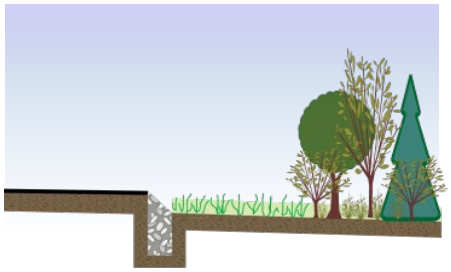
9.10 VEGETATIVE FILTER STRIPS



A vegetative filter strip is a stable, evenly graded area that removes pollutants from stormwater runoff through filtration and biological uptake. In order to provide pollutant treatment, runoff must enter and move through the filter strip as sheet flow; therefore, vegetative filter strips must have shallow enough slopes to maintain this flow condition. When designed in accordance with this chapter, the total suspended solid (TSS) removal rate is 60 - 80%, depending on the type of vegetation.

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	60 - 80% TSS, depending on type of vegetation See Page 3

Stormwater Runoff Quality Mechanisms and Corresponding Criteria	
Vegetative Uptake and Filtration	
Minimum Density of Vegetation	85%
Species Selection	Turf Grass, Meadow Cover, Planted Woods or Existing Forest Areas
Required Length	Minimum Length 25 feet Maximum Length 100 feet See Appropriate Chart on Pages 9-11
Maximum Allowable Slope	See Table on Page 12
Flow Characteristics	Sheet Flow Only

Introduction

A vegetative filter strip is a stable, evenly graded area designed to remove pollutants from the stormwater runoff that flows through it. Filter strips can be designed and planted with a variety of vegetation, or an existing on-site vegetated area with appropriate vegetation and slope can be used. In order to function properly, all stormwater runoff must both enter and move through the filter strip as sheet flow. Vegetative filter strips are intended to treat stormwater runoff generated by contributory drainage areas that are uniformly graded, such as yards, parking lots and driveways, where runoff moves as sheet flow.

Vegetative filter strips treat the pollutants in stormwater runoff through filtration and biological uptake. Because these mechanisms rely on the vegetation in the filter strip, that vegetation must be dense and remain healthy; therefore, filter strips can be used wherever soil conditions, slopes and sunlight permit the establishment and maintenance of a robust plant community.

Vegetative filter strips 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.

To receive credit for the approved 60-80% total suspended solids (TSS) removal rate, vegetative filter strips must be designed to treat the Water Quality Design Storm (WQDS) and in accordance with all of the criteria below. The actual TSS removal rate for a particular vegetative filter strips will depend on the slope, length and type of vegetation in the filter strip. The following table shows the maximum achievable TSS removal rate for each category of vegetation.

Type of Vegetation	TSS Removal Rate
Turf Grass	60%
Meadow Cover	70%
Planted Woods	70%
Existing Forest Areas	80%

Design Criteria

Basic Requirements

There are two categories of vegetative filter strips. The following design criteria apply to all categories and must be met in order to receive the TSS removal rate listed in the preceding table for this BMP. For criteria specific to each category, see the applicable section, beginning on Page 5.

Contributory Drainage Area

- The maximum contributory drainage area limitation is not applicable to a vegetative filter strip.
- In order for the vegetative filter strip to provide treatment, stormwater runoff must be in the form of sheet flow, which generally has a depth of less than one tenth of one foot and can only occur for a relatively short flow length. Since the function of the vegetative filter strip already sets significant limitations on the size of the associated contributory drainage area, a limitation is not applicable.

Inflow Limitations

- Flow through the contributory drainage area must be uniformly distributed and sufficiently low in peak velocity such that sheet flow is maintained throughout the entire contributory drainage area.
- For this to occur, the contributory drainage area must be uniformly graded, with a shallow enough slope to maintain sheet flow; the downstream edge, which is in contact with the upstream edge of the vegetative filter strip, must be perpendicular to the direction of the flow of stormwater runoff.
- The length of the contributory drainage area, measured in the direction of flow, represents the flow path of stormwater runoff. The maximum contributory drainage area length plus the length of the vegetative filter strip is 100 feet.

Vegetation

- There are a number of different types of vegetation that can be used in a filter strip; however, in order to receive the adopted TSS removal rates, selection is limited to the following:

    1. Turf grass,
    2. Meadow cover,
    3. Planted woods and
    4. Existing forest areas.

- To achieve the best performance, the plants must be healthy and the vegetative cover dense; the minimum density of vegetation is 85%. In addition, to attain sufficient surface roughness, the following requirements also apply:

    1. A minimum 3-inch mulch layer is required for newly planted woods and
    2. A minimum 1-inch organic detritus layer is required for existing forested areas.

- Vegetation must be fully established before the vegetative filter strip is put into use as a stormwater management measure.

Required Length

In order to maintain sheet flow throughout, the length of a filter strip must be between:

- The minimum length of 25 feet and
- The maximum length of 100 feet.

The required length of a vegetative filter strip is governed by:

- The slope of the filter strip,
- The vegetation within the filter strip and
- The soils within the contributory drainage area; if the inflow drainage is impervious, use the soil classification beneath the impervious surface.

Vegetative filter strips in excess of 100 feet do not provided an additional TSS removal rate. See Example 4, which begins on Page 15.

Maximum Allowable Slope

The maximum slope of a vegetative filter strip is determined by the following:

- Soils within the upstream contributory drainage area and
- Filter strip vegetation.

Flow Characteristics

- The flow of stormwater runoff through the vegetative filter strip must be sheet flow.
- Because the maximum length stormwater runoff can flow before beginning to concentrate is 100 feet, a mechanism to distribute flow, such as a flow leveler or a stone cutoff trench, is required when the sum of the flow path in the contributory drainage area and the vegetative filter strip exceeds 100 feet. This flow distribution mechanism may only be placed at the boundary between the contributory drainage area and the vegetative filter strip.

Stability

- Vegetative filter strips must be stabilized in accordance with the current version of *Standards for Soil Erosion and Sediment Control in New Jersey*.

Types of Vegetative Filter Strips

There are two types of Vegetative Filter Strips:

1. Vegetative Filter Strips Comprised of Existing Features
2. Newly Created Vegetative Filter Strips

Individual Types of Vegetative Filter Strips

The following section provides additional design criteria for each category of vegetative filter strips. These illustrations depict possible configurations and flow paths and are not intended to limit the design.

Characteristics of Vegetative Filter Strips Comprised of Existing Features

An existing on-site feature can be used as a vegetative filter strip only when the following criteria apply:

- Must have surface features that delay, pond and/or disperse stormwater runoff over the entire length of the filter strip; however, these features cannot concentrate flow and
- Be surveyed and inspected during rain events under existing conditions to determine stormwater runoff flow patterns.

Characteristics of Newly Created Vegetative Filter Strips

A newly designed vegetative filter strip must meet the following criteria:

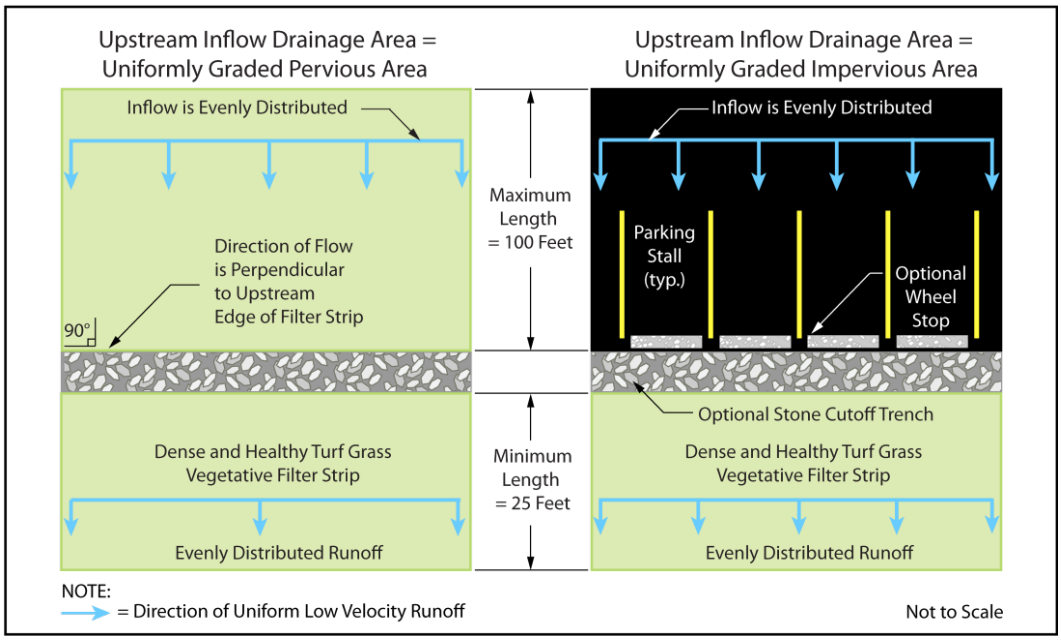
- Uniform grading throughout,
- Mild slopes and
- Have a minimum length of 25 feet, with the measurement taken in the direction of flow.

Basics of Vegetative Filter Strip Configuration

Filter Strips with a Single Type of Vegetation

The illustration below shows, side by side, two examples of vegetative filter strip configurations. On the left side of the figure, stormwater runoff flows evenly from a uniformly graded pervious area to a stone cutoff trench and then into the filter strip. On the right side of the figure, stormwater runoff flows from a uniformly graded parking lot (regulated motor vehicle surface) through a stone cutoff trench and then into the filter strip. As shown in the figure, the maximum length of each contributory drainage areas is 100 feet. In this example, a stone trench, positioned perpendicular to the flow, is employed. The figure below also shows the vegetated filter strip at its minimum required length of 25 feet. In this chapter, length is always measured in the direction of the flow of stormwater runoff.

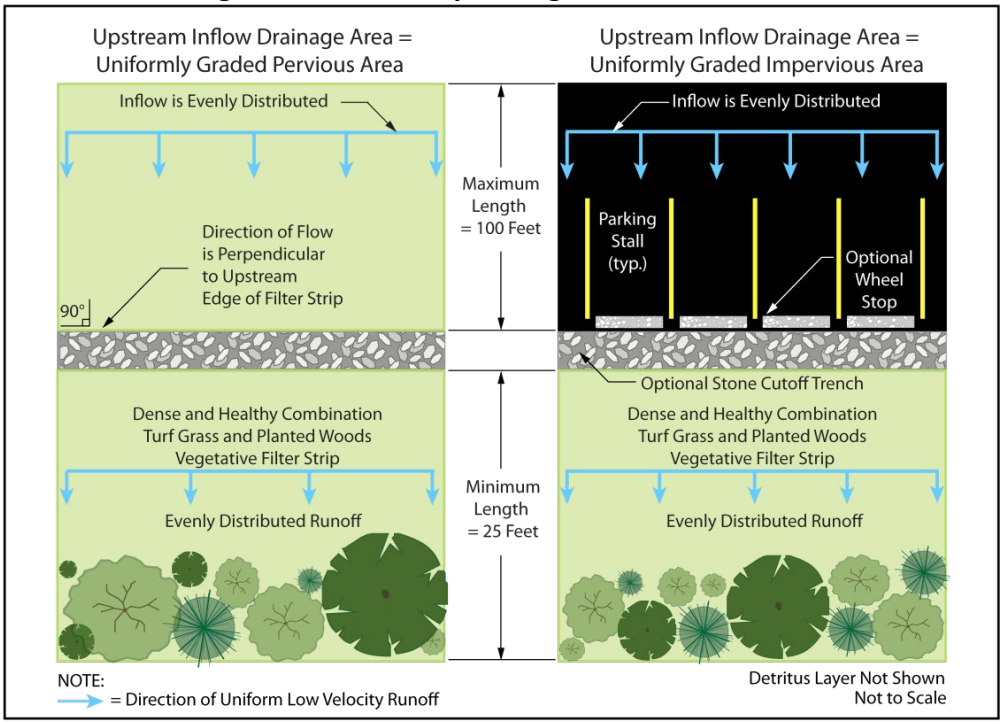
Basic Vegetative Filter Strip Configuration - Plan View



Filter Strips with More Than One Type of Vegetation

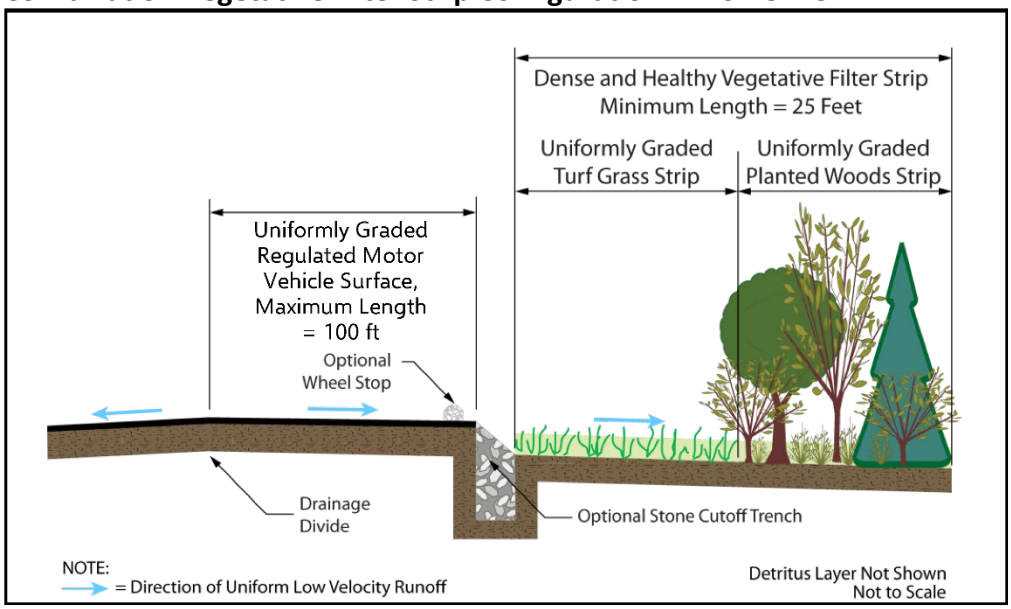
The following illustration shows the same filter strip configurations as above with two different types of vegetation.

Combination Vegetative Filter Strip Configuration – Plan View



The next graphic illustrates a combination vegetative filter strip in profile view. This view highlights the restriction against allowing additional flow to enter at the upstream limit of the contributory drainage area. Again, the contributory drainage area has a maximum length of 100 feet and the filter strip has a minimum length of 25 feet. The use of wheel stops or other parking guides must not impede sheet flow of stormwater runoff.

Combination Vegetative Filter Strip Configuration – Profile View



TSS Removal Rates for Filter Strips with More Than One Type of Vegetation

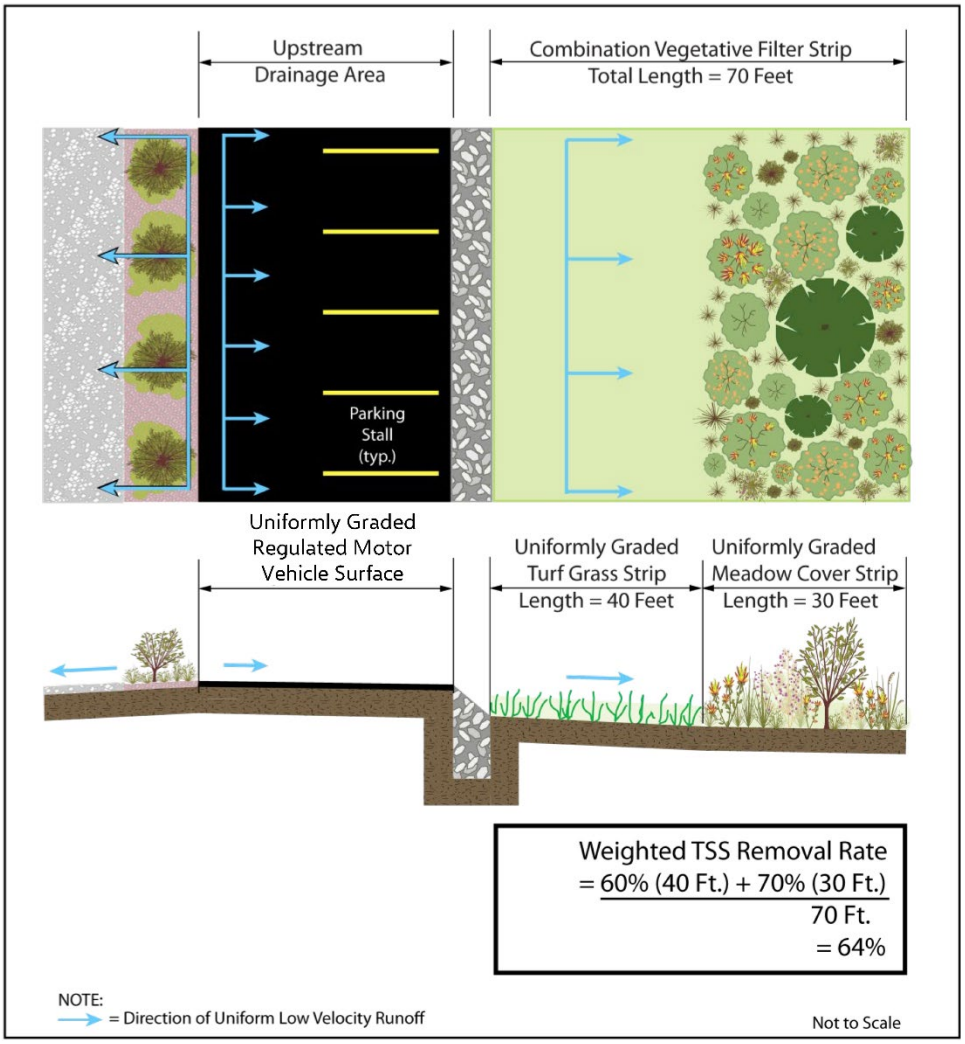
When a vegetative filter strip includes more than one type of vegetation, the TSS removal rate is calculated using a weighted average based on the vegetation types and the length stormwater runoff flows through each type of vegetation. The following example demonstrates how to calculate the removal rate for a combination vegetative filter strip.

Example 1: Compute the weighted TSS removal rate for a combination vegetative filter strip consisting of a Turf Grass section 40 feet in length and a Meadow Cover section 30 feet in length, as shown in the following illustration.

To determine the weighted TSS removal rate for combination vegetative filter strip, the equation used is the sum, for each section, of the product of the TSS removal rate of particular section and the length of that same section, divided by the sum of all the section lengths, as follows:

$$\% \text{ TSS Removal Rate} = \frac{\sum_{i=1}^{n} [(\%TSS)_i \ x \ L_i]}{\sum_{i=1}^{n} L_i},$$

where n is the number of sections, $(\%TSS)_i$ is the TSS removal rate of an individual section, and L_i is the corresponding length of that section.



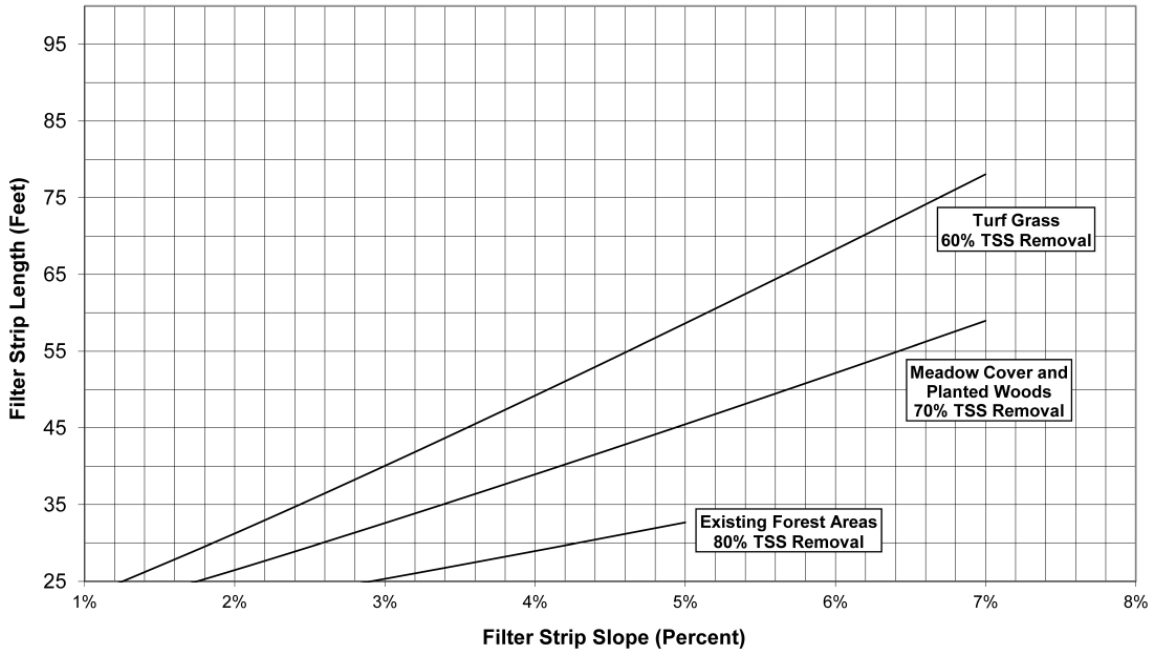
Required Filter Strip Length

The required length of a vegetative filter strip is based on its slope, its vegetation, the soil type and hydrologic soil group (HSG) within the contributory drainage area. The amount of stormwater that runs off of the surface and enters the filter strip during a given rain event is determined by the soils present in the contributory drainage area. In addition, the soils provide the comparable particle sizes that the filter strip will be treating.

The following charts, A through E, are used to determine the required filter strip length; each chart covers a different soil type.

- The length for any vegetative filter strip is 25 feet or greater, up to 100 feet.
- **Extrapolation beyond the extents of the curves is not permitted**.
- The maximum slope that may be used for a particular soil type is found in the next section, which begins on Page 12.

Chart A. Vegetative Filter Strip Length:
Contributory Drainage Area – Hydrologic Soil Group A & Soil Type = Sand



Charts B through E are continued on the following two pages.

Chart B. Vegetative Filter Strip Length:
Contributory Drainage Area – Hydrologic Soil Group A & Soil Type = Sandy Loam

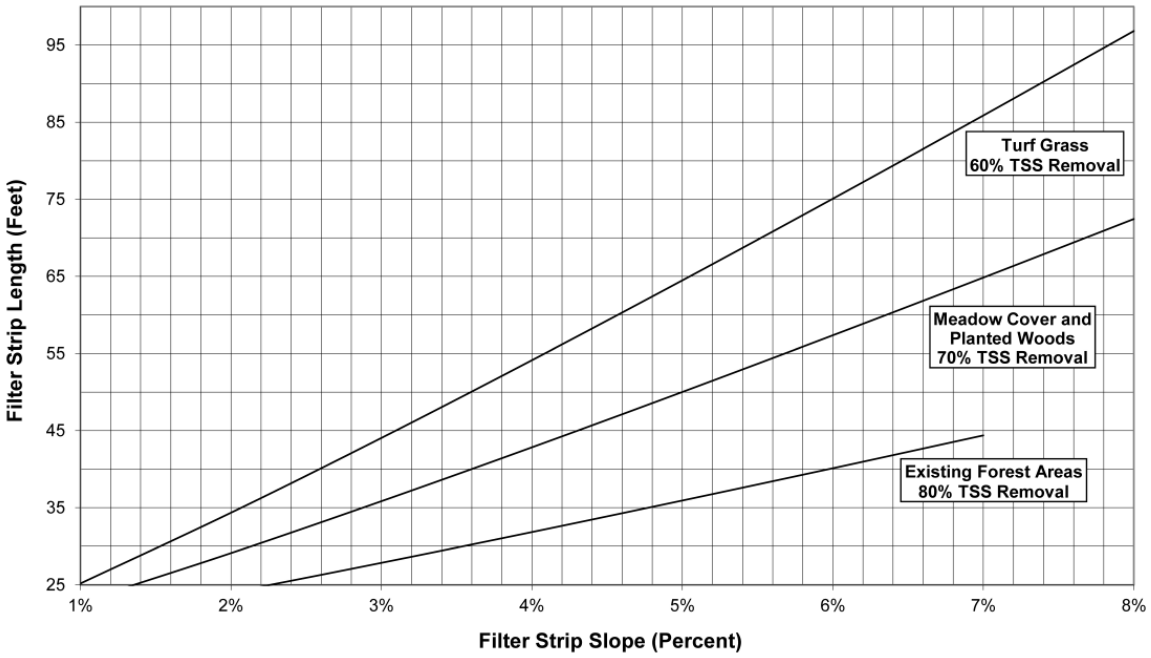


Chart C. Vegetative Filter Strip Length:
Contributory Drainage Area – Hydrologic Soil Group B & Soil Type = Loam, Silt Loam

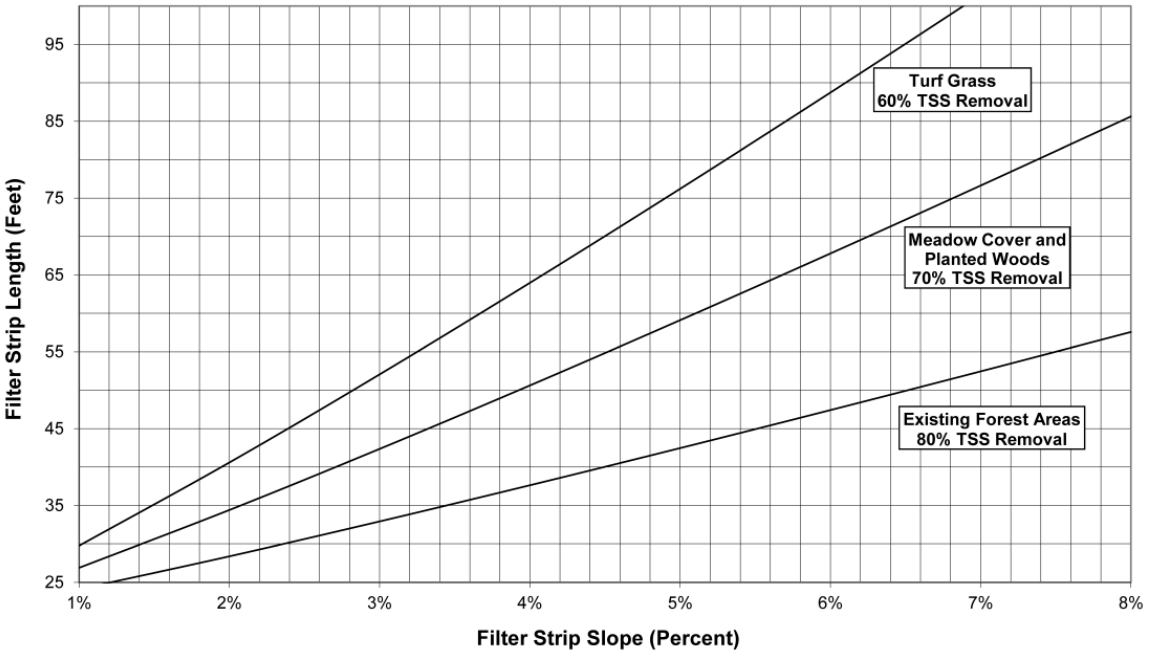


Chart D. Vegetative Filter Strip Length:
Contributory Drainage Area – Hydrologic Soil Group C & Soil Type = Sandy Clay Loam

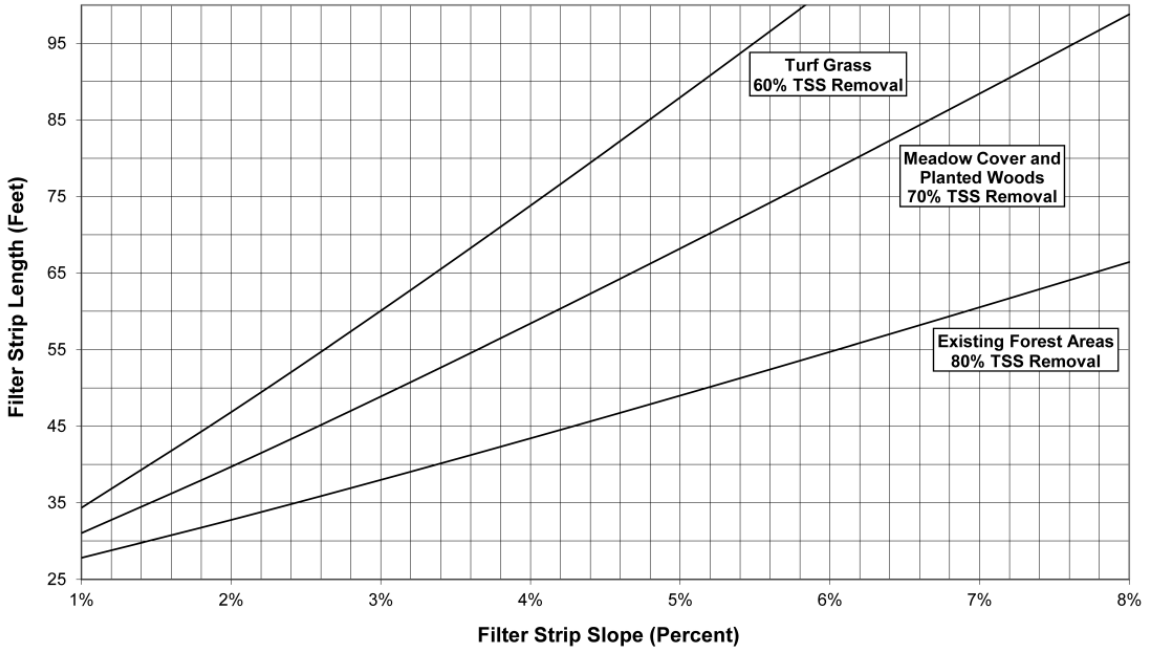
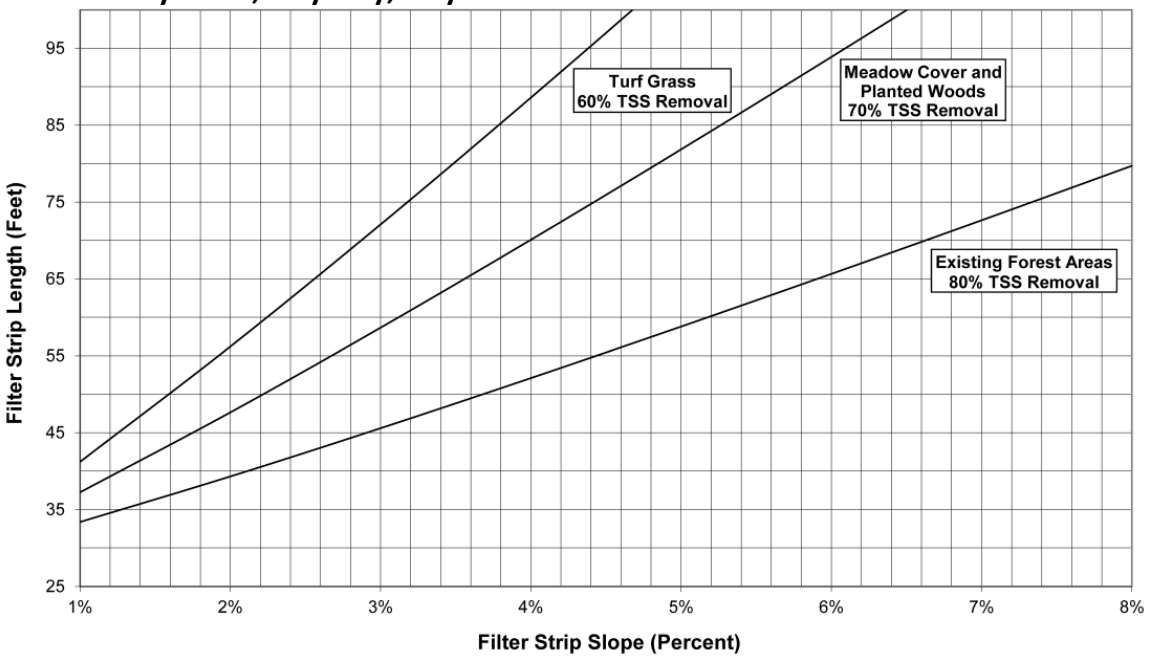


Chart E. Vegetative Filter Strip Length:
Contributory Drainage Area – Hydrologic Soil Group D & Soil Type = Clay Loam, Silty Clay, Clay



Maximum Filter Strip Slope

The maximum allowable slope for a vegetative filter strip is determined by the contributory drainage area soils and the type of vegetation within the filter strip. Both onsite soil investigations and the Web Soil Survey can be used to determine the soils types; if more than one type of soil exists, the soil type with the smallest particle size is used in the filter strip's design. If the post-development contributory drainage area is impervious, the pre-development soil type is used. Once the soil type is determined, the chart below is used to determine the maximum allowable slope for a given vegetative cover. It should be noted these maximums correspond to the slopes shown for each of the three curves in the five preceding charts.

Maximum Filter Strip Slope (%)				
Soil Type	**Hydrologic Soil Group**	**Turf Grass**	**Meadow Cover or Planted Woods**	**Existing Forest Areas**
Sand	A	7	7	5
Sandy Loam	A	8	8	7
Loam, Silt Loam	B	6.9	8	8
Sandy Clay Loam	C	5.8	8	8
Clay Loam, Silty Clay, Clay	D	4.6	6.5	8

How to Determine Filter Strip Length for a Given Slope

The following example illustrates how to use the charts to determine the required vegetative filter strip length:

Example 2: Compute the required filter strip length assuming the strip is to be vegetated with turf grass. A vegetative filter strip with a uniform 5% slope is proposed to treat the stormwater runoff from a contributory drainage area consisting of a paved parking lot. Stormwater runoff enters the filter strip as sheet flow. The maximum sheet flow length across the parking lot does not exceed 100 feet. The soil type in the contributory drainage area is silt loam.

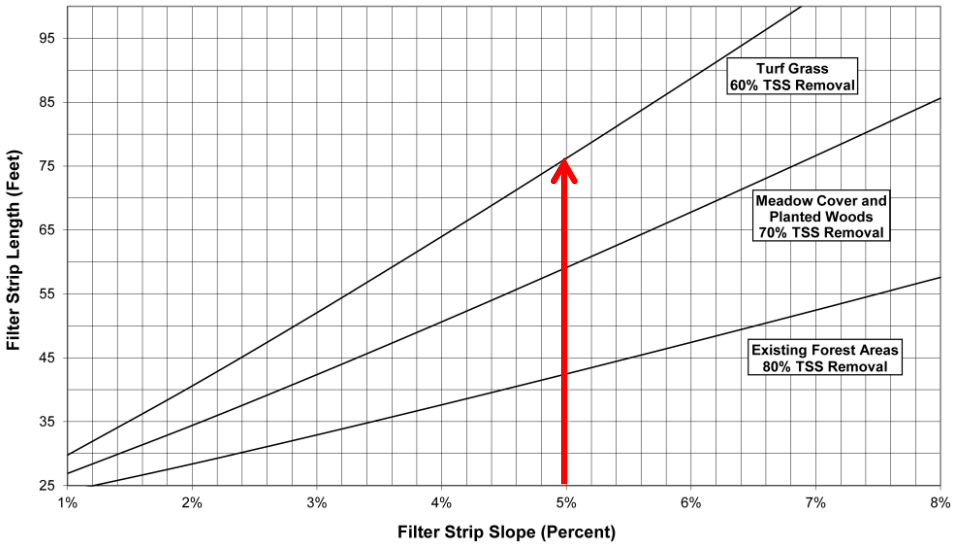
Step 1: Verify that sheet flow is maintained throughout the contributory drainage area.

Step 2: Verify that sheet flow lengths do not exceed maximum allowable.

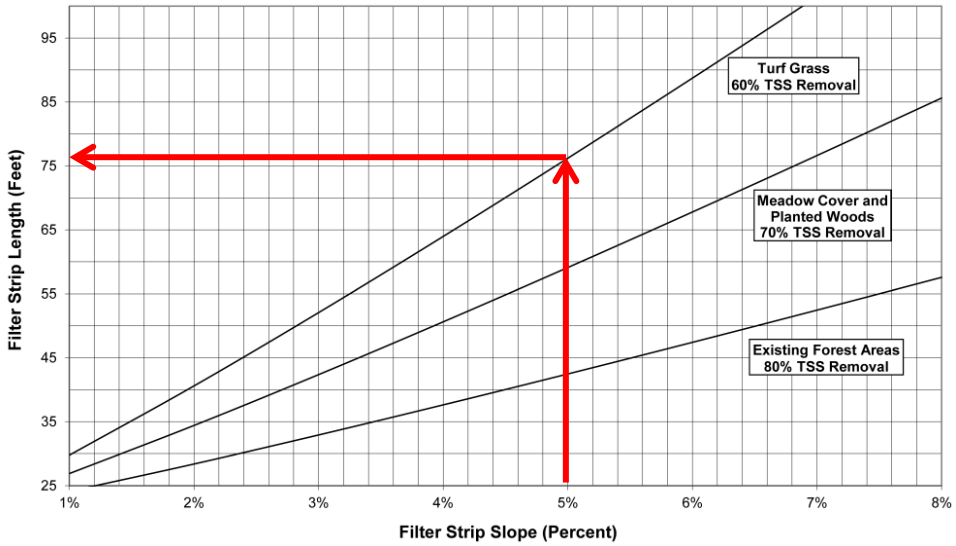
Step 3: Select the appropriate chart based on the Hydrologic Soil Group and soil type. For this example, use Chart C.

Step 4: Verify that the maximum allowable slope is greater than the design. The proposed vegetative filter strip is turf grass. The maximum slope for turf grass in HSG B, from the Table on Page 10, is 8%. The proposed slope is less than the maximum allowable.

Step 5: Using Chart C, draw a vertical line on the slope axis at the 5% mark up to the curve for turf grass, as follows:



Step 6: Draw a 2nd line from the point of intersection with the turf grass curve over to the filter strip length axis, as follows:



Step 7: Determine the required length of the filter strip. The answer is approximately 76 feet.

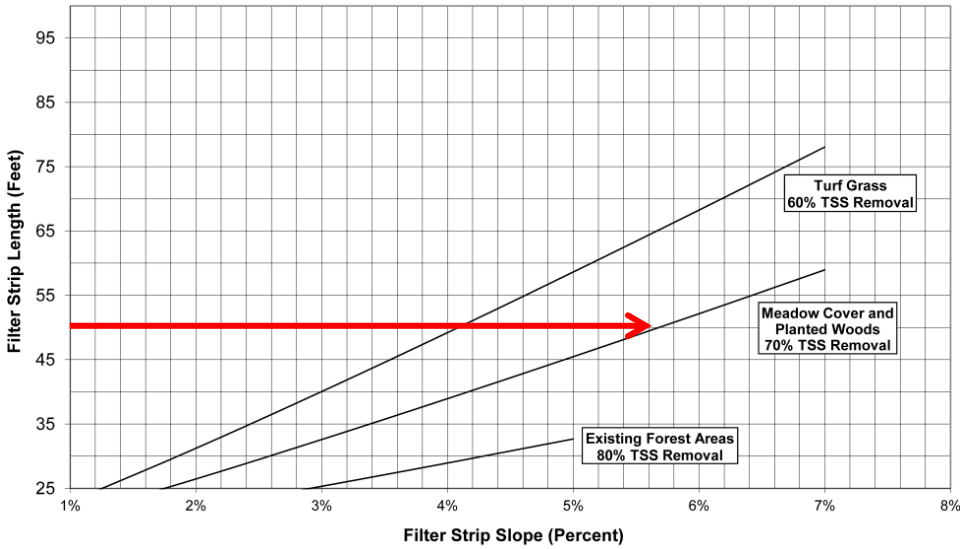
Answer: If constructed in accordance with this chapter, a turf grass vegetative filter strip 76 feet in length at 5% slope will be awarded a TSS removal rate of 60%.

How to Determine Filter Strip Slope When the Length is Known

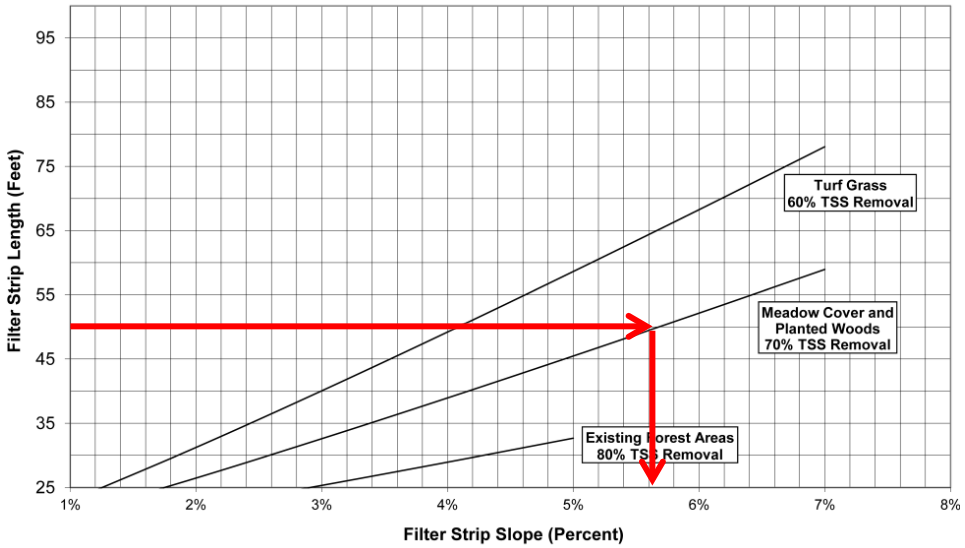
The charts can also be used in reverse to determine the required slope for a given HSG and soil type, length of filter strip and type of vegetative cover, within a contributory drainage area, as in the following example:

Example 3: The proposed design has an upstream contributory drainage area with HSG A and soil type sand. A meadow cover filter strip 50 feet in length is proposed. What slope is required?

Step 1: Using Chart A, a horizontal line is drawn from the vertical axis at the 50 ft mark over to the meadow cover curve.



Step 2: A vertical line is then drawn down from the intersection of the line in Step 1 with the meadow cover curve to the horizontal axis.



Step 3: Determine the maximum slope of the filter strip. The answer is 5.6%.

Answer: If constructed in accordance with this chapter, a meadow cover vegetative filter strip 50 feet in length at 5.6% slope will be awarded a TSS removal rate of 70%.

How to Determine Whether Sheet Flow is Maintained

Because stormwater runoff must both enter and travel through the filter strip as sheet flow, and because runoff begins to concentrate after traveling 100 feet, a mechanism to distribute energy may be necessary to maintain sheet flow. If the length of the contributory drainage area plus the length of the filter strip exceeds 100 feet, an energy dissipation mechanism, such as a stone cutoff trench, placed at the boundary between the contributory drainage area and the vegetative filter strip, may be necessary to maintain sheet flow. For additional information on energy dissipation mechanisms, refer to the *Standards for Soil Erosion and Sediment Control in New Jersey.*

The following examples illustrate when energy dissipation is necessary.

Example 4: A vegetative filter strip is proposed for a contributory drainage area 25 feet in length. Determine whether a stone cutoff trench, or other energy dissipation mechanism, may be necessary at the upstream boundary of a vegetative filter strip under each of the following conditions. What is the % TSS Removal Rate for each scenario listed below?

a. Turf grass filter strip at 6.9% Slope on HSG B, soil type Loam.

b. Meadow cover filter strip at 5.7% Slope on HSG C, soil type Sandy Clay Loam

Step 1: Start with the Appropriate Chart

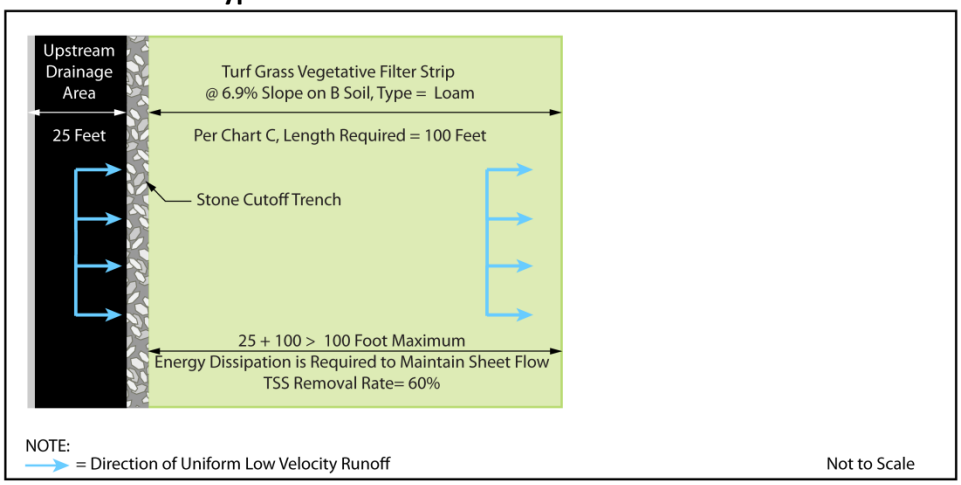
a. Using Chart C for the specified type of filter strip and slope, the length required is 100 feet. The TSS removal rate is 60%.

b. Using Chart D for the listed type of filter strip and slope, the length required is 75 feet. The TSS removal rate is 70%.

Step 2: Check for Maintenance of Sheet Flow

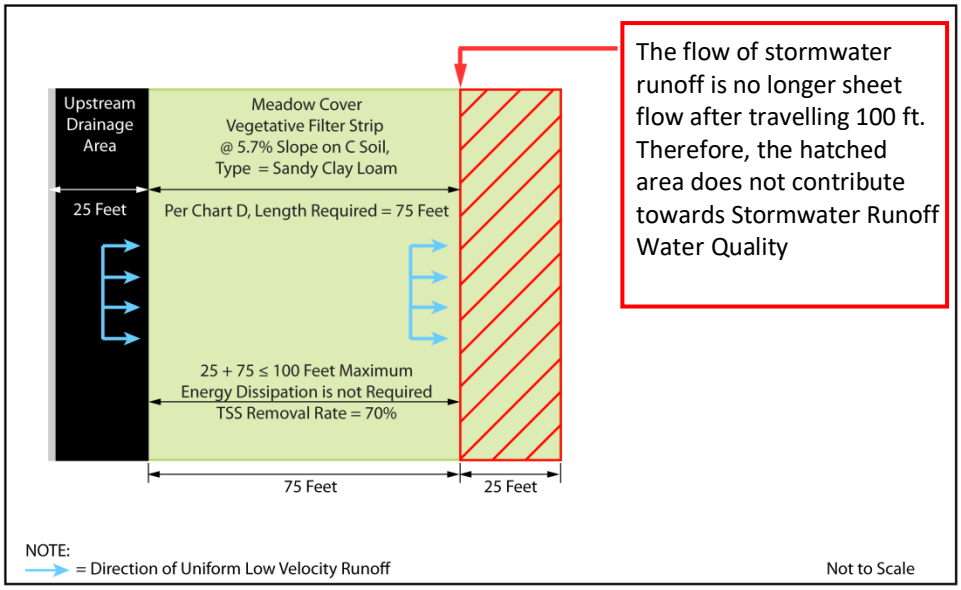
a. From Step 1, the required length of the filter strip is 100 feet, as shown in the following illustration. Because the length of the contributory drainage area plus the length of the filter strip exceeds 100 feet, a stone cutoff trench may be necessary to maintain sheet flow.

Example 4a: Filter Strip Requirements - Turf grass at 6.9% Slope, on HSG B, Soil type = Loam



b. From Step 1, the required length of the filter strip is 75 feet, as shown in the following illustration. Because the length of the contributory drainage area plus the length of the filter strip is 100 feet, a stone cutoff trench is not necessary, and the contributory drainage area receives the 70% TSS removal rate. The downstream section hatched in red does not contribute to stormwater runoff quality because the distance of travel exceeds the 100 foot maximum established for sheet flow.

Example 4b: Filter Strip Requirements – Meadow cover at 5.7% Slope, on HSG C, Soil type = Sandy Clay Loam

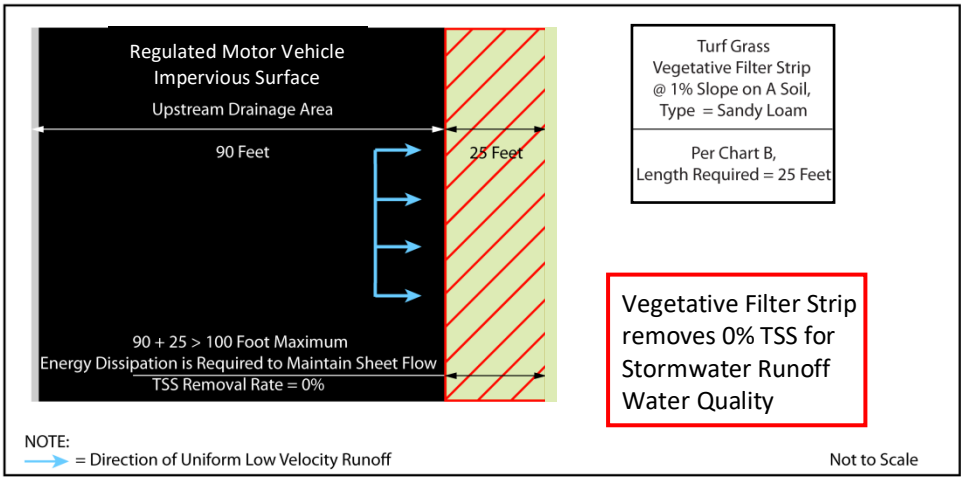


Example 5: A vegetative filter strip is proposed for a contributory drainage area consisting of regulated motor vehicle surface that is 90 feet in length. Determine if a stone cutoff trench may be necessary to maintain sheet flow if the filter strip proposed is at 1% Slope on HSG A, soil type Sandy Loam and is vegetated with turf grass. There is roughly only 28 feet of space available. Determine the length of the vegetative filter strip required. What is the % TSS Removal Rate?

Step 1: Using Chart B for the specified type of filter strip and slope, the length required is 25 feet. The TSS Removal Rate is 60% per the chart.

Step 2: Check for maintenance of sheet flow.

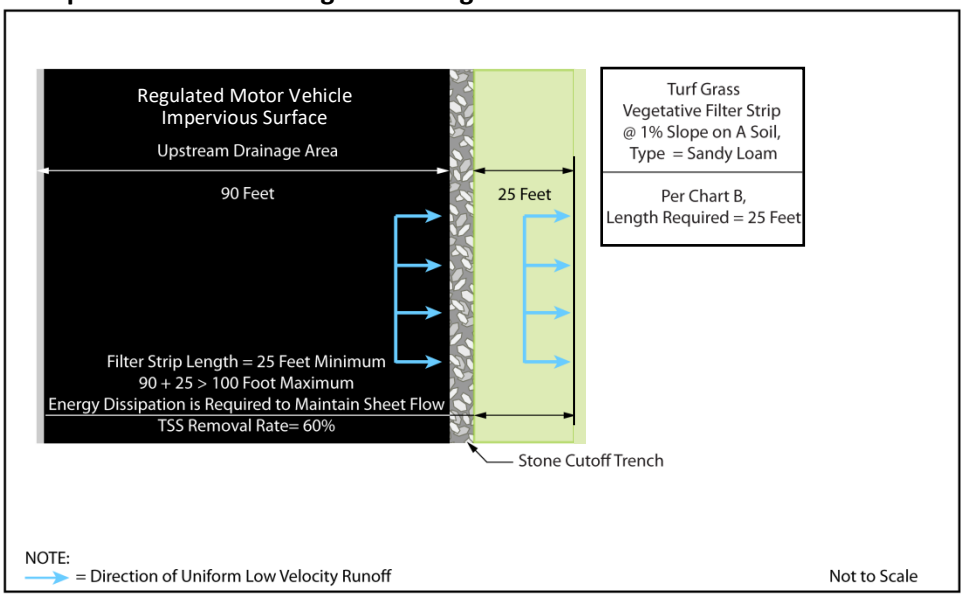
The following illustration shows a vegetative filter strip with no provision for dissipating energy. The sum of the lengths of the flow paths in the contributory drainage area and the vegetative filter strip (90 + 25 = 115) exceeds 100 feet; therefore, sheet flow is not maintained, and **the resulting TSS removal rate for this design is 0%**.



Note: The following alternative does provide treatment for stormwater runoff quality.

The illustration on the following page shows an identical contributory drainage area and vegetative filter strip. The addition of the stone cutoff trench at the down-gradient boundary of the regulated motor vehicle surface allows sheet flow to be maintained; therefore, the TSS removal rate for this configuration is 60%, based on the chart used in Step 1.

Example 5: Alternate Design Providing 60% TSS Removal



Considerations

A number of factors should be considered when using a vegetative filter strip to treat stormwater runoff, including drainage and existing on-site features. Good drainage, both surface and subsurface, is necessary to ensure satisfactory performance. When designing a newly created filter strip, the designer should be aware of potential ponding factors during the planning stage and design the system to allow for sufficient dry periods between flows in order to re-establish aerobic soil conditions. Finally, the most common, naturally occurring filter strips are those upland vegetative stands that are found adjacent to natural watercourses. In some cases, preservation of these upland areas will allow them to continue to function as filter strips.

Maintenance

Regular and effective maintenance is crucial to ensure effective vegetative filter performance; in addition, maintenance plans are required for all stormwater management facilities associated with a major development, pursuant to N.J.A.C. 7:8-5.8. There are a number of required elements in all maintenance plans; 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 vegetative filters are presented below; these requirements must be included in the vegetative filter's maintenance plan. Detailed inspection and maintenance logs must be maintained

General Maintenance

- All structural components must be inspected, at least once annually, for cracking, subsidence, spalling, erosion and deterioration.

- Components expected to receive and/or trap debris and sediment must be inspected for clogging at least twice annually, as well as after every storm exceeding 1 inch of rainfall. These components may include vegetated areas, stone cutoffs and, in particular, the upstream edge of the filter strip where coarse sediment and debris accumulation could cause inflow to concentrate.
- Sediment removal should take place when the filter strip is thoroughly dry and should not result in the loss of vegetation.
- Disposal of debris, trash, sediment and other waste material must be done at suitable disposal/recycling facilities and in compliance with all applicable local, state and federal waste regulations.
- All areas of the filter strip should be inspected for excess ponding after significant storm events, and corrective actions taken when excessive ponding occurs.
- A detailed, written log of all preventative and corrective maintenance performed on the small-scale bioretention system 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.
- Mowing/trimming within the filter strip must be performed on a regular schedule based on specific site conditions.
- 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 remaining vegetation.
- Vegetative cover must be maintained at 85%; damage must be addressed through replanting in accordance with the original specifications.
- All use of fertilizers, pesticides, mechanical treatments and other means to ensure optimum vegetation must not compromise the intended purpose of the filter strip.

Drain Time

- The approximate time for the vegetative filter strip to drain the maximum design storm runoff volume must be indicated in the maintenance manual.
- If the actual drain time is significantly different than the design drain time, the filter strip's planting bed, vegetation and groundwater levels must be evaluated and appropriate measures taken to return the filter strip to minimum and maximum drain time requirements.

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