

ACTIVITY: Water Quality Swales

Water Quality Swales



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

Variations: Swales can be wet or dry.

Components:

- Open trapezoidal or parabolic channel sized to store entire WQ_v . Dry swale infiltrates full WQ_v and wet swale retains WQ_v .
- Filter bed of permeable, engineered soils
- Underdrain system for impermeable soils (dry swale only)
- Wet cells created by check dams (wet swale only)
- Level spreaders every 50 feet, if length exceeds 100 feet.

Advantages/Benefits:

- Stormwater treatment combined with runoff conveyance
- Less expensive than curb and gutter
- Reduces runoff velocity
- Promotes infiltration

Disadvantages/Limitations:

- Higher maintenance than curb and gutter
- Cannot be used on steep slopes
- High land requirement
- Vector concerns (wet water quality swale)
- Requires \approx 3 feet of head

Design considerations:

- Longitudinal slopes less than 4%
- Bottom channel width of 2 to 8 feet
- Underlying soils must have good infiltration or must be replaced (dry swale)
- Side slopes of 3:1 or flatter; 4:1 recommended
- Convey the 10-year storm event with minimum 6 inches of freeboard.

Selection Criteria:

- Water Quality**
80 % TSS Removal
- Accepts Hotspot**
Runoff (impermeable liner required)
- Residential**
Subdivision
- High Density /**
Ultra Urban Use

Maintenance:

- Maintain grass heights
- Remove sediment from forebay and channel
- Remove accumulated trash
- Re-establish plants as needed

M **Maintenance Burden**

L = Low M = Moderate H = High

ACTIVITY: Water Quality Swales**General
Description**

Water quality swales, also known as “enhanced swales” or vegetated open channels, are channels that capture and treat the water quality volume for a site. They are specifically engineered to perform pollutant removal functions. Water quality swales have specific features that allow them to treat the Water Quality Volume (WQ_v). Water quality swales are designed with gradual longitudinal slopes that force runoff to slow down, which allow sediment to settle out while limiting channel erosion. Check dams or other mechanisms are installed perpendicular to the flow to further allow sediment to settle out and runoff to infiltrate.

There are two types of water quality swales, dry and wet:

Dry water quality swales: The dry swale is a vegetated channel that includes a filtering bed of permeable soils overlying an underdrain system. Dry swales are designed to filter or infiltrate the entire WQ_v through this filter bed and underdrain system. Dry swales rely primarily on the filtration mechanism to remove stormwater pollutants. *If it can be demonstrated that the swale can infiltrate the WQ_v within 24 to 48 hours (24 hours is preferred) without an underdrain, the swale may be designed without the underdrain.*

Wet water quality swale: The wet swale is a vegetated channel, also called a wetland channel that acts as a shallow wetland system that retains the WQ_v. The channel supports wetland vegetation in shallow marshy conditions. Usually impermeable or poorly drained soils are necessary to support the sufficient retention of water. Wet swales remove pollutants through sediment settling and biological removal. A wet swale does not require an underdrain.

Enhanced swales can be used in a variety of development types; however, they are primarily applicable to residential and institutional areas of low to moderate density where the impervious cover in the contributing drainage area is relatively low. They can also be used along roads and highways. Dry swales are mainly used in moderate to large lot residential developments, small impervious areas (parking lots and rooftops), and along rural highways. Wet swales tend to be used for highway runoff applications, small parking areas, and in commercial developments as part of a landscaped area. Because of their relatively large land requirement, enhanced swales are generally not used in higher density areas. In addition, wet swales may not be desirable for some residential applications, due to the presence of standing water, which may create nuisance odor or mosquito problems.

The topography and soils of a site will determine the applicability of the use of one of the two enhanced swale designs. Overall, the topography should allow for the design of a swale with sufficient slope and cross-sectional area to maintain nonerosive velocities. The following criteria should be evaluated to ensure the suitability of a water quality swale for meeting stormwater management objectives on a site or development.

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Site and Design Considerations

The following design and site considerations must be incorporated into the design for a water quality swale:

Location:

1. Channels must be sited so that the longitudinal slope is less than 4%. *Drop structures*, which disrupt flow by producing a pool of water behind them and a short drop in the surface gradient for water flowing over the structure, may be used to reduce the velocity of water in areas with greater slopes. Drop structures include check dams.
2. The water quality swale should have a contributing drainage area of five acres or less to prevent problems with distributing flow evenly across the swale.
3. Wet swales may be used where the water table is very high (at or near the surface of the soil) *or* where the water balance in poorly drained soils will support wetland vegetation.

General Design:

4. Both wet and dry water quality swales are designed to treat for water quality, but also to pass larger storms. Runoff enters the channel through a pretreatment forebay. In addition, distributed flow can enter along the sides of the channel after passing through a flow spreader such as a pea gravel diaphragm, level 2 x 12 timbers, or other level spreader along the bank of the channel.
5. Dry water quality swale: consists of an open channel with a filter bed of permeable soils overlaying an underdrain system. Water flows into the channel where it is filtered through the permeable bed. After being filtered, the runoff is conveyed through a perforated pipe and underdrain system to the outlet. A schematic is found in Figure 5.1.
6. Wet water quality swale: consists of an open channel excavated to the water table or to poorly drained soils. Check dams divide the channel into cells. A schematic is found in Figure 5.2.

Physical Specifications:

7. Swales can incorporate raised inlets (4 to 6 inches) to allow for the retention of initial runoff volume.
8. Channel slopes of 1% to 2% and no greater than 4% are recommended. If steeper slopes are necessary, 6 to 12 inch drop structures (see #1 above) can be used to limit runoff energy. Energy dissipators must be installed below drop structures and drop structures must be no closer than 50 feet. The depth of the water at the downstream end of the swale must not exceed 18 inches.
9. Both dry and wet water quality swales must have a bottom channel width of 2 to 8 feet. Wider channels may be installed if designed with berms, walls, or a multi-level cross-section that prevent the channel from meandering and eroding.
10. Cross-sections of dry and wet swales are to be parabolic or trapezoidal with moderate slopes of no greater than 3:1. More gentle slopes of 4:1 are recommended.

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Site and Design Considerations (Continued)

11. Minimum width should be determined using Manning’s equation, with an n of 0.2 to 0.24.
12. Maximum length of the swale shall be 100 feet unless level spreaders are used. Level spreaders shall be placed at least every 50 feet. Maximum length without a level spreader is 80 feet.
13. The maximum ponding depth of the WQ_v must be no greater than 18 inches at the downstream end of the swale. The average ponding depth should be 12 inches.
14. The maximum velocity should be no more than 0.9 feet per second.

Physical Specifications—Dry Swale:

15. Dry swale channels are sized to store and infiltrate the entire water quality volume (WQ_v) with less than 18 inches of ponding and allow for full filtering through the permeable soil layer. The maximum ponding time is 48 hours, though a 24-hour ponding time is more desirable. Refer to PTP-01 for orifice sizing.
16. The bed of the dry swale consists of a permeable soil layer of at least 30 inches in depth, above a 4-inch diameter perforated pipe (AASHTO Schedule 40) longitudinal underdrain in a 6-inch gravel layer. The soil media should have an infiltration rate of at least 0.5 inches/hour (maximum 0.75 inches/hour) and contain a high level of organic material to facilitate pollutant removal. A permeable filter fabric is placed between the gravel layer and the overlying soil.

Table 5.1 Infiltration Rates of Common Soil Types

Common Soil Types	Infiltration Rates (inches/hour)
Coarse Sand	¾ to 2
Fine Sand	½ to 1
Fine Sandy Loam	1/3 to ¾
Silt Loam	¼ to 4/10
Clay Loam	1/10 to ¼

(Source: NRCS, USDA www.soils.usda.gov)

17. The channel and underdrain excavation should be limited to the width and depth specified in the design. The bottom of the excavated trench shall not be loaded in a way that causes soil compaction, and scarified prior to placement of gravel and permeable soil. The sides of the channel shall be trimmed of all large roots. The sidewalls shall be uniform with no voids and scarified prior to backfilling.

Physical Specifications—Wet Swale:

18. Wet swale channels are sized to retain the entire water quality volume (WQ_v) with less than 18 inches of ponding at the maximum depth point.
19. Check dams can be used to achieve multiple wetland cells. V-notch weirs in the check dams can be utilized to direct low flow volumes.

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Site and Design Considerations (Continued)

Pretreatment/Inlets

- 20. Inlets to enhanced swales must be provided with energy dissipators such as riprap.
- 21. Pretreatment of runoff in both a dry and wet swale system is typically provided by a sediment forebay located at the inlet. The pretreatment volume should be equal to 0.1 inches per impervious acre. This storage is usually obtained by providing check dams at pipe inlets and/or driveway crossings.
- 22. Enhanced swale systems that receive direct concentrated runoff may have a 6-inch drop to a flow spreader at the upstream end of the control.
- 23. A flow spreader and gentle side slopes should be provided along the top of channels to provide pretreatment for lateral sheet flows.

Outlet Structures

- 24. *Dry water quality swale* underdrain system must discharge to the storm drainage infrastructure or a stable outfall.
- 25. *Wet water quality swales* must have outlet protection at any outlet so that scour and downstream erosion do not occur.

Other Considerations

- 26. Water quality swales must be designed to safely pass flows that exceed the design storm flows.
- 27. Maintenance access must be provided for all swales.
- 28. Landscaping must specify grass species and/or wetland plants that will thrive under the hydric and soils conditions at the particular site.

As-Built Certification Considerations

After the water quality swale has been constructed, the developer must have an as-built certification of the swale prepared by a registered Professional Engineer and submit it to Metro. The as-built certification verifies that the BMP was installed as designed and approved.

The following components must be addressed in the as-built certification:

- 1. Appropriate underdrain system for dry swales.
- 2. Correctly sized treatment volume.
- 3. Poor soils or groundwater table interface for wet swales.
- 4. Adequate vegetation in place.
- 5. Overflow system in place for high flows.

Maintenance

Each BMP must have an Operations and Maintenance agreement that is submitted to Metro for approval and is maintained and updated by the BMP owner. Refer to Volume 1 Appendix C for the Operation and Maintenance Agreement for swales areas, as well as an inspection checklist. The O&M Agreement must be completed and submitted to Metro with site plans. The BMP owner must maintain and update the BMP operations and maintenance plan. At a minimum, the operations and maintenance plan must address:

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**Maintenance
(Continued)**

1. Inspection and repair/replacement of treatment components.
2. Maintain vegetation at heights of 8 inches or less to prevent thinning of vegetative cover, which lessens swale effectiveness.
3. Removal of debris or dead vegetation.

Landscaping

Dry Swale: Turf grass species appropriate for Metro conditions should be used for dry swale vegetation.

Wet Swale: Emergent vegetation should be planted or wetland soils can be spread on the swale bottom for seeding. Where wetland swales do not intercept the groundwater table, a water balance calculation should be performed to ensure that the swale has a water budget adequate to support wetland species. The water balance calculation is found in the stormwater Constructed Wetland BMP, PTP-02.

**Design
Procedures**

Step 1. Compute the Water Quality Volume.

Calculate the Water Quality Volume (WQ_v), which is the volume that must be stored in the swale.

$$WQ_v = P \times R_v \times A / 12$$

Where:

WQ_v = water quality treatment volume, ac-ft

P = rainfall for the 85th percentile storm event (1.1 in)

R_v = runoff coefficient (see below)

A = site area, acres

$$R_v = 0.015 + 0.0092I$$

Where:

I = site impervious cover, % (for example, 50% equals 50)

Step 2. Determine if the development site and conditions are appropriate for the use of an enhanced swale system (dry or wet swale).

See the *Site and Design considerations*, above.

Step 3. Determine pretreatment volume.

The forebay should be sized to contain 0.1 inches per impervious acre of contributing drainage. The forebay storage volume (F_v) counts toward the total WQ_v requirement and may be subtracted from the WQ_v for subsequent calculations.

$$F_v = 0.1 \text{ inches} \times A_I \text{ acres} \times .0833$$

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**Design
Procedures
(Continued)**

Where:

F_v = Forebay volume (ac-ft)

A_I = Impervious area of drainage basin, acres

0.0833 = conversion factor of acre inches to acre feet

Often, it is more manageable to work with forebay volumes in cubic feet rather than acre feet, because they are small volumes. To convert F_v in acre feet to cubic feet, multiply F_v by 43560 square feet.

Step 4. Determine swale dimensions.

Size bottom width, depth, length, and slope necessary to store WQ_v with less than 18 inches of ponding at the downstream end.

Channel slope cannot exceed 4% (1% to 2% recommended). For more steeply sloped areas, swale must be “stepped” with check dams or similar structures to maintain slope.

Bottom width should range from 2 to 8 feet

Length to width ratio of 5:1 is suggested.

Ensure that side slopes are no greater than 3:1 (4:1 recommended)

See *Site and Design Considerations*, above.

Step 5. Compute number of check dams or similar structures required to detain WQ_v .

Step 6 Calculate drawdown time in the swale.

Dry Swale: Planting soil, 30 inches, should pass a maximum rate of 1.5 feet/day and must completely filter WQ_v in 48 hours.

Wet Swale: Must hold WQ_v .

Step 7 Check 2-year velocity erosion potential and provide 6 inches of freeboard above 10-year storm.

Step 8 Design low flow orifice at downstream headwalls and checkdams.

Design orifice to pass WQ_v in six hours. See PTP-01 Stormwater Ponds for information on orifice sizing.

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**Design
Procedures
(Continued)**

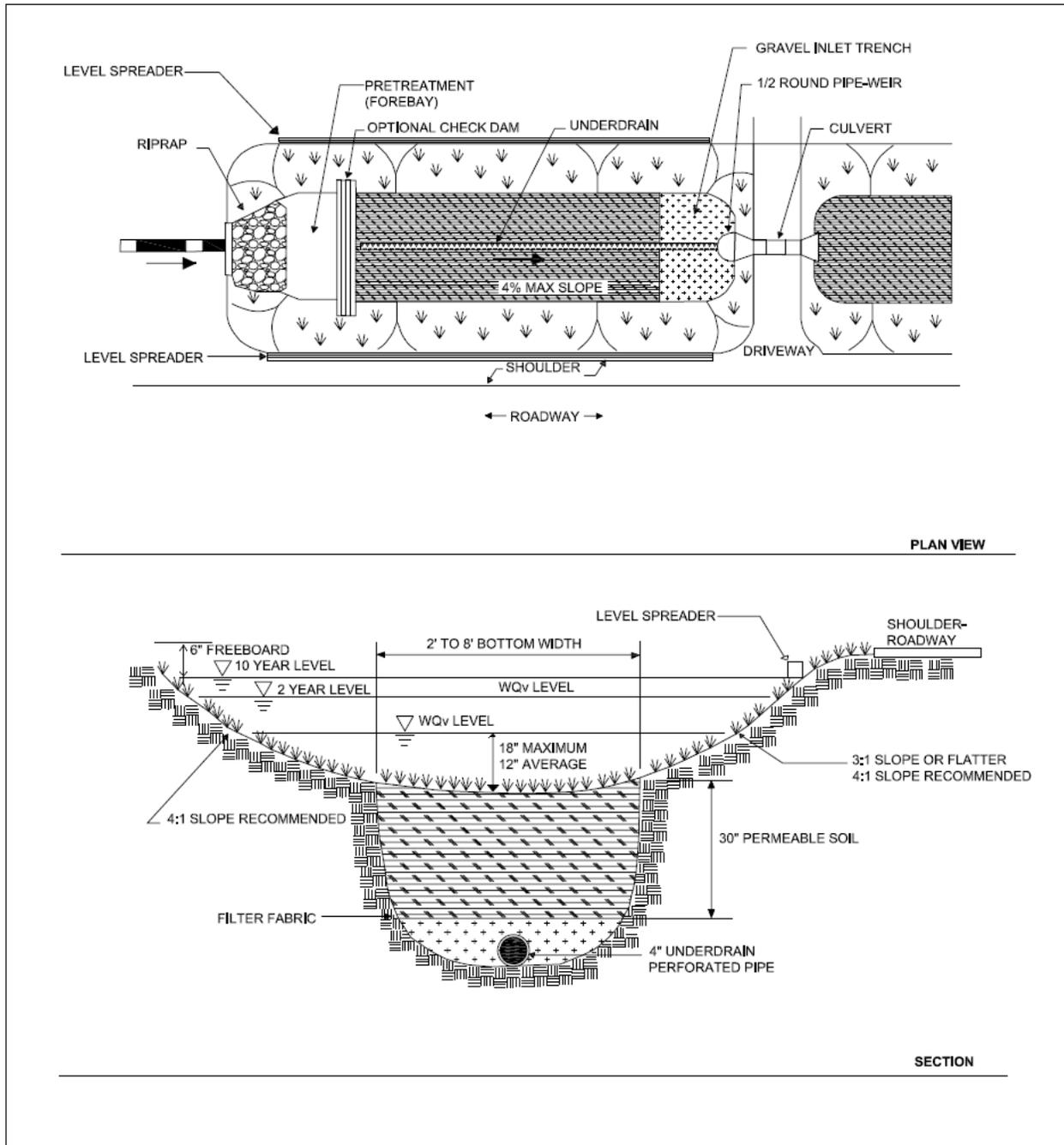
Step 9. Design inlets, sediment forebays and underdrain system (dry swale).

See *Site and Design Considerations*, above.

Step 10 Prepare Vegetation and Landscaping Plan.

A landscaping plan for a dry or wet swale should indicate how the enhanced swale system will be stabilized and established with vegetation.

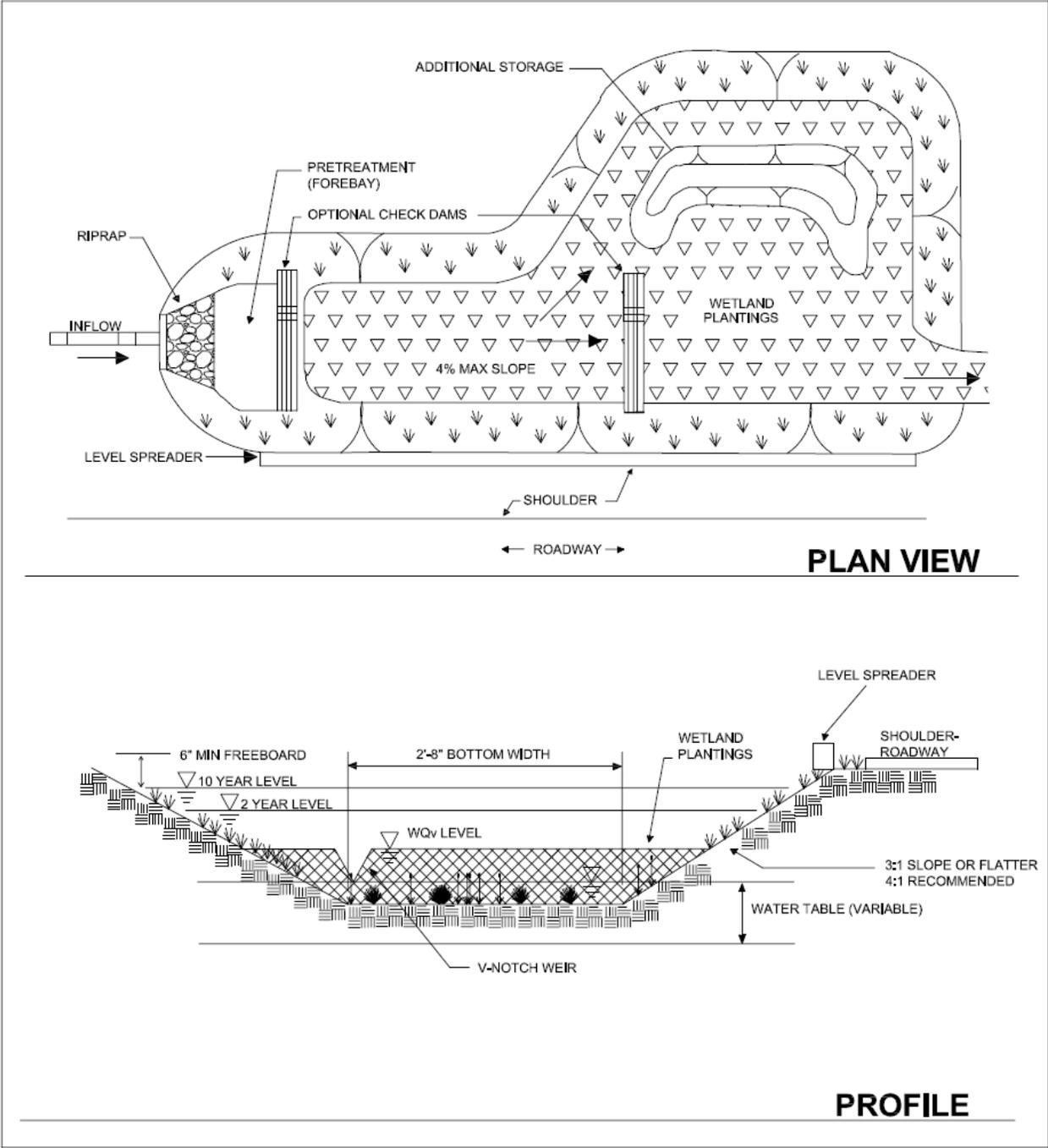
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(Adapted from the Center for Watershed Protection)

Figure 5.1 Dry Water Quality Swale

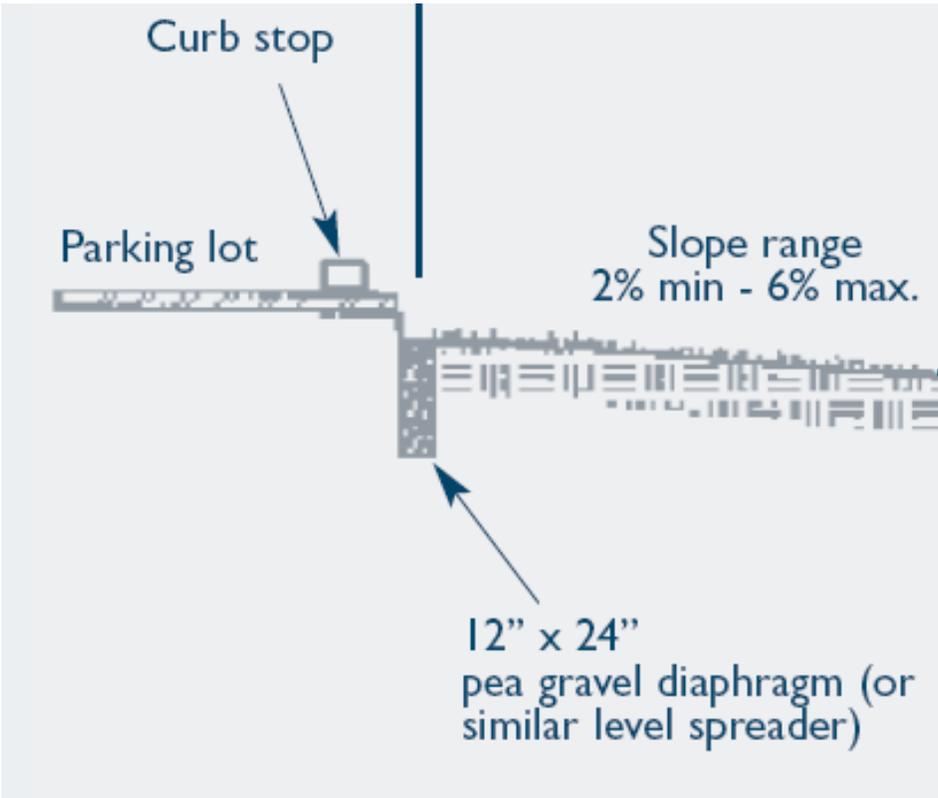
ACTIVITY: Water Quality Swales



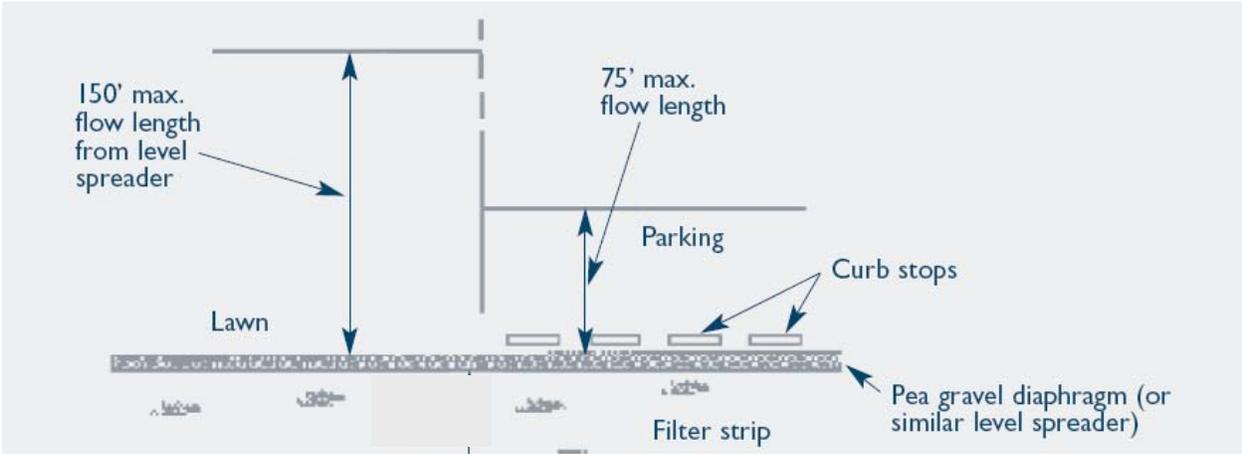
(Adapted from the Center for Watershed Protection)

Figure 5.2 Wet Water Quality Swale

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PLAN VIEW



PROFILE

(Source: Connecticut Stormwater Management Manual)

**Figure 5.3 Example of Level Spreader
(for Swales Receiving Directly Connected Runoff)**

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Suggested Reading

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