LAND AND WATER QUALITY PROTECTION IN HAMPTON ROADS
PHASE I

This report was funded, in part, by the Virginia Coastal Zone Management Program at the Virginia Department of Environmental Quality through Grant # NA11NOS4190122 of the U.S Department of Commerce, National Oceanic and Atmospheric Administration, under the Coastal Zone Management Act of 1972, as amended.

The views expressed herein are those of the authors and do not necessarily reflect the views of the U.S Department of Commerce, NOAA or any of its subagencies.

Federal financial assistance to this project amounted to $90,000, approximately 100% of the total cost.

Preparation of this report was included in the HRPDC Unified Planning Work Program for FY 2011-2012, approved by the Commission at its Executive Committee Meeting of June 16, 2011 and in the HRPDC Unified Planning Work Program for FY 2012-2013, approved by the Commission at its Quarterly Meeting of April 19, 2012.

Prepared by the staff of the
Hampton Roads Planning District Commission

MARCH 2013

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REPORT DOCUMENTATION

TITLE:
Land and Water Quality Protection in Hampton Roads Phase I

REPORT DATE
March 2013

GRANT/SPONSORING AGENCY
DEQ/NOAA

AUTHORS:
Sara J. Kidd, GISP
Jennifer L. Tribo
Benjamin J. McFarlane, AICP

ORGANIZATION NAME, ADDRESS AND TELEPHONE
Hampton Roads Planning District Commission
723 Woodlake Drive
Chesapeake, Virginia 23320
(757)420-8300
http://www.hrpdcva.gov

ABSTRACT
This report provides a summary of the first year of the Hampton Roads Planning District Commission's work under a Section 309 Grant from the Virginia Coastal Zone Management Program. The goal of this work is to develop implementable policies, which will enable local governments to address new Virginia Stormwater Management Regulations and the Chesapeake Bay Total Maximum Daily Load (TMDL). The report contains three major sections. The first section summarizes the impacts of the Virginia Stormwater Management Regulations and the Chesapeake Bay TMDL on local governments. The second section describes some existing tools which can be used to promote water quality policies at the local government level and recommends some policies that can specifically address the impacts of the Virginia Stormwater Management Regulations and the Chesapeake Bay TMDL. The third section describes some software tools which can be used to assess the water quality impacts of development.

ACKNOWLEDGEMENTS
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Virginia Coastal Zone
MANAGEMENT PROGRAM

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INTRODUCTION

In October 2011 the Hampton Roads Planning District Commission was awarded a grant under Section 309 of the Coastal Zone Management Act, as amended, from the Virginia Coastal Zone Management Project to study the impacts of the Chesapeake Bay Total Maximum Daily Load (TMDL) and revised Virginia Stormwater Management Regulations on local development policies and regulations. This project was first described as part of Land and Water Quality Protection section of Virginia's Section 309 Cumulative and Secondary Impacts Strategies for 2011-2016 and is part of a five-year planned program.

This project consists of three parts, which are described in the following report. The first part is an assessment of the impacts of the Chesapeake Bay TMDL and revised Virginia Stormwater Management Regulations will have on local government programs, ordinances, and policies in Hampton Roads. This section focuses on the various tasks and mandates local governments will have to address. The second part is the development of a tool that local governments can use to evaluate their plans and policies for consistency with the goals of the Chesapeake Bay TMDL and stormwater regulations. The focus is on optional policies that aid local government compliance, as opposed to requirements, and will include an assessment of existing tools that promote improving water quality through policy. The third part is an evaluation and available tools local governments can use to model the water quality impacts of development and how possible changes to local policies could alter those impacts. This section includes a demonstration of one of these tools.

This report is intended to be viewed as an interim step before completion of the final guidance document, including recommended policies and actions, at the end of the second year in 2013.

SECTION I – ASSESSMENT OF WATER QUALITY REGULATIONS IMPACTS

Water quality impacts associated with urban growth are magnified by development trends characterized by increasing impervious cover. To address these impacts, recent regulatory changes and program developments, specifically the Chesapeake Bay Total Maximum Daily Load (TMDL) and revised Virginia stormwater management regulations, have resulted in the creation of nutrient reduction goals for Virginia localities. These developments require new land use approaches and development policies that will help localities reduce the impacts of land development on water quality. HRPDC staff has analyzed these water quality requirements and has identified policy and technical tools to assist localities in meeting these requirements while avoiding negative impacts on natural resources. This section of the report is a detailed assessment of the requirements on local governments resulting from the Virginia state stormwater management regulations and the Chesapeake Bay TMDL, including the Phase I and II Watershed Implementation Plans.

While this section will outline the mandatory code and policy changes that localities will need to implement, there are also policy and ordinance changes that local governments may want to implement in order to minimize the cost of regulatory compliance. Localities should review their codes and ordinances related to development in order to identify those that unnecessarily increase the impervious area associated with a development. These optional, but recommended, revisions are discussed in further detail in Section II of this report.

BACKGROUND

The revisions to the Virginia Stormwater Management Regulations (SWM) became effective on September 13, 2011 after a significant stakeholder process that began in 2004 with legislation that transferred stormwater regulatory programs for construction activity and municipal permits from the Department of Environmental Quality (DEQ) to the Department of Conservation and Recreation (DCR) and required DCR to issue regulations to establish statewide post construction stormwater criteria to protect water quality. During its 2012 session, the General Assembly passed additional legislation that requires localities throughout the state, except for towns that are not permitted as a Municipal Separate Storm Sewer System (MS4), to adopt local Virginia Stormwater Management Programs (VSMPs). Starting on July 1, 2014 all development subject to permitting under the Virginia Stormwater Management Program (and sites greater than 2,500 square feet in Chesapeake Bay Preservation Act (CBPA) areas) must meet the new water quality and quantity criteria for post construction stormwater runoff. Local governments will be responsible for reviewing site plans for compliance with these post construction criteria. These regulations are also an important part of the state's efforts to protect and restore the Chesapeake Bay.

The U.S. Environmental Protection Agency (EPA) completed a Total Maximum Daily Load (TMDL) for the Chesapeake Bay watershed on December 29, 2010. The TMDL identified the nitrogen, phosphorus, and sediment reductions that each Bay State needs to achieve in order for the Chesapeake Bay to meet water quality standards. The TMDL included Phase I Watershed Implementation Plans (WIPs) developed by states within the Chesapeake Bay watershed. The Commonwealth of Virginia (Virginia) Phase I WIP outlined the actions expected of the wastewater sector, urban/stormwater sector, agriculture sector, and on-site sewage sector in order to meet statewide nutrient and sediment reduction goals. This document focuses primarily on the actions expected in the urban/stormwater sector.

CURRENT STORMWATER WATER QUALITY CRITERIA

Localities in Tidewater Virginia have been requiring developers to meet water quality standards since 1990 through implementation of the Chesapeake Bay Preservation Act. Any land disturbing activity greater than 2,500 square feet is required to meet performance-based water quality criteria. The post development nonpoint source pollutant runoff load was calculated using the Simple Method and was compared to the calculated pre-development load based upon the average land cover condition or the existing site condition. Stormwater control Best Management Practices (BMPs) were required to be located, designed, and maintained to effectively reduce the pollutant load to the required level based upon the applicable land development situations summarized in Table 1. The 2004 stormwater related legislation applied these performance criteria to all development in Virginia greater than one acre (Virginia Department of Conservation and Recreation, 2012).

Table 1: Virginia Performance Based Water Quality Criteria

Development Situation	Requirement
Existing percent impervious cover is less than or equal to the average land cover condition, and the proposed improvements will create a total percent impervious cover which is less than the average land cover condition.	No reduction in the post development pollutant discharge is required.
Existing percent impervious cover is less than or equal to the average land cover condition, and the proposed improvements will create a total percent impervious cover which is greater than the average land cover condition.	The post development pollutant discharge shall not exceed the pollutant discharge of the average land cover condition.
The existing percent impervious cover is greater than the average land cover condition.	The post development pollutant discharge shall not exceed the pollutant discharge of the average land cover condition or the existing conditions less 10%, whichever is greater.
The existing percent impervious cover is served by an existing stormwater management BMP that addresses water quality.	The pollutant discharge after development shall not exceed the existing pollutant discharge based on the existing percent impervious cover while served by the existing BMP. The existing BMP shall be shown to have been designed and constructed in accordance with proper design standards and specifications, and to be in proper functioning condition.

The numeric value of the performance criteria was calculated using the Simple Method. The Simple Method estimates stormwater runoff pollutant loads for urban areas as a product of annual runoff volume and pollutant concentration. The calculation (Figure 1) requires inputs of impervious cover, stormwater runoff pollutant concentrations, and annual precipitation. The Simple Method calculates annual runoff as a product of annual runoff volume, and a runoff coefficient (Rv). Runoff volume is a function of impervious area (I). Stormwater pollutant concentrations can be estimated from local or regional data, or from national data sources. Table 2 summarizes the pollutant load values from the Nationwide Urban Runoff Program (NURP) studies.

Virginia's Chesapeake Bay Local Assistance Division, part of the Department of Conservation and Recreation, determined a baseline annual load of phosphorous for Tidewater Virginia and established a corresponding baseline impervious surface value, or average land cover condition. An analysis of the Chesapeake Bay watershed in Virginia identified the average land cover condition for impervious area as 16 percent. Using these inputs and an average annual rainfall of 43 inches, the baseline existing land use condition pollutant load value is calculated to be 0.45 lb/ac/yr of phosphorus. Localities had the option to adopt this value as the pre-developed default for the entire locality or to calculate a watershed or locality-wide pre-developed annual load and corresponding impervious value, and designate a watershed-specific or locality-specific average land cover condition. Table 3 summarizes those values for localities within Hampton Roads and translates them to pounds per acre per year using the Simple Method. The difference between the pre- and post-development pollutant load represents the increase in pollutant load that must then be controlled by an appropriate BMP as summarized in Table 4.

Figure 1: Simple Method Calculation

$$\text{Pollutant Load (lb/yr)} = P * Pj * Rv * C * A * 0.226$$

P = Annual precipitation (inches)

Pj = Fraction of runoff producing rainfall events = 0.9

Rv = (0.05 + 0.009*I)

I = Percent Imperviousness

C = Pollutant concentration (mg/l)

Table 2: NURP Pollutant Concentration Values for Urban Stormwater

Pollutant	Concentration	Units
Total Suspended Solids	54.5	mg/L
Total Phosphorus	0.26	mg/L
Total Nitrogen	2.00	mg/L
Copper	11.1	ug/L
Lead	50.7	ug/L
Zinc	129	ug/L

Table 3: Baseline Predevelopment Pollutant Loads in Hampton Roads

Locality	Calculated Average Impervious Area	Phosphorus Load (lb/ac/yr)
Virginia Beach	25	0.64
Newport News	36	0.87
Gloucester	16	0.45
Chesapeake	16	0.45
Eastern Branch of Elizabeth River	52	1.21
Southern Branch of Elizabeth River	28	0.70
Western Branch of Elizabeth River	26	0.66
Coopers Ditch and Horserun Ditch	29	0.73
Norfolk	53	1.23
Hampton	34	0.83
Isle of Wight	16	0.45
James City	16	0.45
Poquoson	16	0.45
Portsmouth: Locality wide pre 1994	41	0.98
Portsmouth: Elizabeth River	19	0.52
Portsmouth: Western Branch	40	0.96
Portsmouth: Southern Branch	54	1.25
Suffolk	16	0.45
Surry	16	0.45
Williamsburg	16	0.45
York	16	0.45

Table 4: Virginia BMP Removal Efficiencies (1999 Handbook)

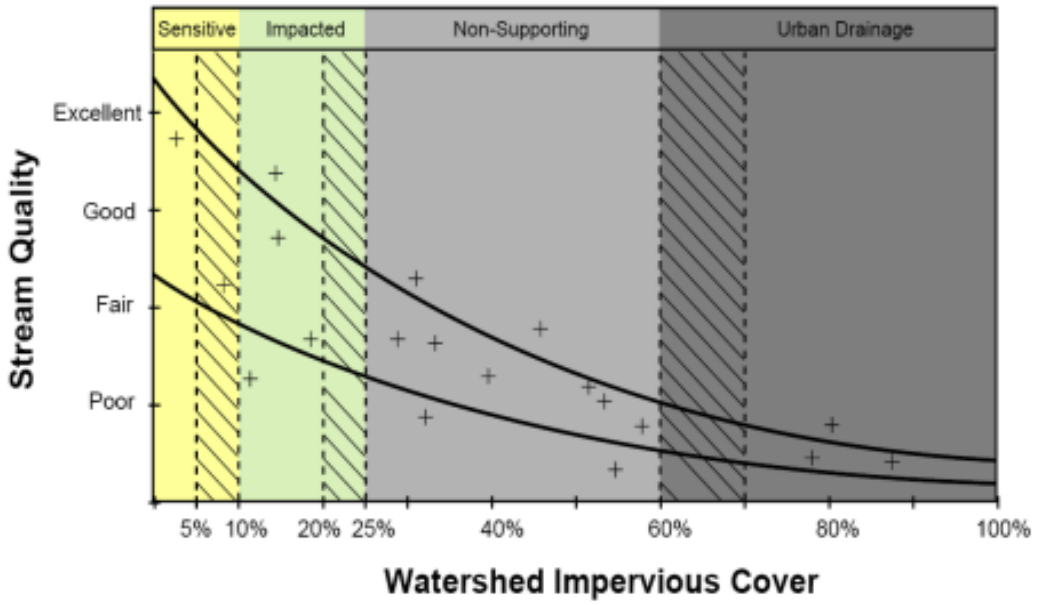
Water Quality BMP	Target Phosphorus Removal Efficiency	Percent Impervious Cover
Vegetated filter strip	10%	**16 - 21%**
Grassed swale	15%	
Constructed wetlands	30%	**22 - 37%**
Extended detention (2 x WQ Vol)	35%	
Retention basin I (3 x WQ Vol)	40%	
Bioretention basin	50%	**38 - 66%**
Bioretention filter		
Extended detention-enhanced		
Retention basin II (4 x WQ Vol)		
Infiltration (1 x WQ Vol)		
Sand filter	65%	**67 - 100%**
Infiltration (2 x WQ Vol)		
Retention basin III (4 x WQ Vol with aquatic bench)		

REVISED STORMWATER CRITERIA/RUNOFF REDUCTION METHOD

Virginia's revised water quality criteria of 0.41 pounds per acre per year of phosphorus will be implemented beginning on July 1, 2014. The criteria was developed to be protective of local water quality and to achieve no net increase in nutrients for new development. The new criterion was calculated using the Runoff Reduction Method rather than the Simple Method and translates to a land cover condition of 10% impervious cover, 30% turf, and 60% forest.

The relationship between impervious cover and water quality was first described by Tom Schueler in 1994 and is known as the impervious cover model (Schueler, 1994). The impervious cover model showed that impervious cover was an important factor for predicting stream quality in urban watersheds. The model illustrated in Figure 2, shows that streams can exhibit signs of degradation in urban watersheds with greater than 10 percent impervious cover. The impervious cover model has since been refined, but the basic relationship between stream quality and urbanization persists.

Figure 2: Impervious Cover Model



The Simple Method described in the previous section uses impervious cover as the sole indicator of a site's water quality impacts. Recent research indicates that land covers including forest, disturbed soils, and managed turf are also significant indicators of water quality. The Runoff Reduction Method accounts for these land covers and provides incentives to protect or restore forest cover and reduce impervious cover and disturbed soils. Runoff reduction is defined as the total volume reduced through canopy interception, soil infiltration, evaporation, rainfall harvesting, engineered infiltration, extended filtration, or evapotranspiration at small sites.

The Runoff Reduction Method for Virginia is focused on site compliance to meet site-based load limits. This means that the proposed Virginia stormwater regulations are aimed at limiting the total load leaving a new development

site. This is a departure from water quality computations of the past, in which the analysis focused on comparing the post-development condition to the pre-development, or an average land cover condition.

The runoff reduction method differs from the Simple Method not only in how pollutant loads are calculated, but also in how it accounts for BMP implementation. The current system for measuring BMP effectiveness is based solely on the percent of pollutant removed by the BMP, but does not account for a BMP's ability to reduce the overall volume of runoff. The runoff reduction method incorporates recent research that shows that some BMPs are quite effective at reducing the volume of runoff that reaches surface waters. Appendix B of the Technical Memorandum for the Runoff Reduction Method describes this research in greater detail and explains the basis for the runoff reduction rates of each BMP. Table 5 summarizes the runoff reduction and pollutant removal rates for allowable BMPs.

Table 5: Comparative Runoff Reduction, Pollutant Removal, and Total Removal for Total Phosphorus

Practice	Percent Runoff Reduction (RR)	Percent Total Phosphorus Removal (PR)[1]	Total Removal (TR)[2]
Green Roof	45 to 60	0	45 to 60
Rooftop Disconnection	25 to 50	0	25 to 50
Rain tanks and Cisterns	40	0	40
Permeable Pavement	45 to 75	25	59 to 81
Grass Channel	10 to 20	15	23 to 32
Bioretention	40 to 80	25 to 50	55 to 90
Dry Swale	40 to 60	20 to 40	52 to 76
Wet Swale	0	20 to 40	20 to 40
Infiltration	50 to 90	25	63 to 93
ED Pond	0 to 15	15	15 to 28
Soil Amendments[3]	50 to 75	0	50 to 75
Sheetflow to Open Space	50 to 75	0	50 to 75
Filtering Practice	0	60 to 65	60 to 65
Constructed Wetland	0	50 to 75	50 to 75
Wet Pond	0	50 to 75	50 to 75

Range of values is for level 1 and level 2 designs

1 EMC based pollutant removal
2 TR = RR + [(100-RR) * PR]
3 Numbers are provisional and are not fully accounted for in Version 1 of the BMP Planning spreadsheet (Appendix A); however future versions of the spreadsheet will resolve any inconsistencies.

Currently, it can be difficult for site designers and plan reviewers to verify BMP design features such as sizing, pretreatment, and vegetation that should be included on stormwater plans in order to achieve a target level of pollutant removal. Certain BMP design features either enhance or diminish overall pollutant removal performance. The Runoff Reduction Method provides clear guidance that links design features with performance by distinguishing between "Level 1" and "Level 2" designs. Virginia's revised stormwater BMP manual will contain design specifications that explain these design features for each BMP.

The central component of the Runoff Reduction method is treatment volume (Tv) illustrated in Figure 3. A site's treatment volume is calculated by multiplying the Virginia's "water quality" rainfall depth (P = one-inch) by the three site cover runoff coefficients (forest, disturbed soils, and impervious cover) present at the site, as shown in Figure 4. By applying site design, structural, and nonstructural practices, the designer can reduce the treatment volume by reducing the overall volume of runoff leaving a site. Table 6 identifies site design practices, runoff reduction practices, and pollutant removal practices that can all be used to meet the water quality criteria from a developed site.

Figure 3: Determining the Stormwater Treatment Volume

$$Tv = \frac{P \times (RvI \times \%I + RvT \times \%T + RvF \times \%F) \times SA}{12}$$

- Tv = Runoff reduction volume in acre feet
- P = Depth of rainfall for "water quality" event (equals 1 inch in Virginia)
- RvI = runoff coefficient for impervious cover[1]
- RvT = runoff coefficient for turf cover or disturbed soils[1]
- RvF = runoff coefficient for forest cover[1]
- % I = percent of site in impervious cover (fraction)
- %T = percent of site in turf cover (fraction)
- %F = percent of site in forest cover (fraction)
- SA = total site area (acres)

[1] Rv values from Figure 4

Figure 4: Site Cover Runoff Coefficients (Rv)

Soil Condition	Runoff Coefficient
Forest Cover	0.02 to 0.05*
Disturbed Soils/Managed Turf	0.15 to 0.25*
Impervious Cover	0.95

Range dependent on original Hydrologic Soil Group (HSG)

Forest A: 0.02 B: 0.03 C: 0.04 D: 0.05
Disturbed Soils A: 0.15 B: 0.20 C: 0.22 D: 0.25

The treatment volume approach has several advantages when it comes to evaluating runoff reduction practices and sizing BMPs:

- Provides effective stormwater treatment for approximately 90% of the annual runoff volume from the site, and larger storms will be partially treated.
- Provides adequate storage to treat pollutants for a range of storm events.
- Provides designers incentives to minimize the amount of both impervious cover and disturbed soils.
- Creates incentives to conserve forests and reduce mass grading by acknowledging the difference between forest and turf cover and disturbed and undisturbed soils.
- Provides an objective measure to gauge the aggregate performance of environmental site design, LID and other innovative practices, and conventional BMPs using runoff volume.

Table 6: Practices Included in the Runoff Reduction Method

Environmental Site Design (ESD) Practices	Runoff Reduction (RR) Practices	Pollutant Removal (PR) Practices
Forest Conservation	Sheetflow to Conserved Open Space	Filtering Practice
Site Reforestation	Rooftop Disconnection: Simple To Soil Amendments To Rain Garden or Dry Well To Rain Tank or Cistern	Constructed Wetland
		Wet Swale
Soil Restoration (combined with or separate from rooftop disconnection)		Wet Pond
Site Design to Minimize Impervious Cover & Soil Disturbance	Green Roof	
	Grass Channels	
	Permeable Pavement	
	Bioretention	
	Dry Swale (Water Quality Swale)	
	Infiltration	
	Extended Detention (ED) Pond	

Virginia developed a compliance spreadsheet designed to help designers and plan reviewers quickly evaluate the implementation of BMPs on a given site and verify compliance with the State stormwater requirements. The spreadsheet:

- Provides a summary of the total site developed condition land cover, pollutant load (Total Phosphorus and Total Nitrogen), and the corresponding design Treatment Volume.
- Allows the designer to quickly evaluate the effectiveness of different BMPs and BMP combinations in up to five different drainage areas.
- Provides a summary for each drainage area that includes the land cover, runoff volume and pollutant load generated in the drainage area, the BMPs selected, and the runoff volume and pollutant load reduced by the selected BMPs.

- Calculates the volume reduction credited towards compliance with quantity control requirements in each drainage area (i.e., channel and flood protection requirements).
- Provides an overall compliance summary report that itemizes BMP implementation in each drainage area as well as overall site compliance.

CHESAPEAKE BAY TMDL

Virginia's strategy to meet the Chesapeake Bay TMDL relies on the implementation of the revised stormwater criteria to achieve no net increase of nutrients from new development. In order to achieve the additional reductions in the urban sector, local governments will need to treat existing development with new BMPs or retrofit existing BMPs to increase performance. Table 7 outlines the average reductions that localities will need to achieve in their developed areas according to Virginia's Phase I WIP. During the Phase II WIP process, local governments in Hampton Roads updated their BMP implementation levels and created a preferred regional scenario that achieved equivalent nutrient reductions as the Phase I WIP but focused on BMPs that were more cost effective and appropriate in the coastal plain. Table 8 compares the BMP implementation requirements in the Phase I WIP with Hampton Roads' preferred alternative.

Table 7: Phase I Watershed Implementation Plan for Urban Stormwater in Virginia

Land Use Category	Practice Description	Level 2 Practice % Coverage	Effective Net Reduction Prorated Over Entire Land Use Category Acreage		
			Nitrogen	Phosphorus	Sediment
Impervious Urban High and Low Intensity	Impervious Cover Reduction	7.5%	0%	5%	6%
	Filtration Practices	7.5%	3%	4%	6%
	Infiltration Practices	8.0%	6%	7%	8%
	Total		**9%**	**16%**	**20%**
Pervious Urban High and Low Intensity	Impervious Cover Reduction				
	Filtration Practices	5%	2%	3%	4%
	Infiltration Practices	5%	4%	4.25%	4.75%
	Total		**6%**	**7.25%**	**8.75%**

Filtration Practice Efficiency: 40% N, 60% P, 85% Sediment
Infiltration Practice Efficiency: 80% N, 85% P, 95% Sediment

Implementation of the urban nutrient reductions necessary to meet the Chesapeake Bay TMDL will be achieved through Municipal Separate Storm Sewer System (MS4) permits. Localities in Hampton Roads subject to MS4 permits will be required to calculate their required reductions using their local land use data and create a Chesapeake Bay TMDL Action Plan that will identify the BMPs that will be implemented to meet these reductions. The MS4 permits have a five year cycle. Five percent of nutrient reductions must be achieved during the first permit cycle, 35 percent in the second permit cycle, and the remaining 60 percent in the third permit cycle. Localities will receive credit for reductions achieved through the implementation of the stormwater regulations on redevelopment projects and for BMPs installed or retrofitted to treat existing development.

Table 8: Hampton Roads Preferred Scenario for urban stormwater to meet the Chesapeake Bay TMDL

BMP Type	Default Phase I WIP Treatment	Existing Treatment	Regional Scenario
Impervious Reduction	7.5%	0.12%	2%
Filter	6%	1%	2%
Infiltration	6%	0.5%	2%
Wet Pond/Wetland		10%	16%
Dry Ponds		7%	8%
Extended Dry Ponds		7%	8%
Tree Planting		0.02%	1%
Nutrient Management		0.4%	41%
Urban Forest Buffers		0.5%	1%
Urban Stream Restoration (ln ft)		4,970	10,799
Shoreline Erosion (ln ft)		5,040	16,727
Street Sweep (lbs)		22,783,200	35,401,240

IMPACT OF STORMWATER REGULATIONS ON LOCAL GOVERNMENTS

Because Virginia's revised stormwater regulations are more stringent than previous stormwater water quality criteria, it may be more onerous and more expensive for developers to meet water quality criteria on site. However, the runoff reduction method does allow a developer to receive credit for implementation of environmental site design techniques and BMPs with enhanced designs and vegetation. Table 9 illustrates the impact of reducing impervious cover using the runoff reduction method compliance spreadsheet.

Table 9: Impact of Reducing Impervious area on a 10-acre Site

	Traditional Development	Better Site Design (Runoff Reduction)
Impervious Area (acres)	3	2.7
Pervious/turf (acres)	7	3.5
Forest (acres)	0	3.8
Estimated Phosphorus Load (lbs)	10.5	8.3
Pounds to be removed	6.4	4.2

In order for developers to be able to take full advantage of the runoff reduction practices, it is important that local government codes and ordinances are consistent with these new principles. Local governments will need to review their codes to allow low impact site design practices. Section II of this report describes these code changes in greater detail.

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SECTION II – TOOL DEVELOPMENT: PLAN EVALUATION METHODOLOGY

The development and implementation of the Chesapeake Bay Total Maximum Daily Load (TMDL) and the updated Virginia Stormwater Regulations pose significant challenges for local governments. Compliance with the TMDL will require local governments to implement changes to codes and ordinances while also constructing or retrofitting much of their stormwater management infrastructure. The mechanism being used to determine how much local governments have to do is a statewide Watershed Implementation Plan (WIP), which describes how each sector will reduce nutrient loads. The urban/stormwater sector is one of five, and has the most direct bearing on how much additional treatment and nutrient reduction localities will be responsible for. While the TMDL addresses nutrient reductions from the top down, the stormwater regulations are a "bottom-up" approach that will require more of individual developers in terms of what they are required to do on properties to treat and handle stormwater runoff. New development will be required to treat all runoff to a more stringent standard than under previous regulations (as described in Section I), while redevelopment projects will have to reduce the total nutrient load on the site by either 20% (for projects greater than or equal to 1 acre) or 10 % (for projects less than one acre) from the previous development.

Taken together, these regulatory changes represent the continuation of a paradigm shift away from the old strategy of conveying stormwater runoff offsite and into water bodies as quickly as possible to a new strategy of attempting to mimic nature by retaining and treating stormwater onsite. This change is occurring in response to the realization that continued urban development has significant impacts on both local and regional environments. The main issue of concern is impervious cover - roads and sidewalks, parking areas, driveways, rooftops - that reduce stormwater infiltration and instead eventually result in significant impacts to local streams through increased runoff quantity and intensity. The new goal is to reduce and/or treat this runoff onsite before it can negatively impact the watershed.

This section aims to identify or develop a tool which local governments can use to evaluate their plans and codes for compatibility with the Chesapeake Bay TMDL and stormwater regulations. It is not intended to be a list of code changes to ensure compliance. Instead, the goal is to identify policies and code changes which can help localities meet their load reduction targets under the TMDL while also working with developers to comply with the new stormwater regulations. This section is divided into two parts. The first is an assessment of some existing tools which have been developed to promote water quality and low impact development policies at the local level. The second part is the identification of various policies and recommendations from these tools and other sources that are particularly suited to addressing the challenges of the TMDL and stormwater regulations.

EXISTING TOOLS

Several tools or guidance documents have been previously created which aim to reduce the negative impact of development on water quality at the local level. This is usually done either by comparing local codes and policies against a specific regulatory standard or providing advice on policies and regulations to change using a collection of best practices. Adapting these existing tools to new purposes - such as complying with the Chesapeake Bay TMDL - can be challenging. In some cases, these tools are developed with specific regulations in mind, so they are not easily altered for different uses. In other cases, the guidance they are providing may not be directly applicable to the new need. However, these tools can still provide useful insight. As part of this project, HRPDC staff identified

and assessed five existing tools for their usefulness and applicability to helping localities better comply with Virginia's new stormwater management regulations and the Chesapeake Bay TMDL. These tools were:

1) The Checklist for Advisory Review of Local Ordinances (Virginia Department of Conservation and Recreation)
2) The Checklist for Advisory Review of Local Ordinances in Non-Tidal Chesapeake Bay Localities (Friends of the Rappahannock, James River Association, Potomac River Conservancy)
3) Municipal Regulations Checklist (New Jersey Stormwater Best Management Practices Manual)
4) Better Site Design Code and Ordinance Worksheet (Center for Watershed Protection)
5) Water Quality Scorecard: Incorporating Green Infrastructure Practices at the Municipal, Neighborhood, and Site Scales (U.S. Environmental Protection Agency)

Each of these five tools had useful features or ideas which Hampton Roads and other Virginia localities could implement to improve local water quality and better comply with the Chesapeake Bay TMDL. They are discussed in greater detail below.

DCR CHECKLIST FOR ADVISORY REVIEW OF LOCAL ORDINANCES

The Chesapeake Bay Preservation Act and its associated regulations (the Chesapeake Bay Preservation Area Designation and Management Regulations) together establish a cooperative state-local program between the Department of Conservation and Recreation and Tidewater Virginia's local governments to balance the two goals of continuing economic development and protecting the health of the Chesapeake Bay.[1] The Act and regulations require these local governments, with assistance from the state, to establish Chesapeake Bay local programs to implement the Act's requirements. These local programs consist of seven elements, including sections of the local comprehensive plan and various ordinances or ordinance revisions (zoning, subdivision, erosion & sediment control) which must be adopted. To help ensure that the regulations are implemented and the goals of the Act are achieved, DCR developed the Checklist for Advisory Review of Local Ordinances, which is used by DCR staff to review local codes and policies for compliance with the Act. The checklist consists of a series of questions divided into four parts, each covering a separate goal of Act through various performance criteria: minimizing land disturbance, preserving indigenous vegetation, minimizing impervious cover, and general water quality protection. The first three sections are tied directly to the performance criteria contained in the Chesapeake Bay regulations, while the final section contains more general elements.

This checklist is intended for use by DCR staff for compliance reviews, although local governments are encouraged to use it to review their own ordinances and policies prior to state review. As such, many local governments may not be very familiar with its contents. The checklist provides a comprehensive set of questions specifically targeted toward assessing local codes for compliance with the Act and regulations. However, it does not rank or prioritize practices or ordinances, nor does it provide recommendations on which documents should be reviewed. It is

[1] Tidewater Virginia is defined by § 10.1-2101 of the Code of Virginia as the Counties of Accomack, Arlington, Caroline, Charles City, Chesterfield, Essex, Fairfax, Gloucester, Hanover, Henrico, Isle of Wight, James City, King George, King and Queen, King William, Lancaster, Mathews, Middlesex, New Kent, Northampton, Northumberland, Prince George, Prince William, Richmond, Spotsylvania, Stafford, Surry, Westmoreland, and York, and the Cities of Alexandria, Chesapeake, Colonial Heights, Fairfax, Falls Church, Fredericksburg, Hampton, Hopewell, Newport News, Norfolk, Petersburg, Poquoson, Portsmouth, Richmond, Suffolk, Virginia Beach, and Williamsburg.

intended to be used as an auditing form and not as a set of recommendations, although the questions that make up the checklist suggest some preferred practices. The checklist does provide citations for the relevant sections of the regulations; however, those citations do not appear to have been updated to reflect recent changes to the Virginia Administrative Code and Code of Virginia, specifically the abolishment of the Chesapeake Bay Local Assistance Board and the placement of its responsibilities and jurisdiction under the Soil and Water Conservation Board.

SUMMARY – DCR CHECKLIST FOR ADVISORY REVIEW OF LOCAL ORDINANCES SUMMARY	
Audience/Intended Users	DCR Staff, local government staff
Advantages	Familiarity, direct relationship to state regulations
Disadvantages	Few, if any, recommendations, no prioritizing of practices
Web Address	http://www.dcr.virginia.gov/stormwater_management/phase3intro.shtml

JRA CHECKLIST FOR ADVISORY REVIEW OF LOCAL ORDINANCES IN NON-TIDAL CHESAPEAKE BAY LOCALITIES

While the Chesapeake Bay Preservation Act allows non-Tidewater localities to adopt programs, the focus of the Act and regulations remains on those localities in Tidewater, even though the Chesapeake Bay watershed includes, in whole or in part, over forty additional cities and counties in Virginia. Since these localities play a significant role in the water quality of the Chesapeake Bay and its tributaries, the James River Association (JRA), along with the Friends of the Rappahannock and the Potomac River Conservancy, undertook an effort to study how non-Tidewater Chesapeake Bay watershed localities were addressing water quality, adapt the existing DCR checklist for non-Tidewater localities, and make recommendations for those localities in terms of new ordinances and programs or modifications to existing ones. Through this project the project coalition worked with graduate students from several Virginia universities to analyze the existing codes and ordinances of non-Bay Act jurisdictions using a modified version of the original DCR checklist. Several questions were removed from the checklist, since they dealt with specific requirements for Bay Act localities, while the team also added a new section of questions addressing low impact development. The report documenting the project includes case studies ("Local Snapshots") of successfully implemented policies or ordinances in non-Bay Act jurisdictions for each of the sections of the checklist.

The modified checklist was intended to be used by students to review local ordinances, with the results being reviewed by local staff for accuracy. As with the original checklist, local government staff could conduct the review internally. Most of the removed questions dealt with the Resource Protection or Management Area sections of the Chesapeake Bay regulations, which would not be applicable to non-Bay Act localities. The added section addressing low impact development included questions addressing septic systems and stormwater management requirements. Overall, the modified checklist appears to improve on the original checklist by offering recommendations and examples.

SUMMARY – JRA CHECKLIST FOR ADVISORY REVIEW OF LOCAL ORDINANCES IN NON-TIDAL CHESAPEAKE BAY LOCALITIES	
Audience/Intended Users	Student reviewers, local government staff
Advantages	Case studies and examples, recommendations of best practices, applicable to non-Bay Act localities
Disadvantages	No prioritizing of practices
Web Address	http://www.jamesriverassociation.org/what-we-do/va-scorecard

NEW JERSEY MUNICIPAL REGULATIONS WORKSHEET

Similar in some ways to the requirements of the Chesapeake Bay Preservation Act, New Jersey's Stormwater Management Rules require municipalities to evaluate their plans and ordinances to allow for "nonstructural stormwater management techniques" or low impact development. Those techniques are described in the New Jersey Stormwater Best Management Practices Manual, with the Municipal Regulations Checklist included as an appendix. The checklist is designed to help localities identify which ordinances to review and how they should be changed. The checklist consists of four parts: vegetation and landscaping, minimizing land disturbance, impervious area management, and vegetated open channels. Each section includes a series of yes/no questions on a theme. For example, under vegetation and landscaping there are four subcategories: preservation of natural areas, tree protection ordinances, landscaping island and screen ordinances, and riparian buffers. In addition to the actual questions, the checklist also provides both a justification for each type of practice as well as some specific recommendations. For example, the checklist includes recommendations for setbacks, street widths, and parking ratios.

For the most part, the New Jersey checklist is similar in both form and content to the DCR checklist. The provision of numeric recommendations is potentially useful. Some of the parts are more robust than the others; the vegetated open channels section contains only two questions while the other three sections each have more than a dozen questions. As with the DCR checklist, there is no weighting of the questions. One potential issue with applying the recommendations from the New Jersey checklist in Virginia is that New Jersey is a Home Rule state, while Virginia observes Dillon's Rule. Enabling legislation may be required to grant Virginia localities the authority to implement some of the recommendations from this checklist.

SUMMARY – NEW JERSEY MUNICIPAL REGULATIONS WORKSHEET	
Audience/Intended Users	Local government staff
Advantages	Detailed recommendations for policy changes, justifications/rationales for recommended practices
Disadvantages	Potentially limited applicability to Virginia localities
Web Address	http://www.njstormwater.org/bmp_manual2.htm

CWP CODES AND ORDINANCES WORKSHEET

In 1998, the Center for Watershed Protection, working for the Site Planning Roundtable, completed *Better Site Design: A Handbook for Changing Development Rules in Your Community*. The goal of this project and the resulting report was to develop a series of recommendations on how to change local ordinances to address water quality and a process by which to implement them at the local government level. The report describes a process where local officials and stakeholders assess their existing rules and compare them with model development principles. Based on this comparison, the local group can then identify ways to change their rules to promote low impact development. The report describes twenty-two model development principles, including current practices, recommended practices, and perceptions and realities. Some sections also describe economic benefits or have case study examples. As part of this effort CWP developed a Codes and Ordinances Worksheet with guidance, recommendations, and scoring for each of the twenty-two model development principles. The assessment consists of three steps: identifying existing development regulations, identifying who is responsible for administering and enforcing those regulations, and then completing and scoring the worksheet. The worksheet is divided into three sections: residential streets and parking lots, lot development, and conservation of natural areas.

The CWP worksheet and handbook cover much of the same ground in terms of content. However, the worksheet and handbook combination differs from the regulatory checklists in some key and potentially useful ways. First, the worksheet begins with a list of local code and policy documents recommended for use in the assessment. This can make the task somewhat easier to accomplish, especially in localities without much experience in addressing stormwater management issues. Second, the worksheet provides numeric standards (as opposed to asking only whether or not a locality has a particular ordinance) and gives each question a score, which allows for the prioritization of those policies which will have the greatest impact (assuming that each question's score is reflective of its relative importance). Both of these features are more useful than a simple yes/no checklist.

SUMMARY – CWP CODES AND ORDINANCES WORKSHEET	
Audience/Intended Users	Local government staff
Advantages	Specific recommendations for policies to implement, justifications/rationales for recommended practices, point system for ranking recommendations, list of documents to review
Disadvantages	Not Virginia-specific, so enabling legislation may be required
Web Address	http://cwp.org/documents/cat_view/77-better-site-design-publications.html

EPA WATER QUALITY SCORECARD

In 2009 the U.S. Environmental Protection Agency published the Water Quality Scorecard, a tool designed to both remove barriers and implement policies at the local government level to promote water quality protection. The tool had two goals: helping communities protect water quality by managing stormwater runoff and educating stakeholders about the water quality implications of local development policies and regulations. The tool provides a comprehensive approach to integrating green infrastructure policies at three scales: the municipality, the neighborhood, and the site. Municipal-level recommendations focus on open space preservation and directing

where growth occurs. Neighborhood-level recommendations focus on the mix and density of uses. Site-level recommendations focus on managing stormwater runoff through best management practices. Recommendations are divided into four categories (adopting plans and education, removing barriers, adopting incentives, and enacting regulations) and placed into five sections (protecting natural resources and open space, promoting compact development and infill, street design, parking, and adopting green infrastructure practices). Each section includes a series of subsections which are composed of a question, a goal, a rationale, and various implementation tools, which are assigned various points.

In addition to the recommendations, the publication also includes a list of documents and policies to review and recommendations for which municipal departments should participate in the review process. Each section is also accompanied by a list of helpful resources and case studies. The document also includes some recommendations for improving interdepartmental cooperation. Much of the content is similar to the other documents reviewed, with an additional focus on large scale green infrastructure and conservation policies. The breakdown of categories is particularly helpful in quickly identifying which areas to look at for specific policies. While the majority of specific implementation practices are awarded only one point, the use of a point system does provide some feedback as to which policies are the most effective or useful. Using the scoring system through a comprehensive review can provide a relatively quick assessment of how well a locality is doing in terms of promoting water quality.

SUMMARY – EPA WATER QUALITY SCORECARD	
Audience/Intended Users	Local government staff
Advantages	Specific recommendations, justifications/rationales for recommended practices, point system for ranking recommendations
Disadvantages	Not Virginia-specific, so enabling legislation may be required
Web Address	http://www.epa.gov/smartgrowth/water_scorecard.htm

TOOL RECOMMENDATIONS

In reviewing these existing tools, several key features stand out as particularly useful for local governments when reviewing their existing policies and documents. First, a list of specific documents, policies, regulations, and ordinances to review is necessary to perform a comprehensive review, especially since many different policies affect stormwater runoff and water quality. Second, specific questions and recommendations can help localities identify which policies need to change and how they should be changed. Third, a point or other ranking system can be helpful in identifying which changes should be given priority. Several of the documents, specifically the CWP Worksheet and EPA Scorecard, appear to be the best in terms of potential usability by local governments in addressing the Chesapeake Bay TMDL and new stormwater regulations. However, the policies which should be reviewed for compatibility are not identical to the recommendation in those documents. Some potential recommendations are discussed below.

TOOL ASSESSMENT – KEY FEATURES			
Checklist/Tool	**List of Documents**	**Recommendations**	**Scoring System**
DCR			
JRA		X	
New Jersey		X	
CWP	X	X	X
EPA	X	X	X

RECOMMENDED POLICIES

The new stormwater regulations and the Chesapeake Bay TMDL place significant new requirements on local governments. Many resources exist which local governments can use to promote water quality through their plans and policies, as shown by the examples above. The implementation of the Chesapeake Bay TMDL and the new stormwater regulations alters the incentives for enacting water quality protection policies. Prior to the new regulations, incentives were often required to get developers to incorporate better site development practices outside CBPA areas. Developers were not yet responsible for all the runoff generated by their developments. Under this regime, the combination of the "no net increase" policy and the use of the Runoff Reduction Method (as opposed to the Simple Method) results in individual developers having to implement more stormwater management on their own, without incentives from local governments. Unfortunately, while new developments now have to meet stringent stormwater management requirements, under Virginia's Watershed Implementation Plans, local governments will get no credit toward their load reduction goals from new development. All reductions that count towards local reduction targets must come from either retrofits of existing developments or redevelopment projects.

Based on this change to the water quality/development impacts incentive structure, proposed policies can be placed into two categories: new development policies and redevelopment policies. Policies related to new development should have the goal of reducing impervious cover mandates, which can make development more feasible and affordable, while also improving water quality. Policies related to redevelopment should focus on encouraging redevelopment in general and on promoting cost effective retrofits to existing development.

POLICIES RELATED TO NEW DEVELOPMENT

Previously, policies to promote water quality on new development took the form of mandates, such as capping the amount of impervious surface on a lot based on density and zoning, or requiring a certain percentage of tree canopy to be in place within a decade or two after construction. These policies are often enabled by state law, and are put in place because it is assumed that developers would not take those steps on their own[2]. Under the new system, developers have significant incentives to both limit impervious cover and retain tree canopy on their sites,

[2] The enabling authority for regulating impervious cover is found in the Chesapeake Bay Preservation Area Designation and Management Regulations General Performance Criteria, 4VAC50-90-130. The enabling authority for requiring minimum tree canopy coverage is found § 15.2-961 of the Code of Virginia.

due to how both are treated by the Runoff Reduction Method spreadsheets. However, local policies often set minimum requirements (such as of parking spaces, and setbacks) that can result in excess impervious cover. Other local policies can also impede the use of various stormwater best management practices.

The amount of impervious cover on a site is driven by two factors: the planned use of the site and local government regulations. Buildings are the most obvious examples of impervious cover. Supporting infrastructure, such as parking lots, driveways, loading docks, and other components can also result in significant amounts of impervious cover. However, a significant amount is the result of local restrictions and requirements related to the placement of a building on a site and transportation requirements. These requirements currently set a minimum for how much impervious cover will be on a developed site; reducing or eliminating these requirements can significantly help developers comply with the new stormwater regulations. These regulations include parking requirements, road standards, setbacks, and material requirements. Localities should first identify what their current requirements are and then assess whether those requirements are too high.

PARKING

Local parking requirements are usually established based on industry standards or historic practices for each land use. However, these standards may often result in excessive amounts of parking and view individual properties in isolation from their neighbors. **Shared or cooperative parking arrangements** are one method of reducing overall parking and can be very effective in mixed use areas where each use's traffic dominates a different time of day (for example, banks or offices during the day, and restaurants or entertainment venues during the evening). The *Better Site Design* handbook includes a model shared parking ordinance and legal agreement; Leesburg, Virginia has a shared parking provision in its code.[3] Localities can also **reduce minimum parking requirements**; both the New Jersey checklist and CWP worksheet suggest minimum ratios of 3.0 spaces per 1000sqft for offices and 4.5 spaces were 1,000sqft for shopping centers. Localities can also consider reducing the minimum size of individual parking spaces. Another tactic localities can use is to **allow for pervious pavement in parking areas**, which can reduce runoff by allowing some stormwater to infiltrate while still providing sufficient parking.

ROAD STANDARDS

Roads are one of the largest sources of impervious cover in both private and public developments. Roadway widths are based on standards developed for various quantities of daily traffic and in the past have often been criticized for being too wide. Both the CWP worksheet and New Jersey checklist recommend street widths between 18 and 22 feet for low density residential development. At minimum, **localities should assess their standards to make sure they are no larger than the current VDOT standard**, which is now 24 feet or 29 feet for roads with up to 2000 average daily traffic depending on whether there are two or fewer lanes of on-street parking. Localities can also **encourage efficient street layouts** (such as using a straight grid instead of curvilinear roads and/or cul-de-sacs) to reduce the overall length of roadway and **reduce minimum radii for cul-de-sacs**.

[3] Town of Leesburg Zoning Ordinance Article 11 Section 11.4.2

SITE DESIGN

The physical layout of developments has a significant impact on the amount of impervious surface used for roads, driveways, and sidewalks. In addition to encouraging efficient street layouts, localities can **encourage and promote the use of cluster developments** to reduce the total length of roadway constructed for a development. While cluster developments are allowed by-right in some localities, local governments can **encourage them further by offering density bonuses** based on locally developed criteria.[4] For example, in exchange for clustering to minimize impacts on an ecologically sensitive area, a local government could grant a developer an extra dwelling unit per acre. Localities should also **assess their setback requirements, specifically front setbacks, to determine whether or not they are excessive**. Excessive front setbacks can result in overly long driveways, resulting in more impervious surface.

IMPEDIMENTS TO BMPS

Vegetation is a useful component of many stormwater best management practices. Localities should assess their ordinances for landscaping, nuisances, and performance standards to **make sure that no ordinances are preventing the implementation of vegetated BMPs**. An example of this would be the use of native vegetation in swales, which may not be allowed based on weed ordinances. Localities should also **analyze their maintenance and other policies to prevent undesired trimming or clearing** of vegetation BMPs. Localities should also **assess whether their stormwater management ordinances prevent the use of swales or other similar BMPs** in lieu of curbs and gutters in certain areas.

POLICIES RELATED TO REDEVELOPMENT

Redevelopment provides a major opportunity for local governments to meet their load reduction targets without the use of public funds. Although redevelopment trends are hard to project, redevelopment projects and their reductions can be tracked and counted as localities submit progress updates as part of their compliance with the Chesapeake Bay TMDL. Redevelopment as a BMP strategy is considered in greater detail in another HRPDC report (CH2M HILL, 2012). Redevelopment can have several benefits, in addition to the water quality benefits resulting from implementing the stormwater regulations: floodplain management, hazard mitigation, recreation, beautification, urban renewal, and economic development are some of the additional benefits to be gained from strategic redevelopment efforts. In general, localities should encourage redevelopment projects where feasible as they provide a direct return in terms of nutrient load reductions. Several policies can be used to promote redevelopment projects:

- **expedited reviews** by local government staff;
- the establishment of **priority investment districts**, where localities prioritize funding for maintenance and new infrastructure projects, such as roads;
- **business improvement or tax increment financing districts**, which can allow businesses to located in areas where infrastructure and other improvement projects are directly funded by their tax contributions.

[4] Code of Virginia § 15.2-2286.1

Localities can also adopt preservation or protection policies such as:

- downzoning or rezoning areas (such as conservation or agricultural areas) to have lower development densities;
- adopting agricultural and open space preservation policies, such as purchase of development rights programs (which remove the possibility of future development) or land use taxation policies (which tax land according to how it is used as opposed to its fair market value)
- transfer of development rights programs, which can target specific areas to "send" development to specified receiving areas (which can be developed areas where existing development can be intensified)
- density bonuses, which can be used to incentivize developers to buy development rights in sending areas and move them to redevelopment areas[5]

Other policies can be used to improve existing neighborhoods and address stormwater management, such as identifying vacant or blighted properties and converting them to open space or parks. Localities can also take advantage of broad zoning powers to identify urban growth areas or development districts and restrict development outside these areas through high minimum lot size requirements.

CONCLUSION

While the new stormwater regulations and Chesapeake Bay TMDL will create new challenges for both local governments and property developers, there are policies and ordinance changes localities can adopt to improve compliance with both programs. The second year of this project will include further identification of appropriate policies, refinement of the tool, and testing of the tool with pilot localities.

[5] Transfer of Development Rights ordinances are authorized under Code of Virginia § 15.2-2316.2

SECTION III – TOOL EVALUATION FOR MODELING DEVELOPMENT IMPACTS

In light of the revised Virginia stormwater management regulations as well as the Chesapeake Bay Total Maximum Daily Load (TMDL), analyzing potential changes to development regulations, land use plans, or zoning regulations may assist Hampton Roads localities in reaching their nutrient reduction goals. Any nutrient reduction that can be achieved through policy changes gives developers a head start as they prepare their plans. The objective of this exercise was to research and evaluate existing methodologies in order to determine the ideal tool, model, workflow, or combination thereof for local government staff in Hampton Roads to analyze the impact of different development or redevelopment scenarios on stormwater runoff.

The evaluated tools applicable to this project fall into three categories: decision support systems, water quality models, and environmental impacts analysis. Most are also based on geographic information systems (GIS) technology or are easily integrated into GIS. GIS tools are ideal because they not only have the ability to calculate stormwater runoff like a spreadsheet or database, but important geographic factors such as land use and zoning regulations can be modeled visually.

The following section provides an overview of the different tools evaluated and the pros and cons of each. The selected methodology was then tested with a small sample analysis.

REVIEW OF EXISTING TOOLS

The following list of tools is not inclusive of all land use/stormwater/environmental planning tools available. The tools chosen for evaluation were deemed to have the most potential to be applicable to this project in terms of estimating the impacts of land use policy changes on stormwater runoff.

The following software/methodologies were reviewed for this study:

DECISION SUPPORT SYSTEMS

- CommunityViz®
- INDEX PlanBuilder

WATER QUALITY MODELS

- OpenNSPECT
- PLOAD
- inForest

ENVIRONMENTAL IMPACT ANALYSIS TOOLS

- i-Tree Hydro
- inVEST

CommunityViz®

http://placeways.com/communityviz

CommunityViz is a GIS-based decision support system (DSS) that is geared toward local planners. It is an extension, at an additional cost, for ArcGIS Desktop that allows the user to develop multiple scenarios for planning using interactive tools. The Scenario 360 module allows for variable inputs by the user into the analysis that results in a visual comparison of economic, social, or environmental indicators. There are built-in tools for scenario sketching, land fragmentation, suitability, and build-out analysis. The graphs and reporting tools allow stakeholders to evaluate or score the presented scenarios. The Scenario 3D module allows the user to create 3D models of the project or scenarios for visual evaluation. CommunityViz aims to be a flexible, interactive tool.

REQUIRED DATA:

- Variable

ADVANTAGES:

- Extremely flexible
- Allows for users to create their own formulas for indicators
- User can change assumptions interactively
- Visual comparison of different scenarios
- Standard indicators are easily configured
- Set goals and evaluate them

DISADVANTAGES:

- Steep learning curve for new users or those who are not as familiar with GIS
- Stormwater runoff calculations are not standard; must be customized
- Price ($500 for annual license/$850 for annual license and support)
- Must use ArcGIS Desktop

INDEX PLANBUILDER

http://www.crit.com/

INDEX PlanBuilder is a similar DSS to CommunityViz – its aim is to bring stakeholders together to make decisions based on evaluating alternative scenarios. INDEX is also an additional cost extension to ArcGIS Desktop but also offers an open source GIS application for the Internet. INDEX also features scenario building, goal tracking, scenario ranking, and progress reporting. Over 150 standard indicators are available including stormwater runoff, nonpoint source pollution, and imperviousness. However, stormwater runoff and non-point source pollution are standard indicators calculated using the U.S Environmental Protection Agency's (EPA) Smart Growth Water Assessment Tool for Estimating Runoff (SG WATER) methodology.

REQUIRED DATA:

- Variable

ADVANTAGES:

- Visual comparison of different scenarios
- Ability to create reports of scenarios
- Standard indicators are easily configured
- Set goals and evaluate them
- Stormwater runoff is a standard indicator

DISADVANTAGES:

- Some indicators require Advanced or Standard level license of ArcGIS Desktop
- No ability to customize indicators but can link to other models and import/export data files
- Steep learning curve for new users or those who are not as familiar with GIS
- Only compatible with ArcGIS 9.3
- Price ($1,900)

WATER QUALITY MODELS

OpenNSPECT

http://www.csc.noaa.gov/digitalcoast/tools/opennspect

The Open-source Nonpoint Source Pollution and Erosion Comparison Tool (OpenNSPECT) is designed to simulate erosion, pollution, and the accumulation of both from overland flow. Primarily used at the watershed level, OpenNSPECT provides estimates and maps surface water runoff, pollutant loads and concentrations, and sediment loads. The software also allows for alternative land use scenarios to be created in order to evaluate the impact on water quality. Pollutant loading is derived from land cover coefficients multiplied by the accumulated runoff for the watershed.

OpenNSPECT was developed by the National Oceanic and Atmospheric Administration's (NOAA) Coastal Services Center (CSC). Originally built as an extension to ArcGIS Desktop, the tool is now based on the open-source GIS called MapWindow.

REQUIRED DATA:

- Land Use/Land Cover
- Elevation
- Soil
- Rainfall factor (R factor)
- Precipitation
- Coefficients

ADVANTAGES:

- MapWindow and OpenNSPECT are both free
- Easy to learn
- Gives a good general overview of impact on different land use scenarios for medium to large watersheds
- Ability to run multiple scenarios

DISADVANTAGES:

- Analysis requires raster GIS data (grids) so it is not precise in estimations
- No customization possible
- Watershed scale analysis only

PLOAD (BASINS)

http://water.epa.gov/scitech/datait/models/basins/BASINS4_index.cfm

The Pollutant Loading Estimator (PLOAD) is a component of the Better Assessment Science Integrating Point & Non-point Sources (BASINS) multipurpose environmental analysis system developed by the Environmental Protection Agency (EPA). The overall purpose of developing BASINS was to support the development of Total Maximum Daily Loads (TMDLs). PLOAD is a GIS-based tool to calculate nonpoint source pollutant loads for watersheds. PLOAD can use either Export Coefficients method or the EPA's Simple Method. There is also an option to incorporate best management practices (BMPs). The user also has the ability to run different scenarios and compare the results. PLOAD is best used on the watershed scale as a way to generally estimate pollutant loads. PLOAD is run within the open source GIS software, MapWindow.

REQUIRED DATA:

- Land use/land cover
- Pollutant loading rate data tables
- BMP information (optional)

ADVANTAGES:

- MapWindow and PLOAD are both free
- Easy to learn
- Gives a good general overview of impact on different land use scenarios for medium to large watersheds
- Ability to run multiple scenarios

DISADVANTAGES:

- Analysis requires raster GIS data (grids) so it is not precise in estimations
- No customization possible
- Watershed scale analysis only
- Detailed analysis requires more detailed inputs

InFOREST

http://inforest.frec.vt.edu/

InForest is a GIS-based tool hosted online and designed to provide quick access to data about natural resources. It was developed by Virginia Tech for the Virginia Department of Forestry. InForest has two main components. First, it provides a GIS data browser to access layers such as land use and forest cover. It also features three Ecosystem Service Calculators: carbon sequestered in a forest stand, nutrient and/or sediment runoff, and nutrient offset for the Virginia Nutrient Trading Program (Chesapeake Bay watershed only). The nutrient/sediment runoff tool uses the Generalized Watershed Loading Function (GWLF) method to estimate parcel level or watershed level nutrient and sediment loadings. The nutrient/sediment runoff tool is a wizard-based tool where the user can select either a HUC 12[6] drainage area for analysis or they can draw a specific study area on the interactive map. The application automatically calculates the acres of each type of land cover and allows the user to adjust it. Then the user can enter changes in acreage to the area of choice to see the results in the nutrient load.

REQUIRED DATA:

- None

ADVANTAGES:

- No GIS software required; hosted online
- Easy to use wizard
- Allows user to draw study area or use watershed boundary for analysis

DISADVANTAGES:

- No customization possible
- No other indicators can be calculated
- Very basic analysis

[6] Hydrologic Unit Codes, or HUCs, are assigned to various levels of watersheds or drainage areas. HUC 12s are subwatersheds, the smallest hydrologic units. The other classification levels are regions (HUC 2), subregions (HUC 4), basins (HUC 6), subbasins (HUC 8), and watersheds (HUC 10).

ENVIRONMENTAL IMPACT ANALYSIS TOOLS

i-TREE HYDRO

http://www.naturalcapitalproject.org/download.html

i-Tree is a suite of software tools developed by the U.S. Department of Agriculture (USDA) Forest Service mainly to provide urban forestry planners with analysis and assessment tools. Although primarily an urban forestry tool, the Hydro module of i-Tree was developed in order to analyze the changes that tree canopy and impervious surfaces have on stream flow and water quality. i-Tree Hydro simulates hourly changes in stream flow and water quality as well.

REQUIRED DATA:

- Land use/land cover
- Digital Elevation Model
- Streamflow data
- Weather data
- Evapotranspiration data

ADVANTAGES:

- i-Tree is free software
- GIS software is not required to run the model, but is needed to prepare input data
- Ability to run multiple scenarios
- Easy to run model after set up

DISADVANTAGES:

- More expertise is needed to be able to set up
- No customization possible
- No other indicators can be calculated
- Works only at watershed level
- Requires tabular data

InVEST

http://www.naturalcapitalproject.org/InVEST.html

InVEST (Integrated Valuation of Environmental Services and Tradeoff) is a robust suite of tools developed to calculate the value of several different ecosystem services in order to demonstrate the benefits of "natural capital." InVEST was developed by the Natural Capital Project, a non-profit organization. It contains several different marine models (including a marine water quality model) as well as several terrestrial and freshwater models. For the purposes of this project, the "Water Purification Nutrient Retention" model was assessed.

The nutrient retention model calculates the amount of nutrients retained within a watershed then averages the amount of nutrients that are retained or released. InVEST is also able to calculate the economic value of the nutrient retention in a watershed through the presumed treatment costs that will not occur. InVEST is a plugin for ArcGIS desktop software.

REQUIRED DATA:

- Digital elevation model
- Soil depth
- Precipitation data
- Evapotranspiration data
- Plant Available Water Content
- Land use/land cover

ADVANTAGES:

- Easy to use wizard
- Calculates economic value of nutrient retention
- More control over inputs for calculation

DISADVANTAGES:

- Requires detailed data in GIS to run
- Can only calculate one nutrient at a time
- Best results at watershed level due to using raster GIS data

SELECTING A METHODOLOGY

In selecting a methodology to use in evaluating potential policy changes on stormwater runoff, several criteria were considered:

EASE OF USE – The evaluated tools ranged from very simple wizards to very complicated setups

PRICE/ACCESSIBILITY – A few of the tools evaluated were free, some were free but require ArcGIS desktop, while other tools are paid and require ArcGIS software.

REQUIRED INPUT DATA – Some of the tools required several detailed data layers or tables in order to calculate nutrient runoff while others used general, coarse data for more generic analysis.

MODEL IMPACT OF LAND USE POLICY CHANGES – While all of the tools were able to take land use/land cover into account to create alternate scenarios of nutrient loads, none were directly able to evaluate policy changes, such as required tree canopy ratios, setbacks, or impervious surface ratios. CommunityViz and potentially INDEX have this capability, but only after customizing the software.

ABILITY TO CREATE SCENARIOS – All of the tools can be run multiple times with alternative land use/land cover inputs, however only the decision support systems are able to analyze different scenarios side by side.

It is clear that none of the tools meet the objective of this project "off the shelf," so HRPDC staff looked at the feasibility of combining several tools and using them in concert. One such example of this is the "Integrated Land-Sea Toolkit" developed to evaluate alternative land use scenarios in Aransas County, Texas (Crist, et al., 2009). The authors of the Toolkit created a methodology that integrates three software programs: CommunityViz, Natureserve Vista[7], and NSPECT (now OpenNSPECT). This project was successful in that the researchers were able to demonstrate that the Future Trend scenario did not meet as many of the ecological and socioeconomic goals of Aransas County as the Mitigation Scenario (Madden & Morehead, 2011). Although the Toolkit demonstrates that interoperability of multiple software tools is feasible, this particular combination did not meet the needs of this grant project. Other possible ways to integrate tools were investigated rather than replicate the analysis from the Integrated Land-Sea Toolkit.

It also became apparent after reviewing the selected tools that the methods used to calculate stormwater runoff should also be a critical factor in selecting a tool, depending on the needs of the user. The reviewed tools used a variety of methods including the EPA's Simple Method, the Generalized Watershed Loading Function, and simple land cover coefficients.

Since the objective of this project was to select a tool most applicable for Hampton Roads, HRPDC staff felt that incorporating the Virginia Runoff Reduction Method (VRRM) into the methodology would be ideal, if possible. The VRRM was developed by the Center for Watershed Protection and the Chesapeake Stormwater Network to serve as a tool to assist Virginia localities with compliance for the new Virginia stormwater regulations that went into effect in 2011. The goal of the VRRM is to encourage better site design to minimize the runoff on developed areas

[7] Natureserve Vista is an extension for ArcGIS that focuses mainly on evaluating scenarios for their conservation value and goals.

while also providing a way to account for the effectiveness of existing or proposed best management practices (BMPs) (Battiata, Collins, Hirshman, & Hoffman, 2010).The VRRM is available as a set of two spreadsheets – one for new development and one for redevelopment.

RECOMMENDED METHODOLOGY

After reviewing many different types of software tools, spreadsheets, and models, HRPDC staff concluded that the most robust and flexible tool to evaluate impacts of potential policy changes on stormwater runoff is CommunityViz customized to run the VRRM. CommunityViz provides the most flexibility in set up and analysis even though some customization is involved. In essence, the formulas used in the VRRM spreadsheets can be set up in CommunityViz as indicators and are calculated "on the fly" as changes to land use policies are modeled in the GIS. The result is the ability to compare policies such as tree canopy ratios, impervious ratios, or zoning requirements (such as setbacks and lot size) on the Total Phosphorus Load, Total Nitrogen Load, Total Phosphorus Reduction Required, and Treatment Volume. The tool will allow planners to gain an overall sense of the impact of certain policy changes on water quality for a given geographic area. Then, any specific refinements required due to existing or proposed BMPs can be completed directly in the VRRM spreadsheets.

The advantage to using VRRM is that the stormwater runoff calculations are consistent with the method that Virginia requires for compliance with the stormwater regulations. This eliminates the need to go back and forth between another tool using a different stormwater calculation method and the VRRM spreadsheets.

TOOL DEMONSTRATION

To demonstrate the efficacy of the recommended method, HRPDC staff developed a sample analysis. The analysis allowed HRPDC staff to ensure that the recommended method would be successful. This particular test looked at a small neighborhood with only one zoning class in order to simplify the setup of the demonstration.

For the sample analysis, a small neighborhood (approximately 154 acres) in northern Suffolk, Virginia along the Nansemond River was used to develop the methodology (Figure 5). These parcels were arbitrarily chosen to represent potential new development. The smaller study area allowed for both ease of tool development and a faster processing time. The methods described below can be scaled to an entire jurisdiction or used for a single site development. The detailed description of the setup of the tool can be found in Appendix A.

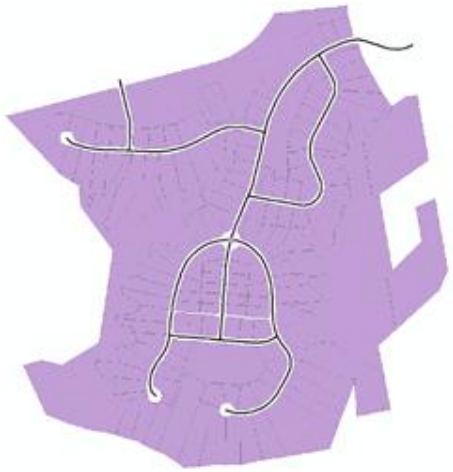

Figure 5: Study Area for Analysis

Assumptions in CommunityViz are inputs that can be adjusted interactively by the user. Indicators are outputs of an analysis that will be used in the decision making process (such as a sum of P load across all parcels). When assumptions are changed, the analysis is re-run and the change in the indicators can be viewed in charts, directly within ArcGIS.

For this test case, assumptions were set up for tree canopy ratio, turf ratio, and impervious surface ratio, to coincide with the land cover classes used in the VRRM spreadsheets. When one of these ratios is changed by the user with the sliders (Figure 6) then the indicators are automatically calculated in the GIS.

The first scenario ("Current Conditions") was set up using the ratios given in the City of Suffolk's zoning code for the Rural Residential district (RR) rather than calculating the actual land cover on the ground. The advantage to using this method is that the ratios are actual inputs to the VRRM formulas in CommunityViz which allows for interactivity with the model. Trying to capture land cover from another data source (such as satellite data) and converting land use categories into VRRM compatible categories creates an extra processing step and does not allow for analysis of land use policies. So, given a tree canopy ratio of 0.2 and an impervious surface ratio of 0.16 in the RR district, it can be assumed the remaining land cover of a parcel falls into the managed turf category with a 0.64 ratio.

A second scenario ("Tree Canopy – Increase") was also set up in order to compare what happens to the nutrient load and treatment volume if the tree canopy requirement were changed to 0.3 in the RR zone. The assumptions were changed (with the turf ratio decreasing to 0.54 in order for the three ratios to equal 1) and the charts were automatically updated with the new nutrient loading numbers. The two scenarios can be compared side by side, as shown in Figure 7. A summary of the results is show in Table 10.

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Figure 6: Assumptions Interface in CommunityViz

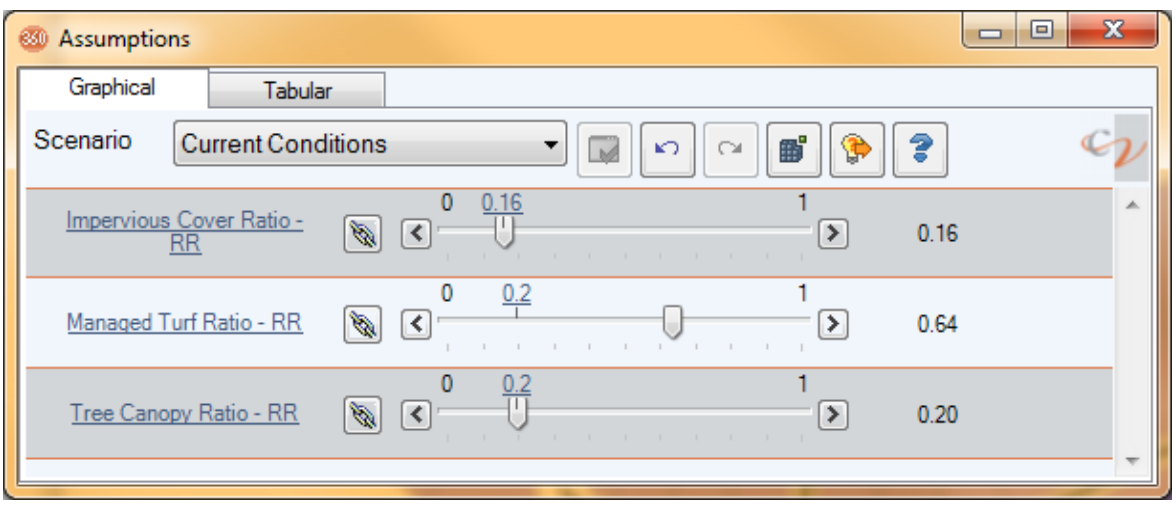
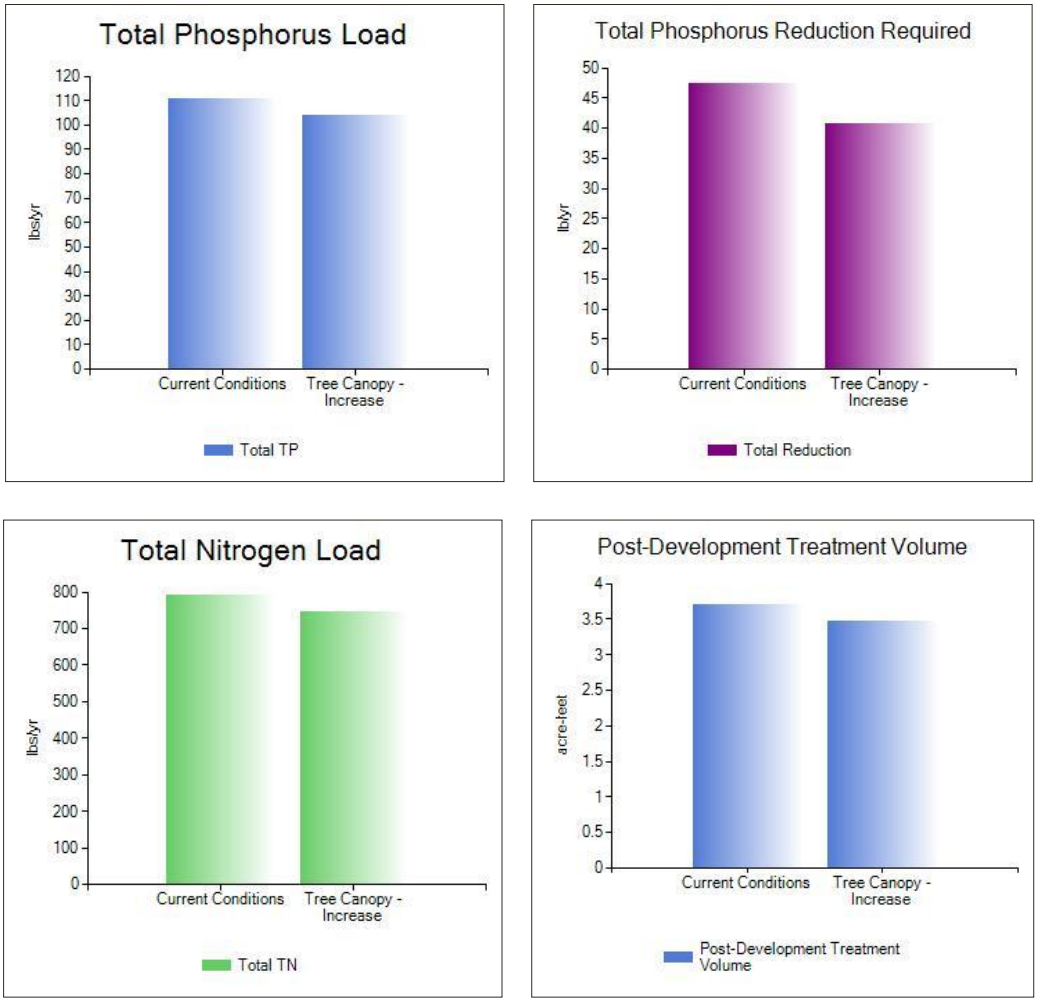


Table 10: Comparison of Scenarios from Sample Analysis

	Current Conditions Scenario	Tree Canopy – Increase Scenario
Assumptions (Variables)		
Tree Canopy Ratio	0.20	0.30
Managed Turf Ratio	0.64	0.54
Impervious Surface Ratio	0.16	0.16
Theoretical Land Cover (Inputs)		
Total Forested	30.85 acres	46.28 acres
Total Managed Turf	98.73 acres	83.31 acres
Total Impervious Surface	24.68 acres	24.68 acres
Indicators (Outputs)		
Total P Load	110.62 lbs/yr	103.97 lbs/yr
Total N Load	791.37 lbs/yr	743.80 lbs/yr
Total P Reduction Required	47.37 lbs/yr	40.72 lbs/yr
Post-Development Treatment Volume	3.70 acre-feet	3.48 acre-feet

Figure 7: Charts Comparing the Results of Current Conditions Scenario with the Increased Tree Canopy Ratio Scenario



CONCLUSION

Considering the available technology and the requirements of the new stormwater management regulations, HRPDC staff determined that the most powerful and flexible methodology currently available to evaluate land use policy changes on stormwater runoff is customizing CommunityViz software to incorporate equations from the VRRM spreadsheets. The test case conducted in this study demonstrated that the combination of resources creates a useful and relevant tool. CommunityViz can be customized even further and other land use planning scenarios can be explored while still incorporating stormwater runoff calculations in the decision-making process.

As previously mentioned, this analysis can be scaled to work for an entire city, watershed or down to a specific proposed development. In the second year of this grant project, HRPDC staff will look at incorporating the VRRM redevelopment spreadsheet into CommunityViz as well. The methodology will also be used to create a more in-depth analysis for two representative localities (urban and suburban) in Hampton Roads. Local government staff will be involved in this process.

Ideally, in the future, an online tool similar to InForest could be developed to replace the need for ArcGIS and CommunityViz and make the methodology more accessible to local planners in Virginia. As an alternative, it may be worth exploring whether it is possible to modify the InForest tool to use the VRRM instead of the Generalized Watershed Loading Function, as a first step.

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APPENDIX A – TOOL METHODOLOGY

In order to demonstrate the recommended methodology, HRDPC staff developed a sample analysis. The following section describes the detailed process of customizing CommunityViz with the Virginia Runoff Reduction Method (VRRM) new development spreadsheet.

DATA PREPARATION

The VRRM spreadsheet requires the use of several constant values, land cover, and soil types. The land cover acreage should be calculated using three categories: Forest/Open Space (undisturbed, protected forest/open space or reforested land), Managed Turf (disturbed, graded for yards or other turf to be mowed/managed), and impervious cover while also divided into soil type groups.

In order to evaluate policy changes such as tree canopy or impervious cover requirements, the land cover should be correlated to the zoning district. Instead of calculating existing land cover using satellite imagery or other data, the tree canopy and impervious cover ratios found in the City of Suffolk's zoning code were used to approximate the minimum amount of forest/open space and the maximum impervious area that would hypothetically be found on each parcel. The remaining percentage of land would then fall into the managed turf category. It is important to note here that this method is not suitable for agricultural lands.

For example, the RR zoning district (rural residential) was used for this sample analysis. The minimum required tree canopy ratio for RR is 0.2 and the maximum impervious ratio allowed is 0.16. This leaves 0.64 to be included in the managed turf category.

Adding to the challenge is that the VRRM requires that a different coefficient be used for each of three land cover types broken down into the four soil types (Figure 8). To calculate these acreages, parcel data with zoning classifications was obtained from the City of Suffolk and combined with Soil Survey Geographic (SSURGO) GIS data. Using a simple intersect command in Esri's ArcGIS, each parcel was broken into parts as defined by the soil types occurring on that parcel. However, in order to proceed with the analysis, the parcels must remain intact. So, the "broken" parcels data were exported to a spreadsheet where a pivot table was created to summarize the acreage found in each parcel by soil type by the unique geographic parcel identification number (GPIN).The new pivot table was joined to the original parcel dataset (unbroken by soil types) in GIS so that the percent of each soil type found in each parcel was contained in the attribute table of the intact parcel (Figure 9).

Figure 8: Land Cover portion of the Virginia Runoff Reduction Method spreadsheet

Land Cover (acres)					
	A soils	B Soils	C Soils	D Soils	Totals
protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	0.00	0.00	0.00
Impervious Cover (acres)	0.00	0.00	0.00	0.00	0.00
				Total	0.00

Figure 9: Attribute table of parcels showing acreage by soil type

GPIN	ZONE_CLASS	TotalAcres	A_Acres	B_Acres	C_Acres	D_Acres
0469-70-1951	RR	0.712348	0	0.17222	0.402164	0.137965
0469-71-1080	RR	0.728367	0	0.069629	0.568087	0.090651
0469-71-1182	RR	0.723577	0	0.011494	0.571611	0.140471
0469-83-6073	RR	0.191246	0	0	0.191246	0
0469-82-6987	RR	0.66907	0	0	0.66907	0
0469-82-7867	RR	0.68639	0	0	0.68639	0
0469-82-8726	RR	0.710073	0	0.056895	0.653178	0

CommunityVIZ ANALYSIS

A CommunityViz analysis has several components: assumptions, dynamic attributes, and indicators. Assumptions are inputs needed to run the analysis and can be fixed or variable (e.g. land use coefficients). Dynamic attributes are automatically updated as the assumptions are changed. The attributes describe some characteristic about the data (e.g. total phosphorus (P) load for a parcel). Indicators are impacts or performance measures that generally describe the entire scenario rather than an individual feature (e.g. the total P load for the entire subdivision). The analysis was set up as shown in Table 11.

Table 11: CommunityViz sample analysis inputs and outputs

Assumptions	Dynamic Attributes	Indicators
Annual Rainfall	Acres – Forest, Soil A, RR district	Total Acres of Forest/Open Space
Target Rainfall Event	Acres – Forest, Soil B, RR district	Total Acres of Managed Turf
Phosphorus EMC	Acres – Forest, Soil C, RR district	Total Acres of Impervious Cover
Nitrogen EMC	Acres – Forest, Soil D, RR district	Total TP
Pj	Acres – Turf, Soil A, RR district	Total TN
Target Phosphorus Load	Acres – Turf, Soil B, RR district	Total Required P Reduction
Rv coefficient – Forest, Soil A	Acres – Turf, Soil C, RR district	Total Treatment Volume
Rv coefficient – Forest, Soil B	Acres – Turf, Soil D, RR district	
Rv coefficient – Forest, Soil C	Acres – Impervious, Soil A, RR district	
Rv coefficient – Forest, Soil D	Acres – Impervious, Soil B, RR district	
Rv coefficient – Turf, Soil A	Acres – Impervious, Soil C, RR district	
Rv coefficient – Turf, Soil B	Acres – Impervious, Soil D, RR district	
Rv coefficient – Turf, Soil C	Rv Impervious	
Rv coefficient – Turf, Soil D	Rv Turf	
Rv coefficient – Impervious, Soil A	Rv Forest	
Rv coefficient – Impervious, Soil B	TP	
Rv coefficient – Impervious, Soil C	TN	
Rv coefficient – Impervious, Soil D	Required P Reduction	
Impervious Ratio – RR district	Treatment Volume	
Turf Ratio – RR district		
Tree Canopy Ratio – RR district		

Assumptions can be fixed or variable. For this demonstration, all of the constants in the VRRM were added as fixed assumptions so that they could be called upon by the formulas in the attributes. The three variable assumptions were the three land cover ratios. The assumptions can be adjusted using the sliding bars by the user (Figure 6).

Once the assumptions were set up, then the dynamic attributes could be created. At this point, the equations from the VRRM spreadsheet were recreated to calculate the total nutrient loads for phosphorus and nitrogen for the given area. Several intermediate calculations were also done (such as acres per soil type by land cover and average land cover coefficients) as shown in Table 11. Example formulas are shown below and also in Figure 10. Each of the dynamic attributes is calculated for a single parcel.

ACRES OF LAND USE BY SOIL TYPE

```
IfThenElse ( If ( [ Attribute:zone_class ] = "RR" ), Then ( [ Assumption:Tree Canopy Ratio - RR
] * [ Attribute:A_Acres ] ), Else ( 0 ) )
```

RV COEFFICIENT FOR LAND USE

```
( [ Assumption:Rv Forest A ] * [ Attribute:LC_Forest_ Asoil_ RR ] + [ Assumption:Rv Forest B ] *
[ Attribute:LC_Forest_ Bsoil_ RR ] + [ Assumption:Rv Forest C ] * [ Attribute:LC_Forest_ Csoil_
RR ] + [ Assumption:Rv Forest D ] * [ Attribute:LC_Forest_ Dsoil_ RR ] ) / [ Attribute:Sum_Forest
]
```

SITE RV COEFFICIENT

```
( [Attribute:Rv Forest ] * ( [ Attribute:Sum_Forest ] / [ Attribute:TotalAcres ] ) ) + ( [
Attribute:Rv Turf ] * ( [Attribute:Sum_Turf ] / [Attribute:TotalAcres ] ) ) + ( [Attribute:Rv
Impervious ] * ( [ Attribute:Sum_Impervious ] / [ Attribute:TotalAcres ] ) )
```

TOTAL P

```
[Assumption:Annual Rainfall ] * [Assumption:Pj ] * ([Attribute:Treatment Volume ] / [
Assumption:Target Rainfall Event ] ) * [ Assumption:Phosphorus EMC ] * 2.72
```

TOTAL P REDUCTION

```
[Attribute:TP ] - ( [Assumption:Target Phosphorus Load ] * [Attribute:TotalSoilAcres ] )
```

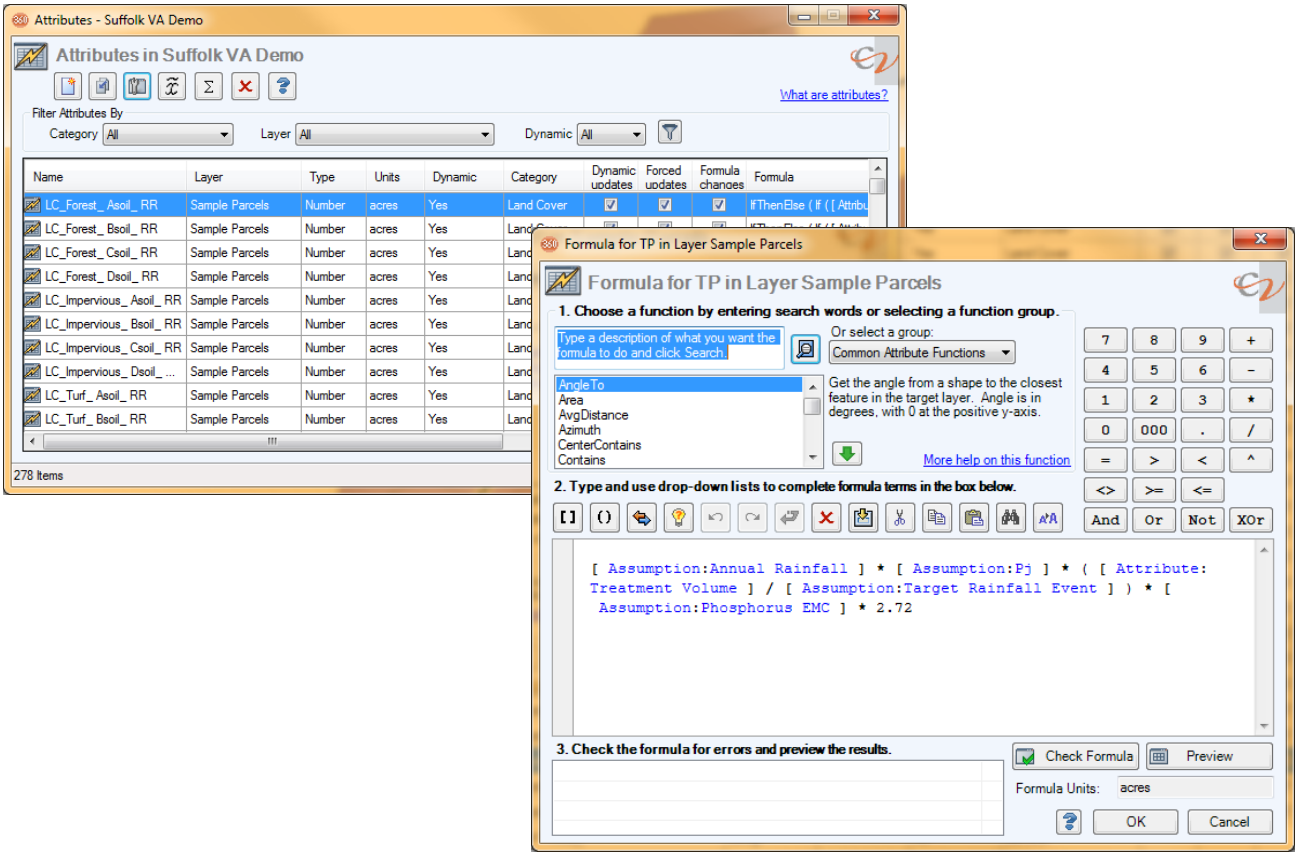
TOTAL N

```
[Assumption:Annual Rainfall ] * [Assumption:Pj ] * ([Attribute:Treatment Volume ] / [
Assumption:Target Rainfall Event ] ) * [Assumption:Nitrogen EMC ] * 2.72
```

TOTAL TREATMENT VOLUME

```
( [Assumption:Target Rainfall Event ] * [Attribute:Site Rv ] * [Attribute:TotalSoilAcres ] / 12 )
```

Figure 10: Screen captures of dynamic attributes dialog in CommunityViz with the formula dialog box for Total P

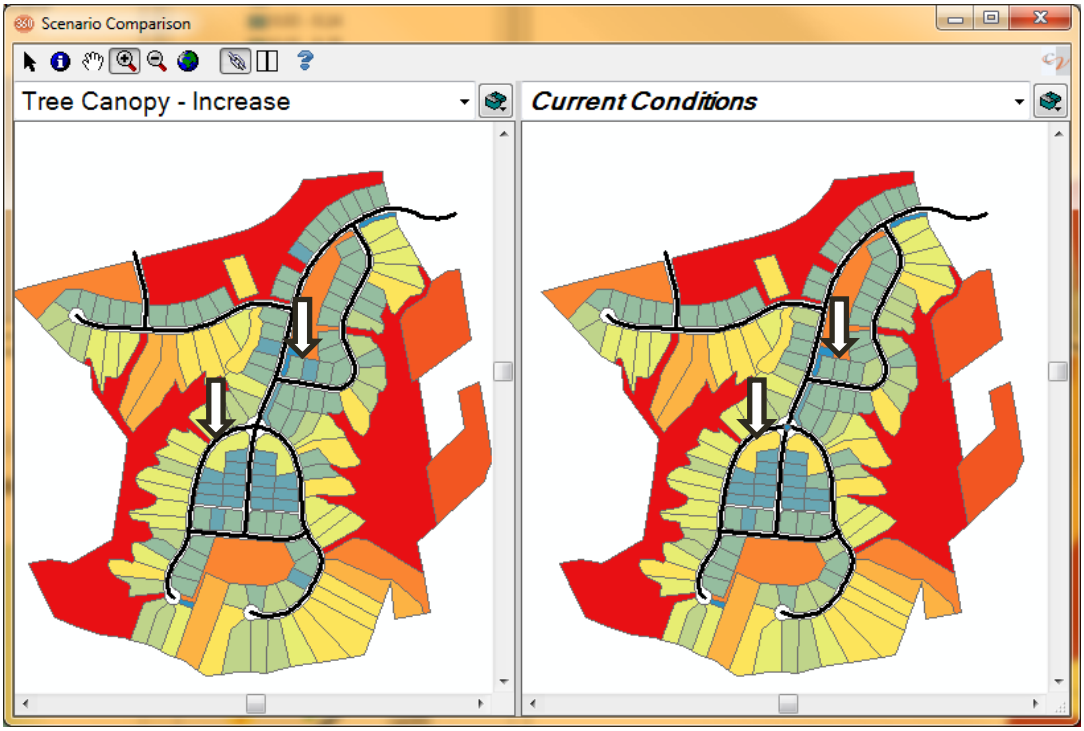


Indicators can best be thought of as summaries of the dynamic attributes as they give the "big picture" of the results of the analysis. For this project, all of the indicators were merely sums of the dynamic attributes. Rather than calculating a value for a single parcel, the indicators wizard allows the user to sum up values of interest for all of the parcels, such as the Total P load for the entire study area. There is also an option to view the indicators as charts, which assists with visually displaying the results (Figure 7).

It is also possible to symbolize the study area by an attribute of interest and compare the scenarios side by side. In Figure 11, the Current Conditions scenario is viewed next to the Tree Canopy Increase scenario with the symbology indicating which parcels have a higher Total P load. Since this demonstration was in a small area, the differences between the scenarios is subtle but it does demonstrate how useful this ability could be to the decision making process.

The indicator charts as well as the map symbology are meant to be interactive. If the user changes the assumptions with the slider bar, then the both the charts and maps are updated. The charts can also show what the previous values were so it is easier to compare the changes.

Figure 11: Side by side comparison of scenarios showing P load by parcel.



See arrows – differences are subtle in this small study area

APPENDIX B – APA-VA SESSION/PRESENTATION

The following presentation was given to planners from across Virginia during a session of the annual conference of the Virginia Chapter of the American Planning Association at Wintergreen, Virginia on July 20, 2012. The presentation was given by two HRPDC staff members, Principal Water Resources Engineer Whitney Katchmark and Regional Planner Benjamin McFarlane, and discussed the connection between water quality and planning and how HRPDC staff was working with Hampton Roads local governments to promote policies to improve water quality in the Chesapeake Bay watershed. This included a discussion of the Section 309 grant. The presentation was followed by questions and discussion. The description of the session, as submitted to the chapter, is given below.

NAME OF SESSION:

Water Quality, the Chesapeake Bay TMDL, and Planning

SESSION DESCRIPTION:

The Chesapeake Bay Total Maximum Daily Load and new Virginia stormwater management regulations present significant challenges to Virginia's coastal communities. One result of these regulatory measures was the creation of nutrient reduction goals for each locality. As a result, local governments are required to development Watershed Implementation Plans to map out how these nutrient reduction goals will be achieved. New land use approaches and development policies are needed to help local governments comply with these requirements and reduce the impacts of land development on water quality.

The Hampton Roads Planning District Commission played a key part in the region's localities' efforts to respond to and comment on the Chesapeake Bay TMDL as it was being developed. In addition, the HRPDC helped coordinate a unified regional response by the affected localities and continues to work with local government staff to identify cost-effective methods to achieve nutrient reduction goals. To support this work, HRPDC received a Section 309 Grant from the Virginia Coastal Zone Management Program to develop ways to improve and protect the quality of the region's land and water resources. To date, this grant has included efforts to: summarize the impacts of the Chesapeake Bay TMDL and stormwater management regulations on local governments and development; develop a tool local governments can use to assess their local policies for water quality impacts; and identify a tool local governments can use to estimate the potential impacts of future development. HRPDC staff is working with two pilot localities in the region to test and implement these tools.

The presenter(s) will give an overview of the Hampton Roads region's response to the Chesapeake Bay TMDL and the results from the grant project described above. The presentation will include a demonstration of how to use the various tools.

Water Quality, the Chesapeake Bay TMDL, and Planning

APA Virginia 2012

Whitney Katchmark, P.E.
Principal Water Resources Engineer
Hampton Roads PDC

Benjamin McFarlane, AICP
Regional Planner
Hampton Roads PDC

Presentation Overview

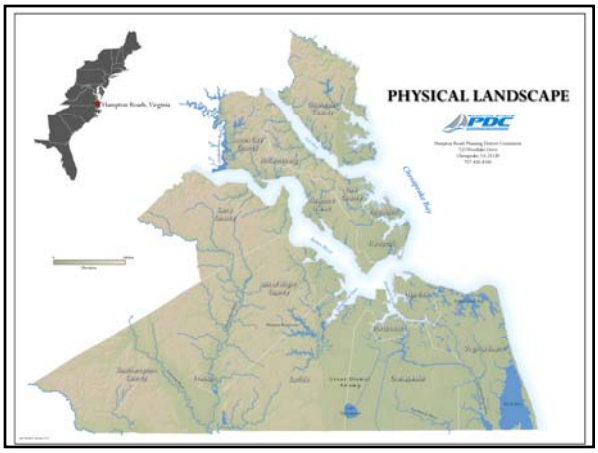
- Introduction
- The Connection Between Water Quality and Planning
- History and Overview of Water Quality Efforts in the Chesapeake Bay Watershed, Pre-TMDL
- The Chesapeake Bay TMDL
- Reconnecting Water Quality and Planning

What is the HRPDC?

- 1 of 21 Regional Planning Agencies
- State enabled; locally created
- 16 Cities & Counties; several Towns; 1.7 million people; 3,000 square miles; 5,000 miles shoreline
- Commission – 45 local elected officials & CAO
- Staff – Executive Director & 45 staff
- Funding – Local contributions, grants, and contracts
- Functions – Economics, Housing, Transportation, Environmental, Emergency Management
- Budget $12,000,000 +
- Role – Policy & Technical Analysis, Planning & Engineering Studies, Cooperative Problem Solving, Coordination

What does HRPDC do?

- The Commission:
  - "**serves as a forum** for local and elected officials and chief administrators to **deliberate** and **decide** issues of **regional importance**"
- The Staff:
  - "provides the local governments and citizens of Hampton Roads credible and timely **planning, research, and analysis** on matters of mutual concern, and"
  - "**provides leadership and offers strategies and support services** to other public and private, local, and regional agencies, in their efforts to improve the region's quality of life."



WATER QUALITY AND PLANNING

What's the Connection?

- In many if not most localities, responsibility for maintaining or improving water quality is decoupled from planning
- Planning decisions can have a major impact on water quality due to the location and intensity of development
  - Certain areas are more sensitive than others (e.g. riparian buffers)
  - More impervious cover = lower water quality

Impacts of Impervious Cover

- Impervious surfaces – parking lots, road, rooftops – have a direct, negative impact on watershed health
  - Runoff moves faster over impervious surfaces, causing shoreline erosion when it reaches waterways.
  - Runoff does not infiltrate into the ground, resulting in more water delivered to streams.

Why now?

- Previous efforts to improve water quality in the Chesapeake Bay have not worked well enough
- The Chesapeake Bay TMDL and Virginia's new stormwater management regulations have placed new requirements on local governments to achieve water quality goals
  - Enforceable limits on nutrients (nitrogen, phosphorus, sediments)
  - Deadlines for achieving load reductions

Changes in Stormwater Management Approaches

- Previous paradigm:
  - Move water offsite and into waterways as quickly as possible
- New paradigm:
  - Infiltrate onsite
  - Reduce quantity and velocity of water delivered to streams and waterways
- This change has major implications for the planning, design, and development of sites

Changes in Stormwater Management Approaches

- Old paradigm required solutions in terms of engineering and infrastructure
- New paradigm requires new solutions
  - Land use changes
  - Better site design
  - Integration of stormwater with landscaping
  - Opportunity for multiple benefits
    - Floodplain management and hazard mitigation
    - Recreation
    - Beautification
    - Urban renewal and Smart Growth
    - Economic development

Planning and Water Quality

- HRPDC is currently working on several projects to help its member localities address the Chesapeake Bay TMDL
- Coastal Zone Management Program
  - Competitive Grant: BMPs on Private Property
  - Competitive Grant: Redevelopment as a TDML Strategy
  - Section 309 Grant: Land & Water Quality Protection in Hampton Roads
- NFWF Grant: Coordinating Local Input Into the Phase II Watershed Implementation Plan
- DCR: Chesapeake Bay Locality Planning Assistance

Land & Water Quality Protection

- **Grant Amount**: $90,000
- **Project Summary**: Analyze impact of water quality requirements on Hampton Roads localities and develop policy recommendations to meet the requirements.
- **Deliverables**:
  - Assessment of impact of water quality regulations.
  - Comprehensive plan and ordinance evaluation methodology.
  - Methodology to assess development impact.
- **Timeframe**: Year 1: October 2011 – September 2012
  - Designed as 3-year project.
- **Work Performed By**: HRPDC staff

BMPs on Private Property

- **Grant Amount**: $30,000
- **Project Summary**: Assess potential for nutrient reductions from private property and redevelopment.
- **Deliverables**:
  - Estimate regional redevelopment potential and calculate nutrient reductions to be achieved by new stormwater regulations.
  - Examine feasibility of placing BMPs on private property and develop a framework to guide implementation
- **Timeframe**: November 2011 – June 2012
- **Work Performed By**: Consultant (Wetlands Watch)

Chesapeake Bay Small Watershed Grants

- **Grant Amount**: $50,000
- **Project Summary**: Support the Phase II WIP Stakeholder process and assist local governments in developing strategies.
- **Deliverables**:
  - Regional Phase II WIP strategy that includes locality plans.
  - BMP decision matrix that includes ancillary benefits of different types of stormwater BMPs.
- **Timeframe**: September 2011 – March 2012
- **Work Performed By**: HRPDC staff

Chesapeake Bay Locality Planning Assistance

- **Grant Amount**: $15,000
- **Project Summary**: Coordinated effort with Chesapeake Bay Planning District Commissions.
- **Deliverables**:
  - Support Phase II WIP efforts and share information between PDCs.
- **Timeframe**: October 2011 – March 2012
- **Work Performed By**: HRPDC staff

PRE-TMDL EFFORTS

Chesapeake Bay Water Quality Efforts

- Chesapeake Bay Agreement of 1983
  - Recognized the need for a collaborative effort to address Chesapeake Bay water quality issues
  - DC, Maryland, Pennsylvania, Virginia, and U.S. EPA
- Chesapeake Bay Agreement of 1987
  - First numeric goals for reducing pollution (N, P) and restoring the Bay's ecosystem
  - Led to Virginia's Chesapeake Bay Preservation Act

Chesapeake Bay Preservation Act

- The Chesapeake Bay Preservation Act establishes a cooperative state-local program to balance economic development and water quality protection in the Chesapeake Bay Watershed
- The Act was the first attempt in Virginia to integrate land use planning with the improvement of water quality
- Requires that local governments in Tidewater Virginia (defined in the Act) establish Chesapeake Bay local programs to implement the Act

Chesapeake Bay Preservation Act

- Local governments are primary actors, with state support and oversight
- Requires program compliance reviews for local governments

Chesapeake Bay Preservation Act

- The Act directs the Soil and Water Conservation Board to develop land use and development regulations to protect water quality in the Chesapeake Bay
- Five goals:
  1. Protect existing high quality state waters and restore others to permit public uses and support aquatic life
  2. Safeguard clean waters from pollution
  3. Prevent any increase in pollution
  4. Reduce existing pollution
  5. Promote water resource conservation

Chesapeake Bay Preservation Act

- Local governments are authorized to exercise police and zoning powers to protect the quality of state waters
- The Act requires local governments in Tidewater to take several actions to protect local water quality
  - Designate Chesapeake Bay Preservation Areas
  - Incorporate water quality protection into comprehensive plans, zoning ordinances, and subdivision ordinances
- Non-Tidewater localities are authorized to adopt similar provisions

Chesapeake Bay Regulations

- Under the regulations, all Tidewater localities (cities, counties, and towns) are required to development local programs
- Each local program must include:
  - Map of Chesapeake Bay Preservation Areas (CBPAs)
  - Performance Criteria for CBPAs
  - Comprehensive plan element
  - Zoning ordinance or revision
  - Subdivision ordinance or revision
  - Erosion & Sediment Control Ordinance
  - Plan of Development Process

Chesapeake Bay Regulations

- Chesapeake Bay Preservation Areas
  - Resource Protection Areas
    - Areas adjacent to water bodies with perennial flow that have an intrinsic water quality value (e.g. tidal wetlands, tidal shores, 100ft landward buffer, etc.)
  - Resource Management Areas
    - Areas contiguous to Resource Protection Areas that are important to maintaining water quality or the value of Resource Protection Areas (e.g. floodplains, sensitive lands, non-tidal wetlands not in RPAs, etc.)
  - Intensely Developed Areas
    - Areas that have been developed and where little of the natural environment remains

Chesapeake Bay Regulations

- Regulations require localities to identify and designate Chesapeake Bay Preservation Areas and apply various performance criteria to those areas
- These criteria specify what actions are permitted in CBPAs
  - Land uses
  - Encroachments
  - Exceptions

Chesapeake Bay Regulations

- Performance Criteria Goals
  1. Prevent a net increase in nonpoint source (NPS) pollution from new development and redevelopment on areas previously treated
  2. Achieve a 10% reduction in NPS pollution when redeveloping land not previously treated
  3. Achieve a 40% reduction in NPS pollution from agriculture and silviculture

Chesapeake Bay Regulations

- Performance Criteria
  - Minimize land disturbance
  - Preserve indigenous vegetation
  - Maintain BMPs
  - Permit large-scale developments
  - Minimize impervious cover
  - Maintain septic systems
  - Manage stormwater (including BMPs and permits)

Chesapeake Bay Regulations

- Comprehensive Plan Requirements
  - Data collection
    - Sensitive lands/constraints to development
    - Waterfront uses
    - Pollution sources
  - Analysis and policy discussions
    - Constraints to development
    - Water supply
    - Waterfront uses and access
    - Erosion
    - Etc.
  - Land use plan maps
  - Implementing measures

Chesapeake Bay Regulations

- The implementation of the Chesapeake Bay Preservation Act and its associated regulations has shown that integrating land use planning and water quality goals is feasible.
- However, lack of improvement in the Chesapeake Bay's water quality has resulted in new regulatory approaches: the Chesapeake Bay TMDL and Virginia's new Stormwater Management Regulations.

THE CHESAPEAKE BAY TMDL

Overview

How is water quality regulated?

- What is an impaired waterway?
- What is a TMDL?
- How is a TMDL Implementation Plan enforced?

Chesapeake Bay TMDL

- Requirements for Stormwater sector
- Deadlines
- Local challenges

Process to identify Impaired Waters

1. Every two years Virginia must identify waters that do not meet Water Quality Standards.
2. Department of Environmental Quality (DEQ) evaluates water and fish tissue samples.
3. If a water is impaired, DEQ will calculate the allowable amount of pollutant that the waterway can assimilate without violating water quality standards.

   Total Maximum Daily Load (TMDL) = Quantity of pollutant

4. Implementation Plan: Identify ways to reduce pollutant loads to meet the TMDL.

Types of Impairments

- **Public Water Supply**
- **Fish or Shellfish Consumption**
- **Swimming/Recreation**
- **Aquatic Life**

Hampton Roads Impairments

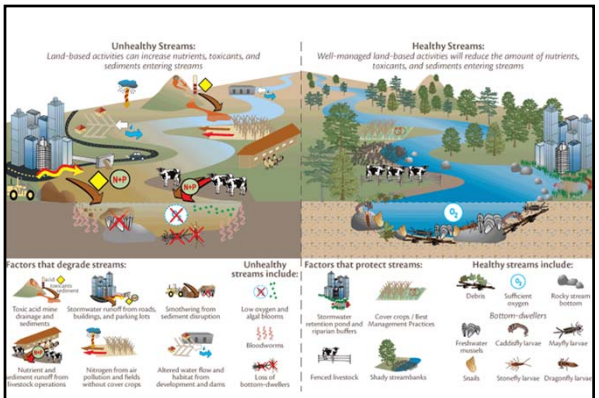
- Fish/Shellfish Consumption impairments due to PCBs and Bacteria.
- Swimming / Recreation impairments due to Bacteria.
- Aquatic Life impairments due to Phosphorus, Sediment, Dissolved Oxygen, Chlorophyll-a.

Process to clean up an Impaired Waterway

TMDL Implementation Plans

1. **Identify sources of pollution.**
2. **Identify source reduction activities.**

- Traditionally, focused on point sources like pipes from industrial facilities.
- Impairments in Hampton Roads are primarily due to nonpoint sources.
  - Air pollution (car exhaust, smokestack emissions)
  - Stormwater runoff (fertilizer, pet waste, sediment)
  - Legacy pollutants in sediments (industrial waste, dioxin, PCBs)
- More difficult to quantify and control nonpoint sources.



TMDL Implementation Plans

Implementation Plans identify actions necessary to reduce pollutants to meet the TMDL.

- **Wastewater solutions:** upgrade treatment, repair pipes, eliminate overflows by increasing pipe/pump station capacity
- **Stormwater solutions:** reduce fertilizer, pet waste stations/education, treat runoff with Best Management Practices (BMPs)
- **Agricultural solutions:** reduce fertilizer, exclude livestock from streams, use cover crops
- **Septic tank solutions:** repairs, pump outs, upgrades

Enforcement of TMDL Implementation Plans

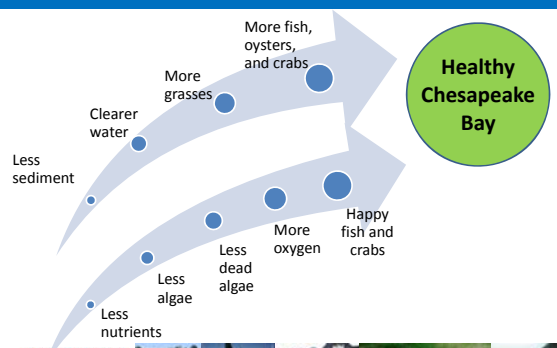
Wastewater and Stormwater pollutant reductions may be enforced by including TMDL limits in discharge permits.

- Wastewater systems have discharge permits - National Pollutant Discharge Elimination System (NPDES) Permit.
- Most localities in Hampton Roads have a Municipal Separate Storm Sewer System (MS4) Permit for stormwater.
- There is no enforcement mechanism for meeting TMDL goals associated with septic tanks and agricultural runoff.
- EPA sets and enforces air pollution reductions.

Chesapeake Bay TMDL

- Chesapeake Bay TMDL addresses impairments for Aquatic Life.
- TMDL sets limits on the amount of **nitrogen, phosphorus, and sediment** that goes into the Bay.
- Each State developed its own **Watershed Implementation Plan (WIP)** and chose how to divide nutrient reductions among sectors and localities.
- Sectors include Air, Agriculture, Wastewater, Septic, and Stormwater.

Benefits of Nutrient Reductions



Bay TMDL Schedule

- Unlike other TMDLs, the Bay TMDL has a deadline for implementing the nutrient reductions.
- Only 15 years to plan, negotiate, finance, and construct projects to remove nutrients and sediment.
- Consequences
  - Fines
  - Enforcement actions: "EPA Backstops"

2011
- EPA issued revised TMDLs based on refined 5.3.2 Watershed Model.
- Phase II WIPs submitted with implementation plans at basin and/or local (county) levels.

2017
- Phase III WIPs to be submitted.
- 60% of WIP Implementation to be achieved.
- EPA to formally assess implementation progress.

2025
- 100% of WIP Implementation to be achieved Bay-wide.

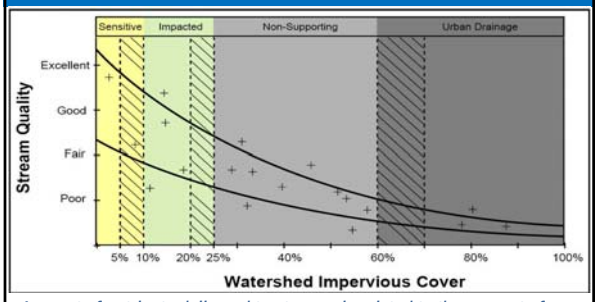
Virginia's WIP: Stormwater Sector

- **Retrofits:** Reduce nutrients and sediment loads from existing land by retrofitting existing urban property.
- **New Regulations:** Avoid increasing nutrient loads associated with new development by requiring each project to cause no net increase in nutrient loads.
- **Fertilizer:** Approved State-wide fertilizer restrictions to reduce amount of phosphorus in most products.
- **Trading:** Develop nutrient credit trading program to allow flexibility and most cost effective solution.

Local Targets & Timeline

- Local Targets: Virginia divided nutrient and sediment reductions by locality and by sector.
- Each locality can pick a strategy to meet the reductions.
- State-wide goal of implementing 60% of the reductions by 2017 applies to the combination of all sectors.
  - All wastewater reductions will be completed before 2017.
  - Other sectors will take much longer to implement.
- Phase I MS4s must implement:
  - 5% of reductions needed to meet Level 2 goals in first 5 years.
  - 35% of reductions required in second 5 years.
  - Remaining 60% of reductions required in third 5 year permit.

Reduce Impervious Land = Reduce Nutrient Loads



Amount of nutrients delivered to streams is related to the amount of Impervious Cover and type of land cover.

Sources of Nitrogen & Phosphorus

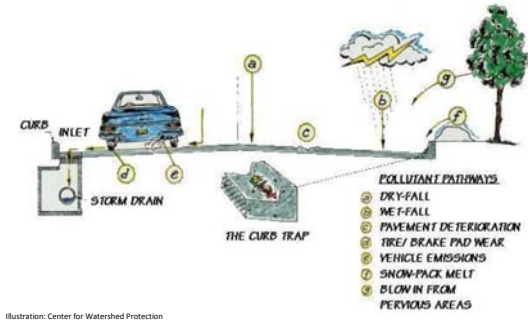


Illustration: Center for Watershed Protection

WIP Scenario for Stormwater Retrofits

Land Use Category	Practice Description	Level 2 Practice % Coverage	Effective Net Reduction Prorated Over Entire Land Use Category Acreage N	P	Sediment
Impervious Urban High and Low Intensity					
	Impervious Cover Reduction	7.5%	0%	5%	6%
	Filtration Practices	7.5%	3%	4%	6%
	Infiltration Practices	8.0%	6%	7%	8%
	Total		**9%**	**16%**	**20%**
Pervious Urban High and Low Intensity					
	Impervious Cover Reduction	-			
	Filtration Practices	5%	2%	3%	4%
	Infiltration Practices	5%	4%	4.25%	4.75%
	Total		**6%**	**7.25%**	**8.75%**

Data Issues

- Imperviousness is measured using land cover data (what's on the ground) as opposed to land use data (what activities are occurring there)
- There are issues with the accuracy of the Bay Program's land cover datasets, and most localities (at least in Hampton Roads) do not track land cover
- There are also issues with land ownership and responsibility for TMDL implementation
  - Federal lands
  - State lands

Local input for Virginia WIP

- Deadline was February 1, 2012.
- Information Requested from local governments
  1. Develop a current BMP inventory.
  2. Evaluate land use/ land cover information.
  3. Review BMP scenarios identified in the Phase I WIP, and develop preferred local scenarios that provide a similar level of treatment.
  4. Develop strategies to implement the BMP scenarios.
  5. Identify any resource needs to implement the strategies.

Factors to Consider

Local Government Criteria

- Cost effectiveness
- Ease of implementation
- Long-term O&M costs
- Project Visibility
- Public Education & Outreach

Local Government Objectives

- Improve Local Water Quality
- Urban Renewal / Beautification
- Expand trail system
- Protect drinking water
- Economic Development

Potential Implementation Strategies

New nutrient management techniques to maintain ballfields and golf courses	Partnering with Watershed groups to find citizens willing to install BMPs on their private property.
Stormwater retrofits at parks, schools, and municipal centers	Encourage redevelopment projects
No discharge zones in tidal waters	Increased sewer maintenance or recordkeeping for leaks & overflows
Development of green streets	Increased street sweeping
Increased tree canopy requirements	Septic tank pump-outs or upgrades

Multiple Benefits of Stormwater Retrofits

- Retrofitting existing developments to incorporate stormwater best management practices provides opportunities to address other existing issues or deficiencies in other areas
  - Floodplain management and hazard mitigation
  - Recreation
  - Beautification
  - Urban renewal and Smart Growth
  - Economic development

Stormwater and Floodplain Management

- Restoring buffers can help mitigate damage from coastal flooding
- Removing impervious cover and replacing it with stormwater BMPs can improve water infiltration, lessening the risk of flooding during storm events
- At a larger scale, existing development can be removed through acquisition from floodplains to restore them to their natural state and reduce vulnerability of property to flooding and sea level rise

Stormwater and Recreation

- Stormwater BMPs provide opportunities for passive recreation
  - Trails
  - Public access to waterfronts
  - Green space
- BMPs can be integrated into active recreation facilities
  - Natural vegetation around sports fields
  - Nutrient management

Stormwater and Beautification

- Stormwater BMPs can improve the appearance of streetscapes and other areas
  - Street trees
  - Green streets
  - Pervious pavers
  - Pocket parks
  - Green roofs
  - Natural vegetation
  - Urban planters

Stormwater and Urban Renewal/Smart Growth

- Redevelopment projects must reduce nutrient loads by 20%
- Encouraging urban renewal in areas without existing stormwater management practices can help achieve TMDL goals as well as providing needed redevelopment
- Localities also can benefit by concentrating growth and encouraging redevelopment in specific areas

Stormwater and Economic Development

- Encouraging private redevelopment as an economic development strategy can provide the same stormwater and nutrient load reduction benefits
- Economic Development departments should be brought in as partners to both encourage and track private sector redevelopment

Getting Credit for Your Strategies

- The most cost-effective strategies for local governments will be those that address multiple issues
- The Bay TMDL is not just about improving water quality – it's about getting credit for it
- Tracking of projects is critical, since the Bay Model will include validation and verification of local implementation efforts

How you can help

- Educate taxpayers who don't understand the Bay TMDL, sources of nutrients, and how BMPs work.
- Encourage private property owners to install BMPs. There is no regulatory authority to require retrofits.
- Appreciate Adaptive Management –local targets will likely change between now and 2025 deadline but will ultimately result in better solutions.
- Focus on multiple benefits.

Retrofit Existing Development

- Runoff Reduction Method: Slow runoff and encourage infiltration into soil.
- Collect runoff from impervious areas and put it in a BMP – best management practice.

How do Best Management Practices work?	
1. **Sedimentation** – sand and dirt settle out of water if flowrate is slowed.	4. **Adsorption** – chemical reaction to remove dissolved pollutants.
2. **Filtration** – physically strain water using filter media.	5. **Microbial Action** – bacteria breakdown nutrients. i.e. Denitrification: dissolved nitrate converted to nitrogen gas
3. **Plant resistance and uptake** – leaves intercept rain; roots absorb nutrients.	

Key Decisions: Ordinance Revisions

- **Identify which ordinances or guidance documents could be revised.**
  - **May have local policies that limit the use of some stormwater controls or encourage excessive impervious area.**
- **Identify local policy priorities and strategy.**
  - **Develop a program that partners with citizen groups to identify opportunities to help locality meet Bay TMDL targets.**
  - **Encouraging redevelopment will generate more nutrient reduction credits than new development.**
  - **Localities may want to build BMPs to offer local credits or identify BMP projects on public property for offsets.**

Nutrient Reductions Required in James River: EPA solution vs Virginia's plan

Source	Nitrogen Reduction		Phosphorus Reduction	
	EPA Backstops	VA WIP	EPA Backstops	VA WIP
Agriculture	1%	22%	27%	36%
Stormwater	41%	14%	53%	19%
Wastewater	42%	15%	29%	10%

EPA's plan for Reasonable Assurance

EPA could implement Backstops if Virginia's Phase II WIP does not provide reasonable assurance that TMDL will be implemented.

- Backstops require 1,460,000 lbs/yr of N removed from urban stormwater in James & York basins.
- Phase I WIP requires 489,000 lbs/yr of N removed from urban stormwater in James & York basins.
- Urban stormwater backstops would cost Hampton Roads approximately $6B more than the Phase I WIP.

IMPLEMENTING THE BAY TMDL THROUGH PLANNING

Section 309 Grant

- Three categories of development regulations and programs to review (policies, codes & ordinances, practices)
  - New development
    - How to incorporate BMPs more effectively into new subdivisions
  - Redevelopment
    - Policies to promote redevelopment
  - Existing Development
    - Programs to encourage BMPs on private property/develop BMPs on public property

New Regulations vs. Old Regulations

- Performance Criteria
  - "No net increase" for new development
  - 20% reduction if greater than 1 acre, 10% if less vs. 10% reduction
- Model differences
  - Runoff Reduction Method calculates runoff and pollutants for entire site, not just impervious area
  - Simple Method only used impervious area

Implications for Local Governments

- Stormwater regulations mandate local governments to take certain actions
- Bay TMDL requirements will require additional action by local governments
- Offsets may be more appropriate for some projects; local offset programs, if adopted, will give localities control over the location and type of those offsets
  - Opportunities for large scale retrofit projects by pooling offset funds

Implications for Local Governments

- Opportunities exist to modify existing plans, ordinances, and programs to achieve Bay TMDL and Stormwater goals, make them less expensive, and provide multiple benefits to localities
  - Site design
    - Preserve forested areas
    - Reduce setbacks
  - Roadway specifications
    - Narrower roadways, fewer cul de sacs
  - Parking requirements
    - Parking maximums, reduced minimums, pervious pavement
  - Vegetation ordinances