

Economic Impact Analysis of Revisions to the Virginia Stormwater Regulation

Final Report¹

Kurt Stephenson

Professor
Department of Agricultural and Applied Economics
Virginia Tech
Blacksburg, VA 24061

Bobby Beamer

Economist
BBeamer LLC
Keswick, VA 22947

Submitted to:

Virginia Department of Conservation and Recreation

December 31, 2008

¹ The authors gratefully acknowledge the input, assistance, and comments provided by DCR staff. The authors also thank local government staff, nongovernmental organization staff, and private consultants/builders who provided technical input and assistance. While acknowledging this assistance, all statements, conclusions, omissions, or errors are the sole responsibility of the authors.

Economic Impact Analysis of Revisions to the Virginia Stormwater Regulation

Outline

	Page
I) Overview of Existing and Proposed Stormwater Management in Virginia	2
1) Summary of relevant existing regulations	2
2) Summary of proposed regulations	4
II) Anticipated Economic Impact of the Proposed Regulation	6
1) Description of the individuals, businesses or other entities likely to be affected by the regulation	7
2) The number of such entities that will be affected	7
- Sampling of local programs	8
- Estimation of disturbed acres and permits	8
- Results	10
- Future trends	11
3) All projected costs of the regulation for affected individuals, businesses, or other entities	12
a) On-site stormwater control costs	12
- Stormwater Control Costs	16
- Incremental costs: Illustrations applying proposed water quality criteria	19
- Fees	22
b) Off-site options and pro-rata programs	24
c) Benefits	27
- Water quality benefits	28
- Water quality benefits from nutrient reductions	29
4) Projected cost of the regulation on local governments	31
a) Existing Local Stormwater Programs: Program Administration Costs	34
b) Administration of Local Stormwater Programs in Areas without Existing Stormwater Programs	35
5) Projected cost to the state to implement and enforce the proposed regulation	35
a) DCR Administration of Local Stormwater Programs in Nondelegated Areas	35
b) DCR oversight costs	36
c) Local Program Costs and Fee Revenues	39
d) VDOT compliance activities and costs	39
6) Summary	40
References	41

Economic Impact Analysis of Revisions to the Virginia Stormwater Regulation

The Virginia Soil and Water Conservation Board (Board), with the assistance of the Virginia Department of Conservation and Recreation (DCR), proposes a comprehensive revision of Virginia's regulations regarding the control and treatment of stormwater runoff from land development activities. The purpose of this document is to review the possible economic impact of the proposed regulation to the state of Virginia. Part I of this analysis will describe the existing stormwater regulation and proposed revisions. The cost of the proposed changes to the private sector, local governments, and state agencies is analyzed in Part II. The types of benefits citizens of the Commonwealth might receive under the proposed changes are also qualitatively described in Part II.

I. Overview of Existing and Proposed Stormwater Regulations in Virginia

1. Summary of relevant existing regulations

Currently local governments administer local erosion and sediment control (E&S) requirements (runoff from construction activities) under 4VAC50-30-30. The regulations list 19 minimum standards that must be met, including some volume control requirements (4VAC50-30-40.19). To protect existing stream channels, the regulations state that if existing natural channels are not adequate, stream channels shall be improved to contain a 10-year storm and to ensure that a 2-year storm does not erode the channel or banks or to meet the pre-development peak runoff rate from a 2-year storm (discharging into a natural channel).

Virginia also has an existing stormwater management program. Local governments identified in the Chesapeake Bay Preservation Act (see below) and localities permitted under the Board's MS4 program are required to adopt a local stormwater management program (§10.1-603.3). As outlined in the existing stormwater regulations, all local stormwater management programs must meet a set of general criteria (4VAC50-60-50 and 60). The general criteria establish general engineering practices, compliance with erosion and sediment control law, and inspection and maintenance plans for all stormwater management facilities. In addition, all stormwater water management programs must contain provisions to prevent flooding of downstream properties, based primarily on preventing the 10-year post development peak flow from exceeding the 10-year pre-development peak flow (4VAC50-60-80).

Existing state stormwater regulations contain provisions to limit channel erosion (4VAC50-60-70) and improve stormwater runoff quality (4VAC 50-60-60). The regulations identify water quality criteria for any land-disturbing activity. The water quality criteria can be met with "performance-based" criteria or "technology-based" criteria. The performance based criteria (4VAC 50-60-60B) are generally as follows:

- No reduction in the after disturbance pollution is required if existing land cover is less than average land cover condition (assumed to be 16% impervious cover or as established by local stormwater management program).
- Pollutant discharge shall not exceed the existing pollutant discharge (average land cover) in situations where the pre-development percent impervious cover is less than the average land cover condition, but post development impervious cover will exceed average land cover condition.
- Pollutant discharge after disturbance must be 10% less than existing conditions in situations where land disturbing activities occur on land with percent impervious cover exceeding average land condition.
- Pollutant discharge after disturbance cannot exceed existing pollutant discharge for land served by an existing stormwater best management practice (BMP).

Compliance with water quality criteria can also be achieved by applying technology based criteria. The technology-based criteria identify a variety of BMPs that can be used to treat post development stormwater runoff (4VAC 50-60-60C). The BMPs must be designed to meet the pollutant removal efficiencies identified in the regulation.

Under both state law and the federal Clean Water Act, the Department also regulates construction activity of size (land disturbing activities of one acre or greater, except in all areas of the jurisdictions designated as subject to the Chesapeake Bay Preservation Area Designation and Management Regulations, where activities of 2,500 square feet or greater are regulated), statewide through the General Permit for Discharges of Stormwater from Construction Activities. In 2004 the General Assembly assigned state stormwater regulatory responsibility to the Board and DCR and instructed the Board to “protect the water quality and quantity of state waters from potential harm of unmanaged stormwater.” (§10.1-603.2:1). Under this legislation, the Board has expanded stormwater water quality and quantity criteria (defined above) and stormwater pollution prevention plan requirements to the rest of the state under the auspices of the general permit coverage (4VAC50-60-1170, Section II.D.2.c.1).²

The Chesapeake Bay Preservation Act (§§10.1-2103-2107) and regulations (9 VAC 10-20-10 et seq.) requires local governments to develop plans to protect waters in designated areas (called Chesapeake Bay Preservation Areas) identified as 29 counties, 17 cities, and 38 towns in the eastern portion of the Bay watershed.³ Stormwater requirements must be consistent with water quality provisions in the stormwater management regulations (described above). The regulations require a no net increase in pollution from predevelopment levels for any new development or redevelopment that has a water quality BMP; or achieve a 10% reduction in NPS pollution from redevelopment lands without an existing BMP (9VAC 10-20-110). The regulation also allows compliance through a “regional stormwater management program” that achieves equivalent water quality results (9 VAC 10-20-120.8(a2)). The regulations also allow localities to designate certain areas as “Intensely Developed Areas”.⁴ Local government can subject all land within an IDA to the redevelopment stormwater criteria (9 VAC10-20-100). In addition, regulations require riparian buffers in Resource Protection Areas along perennial streams, tidal wetlands/shores, and nontidal wetlands connected to streams. General performance criteria require minimizing land disturbance, preserving indigenous vegetation, and minimizing impervious cover to maximum extent practicable. Land disturbances exceeding 2,500 ft² are subject to these requirements.

Some local governments over a certain population size (Phase I) or located in Urbanized Areas as defined by the U.S. Census Bureau(Phase II) that operate a municipal separate storm sewer drainage system (MS4) must also administer a stormwater program under the federal Clean Water Act National Pollutant Discharge Elimination System (NPDES) regulatory program.

Stormwater discharges from Phase I municipal separate storm sewer systems are authorized under individual VSMP permits that require the MS4 owner/operator to implement a collective series of programs to control the discharge of pollutants from its storm sewer system to the maximum extent practicable in a manner that protects the water quality of nearby streams, rivers, wetlands and bays. These programs must include elements to: 1) Operate and maintain structural stormwater controls; 2) Control discharges from areas of new development and significant redevelopment; 3) Operate and maintain public streets, roads, and highways; 4) Identify, monitor and control discharges from municipal waste treatment, storage, or disposal facilities; 5) Control pollutants related to application of pesticides, herbicides, and fertilizers; 6) Implement an inspection program to enforce ordinances, which prohibit illicit connections and illegal dumping into the MS4; 7) Screen the MS4 for illicit connections and illegal dumping; 8) Implement standard investigative procedures to identify and terminate sources of illicit

²“(1) The SWPPP shall include a description of, and all necessary calculations supporting, all post-construction stormwater management measures that will be installed during the construction process to control pollutants in stormwater discharges after construction operations have been completed. Structural measures should be placed on upland soils to the degree attainable. Such measures must be designed and installed in accordance with applicable local and/or state requirements.”

³ 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. Cities of Alexandria, Chesapeake, Colonial Heights, Fairfax, Falls Church, Fredericksburg, Hampton, Hopewell, Newport News, Norfolk, Petersburg, Poquoson, Portsmouth, Richmond, Suffolk, Virginia Beach, and Williamsburg. Towns within the Tidewater area of the state are also subject to these regulations. Map at:

http://www.dcr.virginia.gov/chesapeake_bay_local_assistance/abtprogram_Tidewater_map.shtml

⁴ To be designated IDA, an area one of the following conditions must be met: 1) area is at least 50% impervious, 2) currently served by public water, sewer, or constructed stormwater drainage, or 3) housing density of at least 4 dwelling units per acre.

connections or discharges; 9) Prevent, contain, and respond to spills that may discharge into the MS4; 10) Limit the infiltration of sanitary seepage into the MS4; 11) Identify, monitor and control discharges from municipal landfills; hazardous waste treatment, storage, disposal and recovery facilities; facilities that are subject to EPCRA Title III, Section 313; and any other industrial or commercial discharge the permittee determines are contributing a substantial pollutant loading to the MS4; 12) Control pollutants in construction site runoff; and, 13) Conduct public education regarding stormwater. Phase I covers large and medium size municipalities (populations exceeding 100,000) and includes Arlington County, Chesapeake, Chesterfield County, Fairfax County, Hampton, Henrico County, Newport News, Norfolk, Portsmouth, Prince William County, and Virginia Beach.

The Phase II MS4 regulations require that MS4 programs establish six minimum control measures: 1) public education for stormwater impacts; 2) public involvement/ participation, 3) illicit discharge detection and elimination, 4) construction site stormwater runoff control, 5) post-construction stormwater management in new development and redevelopment, and 6) pollution prevention/good housekeeping for municipal operations. The MS4 program is being implemented in 2 phases. Phase 2 extends permit coverage to smaller jurisdictions with separate storm sewer systems and located in Urbanized Areas (Blacksburg, Bristol, Charlottesville, Danville, Fredericksburg, Harrisonburg, Lynchburg, Richmond, Roanoke, and Winchester areas). The federal program does not establish numeric limits for MS4 permit holders, but rather requires localities to identify actions and practices to reduce discharge of pollutants to the “maximum extent practicable” and to protect water quality. All MS4 programs in Virginia, however, must also ensure that new development and redevelopment projects demonstrate consistency with the technical criteria described in the state stormwater regulations, but are not necessarily required to review site plans for stormwater quality.⁵

2. Summary of proposed regulations

The state proposes modifications to the existing stormwater water quantity and quality requirements that will be applied to every land disturbing activity not exempted by state law (§10.1-603.8B).⁶ Land disturbing activity subject to this regulation generally includes disturbances of 2,500 ft² or more in the Chesapeake Bay Preservation Act areas and disturbances of an acre or more elsewhere in the state (with some smaller areas included when a part of a larger common plan of development or sale).

The proposed regulations establish statewide water quality design criteria for land disturbing activities. For new land development projects, water quality plans must be designed so that the total phosphorus load shall not exceed 0.28 pounds per acre per year (4VAC50-60-63). The phosphorus load criterion was derived from Chesapeake Bay Tributary Strategies and reductions needed to achieve Bay-wide nutrient reductions derived from the Chesapeake Bay 2000 Agreement. The 0.28/lb/yr phosphorus design criteria represents the average per acre edge of field loading from agriculture, forest and mixed open land uses (estimated from Chesapeake Bay Program watershed model) if the 2005 tributary strategies input deck was fully implemented (DCR 2008). For development that occurs on prior developed land, the designs must allow for the total phosphorus loads to be reduced by 20% below predevelopment levels. While the Chesapeake Bay Tributary Strategies called for phosphorus reductions exceeding 40%, a lower water quality criteria for redevelopment was chosen 1) to achieve additional load reductions from urban areas over existing regulations, and 2) to avoid higher barriers to redevelopment. No explicit sediment or nitrogen water quality design criteria were established because it was determined that the stormwater management practices used to achieve the necessary phosphorus reductions would also result in reductions of nitrogen, sediment, and other potential pollutants.

Compliance is determined by implementing control practices outlined in 4VAC50-60-65. The revisions provide three general ways to reduce phosphorus loads: 1) managing land use conversion (forest, turf, and impervious cover), 2) reducing runoff volumes, and 3) treatment of stormwater runoff. An initial list of best management practices that can be used to achieve the phosphorus criteria are listed in 4VAC50-60-

⁵ Personal communication, Doug Fritz, DCR MS4 Program Manager, September 8, 2008.

⁶ Exemptions under this regulation include land disturbing activities generally associated with agricultural, forest, and mining activities (§10.1-603.8B). Road projects may also be exempted if certain minimal impacts can be demonstrated.

65B. Other BMPs available to comply with the stormwater requirements are listed on the new Virginia Stormwater BMP Clearinghouse website (<http://www.vwrrc.vt.edu/swc>). The removal efficiency of each BMP includes phosphorus removal from treating the pollutant concentration in the stormwater as well as the percent removal achieved by preventing runoff from occurring (based upon 1 inch of rainfall, 90% storm). The addition of the runoff reduction potential of individual stormwater control practices reflects a substantive change over the existing regulation. Similar to existing practice, the calculation of phosphorus loads is based primarily on the “simple method” (see Virginia Stormwater Handbook) that relates phosphorus load to total impervious surface. The simple method calculation, however, is modified by adding phosphorus loading coefficients for turf and forest land cover. To assist in determining compliance, DCR has also developed an Excel stormwater compliance spreadsheet.

Water quantity control requirements (4VAC50-60-66) establish minimum standards for downstream flood protection and stream channel protection. The proposed regulation establishes different criteria based on the condition of the existing stormwater conveyance systems. Four general classifications of conveyance systems are identified: 1) man-made conveyance systems, 2) restored streams (designed to restore natural stream channels), 3) stable natural stream channels, and 4) unstable natural stream channels. For stream channel protection, general water quantity criteria are (4VAC50-60-66A):

- Man-made conveyance: stormwater releases following land disturbing activity conveys post-development peak flow from 2-year, 24-hour storm without causing erosion.
- Restored stream channel: runoff following land disturbing activity will not exceed design of the restored stormwater conveyance system or result in instability of that system.
- Stable natural stream channel: will not become unstable as a result of the peak flow from the 1-year, 24-hour storm and provides a developed peak flow rate equal to the pre-developed flow rate times the pre-developed runoff volume divided by the developed runoff volume.
- Unstable natural stream channel: runoff following a land-disturbing activity shall be released into a channel at or below a peak developed flow rate based on the 1-year 24-hour storm where the developed peak flow rate is equal to the peak flow rate from the site in a forested condition times the volume of runoff from the site in a forested condition divided by the developed runoff volume.

For flood protection, general water quantity criteria are (4VAC50-60-66B):

- Man-made conveyance must confine the post development peak flow rate from the 10-year, 24-hour storm.
- Restored stream channel: Peak flow rate from the 10-year, 24-hour storm following the land disturbance will be confined within the system.
- Natural stream channel that does not currently flood during a 10-year, 24-hour storm: Post development peak flow from the 10-year, 24-hour storm is confined within the system.
- Natural stream channel where localized flooding exists during a 10-year, 24-hour storm: Post development peak flow rate for 10-year, 24-hour storm shall not exceed predevelopment peak flow from the area under forested conditions.

These criteria do not have to be met under certain conditions where the land disturbance is small relative to the size of the drainage area or results in small contributions to overall peak flow (4VAC50-60-66C). It is also possible that runoff volume reduction achieved through the implementation of water quality control practices would be sufficient to reduce or avoid the need for water quantity controls.

The proposed regulation allows, in certain situations, water quality and quantity objectives to be met off-site from the disturbed site. Section 4VAC50-60-65F and G allow land disturbers to meet water quality criteria off-site. Specifically, the proposed regulations provide that off-site controls “shall achieve the required pollutant reductions either completely off-site in accordance with the plan or in a combination of on-site and off-site controls.” In localities with an approved comprehensive watershed management plan (4VAC50-60-96), offset activities can occur within the same HUC⁷ or any locally designated watershed. Without such a plan, offsite controls may be allowed, but must be located within the same HUC or

⁷ “Hydrologic Unit Code” or “HUC” means a watershed unit established in the most recent version of Virginia’s 6th Order National Watershed Boundary Dataset. Sixth order HUC range in size from 10,000 to 40,000 acres. See http://www.dcr.virginia.gov/soil_&_water/hu.shtml

adjacent downstream HUC to the land disturbing site (4VAC50-60-65.G.4). In addition, water quantity objectives could also be met offsite if a locality has a Board approved watershed stormwater management plan and equivalent off-site reductions are demonstrated. In areas with approved watershed plans, localities are also permitted to develop a pro rata fee program. Such a program allows land disturbers to pay a per unit fee (\$ per pound of P) to meet all or a portion of a regulatory requirement. Fee funds must be used, by Virginia Code requirements (§15.2-2243), to fund actions to achieve equivalent results offsite. Local programs administered by DCR would not have fee system and must confine water quality offset activities within, or adjacent to, the impacted HUC. Additionally, the regulations also provide for a request for an exception that may be granted by a local program in accordance with 4VAC50-60-122.

Linear (road) projects are also subject to the water quality and quantity requirements (VAC 50-60-76). Unless exempt from §10.1-603.8B, linear development projects shall “control post-development stormwater runoff in accordance with a site-specific stormwater management plan or a comprehensive watershed stormwater management plan developed in accordance with these regulations”

The proposed regulations also require a stormwater management plan for land disturbing activities. The plan applies the water quality and quantity technical criteria to the land disturbance (4VAC50-60-93).

Program Administration and Permitting: The proposed regulation establishes the requirements for local governments that are required to assume the primary authority to administer the provisions of the proposed regulations as well as for those localities that may elect to administer a program (4VAC50-60-104). DCR’s aim is to encourage local governments (counties, cities, and towns) that are not required to administer a program to voluntarily assume this responsibility. Local governments developing a qualifying program must administer the stormwater program in accordance with general criteria outlined in Part IIIA. In general, a local qualifying program must provide

- technical criteria to be used in the qualifying local program;
- procedures for the submission and approval of stormwater management plans (4VAC50-60-108)
- assessment and collection of fees;
- inspection and monitoring of land disturbing activities (generally 4VAC50-60-114);
- procedures and policy for long-term inspection and maintenance of stormwater facilities (4VAC 50-60-124);
- reporting and record keeping (4VAC30-60-126); and
- enforcement (4VAC30-60-116).

If the local government elects not to administer a program, DCR is required to assume the basic responsibilities of program implementation and administration described above (Part IIIB).

The regulations also define state oversight responsibilities for the Board and DCR. Section 4VAC50-60-159 describes the general procedure and requirements the Board must use for authorizing a locality to administer a stormwater management program. Once a locality is approved to administer a stormwater management program, section 4VAC50-60-157 describes Board oversight of that program. The Board must review all administered stormwater programs a minimum of once every 5 years (including those administered by DCR). The review will generally consist of reviewing approved site development plans, inspection and enforcement activities, and fee accounting practices. The Board is authorized to pursue corrective actions for noncompliant local programs.

II. Anticipated Economic Impact of the Proposed Regulation

The proposed regulations will generally increase the cost of most land disturbing activities across the entire state. These costs will be incurred by land developers and private landowners for construction and long-term maintenance. Additional costs also will be incurred by local governments and DCR when administering stormwater management programs. Public resources include costs for stormwater plan review and approval, pre and post-construction BMP inspections, tracking/record-keeping, and

enforcement (see Section 4). State administrative and program oversight is also required of locally administered programs (Section 5).

To the extent possible, regulatory impact analysis must evaluate and compare behavioral changes, outcomes, and costs of the proposed regulation to the conditions that would exist without the proposed regulation. Unless otherwise noted, the without (reference) condition is the set of existing Virginia and federal regulations that apply to stormwater management (defined above). Given to the project site-by-site differences related to stormwater control designs, the high degree of variability in costs associated with BMP selection, local program allowances, and off-site alternatives, no comprehensive cost estimate of the proposed regulatory change could be produced. To the extent possible, the analysis compares different stormwater water quality and quantity criteria requirements to the existing regulations in order to illustrate how opportunity costs may change due to the regulatory revisions. Case scenarios are also included that provide examples that illustrate the potential economic scope of the regulations.

1. Description of the individuals, businesses or other entities likely to be affected by the regulation

The proposed regulation revises water quality and quantity control requirements for land disturbing activities. As such, the proposed regulations will primarily impact private land developers, public land developers, businesses, and homeowners. Private land developers across the state may face increased land development costs associated with these new regulations in many situations. A portion of those costs will be passed down to buyers of newly constructed properties, homeowners and businesses. Although maintenance of stormwater control facilities should be conducted under today's regulations, many commercial property owners and some residential property owners across the state may still face higher long-term costs associated with maintenance of stormwater control facilities because of the potential for the installation of a greater number of these facilities to meet the proposed requirements and higher maintenance costs associated with some types of BMPs. Virginia residents will also likely pay for the higher costs associated with local stormwater program requirements (see Section 4).⁸

Public agencies (such as state colleges and universities, state agencies, and municipalities) involved in public works and construction projects will also be required to comply with these requirements. The Virginia Department of Transportation, for example, will be subject to revised runoff control requirements associated with road construction and modification activities.

The direct expenditures (costs) associated with implementing the proposed stormwater requirements may increase upon the current demand for stormwater design and construction services. The comprehensive nature of the regulations and the additional technical requirements will necessitate the greater use of environmental consultants and engineers to design stormwater plans and oversee the implementation of stormwater practices. Businesses providing construction and earthmoving services will also be impacted, although the direction of change is difficult to assess since the type and magnitude of construction and earthmoving activities will change simultaneously.

The general public as a whole also benefits from additional stream channel and flood protection. Additional stream channel protection will provide the public additional assurances that habitat and aquatic diversity will be protected from the impacts of urban land use change. The emphasis on runoff reduction may increase local groundwater recharge and thus protect local stream baseflow during drier parts of the year. The proposed revisions in the water quality criteria will provide reductions in nutrient loads from development activities from what otherwise would have occurred in absence of the revisions.

2. The number of such entities that will be affected

Since the proposed regulation is statewide, the regulation will impact every individual, business, or agency described above. To estimate the total extent to which this regulation would apply, the total historical and projected land disturbance within the state was estimated.

⁸ For localities with stormwater utilities, the increase in cost for stormwater control facilities long-term maintenance may be paid for by higher fees. Other localities would have to cover the higher costs through existing local and state revenue sources.

Data obtained from DCR's existing stormwater permitting database was used as the starting point to estimate the historical extent of disturbed acreage and number of general permit coverages issued on a calendar year basis. Preliminary inquiries suggested that the state permitting data under-reported the amount of disturbed acres recorded under local erosion and sediment control programs. Statistical procedures were used to estimate the extent of the "under-counting" of disturbed acreage and number of land disturbing permits. A sampling process was used to identify counties and cities (localities) where more detailed local data would be collected on permit coverage and disturbed acres. To ensure that a representative cross-section of localities was sampled, counties and cities across the state were initially grouped based on a variety of characteristics. Permit and land disturbing data were collected on a sample of localities. Based on observed under-reporting, state permit and disturbed acreage data were adjusted to estimate the total land disturbing activity and number of permits for the state.

Sampling of local programs

Cluster analysis was used to form the localities into similar groups based on various characteristics. DCR permits were classified as one of four types: residential, commercial/industrial, roads, or other. The number of permits for each category and the number of disturbed acres for each category were used as the primary characteristics describing the localities. Other characteristics used in the cluster analysis included population, land area, and location in the Chesapeake Bay Preservation Area. Initial clustering indicated a strong tendency to distinguish between localities in the Chesapeake Bay Preservation Area and those that were not. Therefore, to improve the performance of the clustering process, two groups were formed based on this division. K-means cluster analysis was then used to group the 29 counties and 17 cities in the eastern portion of the Bay watershed into 10 clusters, with the remaining counties and cities grouped into 14 clusters.

Individual localities within each cluster group were selected to participate in a spot check survey. Appropriate local officials were contacted to determine the number of permits and disturbed acreage under permit from their local Erosion and Sediment Control programs. At least one locality from each of the 24 clusters was contacted by the researchers, totaling 32 contacts in all. Sixteen contacts provided data for an effective response rate of 50%. The response rate within the CBPA and non-CBPA areas were identical, with five of 10 contacts providing responses within CBPA localities and 11 of 22 contacts responding from localities outside of the CBPA. In addition to these data, preliminary data from an additional seven localities (two within CBPA, five outside) were provided by DCR based on local data collected at regional DCR offices (DCR is further revising and expanding upon its dataset.). Thus sample data of permit numbers and disturbed acreage were obtained from 23 localities representing the majority of the program clusters (17 of the 24 clusters).

It was understood through this process that comparing state stormwater general permit coverage to local erosion and sediment control permit issuance was not a direct relationship due to a variety of factors but that it was a reasonable approach to exploring the magnitude of potential under-reporting.

Estimation of disturbed acres and permits

Local program data of disturbed acres and permits were paired with its corresponding DCR registry data.⁹ After considering different methods and models, and the removal of statistical outliers, a simple linear relationship between DCR and local data was found to be the most intuitive and robust estimator.

A linear relationship of the form $y = mx + b$ was calculated for both disturbed acreage and number of permits. In the equation, y is the reported quantity (of permits or disturbed acres) from the locality, x is the corresponding quantity from DCR database, m is the slope of the line, and b is the vertical intercept. Interpretation of the linear model is straightforward. If the data collected from the localities had matched the data from DCR perfectly, the intercept (b) would be zero and the slope of the line (m) would be one.

⁹ Overall, 174 observations were used for the annual disturbed acreage relationship, and 144 observations were used for the number of annual permits relationship. It should be noted that less than 10% of the observations were from within the CBPA.

The actual results of the regression are shown in Figure 1 and Figure 2.¹⁰ The intercept (15.911 for permits and 28.86 for disturbed acres) represents an average value of missed data for all DCR observations. The slope (1.4458 for permits and 1.06974 for disturbed acres) of the estimated line shows the additional change in the quantity from the localities for each additional unit shown in the DCR data. For example, the slope of 1.06974 for the disturbed acreage suggests that, in addition to the 28 missed acres represented by the intercept there is an additional 0.07 disturbed acres reported by the localities for each acre listed in the DCR data.

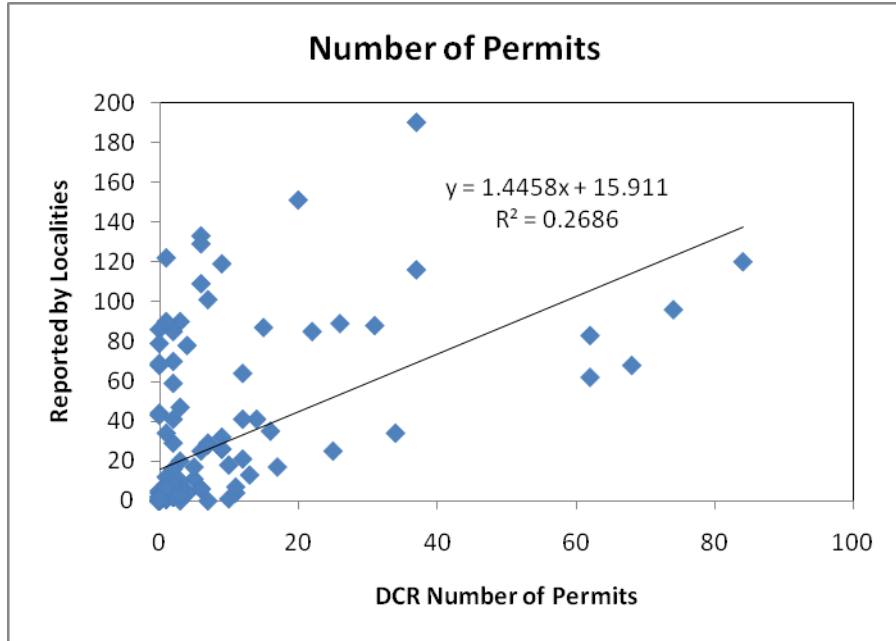


Figure 1: Linear Regression for Number of Permits

¹⁰ Other regressions were considered that included various dummy variables to allow for a difference between the CBPA region and the rest of the state. None of these variables were statistically significant. This could be due, at least in part, to the small representation of the CBPA within the data, as noted in footnote 8 above.

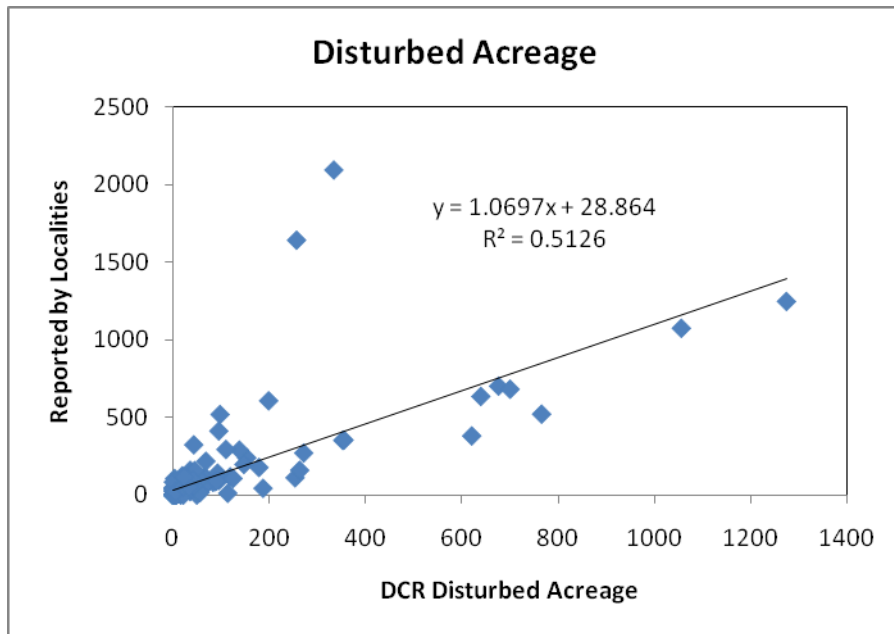


Figure 2: Linear Regression for Disturbed Acreage

Results

The linear models described above were used to produce state-wide estimates of disturbed acres and permit numbers based on the DCR data. Although the correlation coefficients (R^2) were not high, annual totals from DCR data were used to provide an estimate of the number of permits and amount of disturbed acreage for each of the counties and independent cities in Virginia.¹¹ Summary results, compared with the original DCR data are shown in Table 1.

Table 1: Estimates of Permits and Disturbed Acres (Calendar Year)

	Permits			Disturbed Acres		
	2005	2006	2007	2005	2006	2007
DCR Total for Virginia	1,904	2,733	2,482	24,357	32,331	26,027
Estimated Total for Virginia	4,917	6,115	5,752	31,258	39,713	32,745

The estimated activity at the local level suggests that the undercount permit numbers exceeds the undercount of disturbed acres. These results would be expected under the assumption that small developments (less than 5 acres) would be the most under-reported permit group in the state DCR data base. The under-reporting of small projects could have a large impact on permit totals, but a relatively smaller impact on total reported disturbed acres. In areas outside the Chesapeake Bay Preservation Act area, however, local erosion and sediment control permit data might also contain projects that are less than an acre (but greater than 10,000 ft²). Thus, the local data from these areas may over-estimate the total amount of stormwater permits because projects under one acre would not be required to obtain stormwater permit coverage (only E&S). Additionally an over-estimate could occur due to local reporting of individual building permits that may be covered by fewer stormwater permits under a common plan of development. The extent of such potential bias could not be assessed with the available data.

¹¹ A detailed description of the methods used in performing estimates is available in a separate document titled "Discussion of Estimation Issue in DCR Stormwater Project."

However, based on the under-reporting suggested by this analysis, DCR is conducting further analyses to refine the permit estimates that will be included in the Department's regulatory analysis document (see Fee discussion in II.3a).

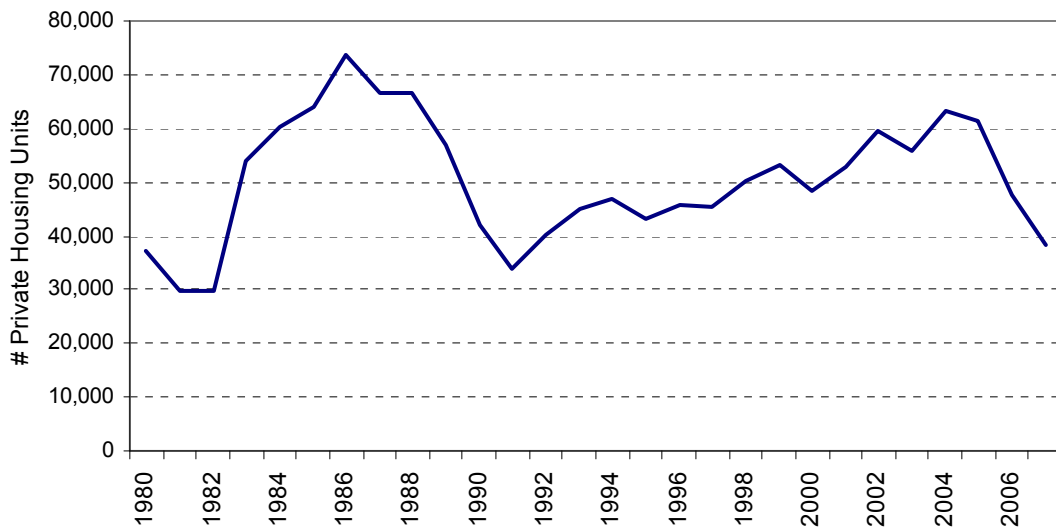
Reliable information about the portion of developed acres that are redevelopment could not be estimated. As part of the survey process, localities were asked about the ratio of new development versus redevelopment within their area. Results are anecdotal; however, in general, areas in the western and southern parts of the state indicate that redevelopment accounts for no more than 10% of their land disturbing activities. On the other hand, more urban areas in the northern and eastern sections report the opposite. One area in northern Virginia estimated approximately 90% of all development is redevelopment.

Future trends

To estimate the entities affected by the regulation, estimates of *future* land disturbing activities is necessary. Making future projections based on historical data and trends on land disturbing activities, however, is difficult due to the limited and incomplete data. To put the land disturbing activity during the 2005-2007 period into perspective, proxy measures or scales of land development activity were sought. Land disturbing activities are generally tied to the overall level of economic activity within the state. Home building comprises a significant portion of the land disturbing activities and may serve as a proxy for the relative level of land disturbing activities. Figure 3 shows the number of new housing starts from 1980 to 2007. Beyond 2007, the Virginia Home Builders Association projects a decline of 24% in the number of housing starts for 2008 and an increase of only 15% over 2008 in 2009. Given the current turmoil in the credit and housing markets, these numbers may be adjusted downward and the duration of the downturn is uncertain at this time.

Long-term historical trends, however, indicate that private housing starts in Virginia average slightly more than 50,000 units per year. Housing starts also show significant year-to-year variation. During the 1980-82, 1990-91, and 2006-current economic downturns, housing starts dropped significantly (multiple year declines exceeding 20% annually). Average housing starts during the 2005–2007 time period averaged slightly more than 49,000 per year. While housing starts declined over this 3 year period, the three year average is roughly equivalent to the 28-year historical average.

Assuming that the 2005-2007 period is, as a whole, roughly representative of the historical level of land disturbing activities in the state, estimates of the level of land disturbing activities during this period might reasonably be assumed to approximate future ranges of land disturbing activity. The average annual estimated disturbed acres in Virginia during the 2005-2007 period was 34,572 acres (27,571 acres using only DCR registry information, see Table 1). The average annual number of permits issued annually during 2005-2007 was 5,595. Once the housing and development market emerges from the current economic downturn, a reasonable estimate of future disturbed acres would be between 30,000 and 40,000 acres per year and the annual number of stormwater permits between 4,000 and 7,000.



Source: U.S. Census

Figure 3: Total Housing Starts (single and multifamily) in Virginia

3. All projected costs of the regulation for affected individuals, businesses, or other entities

3a. On-site stormwater control costs.

Conceptually, the costs of providing stormwater controls are all opportunity costs (EPA, 2000). Opportunity costs are the value of alternatives (next best) given up by society to achieve a particular outcome. Opportunity costs of stormwater control include direct costs necessary to control and treat runoff including construction costs and the present value of annual operation and maintenance costs. Initial installation costs should also include the value of foregone opportunities on the land used for stormwater control, typically measured as land price. Stormwater control costs also include the expertise needed to design stormwater management practices and systems. Private sector costs might include time and administrative cost associated with gaining regulatory approval of stormwater management plans/designs. These costs are exclusive of public costs of administering a stormwater program (see section 4 and 5 below). Opportunity costs also include other values that might be given up as a consequence of stormwater management. For example, the creation of a constructed wetland in a residential area might be opposed because of perceived safety, aesthetic, or nuisance concerns (undesirable insect or animal species). In this case, the diminished satisfaction of nearby property owners is an opportunity cost associated with the constructed wetland. On the other hand, if stormwater controls are considered a neighborhood amenity (e.g., wet pond in a park setting) offsetting benefit would be provided (see discussion below).

The proposed regulation will expand both the scope and intensity of stormwater management activities on land disturbing projects. The proposed regulations would double the phosphorus reductions required for redevelopment and increase phosphorus removal requirements for new development. Additional levels of water quantity control would be required, primarily for discharges to unstable stream channels.

A projection of the incremental private on-site stormwater control costs require 1) estimating the level and type of incremental actions and controls that would occur above what would occur under the existing regulations (assumes existing regulations would apply to future development in absence of proposed regulations), and 2) estimating the unit costs associated with the actions/controls implemented. A total projected cost estimate for the state, however, cannot be reliably projected. The uncertain behavioral responses (both by the land disturber and locality), variation in site specific conditions, and the complexity

of the application of technical requirements make estimation of total state costs unreliable. Rather this analysis will review factors that will likely influence (increase or decrease) compliance costs. To the extent possible, costs for case study examples and applications will be provided.

The proposed regulation places new emphasis on reducing stormwater runoff volume as a means to improving stormwater quality and reflect recent recommendations for improving stormwater management (NRC 2008). Under the existing regulations, stormwater control practices are assigned specific phosphorus removal efficiency (4VAC50-60-60). These efficiencies specify the percentage of phosphorus removed from a total volume of water. The proposed revisions delineate that phosphorus removal can be achieved by both reduction in pollutant concentration and by reduction in runoff volumes. (4VAC50-60-65). For instance, infiltration stormwater practices prevent a percentage of a storm event (of a given size) from ever directly entering a stream system. Reducing runoff volume can reduce P loads simply by reducing the amount of water leaving the site (assuming concentration of P in the runoff remains unchanged).¹² The P reduction achieved through runoff reduction is in addition to any reduction achieved by practices' treatment processes (reducing phosphorus concentration in the remaining runoff).¹³ In addition to the runoff volume estimates, the pollutant removal achieved by treatment (lowering P concentration) were also refined and revised for some practices. The net effect of counting runoff reduction and revisions to the pollutant (P) concentration removal efficiencies means that total percent phosphorus removal credited to most stormwater practices (total phosphorus removal efficiencies) is now higher under the proposed regulation.¹⁴

In addition, the regulations add several new control options available for compliance as well as allowing additional practices to be added through the new BMP Clearinghouse (4VAC 50-60-65B). The additional control options and the acknowledgement of pollutant removal possibilities of runoff reduction increase choice and may reduce the number of structural controls that will be necessary to treat stormwater runoff. Consequently, the addition of control practices and the higher removal efficiencies for most stormwater control practices will tend to reduce the cost of phosphorus control (holding all other cost influencing factors constant).

What type of controls available to land disturbers, however, will depend on which type of stormwater control measures are allowed by a local program (or allowed by DCR in areas without a designated program). Local jurisdictions can limit or specify the type of BMPs available for compliance and there may be a number of valid reasons for doing so. For instance, some infiltration practices may be infeasible or impractical in certain regions of the state, including those areas with karst topography (ex. areas within the Shenandoah Valley) and areas with shallow groundwater tables (ex. areas in the coastal plain). In addition, some local stormwater program managers have voiced concerns about the feasibility and cost of inspection and enforcement of certain types of decentralized practices (see discussion section 4 below). To the extent compliance choices are limited, the cost for land disturbers to comply with the water quality requirements increases.

An important criterion in designing and sizing a stormwater control practice is identifying the volume of water to be treated. The proposed regulations increase the volume of water subject to water quality treatment (§4VAC50-60-65). The existing stormwater regulations require many stormwater control practices to treat of the volume of water associated with the first ½ inch of rain multiplied by the impervious surface of the land development project. Water volume in excess of the design volume would enter water bodies untreated or partially treated. Approximately 70 to 75% of all rain events in Virginia

¹² Under actual field conditions, this assumption may not always hold. For instance, a recent USGS study compared adjacent watersheds with different approaches to controlling runoff. One watershed used a variety of infiltration practices to reduce runoff volume (called low impact development or LID), while the other watershed used mostly conventional practices to capture runoff (ponds). While the runoff volumes in the LID watershed were substantially lower, the total phosphorus loads were higher over a 7 year period in the LID watershed because (presumably) the concentration of P in runoff was higher in some storm events under LID. See Selbig and Bannerman 2008.

¹³ In some cases, however, practices that reduce runoff volumes may *increase* the nutrient concentration in runoff. For instance, green roofs are assigned a runoff reduction between 45 and 60 percent in the proposed regulation (4VAC50-60-65C). However, some research finds that nutrient concentrations in the remaining roof runoff will likely increase (see Hunt and Szpir 2006).

¹⁴ There are exceptions. For instance the phosphorus removal percentage of dry extended detention ponds decreases under the proposed regulation

are ½ inch of rain or less. The proposed regulation increases the amount of water that requires treatment from the first ½ inch of runoff from impervious areas to the runoff from the first inch of rain from both impervious and turf areas. Approximately 90% of all rain events in Virginia are 1 inch of rain or less. The additional stormwater treatment volume (from both the larger rain event and the added turf area) will likely increase the size of structural stormwater control practices to treat this additional volume, thus incrementally increasing costs (all other factors held constant).¹⁵

The proposed regulation also establishes new design criteria and pollutant removal efficiencies for stormwater practices. Design criteria identify the standards used to size and construct stormwater practices. The design criteria can be quite detailed and were revised for all of the stormwater control practices listed in the regulation. It is unclear how the revised design criteria influence costs.

The proposed regulation increases stormwater water quality criteria for new development. Where localities are not already employing more stringent standards, the proposed phosphorus water quality criterion will require the implementation and maintenance of additional stormwater controls. The new water quality criteria establishes a 0.28 lb/ac/yr phosphorus criteria that is more stringent than the current water quality criteria computed under the existing regulation. The reduction requirements under existing regulations are based on preventing an increase in phosphorus load from the pre-development land cover. The existing regulations typically do not face any phosphorus control requirements for development with less than 16% impervious surface (average land cover condition).¹⁶ Finally the existing regulation computes total phosphorus loads based only on total impervious surface. Procedures under the proposed regulation add P contributions from turf and forest areas in order to provide a more comprehensive accounting of phosphorus loads from the developed site.

Figure 4 shows general per acre phosphorus reduction requirements for new development under the proposed and existing regulation. The graph charts total phosphorus reduction requirements for developments with different levels of impervious surface. The total P load reduction required under the existing regulation was computed using the Simple Method as outlined in the *Virginia Stormwater Handbook*.¹⁷ The P reduction requirements under the proposed regulation were calculated using the DCR compliance spreadsheet. Total P load reductions were calculated using different assumptions for nonimpervious (pervious) land cover. One scenario assumes all pervious (nonimpervious) area is turf/lawn and represents the upper bound total P reduction required. Another scenario assumes that 80% of pervious areas remain, or are converted to, a forested cover condition. This scenario approximates a lower bound estimate of total P reduction required under the proposed regulation.

The proposed revised regulation increases the total phosphorus reduction requirement between 0.14 and 0.45 lbs/ac, depending on assumptions about composition of impervious and pervious surfaces (the difference between proposed and existing reduction curves in Figure 4). The increase is due to a number of factors. First and most obvious, the effective load standard has been lowered to .28 lbs of P per acre. Second, the proposed regulation also calculates P load from two types of pervious areas, managed turf and forest. The existing regulation calculates P load from impervious surfaces only. The effect of including pervious surface will have larger relative impacts for low density developments with significant turf cover (see Figure 4). As an illustration, a new development with 20% impervious cover would be required to remove 0.07 pounds per acre under the existing regulation. If the 80% remaining land was turf, the total P load reduction requirement would 0.52 pounds per acre under the proposed regulation (top line in Figure 4). The load reduction requirement can be reduced considerably, however, by preserving more forest cover on the remaining pervious areas (e.g. middle line in Figure 4). Finally, the proposed regulation tightens the threshold under which new developments must reduce phosphorus

¹⁵ It should be noted that the costs of controlling this additional treatment volume may be partially offset by the new BMP performance criteria that gives more pollution removal credit for practices that reduce runoff volume.

¹⁶ Recall that the default existing land use condition is assumed to be 16% impervious, although localities are granted discretion to provide a more refined delineation of existing land use condition.

¹⁷ Calculated assuming the default existing land use condition of 16% impervious.

loads. For example, new development with 10% impervious surface and significant turf area would likely face some phosphorus reduction requirement under the proposed regulation.¹⁸

Figure 4 also illustrates that for both the proposed and existing regulation, the computed P reduction requirement increases with total impervious surface cover. Under the proposed regulation, the P reduction requirement for a development with 10% impervious surface and 90% turf is 0.35 lbs/ac, while the P reduction requirement as a development with 90% impervious surface and 10% turf is 1.72 lbs/ac (a nearly 5 fold increase). Moving from a site-by-site perspective to a watershed perspective, however, may produce different conclusions. Based on this site-by-site method, low density developments would produce less estimated phosphorus runoff than medium or high density areas. Very low density developments (1 dwelling unit per 3 to 5 acres) would unlikely face any water quality control requirements (Figure 4 and Table 2). Yet, on a watershed basis, low density (“sprawl”) development increases the overall rate of land conversion to urban uses, creates more impervious area per capita, and increases dependence on auto transport (thus increasing emissions and roadway impervious surfaces). Highly impervious areas accompanied by dense population settlement can produce net water quality improvements, independent of whether stormwater controls are implemented (Bosch et al. 2003; EPA 2006). For example, if high levels of impervious cover are accompanied by higher population densities, the overall watershed effect may be to decrease the rate of urban land conversion, decrease impervious surface per capita, and lower overall urban pollutant loads. As currently conceived, the nutrient load reductions from foregone land conversion are not counted against the calculated on-site loads. Although empirical evidence is limited, on-site effluent treatment costs (expressed on a per pound basis) are expected to be higher for highly impervious areas relative to low impervious areas. Higher phosphorus control costs in high density developments create financial disincentives that may work at cross purposes with larger watershed objectives.¹⁹

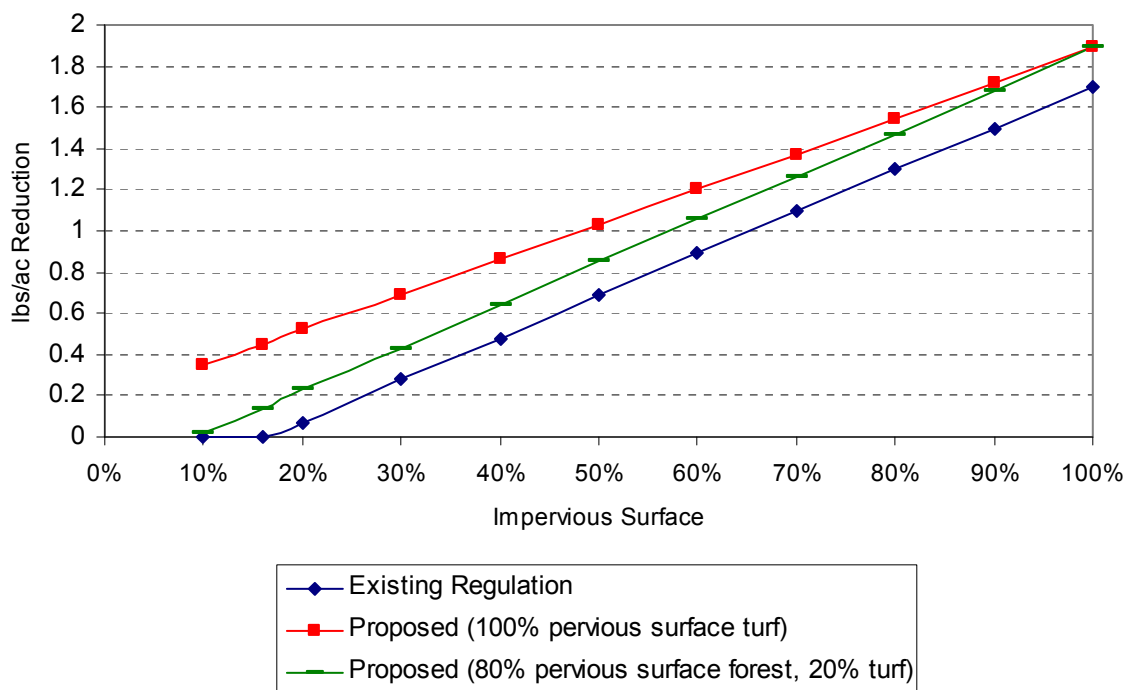


Figure 4: Per Acre Phosphorous Reduction Requirement (New Development)

The proposed regulation doubles the phosphorus requirement for redevelopment from 10% P reduction from predevelopment levels to a 20% reduction. Stormwater control costs (measured on per pound of P reduction) are expected to be higher in redevelopment areas (without stormwater controls) than for new

¹⁸ As a reference, housing developments with 1, 4 or 8 houses per acre might have 20%, 38%, and 65% impervious surface respectively (EPA 2006).

¹⁹ The addition of turf areas to the computation of P load (as described above), however, would somewhat offset this disincentive.

development.²⁰ However, since the criterion is expressed as a percentage reduction from predevelopment levels, the redevelopment will not usually be as stringent as the 0.28 load standard for new development. For redevelopment with impervious cover ranging from 50 to 100%, the additional 10% reduction would translate into an additional phosphorus reduction ranging from 0.13 and 0.22 lbs/ac.

Stormwater Control Costs

In general, the cost to control and treat stormwater runoff is incompletely understood and gaps exist in the literature. Extrapolating existing empirical cost analysis to field conditions is challenging given that stormwater treatment exhibits considerable site-specific variation resulting from different soil, topography, climatic conditions, development forms, local economic conditions, and regulatory requirements (Lambe et al., 2005).

The literature on stormwater costs tend to be oriented around construction costs of more conventional types of stormwater control practices such as ponds, constructed wetlands, detention basins, sand filters and bioretention areas (Wiegand et al., 1986; SWRPC, 1991; Brown and Schueler, 1997; Wossink and Hunt, 2003; Lambe et al. 2005). These studies generally find that construction costs decrease on a per unit basis as the overall size (expressed in volume or drainage area) of the stormwater BMP increases (Lambe et al., 2005). These within-practice economies of scale are generally found across conventional stormwater controls including wet ponds, detention ponds, and constructed wetlands (Brown and Schueler 1997; EPA 1999; Wossink and Hunt, 2003).

Increasing attention has been paid to small-scale practices (serving small parcels and lots) including efforts to increase infiltration and retain water through such means as green roofs, permeable pavements, rain barrels, and rain gardens. The costs of these practices, in general, are less well understood compared to the other stormwater practices. In general, per unit construction and design costs exceed larger scale conventional stormwater practices. Others have suggested that per unit costs to reduce runoff may be less for these small-scale distributed practices after considering higher infiltration rates and retention rates (MacMullan and Reich 2007). Furthermore, reducing the volume of runoff through the use of such practices may result in lowering the cost of the overall drainage infrastructure, since less water will have to be conveyed. Other classes of small, on-site practices, such as grass swales and filter strips, may also be implemented for relatively low cost.

Almost all stormwater control measures require active long-term maintenance in order to continue to provide volume and water quality benefits (Hoyt and Brown, 2005; Hunt and Lord, 2006). Compared to construction costs, less is known about long-term operation and maintenance costs (Wossink and Hunt 2003; Lambe et al. 2005; MacMullan and Reich 2007). A recent Water Environment Research Federation study (2004, p.5-5) concluded that "there is an urgent need to appraise the frequency and cost (level of activity) of maintenance required to achieve appropriate performance levels of BMP/SUDs in different climates."

Stormwater control maintenance often consists of routine maintenance activities as well as periodic retrofits. The type, frequency, and extent of maintenance requirements differ between stormwater control practices (EPA 1999). The most common stormwater practices implemented in Virginia, extended detention ponds and wetponds, require annual or as-needed maintenance for vegetation control (mowing), clearing debris, and embankment and slope repair. More extensive maintenance (retrofits), such as the removal of accumulated sediment from the pond itself may be needed every 20 years (or when pond loses half of its original storage volume). In areas without adequate upstream stream channel protections, the sedimentation rate can be significantly accelerated, increasing the frequency and cost of maintaining functions of downstream ponds. The dredged material must typically be land-filled because the sediments will contain contaminants. Larger pond structures also carry costs associated with a nonzero probability of structural dam failure, which causes environmental, property, and human health damages downstream.

²⁰ There may be instances where the costs of providing for the additional 10% removal will not increase because the new BMP performance criteria generally assigns more higher pollution removal credit for each BMP.

Local stormwater programs in Virginia have less experience with filtration and infiltration practices. Bioretention, infiltration, and filtration practices, however, all generally require more frequent maintenance than ponds to maintain performance (EPA 1999). All require annual or regular maintenance. For instance, bioretention areas require regular mulching, trash removal, plant maintenance and replacement, and minor erosion related repairs (Hunt and Lord 2005). More extensive periodic maintenance, however, is required to maintain filtering and infiltration functions. In general, activities to remove excess sediments, remove biofilms, or replace (often partial) filter media must be accomplished on a 3 to 5-year cycle. More extensive excavation may be required in case of severe clogging. Costs may also be incurred to discard soil and filter media.

Based on the limited information available, however, long-term maintenance costs represent a substantial share of stormwater control costs. Based on annual maintenance costs from EPA (1999), the present value of annual maintenance costs is estimated to be between 40 and 85% of construction costs for wet ponds and constructed wetlands and between 70 and 100% for swales and bioretention areas. The total present value of annual maintenance costs for infiltration trenches and sand filters can range from 70 to 280% of total construction costs. Other studies confirm that over the life of many stormwater control practices, maintenance costs may equal or exceed construction costs (Center for Watershed Protection 2000). The very limited evidence above suggests that maintenance of conventional ponds costs less than for other types of stormwater control practices. During interviews with local stormwater managers in Virginia, one local government reported that the annual cost to maintain publicly managed bioretention areas (over \$8,000/yr per bioretention facility) was more than five times more expensive than the annual cost to maintain publicly managed ponds.²¹

As outlined in the regulation, these costs will be incurred primarily by commercial, industrial, residential property owners or local governments who manage regional facilities. The evidence on the long-term performance of stormwater BMPs under actual conditions is also limited. Assuring long-term performance, however, will also require expenditure of resources. Private landowners have limited financial incentives to incur the annual and periodic retrofit costs to maintain stormwater practices. Thus, local governments will be required to devote sufficient resources to post-construction inspection and enforcement to ensure that practice performance is maintained over time (see Section II.4).

The proposed regulation offers opportunities to reduce phosphorus by altering the design of any development, independent of the specific control practices imposed. New P calculation procedures assign lower P loads to forest and turf areas. Low to medium density developments can lower phosphorus control requirements by reducing effective impervious cover through cluster development patterns, preserving forest cover, reducing street widths, reducing curb and gutter, and reducing in the number of cul-de-sacs (Center for Watershed Protection 2000).²² Quantifying the cost of many of these design features is more challenging, and the literature is much less developed or conclusive than the literature on conventional control practices. Many development design features (clustering, reduced setbacks, narrower streets, less curb and gutter, etc.) can lower construction and infrastructure costs. Such features may reduce the capital cost of subdivision development from 10 to 80% (Center for Watershed Protection 2000; EPA 2007b). On the other hand, the evidence is unclear how property owners value these design features. If consumers prefer characteristics associated with conventional developments (large suburban lot, cul-de-sacs, curb and gutter) then removal of these features impose an opportunity cost in the form of reduced amenity value (measured as reduced housing price). For example, most statistical studies in the U.S. housing market find that consumers prefer homes with larger lots and are willing to pay premiums for homes located on cul-de-sacs, presumably for privacy and safety reasons (Fina and Shabman 1999; Song and Knapp 2003; Kopits, McConnell and Walls 2007). These effects, however, might be partly offset by the higher value consumers might place on the proximity of

²¹ The fact that construction and long-term maintenance costs may be different may present barriers and disincentives to installing cost effective combinations of stormwater controls. Land developers, for instance, have incentives to minimize the cost of meeting a regulatory obligation. Since the land developer typically does not pay long-term maintenance costs, financial incentives exist to minimize upfront (construction) costs, even if the total life cycle costs are high.

²² The ability achieve these reductions in effective impervious surface, however, will be limited and constrained to varying degrees by local zoning and subdivision ordinances and state road construction requirements (example those for fire safety).

open space to their homes (Cheshire and Sheppard, 1995; Stephenson et al. 2001; Qiu et al., 2006; Mohamed 2006). Whether the value of open space is sufficient to offset the diminished value of smaller lots in cluster developments remains largely an unresolved issue and one that is probably determined by local market conditions.

Most stormwater control practices listed in the proposed regulation require land to be designated for water treatment, storage, filtration or infiltration. Land for stormwater control represents a significant opportunity cost. Land devoted to stormwater control results in lower development densities and/or loss of other land uses (e.g. loss of recreational or landscaping space to stormwater facilities). While land costs are site specific and exhibit spatial variation, land costs may be the single biggest cost outlay of land-intensive stormwater control practices in highly urban settings (Wossink and Hunt 2003).

Other costs include design and permitting costs. Brown and Schueler (1997) provide general “rule of thumb” estimates that design and permitting cost can range between 25 and 37% of construction costs. Another cost is the time delays in securing the necessary approval to begin development. Time delays are frequently cited as a major cost by the developer community (Randolph et al. 2007). Experience and good plan design would be a critical element in reducing these time costs.

Little systematic research has been conducted on the relationship between stormwater control costs and high-density development/redevelopment. Most stormwater control practices require space. In highly dense development, land costs tend to be high and the space available for storage, treatment, and infiltration of runoff diminishes (Wossink and Hunt 2003). Limited space also reduces available treatment options. Space constraints often require filtration and storage devices to be built underground. In redevelopment areas, construction costs increase as existing infrastructure must be modified, moved, or built around. While little empirical evidence exists, there appears to be a reasonable expectation that the cost of treating a given volume of water increases as the percentage of impervious cover increases (holding the size of the development constant). This relationship between cost and impervious area also highlights the economic importance of being able to spatially target phosphorus and water quantity controls in areas with more cost effective treatment options (see off-site and pro-rata share discussion below).

Randolph et al. (2007) report on the cost of complying with environmental regulations for five residential developments in the northern Virginia (across 3 counties within Chesapeake Bay Preservation Area). The developments represented a mix of greenfield and infill development with densities of 1 to 3.5 dwelling units per acre (approximately 20 to 40 % estimated impervious area). Stormwater control costs included only construction costs for wet ponds. Stormwater costs, however, were separate from erosion and sediment control costs. The findings from these case studies indicate that stormwater costs range from \$350 to \$7,000 (\$1,900 average) per dwelling unit and \$500 to \$7,000 per acre (\$3,900/ac average). These costs reflected in the case studies would likely more than double if land and maintenance costs were included (see discussion above).

As a nutrient management strategy, urban stormwater control tends to be the most costly means for reducing nutrient loads. Considering maintenance, capital construction, and land costs, recent estimates for North Carolina indicate that annual cost for wet ponds and constructed wetlands range between \$100 to \$3,000 per treated acre (typically less than \$1,000).²³ Per acre annual costs for bioretention and sand filters typically ranged between \$300–\$3,500 and \$4,500–\$8,500 respectively (Wossink and Hunt, 2003).

The cost of reducing nutrients *on a per pound* basis will typically be hundreds and sometimes thousands of dollars per pound (Aultman 2007; Brown and Schueler 1997). For example, based on removal effectiveness and costs estimates from Brown and Schueler (1997), the annual cost to reduce a pound of phosphorus with wet ponds or bioretention areas ranged from \$560 to \$1,500/lb/yr.²⁴ These estimates include construction, land, and operation and maintenance costs for a hypothetical five acre commercial

²³ These costs would then need to be allocated between water quality and water quantity treatment.

²⁴ Assumes all water quality control costs are allocated to phosphorus removal only.

site and a 25 acre residential site.²⁵ As an illustration of the unit costs of meeting the current redevelopment criteria, the total capital cost for a small commercial development was \$4,500/lb/yr.²⁶ These estimates are based on the costs for water quality treatment only (water quantity controls represent additional costs), but assume all water quality costs are assigned to phosphorus removal.

These control costs are significantly higher than nutrient control costs from point sources or agricultural nonpoint sources (Chesapeake Bay Commission 2004; Shulyer 1995).²⁷ A recent Chesapeake Bay Commission (2004) report estimated annual point source phosphorus control costs to be \$74/lb. Enhanced nutrient management (currently considered beyond a Tributary Strategy baseline practice) cost an estimated \$96 per pound of phosphorus.

Incremental costs: Illustrations applying proposed water quality criteria.

The proposed criteria was tested on a limited number of existing and planned developments to gain a better understanding of what type of incremental actions and costs would be required to meet the new water quality and quantity criteria. The information provided in this section came from three general sources. First, DCR conducted design “charettes” in the fall of 2008. Stormwater design teams proposed plans to meet the revised water quality and quantity test for a small commercial site and a medium density residential development. Second, land developers (permittees) and consulting firms voluntarily supplied alternative stormwater designs for 5 recently completed or planned developments. Finally, one environmental group commissioned stormwater plan designs for 6 developments. These developments do not represent a random sample although they do characterize many types of developments occurring across the Commonwealth. The examples used are drawn mainly from the eastern portion of the state and are provided by the volunteer efforts of a variety of groups. In each case, efforts were made to identify the activities and costs required to meet both the existing and proposed regulation.

With these caveats, the developments evaluated are summarized in Table 2. The developments do represent a broad cross section of different development types. The developments were almost evenly split between residential and commercial development types. Two of the six commercial developments were redevelopment projects (see Comm5 and Comm6, Table 2). All remaining projects were new developments. The residential developments tended to be low to medium density development with only one site above 4 dwelling units per acre. None of the developments occurred in ultra-urban areas (over 75% impervious surface).

All development cases in Table 2 were able to meet stormwater quality and quantity requirements on-site. The two low density residential developments met the revised water quality standard in their existing form (Resid3 and Resid7 in Table 2). Both developments had less than 10% impervious cover and significant forest cover on remaining (pervious) land. This result is consistent with the general result shown in Figure 4. The proposed revisions to the water quantity requirements were the binding regulatory constraint for two of the 13 development projects (Resid 3 and Comm6). For water quality controls, the stormwater development designs reflect a mix of conventional treatment and runoff volume reduction practices. The use of bioretention areas, ponds, and swales were commonly used control practices. The residential development with the highest development density (dwelling unit/ac) was able to meet water quality criteria by upgrading the treatment level of a large stormwater pond (Table 2, Resid2). For this development, compliance was achieved without any reductions in runoff volume and reflected the impact

²⁵ Construction cost estimates were converted to current 2007 dollars. Operation and maintenance costs were derived from EPA (1999) and assuming land costs of \$50,000 per acre. Total costs were annualized using discount rate of 5%. The wetpond cost estimates assume that only a third of the cost of the wetpond is assigned to water quality (the remainder of the cost assigned to water quantity control).

²⁶ The project was a one acre development, mostly impervious. Two proprietary filtration devices installed at a total cost of \$19,370 to achieve the required remove 0.22lbs/P/yr from the site. Maintenance and land costs were assumed to be zero, thus represents a lower bound estimate.

²⁷ The Chesapeake Bay Commission 2004 succinctly summarized the challenge of managing urban loads: while urban sources are the fastest growing source of nutrient load to the Bay, “the job to reduce stormwater impacts from developed land will be expensive, difficult to measure and effective only over the long-term.” (p. 10). In Virginia’s tributary strategy document, urban runoff contributes 18% of Virginia’s phosphorus load to the Bay, but crude cost analysis estimates that urban runoff controls will make up 75% of the cost to meet Virginia’s reduction commitment (Virginia Secretary of Natural Resources 2005).

of revisions to the phosphorus removal efficiencies (75% P concentration reduction for level 2 wetpond). The two redevelopment sites were also able achieve the new water quality and quantity criteria.

Table 2: Descriptions of Developments Used to Evaluate Revised Regulatory Requirements

NAME	Dev Type	Dev Size (ac)	% Land Cover (Imperv/Turf/Forest)	Density DU/ac	Additional Actions Required to Meet Proposed Regulatory Requirements
Comm1	New	0.75	47%/53%/0%	N/A	Reduction in parking spaces, bioretention areas, dry swale, detention facility.
Comm2	New	15.2	43%/57%/0%	N/A	Eight additional biofilters; some substitution of impervious with permeable pavement
Comm3	New	15.6	67%/33%/0%	N/A	New criteria can be met with current underground detention/stormwater filtration and upgrading large wet pond from type 1 to type 2 treatment level.
Comm4	New	11.1	66%/32%/2%	N/A	The current stormwater design utilizes an LID approach with 25,000 ft ² of bioretention facilities and soil amendments. New requirements could be met with a type 2 wet pond. Meeting new criteria with LID approach would require upgrading the bioretention to meet new design standards but with a similar area.
Comm5	Re Dev	1.65	Imp Predev,65% Imp Postdev,75%	N/A	Existing detention basin is converted to extended detention basin, 1/6 th of the new pavement is permeable and 2,000 gallon cistern.
Comm6	Re Dev	54	Imp Predev,58% Imp Postdev,69%	N/A	Water quality redevelopment criteria met with no additional controls (existing 2.4 acre retention pond), but new water quantity criteria requires reconfiguration of piping and addition of rain tank and pump system.
Resid1	New	8.8	25%/42%/33%	3.3	Grass swales, expanded bioretention areas, forest cover preservation
Resid2	New	26.5	50%/50%/0%	7	Upgrade large wet pond from type 1 to type 2 treatment level.
Resid3	New	42.6	9.1%/35%/56%	0.66	Existing cluster development (19 ac disturbed) meets WQual criteria with no additional treatment. Activities to meet WQuant requirement: roof disconnect, grass swales, porous pavement.
Resid4	New	43.3	21%/49%/30%	1.82	Roof top disconnect, porous pavement, added size for infiltration basin. One pond to meet WQuantity requirements.
Resid5	New	55	40%/53%/7%	3.73	Upgrade and expand dry detention basin to type 2 wet pond, in addition to the other planned stormwater facilities.
Resid6	New	14.9	Traditional: 25%/58%/17% Cluster: 20%/63%/17%	1.68	Change from 9,583 s.f. of bioretention and swales to 9,500 s.f. of level 1 dry swale, 700 l.f. of grassed swale, 5,000 s.f. of soil amendments and 50 rain barrels.
Resid7	New	270	5%/16%/79%	0.13	None. No stormwater controls required.

The incremental phosphorus removed from revisions to the water quality criteria, and the added cost to achieve these reductions, are shown in Table 3. Incremental phosphorus reductions achieved is an estimate of the additional annual reductions in phosphorus loads achieved above existing (current) water quality requirements. Incremental upfront costs are construction, material, land and design costs associated with the additional controls needed to comply with the proposed regulations. Incremental annual costs are the annualized cost of incremental upfront costs plus an estimate of the annual operation and maintenance costs. Finally, the incremental (marginal) cost to achieve the additional phosphorus reductions achieved by the revised water quality criterion is reported in the last column of Table 3. In two cases, additional costs were necessary to comply with water quantity criteria, but not the water quality criteria. In these cases, the cost per pound of phosphorus removal measure is not applicable (incremental costs were attributed to water quantity requirements). Data for three developments (Comm1, Resid1, and Resid2) are not reported in Table 3 due to inadequate baseline information or lack of cost data.

The incremental upfront costs to maintain compliance with the proposed revisions ranged from \$0 to \$750,000 per development project. For residential projects, stormwater BMP upfront costs (construction and land costs) were between \$0 and \$6,000 per dwelling unit depending on the scenario). For projects requiring additional phosphorus control, the addition reduction in P loads achieved per development site range from 0.23 to 19.2lbs/yr (between 0.14 to 0.41 pounds/ac). The incremental (marginal) phosphorus control costs (including upfront costs and operation & maintenance costs) range from \$825 to \$15,300 per pound per year (assuming all costs are assigned to P removal and no cost assigned to reductions in other constituents such as nitrogen, sediment, etc). Expressed on a cost per pound basis, phosphorus control costs appear to loosely increase with impervious area. The projects with the highest estimated per unit costs were a commercial development (Comm2) and a redevelopment site (Comm5).

Table 3: Incremental Phosphorus Reductions and Costs of Selected Developments

NAME	Dev Size (ac)	Incremental P Reduction for Site [‡]	Increase in Incremental Upfront Costs	Incremental Annualized Cost*	Incremental Cost per Pound per Year
Comm2	15.2	3.9	\$551,570	\$59,657	\$15,296
Comm3	15.6	4.4	\$40,000 to \$70,000	\$3,638 (low) to \$9,867 (high)	\$825 to \$2,237
Comm4	11.1	3	\$60,000 to \$120,000	\$5,457 (low) to \$16,914 (high)	\$1,819 to \$5,638
Comm5	1.65	0.23	\$17,500	\$1,592 (low) to \$2,467 (high)	\$6,920 to \$10,725
Comm6	54	None Needed	\$100,000 [◊]	\$7,095 ^Δ	Not Applicable
Resid3	42.6	None Needed	\$99,600 [◊]	\$8,490	Not Applicable
Resid4	43.3	8.3	\$206,279	\$21,922	\$2,641
Resid5	55	19.2	\$350,000 to \$750,000	\$31,833 (low) to \$105,714 (high)	\$1,658 to \$5,506
Resid6	14.9	5.7 to 6.05	\$54,500 to \$154,500	\$4,956 (low) to \$21,777 (high)	\$868 to \$3,600
Resid7	270	0	0	0	Not applicable

[‡]Represents estimated or an approximate additional P reduction. Comparing changes in load from existing and proposed regulations is complicated by the fact that load estimation methods and BMP sizing/design criteria differ between existing and proposed regulations.

*Unless otherwise noted, includes estimates of capital, land, and maintenance costs. Costs annualized over 25 years at 5% discount rate. High and low estimates based on assumptions that annual maintenance costs range from 2% to 7% of incremental upfront costs.

[◊] Cost to meet revised water quantity criteria only.

^Δ Does not include maintenance costs.

Fees

The regulatory revisions also propose a new stormwater permit fee structure (4 VAC 50-60-800 through 830). The number and size of permits that are expected to be managed under the proposed regulations is important for a number of reasons. The fees will be used by DCR and local stormwater programs to help finance the costs of implementing the stormwater program (as outlined in Section II.4 of this report). As currently calculated based on the original DCR estimate of 3,000 permits issued per year, local governments with an approved stormwater program receive 72% of collected fees, with the remainder (28%) going to DCR through the Virginia Stormwater Management Fund (4 VAC50-60-780). The number of permits will be important for estimating the management workload at both the local and state levels. Furthermore, the distribution of the permits by size determines the stormwater revenue generated under the proposed fee structure. It should be noted, however, that these fees do not represent (and should not be interpreted as) a societal cost from the revised regulations, but rather the fees determine who bears the burden of paying for program implementation costs. To the degree that fees will increase, the higher fees shift responsibility for paying for program implementation from the local/state governments to land disturbers (permit applicants).

The estimation of the total amount of fees that would be collected under the proposed regulation requires not only an estimate of the number of permits that are expected to be issued, but the distribution of those permits by the size of the land disturbance. The estimated total permits issued annually are shown in Table 1 (Section II.2). Information on the distribution of these permits according to size of land disturbing activities, however, was more limited. Specifically, the data supplied by the local governments did not typically contain information on the number of permits and land disturbance size.

Several approaches were used to estimate the distribution of permits according to the size of land disturbance. First, DCR provided an initial estimate of permit distribution and fee revenue in a discussion document dated September 8, 2008 (see Table 4). DCR's estimate of the distribution of permits was based on the DCR state permit registry. DCR also assumed 3,000 annual permits.

Table 4: Initial DCR estimates of revenue from fees

Project Size	% of Permits	# of permits	Fee per permit	Revenue Generated
> 2,500sqft, < 0.5 acre	7%	210	\$290	\$60,900
> 0.5 acre, < 1acre	8%	240	\$1,500	\$360,000
>1 acre, < 5 acres	40%	1,200	\$2,700	\$3,240,000
>5 acres, < 10 acres	17%	510	\$3,400	\$1,734,000
>10 acres, < 50 acres	23%	690	\$4,500	\$3,105,000
>50 acres, < 100 acres	3%	90	\$6,100	\$549,000
>100 acres	2%	60	\$9,600	\$576,000
				\$9,624,900
DCR's 28% of Fees				\$2,694,972

Source: "Discussion Document on Department Fees" Virginia Department of Conservation and Recreation, September 8, 2008

The distribution reported in Table 4 can be generalized as a gamma distribution. Gamma distributions are best for data where there are many observations near zero, but progressively fewer as the values increase. Fitting a gamma distribution to the disturbed acreage data resulted in parameters of shape 0.5702 and scale 18.59 (standardized gamma distribution $\Gamma(0.5702, 18.59)$). Defining the distribution in this manner is comparable to fitting a regression line to a set of data: it provides a smooth, standardized description of the data of interest.

Yet, the distributions above are drawn from the state registry database that is thought to under report annual permits (Table 1). Furthermore, based on the discussion in Section II.2, there is reason to suspect that the number of smaller development projects are disproportionately under represented, thus also likely altering the distribution of permits.

To address the issue of permit undercount, DCR is currently conducting a systematic comparison of the state permit registry data with local permit data supplied to their regional offices. DCR compared state permit data with permit data for a select number of local government programs. The comparison was for data available for fiscal year 2008. The local data are sufficiently detailed for some localities to allow for a permit-by-permit comparison of the DCR database with data provided by local programs. The preliminary results suggest a state undercount of permit data with permits less than 5 acres disproportionately under represented. From this preliminary analysis, DCR concurs that their database does indeed reflect fewer permits than have been issued on the local level. Extrapolating DCR's preliminary data over the entire state and for an entire year (estimates may be subject to change). DCR suggests that the total permits could approach 7,000 annually. Upon the completion of their analysis, DCR will incorporate the final refined estimates they are generating into the regulatory discussion form.

Revenue estimates generated by the proposed fee structure are shown in Table 6. The estimates were based on two different distributions of permits: the permit distribution based on the state registry data and a gamma distribution of that data (see Table 5 for a summary). The distributions are then applied to three different assumptions about the number of permits that would be issued annually: 3,000 permits based on the state level DCR historical data, 5,600 permits based on the average annual number of permits projected in Table 1, and 7,000 permits based on upper bound permit estimate (see page 11). Combining the different estimates of number of permits with the different estimates of their distribution provides a matrix of possible revenues under the different assumptions (Table 6). An additional scenario will be developed by DCR upon completion of their data analysis.

Table 5: Comparison of permit size distributions under different assumptions

Permit Size	Original DCR	Gamma Distribution
> 2,500sqft, < 0.5 acre	7%	10.7%
> 0.5 acre, < 1acre	8%	6.9%
>1 acre, < 5 acres	40%	28.6%
>5 acres, < 10 acres	17%	18.1%
>10 acres, < 50 acres	23%	33.1%
>50 acres, < 100 acres	3%	2.5%
>100 acres	2%	0.1%

Table 6: Fee Revenues under Different Assumptions of Number and Distribution of Permits

Distribution by size \ No. of Permits	3,000 (Original DCR)	5,600 (Table 1)	7,000 (Upper Bound)
Original DCR	\$9,624,900	\$17,966,480	\$22,458,100
<i>28% to DCR</i>	\$2,694,972	\$5,030,614	\$6,288,286
Gamma Distribution	\$9,523,284	\$17,772,888	\$22,216,110
<i>28% to DCR</i>	\$2,666,520	\$4,976,409	\$6,220,511

Given the compelling evidence of undercounting of permits in the registry database, an annual estimate of 3,000 permits is probably low for a typical year. The future number of permits during normal economic conditions would more likely be in the 4,000 to 7,000 range. The total annual permit fees collected assuming 3,000, 5,600 and 7,000 permits would be approximately \$9, \$18 million, and \$22 respectively. Of total fees collected, DCR would collect 28% for overall program administration (assuming percentages remain the same as currently specified under 4VAC50-60-780). According to Table 6, fee revenue for DCR program oversight would be between \$2.7 and \$6.3 million per year (assuming 3,000 and 7,000

permits respectively).²⁸ Given the uncertainty of the current economic environment, however, the impact on program revenue from fluctuations in the number of permits issued is also worth noting.

According to DCR, it also should be noted that should DCR's final permit computations substantiate a significant under-reporting of permits, then the Department will need to reassess needed staff to support an increased permit load as well as revisit the fee amounts and DCR's percentage of the fees.

3b. Off-site options and pro rata programs

The offsite provisions and the pro rata system is an important and critical feature of the regulation. In highly urban settings (particularly redevelopment), some local programs report that on-site compliance is difficult and costly under the existing regulations. The more stringent water quality and quantity criteria and their focus on onsite runoff volume management will likely mean additional projects will face compliance challenges and increased costs for on-site control. Other land disturbances may face other types of site constraints (topography, soils, high groundwater tables, etc).

The off-site provisions in the proposed revisions offer needed compliance options and may allow greater opportunity to get more water quality protection for every dollar spent. Allowing land disturbers and local program administrator's flexibility to determine how and where water quality can be addressed may improve compliance opportunities and significantly reduce overall costs. Land disturbers would treat on-site up to the point that it is cost effective to do so (or as required by the local program) and then either pay a fee or achieve regulatory obligations off-site. The lower off-site control costs, the greater the cost-savings would be from a pro rata program or the off-site compliance option. An effective off-site/pro-rata program may be a necessity for highly impervious areas.

The magnitude of the cost savings, however, is uncertain at this point. Part of the uncertainty arises on the degree of flexibility localities will have in designing and implementing these programs. It is also uncertain how many localities will offer off-site compliance options.

A number of factors influence the cost reducing potential of the off-site/pro rata fee option. Three factors, in particular, will influence total stormwater control costs: sequencing preferences, allowable geographic area of off-site controls, and allowable off-site control options.

Sequencing refers to whether the local stormwater program would require land disturbers to undergo a process that gives preferential treatment to on-site controls before being allowed to consider off-site options (including payment of in lieu fees). Strict preferences for on-site control typically require the regulated party to demonstrate that on-site controls are either technically infeasible or prohibitively expensive. Strict sequencing rules will limit opportunities for lower cost and perhaps (in some circumstances) more environmentally effective off-site options (see discussion below). The proposed regulations are silent on regulatory preference for on-site controls.

The geographic area where off-site controls can be applied also influences the degree to which cost effective controls can be implemented. Greater flexibility on where off-site controls can be located will reduce costs and possibly improve environmental outcomes (other factors constant). For localities without a comprehensive watershed management plan, the regulation allows limited offset options for water quality criteria only. With a Board-approved watershed management plan, a local program can secure off-site reductions for either water quality or quantity within or adjacent to the impacted HUC or within "designated watersheds".²⁹ The watershed management plan requires consideration of the existing conditions and creates a plan to target and plan for future economic growth and environmental improvement. The cost effectiveness of off-site controls applies only if outcomes are achieved offsite that

²⁸ In addition, DCR would also receive 72% of all fees collected in areas without a delegated stormwater program. Roughly one quarter of all stormwater permits are estimated to be these nondelegated areas (assuming current estimates of 62 counties and 12 independent cities hold). Based on these assumptions, DCR could collect an additional \$1.7 to \$4.0 million in fees for local program administration (based on a range of 3,000 to 7,000 permits respectively). The remainder of all fee revenue (\$5.2 to \$12.1 million) would go to local delegated stormwater programs (assuming percentages specified in 4VAC50-60-780 do not change).

²⁹ In the event that a local water body is impaired by phosphorus, local programs can limit off-site options.

would be equivalent to those required on-site. Stormwater control programs, in general, provide three general sets of services; flood protection, channel/habitat protection, and water quality services. Each may be somewhat separable and each may have different spatial impacts and a watershed management plan can allow flexibility in how these impacts are offset. For example, flood protection is typically provided in close proximity to the impact in order to protect properties immediately downstream. Yet, flood protection can be provided without significant reductions in pollutant loads. Nutrient management to improve water quality offers more opportunity to move controls further off-site.³⁰ The flexibility and cost-saving potential of the off-site and pro rata provisions will depend partly on how broadly or narrowly “designated watershed” is interpreted by DCR in allowing off-site controls.

Finally, the way in which the water quality and quantity impacts can be offset off-site will also determine cost effectiveness. Existing pro rata programs in the Chesapeake Bay Preservation Area have been allowed to construct regional stormwater ponds, undergo stream restoration projects, and preserve open space as a way to offset phosphorus loads from land development activity. Such fees typically range from \$5,000 to \$8,000 per pound (or if expressed as an equivalent annual cost, \$250 to \$400/lb/yr). In localities where such programs exist, land disturbers are frequently willing to pay these fees rather than build additional onsite phosphorus control, suggesting that on-site phosphorus control costs are higher than these fees (this is consistent with empirical research on costs, see discussion above). The cost savings achieved by these programs support cost research that finds significant economies of scale for regional or larger scale projects. Several local officials interviewed during this analysis, however, indicated that these fees are likely to increase over time. Reasons for this increase include a decrease in the number of favorable and low cost offset sites, an increase in administrative and permitting costs of working in and around perennial streams (particularly for regional pond construction), and less willingness of state and federal regulatory officials to allow construction of regional stormwater facilities on perennial streams.

Conceptually, cost effectiveness will be enhanced if programs focus on achieving and maintaining a desired outcome (e.g., pound of P removed for example), rather than proscribing the means to achieve the outcome. The differences in per unit control costs across sources suggest that there are numerous options to lower compliance costs. Creating opportunities to secure phosphorus reductions (above and beyond reductions outlined in the state Tributary Strategies) from sources other than the construction of stormwater BMPs could lower costs. The following list of actions is only illustrative of the types of ways that could conceivably be available to reduce the cost of complying with the phosphorus control requirement.

- **Biomass Harvest.** The harvest of algal biomass could also be used to remove nutrients from ambient waters. One such system, Algal Turf Scrubber, grows filament algae using ambient water pumped over a flat prepared growing area. Water is then discharged back into receiving water and total nutrients removed from water can be measured as biomass weight and nutrient concentration. This technology is currently used in Florida to remove phosphorus from ambient waters and studies estimate the cost of phosphorus removal at \$16 and \$50/lb/yr (Hydromontia 2005). Advocates claim such a facility can remove over a thousand pounds of P per acre per year. Operated in conjunction with a municipal wastewater treatment plant, such a system could serve as a nutrient compliance offset for both municipal point and nonpoint nutrient control requirements. Currently, a biomass harvesting project is being piloted on the Susquehanna River in Pennsylvania (Crable 2008).
- **Density Credits:** From a watershed perspective, land settlement patterns may have the largest overall potential to reduce the impact of urban runoff on water quality (see discussion above). Localities in other states waive stormwater water quality criteria (grant exemptions) for high density developments or for brownfield redevelopment based on the premise that such

³⁰ Not all pollutant discharge will necessarily adversely impact local water quality. For instance, nutrient loads may not necessarily be a water quality concern in the immediate vicinity of the development impact, but rather may have adverse water quality consequences further downstream (in a reservoir or estuary). In the Chesapeake Bay watershed, tributary strategies focus on achieving nitrogen and phosphorus goals within entire river basins. Municipal waste water treatment plants and industrial point sources operating under the Virginia trading program may reallocate phosphorus and nitrogen within tributaries.

development has lower overall watershed impacts than low density development (NRC 2008; Lemoine 2007).³¹ Such designations may offer localities additional flexibility in lowering compliance costs while at the same time providing watershed-wide water quality benefits. The logic is that total water quality can be improved on a watershed basis by settling more people on less land, even if the onsite runoff (or load) from the relatively small impacted area may be high.

- Under Virginia's Chesapeake Bay Watershed Nutrient Credit Exchange (§62.1-44.19:12-19) point source discharges (municipal wastewater treatment plants and industrial dischargers) must meet stringent nitrogen and phosphorus annual load limits, called wasteload allocation (WLA). Existing point sources that exceed their annual wasteload allocation have a number of options to remain in compliance. One option offered by the state includes securing nonpoint source reduction credits from Virginia's Water Quality Improvement Fund. Credits are documented reductions in nonpoint source loads that exceed reductions required by any regulatory requirements or by the Virginia Chesapeake Bay tributary strategies. Currently Virginia charges \$11.06/lb for nitrogen credits and \$5.04/lb for phosphorus credits (9VAC 25-820-70j3). These fees were based on state estimates of the annual cost of nutrient removal from agricultural BMPs. A similar type of program could be offered to land disturbers to offset stormwater impacts. Conceptually, land disturber could make a lump sum payment of \$168 into a financial trust or foundation that would generate a stream of annual \$5 payments in perpetuity (assuming a modest 3% growth). Even if the cost of these offset fees increased 10 fold (to account for uncertainty, rising control costs, etc) the cost would still be significantly lower than existing pro rata fees or on-site stormwater control costs.
- Chemical treatment. Several localities in the U.S. use chemical treatment processes (e.g. alum) to remove phosphorus and nitrogen from urban stormwater. For example, one regional stormwater treatment facility serving a 1,160 acre urban drainage was designed to remove 14,000 pounds of phosphorus per year in Florida (Herr and Harper 2000). Costs using such processes are reported to be only 30% of the cost of a wet detention system (Herr and Harper 2000).
- Wetlands are often noted for their nutrient cycling services. The regulation identifies constructed stormwater wetland as an acceptable stormwater practice, but constructing small scale treatment wetlands in urban environments is expensive (similar in cost to stormwater ponds). In comparison, large scale restoration of degraded or former floodplain wetlands may be a less expensive way secure phosphorus reductions.³² Restoring former flood plain wetlands may involve simply restoring hydrologic function and wetland vegetation to drained flood plain agricultural land (which were often wetlands themselves before being converted). Restored floodplain wetlands can increase the capacity of aquatic ecosystem to remove nutrients because the represent new nutrient removal capacity to the system.

It is unclear at this time the extent to which localities administering their own stormwater program can pursue different (nonstormwater) types of phosphorus offsets.

One challenge to pro-rata programs, however, is that state law only allows localities to use such pro-rata fees to pay for design and construction costs (§15.2-2243). Since long-term maintenance costs may not be paid with pro-rata fees, the fees do not reflect the total cost of the offset. As noted above, long-term maintenance costs are a significant cost of stormwater management. Long-term maintenance costs may be paid by private owners of stormwater controls, shared between private landowners and the local stormwater management program, or incurred by the local stormwater management program (in the case of publically owned regional stormwater treatment facilities). These legislative restrictions place incentives for localities to narrow the range of possible offset activities to those that are more capital

³¹ The comprehensive watershed management provision of the regulation (4VAC 50-60-96) does not grant authority to alter water quality criteria in specifically designated areas.

³² The Wetlands Initiative. Undated fact sheet. "Can Wetlands Cost Effectively Manage Nutrients"

intensive. However, under the provisions of law, a locality may establish stormwater utility service fees to address, among other things, maintenance and inspection of BMPs in accordance with §15.2-2114.

Development projects located in state-managed areas or local areas without a pro rata program have much more limited opportunities to reduce costs off-site. For example, land disturbers in areas with a DCR administered programs will not have the advantages of a pro-rata program. One option the state may wish to consider in the future is the development of a state-wide urban offset program. North Carolina, for example, administers a state-wide in lieu fee program called the Ecosystem Enhancement Program (NCEEP). A regional state administered offset program option is also offered under Virginia's point source program (see above). A state-wide or regional program may be able have more opportunities to target fee resources to areas and sites where water quality improvements can achieve more reductions with higher probabilities of success. A state-wide program could serve a significant portion of the state where pro-rata systems are not available and also achieve administrative economies of scale by being able to more effectively consolidate management activities across more disturbed acres. Finally, such a program may be able to expand the cost reducing offsite options to a greater number of regulated parties.

3c. Benefits

The benefits of the proposed regulation are the additional improvements to the state's water bodies that would be achieved in the future with the proposed regulation as compared to what would be achieved with the existing regulation. Given the complexity of stormwater impacts and the comprehensive nature of the regulation, quantitative estimates are not possible. However, the range of possible benefits and indicators of the relative magnitude of possible benefits from the proposed regulation are summarized.

Conceptually, stormwater benefits are represented in Figure 5. As outlined in the proposed regulation, stormwater control practices alter flow and runoff quality stemming from land use change. These changes could then change a number of man-made and water-related services that are of value to people. These services include reductions in flood risk, avoided infrastructure costs, aquatic life support, recreation, and aesthetics (Braden and Johnston 2004). Commercial fisheries may also benefit from additional stormwater controls. Economic benefits are the value of these service changes to people.

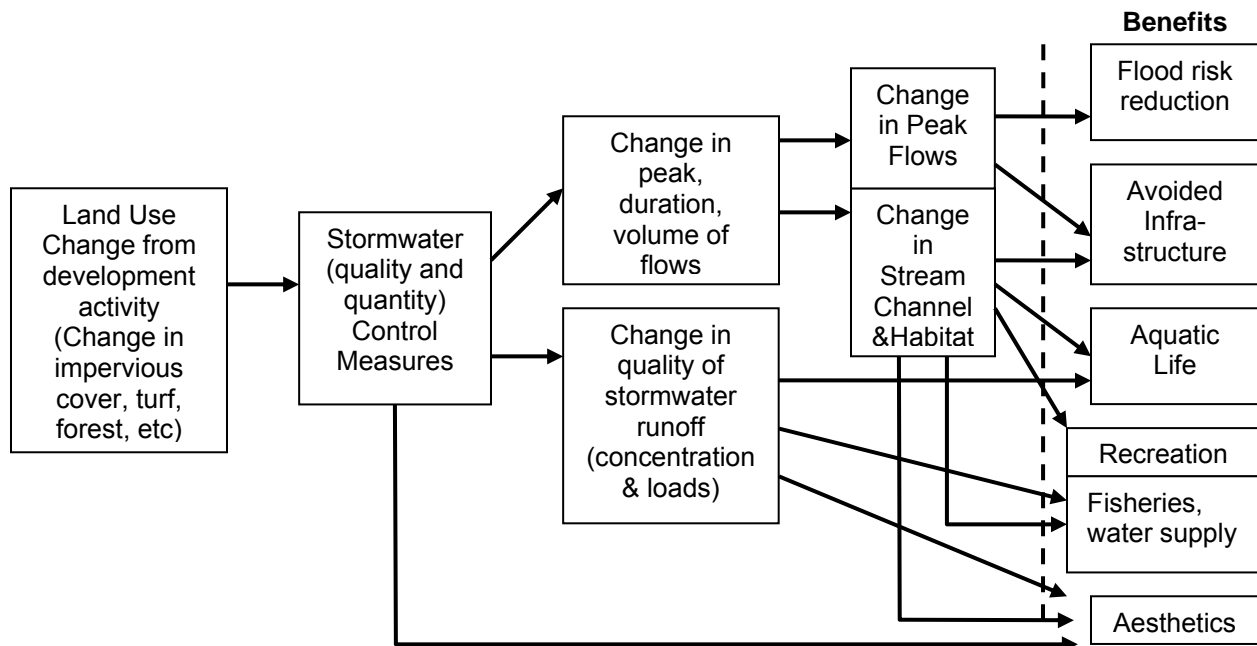


Figure 5: Benefits of Stormwater Control

Stormwater management also reduces the peak, duration and volume of stormwater runoff. The control of flows have significant consequences on stream habitat, flood related property damages, downstream infrastructure, and aesthetics (Streiner and Loomis 1995; Johnston, Braden and Price 2006). Virginia's current erosion and sediment and existing stormwater control programs provide some level of runoff control, primarily associated with control of peak flows. Johnston, Braden, and Price estimate differences in flood damage and infrastructure costs (primarily culverts) from conventional residential stormwater designs (stressing stormwater detention) versus conservation design (greater emphasis on infiltration and disturbed practices). The additional volume control achieved under conservation design was estimated to provide additional flood risk reduction benefits (between 0.4% and 2.5% of the value of downstream properties) and a reduction in infrastructure (culvert) costs for the developed area. In other cases, some elements of conservation design may directly improve the aesthetic environment for surrounding property owners (see Figure 5). For instance, the property owners are willing to pay more for properties adjacent to riparian areas and to open space (Qiu, Prato, and Boehm 2006).

Numerous studies have established a statistical correlation between urban land cover (as measured by impervious cover, effective impervious cover, road density, etc) and different measures of in-stream biotic diversity (ex. indices of biological integrity, measures of diversity of benthic macroinvertebrate life, etc). Studies overwhelmingly report an inverse relationship between measures of urban land cover (measured as impervious surface, road density, etc) and downstream biotic measures/indices (Davies and Jackson 2006; Center for Watershed Protection 2003; Wang et al. 2001; NRC 2008). Many studies report measures of biotic diversity begin to be reduced for relatively small amounts of impervious cover (~10%).

Empirical research of the extent to which these impacts might be reduced or avoided by various stormwater control practices is still emerging. Some existing studies suggest that control of peak flow alone has minimal impact on improving aquatic conditions (Maxted, J. R., and E. Shaver 1997; Roesner, Bledsoe and Brashear 2001). The proposed regulation, however, provides incentives to reduce runoff volume and imposes new water quantity criteria on controlling energy input to the stream. The proposed regulations requires more stringent requirements for unstable streams to energy inputs approximating forested conditions (§4VAC 50-60-66.A.3). The incentives to implement runoff reduction practices can also assist in efforts to more closely approximate the hydrology of predevelopment conditions. Reducing the volume, duration, and magnitude of flows will increase the probability of maintaining and improving biotic diversity in streams (NRC 2008). However, as the percentage of impervious cover increases in a watershed; the possibility that management efforts can restore biological conditions to pre-urban conditions in these watersheds is likely to diminish (Booth and Jackson 1997). Thus, the achievable stream restoration benefits (specifically aquatic diversity) may be small for new development or redevelopment in sub-watersheds with high percentages of impervious surfaces. The pro rata share provision of the regulation, however, offers some opportunities to redirect and target financial resources to other areas that have a higher probability to improve and maintain overall stream conditions.

It should be noted that many of the aquatic benefits from management of the runoff volumes generally accrue in relatively close geographic proximity to the stormwater control measures. Thus, the local citizens and governments incurring the higher stormwater control costs are also likely to be the same group of citizens that benefits most from these efforts.

Water quality benefits

While the proposed regulation focuses on nutrients (specifically phosphorus), many of the practices and strategies to control phosphorus will also lower the discharge of other pollutants associated with urban stormwater discharge. A number of chemical constituents are commonly found in stormwater runoff including a variety of heavy metals (zinc, copper, lead, chromium, etc), pathogens, suspended solids, oil/grease, and organics (BOD) that are commonly found in stormwater (Burton and Pitt 2002; Center for Watershed Protection 2003; Lee and Jones-Lee 2004; NRC 2008). It is reasonable to expect that the concentration of many of these contaminants increases with the level of urban activity (measured by population density, economic activity, or impervious surface). In sufficient quantities, these constituents can adversely impact aquatic life, human health, and possibly recreational activities. The proposed

regulations place new emphasis on runoff reduction and infiltration practices and can reasonably be expected to provide ancillary reductions of these other pollutants.

A significant analytical challenge in estimating the benefits of stormwater management is identifying the incremental improvement that can be achieved through the variety of stormwater controls. Tracing out this incremental impact requires identifying stormwater control practices used to control stormwater runoff, establishing the relationship between practices and pollutant removal, linking changes in pollutant loads to changes in water quality/quantity conditions, and then relating water quality and quantity conditions to physical and instream biological conditions of concern to people. For example a variety of studies have noted that people place a higher value on properties located along water bodies with improved water quality (Leggett et al 2000; Poor et al. 2001). However, these studies typically do not establish causal linkages between water quality and urban stormwater runoff. Conceptually, the value of stormwater management to water quality would require assessing the contribution of stormwater control practices to water quality improvements.

Water quality benefits from nutrient reductions

The proposed water quality criteria were established based on meeting Virginia's nutrient reduction requirements under the Chesapeake Bay Agreement. In 2000, Virginia along with the federal government and other Bay states signed the *Chesapeake 2000* Agreement. The agreement renewed commitments to lower nutrient and sediment loads to improve Bay water quality. Water quality standards were then established for different segments of the Chesapeake Bay and tributaries. The standards established criteria for dissolved oxygen and water clarity. Modeling conducted by Chesapeake Bay Program then analyzed the relationship between total nitrogen and phosphorus loads delivered to the Bay and the probability and frequency of attainment with water quality standards. The final annual load target agreed upon was 175 million pounds of nitrogen and 12.8 million pounds of phosphorus. At these load levels, the model estimated attainment with the dissolved oxygen criteria in most areas, but with some probability of occasional nonattainment (EPA 2003). As with any modeling of natural systems, uncertainty surrounds these estimated effects. Published estimates of the response to dissolved oxygen levels for incremental changes to the 175 and 12.8 million pound nitrogen and phosphorus load target could not be located.

Virginia's portion of this overall load target is 51.4 million pounds of nitrogen and 6 million pounds of phosphorus (delivered load to the Chesapeake Bay from all tributaries) (Chesapeake Bay Program Office 2008). Through the Virginia's Tributary Strategy planning process, plans were devised to achieve nutrient load targets. The plans (not part of a regulatory process) allocated nutrient load reduction targets to specific types of discharge sources (Virginia Secretary of Natural Resources 2005). Urban phosphorus loads from all urban land was estimated to be 1.86 million pounds in 2007. Of these pounds, the Chesapeake Bay Watershed Model estimates that 87% of the urban phosphorus load originates from pervious urban surfaces, with the remaining share of urban load from impervious surfaces. The state Tributary strategies aim to reduce urban loads to 1.04 million pounds (817,000 pound reduction from 2007).³³ While urban stormwater loads are not the largest source of nutrients to the Bay, as a group they are the only major class of sources where loads have increased over time (EPA 2007; Chesapeake Bay Program Office 2008).

The achievement of the Chesapeake Bay goals has been an important water quality goal for the state for over 20 years. The Chesapeake Bay makes numerous and fundamental contributions to the economy and the citizens of the Commonwealth. The Bay supports a variety of commercial and recreational fisheries. The benefits (measured primarily as the increased recreational benefits) from state and federal policy efforts through 1996 was estimated to be between \$360 million to \$1.8 billion (Morgan and Owen 2001). These benefits were confined only to recreational benefits and to those currently living within the Bay watershed.

³³ Chesapeake Bay Program Office. "Loads and Land Use Acreage" Excel Spreadsheet. Accessed on-line at <http://www.chesapeakebay.net/tribtools.htm#allocations>.

The contribution to those benefits from this proposed regulation could not be estimated. However, a crude estimate of the additional reductions that might be obtained beyond what is achieved under the existing regulations is possible. Beginning with the Chesapeake Bay Preservation Act areas, the new proposed stormwater water quality criteria would achieve additional (modeled) phosphorus reductions ranging from 0.15 to 0.45 lbs/ac/yr (see Figure 2 and Table 3). Land disturbance on new development would achieve reductions of 0.13 to 0.22 lbs/ac/yr.³⁴ Based on available evidence, slightly more than half of all disturbed acres in the state occur within the Chesapeake Bay Preservation Area. Assuming that 17,500 acres will be disturbed each year in the Chesapeake Bay watershed (estimated average land disturbance in CBPA area between 2005-2007) total phosphorus reductions achieved beyond the existing regulations would be 2,480 and 7,470 lbs/yr in the Chesapeake Bay Preservation Act areas. These estimates assume redevelopment acres range for 10 to 40% of total disturbed acres. The total site reductions achieved over the course of a decade would be between 27,300 and 411,000 lbs over what would be achieved under the existing regulation. These figures are changes in estimated loads leaving the development site but not delivered to the Chesapeake Bay. Phosphorus load reaching the Chesapeake Bay would need to be adjusted for fate and transport using attenuation ratios. Furthermore, it should be stressed that these estimates are *not* changes in phosphorus loads that stem from a change in land cover/use, but rather the additional reductions that could occur from more stringent water quality criteria.³⁵

While the water quality criteria in the proposed regulation were derived to meet Chesapeake Bay Tributary strategies, the same phosphorus criteria are proposed for the entire state. Watersheds outside the Bay include Chowan, Roanoke, New River, Holston, Clinch and Big Sandy. In general, these areas are less densely populated than the eastern portions of the Chesapeake Bay watershed and nutrient related contributions from urban runoff would be expected to be much smaller. Furthermore, many of these areas of Virginia do not yet face the same regional water quality issues related to nutrient enrichment as those found in the Chesapeake Bay. Establishing differential stormwater water quality criteria based on the differential local and regional benefits that could be achieved from additional nutrient reductions can improve the economic efficiency of the proposed regulation.³⁶

Watersheds beyond the Chesapeake Bay have yet to apply the same level of nutrient control requirements across a wide range of nutrient sources. If localized nutrient issues occur or are a possible water quality concern in these non-Bay watersheds, more cost effective and larger nutrient reductions could be achieved by securing reductions from sources other than incremental reductions from urban stormwater. Achieving additional phosphorus removal through the application of more stringent water quality criteria (effectively lowered from 0.45 lbs/ac to 0.28 lbs/ac) are achieved at estimated costs of \$900 to \$15,000 per pound of phosphorus (see Table 3). Agricultural and regulated point sources can achieve nutrient reductions at significantly lower unit costs. Given the relatively small scale of urban development in most parts of the non-Chesapeake Bay region, the more stringent phosphorus criteria would likely achieve modest phosphorus reductions relative to other sources. In areas where nutrient impairments may occur and are substantively related to urban development, a number of policy options already exist. For instance, urbanized areas regulated under the MS4 program may face different water quality concerns and apply different standards. In rural areas, local governments always have the option (and some incentive) to adopt programs and land use controls to protect any local water deemed to have special importance to the local economy (trout waters for instance).

The Virginia General Assembly has acted in ways that acknowledge the efficacy and fairness of differential nutrient control requirements across to the Commonwealth. Through the Chesapeake Bay

³⁴ Load changes based on procedures in DCR's compliance spreadsheet.

³⁵ The distinction is not trivial. The 0.28 standard for new development achieves additional reductions from what would be achieved under the existing regulation, but if the new development was built on land previously forest (P load rate 0.03lb/ac), the development would increase loadings to the Bay *regardless* of what water quality criteria is adopted (the issue the regulation addresses is how large the increase will be). Conversely, if the new development occurred on former agricultural cropland, the conversion to an urban use would likely lower total P loads from that area (the issue addressed by the proposed regulation is how large the decrease will be).

³⁶ This discussion mainly applies to the application of stormwater water *quality* criteria. The local benefits from the application of water *quantity* criteria would be unaffected by this discussion.

Preservation Act, the General Assembly required restrictions on land use (e.g. buffers) for only landowners in the 29 Tidewater counties. The Virginia General Assembly has imposed more stringent nitrogen and phosphorus requirements on municipal and industrial point sources located within the Bay watershed through the 2005 Chesapeake Bay Watershed Nutrient Credit Exchange Act §62.1-44.19). Through these actions the General Assembly has authorized and legitimized the appropriateness of more stringent nutrient controls for areas within the Chesapeake Bay watershed. Furthermore, the General Assembly has not stipulated that phosphorus water quality criteria established by the Board must be uniform across the state.

Implementing different stormwater water quality criteria across different watersheds would represent a minimal change in administrative costs. The stormwater design, evaluation, and permitting process would remain unchanged. The DCR stormwater compliance spreadsheet would require only minor changes. The type of stormwater practices offered and the design criteria of those practices would not need to be modified.

4. Projected cost of the regulation on local governments

The proposed regulation will require local governments to spend additional resources on administering stormwater control. The proposed regulation aims to extend federal authorization for administering the Virginia Stormwater Management Program General Permit for Discharges of Stormwater from construction activities (4VAC40-6-102) to local governments. The proposed regulation establishes standards and procedures of a locally administered stormwater management program. In delegated program areas, this proposed change will consolidate permitting of land disturbing activities into a single permitting process with the potential of streamlining the permitting process for regulated entities.

In general, local administration of a stormwater program involves a number of activities including:

- Stormwater BMP plan review and approval
- Stormwater BMP construction inspection
- Stormwater BMP record keeping/tracking
- General Permit coverage issuance
- General Permit enforcement
- Stormwater BMP long-term post-construction compliance monitoring & enforcement
- Receipt of permitting and program administration fees

This analysis below draws upon two data sources. First, DCR conducted a survey of local stormwater and erosion and sediment control programs in the summer of 2007. Thirty-three counties (more than a third of all counties) and 9 cities completed or partially completed the survey. Second, during the fall 2008, interviews were conducted with staff for 7 large stormwater programs within the Chesapeake Bay Preservation Act area (jurisdictions representing about a third of Virginia's total population).

The analysis identifies possible ways the proposed changes will impact program administration costs to state and local government. The expenditure of additional resources to implement the proposed changes represents a societal cost that is in addition to practices and actions associated with constructing and maintaining stormwater control practices. Any changes in program administration cost, however, must be distinguished conceptually from those who will pay the cost. Although program costs are expected to increase for state and local governments in ways described below, the proposed fee structure will mean that a portion of those costs will be paid by the regulated community.

Based on available information, most localities with stormwater management programs rely primarily on conventional stormwater control practices (e.g. extended detention basins and wetponds) to meet existing water quality and quantity criteria. These conventional practices can also be used to capture and treat runoff from a larger land area. Some local governments have expressed concern that the emphasis on runoff reduction and the more stringent water quality criteria will increase the use or need of less conventional and smaller scale stormwater control practices. The expected change in the number and

composition of stormwater BMPs is expected to increase local government administration costs in several ways. During interviews, some local stormwater managers estimated that five to ten smaller scale stormwater BMPs may be needed to treat a given land disturbance that would have been treated with a single conventional best management practice under the existing regulations. The increase in the number and type of BMPs needed to treat any given acre of disturbed land may increase local stormwater program administration costs.

Stormwater plan review costs are expected to increase. Plan review will require more hours and perhaps the acquisition of additional expertise or training of existing personnel as the complexity of stormwater designs increase. Depending on the complexity of the smaller scale distributed infiltration and filtration BMPs, construction inspection costs may increase. First, localities may not have expertise to inspect for the proper installation of practices such as green roofs, porous pavement, and practices that require subsurface infiltration and drainage structures. Some local programs have suggested that they may need to either hire additional expertise or contract out for inspections for certain types of practices. DCR also plans to offer certification and training programs designed to provide training necessary to appropriately assess these practices. Similar to some conventional stormwater controls, additional inspections may be required during construction for some practices – for example infiltration and filtration practices currently available for use that require subsurface drains and specific soil mixes that should be inspected during construction. Finally, use or reliance on smaller scale BMPs (often collectively referred to as LID) increases the number of facilities needed to treat a given land development, thus increasing the number of inspections and the related costs.

An effective stormwater program also requires a system to inventory and track BMPs, long-term compliance monitoring (inspection), and enforcement against noncompliance. Such a system is essential to ensure that practices continue to provide water quality and quantity control services over time. A long-term compliance system requires developing a BMP tracking system, system of inspection, administration and follow-up for violations, and initiation of enforcement actions if deficiencies and violations are not corrected. Recent reports conclude that a major challenge confronting stormwater programs across the United States is inadequate plans and resources to ensure the long-term maintenance of stormwater infrastructure (GAO 2007; NRC 2008).

A long-term inspection and compliance program is typically the last programmatic phase to be developed in most stormwater management programs. In fact, many localities interviewed indicated that many long-term inspection/compliance programs have just recently been actively implemented. The inspection programs include efforts to identify and cooperatively correct any observed deficiencies or violations of maintenance agreements. Active enforcement in terms of pursuing legal remedies against persistent instances of noncompliance has not been confronted for many active stormwater programs. Some general estimates of stormwater annual inspection and enforcement costs provided by local program administrators range from \$100 to \$500 per stormwater practice. Based on limited evidence from stormwater programs, approximately 1 full time staff equivalent is required for long-term inspection/compliance for every 400 to 450 stormwater practices in the local stormwater inventory (assuming inspections occur every 1 to 2 years).³⁷ Given that the number of practices needed to treat any given area may increase significantly, long-term compliance and enforcement costs will be expected to increase as the rate of new stormwater BMPs added to the existing stormwater inventory increases. The stormwater infrastructure inventory represents a long-term regulatory responsibility and growing cost obligation to local stormwater programs. The new emphasis on run-off reduction, however, may offset some of these costs because of avoided future administration and remediation costs from local drainage problems.

Proposed regulations, however, offer opportunities to manage these additional costs of a long-term inspection and maintenance program. The proposed regulation requires local stormwater programs to develop an inspection program. The inspection program, however, includes a priority system that would allow a locality to target inspections (frequency, type, etc.) based on a number of factors including the

³⁷ Based on limited evidence, local stormwater programs in Virginia average about 400 to 450 stormwater BMPs per 100,000 people under the existing regulation.

type of stormwater practice, contributing drainage area, and downstream conditions (4VAC50-60-114D). In concept such a priority system could target inspection in relation to the relative contribution of any given practice to water quality improvement or the probability of failure. DCR is also considering developing a stormwater practice tracking and reporting system that could help reduce inspection administration costs.

Local stormwater programs can also rely on the private sector to carry out some of the inspection activities. Private inspections are allowed if conducted by a licensed professional and paid for by the owner of the stormwater facility (4VAC 50-60-114C and 114.D4) and in accordance with the inspection schedule outlined in the stormwater facility maintenance agreement (4VAC50-60-124). Although such provisions do not avoid the social cost of inspections, it does allow the local stormwater program to shift some inspection costs to the private sector.³⁸

Local government programs might face higher long-term costs associated with maintaining BMPs. The proposed regulations encourage the assignment of long-term maintenance costs to private landowners. The regulation states that the responsibility for long-term operation and maintenance of stormwater facilities shall remain with property owner or other legally established entity, unless assumed by a government agency (4VAC50-60-124). In many local programs, however, the responsibility of long-term maintenance is frequently assumed or partially assumed, particularly in residential areas, by the local government. Often the landowner or homeowner association will assume responsibility for routine maintenance while the local program will assume responsibility for major retrofits and repairs. Local programs will elect to assume partial responsibility for some types of stormwater practices in some situations because of a perceived inability of the private landowner to effectively carry out the long-term maintenance requirements (Ruppert and Clark).³⁹ Furthermore, as the number of stormwater BMPs proliferate, particularly in residential developments, the probability that some responsible parties will not have the financial means to maintain the BMPs increases. In cases where the legally responsible party does not have the financial ability to pay for maintenance or BMP repair, the local government may face the choice of whether to let the practice fail or assume the long-term cost obligation itself. The precise magnitude of the increase, however, is uncertain since most local programs have limited long-term experience with the maintenance and performance of nonconventional best management practices (the relatively few number of nontraditional practices implemented have been done so only recently) and it is unclear how prevalent the sharing of maintenance responsibility will be.

Some of the proposed stormwater management practices may also present unique monitoring and enforcement challenges. For example, rain gardens, porous driveways, cisterns, green roofs, grass swales, and some types of land use easements (to preserve forest cover for example) are distributed small scale stormwater treatment options that may be located on individual residential properties. The proposed regulations require local stormwater programs to require right-of-entry agreements or easements from the property owner for purposes of inspection and maintenance (4VAC50-60-124C). Placing BMPs on individual parcels, however, can result in management challenges because residents are often unaware of the maintenance requirements or obligations for practices on their property (Ruppert and Clark 2008). Furthermore, local governments may be reluctant to require small scale practices due to privacy and political expediency concerns, particularly in residential situations (Ruppert and Clark 2008). Consequently, local stormwater management programs in Virginia often prohibit or restrict the use of stormwater practices on individual residential lots.

In addition, verifying compliance may be difficult for some nonconventional stormwater control practices listed in the regulation. Most compliance inspections are done through visual inspection. Maintenance of conventional systems, such as ponds, can be done through checks of trash/sediment and, periodically,

³⁸ The use of private third party contractors, however, would also require a separate set of oversight costs. The use of private inspectors to verify performance create incentive compatibility issues because neither the private inspector or the regulated party have an inherent interest in the public's interest in maintaining BMP performance (Ruppert and Clark 2008). The private inspector has a primary interest in paying clients and the client has an interest in a quick and favorable inspection. Thus, private inspections still require cost to certify and spot check private inspectors.

³⁹ The proposed stormwater revisions also allow local governments to conduct necessary repairs or maintenance on negligent stormwater facility owners and then recover the costs from the owner (4VAC50-60-124A).

dam structure. The performance of many nonconventional practices (some practices referred collectively as LID) can be more difficult to verify (Ruppert and Clark 2008). For example porous pavement requires scheduled vacuuming/sweeping to prevent fine particles from decreasing water infiltration. Cisterns require active draw-downs after storm events in order to maintain runoff reduction capacity. Such behavioral actions necessary for maintenance are more challenging to verify. The proper functioning of infiltration or filtering practices may be more difficult to verify except during storm events.

Given the implementation costs and challenges noted above, local stormwater programs may have legitimate reasons for limiting the use of some types of stormwater treatment practices in their jurisdiction. For example, small scale distributed practices may be discouraged by local governments out of legitimate concerns about the public acceptability, long-term cost obligations, or out of concerns of documenting/maintaining performance over time. Restricting BMP options available for land disturbers, however, may make compliance more difficult and costly. Given the stringency of the proposed stormwater quality criteria, it is unclear whether conventional treatment options alone can achieve compliance in some circumstances. Thus, local stormwater programs may face a trade-off between private compliance costs and local government implementation cost. Limiting the number of stormwater practices that can be used to achieve compliance may reduce local government implementation costs but increase private stormwater compliance costs because some lower-cost stormwater control options have been eliminated. If the local program fails to offer enough control options, land developers may find it more difficult to achieve compliance on-site.

4a. Existing Local Stormwater Programs: Program Administration Costs

All counties and cities covered by the Chesapeake Bay Preservation Act (29 counties, 17 cities, and 38 towns) and counties and cities covered by MS4 permits are required by statute to administer a local stormwater management program. Non-CBPA localities required to operate delegated stormwater programs include the cities of Bristol, Charlottesville, Danville, Harrisonburg, Lynchburg, Roanoke, Salem, Winchester, and Christiansburg/Blacksburg area and the counties (partial or total) of Albemarle, Botetourt, Roanoke and Loudoun. These areas represent approximately three quarters of the state population and cover roughly the same percentage of all disturbed acres (2005 to 2007).

The cost to these jurisdictions to implement the new regulations is subject to considerable uncertainty for reasons highlighted above. Most local governments interviewed were reluctant or unable to provide an estimate of the amount of new resources needed for implementation. All agreed that additional staffing and budgetary resources would be necessary.⁴⁰ The challenge of estimating future costs are compounded by the fact that many localities felt that additional resources were needed to adequately implement *existing* stormwater and erosion and sediment control programs. For example, the 2007 DCR survey found that less than half of local stormwater programs had adequate staffing to implement *existing* stormwater requirements. In addition, staff and budgetary resources for erosion and sediment control, zoning, and public work functions are often shared with stormwater management programs, thus making it challenging to isolate costs attributable to just stormwater management. The overlapping responsibilities of program implementation (E&S, stormwater, public works) and the challenge of separating costs across existing and new proposed activities further complicate estimating the increase in costs associated with proposed regulation.

Either through the interview process or the DCR survey, eleven local stormwater programs provided an estimate of the increase in costs or staff needed to comply with the proposed regulations. These programs represented almost one fourth of all disturbed acres in the set of localities identified above. These localities estimated 31 to 41 additional staff in total would be needed to administer the proposed regulation. Three localities provided a minimum estimate of additional staffing needs (e.g. "need at least 2 additional staff"). A rough estimate of the incremental staffing costs for these 11 localities would be between \$2.6 and \$3.4 million per year.⁴¹ Assuming the remaining localities with existing stormwater programs would have to increase in the roughly the same proportion as this sample, total estimated local

⁴⁰ These additional costs would be fully or partially covered by new stormwater fees.

⁴¹ Assumes full time equivalent staff paid at \$36/hour (wage + fringe) plus 10% overhead costs.

government staffing costs may be between \$10.6 and \$14.2 million per year.⁴² These totals exclude increases in long-term maintenance and repair costs that may be assumed by the local programs as a result of the implementation of the proposed regulation. These cost estimates do not include additional educational and technical materials that must be developed to successfully implement the new program (discussed below). Finally, these costs also exclude the annual increase in inspection, tracking, and enforcement costs that will occur as the stormwater infrastructure inventory grows.

4b. Administration of Local Stormwater Programs in Areas without Existing Stormwater Program

The proposed regulation would also require all areas outside the Chesapeake Bay Preservation Act and MS4 programs to comply with the proposed revisions to the regulation. These localities have the option for DCR to administer the stormwater program or applying to assume responsibility for local program administration. These localities include the remaining 62 counties as well as 12 independent cities.⁴³ Towns in these counties also have the option to develop their own program. While representing almost two-thirds of the land area in the state, less than one quarter of the citizens live in these areas. An estimated one quarter of all land disturbed acres in the state between 2005 and 2007 were located here.

It is uncertain what percentage of these local governments will elect to administer a stormwater program. Most of these local governments currently only administer erosion and sediment control programs. Furthermore, state and local programs are struggling to adequately implement the existing E&S program. Of the twenty counties and independent cities responding to DCR's 2007 stormwater survey, only 15% indicated they had sufficient staff resources to administer the existing erosion and sediment control programs. Given the limited existing resources for E&S implementation and almost no experience with stormwater programming, the expectation is that DCR will initially administer the majority of these programs. Regardless of administrative agency, the stormwater programs in these areas will need to be built up from a minimal programmatic foundation.

For purposes of this analysis, it will be assumed that the cost to implement local stormwater management programs in these areas will be incurred (at least initially) by DCR (see next section). To the extent local governments in these areas assume responsibility for program administration, estimates of local government costs can be derived from the discussion in Section II.5a.

5. Projected cost to the state to implement and enforce the proposed regulation

5a. DCR Administration of Local Stormwater Programs in Nondelegated Areas

For purposes of this analysis, it is assumed that DCR will administer local stormwater programs in 62 counties (and towns within) and 12 independent cities. These local governments do not currently administer a local stormwater program and are not required to assume this responsibility. The activities DCR must implement in the administration of these programs are the same as described in section 4.

Estimates of the cost to administer these local stormwater programs are derived using two data sources. First, DCR provided an estimate of the staffing requirements and administrative costs. Second, program staffing in the nondelegated areas was estimated based on the current staffing requirements from operating local stormwater programs in Virginia. Staffing requirements for a sample of existing local stormwater programs was obtained from the 2007 DCR survey of local stormwater programs. Coupled within information on disturbed acres, these staffing estimates could be expressed as stormwater staff requirements per unit of disturbed acres and applied to the nondelegated area.

⁴² These represent estimates of the increase in social cost. How these costs are shared between local government programs and the private sector (who pays) depends on the amount of stormwater fees collected. See the discussion of fees (pages 22-24) for estimates of total fee revenue.

⁴³ Includes all counties outside the CBPA and without a MS4 program and the cities of Bedford, Buena Vista, Covington, Emporia, Franklin, Galax, Lexington, Martinsville, Norton, Radford, Staunton, and Waynesboro.

DCR originally estimated that 24 full time staff would be required to administer the local stormwater program in nondelegated areas (it should be noted that this estimate was based on the issuance of 3,000 permits per year and DCR plans to revise their staffing needs and costs upon finalization of their revised permit computations). Including administrative expenses and staffing costs, DCR initially estimated the total cost to pay and support this staff would be \$1.962 million.⁴⁴ It should be stressed that this cost estimate does not represent the incremental cost of the proposed regulation. Some of these staff resources are also required to administer the existing regulations. Thus, the incremental cost to administer the proposed regulatory revisions is some portion of these costs.

Another estimate of local stormwater staffing requirements for these nondelegated areas was made based on the staffing requirements of existing local stormwater programs. Stormwater program staff estimates for 12 local stormwater programs were obtained primarily from the 2007 DCR survey. Based on DCR estimates of disturbed acres, these 12 stormwater programs administer approximately the same number disturbed acres as the total area DCR is expected to administer (62 counties, 12 independent cities). The 12 local programs estimated that approximately 27 full time staff are devoted to stormwater management activities, but need an additional 13.5 staff to fully implement the existing regulation. Using these estimates of the staffing needs from existing local stormwater programs, then DCR may need between 27 and 40.5 full time staff to implement stormwater programs in nondelegated areas at a cost ranging from \$2.2 to \$3.3 million. The lower estimate is similar to the initial staff estimate calculated by DCR. Such calculations will be revised by DCR.

Several caveats are necessary. The staff estimate based on the staff of existing stormwater programs might be viewed as an underestimate because local programs also indicate the need for additional resources to implement the proposed regulations (see Section 4a above). DCR, however, may be able to achieve some administrative economies of scale by consolidating administrative activities across larger geographic regions in their regional offices.

5b. DCR oversight costs⁴⁵

Under program oversight, DCR will be responsible for the auditing of all local programs on a periodic cycle to insure compliance. A large initial workload will exist in program development including DCR support of the development and review of local program submittals to the Virginia Soil and Water Conservation Board. Associated program development issues will shift through time, but remain indefinitely. Other technical assistance will include supporting local plan review, oversight inspections, and BMP questions. Further, DCR will be required to respond to complaints not resolved at the local level and will need to address issues related to permit issuance and fee accounting. In addition, DCR will develop and maintain the BMP Clearinghouse and the enterprise website and maintain the stormwater management handbook. DCR's initial estimates of staffing needs and computations are based on the issuance of 3,000 permits per year and are subject to revision upon finalization of the permit computations. Initial calculations were as follows:

- 30 FTE x current average salary and benefits of \$35.46/hr x 2080 hrs/yr = \$2,212,704
- 30 FTE x \$8,000 for administrative expenses including rent, utilities, computers, training, travel, printing expenses, etc. = \$240,000
- Annual contract costs associated with enterprise website and BMP Clearinghouse = \$200,000
- Training costs, \$250,000/yr
- Minimum total annual cost = \$2,902,704

It should be recognized that the estimated program oversight cost of \$2.903 million is not an estimate of the new costs required to meet the proposed revisions to the stormwater regulation. A number of the

⁴⁴ Assumes hourly salary and benefit rate of \$35.46/hr and \$8,000 in administrative expenses (overhead, travel, etc) per staff position.

⁴⁵ This section draws text and estimates directly from "Discussion Document on Department Fees" (pp. 3-6), Virginia Department of Conservation and Recreation (September 8, 2008).

staff included in the estimate above (including those needed for oversight and program administration collectively) are already on staff at DCR and do not represent new positions. A detailed explanation of DCR oversight activities for the stormwater management program is as follows:

Program Audits – 4FTE

DCR staff will conduct program audits on all local and DCR administered stormwater management programs. The audits will evaluate compliance with the Stormwater Management Act and attendant regulations. The audit will evaluate the following:

- Local program ordinance and procedures
- Stormwater plan reviews
- Inspections of active projects
- Inspections of completed projects and associated stormwater BMPs
- Compliance and enforcement efforts
- Complaint responses
- General Permit coverage

A 3-year review cycle would utilize two 2-member teams. The review effort will be as follows:

- 3-year cycle – 60 programs reviewed per year
- Each team to review 30 programs per year
- Time for one program review – 1 week
- Time for one program Corrective Action plan and Technical Assistance for program development – 0.5 week

Program Audit Staffing need = 4 FTE

Program Technical Assistance – 5FTE

DCR staff will provide technical assistance to local programs regarding plan reviews, inspections, BMPs, and interpretations of the Stormwater Management Act and attendant regulations. DCR staff presently provide this assistance in the ESC Program and staff records indicate an average assistance to each program of 6 days per year. DCR field staff or contractors implementing the program locally will need equivalent support.

179 programs x 6 days = 1074 days x 8 hrs/day = 8,592 hrs

Staff estimate for technical assistance = 8,592 hrs / 1,832 hrs/staff = 4.7

Program Technical Assistance support need = 5 FTE

Complaint Resolution by DCR – 3FTE

DCR staff will respond to complaints regarding stormwater management issues that are not resolved satisfactorily by the locally run programs and in support of regional DCR implementing staff. Based on DCR staff records, approximately 212 complaints are received annually. Time estimates for complaint response varies from 1 day to several weeks. The average time for complaint resolution is approximately 3 days.

Complaint Response – time/staff estimates:

212 complaints x 3 days/complaint = 636 days x 8 hrs/day = 5,088 hrs

Staff estimate for complaints = 5,088 hrs / 1,832 hrs/staff = 2.8 Staff

Program Complaint Resolution Assistance support need = 3 FTE

DCR Program Coordination and Development by DCR – 12FTE

For DCR run local programs, DCR staff will spend considerable time and effort in coordinating with localities and in ensuring the proper integration of the DCR run stormwater management program with the locality's related permitting programs. Staff will have to meet regularly with local staff to properly integrate project submissions, reviews, approvals, and permitting. Also, there is the initial workload associated with assisting localities in preparation of their program submittals for the Virginia Soil and Water Conservation Board and then on-going to assist with corrective actions following program reviews, etc.

73 DCR-run programs x 3 weeks/locality = 219 weeks x 40 hrs/week = 8,760 hrs
106 local-run programs x 1.5 weeks/locality = 159 weeks x 40 hrs/week = 6,360 hrs

Staff estimate for program coordination = 15,120 hrs / 1,832 hrs/staff = 8.3 Staff

Program management, EPA coordination, record oversight, permit tracking, reporting, regulatory coordination, and financial management = 4 Staff

Program Coordination and Development support need = 12 FTE

DCR Enforcement Actions – 4FTE

DCR may become involved in enforcement where compliance is not achieved at the local level. The majority of enforcement actions are successful in their initial stages. However, some compliance issues are not resolved locally and require more significant enforcement responses in order to achieve compliance or extract penalties.

If we assume that 3,000 permits will be issued annually and that the occasional significant enforcement actions equate to an average of 2.5 hours per permit issued, then enforcement time will require 7,500 staff hours per year or 4.1 staff.

Program Enforcement Action support needs = 4 FTE

Enterprise Website – 1FTE

DCR will develop and implement an enterprise website related to the implementation and tracking of the consolidated stormwater management program. The enterprise site will allow for online payment of fees, distribution of the fees paid to localities and DCR, general permit issuance and program reporting. After the initial development and testing costs, DCR will have costs associated with the operation and maintenance of the enterprise site. These operation and maintenance costs are expected to total \$100,000 per year to cover annual server and network costs.

Enterprise Website support needs = 1 FTE plus annual server and network costs

BMP Clearinghouse and Website – 1FTE

DCR will develop and oversee a BMP Clearinghouse and website to provide up-to-date information related to stormwater management practices and program guidance. The clearinghouse will require development and maintenance contracts with the Virginia Water Resources center at Virginia Tech. The anticipated costs associated with the oversight and maintenance of the clearinghouse is approximately \$100,000 per year.

BMP Clearinghouse and Website support needs = 1 FTE plus annual contract costs

Training and Certification Costs

DCR will face significant transition costs in implementing these regulations. More than half of all local governments and local developers across the Commonwealth have little or no experience or expertise in stormwater management. For local programs with stormwater programs, the state is also introducing new

compliance tools and the regulations encourage a variety of stormwater practices which many local programs have not yet (to date) promoted or have little experience with reviewing design specifications or inspecting. This transition will require investments by DCR in stormwater program education and dissemination of technical information. A certification program will be required for locality and DCR staff. DCR expects that the development and implementation of the training program will cost approximately \$250,000 per year.

5c. Local Program Costs and Fee Revenues

DCR expects to pay for the majority of state stormwater program operating costs (oversight as well as operating local programs) with permit fee revenue (Table 6). These fees are based on the number permits managed each year by DCR or by the designated local stormwater programs. Fee revenue would appear sufficient to pay for the majority or all of the incremental program administration costs in an “average” or typical year. Yet, program revenue will be largely dependent on the level of economic activity in the construction industry. Furthermore, fee revenue would be expected to show more variation over the business cycle than other revenue sources (e.g. general tax revenues or general stormwater utility fees). For example, consider housing starts as one proxy measure for the possible variation in fee revenue (see Figure 1). The historical record shows that housing starts can change dramatically around the business cycle. For instance, 2 to 3 years during an economic recovery, housing starts can more than double in number. The downside risk is similar in magnitude. Between 1989 and 1992 housing starts fell by half. Similar or greater drops were experienced in the early 1980s. The extent to which housing starts and construction activity will drop in the current recession is yet to be seen. Assuming building permits track closely with stormwater permit applications in terms of relative volatility, such data give a sense of the relative magnitude of revenue variability that could be faced by the state stormwater program.

Some program costs (program oversight costs, long-term inspection/enforcement, maintenance costs) must be incurred annually, and are mostly independent of the level of current development activity. Given that DCR and local program activities under this proposed rule face a highly variable revenue source, DCR and local governments should develop clear plans to manage its variable revenue stream in a way that does not disrupt monitoring and enforcement of these regulations.

5d. VDOT compliance activities and costs

The cost of road construction will increase as a result of the proposed regulation. While costs will increase, a total annual estimate of the increased cost to comply with the proposed standards, however, could not be estimated at this time. Between 2005 and 2007, Virginia Department of Transportation road construction projects obtained permits to cover slightly more than 1,000 disturbed acres per year for the state.

The proposed regulation will increase both road construction and post construction maintenance costs. The redevelopment water quality criteria would apply for road construction and improvement projects to existing roads. New road or major expansions of existing roads will likely be subject to the proposed 0.28lb/ac phosphorus water quality standard. Under current regulations, the vast majority of stormwater control structures constructed for road projects are extended dry detention basins. To achieve compliance with the new water quality criteria will require greater reliance on filtration and infiltration types of BMPs. As noted in the cost discussion above, such practices are often more costly to both construct and maintain. Furthermore, new road construction will likely require wider right-of-ways in order to install stormwater control practices, thus increasing land acquisition costs.

VDOT expects achieving the redevelopment water quality criteria for projects located in urban areas and rural secondary roads will be more technically challenging and costly than for new road projects. Urban areas and rural secondary roads typically have narrow right-of-ways. Urban streets may face additional challenges to treating water in high percentages of impervious surface and curb-and-guttered streets. All limit the suitable land areas for treating stormwater runoff. In many cases, VDOT expects to rely on some off-site controls to achieve compliance.

6. Summary

The proposed revisions to Virginia stormwater regulations will likely produce improvements in the condition of receiving waters. The new emphasis on reducing runoff volumes can produce important benefits related to the condition of aquatic habitat by reducing the energy pulses produced during storm events. New water quantity control requirements also provide benefits in terms of additional flood protection and instream aquatic protection. Acknowledging and accounting for the runoff reduction potential of many types of stormwater control practices will increase compliance options and increase the effectiveness of state stormwater regulations.

The proposed regulatory revisions also impose more stringent stormwater water quality criteria. The proposed stormwater regulatory revisions will produce additional reductions in phosphorus and other effluent loads produced from urban land conversion (land use change to impervious cover and turf). Achieving additional improvements in the quality of stormwater will impose new costs on land development activities. In development case examples, the new water quality and quantity standards could be achieved on the development site. The cost of incremental reductions in nutrient loads from the application of stormwater controls, however, is high relative to other nutrient removal options. Uncertainties exist over the long-term cost and effectiveness of many stormwater control practices. The cost of achieving additional nutrient reductions in highly urban settings and other areas with site specific constraints is still uncertain but potentially high. The off-site and pro-rata provisions in the regulation offer opportunities to lower costs and enhance benefits to affected watersheds if properly implemented. The total incremental costs to the state of implementing additional stormwater control practices to meet the proposed regulatory changes could not be estimated at this time.

The proposed revisions apply the same water quality and quantity criteria across the entire state. New proposed stormwater water quality criteria was based on estimates of the nutrient reductions needed to achieve reductions called for in the Chesapeake Bay Tributary Strategies. Economic efficiency of the proposed regulation could be improved by applying differential water quality criteria in watersheds across the state based on the relative water quality benefits that can be achieved.

The proposed regulation will produce improvements in the stormwater permitting structure and will strengthen the administrative tools localities need to implement stormwater programs. While the proposed changes will increase the number and type of control practices that can be used, these changes will also increase the sophistication and resources needed for stormwater design and program administration. The greater expected use of smaller scale distributed practices could increase the costs of local stormwater management, particularly in terms of ensuring the long-term maintenance and performance of stormwater control practices over time. The local and state government cost to administer local stormwater programs will increase (rough estimates range between \$13 and \$17.5 million, but estimates are not final). State agency cost (DCR) for overall program administration will be a minimum of \$3 million per year (estimates are not yet final). These costs are expected to be partially to fully covered by additional fees imposed on land disturbing permit applicants.

References:

- Aultman, Stephen. 2007. *Analyzing Cost Implications of Water Quality Trading Provisions: Lessons from the Virginia Nutrient Credit Exchange Act*. M.S. Thesis, Department of Agricultural and Applied Economics, Virginia Tech.
- Braden, J.B. and D. M. Johnson. 2004. "Downstream Economic Benefits from Stormwater Management" *Journal of Water Resources Planning and Management* Nov/Dec: 498-505.
- Brown, W., and T. Schuler. 1997. *The Economics of Stormwater BMPs in the Mid-Atlantic Region*. Ellicott City, MD: Center for Watershed Protection.
- Booth, D. B., and C. R. Jackson. 1997. "Urbanization of aquatic systems—degradation thresholds, stormwater detention, and the limits of mitigation". *Water Resources Bulletin* 33:077–1090.
- Bosch, D.J., V.K. Lohani, R.L. Dymond, D.F. Kibler, and K. Stephenson. 2003. "Hydrological and Fiscal Impacts of Residential Development: Virginia Case Study." *Journal of Water Resources Planning and Management* 129 (March/April): 107-114.
- Burton, G. A. Jr. and Pitt, R. E. 2002. *Stormwater Effects Handbook: A Toolbox for Watershed Managers, Scientists and Engineers*. Lewis Publishers, Boca Raton, FL.
- Center for Watershed Protection 2003. "Impacts of Impervious Cover on Aquatic Systems" Watershed Protection Research Monograph No. 1, Ellicott City, MD.
- Center for Watershed Protection. 2000a. "Introduction to better site design". *Watershed Protection Techniques* 3(2): 623-632.
- Chesapeake Bay Commission. 2004. *Cost Effective Strategies for the Bay: Six Smart Investments for Nutrient and Sediment Reduction*. Online at: http://www.chesbay.state.va.us/Cost_Reports.htm
- Chesapeake Bay Program Office. "Table 2. Chesapeake Bay Watershed Nitrogen, Phosphorus and Sediment Cap Load Allocations by Jurisdiction." Accessed online at: <http://www.chesapeakebay.net/tribtools.htm#allocations>
- Chesapeake Bay Program Office. 2008. "Reducing Pollution" Online at: http://www.chesapeakebay.net/status_reducingpollution.aspx?menuitem=19691
- Cheshire, P., and S. Sheppard. 1995. On the price of land and the value of amenities. *Economica* 62: 247-267.
- Cable, Ad. 2008. Project Aims to Produce Bio-fuel while Cleaning up the Bay" *Lancaster Online.com* <http://articles.lancasteronline.com/local/4/230602>
- Davies, S. P., and S. K. Jackson. 2006. "The biological condition gradient: A descriptive model for interpreting change in aquatic ecosystems". *Ecological Applications* 16(4):1251–1266
- Environmental Protection Agency. "Urbanized Area Maps for Virginia". Accessed Online, September 8, 2008 at <http://cfpub.epa.gov/npdes/stormwater/urbanmapresult.cfm?state=VA>
- Environmental Protection Agency (EPA). 1999. *Preliminary Data Summary of Urban Stormwater Best Management Practices*. Office of Water. EPA-821-R-99-012. Washington DC: EPA.
- Environmental Protection Agency. 2000. "Social costs in guidelines for preparing economic analysis." Publication 240 R-00-003. Washington DC: EPA.

Environmental Protection Agency. October 2003. *Technical Support Document for Identification of Chesapeake Bay Designated Use and Attainability*. EPA 903-R-03-004, EPA Region III and Chesapeake Bay Program Office.

Environmental Protection Agency. 2006. *Protection Water Resources with High-Density Development*. EPA 231-R06-001. Washington DC.

Environmental Protection Agency. 2007. *Development Growth Outpacing Progress in Watershed Efforts to Restore the Chesapeake Bay*. Office of the Inspector General. Report No. 2007-P-00031. Washington DC.

Environmental Protection Agency. 2007b. *Reducing Stormwater Costs Through Low Impact Development (LID) Strategies and Practices*. EPA 841-F-07-006. Washington DC.

Fina, M., and L. Shabman. 1999. "Some unconventional thoughts on sprawl." *William and Mary Environmental Law Review* 23 (3): 739-775.

General Accounting Office (GAO). 2007. *Further Implementation and Better Cost Data Needed to Determine Impact of EPA's Storm Water Program on Communities*. GAO-07-479.

Hager, M. C. 2003. "Low impact development: lot-level approaches to stormwater management are gaining ground." *Stormwater* (Jan-Feb 2003).

Herr, J.L. and H.H. Harper. "Reducing Nonpoint Source Pollutant Loads to Tampa Bay Using Chemical Treatment." Proceedings of the Water Environment Federation WEFTEC 2000. pp.633-653. Abstract online at: <http://www.ingentaconnect.com/content/wef/wefproc/2000/00002000/00000014/art00042>

Hoyt, S., and T. Brown. 2005. "Stormwater pond and wetland maintenance concerns and solutions." Paper presented at the EWRI 2005: Impacts of Global Climate Change Conference, American Society of Civil Engineers, Anchorage, Alaska, May 15-19.

Hunt, W.F. and B. Lord. 2005. "Bioretention Performance, Design, Construction, and Maintenance." *Urban Waterways*. North Carolina Cooperative Extension Service. AG-588-05.

Hunt, W. F., and B. Lord. 2006. *Maintenance of stormwater wetlands and wet ponds*. North Carolina Cooperative Extension Service AGW-588-07

Hunt, W.F. and L.L. Szpir. 2006 "Permeable Pavements, Green Roofs, and Cisterns" *Urban Waterways*. North Carolina Cooperative Extension Service. AG-588.06.

Hunt, W. F., W. G. Lord, and J. T. Smith. 2005. "Determining BMP inspection and maintenance costs of structural BMPs in North Carolina." Paper presented at the EWRI 2005: Impacts of Global Climate Change Conference, American Society of Civil Engineers, Anchorage, Alaska, May 15-19.

Hydromentia. July 2005. *Single Stage Algal Turf Scrubber Present Worth Cost and By-Product Market Analysis*. Final report to South Florida Water Management District.

Johnston, D.M, J.B. Braden, and T.H. Price. 2006. "Downstream Economic Benefits of Conservation Development." *Journal of Water Resources Planning and Management*. Jan/Feb: 35-43.

Kopits, E., V. McConnell, and M. Walls. 2007. "The Trade Off Between Private Lots and Public Open Space in Subdivisions at the Urban-Rural Fringe." *American Journal of Agricultural Economics* 89 (5).

Lambe, L., M. Barrett, B. Woods-Ballard, R. Kellagher, P. Martin, C. Jefferies, and M. Hollon. 2005. *Performance and Whole Life Costs of Best Management Practices and Sustainable Urban Drainage Systems*. Water Environment Research Foundation, Publication 01-CTS-21T, Alexandria VA: WERF.

- Lemoine, R. 2007. "An Evaluation of the Reduced Environmental Impact From High Density Development." *Stormwater* (October). Online at: http://www.stormcon.com/sw0710_evaluation.html
- Lee, G. F. and A. Jones-Lee. 2004. "Urban Creek and Lake Water Quality Issues." *Stormwater Runoff Water Quality Science/Engineering Newsletter*. Volume 7, No.6. August 6.
- Leggett, C. G., et al. 2000. "Evidence of the effects of water quality on residential land prices." *J. Environmental Economics and Management* (39)2: 121–144.
- MacMullan, E. and S. Reich. 2007. *The Economics of Low-Impact Development: A Literature Review* ECONorthwest, Eugene Oregon
- Maxted, J. R., and E. Shaver. 1997. "The use of retention basins to mitigate stormwater impacts on aquatic life." pp. 494-512. *Effects of Watershed Development and Management on Aquatic Ecosystems*. L. A. Roesner (Ed.). New York: American Society of Civil Engineer.
- Mohamed, R. "The Economics of Conservation Subdivisions: Price Premiums, Improvement Costs, and Absorption Rates." *Urban Affairs Review* 41(Jan)3: 376-399.
- Morgan, C. and N. Owens. 2001. "Benefits of water quality policies: the Chesapeake Bay", *Ecological Economics* (39)2: 271-284.
- National Research Council (NRC). 2008. *Urban Stormwater Management in the United States*. National Academies Press, Washington D.C.
- Poor, P. J., K. J. Boyle, L.O. Taylor, R. Bouchard. "Water Clarity in Hedonic Value Models" *Land Economics*, (77)4: 482-493.
- Randolph, J., A.C. Nelson, J.M. Schilling, J. Logan, M. Nowak, and J.M. McElfish. 2007. *Effects of Environmental Regulatory Systems on Housing Affordability*. Report prepared for U.S. Department of Housing and Urban Development, Washington DC.
- Roesner, L. A., B. P. Bledsoe, and R. W. Brashear. 2001. "Are best-management-practice criteria really environmentally friendly?" *Journal of Water Resources Planning and Management* 127(3):150-154.
- Ruppert, T. and M. Clark. 2008. "Understanding and Overcoming Legal and Administrative Barriers to LID: A Florida Case Study." Paper presented at ASCE EWRI International Low impact Development Conference, Seattle, WA, November 16-19.
- Qiu, Z. T. Prato, and G. Boehm. 2006 "Economic Valuation of Riparian Buffer and Open Space in a Suburban Watershed" *Journal of the American Water Resources Association*. Dec: 1583-1596.
- Selbig, and R. Bannerman. 2008. *A Comparison of Runoff Quantity and Quality from Two Small Basins Undergoing Implementation of Conventional and Low-Impact-Development (LID) Strategies: Cross Plains, Wisconsin, Water Years 1999-2005*. USGS Scientific Investigations Report 2008-5008
- Shulyer, L.R. 1995. *Cost Analysis for Nonpoint Source Control Strategies in the Chesapeake Basin*. Publication CBP/TRS 136/95 and EPA 903-R-95-0005.
- Song, Y., and G. Knaap. 2003. "New urbanism and housing values: a disaggregate assessment." *Journal of Urban Economics* 54(2):218-238
- Stephenson, K., C. Speir, L. Shabman, and D. Bosch. 2001. "The Influence of Residential Development Patterns on Local Government Costs and Revenues." Rural Economic Analysis Program, REAP Report 51. Online at: <http://www.reap.vt.edu/reports.html>

Streiner, C.F. and J.B. Loomis. 1995. "Estimating the benefits of urban stream restoration using the hedonic price method." *River* 5(4): 267-278.

SWRPC (Southeastern Wisconsin Regional Planning Commission). 1991. *Costs of Urban Nonpoint Source Water Pollution Control Measures*. Technical Report No. 31. Waukesha, WI: Southeastern Regional Planning Commission.

Virginia Department of Conservation and Recreation. "Discussion Document on the Phosphorus Standard Established in the Proposed Regulations" Richmond, VA. September 5, 2008.

Virginia Department of Conservation and Recreation "Discussion Document on Department Fees", September 8, 2008.

Virginia Secretary of Natural Resources. January 2005. *Chesapeake Bay Nutrient and Sediment Reduction Tributary Strategy*. Accessed online at:
<http://www.naturalresources.virginia.gov/Initiatives/WaterQuality/>

Wang, L., J. Lyons, P. Kanehl, and R. Bannerman. 2001. "Impacts of urbanization on stream habitat and fish across multiple spatial scales". *Environmental Management* 28(2):255-266.

Water Environment Research Foundation. 2004. *Post-Project Monitoring of BMPs/SUDs to Determine Performance and Whole-Life Costs: Phase 1*. IWA Publishing: London.

Wiegand, C., T. Schueler, W. Chittenden, and D. Jellick. 1986. "Cost of urban stormwater runoff controls." Pp. 366-380 In Proceedings of an Engineering Foundation Conference. Urban Water Resource, ASCE, Henniker NH, June.

Wossink, A., and B. Hunt. 2003. *The Economics of Structural Stormwater BMPs in North Carolina*. Research Report Number 344. North Carolina Water Resources Research Institute.