

Figure 6.17 Perimeter Sand Filter (F-3)

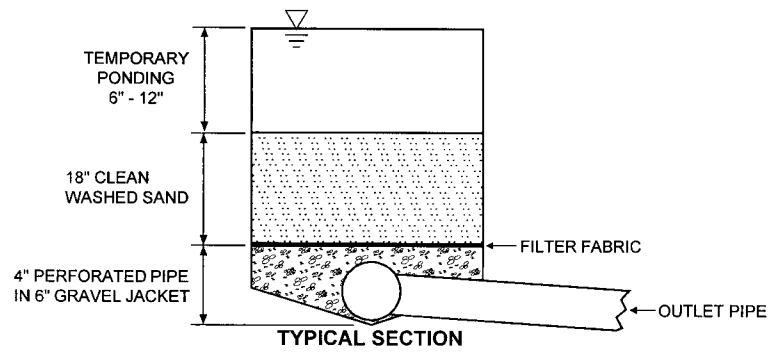
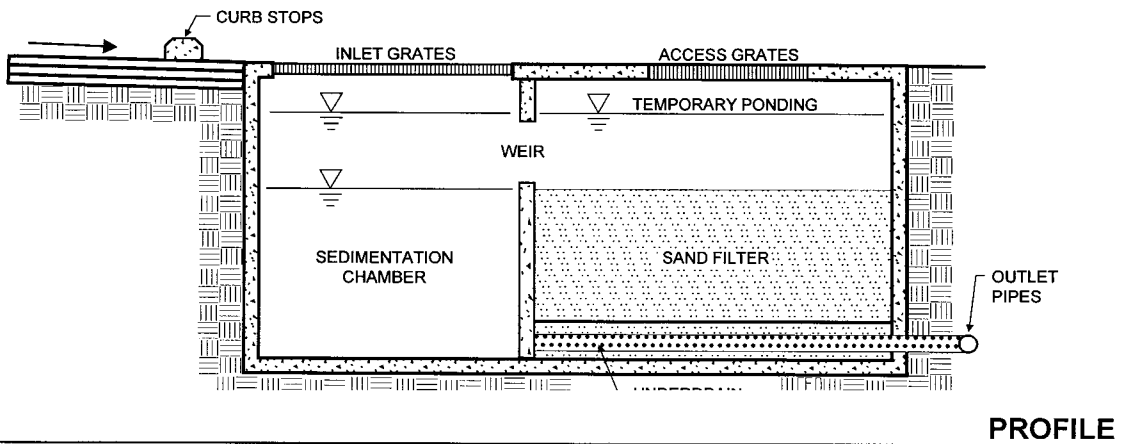
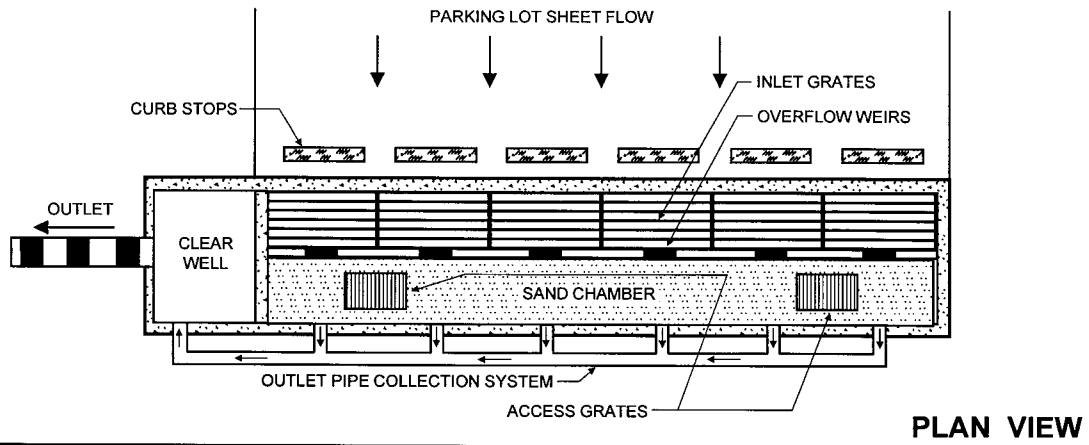
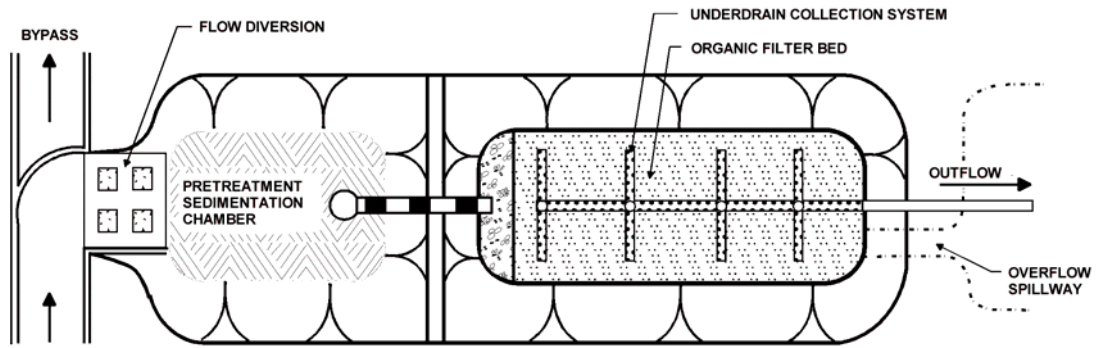
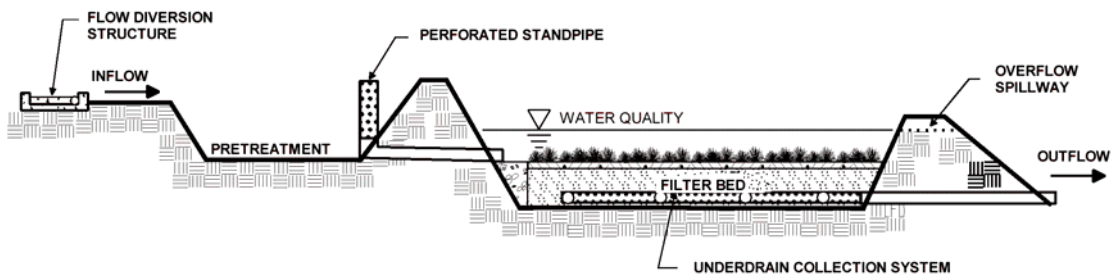


Figure 6.18 Organic Filter (F-4)



PLAN VIEW



PROFILE

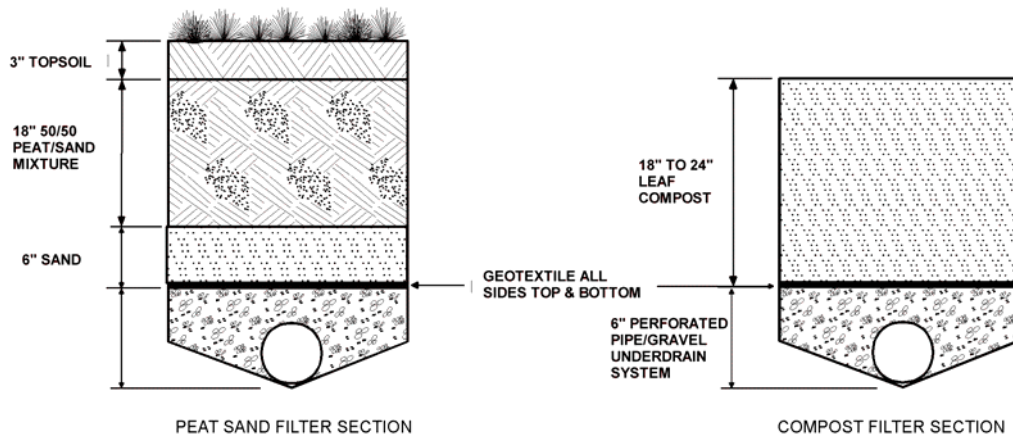
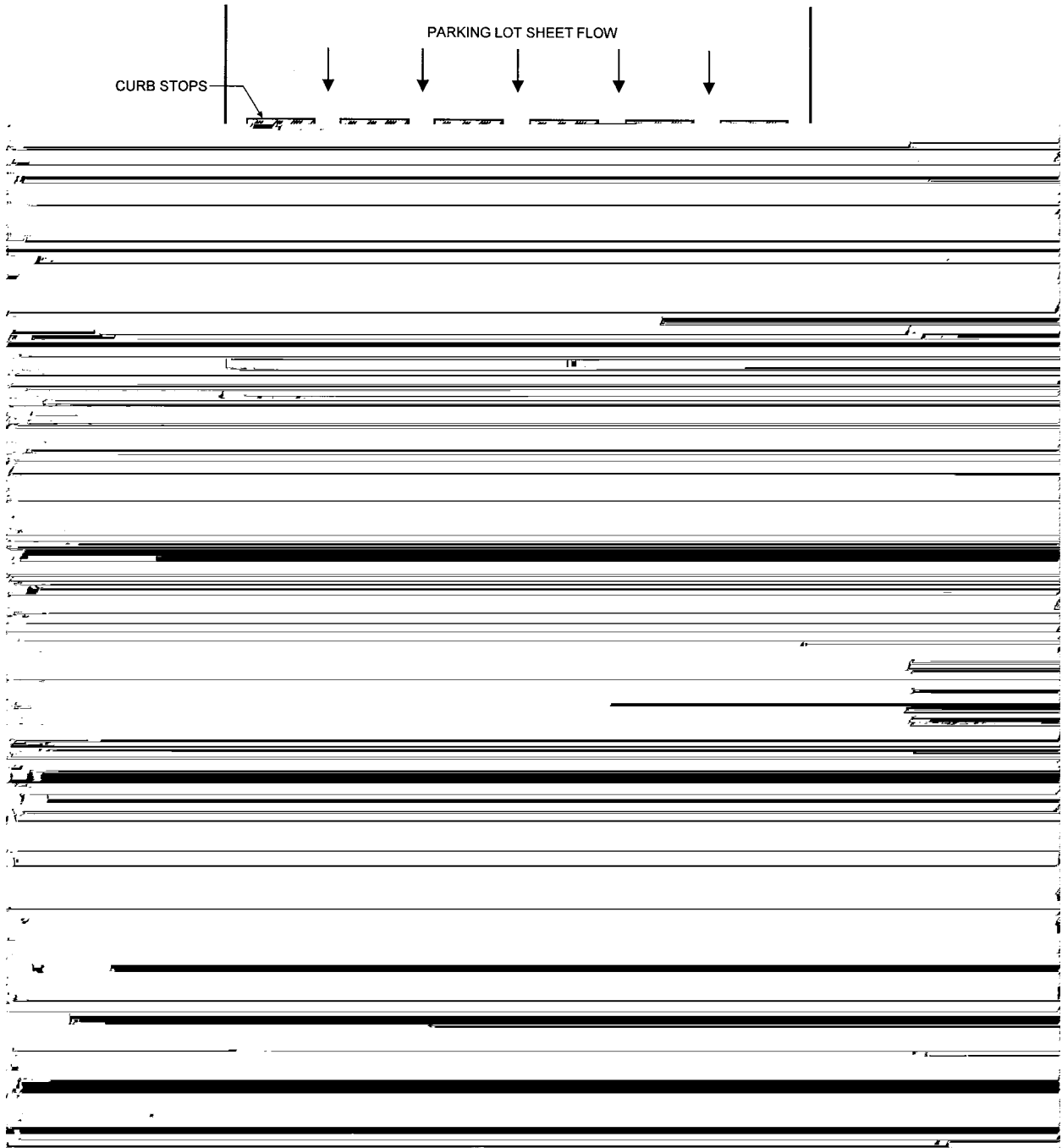


Figure 6.19 Bioretention (F-5)



Design Guidance

- Most stormwater filters require four to six feet of head, depending on site configuration and land area available. The perimeter sand filter (F-3), however, can be designed to function with as little as 18" to 24" of head.
- The recommended maximum contributing area to an individual stormwater filtering system is usually less than 10 acres. In some situations, larger areas may be acceptable.
- Sand and organic filtering systems are generally applied to land uses with a high percentage of impervious surfaces. Sites with imperviousness less than 75% will require full sedimentation pretreatment techniques.

Required Elements

- If runoff is delivered by a storm drain pipe or is along the main conveyance system, the filtering practice shall be designed off-line (see Appendix K).
- An overflow shall be provided within the practice to pass a percentage of the WQ_v to a stabilized water course. In addition, overflow for the ten-year storm shall be provided to a non-erosive outlet point (i.e., prevent downstream slope erosion).
- A flow regulator (or flow splitter/diversion structure) shall be supplied to divert the WQ_v to the filtering practice, and allow larger flows to bypass the practice.
- Stormwater filters shall be equipped with a minimum 4" perforated pipe underdrain (6" is preferred) in a gravel layer. A permeable filter fabric shall be placed between the gravel layer and the filter media.
- Require a minimum 2' separation between the filter bottom and groundwater.

Required Elements

- Dry or wet pretreatment shall be provided prior to filter media equivalent to at least 25% of the computed WQ_v . The typical method is a sedimentation basin that has a length to width ratio of 1.5:1. The Camp-Hazen equation is used to compute the required surface area for sand and organic filters requiring full sedimentation for pretreatment (WSDE, 1992) as follows:

- The required sedimentation basin area is computed using the following equation:

$$A_s = -(Q_o/W) \cdot \ln(1-E)$$

where:

- A_s = Sedimentation basin surface area (ft²)
- E = sediment trap efficiency (use 90%)
- W = particle settling velocity (ft/sec)
 - use 0.0004 ft/sec for imperviousness (I) ≤ 75%
 - use 0.0033 ft/sec for I > 75%
- Q_o = Discharge rate from basin = (WQ_v/24 hr/3600s)
- WQ_v=Water Quality Volume(cf)

This equation reduces to:

$$A_s = (0.066) (WQ_v) \text{ ft}^2 \text{ for } I \leq 75\%$$

$$A_s = (0.0081) (WQ_v) \text{ ft}^2 \text{ for } I > 75\%$$

Design Guidance

- Adequate pretreatment for bioretention systems should incorporate all of the following: (a) grass filter strip below a level spreader or grass channel, (b) gravel diaphragm and (c) a mulch layer.
- The grass filter strip should be sized using the guidelines in Table 6.2.

Table 6.2 Guidelines for Filter Strip Pretreatment Sizing								
Parameter	Impervious Parking Lots				Residential Lawns			
	Maximum Inflow Approach Length (ft.)	35		75		75		150
Filter Strip Slope	≤2%	≥2%	≤2%	≥2%	≤2%	≥2%	≤2%	≥2%
Filter Strip Minimum Length	10'	15'	20'	25'	10'	12'	15'	18'

- The grass channel should be sized using the following procedure:
 - Determine the channel length needed to treat the WQ_v, using sizing techniques described in the Grass Channel Fact Sheet (Chapter 5).
 - Determine the volume directed to the channel for pretreatment
 - Determine the channel length by multiplying the length determined in step 1 above by the ratio of the volume in step 2 to the WQ_v.

Required Elements

- The entire treatment system (including pretreatment) shall be sized to temporarily hold at least 75% of the WQ_v prior to filtration.
- The filter media shall consist of a medium sand (meeting ASTM C-33 concrete sand). Media used for organic filters may consist of peat/sand mix or leaf compost. Peat shall be a reed-sedge hemic peat.
- Bioretention systems shall consist of the following treatment components: A four foot deep planting soil bed, a surface mulch layer, and a six inch deep surface ponding area. Soils shall meet the design criteria outlined in Appendix H.

Design Guidance

- The filter bed typically has a minimum depth of 18". The perimeter filter may have a minimum filter bed depth of 12".
- The filter area for sand and organic filters should be sized based on the principles of Darcy's Law. A coefficient of permeability (k) should be used as follows:

Sand:	3.5 ft/day (City of Austin 1988)
Peat:	2.0 ft/day (Galli 1990)
Leaf compost:	8.7 ft/day (Claytor and Schueler, 1996)
Bioretention Soil:	0.5 ft/day (Claytor and Schueler, 1996)

The required filter bed area is computed using the following equation

$$A_f = (WQ_v) (d_f) / [(k) (h_f + d_f) (t_f)]$$

Where:

A_f = Surface area of filter bed (ft²)

WQ_v = Water Quality Volume (cf)

d_f = Filter bed depth (ft)

k = Coefficient of permeability of filter media (ft/day)

h_f = Average height of water above filter bed (ft)

t_f = Design filter bed drain time (days)

(1.67 days or 40 hours is recommended maximum t_f for sand filters, two days for bioretention)

Required Elements

- A dense and vigorous vegetative cover shall be established over the contributing pervious drainage areas before runoff can be accepted into the facility
- Landscaping is critical to the performance and function of bioretention areas. Therefore, a landscaping plan must be provided for bioretention areas.

Design Guidance

- Surface filters can have a grass cover to aid in pollutant adsorption. The grass should be capable of withstanding frequent periods of inundation and drought.
- Planting recommendations for bioretention facilities are as follows:
 - Native plant species should be specified over non-native species.
 - Vegetation should be selected based on a specified zone of hydric tolerance.
 - A selection of trees with an understory of shrubs and herbaceous materials should be provided.
 - Woody vegetation should not be specified at inflow locations.
 - Trees should be planted primarily along the perimeter of the facility.
 - A tree density of approximately one tree per 100 square feet (i.e., 10 feet on-center) is recommended. Shrubs and herbaceous vegetation should generally be planted at higher densities (five feet on-center and 2.5 feet on center, respectively).

Required Elements

- A legally binding and enforceable maintenance agreement shall be executed between the facility owner and the local review authority to ensure the following:
 - Sediment shall be cleaned out of the sedimentation chamber when it accumulates to a depth of more than six inches. Vegetation within the sedimentation chamber shall be limited to a height of 18 inches. The sediment chamber outlet devices shall be cleaned/repared when drawdown times exceed 36 hours. Trash and debris shall be removed as necessary.

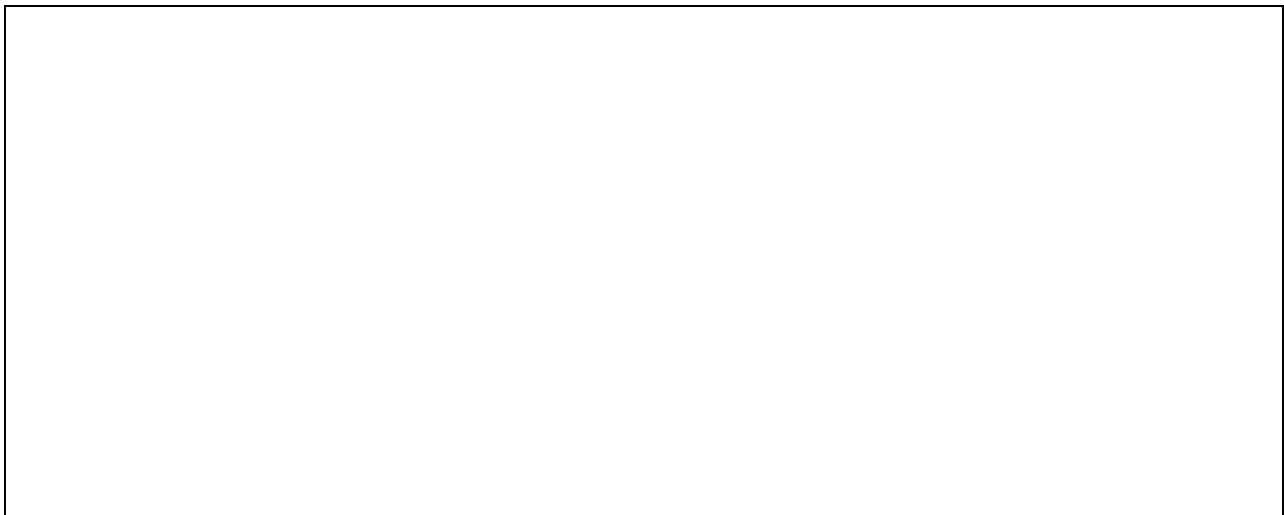
- Silt/sediment shall be removed from the filter bed when the accumulation exceeds one inch. When the filtering capacity of the filter diminishes substantially (i.e., when water ponds on the surface of the filter bed for more than 48 hours), the top few inches of discolored material shall be removed and shall be replaced with fresh material. The removed sediments shall be disposed in an acceptable manner (i.e., landfill).
- A stone drop (pea gravel diaphragm) of at least six inches shall be provided at the inlet of bioretention facilities (F-6). Areas devoid of mulch shall be re-mulched on an annual basis. Dead or diseased plant material shall be replaced.

Design Guidance

- Organic filters or surface sand filters that have a grass cover should be mowed a minimum of three times per growing season to maintain maximum grass heights less than 12 inches.

In cold climates, stormwater filtering systems need to be modified to protect the systems from freezing and frost heaving. The primary cold climate concerns to address with regards to filtering systems are:

- Freezing of the filter bed
- Pipe freezing
- Clogging of filter



Freezing of the Filter Bed

- Place filter beds for underground filter below the frost line to prevent the filtering medium from freezing during the winter.
- Discourage organic filters using peat and compost media, which are ineffective during the winter in cold climates. These organic filters retain water, and consequently can freeze solid and become completely impervious during the winter.
- Combine treatment with another SMP option that can be used as a backup to the filtering system to provide treatment during the winter when the filter is ineffective

Pipe Freezing

- Use a minimum 8" underdrain diameter in a 1' gravel bed. Increasing the diameter of the underdrain makes freezing less likely, and provides a greater capacity to drain standing water from the filter. The porous gravel bed prevents standing water in the system by promoting drainage. Gravel is also less susceptible to frost heaving than finer grained media.
- Replace standpipes with weirs, which can be "frost free." Although weir structures will not always provide detention, they can provide retention storage (i.e., storage with a permanent pool) in the pretreatment chamber.

Clogging of Filter with Excess Sand from Runoff

- If a filter is used to treat runoff from a parking lot or roadway that is frequently sanded during snow events, there is a high potential for clogging from sand in runoff. In these cases, the size of the pretreatment chamber should be increased to 40% of the treatment volume. For bioretention systems, a grass strip, such as a swale, of at least twenty-five feet in length should convey flow to the system.
- Filters should always be inspected for sand build-up in the filter chamber following the spring melt event.

Sand/ Organic Filters



Description: Multi-chamber structure designed to treat stormwater runoff through filtration, using a sediment forebay, a primary filter media and, typically, an underdrain collection system.

Design Variations: Surface Sand Filter (F-1), Underground Sand Filter (F-2), Perimeter Sand Filter (F-3), Organic Sand Filter (F-4)

KEY CONSIDERATIONS

CONVEYANCE

- If stormwater is delivered by stormdrain, design off-line.
- Overflow shall be provided to pass a fraction of the WQ_v to a stabilized watercourse.
- Overflow for the ten-year storm to a non-erosive point.
- Flow regulator needed to divert WQ_v to the practice, and bypass larger flows.
- Underdrain (4" perforated pipe minimum; 6" preferred)

PRETREATMENT

- Pretreatment volume of 25% of WQ_v .
- Typically a sediment basin with a 1.5:1 L:W ratio, sized with the Camp-Hazen equation (See Section 6.4.3)

TREATMENT

- System must hold 75% of the WQ_v
- Filter media shall be ASTM C-33 sand for sand filters
- Organic filters shall be a peat/sand mix, or leaf compost.
- Peat shall be reed-sedge hemic peat

LANDSCAPING

- Contributing area stabilized before runoff is directed to the facility

MAINTENANCE REQUIREMENTS:

- Legally binding maintenance agreement.
- Sediment cleaned out of sedimentation chamber when it reaches more than 6" in depth.
- Vegetation height limited to 18"
- Sediment chamber cleaned if drawdowns exceed 36 hours.
- Trash and debris removal
- Silt/sediment removed from filter bed after it reaches one inch.
- If water ponds on the filter bed for greater than 48 hours, remove material, and replace.

STORMWATER MANAGEMENT SUITABILITY

- Water Quality**
- Channel Protection**
- Overbank Flood Protection**
- Extreme Flood Protection**

Accepts Hotspot Runoff: Yes
(requires impermeable liner)

IMPLEMENTATION CONSIDERATIONS

- Capital Cost**
- Maintenance Burden**

Residential

Subdivision Use: No

High Density/Ultra-Urban: Yes

Drainage Area: 2-10 acres max.

Soils: No restrictions

Other Considerations:

Typically needs to be combined with other controls to provide water quantity control

Key: L=Low M=Moderate H=High

<u>POLLUTANT REMOVAL</u>	
G	Phosphorus
G	Nitrogen
G	Metals - Cadmium, Copper, Lead, and Zinc removal
F	Pathogens - Coliform, Streptococci, E.Coli removal
Key: G=Good F=Fair P=Poor	

Bioretention Areas (F-5)



Description: Shallow stormwater basin or landscaped area which utilizes engineered soils and vegetation to capture and treat runoff. The practice is often located in parking lot islands, and can also be used to treat residential areas.

<p style="text-align: center;"><u>KEY CONSIDERATIONS</u></p> <p>CONVEYANCE</p> <ul style="list-style-type: none"> • Provide overflow for the 10-year storm to the conveyance system. • Conveyance to the system is typically overland flow delivered to the surface of the system, typically through curb cuts or over a concrete lip. <p>PRETREATMENT</p> <ul style="list-style-type: none"> • Pretreatment consists of a grass channel or grass filter strip, a gravel diaphragm, and a mulch layer, sized based on the methodologies described in Section 6.4.2. <p>TREATMENT</p> <ul style="list-style-type: none"> • Treatment area should have a four foot deep planting soil bed, a surface mulch layer, and a 6" ponding layer. • Size the treatment area using equations provided in Chapter 6. <p>LANDSCAPING</p> <ul style="list-style-type: none"> • Detailed landscaping plan required. <p>MAINTENANCE</p> <ul style="list-style-type: none"> • Inspect and repair/replace treatment area components • Stone drop (at least 6") provided at the inlet • Remulch annually 	<p style="text-align: center;"><u>STORMWATER MANAGEMENT SUITABILITY</u></p> <p><input checked="" type="checkbox"/> Water Quality</p> <p><input type="checkbox"/> Channel Protection</p> <p><input type="checkbox"/> Overbank Flood Protection</p> <p><input type="checkbox"/> Extreme Flood Protection</p> <p>Accepts Hotspot Runoff: Yes <i>(requires impermeable liner)</i></p>
<p style="text-align: center;"><u>POLLUTANT REMOVAL</u></p> <p><input type="checkbox"/> G Phosphorus</p> <p><input type="checkbox"/> G Nitrogen</p> <p><input type="checkbox"/> G Metals - Cadmium, Copper, Lead, and Zinc removal</p> <p><input type="checkbox"/> F Pathogens – Coliform, Streptococci, E.Coli removal</p> <p style="text-align: center;">Key: G=Good F=Fair P=Poor</p>	<p style="text-align: center;"><u>IMPLEMENTATION CONSIDERATIONS</u></p> <p><input type="checkbox"/> M Capital Cost</p> <p><input type="checkbox"/> M Maintenance Burden</p> <p>Residential Subdivision Use: Yes</p> <p>High Density/Ultra-Urban: Yes</p> <p>Drainage Area: 5 acres max.</p> <p>Soils: <i>Planting soils must meet specified criteria; No restrictions on surrounding soils</i></p> <p>Other Considerations:</p> <ul style="list-style-type: none"> • <i>Use of native plants is recommended</i> <p style="text-align: center;">Key: L=Low M=Medium H=High</p>

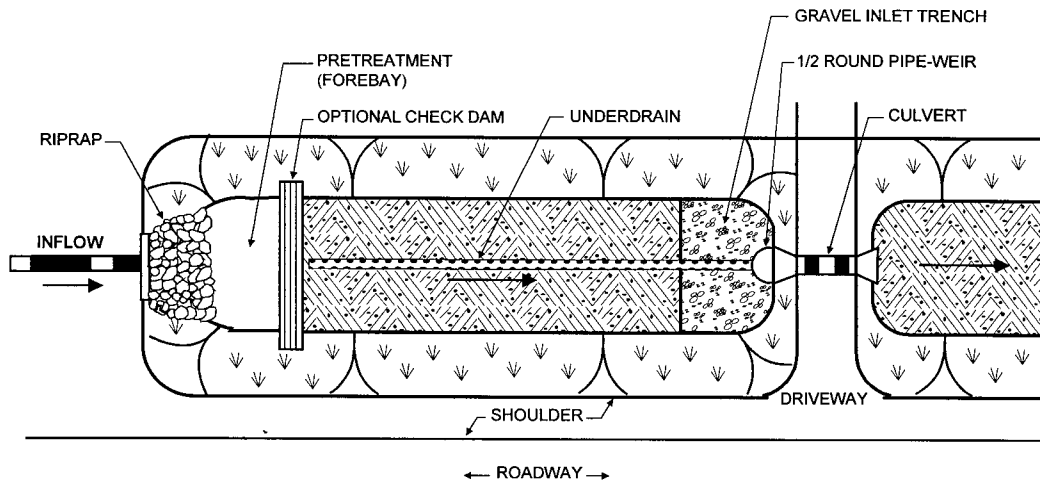
Section 6.5 Open Channel Systems

Open channel systems are vegetated open channels that are explicitly designed to capture and treat the full WQ_v within dry or wet cells formed by check dams or other means. Design variants include:

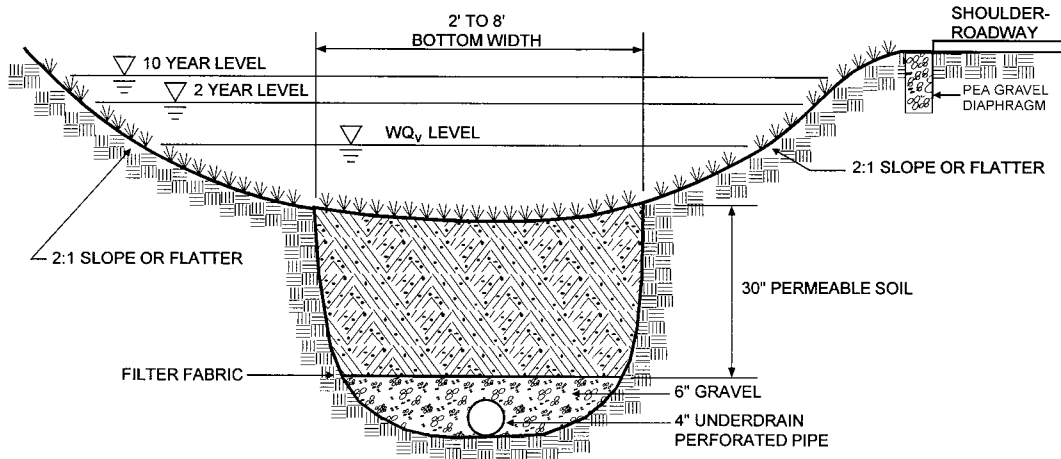
- O-1 Dry Swale (Figure 6.20)
- O-2 Wet Swale (Figure 6.21)

Treatment Suitability: Open Channel Systems can meet water quality treatment goals only, and are not appropriate for Cp_v or Q_p .

Figure 6.20 Dry Swale (O-1)

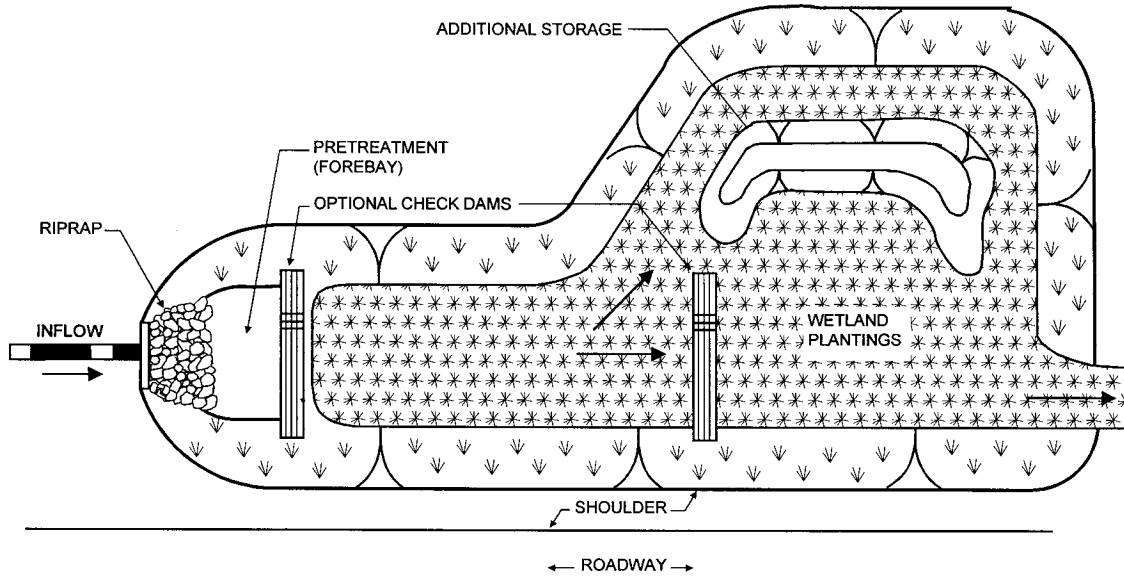


PLAN VIEW

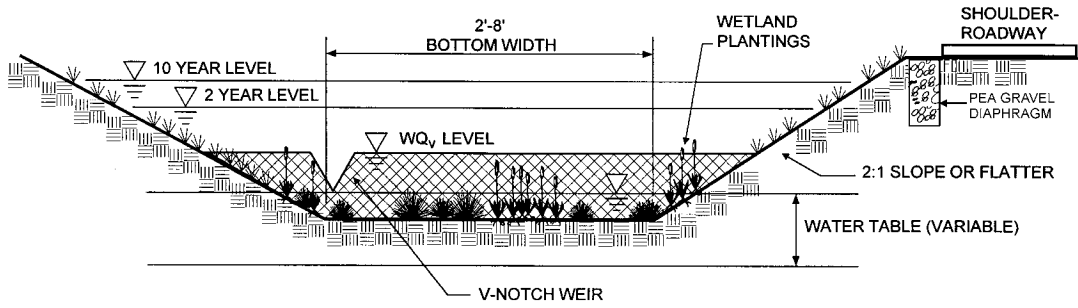


SECTION

Figure 6.21 Wet Swale (O-2)



PLAN VIEW



PROFILE

Required Elements

- The system shall have a maximum longitudinal slope of 4.0%

Design Guidance

- Dry Swales (O-1) are primarily applicable for land uses such as roads, highways, residential development, and pervious areas.
- Wet Swales (O-2) should be restricted in residential areas because of the potential for stagnant water and other nuisance ponding.
- Provide a 2' separation distance from groundwater for O-1.

Required Elements

- The peak velocity for the two-year storm must be non-erosive (i.e., 3.5-5.0 fps). (See Appendix L for a table of erosive velocities for grass and soil).
- Open channels shall be designed to safely convey the ten-year storm with a minimum of 6 inches of freeboard. Note that some agencies or local municipalities may design channel to convey a different design storm.
- The maximum allowable temporary ponding time within a channel shall be less than 48 hours. An underdrain system shall be used in the dry swale to ensure this ponding time.
- Channels shall be designed with moderate side slopes (flatter than 3:1) for most conditions. 2:1 is the absolute maximum side slope.

Design Guidance

- Open channel systems which directly receive runoff from impervious surfaces may have a 6 inch (maximum) drop onto a protected shelf (pea gravel diaphragm) to minimize the clogging potential of the inlet.
- The underdrain system should be composed of a 6" gravel bed with a 4" PVC pipe.
- If the site slope is greater than 2%, check dams may be needed to retain the water quality volume within the swale system.

Required Elements

- Provide 10% of the WQ_v in pretreatment. This storage is usually obtained by providing checkdams at pipe inlets and/or driveway crossings.

Design Guidance

- Utilize a pea gravel diaphragm and gentle side slopes along the top of channels to provide pretreatment for lateral sheet flows.

Required Elements

- Temporarily store the WQ_v within the facility to be released over a minimum 30 minute duration.
- Design with a bottom width no greater than eight feet to avoid potential gullyng and channel braiding, but no less than two feet.
- Soil media for the dry swale shall meet the specifications outlined in Appendix H.

Design Guidance

- Open channels should maintain a maximum ponding depth of one foot at the mid-point of the channel, and a maximum depth of 18" at the end point of the channel (for storage of the WQ_v).

Design Guidance

- Landscape design should specify proper grass species and wetland plants based on specific site, soils and hydric conditions present along the channel (see Appendix H for landscaping guidance for New York).

Required Elements

- A legally binding and enforceable maintenance agreement shall be executed between the facility owner and the local review authority to ensure the following:

- Sediment build-up within the bottom of the channel or filter strip is removed when 25% of the original WQ_v volume has been exceeded.
- Vegetation in dry swales is mowed as required during the growing season to maintain grass heights in the 4 to 6 inch range.

For open channel systems, the primary cold climate design challenges that need to be addressed are:

- Snowmelt infiltration on frozen ground
- Culvert freezing
- The impacts of deicers on channel vegetation.

Snowmelt Infiltration on Frozen Ground

- In order to ensure that the filter bed remains dry between storm events, increase the size of the underdrain pipe to a minimum diameter of 6" with a minimum 1' filter bed.
- The soil bed permeability of the dry swale should be NRCS class SM (NRCS, 1984), which is slightly higher than in the base criteria. This increased permeability will encourage snowmelt infiltration.

Culvert Freezing

- Use culvert pipes with a minimum diameter of 18".
- Design culverts with a minimum 1% slope where possible.

The Impacts of De-icers on Channel Vegetation

- Inspect open channel systems after the spring melt. At this time, residual sand should be removed and any damaged vegetation should be replaced.
- If roadside or parking lot runoff is directed to the practice, mulching may be required in the spring to restore soil structure and moisture capacity to reduce the impacts of deicing agents.
- Use salt-tolerant plant species in vegetated swales.

Open Channels



Description: Vegetated channels that are explicitly designed and constructed to capture and treat stormwater runoff within dry or wet cells formed by check dams or other means.

Design Options:
Dry Swale (O-1), Wet Swale (O-2)

<u>KEY CONSIDERATIONS</u>	<u>STORMWATER MANAGEMENT SUITABILITY</u>
<p>FEASIBILITY</p> <ul style="list-style-type: none"> Maximum longitudinal slope of 4% <p>CONVEYANCE</p> <ul style="list-style-type: none"> Non-erosive (3.5 to 5.0 fps) peak velocity for the 2-year storm Safe conveyance of the ten-year storm with a minimum of 6 inches of freeboard. Side slopes gentler than 2:1 (3:1 preferred). The maximum allowable temporary ponding time of 48 hours <p>PRETREATMENT</p> <ul style="list-style-type: none"> 10% of the WQ_v in pretreatment, usually provided using check dams at culverts or driveway crossings. <p>TREATMENT</p> <ul style="list-style-type: none"> Temporary storage the WQ_v within the facility to be released over a minimum 30 minute duration. Bottom width no greater than 8 feet, but no less than two feet. Soil media as detailed in Appendix H. <p>MAINTENANCE</p> <ul style="list-style-type: none"> Removal of sediment build-up within the bottom of the channel or filter strip when 25% of the original WQ_v volume has been exceeded. Maintain a grass height of 4" to 6" in dry swales. 	<p><input checked="" type="checkbox"/> Water Quality</p> <p><input type="checkbox"/> Channel Protection</p> <p><input type="checkbox"/> Overbank Flood Protection</p> <p><input type="checkbox"/> Extreme Flood Protection</p> <p>Accepts Hotspot Runoff: Yes <i>(requires impermeable liner)</i></p> <p style="text-align: center;"><u>IMPLEMENTATION CONSIDERATIONS</u></p> <p><input type="checkbox"/> Capital Cost</p> <p><input type="checkbox"/> Maintenance Burden</p> <p>Residential Subdivision Use: Yes High Density/Ultra-Urban: No Drainage Area: 5 acres max. Soils: No restrictions Other Considerations:</p> <ul style="list-style-type: none"> Permeable soil layer (dry swale) Wetland plants (wet swale) <p style="border: 1px solid black; padding: 2px;">Key: H=High M=Medium L=Low</p>
<p style="text-align: center;"><u>MANAGEMENT CAPABILITY</u></p> <p><input type="checkbox"/> G Phosphorus</p> <p><input type="checkbox"/> F Nitrogen</p> <p><input type="checkbox"/> G Metals - Cadmium, Copper, Lead, and Zinc removal</p> <p><input type="checkbox"/> P Pathogens - Coliform, Streptococci, E.Coli removal</p> <p style="border: 1px solid black; padding: 2px; text-align: center;">Key: G=Good F=Fair P=Poor</p>	

