the geotextile fabric provides a **transition layer** of media and drain rock.

9. BWQF filters shall not be used in combination with a downstream pump system.

Intent: BWQF filters are designed to prevent water from backing up into the filter layer; the underdrain system must drain freely. If the pump fails, the filter will become saturated, create anoxic conditions, and release pollutants.

1.3.8 Underdrain Materials

1. Underdrain **pipe** shall be minimum 6 inch diameter perforated PVC, SDR 35. One acceptable specification for perforations is as follows: 2 rows of holes ($\frac{1}{2}$ -inch diameter) spaced 6 inches apart longitudinally (max), with rows 120 degrees apart (laid with holes downward). Other drain pipe may be used if it adequately drains the filter.
2. **Drain rock** shall be $1\frac{1}{2}$ to $\frac{3}{4}$ -inch rock, washed and free from clay or organic material.
3. If a geotextile drain strip system is used, the attached **geotextile fabric** should not be used, or the fabric side should be positioned away from the media. Geotextile is already required between the media and drain rock layers, and must meet the specifications in WSDOT Standard Specifications, 9-33.2(1) Geotextile Properties / Table 1 / Moderate Survivability / Woven, and Table 2, Class A, to avoid clogging the filter prematurely.

1.3.9 Access Roads & Setbacks

1. An access road shall be provided to the inlet and outlet of a BWQF filter for inspection and maintenance purposes. Requirements for access roads are the same as for detention ponds (see Section 5.1.1.1, "Design of Access Roads" and "Construction of Access Roads").
2. The location of the facility relative to **site** constraints (e.g., buildings, property lines, etc.) shall be the same as for detention ponds (see Section 5.1.1) except as noted in 3, below. See Section 6.2.3 (p. 6-23) for typical setback requirements for WQ facilities.
3. For a BWQF filter that infiltrates to ground, setbacks shall be same as those for infiltration ponds, (see Section 5.2.2).

1.3.10 Side Slopes, Fencing, and Embankments

See SWDM Section 6.2.3 for applicable requirements.

1.3.11 Planting

1. **No top soil** shall be added to the BWQF.

Growing and maintaining vegetation is required and necessitates selecting species that can tolerate the demanding environment of the BWQF. BWQF experience long periods of saturation during the winter wet season, followed by extended dry periods during the summer. Vegetation must be capable of surviving drought as well as wetness. Appropriate plants should be selected for sun exposure, soil moisture, and adjacent plant communities. Native species or hardy cultivars are recommended that can flourish with no nutrient or pesticide inputs and only 2-3 years watering for establishment. Invasive species control may be necessary. See the approved planting list for allowed vegetation types and density, grouped by applicability to various moisture, sun exposure, etc. applications.

2. To prevent any use that could compact and potentially damage the filter surface, both **permanent and temporary structures** (e.g., playground equipment or bleachers) are not permitted.
3. If the BWQF is located in a Sensitive Lake Protection Area, or discharges to a stream that is listed as a Dissolved Oxygen (DO) Problem (Type 2) under “Downstream Water Quality Problems Requiring Special Attention” (Section 1.2.2.1.2) and the problem cause has been identified as nutrient loading, then low phosphorus fertilizers (such as formulations in the proportion 3:1:3 N-P-K or less) or slow-release phosphorus formulations should be used, and at no more than the minimum agronomic rate. Regardless of location, the fertilizer must meet the requirements of Chapter 15.54.500 RCW limiting the use of fertilizer containing phosphorus.
4. Vegetation design for BWQFs in KC right of way shall be as approved by the King County Road Engineer.

Plant list is provided in the following table

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Scientific Name	Common Name	Exposure			Height	Zone				PNW Native
		Shade	Partial Shade	Sun		1a	1b	2	3	
Trees and Shrubs										
<i>Amelanchier alnifolia</i>	Serviceberry		X	X	6-12'				X	Yes
<i>Arbutus unedo 'compacta'</i>	Dwarf strawberry tree		X	X	6-10'				X	No
<i>Ceanothus thyrsiflorus</i>	California lilac		X	X	8-12'				X	No
<i>Ceanothus velutinus</i>	Snowbrush		X	X	2-10'				X	Yes
<i>Cornus sericea 'Kelseyi'</i>	Red twig dogwood		X	X	3-9'	X		X	X	Yes
<i>Garrya elliptica</i>	Coast silk tassel			X	8'				X	Yes
<i>Holodiscus discolor</i>	Ocean spray		X	X	4-15'			X	X	Yes
<i>Mahonia aquifolium</i>	Tall Oregon grape	X	X	X	3-10'			X	X	Yes
<i>Myrica californica</i>	Pacific wax myrtle		X	X	15-25'				X	Yes
<i>Oemleria cerasiformis</i>	Osoberry (Indian plum)		X		5-15'			X	X	Yes
<i>Philadelphus lewisii</i>	Mock orange		X	X	5-10'				X	Yes
<i>Physocarpus capitatus</i>	Pacific ninebark		X	X	6-12'			X	X	Yes
<i>Ribes sanguineum</i>	Red flowering currant		X	X	5-10'			X	X	Yes
<i>Rosa nutkana</i>	Nootka rose		X	X	4-10'			X	X	Yes
<i>Rosa woodsii</i>	Wood rose		X	X	3-5'			X	X	Yes
<i>Symphoricarpos albus</i>	Snowberry		X	X	2-6'			X	X	Yes
<i>Vaccinium ovatum</i>	Evergreen huckleberry		X	X	3-10'				X	Yes
Zone 1a: surface of media layers closest to inlet or flow spreader Zone 1b: surface of media layers Zone 2: side slopes in ponding area Zone 3: area above ponding area										

Scientific Name	Common Name	Exposure			Height	Zone				PNW Native
		Shade	Partial Shade	Sun		1a	1b	2	3	
Groundcover, Perennials, and Ferns										
<i>Arctostaphylos uva-ursi</i>	Kinnikinnick		X	X	0.5- 1'			X	X	Yes
<i>Armeria maritima</i>	Sea thrift			X	1-1.5'				X	Yes
<i>Athyrium filix-femina</i>	Lady fern	X	X		3'			X	X	Yes
<i>Blechnum spicant</i>	Deer fern	X	X		1-2'			X	X	Yes
<i>Cistus purpureus</i>	Orchid rock rose			X	2-4'				X	No
<i>Dasiphora fruticosa</i>	Shrubby cinquefoil			X	2-4'				X	Yes
<i>Epimedium x perralchicum</i>	Yellow epimedium		X		1'				X	No
<i>Equisetum hyemale</i>	Scouring rush		X	X	3'	X	X			Yes
<i>Fragaria chiloensis</i>	Beach strawberry		X	X	0.5'				X	Yes
<i>Gaultheria shallon</i>	Salal	X	X		3-6'			X	X	Yes
<i>Geranium macrorrhizum</i>	Hardy cranesbill	X	X	X	1-1.5'			X	X	No
<i>Grindelia integrifolia</i>	Puget Sound gumweed		X	X	1-2'	X	X	X	X	Yes
<i>Helianthemum nummularium</i>	Sunrose			X	2'				X	No
<i>Lavandula angustifolia</i>	Lavender			X	2'				X	No
<i>Lupinus latifolius</i>	Broadleaf lupine		X	X	1-4'				X	Yes
<i>Mahonia repens</i>	Creeping Oregon grape		X	X	3'			X	X	Yes
<i>Achillea millefolium</i>	Western yarrow		X	X	3'				X	Yes
<i>Sedum spatulifolium</i>	Broadleaf stonecrop			X	0.5'				X	Yes
<i>Sidalcea hendersonii</i>	Henderson's Checkermallow		X	X	2-5'	X				Yes
<i>Solidago canadensis</i>	Goldenrod		X	X	2-4'			X	X	Yes
<i>Symphyotrichum subspicatum</i>	Douglas aster		X	X	1-3'	X	X	X	X	Yes
<i>Vancouveria hexandra</i>	Inside-out flower	X	X		1-1.5'			X	X	Yes
Zone 1a: surface of media layers closest to inlet or flow spreader Zone 1b: surface of media layers Zone 2: side slopes in ponding area Zone 3: area above ponding area										

Scientific Name	Common Name	Exposure			Height	Zone				PNW Native
		Shade	Partial Shade	Sun		1a	1b	2	3	
Sedges, Rushes, and Grasses										
<i>Bouteloua gracilis</i>	Blue gamma			X	1-2'				X	No
<i>Carex macrocephala</i>	Big-head sedge			X	1'	X	X			Yes
<i>Carex obnupta</i>	Slough sedge		X	X	1-4'	X				Yes
<i>Carex pachystachya</i>	Chamisso sedge		X	X	2-3'	X	X			Yes
<i>Carex pansa</i>	Sand sedge	X	X		1'	X	X			Yes
<i>Festuca californica</i>	California fescue		X	X	1-3'				X	Yes
<i>Festuca glauca</i>	Blue fescue			X	1-2'				X	Yes
<i>Festuca rubra</i>	Red fescue		X	X	1.5'	X	X			Yes
<i>Helictotrichon sempervirens</i>	Blue oat grass		X		2-3'				X	No
<i>Juncus effusus</i>	Common rush			X	1-2'	X				Yes
<i>Juncus patens</i>	Spreading rush			X	1-2'	X				Yes
<i>Juncus tenuis</i>	Slender rush			X	1-2'	X				Yes
<i>Leymus mollis</i>	American dune grass			X	3'	X	X			Yes
<i>Muhlenbergia rigens</i>	Deer grass		X	X	3-5'				X	No
<i>Muhlenberia capillaris</i>	Pink muhly grass			X	3'				X	No
<i>Pennisetum orientale</i>	Oriental fountain grass			X	2'				X	No
Zone 1a: surface of media layers closest to inlet or flow spreader Zone 1b: surface of media layers Zone 2: side slopes in ponding area Zone 3: area above ponding area										

1.3.12 Recommended Design Features

The following design features should be incorporated into BWQF designs where *site* conditions allow:

1. A **horticultural specialist** should be consulted for advice on planting.
2. A BWQF can add landscape interest and may be incorporated into the project **landscape design**. Interior side slopes may be stepped with flat areas for planting. Perennial beds may be planted above the overflow water surface elevation. However, large shrubs and trees are not allowed in the filter area because falling leaves and needles can clog the filter surface, requiring more frequent maintenance, and roots may damage the structure and/or function of the filter. *Note: Examples of areas with stepped side slopes can be found at the Ballard Locks in Seattle and at Luther Burbank Park on Mercer Island.*
3. Recreational use of the BWQF filter surface is not allowed as activity can disrupt the structure and function of the filter media. Signage discouraging recreation is required. Signage shall be placed for maximum visibility from adjacent streets, sidewalks, and paths. More than one sign may be required to be sure the advisory will be noted by anyone approaching the facility.

1.3.13 Construction Considerations

1.3.13.1 If BWQF are put into service before construction

If BWQF are put into service before construction of all parcels within the catchment is complete and all disturbed soil in the BWQF catchment has been stabilized, the filter will very likely clog prematurely. If individual lots are not stabilized, the options for **protection from upstream erosion** given in Section 5.2.1 for infiltration ponds may be used.

An **alternative** is to install the BWQF including full excavation for the filter media and underdrain layers, delaying placement of the media and underdrains until the *project site* is stabilized. The partially complete BWQF will then function like a small wetpond. Later, the accumulated sediment must be removed and the underdrain with gravel, geotextile separator, and media layers placed. A second alternative is to place only the gravel underdrain during the construction phase. Then clean the gravel and place the geotextile separator and media layer(s) after the *project site* is stabilized.

The County will not assume maintenance responsibility or release financial guarantees unless the BWQF is installed per design and functioning properly. **Careful placement of the media layers** is necessary to avoid formation of voids that could lead to short-circuiting, particularly around penetrations for underdrain cleanouts, as well as to prevent damage to the underlying underdrain system. Voids between the trench wall and geotextile fabric should also be avoided.

1.3.13.2 Blending, Delivery, Protection, and Placement

The blending, handling, and placement of the HPBSM Primary and Polishing Layers needs to be done carefully to ensure a successful installation.

- a. The contractor should prepare a Blending, Delivery, Protection, and Placement plan and submit it to the designer for review. The HPBSM Primary and Polishing HPBSM Layer media shall be mechanically blended to produce a homogeneous mix by a blending

vendor/contractor with soil blending experience. The blending should occur on an impervious (asphalt or concrete) surface pad that has been thoroughly washed clean (e.g., pressure washed) prior to blending or in purpose-built soil blending equipment that has been washed. The blending pad shall be large enough to be able to turn and mix the media without introducing contamination. The blending pad shall be free of standing water before blending and shall be protected from stormwater run-on from areas off of/adjacent to the pad. The measurement of the components to be blended shall be by measuring in full vessels of a known volume. Estimating the volumes of materials of partially full buckets or vessels shall not be used. Prior to blending, the coconut coir fiber shall be loose and hydrated such that its density is 4-5 pounds per cubic foot. The materials shall be blended until they are in a homogenous mixed state and then protected from contamination or saturation during storage, delivery, stockpiling, and placement.

- b. The HPBSM layers should not be placed if the area is frozen, has standing water, is excessively wet or saturated, or has been subjected to more than 1/2 inch of precipitation within 48 hours before placement, unless approved otherwise by the Engineer. Do not place the HPBSM layers if adequate temporary erosion and sediment control measures are not in place to protect the media from contamination by silt laden run-off. Place HPBSM layers loosely and evenly, no deeper than these specifications unless otherwise approved by the Engineer, on a properly prepared subgrade. After each lift, rake the surface to a uniform grade. Consolidate the entire surface area of each lift by boot compaction or a lawn roller and rake again to scarify before placing subsequent lifts or planting.

1.3.14 Maintenance Considerations

BWQF are subject to clogging by fine sediment, oil and grease, and other debris (e.g., trash and organic matter such as leaves). Filters and pretreatment facilities should be inspected every 6 months during the first year of operation. Inspections should also occur immediately following a storm event to assess the filtration capacity of the filter. Once the filter is performing as designed, the frequency of inspection may be reduced to once per year. In addition to the following, applicable requirements from Appendix A for bioretention (No. 31), sand filter ponds (No. 19), and infiltration facilities (No. 2), should be adhered to.

During an inspection the following features should be evaluated and maintained as needed:

1. Remove debris and sediment from the pretreatment facility when depth exceeds 12 inches.
2. Remove debris and sediment from the surface of the filter when accumulations exceed 0.5 inches.
3. Observe operation of the overflow and drawdown time in the filter. Frequent overflow through the grated "birdcage" or "jailhouse" window into the outlet structure or slow drawdown are indicators of plugging problems. Under normal operating conditions, a BWQF should completely empty within 0.5 to 4 hours following a storm event (i.e., after the inflow of runoff to the filter ceases), depending on pond depth (limited to maximum of 1 foot storage depth). Generally, if drawdown times exceed this range, corrective maintenance is needed. Recommendations for improving filter performance are summarized below:
 - a) Remove debris and sediment from the surface of the filter
 - b) Ensure that underdrain (if present) is not clogged. If necessary, clear underdrain.
 - c) Check for other water inputs (e.g., groundwater, illicit connections).

- d) Aerate the filter surface to improve permeability.
 - e) Till the filter surface. Two separate passes following a criss-cross pattern (i.e., second pass at right angles to the first) are recommended.
 - f) Remove and replace upper level (4-6") of media.
Rapid drawdown in the filter (i.e., greater than 12 inches per hour) indicates short-circuiting of the filter media. Inspect the cleanouts on the underdrain pipes and along the base of the embankment for leakage.
4. Formation of rills and gullies on the surface of the BWQF filter may indicate improper function of the inlet flow spreader or poor compaction. Check for accumulation of debris on or in the flow spreader, and refill rills and gullies with media per the design.

1.3.15 Other maintenance practices to ensure proper operation

Other maintenance practices that should be employed to ensure proper operation of the BWQF filter are summarized below:

1. Avoid use of fertilizers along the bottom or sides of a BWQF. Any fertilizer used must meet the requirements of Chapter 15.54.500 RCW limiting the use of fertilizer containing phosphorus².
2. Avoid driving heavy machinery or equipment on the BWQF to minimize compaction of the filter media, prevent the formation of ruts in the surface of the filter that could concentrate or channelize flow, and prevent damage to the underdrain system. Use only low ground pressure tracked equipment (4.6 pounds per square inch or less ground pressure). The number of passes over BWQF should be minimized to the greatest extent possible.
3. Mow grass as needed, and remove the cut grass from the BWQF.
4. Water designed vegetation periodically when needed, especially during the summer dry season.
5. Discourage use of the BWQF by pets by installing signs reminding residents of scoop laws, providing scoop stations near the facilities, planting barriers such as barberry, and/or providing other measures as appropriate.

1.4 Modifications for combining with an Infiltration Pond

Where an infiltration pond is proposed for flow control, a BWQF may be combined with the infiltration pond by making the following modifications in design criteria:

1. The "**100-year Overflow Conveyance**" requirements for infiltration ponds (see Section 5.2.1) shall apply in place of the "**Overflow and Bypass**" requirements for BWQF.
2. The "**Filter Composition**" criteria are changed to eliminate the requirement for an underdrain system.

² <http://apps.leg.wa.gov/billinfo/summary.aspx?bill=1489&year=2011>

3. The "**Underdrain System**" and "**Underdrain Materials**" criteria for BWQF filters are not applied. Water infiltrating through the BWQF need not be collected but may simply continue infiltrating downward into native soils.
4. The sides of the infiltration pond must be provided with a **treatment liner** up to the WQ design water surface elevation, at a minimum. In a groundwater protection area, the liner must extend up to the overflow water surface elevation of the pond. See Section 6.2.4 (Facility Liners) for information on liners.

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