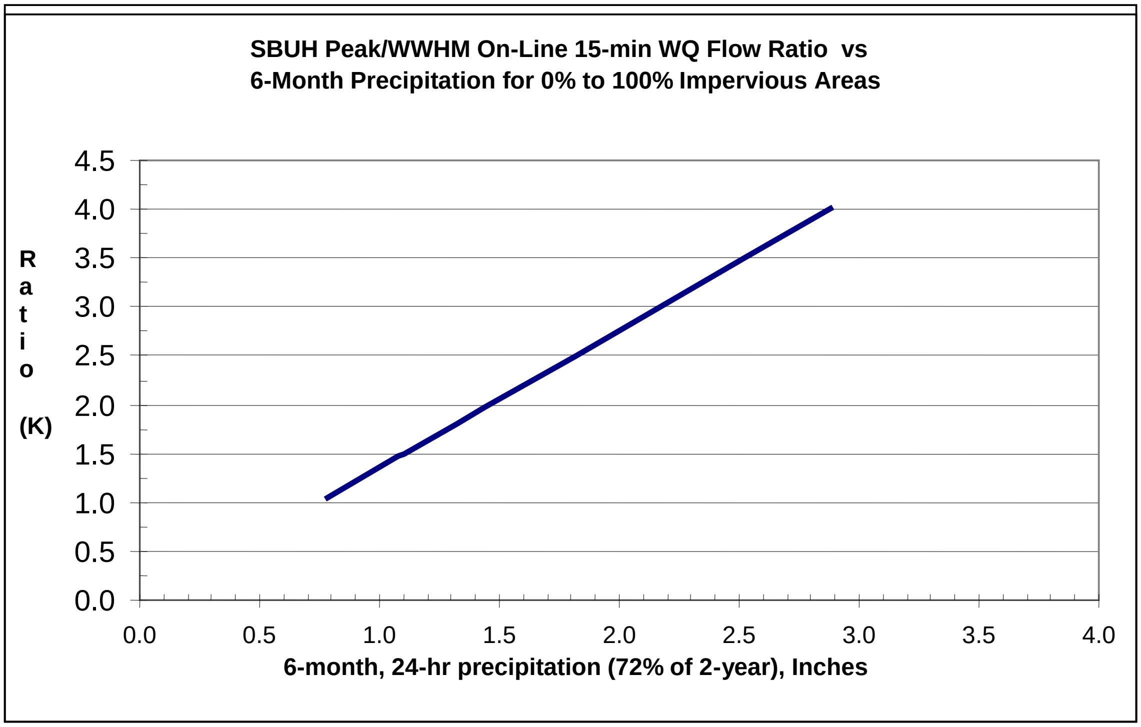



**Figure 5.17 – Ratio of SBUH Peak/WQ Flow**

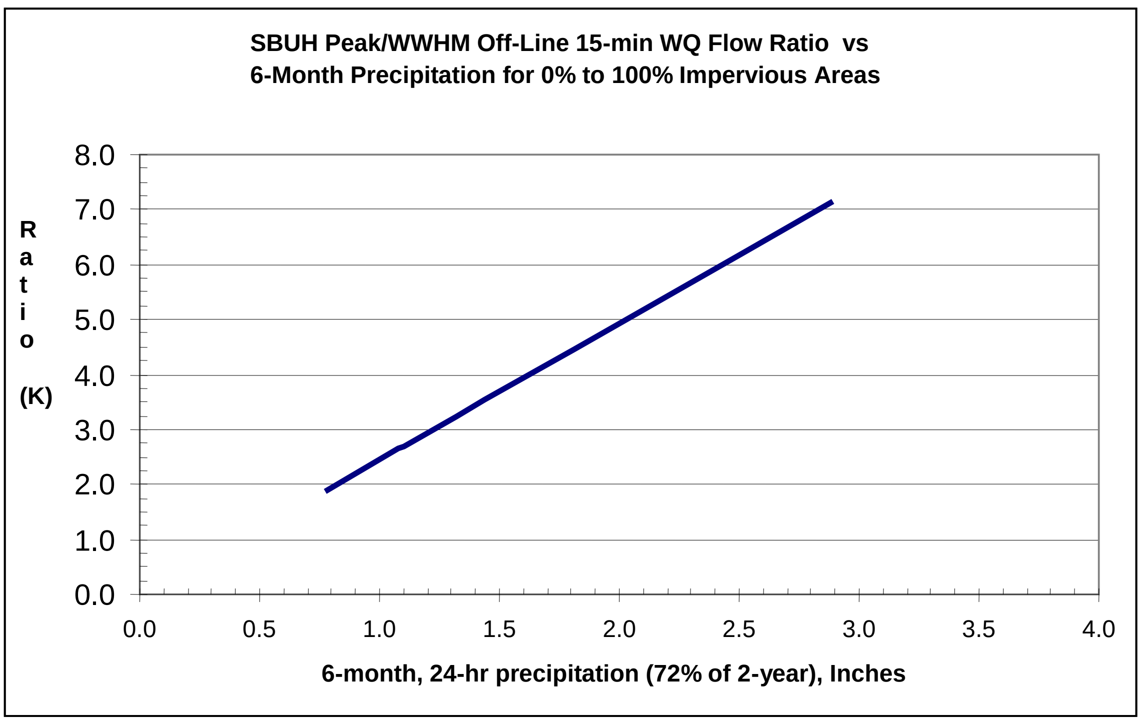



**Figure 5.18 – Ratio of SBUH Peak/WQ Flow**

4) Reduce the developed surface area to gain space for biofiltration.
5) Increase the longitudinal slope.

6) Increase the side slopes.

7) Nest the biofilter within or around another BMP.

***Check for Stability (Minimizing Erosion)***

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

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

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

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

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

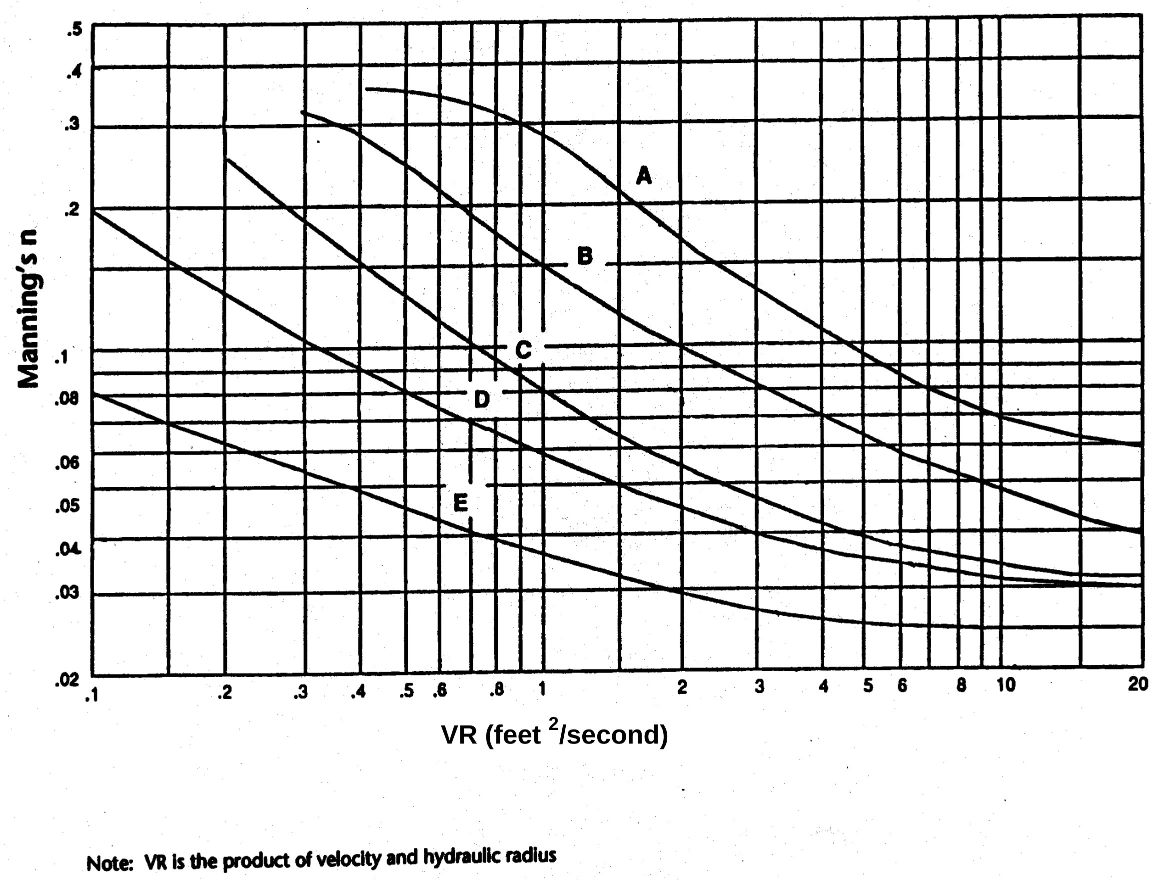
***Stability Check Steps (SC)***

**Table 5.6 – Guide for Selecting Degree of Retardance [(a)]**

| Coverage | Average Grass Height (inches) | Degree of Retardance |
|---|---|---|
| **Good** | <2 | E. Very Low |
| | 2-6 | D. Low |
| | 6-10 | C. Moderate |
| | 11-24 | B. High |
| | >30 | A. Very High |
| **Fair** | <2 | E. Very Low |
| | 2-6 | D. Low |
| | 6-10 | D. Low |
| | 11-24 | C. Moderate |
| | >30 | B. High |

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

**SC-4.** Select a trial Manning's n for the high flow condition. The minimum value for poor vegetation cover and low height (possibly, knocked from the vertical by high flow) is 0.033. A good initial choice under these conditions is 0.04.




Source: Livingston, et al, 1984

**Figure 5.19 – Relationship of Manning's n with VR for Various Degrees of Flow Retardance**

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

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

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

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

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

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

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

**SC-11**. Compare the A, computed in step SC-10 of the stability analysis, with the A from the biofiltration capacity analysis (step D-5).

If less area is required for stability than is provided for capacity, the capacity design is acceptable.  If not, use A from step SC-10 of the stability analysis and recalculate channel dimensions.

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

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

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

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

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

***Completion Step (CO)***

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

### *Example of Design Calculations for Biofiltration Swales*

#### *Preliminary Steps*

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

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

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

#### *Design for Biofiltration Swale Capacity*

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

**D-2.** Use n = 0.20 to $n_2 = 0.30$

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

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

Where:

n = 0.20 y = 0.25 ft
Q = 0.2 cfs s = 0.02
Z = 3

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

$b \approx 4.0$ ft

At $n_2$; $b_2 = 6.5$ feet

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

T = b + 2yZ = 4.0+ [2(0.25)(3)] = 5.5 feet

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

$A = by + Zy^2 = (4.0)(0.25) + (3)(0.25^2) = 1.19$ ft²

**D-6.** Calculate the flow velocity (V)

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

for K = 1. Actual K is determined per Figure 5.17

$0.17 < 1.0$ ft/sec $\therefore$ OK

**D-7** Calculate the Length (L)

$L = Vt(60 \text{ sec/min})$

$= 0.17 (9)(60)$

For t = 9 min, L = 92 ft. at n; expand to a minimum of 100 foot length per design criterion

At $n_2$; L = 100 ft.

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

***Check for Channel Stability***

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

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

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

**SC-4.** Select trial Manning's n = 0.04

**SC-5**. From Figure 5.19, $VR_{appx} = 3 \text{ ft}^2/\text{s}$

**SC-6**. Calculate R

$$R = \frac{VR_{appx}}{V_{max}} = 1.0 \text{ ft}$$

**SC-7**. Calculate $VR_{actual}$

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

**SC-8.** $VR_{actual}$ from step SC-7 > $VR_{appx}$ from step SC-5 by > 5%.

Select new trial n = 0.0475

Figure 5.19: $VR_{appx} = 1.7 \text{ ft}^2/\text{s}$

$R = 0.57$ ft.

$VR_{actual} = 1.73\ ft^2/s$ (within 5% of $VR_{appx} = 1.7$)

**SC-9**. Calculate V

$$V = \frac{VR_{actual}}{R} = \frac{1.73}{0.57} = 3\ ft\ /\ sec$$

V = 3 ft/sec $\leq$ 3 ft/sec, Vmax $\therefore$ OK

**SC-10.** Calculate Stability Area

$$A_{Stability} = \frac{Q}{V} = \frac{1.92}{3} = 0.64\ ft^2$$

**SC-11**. Stability Check

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

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

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

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

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

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

Total channel depth = 0.75 ft

Top Width = b + 2yZ

= 4 + (2)(0.75)(3)

= 8.5 ft

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

For b = 4 ft, y = 0.75 ft

Z = 3, s = 0.02, n = 0.2

$A = by + Zy^2 = 4.68\ ft^2$

$R = \{by + Zy^2\}/\{b + 2y(Z^2 + 1)^{0.5}\} = 0.53$ ft.

**SC-15.** Calculate Flow Capacity at Greatest Resistance

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

Q = 3.2 cfs > 1.92 cfs $\therefore$ OK

Completion Step

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

The final channel dimensions are:

Bottom width, b = 4 feet
Channel depth= 0.75 feet
Top width = b + 2yZ = 8.5 feet

**No check dams are needed for a 2% slope.**

***Soil Criteria***

- The following top soil mix at least 8-inch deep:
  - Sandy loam 60-90 %
  - Clay 0-10 %
  - Composted organic matter, 10-30 % (excluding animal waste, toxics)
- Use compost amended soil where practicable
- Till to at least 8-inch depth
- For longitudinal slopes of < 2 percent use more sand to obtain more infiltration
- If ground water contamination is a concern, seal the bed with clay or a geomembrane liner

***Vegetation Criteria***

- See Tables 5.7, 5.8 and 5.9 for recommended grasses, wetland plants, and groundcovers.
- Select fine, turf-forming, water-resistant grasses where vegetative growth and moisture will be adequate for growth.
- Irrigate if moisture is insufficient during dry weather season.
- Use sod with low clay content and where needed to initiate adequate vegetative growth. Preferably sod should be laid to a minimum of one-foot vertical depth above the swale bottom.
- Consider sun/shade conditions for adequate vegetative growth and avoid prolonged shading of any portion not planted with shade tolerant vegetation.

- Stabilize soil areas upslope of the biofilter to prevent erosion
- Fertilizing a biofilter should be avoided if at all possible in any application where nutrient control is an objective. Test the soil for nitrogen, phosphorus, and potassium and consult with a landscape professional about the need for fertilizer in relation to soil nutrition and vegetation requirements. If use of a fertilizer cannot be avoided, use a slow-release fertilizer formulation in the least amount needed.

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

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

| Mix 1 | | Mix 2 | |
|---|---|---|---|
| 75-80 percent | tall or meadow fescue | 60-70 percent | tall fescue |
| 10-15 percent | seaside/colonial bentgrass | 10-15 percent | seaside/colonial bentgrass |
| 5-10 percent | Redtop | 10-15 percent | meadow foxtail |
| | | 6-10 percent | alsike clover |
| | | 1-5 percent | marshfield big trefoil |
| | | 1-6 percent | Redtop |

Note: *all percentages are by weight. * based on Briargreen, Inc.*

| Table 5.8 – Groundcovers And Grasses Suitable for the Upper Side Slopes of a Biofiltration Swale in Western Washington | |
|---|---|
| **Groundcovers** | |
| kinnikinnick* | *Arctostaphylos uva-ursi* |
| Epimedium | *Epimedium grandiflorum* |
| creeping forget-me-not | *Omphalodes verna* |
| -- | *Euonymus lanceolata* |
| yellow-root | *Xanthorhiza simplissima* |
| -- | *Genista* |
| white lawn clover | *Trifolium repens* |
| white sweet clover* | *Melilotus alba* |
| ------- | *Rubus calycinoides* |
| strawberry* | *Fragaria chiloensis* |
| broadleaf lupine* | *Lupinus latifolius* |
| **Grasses (drought-tolerant, minimum mowing)** | |
| dwarf tall fescues | *Festuca* spp. (e.g., Many Mustang, Silverado) |
| hard fescue | *Festuca ovina duriuscula* (e.g., Reliant, Aurora) |
| tufted fescue | *Festuca amethystine* |
| buffalo grass | *Buchloe dactyloides* |
| red fescue* | *Festuca rubra* |
| tall fescue grass* | *Festuca arundinacea* |
| blue oatgrass | *Helictotrichon sempervirens* |

### *Construction Criteria*

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

### *Maintenance*

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

## BMP T9.20 Wet Biofiltration Swale

### *Description*

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

### *Performance Objectives*

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

### *Applications/Limitations*

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

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

### *Design Criteria*

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

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

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

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

***Criterion 1:*** The bottom width may be increased to 25 feet maximum, but a minimum length-to-width ratio of 5:1 must be provided. No longitudinal dividing berm is needed. *Note: The minimum swale length is still 100 feet.*

***Criterion 2:*** If longitudinal slopes are greater than 2 percent, the wet swale must be stepped so that the slope within the stepped sections averages 2 percent. Steps may be made of concrete block or poured in place concrete retaining walls with rock filled sumps at the downstream side, log check dams, or short riprap sections. No underdrain or low-flow drain is required.

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

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

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

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

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

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

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

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

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

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

**Maintenance Considerations:**

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

| Table 5.9 – Recommended Plants for Wet Biofiltration Swale | | |
|---|---|---|
| **Common Name** | **Scientific Name** | **Spacing (on center)** |
| Shortawn foxtail | *Alopecurus aequalis* | seed |
| Water foxtail | *Alopecurus geniculatus* | seed |
| Spike rush | *Eleocharis spp.* | 4 inches |
| Slough sedge* | *Carex obnupta* | 6 inches or seed |
| Sawbeak sedge | *Carex stipata* | 6 inches |
| Sedge | *Carex* spp. | 6 inches |
| Western mannagrass | *Glyceria occidentalis* | seed |
| Velvetgrass | *Holcus mollis* | seed |
| Slender rush | *Juncus tenuis* | 6 inches |
| Watercress* | *Rorippa nasturtium-aquaticum* | 12 inches |
| Water parsley* | *Oenanthe sarmentosa* | 6 inches |
| Hardstem bulrush | *Scirpus acutus* | 6 inches |
| Small-fruited bulrush | *Scirpus microcarpus* | 12 inches |

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

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

**BMP T9.30 Continuous Inflow Biofiltration Swale**

***Description***

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

***Applications***

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

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

***Design Criteria***

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

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

**BMP T9.40  Basic Filter Strip**

***Description:***

A basic filter strip is flat with no side slopes (Figure 5.20). Contaminated stormwater is distributed as sheet flow across the inlet width of a biofilter strip.

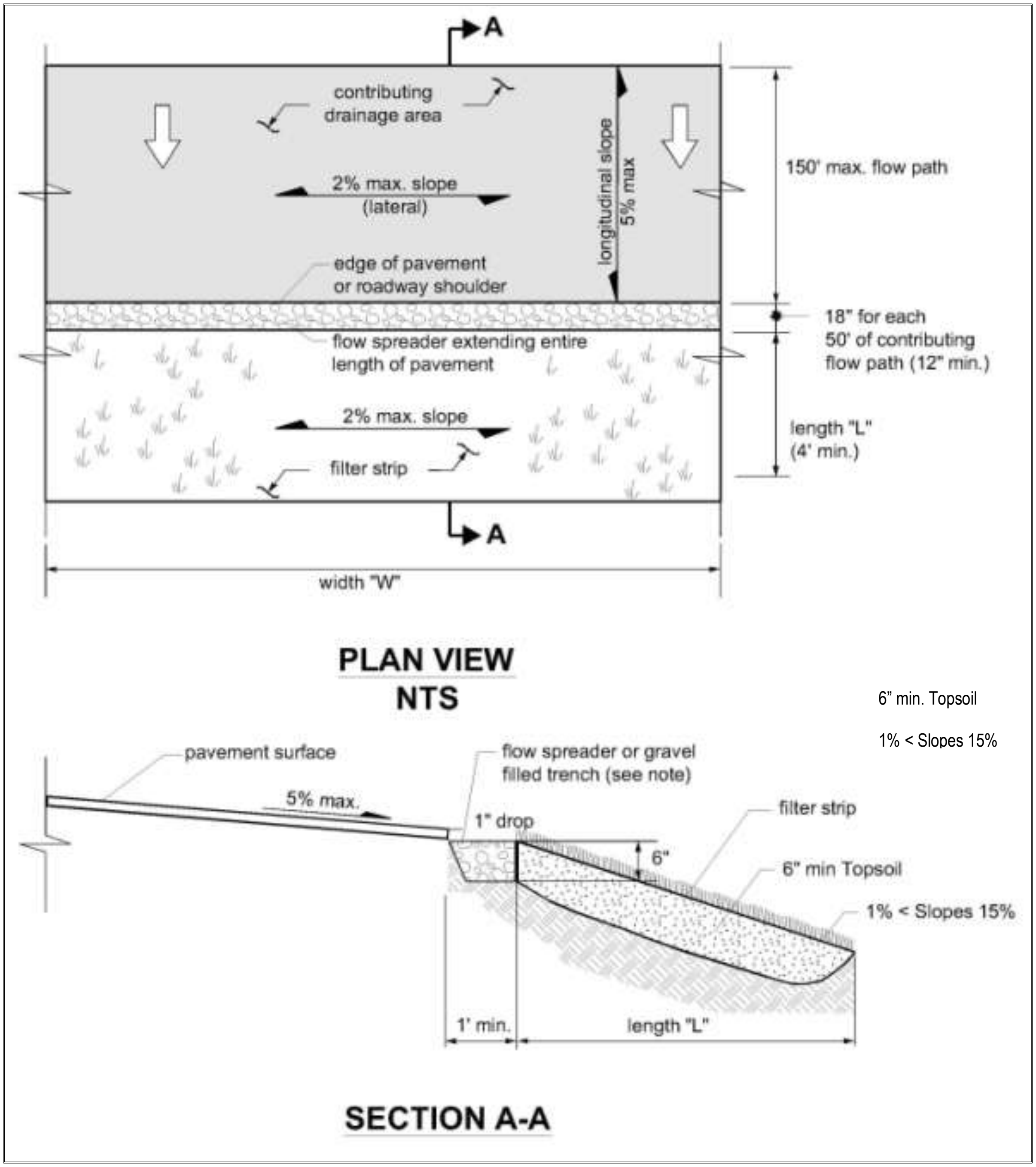



**Figure 5.20 – Typical Filter Strip**

***Applications/Limitations:***

The basic filter strip is typically used on-line and adjacent and parallel to a paved area such as parking lots, driveways, and roadways. Where a filter strip area is compost-amended to a minimum of 10% organic content in accordance with BMP T5.13; with hydroseeded grass maintained at 95% density and a 4-inch length by mowing and periodic re-seeding (possible landscaping with herbaceous shrubs), the filter strip serves as an Enhanced Treatment option.

***Design Criteria for Filter strips:***

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

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

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

Substituting for AR:

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

Where:

$Ty = A_{rectangle,\ ft}{}^{2}$

$y \approx R_{rectangle}$, design depth of flow, ft. (1 inch maximum)

Q = peak Water Quality design flow rate based on WWHM, $ft^3$/sec (See Appendix I-B, Volume I)

K = The ratio determined by using Figure 5.17

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:

$y = [KQn/1.49Ts^{0.5}]^{0.6}$

y must not exceed 1 inch

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

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

$V = KQ/Ty$
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:

**$L = tV = 540V$**

## BMP T9.50 Narrow Area Filter Strip

### *Description:*

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

### *Applications/Limitations:*

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

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

### *Design Criteria:*

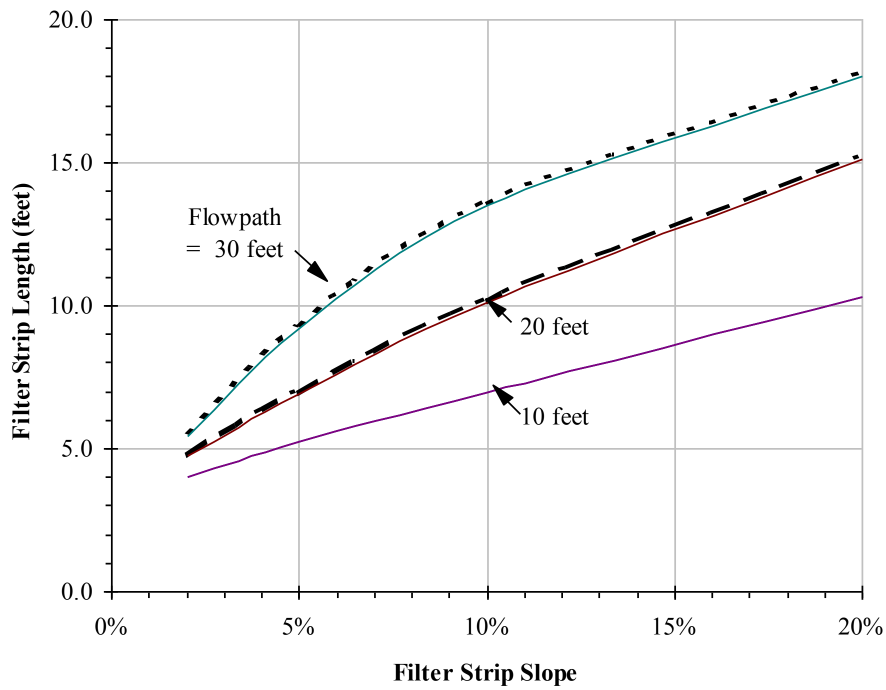
Design criteria for narrow area filter strips are the *same as specified for basic filter strips*. The sizing of a narrow area filter strip is based on the length of flowpath draining to the filter strip and the longitudinal slope of the filter strip itself (parallel to the flowpath).

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

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

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

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




*Note: minimum allowable filter strip length is 4 feet*

**Figure 5.21 – Filter Strip Lengths for Narrow Right-of-Way**

# Chapter 10 - Wetpool Facilities

## 10.1 Purpose

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

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

## 10.2 Application

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

## 10.3 Best Management Practices (BMPs) for Wetpool Facilities

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

### BMP T10.10 Wetponds - Basic and Large

#### *Purpose and Definition*

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

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

### *Applications and Limitations*

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

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

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

### *Design Criteria*

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

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

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

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

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

**Sizing Procedure**

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

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

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

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

where $V$ = wetpool volume (cf)

$h$ = wetpool average depth (ft)

$A_1$ = water quality design surface area of wetpool (sf)

$A_2$ = bottom area of wetpool (sf)

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

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

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

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

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

e) Calculate the velocity head $V_H$ ($V_H = V_c^2 / 2g$, where $g$ is the gravitational constant, 32.2 feet per second).

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

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

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

## Wetpool Geometry

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

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

- Sediment storage shall be provided in the first cell. The sediment storage shall have a minimum depth of 1 foot. A fixed sediment depth monitor should be installed in the first cell to gauge sediment accumulation unless an alternative gauging method is proposed.
- The minimum depth of the first cell shall be 4 feet, exclusive of sediment storage requirements. The depth of the first cell may be greater than the depth of the second cell.
- The maximum depth of each cell shall not exceed 8 feet (exclusive of sediment storage in the first cell). Pool depths of 3 feet or shallower (second cell) shall be planted with emergent wetland vegetation (see Vegetation).
- Inlets and outlets shall be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet shall be at least 3:1. The ***flowpath length*** is defined as the distance from the inlet to the outlet, as measured at mid-depth. The ***width*** at mid-depth can be found as follows: width = (average top width + average bottom width)/2.
- Wetponds with wetpool volumes less than or equal to 4,000 cubic feet may be single celled (i.e., no baffle or berm is required). However, it is especially important in this case that the flow path length be maximized. The ratio of flow path length to width shall be at least 4:1 in single celled wetponds, but should preferably be 5:1.
- All inlets shall enter the first cell. If there are multiple inlets, the length-to-width ratio shall be based on the average flowpath length for all inlets.
- The first cell may be lined in accordance with the liner requirements contained in Section 4.4 and Snohomish County EDDS.

## Berms, Baffles, and Slopes

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

- A berm or baffle shall extend across the full width of the wetpool, and tie into the wetpond side slopes. The geotechnical analysis, if required, shall address situations in which one of the two cells is empty while the other remains full of water.

- The top of the berm may extend to the WQ design water surface or be 1-foot below the WQ design water surface.
- The interior berm or baffle may be a retaining wall provided that the design is prepared and stamped by a licensed civil engineer. If a baffle or retaining wall is used, it should be submerged one foot below the design water surface to discourage access by pedestrians.

**Inlet and Outlet**

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

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

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

- A sump is not required in the outlet structure for a wetpond that does not provide detention storage.
- The pond outlet pipe (as opposed to the manhole or type 2 catch basin outlet pipe) shall be back-sloped or have a turn-down elbow, and extend 1 foot below the WQ design water surface.
- The pond outlet pipe shall be sized, at a minimum, to pass the on-line WQ design flow.
- The overflow criteria for wetponds designed to provide only treatment are as follows:

a) The requirement for primary overflow is satisfied by either the grated inlet to the outlet structure or by a birdcage above the pond outlet structure.

*b)* The bottom of the grate opening in the outlet structure shall be set at or above the height needed to pass the WQ design flow through the pond outlet pipe. *Note: The grate invert elevation sets the overflow water surface elevation.*

c) The grated opening should be sized to pass the 100-year design flow. The capacity of the outlet system should be sized to pass the peak flow for the conveyance requirements.

**Access and Setbacks**

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

**Vegetation**

Vegetation requirements set forth in Chapter 5-10 of Snohomish County EDDS shall apply to wetponds, unless in conflict with the following requirements, in which case the following requirements will take precedence.

- Large wetponds intended for phosphorus control should not be planted within the cells, as the plants will release phosphorus in the winter when they die off.
- If the second cell of a basic wetpond is 3 feet or shallower, the bottom area shall be planted with emergent wetland vegetation. See Table 5.10 for recommended emergent wetland plant species for wetponds. Intent: Planting of shallow pond areas helps to stabilize settled sediment and prevent resuspension.
- Cattails (Typha latifolia) are not recommended because they tend to crowd out other species and will typically establish themselves anyway.
- If the wetpond discharges to a phosphorus-sensitive lake or wetland, shrubs that form a dense cover should be planted on slopes above the WQ design water surface on at least three sides. For banks that are berms, no planting is allowed if the berm is regulated by dam safety requirements. The purpose of planting is to discourage waterfowl use of the pond and to provide shading. Some suitable trees and shrubs include vine maple (Acer circinatum), wild cherry (Prunus emarginata), red osier dogwood (Cornus stolonifera), California myrtle (Myrica californica), Indian plum (Oemleria cerasiformis), and Pacific yew (Taxus brevifolia) as well as numerous ornamental species.
- Evergreen or columnar deciduous trees along the west and south sides of ponds are recommended to reduce thermal heating, except that no trees or shrubs may be planted on berms meeting the criteria of dams regulated for safety. In addition to shade, trees and shrubs also discourage waterfowl use and the attendant phosphorus enrichment problems they cause. Trees should be set back so that the branches will not extend over the pond.

### *Maintenance*

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

**Table 5.10 – Emergent Wetland Plant Species Recommended for Wetponds**

| Species | Common Name | Notes | Maximum Depth |
|---|---|---|---|
| **INUNDATION TO 1-FOOT** | | | |
| *Agrostis exarata*[(1)] | Spike bent grass | Prairie to coast | to 2 feet |
| *Carex stipata* | Sawbeak sedge | Wet ground | |
| *Eleocharis palustris* | Spike rush | Margins of ponds, wet meadows | to 2 feet |
| *Glyceria occidentalis* | Western mannagrass | Marshes, pond margins | to 2 feet |
| *Juncus tenuis* | Slender rush | Wet soils, wetland margins | |
| *Oenanthe sarmentosa* | Water parsley | Shallow water along stream and pond margins; needs saturated soils all summer | |
| *Scirpus atrocinctus (formerly S. cyperinus)* | Woolgrass | Tolerates shallow water; tall clumps | |
| *Scirpus microcarpus* | Small-fruited bulrush | Wet ground to 18 inches depth | 18 inches |
| *Sagittaria latifolia* | Arrowhead | | |
| **INUNDATION 1 TO 2 FEET** | | | |
| *Agrostis exarata*[(1)] | Spike bent grass | Prairie to coast | |

| | | | |
|---|---|---|---|
| *Alisma plantago-aquatica* | Water plantain | | |
| *Eleocharis palustris* | Spike rush | Margins of ponds, wet meadows | |
| *Glyceria occidentalis* | Western mannagrass | Marshes, pond margins | |
| *Juncus effusus* | Soft rush | Wet meadows, pastures, wetland margins | |
| *Scirpus microcarpus* | Small-fruited bulrush | Wet ground to 18 inches depth | 18 inches |
| *Sparganium emmersum* | Bur reed | Shallow standing water, saturated soils | |
| **INUNDATION 1 TO 3 FEET** | | | |
| *Carex obnupta* | Slough sedge | Wet ground or standing water | 1.5 to 3 feet |
| *Beckmania syzigachne*(1) | Western sloughgrass | Wet prairie to pond margins | |
| *Scirpus acutus*(2) | Hardstem bulrush | Single tall stems, not clumping | to 3 feet |
| *Scirpus validus*(2) | Softstem bulrush | | |
| **INUNDATION GREATER THAN 3 FEET** | | | |
| *Nuphar polysepalum* | Spatterdock | Deep water | 3 to 7.5 feet |
| *Nymphaea odorata*(1) | White waterlily | Shallow to deep ponds | to 6 feet |

*Notes*:

(1) Non-native species. *Beckmania syzigachne* is native to Oregon. Native species are preferred.

(2) *Scirpus* tubers must be planted shallower for establishment, and protected from foraging waterfowl until established. Emerging aerial stems should project above water surface to allow oxygen transport to the roots.

*Primary sources*: Municipality of Metropolitan Seattle, *Water Pollution Control Aspects of Aquatic Plants*, 1990. Hortus Northwest, *Wetland Plants for Western Oregon*, Issue 2, 1991. Hitchcock and Cronquist, *Flora of the Pacific Northwest*, 1973.

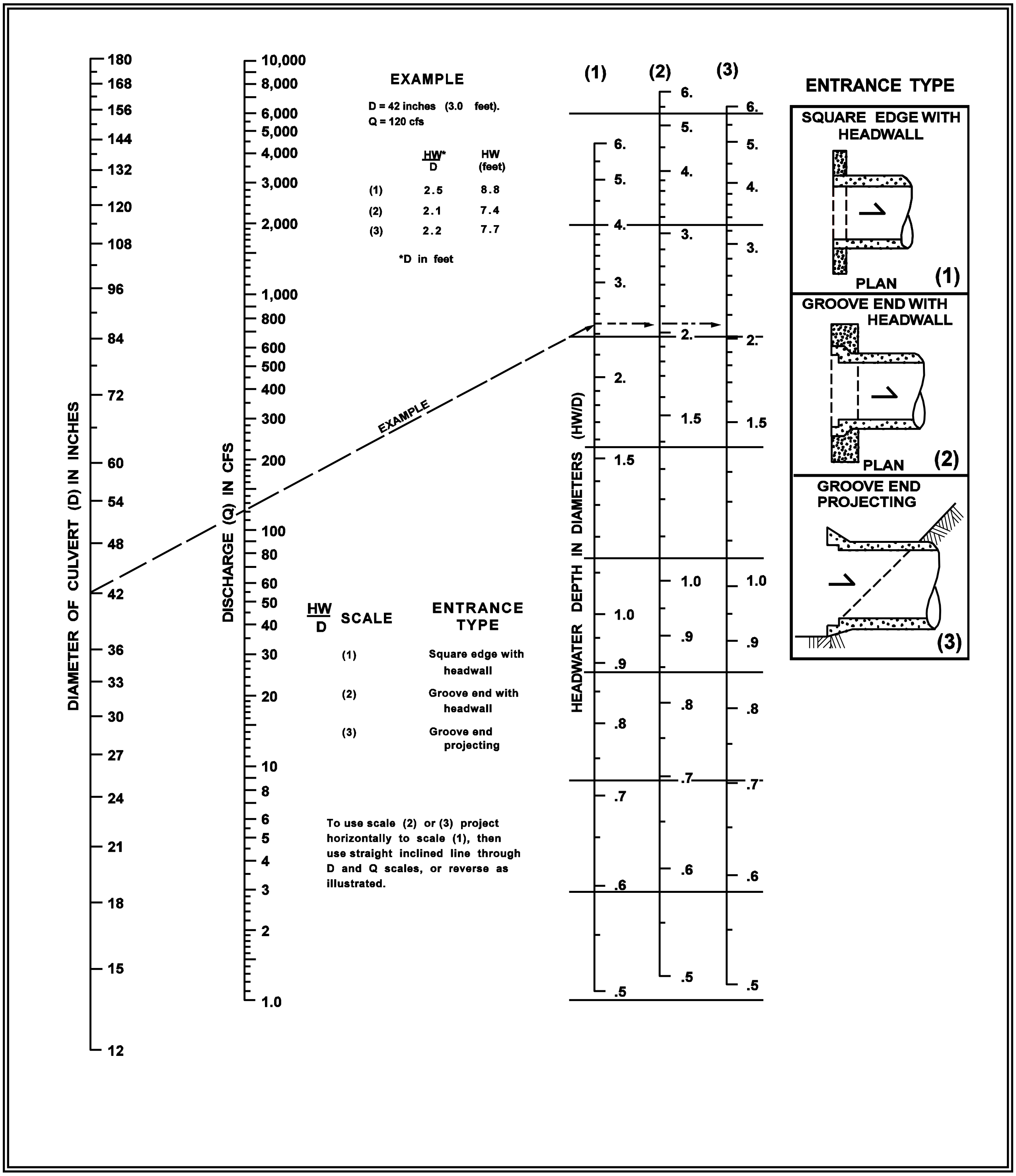



**Figure 5.22 – Headwater Depth for Smooth Interior Pipe Culverts with Inlet Control**

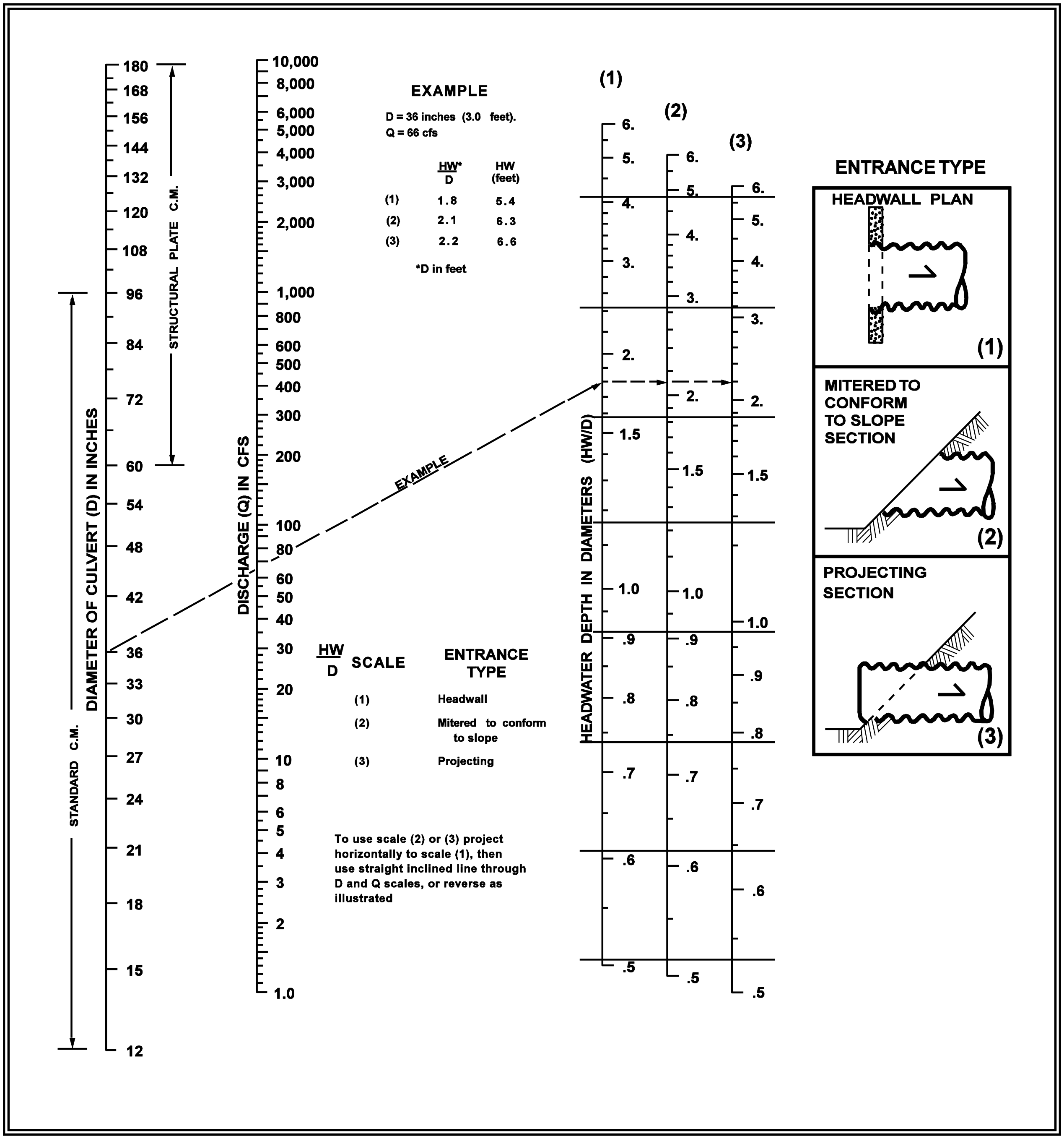
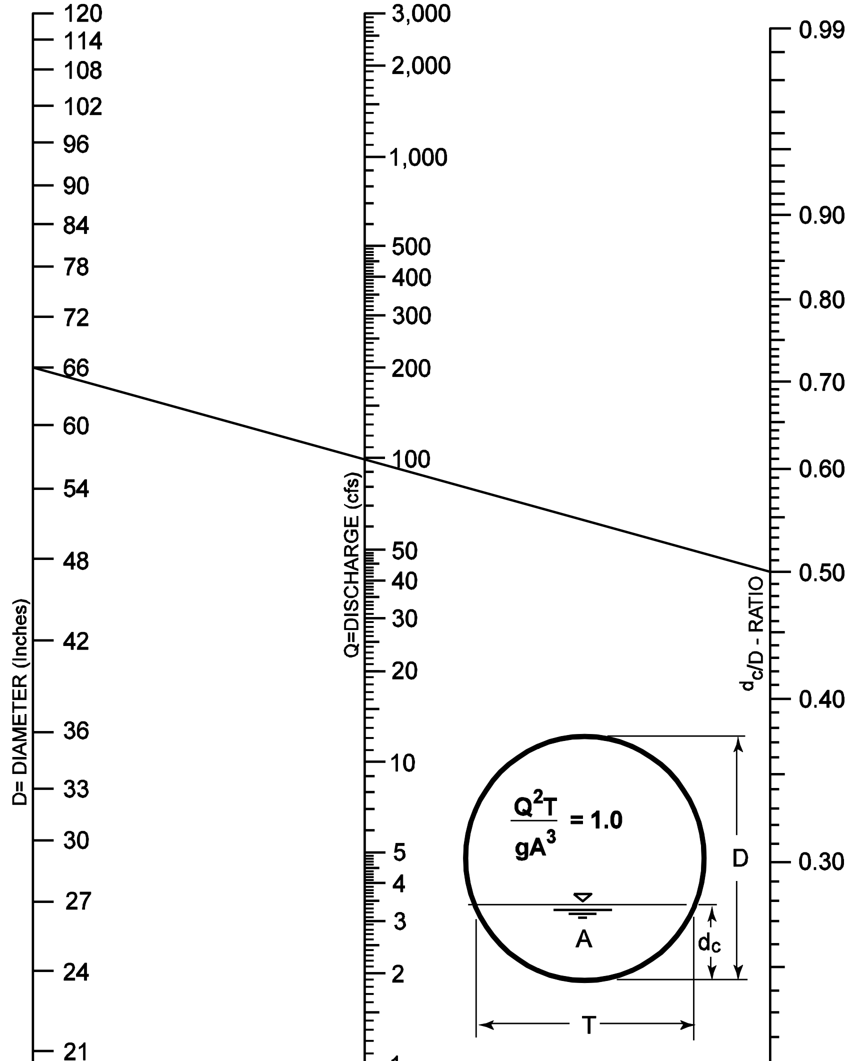



**Figure 5.23 – Headwater Depth for Corrugated Pipe Culverts with Inlet Control**




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

| **EXAMPLE** |
|---|
| D = 66 inches, Q = 100cfs<br>$d_c$/D - Ratio = 0.50<br>$d_c$ = (0.50)(66 inches)= 33 inches √ (12 inches/ft)<br>$d_c$= 2.75 feet |

**Figure 5.24 – Critical Depth of Flow for Circular Culverts**

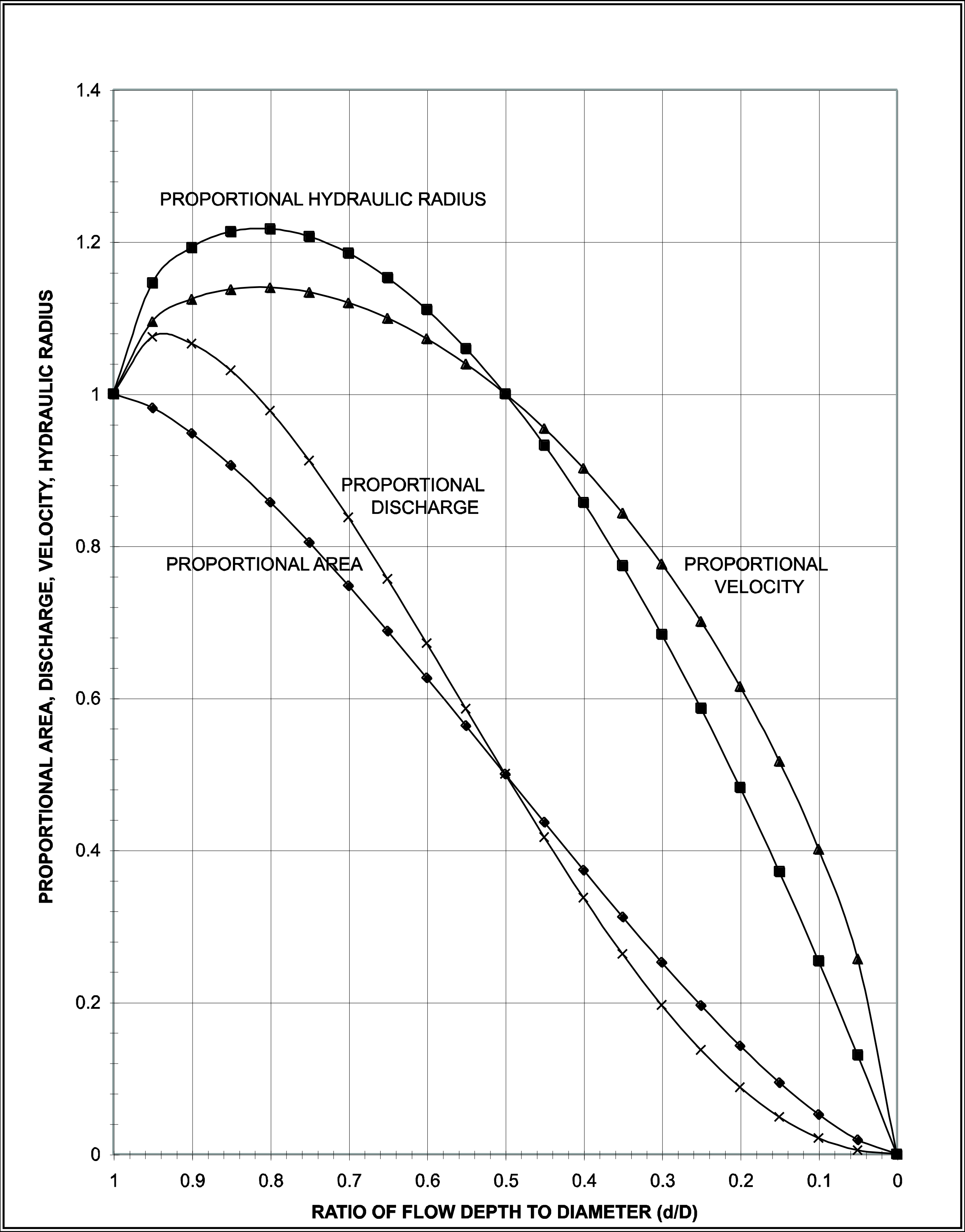



**Figure 5.25 – Circular Channel Ratios**

## BMP T10.20 Wetvaults

### *Purpose and Definition*

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

### *Applications and Limitations*

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

### *Design Criteria*

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

### Sizing Procedure

The sizing procedure for a wetvault is identical to the sizing procedure for a wetpond. The wetpool volume for the wetvault shall be equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, the 91$^{st}$ percentile, 24-hour runoff volume estimated by an approved continuous runoff model may be used.

**Wetpool Geometry**

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

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

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

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

**Vault Structure**

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

- The highest point of a vault bottom must be at least 6 inches below the outlet pipe invert elevation to provide for sediment storage over the entire bottom.
- Wetvaults may be constructed using arch culvert sections provided the top area at the WQ design water surface is, at a minimum, equal to that of a vault with vertical walls designed with an average depth of 6 feet.

**Inlet and Outlet**

- The inlet pipe to the wetvault shall be submerged with the inlet pipe invert a minimum of 3 feet from the vault bottom. The top of the inlet pipe shall be submerged at least 1-foot.
- Unless designed as an off-line facility, the capacity of the outlet pipe and available head above the outlet pipe shall be designed to convey the 100-year design flow for developed site conditions without overtopping the vault. The available head above the outlet pipe must be a minimum of 6 inches.
- The outlet pipe shall be back-sloped or have tee section, the lower arm of which should extend 1 foot below the WQ design water surface to provide for trapping of oils and floatables in the vault.
- Snohomish County may require a bypass/shutoff valve to enable the vault to be taken offline for maintenance.

**Access Requirements**

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

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

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

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

***Maintenance***

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

## BMP T10.30 Stormwater Treatment Wetlands

### *Purpose and Definition*

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

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

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

### *Applications and Limitations*

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

### *Design Criteria*

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

#### Sizing Procedure

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

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

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

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

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

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

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

#### Wetland Geometry

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

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

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

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

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

**Table 5.11 – Distribution of Depths in Wetland Cell**

| Dividing Berm at WQ Design Water Surface | | Dividing Berm Submerged 1-Foot | |
|---|---|---|---|
| **Depth Range (feet)** | **Percent** | **Depth Range (feet)** | **Percent** |
| 0.1 to 1 | 25 | 1 to 1.5 | 40 |
| 1 to 2 | 55 | 1.5 to 2 | 40 |
| 2 to 2.5 | 20 | 2 to 2.5 | 20 |

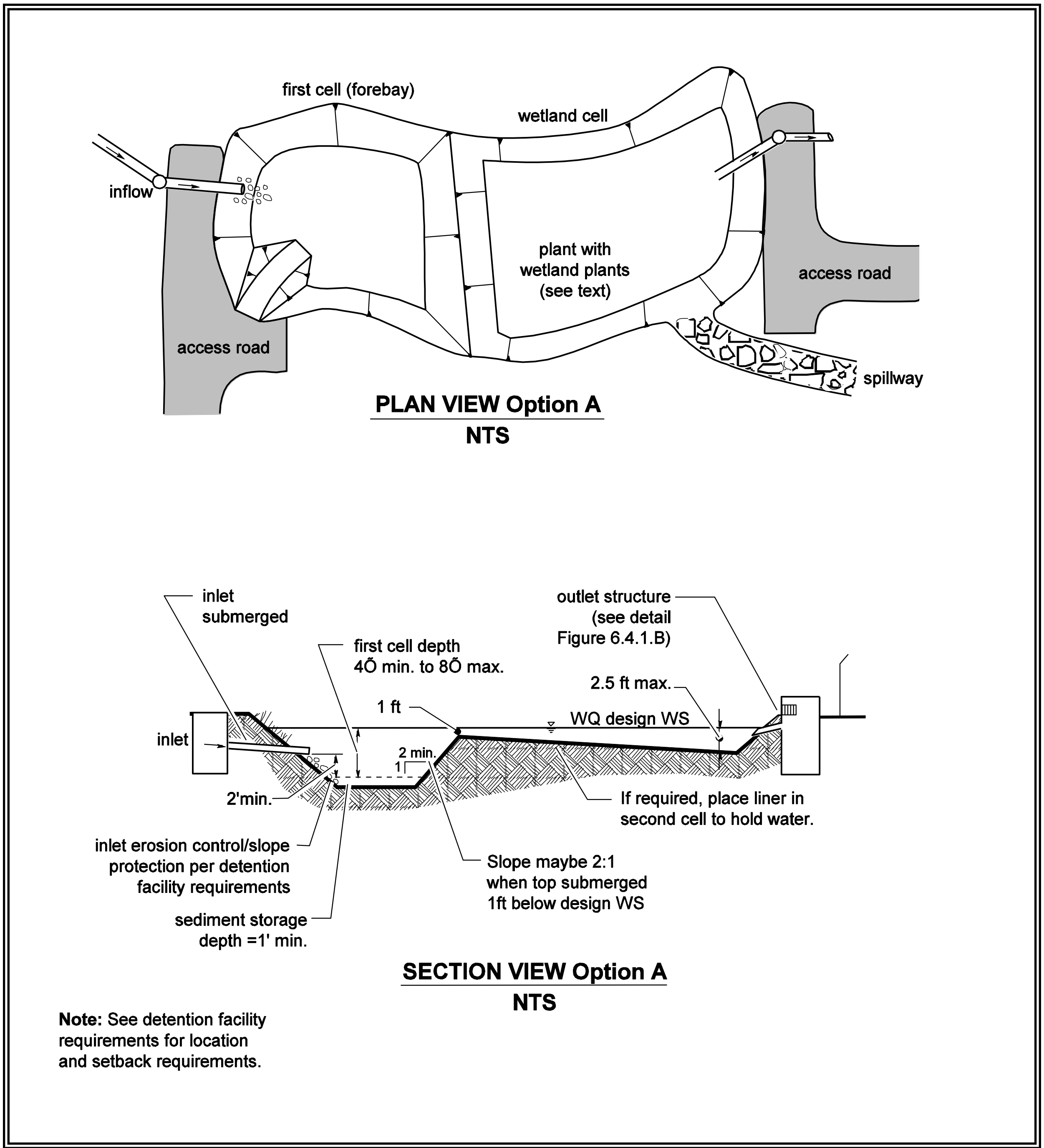



**Figure 5.26 – Stormwater Wetland – Option One**

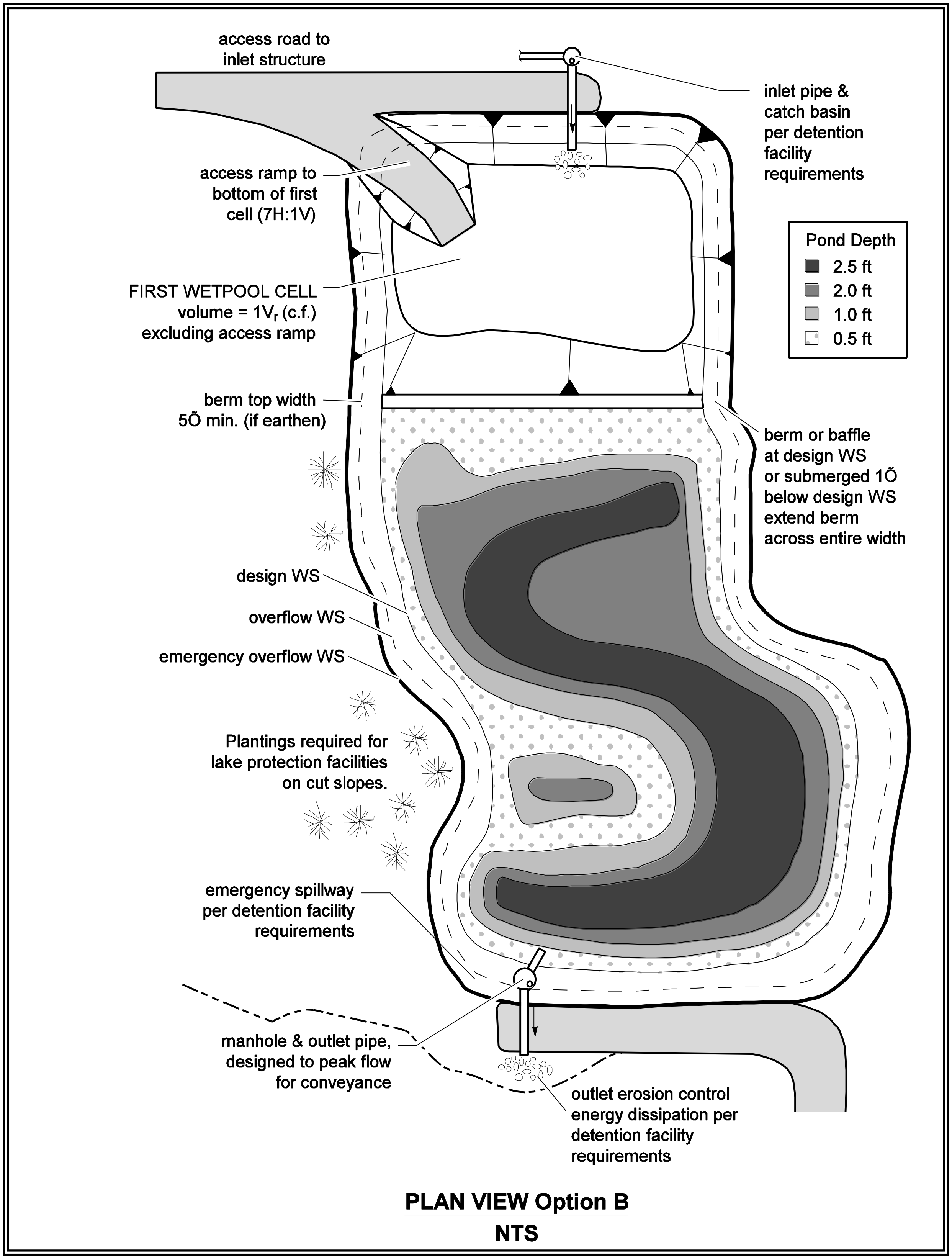



**Figure 5.27 – Stormwater Wetland — Option Two**

### Lining Requirements

The following hydrologic conditions in the wetland shall be met.

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

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

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

### Inlet and Outlet

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

### Access and Setbacks

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

### Vegetation

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

### *Construction Criteria*

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

***Maintenance***

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

## BMP T10.40 Combined Detention and Wetpool Facilities

### *Purpose and Definition*

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

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

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

### *Applications and Limitations*

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

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

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

### *Combined Detention and Wetpond (Basic and Large)*

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

#### Sizing Procedure

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

**Detention and Wetpool Geometry**

- The wetpool and sediment storage volumes shall not be included in the required detention volume.
- The "Wetpool Geometry" criteria for wetponds (see BMP T10.10) shall apply with the following modifications/clarifications:

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

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

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

**Berms, Baffles, and Slopes**

See Wetponds, BMP T10.10. Engineering standards and specifications set forth in Chapter 5-10 Snohomish County EDDS shall apply.

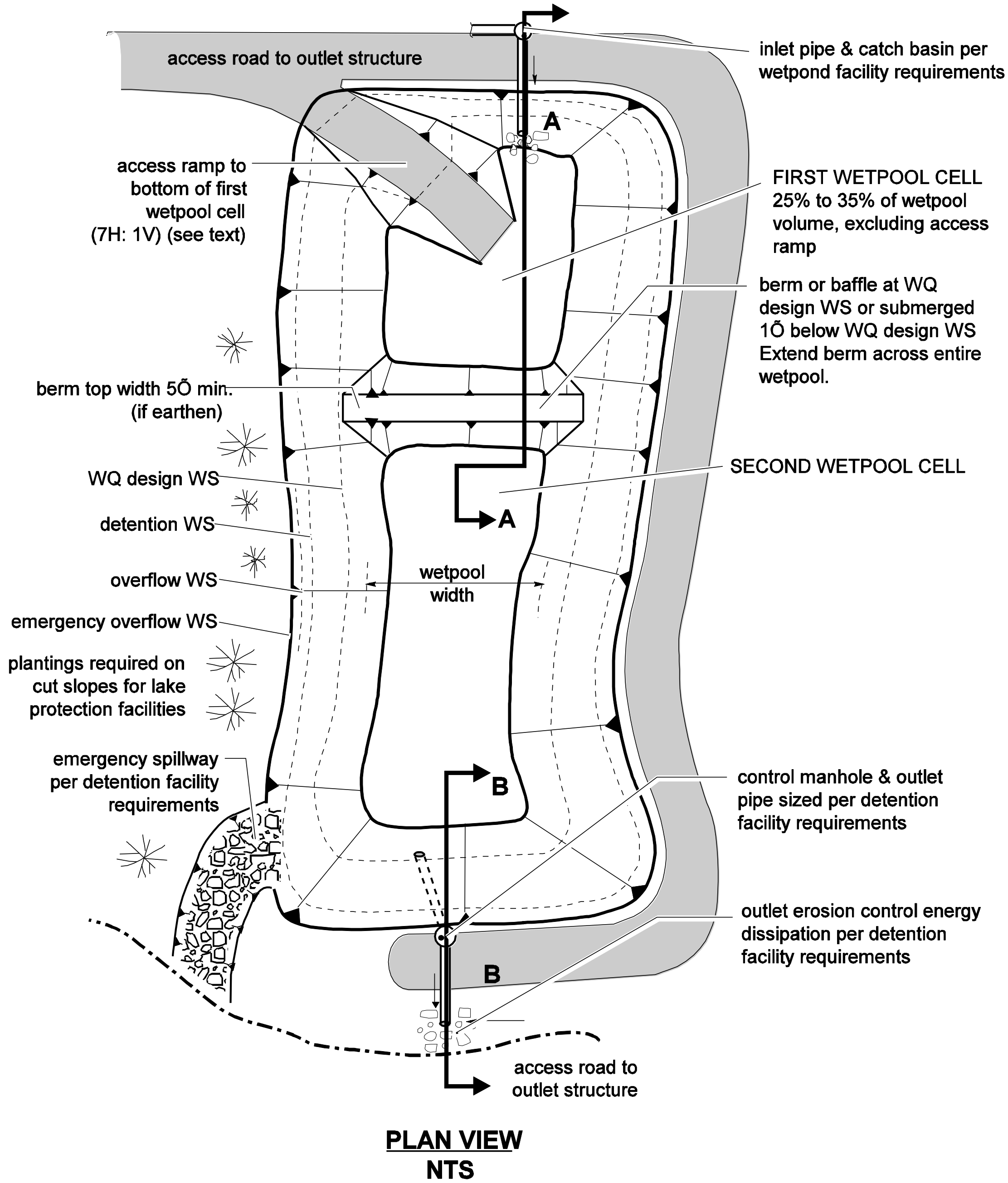



**Figure 5.28 – Combined Detention and Wetpond**

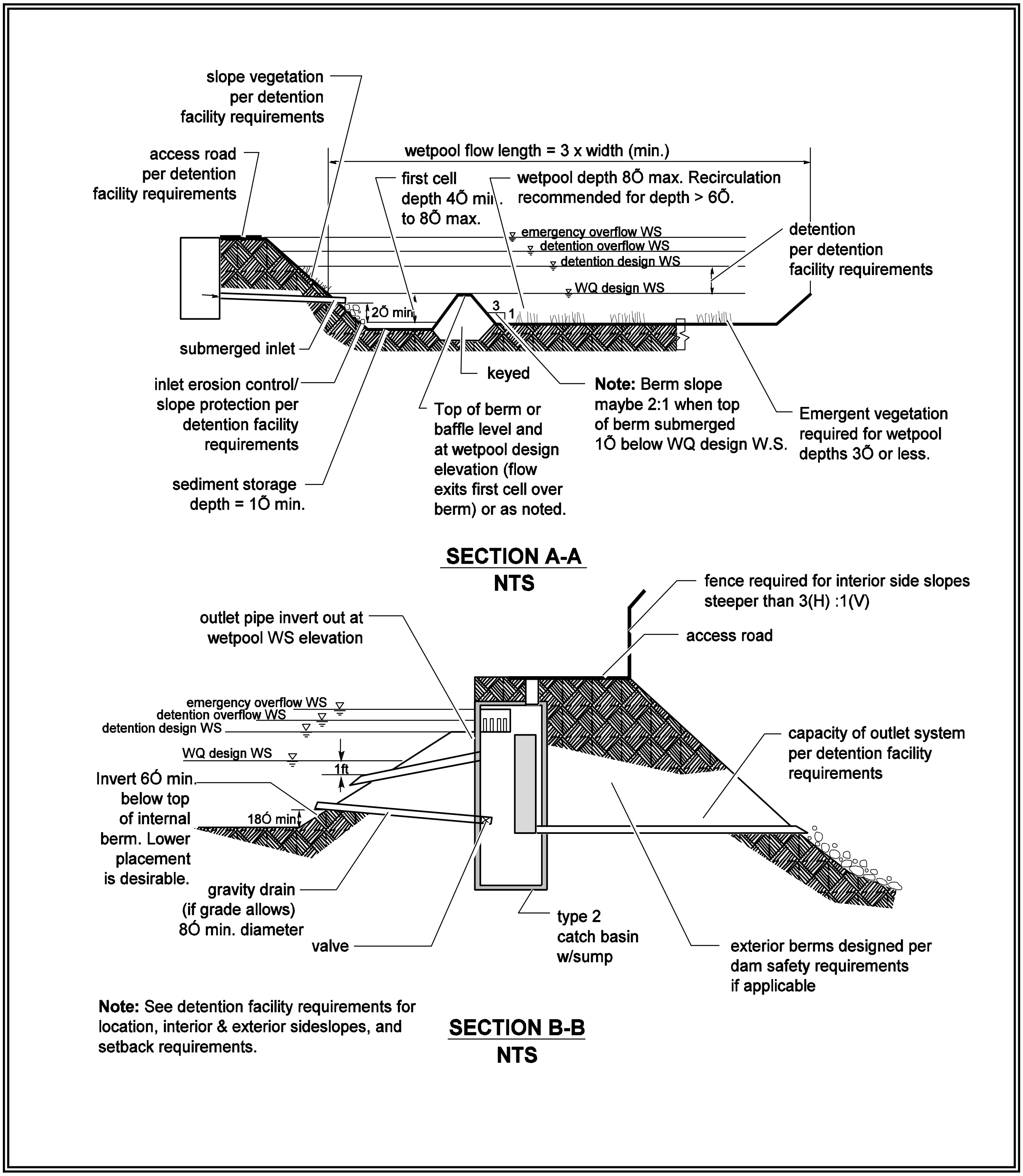
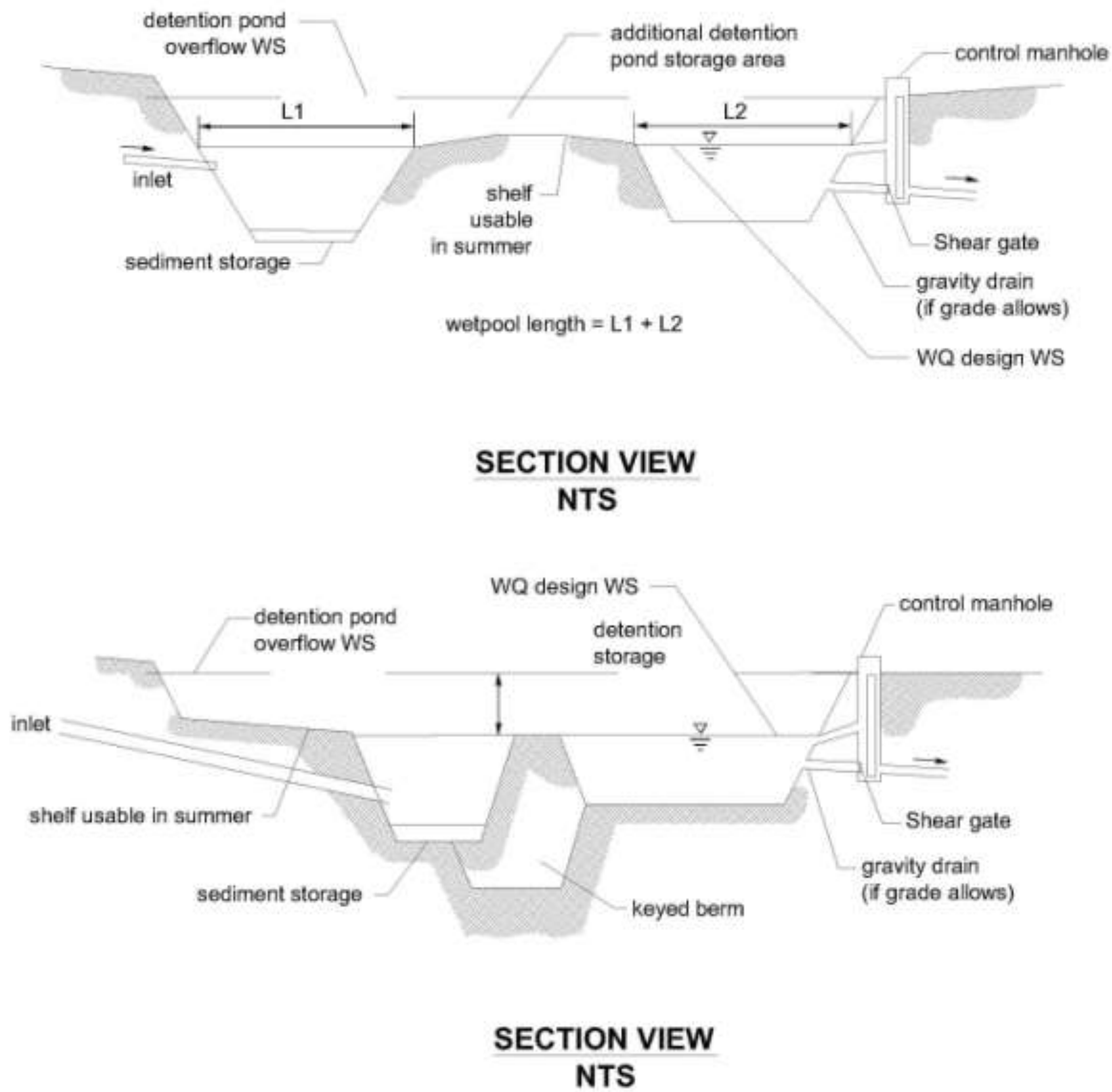



**Figure 5.29 – Combined Detention and Wetpond (Continued)**




**Note:** These examples show how the combined detention/wetpool can be configured to allow for "shelves" for joint use opportunities in dry weather. Other options may also be acceptable.

**Figure 5.30 – Alternative Configurations of Detention and Wetpool Areas**

### Inlet and Outlet

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

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

### Access and Setbacks

Same as for wetponds.

### Planting Requirements

Same as for wetponds.

### Combined Detention and Wetvault

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

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

- The minimum sediment storage depth in the first cell shall average 1-foot. The 6 inches of sediment storage required for detention vaults does not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with detention vault sediment storage requirements.
- The oil retaining baffle shall extend a minimum of 2 feet below the WQ design water surface.

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

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

### Combined Detention and Stormwater Wetland

The sizing procedure for combined detention and stormwater wetlands is identical to those outlined for stormwater wetlands and for detention facilities. Follow the procedure specified in BMP T10.30 to determine the stormwater wetland size. Follow the standard procedure specified in Volume III to size the detention portion of the wetland.

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

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

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

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

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

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

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

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

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

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

# Chapter 11 - Oil and Water Separators

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

## 11.1 Purpose of Oil and Water Separators

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

## 11.2 Description

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

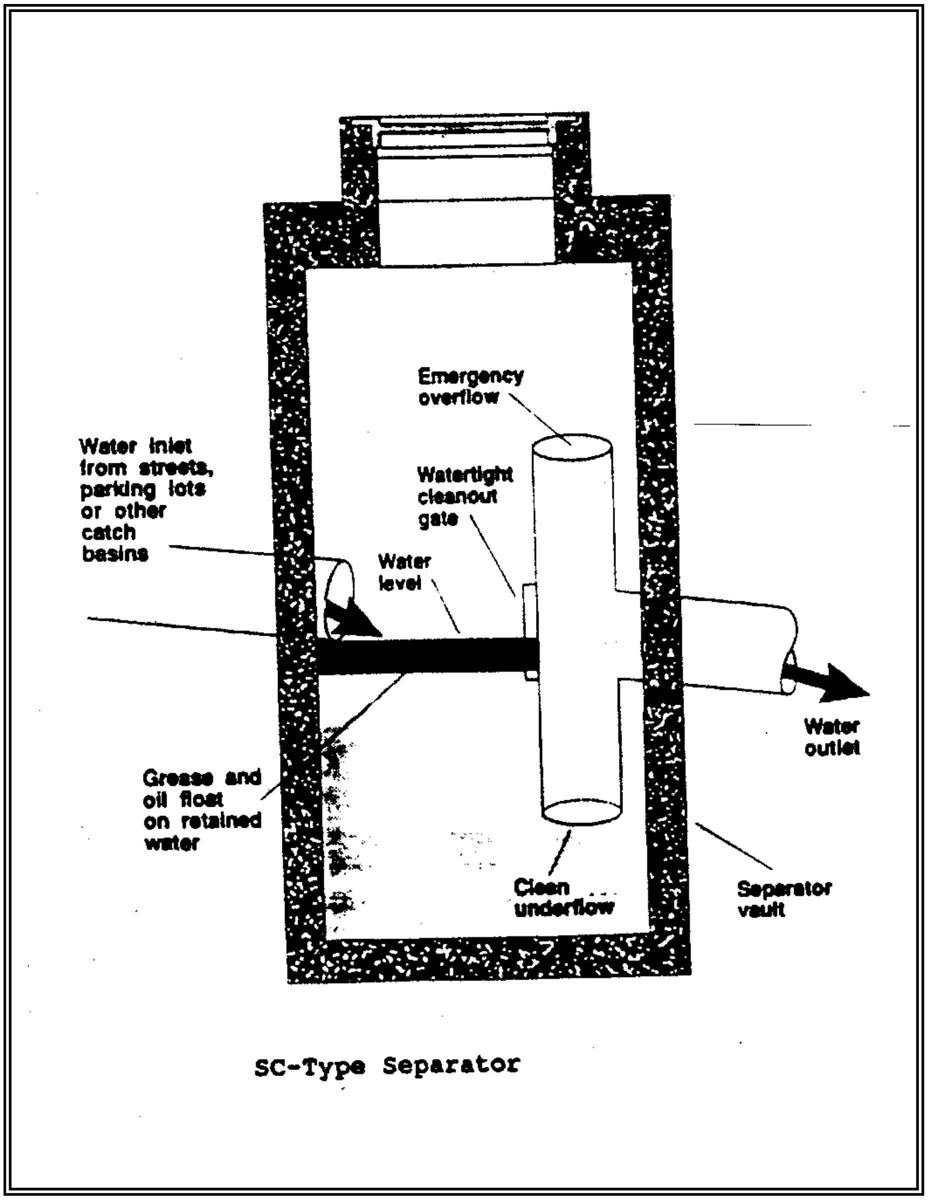



**Figure 5.31 – Spill Control Separator (not for oil treatment)**

## 11.3 Performance Objectives

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

## 11.4 Applications/Limitations

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

- Commercial and industrial areas including petroleum storage yards, vehicle maintenance facilities, manufacturing areas, airports, utility areas (water, electric, gas), and fueling stations.
- Facilities that would require oil control BMPs under the high-use site threshold described in Chapter 2 including parking lots at convenience stores, fast food restaurants, grocery stores, shopping malls, discount warehouse stores, banks, truck fleets, auto and truck dealerships, and delivery services.
- Without intense maintenance oil/water separators may not be sufficiently effective in achieving oil and TPH removal down to required levels.
- Pretreatment should be considered if the level of TSS in the inlet flow would cause clogging or otherwise impair the long-term efficiency of the separator.
- For inflows from small drainage areas (fueling stations, maintenance shops, etc.) a coalescing plate (CP) type separator is typically considered, due to space limitations. However, if plugging of the plates is likely, then a new design basis for the baffle type API separator may be considered on an experimental basis.

## 11.5 Site Suitability

Consider the following site characteristics:

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

## 11.6 Design Criteria-General Considerations

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

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

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

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

- Use only impervious conveyances for oil contaminated stormwater.

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

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

**Criteria for Separator Bays:**

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

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

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

- Include a shutoff mechanism at the separator outlet pipe.

- Use absorbents and/or skimmers in the afterbay as needed.

**Criteria for Baffles:**

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

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

## 11.7 Oil and Water Separator BMPs

Two BMPs are described in this section. BMP T11.10 for baffle type separators, and BMP T11.11 for coalescing plate separators.

**BMP T11.10 API (Baffle type) Separator Bay**

***Design Criteria***

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

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

The following is the sizing procedure using modified API criteria:

- Determine the oil rise rate, Vt, in cm/sec, using Stokes Law, or empirical determination, or 0.033 ft./min for 60µ oil. The application of Stokes' Law to site-based oil droplet sizes and densities, or empirical rise rate determinations recognizes the need to consider actual site conditions. In those cases the design basis would not be the 60 micron droplet size and the 0.033 ft/min. rise rate.
- Stokes Law equation for rise rate, Vt (cm/sec):
- $Vt = [(g)(\rho w - \rho o)(d^2)] / [(18*\mu w)]$

Where:

- Vt = the rise rate of the oil droplet (cm/s or ft/sec)
- g = acceleration due to gravity ($cm/s^2$ or $ft/s^2$)
- ρw = density of water at the design temperature ($g/cm^3$ or $lbm/ft^3$)
- ρo = density of oil at the design temperature ($g/cm^3$ or $lbm/ft^3$)
- d = oil droplet diameter (cm or ft)
- µw = absolute viscosity of the water (g/cm-s or lbm/ft-s)

Use

oil particle size diameter, D=60 microns (0.006 cm)

ρw =0.999 gm/cc. at 32° F

ρo: Select conservatively high oil density. For example, if diesel oil @ ρo =0.85 gm/cc and motor oil @ ρo = 0.90 can be present then use ρo =0.90 gm/cc

µw = 0.017921 poise, gm/cm-sec. at $T_w$=32 °F

Use the following separator dimension criteria:

Separator water depth, d $\geq 3 \leq 8$ feet (to minimize turbulence)

Separator width, 6-20 feet

Depth/width (d/w) of 0.3-0.5

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

1. Determine $V_t$ and select depth and width of the separator section based on above criteria.

2. Calculate the minimum residence time ($t_m$) of the separator at depth d:

$t_m = d/V_t$

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

$V_h = Q/dw = Q/A_v$ ($V_h$ maximum at $< 2.0$ ft/min.)

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

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

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

$l(s) = FQt_m/wd = F(V_h/V_t)d$
$l(t) = l(f) + l(s) + l(a)$
$l(t) = l(t)/3 + l(s) + l(t)/4$

Where:

l(t) = total length of 3 bays = “L” in EDDS Standard Drawing 5-310
l(f) = length of forebay
l(a) = length of afterbay

5. Calculate $V = l(s)wd = FQt_m$, and $A_h = wl(s)$

V = minimum hydraulic design volume
$A_h$ = minimum horizontal area of the separator

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

## BMP T11.11 Coalescing Plate (CP) Separator Bay

### *Design Criteria*

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

$A_h = Q/Vt = [Q] / [(.00386) * ((S_w - S_o)/(\mu_w))]$

Where

- $A_h$ = horizontal surface area of the plates ($ft^2$)
- Vt = rise rate of the oil droplet (ft/min)
- Q = design flowrate ($ft^3$/min)
- $S_w$ = specific gravity of water at the design temperature
- $S_o$ = specific gravity of oil at the design temperature
- $\mu_w$ = absolute viscosity of the water (poise)

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

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

### *Maintenance*

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

# Chapter 12 - Other BMPs and Technologies Approved by the Washington State Department of Ecology

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

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

http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html

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

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

## Table 5.12 Washington State Department of Ecology Use Level Designations or Equivalence Designations

General Use Level Designation (GULD)

| System | Basic | Enhanced | Phosphorus | Oil | Pretreatment |
|---|---|---|---|---|---|
| StormFilter - zeolite/perlite/granular activated carbon media | X | | | | |
| CDS Media Filtration System - perlite | X | | | | |
| WSDOT Media Filter Drain | X | X | X | | |
| Filterra | X | X | | X | |
| CDS System | | | | | X |
| Vortechs | | | | | X |
| AquaSwirl | | | | | X |
| AquaFilter | | | | | X |
| Downstream Defender | | | | | X (sediment only) |
| Stormceptor | | | | | X |

Conditional Use Level Designation (CULD)

| System | Basic | Enhanced | Phosphorus | Oil | Pretreatment |
|---|---|---|---|---|---|
| Filterra | | | X | | |
| BayFilter | X | X | X | | |
| BaySeparator | | | | | X |

Pilot Use Level Designation (PULD)

| System | Basic | Enhanced | Phosphorus | Oil | Pretreatment |
|---|---|---|---|---|---|
| EcoStorm Plus | X | | | | |
| FloGard Perk Filter | X | | | | |
| Up-Flo Filterq | X | | | | X |
| Jellyfish | X | | | | |
| AquaFilter - coarse perlite | X | | | | |
| AquaFilter - AquaBlend C media | | X | X | X | |

## Construction Stormwater Runoff Treatment

General Use Level Designation (GULD)

| System | 100% on-site infiltration | Batch treatment discharge to surface water | Flow-through treatment discharge to surface water |
|---|---|---|---|
| StormKlear Chitosan Enhanced Sand Filtration (CESF) | X | X | X |
| FlocClear CESF | X | X | |
| ChitoVan CESF | X | X | X |
| StormKlear LiquiFloc CESF | X | X | |

Conditional Use Level Designation (CULD)

| System | 100% on-site infiltration | Batch treatment discharge to surface water | Flow-through treatment discharge to surface water |
|---|---|---|---|
| FlocClear CESF | | | |
| StormKlear LiquiFloc CESF | | | X |
| Electrocoagulation Subtractive Technology | | | X |

## Technologies determined by Ecology as equivalent to existing technologies

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

# Volume V References

Caraco, Deborah and Richard Claytor, Stormwater BMP Design Supplement for Cold Climates, Center for Watershed Protection, December 1997.

USEPA, ―Stormwater BMP Design Supplement for Cold Climates”, December 1997.

# Appendix V-A Basic Treatment Receiving Waters

## 1. All salt waterbodies

## 2. Rivers

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

## 3. Lakes

| Lakes | County |
| --- | --- |
| [No lakes in Snohomish County] | |

# Appendix V-B (Also published as Appendix III-D) Procedure for Conducting a Pilot Infiltration Test

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

***Infiltration Test***

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

- The horizontal surface area of the bottom of the test pit should be approximately 100 square feet. For small drainages and where water availability is a problem smaller areas may be considered as determined by the site professional.
- Accurately document the size and geometry of the test pit.
- Install a vertical measuring rod (minimum 5-ft. long) marked in half-inch increments in the center of the pit bottom.
- Use a rigid 6-inch diameter pipe with a splash plate on the bottom to convey water to the pit and reduce side-wall erosion or excessive disturbance of the pond bottom. Excessive erosion and bottom disturbance will result in clogging of the infiltration receptor and yield lower than actual infiltration rates.
- Add water to the pit at a rate that will maintain a water level between 3 and 4 feet above the bottom of the pit. A rotameter can be used to measure the flow rate into the pit.

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

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

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

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

***Data Analysis***

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

**Note:** Use statistical/trend analysis to obtain the hourly flow rate when the flow stabilizes. This would be the lowest hourly flow rate.

Apply appropriate correction factors for site heterogeneity, anticipated level of maintenance and treatment to determine the site-specific design infiltration rate (Volume III, Tables 3.6 and 3.7).

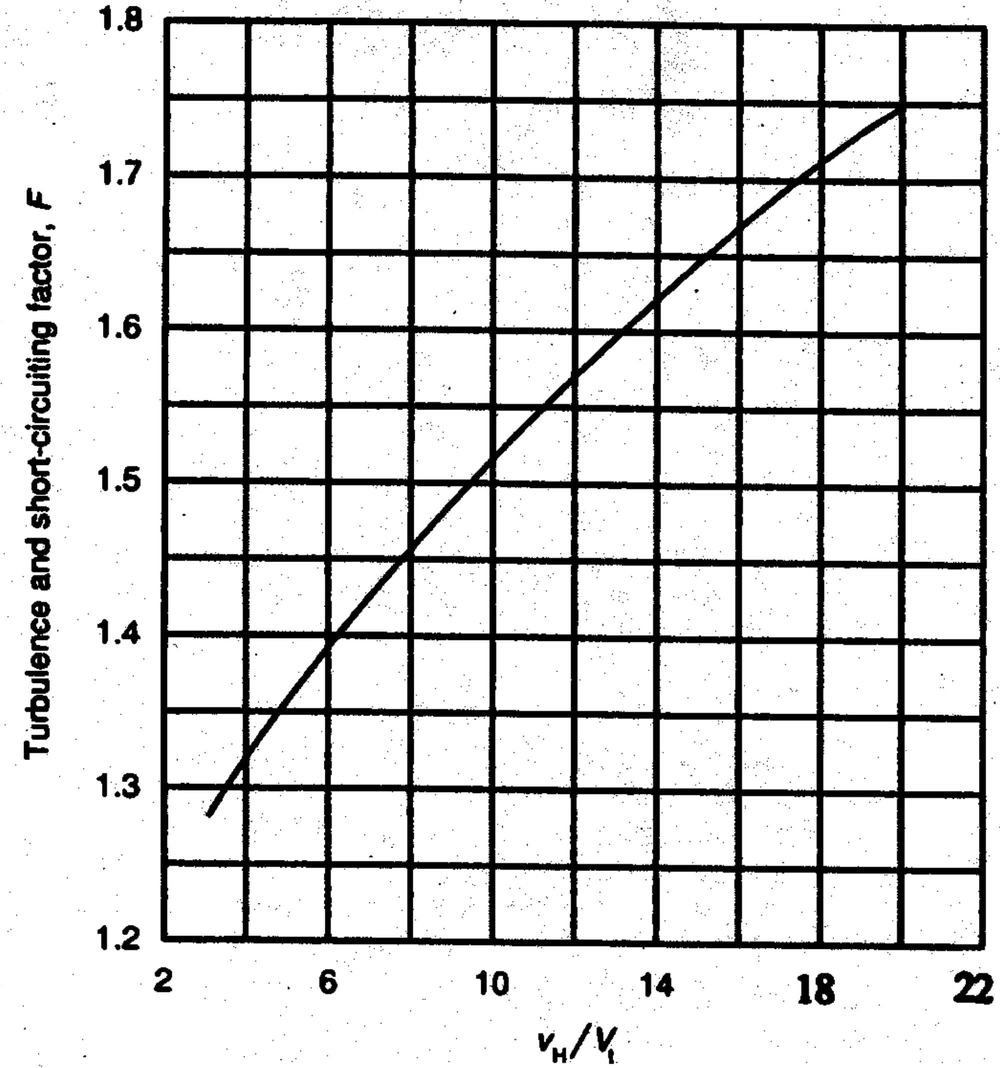
***Example***

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

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

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

# Appendix V-C Turbulence and Short-Circuiting Factor




| $v_H/V_t$ | Turbulence Factor ($F_t$) | $F = 1.2(F_t)$ |
|---|---|---|
| 20 | 1.45 | 1.74 |
| 15 | 1.37 | 1.64 |
| 10 | 1.27 | 1.52 |
| 6 | 1.14 | 1.37 |
| 3 | 1.07 | 1.28 |

**Figure D.1 – Recommended Values of *F* for Various Values of $v_H$/Vt**