# CHAPTER 6
# WATER QUALITY

## Contents

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## 6.0 BMP SIZING AND SELECTION

This chapter describes the requirements for meeting Minimum Requirement #6, Runoff Treatment as defined in Kitsap County Code (KCC) 12.18.060 through 12.18.100.

### A. Treatment Facility Sizing

#### 1. Water Quality Design Storm Volume

a) The 91st percentile, 24-hour runoff volume indicated by the most recent version of the Western Washington Hydrology Model or as specifically called out in this manual.

b) For storage treatment facilities, such as wetponds, wetvaults, and stormwater wetlands, sizing is based on the volume of runoff from the mean annual storm event.

#### 2. Water Quality Design Flow Rate:

a) **Preceding Detention Facilities or when Detention Facilities are not required:** The flow rate at or below which 91% of the runoff volume, as estimated by an approved continuous runoff model, will be treated. Design criteria for treatment facilities are assigned to achieve the applicable performance goal at the water quality design flow rate (e.g., 80% TSS removal).

b) **Downstream of Detention Facilities:** The full 2-year release rate from the detention facility. Alternative methods can be used if they identify volumes and flow rates that are at least equivalent.

#### 3. Water Quality Design for Infiltration based Treatments

a) 91% of the volume of runoff volume of the time series as estimated by the latest version of the Western Washington Hydrology Model is infiltrated through the treatment media.

## 6.1 STEP-BY-STEP SELECTION PROCESS FOR TREATMENT FACILITIES

### 6.1.1 Stormwater treatment facilities shall be:

A. Designed in accordance with the design criteria in this chapter, and
B. Maintained in accordance with the maintenance schedule in Chapter 9 and Appendix 9A.

C. **Objective:** The purpose of runoff treatment is to reduce pollutant loads and concentrations in stormwater runoff using physical, biological, and chemical removal mechanisms so that beneficial uses of receiving waters are maintained and, where applicable, restored. When site conditions are appropriate, infiltration can potentially be the most effective BMP for runoff treatment. ***Please refer to Figure 6.1. Use the step-by-step process outlined below to determine the type of treatment facilities applicable to the project.***

### 6.1.1.1 Step 1: Determine the Receiving Waters and Pollutants of Concern Based on a Site Analysis

The project proponent must determine the natural receiving water for the stormwater drainage from the project site (ground water, wetland, lake, stream, or salt water) to determine the applicable treatment menu from which to select treatment facilities. If the discharge is to the local municipal storm drainage system, the receiving water for the drainage system must be determined.

### 6.1.1.2 Step 2: Determine if an Oil Control Facility/Device is required

The use of oil control devices and facilities is dependent upon the specific land use proposed for development.

A. The Oil Control Menu (Section 6.2) applies to projects that have “high-use sites.” High-use sites are those that typically generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil. These sites are identified in Kitsap County Code (KCC) section 12.18.070. Please refer to the Oil Control Menu for a listing of oil control facility options. <u>Note</u> *that the use of a spill control (SC-type) oil/water separator is required for all impervious surfaces subject to vehicular traffic per KCC12.18.070. The Spill Control requirement is described in Chapter 3, Source Control of Pollution, and is separate from this Oil treatment requirement.*

B. If an Oil Control Facility is required, select and apply an Oil Control Facility. After selecting an Oil Control Facility, proceed to Step 3. If an Oil Control Facility is not required, proceed directly to Step 3.

- Infiltration
- Amended Sand Filter
- Bioretention
- Wetlands
- WSDOT Media Filter Drain
- Emerging Technologies

### 6.1.1.3 Step 3: Determine if Infiltration for Pollutant Removal is Practicable

A. Please check the infiltration treatment design criteria in Chapter 7. Infiltration can be effective at treating stormwater runoff, but soil properties must be appropriate to achieve effective treatment while not adversely impacting ground water resources. The location and depth to bedrock, the water table, or impermeable layers (such as glacial till), and the proximity to wells, foundations, septic tank drainfields, and unstable slopes can preclude the use of infiltration. Infiltration treatment facilities must be preceded by a pretreatment facility, such as a presettling basin or vault, to reduce the occurrence of plugging. Any of the basic treatment facilities, and detention ponds designed to meet flow control requirements, can also be used for pre-treatment. If an oil/water separator is necessary for oil control, it can also function as the pre-settling basin as long as the influent suspended solids concentrations are not high. However, frequent inspections are necessary to determine when accumulated solids exceed the 6-inch depth at which clean-out is recommended.

B. If infiltration is planned, please refer to the General Requirements in Chapter 7. They can affect the design and placement of facilities on your site. For non-residential developments, if your infiltration site is within ¼ mile of a fish-bearing stream, a tributary to a fish-bearing stream, or a lake, please refer to the Enhanced Treatment Menu (Section 6.4). If your infiltration site is within ¼ mile of a phosphorus-sensitive receiving water, please refer to the Phosphorus Treatment Menu (Section 6.3) for special pretreatment needs.

***Note: Infiltration through soils that do not meet the water quality site suitability criteria in Chapter 7 is allowable as a flow control BMP. However, the infiltration facility must be preceded by at least a basic treatment facility. Following a basic treatment facility (or an enhanced treatment or a phosphorus treatment facility in accordance with the previous paragraph), infiltration through the bottom of a detention/retention facility for flow control can also be acceptable as a way to reduce direct discharge volumes to streams and the size of the facility.***

C. If infiltration is practicable, select and apply pretreatment and an infiltration facility. If infiltration is not practicable, proceed to Step 4.

#### 6.1.1.4 Step 4: Determine if Control of Phosphorus is required

A. If the project discharges to a water body requiring phosphorus treatment per KCC 12.18.080, select and apply a phosphorus treatment facility. Please refer to the Phosphorus Treatment Menu in Section 6.3. Select an option from the menu after reviewing the applicability and limitations, site suitability, and design criteria of each for compatibility with the site.

***<u>Note:</u> Project sites subject to the Phosphorus Treatment requirement could also be subject to the Enhanced Treatment requirement (see Step 5). In that event, apply a facility or a treatment train that is listed in both the Enhanced Treatment Menu and the Phosphorus Treatment Menu.***

B. If phosphorus treatment is not required for the site, proceed to Step 5.

#### 6.1.1.5 Step 5: Determine if Enhanced Treatment is required

A. Enhanced treatment is required for sites that discharge to fish bearing water bodies that meet the criteria listed in KCC 12.18.090

B. For developments with a mix of land use types, the Enhanced Treatment requirement shall apply when the runoff from the areas subject to the Enhanced Treatment requirement comprises 50% or more of the total runoff.

C. **If the project must apply Enhanced Treatment, select and apply an appropriate Enhanced Treatment facility.** Please refer to the Enhanced Treatment Menu in Section 6.4. Select an option from the menu after reviewing the applicability and limitations, site suitability, and design criteria of each for compatibility with the site.

D. If Enhanced Treatment and Phosphorous Treatment do not apply to the site, please proceed to Step 6.

#### 6.1.1.6 Step 6: Select a Basic Treatment Facility

A. Basic treatment is required for sites that meet the criteria listed in KCC 12.18.100.

B. Please refer to the Basic Treatment Menu in Section 6.5. Select an option from the menu after reviewing the applicability and limitations, site suitability, and design criteria of each for compatibility with the site.

***You have completed the treatment facility selection process.***

## 6.2 OIL CONTROL TREATMENT

**6.2.1 Application on the Project Site:** Oil control facilities are to be placed upstream of other facilities, as close to the source of oil generation as practical. For high-use sites located within a larger commercial center, only the impervious surface associated with the high-use portion of the site is subject to treatment requirements. If common parking for multiple businesses is provided, treatment shall be applied to the number of parking

stalls required for the high-use business only. However, if the treatment collection area also receives runoff from other areas, the treatment facility must be sized to treat all water passing through it.
High-use roadway intersections shall treat lanes where vehicles accumulate during the signal cycle, including left and right turn lanes and through lanes, from the beginning of the left turn pocket. If no left turn pocket exists, the treatable area shall begin at a distance equal to three car lengths from the stop line. If runoff from the intersection drains to more than two collection areas that do not combine within the intersection, treatment may be limited to any two of the collection areas.

**6.2.2** **Performance Goal:** The facility choices in the Oil Control Menu are intended to achieve the goals of no ongoing or recurring visible sheen, and to have a 24-hour average Total Petroleum Hydrocarbon (TPH) concentration no greater than 10 mg/l, and a maximum of 15 mg/l for a discrete sample (grab sample).

**6.2.3** **Options:** Oil control options include facilities that are small, treat runoff from a limited area, and require frequent maintenance. The options also include facilities that treat runoff from larger areas and generally have less frequent maintenance needs.

**A.** API-Type Oil/Water Separator
**B.** Coalescing Plate Oil/Water Separator
**C.** Catch Basin Inserts (approved by Kitsap County on a case by case basis)
**D.** Linear Sand Filter

***Note: The linear sand filter is used in the Basic, Enhanced, and Phosphorus Treatment menus also. If used to satisfy one of those treatment requirements, the same facility shall not also be used to satisfy the oil control requirement unless enhanced maintenance is assured. This is to prevent clogging of the filter by oil so that it will function for suspended solids and phosphorus removal as well. Quarterly cleaning is required unless the designer specifies a higher frequency.***

## 6.3 PHOSPHORUS TREATMENT MENU

**6.3.1** **Performance Goal:** The Phosphorus Menu facility choices are intended to achieve a goal of 50% total phosphorus removal for a range of influent concentrations of 0.1 – 0.5 mg/l total phosphorus. In addition, the choices are intended to achieve the Basic Treatment performance goal.

**6.3.2** **Options:** Any one of the following options may be chosen to satisfy the phosphorus treatment requirement.

A. Infiltration with appropriate pretreatment – See Chapter 7.

1. Infiltration treatment - If infiltration is through soils meeting the minimum site suitability criteria for infiltration treatment (See Chapter 7), a presettling basin/vault or a basic treatment facility can serve for pretreatment.
2. Infiltration preceded by phosphorus treatment - If the soils do not meet the soil suitability criteria and the infiltration site is within ¼ mile of a phosphorus limited water body, treatment must be provided by one of the other treatment facility options listed below.

**B. Sand Filter with amendment for dissolved phosphorus**
**C. Bioretention filter/rain gardens with amendment for dissolved phosphorus**
**D. WSDOT Media Filter Drain (Formerly known as the Ecology Embankment)**
**E. Stormwater Treatment Wetland**
**F. Manufactured filters certified by Ecology to remove phosphorus**

## 6.4 ENHANCED TREATMENT MENU

**6.4.1 Performance Goal:** The Enhanced Menu facility choices are intended to provide a higher rate of removal of dissolved metals than Basic Treatment facilities. Due to the sparse data available concerning dissolved metals removal in stormwater treatment facilities, a specific numeric removal efficiency goal could not be established when Ecology set this performance goal. Instead, Ecology relied on available nationwide and local data, and knowledge of the pollutant removal mechanisms of treatment facilities to develop the list of options below. In addition, the choices are intended to achieve the Basic Treatment performance goal. The performance goal assumes that the facility is treating stormwater with dissolved Copper typically ranging from 0.003 to 0.02 mg/l, and dissolved Zinc ranging from 0.02 to 0.3 mg/l.

**6.4.2 Options:** Any one of the following options may be chosen to satisfy the enhanced treatment requirement:

**A.** Infiltration with appropriate pretreatment – See Chapter 7.
   **1.** Infiltration treatment - If infiltration is through soils meeting the minimum site suitability criteria for infiltration treatment (See Chapter 7.), a presettling basin/vault or a basic treatment facility can serve for pretreatment.
   **2.** Infiltration preceded by Enhanced Treatment - If the soils do not meet the soil suitability criteria and the infiltration site is within ¼ mile of a fish-bearing stream, a tributary to a fish-bearing stream, or a lake, treatment must be provided by one of the other treatment facility options listed below.

**B.** Sand Filter with amendment for dissolved copper and dissolved zinc
**C.** Bioretention filter/rain garden
**D.** WSDOT Media Filter Drain (Formerly known as the Ecology Embankment)
**E.** Wetpond
**F.** Stormwater Treatment Wetland
**G.** Filter Strip
**H.** Manufactured filters certified by Ecology to remove dissolved copper and dissolved zinc

## 6.5 BASIC TREATMENT MENU

**6.5.1 Performance Goal:** The Basic Treatment Menu facility choices are intended to achieve 80% removal of total suspended solids for influent concentrations that are greater than 100 mg/l, but less than 200 mg/l. For influent concentrations greater than 200 mg/l, a higher treatment goal may be appropriate. For influent concentrations less than 100 mg/l, the facilities are intended to achieve an effluent goal of 20 mg/l total suspended solids.

**6.5.2 Options:** Any one of the following options may be chosen to satisfy the basic treatment requirement:

A. Infiltration
B. Bio-infiltration Swale
C. Sand Filter
D. Vegetated Strips
E. Wetpond
F. Wetvault
G. Stormwater Treatment Wetland
H. Bioretention filter/rain garden
I. WSDOT Media Filter Drain (Formerly known as the Ecology Embankment)
J. Contech StormFilter©
K. Manufactured filters certified by Ecology to meet the basic treatment performance goal

## 6.6 GENERAL REQUIREMENTS FOR STORMWATER FACILITIES

This chapter addresses general requirements for treatment facilities. Requirements discussed in this chapter include design volumes and flows, sequencing of facilities, liners, and hydraulic structures for splitting or dispersing flows.

### 6.6.1 Off-Line vs. On-Line Facilities

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).

A. **Off-line facilities**: 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 must continue to receive and treat the water quality design flow rate to the applicable treatment performance goal. Only the higher incremental portions of flow rates may be bypassed around a treatment facility.
   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 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).

B. **On-line facilities***:* 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 met.
   Treatment facilities that are located downstream of detention facilities shall only be designed as on-line facilities.

### 6.6.2 Flows Requiring Treatment

Runoff from pollution-generating impervious or pervious surfaces must be treated. Such surfaces include those which are 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. Examples include erodible soils that are stockpiled, uncovered process wastes, manure, fertilizers, oily substances, ashes, kiln dust, garbage dumpster leakage, and metal roofs are that are not coated with an inert, non-leachable material (e.g., baked enamel coating).

A surface, whether paved or not, shall be considered subject to vehicular use if it is regularly used by motor vehicles. The following are considered regularly-used surfaces: roads, unvegetated road shoulders, bike lanes within the traveled lane of a roadway, driveways, parking lots, unfenced firelanes, vehicular equipment storage yards, and airport runways.

The following are not considered regularly-used surfaces: paved pedestrian or bicycle pathways separated from and not subject to drainage from roads for motor vehicles, fenced firelanes, and infrequently used maintenance access roads.

Pollution-generating pervious surfaces (PGPS) are 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.

### A. Summary of Areas Needing Treatment

1. All runoff from pollution-generating impervious surfaces is to be treated through water quality facilities.
2. 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.
3. 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 of full dispersion (BMP 5.14) listed in Chapter 5.
4. 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.
5. 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.
6. 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.
7. 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.

### 6.6.3 Sequence of Facilities

In general, all treatment facilities may be installed upstream of detention facilities, although presettling basins are needed for sand filters and infiltration basins. 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 designed to meet the flow duration standard of Minimum Requirement No. 7 may interfere with proper functioning of sand filters. The prolonged flows may cause extended saturation periods within the filter. Saturated sand can lose all oxygen and become anoxic. If that occurs, some amount of phosphorus captured within the filter may become soluble and released. 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.

### 6.6.4 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, such as the first cell of a wetpond, require permanent water for proper functioning.

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 ($1.7 \times 10^{-3}$ 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 ($1.4 \times 10^{-5}$ 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.

## A. General Design Criteria

1 Table 6.2 shows recommendations for the type of liner generally best suited for use with various runoff treatment facilities.

2 Liners shall be evenly placed over the bottom and/or sides of the treatment area of the facility as indicated in Table 6.2. 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.

3 For low permeability liners, the following criteria apply:

a) Where the seasonal high groundwater elevation is likely to contact a low permeability liner, liner buoyancy may be a concern. A low permeability liner shall not be used in this situation unless evaluated and recommended by a geotechnical engineer.
b) 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.
c) 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.

## B. Design Criteria for Treatment Liners

1. A 18” thick layer of soil with a minimum organic content of 5% AND a minimum cation exchange capacity (CEC) of 5 milliequivalents/100 grams can be used as a treatment layer beneath a water quality or detention facility.
2. To demonstrate that in-place soils meet the above criteria, 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).
3. Typically, side wall seepage is not a concern if the seepage flows through the same stratum as the bottom of the treatment BMP. However, if the treatment soil is an engineered soil or has very low permeability, the potential to bypass the treatment soil through the side walls may be significant. In those cases, the treatment BMP side walls may be lined with at least 18 inches of treatment soil, as described above, to prevent untreated seepage. This lesser soil thickness is based on unsaturated flow as a result of alternating wet-dry periods.
4. Organic content shall be measured on a dry weight basis using ASTM D2974.
5. Cation exchange capacity (CEC) shall be tested using EPA laboratory method 9081.
6. Certification by a soils testing laboratory that imported soil meets the organic content and CEC criteria above shall be provided to the local approval authority.

7. Animal manures used in treatment soil layers must be sterilized because of potential for bacterial contamination of the groundwater.
8. Enhanced treatment may be achieved by lining a facility with 18 inches of bioretention filter media.

## C. Design Criteria for Low Permeability Liner Options

1. Compacted Till Liners
   a) Liner thickness shall be 18 inches after compaction.
   b) Soil shall be compacted to 95% minimum dry density, modified proctor method (ASTM D-1557).
   c) Soil shall be placed in 6-inch lifts.
   d) Soils shall be used that meet the following gradation:

2. Clay Liners
   a) Liner thickness shall be 12 inches.
   b) Clay shall be compacted to 95% minimum dry density, modified proctor method (ASTM D 1557).
   c) The slope of clay liners must be restricted to 3H: IV 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 and is subject to approval by Kitsap County.
   d) Where clay liners form the sides of ponds, the interior side slope shall not be steeper than 3: 1, irrespective of fencing. This restriction is to ensure that anyone falling into the pond may safely climb out.

3. Geomembrane Liners
   a) Geomembrane liners shall be ultraviolet (UV) light resistant and have a minimum thickness of 30 millimeters. A thickness of 40 millimeters shall be used in areas of maintenance access or where heavy machinery must be operated over the membrane.
   b) Geomembranes shall be bedded according to the manufacturer's recommendations.
   c) Liners shall be installed so that they can be covered with 12 inches of top dressing forming the bottom and sides of the water quality facility, except for liner sand filters. 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.

d) If possible, liners should be of a contrasting color so that maintenance workers are aware of any areas where a liner may have become exposed when maintaining the facility.

e) 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.

4. Concrete Liners

a) Portland cement liners are allowed irrespective of facility size, and shotcrete may be used on slopes. However, 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. Weight of maintenance equipment can be up to 80,000 pounds when fully loaded.

b) Asphalt concrete may not be used for liners due to its permeability to many organic pollutants.

c) 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.

### 6.6.5 Hydraulic Structures

#### A. 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 in Chapter 4, Flow Control, Flow Splitter Design Criteria.

**B. Flow Spreading Designs**
Flow spreaders function to uniformly spread flows across the inflow portion of water quality facilities (e.g., sand filter or filter strip). For specific design criteria, see Chapter 4, Flow Spreader Design Criteria.

## 6.7 PRETREATMENT

### 6.7.1 Purpose

A. This section 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:

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

### 6.7.2 Best Management Practices (BMPs) for Pretreatment

A. Presettling Basins BMP 6.01
B. Presettling Vaults BMP 6.02
C. Basic Treatment BMPs listed in section 6.5.2
D. Detention Ponds designed per chapter 7

### 6.7.3 Presettling Basin BMP 6.01

**A. Purpose and Definition**

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

**B. Application and Limitations**

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

**C. Design Criteria**

1. A presettling basin shall be designed with a wetpool. The treatment volume shall be at least 20 percent of the $V_b$ determined by the design wetpond sizing criteria found in section 6.11.1.
2. If the runoff in the Presettling Basin will be in direct contact with the soil, it must be lined per the liner requirement in Section 6.6.
3. The Presettling Basin shall conform to the following:
   a. The minimum depth shall be 4 feet; the maximum depth shall be 6 feet.
   b. Inlets and outlets shall be designed to minimize velocity and reduce turbulence. Inlet and outlet structures should be located at extreme ends of the basin in order to maximize particle-settling opportunities.
      (1) Inlets shall be a submerged horizontal Tee configuration no more than 2 ft above the floor of the basin
      (2) Outlets shall be submerged at least 1 ft below the water quality design water surface elevation but no more than 1 ft above the floor of the basin.

**D. Site Constraints and Setbacks**

1. Setbacks shall be the same as the device that the presettling basin serves.

### 6.7.4 Presettling Vault BMP 6.02

Manufactured vaults that have received Ecology TAPE approval for pretreatment may be used as presettling vaults. These devices may also be used in lieu of a forebay for wetponds and wetlands. All manufactured vaults shall be sized based on the diameter of the vault and the criteria found in table 6.4.

## 6.8 INFILTRATION AND BIO-INFILTRATION TREATMENT FACILITIES

### 6.8.1 Purpose

This chapter provides site suitability, design, and maintenance criteria for infiltration treatment systems. Infiltration treatment Best Management Practices (BMPs) serve the dual purpose of removing pollutants (TSS, heavy metals, phosphates, and organics) from stormwater and recharging aquifers.

A stormwater infiltration treatment facility is an impoundment; typically a basin, trench, or bio-infiltration swale whose underlying soil removes pollutants from stormwater. Infiltration BMPs for water quality treatment include:

A. Infiltration basins BMP 6.11
B. Infiltration trenches BMP 6.12
C. Bio-infiltration swales BMP 6.13

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.

For design criteria, refer to Chapter 7, Flow Control, Infiltration Treatment Facilities.

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

### 6.8.2 Bio-Infiltration Swale BMP 6.13

Bio-infiltration swales, also known as Grass Percolation Areas, 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, bio-infiltration 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, or an overflow channel to surface water. Overflows that are directed to a surface water must meet Minimum Requirement #7 or #8 (whichever is applicable) unless the discharge qualifies for a flow control exemption in accordance with the criteria in Minimum Requirement #7.

#### A. Additional Design Criteria Specific for Bio-infiltration Swales

The space available for ponding water within a Bio-infiltration swale can be sized by either:

1. Completely retaining the water quality design volume, i.e., the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model. 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.
2. Using the same design sizing procedures outlined in Chapter 7 for infiltration facilities designed as treatment facilities.
3. Drawdown time for the water quality design volume: 48 hours max. See Site Suitability Criterion (SSC 4) in Chapter 7.
4. Swale bottom: flat with a longitudinal slope less than 1%.
5. The maximum ponded depth: 6 inches.
6. 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 design soil thickness may be reduced to as low as 6 inches if appropriate

performance data demonstrates that the vegetated root zone and the natural soil can be expected to provide adequate removal and loading capacities for the target pollutants. The design professional shall calculate the pollutant loading capacity of the treatment soil to estimate if there is sufficient treatment soil volume for an acceptable design period. (See *Criteria for Assessing the Trace Element Removal Capacity of Bio-filtration Systems*, Stan Miller, Spokane County, June 2000).

***<u>Note:</u> Bioretention Filter media meets this specification and is encouraged***

7. The treatment zone depth of 6 inches or more shall contain sufficient organics and texture to ensure good growth of the vegetation.
8. 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 Chapter 7 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.
9. Native or adapted grass shall be used.
10. Pretreatment of debris, gross TSS, and oil & grease to prevent the clogging of the treatment soil and/or growth of the vegetation is required, where necessary.
11. Identify pollutants, particularly in industrial and commercial area runoff, that could cause a violation of Ecology's ground water quality Standards (Chapter 173-200 WAC). Include appropriate mitigation measures (pretreatment, source control, etc.) for those pollutants.

## 6.9 FILTER MEDIA TREATMENT FACILIITES

### 6.9.1 Purpose

To collect and treat the design runoff volume to remove TSS, phosphorous, dissolved metals, and insoluble organics (including oils) from stormwater.

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

A. Sand Filter BMP 6.21
B. Sand Filter Vault BMP 6.22
C. Linear Sand Filter BMP 6.23
D. Contech Stormfilter © BMP 6.24
E. Media Filter Drain BMP 6.25
F. Bioretention Filters BMP 6.26

### 6.9.2 Sand Filters

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 sand filter, sand filter with level spreader, sand filter vault, and linear sand filter.**

#### A. Performance Objectives

Sand filters are expected to achieve the performance goals for Basic Treatment and Oil Treatment. Based upon experience in King County and Austin, Texas basic sand filters should be capable of achieving the following average pollutant removals:

1. 80 percent TSS at influent Event Mean Concentrations (EMCs) of 30-300 mg/L (King County, 1998) (Chang, 2000)
2. oil and grease to below 10 mg/L daily average and 15 mg/L at any time, with no ongoing or recurring visible sheen in the discharge.

Sand filters can also be amended to meet the phosphorus or enhanced treatment performance goals.

#### B. Applications and Limitations

Sand filtration can be used in most residential, commercial, and industrial developments where debris, heavy sediment loads, and oils and greases will not clog or prematurely overload the sand, or where adequate pretreatment is provided for these pollutants. Specific applications include residential subdivisions, parking lots for commercial and industrial establishments, gas stations, high-use sites, high-density multi family housing, roadways, and bridge decks.

12” min

Sand filters should be located off-line before or after detention (Chang, 2000). Sand filters are also suited for locations with space constraints in retrofit, and new/re-development situations. Overflow or bypass structures must be carefully designed to handle the larger storms. An off-line system is sized to treat 91% runoff volume predicted by a continuous runoff model. If a project must comply with Minimum Requirement #7, Flow Control, the flows bypassing the filter and the filter discharge must be routed to a retention/detention facility.

Pretreatment is necessary to reduce velocities to the sand filter and remove debris, floatables, large particulate matter, and oils. In high water table areas adequate drainage of the sand filter may require additional engineering analysis and design considerations. An underground filter should be considered in areas subject to freezing conditions. (Urbonas, 1997)

### C. Site Suitability

The following site characteristics should be considered in siting a sand filtration system:

1. Space availability, including a presettling basin/vault
2. Sufficient hydraulic head, at least 4 feet from inlet to outlet (except small linear sand filters)
3. Adequate Operation and Maintenance capability including accessibility for O & M
4. Sufficient pretreatment of oil, debris and solids in the tributary runoff

### D. Design Criteria

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.

1. 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.
2. On-line sand filters placed downstream of a detention facility must be sized using WWHM to filter 91% of the runoff volume.
3. 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).
4. 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).

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

## E. Additional Design Information:

1. Runoff to be treated by the sand filter must be pretreated (e.g., presettling basin, etc. depending on pollutants) to remove debris and other solids, and oil from high use sites.
2. Inlet bypass and flow spreading structures (e.g., flow spreaders, weirs or multiple orifice openings) should be designed to capture the applicable design flow rate, minimize turbulence and to spread the flow uniformly across the surface of the sand filter. Stone riprap or other energy dissipation devices should be installed to prevent gouging of the sand medium and to promote uniform flow. Include emergency spillway or overflow structures.
3. Design criteria for the underdrain piping: (types of underdrains include: a central collector pipe with lateral feeder pipes, or, a geotextile drain strip in an 8-inch gravel backfill or drain rock bed, or, longitudinal pipes in an 8-inch gravel backfill or drain rock with a collector pipe at the outlet end.)
4. Upstream of detention underdrain piping should be sized to handle double the two-year return frequency flow indicated by the WWHM (the doubling factor is a safety factor used in the absence of a conversion factor from the 1-hr. time step to a 15 minute time step). Downstream of detention the underdrain piping should be sized for the two-year return frequency flow indicated by the WWHM. In both instances there should be at least one (1) foot of hydraulic head above the invert of the upstream end of the collector pipe.
5. Internal diameters of underdrain pipes should be a minimum of six (6) inches and two rows of ½-inch holes spaced 6 inches apart longitudinally (maximum), with rows 120 degrees apart (laid with holes downward). Maximum perpendicular distance between two feeder pipes must be 15 feet. All piping is to be schedule 40 PVC or greater wall thickness. Drain piping could be installed in basin and trench configurations.
6. Main collector underdrain pipe should be at a slope of 0.5 percent minimum.
7. A geotextile fabric (specifications in Appendix 6C) must be used between the sand layer and drain rock or gravel and placed so that 1-inch of drain rock/gravel is above the fabric. Drain rock should be 0.75-1.5 inch rock or gravel backfill, washed free of clay and organic material.
8. Cleanout wyes with caps or junction boxes must be provided at both ends of the collector pipes. Cleanouts must extend to the surface of the filter. A valve box must be provided for access to the cleanouts. Access for cleaning all underdrain piping shall be provided. This may consist of installing cleanout ports, which tee into the underdrain system and surface above the top of the sand

bed. To facilitate maintenance of the sand filter an inlet shutoff/bypass valve is recommended.

***Note: Other equivalent energy dissipaters can be used if needed.***

9. **Sand specification**: The sand in a filter must consist of a medium sand meeting the size gradation (by weight) given in Table 6.5 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: Standard backfill for sand drains, Wa. Std. Spec. 9-03.13, does not meet this specification and should not be used for sand filters.)*
10. Include an access ramp with a slope not to exceed 7:1, or equivalent, for maintenance purposes at the inlet and the outlet of a surface filter. Consider an access port for inspection and maintenance.
11. Side slopes for earthen/grass embankments shall not exceed 3:1 to facilitate mowing.
12. High groundwater may damage underground structures or affect the performance of filter underdrain systems. There shall be sufficient clearance (at least 2 feet is recommended) between the seasonal high groundwater level (highest level of ground water observed) and the bottom of the sand filter to obtain adequate drainage.

### F. Amendments

Amendments must have the same grain size as that required by the primary media (sand, bioretention filter media , etc.) to maintain the media filtration rate.

1. Phosphorus Treatment:

The volume of the amendment is determined with the following equation:

$$M = \frac{62.4QM_c(C_o - C)}{q_a} \qquad \textbf{Equation 6-}1$$

Where:

$M$ = Quantity of the amendment in pounds
$Q$ = annual runoff flow in cubic feet per year
$M_c$ = maintenance cycle in years
$C_o$ = influent dissolved phosphorus concentration in mg/L
$C$ = effluent dissolved phosphorus concentration in mg/L
$q_a$ = operating capacity of the amendment in mg/kg (Measured at assumed $C_o$)[1]

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[1] If the user is unfamiliar with the term, Operating Capacity, go to Chapter 11 of Minton, 2005, Stormwater Treatment, Biological, Chemical, and Engineering Principles,

**Note:** Equation 6-4 assumes an amendment life of 10 years

**Note:** Assume a $C_o$ of 0.05 mg/L and a C of 0.025 mg/L in the absence of site-specific dissolved phosphorus loading data

d) Enhanced Treatment:

The volume of the amendment/s is determined by summing the volumes determined for copper and zinc using equation 6-1 with the following assumptions:

1) Copper $C_o = 0.02$ mg/L $C = 0.012$ mg/L
2) Zinc $C_o = 0.3$ mg/L $C = 0.075$ mg/L

**G. Construction Criteria**

No runoff shall enter the sand filter prior to completion of construction and approval of site stabilization by the responsible inspector. Construction runoff may be routed to a pretreatment sedimentation facility, but discharge from sedimentation facilities shall by-pass downstream sand filters. Careful level placement of the sand is necessary to avoid formation of voids within the sand that could lead to short-circuiting, (particularly around penetrations for underdrain cleanouts) and to prevent damage to the underlying geomembranes and underdrain system. Over-compaction shall be avoided to ensure adequate filtration capacity. Sand is best placed with a low ground pressure bulldozer (4 psig or less). After the sand layer is placed water settling is recommended. Flood the sand with 10-15 gallons of water per cubic foot of sand.

### 6.9.3 Sand Filter Vault

**A. 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. (Figure 6.5)

**B. Applications and Limitations**

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

**C. Additional Design Criteria for Vaults**

1. Vaults may be designed as off-line systems or on-line for small drainages.
2. In an off-line system a diversion structure shall be installed to divert the design flow rate into the sediment chamber and bypass

the remaining flow to detention/retention (if necessary to meet Minimum Requirement #7), or to surface water.

3. Optimize sand inlet flow distribution with minimal sand bed disturbance. A maximum of 8-inch distance between the top of the spreader and the top of the sand bed is suggested. Flows may enter the sand bed by spilling over the top of the wall into a flow spreader pad or alternatively a pipe and manifold system may be used. Any pipe and manifold system must retain the required dead storage volume in the first cell, minimize turbulence, and be readily maintainable.
4. If an inlet pipe and manifold system is used, the minimum pipe size shall be 8 inches. Multiple inlets are recommended to minimize turbulence and reduce local flow velocities.
5. Erosion protection must be provided along the first foot of the sand bed adjacent to the spreader. Geotextile fabric secured on the surface of the sand bed, or equivalent method, may be used.
6. The filter bed shall consist of a sand top layer, and a geotextile fabric second layer with an underdrain system.
7. Design the presettling cell for sediment collection and removal. A V-shaped bottom, removable bottom panels, or equivalent sludge handling system shall be used. One-foot of sediment storage in the presettling cell must be provided.
8. The pre-settling chamber must be sealed to trap oil and trash. This chamber is usually connected to the sand filtration chamber through an invert elbow to protect the filter surface from oil and trash.
9. If a retaining baffle is necessary for oil/floatables in the presettling cell, it must extend at least one foot above to one foot below the design flow water level. Provision for the passage of flows in the event of plugging must be provided. Access opening and ladder must be provided on both sides of the baffle.
10. To prevent anoxic conditions, a minimum of 24 square feet of ventilation grate shall be provided for each 250 square feet of sand bed surface area. For sufficient distribution of airflow across the sand bed, grates may be located in one area if the sand filter is small, but placement at each end is preferred. Small grates may also be dispersed over the entire sand bed area.
11. Provision for access is the same as for wet vaults. Removable panels must be provided over the entire sand bed.
12. Sand filter vaults must conform to the materials and structural suitability criteria specified for wet vaults.
13. Provide a sand filter inlet shutoff/bypass valve for maintenance
14. A geotextile fabric over the entire sand bed may be installed that is flexible, highly permeable, three-dimensional matrix, and adequately secured. This is useful in trapping trash and litter.

### 6.9.4 Linear Sand Filters

**A. 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 and functions as a flow spreader. (Figure 6.6)

**B. Application Limitations**

1. Applicable in long narrow spaces such as the perimeter of a paved surface.
2. 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.
3. To treat small drainages (less than 2 acres of PGIS + PGPS).
4. To treat runoff from high-use sites for TSS and oil/grease removal, if applicable.

**C. Additional Design Criteria for Linear Sand Filters**

1. A divider wall that is level and extends a minimum of 12 inches above the sand bed shall divide the two cells.
2. Stormwater may enter the sediment cell by sheet flow or a piped inlet.
3. The width of the sand cell must be 1-foot minimum to 15 feet maximum.
4. The sand 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 rock layer may be eliminated when using a shallow plastic drainage channel.
5. The drainpipe must be 6-inch diameter minimum and be wrapped in geotextile and sloped a minimum of 0.5 percent.
   a. Sites serving less than 1 acre may use a shallow plastic drainage channel that provides at least 15 $in^2/ft$ of Water Inlet Area, as shown in figure 6.7.
6. Maximum sand bed ponding depth: 1-foot.
7. Must be vented as for sand filter vaults
8. Linear sand filters must conform to the materials and structural suitability criteria specified for wet vaults.
9. Set sediment cell width as follows:

| Sand filter width, (w) inches | 12-24 | 24-48 | 48-72 | 72+ |
|---|---|---|---|---|
| Sediment cell width, inches | 12 | 18 | 24 | w/3 |

### 6.9.5 StormFilter

The Contech StormFilter® (StormFilter) is a flow-through stormwater filtration system comprised of a vault that houses media-filled cartridges. As stormwater fills the treatment chamber, stormwater filters through the media to the center of the cartridge, and treated stormwater is collected and discharged through underdrain collection pipes Figure 6.8 shows a schematic representation of a StormFilter.

**A. Applications and Limitations**

A StormFilter with ZPG™ (zeolite/perlite/granulated activated carbon) media may be used as a single facility (with pretreatment) to meet the Basic treatment requirement.

The StormFilter may be filled with several types of filter media. Until additional performance data is collected for additional types, **only the ZPG media is acceptable to meet Basic water quality requirements**. Other types of media may be allowed after the media has been approved through the state Department of Ecology's TAPE program.

**B. Methods of Analysis**

StormFilter sizing is based on the water quality design flow and a mass loading method. Since the process and the compost are patented, CONTECH Stormwater Solutions (CSS) personnel will configure a StormFilter based on the design flow provided and specific ***site*** characteristics. The WQ design flow should be based on the WWHM modeled flows rather than on other flow-estimation methods. An accurate description of land use and potential sediment and pollutant loading sources shall also be provided to CSS personnel, who will consider these factors in sizing. The specific sizing methodologies are described below.

**C. StormFilter with ZPG Media for Basic Water Quality Treatment**

1. The maximum flow rate (gpm/cartridge) is based on the effective cartridge height. The **maximum flow rate per cartridge** shall be per Table 6.7. The maximum specific flow rate is 1 gpm/ft$^2$.
2. The StormFilter shall be **sized using both the flow-based and mass-based methods** as described in the *Product Design Manual Version 4.1 (April 2006)*, or the most current version, and the designer shall select the result yielding the larger number of cartridges.
3. StormFilter systems shall be installed in such a manner that the **flows exceeding the design flow rates** (Table 6.6) are bypassed or will not suspend captured sediments.
4. **ZPG media shall conform to the following specifications**. Verification that these specifications are met shall be required.
    a. Each cartridge contains a total of approximately 2.6 cubic feet of media. The **ZPG cartridge** consists of an outer layer of perlite that is approximately 1.3 cubic feet in volume and an inner layer, consisting of a mixture of 90% zeolite and 10%

granular activated carbon, which is approximately 1.3 cubic feet in volume.

   b. **Zeolite Media:** Zeolite media shall be made of naturally occurring clinoptilolite. The zeolite media shall have a bulk density ranging from 44 to 50 lbs per cubic foot and particle sizes ranging from 0.13" (#6 mesh) to 0.19" (#4 mesh). Additionally, the cation exchange capacity (CEC) of zeolite shall range from approximately 1.0 to 2.2 meq/g.
   c. **Perlite Media:** Perlite media shall be made of natural siliceous volcanic rock free of any debris or foreign matter, The expanded perlite shall have a bulk density ranging from 6.5 to 8.5 lbs per cubic foot and particle size ranging from 0.09" (#8 mesh) to 0.38" (3/8" mesh).
   d. **Granular Activated Carbon:** Granular activated carbon (GAC) shall be made of lignite coal that has been steam-activated. The GAC media shall have a bulk density ranging from 28 to 31 lbs per cubic foot and particle sizes ranging from a 0.09" (#8 mesh) to 0.19" (#4 mesh).

## D. Design Criteria

Figure 6.8 illustrates the general configuration of a typical StormFilter unit using standard precast concrete vaults.

1. **General**
   a. Vaults used for a StormFilter shall conform to the **"Materials"** and **"Structural Stability"** requirements specified for detention vaults (see Chapter 7).
   b. Several vault sizes are available for the StormFilter. The details of cartridge configuration and maximum number of cartridges allowed in each size vault are from the manufacturer.
2. **Access Requirements**
   **a.** **Access must be provided** by either removable panels to allow for removal and replacement of the filter cartridges. Removable panels have stainless steel lifting eyes, and weight no more than 5 tons per panel.
   **b.** Access to the **inflow and outlet cells** must also be provided.
   **c.** **Ladder access** is required when vault height exceeds 4 feet.
   **d.** **Locking lids** shall be provided as specified for detention.
   **e.** If removable panels are not used, corner **ventilation pipes** shall be provided, and the **minimum internal height and width** and **maximum depth** shall be met.
3. **Access Roads, Right of Way, and Setbacks**
   Same as for detention vaults.
4. **Construction Considerations**
   Installation of a StormFilter shall follow the manufacturer's recommended procedures.

### 6.9.6 Media Filter Drain

This BMP shall be designed according to the June 2008 edition of the Washington State Department of Transportation *Highway Runoff Manual* BMP RT.07 as contained in appendix 6B.

Bioretention filter media is acceptable as a substitute for the media called out in appendix 6B subject to these two conditions: a) The depth of media is the same as specified for the bioretention filter media; b) Bioretention filter media cannot be used when Phosphorus Treatment is required.

### 6.9.7 Bioretention Filter

**A. Basic and Enhanced Treatment Design Criteria:**

This BMP shall be designed according to the criteria found in the *Kitsap Low Impact Development Guidance Manual* when used as a stand alone BMP to meet basic and enhanced treatment requirements.

**B. Phosphorus treatment Design Criteria:**

The amount of amendment necessary to provide phosphorus treatment shall be determined using the same guidelines as those for amended sand filters (equation 6-1).

**C. Infiltration Basin Treatment Layer:**

Bioretention filter media may be used to line an infiltration basin to provide basic or enhanced treatment prior to infiltration. The media must meet the design criteria found in the *Kitsap Low Impact Development Guidance Manual* and be at least 18 inches thick on the surfaces indicated in table 6.2.

## 6.10 BIOFILTRATION TREATMENT FACILITIES

***Note: Biofiltration <u>Swales</u> are <u>NOT</u> an approved basic treatment BMP for Kitsap County. Studies indicate that Biofiltration swales generally do not provide treatment that meets the basic treatment goals***.

**A. Purpose**

The BMPs are designed to remove low concentrations and quantities of total suspended solids (TSS), heavy metals, petroleum hydrocarbons, and/or nutrients from stormwater.

**B. 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 shall be considered in retrofit situations where appropriate. (Center for Watershed Protection, 1998)

**C. Site Suitability**

The following factors must be considered for determining site suitability:

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

**D. Best Management Practices**

1. BMP 6.31 – Basic Filter Strip & Compost-Amended Filter Strip
2. BMP 6.32 – Narrow Area Filter Strip

### 6.10.1 Basic Filter Strip BMP 6.31

**A. Description:**

1. A basic filter strip is flat with no side slopes (Figure 6.9). Contaminated stormwater is distributed as sheet flow across the inlet width of a biofilter strip.

**B. Applications/Limitations:**

1. 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 5.10; 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.

**C. Design Criteria**

1. Use the Design Criteria specified in Table 6.7
2. Filter strips shall only receive sheet flow.
3. Use curb cuts ≥ 12-inch wide and 1-inch above the filter strip inlet.
4. Calculate the design flow depth using Manning’s equation as follows:

$$Q = (1.49A\, R^{0.67}\, s^{0.5})/n \qquad \textbf{Equation 6-2}$$

Substituting for AR:

$$Q = (1.49Ty^{1.67}\, s^{0.5})/n$$

Where:

$Ty = A_{rectangle, ft}^2$
$y \approx R_{rectangle}$, design depth of flow, ft. (1 inch maximum)
$Q$ = peak Water Quality design flow rate based on WWHM, $ft^3$/sec
$n$ = Manning's roughness coefficient
$s$ = Longitudinal slope of filter strip parallel to direction of flow
$T$ = Width of filter strip perpendicular to the direction of flow, ft.
$A$ = Filter strip inlet cross-sectional flow area (rectangular), $ft^2$
$R$ = hydraulic radius, ft.

Rearranging for y:

$y = [Qn/1.49Ts^{0.5}]^{0.6}$
y must not exceed 1 inch

Calculate the design flow velocity V, ft./sec., through the filter strip:

$V = Q/Ty$
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:

$$L = tV = 540V \qquad \textbf{Equation 6-3}$$

### 6.10.2 Narrow Area Filter Strip BMP 6.32

**A. Description:**

This section describes a filter strip design[2] for impervious areas with flowpaths of 30 feet or less that can drain along their widest dimension to grassy areas.

**B. Applications/Limitations:**

1. A narrow area filter strip could be used at roadways with limited right-of-way, or for narrow parking strips. If space is available to use the basic filter strip design, that design should be used in preference to the narrow filter strip.
2. 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.

**C. 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

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1 This narrow area filter strip design method is included here because technical limitations exist in the basic design method which result in filter strips that are proportionately longer as the contributing drainage becomes narrower (a result that is counter-intuitive). Research by several parties is underway to evaluate filter strip design parameters. This research may lead to more stringent design requirements that would supersede the design criteria presented here.

on the length of flowpath draining to the filter strip and the longitudinal slope of the filter strip itself (parallel to the flowpath).

1. **Step 1*:*** Determine the length of the flowpath from the upstream to the downstream edge of the impervious area draining sheet flow to the 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.
2. **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.
3. **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 6.10. 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.

## 6.11 WETPOOL FACILITIES

This section 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 may be combined with a detention or flow control pond in a combined facility. Included are the following specific facility designs:

Wetponds BMP 6.41
Wetvaults BMP 6.42
Stormwater Treatment Wetlands BMP 6.43
Combined Wetpool/Detention Systems

### 6.11.1 Wetponds BMP 6.41

A *wetpond* is a constructed stormwater pond that retains a permanent pool of water (a "wetpool") at least during the wet season (see the wetpond detail in Figure 6.13). The volume of the wetpool is related to the effectiveness of the pond in settling particulate pollutants.

## A. Applications and Limitations

1. A wetpond requires a larger area than a sand filter, but it can be integrated to the contours of a ***site*** fairly easily. In till soils, the wetpond holds a permanent pool of water that provides an attractive aesthetic feature. 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 with impervious material is one way to deal with this situation.
2. Wetponds may be single-purpose facilities, providing only water quality 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 Section 6.11.4) for a description of combined WQ and detention facilities.
3. Wetponds treat water both by gravity settling and by biological uptake of algae and microorganisms. Wetponds can remove some dissolved pollutants such as soluble phosphorus by this uptake mechanism. They are therefore used in the phosphorus treatment menu in addition to the Basic WQ menu for solids removal. Wetponds work best when the water already in the pond is moved out *en masse* by incoming flows, a phenomena called *plug flow*. Because treatment works on this displacement principle, the dead storage pool 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.

## B. Methods of Analysis

The primary design factor that determines a wetpond's **particulate removal efficiency** is the volume of the wetpool in relation to the volume of stormwater runoff from the *mean annual storm*.[3] The larger the wetpond volume in relation to the volume of runoff, the greater the potential for pollutant removal. 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 as follows:

1. Dissipating energy at the inlet

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[3] The *mean annual storm* is a statistically derived rainfall event defined by the U.S. Environmental Protection Agency in "Results of the Nationwide Urban Runoff Program," 1986. It is defined as the annual rainfall divided by the number of storm events in the year. The NURP studies refer to pond sizing using a $V_b/V_r$ ratio: the ratio of the pond volume $V_b$ to the volume of runoff from the mean annual storm $V_r$. This is equivalent to using a volume factor $f$ times $V_r$.

2. Providing a large length-to-width ratio
   a. Providing a broad surface for water exchange across cells rather than a constricted area.
   b. Minimizing fringe vegetation around the pool perimeter
   c. Maximizing the flowpath between inlet and outlet, including the vertical path, also enhances treatment by increasing residence time.
3. Wetponds designed using the method below and the required design criteria are expected to meet the basic treatment and enhanced treatment performance goals. The actual performance of a wetpond may vary, however, due to a number of factors, including design features, maintenance frequency, storm characteristics, pond algae dynamics, and waterfowl use. Procedures for determining a wetpond's dimensions and volume are outlined below.

**Step 1: Identify required wetpool volume factor (*f*).** A basic wetpond requires a volume factor of 1.0 for residential developments and 1.5 for commercial, industrial and road (other than local access) developments. This means that the required wetpond volume is 1 or 1.5 times the volume of runoff $V_r$ from the mean annual storm (see Steps 2 and 3).

**Step 2: Determine rainfall (*R*) for the mean annual storm.** The rainfall for the mean annual storm *R* is obtained by locating the ***project site*** on Figure 6.12 and interpolating between isopluvials. Convert to feet for use in Equation (6-4).

**Step 3: Calculate runoff from the mean annual storm ($V_r$) for the developed *site*.** The runoff volume $V_r$ is the amount of rainfall that runs off a particular set of land covers. To determine $V_r$, each portion of the wetpond tributary area is assigned to one of four cover types, each having a different runoff coefficient: impervious surface, till grass, till forest, or outwash. Use the following definitions for this calculation step

   a. **Impervious surface** is a compacted surface, such as pavement, gravel, soil, or other hard surfaces, as well as open water bodies.
   b. **Till grass** is post-development grass or landscaped area and onsite forested land on till soil that are not permanently in critical area buffers or covenants. *Till* is soil that does not drain readily and, as a result, generates large amounts of runoff. For this application, till soil types include Buckley and bedrock soils, and alluvial and outwash soils that have a seasonally high water table or are underlain at a shallow depth (less than 5 feet) by glacial till. U.S. Soil Conservation Service (SCS) hydrologic soil groups that are classified as till soils include a few B, most C, and all D soils. See Table 6.X for classification of specific SCS soil types.

c. **Till forest** is all permanent onsite forest and/or shrub cover, located on till soils, that retains the natural understory vegetation and forest duff, irrespective of age, if densities are sufficient to ensure at least 80 percent canopy cover within 5 years. To be counted in this category, forest must be protected as permanent open space. Such areas shall be placed in a separate open space tract or shall be protected through covenants or conservation easements.

d. **Outwash** is soil that infiltrates well and as a result produces small amounts of runoff. SCS hydrologic soil groups classified as outwash soils include all A, most B, and some C soils. See Table 6A.1 of appendix 6A for classification of specific SCS soil types.

Cover categories are based on existing U.S. Department of Agriculture soil survey data or ***site***-specific data where available.

Next, coefficients specific to the four cover types are weighted by the drainage areas and then multiplied by the rainfall $R$ from Step 2 to produce the runoff volume $V_r$:

$$V_r = (0.9A_i + 0.25A_{tg} + 0.10A_{tf} + 0.01A_o) \text{ x } (R) \tag{6-4}$$

where $V_r$ = volume of runoff from mean annual storm (cf)
$A_i$ = area of impervious surface (sf)
$A_{tg}$ = area of till soil covered with grass (sf)
$A_{tf}$ = area of till soil covered with forest (sf)
$A_o$ = area of outwash soil covered with grass or forest (sf)
$R$ = rainfall from mean annual storm (ft)

**Step 4: Calculate wetpool volume ($V_b$).** Use the results of the previous steps to calculate the required wetpool volume according to the following equation:

$$V_b = f\,V_r \tag{6-5}$$

where $V_b$ = wetpool volume (cf)
$f$ = volume factor (1.0 for residential, 1.5 for commercial, industrial, roads)
$V_r$ = runoff volume (cf) from Step 3

**Step 5: Determine wetpool dimensions.** Determine the wetpool dimensions satisfying the design criteria outlined below. A simple way to check the volume of each wetpool cell is to use the following equation:

$$V_b = \frac{h(A_1 + A_2)}{2} \tag{6-6}$$

where $V_b$ = wetpool volume (cf)

$h$ = wetpool depth (ft)
$A_1$ = water quality design surface area of wetpool (sf)
$A_2$ = bottom area of wetpool (sf)

e. **Step 6: Design pond outlet pipe and determine primary overflow water surface.** The design criteria for wetponds calls for a pond outlet pipe to 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:

1) Use the nomographs in Figures 6.17 and 6.18 to select a trial size for the pond outlet pipe sufficient to pass the WQ design flow $Q_{wq}$.
2) Use Figure 6.19 to determine the critical depth $d_c$ at the outflow end of the pipe for $Q_{wq}$.
3) Use Figure 6.20 to determine the flow area $A_c$ at critical depth.
4) Calculate the flow velocity at critical depth using continuity equation ($V_c = Q_{wq} / A_c$).
5) Calculate the velocity head $V_H$ ($V_H = V_c^2 / 2g$), where $g$ is the gravitational constant, 32.2 feet per second).
6) 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 + $d_c$ + $V_H$)
7) Adjust outlet pipe diameter as needed and repeat Steps (a) through (e).

## C. Design Criteria

General wetpond design criteria and concepts are shown in Figure 6.13.

### 1. Wetpool Geometry

a, The wetpool shall be divided into **two cells** separated by a baffle or porous berm.[4] The first cell shall contain 20 percent of the total wetpool volume. The first cell is the forebay and constitutes presettling. The baffle or berm volume shall not count as part of the total wetpool volume. The first cell may be replaced by a presettling vault sized per section 6.7.4.

**1) 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. Use of a pipe and full-width manifold system to introduce water into the second cell is possible on a case-by-case basis if approved by DDES.

b. 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).

c. **Sediment storage** shall be provided in the first cell. The sediment storage shall have a minimum depth of 1 foot.

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[4] As used here, the term *baffle* means a vertical divider placed across the entire width of the pond, stopping short of the pond 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.

d. 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. If the wetpool is a single cell (without pretreattent), the volume equivalent to the first cell shall have a minimum depth of 4 feet.
e. 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 **Planting requirements**).
f. 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.
g. 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.

**2. Berms, Baffles, and Slopes**

a. A berm or baffle shall extend across the full width of the wetpool, and tie into the wetpond side slopes. If the berm embankments are greater than 4 feet in height, the berm **must be constructed by excavating a key** equal to 50% of the embankment cross-sectional height and width. This requirement may be waived if recommended by a geotechnical engineer for specific ***site*** conditions.[5]
b. The **top of the berm shall extend** to the **WQ design water surface** or be one foot below the WQ design water surface. If at the WQ design water surface, berm side slopes must be 3H:1V. Berm side slopes may be steeper (up to 2:1) if the berm is submerged one foot.
    **1) Intent:** Submerging the berm is intended to enhance safety by discouraging pedestrian access when side slopes are steeper than 3H:1V.
c. If good vegetation cover is not established on the berm, **erosion control measures** shall be used to prevent erosion of the berm back-slope when the pond is initially filled.
d. The interior berm or baffle may be a **retaining wall** provided that the design is prepared and stamped by a ***civil engineer***. If a baffle or retaining wall is used, it shall be submerged one foot below the design water surface to discourage access by pedestrians.

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[5] The geotechnical analysis must address situations in which one of the two cells is empty while the other remains full of water. These situations can occur, for example, during pump down of either cell for sediment removal, or when water from the second unlined cell percolates into the ground.

e. Criteria for wetpond **side slopes** and **fencing** are given under chapter 7.

f. Berm **embankments** shall be the same as for detention ponds (see chapter 7.).

See Figure 6.12 for details on the following requirements:

g. The **inlet** to the wetpond shall be **submerged** with the inlet pipe **Internal berms** to lengthen the flow path or allow the inlet and outlet to be at the same side of the pond may be used if an **adjustment** is granted. An adjustment may be granted only if **physical *site* constraints** prevent the standard configuration and design features promote water quality treatment. Required design features to approve an adjustment include minimizing dead spaces, minimizing turbulence, and promoting plug flow. Internal berms must extend to the 2-year water elevation, a minimum of 10 feet must be between the berms, and a distance equal to the width between the internal berms must be provided between the internal berm and the pond side at the point that the flow turns around the berm.

### 3. Inlet and Outlet

Invert approximately two feet from the pond bottom (not including sediment storage). The top of the inlet pipe shall be submerged at least 1 foot. The inlet shall have an open-ended horizontal tee configuration at the end of it.

a. **Intent:** The inlet is submerged to dissipate energy of the incoming flow. The distance from the bottom is set to minimize resuspension of settled sediments and break up thermal stratification. The tee configuration is intended to direct flow toward traditional dead zones and lengthen the flow path. Alternative inlet designs that accomplish these objectives are acceptable.

An **outlet structure** shall be provided. Either a Type 2 catch basin with a grated opening (jail house window) or a manhole with a cone grate (birdcage) may be used. No sump is required in the outlet structure for wetponds not providing detention storage. The outlet structure receives flow from the pond outlet pipe. The grate or birdcage openings provide an overflow route should the pond outlet pipe become clogged. Criterion 5 below specifies the sizing and position of the grate opening.

1) The **inlet** and **outlet** shall be oriented at opposite ends of the pond to maximize the flow length between the two points. See figure 6.12 for optimal placement options.

2) The **pond outlet pipe** (as opposed to the structure outlet) shall be back-sloped or have a turn-down elbow, and extend 1 foot below the WQ design water surface. *Note: A floating outlet, set to draw water from 1 foot below the*

*water surface, is also acceptable if vandalism concerns are adequately addressed.* **Intent:** The inverted outlet pipe provides for trapping of oils and floatables in the wetpond.

3) The **pond outlet pipe** shall be sized, at a minimum, to pass the WQ design flow. *Note: The highest invert of the outlet pipe sets the **WQ design water surface** elevation.*
4) The **overflow** criteria for single-purpose wetponds are as follows:
    a) The requirement for **primary overflow** as described for flow control ponds 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) In flow-through ponds, the grated opening shall be sized to pass the 100-year design flow.
5) An **emergency spillway** shall be provided and designed according to the requirements for detention ponds (see chapter 7).
6) A **gravity drain** for maintenance shall be provided if grade allows.
    a) The **drain invert** shall be at least 6 inches below the top elevation of the dividing berm or baffle. Deeper drains are encouraged where feasible, but must be no deeper than 18 inches above the pond bottom.
    **Intent:** to prevent highly sediment-laden water from escaping the pond when drained for maintenance.
    b) The drain shall be at least 8 inches (minimum) diameter and shall be controlled by a valve. Use of a shear gate is allowed only at the inlet end of a pipe located within an approved structure.
    **Intent:** Shear gates often leak if water pressure pushes on the side of the gate opposite the seal. The gate should be situated so that water pressure pushes toward the seal.
    **Intent:** It is anticipated that sediment removal will only be needed for the first cell in the majority of cases. The gravity drain is intended to allow water from the first cell to be drained to the second cell when the first cell is pumped dry for cleaning.
    c) Operational access to the valve shall be provided to the finished ground surface.
    d) The valve location shall be accessible and well-marked with one foot of paving placed around the box. It must also be protected from damage and unauthorized operation.
    e) A valve box is allowed to a maximum depth of 5 feet without an access manhole. If over 5 feet deep, an access manhole or vault is required.

f) All metal parts shall be corrosion-resistant. Galvanized materials are prohibited where substitutes are available.

4. **Access and Setbacks**
    a. The location of the pond relative to ***site*** constraints (e.g., buildings, property lines, etc.) shall be the same as for detention ponds (see Chapter 7).
    b. Access and maintenance **roads** shall be provided and designed according to the requirements for detention ponds (see chapter 7).
    c. Access and maintenance roads shall extend to both the wetpond inlet and outlet structures.
    d. An access ramp (7H minimum:1V) shall be provided to the bottom of the first cell unless all portions of the cell can be reached and sediment loaded from the top of the pond. Also see chapter 7, "Access Requirements" for more information on access alternatives.
    e. If the **dividing berm** is also **used for access**, it must be built to sustain loads of up to 80,000 pounds.
5. **Signage**
    a. General signage shall be provided according to the requirements for detention ponds (see Chapter 7).
6. **Planting Requirements**
    a. Planting requirements for detention ponds (see Section 7.) also apply to wetponds.
    b. If the second cell of the wetpond is 3 feet or shallower, the bottom area shall be planted with emergent wetland vegetation. See Table 6.9 for recommended emergent wetland plant species for wetponds. **Intent:** Planting of shallow pond areas helps to stabilize settled sediment and prevent resuspension.
    c. Cattails (*Typha latifolia*) are not allowed because they tend to crowd out other species, and the dead shoots need to be removed to prevent oxygen depletion in the wetpool.
    d. If the wetpond is used for phosphorus treatment, shrubs that form a dense cover shall 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.[6] Some suitable trees and shrubs include vine maple (*Acer circinatum*), wild cherry (*Prunus emarginata*), red osier dogwood (*Cornus stolonifera*), California myrtle (*Myrica californica*), Indian

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[6] Waterfowl are believed to limit use of areas where their view of predator approach paths is blocked. Some suitable native shrubs include vine maple, Indian plum, bitter cherry, red osier dogwood, cascara, and red elderberry. Ornamental hedge plants such as English laurel, privet and barberry are also good choices.

plum (*Oemleria cerasiformis*), and Pacific yew (*Taxus brevifolia*) as well as numerous ornamental species.

### D. Recommended Design Features

The following design features should be incorporated into the wetpond design where ***site*** conditions allow:

1. For wetpool depths in excess of 6 feet, it is recommended that some form of **recirculation** be provided in the summer, such as a fountain or aerator, to prevent stagnation and low dissolved oxygen conditions.
2. A flow length-to-width ratio greater than the 3:1 minimum is desirable. If the ratio is 4:1 or greater, then the **dividing berm is not required**, and the pond may consist of one cell rather than two.
3. A **tear-drop shape**, with the inlet at the narrow end, rather than a rectangular pond is preferred since it minimizes dead zones caused by corners.
4. A small amount of **base flow** is desirable to maintain circulation and reduce the potential for low oxygen conditions during late summer.
5. 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 shall 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.

**Intent:** Evergreen trees or shrubs are preferred to avoid problems associated with leaf drop. Columnar deciduous trees (e.g., hornbeam, Lombardy poplar, etc.) typically have fewer leaves than other deciduous trees.

6. The **number of inlets** to the facility should be limited; ideally there should be only one inlet. The flowpath length should be maximized from inlet to outlet for all inlets to the facility.
7. The **access and maintenance road** could be extended along the full length of the wetpond and could double as playcourts or picnic areas. Placing finely ground bark or other natural material over the road surface would render it more pedestrian friendly.
8. The following design features should be incorporated to **enhance aesthetics** where possible:
   a. Provide pedestrian access to shallow pool areas enhanced with emergent wetland vegetation. This allows the pond to be more accessible without incurring safety risks.
   b. Provide side slopes that are sufficiently gentle to avoid the need for fencing (3:1 or flatter).

c. Create flat areas overlooking or adjoining the pond for picnic tables or seating that can be used by residents. Walking or jogging trails around the pond are easily integrated into ***site*** design.
d. Include fountains or integrated waterfall features for privately maintained facilities.
e. Provide visual enhancement with clusters of trees and shrubs. In most pond areas, it is important to amend the soil before planting since ponds are typically placed well below the native soil horizon in very poor soils. Make sure dam safety restrictions against planting do not apply.
f. Orient the pond length along the direction of prevailing summer winds (typically west or southwest) to enhance wind mixing.[7]

### E. Construction Considerations

1. Sediment that has accumulated in the pond must be removed after construction in the drainage area of the pond is complete (unless used for a liner—see Criteria 2 below). If no more than 12 inches of sediment have accumulated after plat construction, cleaning may be left until after building construction is complete. In general, sediment accumulation from stabilized drainage areas is not expected to exceed an average of 4 inches per year in the first cell. If sediment accumulation is greater than this amount, it will be assumed to be from construction unless it can be shown otherwise. The County will not release maintenance and defect financial guarantees or assume maintenance responsibility for a facility unless it has been cleaned of construction phase sediments.
2. Sediment that has accumulated in the pond at the end of construction may be used as a liner in excessively drained soils if the sediment meets the criteria for low permeability or treatment liners defined in Section 6.3.

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[7] Wind moving over the surface of standing water can often induce some mixing of surface and near-surface water, replenishing oxygen and reducing stagnant conditions. If the pond is aligned with the prevailing wind direction, this effect can be maximized.

### 6.11.2 Wetvaults BMP 6.42

A *wetvault* is an underground structure similar in appearance to a detention vault, except that a wetvault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants (see the wetvault details, Figure 6.14). Being underground, the wetvault lacks the biological pollutant removal mechanisms, such as algae uptake, present in surface wetponds.

#### A. Applications and Limitations

A wetvault may be used in any type or size of development. However, it is most practical in relatively small catchments (less than 1.0 acre of impervious surface) with high land values because vaults are relatively expensive. Combined detention and wetvaults are allowed; see Section 6.11.4).

A wetvault is believed to be ineffective in removing dissolved pollutants such as soluble phosphorus or metals such as copper. There is also concern that oxygen levels will decline, especially in warm summer months, because of limited contact with air and wind. However, the extent to which this potential problem occurs has not been documented.

If oil control is required for a project, the wetvault may be combined with the **baffle oil/water separator** facility (see Section 6.12 to fulfill oil control treatment requirement.

#### B. Methods of Analysis

As with wetponds, the primary design factor that determines the removal efficiency of a wetvault is the volume of the wetpool in relationship to the volume of runoff ($V_r$.) from the mean annual storm[8]. The larger the volume, the higher the potential for pollutant removal. Performance is also improved by avoiding dead zones (like corners) where little exchange occurs, using large length-to-width ratios, dissipating energy at the inlet, and ensuring that flow rates are uniform to the extent possible and not increased between cells.

The methods of analysis for a wetvault are **identical to the methods of analysis for the wetpond**. Follow the procedure specified in Section 6.11.1 to determine the wetpool volume for a wetvault.

#### C. Design Criteria

Typical design details and concepts for a wetvault are shown in Figure 6.15.

#### D. Wetpool Geometry

Same as specified for **wetponds** except for the following **two modifications:**

1. **Criterion 3:** 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

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[8] U.S. Environmental Protection Agency, *Results of the Nationwide Urban Runoff Program*, 1986.

roughly proportional to vault width according to the schedule below:

| Vault Width | Sediment Depth (from bottom of side wall) |
|---|---|
| 15' | 10" |
| 20' | 9" |
| 40' | 6" |
| 60' | 4" |

2. **Criterion 5:** 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.

**E. Vault Structure**

1. Wetvaults shall be designed as flow-through systems.
2. The vault shall be separated into two cells by a **wall** or a **removable baffle**.[9] If a **wall or non-removable baffle** 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:
   a.. 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.
   b. The lowest point of the baffle shall be a minimum of 2 feet from the bottom of the vault, and greater if feasible.
3. 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.
4. The two cells of a wetvault shall not be divided into additional subcells by **internal walls**. If internal structural support is needed, post and pier construction may 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.

**Intent:** Treatment effectiveness in wetpool facilities is related to the extent to which plug flow is achieved and short-circuiting and dead zones are avoided. Structural walls placed within the cells can interfere with plug flow and create significant dead zones, reducing treatment effectiveness.

5. Internal walls to lengthen the flow path or allow the inlet and outlet to be at the same side of the vault may be used if an **adjustment** is granted. An adjustment may be granted only if **physical *site* constraints** prevent the standard configuration and design features promote water quality treatment. Required design features to approve an adjustment include minimizing dead spaces, minimizing turbulence, and promoting plug flow. Internal walls must extend to the 2-year water elevation, a minimum of 10 feet must be between the walls, and a distance equal to the width

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[9] As used here, the term *baffle* means a divider that does not extend all the way to the bottom of the vault, or if a bottom baffle, does not extend all the way to the top of the water surface. A *wall* is used here to mean a divider that extends all the way from near the water surface to the bottom of the vault.

between the internal walls must be provided between the internal wall and the vault wall at the point that the flow turns around the wall. All vault requirements apply to each length/segment.

**Intent:** Confined movement around the internal walls creates turbulence, creates dead zones and decreases treatment effectiveness.

6. 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.
7. The **vault bottom** shall slope laterally a minimum of 5% 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****:* The vault bottom may be flat if **removable panels** are provided over the entire vault. Removable panels shall be at grade, have stainless steel lifting eyes, and weigh no more than 5 tons per panel.

8. The highest point of a **vault bottom** must be at least 6 inches below the outlet elevation to provide for sediment storage over the entire bottom.
9. Provision for passage of flows should the outlet plug shall be provided.
10. 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. If arched culverts are used, the manufacturer must certify that they are water-tight.

**Intent:** To prevent decreasing the surface area available for oxygen exchange.

11. Wetvaults shall conform to the **"Materials"** and **"Structural Stability"** criteria specified for **detention vaults** in chapter 7.
12. Where pipes enter and leave the vault below the WQ design water surface, they shall be **sealed** using a non-porous, non-shrinking grout.
13. **Galvanized materials** shall be avoided whenever possible.

**F. Inlet and Outlet**

1. The **inlet** to the wetvault shall be submerged with the inlet pipe invert a minimum of 3 feet from the vault bottom (not including sediment storage). The top of the inlet pipe shall be submerged at least 1 foot. *Note: These dimensional requirements may increase the minimum 4 foot depth of the first cell, depending on the size of the inlet pipe.*

**Intent:** The submerged inlet is to dissipate energy of the incoming flow. The distance from the bottom is to minimize resuspension of settled sediments. Alternative inlet designs that accomplish these objectives are acceptable.

2. 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.
3. The outlet pipe shall be back-sloped or have tee section, the lower arm of which shall extend 1 foot below the WQ design water surface to provide for trapping of oils and floatables in the vault.
4. A **gravity drain** for maintenance shall be provided if grade allows.
    a. The gravity drain should be as low as the ***site*** situation allows; however, the **invert** shall be no lower than the average sediment storage depth. At a minimum, the invert shall be 6 inches above the base elevation of the vault side walls.

**Intent:** This placement prevents highly sediment-laden water from escaping when the vault is drained for maintenance. A lower placement is allowed than for wetponds since the v-shaped vault bottom will capture and retain additional sediments.

b. The drain shall be 8 inches (minimum) diameter and shall be controlled by a valve. Use of a shear gate is allowed only at the inlet end of a pipe located within an approved structure.

**Intent:** Shear gates often leak if water pressure pushes on the side of the gate opposite the seal. The gate should be situated so that water pressure pushes toward the seal.

b. Operational access to the valve shall be provided to the finished ground surface. The valve location shall be accessible and well marked with one foot of paving placed around the box. It must also be protected from damage and unauthorized operation.

c. If not located in the vault, a valve box is allowed to a maximum depth of 5 feet without an access manhole. If over 5 feet deep, an access manhole is required.

### G. Access Requirements

Same as for detention vaults (see Chapter 7). Note: If the 5-foot by 10-foot removable maintenance access also provides inlet/outlet access, then a 3-foot by 3-foot inspection port must be provided at the inlet pipe and outlet structure.

### H. Ventilation Requirements

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% of the total surface area shall be grated. This requirement may be met by one grate or by many smaller grates distributed over the second cell area. If the vault is a single cell, ventilation shall be provided over the second half of the vault. *Note: a grated access door may be used to meet this requirement.*

**Intent:** The grate allows air contact with the wetpool in order to minimize stagnant conditions that can result in oxygen depletion, especially in warm weather.

### I. Access Roads, Right of Way, and Setbacks

Same as for detention vaults (see chapter 7).

### J. Recommended Design Features

The following design features should be incorporated into wetvaults where feasible, but they are not specifically required:

1. The floor of the second cell should slope toward the outlet for ease of cleaning.
2. The **inlet and outlet** should be at opposing corners of the vault to increase the flowpath.
3. A **flow length-to-width** ratio greater than 3:1 minimum is desirable.
4. **Lockable grates** instead of solid manhole covers are recommended to increase air contact with the wetpool.
5. The **number of inlets** to the wetvault should be limited, and the flowpath length should be maximized from inlet to outlet for all inlets to the vault.

### K. Construction Considerations

Sediment that has accumulated in the vault must be removed after construction in the drainage area is complete. If no more than 12 inches of sediment have accumulated after the infrastructure is built, cleaning may be left until after building construction is complete. In general, sediment accumulation from stabilized drainage areas is not expected to exceed an average of 4 inches per year in the first cell. If sediment accumulation is greater than this amount, it will be assumed to be from construction unless it can be shown otherwise. The County will not release maintenance and defect financial guarantees or assume maintenance responsibility for a facility unless it has been cleaned of construction phase sediments.

### L. Modifications for Combining with a Baffle Oil/Water Separator

If the ***project site*** is a ***high-use site*** and a wetvault is proposed to meet the Basic treatment performance goal, the vault may be combined with a baffle oil/water separator. Structural modifications and added design criteria are given below. However, the maintenance requirements for baffle oil/water separators must be adhered to, in addition to those for a wetvault. This will result in more frequent inspection and cleaning than for a wetvault used only for TSS removal.

1. The sizing procedures for the baffle oil/water separator should be run as a check to ensure the vault is large enough. If the oil/water separator sizing procedures result in a larger vault size, increase the wetvault size to match.
2. An **oil retaining baffle** shall be provided in the second cell near the vault outlet. The baffle should not contain a high-flow overflow, or else the retained oil will be washed out of the vault during large storms.
3. The vault shall have a minimum **length-to-width ratio** of 5:1.

4. The vault shall have a design water **depth-to-width** ratio of between 1:3 to 1:2.
5. The vault shall be **watertight** and shall be coated to protect from corrosion.
6. Separator vaults shall have a **shutoff mechanism** on the outlet pipe to prevent oil discharges during maintenance and to provide emergency shut-off capability in case of a spill. A valve box and riser shall also be provided.
7. Wetvaults used as oil/water separators must be **off-line** and must bypass flows greater than the WQ design flow.

**Intent:** This design minimizes the entrainment and/or emulsification of previously captured oil during very high flow events.

### 6.11.3 Stormwater Treatment Wetlands BMP 6.43

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 6.15.

Wetlands created to mitigate disturbance impacts, such as filling, shall 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 the sediment will concentrate pollutants. 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 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, which bind to humic or organic acids.

#### A. 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**.

## B. Methods of Analysis

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.

### 1. Basic Treatment and Enhanced Treatment

Stormwater wetlands designed and constructed using the criteria below are expected to meet the Basic Treatment performance goal of 80% TSS removal and the Enhanced Treatment WQ performance goal.

**Steps 1 through 5: Determine the volume of a wetpond**. Follow Steps 1 through 5 for wetponds (see Section 6.11.1). 75% of the volume of a basic wetpond is used as a template for sizing the stormwater wetland.

**Step 6: Calculate the surface area of the stormwater wetland.** Calculate the surface area of the stormwater wetland by using the volume from Step 5 and dividing by the average water depth (use 1.5 feet).

**Step 7: 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 cell 1.

**Step 8: Determine the surface area of the wetland cell.** Subtract the surface area of the first cell
(Step 7) from the total surface area (Step 6).

**Step 9: 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 a wetpond. 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 ***project site*** so as not to discourage use of this option.

**Step 10: Choose plants.** See Table 6.9 for a list of plants recommended for wetpond water depth zones, or consult a wetland scientist.

### 2. Phosphorus Treatment

Stormwater wetlands designed and constructed using the criteria below are expected to meet Phosphorus Treatment WQ menu goal.

*(**Note**: this BMP must be preceded by a basic treatment BMP if the resulting size is smaller than that required for basic treatment)*

**Step 1: Calculate the surface area of the stormwater wetland.**

$$A = \frac{0.3Q\,C_o}{L_p} \qquad \textbf{Equation 6-7}$$

Where:

- A = surface area of the wetland in square feet
- The factor 0.3 represents the combined ratio of unit conversion factors (28.3 liters/ft3; 10.76 ft2/m2 and 1000 mg/gm)
- $C_o$ = influent dissolved phosphorus concentration in mg/L (assume 0.050 mg/L if no site specific data)
- $L_p$ = design loading of 0.5 gm/m2/year
- Q = water quality flow rate per section 6.0

### 3. Design criteria

Typical details for a **stormwater wetland** are shown in Figure 6.15.

### 4. Wetland Geometry

a. Stormwater wetlands shall consist of two cells, a presettling forebay cell and a wetland cell. The 1st cell may be replaced by a pretreatment device designed per section 6.7.4.The **presettling cell** shall contain a volume equal 20 percent of the wetpool volume calculated in Step 5 of "Methods of Analysis," (Presettling cells are not required for phosphorus treatment wetlands preceded by a basic treatment BMP)

b. The **depth of the presettling cell** shall be between 4 feet (minimum) and 8 feet (maximum).

c. One foot of **sediment storage** shall be provided in the presettling cell.

d. The **wetland cell** shall have an average **water depth** of about 1.5 feet (plus or minus 3 inches).

e. 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 6.15). Alternatively, the second cell may be graded naturalistically from the top of the dividing berm (see Criterion 8 below).

f. 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. Correspondingly, the **side slopes** of the berm must meet the following criteria:

   1) If the top of berm is at the WQ design water surface, the berm side slopes shall be no steeper than 3H:1V.

2) If the top of berm is submerged 1 foot, the upstream side slope may be up to 2H:1V.[10]

g. Two options (A and B) are provided for **grading the bottom of the wetland cell**. Option A is a shallow, evenly graded slope from the upstream to the downstream edge of the wetland cell (see Figure 6.16). Option B is a "naturalistic" alternative, with the specified range of depths intermixed throughout the second cell (see Figure 6.17). 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 6.9 below). The maximum depth is 2.5 feet in either configuration.

**5. Lining Requirements**

**a. In infiltrative soils**, both cells of the stormwater wetland shall be lined. To determine whether a low-permeability liner or a treatment liner is required, determine whether the following conditions will be met. If soil permeability will allow sufficient water retention, lining may be waived.

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.

3) The complete precipitation record should be used when establishing these conditions.

**Intent:** Many wetland plants can adapt to periods of summer drought, so a limited drought period is allowed in the second cell. This may allow a treatment liner rather than a low permeability liner to be used for the second cell. The first cell must retain water year-round in order for the presettling function to be effective.

b. 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.

c. For **geomembrane liners**, a soil depth of 3 feet is recommended to prevent damage to the liner during planting. Hydric soils are not required.

**<u>NOTE:</u> Bioretention Filter Media can be used for this soil requirement**

d. The criteria for liners given in Section 6.3 must be observed.

**6. Inlet and Outlet**

Same as for wetponds but with the added requirement that spill control be provided as detailed in Section 6.12 prior to discharge of runoff

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[10] If the berm is at the water surface, then for safety reasons, its slope must be no greater than 3:1, just as the pond banks must be 3:1 if the pond is not fenced. A steeper slope (2:1 rather than 3:1) is allowed if the berm is submerged in 1 foot of water. If submerged, the berm it is not considered accessible, and the steeper slope is allowed.

from non-roof-top ***pollution generating impervious surface*** into the stormwater wetland.

7. **Access and Setbacks**
   a. Location of the stormwater wetland relative to ***site*** constraints (e.g., buildings, property lines, etc.) shall be the same as for detention ponds (see Chapter 7).
   b. Access and maintenance **roads** shall be provided and designed according to the requirements for detention ponds (see chapter 7). Access and maintenance roads shall extend to both the wetland inlet and outlet structures. An access ramp (7H minimum:1V) shall be provided to the bottom of the first cell unless all portions of the cell can be reached and sediment loaded from the top of the wetland side slopes. Also see "Access Requirements" in chapter 7, for more information on access alternatives.
   c. If the dividing berm is also used for access, it must be built to sustain loads of up to 80,000 pounds.
8. **Signage**
   a. General signage shall be provided according to the requirements for detention ponds (see chapter 7).
9. **Planting Requirements**
   a. The wetland cell shall be planted with emergent wetland plants following the recommendations given in Table 6.9 or the recommendations of a wetland specialist. *Note: Cattails (Typha latifolia) are not allowed. 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.*
   b. If the stormwater wetland is used for phosphorus treatment, shrubs that form a dense cover shall be planted on slopes above the WQ design water surface on at least three sides of the presettling cell. 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.[11] 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.

### 6.11.4 Combined Detention and Wetpool Facilities

Combined detention and WQ wetpool facilities have the appearance of a detention facility but contain a permanent pool of water as well. The

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[11] Waterfowl are believed to limit use of areas where their view of predator approach paths is blocked. Some suitable native shrubs include vine maple, Indian plum, bitter cherry, red osier dogwood, cascara, and red elderberry. Ornamental hedge plants such as English laurel, privet and barberry are also good choices.

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' Detention/wetvault; and Detention/stormwater wetland.

## A. 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.[12] 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.

## B. Methods of Analysis

### 1. Combined Detention and Wetpond

The methods of analysis for combined detention and wetponds are identical to those outlined for wetponds and for detention facilities. Follow the procedure specified in Section 6.11.1 to determine the wetpool volume for a combined facility. Follow the standard procedure specified in Chapter 7 to size the detention portion of the pond.

### 2. Combined Detention and Wetvault

The methods of analysis for combined detention and wetvaults are identical to those outlined for wetvaults and for detention facilities. Follow the procedure specified in Section 6.11.2 to determine the wetvault volume for a combined facility. Follow the standard procedure specified in Chapter 7 to size the detention portion of the vault.

### 3. Combined Detention and Stormwater Wetland

The methods of analysis for combined detention and stormwater wetlands are identical to those outlined for stormwater wetlands and for detention facilities. Follow the procedure specified in Section 6.11.3 to determine the stormwater wetland size. Follow

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[12] Many of the ponds studied in the Nationwide Urban Runoff Program were combined ponds.

the standard procedure specified in Chapter 7 to size the detention portion of the wetland.

## C. Design Criteria

### 1. Combined Detention and Wetpond

The **detention portion** of the facility shall meet the design criteria set forth in Chapter 7.

### 2. Detention and Wetpool Geometry

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

The **"1. Wetpool** Geometry**"** criteria for wetponds shall apply with the following **modifications/clarifications:**

**a. 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.***

**b. 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 sediment storage requirement.

**c. Berms, Baffles, and Slopes**

Same as for wetponds.

**d. Inlet and Outlet**

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

**(1) Criterion 3:** A **sump** must be provided in the outlet structure of combined ponds.

**(2)** f. The detention flow restrictor and its outlet pipe shall be designed according to the requirements for detention ponds.

### 3. Access and Setbacks

Same as for wetponds.

4. Signage

Signage shall be provided according to the requirements for detention ponds (see chapter 7).

### 5. Planting Requirements

Same as for wetponds.

### 6.11.5 Combined Detention and Wetvault

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

B. 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 sediment storage requirement.

C. 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 shall not be modified to function as a baffle oil/water separator as allowed for wetvaults. This is because the added pool fluctuation in the combined vault does not allow for the quiescent conditions needed for oil separation.***

### 6.11.6 Combined Detention and Stormwater Wetland

The design criteria for detention ponds and stormwater wetlands must both be met, except for the following **modifications or clarifications:**

A. The **"Wetland Geometry"** criteria for stormwater wetlands are modified as follows:

1. **Criterion 4:** 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 sediment storage requirement.

**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.

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

**2. Criterion 2:** A **sump** must be provided in the outlet structure of combined facilities.

a. The detention **flow restrictor** and its outlet pipe shall be designed according to the requirements for detention pond.

B. 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' depthT |

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

C. **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 [illegible] survive in the facility. It is **not intended** to protect native wetland plant communities and is **not to be applied to natural wetlands**.

## 6.12 OIL WATER SEPARATORS

### 6.12.1 Performance Objectives

Oil and water separators shall 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

Oil/water separators rely on passive mechanisms that take advantage of oil being lighter than water. Oil rises to the surface and can be periodically removed. The two types of oil/water separators typically used for stormwater treatment are the baffle type or API (American Petroleum Institute) oil/water separator and the coalescing plate oil/water separator.

***BMP 6.51 Baffle oil/water separators*** use vaults that have multiple cells separated by baffles extending down from the top of the vault (see Figure 6.24 for schematic details). The baffles block oil flow out of the vault. Baffles are also commonly installed at the bottom of the vault to trap solids and sludge that accumulate over time. In many situations, simple floating or more sophisticated mechanical oil skimmers are installed to remove the oil once it has separated from the water.

***BMP 6.52 Coalescing plate separators*** are typically manufactured units consisting of a baffled vault containing several inclined corrugated plates stacked and bundled together (see Figure 6.25 for schematic details). The plates are equally spaced (typical plate spacing ranges from $^1/_4$-inch to 1 inch) and are made of a variety of materials, the most common being fiberglass and polypropylene. Efficient separation results because the plates reduce the vertical distance oil droplets must rise in order to separate from the stormwater. Once they reach the plate, oil droplets form a film on the plate surface. The film builds up over time until it becomes thick enough to migrate upward under the influence of gravity along the inclined plate. When the film reaches the edge of the plate, oil is released as large droplets which rise rapidly to the surface, where the oil accumulates until the unit is maintained. Because the plate pack increases treatment effectiveness significantly, coalescing plate separators can achieve a specified treatment level with a smaller vault size than a simple baffle separator.

Oil/water separators are meant to treat stormwater runoff from more intensive land uses, such as high-use sites, and facilities that produce relatively high concentrations of oil and grease. Although baffle separators historically have been used to remove larger oil droplets (150 microns or larger), they may also be sized to remove smaller oil droplets. Both separators may be used to meet a **performance goal of 10 to 15 mg/L** by designing the unit to removal oil particles 60 microns and larger.

### 6.12.2 Applications and Limitations

Oil/water separators are designed to remove free oil and are not generally effective in separating oil that has become either chemically or mechanically emulsified and dissolved in water. Therefore, it **is desirable for separators be installed upstream of facilities and conveyance structures that introduce turbulence and consequently promote emulsification**. Emulsification of oil can also result if surfactants or detergents are used to wash parking areas that drain to the separator. Detergents shall not be used to clean parking areas unless the wash water is collected and disposed of properly (usually to the sanitary sewer).

Oil/water separators are **best located in areas where the tributary drainage area is nearly all impervious, and a fairly high load of petroleum hydrocarbons is likely to be generated**. Oil/water separators are not recommended for areas with very dilute concentrations of petroleum hydrocarbons since their performance is not effective at low concentrations. Excluding unpaved areas helps to minimize the amount of sediment entering the vault, reducing the need for maintenance. A unit that fails and ceases to function can release previously trapped oil to the downstream receiving water, both in release from the oily sediments and from entrainment of surface oils.

Wetvaults may also be modified to function as baffle oil/water separators (see design criteria for wetvaults, Section 6.11.2).

### 6.12.3 Methods of Analysis

#### A. Background

Generally speaking, in most oil and water mixtures the degree of oil/water separation that occurs is dependent on both the time the water is detained in the separator and the oil droplet size. The sizing methods in this section are based on Stokes' law:

$$V_T = \frac{g\left(d_p - d_c\right)D_o^2}{18\mu} \tag{6-8}$$

where $V_T$ = rise velocity of oil droplet
$g$ = gravitational constant

$d_p$ = density of droplet to be removed
$d_c$ = density of carrier fluid
$D_o$ = diameter of oil droplet
$\mu$ = absolute viscosity of carrier fluid

B. The basic assumptions inherent in Stokes' law are: (1) flow is laminar, and (2) the oil droplets are spherical.

Traditional baffle separators are designed to provide sufficient hydraulic residence time to permit oil droplets to rise to the surface. The residence time $T_r$ is mathematically expressed as follows:

$$T_r = \frac{V}{Q} \tag{6-9}$$

where $V$ = effective volume of the unit or container, or $A_s \times H$, where
$A_s$ = surface area of the separator unit, and
$H$ = height of water column in the unit

$Q$ = hydraulic capacity or flow through the separator

The time required for the oil droplet to rise to the surface within the unit is found by the relation:

$$T_T = \frac{H}{V_T} \tag{6-10}$$

where $V_T$ = rise velocity of the oil droplet

The oil droplet rises to the water surface if the residence time in the separator is at least equal to the oil droplet rise time. This can be expressed as follows:

$$T_r = T_T$$

By substituting terms and simplifying:

$$V_T = \frac{Q}{A_s} \tag{6-11}$$

where $A_s$ = surface area of the separator unit

The ratio in Equation (6-11) is designated as the surface overflow rate or loading rate. It is this rate that governs the removal efficiency of the process and predicts whether an oil droplet will be removed by the separator.

### 6.12.4 Method for Baffle Separators

Design steps for the baffle separator are summarized below:

**Step 1: Determine the WQ design flow (*Q*).** The facility is sized based on the WQ design flow (see Section 6.0). The separator **must be designed as an off-line facility**. That is, flows higher than the WQ design flow must bypass the separator.

**Step 2: Calculate the minimum vertical cross-sectional area.** Use the following equation:

$$A_c = \frac{Q}{V_H} \qquad (6\text{-}12)$$

where $A_c$ = minimum cross-sectional area (sf)
$Q$ = water quality design flow (cfs)
$V_H$ = design horizontal velocity (fps)

Set the horizontal velocity $V_H$ equal to 15 times the oil droplet's rise rate $V_T$. A **design rise rate of 0.038 feet per minute shall be used** unless it is demonstrated that conditions of the influent or performance function warrant the use of an alternative value. This value corresponds to 4 degrees Centigrade..

**Step 3: Calculate the width and depth of the vault.** Use the following equation:

$$D = \frac{A_c}{W} \qquad (6\text{-}13)$$

where $D$ = maximum depth (ft)
$W$ = width of vault (ft)
and where $A_c$ is from Step 2 above.

The computed depth $D$ must meet a depth-to-width ratio $r$ of between 0.3 and 0.5 (i.e., $0.3 \le D/W \le 0.5$).

*Note:* $D = (r A_c)^{0.5}$ and
$W = D/r$ and
$r$ = the depth-to-width ratio

**Step 4: Calculate the length of the vault.** Use the following equation:

$$L = FD\left(\frac{V_H}{V_T}\right) \qquad (6\text{-}14)$$

where $L$ = length of vault (ft)
$F$ = turbulence and short-circuiting factor (unitless, see Figure 6.22)
$V_H$ = horizontal velocity (ft/min)
$V_T$ = oil droplet rise rate (ft/min)
$D$ = depth (ft)

The turbulence factor $F$ shall be selected using a $V_H/V_T$ ratio of 15, so $F = 1.64$.

Therefore Equation (6-14) becomes: $L = 1.65 \times 15 \times D$

**Step 5: Check the separator's length-to-width ratio.** The length $L$ of the vault must be at least 5 times its width in order to minimize effects from inlet and outlet disturbances. The length of the forebay shall be approximately $L/3$.

**Step 6: Compute and check that the minimum horizontal surface area (*$A_H$*) criterion is satisfied.** This criterion is expressed by the following equation:

$$A_H = \left(\frac{1.65Q}{0.00055}\right) \leq LW \tag{6-15}$$

**Step 7: Compute and check that the horizontal surface area of the vault forebay.** This area should be 20% of the total volume.

**Step 8: Design the flow splitter and high-flow bypass.** See Chapter 4 for information on flow splitter design.

### 6.12.5 Method for Coalescing Plate Separators

Coalescing plate separators are designed using the same basic principles as baffle separators. The major difference is that in the baffle separator, horizontal separation is related only to water surface area, while in the coalescing plate separator, horizontal separation is related to the sum of the plan-areas of the plates. The treatment area is increased by the sum of the horizontal projections of the plates being added, and is referred to as the plate *effective separation area*.

The basic procedure for designing a coalescing plate separator is to determine the effective separation area required for a given design flow. The specific vault sizing then depends on the manufacturer's plate design. The specific design, analysis, configuration, and specifications for coalescing plates are empirically based and variable. Manufacturers' recommendations may be used to vary the recommendations given below.

**Step 1: Determine the WQ design flow.** The coalescing plate oil/water separator must be sized based on the WQ design flow (see section 6.0). The separator **must be designed as an off-line facility**; flows higher than the WQ design flow must bypass the separator.

**Step 2: Calculate the plate minimum effective separation area (*$A_h$*).** $A_h$ is found using the following equation:

$$A_h = \frac{60Q}{0.00386\left(\dfrac{S_w - S_o}{\mu}\right)} \qquad (6\text{-}16)$$

where $S_w$ = specific gravity of water = 1.0
$S_o$ = specific gravity of oil = 0.85
$\mu$ = absolute viscosity of water (poises); use 0.015674 for temp = $39^{o}$ F
$Q$ = water quality design flow rate (cfs)
$A_h$ = required effective (horizontal) surface area of plate media (sf).

Equation (6-16) is based on an oil droplet diameter of 60 microns. A graphical relation of Equation (6-16) is shown in **Error! Reference source not found.**. This graph may be used to determine the required effective separation surface area of the plate media.

**Step 3: Calculate the collective projected surface area (*$A_p$*).** A key design step needed to assure adequate performance of the separator unit is to convert the physical plate area (the surface area of the plates if laid flat) into the effective (horizontal) separation surface area $A_h$ (calculated in step 2). The effective separation surface area $A_h$ is based on the collective projected horizontal surface area $A_p$ of the plates where the plates are inclined, rather than their laid flat.

$$A_h = A_p = A_a (\cos H) \qquad (6\text{-}17)$$

where $A_a$ = actual collective plate area of the plate configuration (sf)
$H$ = angle of the plates to the horizontal (degree)

This equation is represented graphically in **Error! Reference source not found.**. The designer shall make sure that the manufacturer sizes the oil/water separator using the projected surface area rather than the actual plate area. *Note: For this method, only the* ***lower plate surface*** *may be counted as effective separation surface, regardless of manufacturer's claims.*

**Step 4: Check with specific separator manufacturers.** Check with specific manufacturers to choose a separator that provides the required actual collective plate area calculated in Step 3, and meets the other design criteria given in the next section. The specific vault design will depend upon each manufacturer's design. The geometric configuration and dimensions of the plate pack as well as the vault design are variable and flexible depending on each manufacturer's product.

Table 6.11 provides approximate vault sizes for rough planning purposes. In reality, various manufacturers have quite different designs, both for the plate packs themselves as well as for forebay and afterbays. In addition, standard pre-cast vault dimensions vary with each manufacturer. These various factors can greatly affect the volume of vault needed to provide a given effective separation area. The numbers in Table 6.11 should, then, be considered "order of magnitude" estimates only.

### 6.12.6. Design Criteria

Details for a typical baffle oil/water separator are shown in **Error! Reference source not found.**). **Other designs** and configurations of separator units and vaults are allowed, including above ground units. However, they must produce equivalent treatment results and treat equivalent flows as conventional units.

**1. General Siting**

- a. Oil/water separators **must be installed off-line**, bypassing flows greater than the WQ design flow.
- b. When a separator is required, it **shall precede other water quality treatment facilities** (except wetvaults). It may be positioned either upstream or downstream from flow control facilities, since there are both advantages and disadvantages with either placement.
- c. In moderately pervious soils where **seasonal groundwater** may induce flotation, buoyancy tendencies shall be balanced by ballasting or other methods as appropriate.
- d. Any **pumping devices** shall be installed downstream of the separator to prevent oil emulsification in stormwater.

2. **Vault Structure — General**

   The following criteria apply to both baffle and coalescing plate separators:

   a. Separator vaults shall be **watertight**. Where pipes enter and leave a vault below the WQ design water surface, they shall be sealed using a non-porous, non-shrinking grout.

   b. Separator vaults shall have a **shutoff mechanism** on the outlet pipe to prevent oil discharges during maintenance and to provide emergency shut-off capability in case of a spill. A valve box and riser shall also be provided according to the design criteria for wetponds (see "Inlet and Outlet Criteria section 6.11.1).

3. **Vault Structure — Baffle Separators**

   In addition to the above general criteria, the following criteria apply specifically to baffle separators:

   a. Baffle separators shall be divided into **three compartments**: a forebay, an oil separation cell, and an afterbay. The **forebay** is primarily to trap and collect sediments, encourage plug flow, and reduce turbulence. The **oil separation cell** traps and holds oil as it rises from the water column, and it serves as a secondary sediment collection area. The **afterbay** provides a relatively oil-free cell before the outlet, and it provides a secondary oil separation area and holds oil entrained by high flows.

   b. The **length of the forebay** shall be at least 20% of the volume of the separator.

   c. A **removable flow-spreading baffle**, extending from the surface to a depth of up to $^1/_2$ the vault depth ($D$) is required to spread flows.

   d. The **removable bottom baffle** (sediment-retaining baffle) shall be a minimum of 24 inches (see **Error! Reference source not found.**), and located at least 1 foot from the oil-retaining baffle. A "window wall" baffle may be used, but the area of the window opening must be at least three times greater than the area of the inflow pipe.

   e. A **removable oil retaining baffle** shall be provided and located approximately $^1/_4\ L$ from the outlet wall or a minimum of 8 feet, whichever is greater (the 8-foot minimum is for maintenance purposes). The oil-retaining baffle shall extend from the elevation of the water surface to a depth of at least 50% of the design water depth. Various configurations are possible, but the baffle shall be designed to minimize turbulence and entrainment of sediment.

   f. Baffles may be fixed rather than removable if additional entry ports and ladders are provided so that both sides of the baffle are accessible by maintenance crews.

   g. Baffle separator vaults shall have a minimum **length-to-width ratio** of 5.

   h. The **design water depth** ($D$) shall be no deeper than 8 feet unless approved by DDES.

   i. Baffle separator vaults shall have a **design water depth-to-width** ratio of between 0.3 and 0.5.

## 4. Vault Structure — Coalescing Plate Separators

In addition to the above general criteria, the following criteria apply specifically to coalescing plate separators:

a. Coalescing plate separators shall be divided by baffles or berms into **three compartments**: a forebay, an oil separation cell which houses the plate pack, and an afterbay. The **forebay** controls turbulence and traps and collects debris. The **oil separation cell** captures and holds oil. The **afterbay** provides a relatively oil-free exit cell before the outlet.

b. The **length of the forebay** shall be 20% of the volume of the separator. In lieu of an attached forebay, a separate grit chamber, sized to provide be 20% of the volume of the total volume of separator + grit chamber, may precede the oil/water separator.

### 5. Material Requirements

a. All **metal parts shall be corrosion-resistant**. Zinc and galvanized materials are to be avoided when substitutes are available because of aquatic toxicity potential. Painting metal parts for corrosion resistance is An **oil-retaining baffle** shall be provided. If maintained by the County, the baffle must be a minimum of 8 feet from the outlet wall (for maintenance purposes). For large units, a baffle position of 0.25*L* from the outlet wall is recommended. The oil-retaining baffle shall extend from the water surface to a depth of at least 50% of the design water depth. Various configurations are possible, but the baffle shall be designed to minimize turbulence and entrainment of sediment.

b. A bottom **sediment-retaining baffle** shall be provided upstream of the plate pack. The minimum height of the sludge-retaining baffle shall be 18 inches. Window walls may be used, but the window opening must be a minimum of three times greater than the area of the inflow pipe.

c. It is recommended that entire space between the sides of the plate pack and the vault wall be filled with a solid but light-weight removable material such as a **plastic or polyethylene foam** to reduce short-circuiting around the plate pack. Rubber flaps are not effective for this purpose.

d. If a separator will be maintained by King County, the **separator plates** shall meet the following requirements:

   1) Plates shall be inclined at 45° to 60° from the horizontal. This range of angles exceeds the angle of repose of many solids and therefore provides more effective droplet separation while minimizing the accumulation of solids on the individual plates.
   2) Plates shall have a minimum plate spacing of $^1/_2$-inch and have corrugations.
   3) Plates shall be securely bundled in a plate pack so that they can be removed as a unit.
   4) The plate pack shall be a minimum of 6 inches from the vault bottom.

5) There should be 1 foot of head space between the top of the plate pack and the bottom of the vault cover.

**6. Inlet and Outlet**

a. The **inlet shall be submerged**. A tee section may be used to submerge the incoming flow and must be at least 2 feet from the bottom of the tank and extend above the WQ design water surface.

**Intent:** The submerged inlet is to dissipate energy of the incoming flow. The distance from the bottom is to minimize resuspension of settled sediments. Extending the tee to the surface allows air to escape the flow, thus reducing turbulence. Alternative inlet designs that accomplish these objectives are acceptable.

a. The **vault outlet pipe** shall be sized to pass the WQ design flow before overflow (using the pipe sizing methods in Chapter 4). The vault outlet pipe shall be back-sloped or have a tee extending
1 foot above and below the WQ design water surface to provide for secondary trapping of oils and floatables in the wetvault. *Note: The invert of the outlet pipe sets the **WQ design water surface** elevation.*

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**b. Vault baffles** shall be concrete, stainless steel, fiberglass reinforced plastic, or other acceptable material and shall be securely fastened to the vault.

**c. Gate valves**, if used, shall be designed for seating and unseating heads appropriate for the design conditions.

d. For coalescing plate separators, **plate packs** shall be made of fiberglass, stainless steel or polypropylene.

**7. Access Requirements**

Same as for **detention vaults** (see chapter 7) except for the following **modifications:**

a. Access to **each compartment** is required. If the length or width of any compartment exceeds 50 feet, an additional access point for each 50 feet is required.

b. Access points for the **forebay and afterbay** shall be positioned partially over the inlet or outlet tee to allow visual inspection as well as physical access to the bottom of the vault.

c. For **coalescing plate separators**, the following also apply:

d. Access to the **compartment containing the plate pack** shall be a removable panel or other access able to be opened wide enough to remove the entire coalescing plate bundle from the cell for cleaning or replacement. Doors or panels shall have stainless steel lifting eyes, and panels shall weigh no more than 5 tons per panel.

e. A **parking area or access pad** (25-foot by 15-foot minimum) shall be provided near the coalescing plate bundles to allow for their removal from the vault by a truck-mounted crane or backhoe, and to allow for extracting accumulated solids and oils from the vault using a vactor truck.

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

Same as for detention vaults (see chapter 7).

**9. Recommended Design Features**

a. A **gravity drain** for maintenance is recommended if grade allows. The drain invert should be at a depth equal to the depth of the oil retaining baffle. Deeper drains are encouraged where feasible.

b. The recommended design features for wetvaults should be applied.

c. If large amounts of oil are likely to be captured, a bleed-off pipe and separate waste oil tank may be located adjacent to the vault to channel separated oils into the tank. This improves the overall effectiveness of the facility, especially if maintenance is only annually. It also improves the quality of the waste oil recovered from the facility.

**10.Construction Considerations**

a. Construction of oil/water separators shall follow and conform to the manufacturer's recommended construction procedures and installation instructions as well as Chapter 7 of the *King County Road Standards*. Where the possibility of vault flotation exists, the vault shall be properly anchored in accordance with the manufacturer's recommendations or an engineer's design and recommendations.

b. Particular care must be taken when inserting coalescing plate packs in the vault so as not to damage or deform the plates.

c. Upon completion of installation, the oil/water separator shall be thoroughly cleaned and flushed prior to operating.

**11. Maintenance Considerations**

a. Oil/water separators must be cleaned regularly to ensure that accumulated oil does not escape from the separator. Separators should be cleaned by November 15 of each year to remove accumulation during the dry season. They must also be cleaned after spills of polluting substances such as oil, chemicals, or grease. Vaults must also be cleaned when inspection reveals any of the following conditions:

   1) Oil accumulation in the oil separation compartment equals or exceeds 1 inch, unless otherwise rated for greater oil accumulation depths recommended by the specific separator manufacturer.

   2) Sediment deposits in the bottom of the vaults equals or exceeds 6 inches in depth.

b. For the first several years, oil/water separators should be checked on a quarterly basis for proper functioning and to ensure that accumulations of oil, grease, and solids in the separator are at acceptable levels. Effluent from the vault shall also be observed for an oil sheen to ensure that oil concentrations are at acceptable levels and that expected treatment is occurring. Separators should also be inspected after large storm events (about 2 inches in 24 hours).

c. Access to separators shall be maintained free of all obstructions, and units shall be readily accessible at all times for inspection and maintenance.

d. Maintenance personnel entering oil/water separator vaults should follow the state regulations pertaining to confined space entry, if applicable.

## 6.13 EMERGING TECHNOLOGIES

Emerging Technologies are any device designed to meet one or more of the treatment levels of this chapter (Basic, Oil, Phosphorus or Enhanced) that are not explicitly allowed in this chapter.

Emerging Technologies that receive a use designation of general or conditional from Ecology use may be used with the concurrence of Kitsap County to satisfy the applicable treatment menu within this chapter.

Emerging Technologies that receive a use designation of Pilot from Ecology may only be used if approved by Kitsap County and Ecology.

Project proponents are encouraged to contact Kitsap County prior to submitting their design to discuss any proposed use of an emerging technology.