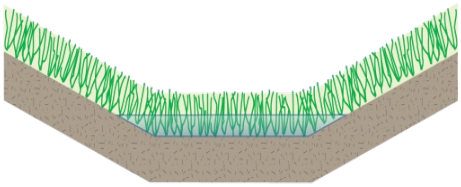
9.3 Grass Swales



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 – Applicable Design and Performance Standards		
	Green Infrastructure	Yes
	Stormwater Runoff Quantity	Not Allowed
GR	Groundwater Recharge	Not Allowed
%	Stormwater Runoff Quality	≤ 50% TSS

Stormwater Runoff Quality Mechanisms and Corresponding Criteria	
Settling	
Minimum Length	50 feet
Manning's n value	0.25 for the Water Quality Design Storm
Vegetative Uptake and Filtration	
Minimum Density of Vegetation	95%
Grass Height	Between 3 and 6 inches
Maximum Longitudinal Slope	10%
Minimum Separation from the Seasonal High Water Table	≥ 1 ft, when the swale is designed with a slope ≥ 2 % ≥ 2 ft, when the swale is designed with a slope < 2%
Minimum Required Length	For 50% TSS Removal Rate: 50 Feet - singular point of inflow 200 Feet - continuous inflow along entire length
Flow Characteristics for the Water Quality Design Storm	Maximum 2 inch depth of flow Maximum flow 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 receiving stormwater runoff from small contributory 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 stormwater runoff produced 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 runoff downstream.

Grass swales are rarely used on their own, as they are incapable of meeting the stormwater runoff quality, stormwater runoff quantity and groundwater recharge standards without the use of another BMP downstream of the grass swale. For this reason, the maximum contributory drainage area to an individual grass swale will also be controlled by any similar limitation applicable to the downstream BMP used, in conjunction with the grass swale, to achieve the applicable stormwater runoff quality, stormwater runoff quantity or groundwater recharge standard(s). Therefore, the maximum contributory drainage area limit is not applicable to grass swales.

Grass swales must have a maintenance plan and must be reflected in a deed notice recorded in the county clerk's office to prevent alteration or removal.

Applications

Pursuant to N.J.A.C. 7:8-5.2(a)(2), the minimum design and performance standards for groundwater recharge, stormwater runoff quality and stormwater runoff quantity at N.J.A.C. 7:8- 5.4, 5.5 and 5.6 shall be met by incorporating green infrastructure in accordance with N.J.A.C. 7:8-5.3.

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*.

To merit the approved TSS removal rate of up to a maximum of 50%, grass swales must be designed to treat the Water Quality Design Storm (WQDS) and in accordance with all of the design criteria below.

Design Criteria

Basic Requirements

There are two types of grass swales; the following design criteria apply to all categories and must be incorporated into the design in order to receive the approved 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 a particular type, see the applicable section, beginning on Page 6.

Contributory Drainage Area

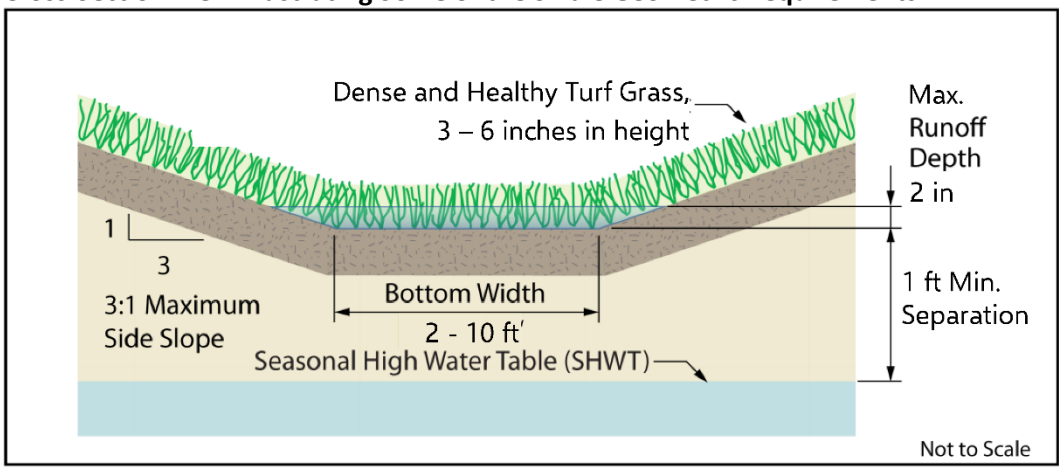
- The maximum contributory drainage area limitation is not applicable to a grass swale.
- The swale design will be governed by any maximum contributory drainage area limitation for the receiving BMP, along with the geometric constraints and the maximum depth of flow limitation for the Water Quality Design Storm (WQDS). These are further discussed below.

Cross-sectional Geometry

An illustration is provided on the following page to graphically represent the following criteria:

- The 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.
- The minimum separation between the bottom of the swale and the seasonal high water table (SHWT) must be as follows, in accordance with Table 5-1 in N.J.A.C. 7:8-5.2(f):
  - ☐ At least 1 foot, when the swale is designed with a slope equal to or greater than 2 percent; or
  - ☐ A minimum of 2 feet, when the swale is designed with a slope of less than 2 percent.

Cross-Section View Illustrating Some of the Swale Geometric Requirements



Longitudinal Geometry

- Ideally, the minimum slope of a grass swale is 2%; however, in some instances, this will result in a WQDS runoff velocity greater than 0.9 feet per second. In such a situation, the slope may be reduced to 1.5%. To ensure the swale is free of standing water, whenever the slope is 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 *Chapter 12: Soil Testing Criteria* 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%.
- The minimum length required to receive the 50% TSS removal rate for the entire length of the grass swale, depends on the type of swale.
  - ☐ When runoff enters a grass swale at a single location, such as at a pipe outfall, the swale is called a *Point Inflow Grass Swale*. 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.
  - ☐ When runoff enters a grass swale either continuously along the length or at multiple distributed locations, e.g., along the edge of an uncurbed motor vehicle surface, such as a roadway or parking lot, the swale is called a *Linear Inflow Grass Swale*. 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 lower TSS removal rate is calculated based on a weighted average. See Example 7 for more information on calculating TSS removal rates using a weighted average.

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 WQDS for TSS removal.
- The maximum allowable depth of runoff produced by the WQDS in the swale for the WQDS is 2 inches.
- The maximum allowable velocity is 0.9 feet/second for runoff produced by the WQDS.
- All standing water must drain from the surface of the grass swale within 72 hours.
- Stormwater calculations must not include exfiltration of runoff as a means of discharge or as discarded flow. Exfiltration is defined as any discharge of runoff from the swale into the subsoil.

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 design criteria in the basic requirements section must be met in order for the swale to receive a TSS removal rate.** The checklist and flowchart provided below may be helpful in determining the TSS removal rate for a particular grass swale.

Grass Swale Checklist and General Flow Chart

Checklist

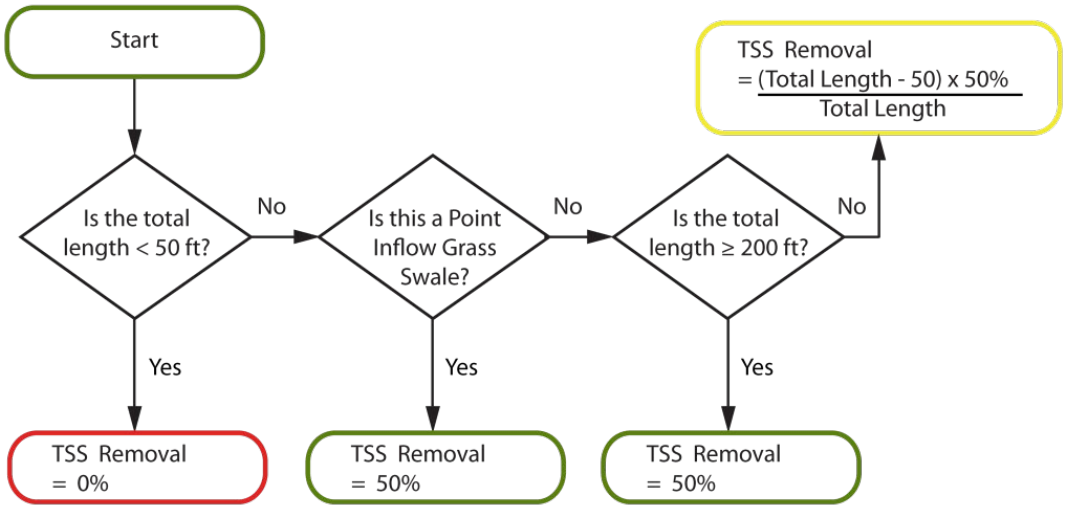
____ Swale Design meets all Cross Sectional Geometry Criteria

____ Swale Design meets all Flow Characteristics Criteria

____ Swale Design meets all Longitudinal Geometry Criteria

____ Swale Design meets all Stability Criteria

If all of the above items are checked, begin Flow Chart



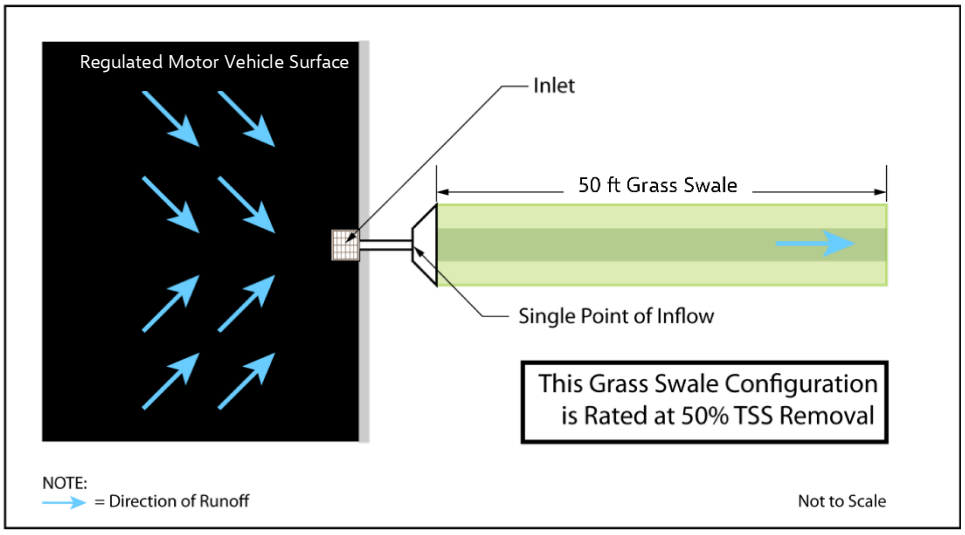
Individual Types of Grass Swales

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

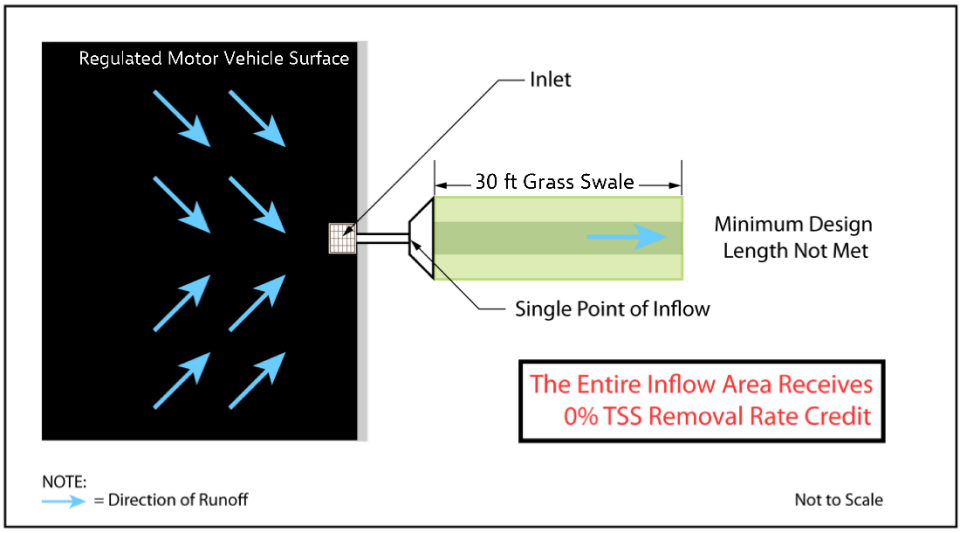
Example 1 shows a 50 foot Point Inflow Grass Swale receiving runoff from a regulated motor vehicle surface; the inflow enters at the upstream end of the 50 foot swale. Because all of the runoff produced by the contributory drainage area is collected prior to entering the swale, and assuming that all of the other design criteria for water quality are met, the entire inflow contributory 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%, as does the inflow contributory drainage area.

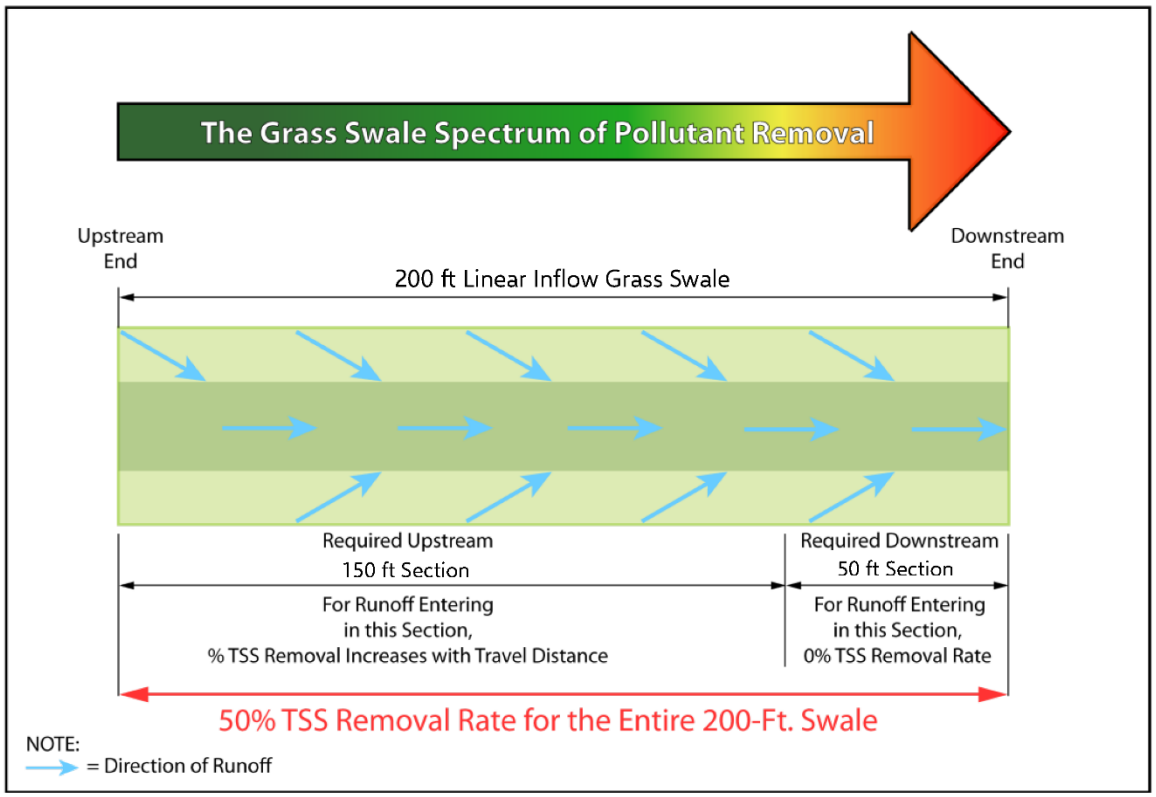
Example 2



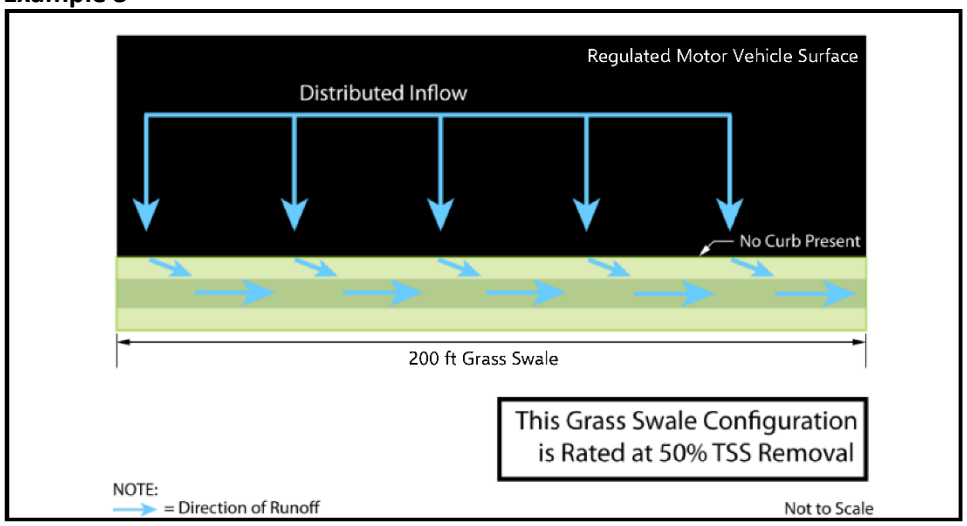
Linear Inflow Grass Swales

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, up to a maximum TSS removal rate of 50%. Runoff entering at the downstream end receives much less treatment than runoff entering upstream. Moreover, runoff must travel at least 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



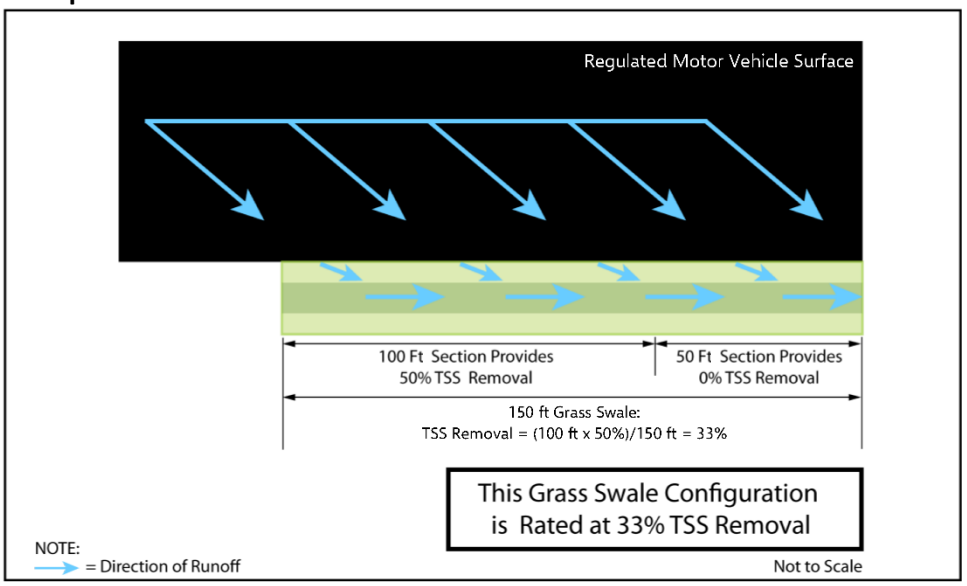
Example 3



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 contributory 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



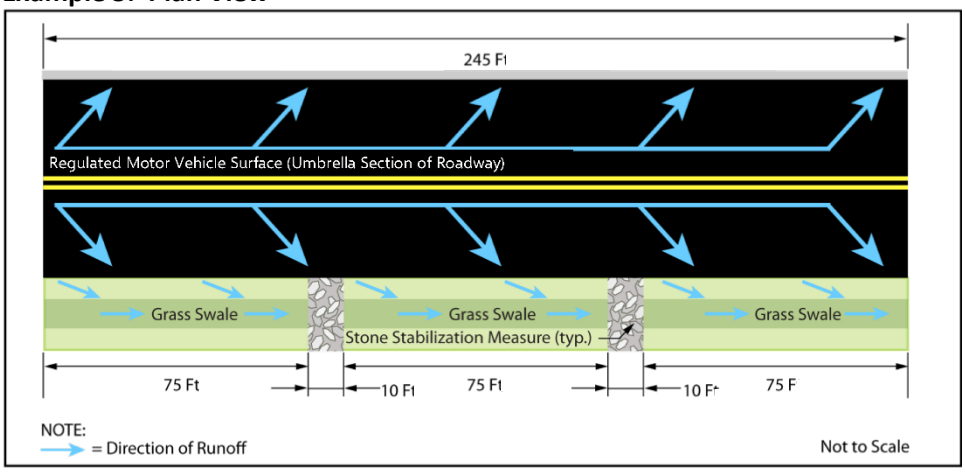
Linear Inflow Grass Swales with Non-Vegetative Stabilization

Example 5 shows a Linear Inflow Grass Swale constructed to provide water quality treatment along one side of a roadway with impervious cover. In this example, the swale is constructed with non-vegetative stabilization at periodic intervals. The entire contributory drainage area flowing into this swale will receive the 50% TSS removal rate provided that the design meets the following criteria:

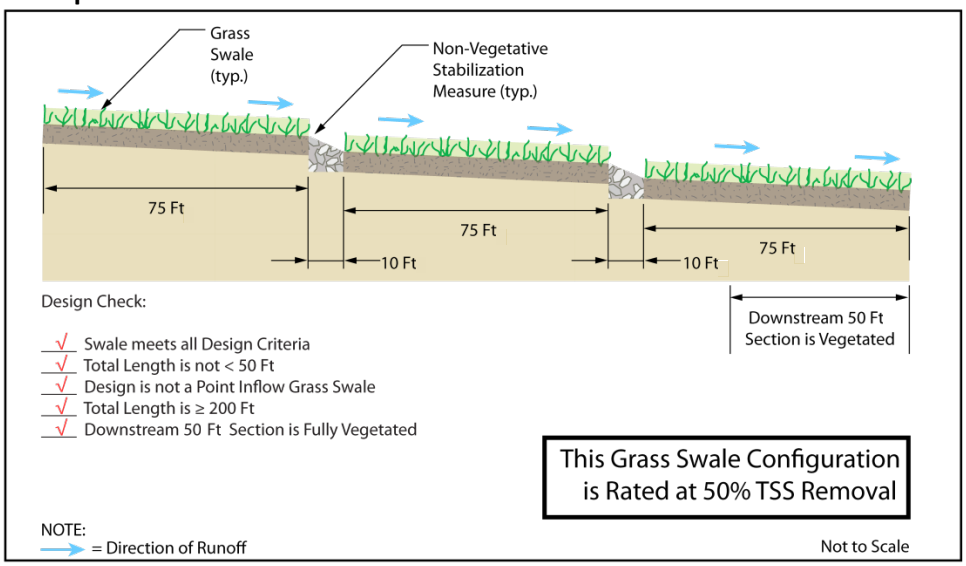
- The swale is at least 200 feet in length; the length and TSS removal rate calculations may not include the sections of the swale that consist of non-vegetative stabilization.
- The 50 foot section of the swale at the downstream end must be fully vegetated and may not consist of non-vegetative stabilization.

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 contributory drainage area to this swale receives the 50% TSS removal rate.

Example 5: Plan View



Example 5 Profile View



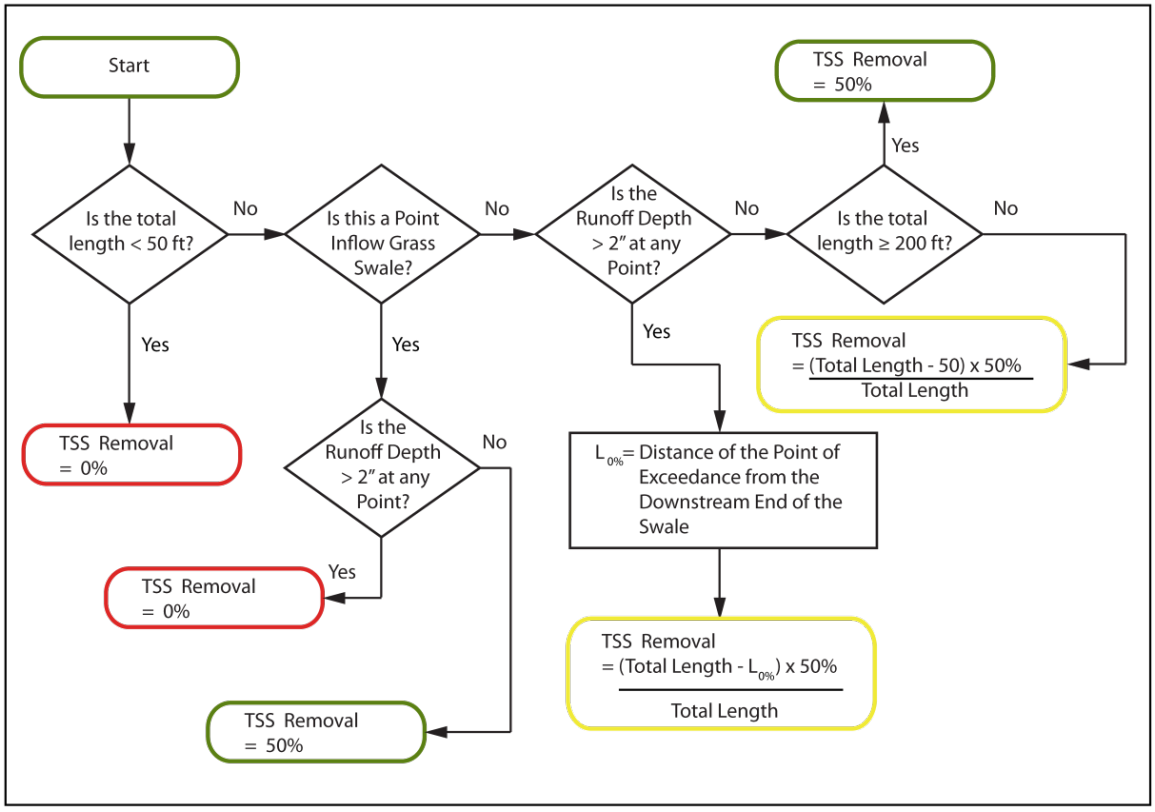
Reductions in TSS Removal Rate for Excessive Runoff Depth

As mentioned in the *Design Criteria* section, to receive a 50% TSS removal rate for the entire inflow contributory drainage area, the depth of runoff produced by the WQDS 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 must be reduced as follows.

- For a Point Inflow Grass Swale, the entire swale and contributary inflow drainage area receive 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.

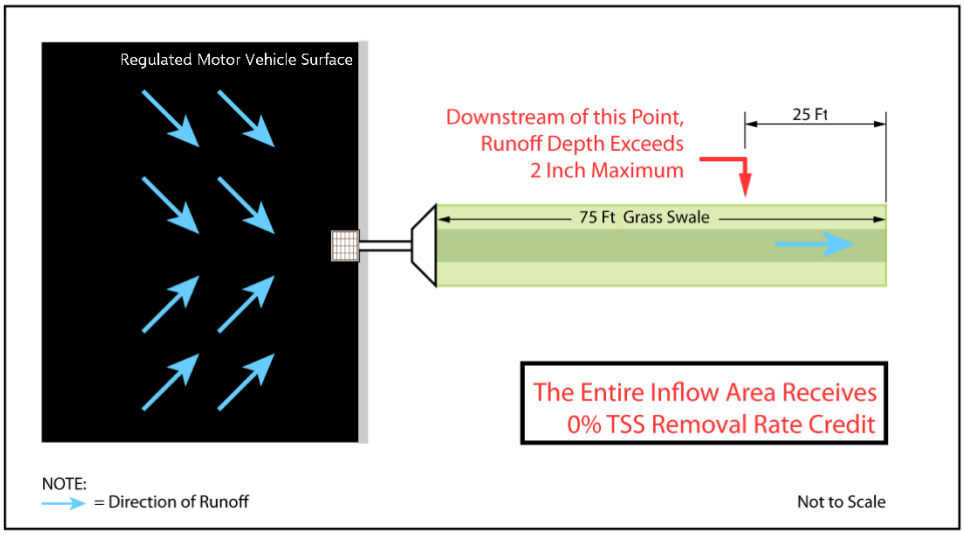
The flowchart below includes a method for calculating the TSS removal rate for this scenario.

Expanded Flowchart for Computing Reductions in TSS Removal



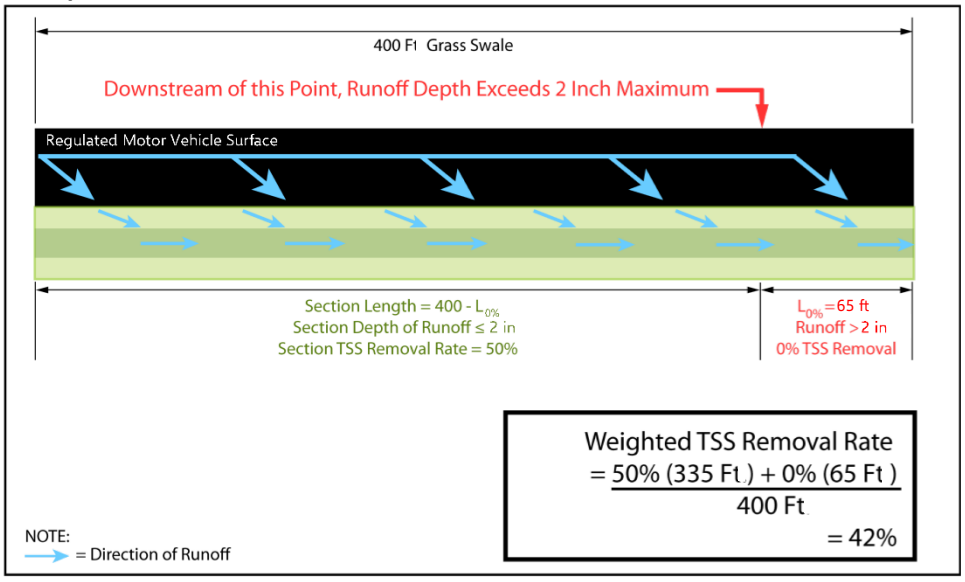
Example 6 shows a Point Inflow Grass Swale with a runoff depth that exceeds the maximum 2 inches. Despite its compliance with all other design criteria, the inflow contributory drainage area treated by this swale receives a 0% TSS removal rate.

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



Note: Although the portion of the swale treating the last 65 feet of the roadway in Example 7 does not receive the 50% TSS removal rate, the grass swale may be used as a vegetated conveyance to transport stormwater runoff to a down-gradient stormwater BMP in the treatment train. The reduced TSS removal rate calculated above would be used in the equation found in N.J.A.C. 7:8-5.5(e) to determine the TSS removal rate for these BMPs in series, as discussed in the next section.

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.

Finally, the use of fertilizers in a swale may exacerbate environmental conditions in any receiving water bodies within the watershed. Therefore, the selection of turf grass species should take into account the need for fertilizing treatments and the impacts on other vegetation on site as well as within the project surrounds.

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. Detailed inspection and maintenance logs must be maintained. Detailed inspection and maintenance logs must be maintained.

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, as well as after every storm exceeding 1 inch of rainfall.

- 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.
- A detailed, written log of all preventative and corrective maintenance performed on the swale must be kept, including a record of all inspections and copies of maintenance-related work orders. Additional maintenance guidance can be found at:

  https://www.njstormwater.org/maintenance_guidance.htm.

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 must be carefully maintained to fall within the required grass height range of 3 to 6 inches.
- Grass clippings must 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 to address water quality and as a vegetative conveyance.

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