

STORMWATER POLLUTANT REMOVAL

3.1 INTRODUCTION

In 1991, the County of Henrico adopted ordinance revisions to incorporate the required components of the Chesapeake Bay Preservation Area (CBPA) Designation and Management Regulations (9VAC10-20 et seq.). One of these required components involves stormwater quality criteria that mandate specific levels of pollutant load reduction from stormwater runoff. Up until June 23, 1993, these criteria were applied to development projects within Chesapeake Bay Preservation Areas. However, on June 23, 1993, application of these stormwater quality criteria was expanded to all areas within the County to satisfy the stormwater quality requirements of the County's Virginia Pollution Discharge Elimination System (VPDES) permit. The criteria included in this Chapter are also authorized by the Virginia Stormwater Management Law (§ 10.1-603.1 et seq. of the Code of Virginia).

As mentioned, the criteria require specific levels of performance and the standards are discussed in Section 3.3. This Chapter provides guidance for calculating the required level of pollutant removal and guidance for complying with the pollutant removal requirement through the use of required best management practices (BMPs). In some cases however, the pollutant removal requirement must be addressed through a contribution to the Environmental Fund as part of the Stream Assessment/Watershed Management Program. The Watershed Program is discussed in Chapter 2 of this Manual. Although the Watershed Program will eliminate the need for some BMPs, on-site BMPs will continue to be required for many proposed developments and will represent a significant means to reduce pollutants from stormwater in the County.

Please note that this Chapter of the Manual is not intended to provide detailed information regarding stormwater management theory, BMP sampling field data, or discussions of the CBPA and VPDES regulations. Numerous manuals, handbooks, etc. are available pertaining to these issues, including *Controlling Urban Runoff* published by the Metropolitan Washington Council of Governments, the *Chesapeake Bay Local Assistance Manual*, *Analysis of Urban BMP Performance and Longevity Manual*, *Guidance Manual for Preparation of NPDES Permit Applications*, and the *Northern Virginia BMP Handbook*. In addition, the Department of Public Works recognizes that stormwater quality management is constantly evolving. Therefore, periodic updates to this Chapter will be necessary to reflect the current technology.

3.2 APPLICABILITY

Other than the exempt activities listed in Section 3.9 of this Chapter, the stormwater quality criteria and resulting pollutant load reductions are applicable to all projects within the

County that result in 2,500 square feet or more of land disturbance. However, there are certain provisions to address “transitional” projects as follows:

1. Projects that obtained final approval prior to November 15, 1991 are required to meet the stormwater quality requirements to the maximum extent practicable, and
2. Projects that obtained and maintained conditional approval (for subdivisions) or plan of development approval by the Planning Commission prior to or at its July 1993 meeting are required to meet the stormwater quality requirements within CBPAs on the project site.

3.3 WATER QUALITY CRITERIA

The following standards of pollutant load reduction are mandated by § 9VAC-10-20-120 of the CBPA Regulations:

1. For development, the post-development nonpoint source pollution runoff load shall not exceed the pre-development load based upon average land cover conditions.
2. Redevelopment of any site not currently served by water quality best management practices shall achieve at least a 10% percent reduction of nonpoint source pollution in runoff compared to the existing runoff load from the site.
3. Post-development runoff from any site to be redeveloped that is currently served by water quality best management practices shall not exceed the existing load of nonpoint source pollution in surface runoff.

The CBPA Regulations also specify the following options for localities to comply with the standards:

1. Incorporation on the site of best management practices that achieve the required control;
2. Compliance with a locally adopted regional stormwater management program incorporating pro-rata share payments pursuant to the authority provided in § 15.2-2243 of the Code of Virginia that results in achievement of equivalent water quality protection;
3. Compliance with a state or locally implemented program of stormwater discharge permits pursuant to § 402(p) of the federal Clean Water Act, as set forth in 40 C.F.R. Parts 122, 123, 124, and 504; and
4. For a development site that is completely impervious as currently developed, restoring a minimum 20% of the site to vegetated open space.

For purposes of calculating the pollutant loads necessary to evaluate compliance with the standards, the Simple Method is used. This procedure is described in the ***Chesapeake Bay Local Assistance Manual*** and its derivation can be found in Appendix A of

Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. In addition, the average land cover condition used for the County is assumed to be 16 percent impervious and phosphorus is considered the keystone pollutant. Subsequently, the flow-weighted mean pollutant concentration factor is 0.26 mg/l.

3.4 DEVELOPMENT SITUATIONS

In order to determine the correct standard and to assist the applicant with compliance with the standards, several development situations have been developed that describe the project characteristics (impervious percentages, etc.) and the pollutant removal requirement based on the appropriate pollutant load reduction standard. All proposed development projects will be described by one of these development situations.

3.4.1 SITUATION ONE

Situation One describes land development projects in which the existing impervious cover (I_{exist}) is less than or equal to 16% and the proposed improvements will create a total impervious cover (I_{post}) that is less than 16%. There is no pollutant removal requirement (RR) for this situation. Worksheet 3.01 is used for this situation and must be completed and included with the plan submittal.

3.4.2 SITUATION TWO

Situation Two describes land development projects in which the existing impervious cover (I_{exist}) is less than or equal to 16% and the proposed improvements will create a total impervious cover (I_{post}) that is greater than 16%. The pollutant removal requirement (RR) for this situation is equal to the difference between the pre-development pollutant loading (L_{pre}) and the post-development pollutant loading (L_{post}) amounts (take pre-development loadings at 16% impervious cover). Worksheet 3.02 is used for this situation and must be completed and included with the plan submittal.

3.4.3 SITUATION THREE

Situation Three describes land development projects in which the existing impervious cover (I_{exist}) is greater than 16%. The pollutant removal requirement shall be the smaller of the following:

1. The post-development pollutant loading (L_{post}) minus 90% of the existing polluting loading, or
2. The post-development pollutant loading (L_{post}) minus the pollutant loading associated with 16% impervious cover (L_{16}) over the site.

Worksheet 3.03 is used for this situation and must be completed and included with the plan submittal.

Usually, the pollutant removal requirement for this situation will be determined using the area of the parcel as the project area. However, for small projects on large, previously developed parcels, a portion of the parcel may be designated as a “planning area” to be serve as the project site. **Planning area** means a designated portion of the parcel on which the land development project is located. Planning areas shall be established by delineation on a master plan. Once established, planning areas shall be applied consistently for all future projects.

If proposed, planning areas must be delineated on an overall plan for the parcel and the delineation must be included with the POD. Upon approval by the Department of Public Works, planning areas must be applied consistently for all future projects on the parcel.

Note this planning area serves only as the basis for calculating the pollutant removal requirements for a project. The designation of planning areas neither redefines nor replaces any other designations established or required by other departments or agencies.

3.4.4 SITUATION FOUR

Situation Four describes land development projects in which the existing impervious cover is served by an existing stormwater management BMP(s) that addresses water quality. The post-development pollutant loading must not exceed the net existing pollutant loading (the existing pollutant loading minus the load removed by the BMP). The existing BMP must be shown to have been designed and constructed in accordance with proper standards and specifications, and to be in proper functioning condition. Worksheet 3.04 is used for this situation and must be completed and included with the plan submittal.

3.4.5 SITUATION FIVE

Situation Five describes land development projects in which the existing impervious cover is greater than 16% and the proposed development (additional impervious cover and impervious cover that will replace existing impervious cover) is less than or equal to 10% of the existing impervious cover on the site. This development shall be considered "insignificant". The pollutant removal requirement (RR) for this situation is equal to the pollutant load produced by the proposed development (additional impervious cover and impervious cover that will replace existing impervious cover). There is no additional 10% requirement for the remainder of the site. Worksheet 3.05 is used for this situation and must be completed and included with the plan submittal.

Multiple "insignificant" development projects must comply with other appropriate standards once the cumulative amount of the projects has become greater than 10% of the original site.

3.4.6 OTHER DEVELOPMENT SITUATIONS

The removal requirement for land development projects (out parcels, etc.) where the overall project (i.e. shopping center) was approved prior to water quality requirements is the load created by the difference between the amount of impervious cover that was originally approved and the amount of impervious area that is proposed.

The removal requirement for land development projects (out parcels, etc.) where the water quality requirements were covered with the overall project (i.e. shopping center) and the proposed project is more impervious than what was approved with the original project is the load created by the difference between the amount of impervious cover that was originally approved and the amount of impervious area that is proposed.

In order to determine the correct standard and to assist the applicant with compliance with the standards, several worksheets and forms have been developed and are included in this manual.

In an effort to expedite plan approval, the County will no longer accept calculation methods which deviate from the ones found in this Chapter, unless approved by the County Engineer.

3.5 COMPLIANCE WITH THE POLLUTANT REMOVAL REQUIREMENT

Depending on the characteristics of the project and the Watershed Management Area in which the project is located, compliance with the calculated pollutant removal requirement is achieved in one of following ways:

1. Contribute to the Environmental Fund, or
2. Provide a BMP that achieves the pollutant removal requirement, or
3. Compliance with a state or locally implemented program of stormwater discharge permits pursuant to § 402(p) of the federal Clean Water Act, as set forth in 40 C.F.R. Parts 122, 123, 124, and 504.

In order to determine the required method of compliance with the pollutant removal, refer to Section 2.7 of this Manual. Guidance for contribution to the Environmental Fund is also included in Chapter 2.

If the pollutant removal requirement must be achieved by providing a BMP, compliance with the requirement must be indicated on Worksheet 3.06. Note that pollutant removal credit is provided for those projects that provide a forested Stream Protection Area in accordance with Minimum Standard 9.10 and energy dissipators in accordance with Minimum Design Standard 9.01. This removal credit is also calculated on Worksheet 3.06.

3.6 BEST MANAGEMENT PRACTICES

There are many types of best management practices (BMPs) that the County has determined are acceptable methods of stormwater pollutant removal. However, no single BMP is suited for every situation and each type has limitations, advantages and disadvantages relating to efficiencies, space, maintenance requirements, etc. In addition, County policy and the design criteria included in this Manual may preclude certain BMPs from being acceptable options for specific projects.

3.6.1 BMP POLLUTANT REMOVAL EFFICIENCIES

The specific design criteria for the various types of BMPs are included in the Minimum Design Standards of Chapter 9. However, Table 3.1 lists the various types of BMPs, design variations and their respective phosphorus removal efficiency. BMPs must be designed based on these efficiencies and shall be located and maintained to effectively reduce the pollutant load to the required level.

Acceptable BMP		Average Total Phosphorus Removal Efficiency	With 10% Additional Volume In Forebay
Minimum Design Standard	Description/Design		
MS 9.02	Grassed Swale	20%	25%
MS 9.03	Extended Detention Basin		
	Design 1 – 1 x WQV detained 12 hours	20%	25%
	Design 2 – 2 x WQV detained 30 hours	30%	35%
	Design 3 – 2 x WQV detained 40 hours	35%	40%
MS 9.04	Extended Detention with Shallow Marsh 2 x WQV detained 30 hours	50%	55%
MS 9.05	Retention Basin (Wet Pond)		
	Design 1 – 1 x WQV	35%	40%
	Design 2 – 2.5 x WQV	40%	45%
	Design 3 – 4 x WQV	50%	55%
	Design 4 – 10 x WQV	65%	
	Design 5 – 4 x WQV with Wetland System	65%	
MS 9.06	Bioretention Basin		
	Design 1 – 1 x WQV	50%	
	Design 2 – 2 x WQV	65%	
MS 9.07	Sand Filter		
	Delaware Sand Filter	65%	
	All Other Sand Filters	40%	
MS 9.08	Infiltration Trench	20%	

WQV = ½” of runoff per impervious acre

Although all extended detention and retention basins require forebays, the basin may achieve an additional 5% removal efficiency if the required forebays provide 10% additional volume.

Where a method or facility without an efficiency rating is proposed, the designer must adequately substantiate the rating before the design will be considered for approval.

BMPs may be constructed in series; however, the maximum combined pollutant removal efficiency recognized by the County of Henrico is 65%. Henrico County uses a maximum phosphorus removal efficiency of 65% for both individual BMPs and BMPs in series. Phosphorus in urban runoff is approximately 60% particulate form and 40% soluble form. Settling is the principal mechanism used by BMPs to remove pollutants and therefore, the soluble phosphorus remains in runoff after treatment by a BMP.

Table 3.1

3.6.2 GENERAL DESIGN GUIDELINES

All proposed projects required to comply with the stormwater quality criteria must address the following general design guidelines:

1. Stormwater management (SWM) addresses the quantity of runoff, while Best Management Practices (BMPs) address the quality of runoff. While there are differences between the performance criteria, the two management strategies will often be employed within the same structure or facility. Standards which apply to one set of performance criteria shall not lessen the performance criteria of the other.
2. If both quantity and quality management are provided within the same facility, the final design shall ensure that the performance criteria and maintenance are compatible.
3. Pollutant loadings shall be determined by the calculation methods set forth in this manual.
4. For development incorporating an existing BMP, basin, or pond, the engineer shall certify that the facility is in good working order and performing at the necessary level of service and provide supporting calculations/information as necessary.
5. Underground structures detaining flows and not providing infiltration, or not documented to reduce pollutant loads, shall not be allowed as BMPs.
6. Volume control BMPs, such as porous pavement and modular pavement, are recognized as difficult to maintain, are subject to high rates of failure, and are not accepted as BMPs unless approved by the Director of Public Works.
7. Gravel parking areas which are subject to vehicular traffic and subsequent compaction shall be considered as impervious.
8. Maintenance activities such as repaving a previously approved or legally "nonconforming" impervious area shall not be considered as development when calculating the pollutant removal requirement.
9. Subdivisions which are to be submitted in phases (Section A, Section B, etc.) must address stormwater quality and quantity (where applicable) for the entire subdivision as part of the first phase submittal. BMP calculations, location(s), and design option(s) must be identified on an overall subdivision plan and approved by the Department of Public Works prior to any phase plan approval. The BMP must be constructed during the phase that increases the impervious cover for the subdivision to 16% or greater.
10. The Water Quality Volume may not be stored in any County maintained easements or rights-of-way. It is recommended that privately maintained systems should consider using O-ring pipe in situations where the storm sewer will be temporarily inundated. O-ring pipe must be installed on non-County maintained storm sewer systems that will permanently hold the Water Quality Volume.

3.6.3 BMP LOCATION

Proposed BMPs must be located to adhere to the following siting constraints:

1. A BMP must meet minimum front yard setback requirements from the public right of way. The setback for the BMP is measured as the distance from the highest continuous contour elevation inside the BMP to the ultimate right of way line. These setbacks are identified below:
 - a. Residential Zoned Districts (all “R” Districts including A-1) - The BMP must honor the setback specified for the primary dwelling.
 - b. Non-residential Zoned Districts - The BMP must honor a minimum setback of 25 feet from the ultimate right of way.
2. A distance equivalent to the rear yard setback in residential development must be provided from the rear of the buildable area to the highest continuous contour elevation inside the BMP.
3. The BMP must be located outside all transitional or proffered buffer areas or planting strip easements.
4. If highly visible from the public right of way, the BMP shall be effectively screened from the public right of way or less intense uses of adjacent properties. Examples of acceptable screening include fencing, landscape hedging or a combination of these features.
5. Infiltration trenches, sand filters, and wet ponds are not permitted in any single family residential development. Regional wet ponds and existing ponds are allowed in residential development under certain conditions. BMPs can not be located within the limits of the Resource Protection Area (or the 100' buffer) or the Stream Protection Area unless:
 - a. There are no other reasonable alternatives, and
 - b. The encroachment is the absolute minimum necessary to site the BMP. BMPs can not be located in the lower (seaward) 50 feet of the RPA buffer or in the lower (seaward) 35 feet of the SPA , and
 - c. Buffer equivalency has been provided in accordance with the Chesapeake Bay Local Assistance Manual for impacts to the RPA buffer.
6. BMPs may be located within the 100-year floodplain, however, they must be located outside the 25-year floodplain.
7. In general, BMP facilities for subdivisions shall be extended detention ponds (with or without a shallow marsh). Draw down time for extended detention ponds shall not exceed 30 hours in subdivisions. These BMPs shall be located in the rear yard of all residential units or in a common area controlled and maintained by a homeowners association. The BMP must be a minimum of 20 feet from the principal structure.

3.6.4 BMP ACCESS

In general, all BMPs shall be designed to provide adequate access for maintenance activities. However, the following specific provisions must be met for all County maintained BMPs:

1. An access easement around the BMP facility is required. In addition, BMP facility easements shall be provided to adequately contain the 10-year ponding level (plus six inches of freeboard), embankment, outlet structures, and an appropriate width (minimum 12 feet) of maintenance area around the 10-year ponding area that permits access to the dam, outlet structures, and embankments.
2. Access to a BMP facility shall be contained within an easement of not less than twenty (20) feet in width and shall not exceed a grade or cross-slope of 12:1. The easement must either be in a common area or located completely on a lot (not split by a property line).
3. The access easement shall not have any obstacles, vegetation, or cross-slopes that would prevent ease of access for maintenance equipment.
4. A 12' minimum access should be provided for maintenance capabilities for all dams and inlet and outlet structures.
5. A 12' easement is required from the downstream toe of slope or from the limits of cut on an excavated basin.

3.6.5 BMP MAINTENANCE

Periodic maintenance of BMPs is required and inspections will be conducted to determine whether the facilities are being maintained. All BMPs constructed in the County must have a maintenance agreement on file with the Department of Public Works and recorded in the Circuit Court Clerk's Office, regardless of whether long term maintenance is provided by the County. A copy of the required maintenance agreement is included in the Appendix of this Manual.

For BMPs in subdivisions for which the County collected \$100.00 per lot prior to recordation, the County will provide long term maintenance (i.e. dredging) of extended detention basins and shallow marsh basins. Short term maintenance of basins (grass cutting, trash pick-up) shall be provided by the developer or Homeowners' Association. This also applies to zero lot line developments.

For BMPs on POD and certain subdivisions that did not contribute \$100.00 per lot prior to recordation, maintenance of the BMPs is the responsibility of the owner or Homeowners' Association. This includes short term (i.e. grass cutting, trash pick-up) as well as long term (i.e. dredging) maintenance activities. All designs must address potential maintenance problems as part of the submittal.

3.6.6 EXISTING WET PONDS

Existing wet ponds in single-family residential subdivisions are permitted to remain in place; however, the subdivision must be designed in such a manner that the existing pond meets each of the following criteria:

1. The pond must be located in a common area, and
2. There must be a minimum of 50 feet between any buildable area and the normal pool elevation of the pond, and
3. All access and easement requirements must be met, and
4. The pond must be an amenity for the entire subdivision, and
5. In order to use an existing wet pond as a BMP:
 - a. The pond must meet the design criteria included in Minimum Design Standard 9.05, and
 - b. A letter from the U.S. Army Corps of Engineers must be submitted stating the pond can be maintained as a BMP and that either a permit would not be required or a permit would be issued for such maintenance activity.

3.6.7 SAFETY DESIGN

The design of the BMP shall contain any features necessary to eliminate safety concerns for the public. For example, guardrail may be required due to the proximity of the BMP to vehicular traffic. The Director of Public Works reserves the right to deny approval of any BMP facility in a single family residential development which is deemed to be a potential nuisance or hazard.

3.6.8 BMP INSPECTION

BMPs will be inspected at two phases of construction - "rough grading" and "final conformance". The developer, the developer's engineer, and County staff should be present at these inspections. Prior to final acceptance by the County, a letter of conformance may be required from the developer's engineer. These inspection requirements are incorporated into the County's standard Erosion and Sediment Control plan sheet.

3.6.9 FIELD CONDITION CHANGES

Prior to final acceptance, the County will determine whether the BMP has been built in accordance with the approved plans. If discrepancies between the designed and "as-built" BMP exist, they must be addressed. If these discrepancies cannot be corrected in accordance with the approved plan, a revised plan may be required.

Proposed BMP revisions that alter the type of BMP may need to be reviewed by the Planning Commission. For example, if during construction springs were encountered and the previously approved dry basin design needs to be changed to a shallow marsh, approval must first be obtained from the Planning Commission.

3.7 EXEMPTIONS

The following activities are exempt from the requirements of this Chapter:

1. Minor land disturbing activities involving less than 2,500 square feet of land disturbance.
2. Agricultural and silvicultural operations as outlined in Chapter 10 and Chapter 24 of the Code of the County of Henrico Virginia.
3. Surface mining, exploration or drilling operations as exempted in Chapter 10 of the Code of the County of Henrico Virginia.
4. Individual utility connections and/or the maintenance of utility lines.
5. Other applicable exemptions as identified in Chapter 10 of the Code of the County of Henrico Virginia.

3.8 WAIVERS

The Director of Public Works may consider granting a waiver of the stormwater quality requirements for the following:

1. Single family developments which involve three lots or less, with an aggregate impervious area less than 25 percent.
2. Applicable waivers for Chesapeake Bay Preservation Areas identified in Chapter 24 of the Zoning Ordinance (§ 24-106.3).
3. Inadequate site availability for a suitable BMP structure, as determined by the Director of Public Works. The waiver request shall include technical documentation and computations necessary to support the request.
4. If full compliance with the pollutant removal requirement is demonstrated to be unachievable, the portion that cannot be achieved by the proposed BMP(s) shall be accomplished through a contribution to the Environmental Fund. However, the pollutant removal that is not achieved must be less than the pollutant removal requirement associated with 25% impervious coverage ($L_{25\%} - L_{16\%}$) on the site.

All requests for waivers must be submitted in writing to the Director of Public Works and sent to the attention of the County's Review Engineer.

The Director of Public Works, in conjunction with the Director of Planning, or on appeal to the County Manager, may consider exceptions to the BMP location guidelines. An exception may be considered only after a conceptual landscaping plan for the BMP and surrounding area is provided in accordance with Minimum Design Standard 9.12 found in Chapter 9 of this Manual. The exception request shall be such that the BMP provides only the minimum encroachment necessary and does not adversely affect:

1. The aesthetic appearance and value of the development.
2. The visibility or value of abutting or adjacent properties.
3. The health, safety and welfare of persons residing on, working on, or visiting the premises.
4. Traffic or pedestrian safety.
5. The improvement or maintenance of the abutting public right of way.

3.9 PLAN SUBMITTAL REQUIREMENTS

A plan shall not receive final approval from the Department of Public Works unless it includes the manner in which the pollutant requirement resulting from the project will be addressed. The following items and information must be submitted prior to final approval:

1. For projects required to provide a BMP to address the pollutant removal requirement, BMP design shall be submitted as part of the site development plans, including, but not limited to:
 - a. Calculations, assumptions, and criteria used in the design of the BMP, plans, and profiles.
 - b. Plans and profiles, including horizontal and vertical controls, elevations, sizes, slopes, and materials.
 - c. Location, dimensions, and design details required for each BMP facility, as specified in the corresponding sections of this manual.
 - d. A map of the drainage area served by the BMP.
 - e. Depth to high water table or seasonal high water table, percolation tests, and calculations for gravel trenches or pits proposed to incorporate infiltration into soil. The Department of Public Works reserves the right to require additional calculations and/or information which may be necessary to evaluate the design of the facility.
 - f. Additional plan requirements as identified in Chapter 10 (E&S Ordinance) and Chapter 24 (Zoning Ordinance).
 - g. For each BMP proposed, the BMP Information Summary Chart found in the Appendix of this Manual must be completed.
 - h. Topsoil, sodding or other measures and techniques should be specified as a part of the BMP design to ensure that a healthy mature stand of vegetation is established **immediately** after grading for the BMP/Sediment basin.
 - i. Fencing, landscaping, ground cover and other measures and techniques should be specified as part of the BMP design to provide adequate screening of the BMP structure.
2. All submittals must include the calculations for the pollutant removal requirement on the plans. If the calculations indicate that pollutant removal is required, a

compliance worksheet must also be included. If the pollutant removal requirement is met by a BMP, a BMP design worksheet must be shown on the plans as well.

3. In addition to the information listed in items 1 and 2 above, proposals for the construction of extended detention basins without shallow marshes and wet ponds must also include the following:
 - a. Adequate information to prove all design criteria in Minimum Design Standards 9.03 found in Chapter 9 of this Manual (Extended Detention Basins) and 9.05 found in Chapter 9 of this Manual (Retention Basins) have been met.
 - b. Calculations of the BMP stage-storage, including elevation, area, incremental volume, and the cumulative volume in cubic feet.
 - c. Composite discharge curve developed by comparing the inlet control of all the individual structures comprising the basin outfall and the outlet control of the discharge structure. If the BMP discharges to a swale or channel, the outlet control analysis needs to consider the effects of tailwater. If the BMP discharges to a storm sewer system, the outlet control analysis should be based on the hydraulic grade line.
 - d. Calculations of the 10-year and 100-year post-developed flows.
 - e. Analysis of the 10-year and 100-year post-developed flows through the basin.
 - f. Water surface elevations of the water quality volume and the 10-year and 100-year post-developed flows.
 - g. Detail of BMP outlet structure with all information shown. (Inverts, lengths, widths, slopes, weir elevations, top elevations, etc.)
 - h. Spillway capacity analysis if a spillway is utilized.
 - i. Basin length, width, and slopes labeled on the plan (e.g. 3:1, 4:1).
 - j. Access to and around the BMP identified.

4. In addition to the information listed in items 1, 2, and 3 above, proposals for the construction of extended detention basins with shallow marshes must also include the following:
 - a. All information needed for extended detention ponds.
 - b. Soils information.
 - c. Marsh planting plan (see Minimum Design Standard 9.04).

WORKSHEET 3.01 - SITUATION ONE

Compile existing site-specific data and determine existing site imperviousness (I_{EXIST}). For the purposes of these calculations, site area (A_{SITE}) is defined as the entire parcel. A_{EXIST} represents the actual amount of existing impervious cover on the site.

A_{SITE}	=	_____ acres	
A_{EXIST} structures	=	_____ acres	
parking lot	=	_____ acres	
roadway	=	_____ acres	
other	=	_____ acres	
Total A_{EXIST}	=	_____ acres	
I_{EXIST}	=	($Total A_{EXIST} \div A_{SITE}$) x 100	
I_{EXIST}	=	_____ % (expressed in whole numbers)	

Compile post-development site-specific data and determine post-development site imperviousness (I_{POST}). For the purposes of these calculations, site area (A_{SITE}) is defined as the entire parcel. A_{POST} represents the actual amount of impervious cover on the site once the proposed development is complete.

A_{SITE}	=	_____ acres	
A_{POST} structures	=	_____ acres	
parking lot	=	_____ acres	
roadway	=	_____ acres	
other	=	_____ acres	
Total A_{POST}	=	_____ acres	
I_{POST}	=	($Total A_{POST} \div A_{SITE}$) x 100	
I_{POST}	=	_____ (expressed in whole numbers)	

If $I_{EXIST} \leq 16\%$ and $I_{POST} \leq 16\%$, STOP. There is no pollutant removal requirement. Otherwise, refer to Section 3.4 of the Manual for development situation determination.

WORKSHEET 3.02 - SITUATION TWO

Compile existing site-specific data and determine existing site imperviousness (I_{EXIST}). For the purposes of these calculations, site area (A_{SITE}) is defined as the entire parcel. A_{EXIST} represents the actual amount of existing impervious cover on the site.

A_{SITE}	=	<u> </u> acres
A_{EXIST} structures	=	<u> </u> acres
parking lot	=	<u> </u> acres
roadway	=	<u> </u> acres
other	=	<u> </u> acres
Total A_{EXIST}	=	<u> </u> acres
I_{EXIST}	=	$(Total\ A_{EXIST} \div A_{SITE}) \times 100$
I_{EXIST}	=	<u> </u> % (expressed in whole numbers)

Compile post-development site-specific data and determine post-development site imperviousness (I_{POST}). For the purposes of these calculations, site area (A_{SITE}) is defined as the entire parcel. A_{POST} represents the actual amount of impervious cover on the site once the proposed development is complete.

A_{SITE}	=	<u> </u> acres
A_{POST} structures	=	<u> </u> acres
parking lot	=	<u> </u> acres
roadway	=	<u> </u> acres
other	=	<u> </u> acres
Total A_{POST}	=	<u> </u> acres
I_{POST}	=	$(Total\ A_{POST} \div A_{SITE}) \times 100$
I_{POST}	=	<u> </u> (expressed in whole numbers)

If $I_{EXIST} \leq 16\%$ and $I_{POST} > 16\%$, proceed to calculation of pollutant loadings. Otherwise, refer to Section 3.4 of the Manual for correct development situation determination.

Calculate the pre and post-development pollutant loadings for the site using the Simple Method.

$$L = P \times P_J \times [0.05 + (0.09 \times I)] \times C \times A \times 2.72 / 12$$

Where:

P_J	=	unitless rainfall correction factor
	=	0.9 for all of Tidewater, Virginia
P	=	annual rainfall depth in inches
	=	43 for the Richmond Metropolitan Area
C	=	flow weighted mean concentration of total phosphorus
	=	0.26 mg/l for the entire County
$I_{WATERSHED}$	=	average land cover condition of the Bay watershed
	=	16 percent

Calculate the pre-development load (L_{PRE}):

$$\begin{aligned} L_{PRE} &= [0.05 + (0.009 \times I_{WATERSHED})] \times 2.28 \times A_{SITE} \\ &= [0.05 + (0.009 \times \underline{16})] \times 2.28 \times \underline{\hspace{2cm}} \\ L_{PRE} &= \underline{\hspace{2cm}} \text{ pounds per year} \end{aligned}$$

Calculate the post-development load (L_{POST}):

$$\begin{aligned} L_{POST} &= [0.05 + (0.009 \times I_{POST})] \times 2.28 \times A_{SITE} \\ &= [0.05 + (0.009 \times \underline{\hspace{2cm}})] \times 2.28 \times \underline{\hspace{2cm}} \\ L_{POST} &= \underline{\hspace{2cm}} \text{ pounds per year} \end{aligned}$$

Calculate the pollutant removal requirement (RR):

$$\begin{aligned} RR &= L_{POST} - L_{PRE} \\ &= \underline{\hspace{2cm}} - \underline{\hspace{2cm}} \\ &= \underline{\hspace{2cm}} \text{ pounds per year} \end{aligned}$$

WORKSHEET 3.03 - SITUATION THREE

Compile existing site-specific data and determine existing site imperviousness (I_{EXIST}). For the purposes of these calculations, site area (A_{SITE}) is defined as the entire parcel. A_{EXIST} represents the actual amount of existing impervious cover on the site.

A_{SITE}	=	<u> </u> acres	
A_{EXIST} structures	=	<u> </u> acres	
parking lot	=	<u> </u> acres	
roadway	=	<u> </u> acres	
other	=	<u> </u> acres	
Total A_{EXIST}	=	<u> </u> acres	
I_{EXIST}	=	$(Total\ A_{EXIST} \div A_{SITE}) \times 100$	
I_{EXIST}	=	<u> </u>	% (expressed in whole numbers)

Compile post-development site-specific data and determine post-development site imperviousness (I_{POST}). For the purposes of these calculations, site area (A_{SITE}) is defined as the entire parcel. A_{POST} represents the actual amount of impervious cover on the site once the proposed development is complete.

A_{SITE}	=	<u> </u> acres	
A_{POST} structures	=	<u> </u> acres	
parking lot	=	<u> </u> acres	
roadway	=	<u> </u> acres	
other	=	<u> </u> acres	
Total A_{POST}	=	<u> </u> acres	
I_{POST}	=	$(Total\ A_{POST} \div A_{SITE}) \times 100$	
I_{POST}	=	<u> </u>	(expressed in whole numbers)

If $I_{EXIST} > 16\%$ and the existing impervious area is not served by a BMP, proceed with calculation of pollutant loadings. Otherwise, refer to Section 3.4 of the Manual for correct development situation determination.

Calculate the pre and post-development pollutant loadings for the site using the Simple Method.

$$L = P \times P_J \times [0.05 + (0.09 \times I)] \times C \times A \times 2.72 / 12$$

Where:

- P_J = unitless rainfall correction factor
- = 0.9 for all of Tidewater, Virginia
- P = annual rainfall depth in inches
- = 43 for the Richmond Metropolitan Area
- C = flow weighted mean concentration of total phosphorus
- = 0.26 mg/l for the entire County
- $I_{WATERSHED}$ = average land cover condition of the Bay watershed
- = 16 percent

<p>Calculate the pre-development load (L_{PRE}):</p> $L_{PRE} = [0.05 + 0.009 \times I_{EXIST}] \times 2.28 \times A_{SITE}$ $= [0.05 + (0.009 \times \underline{\hspace{1cm}})] \times 2.28 \times (\underline{\hspace{1cm}})$ <p>$L_{PRE} = \underline{\hspace{2cm}}$ pounds per year</p>	<p>Calculate the load based on 16% impervious cover (L_{16}):</p> $L_{16} = [0.05 + 0.009 \times 16] \times 2.28 \times A_{SITE}$ $= [0.05 + (0.009 \times \underline{16})] \times 2.28 \times (\underline{\hspace{1cm}})$ <p>$L_{16} = \underline{\hspace{2cm}}$ pounds per year</p>
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Calculate the post-development load (L_{POST}):

$$L_{POST} = [0.05 + 0.009 \times I_{POST}] \times 2.28 \times A_{SITE}$$

$$= [0.05 + (0.009 \times \underline{\hspace{1cm}})] \times 2.28 \times (\underline{\hspace{1cm}})$$

$L_{POST} = \underline{\hspace{2cm}}$ pounds per year

Calculate the pollutant removal requirement (RR). The removal requirement shall be the smaller of the following

$RR = L_{POST} - (0.9 \times L_{PRE})$ $= \underline{\hspace{1cm}} - (0.9 \times \underline{\hspace{1cm}})$ $= \underline{\hspace{1cm}}$ pounds per year	$RR = L_{POST} - L_{16}$ $= \underline{\hspace{1cm}} - \underline{\hspace{1cm}}$ $RR = \underline{\hspace{1cm}}$ pounds per year
--	--

$RR = \underline{\hspace{2cm}}$ pounds per year

WORKSHEET 3.04 - SITUATION FOUR

Compile existing site-specific data and determine existing site imperviousness (I_{EXIST}). For the purposes of these calculations, site area (A_{SITE}) is defined as the entire parcel. A_{EXIST} represents the actual amount of existing impervious cover on the site.

A_{SITE}	=	<u> </u> acres	
A_{EXIST} structures	=	<u> </u> acres	
parking lot	=	<u> </u> acres	
roadway	=	<u> </u> acres	
other	=	<u> </u> acres	
Total A_{EXIST}	=	<u> </u> acres	
I_{EXIST}	=	$(Total\ A_{EXIST} \div A_{SITE}) \times 100$	
I_{EXIST}	=	<u> </u> %	(expressed in whole numbers)

Compile post-development site-specific data and determine post-development site imperviousness (I_{POST}). For the purposes of these calculations, site area (A_{SITE}) is defined as the entire parcel. A_{POST} represents the actual amount of impervious cover on the site once the proposed development is complete.

A_{SITE}	=	<u> </u> acres	
A_{POST} structures	=	<u> </u> acres	
parking lot	=	<u> </u> acres	
roadway	=	<u> </u> acres	
other	=	<u> </u> acres	
Total A_{POST}	=	<u> </u> acres	
I_{POST}	=	$(Total\ A_{POST} \div A_{SITE}) \times 100$	
I_{POST}	=	<u> </u> %	(expressed in whole numbers)

If $I_{EXIST} > 16\%$ and the existing impervious area is served by a BMP, proceed with calculation of pollutant loadings. Otherwise, refer to Section 3.4 of the Manual for correct development situation determination.

Calculate the pre and post-development pollutant loadings for the site using the Simple Method.

$$L = P \times P_J \times [0.05 + (0.09 \times I)] \times C \times A \times 2.72 / 12$$

Where:

P_J	=	unitless rainfall correction factor
	=	0.9 for all of Tidewater, Virginia
P	=	annual rainfall depth in inches
	=	43 for the Richmond Metropolitan Area
C	=	flow weighted mean concentration of total phosphorus
	=	0.26 mg/l for the entire County
$I_{WATERSHED}$	=	average land cover condition of the Bay watershed
	=	16 percent

Calculate the existing development load (L_{EXIST}):

$$L_{EXIST} = [0.05 + (0.009 \times I_{EXIST})] \times 2.28 \times A_{SITE}$$

$$= [0.05 + (0.009 \times \underline{\hspace{2cm}})] \times 2.28 \times \underline{\hspace{2cm}}$$

$$L_{EXIST} = \underline{\hspace{2cm}} \text{ pounds per year}$$

Calculate the post-development load (L_{POST}):

$$L_{POST} = [0.05 + (0.009 \times I_{POST})] \times 2.28 \times A_{SITE}$$

$$= [0.05 + (0.009 \times \underline{\hspace{2cm}})] \times 2.28 \times \underline{\hspace{2cm}}$$

$$L_{POST} = \underline{\hspace{2cm}} \text{ pounds per year}$$

Calculate the pollutant removal requirement for this project ($RR_{PROJECT}$):

$$RR_{PROJECT} = L_{POST} - L_{EXIST}$$

$$= \underline{\hspace{2cm}} - \underline{\hspace{2cm}}$$

$$= \underline{\hspace{2cm}} \text{ pounds per year}$$

Calculate the overall pollutant removal requirement (RR_{TOTAL})

$$RR_{TOTAL} = RR_{PROJECT} + RR_{EXIST}$$

RR_{EXIST} = the existing pollutant removal requirement for the site

$$RR_{TOTAL} = \underline{\hspace{2cm}} + \underline{\hspace{2cm}}$$

$$= \underline{\hspace{2cm}} \text{ pounds per year}$$

WORKSHEET 3.05 - SITUATION FIVE

Compile existing data and determine existing site imperviousness (I_{EXIST}). For the purposes of these calculations, site area (A_{SITE}) is defined as the entire parcel. A_{EXIST} represents the actual amount of existing impervious cover on the site.

A_{SITE}	=	_____	acres
A_{EXIST} structures	=	_____	acres
parking lot	=	_____	acres
roadway	=	_____	acres
other	=	_____	acres
Total A_{EXIST}	=	_____	acres
I_{EXIST}	=	$(Total\ A_{EXIST} \div A_{SITE}) \times 100$	
I_{EXIST}	=	_____	% (expressed in whole numbers)
$A_{EXIST} \times 0.10$	=	_____	acres

Compile post-development data and determine post-development project imperviousness ($I_{PROJECT}$). For the purposes of these calculations, project area ($A_{PROJECT}$) is defined as the area of proposed impervious cover associated with this project (additional impervious cover and impervious cover that will replace existing impervious cover). A_{POST} represents the actual amount of impervious cover on the site once the proposed development is complete.

$A_{PROJECT}$:	structures	=	_____	acres
	parking lot	=	_____	acres
	roadway	=	_____	acres
	other	=	_____	acres
	Total $A_{PROJECT}$	=	_____	acres
	Total $A_{PROJECT}$	≤	$A_{EXIST} \times 0.10$	
	_____	≤	_____	

If $I_{EXIST} > 16\%$ and $A_{PROJECT} \leq [0.1 \times A_{EXIST}]$, proceed with calculation of pollutant loadings. Otherwise, refer to Section 3.4 of the Manual for correct development situation determination.

Calculate the pre and post-development pollutant loadings for the site using the Simple Method.

$$L = P \times P_J \times [0.05 + (0.09 \times I)] \times C \times A \times 2.72 / 12$$

Where:

- P_J = unitless rainfall correction factor
- = 0.9 for all of Tidewater, Virginia
- P = annual rainfall depth in inches
- = 43 for the Richmond Metropolitan Area
- C = flow weighted mean concentration of total phosphorus
- = 0.26 mg/l for the entire County
- $I_{WATERSHED}$ = average land cover condition of the Bay watershed
- = 16 percent

Calculate the load produced by this project ($L_{PROJECT}$):

$$L_{PROJECT} = [0.05 + (0.009 \times I_{PROJECT})] \times 2.28 \times A_{PROJECT}$$

$$= [0.05 + (0.009 \times \underline{\quad 100 \quad})] \times 2.28 \times A_{PROJECT}$$

$$L_{PROJECT} = 2.166 \times A_{PROJECT}$$

$$= 2.166 \times \underline{\hspace{2cm}}$$

$$L_{PROJECT} = \underline{\hspace{2cm}} \text{ pounds per year}$$

Calculate the pollutant removal requirement (RR):

$$RR = L_{PROJECT}$$

$$RR = \underline{\hspace{2cm}} \text{ pounds per year}$$

WORKSHEET 3.06 – COMPLIANCE

Determine the pollutant removal requirement (RR) as calculated on the appropriate development situation worksheet (Worksheet 3.2, Worksheet 3.3, Worksheet 3.4, or Worksheet 3.5).

$$\begin{aligned}
 \text{RR} &= \text{pollutant removal requirement} \\
 &= \underline{\hspace{2cm}} \text{ lbs/yr}
 \end{aligned}$$

Calculate the pollutant loading to the BMP ($L_{\text{ON-SITE}}$) from on-site areas.

$$\begin{aligned}
 A_{\text{ON-SITE}} &= \text{the contributing on-site drainage area to the BMP} \\
 &= \underline{\hspace{2cm}} \text{ acres} \\
 A_{\text{ON-SITE}} &= \text{the amount of on-site impervious cover in the contributing drainage area} \\
 &= \underline{\hspace{2cm}} \text{ acres} \\
 I_{\text{ON-SITE}} &= \text{the percentage of on-site impervious cover for the contributing drainage area to the BMP.} \\
 &= (A_{\text{ON-SITE}} / A_{\text{ON-SITE}}) \times 100 \\
 &= (\underline{\hspace{1cm}} / \underline{\hspace{1cm}}) \times 100 \\
 &= \underline{\hspace{2cm}} \% \\
 L_{\text{ON-SITE}} &= \text{the phosphorus load to the BMP.} \\
 L_{\text{ON-SITE}} &= [0.05 + (0.009 \times I_{\text{ON-SITE}})] \times 2.28 \times A_{\text{ON-SITE}} \\
 &= [0.05 + (0.009 \times \underline{\hspace{1cm}})] \times 2.28 \times \underline{\hspace{2cm}} \\
 &= \underline{\hspace{2cm}} \text{ pounds per year}
 \end{aligned}$$

Calculate the pollutant loading to the BMP ($L_{\text{OFF-SITE}}$) from off-site areas.

$$\begin{aligned}
 A_{\text{OFF-SITE}} &= \text{the contributing off-site drainage area to the BMP} \\
 &= \underline{\hspace{2cm}} \text{ acres} \\
 I_{\text{OFF-SITE}} &= 16\% \quad \textbf{(16\% shall be used for all off-site drainage areas)} \\
 L_{\text{OFF-SITE}} &= \text{the off-site phosphorus load to the BMP.} \\
 &= [0.05 + (0.009 \times I_{\text{OFF-SITE}})] \times 2.28 \times A_{\text{OFF-SITE}} \\
 &= [0.05 + (0.009 \times 16)] \times 2.28 \times \underline{\hspace{2cm}} \\
 &= \underline{\hspace{2cm}} \text{ pounds per year}
 \end{aligned}$$

Calculate the total pollutant loading to the BMP (L_{TOTAL}).

$$\begin{aligned}
 L_{\text{TOTAL}} &= L_{\text{ON-SITE}} + L_{\text{OFF-SITE}} \\
 &= \underline{\hspace{1cm}} + \underline{\hspace{1cm}} \\
 &= \underline{\hspace{2cm}} \text{ pounds per year}
 \end{aligned}$$

Calculate the total pollutant load removed by the proposed BMP(s) ($L_{\text{REMOVED BY BMP}}$). Acceptable BMP types and associated removal efficiencies are listed in Section 3.6.1 of this Manual.

Selected BMP Type	Removal Efficiency	X	L _{TOTAL}	=	L _{REMOVED BY BMP(S)} (lbs/yr)
		X		=	
		X		=	
		X		=	
		X		=	
		X		=	
TOTAL					L _{REMOVED BY BMP(S)}

For BMPs in series, the L_{TOTAL} treated by the second basin is the L_{TOTAL} from the first basin minus the load removed by the first BMP. When the overall removal efficiency for BMPs in series exceeds 65%, the BMPs will be treated as one BMP with a removal efficiency of 65% on the compliance worksheet.

Calculate the pollutant load removed by the Stream Protection Area (L_{REMOVED BY SPA}) provided. In order to receive pollutant removal credit for the Stream Protection Area (SPA), the SPA must be forested in accordance with Minimum Standard 9.10 and energy dissipators (EDs) provided in accordance with Minimum Standard 9.01.

Stream Protection Area	Linear feet provided	X	Pollutant Removal (lb/yr/ft)	=	L _{REMOVED BY SPA} (lbs/yr)
		X	0.00029	=	

Calculate the pollutant load removed by the energy dissipators (L_{REMOVED BY ED}) provided. In order to receive pollutant removal credit for the energy dissipators (EDs), the SPA must be forested in accordance with Minimum Standard 9.10 and energy dissipators provided in accordance with Minimum Standard 9.01.

Energy Dissipators	Number of Energy Dissipators	X	Pollutant Removal (lb/yr/ED)	=	L _{REMOVED BY ED} (lbs/yr)
		X	0.10	=	

Calculate the total pollutant load removal achieved by the BMP(s), SPA, and EDs (L_{REMOVED}).

$$\begin{aligned}
 L_{REMOVED} &= L_{REMOVED BY BMP(S)} + L_{REMOVED BY SPA} + L_{REMOVED BY ED} \\
 &= \underline{\hspace{2cm}} + \underline{\hspace{2cm}} + \underline{\hspace{2cm}} \\
 &= \underline{\hspace{2cm}} \text{ lbs/yr}
 \end{aligned}$$

If the total pollutant load removed (L_{REMOVED}) is greater than or equal to the pollutant removal requirement (RR), the proposed project complies with the pollutant load reduction criteria.

$$\begin{aligned}
 &L_{REMOVED} \geq RR \\
 &\underline{\hspace{2cm}} \geq \underline{\hspace{2cm}}
 \end{aligned}$$