REPORT OF THE VIRGINIA
DEPARTMENT OF ENVIRONMENTAL QUALITY

Application of the Postdevelopment Stormwater Management Technical Criteria, as Established in the Virginia Stormwater Management Program Regulations, in Areas with a Seasonal High Groundwater Table (HJR 587, 2015)

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

HOUSE DOCUMENT NO. 2

COMMONWEALTH OF VIRGINIA
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COMMONWEALTH of VIRGINIA

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To: The Honorable Terence R. McAuliffe, Governor

Members of the General Assembly

From: David K. Paylor

Date: January 8, 2016

Subject: Report on the Application of the Postdevelopment Stormwater Management Technical Criteria in Areas with a Seasonal High Groundwater Table

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I am pleased to provide you with a copy of the Department of Environmental Quality's report on the application of the postdevelopment stormwater management technical criteria, as established in the Virginia Stormwater Management Program Regulations, in areas with a seasonal high groundwater table. This report was prepared pursuant to House Joint Resolution 587 (2015).

This report is also being made available on Virginia's Legislative Information System webpage at: http://lis.virginia.gov.

If you have any questions about the report or would like a hard copy of the report, please contact Elizabeth Andrews, Water Policy Manager at Elizabeth.Andrews@deq.virginia.gov or 804-698-4015.

Application of the Postdevelopment Stormwater Management Technical Criteria, as Established in the Virginia Stormwater Management Program Regulations, in Areas with a Seasonal High Groundwater Table

A Report to
The Honorable Terence R. McAuliffe, Governor,
And
The General Assembly of Virginia

Department of Environmental Quality

December 2015

Table of Contents

Purpose and Scope of Report

The 2015 Virginia General Assembly passed House Joint Resolution Number 587 (HJR 587). The resolution as passed states in part:

> *That the Department of Environmental Quality be requested to study the application of the postdevelopment stormwater management technical criteria, as established in the Virginia Stormwater Management Program Regulations, in areas with a seasonal high groundwater table.*

The resolution specifies that the Department of Environmental Quality (DEQ) evaluate the existing design specifications for best management practices (BMPs) listed on the Virginia Stormwater BMP Clearinghouse and recommend design specification revisions to allow the effective use of these BMPs in areas with a seasonal high groundwater table (SHGT), if applicable. The purpose of this effort is to achieve greater flexibility in meeting the stormwater management requirements in areas with a SHGT.

This report summarizes the work completed during the first year of the study, where DEQ reviewed documents to further understand the issues associated with a SHGT. This effort included providing recommendations for determining areas with a SHGT and learning how SHGTs affect the function of stormwater BMPs. As part of the study, DEQ has performed a literature review of stormwater BMPs to further understand the potential issues of locating BMPs in areas with a SHGT.

The first part of this report defines a SHGT and describes the requirements of the Virginia Stormwater Management Program (VSMP) Regulations (9VAC25-870-10 et seq.). The report discusses the connection between the management of water quality and quantity and the importance of BMP volume reduction benefits to meet the postdevelopment stormwater management requirements. It highlights how other states manage stormwater in areas with a SHGT and proposes potential modifications to existing BMPs for use in areas with a SHGT. The report concludes by providing the background and goals for work to be accomplished during the second year of the study.

Defining a Seasonal High Groundwater Table

The key to defining a SHGT lies in determining the elevation below the ground surface where the water table exists. Watts and Hurt[1] defined the SHGT as occurring "where the soil moisture tension is zero for a significant period (more than a few weeks)." The Florida Administrative Code[2] defines the SHGT as the elevation of the highest level of the saturated zone in the soil in a year with normal rainfall. In Virginia the SHGT is defined in the *Virginia DEQ Stormwater*

[1] Watts, F.C. and G. Wade Hurt. "Determining Depths to the Seasonal High Water Table and Hydric Soils in Florida." Soil Survey Horizons, Vol. 32, No. 4, pp. 117-120, Winter 1991.
[2] St. Johns River Water Management District, 40C-42, F.A.C. "Definitions".

Design Specification No. 8: Infiltration Practices[3] as “the shallowest depth to free water that stands in an unlined borehole or where the soil moisture tension is zero for a significant period (more than a few weeks).” The location of this elevation will determine what BMPs can be used to meet the VSMP Regulations. There are two methods that can be used independently for predicting the SHGT. The first measures the depth of groundwater in a monitoring well during the winter months. The second evaluates redoximorphic features (RMF) in the soil. Neither of the methods is foolproof so using both methods as a cross check may be of benefit.

DEQ recommends use of the “Infiltration Soil Testing Procedures” found in the *Virginia DEQ Stormwater Design Specification No. 8: Infiltration Practices* for determining the SHGT. These procedures are based on an excerpt from “Testing for Infiltration Facilities*”* published as part of the *Fairfax County Public Facilities Manual* by the Fairfax County Department of Public Works and Environmental Services[4]. Fairfax County’s guidance discusses the application of using either the direct observation of the groundwater or the soil morphology method to determine the elevation of the water table. If soil morphology is the method of choice, DEQ also recommends that it be performed by a professional registered in Virginia, with training and experience in soil morphology.

Meeting Requirements of the Virginia Stormwater Management Program Regulations

HJR 587 requests that DEQ make recommendations to achieve greater flexibility in applying the water quantity requirements of the Virginia Stormwater Management Act (§ 62.1-44.15:24 et seq.) and attendant regulations in areas with a SHGT while protecting the Commonwealth's surface waters. In order to address this request, it is important to understand the VSMP Regulations and how the associated BMPs help provide compliance.

Under natural conditions, most stormwater infiltrates into the subsurface. Land cover changes from pervious cover (e.g., woods, grass) to impervious cover (e.g., buildings, pavement) reduce or prevent infiltration into the native soils. The increase in impervious cover causes stormwater runoff volume and peak flows to increase, which have been shown to transport increased loads of nutrients and degrade receiving stream channels.[5]

The Commonwealth of Virginia has adopted a comprehensive stormwater management program to protect local receiving waters from the environmental impacts associated with increased volumes of stormwater runoff. In addition, this program is included in Virginia’s Chesapeake Bay Total Maximum Daily Load (TMDL) Watershed Implementation Plan (WIP) as a key

[3] *Virginia DEQ Stormwater Specification No. 8: Infiltration Practices* can be found on DEQ’s website at http://www.deq.virginia.gov/Programs/Water/StormwaterManagement/VSMPPermits/ConstructionGeneralPermit.aspx.
[4] For additional information, see *Fairfax County Public Facilities Manual*, Section 4-0000 Geotechnical Guidelines.
[5] For more information, see the National Research Council’s report on urban stormwater, available at http://www.epa.gov/npdes/npdes-stormwater-program.

strategy for offsetting future growth resulting from the development of agricultural and forest lands into residential and commercial urban uses.

The Virginia Stormwater Management Act and VSMP Regulations focus on the technical procedures to manage the impacts associated with land cover changes. The VSMP Regulations manage increases in stormwater runoff and its pollutant load by regulating the quantity and quality of stormwater runoff discharging from a development site after the completion of construction.

Water Quantity – Channel Protection

The water quantity requirements include a channel protection component and a flood protection component. This report focuses on the channel protection component. The channel protection requirements of the VSMP Regulations (9VAC25-870-66) contain a set of criteria for the release of stormwater into three types of conveyance systems: (1) manmade, (2) restored, and (3) natural stormwater conveyance systems. Each system has specific technical criteria that must be met before stormwater can be released into the system. For example, stormwater flow to natural stormwater conveyance systems must meet the peak flow rate calculated using the Energy Balance Equation. This equation is based on balancing the predevelopment stormwater volume with the postdevelopment stormwater volume. In its simplest explanation, the ratio of the predevelopment stormwater volume over the postdevelopment stormwater volume is used in the equation to ensure protection of existing channel conditions. The equation also takes into account that volume ratios close to one (1.0) will have a postdevelopment flow rate closer to the predevelopment rate and therefore require less on-site detention.

When stormwater runoff is reduced on-site, generally smaller stormwater detention practices are required at the site's point of discharge to meet the channel protection requirements. In practice, this means if the postdevelopment runoff volume can be reduced, then meeting the water quantity criteria set forth by the VSMP Regulations may not require additional stormwater detention. Two common means of reducing the volume of runoff include incorporating Environmental Site Design (ESD) and/or utilizing volume-reducing BMPs. ESD is a design process to limit the amount of impervious area at the site and to protect and/or utilize the existing natural resources on the proposed development site. Volume-reducing BMPs, as the name implies, reduce the amount of stormwater to be discharged into the downstream stormwater conveyance system.

Water Quality – Virginia Runoff Reduction Method

Under the VSMP Regulations the total phosphorus (TP) mass load from a post-constructed development site must be equal to or less than 0.41pounds per acre per year (9VAC25-870-63).

The VSMP Regulations also dictate that the Virginia Runoff Reduction Method (VRRM[6]), or another equivalent methodology that is approved by the State Water Control Board, be used to determine the post-constructed development site TP mass load (9VAC25-870-65).

The VRRM promotes the use of ESD and BMPs for developing a stormwater management plan that meets the VSMP Regulations for a given development site. The method applies an iterative process utilizing three distinctive design steps to a given site to meet compliance (see Figure 1 below). Step 1 uses ESD, which limits the quantity of stormwater generated on site. Step 2 applies BMPs that provide volume reduction, and Step 3 uses BMPs that provide pollutant removal. BMPs approved for use in Virginia for meeting the water quality requirements of the VSMP Regulations are listed on the Virginia Stormwater BMP Clearinghouse website at http://www.vwrrc.vt.edu/swc/NonProprietaryBMPs.html and http://www.vwrrc.vt.edu/swc/ProprietaryBMPs.html. Step 4, if employed, includes the use of off-site compliance options, including nonpoint source nutrient offsets.[7]

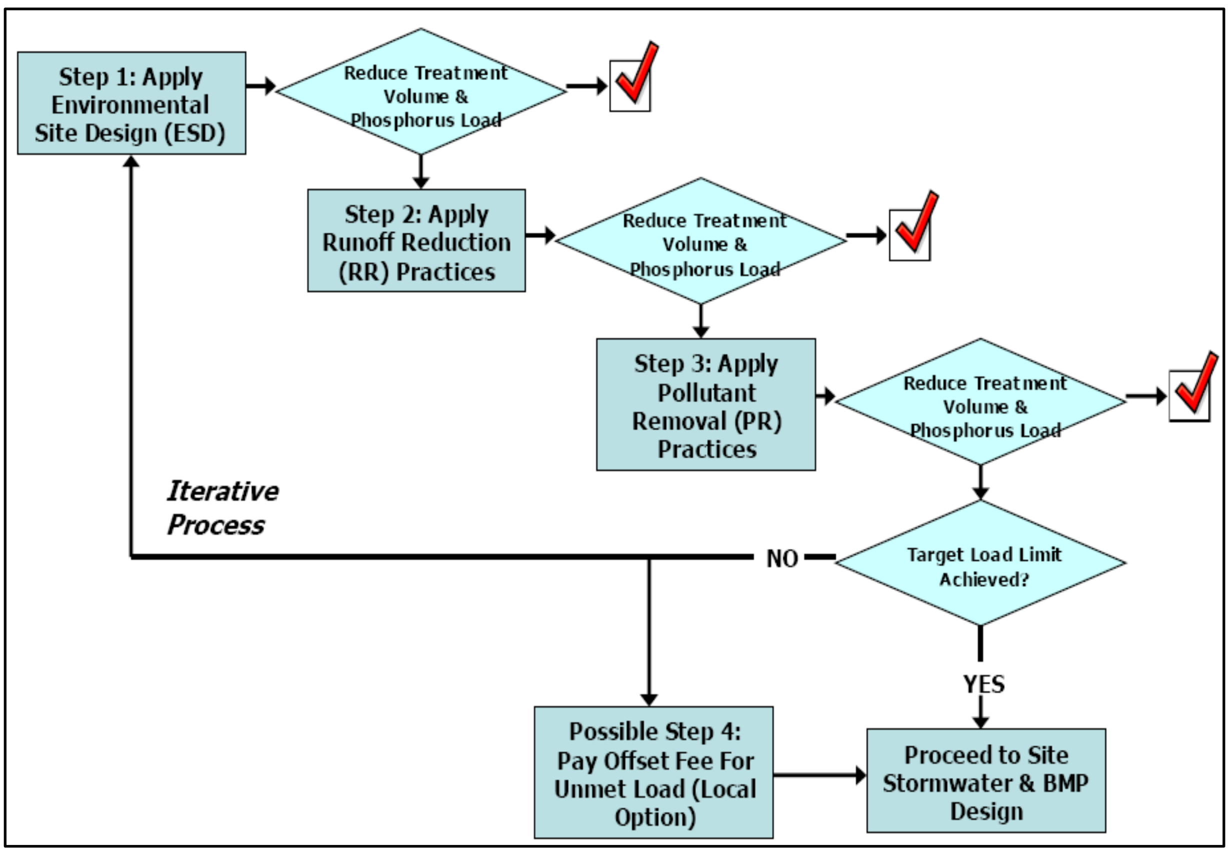

Figure 1. Step-Wise Process for Site Compliance

[6] The VRRM is described in *Virginia Runoff Reduction Method: Instructions & Documentation* (March 28, 2011) and *Technical Memorandum: The Runoff Reduction Method* (Center for Watershed Protection, 2008); both documents are available on the BMP Clearinghouse website: http://www.vwrrc.vt.edu/swc/vrrm.html.
[7] For additional information on how the nutrient credit trading program works, visit the DEQ website at http://www.deq.virginia.gov/Programs/Water/PermittingCompliance/PollutionDischargeElimination/NutrientTrading.aspx.

Virginia Runoff Reduction Method Compliance Spreadsheets

The VRRM is implemented through the use of two compliance spreadsheets (Virginia Runoff Reduction Method Compliance Spreadsheets), one for new development projects and one for re-development projects. These spreadsheets quantify the interrelationship between land cover, water quality compliance, and water quantity. They are available at http://www.vwrrc.vt.edu/swc/vrrm.html.

The spreadsheets perform a variety of calculations. The new development compliance spreadsheet calculates a postdevelopment total phosphorus (TP) mass load based on the proposed land cover. The re-development compliance spreadsheet calculates the TP mass load for the re-developed site based on the existing impervious area plus any additional new impervious land cover. From the TP load information for the developed/re-developed site, the spreadsheets compute the required TP reduction needed to meet the water quality compliance limit of 0.41 pounds per acre per year. The spreadsheets also show when water quality compliance is met through site design that incorporates ESD and/or BMPs listed on the Virginia Stormwater BMP Clearinghouse website.

Both the new development and re-development compliance spreadsheets calculate a water quality treatment volume based on 1-inch of rainfall over the developed/re-developed site. The one inch of rainfall is the 90^{th} percentile rainfall depth, which is used to size BMPs. This value represents the volume of stormwater that can be reduced and/or treated for water quality compliance. Furthermore, the spreadsheets calculate the volume reduced by the BMPs selected to meet the TP limit of 0.41 pounds per acre per year. If BMPs are selected that provide runoff reduction, then this volume is removed from stormwater runoff that would otherwise discharge from the development site.

<u>Virginia Stormwater Best Management Practices</u>

As noted above, HJR 587 requested an evaluation of the existing BMPs referenced in the VSMP Regulations and posted on the Virginia Stormwater BMP Clearinghouse. This section provides general information about these important BMPs.

Each BMP listed in the VSMP Regulations has a TP mass load reduction credit assigned based on literature research conducted by the Center for Watershed Protection[8]. The TP mass load reduction credit is the product of volume reduction and pollutant removal. Volume reduction, also called runoff reduction (RR), is defined as the total annual runoff volume reduced through canopy interception, soil infiltration, evaporation, transpiration, rainfall harvesting, engineered

[8] The Center for Watershed Protection (CWP) is a non-profit organization nationally recognized as a leader in providing research and education on stormwater management and watershed planning.

infiltration, or extended filtration. Pollutant removal (PR) occurs through a variety of mechanisms such as filtration, biological uptake, adsorption, and settling.

The Virginia-approved best management practices are listed in Table 1 below. As shown in the table, some BMPs receive only RR credit; others receive only PR credit; and some are assigned both RR and PR credit. For example, proprietary BMPs listed on the Virginia Stormwater BMP Clearinghouse website, referred to as manufactured treatment devices in Table 1, are only assigned PR credit. The specified RR and PR credit assignments as well as other technical information needed for design are provided on the Virginia Stormwater BMP Clearinghouse website (http://www.vwrrc.vt.edu/swc/NonProprietaryBMPs.html and http://www.vwrrc.vt.edu/swc/ProprietaryBMPs.html).

Many of the practices listed on the Virginia Stormwater BMP Clearinghouse website have two levels of design criteria, known as Level 1 and Level 2. Level 1 is considered a standard design, and Level 2 is considered an enhanced design. Level 2 BMPs are designed with a larger treatment surface area, have enhanced design geometry and hydraulics, and/or have enhanced vegetative conditions. The enhanced design configuration provides for increased volume reduction (higher RR credit) and/or an increased pollutant removal (higher PR credit), and thus has a higher mass load removal of TP compared to a Level 1 design.

Volume reduction credit assigned to BMPs is based on a number of physically based processes: water storage, infiltration, and extended filtration. Volume reduction credit is assigned to practices that store water within the practice itself. The stored water is available for plant uptake, evaporation, and adsorption. Some of this stored water may later be released and infiltrated into the native soils or into an underdrain system. The slow release of water via an underdrain receives (extended filtration) volume reduction credit because of the delayed delivery of stormwater to the downstream stormwater conveyance system. The slow release of stormwater from a BMP through the underdrain is similar to stormwater discharging to a stream through an undisturbed soil matrix, thus mimicking predevelopment hydrology. The magnitude of these processes is used part in determining if a BMP receives Level 1 or Level 2 designation.

A number of BMPs were incorporated into the VSMP Regulations (9VAC25-870-63) to help achieve water quality compliance after ESD is considered. Even though the water quality treatment volume is only a fraction of the total volume associated with stream protection and/or flood protection water quantity storm events, the volume reduction provided by RR BMPs assists with water quantity compliance. This benefit is the connection between meeting water quality requirements and replicating predevelopment hydrological processes.

Table 1. Best Management Practices (BMPs)

Practice	Volume Reduction (RR Credit)	Pollutant Removal (PR Credit)	Design Levels	Minimum Groundwater Separation Required (ft)
Rooftop Disconnection	X		No	2
Sheet Flow to COS/VFS[a]	X		No	2
Grass Channels	X	X	No	2
Soil Amendments			No	1.5
Green Roofs	X		Yes	N/A
Rainwater Harvesting	X		No	N/A
Permeable Pavement	X	X	Yes	2
Infiltration	X	X	Yes	2
Bioretention	X	X	Yes	2[b]
Dry Swales	X	X	Yes	2
Wet Swales		X	Yes	0
Constructed Wetlands		X	Yes	N/A
Wet Ponds		X[c]	Yes	N/A
Filtering Practice		X	Yes	2
Extended Detention Pond	X[d]	X	Yes	2
Manufactured Treatment Devices		X	No	N/A

[a] COS means Conserved Open Space, VFS means Vegetative Filter Strip
[b] Vertical groundwater separation distance reduced in Coastal Plain areas
[c] PR credit reduced when practice intercepts groundwater
[d] Only Level 2 receives RR credit

Constraints on BMP Performance

Physical constraints, such as a SHGT, karst geology, bedrock, and fill material, may alter the volume reduction credit assigned to the BMPs listed on the Virginia Stormwater BMP Clearinghouse. Appendix A presents physical constraints that may restrict or prohibit the use of certain BMPs. These physical constraints influence the ability of water to infiltrate into the surrounding soil matrix. When a decrease in infiltration occurs, the volume reduction capability of the practice is compromised.

Practices that depend on infiltration for TP mass load removal credit do so by moving the water into the unsaturated soil zone (i.e., the vadose zone) where physical, chemical, and biological processes occur to reduce the pollutant load of the water. Water treated within the unsaturated soil zone is then transported to either a receiving channel or groundwater. Because practices that rely on infiltration require an unsaturated soil zone, there must be a minimum vertical separation distance between the bottom of the BMP and the groundwater table. A minimum vertical separation distance (see Table 1 above) is established to:

- Ensure that water will flow out of the BMP and into the unsaturated soil zone (i.e., maintain a positive hydraulic gradient);

- Protect groundwater from nutrients, metals, bacteria, and other constituents in water discharged from the BMP; and
- Protect the BMP from flooding. Within the separation zone, a phenomenon called "groundwater mounding" can occur. This phenomenon results from a buildup of water that occurs on top of the groundwater table. If the mound were to build to the elevation of the BMP, then the BMP would flood and no longer be effective.

The National Resources Conservation Service[9] (NRCS) hydrological soil classification also influences the magnitude of the volume reduction credit assigned to BMPs. The classification rates soil infiltration capacity on a scale of low to high. Soils with high infiltration capacity are good candidates for all infiltration practices (e.g., bioretention, permeable pavement, infiltration). Soils with lower infiltration rates either require underdrains with a slow release to the downstream stormwater conveyance system or soil amendments to provide infiltration. Soils with poor infiltration capacities will not permit the BMP to drain within a reasonable amount of time, thus potentially causing the BMP to fail.

Comparisons among State Stormwater Management Approaches

The goal of HJR 587 is to achieve greater flexibility in meeting the stormwater management requirements in areas with a SHGT while protecting downstream waters. In an effort to meet this goal, DEQ considered approaches taken by other states in managing stormwater in areas with a SHGT. In comparing state stormwater management programs, a number of fundamental similarities and differences became apparent.

Important similarities among the state stormwater management programs include the following:

- States have the same overarching goals (e.g., to maintain predevelopment site hydrology, prevent downstream water quality degradation, and prevent downstream flooding and erosion);
- States promote ESD as the preferred means of meeting compliance and support BMP use if compliance cannot be met through ESD; and
- The choice of BMPs available for use is consistent across states primarily because there are relatively few proven designs.

[9] For additional information concerning the NRCS soil survey classification system, see the NRCS Web Soil Survey website at http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm.

There are also significant differences among the state approaches, from which DEQ can gain valuable insights and learn of other potential options for managing areas with a SHGT. Some distinctions include the following:

- Whereas all states have the same overarching goals, the criteria used to show whether or not sites are in compliance vary greatly. Many states rely on the control of stormwater volume and peak runoff rates to determine compliance;
- States often award different volume and/or pollutant removal credits for the same BMP. For example, volume credits assigned to BMPs by different states often vary depending on BMP design characteristics; and
- States contrast in their application of criteria. Some states apply their criteria across the entire state, whereas other states have established regional criteria.

This report highlights five state programs that utilize approaches for Virginia's consideration in managing stormwater in areas with a SHGT.

Minnesota

The Minnesota Stormwater Management Program acknowledges that there are situations where it is not feasible to reduce the volume of stormwater runoff leaving a new development, re-development, or linear development site and thus has established three alternative feasible treatment options (FTO) or performance goals for sites with various restrictions[10]:

- FTO 1: Achieve at least 0.55 inch volume reduction and remove 75 percent of the annual TP load.
- FTO 2: Achieve volume reduction to the maximum extent practicable (determined by local authority) and remove 60 percent of the annual TP load.
- FTO 3: Off-site mitigation can be used.

Individuals proposing projects are instructed to answer a series of questions to determine whether or not a site has any restrictions (factors that prevent the site from attaining a performance goal), and depending on the site conditions, determine which treatment option needs to be met. For a site with the restriction of a shallow groundwater table, a detailed site investigation, including borings and consultations with experts, is to be made. To determine which performance goal to meet, applicants are to use the site information obtained and answer the following questions:

1. Is there a distance of more than 3 feet of soil depth (more than 10 feet preferred) from the bottom of the BMP to groundwater? (If yes, meet FTO 1. If no, continue.)

[10] For more information, see the website of the Minnesota Pollution Control Agency, available at http://stormwater.pca.state.mn.us/index.php/Performance_goals_for_new_development,_re-development_and_linear_projects.

2. Is BMP relocation feasible on the site to avoid shallow groundwater? (If yes, meet FTO 1. If no, continue.)
3. Can the BMP be raised? (If yes, meet FTO 1. If no, continue)
4. Is it feasible to meet FTO 2? (If yes, meet FTO 2. If no, meet FTO 3)

When FTO 2 is to be met, applicants must provide soil borings or a report from a professional geologist or geotechnical engineer. Infiltration practices are not allowed at sites meeting FTO 2. When FTO 3 is to be met, applicants must provide the site survey, maps, regulations, and/or cost estimates to show that meeting the other two alternative treatment options is not feasible.

Maryland

Maryland acknowledges that the Code of Maryland Regulations for stormwater management could be infeasible at some sites due to various site constraints. Therefore, the *Maryland Stormwater Design Manual*[11] recommends that ESD be used to the maximum extent practicable to meet an equivalent of the required runoff reduction. The manual establishes unified sizing criteria for water quality, recharge, channel protection, overbank flood control, and extreme flood management but also allows for flexibility. Maryland makes allowances within the criteria for geographical differences and site conditions. For example, Maryland established eastern and western rainfall zones with different average annual rainfall depths for use in determining water quality volumes (storage needed to capture and treat runoff from 90 percent of the average annual precipitation). Maryland also decreases the minimum groundwater separation distance to 2 feet for the Eastern Shore, instead of 4 feet which is required for the remainder of the state. The channel protection storage volume requirement does not apply to direct discharges to tidal waters or Maryland's Eastern Shore. To meet the overland flood protection volume requirements, hydrological models are used for determining peak discharge rates, and in this process, the Eastern Shore Dimensionless Hydrograph may be used for sites when appropriate. Whereas the guidance provides options for calculations used, implementation lies within local control so that adjustments for unique land features are determined by the local approving authority.

Georgia

The stormwater management program in Georgia takes a regional approach whereby it provides management tools to the state's 24-county coastal region, an area where a SHGT is common. These tools consist of the *Coastal Stormwater Supplement* (CSS) to the *Georgia Stormwater Management Manual*, a corresponding Microsoft Excel spreadsheet that is consistent with the CSS, a model stormwater ordinance for the coastal region, a stormwater utility manual for local governments, and a stormwater BMP monitoring protocol.[12] The CSS promotes an integrated

[11] The *Maryland Stormwater Design Manual* is available at http://www.mde.state.md.us/programs/water/stormwatermanagementprogram/marylandstormwaterdesignmanual/Pages/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.aspx.
[12] For more information, see the Georgia Environmental Protection Division website at https://epd.georgia.gov/georgia-epd-coastal-stormwater-supplement-stormwater-management-manual.

approach through the protection of natural resources, stormwater management, and site design. Although the CSS provides guidance to local authorities, it does not carry regulatory weight. Instead, localities within the coastal region are encouraged to use the information in the CSS to establish local codes and ordinances to regulate new development and re-development projects.

Delaware

The draft Delaware Sediment and Stormwater Regulations[13] focus on volume control for water quality and quantity compliance. One aspect of interest is the extensive offset provisions that the draft regulations offer if the water quality volume reduction criteria cannot be achieved. The offset options include fees-in-lieu of, trading, retrofitting previously unmanaged sites, mitigation, construction of off-site management measures, banking, or other similar techniques accepted by the Department of Natural Resources and Environmental Control, Division of Watershed Stewardship or a local agency. In order to implement the offset program, a maximum extent practicable (MEP) determination must be submitted that meets MEP thresholds. If the thresholds are exceeded based on BMP construction costs and other factors then the offset may be granted. This cost-based approach compares site costs to comply with a value that the state determines to be the maximum that a site should spend. If the expected site expenses to comply with the regulations exceeds the threshold value, then offset approaches are allowed.

New York

New York's stormwater program focuses on volume reduction. It is similar to Maryland's program in that New York also offers a unified stormwater sizing criteria for water quality, runoff reduction, channel protection, overbank flood control, and extreme flood management. However, unlike Maryland, New York requires 100% of the runoff reduction volume be infiltrated on site.

New York's stormwater program includes a required planning process that must be followed when addressing stormwater management in new development and redevelopment projects. Its *2015 Stormwater Management Design Manual*[14] outlines this five-step approach:

1. Conduct site planning to preserve natural features and reduce impervious cover;
2. Calculate the water quality volume for the site;
3. Incorporate runoff reduction techniques and standard stormwater management practices (SMPs) with Runoff Reduction Volume (RRv) capacity;
4. Use standard stormwater management practices (SMPs), where applicable, to treat the portion of water quality volume not addressed by runoff reduction techniques and standard SMPs with RRv capacity; and,

[13] For additional information concerning the Delaware Sediment and Stormwater Regulations see their website at http://www.dnrec.delaware.gov/swc/pages/sedimentstormwater.aspx.
[14] The *2015 Stormwater Management Design Manual* is available at http://www.dec.ny.gov/chemical/29072.html.

5. Design volume and peak rate control practices where required.

During the SMP selection phase, designers are to identify site considerations that may restrict the use of a practice. For example, the designer is to determine if the water table at a particular development site might limit the use of a SMP. To aid in this process, the design manual includes the minimum depth to the seasonally high water table from the bottom elevation, or floor, of a practice. If the SHGT limits the use of runoff reduction practices so that the site cannot meet compliance, New York Stormwater Regulations state that a minimum RRv be calculated and achieved.

Modifications to BMPs and Other Compliance Options

Part of the purpose of HJR 587 is to determine if the existing BMP design specifications can be amended for use in areas with a SHGT and thereby achieve greater flexibility for these areas in complying with the VSMP Regulations. Please note that many of the BMPs listed in the VSMP Regulations already include modifications to the design specifications that can be applied to areas within a SHGT. For example, the vertical groundwater separation distance for bioretention may be reduced to 1 foot in coastal plain areas (see Table 1 above). The challenge moving forward is to determine if any additional BMP design modifications have the potential to provide volume and TP load reduction credit without compromising the overall BMP functionality.

Other tools are available within the Virginia Stormwater Management Program to achieve compliance in addition to the previously discussed BMP design modifications. These tools include:

- Treatment trains consisting of at least two BMPs placed in series where the upstream practice discharges to the downstream practice. Any volume or pollutant (e.g., total phosphorus) not treated by the upstream practice is passed on to the downstream practice for additional treatment. Usually, the second practice in a series will also have an additional area draining to it. The most effective combinations of BMPs in series are when the removal processes differ between the practices.
- Off-site compliance options, including the use of nonpoint source nutrient offsets is another possible means to comply with the VSMP Regulations.[15]

Continuation of Literature Review

Much has been gained during this year of study. Information on approaches used by other states provides options for Virginia to consider. Literature research in this area will continue in year

[15] See § 62.1-44.15:35 of the Virginia Stormwater Management Act. For additional information on how the nutrient credit trading program works, visit the DEQ website at http://www.deq.virginia.gov/Programs/Water/PermittingCompliance/PollutionDischargeElimination/NutrientTrading.aspx.

two of the study. Most of the literature read this year acknowledges the importance of infiltration as the dominant process for volume reduction; however, inclusion of evaporation, transpiration, and interception may lead to an increase in volume reduction credit. Additional investigation of this approach is planned for the coming year. This continued effort could lead to a refinement of the volume reduction credit assigned to specific BMPs. For example, it could provide a basis for assignment of volume reduction credit to constructed wetlands and wet ponds, practices that currently receive no volume reduction credit.

Beyond researching possible design modifications to BMPs, possible watershed-specific targets may be another avenue to consider. The use of established models within specific watersheds to determine site targets, as used in some states, could be of benefit to the Commonwealth of Virginia. Other ideas from state programs may provide insight on ways to base the technical criteria on physical characteristics of specific regions.

A third area of further research is to review more recent research studies performed on the specific BMPs listed in the Virginia Stormwater BMP Clearinghouse. By reviewing this information, possible design changes and enhancements could be considered for additional TP mass load reduction credit. This research may also lead to changes in the BMP specification that will compensate for the presence of a SHGT.

Next Steps

The following is a list of tasks to be carried out within the second year of DEQ's study. These tasks will be accomplished concurrently with the ongoing literature review. The tasks include:

- Stakeholders Meeting #1.
    - Discuss and solicit input on HJR 587 report submitted to the Governor and General Assembly in January 2016
    - Identify issues and/or concerns not previously identified by DEQ
    - Solicit experiences previously encountered by stakeholders
- DEQ evaluation of information provided at Stakeholders Meeting #1.
- Develop interim report based upon stakeholder input, DEQ evaluation, and additional DEQ research.
- Stakeholders meeting #2.
    - Discuss and solicit input on draft HJR 587 report due January 2017
- Based upon stakeholder input, finalize HJR 587 report to be submitted January 2017.

Appendix A

BMP Physical Constraints Matrix

BMP Group	Specific BMP	Soils [1]	Water Table Separation	Depth to Bedrock or Shallow Soils	Contributing Drainage Area (ac)	Max. Site Slope [2]	Hydraulic Head (ft)	Karst Geology or Sinkhole	Cold Climate
Runoff Volume Reduction	Rooftop Disconnection	Join with additional runoff reduction practice on C-D soils	2 feet	2 feet	Maximum 1,000 sq. ft. to each roof discharge point	1-2%	1 foot	Preferred	Frozen ground may hinder disposal of water
	Sheet flow to Vegetated Filter or Conserved Open Space	Any soil except fill; best to use w/ compost amendments on C-D soils	2 feet	2 feet	3 max.	6% for open space; 8% for grass filter strip	1 to 2 feet	Preferred	No concerns or needed adaptations
	Soil Compost Amendments	HSG B-D soils	1.5 feet	1.5 feet	Contributing Impervious area should not exceed area of amended soil	10%	1 foot	OK	OK, except for areas used for snow storage
	Vegetated Roof	NA	NA	NA	NA	NA	1 to 2 feet	Preferred	Plan for snow loading and hardy veg. cover
	Rainwater Harvesting	NA	Below-grade tanks must be above water table	Below-grade tanks must be above bedrock	Rooftop (only) area draining to the tank	NA	Varies with purpose and design	Preferred	Locate indoors or under-ground; others should be operated season-ally
Swales & Open Channels	Grass Channel	Must achieve additional res. time (min. 10 minutes) if C-D soils	2 feet	2 feet	5 max.	2-4%	2 to 3 feet	OK [3]	OK
	Dry Swale	Made Soil; must use underdrain if on C-D soils	2 feet	2 feet	5 max.	4%	3 to 5 feet	Preferred [3]	Medium benefit & limitation

BMP Group	Specific BMP	Soils[1]	Water Table Separation	Depth to Bedrock or Shallow Soils	Contributing Drainage Area (ac)	Max. Site Slope[2]	Hydraulic Head (ft)	Karst Geology or Sinkhole	Cold Climate
Filtering Systems	Filtering Practice	NA	2 feet	2 feet	5 max.[4]; 0.5 to 2 preferred	NA	2 to 10 feet	Preferred, but must use impermeable liner	OK if place below frost line and use pretreatment ; Chlorides will move through untreated
	Bioretention 1 (with underdrain)	Made Soil	2 feet	2 feet	5 max.[4]; 0.5 to 2 preferred	1-5%	4 to 5 feet	OK, but must use under-drain and impermeable liner	OK; use salt-tolerant veg. and pretreatment ; Chlorides will move through untreated
Infiltration Practices	Permeable Pavement 1	Must use underdrain on C-D soils	2 feet	2 feet	Ratio of contrib. pavement area to Permeable Pavement area may not exceed 2:1	1-3%	2 to 4 feet	Large-scale or Level 2 Prohibited; Small-scale OK; must have liner and under-drain; extensive pre-treatment required	Limited; Use special design features; Active mgmt needed to prevent infiltration of chlorides and soluble toxics
	Permeable Pavement 2	Minimum measured $f_c > 0.5$ in/hr							
	Infiltration	Minimum measured $f_c > 0.5$ in/hr			< 2, and close to 100% impervious	0-5%	2 to 4 feet		
	Urban Bioretention	NA	2 feet	2 feet	5 max.[4]; 0.5 to 2 preferred	1-5%	4 to 5 feet	Preferred	OK; use salt-tolerant veg. and pretreatment ; Chlorides will move through untreated
	Bioretention 2 (Bioinfiltration, with no underdrain)	Made Soil; use underdrain if C or D[3] base soils	3 feet	2 feet	5 max.[4]; 0.5 to 2 preferred	1-5%	4 to 5 feet	Not Recmd, esp. large scale; extensive pretreatment required	OK; use salt-tolerant veg. and pretreatment ; Chlorides will move through untreated

BMP Group	Specific BMP	Soils [1]	Water Table Separation	Depth to Bedrock or Shallow Soils	Contributing Drainage Area (ac)	Max. Site Slope [2]	Hydraulic Head (ft)	Karst Geology or Sinkhole	Cold Climate
Basins	Wet Swale	Best on HSG C or D soils	Below water table	2 feet below bottom of swale	5 max..	2% thru swale	2 feet	Not Recmd	Medium benefit & limitation
	Constructed Wetland	HSG-A or B soils may require liner	Below water table if no hotspot or aquifer present; otherwise, a 2 foot separation	2 feet below bottom of wetland	25 min. [6]	NA	2 to 4 feet	OK; use impermeable liner; limit depth; geotech. tests needed; max. ponding depth	OK; use salt-tolerant vegetation
	Wet Pond	HSG-A or B soils may require liner	Below water table if no hotspot or aquifer present; otherwise, a 2 foot separation	2 feet below bottom of wetland	25 min. [5]	NA	6 to 8 feet	Not Recmd [6]	OK; limit depth to avoid stratification; adapt outlet structure
	Extended Detention 1	HSG-A or B soils may require liner	2 feet	2 feet	< 10	NA	6 to 10 feet	Not Recmd [6]	OK
	Extended Detention 2				> 10				
Manufactured Treatment Devices	Hydrodynamic Devices	NA	Varies with device; Must have clearance below bottom of device	Varies with device; Must have clearance below bottom of device	Manuf Recmd	NA	Manuf Recmd	OK	Manuf Recmd
	Filtration Devices	NA			Manuf Recmd	NA	Manuf Recmd	OK	Manuf Recmd

KEY: OK = not restricted; WT = water table; PT = pretreatment; f_c = soil permeability

[1] USDA-NRCS Hydrologic Soil Groups (HSGs)

[2] Refers to post-construction slope across the location of the practice

[3] Denotes a required limit, other elements are planning level guidance and may vary somewhat, depending on site conditions

[4] Drainage area can be larger in some instances.

[5] 10 acres may be feasible if ground water is intercepted and/or if water balance calculations indicate a wet pool can be sustained, and an anti-clogging device must be installed

[6] If detention is used, then an impermeable liner must be placed at the bottom of the basin and geotechnical tests should be conducted to determine the maximum allowable depth