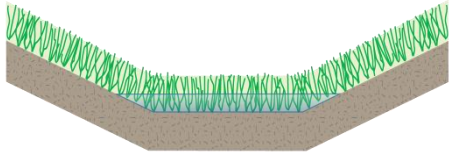






## 9.12 GRASS SWALES



A grass swale is a stable, parabolic or trapezoidal channel that is lined with turf; it is used to improve water quality and convey stormwater runoff. Grass swales do not rely on the permeability of the underlying soil for pollutant removal; instead, pollutants are removed by settling and filtration through the grass. The maximum total suspended solids (TSS) removal rate is 50%.

### N.J.A.C. 7:8 Stormwater Management Rules - Design and Performance Standards

	Nonstructural Strategies	Assist with Strategies #4 and 8; See Page 2
	Water Quantity	Not Allowed
	Groundwater Recharge	Not Allowed
	Water Quality	≤ 50% TSS

### Water Quality Mechanisms and Corresponding Criteria

Settling	
Minimum Length	50 feet
Manning's n value	0.25 for Water Quality Design Storm
Vegetative Uptake and Filtration	
Minimum Density of Vegetation	95%
Grass Height	Between 3 and 6 inches
Longitudinal Slope	Between 2 - 10%
Minimum Required Length	For 50% TSS Removal Rate: 50 Feet - singular point of inflow 200 Feet - continuous inflow along entire length
Flow Characteristics	Maximum 2-inch depth Maximum velocity 0.9 feet/second Must fully drain within 72 hours

## Introduction

Grass swales are turf lined channels used to convey and treat stormwater. Swales reduce suspended particles through filtration and settling and are best suited to treat runoff generated from impervious surfaces of small drainage areas. Typically grass swales are installed in low-gradient lawns, median strips, parking lot islands, unused lot areas and utility easements, where downstream flow attenuation is provided to control larger storm events. Grass swales can be used wherever soil conditions, slopes and sunlight permit the establishment and maintenance of a dense stand of vegetation.

Low velocities and shallow depths of runoff generated by the Water Quality Design Storm allow for particulate settling; while at the same time, the blades of grass in the swale filter the suspended solids. Because these pollutant removal mechanisms do not rely on infiltration into the subsoil, soil permeability is not a design consideration. For larger storm events, the swale can be designed to convey stormwater downstream.

Grass swales must have a maintenance plan, and, if privately owned, must be protected by easement, deed restriction, ordinance or other legal measure that prevents its neglect, adverse alteration or removal.

## Applications



The nonstructural stormwater management strategies design standard in the Stormwater Management rules must be addressed for all major development, pursuant to N.J.A.C. 7:8-5.3(a). The site evaluation for nonstructural strategies must consider all nine strategies. The design of a grass swale could assist in maximizing the following strategies:

- Strategy #4: The minimization of the decrease in time of concentration;
- Strategy #8: The provision of vegetated, open-channel conveyances.

Additional information on nonstructural stormwater management strategies can be found in *Chapter 2: Low Impact Development Techniques*.



Grass swales may be designed to convey storm events larger than the Water Quality Design Storm; regardless of the design storm chosen, all grass swales must be designed for stability and capacity in accordance with the *Standards for Soil Erosion and Sediment Control in New Jersey*, as required by N.J.A.C. 7:8 Stormwater Management rules.



To receive credit for a maximum of 50% TSS removal rate, grass swales must be designed to treat the Water Quality Design Storm and in accordance with the all of the criteria below.

## Design Criteria

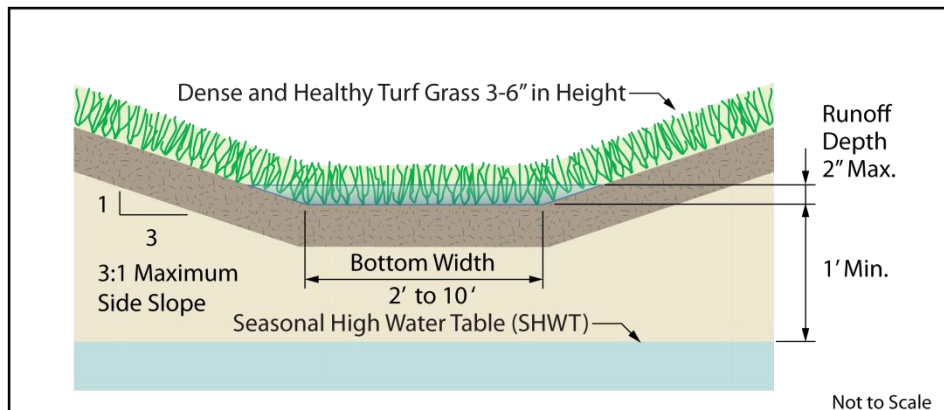
### Basic Requirements

There are two categories of grass swales; the following design criteria apply to all categories and must be met in order to receive a TSS removal rate for this BMP. It is critical that all grass swales are designed in accordance with these criteria in order to ensure proper operation, to maximize the functional life of the system, and to ensure public safety. For criteria specific to each category, see the applicable section, beginning on page 6.

#### Cross-Sectional Geometry

- Grass height must be established and maintained between 3 and 6 inches.
- The swale may be trapezoidal or parabolic, with a bottom width between 2 and 10 feet.
- The maximum allowable side slope is 3:1, with a recommended side slope of 4:1.
- There must be a minimum separation of 1 foot between the bottom of the swale and the seasonal high water table (SHWT).

#### Swale Cross-Section



#### Flow Characteristics

- The runoff depth must be calculated using Manning's Equation with a Manning's  $n$  value of 0.25. This Manning's  $n$  value may only be used with the Water Quality Design Storm for TSS removal.
- The maximum allowable depth of runoff in the swale is 2 inches.
- The maximum allowable velocity is 0.9 feet/second.
- All standing water must drain from the surface of the grass swale within 72 hours.

## Longitudinal Geometry

- The minimum longitudinal slope is 2%. In situations where the design criteria cannot be met using the 2% slope, such as when runoff velocity exceeds the maximum of 0.9 feet per second, this slope may be reduced to 1.5%. At this reduced slope, some infiltration of runoff into the subsoil will be necessary in order for the swale to drain in the required 72 hours. Therefore, for any grass swale designed with a slope less than 2%, a minimum 2-foot separation from the SHWT and a field-tested subsoil permeability rate of at least 1 inch/hour in accordance with the soil testing procedures found in Appendix E are required. Grass swales may not be used to meet the groundwater recharge requirement at N.J.A.C. 7:8-5.4(a)2.
- The maximum longitudinal slope is 10%.
- In order to receive the 50% TSS removal rate for the entire length of a Point Inflow Grass Swale, the minimum swale length is 50 feet.
- In order to receive the 50% TSS removal rate for the entire length of a Linear Inflow Grass Swale, the minimum swale length is 200 feet; however, for swales with lengths less than 200 feet, a weighted average may be achieved. See Example 5 for more information on calculating TSS removal rates using a weighted average.

## Stability

- Grass swales must be stabilized in accordance with the current version of *Standards for Grassed Waterways in the Standards for Soil Erosion and Sediment Control in New Jersey*.

## Types of Grass Swales

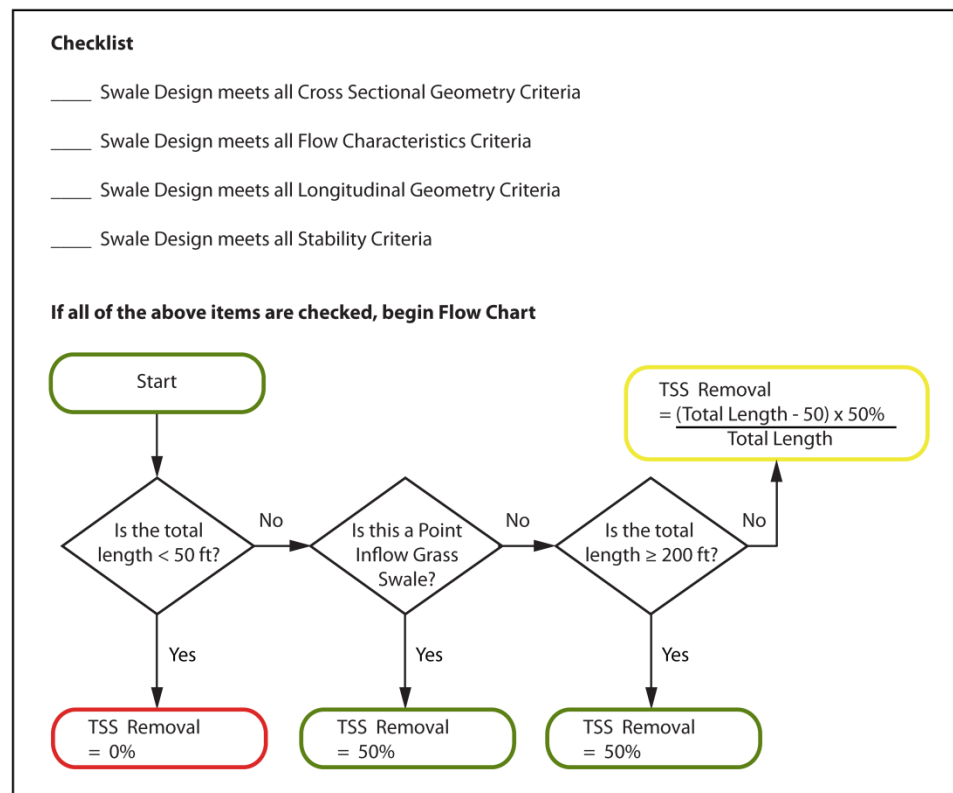
There are two types of grass swales:

1. Point Inflow
2. Linear Inflow

Runoff enters a Point Inflow Grass Swale at a single location, such as a pipe. A Linear Inflow Grass Swale receives distributed runoff along its entire length; a grass-lined ditch along an uncurbed section of roadway is an example of a Linear Inflow Grass Swale.

TSS removal rates vary depending on the type and configuration of the swale. The section beginning on page 6 provides examples of how to calculate the TSS removal rate for different configurations. **Regardless of the design, all of the criteria in the basic requirements section must be met in order for the swale to receive a TSS removal rate.** The following checklist and flowchart may be helpful in determining the TSS removal rate for a particular grass swale.

### Grass Swale Checklist and General Flow Chart



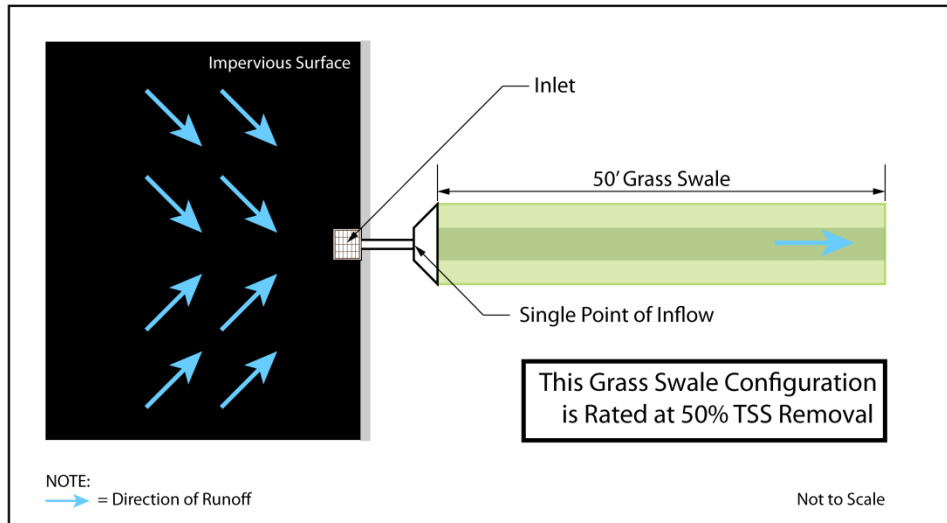
## Individual Types of Grass Swales

This section provides detailed design criteria for each grass swale category. The illustrations depict possible configurations and flow paths and are not intended to limit the design.

## Point Inflow Grass Swales

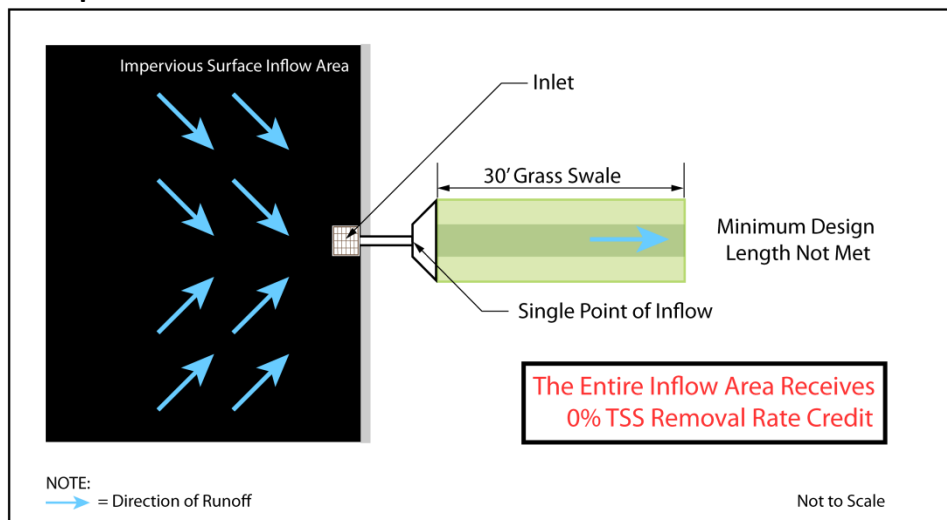
Example 1 shows a 50-foot Point Inflow Grass Swale receiving runoff from an impervious area; the inflow enters at the upstream end of the 50-foot swale. Because all of the runoff produced by the drainage area is collected prior to entering the swale, and assuming that all of the other design criteria for water quality are met, the entire inflow drainage area receives the 50% TSS removal rate.

### Example 1:



In Example 2, the swale length does not meet the minimum requirement of 50 feet; therefore, this Point Inflow Grass Swale achieves a TSS removal rate of 0% and no TSS removal credit is allotted to the inflow drainage area.

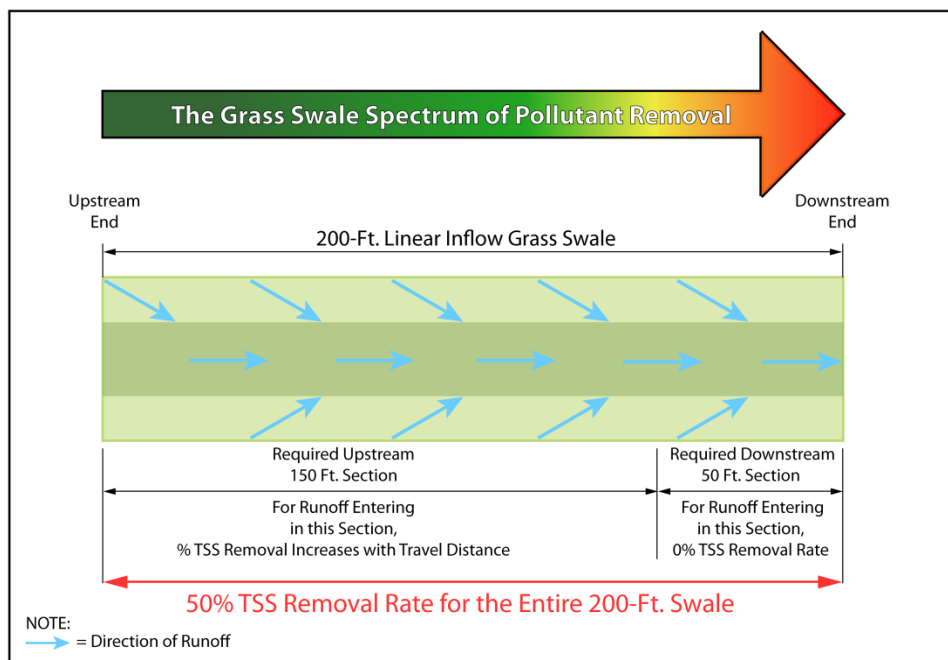
### Example 2:



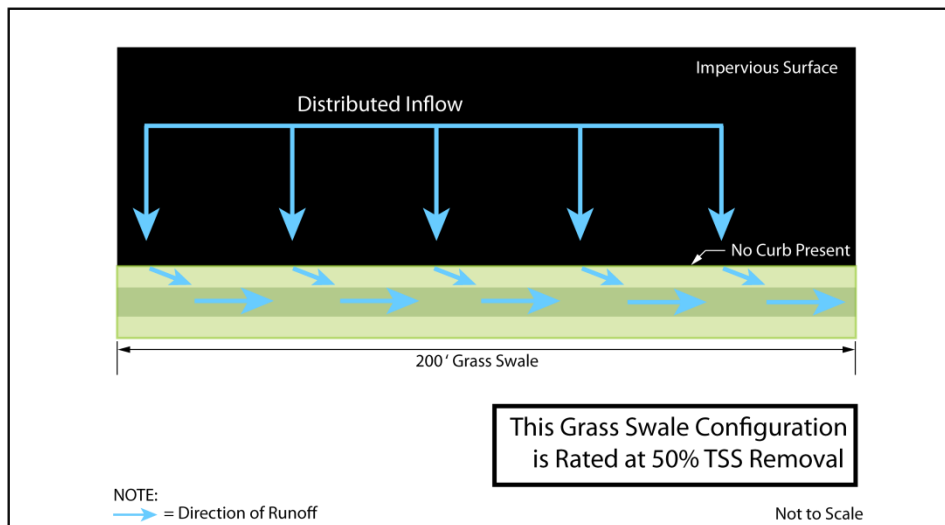
## Linear Inflow Grass Swales

The following graphic illustrates the gradient of pollutant removal within a 200 foot Linear Inflow Grass Swale. Because grass swales treat runoff through vegetative uptake and filtration, the amount of treatment increases with increased flow lengths. Runoff entering at the downstream end receives much less treatment than runoff entering upstream. Moreover, runoff must travel farther than 50 feet for adequate treatment. For calculation purposes, the required downstream 50-foot section of a Linear Inflow Grass Swale is awarded a 0% TSS removal rate. However, swales 200 feet in length are awarded a 50% TSS removal rate, provided that they meet all other criteria, because the runoff entering upstream receives enough treatment to compensate for the low level of treatment in the downstream section, as shown in Example 3 on the following page.

### Linear Inflow Grass Swale – Pollutant Removal



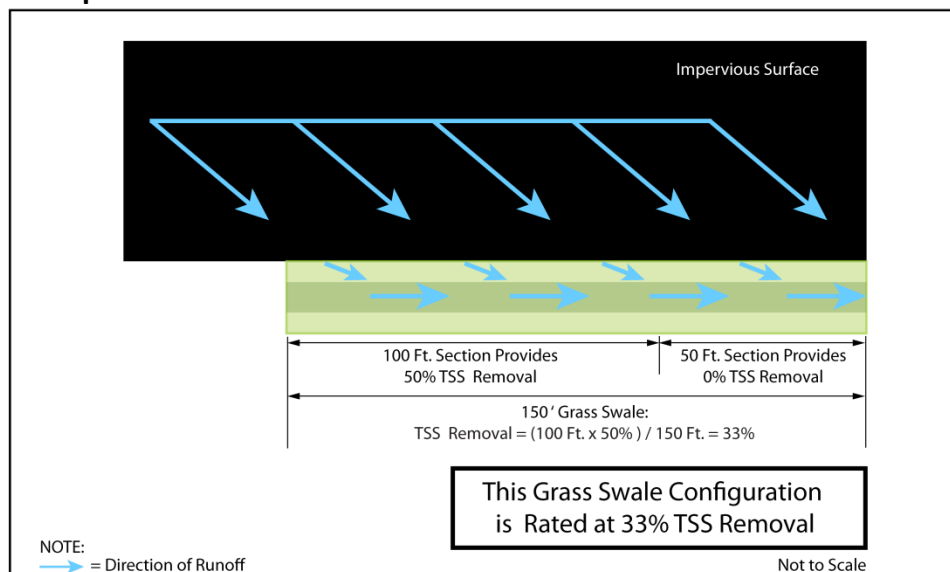
### Example 3:



### Linear Inflow Grass Swales less than 200 Feet in Length

Example 4 shows a 150-foot Linear Inflow Grass Swale that collects runoff from a roadway. In this example, however, the TSS removal rate for the entire inflow drainage area is less than 50% because the swale is less than 200 feet in length. As mentioned above, the minimum 200-foot length is necessary to offset the 0% TSS removal provided by the 50-foot section of the swale located at the downstream end. When the swale length is less than 200 feet, the two sections are evaluated using the formula from the flowchart depicted on page 5, resulting in a weighted average for TSS removal, as shown below.

### Example 4:





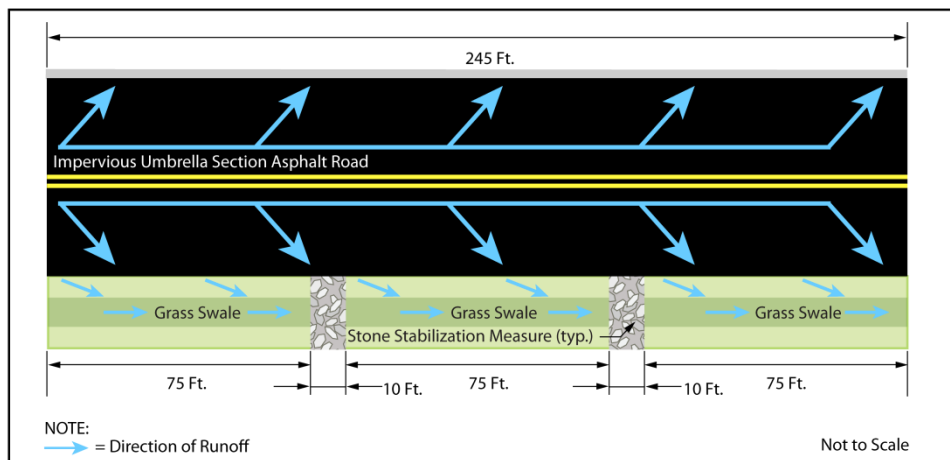
## Linear Inflow Grass Swales with Non-Vegetative Stabilization

Example 5 shows a Linear Inflow Grass Swale similar to the swale in Example 4. In this example, however, the swale is constructed with non-vegetative stabilization at periodic intervals. The entire drainage area flowing into this swale will receive the 50% TSS removal rate provided that the design meets the following criteria:

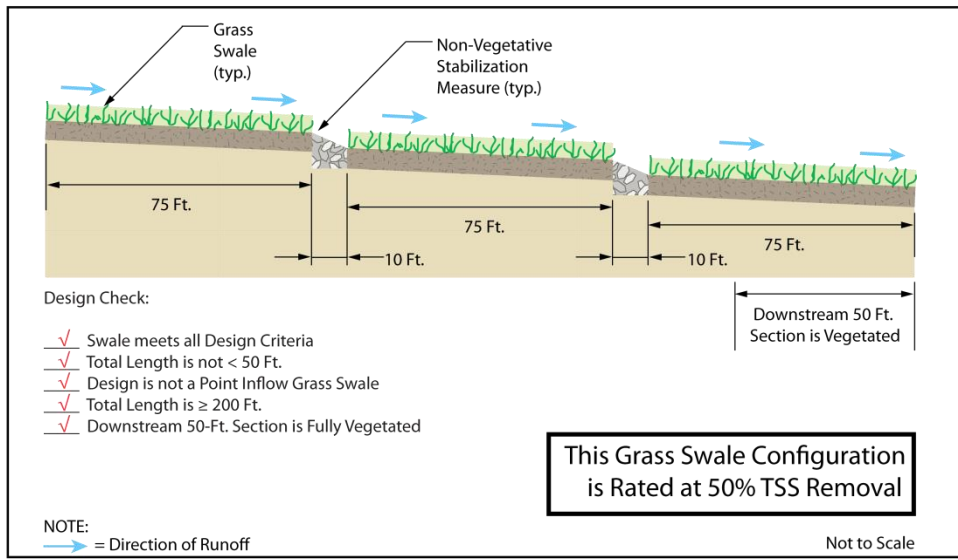
- The swale is at least 200 feet in length; the length and TSS removal rate calculations may not include the sections of the swale that consist of non-vegetative stabilization.
- The 50-foot section of the swale at the downstream end must be fully vegetated and may not consist of non-vegetative stabilization.

The TSS removal rate in this example is based on the three grass segments. The grass segments are each 75 feet in length, with 10 feet of non-vegetative stabilization between each segment. The length of the non-vegetative stabilization is excluded from the length calculation of the swale; therefore, the entire inflow drainage area to this swale receives the 50% TSS removal rate.

### Example 5: Plan View



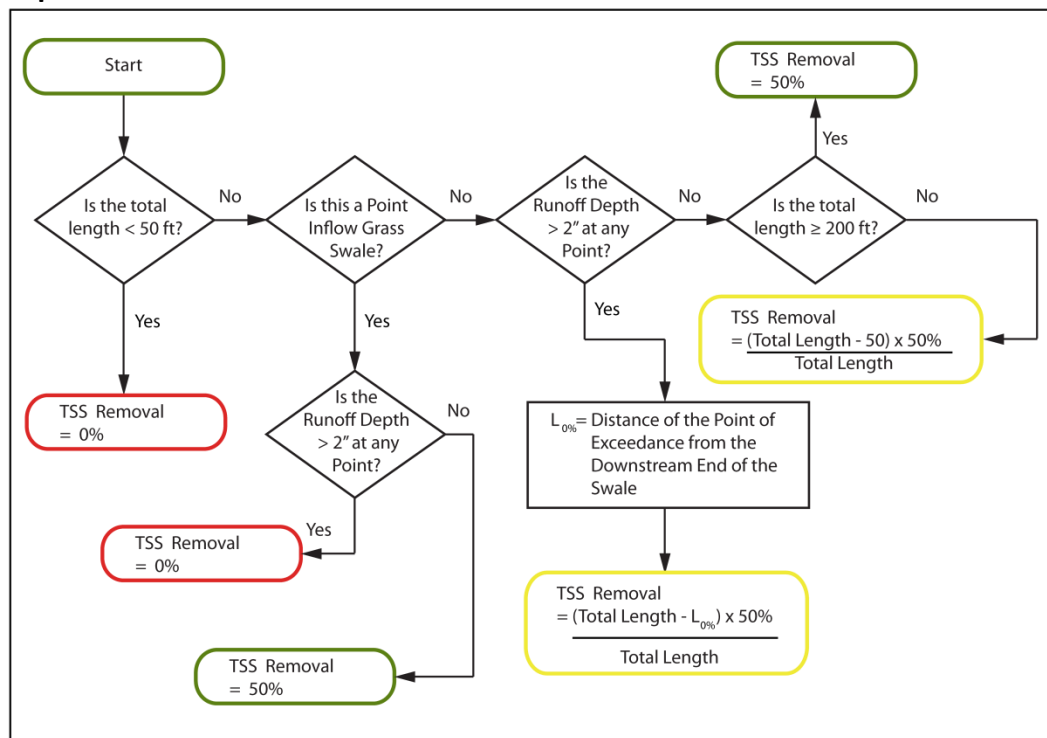
### Example 5: Profile View



## Reductions in TSS Removal Rate for Excessive Runoff Depth

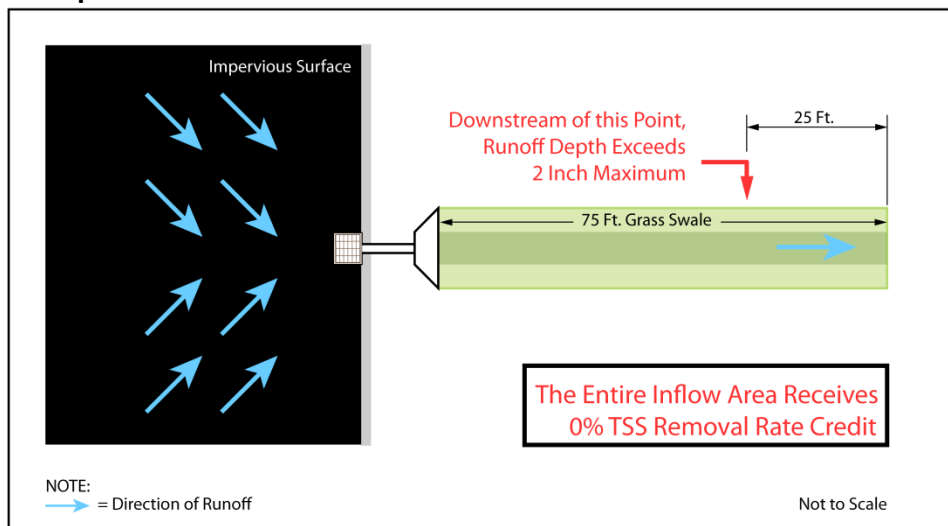
As mentioned in the *Design Criteria* section, to receive 50% TSS removal credit for the entire inflow drainage area, the depth of runoff in any type of grass swale may not exceed 2 inches. If the depth of runoff exceeds 2 inches, the TSS removal rate of the swale is reduced. For a Point Inflow Grass Swale, the entire swale and contributing drainage area receives a TSS removal rate of 0%. For a Linear Inflow Grass Swale, the TSS removal rate calculation depends on the length of the swale and the distance of the point of exceedance from the downstream end of the swale. The flowchart below includes a method for calculating the TSS removal rate for this scenario.

**Expanded Flowchart**



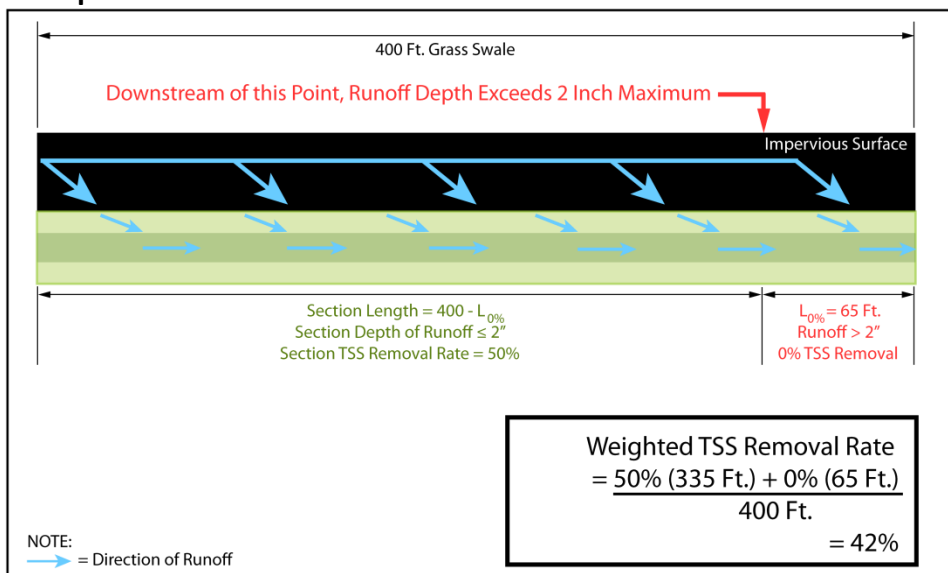
Example 6 shows a Point Inflow Grass Swale with a runoff depth that exceeds the maximum 2 inches. Despite its compliance with all other design criteria, the inflow drainage area treated by this swale receives no TSS removal credit.

#### Example 6:



Example 7 illustrates the TSS removal rate calculation for a 400-foot Linear Inflow Grass Swale with a runoff depth exceedance beginning at a distance of 65 feet from the downstream end of the swale.

#### Example 7:



Although the last 65 feet of the roadway in Example 7 does not receive the 50% TSS removal rate, it may qualify as a vegetated conveyance for the purposes of demonstrating compliance with the nonstructural stormwater management strategies, as discussed above. Additional information on nonstructural stormwater management strategies can be found in *Chapter 2: Low Impact Development Techniques*.

## TSS Removal Rates for BMPs in Series

The adopted TSS removal rates for grass swales is less than the 80% TSS removal rate typically required in the Stormwater Management rules at N.J.A.C. 7:8. Therefore, it may be necessary to use a series of BMPs to achieve the required TSS removal.

A simplified equation to calculate the total TSS removal rate for two BMPs in series can be found at 7:8-5.5(c). The use of this equation may not be used for two of the same BMPs in series to increase the adopted TSS removal rate of that BMP; however, it may be used to estimate the total TSS removal rate of a swale used in combination with another type of BMP. For more information on BMP in series, see *Chapter 4: Stormwater Pollutant Removal Criteria*.

## Considerations

A number of factors should be considered when using a grass swale to treat stormwater, particularly the existing ecology of the site. The siting of a grass swale in proximity to deciduous trees may require additional inspection/maintenance due to the accumulation of leaves, twigs and branches in the swale. The presence of adequate sunlight should also be considered; swales should not be placed in areas with excessive tree canopy because shading may inhibit the growth of vegetation in the swale.

Another factor that must be considered is installation techniques; the use of turf reinforcements, such as erosion mats, can protect the swale and increase both its stability and longevity. Additionally, the use of pegged sod instead of seed allows the vegetation to establish more quickly and reduces the chances of failure.

The location of a grass swale can directly affect the frequency with which it is maintained; the siting of a swale in a visible area can promote maintenance. In addition, the following maintenance methods should be considered when developing a maintenance plan for a swale: the use of an aerator, bagging the plugs, the use of a tractor or power rake, and vacuuming to maintain the design depth. Finally, the safety of maintenance personnel during mowing should be considered when designing the side slopes of the grass swale.

## Maintenance

Regular and effective maintenance is crucial to ensure effective grass swale performance; in addition, maintenance plans are required for all stormwater management facilities associated with a major development. There are a number of required elements in all maintenance plans, pursuant to N.J.A.C. 7:8-5.8; these are discussed in more detail in *Chapter 8: Maintenance of Stormwater Management Measures*. Furthermore, maintenance activities are required through various regulations, including the New Jersey Pollutant Discharge Elimination System (NJPDES) Rules, N.J.A.C. 7:14A. Specific maintenance requirements for grass swales are presented below; these requirements must be included in any maintenance plan that includes grass swales; in addition, cross-sectional views of all grass swales constructed on-site should be included.

### General Maintenance

- All components must be inspected, at least once annually, for cracking, subsidence, spalling, erosion and deterioration.
- Components expected to receive and/or trap debris must be inspected for clogging at least twice annually.
- Sediment removal should take place when the swale is thoroughly dry and should not result in the loss of vegetation.
- Disposal of debris, trash, sediment and other waste should be done at a suitable disposal/recycling facility and in accordance with all applicable local, state and federal waste regulations.

### Vegetated Areas

- Bi-weekly inspections are required when establishing/restoring vegetation.
- A minimum of one inspection during the growing season and one inspection during the non-growing season is required to ensure the health, density and diversity of the vegetation.
- Vegetative cover must be maintained at 95%; damage must be addressed through replanting in accordance with the original specifications.
- Mowing and/or trimming of vegetation should be performed on a regular schedule based on specific site conditions.
- Grass outside of the swale should be mowed at least once a month during growing season.
- Grasses within the swale should be carefully maintained to fall within the required grass height range of 3 to 6 inches.
- Grass clippings should either be removed or sufficiently small to avoid both damage to the turf and the facilitation of mosquito breeding.

- Vegetated areas must be inspected at least once annually for erosion, scour and unwanted growth; any unwanted growth should be removed with minimum disruption to the soil bed and remaining vegetation.
- If disruption to the vegetation occurs, the area must be re-seeded. If ponding in excess of 72 hours occurs, action must be taken to either re-establish the appropriate slope and/or permeability rate of the soil bed.
- All use of fertilizers, mechanical treatments, pesticides and any other means utilized to assure optimum vegetation health should not compromise the intended purpose of the swale.

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