VIRGINIA TECH™

# ANNUAL STANDARDS AND SPECIFICATIONS

**FOR**

## EROSION AND SEDIMENT CONTROL

**AND**

## STORMWATER MANAGEMENT

**VIRGINIA TECH SITE AND INFRASTRUCTURE DEVELOPMENT**

**EFFECTIVE:**

**January 1, 2019**

This document is submitted in accordance with 9VAC25-870-170, which requires submission to DEQ, on an annual basis, of standards and specifications consistent with the Virginia Stormwater Management Act, the General VPDES Permit for Discharges of Stormwater from Construction Activities, the VSMP Regulations and the Erosion and Sediment Control Laws and Regulations. This document describes how land-disturbing activities shall be conducted on lands owned by Virginia Tech.

## Table of Contents

## APPENDICES

## ACRONYMS

| | |
|---|---|
| A | Drainage area, acres (stormwater hydrology) |
| Administrator | Program Administrator for VTSID or designee who administers and enforces the requirements of the approved Virginia Tech Annual Standards and Specifications |
| B | VDOT rainfall coefficient, no units (stormwater hydrology) |
| BMP | Best Management Practice |
| C | Runoff coefficient, no units (stormwater hydrology) |
| $C_f$ | Saturation factor, no units (stormwater hydrology) |
| CGP | Construction General Permit |
| CMP | Corrugated Metal Pipe |
| CN | Curve Number (stormwater hydrology) |
| CWA | Clean Water Act |
| D | VDOT rainfall coefficient, no units (stormwater hydrology) |
| $D_e$ | Critical storm duration, minutes (stormwater hydrology) |
| DEQ | Virginia Department of Environmental Quality |
| DPOR | Department of Professional and Occupational Regulation |
| E | VDOT rainfall coefficient, no units (stormwater hydrology) |
| ESC | Erosion and Sediment Control |
| g | Gravity coefficient, 32.2 feet/$s^2$ |
| H | Height or depth of water, feet $H_f$, $H_i$, $H_m$, |
| $H_o$, HΔ | Head losses in piping and structures, feet (storm drain hydraulics) |
| HDPE | High Density Polyethylene |
| HGL | Hydraulic Grade Line |
| HUC | Hydrologic Unit Code |
| I | Rainfall intensity, inches per hour (stormwater hydrology) |
| $I_{post}$ | Post-development impervious cover, percentage (water quality Simple Method calculation) |
| $I_{existing}$ | Existing impervious cover, percentage (water quality Simple Method calculation) |
| K, $K_i$, $K_o$ | Head loss coefficients for piping, no units |
| $L_{pre}$ | Pre-development pollutant loading, pounds per year (water quality Simple Method calculation) |
| $L_{post}$ | Post-development pollutant loading, pounds per year (water quality Simple Method calculation) |
| NFIP | National Flood Insurance Program |
| Q | Stormwater flow, gallons per minute (gpm) or cubic feet per second (cfs) |
| R | Hydraulic radius, feet (open channel hydraulics) |
| $r_c$ | Stream bend radius, center, feet (open channel hydraulics) |
| $r_i$ | Stream bend radius, inside bank, feet (open channel hydraulics) |

| | |
|---|---|
| $r_o$ | Stream bend radius, outside bank, feet (open channel hydraulics) |
| Responsible party | Individual(s) or department(s) responsible for maintaining stormwater management facilities, including but not limited to basins, other BMPs, storm drains, culverts, ditches and swales in accordance with a maintenance agreement. |
| S | Slope, feet per feet (open channel or pipe hydraulics) |
| SCS | Soil Conservation Service |
| VTSID | Virginia Tech Site and Infrastructure Development |
| SWM | Stormwater Management |
| SWPPP | Stormwater Pollution Prevention Plan |
| $t_c$ | Time of concentration, hours (stormwater hydrology) |
| $T_p$ | Time to peak flow, hours (stormwater hydrology) |
| $T_r$ | Time to recede, hours (stormwater hydrology) |
| $T_t$ | Travel time, hours (stormwater hydrology) |
| TMDL | Total Maximum Daily Load |
| USACE | U.S. Army Corps of Engineers |
| V, $V_i$, $V_o$ | Velocity, feet per second (open channel and pipe hydraulics) |
| VDOT | Virginia Department of Transportation |
| VDOT Drainage Manual | Virginia Department of Transportation, Drainage Manual, Current Edition |
| VDOT Specifications | Virginia Department of Transportation, Road and Bridge Specifications, Current Edition |
| VDOT Standards | Virginia Department of Transportation, Road and Bridge Standards, Current Edition |
| VESCH | Virginia Erosion and Sediment Control Handbook, Current Edition |
| VMRC | Virginia Marine Resources Commission |
| VPDES | Virginia Pollutant Discharge Elimination System |
| VSMP | Virginia Stormwater Management Program, as administered by DEQ |
| VSWMH | Virginia Stormwater Management Handbook, Current Edition |
| VT | Virginia Tech |
| VTAS&S | Virginia Tech Annual Standards and Specifications |

## DEFINITIONS

The words and terms used in these Standards & Specifications shall have the meanings defined in the regulations listed in Section 1.0 unless the context clearly indicates otherwise. The following definitions apply to these Standards & Specifications:

***"Applicant"*** means person or persons providing submittals to VTSID to engage in a regulated land-disturbing activity (e.g., Operator, Permittee, Designer or designee).

***"Licensed professional"*** means a professional registered in the Commonwealth of Virginia pursuant to Article 1 (§ 54.1-400 et seq.) of Chapter 4 of Title 54.1 of the Code of Virginia. For purposes of these Standards and Specifications a licensed professional is one that is certified by DPOR as an Architect, Professional Engineer, Land Surveyor, or Landscape Architects.

***"Local technical criteria (for SWM)"*** means technical criteria in a DEQ approved local ordinance that is more stringent than the technical criteria described in Part II B of 9VAC25-870.

***"Operator (for SWM)"*** means the contractor of a regulated activity. In the context of the Standards & Specifications, Operator means any person associated with a construction project that meets either of the following two criteria: (i) the person has direct operational control over construction plans and specifications, including the ability to make modifications to those plans and specifications or (ii) the person has day-to-day operational control of those activities at a project that are necessary to ensure compliance with a stormwater pollution prevention plan for the site.

***"Permittee"*** means the Operator to whom the General Permit for Discharges of Stormwater from Construction Activities (Construction General Permit) is issued.

***"Stormwater Management Facility"*** means a control measure that controls stormwater runoff and changes the characteristics of that runoff including, but not limited to, the quantity and quality, the period of release or the velocity of flow. For purposes of water quality, a stormwater management facility means approved practices as described on the Virginia Stormwater BMP Clearinghouse Website.

***"VTAS&S for ESC"*** includes the information described in the standards and specifications regarding ESC.

***"VTAS&S for SWM"*** includes the information described in the standards and specifications regarding SWM.

***"VT Project Manager"*** means the individual managing the land disturbing activities.

## 1.0 INTRODUCTION

Virginia Tech Site and Infrastructure Development's (VTSID) stormwater management goals ensure compliance and minimize and mitigate adverse effects of land development by implementing effective stormwater management Best Management Practices (BMPs) as required by the Virginia Department of Environmental Quality.

As land is developed and woodlands and pastures are converted to more urban uses, the increase in impervious surfaces (pavements and buildings) increases adverse effects including:

- Flooding
- Erosion and deposition of sediment in streams
- Property damage due to flooding, erosion, or deposition
- Less base flow in streams due to less groundwater recharge
- Runoff of pollutants (nutrients, sediment, bacteria, oil)
- Decreased stream biodiversity

Virginia Polytechnic Institute and State University, commonly known as Virginia Tech (VT), is required per §62.1-44. 15:31 of the Virginia Stormwater Management Act to submit standards and specifications for approval by the Virginia Department of Environmental Quality (DEQ) to describe how land-disturbing activities shall be conducted on VT properties. In response, VT has adopted the Virginia Tech Annual Standards and Specifications for Erosion and Sediment Control and Stormwater Management (VTAS&S) that guide regulated land-disturbing activities on VT properties. The VTAS&S incorporate, by reference, the following laws and attendant regulations:

- Virginia Stormwater Management (SWM) Act (§62.1-44. 15:24 et seq.) and Virginia Stormwater Management Program (VSMP) Regulations (9VAC25-870);
- General VPDES Permit for Discharges of Stormwater from Construction Activities (9VAC25-880);
- Virginia Erosion and Sediment Control (ESC) Law (§62.1-44.15:51 et seq.) and Virginia Erosion and Sediment Control Regulations (9VAC25-840);
- Erosion and Sediment Control and Stormwater Management Certification Regulations (9VAC25-850); and where applicable,
- Chesapeake Bay Preservation Act (§62.1-44.15:67 et seq.) and Chesapeake Bay Preservation Area Designation and Management Regulations (9VAC25-830).

The VTAS&S serves as a local supplement to, and not as a replacement for, existing State guidance manuals that address proper stormwater management design techniques. These manuals include:

- Virginia Department of Environmental Quality Stormwater Management Handbook, First Edition 1999 & Second Edition 2013
- Virginia Department of Transportation Drainage Manual
- Virginia Department of Environmental Quality Erosion and Sediment Control Handbook

The VTAS&S are submitted annually to DEQ for their review and approval based on consistency with the law and regulations listed above. The VTAS&S shall apply to all applicable land-disturbing activities, as described in this chapter. The use of this document and generally accepted references should ensure that standard, acceptable design practices are used for stormwater management designs.

Administration and enforcement of the VTAS&S will be performed by Virginia Tech Site and Infrastructure Development (VTSID) as described herein. Virginia Tech shall ensure responsible staff and its representatives obtain the necessary certifications through DEQ in accordance with the Erosion and Sediment Control and Stormwater Management Certification Regulations (9VAC25-850). Certifications will be dependent on the individual's role in implementing the VTAS&S and may include Program Administrator, Plan Reviewer and/or Inspector. The VTSID Stormwater Compliance Manager shall have overall administrative responsibility for the VTAS&S.

DEQ is the regulatory authority for ESC and SWM on state agency projects. DEQ provides oversight of the Virginia Tech Annual Standards and Specifications for Erosion and Sediment Control and Stormwater Management and its implementation by Virginia Tech VTSID. Inspection reports conducted by VTSID as well as complaint logs and complaint responses may be required to be submitted to the DEQ. Virginia Tech may be required to provide weekly e-reporting to the Department's applicable regional office that include: inspection reports; pictures; complaint logs and complaint responses; and other compliance documents. VTSID will submit project information to the DEQ bi-annually for all active ESC and SWM regulated land-disturbing activities. DEQ may perform random site inspections or inspections in response to a complaint to assure compliance with the associated laws/regulations and these annual standards and specifications. DEQ may take enforcement actions as required.

The Department shall assess an administrative change to cover the costs of services rendered associated with its responsibilities pursuant to §62.1-44.15:31. The Board shall have the authority to enforce approved specifications and change fees equal to the lower of (i)$1,000 or (ii) an amount sufficient to cover the costs associated with standards and specification review approval, project inspections, and compliance.

### 1.1 Contents of the Standards & Specs

The VTAS&S have been framed to guide a land-disturbing activity through planning, plan approval and construction to ensure consistency with the regulatory requirements referenced in this Section. The VTAS&S include four distinct sections:

Chapter 1 – Introduction – presents the general background and purpose behind the VTAS&S. The chapter documents the goals of the program, the applicable requirements for land disturbance, and the administration of the program.

Chapter 2 – Plan Review and Approval – presents the process that the Applicant and VTSID follow to assure that the requirements of the VTAS&S are met. The chapter covers the conception, submittal, review, and approval of the Erosion and Sediment Control and Stormwater Management Plans as applicable.

Chapter 3 – Construction Process – presents the necessary procedures for VTSID, Operators, Contractors and Designers during construction through the termination of a project.

Chapter 4 – Maintenance of SWM Facilities – presents Virginia Tech responsibilities and procedures to ensure long-term care and maintenance of permanent stormwater management facilities.

### 1.2 Authority

The VTAS&S provide the policies and procedures that implement the state laws and regulations as they pertain to erosion and sediment control and stormwater management, including storm drainage. In the event that any part of this VTAS&S is held to be illegal or void, this shall not have the effect of making illegal or void the VTAS&S in its entirety, or any other section thereof, which shall remain effective.

### 1.3 Erosion and Sediment Control

The VTAS&S for ESC apply to VT properties where land-disturbing activities are equal to or greater than:

- 10,000 square feet;
- 5,000 square feet for projects located on VT Main Campus;Any more stringent threshold established in a locality's DEQ-approved ESC Program ordinance (e.g., 5,000 square feet for the Town of Blacksburg); or
- 2,500 square feet if the project is within a Chesapeake Bay Preservation Area (CBPA).

Appendix A provides information for each VT property throughout the Commonwealth to assist in determining if a land-disturbing activity is subject to the more stringent local threshold or the CPBA threshold. For the purposes of applicability to the VTAS&S for ESC, a land-disturbing activity is defined as:

> *ESC Land-Disturbing Activity* – means any man-made change to the land surface that may result in soil erosion from water or wind and the movement of sediments into state waters or onto lands in the Commonwealth, including, but not limited to, clearing, grading, excavating, transporting and filling of land.

Exceptions to the applicability of the VTAS&S for ESC that are potentially relevant to VT include:

- Installation, maintenance, or repair of underground public utility lines when such activity occurs on, and is confined within, an existing hard surfaced road, street or sidewalk;
- Septic tank lines or drainage fields unless included in an overall plan for land-disturbing activity relating to construction of the building to be served by the septic tank system;
- Tilling, planting, or harvesting of agricultural, horticultural, or forest crops, livestock feedlot operations, including engineering operations as follows: construction of terraces, terrace outlets, check dams, desilting basins, dikes, ponds, ditches, strip cropping, lister furrowing, contour cultivating, contour furrowing, land drainage and land irrigation;

- Installation of fence, sign posts, telephone and electric poles, and other posts or poles; and
- Emergency work to protect life, limb or property, and emergency repairs; however, the land area disturbed shall be shaped and stabilized in accordance with the requirements of the VTAS&S.

### 1.4 Stormwater Management

The VTAS&S for SWM are applicable where a land-disturbing activity is equal to or greater than:

- 1-acre; or
- 2,500 square feet if the project is within a CBPA; or
- Any disturbed area for a project that is seeking LEED certification, per LEED requirements.

*SWM Land-Disturbing Activity* - means a man-made change to the land surface that potentially changes its runoff characteristics, including clearing, grading, or excavation.

Exceptions to the applicability of the VTAS&S for SWM that are potentially relevant to VT include:

- Clearing of lands specifically for agricultural purposes and the management, tilling, planting, or harvesting of agricultural, horticultural, or forest crops, livestock feedlot operations including engineering operations as follows: construction of terraces, terrace outlets, check dams, desilting basins, dikes, ponds, ditches, strip cropping, lister furrowing, contour cultivating, contour furrowing, land drainage, and land irrigation;
- Discharges to a sanitary sewer or a combined sewer system;
- Routine maintenance that is performed to maintain the original line and grade, hydraulic capacity, or original construction of the project. The paving of an existing road with a compacted or impervious surface and reestablishment of existing associated ditches and shoulders shall be deemed routine maintenance; and
- Land-disturbing activities in response to a public emergency where the related work requires immediate authorization to avoid imminent endangerment to human health or the environment. In such situations, VTSID and the DEQ shall be advised of the disturbance within seven days of commencing the land-disturbing activity, and compliance with the administrative requirements described in Section 2.4 are required to be submitted to VTSID within 30 days of commencing the land-disturbing activity.

### 1.5 Stormwater Management for Non-Regulated Projects

Development projects on VT properties may incorporate the construction of a SWM practice that is not required by the SWM laws and regulations. The incorporation of these practices may occur as part of a building project to assist in achieving credit towards environmental rating system certifications. Any stormwater management practice that does not otherwise qualify as subject to the VTAS&S for SWM shall require approval of a SWM Plan from VTSID, as described in Chapter 2. The practice shall be designed per the Virginia Stormwater Management Handbook and the standards and specifications in the Virginia Stormwater BMP Clearinghouse.

## 1.6 Administration

### 1.6.1 General

The policies and procedures contained within the VTAS&S shall be administered by the Program Administrator in Virginia Tech Site and Infrastructure Development.

### 1.6.2 Manual Amendments

This VTAS&S will be revised annually, as necessary to address:

- Changes in technology.
- Changes in accepted construction practices.
- Changes in Federal and/or State requirements.
- Items that require clarification to avoid confusion.
- Development issues that potentially impact public health, safety and welfare.

Amendments to the VTAS&S will be submitted to the DEQ for review and approval and posted on the VTSID website, http://www.facilities.vt.edu/permits-inspections/stormwater-management.html, and will become effective on the date listed on the website. It is the user's responsibility to check the website and verify that they have the latest requirements.

## 1.7 Approval and Permits

The Applicant is responsible for acquiring all required approvals and permits.

### 1.7.1 Local Approval and Permits

The review and approval of ESC and SWM Plans for projects meeting the requirements of sections 1.3, 1.4 and 1.5 is required before University Building Official permits will be issued. Once plans are approved, VTSID will issue a Land Disturbance Permit in conjunction with the University Building Official's permit.

### 1.7.2 VSMP Permit

The Department of Environmental Quality's role in the approval of land disturbing activities is to provide coverage under the Construction General Permit for Discharges of Stormwater from Construction Activities (CGP), for projects of 1 acre or more of disturbance. It is the sole responsibility of the Operator, serving as the Permittee, to submit for the DEQ approval under the Construction General Permit prior to beginning land disturbance. A copy of all forms and approvals submitted to and received by the DEQ by the Permittee shall be submitted to VTSID.

### 1.7.3 Joint Permit Application

Wetlands and streams are protected under several Federal and State programs. Whenever jurisdictional wetlands or streams are impacted by land disturbing activities, a Joint Permit Application must be completed and filed with the Virginia Marine Resources Commission (VMRC). All permits required by the reviewing agencies must be obtained prior to approval from VTSID for any regulated land-disturbing activity. VMRC will distribute the Joint Permit Application to the U.S. Army Corps of Engineers (USACE) and the Virginia Department of Environmental Quality (DEQ) and Federal and State

agencies in processing the permit application. Upon receipt of an acceptable application the following permits may be issued:

- USACE Federal Section 404 Permit
- DEQ Virginia Water Protection Permit
- VMRC Permit

### 1.8 Reference Sources

These annual standards and specifications serve as a supplement to existing state design manuals that address proper stormwater management design techniques, and not to replace them. In the case of a contradiction or conflict, the more stringent requirement shall apply. The requirements of the following state design manuals and standards are incorporated into this document by reference.

- Virginia Stormwater Management Handbook, Volumes I and II, prepared by the Virginia Department of Environmental Quality, first edition dated 1999 and second edition dated 2013, as amended. Hereafter throughout this document referred to as the VSWMH first edition or second edition.
- Virginia Department of Transportation Drainage Manual, prepared by the Hydraulics Section of the Virginia Department of Transportation, dated 2002 or latest version, as amended. Hereafter throughout this document referred to as the VDOT Drainage Manual.
- Virginia Department of Transportation Road and Bridge Standards, Volumes I and II, prepared by the Virginia Department of Transportation, dated 2001 or latest version, as amended. Hereafter throughout this document referred to as the VDOT Standards.
- Virginia Department of Transportation Road and Bridge Specifications, prepared by the Virginia Department of Transportation, dated 2002 or latest version, as amended. Hereafter throughout this document referred to as the VDOT Specifications.
- Virginia Erosion and Sediment Control Handbook, prepared by the Virginia Department of Environmental Quality, dated 1992 or latest version, as amended. Hereafter throughout this document referred to as the VESCH.
- Virginia Department of Environmental Quality Erosion and Sediment Control Technical Bulletin #4 – Nutrient Management for Development Sites.
- Virginia Stormwater BMP Clearinghouse Website, administered by the Virginia Department of Environmental Quality and the Virginia Water Resources Research Center, located at http://www.vwrrc.vt.edu/swc/StandardsSpecs.html
- Virginia Department of Conservation and Recreation (DCR) Native v. Invasive Plant Species for Erosion and Sediment Control Frequently Asked Questions. This DCR FAQ updated the VESCH Temporary and Permanent Seeding specifications.

## 2.0 PLAN REVIEW & APPROVAL

In order to maintain the character and integrity of Virginia Tech properties, to promote excellence of design and development and to prevent environmental hazards, plans must be submitted and reviewed for regulated land-disturbing activities as described in Chapter 1. To verify compliance with the VTAS&S, this chapter describes the development process once a land-disturbing activity has been identified to be subject to the VTAS&S. As described in Chapter 2, a regulated land-disturbing activity may be subject to:

- ESC submission requirements and technical criteria described in Section 2.3.1;
- ESC and SWM submission requirements and technical criteria described in Sections 2.3.1 and 2.4.2; or
- SWM Plan only, if a project includes a SWM facility as described in Section 1.5.

All submissions are to be provided by the Applicant to VTSID and require VTSID approval on the plans (in the form of an approval stamp signed by a certified Plan Reviewer). Submitted plans shall provide an approval stamp location for VTSID on the right side of the sheet, in the same location on all sheets of the plan. For a land-disturbing activity equal to or greater than one acre, a CGP, issued by the DEQ, is also required prior to the commencement of land disturbance.

### 2.1 Overview of the Review & Approval Process

Submittal of a concept plan prior to submittal of an ESC or SWM plan is strongly recommended by VTSID in certain situations and may be submitted for any project, as deemed appropriate by the Applicant.

The submittal, review, and approval of ESC and SWM Plans shall adhere to the general guidelines as follows:

- VTSID, upon receipt of a plan, shall have fifteen (15) days to review the site development plan for completeness and notify the Applicant. If the plan is rejected for incompleteness, VTSID shall provide written comments of the deficiencies to the Applicant.
- Five to ten days following submission, the Applicant shall set up a meeting with VTSID and design engineer to review the plan.
- Upon acceptance of the completed plan, VTSID shall have forty-five (45) days from the date of completeness notification to review and either approve or disapprove the plan. Approval or disapproval of the plan will be in writing to the Applicant.
- The Applicant may correct and resubmit the plan following disapproval. When resubmitting, the resubmittal shall include a review comments response letter addressing how all review comments were addressed in the resubmitted plan. A new application is not required.
- VTSID, upon receipt of a resubmitted plan, shall have forty-five (45) days to review and approve or disapprove the resubmitted plan. Approval or disapproval of the plan will be in writing to the Applicant.

- Upon VTSID approval of a plan, should a land-disturbing activity associated with the approved plan not begin within a 180-day period following approval or cease for more than 180 days, VTSID may evaluate the plan to determine whether the plan still satisfies the VTAS&S and to verify that all design factors are still valid. If VTSID finds the previously approved plan to be inadequate, a modified plan shall be submitted for approval.

### 2.2 Concept Plan Submittal

Prior to submitting any plans for review, the Applicant may submit a ESC/SWM concept plan to the Administrator for the proposed development. Applicants are recommended to consult with VTSID to discuss the conceptual stormwater management design and to determine if they are subject to additional stormwater design requirements, prior to submittal.

### 2.3 Erosion & Sediment Control Plan Submittal

Land-disturbing activities subject to the VTAS&S for ESC requires a VTSID-approved ESC Plan. The required submittals, as listed in Section 2.3.2, will be reviewed for consistency with the Minimum Standards described in Section 2.3.1 by an individual certified in accordance with the ESC and SWM Certification Regulations (9VAC25-850).

The review shall be in accordance with Section 2.1.

#### 2.3.1 ESC Minimum Standards

The ESC Plan shall be consistent with the requirements of the Virginia ESC Regulations (9VAC25-840) and the latest edition of the Virginia Erosion and Sediment Control Handbook (VESCH) and shall specifically address each applicable minimum standard described in 9VAC25-840-40.

When applicable, the ESC Plan shall also address more stringent local requirements for erosion and sediment control. For planning purposes, localities known to have more stringent local criteria for ESC are identified in Appendix A. However, it is the responsibility of the ESC Plan preparer to review the locality's ESC ordinance for more stringent requirements and incorporate them into the ESC Plan.

#### 2.3.2 ESC Plan Requirements

The following shall be submitted by the Applicant to VTSID for review when a land-disturbing activity is subject to the VTAS&S for ESC. One (1) hard-copy and an electronic pdf copy of each following item shall be provided to VTSID for review:

- Land Disturbance Application Form – A copy of the form is provided in Appendix B.
- Completed ESC Plan Checklist – The ESC Plan Checklist in Appendix E is provided to assist the ESC Plan preparer and reviewer with ensuring compliance with the minimum standards and the VTAS&S. Each applicable item on the checklist shall be addressed in the ESC Plan or ESC Narrative certified by the licensed professional. Written reference on the checklist to the location (Plans or Narrative) as to where an item has been addressed is recommended to assist with plan development and review.

- ESC Plan – The ESC Plan shall be signed and sealed by a licensed professional and demonstrate compliance with the technical criteria described in Section 2.3.1.
- ESC Plan Narrative – The ESC Plan Narrative shall be signed and sealed by a licensed professional and is considered part of the ESC Plan. The Narrative shall incorporate supporting information necessary to demonstrate compliance with the minimum standards described in Section 2.3.1.

Resubmittals to address comments provided by VTSID as the result of a review shall include a cover letter from the licensed professional that explicitly responds to each comment from the review. Each response shall describe how the comment was addressed with reference to the locations of the changes in the Plan and/or Narrative. Any other changes not specifically addressed in the response to comments from the previous review shall also be described.

Submittals for approval shall include one (1) 11x17 copy of the plans in addition to the full size copy.

### 2.3.3 Narrative

The ESC Plan Narrative shall be signed and sealed by a licensed professional and is considered part of the ESC Plan. The Narrative shall incorporate supporting information necessary to demonstrate compliance with the minimum standards described in Section 2.3.1. The ESC Plan Narrative shall include:

- Project Description
- Existing Site Conditions
- Adjacent Areas
- Offsite Areas
- Critical Areas
- Soils
- Cut/Fill Calculations
- Erosion and Sediment Control Measures
- Permanent Stabilization
- Stormwater Runoff Considerations
- Sequence and Timing of Land Disturbing

### 2.3.4 ESC Plan Variances/Deviations

An Applicant may request a variance from the ESC minimum standards through VTSID. A variance request shall be provided in writing and may be considered prior to plan approval or during construction under the following conditions:

- The Applicant requests, in writing, a variance with explanation of the reasons for requesting the variance. Reasons must be specific to restrictive site conditions, and the variance shall be the minimum necessary to mitigate for the site restriction.
- The request shall include alternative measures to address potential downstream transport of sediment that could result from the granting of the variance.

- The request shall describe how the alternative measure(s) meets the intent of the minimum standard (9VAC25-840-40) for which the variance is sought.
- A variance will not be granted in any case where the granting of the variance could cause damage to downstream property. It is the responsibility of the Applicant to demonstrate in the request that downstream properties will be protected from erosion, sedimentation and flooding.
- Specific variances which are allowed by VTSID shall be documented on the ESC Plan.

Requests for variances will be considered by VTSID, and if deemed appropriate, VTSID will submit the request to DEQ for approval.

If the plan shows a deviation by the use of a non-VESCH control measures not listed in Appendix F as previously approved, the designer is required to submit all applicable practical information including definition, purpose, condition where the practice applies, planning consideration, design criteria, construction specification, design tables, plates and maintenance and inspections. VTSID reserves the right to approve or disapprove the non-VESCH control measure on a project-specific basis.

ESC measures shall be designed and constructed in accordance with the VESCH or the manufacturer's recommendations as applicable. VTSID and the DEQ have the discretion to disallow the use of any of the previously approved measures based on findings that demonstrate poor performance related to sedimentation control or maintenance. Sufficient detail shall be provided on the ESC Plan and in the Specifications for proprietary measures, including any necessary computations, installation instructions, and inspection and maintenance instructions. Installation and maintenance shall be per the manufacturer's recommendations. A list of approved, non-VESCH measures can be found in Appendix F. Should non-VESCH control measures fail to effectively control soil erosion, sediment deposition, and non-agricultural runoff, then VESCH control measures shall be utilized.

Deviations for consideration of ESC measures not listed in Appendix F will only be considered when requested by an Applicant as part of a proposed ESC Plan or on-going land disturbance with an approved ESC Plan.

### 2.4 Stormwater Management Plan Review & Approval

Land-disturbing activities subject to the VTAS&S for SWM require a VTSID-approved SWM Plan. The required submittals, as listed in Section 2.4.1, will be reviewed for consistency with the technical criteria described in Section 2.4.2 and 2.4.3 by an individual certified in accordance with the ESC and SWM Certification Regulations (9VAC25-850).

Within 45 days of the notification of completion VTSID will provide an approval or a letter providing the reasons the SWM Plan could not be approved.

#### 2.4.1 Submittal of Stormwater Calculations

Calculations shall be submitted to VTSID supporting the stormwater management and storm drainage design. Calculations shall be well organized and coordinated with the design to allow for efficient

review by VTSID. Calculations shall be bound together in a booklet with pages numbered. Submittals shall include calculation software files (i.e. HydroCAD, Hydraflow, etc.) in addition to electronic pdf versions and a bound copy. Calculations shall follow the following general format:

- Cover Sheet – The cover sheet shall contain the project name, design professional's name, calculations date, and the seal and signature of the design professional.
- Table of Contents – A table of contents shall be provided to assist the reviewer in locating information in the calculations. All pages must be sequentially numbered.
- Project Description – A general description of the project providing information to assist the reviewer in understanding the nature and scope of the project and of the storm drainage and stormwater management facilities that are proposed.
- Criteria and Methodology – A listing of the basic design criteria and methodologies that the calculations will follow to demonstrate that the basic design criteria are met.
- References – A listing of the references that are used in the calculations.
- Assumptions – A listing of all assumptions, and justification of the assumptions that are used in the calculations.
- Analysis – The body of the calculations shall be clearly labeled as to which Stormwater management facility or storm drainage system the calculations pertain. The calculations shall be step-by-step to ensure that a reviewer that is not familiar with the project can follow the progression of the calculations. Provided input and output information shall be clearly identified, if highlighted only in yellow, to ensure that the input information is clearly supported in the calculations, and that the output is properly evaluated in the summary and conclusions. All calculation parameters must be fully supported and documented and include the design storm frequency, rainfall intensity/depth and duration, times of concentration, hydrologic soil groups, curve numbers or runoff coefficients; calculations identifying total runoff volumes for each watershed area, infiltration rates (where applicable), culvert, headwaters, storm drain, and open channel capacities, flow velocities, data on the increase in rate and volume of runoff for the specified design storms, pre- and post-development phosphorus loadings, downstream channel analysis and all other calculations needed to support the proposed design, as identified in the Virginia Stormwater Management Handbook, the Virginia Erosion and Sediment Control Handbook and the VTAS&S.
- Summary and Conclusions – A summary of the results, preferably in tabular or chart form for each storm drainage system and stormwater management facility to indicate that the land disturbing project meets the requirements of the VTAS&S, with conclusions.
- Appendices and Attachments – Any supporting information such as drainage area maps, soil survey maps, USGS quadrangle maps, design nomographs, and computer printouts.

Calculations that are not well organized and coordinated with the design shall be rejected, and the submittal shall not be reviewed until proper calculations are submitted.

### 2.4.2 SWM Technical Criteria

The SWM Plan shall be consistent with Part II A (9VAC25-870-55 parts A through C) and Part II B of the VSMP Regulations. Design standards and specifications shall be consistent with the Virginia Stormwater BMP Clearinghouse Website, the latest edition of the Virginia Stormwater Management Handbook, and the supplemental criteria in the VTAS&S.

When applicable and to the maximum extent practicable, the SWM Plan shall comply with any local VSMP authority's additional technical requirements for stormwater management adopted within a DEQ-approved local ordinance. Localities with additional technical requirements for SWM are identified in Appendix A. However, it is the responsibility of the SWM Plan preparer to:

- Review the locality's SWM ordinance for specific requirements and incorporate them into the SWM Plan to the maximum extent practicable.
- Where applicable, demonstrate to VTSID that the locality's additional technical requirements are not practicable and include information in the SWM Plan Narrative demonstrating the impracticability.

### 2.4.3 VT Supplemental Technical Criteria

For the purposes of the technical criteria for water quality described in Part II B of the VSMP Regulations, the planning area shall be defined as the limits of disturbance.

Propriety BMPs that are approved on the BMP Clearinghouse website are the only proprietary BMPs allowed on Virginia Tech property. VTSID reserves the right to not approve certain BMPs based on site condition.

### 2.4.4 SWM Plan Requirements

The following shall be submitted by the Applicant to VTSID for review when a land-disturbing activity is subject to the VTAS&S for SWM. One (1) hard-copy and an electronic pdf copy of each following item shall be provided to VTSID for review:

- Land Disturbance Application Form – A copy of the form is provided in Appendix B.
- Completed SWM Plan Checklist – The SWM Plan Checklist in Appendix E is provided to assist the SWM Plan preparer and reviewer with ensuring compliance with the technical criteria and the VTAS&S. Each applicable item on the checklist shall be addressed in the SWM Plan or SWM Narrative. Written reference on the checklist to the location (Plans or Narrative) as to where an item has been addressed is recommended to assist with plan development and review.
- SWM Plan – The SWM Plan shall be signed and sealed by a licensed professional and provide all of the information described in 9VAC25-870-55 (Stormwater Management Plans) of the VSMP regulations. When applicable, the SWM Plan shall also address local technical requirements as described in Section 2.4.2.
- SWM Plan Narrative – The SWM Plan Narrative shall be signed and sealed by a licensed professional and is considered part of the SWM Plan, incorporating supporting information

necessary to demonstrate compliance with the technical criteria described in Sections 2.4.2 and 2.4.3.

- Completed VSWMH BMP Checklist – As applicable, provide the applicable BMP Design Checklist from Appendix 8-A of the VSWMH, latest edition. A BMP-type specific checklist shall be provided for each BMP proposed in the SWM Plan.
- Exception Request – Where applicable, the Applicant shall provide a written request that addresses the conditions described in Section 2.4.5.

Resubmittals to address comments provided by VTSID as the result of a review shall include a cover letter from the licensed professional that explicitly responds to each comment from the review. Each response shall describe how the comment was addressed with reference to the locations of the changes in the Plan and/or Narrative. Any other changes not specifically addressed in the response to comments from the previous review shall also be described in the cover letter.

Submittals for approval shall include one (1) 11x17 copy of the plans in addition to the full size copy.

### 2.4.5 SWM Plan Exceptions

An Applicant may request in writing an exception to the SWM technical criteria and design standards and specifications through VTSID. An exception may be granted provided that:

- The exception is the minimum necessary to afford relief;
- Reasonable and appropriate conditions are imposed as necessary upon any exception granted so that the intent of the Virginia Stormwater Management Act and the technical criteria is preserved;
- Granting the exception will not confer any special privileges that are denied in other similar circumstances; and
- The request is not based upon conditions or circumstances that are self-imposed or self-created.

Economic hardship alone is not a sufficient reason to request an exception from the requirements of the technical criteria or design standards and specifications. The following exceptions will not be granted:

- The requirement that a land-disturbing activity obtain a CGP, when applicable.
- The use of a BMP not found on the BMP Clearinghouse.
- Requirements for phosphorus reductions.

Requests for exceptions will be considered by VTSID, and if deemed appropriate, VTSID will submit the request to DEQ for consideration of approval.

## 2.5 Stormwater Pollution Prevention Plans (SWPPP) Submittal

A land-disturbing activity that disturbs an acre or greater requires a General Permit for Discharges of Stormwater from Construction Activities (9VAC25-880), also known as the Construction General Permit. The Construction General Permit is issued by the Virginia DEQ and coverage is required

throughout the duration of the land-disturbing activity. The Operator shall obtain permit coverage as the Permittee and provide VTSID with the completed Registration Statement and SWPPP at the preconstruction meeting described in Section 2.7. The Registration Statement is required prior to the commencement of the land-disturbing activity and shall be maintained in the project SWPPP described herein. The Permittee is responsible for compliance with the permit conditions. VTSID will provide oversight of permit compliance through site inspections as described in Section 3.3.

Prior to submission of a Registration Statement to DEQ for coverage under the Construction General Permit, the project is required to have a VTSID-approved ESC and SWM Plan included as part of the site-specific SWPPP. The SWPPP shall be prepared and certified using the Virginia Tech SWPPP Template, in accordance with the permit, by the Permittee or duly authorized representative. The Permittee is responsible for implementation of the SWPPP and may delegate authority for certifications (e.g., SWPPP amendments, inspection reports, etc.) in writing.

The SWPPP shall be appropriately sealed and signed by a professional engineer. A SWPPP is comprised of the following:

- An Erosion and Sediment Control Plan;
- A Stormwater Management Plan;
- A Pollution Prevention Plan; and
- Any additional control measures necessary to address a TMDL.

### 2.5.1 Pollution Prevention Plan Requirements

The pollution prevention plan submittal shall address potential pollutant-generating activities that may reasonably be expected to affect the quality of stormwater discharges from the construction activity, including any support activity. The Pollution Prevention Plan shall:

a. Identify the potential pollutant-generating activities and the pollutant that is expected to be exposed to stormwater;
b. Describe the location where the potential pollutant-generating activities will occur, or if identifies on the site plan, reference the site plan;
c. Identify all non-stormwater discharges, as authorized in Part I E of this general permit, that are or will be commingled with stormwater discharges from the construction activity, including any applicable support activity;
d. Identify the person responsible for implementing the pollution prevention practice or practices for each pollutant generating activity (if other that the person listed as the qualified personnel);
e. Describe the pollution prevention practices and procedures that will be implemented to:
    1. Prevent and respond to leaks, spills and other releases including (i) procedures for expeditiously stopping, containing and cleaning up spills, leaks and other releases; and (ii) procedure for reporting leaks, spills and other releases in accordance with Part III G;
    2. Prevent the discharge of spilled and leaked fuels and chemicals from vehicle fueling and maintenance activities (e.g., providing secondary containment such as spill berms, decks,

spill containment pallets, providing cover where appropriate, and having spill kits readily available);

3. Prevent the discharge of soaps, solvents, detergents, and wash water from construction material, including the clean-up of stucco, paint, form release oils, and curing compounds (e.g., providing (i) cover (e.g., plastic sheeting or temporary roofs) to prevent contact with stormwater (ii) collection and proper disposal in a manner to prevent contact with stormwater; and (iii) a similarly effective means designed to prevent discharge of these pollutants);
4. Minimize the discharge of pollutants from vehicle and equipment washing, wheel wash water, and other types of washing (e.g., locating activities away from surface waters and stormwater inlets or conveyance and directing wash waters to sediment basins or traps, using filtration devices such as filter bags or sand filters, or using similarly effective controls);
5. Direct concrete wash water into a leak-proof container or leak-proof settling basin. The container or basin shall be designed so that no overflows can occur due to inadequate sizing or precipitation. Hardened concrete wastes shall be removed and disposed of in a manner consistent with the handling of other construction wash waters and shall not be discharged to surface waters;
6. Minimize the discharge of pollutants from storage, handing, and disposal of construction products, materials and wastes including (i) building products such as asphalt sealants, copper flashing, roofing material, adhesives and concrete admixtures; (ii) pesticide, herbicides, insecticides, fertilizers, and landscape materials; and (iii) construction and domestic wastes such as packaging materials, scrap construction materials, masonry products, timber, pipe and electrical cuttings, plastics, Styrofoam, concrete, and other trash or building materials;
7. Prevent the discharge of fuels, oils, and other petroleum products, hazardous or toxic wastes, and sanitary wastes; and
8. Address any other discharge from the potential pollutant-generating activities not addressed above; and

f. Describe procedures for providing pollution prevention awareness of all applicable wastes, including any wash water, disposal practices, and applicable disposal locations of such wastes, to personnel in order to comply with the conditions of the general permit. The operator shall implement the procedures described in the SWPPP.

Discharges from dewatering activities, including discharges from dewatering of trenches and excavations, are prohibited unless managed by appropriate controls.

### 2.5.2 Special Conditions for Total Maximum Daily Loads

Dependent on the location of a project, special conditions may be applicable if a wasteload allocation has been assigned to construction activities in a DEQ-approved Total Maximum Daily Load (TMDL). DEQ will indicate in the Construction General Permit coverage letter if the TMDL Special Conditions

apply to the project. In the case that special conditions apply, the Permittee is responsible for incorporating the more stringent DEQ regulations in accordance with 9VAC25-880-70-Part I.B.4.

### 2.6 Off-Site Land-Disturbing Activities

Off-site support facilities are defined as those facilities such as staging areas, equipment and material storage areas, unsuitable and surplus material disposal areas, borrow areas, etc., which are located outside of the project limits shown on an approved ESC and/or SWM Plan. Off-site support facilities may be located within or outside of VT property. It is the responsibility of the Applicant to ensure plans are approved and permits are obtained for support facilities prior to the commencement of the main land-disturbing activity. The Applicant shall provide VTSID with copies of local land disturbing permits for LDAs not on VT property.

### 2.7 Changes and Amendments to an Approved Plan

Changes and amendments to an approved Erosion and Sediment Control or Stormwater Management Plan may only be made with the approval of VTSID and will be submitted to VTSID through the VT project manager. VTSID, upon receipt of a change or amendment to an approved plan, shall have up to ten (10) business days to review and approve or disapprove the resubmitted plan. Proposed changes may be submitted in PDF format via email. Changes which significantly impact function and design shall come from the design professional. Location and other minor changes may come from the Contractor. VTSID has sole discretion over how a change or amendment must be submitted. Approval or disapproval of the resubmitted plan shall be made in writing to the Applicant. All changes shall be submitted, reviewed, and approved BEFORE any action is taken on the change in the field.

The Operator is responsible for updating the Registration Statement with the DEQ if a plan change or amendment affects the information originally submitted.

### 2.8 Pre-Construction Meeting

A preconstruction meeting is required for all regulated land-disturbing activities subject to the VTAS&S, prior to the commencement of the land disturbance. The VT Project Manager or Operator is responsible for coordination of the meeting and shall notify VTSID at least five (5) business days prior to the proposed meeting date. The certified Responsible Land Disturber (RLD), as defined in 9VAC25-850-10, shall be identified on the plans at, or prior to, the preconstruction meeting. The VT Project Manager shall ensure the individuals identified in Section 1 of the Preconstruction Meeting Form (see Appendix I) attend the meeting and the checklist items in Section 2 of the form are available at the meeting. A completed SWPPP will be required at the preconstruction meeting, using the template provided by VTSID.

## 3.0 IMPLEMENTATION THROUGH CONSTRUCTION

The Contractor/Operator and VTSID are responsible for ensuring implementation of the approved plan in accordance with the VTAS&S throughout the construction and until VTSID and DEQ acceptance of the site and any stormwater BMP's and termination of any permits.

### 3.1 Contractor/Operator Responsibilities

For land-disturbing activities subject to the VTAS&S, the Contractor/Operator's responsibilities prior to and during construction may include, but are not limited to:

- Obtaining necessary permit coverage and plan approvals for the site and for applicable off-site activities;
- Adhering to the approved plans;
- Maintaining the approved plans and an up-to-date SWPPP (e.g., plan modifications and inspection reports) on the project site at all times;
- Performing self-inspections per the Construction General Permit. The Permittee shall have inspections performed by a DEQ-certified ESC/SWM Inspector per 9VAC25-850;
- Responding to any corrective action(s) within specified time frames identified as the result of a VTSID or DEQ inspection;
- Providing certifications for applicable ESC measures as described in Section 3.2;
- Providing certified SWM BMP Report per Section 4;
- Contacting VTSID and VT project manager in the event of a cavern/sink hole discovery prior to any further excavation and any back fill; and
- Notify VTSID and VT project manager of any illicit discharges that occur on site during construction.

### 3.2 ESC Installation Certifications (applicable to all VT property in the Town of Blacksburg)

Section 10-207(b)(6&8) of the Town of Blacksburg ESC Ordinance requires ESC measures that require calculations to be identified on the plans with a tabular summary. These measures, including sediment basins, sediment traps, conveyance channels (including diversions), and detention basins serving as sediment basins, require certification that they were built according to the approved ESC Plan. Upon installation of these measures, the Operator is responsible for providing a written certification by a design professional as to completeness and correctness of the installation of the measure.

The certification letter shall be completed and provided to VTSID within 14 business days of the installation of the measure. If the measure was not installed according to the approved plan, VTSID may require corrective action. Failure to provide certification, or to properly install the measures in accordance with the approved plan, may result in enforcement actions, as described in Section 3.4.

### 3.3 Inspections

VTSID will perform inspections on all projects subject to the VTAS&S. The individual performing inspections on behalf of VTSID shall be a Certified Project Inspector for ESC and SWM, as applicable, in

accordance with the ESC and SWM Certification Regulations (9VAC25-850). Where a Construction General Permit is required, quarterly VTSID SWPPP inspections will be performed in addition to the required Permittee's self-inspections in accordance with the Construction General Permit. The applicable inspection report provided in Appendix J shall be completed by the inspector on each inspection and a copy provided to the appropriate individual identified on the Preconstruction Meeting Form (Appendix I) within 2 business days.

DEQ may perform random site inspections or inspections in response to a complaint to assure compliance with the associated laws/regulations and the VTAS&S. DEQ may take enforcement action at their discretion.

VTSID will conduct the following ESC inspections, at a minimum:

- After the installation of initial ESC measures per the approved ESC Plan;
- At least once in every two-week period;
- Within 48 hours following any runoff-producing (precipitation greater than 0.25") storm event;
- At the completion of the project; and
- Periodically as deemed necessary by VTSID.

The Operator shall not commence additional land-disturbing activities until after a VTSID inspection of the initial ESC measures per the approved ESC Plan. Inspection reports shall specify a required corrective action for each violation noted and a date by which the corrective action must be completed.

### 3.3.1 Structural Inspections

The Operator shall schedule an inspection with VTSID for all BMPs and critical components by 4 pm the day before the inspection, and prior to installation. The following are examples of, but not limited to, critical components:

- Stormwater pond embankment;
- Pond outlet structures;
- Setting of any concrete BMP structures – does not include precast drop inlets or manholes;
- Energy dissipation structures and any outfall structure discharging into a jurisdictional wetland;
- Infiltration or bioretention BMPs; or
- Any other key BMP component as determined by VTSID.

The Operator is responsible for performing inspections of the construction activities sufficient to confirm that the site is in compliance with the construction of storm drainage systems and stormwater management facilities and that BMPs are in conformance with the approved Stormwater Management Plan.

## 3.4 Violations

Instances of non-compliance with VTAS&S on regulated projects may be noted for the following circumstances:

- No approved ESC and/or SWM Plan;
- Failure to install stormwater BMPs or erosion and sediment controls;
- Stormwater BMPs or erosion and sediment controls improperly installed or maintained;
- Failure to conduct required inspections;
- Incomplete, improper, or missed inspections;
- Discharges not in compliance with the requirements of Section 9VAC25-880-70 of the general permit;
- No Construction General Permit registration;
- No SWPPP;
- Incomplete or outdated SWPPP; and
- SWPPP not available for review.

Notice of any violations shall be provided to the Operator in the form of an inspection report from VTSID. The notice shall specify the measures needed to comply with the plan and shall specify the time within which such measures shall be completed. If a time frame is not provided, the deadline will default to the next required inspection by VTSID.

### 3.5 Notice to Comply (NTC) and Stop Work Orders (SWO)

If VTSID notes a violation for the third consecutive inspection that has not been corrected within six (6) weeks of the initial notice, VTSID shall issue a written Notice to Comply, delivered in person or by registered or certified mail to the Operator. Should the Operator not address the violations noted on the Notice to Comply within the given timeframe, VTSID shall issue a Stop Work Order in accordance with §62.1-44.15:58.

If VTSID finds that a regulated land-disturbing activity has begun without an approved plan, has violations that are causing or are in imminent danger of causing harmful erosion of lands or sediment deposition in waters within a watershed of the Commonwealth, or is otherwise substantially impacting water quality, it may issue, without advance notice, a Stop Work Order.

The Notice to Comply and Stop Work Order shall include:

- The name and address of the responsible party.
- The address when available or a description of the building, structure or land upon which the violation is occurring.
- A statement specifying the nature of the violation.
- A description of the remedial measures necessary to correct the violation and a time schedule for the completion of such remedial action.
- A statement of the penalty or penalties that may be assessed against the person to whom the notice of violation is directed, should the remedial measures not be implemented.

If a project site is under construction and receives a Stop Work Order, all approved land-disturbing activities on the site shall cease until the specified corrective measures have been taken or, if land-

disturbing activities have commenced without an approved plan, all land-disturbing activities shall be stopped and immediately mitigated with the necessary ESC measures until an approved plan or any required permits are obtained.

The Stop Work Order will be in effect for seven days from the date of the order, at which time VTSID may issue a subsequent order until all violations have been addressed. Upon completion of the remedial measures, VTSID shall inspect the work and authorize the Operator in writing that the Stop Work Order has been removed and work may recommence.

Failure to comply with a Stop Work Order or a Notice to Comply may result in the revocation of the permit, as applicable, and any associated University Building Official permits.

### 3.6 Termination of Land Disturbance

The Operator shall submit the Termination of Land Disturbance Form (Appendix L) to VTSID upon:

- The approval of the Record Report submittal described in Section 4 and
- Verification that the area of disturbance has been stabilized to the satisfaction of VTSID.

Acceptance of the Record Report submittal does not release the Operator from any post-construction warranty, and the Permittee, as applicable, shall not terminate the Construction General Permit coverage until receipt of a VTSID-approved Termination of Land Disturbance Form. The Operator shall be responsible for any and all maintenance of BMPs and stormwater systems on the site up until the Termination of Land Disturbance.

## 4.0 Record Report for Stormwater Management Facilities

The Applicant shall submit as-built documentation to VTSID prior to final acceptance of the project, verifying that the stormwater management facilities and storm drainage systems have been constructed in accordance with the approved Erosion and Sediment Control Plan and Stormwater Management Plan. Initial submission of the record report shall be done electronically, and the final submission must be in a three ring binder. In addition, once the as-built documentation has been submitted, VTSID will conduct a final inspection to confirm the accuracy of the as-built documentation.

Specific requirements for as-built documentation and certification will be determined by VTSID and Applicant during the plan review and preconstruction meeting process. Documentation shall include the following:

- A completed and certified copy of the Stormwater Management Facility Record Report and Certification Form in Appendix K;
- A Record Report including a signed and sealed copy of the certifying professional's inspection log, including incremental surveys (drawings), photographs, construction logs, inspection reports, geotechnical testing reports, soil reports, certification of materials, and all other information necessary to certify that the SWM facility has been built in accordance with the approved Plan; and
- A Record Drawing (as-built) signed and sealed by the licensed professional that includes:
  - The long-term inspection and maintenance schedule for the SWM facility (extracted from the SWM Plan or SWM Narrative); and
  - An exhibit of the total drainage area being served by the stormwater practice with the total impervious and pervious areas within the drainage area.

Once VTSID approves the Record Report, the Operator shall schedule a final inspection of the project site prior to final acceptance of the project by VTSID.

In the case that a SWM facility has not been constructed in accordance with the approved SWM Plan, then the licensed professional responsible for certifying the as-built shall immediately notify VTSID. Generally, there are two potential options when a facility has not been constructed in accordance with the approved Plan:

*Option 1:* Re-construct the facility in accordance with the approved Plan and submit a new Record Report for review and approval by VTSID.

*Option 2:* Perform calculations and analysis, based on the licensed professional's surveys, data, inspections, and other applicable documentation necessary to verify the as-built conditions satisfy the BMP standards and specification and the applicable ESC minimum standards and SWM technical criteria and submit the final report as required in this section.

## 5.0 Record Retention

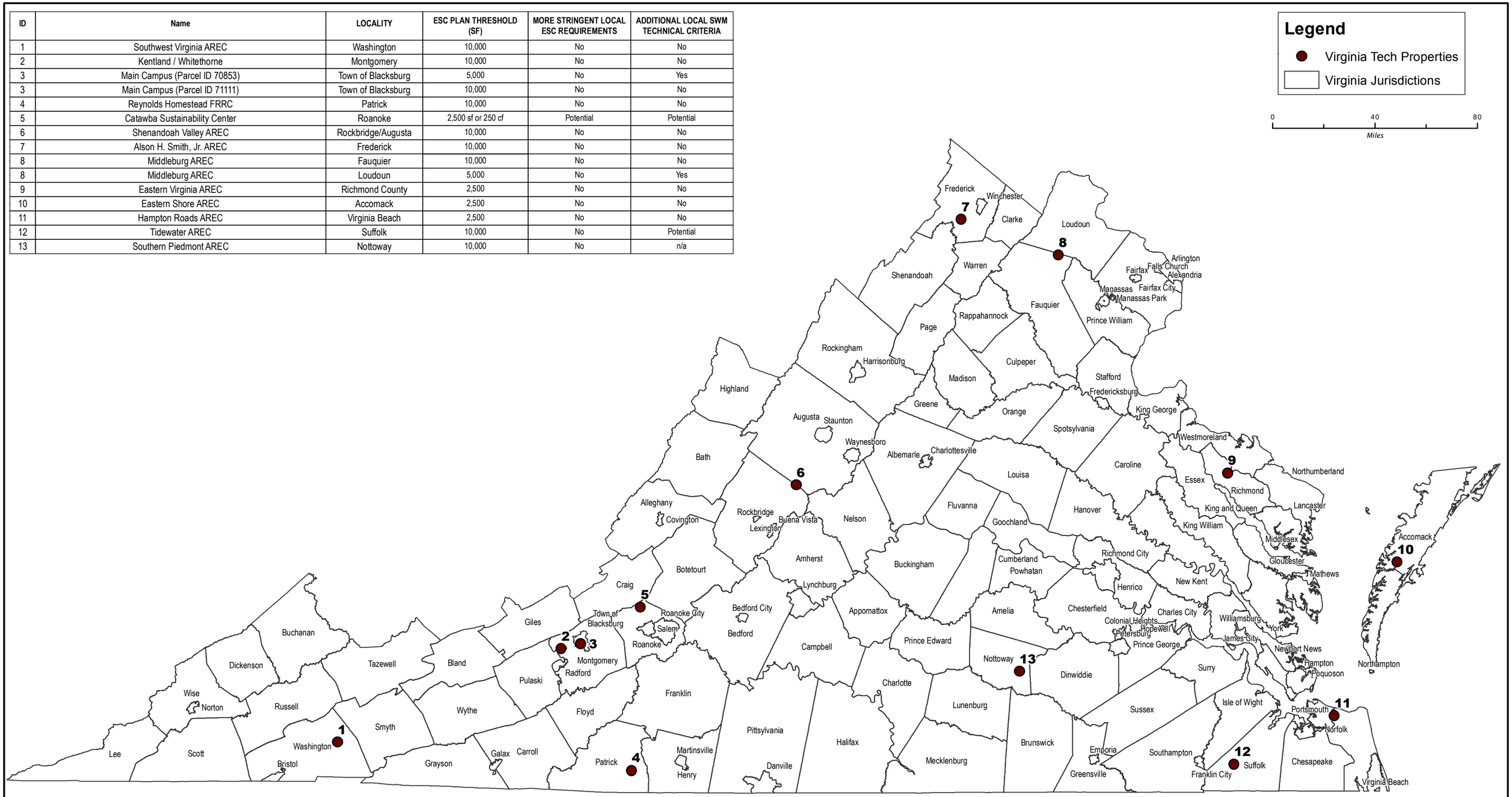
The following record retention is required both during a project and after state permit termination or project completion:

1. Project records, including approved stormwater management plans, shall be kept for three years after state permit termination or project completion.
2. Stormwater management facility inspection records shall be documented and retained for at least five year for the date of inspection.
3. Construction record drawings shall be maintained in perpetuity or until a stormwater management facility is removed.
4. All registration statements submitted in accordance with 9VAC25-870-59 shall be documented and retained for at least three years from the date of project completion or state permit termination.
5. The AS&S holder shall maintain, either on site or in AS&S files, a copy of the approved ESC plan and a record of inspections for each active land-disturbing activity.

# APPENDIX A

Statewide Coverage Map of Virginia Tech Properties

| ID | Name | LOCALITY | ESC PLAN THRESHOLD (SF) | MORE STRINGENT LOCAL ESC REQUIREMENTS | ADDITIONAL LOCAL SWM TECHNICAL CRITERIA |
|---|---|---|---|---|---|
| 1 | Southwest Virginia AREC | Washington | 10,000 | No | No |
| 2 | Kentland / Whitethorne | Montgomery | 10,000 | No | No |
| 3 | Main Campus (Parcel ID 70853) | Town of Blacksburg | 5,000 | No | Yes |
| 3 | Main Campus (Parcel ID 71111) | Town of Blacksburg | 10,000 | No | No |
| 4 | Reynolds Homestead FRRC | Patrick | 10,000 | No | No |
| 5 | Catawba Sustainability Center | Roanoke | 2,500 sf or 250 cf | Potential | Potential |
| 6 | Shenandoah Valley AREC | Rockbridge/Augusta | 10,000 | No | No |
| 7 | Alson H. Smith, Jr. AREC | Frederick | 10,000 | No | No |
| 8 | Middleburg AREC | Fauquier | 10,000 | No | No |
| 8 | Middleburg AREC | Loudoun | 5,000 | No | Yes |
| 9 | Eastern Virginia AREC | Richmond County | 2,500 | No | No |
| 10 | Eastern Shore AREC | Accomack | 2,500 | No | No |
| 11 | Hampton Roads AREC | Virginia Beach | 2,500 | No | No |
| 12 | Tidewater AREC | Suffolk | 10,000 | No | Potential |
| 13 | Southern Piedmont AREC | Nottoway | 10,000 | No | n/a |



# APPENDIX B

Land Disturbance Application Form

(VTSID-01)

# LAND DISTURBANCE APPLICATION FORM

**Instructions:** This form shall be completed and submitted to VTSID for all projects involving land disturbances on VT-owned properties.

**Project Name:** _____

**Date of submittal:** _____

**Project/Work Order Number:** _____

**Project Location (Address):** _____

_____

**APPLICANT**

**Name:** _____

**Phone:** _____

**Email:** _____

**Project Location (Latitude, Longitude):** _____

**Estimated Area of Disturbance (sq. ft.):** _____

**Estimated Impervious Area (sq. ft.): Pre-Development:** _____ **Post-Development:** _____

**Estimated Dates:** _____ **to** _____ **or Duration (months):** _____

**Describe the land-disturbance(s) involved with the project, including any offsite activities:** _____

_____

_____

_____

_____

_____

| SUBMISSION ITEM | INCLUDED | |
|---|---|---|
| | YES | NO |
| Land Disturbance Application Form | ☐ | ☐ |
| Project Location Map | ☐ | ☐ |
| Area of Disturbance Map | ☐ | ☐ |

**Applicant (Print):** _____

**Applicant Signature:** _____

INFORMATION BELOW TO BE COMPLETED BY SID

SID has verified receipt of the applicable submittal items identified above on _____.

Received by: _____

Based on the Area of Disturbance, the project is: ☐ Regulated or ☐ Not Regulated for Erosion and Sediment Control

Based on the Area of Disturbance, the project is: ☐ Regulated or ☐ Not Regulated for Stormwater Management

# APPENDIX C

Virginia Tech Stormwater Design Manual

VIRGINIA TECH

## Table of Contents

# 1.0 STORMWATER HYDROLOGY

Stormwater hydrology defines the means and methods to calculate stormwater runoff from a designated area. This section documents the hydrologic practices used to establish design flows necessary to prepare the required stormwater peak flow and storage calculations.

## 1.1 References

Except where more stringent requirements are presented in this Design Manual, stormwater hydrology shall comply with state requirements. The primary design references are:

- VDOT Drainage Manual
- VA Stormwater Management Handbook
- VA Stormwater BMP Clearinghouse website specifications

## 1.2 Design Frequencies

### 1.2.1 General

Design frequencies shall be selected consistent with good engineering practice and regulatory requirements. The design frequency requirements in this Design Manual are minimum standards - specific conditions may dictate that less frequent design frequencies should be used.

### 1.2.2 Storm Drainage Systems

Storm drainage systems consist of open channels, culverts, and storm drains. Designs shall be based on the following minimum design storm frequencies:

| Type of System | Frequency |
|---|---|
| Open Channels: Channel Capacity | 10- year |
| Open Channels: Protective Lining | 2- year |
| Culverts | 10-year |
| Storm Drains | 10-year |

Additionally, all storm drainage designs for open channels, culverts, and storm drains shall be checked for the 100-year flow condition where there is the possibility of downstream flooding, overtopping primary roads, experiencing significant economic loss, or catastrophic failure. Where justified by the consequences of failure, the minimum design recurrence interval shall be increased.

## 1.3 Stormwater Management Facilities

Certain stormwater management facilities temporarily store a portion of stormwater runoff to mitigate increases to stormwater runoff peak flows and volumes due to the effects of land development.

## 1.4 New Development

Channel protection and flood protection shall be addressed in accordance with the criteria set forth in Section 9VAC25-870-66 of the Stormwater Management Regulations.

## 1.5 Time of Concentration ($t_c$) and Travel Time ($T_t$)

### 1.5.1 General

Travel Time ($t_t$) is the time it takes runoff to travel from one location to another in a watershed. Travel Time is a component of Time of Concentration ($t_c$), which is the time for runoff to travel from the most hydraulically distant point in the watershed to the outfall. The Time of Concentration is computed by summing all the travel times for consecutive components of the drainage conveyance system. Travel Time and Time of Concentration generally consist of three flow types – overland flow, shallow concentrated flow, and open channel flow. The following methods shall be used to determine the flow and velocity for the various conditions; however, the results shall be reviewed for reasonableness, and the results shall be revised if needed to provide a reasonable velocity and flow time that will best represent the study area.

When designing a drainage system, the Time of Concentration is not necessarily the same before and after land disturbing activities have been completed. Therefore, the travel time path shall be reflective of the actual conditions both before and after the land disturbing activities. If $t_c$ is less than five minutes, then a value of five minutes will be used for all calculations. Whereas, if $t_c$ is greater than or equal to five minutes, then the calculated value will be used.

In some cases, runoff from a portion of the drainage area that is highly impervious may result in a greater peak discharge than would occur if the entire drainage area were considered. In this case, adjustments shall be made to the drainage area by disregarding those areas where the travel time is too long to add substantially to the peak discharge.

To prevent small drainage areas from skewing the time of concentration calculation results, when establishing subdrainage areas for analysis, the largest subdrainage area shall be no greater than 5 times the area of the smallest subdrainage area.

### 1.5.2 Overland (Sheet) Flow

Overland flow is flow that occurs at the upper end of a watershed, where flow is not concentrated and there are no channels. The length of overland flow shall be reflective of actual conditions and shall normally be no greater than 100 feet.

### 1.5.3 Shallow Concentrated Flow

Shallow concentrated flow is the flow that occurs when minor rivulets form just downstream from the overland flow. The maximum allowable length for shallow concentrated flow shall be 1000 feet.

#### 1.5.4 Open Channel Flow

Open channel flow occurs where stormwater flow converges in gullies, ditches, and natural or man-made conveyances.

#### 1.5.5 Pipe Flow

Pipe flow is the flow that occurs through culverts and storm drains. Use full-flow pipe velocities, unless it can be shown that the pipe will operate at partially full conditions. If it can be shown that the pipe will operate at a partially full condition, then the partially full pipe velocity may be used.

Design of culverts is presented in Chapter 3. Design of storm drain systems is presented in Chapter 4.

### 1.6 Hydrologic Methods

#### 1.6.1 General

There are a variety of widely used hydrologic methodologies. Each has its strengths and weaknesses. In the interest of standardizing hydrologic calculations, the following methodologies will be used for all projects, unless a variance is granted. A variance will only be granted if it may be demonstrated that good engineering practice dictates the use of another method.

#### 1.6.2 Peak Discharge Methods for Design of Storm Drainage Systems

The Rational Method may be used to design storm drainage systems for drainage areas up to 200 acres.

The SCS Method may be used for drainage areas up to 10 square miles.

For drainage areas greater than 10 square miles, calculations shall be performed using at least two separate methods as described in the VDOT Drainage Manual (SCS Method, regression equations, and/or stream gage data). The design peak flow shall be selected based on a professional evaluation of the results of the various methods.

#### 1.6.3 Hydrograph Methods for Design of Stormwater Management Facilities

The SCS method must be used to design stormwater management facilities

### 1.7 Methodologies

Following is an abbreviated discussion of each method. Refer to the VDOT Drainage Manual for a more complete discussion of the Rational Method and the VA SWM Handbook for a more complete discussion of the SCS Method.

#### 1.7.1 Rational Method

##### 1.7.1.1 General

The Rational Method is expressed as:

$$Q = C_f CIA$$

Where:

Q =Peak flow rate of runoff, cubic feet per second (cfs)

$C_f$ =Saturation factor

C =Runoff coefficient representing a ratio of runoff to rainfall (dimensionless) (See VESCH Table 5-2 Below)

I =Average rainfall intensity for a duration equal to the time of concentration for a selected return period (in/hr)

A =Drainage area contributing to the design location, acres (ac)

**TABLE 5-2**
**VALUES OF RUNOFF COEFFICIENT (C) FOR RATIONAL FORMULA**

| Land Use | C | Land Use | C |
|---|---|---|---|
| Business: | | Lawns: | |
| Downtown areas | 0.70-0.95 | Sandy soil, flat, 2% | 0.05-0.10 |
| Neighborhood areas | 0.50-0.70 | Sandy soil, average, 2-7% | 0.10-0.15 |
| | | Sandy soil, steep, 7% | 0.15-0.20 |
| | | Heavy soil, flat, 2% | 0.13-0.17 |
| | | Heavy soil, average, 2-7% | 0.18-0.22 |
| | | Heavy soil, steep, 7% | 0.25-0.35 |
| Residential: | | Agricultural land: | |
| Single-family areas | 0.30-0.50 | Bare packed soil | |
| Multi units, detached | 0.40-0.60 | * Smooth | 0.30-0.60 |
| Multi units, attached | 0.60-0.75 | * Rough | 0.20-0.50 |
| Suburban | 0.25-0.40 | Cultivated rows | |
| | | * Heavy soil, no crop | 0.30-0.60 |
| | | * Heavy soil, with crop | 0.20-0.50 |
| | | * Sandy soil, no crop | 0.20-0.40 |
| | | * Sandy soil, with crop | 0.10-0.25 |
| | | Pasture | |
| | | * Heavy soil | 0.15-0.45 |
| | | * Sandy soil | 0.05-0.25 |
| | | Woodlands | 0.05-0.25 |
| Industrial: | | Streets: | |
| Light areas | 0.50-0.80 | Asphaltic | 0.70-0.95 |
| Heavy areas | 0.60-0.90 | Concrete | 0.80-0.95 |
| | | Brick | 0.70-0.85 |
| Parks, cemeteries | 0.10-0.25 | Unimproved areas | 0.10-0.30 |
| Playgrounds | 0.20-0.35 | Drives and walks | 0.75-0.85 |
| Railroad yard areas | 0.20-0.40 | Roofs | 0.75-0.95 |

Note: The designer must use judgement to select the appropriate "C" value within the range. Generally, larger areas with permeable soils, flat slopes and dense vegetation should have the lowest C values. Smaller areas with dense soils, moderate to steep slopes, and sparse vegetation should be assigned the highest C values.

#### 1.7.1.2 Saturation Factor

The saturation factor ($C_f$) is an adjustment factor for modifying the runoff coefficient (C) for storms that are less frequent than a 10-year recurrence interval. The product of $C_f$ and C should not be greater than 1.0. Where the product of $C_f$ and C is greater than 1.0, use 1.0.

| Recurrence Interval (Years) | $C_f$ |
|---|---|
| 2, 5, and 10 | 1.0 |
| 25 | 1.1 |
| 50 | 1.2 |
| 100 | 1.25 |

#### 1.7.1.3 Runoff Coefficient

The runoff coefficient (C) is a variable of the Rational Method that requires significant judgment and understanding for proper selection.

As the slope of the drainage basin increases, the selected C-value should also increase as follows:

- The lower range of C-values should be used where the majority of the slopes are less than 2 percent.
- The average range of C-values should be used where the majority of slopes are 2 to 5 percent.
- The higher range of C-values should be used where the majority of the slopes are greater than 5 percent.

The C-value selection should be based on the soil type as follows:

- The lower range C-values should be used in sandy and other more pervious soils
- The higher range of C-values should be used in clayey and other less pervious soils.

It is often necessary to develop composite C-values based on the different land uses and other factors in a drainage basin. The composite C-value must be representative of the drainage basin. As noted in 1.3.1, averaging the C-value for mixed pervious/impervious watersheds may underestimate the peak flow rate.

#### 1.7.1.4 Average Rainfall Intensity

Rainfall intensity (I) shall be determined by utilizing NOAA or Atlas 14.

#### 1.7.1.5 Drainage Area

Drainage area (A) is measured in acres and is determined from evaluating a topographic map of the area.

### 1.7.2 SCS Method

#### 1.7.2.1 General

The SCS Method may be used for computing peak flow rates and generating hydrographs for storms of selected return frequencies. This approach takes into account the time distribution of the rainfall, the initial rainfall losses to interception and depression storage, and an infiltration rate that decreases during the course of a storm. 24-Hour Rainfall and Distribution

The 24-hour rainfall is determined by consulting NOAA Atlas 14.

#### 1.7.2.2 Curve Number

The SCS method uses a combination of soil conditions and land use (ground cover) to assign a runoff factor to an area. These runoff factors, or runoff curve numbers (CN), indicate the runoff potential of an area. The CN requires significant judgment and understanding for proper selection.

When calculating existing rates of runoff (pre-construction), assume that all cover types are in good hydrologic condition.

Hydrologic Soils Groups include types A, B, C, and D, with type A being the most permeable and type D the least permeable. Soils maps for Virginia may be obtained by referring to http://soils.usda.gov/.

#### 1.7.2.3 Drainage Area

Drainage areas for each sub-basin should be identified on an appropriate topographic map. The USGS quadrangle maps are often appropriate to delineate drainage areas that extend beyond the site development area.

#### 1.7.2.4 Elevation – Storage Relationship

When runoff hydrographs are being routed through a stormwater management facility, the relationship between the elevation (or depth) of stored water in the facility and storage volume needs to be known and input into the calculation. Often this information is obtained by determining the pond area bounded by contour lines on a grading plan. Enough data pairs (elevation – storage) must be provided to properly model conditions.

#### 1.7.2.5 Elevation – Discharge Relationship

When runoff hydrographs are being routed through a stormwater management facility, the relationship between the elevation (or depth) of stored water in the facility and the discharge rate from the facility needs to be known and input into the calculation. The development of this relationship requires an understanding of the design conditions and underlying hydraulic principles. The hydraulic principles and equations governing the discharge rate will often change several times at varying elevations, based on the flow control and conveyance structures. These include weir flow,

orifice flow, culvert inlet control, culvert outlet control, open channel flow, and possible effects from downstream tailwater.

## 1.8 Pre-Development Conditions

### 1.8.1 Site Development

Pre-development hydrologic calculations for land disturbing activities shall consider the site conditions that exist at the time that plans for the land development are submitted to SID. Where phased development or plan approval occurs (preliminary grading, demolition, etc.), the existing conditions at the time prior to the first item being submitted shall establish the pre-development conditions.

For the purposes of computing pre-development runoff, all pervious lands on the site shall be assumed to be in good hydrologic condition, regardless of conditions existing at the time of computation.

## 1.9 Drainage Area Analysis

When determining the stormwater management requirements for quantity control, an analysis of the pre- and post-development site conditions must be conducted. The drainage area analysis shall reflect the ultimate development conditions of the property where the land disturbing activity is being conducted.

To prevent the undersizing of stormwater management components, upstream property conditions in the entire watershed shall be considered in the drainage area analysis. Improvements to stream channels and conveyance systems shall be analyzed based on the ultimate development conditions. Design of drainage infrastructure shall be based on proposed development and the associated density of impervious areas.

When a site contains or is divided by multiple drainage areas, the downstream receiving channel for each area must be analyzed in accordance with section 9VAC25-870-66 of the VSMP regulations.

When a site drains to more than one Hydrologic Unit Code (HUC), the pollutant load reduction requirements shall be applied independently within each HUC, unless reductions are achieved in accordance with a comprehensive stormwater management plan.

The downstream limits of analysis and channel adequacy shall be determined in accordance with section 9VAC25-870-66 of the VSMP regulations.

# 2.0 OPEN CHANNELS

Open channels are man-made ditches, channels, as well as natural channels, that are used to convey stormwater runoff. This section defines the criteria and restrictions to be used in designing open channels.

Grass Channels are a type of water quality BMP with design requirements beyond those of the typical open channel. The design specifications for Grass Channels can be found on the VA Stormwater BMP Clearinghouse website.

## 2.1References

Except where more stringent requirements are presented in this Design Manual, open channels shall comply with VDOT and DEQ requirements. The primary design references are the latest editions of the following:

- VDOT Drainage Manual
- VDOT Road and Bridge Standards
- VA Erosion and Sediment Control Handbook
- Hydraulic Engineering Circular Number 15 (HEC-15), Design of Roadside Channels with Flexible Linings

## 2.2Design Methodology and Criteria

### 2.2.1 Open Channels

Open channels are classified as either major channels or minor channels. The base design storm for storm drainage systems are the 2- and 10-year, 24-hour storm events, for velocity and capacity. However, the entire system must be capable of handling a 100-year, 24-hour design storm.

### 2.2.2 Design Flow

Design flow for open channels is contained in Chapter 1. Design flows for open channels must be contained within the channel with adequate freeboard from the top of the bank to the peak water surface elevation. See section 2.2.9 for adequate freeboard requirements for capacity calculations.

Capacity calculations shall be made at the flattest section of the channel.

### 2.2.3 Hydrology

See Chapter 1 for the methodology used to determine peak flows for a given design frequency.

### 2.2.4 Channel Hydraulics

Open channel design will be based on Manning's Equation for open channel flow:

$$Q = A \times 1.49/n \times R^{2/3} \times S^{1/2}$$

Where:

Q =Flow rate in the open channel (cfs)

A =Cross-sectional area of the flow in the channel ($ft^2$)

R =Hydraulic radius, A/wetted perimeter (ft)

S =Channel slope (ft/ft)

n =Channel roughness coefficient (See VDOT Table: Appendix 7D-1 below)

**Appendix 7D-1 Values of Roughness Coefficient n (Uniform Flow)**

| Type of Channel and Description | Minimum | Normal | Maximum |
|---|---|---|---|
| LINED CHANNELS (Selected linings) | | | |
| a. Concrete | | | |
| 1. Trowel finish | 0.011 | 0.013 | 0.015 |
| 2. Float finish | 0.013 | 0.015 | 0.016 |
| 3. Gunite, good section | 0.016 | 0.019 | 0.023 |
| b. Asphalt | | | |
| 1. Smooth | 0.013 | 0.013 | - |
| 2. Rough | 0.016 | 0.016 | - |
| c. Riprap (st'd VDOT sizes)* | | | |
| 1. Class 1A | 0.033 | 0.038 | - |
| 2. Class 1 | 0.035 | 0.040 | - |
| 3. Class 2 | 0.037 | 0.042 | - |
| 4. Class 3 | 0.039 | 0.045 | - |
| 5. Type I | 0.041 | 0.047 | - |
| 6. Type II | 0.044 | 0.050 | - |
| EXCAVATED OR DREDGED | | | |
| a. Earth, straight and uniform | | | |
| 1. Clean, recently completed | 0.016 | 0.018 | 0.020 |
| 2. Clean, after weathering | 0.018 | 0.022 | 0.025 |
| 3. Gravel, uniform section, clean | 0.022 | 0.025 | 0.030 |
| 4. With short grass, few weeds | 0.022 | 0.027 | 0.033 |
| b. Earth, winding and sluggish | | | |
| 1. No vegetation | 0.023 | 0.025 | 0.030 |
| 2. Grass, some weeds | 0.025 | 0.030 | 0.033 |
| 3. Dense weeds or aquatic plants in deep channels | 0.030 | 0.035 | 0.040 |
| 4. Earth bottom and rubble sides | 0.025 | 0.030 | 0.035 |
| 5. Stony bottom and weedy sides | 0.025 | 0.035 | 0.045 |
| 6. Cobble bottom and clean sides | 0.030 | 0.040 | 0.050 |
| c. Dragline excavated or dredged | | | |
| 1. No vegetation | 0.025 | 0.028 | 0.033 |
| 2. Light brush on banks | 0.035 | 0.050 | 0.060 |
| d. Rock cuts | | | |
| 1. Smooth and uniform | 0.025 | 0.035 | 0.040 |
| 2. Jagged and irregular | 0.035 | 0.040 | 0.050 |
| e. Channels not maintained, weeds and brush uncut | | | |
| 1. Dense weeds, high as flow depth | 0.050 | 0.080 | 0.120 |
| 2. Clean bottom, brush on sides | 0.040 | 0.050 | 0.080 |
| 3. Same, highest stage of flow | 0.045 | 0.070 | 0.110 |
| 4. Dense brush, high stage | 0.080 | 0.100 | 0.140 |
| NATURAL STREAMS | | | |
| 1. Minor streams (top width at flood stage <100 ft) | | | |
| a. Streams on Plain | | | |
| 1. Clean, straight, full stage, no rifts or deep pools | 0.025 | 0.030 | 0.033 |
| 2. Same as above, but more stones/weeds | 0.030 | 0.035 | 0.040 |
| 3. Clean, winding, some pools/shoals | 0.033 | 0.040 | 0.045 |
| 4. Same as above, but some weeds/stones | 0.035 | 0.045 | 0.050 |
| 5. Same as above, lower stages, more ineffective slopes and sections | 0.040 | 0.048 | 0.055 |
| 6. Same as 4, but more stones | 0.045 | 0.050 | 0.060 |
| 7. Sluggish reaches, weedy, deep pools | 0.050 | 0.070 | 0.080 |

* Rev 7/09

**Appendix 7D-1 Values of Roughness Coefficient n (Uniform Flow)**

| Type of Channel and Description | Minimum | Normal | Maximum |
|---|---|---|---|
| 8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush | 0.075 | 0.100 | 0.150 |
| b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages | | | |
| 1. Bottom: gravels, cobbles and few boulders | 0.030 | 0.040 | 0.050 |
| 2. Bottom: cobbles with large boulders | 0.040 | 0.050 | 0.070 |
| 2. Floodplains | | | |
| a. Pasture, no brush | | | |
| 1. Short grass | 0.025 | 0.030 | 0.035 |
| 2. High grass | 0.030 | 0.035 | 0.050 |
| b. Cultivated area | | | |
| 1. No crop | 0.020 | 0.030 | 0.040 |
| 2. Mature row crops | 0.025 | 0.035 | 0.045 |
| 3. Mature field crops | 0.030 | 0.040 | 0.050 |
| c. Brush | | | |
| 1. Scattered brush, heavy weeds | 0.035 | 0.050 | 0.070 |
| 2. Light brush and trees, in winter | 0.035 | 0.050 | 0.060 |
| 3. Light brush and trees, in summer | 0.040 | 0.060 | 0.080 |
| 4. Medium to dense brush, in winter | 0.045 | 0.070 | 0.110 |
| 5. Medium to dense brush, in summer | 0.070 | 0.100 | 0.160 |
| d. Trees | | | |
| 1. Dense Willows, summer, straight | 0.110 | 0.150 | 0.200 |
| 2.Cleared land with tree stumps, no sprouts | 0.030 | 0.040 | 0.050 |
| 3. Same as above, but with heavy growth of sprouts | 0.050 | 0.060 | 0.080 |
| 4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches | 0.080 | 0.100 | 0.120 |
| 5. Same as above, but with flood stage reaching branches | 0.100 | 0.120 | 0.160 |
| 3. Major Streams (top width at flood stage > 100 ft) | | | |
| The n-value is less than that for minor streams of similar description, because banks offer less effective resistance. | | | |
| a. Regular section with no boulders or brush | 0.025 | - | 0.060 |
| b. Irregular and rough section | 0.035 | - | 0.100 |

Source: Chow, V.T., FHWA's HDS-6 publication*

* For bare earth linings when the soil classifications in accordance with either AASHTO or USCS designations are known, use the Manning's "n" values recommended in the appropriate table from Appendix 7D-2

### 2.2.5 Channel Velocity

The lining of open channels with drainage areas of five acres or less shall be designed to withstand the erosive effects of a 2-year storm.. The final design shall be consistent with velocity limitations for the selected channel lining, as presented in Table 2-1.

Open channels associated with dam embankment spillways or other structures where catastrophic failure could result from a lining failure may be required to be designed to withstand a more severe storm event.

Where open channels receive flow from storm drains, culverts, or other open channels, or in other areas where channel velocity may cause scouring or erosion, outlet protection or energy dissipation

may be necessary to reduce the potential for severe erosion. For the design of energy dissipation devices, see Chapter 6.

Velocity calculations shall be made at the steepest section the channel.

**TABLE 2-1**
**Maximum Velocity Based on Channel Lining**

| Channel Lining | Maximum Velocity (Design Storm) | |
|---|---|---|
| | Erosion Resistant Soils[1] | Easily Erodible Soils[2] |
| Vegetative Lined Channels | | |
| Tall Fescue Grass Mixtures | 5 fps | 3 fps |
| Kentucky Bluegrass | 5 fps | 3 fps |
| Annual and Perennial Rye | 4 fps | 3 fps |
| Sod | 4 fps | 3 fps |
| Geosynthetic Lined Channels | | |
| VDOT EC-2 | 4 fps | |
| VDOT EC-3, Type A | 7 fps | |
| VDOT EC-3, Type B | 10 fps | |
| Other | Per Mfr Recommendations | |
| Riprap | Dependent on stone size and thickness, see VDOT Drainage Manual for design of riprap | |
| Concrete | None | |

[1] Erosion resistant soils include those with a high clay content and high plasticity, silty clay, sandy clay, and clay.
[2] Easily erodible soils include those with a high content of fine sand or silty, lower plasticity or non-plasticity, sand, silt, sandy loam, and silty loam with an erodibility factor (K) greater than 0.35.

### 2.2.6 Channel Slope

Generally the slope of an open channel shall be established by the site topography. Open channels must be graded to drain with no standing water following a rain event. The minimum allowable grade shall be 2 percent for vegetative lined and riprap-lined open channels and 1 percent for a concrete open channel.

The maximum allowable grade for a stormwater channel shall be dependent on the channel lining materials and its ability to withstand erosion during the design storm.

### 2.2.7 Cross Sectional Area

Open channel cross-sectional area shall be designed based on site restrictions and channel capacity requAcceptable cross-sectional area options include:

- Vee
- Parabolic
- Trapezoidal
- Rectangular

#### 2.2.7.1 Vee

For design aids, see the VDOT Drainage Manual and the VA ESC Handbook.

The maximum side slope of a vee-shape open channel is 3 horizontal to 1 vertical for natural or vegetated channels and is 2 horizontal to 1 vertical for riprap, concrete or as approved by SID.

#### 2.2.7.2 Parabolic

For design aids, see the VDOT Drainage Manual and the VA ESC Handbook.

#### 2.2.7.3 Trapezoidal

For design aids, see the VDOT Drainage Manual and the VA ESC Handbook.

The maximum side slope of a trapezoidal-shape open channel is 3 horizontal to 1 vertical for natural or vegetated channels and is 2 horizontal to 1 vertical for all other linings engineered to be stable at this slope.

#### 2.2.7.4 Rectangular

Rectangular channels shall only be allowed where site restrictions prevent the installation of a vee, parabolic, or trapezoidal channel.

The requirements for rectangular channels apply to any open channel with side slopes greater than 2 horizontal to 1 vertical and include the following:

- Rectangular channels must either be constructed of concrete or gabions.
- An approved safety barrier must be placed on both sides for the length of the rectangular channel, where the channel is more than 3 feet deep.
- Care must be taken to ensure that energy dissipation is placed at the outfall of the rectangular channel to prevent erosion at the discharge point.

### 2.2.8 Channel Lining

An open channel lining shall be designed based on the cross-section, slope, and channel velocity requirements. The design may be based on a consideration of either permissive velocity or tractive force as described in the VDOT Drainage Manual.

The preferred method for analyzing channel linings is to compare the maximum permissible velocity for the channel lining, listed in Table 2.1 in this chapter of the Design Manual, to the design velocity computed using Manning's equation to verify the selected lining is adequate. As an alternative, the selected lining may be analyzed using the Tractive Force Method in the VDOT Drainage Manual. This method analyzes critical shear loading on the open channel bottom and side slopes. The permissible tractive force for various soils is located in the Appendix of the VDOT Drainage Manual.

Open channels may have different lining materials in different channel reaches based on velocity and potential erosion conditions. Care must be exercised to avoid erosion at open channel transition points.

The open channel lining will have an impact on the design capacity in the form of the roughness coefficient. Allowable open channel linings include the following:

#### 2.2.8.1 Natural

To the extent possible, natural channels shall be preserved.

To determine the permissible velocities in natural channels, based on soil conditions, use permissible velocities based on soil conditions published in the VDOT Drainage Manual. If the design storm velocity exceeds the permissible velocity, a natural channel cannot convey the stormwater runoff without modifying the discharge flow conditions or improving the natural channel.

#### 2.2.8.2 Vegetative-Lined

Vegetated or grass-lined channels include man-made channels lined with established vegetation. These channels usually include a geosynthetic mat for channel stabilization for design flow velocities.

The type of grass allowable for vegetative-lined open channels is dependent on the slope of the channel and the peak calculated velocity. Table 2-1 details the maximum permissible velocities for various channel linings.

A permanent channel stabilization geosynthetic mat should be considered for all vegetated channels. There is a wide variety of geosynthetic stabilization mat options from various manufacturers. The geosynthetic mat selected should be adequate for the slope and design flow velocities calculated for the channel. Where appropriate, VDOT Road and Bridge Standard EC-2 or EC-3 may be used.

Where a permanent geosynthetic mat is used to provide channel stabilization, information on the proposed mat, in the form of the manufacturer's catalog information, shall be submitted as a part of

the stormwater management plan. The catalog information shall include the manufacturer's recommendations for maximum allowable velocity. Design drawings must state that the geosynthetic stabilization mat shall be installed in strict accordance with the manufacturer's recommendations.

Where a permanent channel stabilization geosynthetic is not used, a temporary geosynthetic lining designed to provide a measure of the bed/bottom and bank stability until such time as a reasonably stable and mature stand of vegetation is established shall be provided.

#### 2.2.8.3 Riprap-Lined

The use of vegetated and geosynthetic-lined open channels for mild-sloped open channels and concrete for steep-sloped open channels is encouraged. Riprap-lined channels will not be acceptable where vegetated or geosynthetic-lined open channels are feasible. However, where design flow velocities exceed the erosive capability of a natural or vegetative-lined channel, riprap may be used as a channel lining in areas where erosion is a concern. For an extended length of high velocity channel, consideration should be given to using a concrete channel rather than riprap.

Use of riprap-lined channels requires pre-approval from SID.

Where riprap is approved by SID, it shall meet VESCH Specification 3.19, VDOT Standards, and VDOT Specifications.

### 2.2.8 Concrete-Lined

Concrete shall be considered where design velocities dictate or where there is a need to provide the maximum level of erosion protection.

### 2.2.9 Freeboard Requirements

Open channels shall have a minimum of 6" of freeboard above the calculated water surface elevation for the design peak flow, unless the flow is supercritical. Where the flow is supercritical, a minimum of 12" of freeboard is required. Flow is supercritical when:

$$V / (32.2 \times H)^{0.5} > 1$$

Where:

V =Velocity (fps)
H =Depth of flow (feet)

At channel bends and curves, the freeboard shall be measured from the calculated water surface elevation, including the increased depth due to the superelevation of the water surface.

### 2.2.10 Calculation of Depth of Flow at Bends and Curves

Increases in the depth of flow occur at bends and curves due to the superelevation of the water surface. Superelevation of the water surface at bends and curves is calculated, using the VDOT Drainage Manual, by:

$$\Delta Z = V^2 / (32.2 \times r_c) \times (r_o - r_i)$$

Where:

$\Delta Z$ =Difference in water surface elevation between the concave and convex banks (ft)
V =Average velocity (ft/s)
$r_c$ =Radius of the center of the stream at the bend (ft)
$r_o$ =Radius of the outside bank of the stream at the bend (ft)
$r_i$ =Radius of the inside bank of the stream at the bend (ft)

The increase in the normal stream flow depth at the outer bank of an open channel bend is one half of $\Delta Z$.

### 2.2.11 Environmental Considerations and Aquatic Organism Protection

Construction or modifications to open channels shall comply with all applicable laws and regulations. The applicant is responsible for procuring all necessary permits, such as USACE and DEQ Wetland Permits, DEQ VPDES Permits, etc., prior to obtaining SID approval.

### 2.2.12 Maintenance Requirements

The Operator is responsible for maintenance of open channels until the termination of land disturbance as described in the Annual Standards and Specifications. Maintenance includes periodically pruning or mowing vegetation and removing debris.

No one shall fill, modify, or construct structural modifications that impair or restrict flow in open channels.

# 3.0 CULVERTS

A culvert is a single run of storm drain pipe that conveys water or stormwater under a road, railway, embankment, sidewalk, or other open channel obstruction. A culvert typically connects two open channels, but it may connect an open channel to a storm drain.

Proper culvert design must consider many factors including:

- Design Flow
- Inlet conditions (flow approach conditions, allowable headwater, culvert inlet configuration)
- Culvert conditions (pipe roughness, pipe slope, diameter and length)
- Tailwater depth
- Buoyancy potential
- Environmental considerations and effects on aquatic life
- Design loads and service life of the pipe material

Refer to the VDOT Drainage Manual for a more thorough discussion of these items. For the design of stormwater inlets and storm drains, see Chapter 4.

## 3.1 References

Except where more stringent requirements are presented in this Design Manual, culverts shall comply with VDOT requirements. The primary design reference is the VDOT Drainage Manual. Other appropriate references include the latest editions of the following:

- VDOT Road and Bridge Standards
- VDOT Road and Bridge Specifications
- VA ESC Handbook
- VDOT Instructional and Informational Memorandum IIM-LD-121.15, Allowable Pipe Criteria for Culverts and Storm Sewers
- FHWA Hydraulic Design of Highway Culverts HDS No. 5, Pub. No. FHWA- HIF-12-026
- FHWA Debris Control Structures Evaluation and Countermeasures HEC No. 9, Pub. No. FHWA-IF-04-016
- FHWA Culvert Design for Aquatic Organism Passage HEC No. 2, Pub. No. FHWA-HIF-11-008

## 3.2 Design Methodology and Criteria

### 3.2.1 Computational Methods

Computations may be manual or by computer program.

Manual computations use design equations and nomographs. Results are documented on VDOT's Design Form LD-269.

There are a number of computer programs available to design culverts. Any of these computer programs will be acceptable if their methodologies are based on the same equations and nomographs accepted by VDOT, and if they provide the same documentation of inputs, assumptions, and output as are contained on VDOT's Design Form LD-269.

### 3.2.2 Hydrology

#### 3.2.2.1 Design Flow Methodology

See Chapter 1 for methodology used to determine design flows. Generally culverts shall be designed based on the peak flow (steady state), ignoring the effects of temporary upstream storage.

### 3.2.3 Culvert Hydraulics

#### 3.2.3.1 Design Flow

Culverts shall be designed in accordance with the VDOT Drainage Manual, latest edition.

Compliance with the National Flood Insurance Program (NFIP) is necessary for all locations where construction will encroach on a 100-year floodplain. The Town of Blacksburg administers the NFIP on the Virginia Tech main campus, in accordance with Executive Memorandum 2-97.

In addition, the 100-year peak flow (without the addition of the obstruction allowance) shall be routed through all culverts, determining the headwater depth behind the culvert with road overtopping, to ensure that buildings and other structures are not flooded and that adjacent roadways and adjacent properties do not suffer significantly increased damage during the 100- year storm event. Storage impacts of water behind the culvert may be considered in the calculation but is not required.

#### 3.2.3.2 Allowable Headwater

The allowable headwater is the depth of water that can be ponded at the upstream end of the culvert during the design condition, as measured from the culvert inlet invert.

The allowable headwater depth shall be limited by the following conditions:

- Headwater does not cause upstream property damage;
- Headwater does not increase the 100-year flood elevation, as mapped by NFIP;
- During a design storm event, the water surface shall be a minimum of 18 inches below the shoulder of the road at the point where the culvert crosses, or the low point of the road grade where the water would overtop the road;
- Headwater depth shall not exceed 1.5 times the diameter or height of the culvert barrel;
- Headwater depth shall not be such that stormwater flows to other ditches or terrain, which permit the flow to divert around the culvert.
- In most instances, the roadway overtopping may be treated as a broad crested weir.

- The maximum overtopping depths during a 100-year storm event for various street classifications are as follows:

| Classification | Max. Depth at Crown | Max. Velocity |
|---|---|---|
| Local/Collector | 1 ft* | 6 fps |
| Arterial/Highway | No Overflow | No Overflow |

#### 3.2.3.3 Tailwater Conditions

Tailwater is the water into which a culvert outfall discharges. Culvert design shall be based on tailwater conditions that could reasonably be anticipated during the design condition.

- If an upstream culvert outlet is located near a downstream culvert inlet, the headwater elevation of the downstream culvert may establish the design tailwater depth at the upstream culvert.
- If the culvert discharges into a lake, pond, stream, or other body of water, the maximum water elevation of the body of water during the design storm may establish the design tailwater elevation at the upstream culvert.

#### 3.2.3.4 Inlet and Outlet Control

Culvert hydraulic design shall consider both inlet and outlet control conditions. For a culvert operating under inlet control, the headwater elevation is governed by the inlet geometry. For an outlet control culvert, the inlet geometry, barrel characteristics and tailwater elevation all impact the headwater elevation.

Minimum culvert performance is determined by analyzing both inlet and outlet control for a given flow and using the highest resulting headwater.

**Inlet Control**

The following factors are considered when calculating inlet control headwater:

- Inlet Area – cross sectional area of the culvert entrance face
- Inlet Edge – projecting, mitered, headwall, or beveled edges are common
- Inlet Shape – rectangular, circular, elliptical, or arch are common

Nomographs for calculating headwater and flow capacity are found in the VDOT Drainage Manual.

**Outlet Control**

The following factors are considered when calculating outlet control headwater:

- Manning's Roughness (n) – based on barrel material

- Barrel Area – cross section perpendicular to the flow
- Barrel Length
- Barrel Slope
- Tailwater Elevation

Outlet control affects the hydraulic grade line of the flow through the culvert. To calculate the hydraulic grade line, reference the equations for velocity, velocity head, entrance losses, friction losses, and exit losses contained in the VDOT Drainage Manual.

For nomographs, cross sections, and pipe materials, see the VDOT Drainage Manual.

#### 3.2.3.5 Culvert Velocity

Outlet velocity must be checked to assure that excessive erosion and scour problems will not occur.

Culvert outlet protection shall be provided in accordance with the standards and specifications for Outlet Protection and Riprap in the VA ESC Handbook.

Culverts under roadways shall be provided with end sections or endwalls in accordance with the outlet protection requirements of the VDOT Drainage Manual.

Where a special design is needed to reduce outlet velocity, it shall be designed in accordance with VDOT standards.

The minimum velocity in a culvert barrel must be adequate to prevent siltation at low flow rates. At a minimum this velocity shall be 3 feet per second for a 2-year storm event.

### 3.2.4 Structural Design

All culverts shall be designed to withstand a HS-20 highway loading, unless it crosses under a railroad, in which case the culvert shall be designed for railroad loads. The structural design shall consider the depth of cover, trench width and condition, bedding type, backfill material, and compaction.

### 3.2.5 Materials

Culverts in public easements or rights-of-way shall be constructed of materials based on the following:

- Culverts under a roadway in the right-of-way shall be VDOT approved materials.
- Culverts under sidewalks, trails, etc. shall be reinforced concrete pipe (RCP) or HDPE.

### 3.2.6 Culvert Sizes

The minimum culvert size shall be 18-inch diameter.

Culverts shall meet all cover conditions required. Where the site conditions preclude the use of a single culvert barrel to meet the design flow conditions, multiple barrel culverts are acceptable.

The maximum length of a culvert shall be 300 feet. A culvert longer than 300 feet shall have manholes or junction boxes and shall fall under the requirements of Chapter 4.

### 3.2.7 End Conditions

Headwalls and end sections shall normally be required on inlets and outlets, as described below.

#### 3.2.7.1 Prefabricated End Sections

Prefabricated end sections, or flared end sections, provide for a better flow path, improving the design flow and headwater conditions.

Prefabricated end sections shall be provided for culverts 18-inch to 36-inch diameter, except:

- Where culvert alignment exceeds 20 feet in vertical elevation change or culvert slope exceeds a 2:1 slope, a standard concrete headwall shall be provided instead of a prefabricated end section.
- Where a concrete headwall is provided.

#### 3.2.7.2 Concrete Headwalls and Structures

Precast concrete headwalls shall be provided at all culvert inlets and outlets, unless other end conditions are allowed, as stated above. Precast concrete headwalls shall meet the requirements of the VDOT Road and Bridge Standards and VDOT Road and Bridge Specifications.

Wingwalls may be required in conjunction with headwalls. Culvert pipes 48” or larger in diameter shall have concrete wingwalls. Wingwalls are generally used where the culvert is skewed to the normal channel flow or where the side slopes of the channel or roadway are unstable. Wingwalls shall meet the requirements of the VDOT Standards and VDOT Specifications. Wingwalls shall be set at an angle between 30 degrees and 60 degrees from the headwall.

Concrete aprons may be used at the entrance or the exit of a culvert. Aprons are typically used where high velocities or headwater conditions may cause erosion upstream or downstream of the culvert. An apron shall not protrude above the normal stream bed elevation.

Special design concrete slab end treatment, per VDOT Standards, may be used as a concrete end section.

### 3.2.8 Multiple Barrel Culverts

Multiple barrel culverts shall be allowed where single culverts cannot handle the design flow while meeting the required cover or headwater condition requirements. The design of multiple barrels should avoid the need for excessive widening of the upstream or downstream receiving channels.

The minimum spacing between culverts in a multiple barrel culvert design shall be that required to provide adequate lateral support and allow proper compaction of bedding material under the pipe haunches.

### 3.2.9 Culvert Skew

Where possible, culverts shall be installed parallel to the flow path. The maximum allowable skew shall be 45 degrees as measured from the line perpendicular to the roadway centerline.

### 3.2.10 Buoyancy

Verify that the culvert pipe, end sections, and concrete endwall structures will not fail under hydrostatic uplift conditions.

The buoyancy force consists of the weight of water displaced by the pipe and the fill material that is over the pipe (below the headwater depth). The force resisting buoyancy includes the weight of the pipe, weight of the water within the pipe, and the weight of fill material over the pipe.

Buoyancy is more likely to be a problem where:

- Lightweight pipe is used
- The pipe is on a steep slope (usually inlet control with the pipe flowing partially full)
- There is little weight on the end of the pipe (flat embankment slopes, minimum cover, and/or no endwalls)
- High headwater depths (HW/D>1.0)

Suitable cover, footings, or anchor blocks may be required to ensure the culvert's integrity during design conditions.

### 3.2.11 Debris and Trash Racks

In general, trash racks or debris deflectors shall not be used where other site modifications may be made to prevent excessive trash or debris from entering the culvert. However, they may be required at specific locations by SID where large amounts of storm debris may be anticipated.

## 3.3 Installation

All culvert pipe, headwalls, end sections, outlets, and other peripheral structures shall be installed in accordance with VDOT requirements and the manufacturer's recommendations. The characteristics of the trench, bedding, and pipe material all impact the structural strength of the pipe system. The installed culvert conditions shall comply with the design assumptions and calculations.

### 3.3.1 Bedding Material

Bedding material and installation shall comply with the requirements of the VDOT Specifications.

### 3.3.2 Backfill

Backfill shall be suitable material and shall be placed and compacted in accordance with VDOT Specifications.

A minimum of 12" of backfill shall be placed over the top of a HDPE or CMP culvert prior to placing pavement or other surface treatment.

### 3.4 Environmental Considerations and Aquatic Organism Protection

Where compatible with good hydraulic engineering, a culvert shall be located in “dry” conditions. Where this is not possible, the culvert shall be located to minimize impacts to streams or wetlands.

When a culvert is set in a perennial stream, the invert of the culvert shall be set below the normal flow line of the stream as required in the VDOT Drainage Manual. The grade of the culvert shall not exceed the grade of the natural stream in that section.

Where construction requires environmental permits, the applicant shall be responsible for obtaining all necessary environmental permits and complying with their requirements.

### 3.5 Maintenance Requirements

The Operator is responsible for maintenance of culverts until the termination of land disturbance as described in the Annual Standards and Specifications.

# 4.0 STORM DRAINS

A storm drainage system consists of two or more interconnected pipes and one or more structures designed to intercept and convey stormwater runoff from specific storm event without surcharge. Storm drains collect and transport stormwater from a site primarily through the use of a closed pipe network. For the stormwater to be efficiently handled in a storm drain, the site must also have an efficient way to collect stormwater runoff and have it enter into the piped network. Once in the storm drain, the stormwater is routed to a discharge outfall.

Storm drainage systems include:

- Inlets
- Storm drain piping and structures that convey stormwater runoff to the outfall

This section defines criteria and restrictions that shall be used in designing and constructing storm drains. See the VDOT Drainage Manual for more in-depth information.

Profiles for all storm drains 12 inches in diameter and greater shall be provided on the site plans.

## 4.1 References

Except where more stringent requirements are presented in this Manual, storm drainage systems shall comply with VDOT and DEQ requirements. The primary design reference is the VDOT Drainage Manual. Other appropriate references include:

- VDOT Standards
- VDOT Road and Bridge Specifications
- VA ESC Handbook

## 4.2 Design Methodology and Criteria

### 4.2.1 Computational Methods

Computations may be manual or by computer program.

Manual computations use design equations and nomographs. Results may be documented on VDOT work sheets.

- Form LD-204 Stormwater Inlet Computations
- Form LD-229 Storm Drain Design Computations
- Form LD-347 Hydraulic Grade Line Computations

There are a number of computer programs available to design storm drainage systems. Any of these computer programs will be acceptable if their methodologies are based on the same equations and nomographs accepted by VDOT, and if they provide the same documentation of inputs, assumptions, and output as are contained on VDOT's work sheets.

Computational methods are explained in detail, including comprehensive design examples, in the VDOT Drainage Manual.

### 4.2.2 Hydrology

See Chapter 1 for the methodology used to determine design flows. Calculations establishing the design flow shall be submitted with the Stormwater Management Plan. Design flows shall be based on the ultimate build-out of the project, or of the campus precinct in accordance with the Virginia Tech Stormwater Management Master Plan.

### 4.2.3 Design Flows

Inlets shall be designed for 10-yr storm frequencies and intensities consistent with the VDOT Drainage Manual.

Storm drains shall be designed in accordance with Chapter 1 of this manual.

### 4.2.4 Measures to Convey Stormwater Runoff to Inlets

#### 4.2.4.1 Curb and Gutter

Curb and gutter at the edge of pavements may be used to collect stormwater runoff from roadways. Curbing captures stormwater runoff and directs it to stormwater collection inlets while protecting adjacent properties from flooding and erosion due to sheet flow runoff from the impervious roadways.

A curb and gutter forms a triangular conveyance channel. When a storm occurs, the runoff from the road creates a spread of water from the curb. The curb and gutter must be designed to convey this flow and with associated drainage structures prevent the spread onto the roadway from impacting traffic. The spread width of flow is determined by using nomographs. For curb and gutter flow, a Manning's n value of 0.015 is used in the computational analysis.

Curb and gutter dimensions and design shall meet VDOT Standards.

#### 4.2.4.2 Open Channels

Open channels may be used to collect site drainage and convey it to a storm drain inlet. Design requirements for open channels are covered in Chapter 2.

### 4.2.5 Storm Drain Inlets

#### 4.2.5.1 General

Storm drain inlets are used to collect stormwater runoff from roads, sidewalks, or low elevations during storm events and provide a method for conveying the stormwater into the storm drain system. This is usually accomplished by placing storm drain inlets at regular intervals or at key locations to intercept flows and control the stormwater spread width. The design criteria for limiting the spread of water on travel lanes is found in the VDOT Drainage Manual.

There are several different types of storm drain inlets that can be used to meet this purpose, and the designer shall choose the proper inlet structure based upon site conditions and design conditions to maximize the drainage efficiencies.

- Curb
- Grate
- Slotted Drain/Trench
- Combination

Stormwater management plans shall include a contour plan with sufficient contours shown to ensure positive drainage to an inlet. Inlet Volume Capacity Calculations are required with the Stormwater Management Plan submittal.

### 4.2.6 Storm Drain Inlets

#### 4.2.6.1 Curb Inlets

Curb inlets are vertical openings in the curb covered by a top slab. These inlets can convey large quantities of water, but also allow for large amounts of debris to enter the storm drain system.

Curb inlets shall be used to the maximum extent possible for pavement drainage.

#### 4.2.6.2 Grate Inlets

Grate inlets are horizontal grates that are usually used in depressed medians or in other areas of low elevations. Grate inlets are often referred to as drop inlets or DIs. Grate inlets shall be pedestrian rated when installed in paved areas. Where they are used in pavement, inlet grates shall be bicycle safe.

#### 4.2.6.3 Combination Inlets

Combination inlets combine both the vertical opening used by curb inlets and the horizontal grate used by grate inlets. These inlets are often used when the inlet chamber is required to be under the gutter or street pavement away from the sidewalk or other utilities. Combination inlets shall be avoided where possible. Where they are used, they must have bicycle-safe grates.

#### 4.2.6.4 Trench Drain Inlets

Trench drain inlets are cast-in-place or precast concrete trenches covered by a grate that are used to intercept sheet flow.

#### 4.2.6.5 Inlet Locations

Inlets shall be located to meet the design requirements of the VDOT Drainage Manual for maximum spread width. In addition, inlets shall be provided, regardless of contributing drainage area, as follows:

- At sag points in the gutter grade.
- Either side of sag point inlet (flanking inlets).
- Upstream of median breaks, crosswalks, and street intersections.

- Immediately upstream and downstream of bridges.
- On side streets at intersections, where flow is approaching the main line.
- Behind curbs, shoulders, or sidewalks to drain low areas or intercept concentrated flow.
- At 1% cross slope upstream of cross slope reversals.
- At any low elevation in the grade.

Inlets installed in pathways likely to be used by pedestrians or bicyclists shall be a pedestrian rated grate.

#### 4.2.6.6 Access

All inlets shall have a removable grate or manhole cover to allow access for clean out.

#### 4.2.6.7 Inlet Capacities

The capacities of each inlet type are contained in the VDOT Drainage Manual. Capacities are determined from equations or nomographs that are contained within the VDOT Drainage Manual. Documentation of inlet capacity shall be made on VDOT Form LD-204, Stormwater Inlet Computations or computer modeling output.

#### 4.2.6.8 Separation of Pipes

Where two or more storm drains enter a concrete structure at or near the same elevation, a 6" minimum horizontal clearance must be maintained between the pipes. Additional clearance between pipes shall be provided if required to protect the structural integrity of the structure.

### 4.2.7 Storm Drain Pipes

#### 4.2.7.1 Flow Capacity

Based on the size and slope of the storm drain, the design capacity for a pipe flowing full can be determined using Manning's equation.

$$Q = A \times 1.49/n \times R^{2/3} \times S^{1/2}$$

Where:

Q =Flow in the pipe (cfs)
A =Cross-sectional Area of the pipe ($ft^2$)
R =Hydraulic radius; for circular pipe flowing full, R=Diameter/4 (ft)
S =Storm drain slope (ft/ft)
n =Pipe roughness coefficient

The design flow capacity of a storm drain shall comply with the design frequencies set forth in the VDOT Drainage Manual. In a roadway underpass, or depressed section, where ponded water can only be removed through the storm drain system, a 100-year frequency storm event shall be used to design the storm drain at the sag point.

#### 4.2.7.2 Storm Drain Slope

To deter the settling of debris and sediment in the storm drain pipe, the pipe shall be designed to ensure positive slope and maintain a minimum velocity of 3 feet per second during a 2-year frequency storm.

The maximum pipe velocity in any storm drain shall be 20 feet per second during a 10-year frequency storm to prevent excessive abrasion of the pipe and erosion at the discharge. If the pipe velocity exceeds 15 feet per second during a 10-year frequency storm, a reinforced concrete storm drain pipe is required.

Storm drains shall be sloped to meet the velocity requirement set in this chapter. Slopes greater than 16 percent shall be avoided if possible. If unavoidable, drop structures shall be utilized in steeper terrain. In addition, storm drains with slopes steeper than 16% must have anchor blocks for support.

#### 4.2.7.3 Pipe Size

The minimum recommended conduit size for storm drainage pipe is 15-inch diameter or its equivalent for non-circular shapes. Where necessary, it will be permissible to use a 12-inch diameter pipe for laterals or initial pipe runs of 50 feet or less. Pipe size shall not be reduced along the direction of the flow, except as required for proper operation of stormwater management facilities.

#### 4.2.7.4 Access

Regardless of pipe size, a cleanout access point, either an inlet, manhole, or junction box shall be provided at a maximum of every 300 feet of pipe.

#### 4.2.7.5 Water-Tight Joints

The use of water-tight joints is encouraged to prevent infiltration of groundwater, and potential pollutants carried by contaminated groundwater, and to prevent settlement problems from occurring due to soil materials washing into storm drains.

SID reserves the right to require the use of water-tight joints in the following locations:

- Culverts and storm drains under pavement, sidewalks, or concrete structures
- Through stormwater “hotspots”
- In areas where groundwater may be contaminated by pollutants
- On steep slopes
- Culverts

The following land uses and activities are designated as stormwater hotspots:

1) Vehicle salvage yards and recycling facilities
2) Vehicle fueling stations
3) Vehicle service and maintenance facilities

4) Vehicle and equipment cleaning facilities
5) Fleet storage areas (bus, truck, etc.)
6) Industrial sites (for SIC codes contact VA DEQ)
7) Marinas (service and maintenance areas)
8) Outdoor liquid container storage
9) Outdoor loading and unloading facilities
10) Public works storage areas
11) Facilities that generate or store hazardous materials
12) Commercial container nursery
13) Golf courses
14) Chemical storage
15) Dry cleaning operations

### 4.2.8 Determination of Hydraulic Grade Line

#### 4.2.8.1 General

The hydraulic grade line represents the free water surface elevation of water in a pipe system. Where the hydraulic grade line is above the top of a pipe, the pipe is flowing under pressure. The hydraulic grade line in a manhole or other structure is the elevation to which water will rise.

Hydraulic grade lines shall be calculated and evaluated for all storm drains. The hydraulic grade line shall be calculated using VDOT methods and equations that are fully described in the VDOT Drainage Manual. Calculations shall be documented on VDOT Form LD-347, Hydraulic Grade Line Computations, or computer modelling output. The output shall be in the form of profiles showing the HGL in relation to the pipe and structures.

The hydraulic grade line shall not exceed any critical elevation during the design storm. Critical elevations include rising above the ground elevation at inlets or other structures, or reaching an elevation where storm flow could back up to cause flooding damage.

The calculation of the hydraulic grade line begins at the system outfall and proceeds upstream to each structure in the system. The calculation is based on the principal of conservation of energy as shown below and includes major and minor energy losses:

$$HGL_{us} = HGL_{ds} + H_f + H_m$$

Where:

$HGL_{us}$ = Elevation of hydraulic grade line at the upstream structure
$HGL_{ds}$ = Elevation of hydraulic grade line at the downstream structure
$H_f$ = Pipe friction loss
$H_m$ = Summation of minor head losses (junctions, bends, etc.)

Major head losses are attributable to friction losses within the pipe. Minor head losses include losses from:

- Junctions
- Exits
- Entrances
- Bends in Pipes
- Access holes
- Conflict pipes
- Plunging flow
- Expansions and contractions
- Appurtenances such as weirs, diverters, valves and meters

- Outfall Conditions

The hydraulic grade line starts at the system outfall. At this point the hydraulic grade line shall be the actual tailwater elevation or the elevation of 0.8 times the diameter of the outlet pipe, whichever is higher. If the system discharges into a detention or retention pond, the hydraulic grade shall start at the 10-year water surface elevation.

- Pipe Friction Losses

The friction slope is the energy slope for that run of pipe. The friction slope is determined by inserting pipe information and design flow into Manning's equation and solving for S (slope). The total friction head loss in the run of pipe is the friction slope multiplied by the length of the run.

Where the hydraulic grade line falls below the crown of the pipe, the elevation of normal flow is the hydraulic grade line.

- Junction Losses

**General**

Junction head losses are the summation of entrance ($H_i$), exit ($H_o$), and bend losses ($H_\Delta$). When calculating junction losses it is important to use actual flow velocities. If pipes are flowing partially full, then partially full velocities are used.

**Entrance (Expansion) Losses**

Entrance loss at a junction is given by:

$$H_i = K_e (V_i^2 / 2g)$$

Where:

$H_i$ = Entrance head loss
$K_e$ = Entrance loss coefficient. $K_e$ = 0.35
$v_i$= Velocity in the inlet pipe. Where more than one inlet pipe is present, use the velocity from the pipe that has the greatest momentum (Q*V)
g = Gravitational acceleration constant, 32.2 ft/s$^2$

**Exit (Contraction) Losses**

Exit loss at a junction is given by:

$$H_o = K_o(V_o^2 / 2g)$$

Where:

$H_o$ = Exit head loss
$K_o$ = Exit loss coefficient. $K_o$ = 0.25, except that $K_o$ = 0.3 when computing the loss leaving the initial inlet
$V_o$ = Velocity in the outlet pipe
g = Gravitational acceleration constant, 32.2 ft/s$^2$

**Bend Losses**

Bend losses at a junction are dependent on the angle between the inlet and outlet pipes. If the inlet and outlet pipe are in line with one another (no bend), the angle is 0 degrees and there is no bend loss. As the angle increases towards 90 degrees, the bend loss increases. Storm drain systems should not be designed with bend angles greater than 90 degrees. Where more than one pipe enters a junction at an angle, the $H_\Delta$ should be figured on all bends and the largest one used as the bend loss. The bend loss is given by:

$$H_\Delta = K (V_i^2 / 2g)$$

Where:

$H_\Delta$ = Head loss at bend
K = Bend loss coefficient. K is determined by consulting Figure 9-9 in the VDOT Drainage Manual.
$V_i$ = Velocity in the inlet pipe.
g = Gravitational acceleration constant, 32.2 ft/s$^2$

**Plunging Losses**

Where surface inlet inflow is 20 percent or more of the total flow through a junction, or when a lateral pipe enters a junction with its invert elevation above the crown of the outgoing pipe and the flow in the lateral pipe is 20 percent or more of the total flow through the junction, the total head loss from

the structure ($H_i + H_o + H_\Delta$) shall be multiplied by 1.3 (increased by 30 percent). This adjustment is cumulative with the adjustment for plunging losses.

**Inlet Shaping**

Inlet shaping refers to how the invert is shaped to provide smooth flow through the structure and is required in all manholes and inlets. When VDOT Standard IS-1, inlet shaping, is used in a structure, the total head loss from the structure ($H_i$ + Ho + HΔ) shall be multiplied by 0.5 (decreased by 50 percent). This adjustment is cumulative with the adjustment for inlet shaping.

#### 4.2.9 100-Year Conditions

Where there is the possibility of building structures flooding, conditions during the 100-year storm shall be analyzed to verify that all existing and proposed structures do not flood. Flow from the 100-year storm may be carried overland as well as by the storm drain system.

#### 4.2.10 Materials

##### 4.2.10.1 Structures

All stormwater structures (inlets, manholes, and junction boxes) located in public easements or rights-of-way shall be precast or cast-in-place concrete. All structures, frames, grates, and covers shall be in accordance with VDOT Standards and VDOT Specifications.

##### 4.2.10.2 Storm Drain Pipe

Storm drain pipe in roadways shall be constructed of Reinforced Concrete Pipe (RCP). Storm drain pipe in sidewalks, trails, etc shall be constructed of Reinforced Concrete Pipe (RCP) or High Density Polyethylene (HDPE). Corrugated Metal Pipe (CMP) shall not be allowed.

#### 4.2.11 Structural Design

All inlet structures, frames and grates; and pipes shall be designed to withstand a HS-20 loading, unless a pipe crosses a railroad, in which case the pipe shall be designed for railroad loads. The structural design shall consider the depth of cover, trench width and condition, bedding type, backfill material, and compaction.

### 4.3 Installation

All inlets, pipes, and associated structures shall be installed in accordance with VDOT Specifications and the manufacturer's recommendations. The characteristics of the trench, bedding, and pipe material all impact the structural strength of the pipe system. The installed pipe conditions shall comply with the design assumptions and calculations.

#### 4.3.1 Bedding Material

Bedding material and installation shall comply with the requirements of the VDOT Specifications.

#### 4.3.2 Backfill

Backfill shall be suitable material and shall be placed and compacted in accordance with the VDOT Specifications.

Before passage of equipment, a minimum of 12" cover shall be placed over the top of a storm drain pipe prior to placement of pavement or other surface treatment. Additional depth of cover shall be provided if recommended by the manufacturer.

#### 4.3.3 Separation of Utilities

Where storm drains cross other utilities, at least 1 foot of vertical separation shall be provided. Where 1 foot of vertical separation cannot be provided, special provisions shall be made in the bedding and backfill to avoid settlement that could cause point loadings on the storm drain or other utility.

Waterlines and sewer lines shall not pass through a storm drain inlet or manhole.

### 4.4 Environmental Impacts

Construction or modifications to storm drains shall comply with all applicable laws and regulations. The applicant is responsible for procuring all necessary permits.

### 4.5 Erosion Protection at Outfalls

Erosion protection at storm drain outlets shall be provided in accordance with the outlet protection standards contained in the VA ESC Handbook and the VDOT Drainage Manual.

### 4.6 Maintenance Requirements

The Operator is responsible for maintenance of storm drains until the termination of land disturbance as described in the Annual Standards and Specifications.

# 5.0 STORMWATER DETENTION

Stormwater detention facilities are a means of attenuating increases in peak flow rates caused by land development. In addition to providing flood control, stormwater detention facilities can protect downstream channels from increases in erosion and may provide a measure of water quality treatment. This chapter addresses general requirements for detention facilities as they relate to attenuating peak flow rates.

When a storm event occurs, stormwater runoff enters the detention facility. The outlet structure allows a portion of the stormwater runoff to discharge from the facility, while the remainder of the stormwater runoff is temporarily stored. After the end of the storm, water continues to discharge from the facility until it is empty or the permanent pool elevation is reached.

Stormwater detention facilities, as listed in VA Stormwater BMP Clearinghouse and DEQ Stormwater Regulations, include:

- Part IIB
    - Bioretention (Including Urban Bioretention)
    - Constructed Wetlands
    - Wet Ponds
    - Extended Detention Ponds
    - Underground Detention Facilities
- State Existing Facilities (Under Part IIC)
    - Detention Pond
    - Enhanced Extended Detention Pond

An underground detention facility consists of pipes or manufactured underground chambers used to temporarily store stormwater runoff following a storm event, discharging it at a controlled rate through a hydraulic outlet structure to a downstream conveyance system. An underground detention facility is dry during non-rainfall periods.

In addition to detention, the design requirements specified by this chapter shall apply to ponds created as amenities, research ponds, and farm ponds.

## 5.1 References

Except where more stringent requirements are presented in this Manual, the design and construction of stormwater detention facilities shall comply with VDOT and DEQ requirements. The primary design references are:

- VA SWM Handbook
- VDOT Drainage Manual
- VA ESC Handbook
- VDOT Standards

- VA Stormwater BMP Clearinghouse

## 5.2 Design Methodology and Criteria

### 5.2.1 Hydrology

See Chapter 1 for methodology used to determine design flows.

### 5.2.2 Design Flows and Storage Volumes

To properly design stormwater detention facilities, a flow routing program shall be used with an appropriate elevation-storage-discharge relationship for the design storm events.

### 5.2.3 Detention Facility Locations

Stormwater detention facilities should not be constructed within a Federal Emergency Management Agency (FEMA) designated 100-year floodplain. If this is unavoidable, the facility shall comply with all applicable regulations under the National Flood Insurance Program, 44 CFR Part 59.

The following factors shall be addressed when siting a stormwater detention facility:

- Geotechnical conditions, including soil conditions
- Karst topography
- Groundwater levels
- Existing and proposed utilities
- Aesthetic impacts on surrounding properties
- Environmental impacts, including wetlands

Stormwater basins shall be located to minimize the aesthetic impacts to adjacent properties. Basins shall be set back from property lines a distance equal to the minimum width of the applicable required Source.

Locate stormwater detention facilities to avoid collecting significant amounts of drainage from offsite areas.

All stormwater management basins shall be lined with either a clay liner or an impermeable High Density Polyethylene (HDPE) liner.

Stormwater basins shall be set back in accordance with VA Stormwater BMP Clearinghouse Specification No. 15.

### 5.2.4 Detention Basin Grading

Stormwater basins shall be graded to blend into the surrounding topography with the following conditions:

- Basin side slopes shall be no steeper than 3H:1V.
- Provisions shall be made for the long-term maintenance of basin slopes and periodic access for maintenance of the outlet structure and emergency spillway and removal of accumulated sediment and debris.

- The maximum allowable depth of a stormwater detention basin shall be 15 feet, as measured from the top of the embankment to the lowest point in the basin.
- The bottom of the basin shall be designed so that the entire bottom of the Extended Detention Basin is sloped at 1% to facilitate positive drainage to the outlet structure.

In addition to the above requirements, the following standards of practice should be used when designing a stormwater basin, to the extent possible:

- In order to prevent short-circuiting of a stormwater basin's storage areas, the length-to-width ratio of the basin should be a minimum of 2:1, with the flow entering the basin as far from the outlet structure as possible. A 3:1 ratio is desired where possible.
- To minimize cut and fill, the long dimension of a stormwater basin should run parallel to the contours.

### 5.2.5 Embankments and Emergency Spillways

Embankments and emergency spillways shall be designed in accordance with the Earthen Embankment and Vegetated Emergency Spillway specifications on the VA Stormwater BMP Clearinghouse website. A geotechnical study for the embankment and basin is required.

### 5.2.6 Outlet Structures and Release Rates

#### 5.2.6.1 Stormwater Release Rates

Stormwater detention facilities shall be designed with an outlet structure to control the release rate of stormwater being held in the facility. Design release rates shall meet the requirements set forth in Chapter 5.

Research ponds, farm ponds and ponds created as amenities shall be exempt from release rate requirements.

#### 5.2.6.2 Outlet Structure Criteria

Outlet structures generally include a principal spillway and an emergency spillway. An outlet structure may take the form of combinations of risers, pipes, weirs, or orifices. The principal spillway is intended to release flow from the design storm events at the necessary controlled rate, without allowing flow to enter the emergency spillway. The sizing of the outlet structure shall be based on the results of the hydrologic routing calculations or model. Due to the tendency of clogging, the minimum orifice diameter shall be 3 inches. A basin drain shall be installed to allow for dewatering.

Outlets from stormwater detention facilities shall be designed to function without manual, electrical, or mechanical controls.

Where necessary, energy dissipaters shall be placed at the outfall to provide a non-erosive velocity from the facility to a channel. See Chapter 6 for the design of outfall protection.

Where a stormwater basin with an earthen embankment does not have an emergency spillway, the principal spillway shall be sized to safely pass the flow from the 100-year storm without overtopping the embankment. In addition, the minimum size of the primary spillway shall be 24 inches.

Freeboard for detention basin facilities are as follows:

- 1 foot of freeboard for basins that have an emergency spillway that is measured from the calculated design water surface elevation to the top of the embankement; or
- 2 foot of freeboard for basins that do not have an emergency spillway that is measured from the calculated design water surface elevation to the top of the embankment.

Where a stormwater basin has an outfall with an emergency spillway, the outfall shall be sized to safely pass the flow from the 10-yr storm and the emergency spillway shall be sized to safely pass the 100-yr storm. For a stormwater basin that does not have an emergency spillway, the outfall shall be sized to safely pass the flow from the 100-yr storm.

For examples of design calculations of outlet structure orifices and weirs, see the VDOT Drainage Manual.

All riser structures shall be cast-in-place, precast concrete, or PVC unless a substitute material has been approved by SID. Standards for riser structures may be found in the VDOT Standards. Riser buoyancy calculations are required.

Outlet pipes shall be reinforced concrete pipe with rubber gasket watertight joints, shall have appropriate seepage control, and shall be installed on a concrete cradle from the toe of the pipe to the riser for the entire length of the outfall pipe. Concrete cradle shall be in accordance with the requirements of the VDOT Standards.

### 5.2.7 Landscaping

Stormwater basin embankments shall be stabilized. Plant selection and installation shall be in accordance with the standards of the VA Stormwater BMP Clearinghouse website specifications. Trees and shrubs shall not be planted within a stormwater detention basin, nor on a stormwater basin berm, dam, or emergency spillway.

Native plants will be used to the maximum extent possible.

### 5.2.8 Underground Detention

#### 5.2.8.1 Materials

All materials used in underground detention facilities shall be corrosion-resistant, consisting of reinforced concrete, corrugated high density polyethylene pipe, or similar approved material.

#### 5.2.8.2 Slope

Underground detention facilities shall be sloped to drain at a minimum floor slope of 1 percent.

#### 5.2.8.3 Capacity

Underground detention facilities and other storm drainage system and facility components shall be sized such that the 100-year design storm may be routed through the drainage system and facilities with no damage to the surface property.

#### 5.2.8.4 Accessibility and Maintainability

All underground detention facilities shall be designed to be readily accessible for periodic inspection and maintenance from the surface without the need to perform confined space entry.

Providing pre-treatment to remove sediments before or at the entrance of the underground detention facility to improve water quality and/or improve maintainability shall be included to the maximum extent practicable in the design.

### 5.2.9 Trash Racks

Outlet structures shall be equipped with an appropriate trash rack. The trash rack shall be in accordance with the VA SWM Handbook.

## 5.3 Environmental Impacts

Environmental impacts shall be carefully considered when designing stormwater detention facilities. Stormwater detention facilities shall be designed in accordance with MS-14. Proposing basins in low-lying areas with potentially environmentally sensitive areas requires careful consideration, coordination, approval, and permitting with SID and state and federal agencies to evaluate the suitability of constructing in these areas. Environmentally sensitive areas include, but are not limited to wetlands, shallow marshes, jurisdictional waters, natural watercourses, wildlife habitat, etc. and may be protected by state and/or federal laws. With careful planning, it may be possible to incorporate wetland mitigation into the basin design.

Construction of stormwater basins or modifications to existing basins shall comply with all applicable laws and regulations. The applicant is responsible for procuring all necessary permits, such as US Army Corps of Engineers and Virginia DEQ Wetland Permits, Virginia DEQ VPDES Permits, etc., and providing SID with the permit documentation prior to beginning construction.

Detention facilities may be coordinated with a Virginia Tech regional stormwater management facility or the Virginia Tech Stormwater Management Master Plan.

# 6.0 ENERGY DISSIPATION

Outlet protection for culverts, storm drains, BMP outlets, and steep open channels is essential to prevent high velocity flows from eroding downstream channels and damaging drainage structures. Erosion problems at culverts or at the outlets of detention basins are a common occurrence. Determination of the flow conditions, scour potential, and channel erosion resistance shall be standard procedure for all designs.

Outlet protection can be a channel lining, structure, or flow barrier designed to lower excessive flow velocities and prevent erosion and scour.

Outlet protection shall be employed whenever the velocity of flow at a pipe or open channel outlet exceeds the erosive velocity of the immediate downstream reach.

Energy dissipation may take the form of the following:

- Erosion control stone outlet protection.
- Erosion control stone-lined channels
- Riprap outlet basins
- Concrete baffled outlets

## 6.1 References

Except where more stringent requirements are presented in this Design Manual, energy dissipators shall comply with VDOT and other state requirements. The primary design references are the VDOT Drainage Manual and the VA ESC Handbook. Other appropriate references include:

- VDOT Road and Bridge Standards
- VDOT Road and Bridge Specifications
- VA Stormwater Management Handbook
- FHWA Design of Riprap Revetment HEC No. 11 (Pub. No. FHWA-IP-89-016 1989/2000)
- FHWA Hydraulic Design of Energy Dissipators for Culverts and Channels HEC No. 14 (Pub. No. FHWA-EPD-86-110 Sept. 1983 & FHWA-IF-00-02 2000)
- U.S. Dept. of the Interior – Bureau of Reclamation: Hydraulic Design of Stilling Basins and Energy Dissipators (Engineering Monograph No. 25)
- U.S. Dept. of the Interior – Bureau of Reclamation: Design of Small Canal Structures

## 6.2 Design Methodology and Criteria

### 6.2.1 Outlet Velocity

Where the outlet velocity from culverts, storm drain outfalls, or open channels is high, and channel or pipe modifications cannot adequately reduce the velocity, energy dissipation may be necessary. See the VDOT Drainage Manual and/or the VA ESC Handbook for methodologies to determine design outlet velocities from open channels, culverts, and storm drains.

### 6.2.2 Erosion Control Stone

The most common form of energy dissipation is the use of erosion control stone at the outlet. Protection is provided primarily by having sufficient length and flare to dissipate energy by expanding the flow. The outlet velocities are computed for the 10-year discharge.

Where a pipe discharges into a channel, the apron shall extend across the channel bottom and shall extend up the bank to a depth of one foot above the maximum tailwater depth from the design storm event. The dimensional requirements of the erosion control stone apron shall be determined using the graphical curves in the VA ESC Handbook.

Generally, the use of erosion control stone for energy dissipation is limited to a maximum velocity of 19 feet per second. Alternative means of energy dissipation shall be required where the discharge velocity is greater than 19 feet per second. Alternative means include riprap stilling basins or concrete baffled outlets. The use of alternative means of energy dissipation requires the approval of VDOT when located in a VDOT right-of-way.

### 6.2.3 Riprap Basins

A riprap outlet basin is a depressed area of riprap placed at the outlet of a high velocity culvert, storm drain or open channel. The riprap reduces the exit velocity by expanding the flow over the riprap length and width and forming a hydraulic jump.

For the design of riprap basins, refer to the VDOT Drainage Manual. Dissipator geometry may also be computed using the “Energy Dissipator” module that is available in the computer program FHWA HY8, Culvert Analysis.

### 6.2.4 Baffled Outlets

A baffled outlet usually consists of a concrete box structure with a vertical hanging concrete baffle and an end sill. Several variations of concrete baffled outlets have been published by VDOT and other state and local transportation and stormwater management agencies. Baffled outlets are usually used when very high exit velocities exist at piped or channel transitions. Baffled outlets function by dissipating energy through impact of the water hitting the baffle and through the resulting turbulence. A tailwater depth is not required for adequate energy dissipation, but will help smooth the outlet flow.

This type of outlet protection may be used with outlet velocities up to 50 feet per second.

Baffled outlets are not included in the state guidance handbooks. Hydraulic design procedures for baffled outlets may be found in the U.S. Department of Interior, Bureau of Reclamation, Design of Small Canal Structures, 1978.

### 6.2.5 Additional Energy Dissipators

For additional energy dissipators, refer to FHWA HEC No 14, Hydraulic Design of Energy Dissipators for Culverts and Channels.

### 6.3 Installation Requirements

Energy dissipators shall be installed and constructed according to all applicable FHWA, VDOT, and state requirements and recommendations.

### 6.4 Environmental Impacts

Construction or modifications to energy dissipation structures shall comply with all applicable laws and regulations. The applicant is responsible for procuring all necessary permits, such as US Army Corps of Engineers and VA DEQ Wetland Permits, etc.

### 6.5 Maintenance Requirements

The Operator is responsible for maintenance of energy dissipation structures in accordance with VESCH standards until the termination of land disturbance as described in the Annual Standards and Specifications.

# 7.0 STORMWATER POLLUTANT REMOVAL PRACTICES

A wide variety of Best Management Practices (BMPs) and general development strategies may be utilized to remove environmentally harmful pollutants from stormwater runoff. Allowable BMPs are listed on the VA Stormwater BMP Clearinghouse website.

## 7.1 References

Except where more stringent requirements are presented in this Design Manual, stormwater quality best management practices shall comply with DEQ requirements. The primary design reference is the VA Stormwater BMP Clearinghouse website.

## 7.2 Stormwater Quality Requirements

Stormwater runoff generated from land disturbing activities shall be treated through best management practices designed to remove pollutants from the stormwater. The required pollutant removal shall be dependent on the land cover conditions.

For most projects, the BMPs will be designed to remove phosphorus from the stormwater runoff. Generally, when a BMP is efficient in removing phosphorus from the stormwater runoff, it is assumed that easier to remove pollutants such as heavy metals and total suspended solids have also been adequately removed.

Where appropriate, additional pollutants may be required to be removed from the stormwater runoff based on the presence of stormwater hotspots (land use activities that generate highly contaminated runoff, as determined by SID). These pollutants may include the following:

- Total Suspended Solids, in areas with highly erodible soils.
- Total Petroleum Hydrocarbons (TPH), fueling stations or areas with fuel- contaminated soil.
- Heavy Metals, in areas with contaminated soils.
- High temperature runoff.

Land disturbing activities shall also comply with all additional water quality requirements as indicated in the Virginia Tech Annual Standards and Specifications, current version.

Proposed Common Plan developments shall apply stormwater quality management criteria to the land development project as a whole. Individual projects in Common Plan developments shall not be considered separate land development projects in regards to water quality. Hydrologic parameters shall reflect the ultimate land development and shall be used in all engineering calculations.

Where stormwater quality requirements must be implemented, stormwater runoff must flow through appropriate BMPs before the water is discharged from the site.

## 7.3 Stormwater Quality Calculations

To meet the requirements of section 9VAC25-870-65 of the VSMP regulations, the Virginia Runoff Reduction Method (VRRM) will be utilized to verify compliance. The VRRM water quality compliance

worksheet is available on the DEQ website. This worksheet must be submitted in the SWM Plan. The average one-year rainfall depth shall be 43 in.

### 7.4 Manufactured BMP Systems

A manufactured BMP system is a structural measure that is specifically designed and sized by a manufacturer to intercept stormwater runoff and prevent the transfer of pollutants downstream. Use of Manufactured BMPs will only be allowed if the device is approved and listed on the VA Stormwater BMP Clearinghouse website.

# APPENDIX D

Erosion and Sediment Standard Notes

# VIRGINIA TECH STANDARD GENERAL EROSION AND SEDIMENT CONTROL NOTES

ES-1 – Unless otherwise indicated, all vegetative and structural Erosion and Sediment Control practices shall be constructed and maintained in accordance with the Virginia Tech Annual Standards and Specifications for Erosion and Sediment Control and Stormwater Management and the Virginia Erosion and Sediment Control Handbook (VESCH), Latest Editions. The Contractor can use manufactured Erosion and Sediment Control measures with prior approval from VTSID.

ES-2 – Virginia Tech Site and Infrastructure Development shall be notified one week prior to the pre-construction conference, one week prior to the commencement of land disturbing activity, and one week prior to the final inspection.

ES-3 – All Erosion and Sediment Control measures are to be placed prior to or as the first step in clearing.

ES-4 – The narrative prepared for the plan is part of the plans and shall be used in conjunction with the plans. A copy of the approved Erosion and Sediment Control plan and narrative and the relevant VESCH sections, shall be maintained on the site at all times.

ES-5 – Prior to commencing land disturbing activities in the areas other than indicated on the these plans (including, but not limited to, off-site borrow or waste areas), the contractor shall submit a supplementary Erosion and Sediment Control plan to Virginia Tech Site and Infrastructure Development for review and approval.

ES-6 – Install additional Erosion and Sediment Control measures as required to prevent sediment-laden runoff from leaving the site, and as determined by Virginia Tech Site and Infrastructure Development.

ES-7 – All disturbed areas are to drain to approved sediment control measures at all times during land disturbing activities and during site development until final stabilization is achieved.

ES-8 – During dewatering operations, water will be pumped into an approved filtering device.

ES-9 – For the purposes of plan approval, the engineer of record for the Erosion and Sediment Control plan and narrative will be the certified Responsible Land Disturber for this project up to the award of the contract. Upon award of the contract, the contractor shall have a certified Responsible Land Disturber for this project.

ES-10 – The Responsible Land Disturber shall be added to the plan at the pre-construction conference.

ES-11 – The Responsible Land Disturber shall inspect Erosion and Sediment Control measures and practices for proper installation and deficiencies immediately after each runoff-producing rainfall event, at least daily during prolonged rainfall, and bi-weekly when no rainfall events occur. Any necessary repairs or cleanup to maintain the effectiveness of the Erosion and Sediment Control measures shall be made immediately.

ES-12 – As the Erosion and Sediment Control plan approving authority, Virginia Tech Site and Infrastructure Development may revise the approved plan if inspection reveals that the approved plan is inadequate to satisfy applicable standards.

ES-13 – Store excavated topsoil in topsoil stockpiles within the limits of construction with silt fence on the downslope side in accordance with the VESCH, latest edition.

ES-14 – All disturbed areas not otherwise hardscaped and stabilized are to be seeded in accordance with the seeding specifications in the VESCH, latest edition.

ES-15 – Seed and mulch all soil stockpiles and materials left undisturbed in accordance with the VESCH, latest edition.

ES-16 – All culvert inlet protection and storm drain inlet protection must remain in place until final upslope stabilization is achieved.

ES-17 – The following Erosion and Sediment Control measures require certification by the design professional upon installation and prior to commencing general site construction. If these measures are not utilized then the plan shall state that fact.

A. Sediment Basin
B. Conveyance Channels
C. Detention Basins serving as Sediment Basins

ES-18 – Soil test shall be done by Virginia Tech Extension Service or other approves testing services prior to seeding. The soil test should determine a minimum of the following: mechanical analysis; magnesium, potassium, and phosphorus levels; soluble salt level; pH; organic matter and recommended amendments. Soil tests shall be taken from each contiguous planting area. The soil tests results and recommended amendments shall be submitted to the Professional and VTSID. Nutrients listed shall be evaluated in terms of "plants available" nutrients.

ES-19 – Topsoil shall be obtained from in-site or off-site sources, as applicable to provide 6-inch minimum depth over all areas disturbed during construction. Topsoil shall be fertile, friable loam, containing not less than 2% by weight of finely divided, decomposed vegetable matter. Topsoil shall be free of subsoil, clay lumps, brush, weeds, roots larger than ½ inch diameter, stones larger than ½ inch diameter, and other material toxic or harmful to growth. Topsoil shall be free of plant parts or Bermudagrass, Quackgrass, Johnsongrass, Mugwort, Nutsedge, Poison Ivy, Canadian Thistle or others as specified.

A. Topsoil shall meet acceptable soil test levels as specified in soil testing. A certificate of soil test analysis must be submitted to the Professional for approval before any topsoil is delivered to the project.
B. Topsoil salvaged form the site shall be tested as specified in soil testing. If tests show deficiencies, the soil shall be amended to comply with acceptable soil test results or replaces with acceptable soil.
C. Topsoil installed on-grade shall attempt to match existing soil texture except for situations where a clay subsoil exists. Where a clay subsoil exists, use loan or silt loam topsoils.

ES-20 – Contactor is responsible for getting approval of grass seed mixture from VTSID to verify compliance with VESCH Specification 3.32. This approval is required prior to final site stabilization.

# APPENDIX E

Plan Preparer/Reviewer Checklists

(VTSID-02 & VTSID-03)

# ESC PLAN PREPARER/REVIEWER CHECKLIST

**Instruction:** The checklist shall be completed if an ESC Plan and Narrative is required per the VT Annual Standards and Specifications for ESC and SWM. The completed checklist shall be provided with the ESC Plan submittal. The Plan and Narrative submitted for review shall be signed and sealed by a licensed professional. This checklist is not inclusive. The licensed professional is responsible for ensuring plans address all applicable ESC laws and regulations.

**Project Name:** _____ **Project Location:** _____

**Submittal Date:** _____ **Date on Plans:** _____

**Design Engineer (Printed):** _____ **Email:** _____

| Yes | N/A | General |
|---|---|---|
| ☐ | ☐ | **CHECKLIST** – Completed ESC checklist provided in the ESC Narrative. |
| ☐ | ☐ | **VTAS&S** – Note the applicable Virginia Tech Annual Standards and Specifications version on both covers. |
| ☐ | ☐ | **PROFESSIONAL SEAL** – The designer's original seal, signature, and date are required on the cover sheet of each Narrative and each sheet in a set of Plan sheets for approval. |
| ☐ | ☐ | **NUMBER OF PLAN SETS** – One (1) complete full size set of plans must be submitted for review. One (1) 11x17 size set of plans must be submitted with the final submittal for approval, digital signatures on seals are acceptable for the 11x17 size plan set. |
| ☐ | ☐ | **ELECTRONIC PLAN SUBMITTAL** – PDF versions of all submitted documentation shall be submitted for review. Electronic versions can have digital signatures on seals. |
| ☐ | ☐ | **REVIEW COMMENT RESPONSE LETTER** – Submit a review comment response letter with each subsequent plan submittal that addresses all comments in the previous review's comment letter from VTSID. |
| ☐ | ☐ | **VARIANCE** – All required documentation submitted for SID review and submittal to DEQ for approval. |
| ☐ | ☐ | **ADDITIONAL PERMITS** – If the project impacts any wetlands or surface waters, are all correspondence and permits concerning any proposed impacts to jurisdictional wetlands, stream and channels included? |
| **Yes** | **N/A** | **ESC *Narrative* Requirements** |
| ☐ | ☐ | **PAGE NUMBERS/TABLE OF CONTENTS** – Provide a clearly organized narrative with pages numbers. |
| ☐ | ☐ | **PROJECT DESCRIPTION** – Description of the purpose and nature of land disturbing activity and the area to be disturbed. Include the pre and post development impervious areas. |
| ☐ | ☐ | **EXISTING SITE CONDITION** – Description of existing topography, ground cover, and drainage. |
| ☐ | ☐ | **ADJACENT AREAS** – Description of neighboring areas such as agricultural areas, streams, lakes, roads, floodplains, etc., that might be impacted by the land disturbance. |
| ☐ | ☐ | **OFF-SITE AREAS** – Description of any off-site land disturbing activities that may occur (disposal areas, etc.) |
| ☐ | ☐ | **SOILS** – Description of conditions, including hydrologic soil groups, mapping unit, erodibility, permeability, surface runoff, and a brief description of depth, texture and soil structure. Mapping of soil variations should be provided in the narrative. |
| ☐ | ☐ | **CRITICAL AREAS** – Description of areas that have potentially serious erosion problems or that are sensitive to sediment impacts (e.g., steep slopes, channels, wetlands, springs, etc.). |
| ☐ | ☐ | **EROSION AND SEDIMENT CONTROL MEASURES** – Description of the measures that will be used for ESC on the site and their installation, inspection, and maintenance standards and specifications. |
| ☐ | ☐ | **PERMANENT STABILIZATION** – Description, including specifications, of how the site will be stabilized after construction is completed. |
| ☐ | ☐ | **STORMWATER RUNOFF DESCRIPTION** – Description of any increase in peak runoff rates and the effects on downstream erosion and flooding. The description shall include the strategy to control stormwater runoff as well as tables for quick reference to pertinent information. |
| ☐ | ☐ | **SWM FACILITY MAINTENANCE** – Provide a table with a recommended schedule of inspection and maintenance along with the responsible party's name and contact information. |
| ☐ | ☐ | **STREAM CHANNEL EROSION** – Verify adherence to 9VAC25-870-66B. |
| ☐ | ☐ | **FLOODING** – Verify adherence to 9VAC25-870-66C. |

| | | |
|---|---|---|
| ☐ | ☐ | **CALCS FOR TEMP. ESC MEASURES** – Provide the calculations required by the standards and specifications. |
| ☐ | ☐ | **STORMWATER MANAGEMENT CALCULATIONS** – Provide exhibits showing the drainage areas, direction of flow, and acreage of each of the site drainage areas that discharge runoff off-site, for pre- and post-development. Provide supporting calculations from the drainage areas and verify that MS-19 is satisfied. |
| ☐ | ☐ | **SPECIFICATIONS** – Include for all site work and stormwater management structures. |
| **Yes** | **N/A** | **ESC *Plan* Requirements** |
| ☐ | ☐ | **LOCATION AND VICINITY MAP** – Locate the site in relation to the surrounding area. Include any landmarks and road information that might assist in locating the site. |
| ☐ | ☐ | **RESPONSIBLE LAND DISTURBER** – Provide a location on the Plan cover sheet for identification of the RLD. |
| ☐ | ☐ | **NORTH ARROW** – The direction of north in relation to the site. |
| ☐ | ☐ | **LEGEND** – List all ESC measures used, the VESCH uniform code symbol, and the standard and spec number. |
| ☐ | ☐ | **APPROVAL LOCATION** – Designate a single location on the right side of all plan sheets for a 2.5” by 2.5” box for VTSID stamp approval. |
| ☐ | ☐ | **EROSION AND SEDIMENT CONTROL GENERAL NOTES** – Include (ES-1 through ES-20) found in the Appendix of the Virginia Tech Annual Standards and Specifications. |
| ☐ | ☐ | **MINIMUM STANDARDS** – Include all 19 minimum standards definitions, supplemented with how the plan is addressing each standard. |
| ☐ | ☐ | **EXISTING/PROPOSED CONDTIONS** – Including existing contours (2’ interval min.), surface waters and other surface features, existing tree lines, buildings, parking lots, access roads, utility construction and features. Show all physical items that could affect or be affected by erosion, sediment, and drainage. |
| ☐ | ☐ | **EXISTING CONDITIONS GRAYED OUT** – All existing conditions are to be shown as grayed out on all proposed plan sheets (i.e. site plan, grading plan, etc.). |
| ☐ | ☐ | **PROPERTY/EASEMENT LINES** – For each adjacent, non-Virginia Tech property, list the deed book and page number and the property owner's name and address. |
| ☐ | ☐ | **DEMOLITION PLAN** – Identify features to be demolished and ESC measures required for the demolition |
| ☐ | ☐ | **LIMITS OF DISTURBANCE** – Clear delineation of the **limits of disturbance**, with total disturbed area called out including utilities, laydown areas, staging areas, unpaved access roads, etc. Area to be staked at 100’ intervals for permitted projects. |
| ☐ | ☐ | **PROTECTION AREAS** – Show fencing or other measures to protect areas that are not to be disturbed. |
| ☐ | ☐ | **CRITICAL AREAS** – Clearly identify critical areas and their appropriate protections. |
| ☐ | ☐ | **ESC SEQUENCE OF CONSTRUCTION** - Sequence to include initial inspection by VTSID prior to land disturbance. |
| ☐ | ☐ | **ESC SEQUENCE OF CONSTRUCTION** - Sequence to include Topsoil inspection by VTSID prior to stabilization. Inspection to be scheduled a minimum 5 business days in advance. |
| ☐ | ☐ | **ESC PRACTICE LOCATIONS** – Note each location used on the site with a unique identification number for multiple practices (i.e., SF1, SF2, etc.). |
| ☐ | ☐ | **TOPSOIL STOCKPILE** – Topsoil stockpile area shown on plans with appropriate ESC measures. |
| ☐ | ☐ | **OFF-SITE AREAS** – Documentation of land disturbing approvals and identification of any off-site land disturbing activities and their appropriate ESC controls. |
| ☐ | ☐ | **FINISHED FLOOR ELEVATION** – All buildings and pads on site, including basements. |
| ☐ | ☐ | **STORM DRAINS** – Provide profiles of all proposed storm drains and the plan shall include the pipe size, pipe material, and flow direction arrows for all proposed and existing storm drains, excluding roof drains. |
| ☐ | ☐ | **DETAILS** – Site-specific details for all ESC measures included within the project. Proprietary measures shall include any information for construction, maintenance, and inspection per the manufacturer’s specifications. |
| **Yes** | **N/A** | **Minimum Standard Requirement (9VAC25-840-40)** |
| ☐ | ☐ | Permanent or temporary soil stabilization shown where required on plans using standard symbols and abbreviations in Chapter 3 of the VESCH. **(MS-1, MS-3, and MS-5)** |
| ☐ | ☐ | Stabilization and/or protection measures for soil stockpiles and borrow areas. **(MS-2)** |
| ☐ | ☐ | Detailed **sequence of construction** shown on the plan ESC plan sheet that includes the phasing of installation of ESC measures with sediment trapping measures as a first step prior to upslope land disturbance. **(MS-4)** |

| | | |
|---|---|---|
| ☐ | ☐ | Drainage area maps for sediment traps and sediment basins included in the narrative. **(MS-6)** |
| ☐ | ☐ | Stabilization measures provided for slopes steeper than 3:1. **(MS-7)** |
| ☐ | ☐ | Measures to prevent concentrated flow from flowing down cut or fill slopes (e.g. slope drains). **(MS-8)** |
| ☐ | ☐ | Measures to address water seeping from a slope face. **(MS-9)** |
| ☐ | ☐ | Inlet protection provided for all operational storm drain and culvert inlets. **(MS-10)** |
| ☐ | ☐ | Outlet protection and/or channel linings provided for all stormwater conveyance channels and receiving channels prior to being made operational (see sequence of construction). **(MS-11)** |
| ☐ | ☐ | Measures to minimize encroachment and sediment transport for work in a live watercourse **(MS-12)** |
| ☐ | ☐ | Temporary stream crossings of non-erodible material where a live watercourse must be crossed by construction vehicles more than twice in any six-month period. **(MS-13)** |
| ☐ | ☐ | Applicable federal, state and local regulations pertaining to working in or crossing live watercourses are addressed and summarized on the plan. **(MS-14)** |
| ☐ | ☐ | Stabilization measures for bed and banks of live watercourse subject to disturbance. **(MS-15)** |
| ☐ | ☐ | Unique requirements for underground utility line installations have been addressed. **(MS-16)** |
| ☐ | ☐ | Measures are shown on plan to minimize sediment transport onto public and/or paved roads. **(MS-17)** |
| ☐ | ☐ | Adequacy of each receiving channel and pipe verified with calculations. **(MS-19)** |

# SWM PLAN PREPARER/REVIEWER CHECKLIST

**Instruction:** The checklist shall be completed if a SWM Plan and Narrative is required per the VT Annual Standards and Specifications for ESC and SWM. The completed checklist shall be provided with the SWM Plan submittal. The Plan and Narrative submitted for review shall be signed and sealed by a licensed professional. This checklist is not inclusive. The licensed professional is responsible for ensuring plans address all applicable SMW laws and regulations.

**Project Name:** _____ **Project Location:** _____

**Submittal Date:** _____ **Date on Plans:** _____

**Design Engineer (Printed):** _____ **Email:** _____

| Yes | N/A | General |
|---|---|---|
| ☐ | ☐ | **ESC GENERAL** – All items are included from the required ESC "General" checklist category. |
| ☐ | ☐ | **CHECKLIST** – Completed SWM checklist provided in the SWM Narrative |
| ☐ | ☐ | **EXCEPTION** – All required documentation submitted for SID review and submittal to DEQ for approval. |
| **Yes** | **N/A** | **SWM *Narrative* Requirements** |
| ☐ | ☐ | **ESC NARRATIVE** – All items are included from the required "ESC *Narrative* Requirements" checklist category. |
| ☐ | ☐ | **LAND COVER** – Summary table and map with pre- and post-development land cover conditions (i.e., forest, managed turf, and impervious areas). |
| ☐ | ☐ | **QUANTITY & QUALITY NARRATIVE** – Discussion of the stormwater management strategy to address water quantity and quality criteria. |
| ☐ | ☐ | **STORMWATER DISCHARGE DESCRIPTIONS** – Information on the type and location of stormwater discharges, including information on the features to which stormwater is being discharged, including surface waters or karst features if present. |
| ☐ | ☐ | **PROPOSED SWM** – Information on the proposed stormwater management facilities, including (i) the type of facility; (ii) location, (iii) impervious and pervious acres treated; and (iv) the surface waters or karst features into which the facility will discharge. |
| ☐ | ☐ | **SWM FACILITY OPERATION AND MAINTENANCE** – A general description of the proposed stormwater management facilities and the mechanism through which the facilities will be operated and maintained after construction is complete. |
| ☐ | ☐ | **GEOTECHNICAL REPORT** – Include when required for BMPs or other site specific needs. Include infiltration rates when required for a BMP. |
| ☐ | ☐ | **BORING LOCATIONS AND LOGS** – Provide information on boring locations in the area of borrow areas, basin areas, and embankments (centerline principal spillway, emergency spillway, abutments). Include Unified Soil Classifications, soil descriptions, seasonal high groundwater table depths, etc. |
| ☐ | ☐ | **KARST REGIONS** – Provide any additional geophysical investigation, consideration, and recommendations for any projects within Karst environments. |
| ☐ | ☐ | **LOCALITY REQUIREMENTS** – Description of the locality's additional technical requirements, if any, and how they were addressed to the maximum extent practicable. |
| **Yes** | **N/A** | **Hydrologic Computations** *(Narrative)* |
| ☐ | ☐ | **DRAINAGE AREAS** – Pre- and Post-development mapping that includes all contributing drainage areas, CN labels, and time of concentration flow paths, slopes, and lengths used for runoff hydrographs. |
| ☐ | ☐ | **RAINFALL** – Precipitation frequency data recommended by the U.S. National Oceanic and Atmospheric Administration (NOAA) Atlas 14. Partial duration time series shall be used for the precipitation data. |
| ☐ | ☐ | **CURVE NUMBERS** – Summary table for determination of runoff curve numbers. |
| ☐ | ☐ | **TIME OF CONCENTRATION** – Time of concentration calculations. |
| ☐ | ☐ | **HYDROGRAPHS** – Pre- and post-development runoff hydrographs. |
| **Yes** | **N/A** | **Hydraulic Computations** *(Narrative)* |

| | | |
|---|---|---|
| ☐ | ☐ | **ROUTING** – Routing computations for each proposed stormwater management facility for each applicable design storm provided in the narrative. |
| ☐ | ☐ | **PEAK RUNOFF SUMMARY** – Summary table of pre- and post-development peak runoff rates for each point of discharge from the site provided in narrative. |
| ☐ | ☐ | **STORM ELEVATIONS** – Maximum water surface elevations for design storms shown in sections or profiles for each stormwater management facility. |
| ☐ | ☐ | **FREEBOARD** – Adequate freeboard is provided for impoundments as shown on the plans based on computations in the narrative. |
| ☐ | ☐ | **HYDRAULIC GRADE LINE** – Computations in the narrative with indication of locations of surcharge or inadequacy. |
| ☐ | ☐ | **STORM DRAIN CALCULATIONS** – Storm drain design, culvert, drop inlet backwater, and gutter spread calculations. |
| ☐ | ☐ | **PIPE PROFILES** – Provide profiles of all storm conveyances (except roof drains) on plans. Profiles should include existing and proposed grade, structure types, pipe materials and sizes, slopes, inverts, etc. HGL information shall be shown in profile format in the narrative in addition to tabular format. |
| **Yes** | **N/A** | **Water Quality Computations** *(Narrative)* |
| ☐ | ☐ | **VRRM SPREADSHEET** – Provide Runoff Reduction Method spreadsheet output including:<br>• Site loadings<br>• Required reductions<br>• Input for each BMP employed and reductions achieved by each BMP<br>• Compliance worksheet<br>• Adjusted CN worksheet, when applicable. |
| ☐ | ☐ | **TREATMENT VOLUME** – Stage-storage information indicating the treatment volume required and volume provided as well as all subsequent calculations. |
| ☐ | ☐ | **BMP SPECS** – Include the Virginia BMP Clearinghouse design specifications for all proposed SWM BMPs. |
| ☐ | ☐ | **BMP CHECKLIST** – A BMP-type specific checklist from Appendix 8-A of the Virginia Stormwater Management Handbook, latest edition, is completed and provided in the narrative for each proposed BMP. |
| **Yes** | **N/A** | **SWM *Plan* Requirements** |
| ☐ | ☐ | **ESC PLAN** – All items are included from the required “ESC *Plan* Requirements” checklist category. |
| ☐ | ☐ | **BORINGS** – Locations of test borings. |
| ☐ | ☐ | **COMPACTION** – Compaction requirements specified. |
| ☐ | ☐ | **SWM FACILITY CERTIFICATION** – Plans shall list all SWM facilities and critical construction inspection time frames (e.g., liner, underdrain and outlet pipe installation) for which SWM BMP certification is required per Section 4.1.2 of the VT Annual Standards and Specifications for ESC and SWM. |
| ☐ | ☐ | **GENERAL NOTE** – The following note is on the plan: "A certified construction record drawing for permanent SWM facilities shall be submitted to Virginia Tech SID for approval per section 4.1.2 of the VT Annual Standards and Specifications for ESC and SWM. Construction inspections, photographs and surveys, performed by a licensed professional, shall be required at each stage of installation (construction) as necessary to certify that the SWM facility has been built in accordance with the approved plan and design specifications. The Contractor shall provide a minimum of 2 business days’ notice to the certifying professional to allow for critical inspections." |
| ☐ | ☐ | **BMP MAINTENANCE** – Include an inspection and maintenance plan for each permanent SWM facility. For manufactured permanent BMPs, the construction drawings shall include manufacturer’s recommendations on maintenance and inspection. |
| ☐ | ☐ | **BMP IDENTIFICATION** – Identification of BMP IDs as assigned by the VTSID Department in a table format that provides: BMP ID (provided by SID), BMP Description, and Name, Title, Department, Phone Number, and Email of responsible party for the maintenance of each BMP. |

# APPENDIX F

Non-VESCH Specifications

## NON-VESCH SPECIFICATION

**Table D-1**

**Proprietary ESC measures previously approved for use on properties subject to the VT Annual Standards and Specifications for ESC and SWM.***

*(VESCH Standard and Specification 3.05)*

- ACF Environmental Silt Fence
- Super Silt Fence

Inlet Protection *(VESCH Standard and Specification 3.07)*

- ACF Environmental Gutterbuddy Curb Inlet Drain Filters
- ACF Environmental GutterEEL Curb Inlet Drain Filters
- ACF Environmental SiltSack Sediment Capture Device
- Dandy Bag Inlet Protection System
- Dandy Curb Grateless Curb Inlet and Median Barrier Inlet Protection System
- Dandy Curb Bag Curb and Gutter Inlet/Grate Protection System
- Dandy Curb Sack Curb and Gutter Protection System
- Dandy Pop (Pop-up Dandy Bag) Inlet Protection System
- Dandy Sack Inlet Protection System
- Rapid Flow Drain Filter – Polystyrene Aggregate

Dewatering *(VESCH Standard and Specification 3.26)*

- Dandy Dewatering Bag
- Dirtbag Dewatering Bag

*** VTSID does not promote the ESC measures listed and takes no responsibility for their performance.**

# APPENDIX G

DEQ Two-Week E-Notification Form

(VTSID-04)

# VIRGINIA TECH REGULATED LAND DISTURBING ACTIVITIES
# TWO-WEEK E-NOTIFICATION TO DEQ

## Section 1– General Information:

| | | |
|---|---|---|
| Project Name: | Project Location: | |
| Acres Disturbed: | Project Start Date: | Project Finish Date: |
| Project Description: | | |
| CGP Permit Number if applicable: | | |

## Section 2– Plan Approval Verification:

| | | |
|---|---|---|
| Project Manager: | Project Manager Phone: | Project Manager Email: |
| Responsible Land Disturber: | Certification Number: | |
| RLD Phone: | RLD Email: | |

## Section 2– Variances:

List any variances, waiver or exemptions associated with this project:

_____
_____
_____

Signature: _____ Date: _____

# APPENDIX H

DEQ AS&S Entity Form

(VTSID-05)

# ANNUAL STANDARDS & SPECIFICATION (AS&S) ENTITY INFORMATION GENERAL VDPES PERMIT FOR DISCHARGES OF STORMWATER FROM CONSTRUCTION ACTIVITIES (VAR10)

## Section 1– General Information:

| | |
|---|---|
| AS&S Entity: | Project Name[1]: |
| Acres Disturbed: | Operator[2]: |
| Project Description: | |
| Technical Criteria Used: | |

## Section 2– Plan Approval Verification:

| | |
|---|---|
| DEQ Certified ESC Plan Reviewer Name: | Certification Number: |
| DEQ Certified SWM Plan Reviewer Name: | Certification Number: |

Printed Name: _____ Title: _____

Signature: _____ Date: _____

[1]Project name as it appears on the Registration Statement, which the Entity is allowing to be covered under their AS&S

[2]Operator of project that Entity is allowing to operate under their AS&S.

# APPENDIX I

## Preconstruction Meeting Form

(VTSID-06)

# PRECONSTRUCTION MEETING FORM

**Instruction:** This form shall be completed prior to the commencement of land disturbance. The purpose of this form is to have SID and the Contractor acknowledge responsibilities in accordance with the VT Annual Standards and Specifications for the ESC and SWM. A copy of this completed form shall be maintained by SID and the Contractor and be readily available upon request.

## Section 1 – Project Information

Project Name: _____ Date: _____

Project Location/Description: _____

SID Representative: _____

Primary Contractor/ Construction General Permit Operator:

_____

Responsible Land Disturber: _____

## Section 2 – Checklist

The conditions of this section shall be met and this form shall be signed by the Contractor Operator prior to the commencement of land disturbance (check those that apply):

- ☐ Approved ESC Plan
- ☐ Approved SWM Plan
- ☐ Completed, site-specific SWPPP (projects ≥ 1 acre)
- ☐ Identification of the Responsible Land Disturber
- ☐ Coverage Letter for the General Permit for Discharges of Stormwater from Construction Activities
- ☐ Any off-site areas associated with this project have been identified and approval documentation provided
- ☐ Conditions of Termination of Land Disturbance form discussed
- ☐ Discussion of responsibilities and standards for the SWM Record Report

## Section 3 – Acknowledgement of the VT Annual Standards and Specifications for ESC and SWM

*(To be completed by the Contractor/Operator)*

I acknowledge my responsibilities to conduct the land disturbance activity in accordance with the approved Plans throughout the duration of the project, to seek approval from VTSID for any significant changes to the plan, to adhere to the conditions of the Construction General Permit (when applicable), to oversee the maintenance of the Stormwater Pollution Prevention Plan (when applicable), and to notify the SID Project Inspector immediately after the initial installation of ESC measures and in the event of a significant discharge of sediment or other pollutants from the site.

Name: _____

Signature: _____ Date: _____

# APPENDIX J

## Construction Site Inspection Forms

(VTSID-07 & VTSID-08)

# VIRGINIA TECH ESC INSPECTION REPORT

Project Name: _____ Project Authority: VTSID _____

RLD Name: _____ RLD No. _____

Project Location: _____ Project No: _____

Inspector Name: _____ Inspection Date: _____ Time: _____

## *STAGE OF CONSTRUCTION*

| | | |
|---|---|---|
| *Pre-Construction Conference* ☐ | *Rough Grading* ☐ | *Final Stabilization* ☐ |
| *Initial ESC Inspection* ☐ | *Building Construction* ☐ | *Construction of SWM Facilities* ☐ |
| *Clearing & Grubbing* ☐ | *Finish Grading* ☐ | *Other* _____ ☐ |

| *Item#* | *State/Local Regulation*(1) | *Violation* | | *Description and Location of Problem/Violation*(2)*, Required or Recommended Corrective Actions, and Other Comments/Notes* |
|---|---|---|---|---|
| | | *Initial* | *Repeat* | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

(1) Refers to applicable regulation found in the most recent publication of the *Virginia Erosion and Sediment Control Regulations* (9VAC25-840), *Virginia Stormwater Management Regulations* (9VAC25-870), or Virginia Tech Annual Standards & Specifications.

(2) Note whether or not off-site damage resulting from the problem/violation was evident during the inspection.

**REQUIRED CORRECTIVE ACTION DEADLINE DATE:** _____ **Re-inspection Date:** _____
**(DD/MM/YY)** **(DD/MM/YY)**

The required corrective action deadline date applies to all violations noted on this report. If listed violation(s) currently constitute non-compliance and/or required corrective actions are not completed by the deadline, a **NOTICE TO COMPLY**, **STOP WORK ORDER**, and/or other enforcement actions may be issued to the entity responsible for ensuring compliance on the above project.

Inspector: _____ _____
Signature Date

*Acknowledgement of on site report receipt:* _____ _____ _____
*(print)* *(signature)* *(date)*

*This report will be provided to the following parties via mail, fax, or e-mail within 24 hours of inspection:*

# SWPPP Stormwater Construction Site Inspection Report

| General Information | |
|---|---|
| **Project Name:** | **Date of Inspection:** |
| **Location:** Blacksburg, VA | **VSMP Permit #:** |
| **Inspector:** | ***Inspector must be authorized by the Permit Operator to perform inspections. Check here if a Delegation of Authority Form has been included in the SWPPP*** ☐ |
| **Title:** | **Inspector's Contact #:** |
| **Inspector's Qualifications**<br>☐ DEQ Certification Type _____<br>DEQ Certification # _____ Exp. _____<br>☐ RLD # _____ Exp. _____<br>☐ Other _____ | **Inspection Frequency (select one)**<br>☐ Once every four business days<br>☐ Once every five business days and within 48 hours following a storm event of ***0.25" or greater in 24 hours***<br>☐ Monthly where areas have been temporarily stabilized or activities are suspended due to continuous frozen conditions. |
| **Describe present phase of construction:** | |

| Weather Information |
|---|
| **Has there been a measurable storm event (*0.25" or greater in 24 hours)* since the last inspection?** ☐ Yes ◉ No<br>Storm Start Date & Time: Approximate Amount of Precipitation (in):<br>Storm Duration (hrs): |
| **Weather at time of this inspection?** Temperature:<br>☐ Clear ☐ Cloudy ☐ Rain ☐ Sleet ☐ Fog ☐ Snowing ☐ High Winds ☐ Other: |
| **Are there any [stormwater] discharges at the time of inspection?** ☐ **Yes** ☐ **No**<br>**If yes, describe:** |
| **Have any land-disturbing activities occurred outside of the approved ESC plan?** ☐ Yes ☐ No<br>**If yes, describe:** |

| | **BMP / Control Measure**<br>***List all that appear on the approved ESC plan*** | **BMP Installed?** | **Maintenance Required?** | **Corrective Action Needed and Locations**<br>***Initial and date when necessary Corrective Action has been taken*** |
|---|---|---|---|---|
| 1 | Construction Entrance (3.02) | ☐ Yes ☐ No | ☐ Yes ☐ No | |
| 2 | Silt Fence (3.05) | ☐ Yes ☐ No | ☐ Yes ☐ No | |
| 3 | Culvert Inlet Protection (3.08) | ☐ Yes ☐ No | ☐ Yes ☐ No | |
| 4 | Outlet Protection (3.18) | ☐ Yes ☐ No | ☐ Yes ☐ No | |
| 5 | Temporary Rock Check Dams (3.20) | ☐ Yes ☐ No | ☐ Yes ☐ No | |

***Continued on page 2***

| # | BMP / Control Measure | BMP Installed? | BMP Maintenance Required? | Corrective Action Needed and Locations<br>**Initial and date when Corrective Action has been taken* |
|---|---|---|---|---|
| 7 | | ☐Yes ☐No | ☐Yes ☐No | |
| 8 | | ☐Yes ☐No | ☐Yes ☐No | |
| 9 | | ☐Yes ☐No | ☐Yes ☐No | |
| 10 | | ☐Yes ☐No | ☐Yes ☐No | |
| 11 | | ☐Yes ☐No | ☐Yes ☐No | |
| 12 | | ☐Yes ☐No | ☐Yes ☐No | |
| 13 | | ☐Yes ☐No | ☐Yes ☐No | |
| 14 | | ☐Yes ☐No | ☐Yes ☐No | |
| 15 | | ☐Yes ☐No | ☐Yes ☐No | |
| 16 | | ☐Yes ☐No | ☐Yes ☐No | |

Are there any control measures that failed to operate as designed or proved inadequate or inappropriate for a particular location?

Describe any additional corrective actions required (including any changes to the SWPPP that are necessary) as a result of the inspection or to maintain permit compliance:

Describe any corrective actions required from a previous inspection that have not been implemented:

***Continued on Page 3***

| | BMP/activity<br>*Evaluate in accordance with the approved ESC plan.* | Implemented? | Maintenance Required? | Corrective Action Needed and Locations<br>**Initial and date when Corrective Action has been taken* |
|---|---|---|---|---|
| 1 | Are all slopes and disturbed areas that are at | ☐Yes ☐No | ☐Yes ☐No | |

| | BMP/activity<br><br>*Evaluate in accordance with the approved ESC plan.* | Implemented? | Maintenance Required? | Corrective Action Needed and Locations<br><br>**Initial and date when Corrective Action has been taken* |
|---|---|---|---|---|
| | final grade or will remain dormant for 14 days or more stabilized within 7 days? | ☐ N/A | | |
| 2 | Are completed earthen structures, such as embankments, dikes and diversions stabilized immediately? | ☐ Yes ☐ No ☐ N/A | ☐ Yes ☐ No | |
| 3 | Are soil stockpiles and/or borrow areas adequately controlled with perimeter control measures and stabilization? | ☐ Yes ☐ No ☐ N/A | ☐ Yes ☐ No | |
| 4 | Are perimeter controls installed where needed and properly maintained? | ☐ Yes ☐ No ☐ N/A | ☐ Yes ☐ No | |
| 5 | Is there sediment deposition on any property outside of the construction activity? | ☐ Yes ☐ No ☐ N/A | ☐ Yes ☐ No | |
| 6 | Are storm drain inlets properly protected? | ☐ Yes ☐ No ☐ N/A | ☐ Yes ☐ No | |
| 7 | Is the construction exit preventing sediment from being tracked into the street? | ☐ Yes ☐ No ☐ N/A | ☐ Yes ☐ No | |
| 8 | Is trash/litter from work areas collected and placed in covered dumpsters? | ☐ Yes ☐ No ☐ N/A | ☐ Yes ☐ No | |
| 9 | Are washout facilities (e.g., paint, stucco, concrete) available, clearly marked, and maintained? | ☐ Yes ☐ No ☐ N/A | ☐ Yes ☐ No | |
| 10 | Are vehicle and equipment fueling, cleaning, and maintenance areas free of spills, leaks, or any other deleterious material? | ☐ Yes ☐ No ☐ N/A | ☐ Yes ☐ No | |
| 11 | Are materials that are potential stormwater contaminants stored inside or under cover? | ☐ Yes ☐ No ☐ N/A | ☐ Yes ☐ No | |
| 12 | Are non-stormwater discharges (e.g., wash water, dewatering) properly controlled? | ☐ Yes ☐ No ☐ N/A | ☐ Yes ☐ No | |

☐ ***Check here if there are NO incidents of noncompliance; the facility is in compliance with the SWPPP and the General Permit.***

## CERTIFICATION STATEMENT

"I certify under penalty of law that I have read and understand this document and that this document and all attachments were prepared in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

***Inspector*** **Name (Print):**_____ **Title:** _____

**Signature:** _____ **Date:** _____

***Operator*** **Name (Print):**_____ **Title:** _____

***Signature:** _____ **Date:** _____

**The Operator must sign inspection reports unless a Delegation of Authority has been included in the SWPPP.**

# APPENDIX K

SWM Facility Record Drawing & Certifications Form

(VTSID-09)

# SWM Facility Record Report & Certification Form

**Instruction:** The purpose of the stormwater management (SWM) facility record report certification process is to verify that all stormwater management facilities and associated conveyance systems have been built in accordance with the approved plan and the design specifications. All required information shall be submitted to SID for approval in accordance with Section 4.1.2 of the VT Annual Standards and Specifications for ESC and SWM. VTSID approval is required prior to receiving the VT Termination of Land Disturbance that is necessary for the permittee's termination of a Construction General Permit. The following shall be submitted for each permanent post-construction stormwater management facility:

**(1) A completed copy of this form**

- ☐ A copy of this form shall be submitted for each permanent stormwater management facility that has been constructed. The applicant shall ensure that this form is completed in its entirety and all applicable documentation is included with the submittal.
- ☐ A copy of the appropriate Stormwater Record Report Checklist and all applicable documentation shall be submitted.

**(2) Certified Professional Inspection Log**

- ☐ A copy of the applicant's inspection log and photos shall be submitted with this form. This log should document all critical aspects of SWM facility construction to demonstrate compliance with the approved plan and specifications. For example, a bioretention facility requires a liner. Without an inspection log and photos, there would be no assurance post-construction that it was installed to specification because it is not visible from the surface.

**(3) Certified Record Drawing (As-built)**

- ☐ A record drawing of the plans is required to be submitted with this form. The plans should indicate any changes that differ from the approved plans, along with any applicable computations.
- ☐ A clear means, such as a checkmark, shall be used to demonstrate that the applicant agrees with the constructed values.
- ☐ For any revisions to the plans, including numeric changes, a red line shall be used to cross out the original item, and the actual revision shall be entered beside the crossed out value.
- ☐ Elevations shall be to the nearest 0.1 foot.
- ☐ The storage volume of the facility, including all dimensioned structures, shall be verified with the certification.
- ☐ Survey information in plan view with a table showing elevations for each layer of the SWM facility compared to the design elevations, if applicable.
- ☐ All submitted plan sheets shall be labeled as "Record Drawing."

**(4) Long Term Maintenance Responsibility**

| | |
|---|---|
| Responsible Department: | Contact Person: |
| Title: | Contact Information: |

## Section 1– Contractor Information:

| | |
|---|---|
| Company: | Contact Person: |
| Title: | Phone Number: |

| Plan Name: | Plan Date: |
|---|---|

## Section 2– Record Drawing Certifications Statement

A Licensed Professional shall provide the following certification of the SWM Record Report, including inspections, monitoring and other efforts used for the certification of Stormwater Management facilities during construction.

**Record Drawing Certification**

*I certify that I am a Licensed Professional in the Commonwealth of Virginia and that to best of my knowledge, having completed site-specific inspection(s), the stormwater management facility referenced on this form is constructed in accordance with the approved plans and specifications and all of the information provided with this certification is complete and accurate.*

Design Firm Name: _____

Mailing Address: _____

Business Phone: _____

Name of certifying individual: _____ PLACE SEAL HERE

Signature: _____ Date: _____

## Section 3 – Record Report Approval

*(To be completed by SID staff only)*

VTSID Representative (print):_____

Signature: _____ Date: _____

# Stormwater Record Report Checklist – Bioretention

## Section 1 – SWM Facility General Information

| | |
|---|---|
| Project Name: | Project Location: |
| BMP Location (Latitude/Longitude in decimal degrees): | |
| BMP ID: | Total Drainage Area To BMP (Acres): |
| Impervious Drainage Area to BMP (Acres): | Pervious Drainage Area to BMP (Acres): |
| 6th Order HUC: | Date Facility Brought Online: |
| Name of any impaired waters the BMP discharges to (2012 305(b)/303(d)): | |
| Pretreatment:<br>☐ YES<br>☐ NO | If yes, indicate type of pretreatment: |

## Section 2

**Instruction:** This checklist shall be completed if a Bioretention has been designed and installed on a construction site. The completed checklist shall be provided as a part of the Stormwater Record Report submittal for each Bioretention installed. The Stormwater Record Report for the installation of a Bioretention shall contain the following information for submittal to Virginia Tech Site and Infrastructure Development:

- ☐ Completed Stormwater Record Report Checklist - Bioretention
- ☐ Professional Engineer seal and signature
- ☐ Project description
- ☐ Location map showing the location of the Bioretention
- ☐ Original design documents including:
  - ☐ Drainage area maps
  - ☐ VRRM spreadsheet
- ☐ Bioretention details showing:
  - ☐ Underdrain/Outlet storm drain inverts
  - ☐ Riser top elevations
  - ☐ Top of berm/seat wall elevations
  - ☐ Final Planting Plan
  - ☐ Sizing calculations
- ☐ Material specifications for each layer of material used including stone, soil, liner, geotextile, filter fabric, etc.
- ☐ Record survey information including:
  - ☐ Elevations of each layer of the bioretention in multiple locations
  - ☐ Outlet storm drain invert

- ☐ Underdrain inverts
- ☐ Photos of all surveyed elements and all layers being installed
- ☐ Photos of the underdrain and outlet storm drain connections to cleanouts and to the riser structure
- ☐ Photos of liner key-in installation
- ☐ Survey information for the top of the berm/seat wall
- ☐ Survey information for the top of the riser structure

- ☐ Welding testing logs for liner installation, if applicable
- ☐ Updated drainage area maps to reflect any grading amendments affecting the overall drainage area to the Bioretention, if applicable
- ☐ Maintenance and Inspection Schedule/Requirements

Virginia Tech Site and Infrastructure Development reserves the right to not approve the Stormwater Record Report if it does not contain the items listed above.

Professional Engineer: _____ Date: _____

# Stormwater Record Report Checklist –Vegetated Roof

## Section 1 – SWM Facility General Information

| | |
|---|---|
| Project Name: | Project Location: |
| BMP Location (Latitude/Longitude in decimal degrees): | |
| BMP ID: | Total Drainage Area To BMP (Acres): |
| Impervious Drainage Area to BMP (Acres): | Pervious Drainage Area to BMP (Acres): |
| 6th Order HUC: | Date Facility Brought Online: |
| Name of any impaired waters the BMP discharges to (2012 305(b)/303(d)): | |
| Pretreatment:<br>☐ YES<br>☐ NO | If yes, indicate type of pretreatment: |

## Section 2

**Instruction:** This checklist shall be completed if a Vegetated Roof has been designed and installed on a construction site. The completed checklist shall be provided as a part of the Stormwater Record Report submittal for each Vegetated Roof installed. The Stormwater Record Report for the installation of a Vegetated Roof shall contain the following information for submittal to Virginia Tech Site and Infrastructure Development:

- ☐ Completed Stormwater Record Report Checklist – Vegetated Roof
- ☐ Professional Engineer seal and signature
- ☐ Project description
- ☐ Location map showing the location of the Vegetated Roof
- ☐ Original design documents including:
    - ☐ Drainage area maps
    - ☐ VRRM Spreadsheet
- ☐ Vegetated Roof details showing:
    - ☐ Depth of Media
    - ☐ Final Planting Plan
    - ☐ Setbacks
    - ☐ Roof Access
    - ☐ Sizing calculations
    - ☐ Structural Capacity calculations conforming to ASTM E 2397 05 for the roof
- ☐ Material specifications for each layer of material used including waterproof membrane, root barrier, drainage layer, filter fabric and growth media
- ☐ Record survey information including:
    - ☐ Photos of all surveyed elements
    - ☐ Photos of each layer installation

- ☐ Updated drainage area maps to reflect any grading amendments affecting the overall drainage area to the Vegetated Roof, if applicable
- ☐ Maintenance and Inspection Schedule/Requirements

Virginia Tech Site and Infrastructure Development reserves the right to not approve the Stormwater Record Report if it does not contain the items listed above.

Professional Engineer: _____ Date: _____

# Stormwater Record Report Checklist –Dry Swale

## Section 1 – SWM Facility General Information

| | |
|---|---|
| Project Name: | Project Location: |
| BMP Location (Latitude/Longitude in decimal degrees): | |
| BMP ID: | Total Drainage Area To BMP (Acres): |
| Impervious Drainage Area to BMP (Acres): | Pervious Drainage Area to BMP (Acres): |
| 6th Order HUC: | Date Facility Brought Online: |
| Name of any impaired waters the BMP discharges to (2012 305(b)/303(d)): | |
| Pretreatment:<br>☐ YES<br>☐ NO | If yes, indicate type of pretreatment: |

## Section 2

**Instruction:** This checklist shall be completed if a Dry Swale has been designed and installed on a construction site. The completed checklist shall be provided as a part of the Stormwater Record Report submittal for each installation of a Dry Swale. The Stormwater Record Report for installing a Dry Swale shall contain the following information for submittal to Virginia Tech Site and Infrastructure Development:

- ☐ Completed Stormwater Record Report Checklist – Dry Swale
- ☐ Professional Engineer seal and signature
- ☐ Project description
- ☐ Location map showing the location of the Dry Swale
- ☐ Original design documents including:
  - ☐ Drainage area maps
  - ☐ VRRM Spreadsheet
- ☐ Dry Swale details showing:
  - ☐ Underdrain/Outlet storm drain inverts
  - ☐ Riser top elevation
  - ☐ Top of berm/seat wall elevations
  - ☐ Final Planting Plan
  - ☐ Sizing calculations
- ☐ Material specifications for each layer of material used including stone, soil, liner, geotextile, filter fabric, etc.
- ☐ Record survey information including:
  - ☐ Outlet storm drain invert
  - ☐ Underdrain inverts

- ☐ Photos of all surveyed elements and all layers being installed
- ☐ Photos of the underdrain and outlet storm drain connections to cleanouts and to the riser structure
- ☐ Photos of liner key-in installation
- ☐ Survey information for the top of the berm/seat wall
- ☐ Survey information for the top of the riser structure

- ☐ Welding testing logs for liner installation, if applicable
- ☐ Updated drainage area maps to reflect any grading amendments affecting the overall drainage area to the Dry Swale, if applicable
- ☐ Maintenance and Inspection Schedule/Requirements

Virginia Tech Site and Infrastructure Development reserves the right to not approve the Stormwater Record Report if it does not contain the items listed above.

Professional Engineer: _____ Date: _____

# Stormwater Record Report Checklist –Wet Swale

## Section 1 – SWM Facility General Information

| | |
|---|---|
| Project Name: | Project Location: |
| BMP Location (Latitude/Longitude in decimal degrees): | |
| BMP ID: | Total Drainage Area To BMP (Acres): |
| Impervious Drainage Area to BMP (Acres): | Pervious Drainage Area to BMP (Acres): |
| 6th Order HUC: | Date Facility Brought Online: |
| Name of any impaired waters the BMP discharges to (2012 305(b)/303(d)): | |
| Pretreatment:<br>☐ YES<br>☐ NO | If yes indicate type of pretreatment: |

## Section 2

**Instruction:** This checklist shall be completed if a Wet Swale has been designed and installed on a construction site. The completed checklist shall be provided as a part of the Stormwater Record Report submittal for each installation of a Wet Swale. The Stormwater Record Report for installing a Wet Swale shall contain the following information for submittal to Virginia Tech Site and Infrastructure Development:

- ☐ Completed Stormwater Record Report Checklist – Wet Swale
- ☐ Professional Engineer seal and signature
- ☐ Project description
- ☐ Location map showing the location of the Wet Swale
- ☐ Original design documents including:
  - ☐ Drainage area maps
  - ☐ VRRM Spreadsheet
- ☐ Wet Swale details showing:
  - ☐ Underdrain/Outlet storm drain inverts
  - ☐ Riser top elevations
  - ☐ Top of berm/seat wall elevations
  - ☐ Sizing calculations
- ☐ Material specifications for each layer of material used including stone, soil, liner, geotextile, filter fabric, etc.
- ☐ Record survey information including:
  - ☐ Outlet storm drain invert
  - ☐ Underdrain inverts
  - ☐ Photos of all surveyed elements and all layers being installed

- ☐ Photos of the underdrain and outlet storm drain connections to cleanouts and to the riser structure
- ☐ Photos of liner key-in installation
- ☐ Survey information for the top of the berm/seat wall
- ☐ Survey information for the top of the riser structure

☐ Welding testing logs for liner installation, if applicable

☐ Updated drainage area maps to reflect any grading amendments affecting the overall drainage area to the Wet Swale, if applicable

Virginia Tech Site and Infrastructure Development reserves the right to not approve the Stormwater Record Report if it does not contain the items listed above.

Professional Engineer: _____ Date: _____

# Stormwater Record Report Checklist – Rainwater Harvesting

## Section 1 – SWM Facility General Information

| | |
|---|---|
| Project Name: | Project Location: |
| BMP Location (Latitude/Longitude in decimal degrees): | |
| BMP ID: | Total Drainage Area To BMP (Acres): |
| Impervious Drainage Area to BMP (Acres): | Pervious Drainage Area to BMP (Acres): |
| 6th Order HUC: | Date Facility Brought Online: |
| Name of any impaired waters the BMP discharges to (2012 305(b)/303(d)): | |
| Pretreatment:<br>☐ YES<br>☐ NO | If yes indicate type of pretreatment: |

## Section 2

**Instruction:** This checklist shall be completed if a Rainwater Harvesting system has been designed and installed on a construction site. The completed checklist shall be provided as a part of the Stormwater Record Report submittal for each type of Rainwater Harvesting system installed. The Stormwater Record Report for the installation of Rainwater Harvesting systems shall contain the following information for submittal to Virginia Tech Site and Infrastructure Development:

- ☐ Completed Stormwater Record Report Checklist – Rainwater Harvesting
- ☐ Professional Engineer seal and signature
- ☐ Project description
- ☐ Location map showing the location of the Rainwater Harvesting system components
- ☐ Original design documents including:
  - ☐ Drainage area maps
  - ☐ VRRM Spreadsheet
- ☐ Rainwater Harvesting details showing:
  - ☐ Size of Storage Tank
  - ☐ Schematics of tank and piping system configuration
  - ☐ Material type and size of gutter, downspouts and conveyance piping to cistern inlet
  - ☐ Location and type of debris excluder
  - ☐ Sizing calculations
- ☐ Discussion of use of harvested rainwater (irrigation, toilet flushing, etc.)
- ☐ Indicate how overflow water will be directed to minimize stormwater-runoff
- ☐ Updated drainage area maps to reflect any grading amendments affecting the overall drainage area to the Rainwater Harvesting system, if applicable
- ☐ Maintenance and Inspection Schedule/Requirements

Virginia Tech Site and Infrastructure Development reserves the right to not approve the Stormwater Record Report if it does not contain the items listed above.

Professional Engineer: _____ Date: _____

# Stormwater Record Report Checklist – Grass Channel

## Section 1 – SWM Facility General Information

| | |
|---|---|
| Project Name: | Project Location: |
| BMP Location (Latitude/Longitude in decimal degrees): | |
| BMP ID: | Total Drainage Area To BMP (Acres): |
| Impervious Drainage Area to BMP (Acres): | Pervious Drainage Area to BMP (Acres): |
| 6th Order HUC: | Date Facility Brought Online: |
| Name of any impaired waters the BMP discharges to (2012 305(b)/303(d)): | |
| Pretreatment:<br>☐ YES<br>☐ NO | If yes indicate type of pretreatment: |

## Section 2

**Instruction:** This checklist shall be completed if a Grass Channel has been designed and installed on a construction site. The completed checklist shall be provided as a part of the Stormwater Record Report submittal for each Grass Channel installed. The Stormwater Record Report for the installation of a Grass Channel shall contain the following information for submittal to Virginia Tech Site and Infrastructure Development:

- ☐ Completed Stormwater Record Report Checklist – Grass Channel
- ☐ Professional Engineer seal and signature
- ☐ Project description
- ☐ Location map showing the location of the Grass Channel
- ☐ Original design documents including:
  - ☐ Sizing calculations compared to As-Builts
  - ☐ Outfall volume and flow calculations
  - ☐ Final Planting Plan
- ☐ Provide the following information regarding Grass Channels:
  - ☐ Contributing drainage area boundaries, acreage, and land cover
  - ☐ VRRM Spreadsheet
  - ☐ Topography of site including the Grass Channel
  - ☐ Locations of all conveyance system outfalls into the Grass Channel must be shown
- ☐ Provide a plan view showing:
  - ☐ Overall Grass Channel Grading
  - ☐ Layout and dimensions of the Grass Channel, including check dams
- ☐ Provide profiles, section views, and details that show the following:
  - ☐ Cross-section

- ☐ Side slopes
- ☐ Channel bottom width
- ☐ Longitudinal slope
- ☐ Check dam details
- ☐ 10-year storm elevation

☐ Welding testing logs for liner installation, if applicable
☐ Maintenance and Inspection Schedule/Requirements

Virginia Tech Site and Infrastructure Development reserves the right to not approve the Stormwater Record Report if it does not contain the items listed above.

Professional Engineer: _____ Date: _____

# Stormwater Record Report Checklist –Wet Pond

## Section 1 – SWM Facility General Information

| | |
|---|---|
| Project Name: | Project Location: |
| BMP Location (Latitude/Longitude in decimal degrees): | |
| BMP ID: | Total Drainage Area To BMP (Acres): |
| Impervious Drainage Area to BMP (Acres): | Pervious Drainage Area to BMP (Acres): |
| 6th Order HUC: | Date Facility Brought Online: |
| Name of any impaired waters the BMP discharges to (2012 305(b)/303(d)): | |
| Pretreatment:<br>☐ YES<br>☐ NO | If yes indicate type of pretreatment: |

## Section 2

**Instruction:** This checklist shall be completed if a Wet Pond has been designed and installed on a construction site. The completed checklist shall be provided as a part of the Stormwater Record Report submittal for each installation of a Wet Pond. The Stormwater Record Report for installing a Wet Pond shall contain the following information for submittal to Virginia Tech Site and Infrastructure Development:

- ☐ Completed Stormwater Record Report Checklist – Wet Pond
- ☐ Professional Engineer seal and signature
- ☐ Project description
- ☐ Location map showing the location of the Wet Pond
- ☐ Original design documents including:
  - ☐ Drainage area maps
  - ☐ VRRM Spreadsheet
- ☐ Wet Pond details showing:
  - ☐ Underdrain/Outlet storm drain invert
  - ☐ Riser Top Elevation
  - ☐ Top of berm/seat wall elevations
  - ☐ Final Planting Plan
  - ☐ Pretreatment Details
  - ☐ Sizing calculations
- ☐ Material specifications for each layer of material used including stone, soil, liner, geotextile, filter fabric, etc.
- ☐ Record survey information including:
  - ☐ Outlet storm drain invert
  - ☐ Underdrain inverts

- ☐ Photos of all surveyed elements and all layers being installed
- ☐ Photos of the underdrain and outlet storm drain connections to cleanouts and to the riser structure
- ☐ Photos of liner key-in installation
- ☐ Survey information for the top of the berm/seat wall
- ☐ Survey information for the top of the riser structure

☐ Welding testing logs for liner installation, if applicable

☐ Updated drainage area maps to reflect any grading amendments affecting the overall drainage area to the Wet Pond, if applicable

☐ Maintenance and Inspection Schedule/Requirements

Virginia Tech Site and Infrastructure Development reserves the right to not approve the Stormwater Record Report if it does not contain the items listed above.

Professional Engineer: _____ Date: _____

# Stormwater Record Report Checklist –Extended Detention

## Section 1 – SWM Facility General Information

| | |
|---|---|
| Project Name: | Project Location: |
| BMP Location (Latitude/Longitude in decimal degrees): | |
| BMP ID: | Total Drainage Area To BMP (Acres): |
| Impervious Drainage Area to BMP (Acres): | Pervious Drainage Area to BMP (Acres): |
| 6th Order HUC: | Date Facility Brought Online: |
| Name of any impaired waters the BMP discharges to (2012 305(b)/303(d)): | |
| Pretreatment:<br>☐ YES<br>☐ NO | If yes indicate type of pretreatment: |

## Section 2

**Instruction:** This checklist shall be completed if a Dry Swale has been designed and installed on a construction site. The completed checklist shall be provided as a part of the Stormwater Record Report submittal for each installation of a Dry Swale. The Stormwater Record Report for installing a Dry Swale shall contain the following information for submittal to Virginia Tech Site and Infrastructure Development:

- ☐ Completed Stormwater Record Report Checklist – Extended Detention
- ☐ Professional Engineer seal and signature
- ☐ Project description
- ☐ Location map showing the location of the Extended Detention
- ☐ Original design documents including:
  - ☐ Drainage area maps
  - ☐ VRRM Spreadsheet
- ☐ Extended Detention details showing:
  - ☐ Underdrain/Outlet storm drain inverts
  - ☐ Riser top elevation
  - ☐ Final Planting Plan
  - ☐ Forebay Details if Applicable
  - ☐ Sizing calculations
- ☐ Material specifications for each layer of material used including stone, soil, liner, geotextile, filter fabric, etc.
- ☐ Record survey information including:

- ☐ Outlet storm drain invert
- ☐ Underdrain inverts
- ☐ Photos of all surveyed elements and all layers being installed
- ☐ Photos of the underdrain and outlet storm drain connections to cleanouts and to the riser structure
- ☐ Photos of liner key-in installation
- ☐ Survey information for the top of the berm/seat wall
- ☐ Survey information for the top of the riser structure

☐ Welding testing logs for liner installation, if applicable

☐ Updated drainage area maps to reflect any grading amendments affecting the overall drainage area to the Extended Detention, if applicable

☐ Maintenance and Inspection Schedule/Requirements

Virginia Tech Site and Infrastructure Development reserves the right to not approve the Stormwater Record Report if it does not contain the items listed above.

Professional Engineer: _____ Date: _____

# Stormwater Record Report Checklist –Nutrient Credits

## Section 1 – SWM Facility General Information

| | |
|---|---|
| Project Name: | Project Location: |
| Total Drainage Area To BMP (Acres): | |
| Impervious Drainage Area to BMP (Acres): | Pervious Drainage Area to BMP (Acres): |
| 6th Order HUC: | Date Credits Purchased: |
| Name of any impaired waters the BMP discharges to (2012 305(b)/303(d)): | |

## Section 2

**Instruction:** This checklist shall be completed if a construction site has been designed to use Nutrient Credits. The completed checklist shall be provided as a part of the Stormwater Record Report submittal for each use of Nutrient Credits. The Stormwater Record Report for the use of Nutrient Credits shall contain the following information for submittal to Virginia Tech Site and Infrastructure Development:

- ☐ Completed Stormwater Record Report Checklist – Nutrient Credits
- ☐ Professional Engineer seal and signature
- ☐ Project description
- ☐ Location map showing the location where the Nutrient Credits are being used
- ☐ Official Bill of Sale for Nutrient Credits being purchased
- ☐ Original design documents including:
  - ☐ Drainage area maps
  - ☐ VRRM Spreadsheet
- ☐ Nutrient Credit details showing:
  - ☐ Stormwater calculations
- ☐ Updated drainage area maps to reflect any grading amendments affecting the overall drainage area to the site using Nutrient Credits, if applicable

Virginia Tech Site and Infrastructure Development reserves the right to not approve the Stormwater Record Report if it does not contain the items listed above.

Professional Engineer: _____ Date: _____

# Stormwater Record Report Checklist –Manufactured

## Section 1 – SWM Facility General Information

| | |
|---|---|
| Project Name: | Project Location: |
| BMP Location (Latitude/Longitude in decimal degrees): | |
| BMP ID: | Total Drainage Area To BMP (Acres): |
| Impervious Drainage Area to BMP (Acres): | Pervious Drainage Area to BMP (Acres): |
| 6th Order HUC: | Date Facility Brought Online: |
| Name of any impaired waters the BMP discharges to (2012 305(b)/303(d)): | |
| Pretreatment:<br>☐ YES<br>☐ NO | If yes indicate type of pretreatment: |

## Section 2

**Instruction:** This checklist shall be completed if a Manufactured Unit has been designed and installed on a construction site. The completed checklist shall be provided as a part of the Stormwater Record Report submittal for each Manufactured Unit installed. The Stormwater Record Report for the installation of a Manufactured Unit shall contain the following information for submittal to Virginia Tech Site and Infrastructure Development:

- ☐ Completed Stormwater Record Report Checklist – Manufactured Unit
- ☐ Professional Engineer seal and signature
- ☐ Project description
- ☐ Location map showing the location of Manufactured Unit
- ☐ Original design documents including:
  - ☐ Drainage area maps
  - ☐ VRRM Spreadsheet
- ☐ Manufactured Unit details showing:
  - ☐ Stormwater calculations
  - ☐ Manufactures Specifications
- ☐ Welding testing logs for liner installation, if applicable
- ☐ Updated drainage area maps to reflect any grading amendments affecting the overall drainage area to the Manufactured Unit, if applicable
- ☐ Maintenance and Inspection Schedule/Requirements

Virginia Tech Site and Infrastructure Development reserves the right to not approve the Stormwater Record Report if it does not contain the items listed above.

Professional Engineer: _____ Date: _____

# Stormwater Record Report Checklist – Underground Detention

## Section 1 – SWM Facility General Information

| | |
|---|---|
| Project Name: | Project Location: |
| BMP Location (Latitude/Longitude in decimal degrees): | |
| BMP ID: | Total Drainage Area To BMP (Acres): |
| Impervious Drainage Area to BMP (Acres): | Pervious Drainage Area to BMP (Acres): |
| 6th Order HUC: | Date Facility Brought Online: |
| Name of any impaired waters the BMP discharges to (2012 305(b)/303(d)): | |
| Pretreatment:<br>☐ YES<br>☐ NO | If yes, indicate type of pretreatment: |

## Section 2

**Instruction:** This checklist shall be completed if an Underground Detention has been designed and installed on a construction site. The completed checklist shall be provided as a part of the Stormwater Record Report submittal for each Underground Detention installed. The Stormwater Record Report for the installation of an Underground Detention shall contain the following information for submittal to Virginia Tech Site and Infrastructure Development:

- ☐ Completed Stormwater Record Report Checklist – Underground Detention
- ☐ Professional Engineer seal and signature
- ☐ Project description
- ☐ Location map showing the location of the Underground Detention
- ☐ Original design documents including:
  - ☐ Drainage area maps
  - ☐ VRRM spreadsheet, if applicable
- ☐ Underground Detention details showing:
  - ☐ Underdrain/Outlet storm drain inverts
  - ☐ Riser top elevations
  - ☐ Chamber/pipe locations and elevations
  - ☐ Sizing calculations
- ☐ Material specifications for each layer of material used including stone, liner, geotextile, filter fabric, etc.
- ☐ Record survey information including:
  - ☐ Elevations of each layer of the Underground Detention in multiple locations
  - ☐ Elevations of storm drain inverts and orifice plate and weir wall

- ☐ Photos of orifice plate and weir wall
- ☐ Photos of all surveyed elements and all layers being installed
- ☐ Photos of the underdrain and outlet storm drain connections to cleanouts and to the riser structure
- ☐ Photos of liner key-in installation
- ☐ Survey information for the top of the riser structure

- ☐ Welding testing logs for liner installation, if applicable
- ☐ Updated drainage area maps to reflect any grading amendments affecting the overall drainage area to the Underground Detention, if applicable
- ☐ Maintenance and Inspection Schedule/Requirements

Virginia Tech Site and Infrastructure Development reserves the right to not approve the Stormwater Record Report if it does not contain the items listed above.

Professional Engineer: _____ Date: _____

# APPENDIX L

## Land Disturbance Termination Form

(VTSID-10)

# TERMINATION OF LAND DISTURBANCE

**Instruction:** This form is to be used as a request for termination of land disturbance between the Contractor/Operator and SID. Approval of this request will **NOT** result in termination of VAR10 General Permit coverage from the DEQ. The Contractor/Operator **SHALL NOT** terminate VAR10 General Permit coverage with DEQ, when applicable, until Termination of Land Disturbance Approval from SID is granted.

Project Name: _____ VAR10 Permit # (when applicable): _____

## Section 1 – Conditions for Termination of Land Disturbance

The conditions of this section shall be met and this form shall be signed by both the Operator and the VTSID Stormwater Compliance Manager prior to termination of land disturbance (check those that apply):

- ☐ No further land disturbance activities are planned
- ☐ The project area has been stabilized in accordance with the approved plans
- ☐ All temporary erosion and sediment control measures have been removed and resulting disturbances stabilized
- ☐ All pollution prevention measures have been removed from the site and disposed of in a legal manner
- ☐ All permanent, post-construction stormwater management facilities have approved Record Report
- ☐ All trash and debris have been removed from the site

## Section 2 – Operator Certification

"I certify under penalty of law that I have read and understand this document and that this document and all attachments were prepared in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations. "

Operator/Contractor: _____ Company: _____

Signature: _____ Date: _____

## Section 3 – Termination of Land Disturbance Approval

*(To be completed by the Virginia Tech SID Stormwater Compliance Manager only)*

SID recognizes this request to be accurate based on the certification above and terminates the Operator/Contractor's land disturbance activity as it applies to the VT Annual Standards and Specifications for ESC and SWM.

Stormwater Compliance Manager: _____

Signature: _____ Date: _____