WATERSHED SCIENCE BULLETIN

Potential Application of Stormwater Banking in the Chesapeake Bay Watershed Using Two Case Studies

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Introduction

Managing stormwater in urban environments involves numerous implementation constraints. Poor soils, limited space, and utility conflicts make on-site management difficult and/or costly, and it is often challenging to find appropriate vacant property and unconstrained physical space adjacent to individual development projects to mitigate water quality impacts. In the Chesapeake Bay watershed, compliance with stormwater regulations has recently become even more complex with the adoption of volume-based stormwater management requirements for new development and redevelopment and with the establishment of a Bay-wide total maximum daily load (TMDL) for nitrogen, phosphorus, and sediment. The TMDL requires reducing nitrogen by 25%, phosphorus by 24%, and suspended sediment by 20% by 2025 (USEPA 2010).

Recent estimates to implement the Chesapeake Bay TMDL come with a high price tag. Maryland alone is estimated to need more than $7.3 billion to achieve the 2025 TMDL target for the stormwater sector (MDE 2012a). Current stormwater management options to meet these load reductions focus largely on stormwater retrofits, which are costly because they typically involve modifying existing infrastructure. The estimated costs to implement stormwater retrofits are estimated at upwards of $500 per pound of nitrogen removed, compared to $90 per pound for stormwater management on new development, $15 to $47 per pound for wastewater treatment plant upgrades, and less than $5 per pound for agricultural best management practices (BMPs) (Jones et al. 2010; King and Hagan 2011).

Urban site constraints also limit how much of the urban landscape can feasibly be retrofitted (Schueler et al. 2007). In a review of data over the past few years from retrofit inventories in Virginia, the Center for Watershed Protection found that, of the area assessed, only about 6% to 24% could feasibility be treated with retrofits because of poor soils, limited space, or utility conflicts (Center for Watershed Protection, unpublished data). Another challenge for municipalities is how to access the vast acreage of privately-owned developed land to install retrofits that help achieve the pollutant reductions required by the TMDL. Innovative strategies are needed to reduce the costs of stormwater compliance while facilitating local water quality improvements across urban communities.

Stormwater banking has the potential to reduce costs for stormwater permit holders and, when coupled with local incentives, can open up an inventory of properties that would not have otherwise been targeted for restoration. Stormwater banking is defined here as the accrual of credits when an owner builds or funds urban restoration projects for purposes other than or in addition to managing his/her stormwater management requirements. As with traditional mitigation banking, the intent is to provide water quality improvement before it is needed for mitigation of expected stormwater impacts. For background, Table 1 provides a short description of key concepts related to environmental offset and credit programs. This paper describes the potential application of stormwater banking to the stormwater compliance landscape in the Chesapeake Bay watershed, based on a case study analysis of supply and market drivers in two local jurisdictions.

Table 1. Environmental Offset and Credit Program Definitions

Term	Description	How Impacts Are Mitigated		
		At an Off-site Location?	In Advance of Impacts?	Within the Jurisdiction?
Mitigation banking	Restoration, establishment, enhancement, or preservation of a natural resource area, which is then set aside to compensate for future development activities	Yes	Yes	No
Off-site mitigation	Permittee meets a portion or all of their required mitigation at another location, usually within the same watershed as the permitted impact	Yes	No	Yes
Fee-in-lieu	Permittee offsets all or part of their regulatory obligations for stormwater by paying a fee in lieu of meeting the site requirements to a public agency, who uses the funds to construct mitigation projects	Yes	No	Yes
Nutrient trading	Permittee purchases nutrient credits from a nutrient bank to meet a portion of their regulatory obligations	Yes	Yes	No
Stormwater fee credits	Property owner/stormwater fee ratepayer constructs projects on their property to mitigate impacts of impervious cover and receive a credit on their fee	No	No	Yes

Market Drivers and Demand

People invest in stormwater management because of either a regulatory mandate or a financial incentive. A stormwater bank is potentially helpful in both situations. The demand for stormwater banking credits is most likely to come from developers who must meet stormwater management requirements, owners of large impervious parcels who are seeking credits to reduce stormwater utility fees, and regulated municipal separate storm sewer system (MS4) operators whose permits require significant pollutant load reductions to comply with the Chesapeake Bay and local TMDLs. Each of these drivers is described briefly below.

State Stormwater Regulations
Stormwater discharges from new development and redevelopment are regulated under the Clean Water Act National Pollutant Discharge Elimination System (NPDES) program. All new construction disturbing at least one acre must comply with states' versions of the construction general permit, as well as any post-construction standards contained in state or local codes and regulations. In Maryland, Delaware, and the District of Columbia, this threshold is 5,000 ft^2; in tidewater Virginia it is even smaller at 2,500 ft^2 (Schueler and Lane 2012a). Redevelopment projects are also subject to stormwater requirements, but these are sometimes less stringent than for new development, so developers have a financial incentive to choose redevelopment and infill projects over greenfield ones. Many believe that redevelopment, even when it requires a lower standard of stormwater treatment than new development, will result in water quality improvement simply because the site being redeveloped is usually 100% impervious with no stormwater treatment.

Most of the Bay jurisdictions have recently shifted towards requiring significant on-site retention of runoff to improve water quality (Schueler and Lane 2012a). Full compliance with these standards can be a challenge, particularly for redevelopment sites (even where redevelopment stormwater requirements are less stringent than for new development), ultra-urban sites, and/or other specific site constraints, such as poorly drained soils, extensive impervious cover, potential contamination, or utility conflicts. Because of the difficulty and expense of meeting these requirements, there will likely be strong demand for off-site compliance options – such as purchasable credits from a stormwater bank – especially from the redevelopment sector. The maximum demand for off-site compliance options is likely to come from situations where redevelopment stormwater requirements are stringent enough that they make full on-site compliance very costly, but are not so stringent that they make redevelopment a completely unaffordable option.

Municipal Separate Storm Sewer System Permits
Stormwater discharges from MS4s are regulated under the NPDES MS4 program. It is estimated that 423 communities in the Bay watershed are currently regulated under this program (USEPA 2010). Permits for MS4s are issued by states (or by USEPA, as is the case for the District of Columbia) on a five-year cycle; these permits require the development and implementation of a comprehensive stormwater management program to reduce stormwater discharges to the maximum extent practicable (MEP). In the Bay watershed, the most recent MS4 permits generally include provisions for actions to meet the wasteload allocations from all applicable TMDLs, including the Chesapeake Bay TMDL.

The Chesapeake Bay jurisdictions have taken variable approaches regarding these requirements, but all are expected to require a huge capital investment. Cost estimates to comply with the MS4 permits and Chesapeake Bay TMDL for Maryland's ten most populous jurisdictions range from $6.8 million to $89.8 million per jurisdiction per year (MD Department of Legislative Services 2013). The required nutrient and sediment load reductions could provide a tremendous incentive for Chesapeake Bay MS4s to purchase credits from a stormwater bank if they can achieve the same or better pollutant reduction at a lower cost. The Bay restoration requirements will also create some complexities in how banks will function, for example, trading may require translating acres or runoff volume treated into pounds of nitrogen or phosphorus removed due to the differences between how treatment is determined by the states and the Chesapeake Bay Program.

Stormwater Fee Relief
Many communities are implementing fee-based systems to pay for implementation of the MS4 permit requirements. Similar to a water or sewer fee, a stormwater fee is a recurring user fee charged to property owners by a stormwater utility for the service of managing the stormwater runoff and associated pollutants coming from their property. It is estimated that 1,800-2,000 stormwater utilities exist nationwide (Campbell 2013). In 2012, the Maryland General Assembly passed a measure requiring the ten largest jurisdictions in the state to implement a stormwater utility fee to provide the funding needed to reduce stormwater pollution (House Bill 987), while many other localities in the Chesapeake Bay watershed have developed stormwater utilities on their own initiative.

Stormwater fees for non-residential properties are typically calculated based on the amount of (untreated) impervious surface present and can result in significant annual costs to large landowners with highly impervious parcels. Most municipalities that charge a stormwater fee offer fee credits to ratepayers who reduce or treat impervious cover on their property. Property owners with significant impervious acreages have a financial incentive to construct projects that treat impervious cover in order to reduce their annual fee. If these owners oversize the facilities they construct on-site, they could bank the extra credits for sale if a banking system were in place. Alternatively, these landowners could conceivably earn a credit on their stormwater fee either by contributing to an off-site BMP constructed as part of a stormwater bank or by purchasing credits from the bank.

Methods
This study investigated the potential application of stormwater banking in two Chesapeake Bay watershed jurisdictions: the City of Baltimore, Maryland and the City of Hampton, Virginia. The work involved:

- meeting with local government agency partners,
- a review of available literature and existing mitigation banking and off-site compliance programs from around the country (see CWP 2012),
- a review of urban stormwater BMP cost data,

- an analysis of potential regulatory barriers to establishing a local stormwater bank,
- an assessment of options for setting fee schedules and levels, and
- an assessment of potential locations for stormwater banking (i.e., sites where soils, land use, hydrology, etc. make it feasible to install stormwater BMPs) to estimate the supply of sites.

As this paper primarily reports on evaluation of supply for a stormwater bank, the methods section focuses on this task.

While the drivers described above provide sufficient demand for stormwater credits, an effective stormwater bank cannot be established unless there is also an adequate supply of credits. In both Baltimore and Hampton, we gauged the potential for establishing a local stormwater bank by evaluating the potential inventory of off-site locations that have stormwater retrofit or restoration potential and where BMPs can be installed at a relatively low cost, as well as the potential credits that would be generated on those properties. The purpose of this assessment was to determine whether there are sufficient sites and/or credits to establish a stormwater bank and generate an initial list of potential sites that can be used in the beginning stages of a banking program. The basic methods are described in Table 2 and in greater detail in CWP (2013) and CWP (2014).

Table 2. Methods to Assess Potential Locations for Stormwater Banking

Step	Description
Step 1: Determine the Types of Practices and Properties to Target	Identify the types of stormwater practices to be utilized and their potential locations (i.e., types of property such as rights-of-way, or public parks) through discussion with local agency staff, focusing on practices that meet multiple objectives.
Step 2: Conduct a Desktop Analysis of Potential Properties	Use geographic information systems (GIS) to identify potential properties where BMPs can be installed based on land use type, land ownership, and physical characteristics that affect BMP implementation (e.g., soils, water table, distance from utilities).
Step 3: Conduct Field Assessments	Conduct field assessments of potential sites identified in Step 2 to determine their feasibility based on actual site conditions and to further refine the list of potential properties. Basic information collected includes existing conditions, drainage area to the site, area available for a stormwater practice, and any site constraints, such as utilities or trees.
Step 4: Analyze Findings	Compile data from field assessments into a master spreadsheet or database and analyze to determine the number of sites suitable for stormwater practices.
Step 5: Identify Applicable Design Standards and Calculation Methods	The specific design rules, standards, and calculations that apply in the jurisdiction should be determined in advance to ensure that the potential credits are valid and bankable.
Step 6: Calculate Potential Credits Available	For each of the properties where BMPs could be installed, calculate the potential stormwater volume and/or pollutant removal that the proposed practices can achieve using the applicable design standards. Sum the values achieved for each site to determine total potential volume and load reductions.

Case Study #1: City of Baltimore

Background

Baltimore City is regulated under the NPDES Program as a Phase I MS4 community. The draft permit for Baltimore City requires implementation of restoration efforts for 20% of the City's impervious surface that is not already restored to the MEP by the end of the five-year permit cycle (MDE 2012b). In addition, the City must meet special conditions that ensure their discharges comply with the wasteload allocations from the Chesapeake Bay TMDL (and any local TMDLs).

Almost all of the development activity in the City can be categorized as redevelopment. The Maryland Stormwater Management Act of 2007 requires that redevelopment sites reduce existing impervious area by 50% or provide treatment for an equivalent amount of stormwater runoff, and requires implementation of environmental site design techniques to the MEP before alternatives such as structural controls or payment in lieu of can be used (Environment Article 4 §201.1 and §203). These provisions for controlling post-construction stormwater runoff are among the most progressive and protective in the nation. The City's fee-in-lieu system is determined by the estimated costs of providing on-site stormwater management (Baltimore City 2003). The fees are placed in a fund that is used to construct stormwater-related projects. However, there are no pollutant load or volume reduction targets for the offset project that would ensure projects fully offset the stormwater impacts from the sites paying into the fund. On this point in particular, the stormwater banking system being considered here would result in a fundamental shift from how the current fee-in-lieu program works.

The City and the development community have shown an interest in a stormwater banking program as a way to develop a flexible and more affordable process for meeting stormwater management requirements and to put to beneficial use the City's numerous acres of vacant properties. These City-owned lands are spread out over 9,893 different parcels and create a huge maintenance burden for the Department of Public Works. The cost to maintain just the vacant lots owned by the City has been estimated at $7.1 million in 2010 alone (Baltimore Office of Sustainability 2010). Most of these properties have little or no redevelopment potential and can be prime candidates for stormwater retrofits. Building BMPs on these properties also has the potential to make the area more attractive to homebuyers and developers.

Stormwater Banking Scenarios

Given the local market drivers and need, the most likely scenario for stormwater banking in Baltimore is one where the Department of Housing and Community Development (DHCD) makes City-owned vacant properties available to redevelopers either to construct BMPs for off-site mitigation, or sold at a nominal cost to stimulate redevelopment. An alternative to this scenario is that DHCD sells or leases the land to a third party (i.e., a land trust or mitigation banker) who would be willing to construct BMPs and sell credits. In either case, by making these sites readily accessible, the City may be able to facilitate the addition of BMPs to untreated impervious land within jurisdictions that would not have otherwise been redeveloped. Any BMPs constructed through this process could be counted towards the City's MS4 permit requirements (MDE 2014).

Redevelopers with challenging sites will use the banking option if it is less expensive than managing stormwater on site. The City could offer additional financial incentives to make this a viable option, such as subsidizing the cost for redevelopers to construct BMPs. Although the latter approach requires an up-front investment in capital, a recent study in Philadelphia showed that offering a subsidy of $3.50/ft^2 for retrofits on private land combined with off-site mitigation and aggregation programs would make these projects economically viable for private investors. It would also assist the City of Philadelphia with Clean Water Act compliance, and the retrofits would still cost less than what the city would likely be able to achieve installing BMPs in the public right-of-way alone (Valderrama et al 2013).

Results of Banking Location Analysis

For this stormwater banking scenario to be successful in Baltimore it will require not only sufficient demand for redevelopment, but also an adequate supply of municipally-owned properties with retrofit potential. The results of the analysis of potential locations for stormwater banking in Baltimore are presented in Table 3. Banking credits are expressed in runoff volume, which is the basis of Baltimore City's stormwater management requirement for development and redevelopment and nutrient load which is the basis of City's MS4 permit requirement.

Table 3. Stormwater Banking Location Assessment for the City of Baltimore, Maryland

Step	**Results**
Step 1: Identify BMPs and property types	Focus on bioretention, tree planting and impervious cover removal on vacant land
Step 2: Desktop analysis of potential properties	Identified 33,097 vacant properties, 9,893 of which are City-owned, and 1,767 of which are City-owned and have appropriate size, land use and distance from catch basin to install bioretention
Step 3: Field assessment	Assessed random sample of 244 City-owned vacant properties
Step 4: Results analysis	Identified 140 sites where BMPs could be installed; extrapolating out to all vacant properties showed that between 17,238 and 19,752 sites would be appropriate for tree planting or impervious cover removal, while 355-407 sites would be suitable for bioretention.
Step 5: Identify applicable design standards and credit calculation methods	• Maryland Stormwater Design Manual (CWP and MDE 2009) • Maryland Assessment and Scenario Tool (www.mastonline.org) • Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects (Schueler and Lane 2012b)
Step 6: Calculate potential credits for sites identified	Since only a subset of sites were evaluated in the field, the results were extrapolated to vacant properties city-wide. Maryland stormwater management credits: • 3,397,890 to 3,893,718 ft^3/yr Chesapeake Bay TMDL credit: • 17,368 to 20,524 lbs/yr of TN • 2,227 to 2,551 lbs/yr of TP • 391 to 447 tons/yr of TSS

The results of the banking location assessment show that the City of Baltimore's vacant properties offer significant opportunities for the implementation of stormwater BMPs (Figure 1) that could serve as the basis for a local stormwater banking system and/or aid the City in its progress towards meeting its MS4 permit and Chesapeake Bay TMDL requirements. The City is required to reduce nutrient loadings from approximately 4,675 acres of impervious cover to the MEP over the five-year MS4 permit term. Using nutrient loadings for impervious cover from the Phase 5.3 Chesapeake Bay Watershed Model, and assuming that the MEP standard is equivalent to 57% for TP and 66% for TN (MDE 2014), this translates to a required reduction of 47,204 lbs/yr of TN and 4,503 lbs/yr of TP.

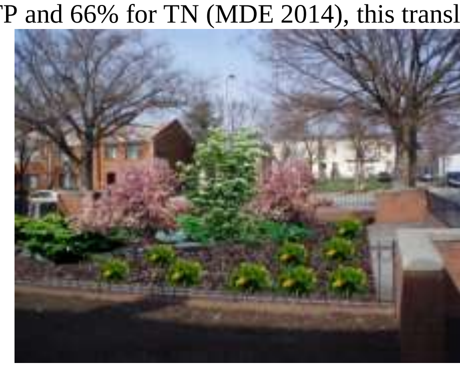

Figure 1. Concepts developed for vacant lots in Baltimore City depicting installation of stormwater practices

Although the potential supply of stormwater credits is significant in Baltimore, the stormwater regulations will only drive demand if there is actual redevelopment activity within the jurisdiction. The City's comprehensive master plan makes the following assumptions regarding additional growth (City of Baltimore Department of Planning 2009):

- approximately 10,000 additional households are planned (this analysis focused only on residential growth, as it was assumed that the expected growth in housing would have the largest cumulative impact on impervious cover),
- an average lot size would be 0.025 acres,
- the average impervious cover is 45%,
- the additional 10,000 households would equate to approximately 112.5 acres of impervious cover, and
- since these are redevelopment projects, no additional nutrient loadings are anticipated.

Using the Phase 5.3 Chesapeake Bay Watershed Model data to calculate pollutant loads from the 112.5 acres of impervious cover, and based on the state requirement to treat 50% of this amount to the MEP standard for runoff reduction practices, the load reductions are 568 lbs/yr of TN and 54 lbs/yr of TP. This represents the maximum potential demand over the six year planning period, as not all sites will exceed the 5,000 ft^2 disturbance threshold that triggers stormwater management requirements (Baltimore City Department of Legislative Reference 2013).

Demand can potentially be increased by providing incentives. A survey of the development community is needed to better evaluate the demand for redevelopment stormwater credits and determine the appropriate price points for these incentives. The potential credits available from the BMP assessment far exceed the potential demand from redevelopment; however, the purchase of lower-cost nutrient credits from BMPs placed on these properties could be an attractive option for the City to help meet the load reductions required by the MS4 permit. This would require a third party to purchase or lease properties and construct BMPs that are less expensive than the costs normally incurred by the City for these practices – i.e., by targeting the most cost-effective projects and/or being able to more efficiently implement practices based on expertise, experience and equipment. If the premise of the private sector being able to build BMPs faster and cheaper is true, it makes the case for a third party to take on this role rather than the City itself.

Case Study #2: City of Hampton, Virginia

Background

The City of Hampton is also a regulated Phase I MS4 community. In Virginia, MS4s are required to develop TMDL Action Plans for demonstrating compliance with their local Chesapeake Bay TMDL Phase II Watershed Implementation Plans. At a minimum, these Action Plans will identify how the municipality will meet the 5% load reduction required in the first five-year MS4 permit cycle, and to the extent practicable, the remaining 35% and 60% reductions in subsequent permit cycles (9VAC 25-890-40). The City's MS4 Permit is still under development by the Virginia Department of Environmental Quality. However, it is expected that the pending permit will be modeled, in part, after Arlington County's permit (VADCR 2013), and include a provision requiring a minimum number of stormwater retrofits managing runoff from prior developed lands. The reductions achieved by these retrofits will count towards the MS4 permit load reduction requirements.

The City, therefore, needs a ready list of available retrofit projects, as well as a strategy for achieving the target load reductions in each permit cycle. Virginia law allows an MS4 jurisdiction to meet its permit load reduction targets through the purchase of credits from Virginia's Chesapeake Bay Watershed Nutrient Credit Exchange Program (credits generally derived from agricultural operations in a rural area). However, the City also wishes to achieve water quality benefits in local waters where possible and keep funds local. Among the many provisions for purchasing credits is one that prohibit trades that are in contravention of local "water quality-based limitations at the point of discharge" (9 VAC 25-870), and in the case of an MS4, it is not all that clear what type of conditions would constitute such a contravention.

Stormwater Banking Scenarios

Two potential stormwater banking scenarios were explored for Hampton. In the first scenario, the City would develop a local off-site compliance program for stormwater management that provides developers with access to candidate public lands for off-site mitigation. The goal is to provide the developer with an opportunity to achieve greater reductions than what is required at a lower cost than what can be achieved on the site. This is a likely scenario in ultra-urban areas where space is limited and the value of the real estate encumbered by the on-site stormwater controls, or the long-term operation and maintenance (O&M) costs of underground practices represent significant cost factors.

The critical issue is whether the City can offer off-site opportunities that are more cost-effective than the allowed purchase of reduction credits through the Nutrient Credit Exchange Program. In most cases, the cost of urban stormwater load reductions is significantly higher than agricultural reductions in terms of unit cost per acre treated and cost per pound of load reduction. However, the Code of Virginia stipulates that nutrient credits cannot be utilized when the uncontrolled discharge will constitute a contravention of local water quality-based limitations; and where such a limitation exists, off-site options may be used provided that such options do not preclude or impair compliance with the local limitation (§62.1-44.15:35.C). The local water quality-based limitation is that expressed by the conditions of the City's MS4 permit: 1) achieve target load reductions from existing urban land, and 2) require specified load reductions from regulated new and redevelopment projects.

In order for the City to effectively achieve these goals and provide alternatives to costly on-site compliance, they must have local off-site options available. Given a comprehensive list of ranked retrofit sites, the City can then offer off-site options that are less costly (and larger in terms of load reduction as would be expected on a pre-selected available retrofit site) as compared to the requirements of the regulated project. The City would take credit for the surplus nutrient and sediment reductions to help achieve their MS4 permit requirements. To explore how this scenario might make economic sense for the City of Hampton and for developers, a theoretical example of stormwater management alternatives is presented in Figure 2 and Exhibit A for "Lottaproblems Creek," taken from CWP and WEG (2010).

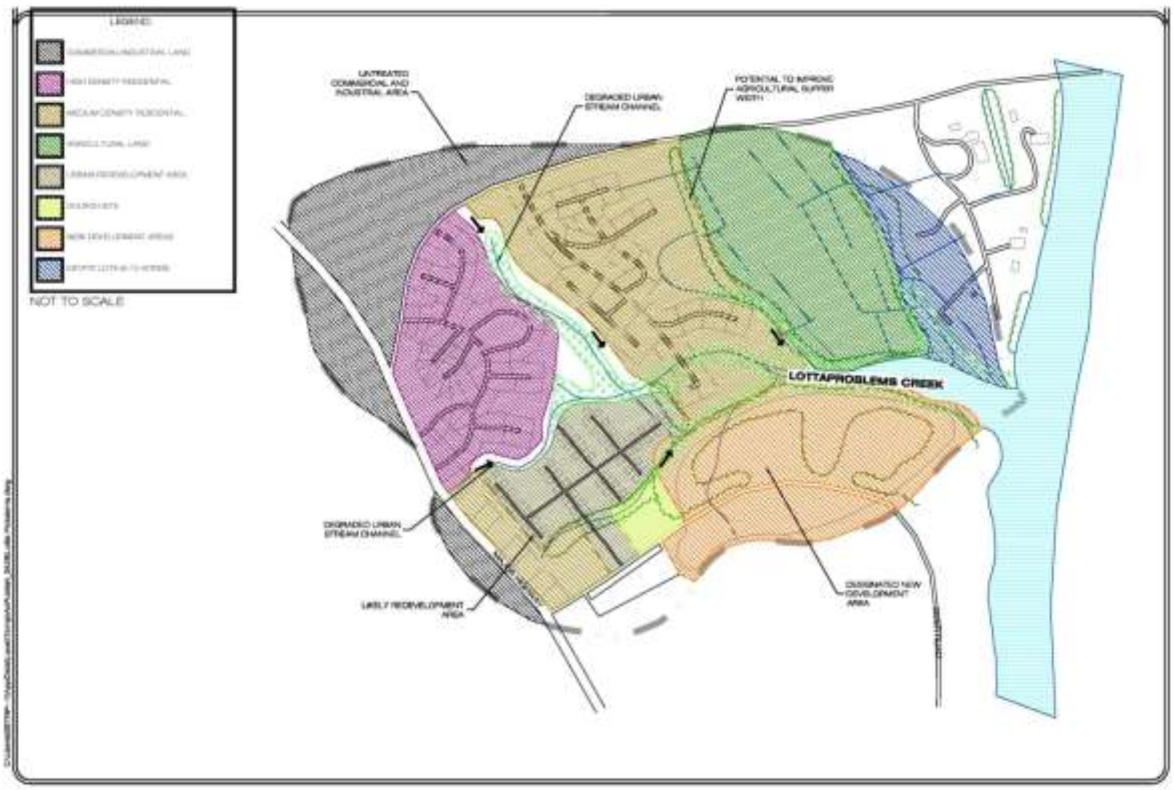

Figure 2. Lottaproblems Creek

Exhibit A. Lottaproblems Creek Example

Current land uses in the approximate two square-mile Lottaproblems Creek watershed are comprised of a mix of commercial, industrial, agricultural, roadways, and mixed residential land uses, with 200+ acres slated for new development and 100 acres slated for redevelopment. Stream channels receiving uncontrolled runoff from existing developed areas are exhibiting down-cutting and widening, resulting in additional sediment and nutrient inputs to downstream waters. Net projected nutrient loading from the overall watershed is approximately 1,600 pounds per year of Total Phosphorus. Stormwater management options for this watershed might include:

<u>Alternative A – Site-By-Site Approach</u>
In this alternative, the proposed new development would be mandated to achieve on site a net load of 0.45/lb/ac/yr; redevelopment would be required to exact a 20% net reduction versus existing loads (both consistent with proposed Virginia criteria). While this scenario would satisfy the regulatory mandate, the results basically "hold the line" on watershed loads, but do not result in an overall reduction. The net cost for treatment for both new development and redevelopment exceeds an estimated $6 million.

<u>Alternative B – Off-site Compliance Approach</u>
Alternative B pursues an approach whereby on-site load control criteria (for new development and redevelopment) are relaxed in exchange for contributions/participation in an off-site compliance program. The establishment of such a fee base could allow for restoration of approximately one mile of degraded urban stream channels, stormwater retrofits treating 10% of the most intense commercial and industrial land uses, agricultural buffer programs, and a variety of other pollution prevention programs that have a direct effect on nutrient loads (septic pump-out programs, street sweeping, etc.). Overall capital costs in this scenario are reduced by approximately $1 million.

The collective costs and results are summarized as follows:

- The off-site compliance scenario (Alternative B) reduces net nutrient loading from the two-square mile watershed by approximately 11%. The "site-by-site" (Alternative A) basically holds the line or allows a slight increase.
- The gross nutrient reductions under Alternative B are 260% of the current regulatory approach.
- The net capital costs for Alternative B are approximately 20% less than Alternative A.

This example does not address the specific type of program or fee mechanism, but is intended to illustrate how, in many instances, stormwater management strategies that expand the focus beyond on-site BMP implementation can achieve greater results with lower overall costs.

The second potential use of a stormwater bank in Hampton is an off-site stormwater fee-credit program, a concept introduced by Valderrama et al (2013). Like most other cities that charge a stormwater fee, Hampton offers credits to commercial ratepayers who install BMPs that treat impervious cover on their property. Commercial owners who choose to install retrofits could oversize them to manage more than is needed to earn the fee credit, and (similar to the first scenario) generate additional stormwater credits that could be sold to other property owners who lack financially attractive onsite options. However, many business owners in the City have expressed a desire to have options for reducing stormwater fees without taking land out of production. An off-site stormwater fee-credit program can address this barrier by allowing commercial ratepayers to either 1) invest in a proposed off-site stormwater project upfront, or 2) purchase credits from a previously constructed stormwater project. In both cases commercial ratepayers would be credited through the utility fee.

The initial seed money to construct restoration projects on public land in the absence of ratepayer investors would come from a pre-set portion of the City's stormwater utility fee revenue. The City would receive credit towards the TMDL requirements for these BMPs. An off-site stormwater fee-credit program would give the City the ability to direct capital to those projects with the greatest economy of scale, i.e., the highest pollution reduction at the lowest cost, which is something that traditional fee-credit programs are unable to do effectively. If the capital cost of investing in an off-site project is competitive with the long term annual fee structure over a pre-set investment return period and there are no other negative factors (such as loss of useable real estate to build on-site or long term O&M costs), then the ancillary benefit of investing in a local water quality project may provide a win-win opportunity for local businesses. This type of program offers the greatest potential to provide a revolving source of capital that would continue to support the selection of the most cost-effective stormwater projects where they are most needed.

Results of Stormwater Banking Location Assessment
For both of the scenarios described above, an adequate supply of potential stormwater retrofit sites is needed. Table 4 presents the results of the inventory of available City-owned locations to install stormwater BMPs in Hampton.

Table 4. Stormwater Banking Location Assessment in Hampton, Virginia

Step	**Results**
Step 1: Identify BMPs and property types	Focus on permeable pavement, impervious cover removal / disconnection, tree planting, grass buffers, vegetated filter strips, ditch enhancements, bioretention, rain gardens, rainwater harvesting and BMP restoration on City-owned properties
Step 2: Desktop analysis of potential properties	Identified 156 sites with retrofit potential
Step 3: Field assessment	Field assessments conducted for 156 sites
Step 4: Results analysis	85 BMPs identified on 58 sites
Step 5: Identify applicable design standards and credit calculation methods	• Virginia Stormwater Management Handbook (VADCR 2011) and draft guidance on meeting the Chesapeake Bay TMDL special condition requirements (Davenport, 2013) • Virginia BMP Clearinghouse http://vwrrc.vt.edu/swc/ • Virginia Assessment and Scenario Tool: www.vasttool.org • Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects (Schueler and Lane 2012b)
Step 6: Calculate potential credits for sites identified	Chesapeake Bay Program credit for TMDL: • 376.1 lbs/yr of TN • 41.2 lbs/yr of TP • 12,342.4 lbs/yr of TSS Virginia DEQ credit for MS4 general permit: • 374.5 lbs/yr of TN • 34.5 lbs/yr of TP Virginia DEQ credit for runoff reduction method compliance: • 297.7 lbs/yr TN • 42.8 lbs/yr TP

Table 5 compares the potential credits generated on the identified banking sites with the City's required pollutant load reductions for the Chesapeake Bay TMDL. Although the percentage of the TMDL load reduction goal met by the potential banking location sites is small, this assessment was limited to the sites that could be evaluated during two days of fieldwork. A separate review of watershed plans within City limits indicates significant nutrient reduction is available from proposed stormwater projects. These projects could be used by the City along with other BMP strategies, such as illicit discharge correction, and tidal shoreline and stream restoration to achieve nutrient reduction goals.

Table 5. Potential Chesapeake Bay TMDL Credits in Comparison to the 2025 TMDL Load Reduction Goal for the City of Hampton

	TMDL Credits (lbs/yr)	**TMDL Load Reduction Goal (lbs/yr)[1]**	**% of TMDL Load Reduction Goal**
TN	376.1	13,068	2.9%
TP	41.2	3,375	1.2%
TSS	12,342.4	1,319,261	0.9%

[1] *Calculated using spreadsheet provided by Virginia Department of Environmental Quality and data from the EPA Bay Model v5.3.2*

Even if a significant number of additional restoration sites are identified, a stormwater bank can only succeed in Hampton if there is sufficient demand for credits from the development/redevelopment sector, or from stormwater fee ratepayers. The City of Hampton's comprehensive plan analyzes expected development activity within the City and states that Hampton has a low inventory of vacant, developable land. It is expected that infill, redevelopment, and revitalization of existing development will be the main source of growth and change within the city (City of Hampton 2006). City planners assumed that the most significant opportunities for redevelopment would be found on larger parcels (five acres or more) with single owners that were developed more than 30 years ago. An evaluation of the existing land uses and information collected from the City Assessor's files led to identify almost 1,000 acres of land (90 parcels) in Hampton that fit such criteria (City of Hampton 2006).

In Virginia, the Stormwater Management Program Regulations requires any development or redevelopment project greater than five acres or that results in ten pounds or more of phosphorus emissions must mitigate at least 75% of the required phosphorus reduction on-site (unless it is demonstrated that compliance cannot practicably be met on-site) (9 VAC 25-870). The premise is that larger sites have sufficient opportunities to implement the new micro-scale and non-structural stormwater practices and achieving the reductions to the MEP on-site is preferred over the purchase of off-site credits. The burden for demonstrating that the requirements cannot practicably be met on-site will likely be less when the alternative is a local off-site compliance or fee-credit program. Therefore, if we assume that one-half of the identified acreage (500 acres) is proposed for redevelopment, and using the Virginia Stormwater Program pollutant loading formulas (Hirschman et al. 2008). Table 6 provides an estimate of the load reduction demand.

Table 6. Potential Nutrient Reduction Demand from Redevelopment in the City of Hampton, VA

Load Reduction Requirement for Redevelopment of 500 Acres[1] (lbs/yr)		Potential Credits[2]
TN[3]	1,729 lbs	432 lbs
TP	241 lbs	60 lbs

[1] Assumed existing developed parcel is 65% impervious, 35% managed turf; and proposed re-developed parcel is 75% impervious and 25% managed turf; State stormwater requirement of 20% load reduction below existing conditions and new impervious area reduced to the new development load limit of 0.41lbs/ac/yr

[2] Assumes 75% of reductions are achieved on-site

[3] There is no state program mandate for TN reduction on regulated land disturbing activities; however, the retirement of TP credits requires the retirement of an equivalent ratio of TN credits

The potential demand for an off-site stormwater fee-credit system is directly related to the potential cost-savings or attractiveness of the fee-credit and the balance between the number of large-scale commercial ratepayers in Hampton and the long-term operations needs of the City's stormwater program. As with most communities that implement a fee-credit program, the City of Hampton caps the available credit at a percentage of the total fee, in this case 45%. The cap is in place to ensure that the City maintains enough annual revenue to support the range of stormwater services funded by the fee. Therefore, the goal of an effective fee-credit program is to set the value of the credit at a level commensurate with the avoided costs to the stormwater utility, while at the same time ensuring that credits are valuable enough to provide incentive for investment in off-site mitigation project (Valderrama et al 2103).

Like most stormwater utilities, the City of Hampton's annual rate of $1,584.94 per acre of impervious cover is significantly less than the cost to provide treatment for that acre. At the current utility fee rate it would seem unlikely for a commercial ratepayer to explore this option unless the fee is raised significantly; however, offering an off-site fee credit may still benefit the City by providing a ready source of revenue to get projects in the ground quickly. One of the next steps for this project is to conduct a survey of the development community and stormwater fee ratepayers in the City to better evaluate the demand for stormwater banking and to help determine the appropriate price points for fee credits and local redevelopment incentives. It will also be important to build a database of the actual costs to implement stormwater practices of varying scales and on public lands in order to better assess the cost for effective stormwater treatment.

Discussion

Although the application of stormwater banking, off-site compliance, or utility fee-credit program options may vary across different jurisdictions, a common theme is that the programs are created by installing restoration projects in urban areas, which has the advantage of keeping both funds and water quality improvements within the jurisdiction. Certainly, in both Baltimore and Hampton there is demand for stormwater credits and a large supply of sites that could serve as the basis for a local stormwater bank. However, the key for making a stormwater banking program work is to ensure the cost of constructing BMPs that generate credit is lower than what a developer or MS4 community would normally have to pay. This is a significant challenge because 1) the enormous variability in urban BMP costs makes a cost comparison difficult, and 2) despite this variability, the costs of urban BMPs are still much greater than the cost to purchase credits (typically generated from agricultural sources) through a state's approved nutrient trading program.

Table 7 presents the estimated construction cost associated with implementation of the BMPs identified in the stormwater banking location assessments in the City of Baltimore and the City of Hampton. These estimates were based on unit costs from King and Hagan (2011). Note that the costs shown in Table 7 do not reflect full life-cycle costs, such as land costs, pre-construction costs, construction costs, cost of capital, operation and maintenance, and program administration. The potential credits generated through implementation of these BMPs in Baltimore represent only half of the reductions required by the City's MS4 permit, and they come at an enormous cost of $196 million. For the City of Hampton, less than 3% of the City's TMDL obligations would be met if all $3 million worth of BMPs were constructed.

Table 7. Estimated Construction Costs for BMPs Identified in Stormwater Banking Location Assessment in Baltimore, MD and Hampton, VA

Location	BMP	Construction Cost[1]
Baltimore	Bioretention	$27.3 million
	Impervious cover removal + tree planting	$168.7million
	Total	*$196 million*
Hampton	Bioretention	$900,067
	Ditch enhancement/wet swale	$123,569
	Dry swale	$14,940
	Permeable pavement	$1.3 million
	Rain garden	$138,273
	Impervious cover removal + tree planting	$476,061
	Total	*$3 million*

[1] Based on unit costs from King and Hagan (2011)

The potential for stormwater banking to offer compliance options that save money for the regulated MS4, developer, or stormwater fee ratepayer lies with the ability of the program to effectively prioritize projects with the following characteristics:

1. Low-value land: while the cost to construct a particular stormwater BMP may be the same whether it is built on the project site or at an off-site urban location, the cost of land will have a significant impact on the overall project cost. The focus on marginal lands such as vacant properties is appealing because of its potential to provide lower cost options.
2. Large-scale projects: stormwater banking offers the opportunity to construct large-scale projects (i.e., stream restoration) that would not have otherwise been possible with a site by site approach. These can be much more cost-effective than numerous individual projects.
3. Performance-based contracting: a banking program where payment is tied to pollution reduction provides a built in incentive for project implementers to improve efficiency and even to experiment with innovative BMPs.
4. Wide range of project types: if a wide range of BMPs are available for off-site mitigation beyond just structural retrofits (e.g., street sweeping), this opens up options that can be much more cost-effective.
5. Location within the jurisdiction: perhaps the key issue that will determine whether a stormwater banking program is viable is the requirement that banking and trading programs cannot be in contravention of local water quality-based limitations which would rule out the purchase of credits from these other sectors which are likely to be located outside of the local watershed.

While the above local stormwater banking structure is designed to address the specific demands and regulatory environment of the Chesapeake Bay watershed, it almost certainly could apply in other parts of the country. Any of the 7,000+ regulated MS4 communities in the US, in particular those faced with complying with local, statewide or regional TMDLs in the MS4 permits, may be looking for an option that lowers the cost of achieving the required pollutant reductions without sending taxpayer money to build agricultural BMPs in a distant watershed. At its simplest, such a program might include an inventory of feasible sites to construct BMPs, and use of performance-based contracting to build them faster and cheaper and target the sites and BMPs with the lowest cost and highest benefits. A more complex scenario might harness the demand for lower fees/stormwater management costs from the development community or stormwater ratepayers to facilitate the construction of BMPs on private land. Each of these scenarios can meet multiple goals of improving local water quality, stimulating the local economy and revitalizing communities by encouraging redevelopment and greening neighborhoods.

Summary

Stormwater regulations, the Chesapeake Bay TMDL, and municipal stormwater fee programs are important drivers of the demand for lower cost compliance options and stormwater fee relief. Stormwater banking has the potential to reduce costs for regulated entities and ratepayers, and since the creation of the bank involves constructing restoration projects in urban areas, it can also alleviate concerns about local water quality that are commonly associated with nutrient trading. When coupled with local incentives, a banking program can open up an inventory of private lands that would not have otherwise been available for restoration; the potential cost savings over retrofitting public rights-of-way is immense.

While this study found a large supply of potential BMPs and credits in the City of Hampton, the supply is dwarfed by the number of sites necessary for the City to meet their TMDL requirements. In Baltimore, the supply of appropriate vacant sites is much greater than what is required for TMDL compliance; however, implementation of BMPs on these sites is only feasible if the banking program is able to successfully incentivize redevelopment. The case studies in Baltimore and Hampton illustrate the complexity of determining how and whether a local stormwater banking program would work, in part because of how differences in state regulations and drivers affect demand. Ideally, a banking program would be flexible enough to meet the needs of all potential investors and credit purchasers.

The next step for our case study communities is to evaluate the demand for stormwater banking through surveys that will also help to determine the appropriate price points for stormwater fee credits and local redevelopment incentives. In addition to an assessment of supply and demand, some important next steps for other communities considering stormwater banking are to conduct an analysis of cost-benefit and market potential, as well as to determine the fee structure, crediting approach, marketing, and administrative needs to implement a pilot a program. It is our hope that the stormwater banking scenarios described in this paper will be tested as pilot studies to determine if the cost savings and other local benefits live up to their potential.

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