

## Grassed Swales



### Practice Description

In the context of BMPs to improve water quality, the term swale (a.k.a. grassed channel, dry swale, wet swale, biofilter, or bioswale) refers to vegetated, open-channel management practices designed specifically to treat and attenuate stormwater runoff for a specified water quality volume. Swales remove pollutants from stormwater by biofiltration, settling, and infiltration. Grassed swales filter pollutants as stormwater runoff moves through the leaves and roots of the grass. By reducing flow velocities and increasing a site's time of concentration, grassed swales contribute to reducing runoff peaks. Grassed swales that are designed with check dams or incorporate depression storage promote infiltration and can help contribute to satisfying a site runoff capture/storage requirement.

Variations of the grassed swale include the grassed channel, dry swale, and wet swale. The specific design features and methods of treatment differ in each of these designs, but all are improvements on the traditional drainage ditch. These designs incorporate modified geometry and other features for use of the swale as a treatment and conveyance practice.

### Planning Considerations

Grassed swales can be applied in most situations with some restrictions. Swales are well suited for treating highway or residential road runoff because they are linear practices. Swales are also useful as one of a series of stormwater BMPs or as part of a treatment train, for instance, conveying water to a detention pond and receiving water from filter strips. Furthermore, swales are highly recommended by the proponents of design approaches such as Low Impact Development and Better Site Design.

The use of grassed swales in new development can be a cost-effective alternative to curb and gutter installation. The swale practices are considered more aesthetically pleasing, although there is the potential for standing water and possible mosquito infestations.

The effectiveness of a swale in both reducing the flow rates and volume of runoff, and removing pollutants, is a function of the size and composition of the drainage area, the slope and cross section of the channel, the permeability of the soil, the density and type of vegetation in the swales, and the swale dimensions. Broad swales on flat slopes with dense vegetation are the most effective. Removal efficiencies are highest for sediment-bound pollutants.

## Design Criteria

In addition to the broad applicability concerns described above, designers need to consider site conditions. In addition, they need to incorporate design features to improve the longevity and performance of the practice while minimizing the maintenance burden.

### Converting Erosion- and Sediment-Control Devices

Swales are often used as erosion- and sediment-control measures during active construction. The same swales can later be used as grassed swale BMPs; however, all of the sediment must be removed, the channel configuration and slope must be re-established (if necessary), and the proper vegetation must be established. See the Grass Swale practice under Runoff Conveyance in Chapter 4 of Volume 1 of this Manual for more information on grass swales as erosion- and sediment-control devices.

### Siting Considerations

In addition to considering the restrictions and adaptations of grassed swales to different regions and land uses, designers need to ensure that this management practice is feasible at the site in question because some site conditions (i.e., steep slopes, highly impermeable soils) might restrict the effectiveness of grassed channels.

#### Drainage Area

Grassed swales should generally treat runoff from small drainage areas (less than 5 acres). If used to treat larger areas, the flows through the swale become too large to produce designs to treat stormwater runoff in addition to conveyance.

#### Capacity

The capacity of the swale must also be checked to ensure that it will be adequate after vegetation is fully established. The resistance to flow should be evaluated using the NRCS retardance factor for the vegetation selected (consult *Grass Swale* in Chapter 4 of Volume 1).

The flow depth of the design event should be evaluated using Manning's equation for the swale type used (parabolic, trapezoidal, or V-shaped). The design requirement is that the

swales convey the design discharge while maintaining a 0.5-foot freeboard and without exceeding the maximum permissible velocity.

If driveways or roads cross the swale, the capacity of the culvert crossing the road or driveway may determine the depth of flow for the design event. In these instances, the culverts should be checked to establish that the backwater elevation does not exceed the banks of the swale. If the culvert discharges to a minimum tailwater condition, the exit velocity for the culvert should be evaluated for design conditions. If the maximum permissible velocity is exceeded at the culvert outlet, riprap or another measure to prevent scour must be used.

## **Slope**

Grassed swales should be used on sites with relatively flat slopes of less than 4 percent slope; 1 to 2 percent slope is recommended. When site conditions require installing the swales in areas with larger slopes, check dams can be used to reduce the influence of the slope. Runoff velocities within the channel become too high on steeper slopes. This can cause erosion and does not allow for infiltration or filtering in the swale.

## **Soils/Topography**

Grassed swales can be used on most soils, with some restrictions on the most impermeable soils. In the dry swale (see Design Variations section below), a fabricated soil bed replaces on-site soils in order to ensure that runoff is filtered as it travels through the soils of the swale.

## **Groundwater**

The required depth to groundwater depends on the type of swale used. In the dry swale and grassed channel options, the bottom of the swale should be constructed at least 2 feet above the groundwater table to prevent a moist swale bottom or contamination of the groundwater. In the wet swale option, treatment is provided by creating a standing or slow-flowing wet pool, which is maintained by intersecting the groundwater.

## **Design Considerations**

Although there are different design variations of the grassed swale (see Design Variations), some design considerations are common to all designs. An overriding similarity is the cross-sectional geometry. Swales often have a trapezoidal or parabolic cross section with relatively flat side slopes (flatter than 3:1), though rectangular and triangular channels can also be used. Designing the channel with flat side slopes increases the wetted perimeter. The wetted perimeter is the length along the edge of the swale cross section where runoff flowing through the swale contacts the vegetated sides and bottom. Increasing the wetted perimeter slows runoff velocities and provides more contact with vegetation to encourage sorption, filtering, and infiltration. Another advantage to flat side slopes is that runoff entering the grassed swale from the side receives some pretreatment along the side slope.

Another similarity among designs is the type of pretreatment needed. In all design options, a small forebay should be used at the front of the swale to trap incoming

sediments. A pea gravel diaphragm, a small trench filled with river-run gravel, should be constructed along the length of the swale and used as pretreatment for runoff entering the sides of the swale. Other features designed to enhance the performance of grassed swales are a flat longitudinal slope (generally between 1 percent and 2 percent) and a dense vegetative cover in the channel. The flat slope helps to reduce the flow velocity within the channel. The dense vegetation also helps reduce velocities, protects the channel from erosion, and acts as a filter to treat stormwater runoff. During construction, it is important to stabilize the channel while the vegetation is becoming established, either with a temporary grass cover or with natural or synthetic erosion-control products. In addition to treating runoff for water quality, grassed swales must convey runoff from larger storms safely. Typical designs allow the runoff from the 2-year storm (i.e., the storm that occurs, on average, once every two years) to flow through the swale without causing erosion. Swales should also have the capacity to pass larger storms (typically a 10-year storm) safely.

### **Ponding and Infiltration**

Ponding can be beneficial if intended and accepted, or it can be a negative if unintended. If unintended and not designed for, extended periods of standing water may result in nuisance conditions and create complaints from residents. Mosquitoes are typically the biggest concern; however, they should generally not be a problem because of the frequent flushing of the ponded water. Also, if wetland vegetation develops, mosquito predators such as other insects and birds often mitigate the mosquito problem. If wetland vegetation and standing water are persistent concerns, these problems can be reduced by maintaining more uniform, steeper slopes in the swale invert or by installing underdrains.

If temporary retention of small amounts of water is desired for enhanced treatment of the stormwater and ecological and visual diversity, there are many ways to achieve that goal. The paragraphs below discuss several methods for retaining water or otherwise modifying the typical swale hydrology. The retained water will infiltrate, be lost through evapotranspiration, or slowly released downstream. It should be noted that the maximum allowable ponding time within a channel is 48 hours, and an underdrain system must be provided if that requirement cannot be met.

### **Check Dams**

A check dam is constructed of earth, stone, or timber 3 to 6 inches high to retain runoff from routine events. A weep hole may be added to enable the area behind an earthen or timber dam to drain slowly. However, the weep hole may be subject to clogging. Shorter check dams can act as level spreaders to help distribute the flow along the swale's cross section.

### **Elevated Drop Inlets**

A drop inlet can be used when a combined system of swales and storm sewers is being used. The swales would serve as the collector system, and the inlet into the main storm sewer system would be elevated slightly to retain runoff from routine events. The height of elevation would depend on the soil, the slope of the swale, and the tolerance for ponding. Wetland vegetation may develop in the ponded areas if the underlying soils are poorly drained.

**Elevated Culverts**

Elevated culverts are used for the same purpose as check dams and elevated drop inlets, to retain runoff from routine events. As with elevated drop inlets, wetland vegetation may develop in the ponded areas if the underlying soils are poorly drained.

**Depression Storage**

Small depressions along the bottom of the swale will trap and store stormwater for later infiltration into the soils. These depressions will also likely accumulate sediment at a quicker pace than other parts of the swale, and will also probably develop wetland vegetation.

**Underdrains**

Underdrains can enhance the performance of swales by providing additional filtration through soil, similar to the process that takes place in bioretention facilities. These “bioretention” swales have a layer of engineered soil underlain by a gravel layer surrounding a perforated pipe. This configuration also reduces ponding time where standing water may be a concern.

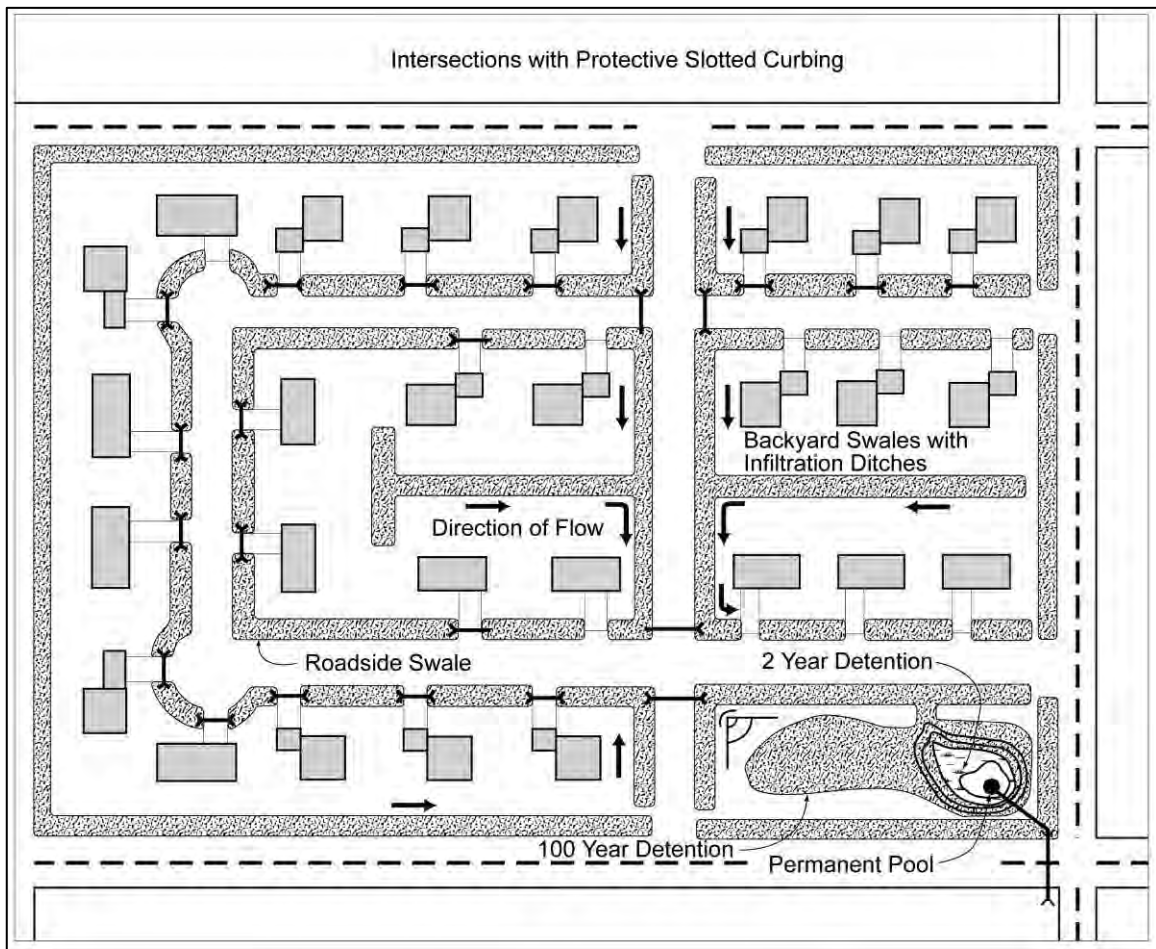


Figure 1 Schematic of Plan for Retrofit of Grassed Swales in Residential Subdivision

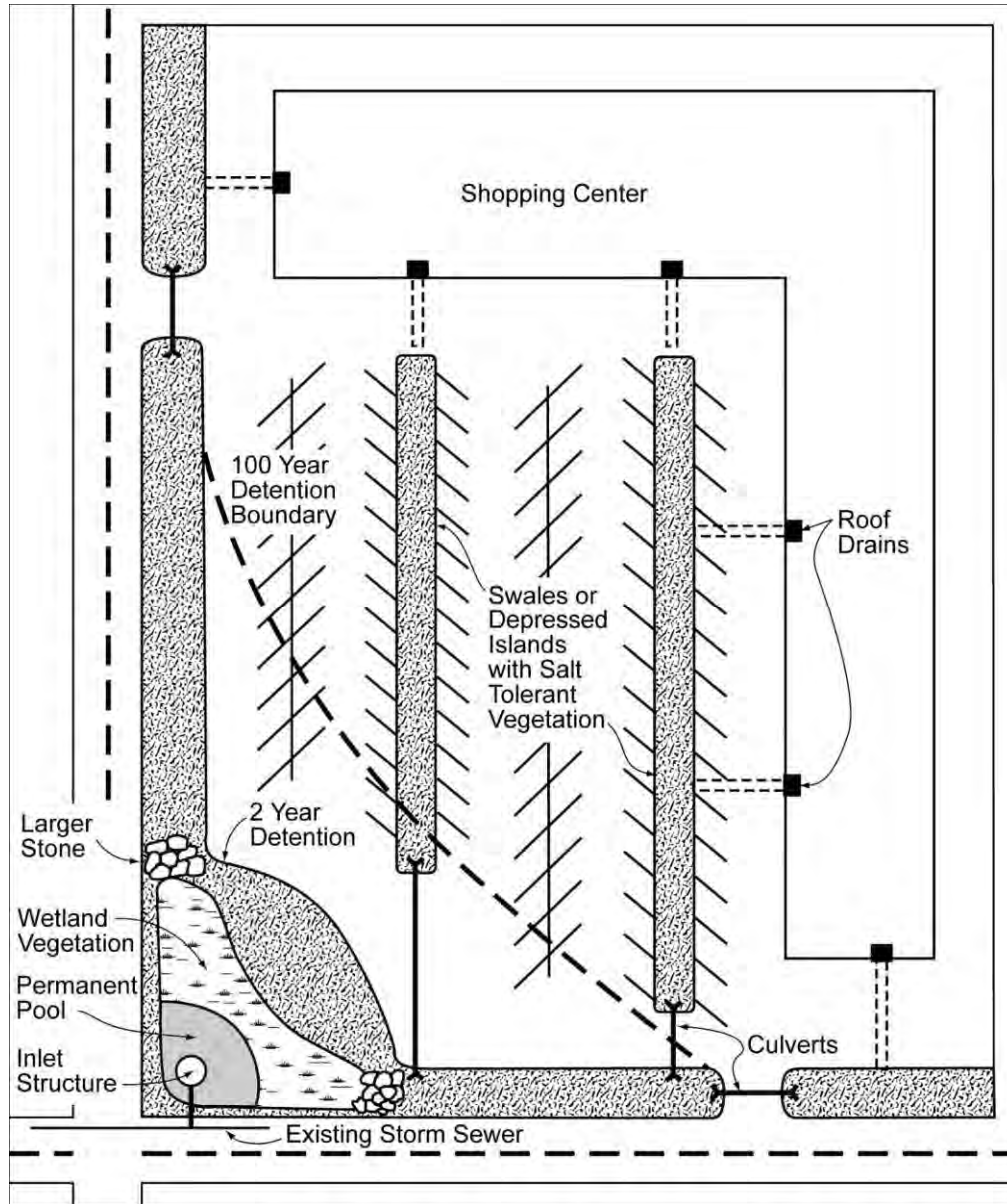


Figure 2 Example of Grassed Swale Used for Parking Lot

## Design Variations

The following discussion identifies three variations of open-channel practices—the grassed channel, dry swale, and wet swale.

### Grassed Channel

Of the three grassed swale designs, grassed channels are the most similar to a conventional drainage ditch, with the major differences being flatter side slopes and longitudinal slopes, and a slower design velocity for water quality treatment of small storm events. Of all of the options, grassed channels are the least expensive but also provide the least reliable pollutant removal. An excellent application of a grassed channel is as pretreatment to other structural stormwater practices. A major difference between the grassed channel and many other structural practices is the method used to size the practice. Most stormwater-management water quality practices are sized by volume. This method sets the volume available in the practice equal to the water quality volume, or the volume of water to be treated in the practice. The grassed channel is a flow rate-based design. Based on the peak flow from the water quality storm, the channel should be designed so that runoff takes, on average, 10 minutes to flow from the top to the bottom of the channel. A procedure for this design can be found in *Design of Stormwater Filtering Systems* (CWP, 1996).

### Dry Swales

Dry swales are similar in design to bioretention areas (see *Bioretention Practice*). These designs incorporate a fabricated soil bed into their design. The native soil is replaced with a sand/soil mix that meets minimum permeability requirements. An underdrain system is installed at the bottom of the soil bed. This underdrain is a gravel layer that encases a perforated pipe. Stormwater treated in the soil bed flows into the underdrain, which routes this treated stormwater to the storm drain system or receiving waters. Dry swales are a relatively new design, but studies of swales with a native soil similar to the man-made soil bed of dry swales suggest high pollutant removal.

### Wet Swales

Wet swales intersect the groundwater and behave similarly to a linear wetland cell (see *Constructed Stormwater Wetland Practice*). This design variation incorporates a shallow permanent pool and wetland vegetation to provide stormwater treatment. This design also has potentially high pollutant removal. Wet swales are not commonly used in residential or commercial settings because the shallow standing water may be a potential mosquito breeding area.

## Construction Considerations

To maximize the infiltration capacity of the swale, compaction of the soil underlying the swale should be avoided. For example, equipment for excavating or grading should operate from the side of the swale instead of the bottom of the swale.



Before vegetation is established in a swale, the swale is particularly vulnerable to scour and erosion. Therefore, protecting the seedbed with a temporary erosion-resistant lining (such as a geosynthetic or fiberglass roving) or other suitable erosion controls is generally necessary. Most vendors will furnish information about the Manning's coefficient ( $n$ ) and will also specify the maximum permissible velocity or allowable unit tractive force (also referred to as the "tractive stress") for the lining material. Swales should be constructed and vegetated early in the construction schedule, preferably before area grading and paving increase the rate of runoff.

Temporary erosion-resistant channel linings should be used to stabilize the swale until the vegetation becomes established. The vendor's instructions for installing channel linings should be followed. If velocities will be high, designers should consider sodding the swale or diverting runoff until vegetation is established.

## Common Problems

Grassed swales are relatively low-maintenance BMPs, but some potential problems include the following:

- Ponded water makes swale difficult to mow, and can cause nuisance problems such as odors, discoloration, and mosquitoes.
- Erosion due to improper vegetation establishment.
- Sediment accumulation due to inadequate erosion-control upstream.

## Maintenance

Routine maintenance of grassed swales will include the removal of trash and debris.

If bare soil or signs of erosion are evident, regrade the soil to remove gully erosion and then re-sod and water until established.

Sediment should be removed if it accumulates within the swale.