TDOT DESIGN DIVISION

DRAINAGE MANUAL

CHAPTER XIII

POST-CONSTRUCTION

STORMWATER QUALITY

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SECTION 13.01 – INTRODUCTION

13.01 INTRODUCTION

This chapter presents the procedures and methods that will be used by the Tennessee Department of Transportation (TDOT) to address post-construction stormwater quality in the design of the Stormwater Control Measures (SCMs) following the Transportation Separate Storm Sewer System (TS4) permit requirements. The information is presented under the assumption that the designer is familiar with the basic principles of hydrology, hydraulics, and stormwater runoff that are typically encountered on a roadway project. This chapter will not discuss watershed hydrology in depth; however, it will assist in calculating the key post-construction stormwater parameters for SCM design. It is assumed that the designer is familiar with the basic principles of watershed hydrology and understands the available methods for determining flood discharges for a given watershed and frequency. Further details of those methods are provided in Chapters 4 and 5 of this Manual.

The guidelines and criteria presented in this chapter are to determine a water quality treatment volume (WQTV) to be used for SCM design. This chapter is not an all-encompassing guidance document for TS4 permit compliance. A minimum control measure (MCM) of the TS4 permit is post-construction/permanent stormwater management in new development and redevelopment, which requires TDOT to adhere to permanent stormwater standards. The goal of this chapter is to assist in the design of SCMs adhering to the TS4 permit. There may be instances where the designer may need to consult outside references depending on the design's complexity.

13.01.01 Application of Permanent Stormwater Standards

The following design criteria shall be considered for each TDOT new development or redevelopment project to determine whether SCMs are required.

New Development Projects are defined as projects that occur where no transportation facility existed prior to the project’s development, and the following conditions are met:

- the project results in one or more acres of disturbance,

- the resulting facility is owned and/or operated by TDOT, and
- the project is located within the jurisdiction of a municipality that holds a current MS4 Phase I or II NPDES Permit.

Redevelopment Projects are defined as projects that occur where an existing transportation facility exists prior to the projects development and the following conditions are met:

- the project results in one or more acres of disturbance,
- the resulting facility is owned and/or operated by TDOT,
- the project is located within the jurisdiction of a municipality that holds a current MS4 Phase I or II NPDES Permit,
- the project creates additional through lanes, and
- no net gain of impervious surface.

13.01.01.01 Project Applicability Criteria

The applicability criteria are broken into four (4) sections as described below. Each development and redevelopment project, as defined above, shall step through the project criteria to determine the project's applicability status. This shall be done in accordance with the schedule indicated in the Project Delivery Network (PDN).

Section 1: Projects in Development Prior to July 31, 2025

Establishes the criteria to be used in determining the demarcation for projects that were in the development phase prior to the conclusion of the two-year implementation period, July 31, 2025.

- Criteria 1.1: Have the project's environmental review/technical studies commenced prior to July 31, 2025?
  - If yes, then SCMs are not required.
  - If not, then proceed to Criteria 1.2.
- Criteria 1.2: Is the project part of an existing legislative initiative (e.g., Transportation Modernization Act, General Fund Transfer, Alternative Delivery's

3-year plan, 3-year Off-system, and On-system Bridge Programs, etc.) prior to July 31, 2025, where funding has been allocated based on submitted projects?
  - If yes, then SCMs are not required.
  - If not, then proceed to Section 2.

<u>Section 2: Program Projects</u>

Establishes the criteria to be used when assessing projects on a program level. Certain TDOT programs, such as safety, maintenance, and emergencies, are driven based on public safety, and the level of service provided cannot be reduced due to SCM implementation.

Programs that fall into this category are directly related to maintaining the quality and safety of the transportation system for public use. Example program types that are covered in Section 2 are, but not limited to, Maintenance, Safety, Emergency, Pedestrian Facilities, ITS, Pavement Projects, Mitigation, Lighting, Signing, Guardrail, Unstable Slopes, and Bridge Repair.

Please proceed to Section 3 for further evaluation if the implementation of SCMs on the project under consideration is not determined to be infeasible in Sections 1 or 2.

<u>Section 3: Project Level Evaluation</u>

Establishes the criteria to be used to determine if SCMs are feasible from a whole project viewpoint.

This section will guide the user through a feasibility evaluation from a project-level standpoint. Certain considerations, such as ownership, limited work area, etc., may result in SCMs not being feasible for the project.

- Criteria 3.1: Will the project result in a net gain of impervious surface and disturb one acre or more of land during construction?
  - If yes, then proceed to Criteria 3.2.
  - If not, submit an SCM consultation to TDEC to request concurrence in accordance with the PDN.

- Criteria 3.2: Will TDOT be the owner/operator of the facility once construction is complete? (e.g., SIAs, Local Program, City and/or County projects, etc.)
    - If yes, then proceed to Section 4.
    - If not, submit an SCM consultation to TDEC to request concurrence in accordance with the PDN.

Section 4: SCM Implementation Evaluation

Establishes the criteria to be used on a watershed basis by outfall per project that requires SCM implementation.

Projects being evaluated in Section 4 have already been screened in Section 3 and determined that SCMs requirements apply to the project. The next step is reviewing the project on a segment level to determine what SCMs are feasible. A project segment is based on the total onsite impervious area contributing drainage within the right-of-way to the respective post-construction stormwater outfall. The criteria below will guide users through a SCM feasibility evaluation, looking at each project segment.

- Criteria 4.1: Can the stormwater runoff from the impervious surface be discharged off the right-of-way as sheet flow?
    - If yes, submit an SCM consultation to TDEC to request concurrence in accordance with the PDN.
    - If not, proceed to Criteria 4.2.
- Criteria 4.2: Does the project segment being evaluated contain contaminated soils, shallow bedrock, steep slopes, drainage patterns, or high-water tables that would make infiltration/treatment infeasible or increase the risk of groundwater contamination?
    - If yes, submit an SCM consultation to TDEC to request concurrence in accordance with the PDN.
    - If not, proceed to Criteria 4.3.
- Criteria 4.3: Will the implementation of SCMs require the additional purchase of ROW and/or result in a significant impact on businesses or residences?

    - If yes, submit an SCM consultation to TDEC to request concurrence in accordance with the PDN.
    - If not, proceed to Criteria 4.4.
- Criteria 4.4: Will the implementation of SCMs require damage/impact to cultural/community resources (historical/archeological sites, cemeteries, parks, wildlife refuge, nature trails, schools)?
    - If yes, submit an SCM consultation to TDEC to request concurrence in accordance with the PDN.
    - If not, proceed to Criteria 4.5.
- Criteria 4.5: Will the incorporation of SCMs result in the impact to regulated features (streams or wetlands) that require additional permitting, mitigation, or result in impacts to Threatened or Endangered species?
    - If yes, submit an SCM consultation to TDEC to request concurrence in accordance with the PDN.
    - If not, proceed to Criteria 4.6.
- Criteria 4.6: Will the implementation of SCMs result in a safety concern?
    - If yes, submit an SCM consultation to TDEC to request concurrence in accordance with the PDN.
    - If not, then SCMs are required in that project segment.

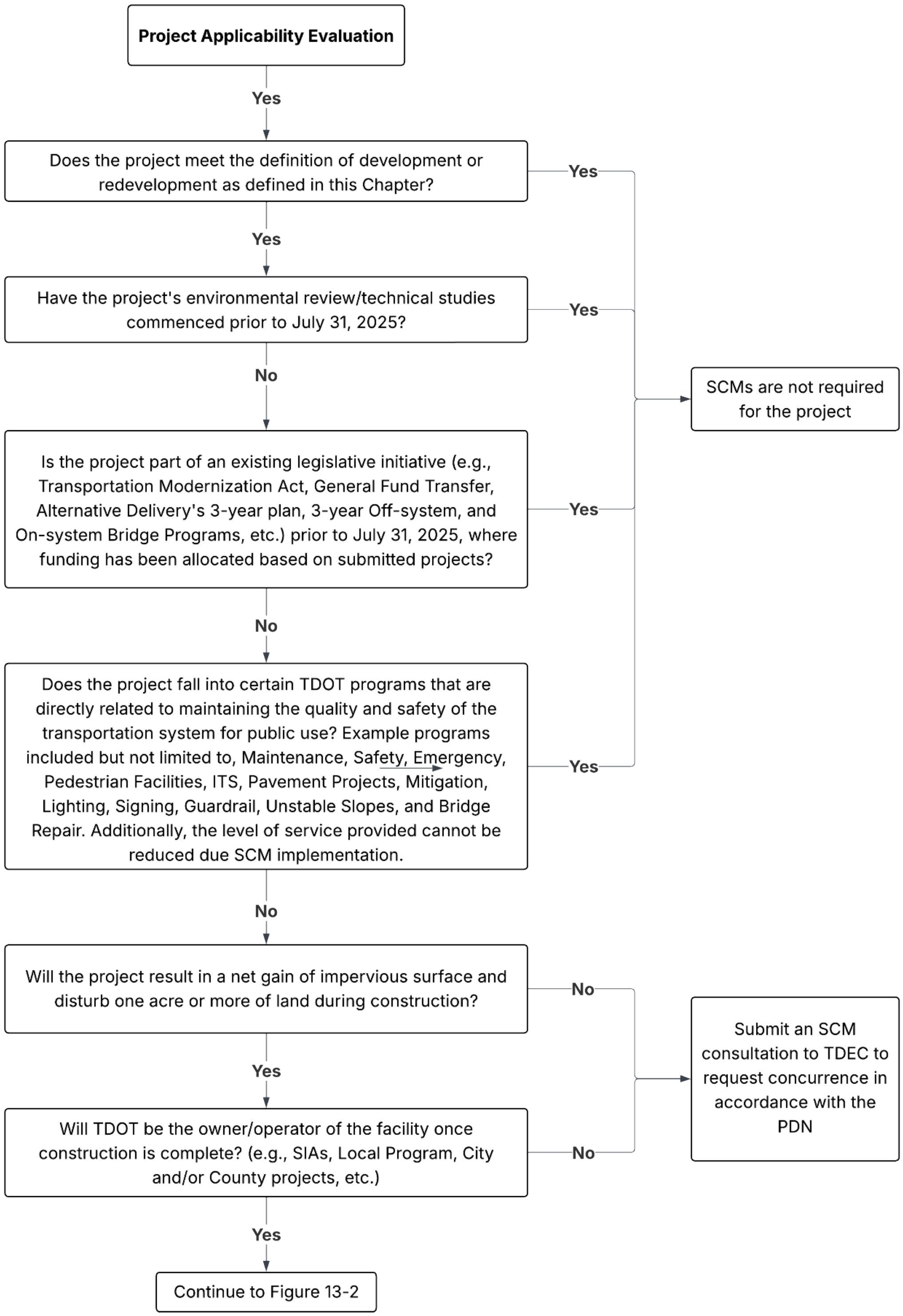

Figure 13-1

TDOT Project SCM Applicability Matrix

Alternative Text: Figure shows decision matrix described in 13.01.01.01 Project Applicability Criteria.

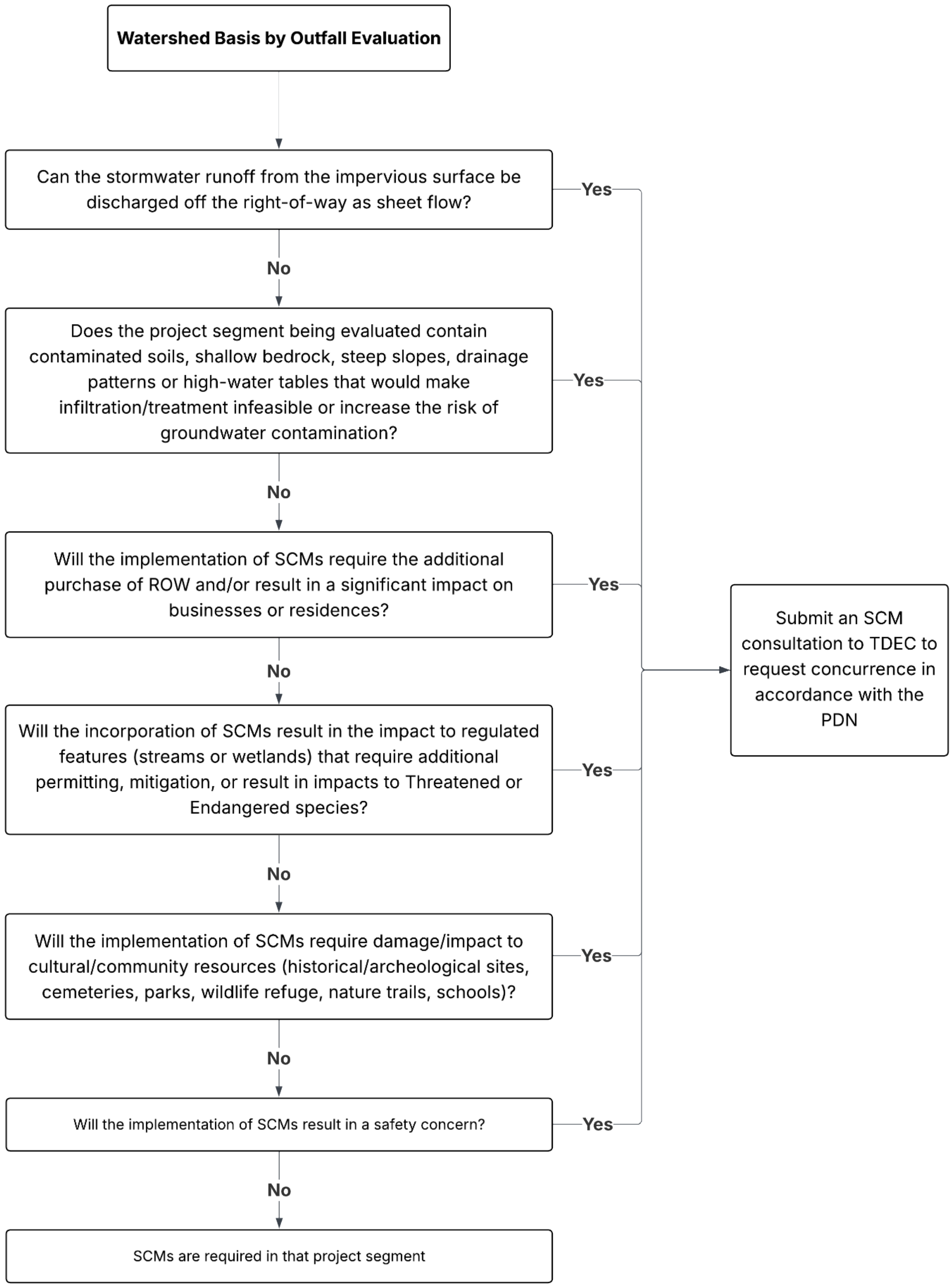

Figure 13-2

Watershed Basis by Outfall SCM Applicability Matrix

Alternative Text: Figure builds off Figure 13-1. Figure demonstrates the evaluation process for determining SCMs.

13.01.02 SCM Project Applicability Decision Concurrence

The decision on the project SCM applicability shall be submitted to the TDOT Environmental Division for review and concurrence in accordance with the PDN.

Once designers have determined that SCMs are necessary on the project, they should reference Table 13-1. Table 13-1 is designed to be used as a starting point for identifying viable SCMs on project sites based on the limiting criteria for each measure.

<table>
<tr><th colspan="2">Stormwater Control Measure (SCM)</th><th>TSS Removal (%)</th><th>SCM Treatment Method</th><th>Recommended Drainage Area (ac)</th><th>Recommended Max Slope (%)</th><th>Depth to High-Water Table/Bedrock (ft)</th></tr>
<tr><td colspan="2">Vegetated Filter Strip</td><td>50%</td><td>Filtration</td><td>N/A</td><td>25%</td><td>1-2 ft</td></tr>
<tr><td colspan="2">Grass Swale</td><td>60-80%</td><td>Filtration</td><td>5 max.</td><td>4%</td><td>2 ft</td></tr>
<tr><td rowspan="2">Bioswale</td><td>With Underdrain</td><td rowspan="2">80%</td><td>Biologically Active Filtration</td><td rowspan="2">5 max.</td><td rowspan="2">5%</td><td rowspan="2">2 ft</td></tr>
<tr><td>Without Underdrain</td><td>Infiltration</td></tr>
</table>

Table 13-1

SCM Screening Criteria Table

Adapted from: GDOT Stormwater Design Guide Table 2.5-1, Revision 1.0, 2024

SECTION 13.02 – DOCUMENTATION PROCEDURES

13.02 DOCUMENTATION PROCEDURES

Design decisions shall be documented, including the computations, supporting the permanent stormwater standards for a project, and, when applicable, the SCMs.

The documentation should be stored in a project folder and should be organized by roadway stationing from the beginning to the end of the project.

If supporting computations are performed by hand, copies of the completed worksheets should be included in the project file. If computer-generated solutions are employed, digital copies of the outputs should be included in the project file. Each computation sheet or computer output should be clearly labeled with the project description, a description of the type of computation, the project station, the date, and the designer's initials. When computerized computations are employed, the designer should include the software name and the version number. This information should be included along with the input data used for the program. Otherwise, it will be necessary to label output files by hand.

The permanent SCMs shall be shown on the proposed layout sheet and the Erosion Prevention and Sediment Control (EPSC) Stage 3 Plans.

The documentation for SCMs is required to contain all necessary information to justify the design of each SCM. The following documentation should be included in the project folder:

For EACH SCM:

- Description of the post-project characteristics of the watershed, such as drainage boundaries, outfalls, conveyance methods, impervious areas, and the peak runoff rates
- Hydrology of the SCMs contributing watershed. See Chapter 4 for additional details.
- Water quality treatment volume computations, outlet hydraulic computations, receiving channel capacity analysis, and documentation of

all storm routings, including inflow and outflow hydrographs for the water quality design storm

- Notes, computations, and sketches applicable to all SCM components

Additional documentation may be required as follows:

- Right-of-way and easement requirements for post-construction access
- Plant schedule with planting diagrams
- Post-construction monitoring plan or schedule

13.02.01 Inspection and Maintenance Note on Plans

SCMs require regular inspection and maintenance throughout their lives to preserve their original design characteristics. The following note should be added to each proposed layout sheet that contains an SCM:

SCM Post-Construction Inspection and Maintenance Note: The SCM has been designed with a requirement for regular inspection and maintenance to ensure that its original design capacity, treatment characteristics, and vegetation will be maintained for the SCM's lifetime. Inspection and maintenance shall be performed in accordance with TDOT requirements. At a minimum, accumulated sediment and debris should be removed as needed to preserve the original design capacity and treatment characteristics. Vegetation is to be replaced with like-kind as needed.

13.02.02 SCM Nomenclature

The naming convention for SCMs shall follow the guidelines listed below the order as they are listed with hyphens between each item:

- County Number
- State Route Number
- Log Mile
- Left, Right, or Center Line

SECTION 13.03 – FUNDAMENTALS OF STORMWATER QUALITY TREATMENT

13.03 FUNDAMENTALS OF STORMWATER QUALITY TREATMENT

This section focuses on an introduction to the principles that shall guide the SCM design and selection process. Designers should have a basic understanding of hydraulic design, including but not limited to drainage area delineation, rational method, SCS method, time of concentration, and ditch design. Designers may reference Chapters 4 and 5 of the TDOT Drainage Manual for Hydrology and Roadside Ditches and Streams, respectively. The fundamentals of stormwater quality treatment are as follows:

13.03.01 Treatment Type

The primary treatment types for stormwater quality treatment are infiltration, biologically active filtration, filtration, and settling.

13.03.01.01 Infiltration

SCMs where infiltration is the primary treatment mechanism allow runoff to drain through underlying soils. Infiltration-based SCMs are applicable only when the underlying soils are hydrologic soil groups (HSG) A and B, or where soil infiltration rates have been tested and are capable of draining the water quality treatment volume within 72 hours. There must be at least 2 feet of separation between the bottom of the infiltration-based SCM and the seasonal high-water table and bedrock.

13.03.01.01.1 Hydrologic Soil Group (HSG)

The HSG shall be determined for the project site to determine the applicability of infiltration-based SCMs. If HSG A or B soils are not present at the proposed SCM location, then site-specific infiltration testing must be performed to justify the use of infiltration-based SCMs. Refer to Chapter 4 of this Manual for further information about HSGs.

13.03.01.01.2 Drawdown Times

Drawdown time is the amount of time it takes for the water quality treatment volume to drain through the infiltration-based SCM into the underlying soils. The drawdown time for infiltration-based SCMs must be 72 hours or less.

13.03.01.02 Biologically Active Filtration

Biologically active filtration uses living micro-organisms to capture and biologically degrade pollutants. Biologically active filtration occurs within the internal water storage (IWS) of the SCM. There must be at least 2 feet of separation between the bottom of the biologically active filtration-based SCM and the seasonal high-water table and bedrock.

13.03.01.02.1 Internal Water Storage (IWS)

IWS is a zone in a SCM where stormwater is retained to create an anaerobic condition within the filtration media. The biologically active filtration-based SCM requires a minimum of 12 inches of IWS.

13.03.01.03 Filtration

SCMs where filtration is the primary treatment mechanism allow runoff to flow through a media or through vegetation to remove pollutants. Filtration-based SCMs rely on hydraulic residence time facilitated by the flow through the media or vegetation.

13.03.01.03.1 Hydraulic Residence Time (HRT)

Hydraulic Residence Time (HRT) is the average time the water quality treatment volume stays within the SCM. HRT is facilitated by using media or vegetation to slow runoff, which promotes contact time to provide filtration, allowing TSS removal in runoff.

13.03.01.03.2 Media

Media treats stormwater runoff and removes pollutants through a variety of filtering materials. Pollutants become trapped in the voids between media particles and on media particle surfaces themselves. Filtration media is selected based on the porosity and varies by layer.

13.03.01.03.3 Vegetation

Vegetation treats stormwater runoff and removes pollutants via biomass pass-through. The vegetation shall have a minimum plant height of 3 ft. The flow depth associated with the stormwater quality design storm shall be contained within the biomass and have a maximum allowable water depth of 2.5-ft.

Minimum Plant Height Required	Maximum Allowable Water Depth
3 feet	2.5 feet

Table 13-2

Allowable Water Height Based on Grass Type

Reference: INDOT Post-Construction Stormwater Management, 2022

The minimum vegetative height of 3-ft can be facilitated by the example seed mixtures shown in Tables 13-3 and 13-4.

Kind & Variety	Percent Seed
Kentucky 31	20%
Perennial Ryegrass	10%
Alfalfa, Buffalo	10%
Orchardgrass	10%
Blossom, Sweet Yellow	5%
Clover, Alsike	5%
Medium Red Clover	5%
Ladino Clover	5%
Birdsfoot Trefoil	5%
Red Top	5%
Switchgrass	10%
Indian Grass	5%
Big Bluestem	5%

Table 13-3

SCM Filtration Summer Mixture

Kind & Variety	Percent Seed
Kentucky 31	20%
Perennial Ryegrass	10%
Alfalfa, Buffalo	10%
Orchardgrass	10%
Blossom, Sweet Yellow	5%
Clover, Alsike	5%
Medium Red Clover	5%
Ladino Clover	5%
Birdsfoot Trefoil	5%
Red Top	5%
Virginia Wild Rye	5%
Canada Wild Rye	5%
Indian Grass	5%
Big Bluestem	5%

Table 13-4

SCM Filtration Winter Mixture

13.03.01.03.4 Settling

SCMs where settling is the primary treatment mechanism rely on the dissipation of energy from incoming runoff and sedimentation, in which coarse sediment and debris sink or fall out of the collected stormwater. Some settling devices also provide secondary screening to improve the capture of floatables and sediment.

13.03.01.03.4.1 Stokes' Law

Stokes' Law describes solids settling in stormwater applications and applies to clays, silts, and fine sands. The settling velocity of solids in a fluid is dependent on the size and density of the solids and the properties of the fluid (i.e., density and viscosity) in which the solids are entrained. For stormwater applications, the fluid in which solids are immersed is assumed to be water, for which density is nearly constant, and viscosity varies only with temperature. Settling is dependent on sediment size, density, and water temperature.

SECTION 13.04 – WATER QUALITY TREATMENT VOLUME

13.04 WATER QUALITY TREATMENT VOLUME

The water quality treatment design storm is a 1-year, 24-hour storm event as defined by the Precipitation-Frequency Atlas of the United States. Atlas 14. Volume 2. Version 3.0 U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA), National Weather Service, Hydrometeorological Design Studies Center, Silver Springs, Maryland, or its digital product equivalent. The water quality treatment volume (WQTV) is a portion of the runoff generated from impervious surfaces at a new development or redevelopment project by the design storm. For design purposes, total suspended solids (TSS) are used as the indicator for the reduction of pollutants. SCMs must be designed to provide an overall treatment rate of 80% TSS of the WQTV. SCMs must be designed to provide full treatment capacity within 72 hours following the end of the preceding rain event for the life of the new development or redevelopment project. The quantity of the WQTV depends on the type of treatment provided, as established in the following table:

Treatment Type for the 1-year, 24-hour Design Storm		
SCM Treatment Type	WQTV	Notes
infiltration, evaporation, transpiration, and/or reuse	runoff generated from the first 1 inch of the design storm	Examples include, but are not limited to, bioretention, storm water wetlands, and infiltration systems.
biologically active filtration, with an underdrain	runoff generated from the first 1.25 inches of the design storm	To achieve biologically active filtration, SCMs must provide 12 inches of IWS
sand or gravel filtration, settling ponds, extended detention ponds, and wet ponds	runoff generated from the first 2.5 inches of the design storm or the first 75% of the design storm, whichever is less	Examples include, but are not limited to, sand filters, permeable pavers, and underground gravel detention systems. Ponds must provide forebays comprising a minimum of 10% of the total design volume. Existing regional detention ponds are not subject to the forebay requirement.
hydrodynamic separation, baffle box settling, other flow-through manufactured treatment devices (MTDs), and treatment trains using MTDs	maximum runoff generated from the entire design storm	Flow-through MTDs must provide an overall treatment efficiency of at least 80% TSS reduction. Refer to subparagraph (2)(d) of Tennessee Rule 0400-40-05-.15
Alternative permanent stormwater standards that provide equal or equivalent reduction of pollutants to the above may be submitted to the Environmental Division for consultation.		

Table 13-5

Water Quality Treatment Volume and Corresponding SCM Treatment Type

Reference: TDOT NPDES Permit TNS077585

13.04.01 Water Quality Treatment Volume Determination

Designers will calculate the WQTV using the respective calculation method described in the following sections.

13.04.01.01 USDA-NRCS Curve Number Method

The USDA-NRCS Curve Number Method (SCS Method) is required to determine the WQTV for the SCM design for all rows of Table 13-5. Any design exceptions are discussed in the corresponding SCM section, if applicable. The runoff volume shall be determined by project segment, which is based on the total onsite impervious area contributing drainage within the right-of-way to the respective post-construction stormwater outfall. See Equations 13-2 and 13-3 for the equations needed for the USDA-NRCS Curve Number Method.

The following equation determines the direct runoff in inches:

$$Q = (P - 0.2S)^2 / (P - 0.8S) \tag{13-2}$$

Where:

Q = accumulated direct runoff, inches

P = accumulated rainfall, in

S = potential maximum soil retention after runoff begins, in

S can be expressed as a function of the SCS CN and is calculated in Equation 13-3.

$$S = (1000/CN - 10) \tag{13-3}$$

Where:

S = potential maximum soil retention after runoff begins, in

CN = Curve Number, accumulated rainfall

13.04.01.01.1 Rainfall Distribution

The Regional Rainfall Distribution as presented in Figure 13-2 shall be referenced to determine the rainfall for the project site. The rainfall distributions will reflect the rainfall depth versus duration data at the project location more accurately. This will lead to more accurate estimates of peak discharges and hydrographs for design of projects.

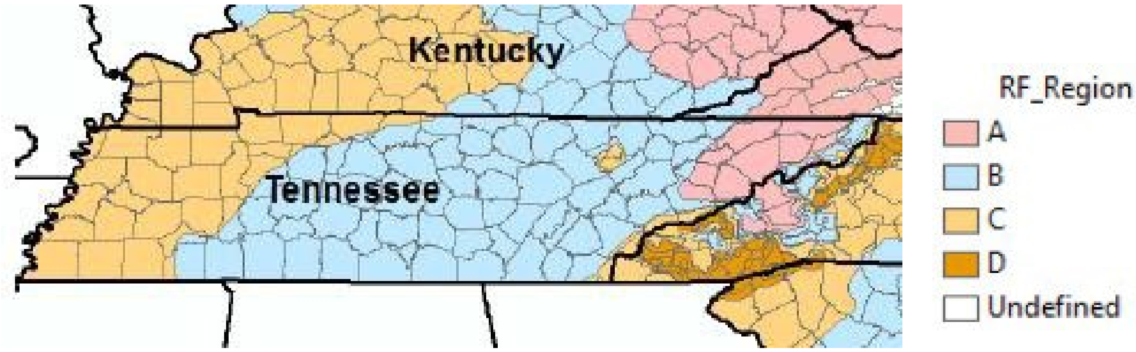

Figure 13-3

Regional Rainfall Distributions for the Ohio Valley Region and Neighboring States

Reference: Design Rainfall Distribution Based on NOAA Atlas 14 Rainfall Depths and Distribution, Figure 4.

Alternative Text: Figure shows Tennessee and parts of bordering states by rainfall region. West Tennessee is primarily Region C, Middle and West are primarily Region B, with exceptions for Morgan County as Region C, and Northeastern Tennessee as Region A.

13.04.02 Treatment Train

In some cases, a single SCM may not provide an overall treatment efficiency of 80% reduction, and the use of SCMs in series, or a treatment train, may be necessary. Equation 13-5 provides the treatment train formula for SCMs in series.

When using treatment trains with manufactured treatment devices (MTDs), the overall treatment efficiency must be at least 80% TSS reduction using the following formula:

$$R = A+B - (A \times B) / 100 \qquad (13\text{-}5)$$

Where:

R = total TSS percent removal from application of both SCMs.

A = the TSS percent removal rate application to the first SCM, and

B = the TSS percent removal rate application to the second SCM

TSS removal rates for MTDs must be evaluated using industry-wide standards. TSS removal rates for other SCMs are provided in Table 13-1.

When not using MTDs, they can utilize infiltration, evaporation, transpiration, reuse, or biologically active filtration followed by sand or gravel filtration, settling ponds, extended detention ponds, or wet ponds, and may subtract the treated WQTV of the upstream SCMs from that of the downstream SCMs.

SECTION 13.05 – TYPES OF STORMWATER CONTROL MEASURES (SCMs)

13.05 TYPES OF STORMWATER CONTROL MEASURES (SCMs)

This section describes several SCMs that may be used on TDOT projects. It also provides guidelines on where and how to apply these control measures.

13.05.01 Vegetated Filter Strip (D-SCM-1)

13.05.01.01 Definition and Purpose

A vegetated filter strip is a uniformly graded and densely vegetated area that promotes sheet flow, resulting in pollutant removal through sedimentation and vegetative filtering. Vegetated filter strips should be planted with the SCM seed mixture as discussed in Section 13.03.01.03.3 of this Chapter. Vegetated filter strips are suggested as an initial SCM within a treatment train to achieve the 80% TSS removal requirement.

13.05.01.02 Appropriate Applications

Vegetated filter strips are most often utilized in rural areas where curb and gutter are absent. The vegetation, slope, and the length of the vegetated filter strip influence the TSS removal rate. Filter strips require a relatively large surface area compared to other SCMs. The overall slope of the area must be assessed when considering applications for vegetated filter strips. Vegetated filter strips have a maximum longitudinal slope of 5%; the lateral slope shall be minimized to prevent the formation of concentrated flow and shall not be applied on slopes greater than 4:1.

13.05.01.03 Limitations

Vegetated filter strips are limited to sheet flow applications. Flow must enter the filter strip as sheet flow spread out over the width (long dimension normal to flow) of the strip, generally no deeper than 1 to 2 inches. If the flow will not enter the filter strip as sheet flow, special provisions must be made to ensure design flows spread evenly across the filter strip, such as the use of a level spreader. Flows that discharge from a vegetated filter strip across right-of-way boundaries and do not immediately concentrate should be re-evaluated under Applicability Criteria 4 to determine whether vegetated filter strip design should proceed per this section.

13.05.01.04 Planning and Design Criteria

Vegetated filter strips are located parallel to the roadway, shall receive sheet flow and be vegetated with a permanent seed mixture. The vegetated filter strip shall be at least 15-ft long to provide filtration and contact time for water quality treatment. The following tables are provided for filter strip sizing based on the pavement width within the SCM drainage area. The filter strip length is measured from the edge of the shoulder.

13.05.02 Grass Swales (D-SCM-2)

13.05.02.01 Definition and Purpose

A grass swale is used for water quality treatment and is designed to convey and treat runoff for a project segment. A swale will convey and treat flow during wet weather events but remain dry during periods of no rainfall. Grass swales should be planted with the SCM seed mixture discussed in Section 13.03.01.03.3 of this Chapter.

13.05.02.02 Appropriate Applications

This control measure may be applied in small open channels conveying stormwater flow and shall adhere to clear zone requirements. Grassed swales shall not be used in any waterways designated as intermittent or perennial streams. Flow rate and slope must be assessed when considering applications for grass swales.

13.05.02.03 Limitations

A grass swale shall not be used when the water table or bedrock is within 2-ft of the bottom ditch elevation. The available ditch length, slope, flow rate, and ultimately the Hydraulic Residence Time will determine TSS removal efficiencies for each grass swale application.

13.05.02.04 Planning and Design Criteria

Grass swales are trapezoidal SCMs that slow runoff and promote TSS removal through filtration. Grass swales should not contain an underdrain and are not limited by HSG. Grass swales have a suggested bottom width ranging between 2 and 10 feet. Swales shall not have slopes steeper than a 3:1 ratio, with a recommended ratio of 5:1. Grass swales are suggested to have a maximum longitudinal slope of 4%, with the controlling parameter being velocity. In areas where the maximum slope or average velocity exceeds 4% or 4 fps, check dams may be implemented to create an effective slope that meets the velocity requirements.

Peak flow shall be calculated for the project segment. Water depth and velocity are important factors when implementing grass swales in larger drainage areas because, as the flow deepens and the velocity increases, the grass swales' effectiveness is thereby reduced. The water depth must be below the height of the permanent vegetation for effective TSS removal. The depth of flow must be at or below the height of the grass in the bottom of the grass swale during the discharge of the 1-year, 24-hour design storm, and a Manning’s n value of 0.15 may be applied. Refer to Tables 13-3 and 13-4 for TDOT’s SCM seed mixture and Table 13-5 for grass heights.

An effective slope may be facilitated by the specification of permanent check dams. The effective slope is measured from the toe of the upstream rock check dam to the weir opening of the downstream rock check dam. Designers shall refer to Chapter 10 for information regarding the design and spacing of check dams.

Adequate vegetation must be established in the grass swale, otherwise, TSS will not be removed. A disadvantage is that before vegetation is established, erosion can occur, so a temporary erosion-resistant lining may be required during construction. Chapter 5 of this Manual shall be referenced for ditch stabilization type; however, concrete and/or riprap lining is not acceptable. Permanent check dams may be required to minimize post-construction erosion within the ditch. EPSC devices should be used while the vegetation is being established. Once vegetation is established, temporary EPSC measures should be removed.

The grass swale should be designed to achieve an HRT in the grass swale that is between 5 and 9 minutes. Table 13-6 indicates the correlation between the HRT and the TSS removal rate. If a TSS removal rate of 80% is not achieved from a single SCM, then a treatment train may be utilized, or an alternate SCM should be considered.

Hydraulic Residence Time (HRT)	Sediment Removal Achieved
9 mins	80%
8 mins	75%
7 mins	70%
6 mins	65%
5 mins	60%

Table 13-6

Hydraulic Residence Time (HRT) vs. Sediment Removal Achieved

Reference: INDOT Post-Construction Stormwater Management, 2022

The design of the grass swale is an iterative process using Manning's Equation for ditch sizing to determine velocity, depth, and subsequently HRT.

Equation 13-6 determines the HRT:

$$T_{ahr} = (L_{swale} / v_{wq}) / 60 \qquad (13\text{-}6)$$

Where:

T_{ahr} = HRT, minutes

L_{swale} = hypotenuse length of swale, feet

v_{wq} = average velocity at the 1-year, 24-hour design storm, ft/s

13.05.03 Bioswales (D-SCM-3 and D-SCM-4)

13.05.03.01 Definition and Purpose

A bioswale is used for water quality treatment and is designed to convey and treat runoff for a project segment. Unlike the grass swale, a bioswale treats the WQTV by allowing sediment particles to be removed through infiltration, biologically active filtration, or filtration.

13.05.03.02 Appropriate Applications

This control measure may be applied in small open channels conveying stormwater flow and shall adhere to clear zone requirements. Bioswales shall not be used in any waterways designated as intermittent or perennial streams. Infiltration rate in subsurface soils and slopes must be assessed when considering applications for bioswales.

13.05.03.03 Limitations

Bioswales shall not be used when the water table or bedrock is within 2-ft of the bottom ditch elevation. Bioswales may be used in all soil types, but the type of bioswale, with or without underdrain, is determined by the in-situ soil HSG.

13.05.03.04 Planning and Design Criteria

Bioswales, where the primary treatment mechanism is infiltration, may be used in areas with in-situ soils of HSGs A or B (or with a site-specific infiltration rate of 0.3 in/hr or higher that has been determined by infiltration testing) without an underdrain. Bioswales with an underdrain may be used in HSGs C or D. Bioswales, where the primary treatment mechanism is biologically-active filtration, must have an underdrain that facilitates an IWS capacity of 12 inches.

Side slopes must be 3:1 or flatter. Minimum longitudinal slopes shall be 0.5% with 1-2% preferred, and 5% being the maximum slope. The recommended bottom width should range between 2 and 10 feet.

The required treatment is achieved as the WQTV flows through the bioswale media and infiltrates into the underlying soil or is captured by an underdrain. The media shall be layered per the following cross-section shown in Figure 13-4. The surface area of the SCM is designed such that the WQTV is contained within the layered media.

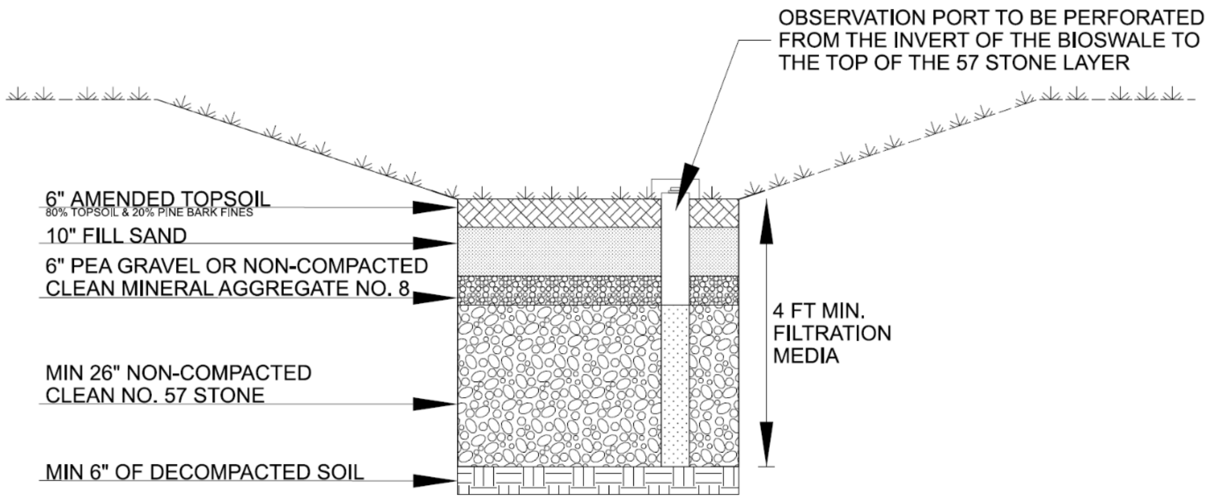

Figure 13-4

Bioswale without Underdrain Cross Section

Alternative Text: Figure shows a bioswale cross-section with biologically active and infiltration media with an observation port. The layers include the following, described from top to bottom: 6" amended topsoil, 10" fill sand, 6" pea gravel or non-compacted clean mineral aggregate number 8, minimum 26" non-compacted clean number 57 stone, and a minimum layer of 6" of decompacted soil.

The porosity of media, shown in Table 13-7, will dictate the available stormwater volume, or "effective volume" provided by the SCM. Geotextile fabric shall be specified to enclose filtration media on vertical sides to prevent horizontal seepage.

Porosity of Media (φ)	
Amended Topsoil	0.25
Fill Sand	0.40
Pea Gravel or No. 8 Stone	0.40
No. 57 Stone	0.60

Table 13-7

Porosity of Media

Adapted from Nashville.gov, GIP-5 Water Quality Swale, 2020

The WQTV has a maximum drawdown time of 72 hours. Drawdown is facilitated by infiltration into the in-situ soils or an underdrain. Specification of an underdrain is determined by the HSG (or site-specific infiltration testing) at the proposed SCM location, as discussed in this section. The diameter of the underdrain shall be sufficient to discharge the WQTV within 72 hours. The underdrain outlet shall facilitate gravity discharge.

Adequate vegetation must be established in the bioswale, as erosion can occur, so a temporary erosion-resistant lining may be required during construction. Chapter 5 of this Manual shall be referenced for ditch stabilization type; however, concrete and/or riprap lining is not acceptable. Permanent check dams are required to promote infiltration/filtration. Observation ports shall be placed halfway between each permanent check dam. Check dams will also minimize construction and post-construction erosion within the ditch. EPSC devices shall be used while the vegetation is being established. Once vegetation is established, temporary EPSC measures should be removed.

SECTION 13.06 – ACCEPTABLE SOFTWARE

13.06 ACCEPTABLE SOFTWARE

TDOT does not endorse any specific software package. Further, TDOT does not warrant the results that may be obtained from any of these computer programs. Evaluation of the results given by any specific computer program and the stormwater facility design is entirely the responsibility of the user.

Models use the computational power of the computer to expedite the time-consuming and repetitive computations normally associated with stormwater routing. The model's analytical power and computational speed give it superior advantages over manual calculations.

The designer is advised that no computer method is completely reliable, and the results from any software package should be carefully evaluated. A clear understanding of the various hydraulic methods involved in SCM design is therefore necessary to successfully apply any of these programs. The TDOT Design Manager should approve the use of any other software for these special circumstances. The designer should refer to the software manuals for further guidance on how to apply the reservoir routing methods provided in the selected software. If the designer uses any approved software, they should include the name of the software and the version number in the project file.

If computations are performed by hand, copies of the completed worksheets should be included in the project file. Each computation sheet or computer output should be clearly labeled with the project description, a description of the type of computation, coordinating project or project stationing, the date, and the initials of the designer. When computerized computations are employed, this information should be included along with the input data used for the program. Otherwise, it will be necessary to label output files by hand.

SECTION 13.07 – APPENDIX

13.07 APPENDIX

TDOT TS4 Stormwater Control Measure (SCM) Planning Tool for Post-Construction/Permanent Stormwater Management

Version 1.0, August 2025

Table of Contents

Disclaimer

This tool, provided for information only, is intended to assist the designer in determining project applicability in accordance with Post-Construction/ Permanent Stormwater Management. This tool is being provided without warranty or liability of any kind to the Department. All liability resides with the user of the tool. The Department's Design Division Drainage Manual shall be used in design of post-construction structures.

References

Tennessee Department of Transportation [TDOT] (2025). "Design Division Drainage Manual."

Version History

Version	Date	Revision Summary
1.0	August 2025	Initial Version

General Instructions

The TDOT TS4 Stormwater Control Measure (SCM) Planning Tool for Post-Construction/Permanent Stormwater Management was developed to document applicability and streamline the initial design and review of Stormwater Control Measures (SCMs). The purpose of this workbook is to provide general drainage area analysis and preliminary SCM sizing. This tool does not replace the need for engineering design and judgement and is only intended to supplement the TS4 design process.

The workbook is divided into the following worksheets:
Introduction: provides a cover sheet of the tool and the table of contents
Instructions: provides general tool description and user instructions Project: serves as the checklist to identify the project applicability

Do not rename the Introduction , Instructions , or Project sheets.

Worksheet Cells have been color-coded to assist users in inputting the required information. The uniform color coding is given below:

(blue cell)	BLUE: user inputs
(green cell)	GREEN: results from user inputs

Before starting your project, be sure to click the Reset Button located on the Project sheet. This ensures the user that you are working with a clean slate and helps avoid errors from leftover data. Specifically, this button unchecks all checkboxes and clears BLUE input cells across the workbook while maintaining the original formatting to prepare the workbook for a fresh start.

Introduction

The Introduction worksheet is the cover sheet for the tool. It provides the table of contents, disclaimer, references, and version history of the tool. Links are provided for quick access to certain worksheets in the tool.

Instructions

The Instructions worksheet provides the user with the detailed instructions on how they should use the tool. This includes general instructions and worksheet specific instructions for the entire workbook. This page should be referred to when any questions arise.

Project

The Project worksheet asks the user to input information about the project location and scope to identify the applicability of SCMs in the project area according to Chapter 13 of TDOT's Drainage Manual. In this sheet, the project will be identified as a New Development Project or a Redevelopment Project as appropriate. Then, it will guide the user through the Project Applicability Criteria as described in Chapter 13 of TDOT's Drainage Manual. Also on this sheet is the Reset Button. This should only be used when first starting the project to help avoid errors from leftover data.

TDOT Project Number:	Coordinates (Approximate Center of Project):
Project Name:	Latitude (DD.DDDDDD):
Agency/Company:	Longitude (DD.DDDDDD):
Contact Person:	County:
Contact Phone:	TDOT Region:
Notes:	

New Development and Redevelopment Project Criteria

Yes No

A project is considered a New Development Project if the following conditions are met:

1. Does this project result in a new transportation facility?
2. Does the project result in one or more acres of disturbance?
3. Is the resulting facility owned and/or operated by TDOT?
4. Is the project located within the jurisdiction of a municipality that holds a current MS4 Phase I or II NPDES Permit? Go to TDEC's Construction General Permit Mapviewer to view the locations of MS4 Phase I or II NPDES Permits.

OR

A project is considered a Redevelopment Project if the following conditions are met:

1. Does this project occur where an existing transportation facilty is located?
2. Does the project result in one or more acres of disturbance?
3. Is the resulting facility owned and/or operated by TDOT?
4. Is the project located within the jurisdiction of a municipality that holds a current MS4 Phase I or II NPDES Permit? Go to TDEC's Construction General Permit Mapviewer to view the locations of MS4 Phase I or II NPDES Permits.
5. Does the project create additional through lanes?
6. Does the project result in no net gain of impervious surface?

Determination:

Since the project is considered neither a New Development Project or a Redevelopment Project as described by the criteria above, SCMs are not required.
Since the project is considered a New Development Project or a Redevelopment Project as described by the criteria above, procede to the Project Applicability Criteria section below. A project can not be both a New Development Project and a Redevelopment Project . Please revisit the criteria and make corrections as needed.
To determine if the project is a New Development Project or a Redevelopment Project please continue to fill out the criteria above.

Project Applicability Criteria	Yes	No
Was the project in the development phase prior to July 31, 2025?		
1.1 Have the project's environmental review/technical studies commenced prior to July 31, 2025?		
1.2 Is the project part of an existing legislative initiative prior to July 31, 2025, where funding has been allocated based on submitted projects? Examples include, but are not limited to, Transportation Modernization Act, General Fund Transfer, Alternative Delivery's 3-year plan, 3-year Off-system, and On-system Bridge Programs.		
Does the project fall into certain TDOT programs that are directly related to maintaining the quality and safety of the transportation system for public use? Example programs include, but are not limited to, Maintenance, Safety, Emergency, Pedestrian Facilities, ITS, Pavement Projects, Mitigation, Lighting, Signing, Guardrail, Unstable Slopes, and Bridge Repair. Additionally, the level of service provided cannot be reduced due to SCM implementation.		
.1 Will the project result in a net gain of impervious surface and disturb one acre or more of land during construction?		
.2 Will TDOT be the owner/operator of the facility once construction is complete?		

Determination:

SCMs are not required.
Continue to answer the above questions to determine if SCMs are required on this project.
Submit an SCM consultation to TDEC to request concurrence in accordance with the Project Delivery Network (PDN). Proceed to TDOT's Drainage Manual Chapter 13 for further evaluation.

13.07.01 Glossary

The following list of terms is representative of those used in erosion prevention and sediment control practices. The terms may not all be used in the chapter text, but rather are commonly used by engineers, scientists, and planners.

BIOMASS - Living matter that comes from plants.

HYDROLOGIC SOIL GROUP (HSG) – A classification of different soil types into groups (A, B, C, and D) according to their minimum infiltration rate, based upon bare soil after prolonged wetting.

IMPERVIOUS AREA – The permanent surfaces in a drainage basin that cannot infiltrate rainfall. Areas typically consist of rooftops, sidewalks, pavements, slabs, driveways, etc.

INFILTRATION – As applied in Hydrology, the process by which water percolates into soil and becomes a part of the groundwater regime. Water which infiltrates during a rainfall event is removed from the direct runoff and usually does not contribute to the peak flood flow rate of a stream.

MANUFACTURED TREATMENT DEVICE (MTD) - a pre-fabricated stormwater treatment structure utilizing settling, filtration, absorptive/adsorptive materials, vortex separation, vegetative components, and/or other appropriate technology to remove pollutants from stormwater runoff.

NRCS – The Natural Resources Conservation Service, a branch of the United States Department of Agriculture.

N-VALUE – An empirical number assigned to a given material as a gauge of its frictional resistance to the flow of water.

POROSITY – Ratio of open space volume to total solids volume.

PROJECT SEGMENT - is the total onsite impervious area contributing drainage within the right-of-way to the respective post-construction stormwater outfall.

RUNOFF – The portion of the water from a rainfall event which flows across the surface of the ground.

RUNOFF COEFFICIENT – A ratio, defined for a given soil type or land use, of the rate of direct runoff to the average rate of rainfall in a storm event.

SCM UNDERDRAIN – Typically a small diameter perforated pipe which allows the bottom of an embankment and an extended detention basin to drain over an extended period of time.

SEDIMENTATION – The gravity-induced settling of soil or other particles which have been transported by water or wind. Forming or depositing sediment.

SEDIMENTS – Fragments of soil which come have been eroded from the ground surface or from rock and are transported by water, wind or other means. The product of erosion.

SHALLOW CONCENTRATED FLOW – An overland flow condition which occurs as sheet flows begin to collect into rills or other small low areas on the surface of the ground. This condition is intermediate between sheet flow and channel flow.

SHEET FLOW – A flow condition in which water moves across the ground surface in a thin sheet. This is usually the first step in the process of forming runoff and can persist only for a short distance before water is concentrated into ground surface irregularities.

STABILIZED – A condition under which soil is held in place by an enduring cover of vegetation, mulch, or other material such that it will resist erosion by rain, flow of water, wind, vehicular traffic, or any other factor.

STORMWATER CONTROL MEASURE – means permanent practices and measures designed to reduce the discharge of pollutants from new development projects or redevelopment projects.

STORMWATER TREATMENT DESIGN STORM – the 1-year, 24-hour design storm as defined by the Precipitation-Frequency Atlas of the United States. Atlas 14. Volume 2. Version 3.0 U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA), National Weather Service, Hydrometeorological Design Studies Center, Silver Springs, Maryland, or its digital product equivalent.

TIME OF CONCENTRATION -- The time required for a particle of stormwater runoff to flow from the most hydrologically distant point in a drainage area to the point of interest, such as an inlet.

TOTAL SUSPENDED SOLIDS (TSS) – solid particles that are not dissolved in water, but remain suspended, often due to their size or density.

TRANSPORTATION SEPARATE STORM SEWER SYSTEM (TS4) – the discharges of stormwater runoff from

- The state roads, interstate highways, and associated right-of-ways that TDOT either owns or maintains and
- Facilities covered under this permit include those that TDOT owns or operates throughout Tennessee.

UNIT HYDROGRAPH – The hydrograph represents a runoff volume of 1 inch associated with a precipitation event of a specified duration. The unit hydrograph is a theoretical hydrograph that is intended to describe how a river at a particular point will react to one inch of runoff, and which can, in turn, be used to derive how the river will react to any amount of runoff.

13.07.02 References

Georgia Department of Transportation. Stormwater Design Guide. Revision 1.0, Atlanta, GA. 2024.

Gulliver, J.S., A.J. Erickson, and P.T. Weiss (editors). 2010. *"Stormwater Treatment: Assessment and Maintenance."* University of Minnesota, St. Anthony Falls Laboratory. Minneapolis, MN.

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Tennessee Department of Environment and Conservation, Division of Water Resources. Tennessee Permanent Stormwater Management and Design Guidance Manual, First Edition. Nashville, TN, 2014.

Metropolitan Government of Nashville & Davidson County, Nashville.gov, Green Infrastructure Practices Water Quality Swales, Nashville, TN 2020.

USDA-NRCS *Design Rainfall Distribution Based on NOAA Atlas 14 Rainfall Depths and Distribution.*

13.07.03 Abbreviations

AADT – Average Annual Daily Traffic

AASHTO – American Association of State Highway and Transportation Officials

AC – Acres

ARAP – Aquatic Resource Alteration Permit

BMP – Best Management Practice

CFR – Code of Federal Regulations

CFS – Cubic feet per second

CRS – Compliance Response Plan

CWA – Clean Water Act

DA – Contributing Drainage Area

DTM – Digital Terrain Model

EA – Environmental Assessment

EIS – Environmental Impact Statement

EC – Erosion Control

EB – Environmental Boundaries

EPA – Environmental Protection Agency

EPSC – Erosion Prevention and Sediment Control

FHWA – Federal Highway Administration

HSG – Hydrologic Soil Group

IDF – Intensity Duration Frequency

MEP – Maximum Extent Practicable

NFF – National Flood Frequency

NOAA – National Oceanic and Atmospheric Administration

NOI – Notice of Intent

NOT – Notice of Termination

NPDES – National Pollutant Discharge Elimination System

NRCS – National Resource Conservation Service (formerly Soil Conservation Service, SCS)

NURP – National Urban Runoff Program

SCM – Storm Control Measure

SCS – Soil Conservation Service

TR-20 – The National Resource Conservation Service Technical Release 20

TR-55 – The National Resource Conservation Service Technical Release 55

TSS – Total Suspended Solids

SWPPP – Stormwater Pollution Prevention Plan

TDEC – Tennessee Department of Environment and Conservation

TMDL – Total Maximum Daily Load

TNCGP – Tennessee Construction General Permit

TS4 – Transportation Separate Storm Sewer System

USDA – United States Department of Agriculture

USGS – United States Geological Survey

USLE – Universal Soil Loss Equation

WQTV – Water Quality Treatment Volume