Appendix C

Cost Analyses and Funding Studies for Maryland's Phase II WIP

This appendix contains:

1. **Supporting information on the estimated costs associated with implementing Maryland's Phase II WIP pollution reduction strategies.**

2. **A narrative description of projected Maryland Department of Transportation (MDOT) TMDL/WIP spending.**

3. **The *Final Report of the Task Force on Sustainable Growth and Wastewater Disposal,* released on December 20, 2011.**

4. **A report entitled *Costs of Stormwater Management Practices in Maryland Counties* by Dr. Dennis King and Patrick Hagan of the University of Maryland Center for Environmental Science.**

5. **A summary of a presentation on *Sustainable Financing for Stormwater Management,* prepared by the Environmental Finance Center of the University of Maryland and presented at the second round of five regional meetings for local Phase II WIP teams, elected officials and stakeholders, held in the fall of 2011 across the State.**

Appendix C

Supporting Information on Phase II WIP Costs

Section 10 of the Maryland Phase II Watershed Implementation Plan summarizes cost estimates for Interim 2017 and Final 2025 Maryland Strategies. This appendix provides supporting calculations to the cost estimates summarized in Section 10. These cost estimates and strategies are subject to refinement and represent one of the many ways to achieve the attainment of the pollution reductions targets.

Costs cover 2010 through the respective years for the Interim and Final strategies. These first-order WIP implementation cost estimates do not include certain financial information and or strategies that might be employed to structure the costs in order to optimize funding. The following items have not been considered:

1. Costs to private sector, e.g., costs for industrial point source upgrades.
2. Programmatic costs, e.g., costs to run on-going programs, staffing, program development costs (e.g., consultant studies, funding system design and implementation) and other needs identified for various State and local strategies.
3. O/M costs (unless noted)
4. Financing costs
5. Time value of money considerations (inflation effect on cost estimate).
6. Other

Urban and Suburban Stormwater

Costs for urban stormwater were estimated, for most BMPs[1], by applying an average cost-per-acre of $12,500. This cost was derived by MDE based on three years of implementation and cost records reported by Phase I MS4 jurisdictions (2009-2011). Table C.1 shows the cost estimation details. For several practices cost estimates are not available (N/A).

The MS4 annual report data reveals that the 11 jurisdictions expended a total of $245,502,000 to operate and maintain their local stormwater programs and another $172,302,000 for capital improvements over the last three years. During that time, 33,424 acres of developed land was retrofitted. The unit capital cost was $5,155 per acre and the combined operating and capital unit cost was $12,500 per acre.

Although the data reported by several jurisdictions indicate higher unit costs than the average cost of $12,500/acre, others were lower. Actual BMP costs may vary for a number of reasons, including:

- Jurisdictions have been able to address many acres of impervious surface with large watershed scale stream restoration projects.

[1] See Notes to Table C.1.

- Implementation to date has been opportunistic, often taking advantage of other work, such as sanitary sewer rehabilitation, to reduce costs.
- Work has taken place on land owned or controlled by the local jurisdiction, eliminating land acquisition costs.
- Using existing programs such as reforestation and street sweeping to provide treatment to existing impervious acres.
- Partnerships with other governmental or private entities i.e total project costs may not be captured in the data.
- Reported program funding data may not accurately reflect true long-term operating and maintenance costs.

Septic Systems

The cost estimate for the Interim and Final Target septic system strategies uses the following unit cost estimates:

- $13,000/system for upgrades to nitrogen removal technology. (Source: MDE)
- $30,000/system for connection to an advanced treatment plant. (Source: MDE)
- $500/system for pumping two-times. (Source: MDE)

The septic system strategy cost estimations are provided in Table C.1 with supplemental notes.

Waste Water Treatment Plant Upgrades

Major WWTPs: ENR & BNR costs (Source: MDE. See Table C.2 below)

Total:	$2.31 Billion (B)
State BNR Grant:	$0.23 B
State ENR Grant:	$1.23 B
Local Cost:	$0.85 B

Minor WWTPs

The septic Task Force used the following cost estimates for upgrading 10 of the largest minor treatment plants in their deliberations (Source: MDE). The Interim WIP Strategy calls for upgrading five (5) plants and uses half of this estimate.

Total:	$124.4 Million (M)
State BNR Grant:	$ 32.1 M
State ENR Grant:	$ 23.1 M
Local Cost:	$ 69.2 M

Table C1: Cost Estimations for Maryland’s Interim and Final Target Strategies for Urban Stormwater and Septic Systems

	A	B	C	D	E	F	G	H	I	J
1	**Developed Land BMPs**		**2010 Progress**	**2017 Interim Strategy**	**Change from 2010**	**2010 Progress**	**2025 Final Strategy**	**Change from 2010**	**2017 Cost**	**2025 Cost**
2	**BMP Name**	**Unit**								
3	Abandoned Mine Reclamation	Acres	-	1,242	1,242	-	1,843	1,843	N/A	N/A
4	Bioretention / Raingardens	Acres	-	19,028	19,028	-	34,716	34,716	$237,850,000	$433,950,000
5	Bioswale	Acres	-	13,919	13,919	-	15,518	15,518	$173,987,500	$193,975,000
6	Dry Detention Ponds and Hydrodynamic Structures	Acres	48,294	49,283	990	48,294	53,259	4,965	$12,375,000	$62,062,500
7	Dry Extended Detention Ponds	Acres	25,901	20,780	-5,122	25,901	27,544	1,643	$0	$20,537,500
8	Impervious Urban Surface Reduction	Acres	4	4,333	4,328	4	31,003	30,998	$54,100,000	$387,475,000
9	MS4 Permit Stormwater Retrofit	Acres	44,266	59,314	15,048	44,266	68,473	24,207	$188,100,000	$302,587,500
10	Permeable Pavement	Acres	-	300	300	-	350	350	$3,750,000	$4,375,000
11	Stormwater Management Generic BMP (1985 to 2002)	Acres	131,252	110,469	-20,783	131,252	97,707	-33,545	$0	$0
12	Stormwater Management Generic BMP (2002 to 2010)	Acres	78,979	77,888	-1,092	78,979	66,449	-12,530	$0	$0
13	Urban Filtering Practices	Acres	3,552	72,900	69,348	3,552	322,842	319,290	$866,850,000	$3,991,125,000
14	Urban Forest Buffers	Acres	340	10,059	9,719	340	26,430	26,090	$121,487,500	$326,125,000
15	Urban Infiltration Practices	Acres	14,458	26,795	12,337	14,458	33,872	19,414	$154,212,500	$242,675,000
16	Urban Tree Planting / Urban Tree Canopy	Acres	-	9,033	9,033	-	15,000	15,000	$112,912,500	$187,500,000
17	Vegetated Open Channels	Acres	-	8,307	8,307	-	28,290	28,290	$103,837,500	$353,625,000
18	Wet Ponds and Wetlands	Acres	54,077	70,351	16,273	54,077	73,504	19,427	$203,412,500	$242,837,500
19	Erosion and Sediment Control on Construction	Acres/Year	29,023	29,023	0	29,023	34,903	5,880	N/A	N/A
20	Erosion and Sediment Control on Extractive	Acres/Year	-	593	593	-	7,739	7,739	N/A	N/A
21	Forest Conservation	Acres/Year	93,350	90,469	-2,881	93,350	91,111	-2,238	N/A	N/A
22	Street Sweeping Mechanical Monthly	Acres/Year	-	7,053	7,053	-	9,033	9,033	N/A	N/A
23	Urban Nutrient Management	Acres/Year	218,071	406,330	188,259	218,071	504,053	285,982	$9,955,085	$26,462,783
24	Street Sweeping Pounds	Lbs/Year	-	9,628,448	9,628,448	-	9,628,448	9,628,448	N/A	N/A
25	Urban Stream Restoration (interim)	Linear Feet	-	430,883	430,883	-	818,473	818,473	$122,801,655	$233,264,805
26	Urban Stream Restoration / Shoreline Erosion Control	Linear Feet	-	605,116	605,116	-	1,273,852	1,273,852	$180,324,568	$379,607,896
27	Total Estimated Urban Practices Cost								$2,545,956,308	$7,388,185,484
28	**SEPTIC SYSTEM**	**Unit**	**2010 Progress (MAST)**	**2017 WIP (MAST) (March 12 2012)**	**2017-2010 (systems)**	**2017 Cost**	**2025 WIP (MAST) (March 12 2012)**	**2025-2010 (systems)**	**2025 Cost**	
29	Connections	Systems	536	8,431	7,895	$236,850,000	42,978	42,442	$1,273,260,000	
30	Denitrification	Systems	2,848	46,029	43,181	$561,353,000	184,214	181,366	$2,357,758,000	
31	Pumping	Systems	0	25,325	25,325	$25,325,000	58,496	58,496	$87,744,000	
32										
33	Total Estimated Septic Cost					$823,528,000			$3,718,762,000	
34										

Explanatory notes to accompany Table C.1

1. The column labeled "2010 – 2017" represents the incremental level of implementation in acres needed beyond 2010 progress to meet the 2017 interim target. The column labeled 2010 – 2025 represents the incremental level of implementation in acres required beyond 2010 progress to meet the 2025 final target.
2. Estimated 2025 costs are cumulative and include 2017 costs, with the exception of annual practices, where annual practices are denoted in the "units" column as acres/year.
3. Where an annual practice was encountered, cost was derived by taking (acres)*(practice cost/acre)* # years. 2017-2010 = 7 years. 2025-2010 = 15 years.
4. Some of the cells in table C.1 show negative numbers, indicated by minus signs. Negative results are because the practices were converted to a different BMP and the acres were subtracted. This could be a result of the choice to use a more efficient BMP in order to optimize reaching the 2017 or 2025 targets.
5. In the March 30, 2012 Final Phase II WIP, stream restoration costs were based on $285/foot of urban stream restored. The source of this estimate is *Estimation and Analysis of Expenses of Design-Bid-Build Projects for Stream Mitigation in North Carolina*, Templeton, Scott R., et. al., Clemson University, Department of Applied Economics and Statistics, Research Report RR 08-01, January 2008. However, in this update of the WIP, shoreline erosion control practices have been modeled as an aggregate BMP with stream restoration. In the prior version, shoreline erosion control costs were based on the average of structural and non-structural cost estimates per foot, which are $350/ft and $125/ft respectively in 2000 dollars. The average, $237/ft, was adjusted to 2010 dollars, assuming 3% inflation, for a final estimate of $310/ft. The source of the unit cost estimates is the *State of Maryland Shoreline Erosion Task Force Final Report*, Maryland Department of Natural Resources, January 2000. For purposes of cost estimation in this updated version of the WIP, an average cost has been used [($285/ft + $310/ft)/2 = $298/ft] to calculate a cost estimate for this combined BMP category.
6. Septic Pumping Assumptions: 1) $500 per pump out; 2) Two pump outs required between 2010 and 2017; 3) a third pump out done between 2017 and 2025
7. The unit "acre" for urban practices means urban developed land (including impervious & pervious cover)
8. The estimated average stormwater cost of $12,500 has been applied to most practices that are common restoration BMPs, with the exception of several practices where a simple calculation did not readily apply:
    a. Practices that were not costed out include street sweeping and shoreline erosion control, and erosion control on extractive because there was insufficient reliable data to support a single average cost.
    b. Additionally, some practices such as erosion and sediment control and abandoned mine reclamation were not costed out because these practices are not within the group of traditional stormwater restoration BMPs

c. For urban nutrient management, the cost was estimated by using a flat per acre cost of approximately $3.50 This cost was derived from an average annual cost of about $1.5 million/year that would address approximately 400,000 acres/year with the understanding that not every acre would require management each year. (MDA source of unit cost).

Table C.2 Costs for Majors WWTPs Upgrades

MAJOR WWTP	Est. Total Upgrade Cost	Total BNR State Share 2010+	Total ENR State Share 2010+	Total Other
ANNAPOLIS	26,562,648	-	13,700,000	12,862,648
BACK RIVER (BNR REFINEMENT)	462,000,000	67,000,000	267,000,000	128,000,000
BLUE PLAINS (MD PORTION ONLY)	401,700,000	38,831,231	203,298,000	159,570,769
BROADNECK	25,370,290		7,851,000	17,519,290
BROADWATER	11,191,000		6,000,000	5,191,000
CAMBRIDGE	9,339,000		8,944,000	395,000
CENTREVILLE	1,000,000		1,000,000	-
CHESAPEAKE BEACH	26,075,400		9,157,000	16,918,400
CONOCOCHEAGUE	36,038,200		27,537,000	8,501,200
COX CREEK	162,644,800		140,485,000	22,159,800
DAMASCUS	6,166,253		5,235,000	931,253
DENTON	6,003,591		4,609,000	1,394,591
DORSEY RUN	3,900,000		3,900,000	-
EMMITSBURG	23,860,000	5,346,000	8,153,000	10,361,000
FREDERICK (BNR REFINEMENT)	62,429,725	3,526,000	27,411,000	31,492,725
FREEDOM DISTRICT (BNR REFINEMENT)	16,560,000	4,334,000	7,891,000	4,335,000
FRUITLAND	5,834,000		3,100,000	2,734,000
HAMPSTEAD	22,000,000	10,000,000	2,000,000	10,000,000
JOPPATOWNE	2,999,732		2,999,732	-
LA PLATA	10,388,000		9,378,000	1,010,000
LEONARDTOWN	16,920,720		6,951,000	9,969,720
LITTLE PATUXENT	107,462,500		35,494,000	71,968,500
MARLAY TAYLOR (PINE HILL RUN)	33,000,000		11,000,000	22,000,000
MARYLAND CITY	8,400,000		3,400,000	5,000,000
MARYLAND CORRECTIONAL INSTITUTE	3,000,000		3,000,000	-
MAYO LARGE COMMUNAL	39,760,000	5,456,000	3,000,000	31,304,000
NORTHEAST RIVER	27,500,000		9,000,000	18,500,000
PARKWAY	18,544,340		16,052,000	2,492,340
PATAPSCO	391,196,400	75,150,000	218,500,000	97,546,400
PATUXENT	20,596,000		13,800,000	6,796,000
PISCATAWAY	7,364,214		6,324,000	1,040,214
PRINCESS ANNE	4,000,000		4,000,000	-
SALISBURY CORRECTIVE ACTION	54,270,000	11,000,000	12,000,000	31,270,000
SENECA	42,500,000		6,900,000	35,600,000
SNOW HILL	14,364,870	3,765,000	3,527,000	7,072,870
SOD RUN	53,029,280		42,633,450	10,395,830
TANEYTOWN	4,400,000		2,870,000	1,530,000
THURMONT	9,000,000		6,889,000	2,111,000
WESTERN BRANCH	82,700,000		39,100,000	43,600,000
WESTMINSTER	27,984,000		16,940,000	11,044,000
WINEBRENNER	17,665,200	2,100,000	7,000,000	8,565,200
Major MD WWTP - Funding Beyond 2010	2,305,720,163	226,508,231	1,228,029,182	851,182,750

Projected Maryland Department of Transportation (MDOT) TMDL Spending – All Modes

2010-2017 = $ 467.2 million*

2010-2025 = $1.5 billion

*Note that spending does not reflect a 60% <u>expenditure of total funds</u> for this effort by 2017. The MDOT program is front-loaded with efforts that can be executed quickly and less expensively, while capacity is built to deliver more complex projects.

**Spending in fiscal years

MDOT is anticipating the cost to fully implement the WIP for all MDOT modes to be approximately $1.5 billion. All the modes are expected to have load reduction requirements in future permits, but the bulk of MDOT's currently known TMDL response cost is attributable to the SHA's MS4 phase I and II permits which cover the eleven central Maryland counties.

Since approximately 80% of the state highway system was constructed before the advent of stormwater regulation, much of the required stormwater treatment will have to be in the form of retrofits to existing highways in already developed areas. The cost of retrofitting with traditional SWM structural facilities in an urban highway setting ranges from $80,000 to $150,000 per acre. New stormwater regulations requiring "Environmental Site Design (ESD) to the Maximum Extent Practicable" took effect in Maryland in May 2010. Based on SHA's limited experience to date, the use of ESD in that same highway setting carries a much higher cost per acre.

In projecting costs for a program of this scope, there are a large number of variables. Right of way costs will vary substantially from one location to another. Construction costs will also vary by location (urban vs. rural or type of highway and clear zones etc). Other variables include the need to relocate utilities, ground water elevations, and karst topography. In view of the cost and time required to pursue a program of retrofits alone, SHA has developed a broader set of equivalent pollution control strategies to be deployed, including:

- Computation and documentation of existing non-structural highway features that provide water quality –swales
- Outfall Stabilization Step Pool Systems
- Reforestation and tree planting
- Stream buffer planting
- Stream restoration
- Street sweeping/inlet cleaning
- Pavement removal
- Nutrient management plans
- Other -such as Education and Illicit Discharge Elimination

The overall cost of the total program will ultimately depend on the constraints encountered in pursuing retrofits and the number of opportunities available for alternative practices.

It also must be noted that implementation of the MDOT strategy will not result in a straight line progression with uniform funding levels each year. State procedures from planning to implementation, including contract procurement, design, right of way acquisition and permitting, will result in a gradual build-up of capacity to deliver this type of project with a greater need for funding occurring in FY 15 and thereafter. Current planning calls for a gradual increase in funding to $100 million/year by 2016. By then it is likely that we will have exhausted the less expensive and readily available opportunities and increased construction activity over design activity.

FINAL REPORT

OF THE

TASK FORCE ON SUSTAINABLE GROWTH & WASTEWATER DISPOSAL

PRESENTED TO

Martin O'Malley
Governor

Anthony G. Brown
Lt. Governor

Thomas V. Mike Miller, Jr.
President of the Senate

Michael E. Busch,
Speaker of the House

December, 2011

Staffed by:

MDE

Maryland Department of Agriculture

MDP
Maryland Department of Planning

Maryland Department of Natural Resources

Final Report of the Task Force on Sustainable Growth and Wastewater Disposal

December 20, 2011

Introduction

The phenomenal natural wealth and abundance provided by the Chesapeake Bay has been vastly diminished. Once teeming with oysters, shad, soft shelled clams, grass shrimp, and Atlantic sturgeon, the Bay now experiences annual dead zones and its formerly lush and widespread meadows of seagrass are fewer and far between. Meanwhile, on the land, within the Bay watershed in Maryland, our forests are declining again after a half century of steady regrowth, and our agricultural heritage continues to disappear.

The decline of our natural and rural resources is caused by a variety of reasons, including common development practices that consume large amounts of land for each new home, lack of sufficient control of some sources of pollution, barriers to growth within our historic towns and cities, and disparate levels of sound land use planning. Lastly, new threats from climate change—including sea-level rise, precipitation changes and worsening storms—are beginning to impact our quality of life and natural resources and are expected to worsen over time.

Despite these losses, Marylanders still have much natural heritage to enjoy, both on the land and within our waters. Wise fishery management methods over the last decade have brought back striped bass, increased blue crab harvests, and are giving renewed hope to oyster restoration. New stormwater management requirements and wastewater treatment plant technologies are reducing the impact from development to our streams and rivers. Many thousands of acres of farms, new parks, and natural areas have been conserved. Smart growth and historic preservation efforts have reinvigorated many of our towns and cities and have slowed the loss of our rural landscape.

We're at a crossroads in many respects. The federal government, recognizing the failure of voluntary efforts to fully restore the Chesapeake Bay, initiated a new accountability framework in 2010: now, each Bay State must develop and implement a watershed implementation plan, and must meet 2-year short-term milestones and complete implementation of restoration measures no later than 2025. Within Maryland, after 10 years of smart growth efforts, despite some significant successes, there is widespread recognition that much more needs to be done if we are to significantly stem the loss of our rural resources and reverse the decline of many of our cities and towns. Recent innovative responses, such as

Maryland's Chesapeake Bay Watershed Implementation Plan, BayStat, the Maryland Sustainable Growth Commission, PlanMaryland, and the Task Force on Sustainable Growth and Wastewater Disposal raise hope that we can find and implement measures to sustain our existing wealth and achieve a more plentiful future for our families and children.

The Task Force on Sustainable Growth and Wastewater Disposal was born out of recognition that outdated wastewater technologies—septic systems—are one of the few nitrogen pollutant sources in Maryland that continues to increase and which often supports wasteful land development practices outside of our sewered areas. If left unchecked, such practices could undermine Maryland's Bay restoration, smart growth, and sustainability efforts. Maryland's population continues to grow and is expected to increase by 1 million people by 2035. Implementing protective measures now will ensure that the land use and pollution impact of future Marylanders is minimized, giving us the greatest chance of success in restoring the Chesapeake Bay and protecting our rural landscape.

Governor Martin O'Malley created the Task Force on Sustainable Growth and Wastewater Disposal in April 2011 through Executive Order 01.01.2011.05. The charge of the Task Force was to "recommend regulatory, statutory, or other actions to address the impacts of major developments on septic systems and their effects on nutrient pollution, land preservation, agri-business, and smart growth" to the Governor and the General Assembly.

Members of the Task Force and Workgroups

The Task Force included 28 members from across Maryland, representing the full spectrum of interested stakeholders. These include:

- Task Force Chair, Delegate Maggie McIntosh of Baltimore City, Chair of the House Environmental Matters Committee
- Task Force Vice Chair, Jon Laria, partner in the law firm of Ballard Spahr and Chair of the Maryland Sustainable Growth Commission
- Erik Fisher, land use planner with the Chesapeake Bay Foundation
- Fred Tutman, Executive Director of the Patuxent Riverkeeper and member of the Patuxent River Commission
- Robert Mitchell, Director of the Environmental Programs Division of Worcester County
- C.R. Bailey, Vice President of Marrick Properties
- Madison "Jimmy" Bunting, Jr., Worcester County Commissioner
- Rob Etgen, Executive Director of the Eastern Shore Land Conservancy
- Pat Langenfelder, President of the Maryland Farm Bureau

- Richard Hutchison, Talbot County farmer
- Jim Rapp, Executive Director of Delmarva Low-Impact Tourism Experiences
- Robert Sheesley, owner of Eco-Sense Inc. environmental consultancy
- Dr. Kelton (Kelly) Clark, Director of the Morgan State University Estuarine Research Center in St. Leonard and Chair of the Patuxent River Commission
- Brian Hammock, attorney, Venable LLC
- Robin Truiett-Theodorson, member and former President of the Abell Improvement Association in Baltimore City
- State Senator Paul G. Pinsky of Prince George's County, lead sponsor of SB 846
- Senator David R. Brinkley of Frederick County
- Delegate Steve Lafferty of Baltimore County, lead sponsor of HB 1107
- Richard Eberhart Hall, Secretary of Planning
- Robert M. Summers, Secretary of Environment
- Earl (Buddy) Hance, Secretary of Agriculture
- John Griffin, Secretary of Natural Resources
- Margaret McHale, Chair of the Critical Area Commission
- David Carey, Bel Air Mayor (representing the Maryland Municipal League)
- Joe Adkins, Frederick City Planning Director (representing the Maryland Municipal League)
- Katheleen Freeman, Caroline County Planning Director (representing the Maryland Association of Counties)
- Chris Trumbauer, Anne Arundel County Councilman (representing the Maryland Association of Counties)
- Russ Brinsfield, Executive Director of the Harry R. Hughes Center for Agro-Ecology in Queenstown

In addition, the Task Force Chair created four workgroups, which were open to all interested parties, and also included specific Task Force members, to develop recommendations for the Task Force to consider. Each workgroup met at least four times. The four workgroups included:

- Existing Infrastructure & Available Technologies (Infrastructure Workgroup), Chair, MDE Secretary Summers
- Impact of Agriculture and Agricultural Land Values (Agricultural Workgroup), Chair, MDA Secretary Hance
- Where and How we Grow in Maryland (Growth Workgroup), Chair, MDP Secretary Hall
- Funding Sustainable Communities and Growth (Funding Workgroup), Chair, DNR Secretary Griffin

State agency staff from MDP, MDE and DNR supported the work of the Task Force and its workgroups. Agendas, meeting minutes, workgroup reports and presentations given to the Task Force and workgroups were posted online on the MDP website at http://planning.maryland.gov/YourPart/septicsTF/septicsTaskForce.shtml

Role of the Maryland Sustainable Growth Commission

Recognizing that there is some overlap of the mission of the Maryland Sustainable Growth Commission with the focus of the Task Force, the Executive Order required the Task Force to coordinate with the Maryland Sustainable Growth Commission, including holding at least two joint meetings with the Commission to coordinate on issues of mutual interest. Two joint meetings were held on September 12 and October 25. The Task Force acknowledges the work of the Concentrating Growth Workgroup of the Maryland Sustainable Growth Commission, which has developed recommendations that would limit the land consumption and overall pollution impact of new development in Maryland. Their recommendations can be found at: http://planning.maryland.gov/YourPart/773/MSGC_Meetings.shtml

Decision-Making Process

The Task Force met ten times from July 2011 through November 2011. Each workgroup met at least four times. State and local government officials, along with researchers and specialists, presented information to the Task Force, specifically those items listed in Section E of Executive Order 01.01.2011.05. The workgroups met and were first tasked with the following: list the impediments to a consensus on principles contained within HB1107 (2011 legislative session), identify the resources needed to move toward a consensus, and outline the direction and early recommendations achieved. Each workgroup was given a list of topics, which were raised by Task Force members as important issues during its first meeting, to use to frame their discussions. Over the course of several meetings, the workgroups identified areas of consensus and areas without consensus in response to the Task Force Chair's request. The areas of consensus and without consensus, with background information, were summarized in the October 25, 2011 workgroup reports at http://planning.maryland.gov/PDF/YourPart/septicsTF/20111025/allWGprogressreports102511.pdf. The workgroup's final recommendations were presented to the Task Force, discussed and voted upon.

Recommendations

Recommendation	Vote
Priority Funding Areas (PFAs) Seek funding for Priority Funding Areas (PFAs) to ensure that essential infrastructure (e.g., roads, schools, water/ sewer, emergency services) and amenities are in place to meet new growth needs, although priority should be given to essential infrastructure. Require the State to update the statewide infrastructure needs assessment on a regular basis with prioritization by the State based on projected growth and available funding. Provide enhanced functionality to PFAs and create incentives for redevelopment.	**Approved**
Building Code Streamline State building code to further encourage redevelopment, reuse and renovation (i.e., Smart Codes II) within PFAs.	**Approved (Senator Brinkley opposed)**
Regulatory Relief Encourage and assist local governments in instituting "green tape" or "fast track" processes to facilitate the development and review process within designated growth areas. Federal, state and local governments should consider clear procedural and regulatory advantages for growth within designated growth areas. The State legislature and State agencies, in partnership with local government, should identify barriers to growth in PFAs and consider recommendations to overcome those barriers.	**Approved (Senator Brinkley opposed)**
Comprehensive Plan Tier Approach Local jurisdictions should designate areas within the land use plan of the local comprehensive plan into one of four tiers as described below. Wastewater disposal methods, rural preservation spending, and other criteria will vary by land use tier.	**Approved (Senator Brinkley and Commissioner Bunting opposed)**

Any increase in load must be fully offset and the site would need to be covered under a Maryland Department of Environment discharge permit to protect water quality based on best science.	**Approved**
Tier I definition: PFAs per the 1997 law. Generally these are local growth areas.	**Approved**
Tier I provision regarding wastewater disposal: PFAs should be on public water and sewer unless there are exceptions or provisions in current law.	**Approved**
Tier II definition: Designated growth area outside of the PFA, that is clearly defined in the county or municipal comprehensive plan (including clear delineation on land use plan maps). Require designation of timeframes for when Tier II areas are phased for growth. Require infrastructure capacity analyses for Tier II areas similar to those required in the Municipal Growth Element.	**Approved**
Tier II provision regarding wastewater disposal: Method of wastewater disposal driven by availability of central sewer. To the extent possible, these areas should be sewered. When not possible, a good faith effort should be made to obtain capacity from adjacent WWTPs.	**Approved**
Tier II provision regarding contiguity of growth areas: Preference for Tier II areas to provide contiguous growth where possible.	**Approved (Senator Brinkley, Commissioner Bunting and Katheleen Freeman opposed)**
Tier III definition: Existing areas not planned for public sewer nor planned for preservation, with a limited amount of development potential. These areas should not be considered for State land preservation funding in most cases.	**Approved (C.R. Bailey, Bob Mitchell, Commissioner Bunting, and Rich Hutchison opposed)**

Tier III provision regarding wastewater disposal: Tier III areas should be most restrictive with respect to development on septics with exceptions developed for rural villages (these include both the State and local definitions). **Tier IV definition:** Areas planned for rural protection: Rural Legacy Areas, Priority Preservation Areas, GreenPrint Areas, County Agriculture Zones and County conservation zoning districts. In some cases, these areas might overlap with the Critical Area. **Tier IV provision regarding wastewater disposal:** Tier IV areas should have the most restrictions on growth on septic systems.	**Approved** **Approved** **Approved (Senator Brinkley and Commissioner Bunting opposed)**
Septics that Must Include Best Available Technology (BAT) Septics that must include BAT: New construction in Chesapeake and Coastal Bays Watersheds; New construction in other N impaired watersheds; Replacement systems in Critical Areas "New construction" includes an alteration of any residence or building where it is determined that the existing OSDS is not adequate to serve the proposed altered building. BAT not required for replacement of an existing septic system outside of the critical areas except as to accommodate new construction.	**Approved (Senator Brinkley and C.R. Bailey opposed)**
Implement Operation and Maintenance (O&M) Regulations for BAT Include provisions to ensure compliance; Ensure O&M for life of system; County oversight of O&M, or management by a manufacturer certified/registered BAT service provider, or management by a homeowner that has obtained certification to maintain their own system.	**Approved (Senator Brinkley opposed)**
Controlling Authority for Shared or Community Systems Allow the use of shared and community systems for new	**Approved**

subdivisions provided that there is a controlling authority approved by MDE, including a county, a municipality, a sanitary district, Maryland Environmental Service, etc.	
Retirement of Development Rights The State should work with EPA to allow landowners who voluntarily retire development rights to qualify for selling nutrient trading credits. This will require certified nutrient reduction for guaranteed nutrient reduction longer term (i.e. long-term offsets), instead of just a pollution prevention program.	**Approved (Senator Pinsky, Fred Tutman and Erik Fisher opposed)**
Timeframe to Exercise Lots If the state were to impose new restrictions limiting the number of new lots on septic development, landowners should not have a defined timeframe to exercise the maximum lots allowed.	**Approved**
Estate Tax Reform Work for estate tax reform so that farms will continue to remain in agriculture and therefore reduce the possibility of development in rural areas. This should be put forward as a separate piece of legislation.	**Approved**
Transferable Development Rights (TDR) Pilot The State should consider sponsoring a TDR interjurisdictional pilot project for which a County and municipalities or together with other counties can volunteer. MDP could offer its insights and assistance, and the State could offer funding, if needed, for a consultant to do local market studies to help determine sending and receiving rates.	**Approved**
Impact on Agricultural Production The State should study the effect on prime farmland of reforestation/afforestation regulations, mitigation requirements for habitat and wetland loss, best management practices, etc. Many acres are taken out of agricultural production to accommodate these programs, laws and regulations.	**Approved**
Bay TMDL Deadline Extension Extend Maryland's timeframe for meeting its TMDL	**Approved**

obligations from 2020 to the 2025 date required by EPA with additional accountability measures.	
Increase BRF Revenue Increase BRF revenue as follows in order to cover existing shortfall in major WWTP ENR upgrades and essentially close the funding gap for implementing other WIP requirements from developed lands: ● Increase average annual residential fee rate to $60/year/dwelling unit beginning in SFY13 and $90/year/dwelling unit beginning in SFY15. Increase average non-residential fee rates and cap accordingly. ● Annually increase the residential and commercial fee rates to equal to the Consumer Price Index (CPI) beginning in SFY16. There will be an annual increase minimum of 1% and annual increase maximum of 3%. ● Conduct a thorough evaluation of progress to date in 2017 and restructure the fee rates accordingly if progress to meet our TMDL obligations by 2025 is not being met. ● Sunset the rate increases back to an average annual residential fee of $30/year/dwelling unit beginning in 2030 if TMDL obligations are met and any remaining debt is retired: or consider eliminating the fee entirely. Sunset average non-residential rates and cap similarly.	**Approved (Senator Brinkley opposed)**
Revise Authorized Uses of the BRF Fund Amend BRF enabling statute to permit funding of stormwater retrofits as an authorized use of the BRF funds. Amend the BRF enabling statute to permit use of the fund for technical assistance grants to local governments for the purpose of providing planning, design and project management support for implementation projects which reduce sediment and nutrients from urban lands that are consistent with accepted Chesapeake Bay TMDL watershed implementation plans.	**Approved**

Maximize Cost Effectiveness Maximize cost effectiveness and efficiencies of state-funded projects utilizing BRF revenue through competition, targeting, and leveraging funds: ● BRF funds should be awarded to local governments through a competitive process in which awards are determined primarily on the goal of maximizing the pounds of nitrogen, phosphorus, and sediment reduced per state dollar expended. ● Pounds of nitrogen, phosphorus, and sediment reduced for septic systems and stormwater projects should be based on scientifically defensible analysis of watershed areas with the highest septic or stormwater loads and immediacy of delivery of nutrients to the Bay. Maps resulting from the above two analyses should be published and made readily available to applicants. ● Competitive grants for 10 major/minor WWTPs upgrades to ENR should be prioritized based first on those areas of the State in which growth is projected to occur without the availability of public sewer, and secondarily on resulting nitrogen, phosphorus, and sediment reduction benefits.	**Approved (Senator Brinkley opposed)**
Expenditure of BRF Funds Change the current 100% BRF funding requirement for failing septic systems in the Critical Area to match the income based scale currently used for septic systems outside of the Critical Area. The State should provide between 25% - 100% of upgrade to BAT dependent upon income. The State should continue to provide $13,000 (average cost of a BAT upgrade) toward connection of a failing septic system to an ENR WWTP. State should provide up to 50% cost share for stormwater retrofit projects based on the above competitive priority ranking system (See *Maximize Cost Effectiveness* recommendation above).	**Approved**

State should continue to allow up to 10% of total BRF revenue to go to ENR WWTP operations and maintenance, but with a cap of $5 million per year.	
Exception Process The Workgroup recommends that MDE and MDP develop an exception process, and recommend the necessary statutory changes, to allow the use of BRF funds for septic hookups in areas outside a PFA where it is consistent with Smart Growth and Bay goals and will not result in sprawl development.	**Approved**
Option for Billing Authorities Provide billing authorities the option to base BRF fee structures on water usage (vs current flat rate) but not on income.	**Approved (Senator Brinkley and Bob Mitchell opposed)**
Guarantee Grants to Implement Stormwater BMPs Guarantee grants to local governments from the increased BRF to implement stormwater BMPs. Beginning in FY13, local governments will annually receive 15% of the non-cover crop BRF revenue generated in their jurisdiction for implementation of approved stormwater BMPs as per conditions below. Beginning in FY18, and subject to recommendations of the BRF Advisory Committee in 2017, the percentage that local governments will annually receive will increase to 25% of the gross BRF revenue generated in their jurisdiction. Submission by local governments and subsequent approval by MDE of an annual implementation plan. Projects identified in the implementation plan must: ● be limited to implementation of authorized stormwater BMPs for meeting Phase II WIP requirements ● be targeted by practice and geography to realize greatest nitrogen, phosphorus, and sediment benefits to the bay per state dollar as identified in State targeting protocols	**Approved (Senator Brinkley opposed)**

• include no more than 1.5% administrative overhead. Funds will be received by the Comptroller's Office via the billing authorities as per current practice, and then reallocated to the local jurisdictions consistent with above conditions. There is no match requirement for jurisdictions to receive the funds. Jurisdictions may use the received funds as match for state funded projects (see below). The remaining 85% (beginning in FY13) and 75% (beginning in FY18) non-cover crop BRF revenue retained by the State will be allocated in the following priority: • completion of ENR upgrades to the remaining six major WWTP plants and retirement of associated debt obligation • to local jurisdictions through a competitive and targeted process for: o upgrades of major/minor WWTPs o septic system upgrades to BAT o septic system connections to WWTPs, and o stormwater BMPs. • Funds will be granted on a competitive and targeted process based on nutrient and sediment benefits to the bay per state dollar as per the *Maximize Cost Effectiveness* and *Expenditure of BRF Funds* recommendations above. A portion of the state retained funds should also be reserved to provide technical assistance to local governments for BMP implementation. The Maryland Association of Counties and Maryland Municipal League will develop and recommend by mutual agreement how the grants for stormwater retrofits shall be distributed to municipalities.	
Maryland Environmental Service The Funding Workgroup recommends pursuing with	**Approved**

Maryland Environmental Service several statutory changes to streamline and clarify their current authorities to assist local governments in implementing the urban practices addressed in the workgroup report.	
Reduction of the BRF Fee The Funding Workgroup recommends that any statutory change authorizing an increase in the BRF fee structure also authorize regulations to be developed by MDE that allow for reduction of the BRF fee to individual property owners based on implementation of approved stewardship practices that reduce nutrient and sediment loads to the Bay. A working group consisting of representatives of state government, local governments, and non-government interests should develop specific implementation proposals and submit to MDE by July 1, 2012 for consideration and promulgation of regulations. The goal of the resulting regulations should be to provide a system of credits for existing best practices and the implementation of new practices that minimize impacts to the Bay.	**Approved**
BNR Upgrades for Major-Minor Plants Expand BRF funding to include the state's 50% share of BNR upgrade costs for 10 major-minor plants that are targeted by the State for subsequent ENR upgrades.	**Approved**

The table below provides an estimate of the local government allocations for stormwater BMPs available through implementation of the *Guarantee Grants to Implement Stormwater BMPs* recommendation:

Table 1. Estimated Local Government Allocations for Stormwater BMPs

By County Geography	FY10 BRF Revenue[1]		Estimated Cumulative Allocations[2]		
	$ Generated	% of Statewide Total	FY13 - FY17 (15%)	FY18 - FY25 (25%)	Total FY13 – FY25
Allegany	$1.0 M	1.51%	$2.0 M	$6.8 M	$8.7 M
Anne Arundel	$6.0 M	9.21%	$12.1 M	$41.1 M	$53.2 M
Baltimore County	$10.5 M	16.29%	$21.4 M	$72.7 M	$94.1 M
Baltimore City	$6.5 M	9.97%	$13.1 M	$44.5 M	$57.6 M
Calvert	$0.7 M	1.11%	$1.5 M	$4.9 M	$6.4 M
Caroline	$0.3 M	0.49%	$0.7 M	$2.2 M	$2.9 M
Carroll	$1.5 M	2.38%	$3.1 M	$10.6 M	$13.7 M
Cecil	$1.0 M	1.55%	$2.0 M	$6.9 M	$8.9 M
Charles	$1.4 M	2.22%	$2.9 M	$9.9 M	$12.8 M
Dorchester	$0.5 M	0.79%	$1.0 M	$3.5 M	$4.6 M
Frederick	$2.4 M	3.65%	$4.8 M	$16.3 M	$21.1 M
Garrett	$0.5 M	0.70%	$0.9 M	$3.1 M	$4.0 M
Harford	$2.5 M	3.86%	$5.1 M	$17.2 M	$22.3 M
Howard	$3.2 M	4.89%	$6.4 M	$21.8 M	$28.3 M
Kent	$0.3 M	0.43%	$0.6 M	$1.9 M	$2.5 M
Montgomery/P.G.	$19.8 M	30.65%	$40.3 M	$136.8 M	$177.1 M
Queen Anne's	$0.6 M	0.86%	$1.1 M	$3.8 M	$5.0 M
St. Mary's	$1.1 M	1.63%	$2.1 M	$7.3 M	$9.4 M
Somerset	$0.3 M	0.39%	$0.5 M	$1.8 M	$2.3 M
Talbot	$0.6 M	0.85%	$1.1 M	$3.8 M	$4.9 M
Washington	$1.6 M	2.51%	$3.3 M	$11.2 M	$14.5 M
Wicomico	$1.2 M	1.85%	$2.4 M	$8.3 M	$10.7 M
Worcester	$1.4 M	2.21%	$2.9 M	$9.9 M	$12.8 M
	$64.7 M	**100.00%**	**$131.5 M**	**$446.2 M**	**$577.7 M**
% of Stormwater BMP Funding Goal[3]:			**8%**	**27%**	**35%**

NOTES:

[1] Represents total FY10 BRF revenue generated by county geography minus portion allocated by statute to cover crop implementation.

[2] Estimates are based on, 1) BRF revenue increases as per *Increase BRF Revenue* Recommendation and 2) FY10 BRF revenue distribution by county geography.

[3] Estimate is based on stormwater BMP funding goal of $1.64 B (Phase 1 and Phase 2 MS4 retrofits on 262,000 acres at a state-share cost of $6,250/acre).

State of Maryland

Martin O'Malley
Governor

Anthony G. Brown
Lt. Governor

DRAFT FINAL REPORT (October 10, 2011)

Ref. No. [UMCES] CBL 11-043

Costs of Stormwater Management Practices In Maryland Counties

Prepared for

Maryland Department of the Environment

Science Services Administration

(MDESSA)

By

Dennis King*and Patrick Hagan

University of Maryland

Center for Environmental Science

(UMCES)

October 10, 2011

*** For questions or comments contact Dennis King at dking@umces.edu**

UNIVERSITY OF MARYLAND

CENTER FOR ENVIRONMENTAL SCIENCE

CHESAPEAKE BIOLOGICAL LABORATORY

P.O . BOX 38, SOLOMONS, MD 20688

Technical Report Series No. TS-626-11 of the University of Maryland Center for Environmental Science

Table of Contents

List of Tables and Figure

1. Executive Summary

This report develops and presents planning level unit cost estimates for implementing stormwater best management practices (SWBMPs) in Maryland counties. These unit costs are expressed as costs per acre of impervious area treated and are estimated here for SWBMPs specified in MDE's recently released Maryland Assessment and Scenario Tool (MAST). The SWBMP unit costs presented here can be used with county MAST output to compare combinations of SWBMPs based on their costs as well as their potential contribution to meeting county TMDL targets. They are "planning level" in the sense that they are intended to be generally accurate when averaged across the state of Maryland and across Maryland counties. Actual SWBMP costs, however, depend in critical ways on site and landscape conditions, project design characteristics, project scale, land costs, level of urbanization, and other factors that differ significantly from one Maryland county to another. Therefore, the tables of planning level pre-construction, construction, and post-construction cost estimates that are presented in the report are followed by tables of county-specific cost adjustment factors. Individual counties may choose to use these adjustment factors so that unit cost estimates better represent their county conditions.

The report also provides links to an MDE website where Excel spreadsheet programs that contain the same tables of cost estimates that are provided in this report are in a format which allows users with more reliable county-level or site-specific SWBMP cost data to adjust (override) component cost estimates and to generate their own county-level unit cost estimates for one or more SWBMPs. This report includes an appendix that provides guidance regarding which county-specific factors influence SWBMP costs, presents quantitative and qualitative indicators of how important they are, and illustrates how some of them differ from one region of the state of Maryland to another.

Table ES-1 (the next page) presents planning level estimates of pre-construction, construction, and post-construction costs, and life cycle and annualized life cycle costs <u>per impervious area treated</u> for each SWBMP. Maryland counties with no better cost estimates can use these default cost estimates as they appear, or adjust them based on the data and guidance provided. Counties with better cost data should use them to override some or all of the input costs used in the cost estimating spreadsheets that generated the planning level costs presented in Table ES-1, and generate their own county-specific unit cost estimates.

To be useful for planning purposes, counties need estimates of overall county costs associated with combinations of SWBMPs that are under consideration. For this purpose the unit cost estimate for each SWBMP in Table ES-1 needs to be multiplied by the number of acres a county is considering treating with that SWBMP (e.g., from MAST), and the results need to be summed for all SWBMPs being considered. It is important to note, however, that the cost of county projects within each SWBMP category may range higher and lower than the (average) planning level unit costs presented in this paper. This means that while the costs provided here are suitable for general planning purposes, they should not be used to judge the costs of all project options within any SWBMP category. Developing a cost-effective or "optimal" mix of county SWBMPs, and a budget strategy to pay for them, will require costing out specific project options within each SWBMP category. The spreadsheet programs that accompany this report should be useful as a standard framework for that more detailed cost analysis.

DRAFT FINAL REPORT (October 10, 2011)

Table: Executive Summary-1 (ES-1)

Table ES-1. Summary Unit Planning Level Stormwater Cost Estimates Per Impervious Acre Treated

Stormwater Management Practice	Pre-Construction Costs[1]	Construction Costs[2]	Land Costs[3]	Total Initial Costs	Total Post-Construction Costs[4]	Total Costs over 20 Years	Average Annual Costs over 20 Years
Impervious Urban Surface Reduction	$ 8,750	$ 87,500	$ 50,000	$ 146,250	$ 885	$ 163,957	$ 8,198
Urban Forest Buffers	$ 3,000	$ 30,000	$ -	$ 33,000	$ 1,210	$ 57,207	$ 2,860
Urban Grass Buffers	$ 2,150	$ 21,500	$ -	$ 23,650	$ 870	$ 41,057	$ 2,053
Urban Tree Planting	$ 3,000	$ 30,000	$ 150,000	$ 183,000	$ 1,210	$ 207,207	$ 10,360
Wet Ponds and Wetlands (New)	$ 5,565	$ 18,550	$ 2,000	$ 26,115	$ 763	$ 41,368	$ 2,068
Wet Ponds and Wetlands (Retrofit)	$ 21,333	$ 42,665	$ 2,000	$ 65,998	$ 763	$ 81,251	$ 4,063
Dry Detention Ponds (New)	$ 9,000	$ 30,000	$ 5,000	$ 44,000	$ 1,231	$ 68,620	$ 3,431
Hydrodynamic Structures (New)	$ 7,000	$ 35,000	$ -	$ 42,000	$ 3,531	$ 112,620	$ 5,631
Dry Extended Detention Ponds (New)	$ 9,000	$ 30,000	$ 5,000	$ 44,000	$ 1,231	$ 68,620	$ 3,431
Dry Extended Detention Ponds (Retrofit)	$ 22,500	$ 45,000	$ 5,000	$ 72,500	$ 1,231	$ 97,120	$ 4,856
Infiltration Practices w/o Sand, Veg. (New)	$ 16,700	$ 41,750	$ 5,000	$ 63,450	$ 866	$ 80,770	$ 4,039
Infiltration Practices w/ Sand, Veg. (New)	$ 17,500	$ 43,750	$ 5,000	$ 66,250	$ 906	$ 84,370	$ 4,219
Filtering Practices (Sand, above ground)	$ 14,000	$ 35,000	$ 5,000	$ 54,000	$ 1,431	$ 82,620	$ 4,131
Filtering Practices (Sand, below ground)	$ 16,000	$ 40,000	$ -	$ 56,000	$ 1,631	$ 88,620	$ 4,431
Erosion and Sediment Control	$ 6,000	$ 20,000	$ -	$ 26,000	$ 10	$ 26,207	$ 1,310
Urban Nutrient Management[5]	$ -	$ 61,000	$ -	$ 61,000	$ 31	$ 61,620	$ 3,081
Street Sweeping[6]	$ -	$ 6,049	$ -	$ 6,049	$ 451	$ 15,079	$ 754
Urban Stream Restoration	$ 21,500	$ 43,000	$ -	$ 64,500	$ 891	$ 82,320	$ 4,116
Bioretention (New - Suburban)	$ 9,375	$ 37,500	$ 3,000	$ 49,875	$ 1,531	$ 80,495	$ 4,025
Bioretention (Retrofit - Highly Urban)	$ 52,500	$ 131,250	$ 3,000	$ 186,750	$ 1,531	$ 217,370	$ 10,869
Vegetated Open Channels	$ 4,000	$ 20,000	$ 2,000	$ 26,000	$ 610	$ 38,207	$ 1,910
Bioswale (New)	$ 12,000	$ 30,000	$ 2,000	$ 44,000	$ 931	$ 62,620	$ 3,131
Permeable Pavement w/o Sand, Veg. (New)	$ 21,780	$ 217,800	$ -	$ 239,580	$ 2,188	$ 283,347	$ 14,167
Permeable Pavement w/ Sand, Veg. (New)	$ 30,492	$ 304,920	$ -	$ 335,412	$ 3,060	$ 396,603	$ 19,830

[1] Includes cost of site discovery, surveying, design, planning, permitting, etc. which, for various BMPs tend to range from 10% to 40% of BMP construction costs.

[2] Includes capital, labor, material and overhead costs, but not land costs, associated implementation; for street sweeping includes only capital cost of mechanical sweeper. Nutrient management construction costs refer to the cost of an outreach campaign, not to any construction costs.

[3] For all stormwater BMPs that require land it is assumed that: 1) the opportunity cost of developable land is $100,000 per acre and 2) 50% of projects that require land take place on developable land with the rest taking place on land that is not developable. This brings the opportunity cost of land for stormwater BMPs that require land to $50,000 per acre. Actual county-specific land cost and percent developable land values can be filled in.
NOTE: The area of some BMPs may be significantly less than the impervious area treated.

[4] Combined annual operating, implementation, and maintenance costs.

[5] Best available data indicate that "retail" (i.e., direct mail) public outreach campaigns cost about $15 per household contacted. For an illustrative county, we assumed that each household has 5,941 sq ft of turf and 2,406 sq ft of impervious cover (medium density development). This means that 7.33 households need to adopt this BMP to potentially result in an acre of turf being treated, at a cost $109.98 per turf acre. Based on a review of direct mail response rates, we assumed that 2% of households contacted will respond positively to this outreach effort, bringing the cost per turf acre treated to $5,497.50/acre. The equivalent on a per-impervious-acre was based on the MDE June 2011 stormwater guidance document, which provides an equivalent for this practice of .09 acres impervious area per one acre of this practice. This estimate does not include any additional costs for soil tests by the homeowner to determine the appropriate amount of fertilizer required.

[6] Capital acquisition cost per impervious acre treated.

2. Introduction

In July, 2011, the Maryland Department of Environment Science Services Administration (MDESSA) commissioned a research team from the University of Maryland Center for Environmental Science (UMCES) to develop "planning level" unit cost estimates of stormwater best management practices (SWBMPs) that Maryland counties can use to help determine the appropriate role of SWBMPs in county Watershed Implementation Plans (WIPs). The goal was to develop cost estimates that represent the average cost of SWBMPs across the state, and to present them in a way that would make them useful for assessing SWBMPs at the county scale. The project was designed to generate useful results by September 1, 2011, in order to give Maryland counties time to use them as they prepare their WIPs to meet the November 18, 2011, deadline for submitting them to MDE.

This report describes and presents the results of that research and includes tables of planning level pre-construction, construction, and post-construction cost estimates for each of the SWBMPs included in MDE's recently released Maryland Assessment and Scenario Tool (MAST). It also provides sets of county adjustment indices that can be used to modify the costs presented in the tables to better reflect county conditions, and presents links to an MDE website that includes the cost tables presented in this report as Excel spreadsheets that allow users in Maryland counties to modify (override) any of the cost estimates provided in this report if and when more reliable county-specific cost data or location-specific cost information are available. The report also presents tables and provides links to spreadsheet tools that show how unit cost estimates can be used with MAST output to generate planning level estimates of overall annual county SWBMP costs, and how those annual cost estimates can be used with other county data to assess county economic impacts of two illustrative county stormwater financing options -- increasing county property taxes and establishing stormwater or impervious area fees.

3. Background

Responsibility for implementing Maryland's Phase I Watershed Implementation Plan (Phase 1 MDWIP) for the Chesapeake Bay rests primarily with Maryland counties. Each Maryland county is currently preparing Phase 2 WIPs that describe the combination of Best Management Practices (BMPs) they plan to use to meet specific county-based Total Maximum Daily Load (TMDL) targets for nitrogen, phosphorus and sediment. These county WIPs are also expected to include estimates of WIP implementation costs and how counties plan to finance their WIPs.

MDE created a data/software program called MAST to help counties compare combinations of BMPs based on their ability to meet TMDL targets. MAST employs estimates of "BMP efficiencies" which are expressed as the "percent reduction in discharges expected per acre treated" for each EPA-approved BMP. For each county the MAST program presents BMP efficiencies for each approved BMP along with estimates of the number of acres that are available in the county to be treated by each BMP. The MAST program allows users in each county to enter the "percent of available acres" they are considering treating with each BMP, and examine how the resulting combination of BMPs will contribute to meeting the county's TMDL targets.

While MAST allows county users to compare potential combinations of BMPs based on their performance, it contains no cost information. Using MAST output to develop county WIPs with no consideration of costs could result in the development of WIPs that meet county TMDL targets, but are prohibitively costly or require spending patterns that are unacceptable. As a result, county users of MAST will need at least planning level estimates of BMP costs to supplement MAST output. It would be best if they could use these BMP cost estimates while they are using MAST in order to compare potential BMP combinations in terms of costs as well as performance before developing their WIPs.

Reliable planning-level unit cost estimates, expressed as costs per acre of impervious area treated (or equivalent), are available for most agricultural BMPs and for some urban BMPs. However, costs for urban SWBMPs vary more widely and are more site-specific and project-specific than the costs of most other BMPs. For this reason, the limited research that has been aimed at developing planning level unit cost estimates for SWBMPs has tended to be location-specific. Most of this research has not been based on experience in Maryland nor has it incorporated actual cost estimates or bids for stormwater projects undertaken in Maryland.

SWBMPs will be important and costly components of most Maryland county WIPs, and while some Maryland counties have sophisticated stormwater programs and highly reliable county-based stormwater cost estimates to work with, others do not. Maryland counties with highly developed stormwater programs also tend to have reliable cost estimates only for SWBMPs that have been used in those counties and not for the wider range of SWBMPs that may be considered. Also, some stormwater cost estimates that are available in some Maryland counties do not fully account for all pre-construction, post-construction, or land costs, or county costs associated with inspecting project sites and enforcing construction and maintenance standards.

The SWBMP costs presented in this report provide Maryland counties that do not have reliable costs with planning level cost estimates they can use. The cost estimating framework (and related spreadsheet programs) used to generate these planning level cost estimates provide those counties that already have reliable estimates of costs for some SWBMPs with a basis for evaluating them based on full cost accounting, and a basis for comparing them with costs of SWBMPs about which they may be less familiar.

4. Format

The following sections describe how planning level SWBMP unit costs were estimated, and how Maryland counties may want to adjust them to better reflect specific county conditions. Sets of tables are then presented that show the incremental development of unit cost estimates for each SWBMP, and illustrate how they can be used with MAST output to assess and compare WIP options. They also show how "rolled up" estimates of overall county costs for all SWBMPs can be used with other county data to evaluate the economic impact of two typical county funding strategies on county households, businesses, and other entities.

Presented with the cost development tables is the address of an MDE website that contains a set of linked Excel spreadsheets which individual counties can use to:

- **Modify** unit cost estimates for SWBMPs if they have better county-specific cost data;
- **Integrate** unit SWBMP cost estimates with MAST output to compare the cost and performance of SWBMP combinations being considered for county WIPs; and
- **Calculate** how county choices about financing alternatives will affect the distribution of county SWBMP costs among county households, businesses, and government entities. This last spreadsheet tool could also be expanded to assess how the creation of multicounty, state, or

federal funding mechanisms (e.g., user fees that are not county based) may reduce the county cost burden of implementing an effective combination of SWBMPs.

The section that includes tables of SWBMP unit costs is followed by sections that describe the cost data sources and approaches that were used to develop them; they also present important caveats that should be understood before using them, and describe some special considerations that should influence how they are used.

5. Focus

The cost estimating framework that was chosen focused on the development of planning level costs for each of the EPA-approved SWBMPs listed in Table 1a (which are the same ones used in the MAST model) and employed the cost categories listed in Table 1b. The aim was to provide full cost accounting, so Table 1b includes some often-overlooked pre-construction and post-construction costs associated with SWBMPs. Many available estimates of SWBMP costs are based on construction costs only, or consider only a subset of the pre-construction or post-construction costs listed in Table 1b. As a result, they can provide a misleading basis for assessing county costs and budget needs. Interviews with county stormwater managers and stormwater contractors, for example, indicate that pre-construction costs associated with locating and surveying potential sites and designing and permitting SWBMP projects can be half as much as actual construction costs. Post-construction costs associated with routine annual maintenance (e.g., debris removal) and intermittent maintenance needs (e.g., dredging every three to five years or so) can average as much as 4% to 7% of construction costs per year which, over twenty years, would be nearly equal to construction costs. Whether a SWBMP is undertaken on public or private land by a public or private entity, the county will incur routine annual costs associated with inspecting SWBMP sites during and after construction and enforcing site design, construction, and maintenance standards. Fines paid to counties for violations that are detected are typically not high enough to significantly offset these routine county SWBMP implementation costs and are not usually used for that purpose.

Most SWBMP cost estimates that are available in the literature do not consider the value of land required for some types of SWBMP projects. For some SWBMPs, such as urban tree planting, the market value of developable land diverted to the SWBMP can be significantly higher than all other project costs combined. However, the average value of developable land varies significantly among Maryland counties and can vary significantly within any given county depending on whether a project site is in a rural, suburban, urban, or ultra-urban setting,. Land dedicated to some SWBMPs, for example land directly adjacent to rivers or streams being used for grass or forested buffers or public park land, may not be developable and, therefore, may have no significant opportunity costs. On the other hand, some county-owned land dedicated to a SWBMP project, even though the county does not have to buy it, does have opportunity costs that are similar to those associated with private land that may be diverted from development to a SWBMP. A review of the relevant economics literature indicated that land costs, if there are any, should be included when estimating overall SWBMP costs if the land is developable and regardless of whether it is privately or publicly owned.

The cost-estimating framework used here develops full life cycle cost estimates based on the sum of initial project costs (pre-construction, construction and land costs) funded by a 20-year county bond issued at 3%, plus total annual and intermittent maintenance costs over 20 years. Annualized life cycle costs are estimated as the annual bond payment required to finance the initial cost of the SWBMP (20-year bond at 3%) plus average annual routine and intermittent maintenance costs.

6. Approach

The separate research tasks that were undertaken to estimate unit costs for SWBMPs in Maryland counties are listed in Appendix C. In general, however, the research approach took place in three stages as follows:

Stage 1: Review the results of previous studies that include estimates of SWBMP costs; apply SWBMP cost estimating software available from the Water Environmental Research Foundation (WERF) using regional R.S. Means U.S. Regional Construction Cost Indexes (January 2011) developed to represent Maryland counties; interview stormwater managers in nine Maryland jurisdictions, stormwater engineers and economists inside and outside of Maryland, and stormwater technology vendors operating in Maryland; and use results to develop preliminary sets of unit cost estimates for each SWBMP.

Stage 2: Employ face-to-face and phone interviews and email exchanges with Maryland county and municipal stormwater experts and consulting stormwater engineers and other stormwater experts to obtain additional cost information, and obtain reactions to the SWBMP unit costs developed during Stage 1.

Stage 3: Use "best professional judgment" to synthesize the results of Stage 1 and Stage 2 into best possible "planning level" estimates of unit costs for SWBMPs implemented in Maryland counties; have them reviewed by stormwater experts; modify them as needed based on their review comments, and present the results in the cost tables included in this report and in publicly available Maryland county SWBMP cost estimating spreadsheets.

7. Sources and Uses of SWBMP Cost Data

7.1. Sources of SWBMP Cost Data

The unit costs presented in this report are a result of a synthesis of cost data collected from the following sources:

- National literature review of published articles and reports from government and non-government organizations (with special emphasis on projects as close as possible to or in Maryland);
- Previously developed SWBMP cost databases and related quantitative models;
- Reviews of Maryland jurisdiction MS4 reports and supporting materials submitted to MDE;
- Interviews with Maryland local jurisdiction staff who manage stormwater and SWBMPs;
- Interviews with representatives of local non-profits who work on stormwater issues and private engineering and construction contractors who work on stormwater projects in Maryland;
- Applications of the Water Environmental Research Foundation (WERF) stormwater unit cost model using cost adjustment indicators developed for Maryland counties with MEANS 2011 Regional Construction Cost Indicators. This literature review and series of interviews informed all of our estimates of BMP unit costs.

Published and generally available articles and reports that contain SWBMP cost data used in the analysis are listed in the **Reference** section of this report; a list of individuals and organizations who provided cost data and insights about how to interpret them are listed in the **Acknowledgements** section.

7.2. Uses of SWBMP Cost Data

Some cost data were provided for specific stormwater projects or sets of stormwater projects; other cost data were available from Maryland counties as previously estimated total or average costs across tens or hundreds of stormwater projects. Most unit cost estimates were available on a per impervious area basis or could be easily converted to that metric. However, some reliable cost estimates were available for projects where information was available about the size of the project area or the volume of rainwater treated or the acres of drainage area treated, but there was no direct estimate of the impervious area treated. In those cases, an attempt was made during interviews to obtain estimates of the approximate impervious area treated or to use industry standard cost adjustment factors. Unit costs based on these relatively indirect methods were considered less reliable than those based on cost estimates where acres of impervious area treated were known. All available cost estimates from all sources were converted to 2011 dollars using MEANS construction cost adjustment indicators, and grouped together for purposes of comparison.

The different types, formats, and reliability of the cost data we collected (e.g., actual 2010 costs for a project in county X vs average costs for 960 projects over 15 years for county Y, and lists of bid prices for projects in county Z) did not allow unit SWBMP costs to be estimated based on any reliable type of statistical analysis. Instead, sets of cost data and cost estimates provided by experts were assessed and compared based on how many modifications were required to put them in a usable format, how consistent they were with one another, whether they were based on actual or estimated costs or bid prices, and best professional judgment about the reliability of the source and the source's experience or familiarity with each particular SWBMP. Preliminary cost estimates developed based on this synthesis of cost data were then presented to selected stormwater experts and finalized into the cost estimates presented in this report. This report and the cost estimates presented in it will be labeled *Final Draft* until county and industry stormwater experts have had time to review and comment on them and, possibly, provide advice about how they can be improved.

8. Research Results

Table 2a provides unit cost estimates associated with one-time pre-construction and construction tasks and land costs associated with each SWBMP; and Table 2b provides unit cost estimates associated with annual and intermittent maintenance costs and annual county implementation costs. Up-front BMP costs developed in Table 2a and annual costs developed in Table 2b are summed in Table 2c to generate estimates of total life cycle costs (over 20 years) and annualized costs (over 20 years) for each SWBMP.

For users in Maryland counties who have no better planning level cost estimates and no clear basis for adjusting those provided here, the last two columns of Table 2c, which provide life cycle costs and annualized costs for each SWBMP, will be most useful. For users in Maryland counties who have cost estimates they believe are more reliable, the component cost estimates presented in Table 2a and Table 2b will be a more useful focus. They show the specific pre-construction, construction, and post-construction cost estimates that were used to generate the overall costs estimates presented in Table 2c.

They can be used to identify and correct specific cost discrepancies (e.g. higher land costs, lower site discovery costs, etc.).

Linked excel spreadsheets of Tables 2a, 2b, and 2c are available at
http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/PhaseIIBayWIPDev.aspx

These linked SWBMP cost estimating spreadsheets allow users to easily change component costs in Tables 2a and 2b to generate new overall life cycle costs and annualized life cycle costs in Table 2c.

For those who do not have enough county-specific cost data to adjust the component cost estimates presented in Tables 2a and 2b, sets of county SWBMP cost adjustment factors are presented in Table 3a and Table 3b. Table 3a includes construction and implementation cost adjustment indices that were developed for each Maryland county based on MEANS cost adjustment tables for 13 Maryland locations, and also includes an overall county SWBMP cost adjustment index. That county SWBMP cost adjustment index is the ratio of the average county cost estimated for nine "typical" SWBMPs specified using the Water Environmental Research Foundation (WERF) stormwater cost software using the county MEANS cost adjustment indicators, and national average (unadjusted) costs estimated for those same SWBMPs using the WERF model.

Table 3b provides more detailed county cost adjustment indices that may be useful for counties that want to modify costs associated with specific types of SWBMPs. Table 3b presents a county cost adjustment index for each of the nine SWBMPs included in the WERF model for each Maryland county; these indices are the ratio of costs estimated for each SWBMP using the WERF model with MEANS county cost adjustment indices divided by the costs for each SWBMP estimate the same way using national average (unadjusted) costs.

The county SWBMP cost adjustment indices presented in Table 3a and Table 3b and the MEANS construction cost indices on which they are based account only for differences in project input costs among Maryland counties. They do not reflect the many other geo-physical, regulatory, and other differences among Maryland counties that could affect SWBMP costs. Table 4 lists some of the most important factors that could result in county costs being higher or lower than the cost estimates presented in Tables 2a, 2b, and 2c, based on factors other than those reflected in the indices presented in Tables 3a and 3b. These factors and their relative importance are described in more detail in Appendix B.

The **References** section of this report includes the names of some publications and reports that allow costs estimated for a typically sized SWBMP to be increased or decreased by a certain percent in situations (or in counties) where typical projects tend to be relatively large or small. Similar percentage adjustments can be applied to cost estimates based on differences in county land costs, site access, or the possibility that SWBMP projects can "piggyback" on other development or public works projects being undertaken at the same site. Although research for this report did not include an examination of how costs should be adjusted based on these factors, an overview of the direction and magnitude of their impacts on costs is included in Appendix B.

8.1. Illustrated Application of Cost Estimates with MAST Output

Table 5 shows how the SWBMP cost estimates presented in Table 2c can be used with county MAST output to compare combinations of SWBMPs based on cost and performance, and provide a basis for making practical decisions about the potential role of SWBMPs in county WIPs.

The sources and uses of the numbers in each of the columns presented in Table 5 are as follows:

Table 5, Columns 1, **2, and 3** include MAST output - the reduction in pounds (not percent) of nitrogen, phosphorous, and sediment discharges expected per acre treated by each SWBMP.

Table 5, Column 4 includes MAST output -- the number of acres that are available in the county to be treated using each SWBMP.

Table 5, Column 5 is the county's control variable – the percent of available acres the county is considering treating with each SWBMP.

Table 5, Column 6 is the actual number of acres treated – the product of Column 4 and Column 5.

Table 5, Column 7 contains the initial BMP cost per acre treated from Table 2a.

Table 5, Column 8 contains average annual maintenance costs per acre treated by each SWBMP from Table 2b.

Table 5, Columns 9 and 10 contain the total costs of the SWBMPs included in Column 6 expressed as Life Cycle Costs over 20 years and Annualized Total Costs.

In Table 5, overall reductions in discharges from any particular combination of SWBMPs are shown at the bottom of Columns 1 – 3, and overall costs of that combination of SWBMPs over twenty years and annualized are shown at the bottom of Columns 9 and 10. Reading across the bottom row of Table 5, therefore, allows users to examine both the performance (contribution to TMDL targets) and expected total dollar costs of the mix of SWBMPs specified by the user in Column 5. In the spreadsheet version of Table 5 the mix of SWBMPs can be adjusted easily, allowing users to examine "if-then" effects of different mixes of SWBMPs on costs and performance.

8.2. Using Overall Cost Estimates to Assess Financing Alternatives

The research on which this paper is based did not directly address county financing strategies for funding SWBMPs. However, Table 6 shows how an overall county SWBMP cost estimate developed in Table 5 might be used to evaluate potential cost impacts on county households, businesses, and government entities of two typical county funding sources – (1)increase in existing county property taxes and (2) a new stormwater or impervious area fee. Although only illustrative, Table 6 uses the results of a recent (2006) analysis by Anne Arundel County and some recent data regarding the value of appraised property and impervious area for that county to illustrate the potential impacts of stormwater financing alternatives to pay $60 million in annual stormwater management costs ($1.2 billion over 20 years).

For purposes of the illustration, assume the $60 million in hypothetical annual stormwater management costs was derived from integrated MAST and unit cost analysis as shown in Table 5. Assume further that based on some undefined cost sharing arrangement the county expects that 7% of county SWBMP costs will be paid by federal sources and 10% of county costs will be paid from state sources. Entering these percents as shown in Table 6 establishes that an annual county commitment of $50 million is required to implement the stormwater component of the county's WIP.

Based on data presented in Table 6 regarding the number of county households and businesses, annual property taxes, and impervious acres associated with various land uses, a user can estimate the general level of costs that will be incurred by county households, businesses, and governments if SWBMP costs are funded by increasing property taxes or by imposing an impervious area fee. The calculations shown in Table 6 are for illustration only. Although they are partly based on actual data from Anne Arundel County, Maryland these data have not been fully analyzed so the results shown may not provide a meaningful assessment of conditions in Anne Arundel County. Table 6 merely illustrates how each Maryland county can use county-specific results from Table 5 and county-specific population, land use, and economic data to assess and compare the county economic impacts of selected county SWBMP financing options.

9. Caveats and Special Considerations

This section describes some important caveats about using the SWBMP unit costs presented in this paper to assess and compare stormwater options for achieving county WIP targets. It also presents some general assumptions and rules of thumb that were used to develop specific cost estimates that may not be suitable for use in all situations. Where users have or can develop cost estimates based on assumptions or rules of thumb that better suit their situations, they are encouraged to use them. The SWBMP cost estimating spreadsheets available at http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/PhaseIIBayWIPDev.aspx make it relatively easy to make these adjustments.

9.1. Caveats

9.1.1. General

We relied as much as possible on cost data for Maryland projects, and adjusted cost data from other regions to reflect conditions in Maryland as much as possible based on advice from Maryland stormwater experts and contractors. Previous sections describe how unit cost estimates were developed, and the **References** and **Acknowledgements** sections at the end of this report provides information about data sources and previous studies that contributed to the cost results presented here.

Because actual SWBMP costs are very site-specific and can vary significantly from one Maryland county to another the planning level unit costs presented in this report are not suitable for assessing costs in specific situations. Differences in soil type, slope, and other landscape features and land use characteristics can cause costs associated with SWBMPs that are identical based on the criteria used to group projects in this report to differ significantly. The same can be said of differences in project scale, project design features, and county zoning and permitting conditions. The cost of implementing SWBMPs tends to be higher in areas with higher population densities because of logistical constraints as well as land values. Because of the limited availability and high cost of land in some urban or ultra-urban areas SWBMPs that appear to be affordable based on planning level cost estimates provided here (e.g., urban tree planting or vegetative swales) may be prohibitively costly in some settings. After several reexaminations of cost information and reviews by Maryland county stormwater experts we concluded that in the absence of more information about specific conditions we have no basis for adjusting the planning level cost estimates provided in this report up or down. With additional cost information this situation is likely to change which is why this report and the cost estimates in it are labeled Draft Final.

BMP Costs and BMP Efficiencies

Unit costs in this report are presented per acre of impervious area treated, not per pound reduction in nitrogen, phosphorus, or sediment deliveries to the Bay. Nutrient or sediment reductions expected from implementing a SWBMP with a low cost per impervious acre treated may not be significant resulting in it having a higher cost per pound reduction in nutrients or sediment deliveries than SWBMPs with much higher costs per area treated. It would be a mistake, therefore, to compare SWBMPs based on the unit costs presented in this paper without also comparing them on the basis of their effectiveness.

Table 5 illustrated how BMP efficiencies for SWBMPs provided in MAST can be used with unit costs presented in this report to determine the cost of the stormwater components of county WIPS. The information presented in Table 5 can also be used to compare the cost effectiveness of SWBMPs in terms of reducing nitrogen, phosphorus, and sediment discharges. Table 7 illustrates the importance of using estimates of both cost and effectiveness in making cost-effective comparisons using two hypothetical SWBMPs, one with low unit costs per impervious area treated and one with high per unit costs. In Table 7, the SWBMP with the lowest average unit cost per acre of impervious area treated is shown to be the lowest cost option for achieving reductions in nitrogen. However, the option with a highest average cost per impervious acre treated is shown to be the least cost option for treating phosphorous because it is much more effective at reducing phosphorus on a per acre basis than the lower cost SWBMP. Table 7 illustrates how using unit SWBMP costs per impervious area treated with MAST output that shows the relative efficiencies of those SWBMPs, as illustrated in Table 5, provides a suitable basis for making planning level cost-effectiveness comparisons of SWBMPs.

9.1.2. Cost Ranges within SWBMP Categories

The unit cost of SWBMPs presented in this report should be relatively accurate when aggregated to the state scale, or when used to represent average or typical SWBMP costs across the state. However, within the state and within counties, the cost of implementing any particular SWBMP will range around this (average) unit cost estimate with some favorable sites having lower than average costs and some unfavorable sites having higher than average costs. MAST output provides estimates of the acres available for treatment by each SWBMP. However, it is reasonable to assume that if the most favorable sites for a given SWBMP are selected the “marginal” cost of implementing any given SWBMP will increase from below average to above average as the percent of available acres treated increases.

The fact that the marginal cost of treating an additional available acre with a particular SWBMP may increase can have significant implications when considering the most cost-effective or “optimal” mix of SWBMPs for implementing county WIPS. This is illustrated in Figure 1 which presents overlapping marginal cost curves for three SWBMP which are each assumed to be applied first at favorable sites with relatively low costs, and then at less favorable sites at higher costs. As Figure 1 illustrates, it is possible, and in some cases likely, that applying SWBMPs with higher (average) unit costs at some sites will have costs that are lower than applying a SWBMP with a much lower average unit cost at some difficult and relatively costly sites. This is most likely to be true, for example, if a county has already implemented a SWBMP with a lower average cost on a large percentage of the most favorable available acres and has treated a relatively small percent of available with another SWBMP with higher average unit costs.

Figure 1 shows that the “optimal expansion path” for using SWBMPs to meet a county TMDL target is likely to be more complicated than treating the highest possible percent of available acres with the SWBMP that is shown in Table 2c to have the lowest average unit cost and then moving on to the SWBMP with the next highest average unit cost. A cost-effective or “optimal SWBMP expansion path” will probably involve a mix of SWBMPs that includes some SWBMPs with relatively high average costs implemented at favorable sites where costs are not only below average, but lower than the cost of above average cost of implementing a SWBMP with a lower average unit cost at the next available site.

9.2. Special Considerations

9.2.1. General

Construction costs for SWBMPs were estimated as described above, other costs were estimated as follows:

1. **Pre-construction Costs** (i.e., discovery, survey design, permitting, planning)
   Based on interviews, reviews of previous cost studies, and industry rules of thumb pre-construction costs were estimated to be between 10% and 40% of construction costs. After reviewing preconstruction cost data for actual and proposed projects and interviewing stormwater experts, best professional judgment was used to estimate preconstruction costs for individual SWBMPs at 10%, 20%, 30%, or 40% of estimated construction costs.
   The percentage used for each SWBMP is indicated in the appropriate frame of the cost spreadsheets available at:
   http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/PhaseIIBayWIPDev.aspx

2. **Land Costs**
   Although land costs vary widely across Maryland and within counties it was decided that not considering land costs for those SWBMPs that require commitments of land would be misleading. Therefore, for all SWBMPs that require land it was assumed that: 1) the opportunity cost of developable land is $100,000 per acre and 2) 50% of projects that require land take place on developable land with the rest taking place on land that is not developable. This brings the opportunity cost of land dedicated to SWBMPs that require land to $50,000 per acre. The cost estimating spreadsheets specify the assumed project acres for each SWBMP and allow users to change the market value of developable land from $100,000 per acre and change the percent of project area that is developable from 50% to arrive at more accurate county specific land cost estimates for each SWBMP. NOTE: For most SWBMPs the acres of impervious area treated is larger than the acres of land required to implement a SWBMP project so the contribution of land costs to unit cost per impervious acre treated (as shown in Table 2a) is usually lower than land value per acre.

3. **Post-construction Costs** (i.e., routine annual maintenance costs plus the average annual cost of intermittent maintenance tasks that are required approximately every 3 to 5 years.)

   Based on interviews, reviews of previous cost studies, and industry rules of thumb annual post-construction costs were estimated to be between 3% and 5% of construction costs, with most experts concurring that for most SWBMPs routine annual maintenance is usually around 2% and average annual intermittent maintenance costs is about the same. After reviews of actual project cost data and interviews with stormwater experts the percentages used to estimate post construction costs for each SWBMP were based on the best professional judgment and range from 0% to 3% for routine annual maintenance and from 0% to 3% (on an average annual basis) for intermittent maintenance.
   The percentage used for each SWBMP is indicated in the appropriate frame of the cost spreadsheets available at:
   http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/PhaseIIBayWIPDev.aspx

4. **Average Annual County Implementation Cost**
   County implementation costs are associated with county costs of inspecting SWBMP projects and enforcing design, construction and maintenance standards. The development of unit costs for county implementation was based on information provided by several Maryland jurisdictions and some cost estimates developed for jurisdictions outside Maryland. They are based on the annual cost of Full Time Equivalent (FTE) staff necessary to perform inspections and deal with enforcement issues (including direct and indirect salary, overhead, an automobile and expenses) and estimates of the annual number of SWBMPs a FTE can manage or is actually assigned to manage. We assumed that a FTE would not be assigned to specific SWBMPs, so we estimated costs per SWBMP to be the same for all SWBMPs. County implementation costs per impervious area treated will be different for different SWBMPs.

9.2.2. Cost Specific

Impervious Urban Surface Reduction:
Impervious urban surface reduction base construction costs include both concrete/asphalt removal and site restoration. Land costs are estimated based on one acre purchased per one impervious acre treated.

Urban Forest Buffers:
An adjustment factor for the amount of impervious acres treated was derived from the Maryland Department of the Environment NPDES Guidance document, June 2011, with 2.94 acres of buffer treating one acre of impervious area. In other words, the unit cost per impervious acre treated that we provide is roughly three times the cost we estimated to plant one acre. We assumed that the riparian land committed to the buffer would not be developable, so no land costs are included.

Urban Grass Buffers:
An adjustment factor for the amount of impervious acres treated was derived from the Maryland Department of the Environment NPDES Guidance document, June 2011, with 3.7 acres of buffer treating one acre of impervious area. In other words, our cost shown is roughly four times what we estimate it would cost to plant one acre. We assumed that the riparian land committed to the buffer would not be developable, so no land costs are included.

Urban Tree Planting:
An adjustment factor for the amount of impervious acres treated was derived from the Maryland Department of the Environment NPDES Guidance document, June 2011, with 2.63 acres of forested urban area treating one acre of pervious area. In other words, our cost shown is roughly three times what we estimate it would cost to plant one acre. (We assume that tree planting to restore forest-like conditions on previously impervious area would be in addition to the cost of impervious urban surface reduction noted for that BMP.) Land costs are estimated based on three acres purchased per one impervious acre treated. Note that these costs may vary considerably from jurisdiction to jurisdiction or site to site.

Wet Ponds and Wetlands:
Unit costs for the wet ponds and wetlands category are based on a synthesis of project data and interviews, with a "typical" project being a pond treating three impervious acres. Other project data supports the conclusion that there may be considerable economies of scale with regard to these ponds.

Dry Detention Ponds:
Unit costs for dry detention ponds are based on a synthesis of project data and interviews, with a "typical" project being a pond treating three impervious acres. Other project data supports the conclusion that there may be considerable economies of scale with regard to these ponds.

Hydrodynamic Structures:
Although hydrodynamic structures are included together with dry detention ponds in Maryland's MAST model, we treated them in a separate category because of cost differences.

Dry Extended Detention Ponds:
Unit costs for dry extended detention ponds are based on a synthesis of project data and interviews, with a "typical" project being a pond treating three impervious acres. Other project data supports the conclusion that there may be considerable economies of scale with regard to these ponds.

Infiltration:
Key sources informing Infiltration unit costs included the Center for Watershed Protection Urban Subwatershed Manual 3, project data provided by Maryland counties, the Maryland Department of Natural Resources, and cost estimates provided by several local stormwater contractors.

Filtering Practices:
Base construction costs for both above- and below-ground filtering practices were estimated based on interviews with contractors and other stormwater professionals who noted that above-ground filtering practices would have a slightly less expensive construction cost, that would be about offset by higher land costs associated with above ground filters. In addition, below-ground filters were reported to have slightly higher maintenance costs than above ground filters.

Erosion and Sediment Control:
We based our estimate on contractor interviews and project data, with a "typical" project being a new residential subdivision at a14 acre development site including silt fences, sediment ponds, and related practices. This estimate should be treated with caution, as contractors noted that this BMP cost can be very site-specific.

Urban Nutrient Management:
Best available data indicate that "retail" (i.e., direct mail) public outreach campaigns cost about $15 per household contacted. For an illustrative county, we assumed that each household has 5,941 square feet of turf and 2,406 square feet of impervious cover (medium density development). This means that 7.33 households need to adopt this BMP to potentially result in an acre of turf being treated, at a cost $109.98 per turf acre. Based on a review of direct mail response rates, we assumed that 2% of households contacted will respond positively to this outreach effort aimed at reducing nutrient runoff which brings the cost per turf acre treated to $5,497.50/acre. The equivalent on a per-impervious-acre basis was derived from the MDE June 2011 stormwater guidance document, which provides an equivalent for this practice of .09 acres of impervious area treated per one acre of this practice. Our estimate does not include any additional costs for soil tests to determine the appropriate amount of fertilizer required. We recognize that there are other approaches a community may wish to employ to encourage adoption of this BMP. For the reasons described above, our estimate should be treated with caution. Also note that we have listed the costs of this outreach program in the "construction costs" column of the tables in this report.

Street Sweeping Cost:
"Construction" costs for street sweeping refer to the acquisition cost of street sweepers per impervious acre treated, and include replacement every 10 years. We based our purchase price on an average between mechanical and vacuum style street sweepers. Maintenance costs include both maintenance and operations of the street sweeper.

Stream Restoration:
Unit cost estimates for stream restoration BMPs were derived from project data provided by Maryland jurisdictions. "Typical" project size was 300 linear feet. The number of impervious acres treated was calculated using the approach described in Maryland Department of Environment NPDES Guidance (June 2011), with 100 linear feet of stream restoration assumed to treat one impervious acre.

Bioretention:
Unit cost estimates for bioretention were split into "new" and "retrofit" categories, with "new" referring to bioretention in suburban settings, and "retrofit" referring to bioretention in highly urban (and more expensive) settings.

Vegetated Open Channels:
Key sources informing vegetated open channels unit costs included the Center for Watershed Protection Urban Subwatershed Manual 3, information provided by Maryland and Virginia counties, and cost estimates provided by several local stormwater contractors.

Bioswale:
Key sources informing bioswales unit costs included the Center for Watershed Protection Urban Subwatershed Manual 3, information provided by Maryland and Virginia counties, and several local stormwater contractors, and applications of the WERF stormwater BMP cost model.

Permeable Pavers:
Unit costs for permeable pavers (with or without sand/vegetation) were based on the assumption that the project area would have been paved with traditional asphalt or concrete if it permeable pavers were not used. We therefore subtracted. We estimated traditional-paving costs to be $5/square foot, but recognize that this estimate may be high or low depending on the method and site and estimated the cost of permeable pavers to be $10 to $12 per square foot. We recognize that there are several different types of permeable pavers with different costs and characteristics and based our costs on the experience of the contractors and vendors we contacted.

The unit cost estimates presented in this report are based on a synthesis of cost data from actual SWBMP projects and previously developed cost estimates we collected during the months of July and August 2011, with valuable contributions by representatives of many local Maryland jurisdictions, stormwater contractors, and other stormwater experts. They are expected to be accurate enough to help Maryland counties as they work to find cost effective solutions for meeting TMDL targets, and also to provide an initial basis for focusing dialogue at the local jurisdiction and state level about how to collect and organize stormwater cost data to provide Maryland with an improved basis for making stormwater management decisions.

The unit cost estimates presented in this report for all SWBMPs would become much more reliable with additional, continual refinements based on cost data from many more projects. We hope that the "total lifecycle cost" framework we used and describe in this report will help Maryland jurisdictions think about a full-cost-accounting approach to tracking SWBMPs, and will also help them organize stormwater cost information in ways that will inform subsequent studies of BMP cost-effectiveness.

10. Acknowledgments

We would like to thank the many individuals we consulted with during July and August, 2011, who provided data, context, and insights which informed this report. The cost estimates included in this report, however, are the results of research performed by the authors and their best professional judgment; they do not necessarily reflect the views of the individuals, organizations, municipalities, and companies we acknowledge below. Our apologies to anyone we might have overlooked.

A special thank you is owed to Tom Schueler, Coordinator of the Chesapeake Stormwater Network, for providing all stormwater researchers with a great deal of useful information compiled over many years, and for his willingness to respond on short notice to our requests for him to review our preliminary cost estimates, compare them with the results of his work, and help us work through various cost estimating details. Tom's earlier work not only contributed directly to our cost estimates, but many of the other sources of cost data we consulted were also based on Tom's work. This by no means indicates that he approves of the cost estimates provided here or how we developed them.

Interviewees and Sources of Cost Data

Abt Associates (Isabelle Morrin and Eloise Castillo)
American Rivers (Katherine Baer and Jeff Odefey)
Anne Arundel County, MD (Ron Bowen, Ginger Ellis and Christopher Phipps)
Baltimore County, MD (Lamar Lewis, Steven Stewart, Robert Wood)
BaySavers (Tom Pank)
Calvert County, MD (P. Rai Sharma, Mary Beth Cook, Michel N. Jackson and John F. Knopp)
Center for Watershed Protection (Bill Stack)
Chesapeake Stormwater Network (Thomas Schueler)
City of Baltimore, MD (Kimberly Burgess)
City of Rockville, MD (Mark Charles, Heather Gewandter and Lise Soukup)
Howard County, MD (Mark Richmond, Howard Saltzman)
Contech (Aimee Connerton)
Charles P. Johnson & Associates (Brian Davila and Jeff Blass)
EA Engineering, Science,& Technology, Inc. (Ali Abbasi, Richard Pfingsten and William Rue)
Frederick County, MD (Shannon Moore)
Maryland Department of the Environment (Paul Emmart, James George and Rich Eskin)
Maryland Department of Natural Resources (Sarah Lane, Brent McCloskey and Jean Raulin)
Metropolitan Washington Council of Governments (Karl Berger)
Montgomery County Stormwater Partners Network (Diane Cameron)
Montgomery County, MD (Meosotis Curtis, Steven Shofar and Amy Stevens)
Prince George's County, MD (Jerry Maldonado)
U.S. Environmental Protection Agency (Kevin DeBell)
Tetra Tech Corporation (Heather Fisher)
VAST Enterprises LLC (David Justice)
Virginia Tech (Kurt Stephenson)
Water Environment Research Foundation (Jeff Moeller)

11.References

Abt Associates Inc. 2010. Development of Cost Curves and Quantification of Ecosystem Services Associated with Strategies Pursuant to the Executive Order to Restore the Chesapeake Bay. Prepared for Office of Research and Development U.S. Environmental Protection Agency. Contract EP-C-07-023 (Work Assignment #2-22 and 3-22).

Bowen, R.E., G.D. Ellis, and C. Phipps. 2011. Personal communication with Ronald Bowen, Director, Ginger Ellis, Administrator Watershed Ecosystem and Restoration Services, and Christopher Phipps, Deputy Director Bureau of Engineering, Anne Arundel County Department of Public Works, Annapolis, MD.

Burgess, K. 2011. Personal communication with Kimberly Burgess, P.E., City of Baltimore Department of Public Works, Surface Water Management Division, Baltimore, MD.

Center for Neighborhood Technology. 2009. National Green Values Calculator Methodology. Appendix B: Metadata of Compiled Costs. Available at: http://greenvalues.cnt.org/national/downloads/methodology.pdf

Center for Neighborhood Technology. 2010. The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits. Available at: http://www.cnt.org/repository/gi-values-guide.pdf

Center for Watershed Protection. 2008. Runoff Reduction Method Technical Memo. Available at: http://www.cwp.org/documents/cat_view/76-stormwater-management-publications/95-runoff-reduction-method-technical-memo.html

Center for Watershed Protection. 2011. In-Lieu Fee Proposal for On-Site Stormwater Management Draft. Prepared for Delaware Department of Natural Resources and Environmental Control, Division of Soil and Water Conservation.

Charles, M., H. Gewandter and L. Soukup. 2011. Personal communication with Mark Charles, Environmental Manager, Heather Gewandter, Stormwater Manager and Lise Soukup, Project Manager, City of Rockville Environmental Management Division, Department of Public Works, Rockville, MD.

Christina Basin Tributary Action Team. 2007. Christina Basin Pollution Control Strategy: A Watershed-based Strategy to Implement Total Maximum Daily Loads in the Brandywine, Red Clay, and White Clay Creeks, and Christina River in Delaware. Prepared for Department of Natural Resources & Environmental Control. Available at: www.wr.udel.edu/ChristinaTribTeam

Curtis, M. 2011. Personal communication with Meosotis Curtis, Manager Watershed Planning and Monitoring, Montgomery County Department of Environmental Protection, Rockville, MD.

Davila, B. and J. Blass. 2011. Personal communication with Brian Davila, President and Jeff Blass, Sector Head Public Sector Division of Charles P. Johnson & Associates, Silver Spring, MD.

Hartmann, J.K. 2010. Memorandum: Budget Memo #16: Stormwater Utility Follow-Up Information. Submitted to Mayor and City Council of City of Alexandria, VA.

Hinman, C. 2007. Rain Garden Handbook for Western Washington Homeowners: Designing your landscape to protect our streams, lakes, bays, and wetlands. Washington State University Pierce County Extension.

Interstate Commission on the Potomac River Basin and J7 LLC. 2011. Maryland Assessment Scenario Tool User's Guide. Available at: http://www.mastonline.org/include/MASTUsersGuide.pdf

International SWBMP Database. Available at: http://www.bmpdatabase.org/ [Accessed August 10, 2011].

Keplinger, Keith. 2003. The Economics of Total Maximum Daily Loads. Natural Resources Journal, Vol. 43, No. 4, Fall 2003. Available at SSRN: http://ssrn.com/abstract=601786

Lane, Sarah. 2011. Personal communication with Sarah Lane, Natural Resources Planner, Maryland Department of Natural Resources, Annapolis, MD.

Lewis, L. 2011. Personal communication with Lamar Lewis, Baltimore County Department of Environmental Protection and Sustainability, Towson, MD.

Low Impact Development Center. 2005. LID BMP Fact Sheets and Case Studies - Fairfax County, Virginia. Available at http://www.lowimpactdevelopment.org/fairfax.htm [Accessed August 10, 2011].

Maryland Department of the Environment. 2011. Accounting For Stormwater Wasteload Allocations and Impervious Acres Treated: Guidance for National Pollutant Discharge Elimination System Stormwater Permits. Baltimore, MD.

Moore, S. 2011. Personal communication with Shannon Moore, Acting Manager Frederick County Sustainability and Environmental Resources, Frederick, MD.

North Carolina Department of Environment and Natural Resources, Division of Water Quality. 2007. Stormwater Best Management Practices Manual. Raleigh, NC.

Prince George's County Department of Environmental Resources, 2002. Prince George's County Bioretention Manual, Environmental Services Division, Department of Environmental Resources, The Prince George's County, Maryland, Revised December 2007. Available at: http://www.co.pg.md.us/Government/AgencyIndex/DER/ESD/Bioretention/bioretention.asp

RSMeans. 2011. Means Expanded Construction Cost Indexes. Available from: http://rsmeans.reedconstructiondata.com/

Richmond, M. 2011. Personal communication with Mark Richmond, P.E., Howard County Government, Storm Water Management Division, Bureau of Environmental Services, Columbia, MD.

Saltzman, H. 2011. Personal communication with Howard Saltzman, P.E., Howard County Government, Storm Water Management Division, Bureau of Environmental Services, Columbia, MD.

Schueler, T. and A. Kitchell. 2005. Manual 2: Methods to Develop Restoration Plans for Small Urban Watershed. Available at: http://www.cwp.org/documents/cat_view/68-urban-subwatershed-restoration-manual-series.html

Schueler, T., D.Hirschman, M. Novotney, J. Zielinski. 2007. Manual 3: Urban Stormwater Retrofit Practices Manual. Available at: http://www.cwp.org/documents/cat_view/68-urban-subwatershed-restoration-manual-series/89-manual-3-urban-stormwater-retrofit-practices-manual.html

Schueler, T., C. Swann, T. Wright, S. Sprinkle. 2005. Manual 8: Pollution Source Control Practices. Available at: http://www.cwp.org/documents/cat_view/68-urban-subwatershed-restoration-manual-series.html

Sharma, P.R., M.B. Cook, M.N. Jackson, and J.F. Knopp. 2011. Personal communication with P. Rai Sharma, Deputy Director Engineering, Mary Beth Cook, Acting Director Planning and Zoning, Mighel N. Jackson, Project Engineer and John F. Knopp, Project Engineer, Calvert County Department of Public Works, Prince Frederick, MD.

Stephenson, K. and B. Beamer. 2008. Economic Impact Analysis of Revisions to the Virginia Stormwater Regulation Final Report. Submitted to Virginia Department of Conservation and Recreation.

Stevens, A. 2011. Personal communication with Amy Stevens, Manager Stormwater Facilities, Montgomery County Department of Environmental Protection, Rockville, MD.

Stewart, S. 2011. Personal communication with Steven Stewart, Manager Watershed. Management and Monitoring, Baltimore County Department of Environmental Protection and Resource Management, Towson, MD.

Tetra Tech, Inc. 2009. Optimal Stormwater Management Plan Alternatives: A Demonstration Project in Three Upper Charles River Communities, Final Report. Prepared for U.S. EPA and Massachusetts Department of Environmental Projection. Available at: http://www.epa.gov/region1/npdes/stormwater/assets/pdfs/StormwaterBMPCostOptimization.pdf

The Stormwater Manager's Resource Center. Assorted Fact Sheets. Available at: http://www.stormwatercenter.net/ [Accessed August 17, 2011].

Treadway, E. and A.L. Reese. 2000. Financial Strategies for Stormwater Management. 3 pp. Available at: http://stormwaterfinance.urbancenter.iupui.edu/PDFs/Treadway.pdf

U.S. Environmental Protection Agency, Region III Chesapeake Bay Program. 2003. Economic Analysis of Nutrient and Sediment Reduction Actions to Restore Chesapeake Bay Water Quality. Annapolis, MD.

Voorhees, T.L. 2007. City of Durham Comments on the Draft Jordan Water Supply Nutrient Strategy Rules. Submitted to NCDENR Division of Water Quality. Available at: http://www.ci.durham.nc.us/departments/wm/jordan_lake_rules.cfm

Water Environment Research Foundation. 2005. Performance and Whole-Life Costs of Best Management Practices (BMPs) and Sustainable Urban Drainage Systems (SUDS) (01-CTS-21-Ta). Available at: http://www.werf.org/AM/Template.cfm?Section=Search&Template=/CustomSource/Research/PublicationProfile.cfm&id=01-CTS-21-TA

Water Environmental Research Foundation. 2009. BMP and LID Whole Life Cost Models: Version 2.0. (SW2R08) Available at:

http://www.werf.org/AM/Template.cfm?Section=Search&Template=/CustomSource/Research/ResearchProfile.cfm&ReportId=SW2R08&ID=SW2R08

Weiss, P.T., J.S. Gulliver, and A.J. Erickson. 2005. The Cost and Effectiveness of Stormwater Management Practices. Minnesota Department of Transportation, St. Paul, MN. Available at: http://www.lrrb.org/pdf/200523.pdf

Wieland, R., D. Parker, W. Gans, and A. Martin. 2009. Costs and Cost Efficiencies for Some Nutrient Reduction Practices in Maryland. Submitted to Maryland Department of Natural Resources.

Wossink, A. and W. Hunt. 2003. The Economics of Structural SWBMPs in North Carolina. WRRI Research Report Number 344. Raleigh, NC

Young, K., S. Stein, P. Cole, T. Kammer, F. Graziano and F. Bank. 1996. Evaluation and Management of Highway Runoff Water Quality. Publication No. FHWA-PD-96-032, U.S. Department of Transportation, Federal Highway Administration, Office of Environment and Planning.

NPDES MS4 and Other Reports:

Baltimore County Department of Public Works 2010. 2010 NPDES MS4 Stormwater Permit Annual Report. Submitted to Maryland Department of Environment. Water Management Administration. Baltimore, MD.

Anne Arundel County Department of Public Works. 2010. 2010 NPDES MS4 Stormwater Permit Annual Report. Submitted to Maryland Department of Environment. Water Management Administration. Baltimore, MD.

Charles County Department of Planning and Growth Management. 2010. 2010 NPDES MS4 Stormwater Permit Annual Report. Submitted to Maryland Department of Environment. Water Management Administration. Baltimore, MD.

Frederick County Department of Public Works. 2010. 2009 NPDES MS4 Stormwater Permit Annual Report. Submitted to Maryland Department of Environment. WaterManagement Administration. Baltimore, MD.

Harford County Department of Public Works. 2010. 2008 NPDES MS4 Stormwater Permit Annual Report. Submitted to Maryland Department of Environment. Water Management Administration. Baltimore, MD.

Howard County Department of Public Works. 2010. 2010 NPDES MS4 Stormwater Permit Annual Report. Submitted to Maryland Department of Environment. Water Management Administration. Baltimore, MD.

Montgomery County Department of Environmental Protection. 2011. 2010 NPDES MS4 Stormwater. Permit Annual Report. Submitted to Maryland Department of Environment. Water Management Administration. Baltimore, MD.

Montgomery County Department of Environmental Protection. 2011. Implementation Plan Guidance Document. Prepared for Montgomery County Department of Environmental Protection by Thomas Schueler, Chesapeake Stormwater Network. February 2011.

Prince Georges County Department of Environmental Resources. 2010. 2009 NPDES MS4 Stormwater Permit Annual Report. Submitted to Maryland Department of Environment. Water Management Administration. Baltimore, MD.

State Highway Administration Highway Hydraulics Division. 2009. 2009 NPDES MS4 Stormwater Permit Annual Report. Submitted to Maryland Department of Environment. Water Management Administration. Baltimore, MD.

12. Tables and Figure

Table 1a. SWBMPs Approved by EPA (and included in MAST)*

1	Impervious Urban Surface Reduction
2	Urban Forest Buffers
3	Urban Grass Buffers
4	Urban Tree Planting
5	Wet Ponds and Wetlands
6	Dry Detention Ponds
7	Hydrodynamic Structures
8	Dry Extended Detention Ponds
9	Infiltration Practices w/o Sand, Veg.
10	Infiltration Practices w/ Sand, Veg.
11	Filtering Practices
12	Erosion and Sediment Control
13	Urban Nutrient Management
14	Street Sweeping
15	Urban Stream Restoration
16	Bioretention
17	Vegetated Open Channels
18	Bioswale
19	Permeable Pavement w/o Sand, Veg.
20	Permeable Pavement w/ Sand, Veg.

*Full description of these SWBMPs are presented in Appendix A.

Table 1b. SWBMP Cost Categories

Initial Costs
Pre-Construction
Construction
Land*
Total Initial Costs
Maintenance Costs
Annual Routine Maintenance
Average Annual Intermittent/Corrective Maintenance
Annual County Implementation Costs
Life Cycle Cost over 20 years
Annualized Cost over 20 years

*This refers to the market value of developable land that becomes undevelopable because of implementation of the BMP. (See the General Caveats Section.)

Table 2a

County SWBMP Unit Cost Development – Part 1, Upfront Costs

Planning Level Unit Cost Development for Stormwater Best Management Practices (BMPs)[1]

PART 1: Initial Costs Per Impervious Acre Treated

Stormwater BMP	Initial Project Costs: Pre-Construction Costs[2]	Construction Costs[3]	Land Costs[4]	Total Initial Costs	Annualized Initial Costs[5]
Impervious Urban Surface Reduction	$ 8,750	$ 87,500	$ 50,000	$ 146,250	$ 9,830
Urban Forest Buffers	$ 3,000	$ 30,000	$ -	$ 33,000	$ 2,218
Urban Grass Buffers	$ 2,150	$ 21,500	$ -	$ 23,650	$ 1,590
Urban Tree Planting	$ 3,000	$ 30,000	$ 150,000	$ 183,000	$ 12,300
Wet Ponds and Wetlands (New)	$ 5,565	$ 18,550	$ 2,000	$ 26,115	$ 1,755
Wet Ponds and Wetlands (Retrofit)	$ 21,333	$ 42,665	$ 2,000	$ 65,998	$ 4,436
Dry Detention Ponds (New)	$ 9,000	$ 30,000	$ 5,000	$ 44,000	$ 2,957
Hydrodynamic Structures (New)	$ 7,000	$ 35,000	$ -	$ 42,000	$ 2,823
Dry Extended Detention Ponds (New)	$ 9,000	$ 30,000	$ 5,000	$ 44,000	$ 2,957
Dry Extended Detention Ponds (Retrofit)	$ 22,500	$ 45,000	$ 5,000	$ 72,500	$ 4,873
Infiltration Practices w/o Sand, Veg. (New)	$ 16,700	$ 41,750	$ 5,000	$ 63,450	$ 4,265
Infiltration Practices w/ Sand, Veg. (New)	$ 17,500	$ 43,750	$ 5,000	$ 66,250	$ 4,453
Filtering Practices (Sand, above ground)	$ 14,000	$ 35,000	$ 5,000	$ 54,000	$ 3,630
Filtering Practices (Sand, below ground)	$ 16,000	$ 40,000	$ -	$ 56,000	$ 3,764
Erosion and Sediment Control	$ 6,000	$ 20,000	$ -	$ 26,000	$ 1,748
Urban Nutrient Management[6]	$ -	$ 61,000	$ -	$ 61,000	$ 4,100
Street Sweeping[7]	$ -	$ 6,049	$ -	$ 6,049	$ 407
Urban Stream Restoration	$ 21,500	$ 43,000	$ -	$ 64,500	$ 4,335
Bioretention (New - Suburban)	$ 9,375	$ 37,500	$ 3,000	$ 49,875	$ 3,352
Bioretention (Retrofit - Highly Urban)	$ 52,500	$ 131,250	$ 3,000	$ 186,750	$ 12,553
Vegetated Open Channels	$ 4,000	$ 20,000	$ 2,000	$ 26,000	$ 1,748
Bioswale (New)	$ 12,000	$ 30,000	$ 2,000	$ 44,000	$ 2,957
Permeable Pavement w/o Sand, Veg. (New)	$ 21,780	$ 217,800	$ -	$ 239,580	$ 16,104
Permeable Pavement w/ Sand, Veg. (New)	$ 30,492	$ 304,920	$ -	$ 335,412	$ 22,545

[1] All costs are expressed per acre of impervious area treated, not per acre of BMP. Initial costs are assumed to take place in year T=0; annual costs are incurred from year T=1 through year T=20.

[2] Includes cost of site discovery, surveying, design, planning, permitting, etc. which, for various BMPs tend to range from 10% to 40% of BMP construction costs.

[3] Includes capital, labor, material and overhead costs, but not land costs, associated implementation; for street sweeping includes only the capital cost of purchasing a mechanical sweeper. Nutrient management construction costs refer to the cost of an outreach campaign, not to any construction costs.

[4] For all stormwater BMPs that require land it is assumed that: 1) the opportunity cost of developable land is $100,000 per acre and 2) 50% of projects that require land take place on developable land with the rest taking place on land that is not developable. This brings the opportunity cost of land for stormwater BMPs that require land to $50,000 per acre. Actual county-specific land cost and percent developable land values can be filled in.
NOTE: The area of some BMPs may be significantly less than the impervious area treated.

[5] Initial BMP costs, including preconstruction, construction, and land costs, are amortized over 20 years at 3% to arrive at annualized initial costs.

[6] Best available data indicate that "retail" (i.e., direct mail) public outreach campaigns cost about $15 per household contacted. For an illustrative county, we assumed that each household has 5,941 sq ft of turf and 2,406 sq ft of impervious cover (medium density development). This means that 7.33 households need to adopt this BMP to potentially result in an acre of turf being treated, at a cost $109.98 per turf acre. Based on a review of direct mail response rates, we assumed that 2% of households contacted will respond positively to this outreach effort, bringing the cost per turf acre treated to $5,497.50/acre. The equivalent on a per-impervious-acre was based on the MDE June 2011 stormwater guidance document, which provides an equivalent for this practice of .09 acres impervious area per one acre of this practice. This estimate does not include any additional costs for soil tests by the homeowner to determine the appropriate amount of fertilizer required.

[7] Capital acquisition cost per impervious acre treated.

Table 2b

County SWBMP Unit Cost Development – Part 2, Annual and Intermittent Costs

Planning Level Unit Cost Development for Stormwater Best Management Practices (BMPs)

PART 2: Annual Maintenance Costs

Stormwater BMP	Routine and Intermittent Maintenance Costs: Annual Routine Maintenance[1]	Routine and Intermittent Maintenance Costs: Average Annual Intermittent Maintenance[2]	Routine and Intermittent Maintenance Costs: Total Annual Maintenance Costs	Average Annual County Implementation Costs[3]	Maintenance, Intermittent Repair, and Implementation Costs[4]: Total (Over 20 Years)	Maintenance, Intermittent Repair, and Implementation Costs[4]: Average Annual (Over 20 Years)
Impervious Urban Surface Reduction	$ 875	$ -	$ 875	$ 10.34	$ 17,707	$ 885
Urban Forest Buffers	$ 600	$ 600	$ 1,200	$ 10.34	$ 24,207	$ 1,210
Urban Grass Buffers	$ 430	$ 430	$ 860	$ 10.34	$ 17,407	$ 870
Urban Tree Planting	$ 600	$ 600	$ 1,200	$ 10.34	$ 24,207	$ 1,210
Wet Ponds and Wetlands (New)	$ 371	$ 371	$ 742	$ 20.67	$ 15,253	$ 763
Wet Ponds and Wetlands (Retrofit)	$ 371	$ 371	$ 742	$ 20.67	$ 15,253	$ 763
Dry Detention Ponds (New)	$ 600	$ 600	$ 1,200	$ 31.01	$ 24,620	$ 1,231
Hydrodynamic Structures (New)	$ 1,750	$ 1,750	$ 3,500	$ 31.01	$ 70,620	$ 3,531
Dry Extended Detention Ponds (New)	$ 600	$ 600	$ 1,200	$ 31.01	$ 24,620	$ 1,231
Dry Extended Detention Ponds (Retrofit)	$ 600	$ 600	$ 1,200	$ 31.01	$ 24,620	$ 1,231
Infiltration Practices w/o Sand, Veg. (New)	$ 418	$ 418	$ 835	$ 31.01	$ 17,320	$ 866
Infiltration Practices w/ Sand, Veg. (New)	$ 438	$ 438	$ 875	$ 31.01	$ 18,120	$ 906
Filtering Practices (Sand, above ground)	$ 700	$ 700	$ 1,400	$ 31.01	$ 28,620	$ 1,431
Filtering Practices (Sand, below ground)	$ 800	$ 800	$ 1,600	$ 31.01	$ 32,620	$ 1,631
Erosion and Sediment Control	$ -	$ -	$ -	$ 10.34	$ 207	$ 10
Urban Nutrient Management	$ -	$ -	$ -	$ 31.01	$ 620	$ 31
Street Sweeping	$ 431	$ -	$ 431	$ 20.67	$ 9,030	$ 451
Urban Stream Restoration	$ -	$ 860	$ 860	$ 31.01	$ 17,820	$ 891
Bioretention (New - Suburban)	$ 750	$ 750	$ 1,500	$ 31.01	$ 30,620	$ 1,531
Bioretention (Retrofit - Highly Urban)	$ 750	$ 750	$ 1,500	$ 31.01	$ 30,620	$ 1,531
Vegetated Open Channels	$ 400	$ 200	$ 600	$ 10.34	$ 12,207	$ 610
Bioswale (New)	$ 600	$ 300	$ 900	$ 31.01	$ 18,620	$ 931
Permeable Pavement w/o Sand, Veg. (New)	$ 1,089	$ 1,089	$ 2,178	$ 10.34	$ 43,767	$ 2,188
Permeable Pavement w/ Sand, Veg. (New)	$ 1,525	$ 1,525	$ 3,049	$ 10.34	$ 61,191	$ 3,060

[1] Annual routine maintenance costs over 20 years; assumes a 3% discount rate, but also a 3% annual increase in maintenance cost which washes out the effect of discounting resulting in a constant present value annual cost throughout the 20 year period.

[2] Intermittent/corrective maintenance tasks are those that accrue every 3 to 5 years; these are averaged here over the 20 year period.

[3] Average annual county cost of inspecting and monitoring stormwater BMPs and enforcing construction and maintanance standards.

[4] Combined annual operating, implementation, and maintenance costs.

Table 2c

Life Cycle (20 years) and Annual SWBMP Unit Cost Estimates

Planning Level Unit Cost Development for Stormwater Best Management Practices (BMPs)

PART 3: Life Cycle (20 years) and Annual Stormwater BMP Unit Cost Estimates

Stormwater BMP	Initial Costs (From Table 2a) Total	Initial Costs (From Table 2a) Annualized Initial Costs	Average Annual Maintenance Costs[1] (From Table 2b)	Total Stormwater BMP Costs per Impervious Acre Treated: Costs (Over 20 Years)	Total Stormwater BMP Costs per Impervious Acre Treated: Average Annual Cost
Impervious Urban Surface Reduction	$ 146,250	$ 9,830	$ 885	$ 163,957	$ 8,198
Urban Forest Buffers	$ 33,000	$ 2,218	$ 1,210	$ 57,207	$ 2,860
Urban Grass Buffers	$ 23,650	$ 1,590	$ 870	$ 41,057	$ 2,053
Urban Tree Planting	$ 183,000	$ 12,300	$ 1,210	$ 207,207	$ 10,360
Wet Ponds and Wetlands (New)	$ 26,115	$ 1,755	$ 763	$ 41,368	$ 2,068
Wet Ponds and Wetlands (Retrofit)	$ 65,998	$ 4,436	$ 763	$ 81,251	$ 4,063
Dry Detention Ponds (New)	$ 44,000	$ 2,957	$ 1,231	$ 68,620	$ 3,431
Hydrodynamic Structures (New)	$ 42,000	$ 2,823	$ 3,531	$ 112,620	$ 5,631
Dry Extended Detention Ponds (New)	$ 44,000	$ 2,957	$ 1,231	$ 68,620	$ 3,431
Dry Extended Detention Ponds (Retrofit)	$ 72,500	$ 4,873	$ 1,231	$ 97,120	$ 4,856
Infiltration Practices w/o Sand, Veg. (New)	$ 63,450	$ 4,265	$ 866	$ 80,770	$ 4,039
Infiltration Practices w/ Sand, Veg. (New)	$ 66,250	$ 4,453	$ 906	$ 84,370	$ 4,219
Filtering Practices (Sand, above ground)	$ 54,000	$ 3,630	$ 1,431	$ 82,620	$ 4,131
Filtering Practices (Sand, below ground)	$ 56,000	$ 3,764	$ 1,631	$ 88,620	$ 4,431
Erosion and Sediment Control	$ 26,000	$ 1,748	$ 10	$ 26,207	$ 1,310
Urban Nutrient Management	$ 61,000	$ 4,100	$ 31	$ 61,620	$ 3,081
Street Sweeping	$ 6,049	$ 407	$ 451	$ 15,079	$ 754
Urban Stream Restoration	$ 64,500	$ 4,335	$ 891	$ 82,320	$ 4,116
Bioretention (New - Suburban)	$ 49,875	$ 3,352	$ 1,531	$ 80,495	$ 4,025
Bioretention (Retrofit - Highly Urban)	$ 186,750	$ 12,553	$ 1,531	$ 217,370	$ 10,869
Vegetated Open Channels	$ 26,000	$ 1,748	$ 610	$ 38,207	$ 1,910
Bioswale (New)	$ 44,000	$ 2,957	$ 931	$ 62,620	$ 3,131
Permeable Pavement w/o Sand, Veg. (New)	$ 239,580	$ 16,104	$ 2,188	$ 283,347	$ 14,167
Permeable Pavement w/ Sand, Veg. (New)	$ 335,412	$ 22,545	$ 3,060	$ 396,603	$ 19,830

[1]Includes routine annual maintenance costs, average annual intermittent maintenance costs, and county implementation costs.

Table 3a

Preliminary County Cost Adjustment Indices

		Means Input Cost Indices[1]		Overall County Stormwater BMP Cost Adjustment Index[2]
Maryland County	**Representative Means Index City**	**Materials Index**	**Installation Index**	
Maryland				
Allegany	Cumberland	0.975	0.819	0.968
Anne Arundel	Annapolis	1.019	0.849	0.996
Baltimore County	Baltimore City	1.020	0.863	0.991
Baltimore City	Baltimore City	1.020	0.863	0.991
Calvert	Waldorf	1.008	0.838	0.987
Caroline	Easton	0.992	0.718	0.974
Carroll	Hagerstown	0.985	0.846	0.984
Cecil	Elkton	0.964	0.860	0.982
Charles	Waldorf	1.008	0.838	0.987
Dorchester	Easton	0.992	0.718	0.974
Frederick	Hagerstown	0.985	0.846	0.984
Garrett	Cumberland	0.975	0.819	0.968
Harford	Baltimore City	1.020	0.863	0.991
Howard	Baltimore City	1.020	0.863	0.991
Kent	Elkton	0.964	0.860	0.982
Montgomery	Silver Spring	0.999	0.837	0.985
Prince George's	College Park	1.008	0.856	0.989
Queen Anne's	Easton	0.992	0.718	0.974
St. Mary's	Waldorf	1.008	0.838	0.987
Somerset	Salisbury	0.996	0.667	0.970
Talbot	Easton	0.992	0.718	0.974
Washington	Hagerstown	0.985	0.846	0.984
Wicomico	Salisbury	0.996	0.667	0.970
Worcester	Salisbury	0.996	0.667	0.970

[1] Means Construction Cost Indices (Volume 37, Number 1, January 2011) lists cost indices for 13 Maryland cities. This table represents indices for Maryland counties based on the nearest of these 13 Maryland cities.

[2] This county cost adjustment index is based on average overall cost differences of 9 stormwater BMPs estimated using the Water Environmental Research Foundation (WERF) model and the Means input cost indices presented in this table. (Both are listed in References.)

Table 3b

Maryland County Cost Adjustment Factors For Nine Representative SWBMPs

Development of the Overall County Stormwater BMP Cost Adjustment Indices[1]

Based on WERF BMPS

Maryland County	Retention Ponds	Swales	Permeable Pavement	Extended Detention Basins	Rain Gardens	Green Roofs	Curb Contained Bioretention	In-curb Planter Vaults	Cisterns	Average
Allegany	0.994	0.943	0.971	0.986	0.995	0.889	0.986	0.954	0.995	0.968
Anne Arundel	1.007	0.953	0.998	0.989	1.004	1.041	1.005	0.965	1.004	0.996
Baltimore County	0.996	0.957	0.992	0.990	1.004	1.003	1.005	0.968	1.004	0.991
Baltimore City	0.996	0.957	0.992	0.990	1.004	1.003	1.005	0.968	1.004	0.991
Calvert	0.995	0.949	0.985	0.988	1.002	1.001	1.000	0.961	1.002	0.987
Caroline	0.991	0.912	0.966	0.979	0.998	0.999	0.991	0.930	0.998	0.974
Carroll	0.995	0.952	0.978	0.988	0.997	0.998	0.991	0.961	0.997	0.984
Cecil	0.995	0.956	0.972	0.989	0.993	0.995	0.983	0.963	0.993	0.982
Charles	0.995	0.949	0.985	0.988	1.002	1.001	1.000	0.961	1.002	0.987
Dorchester	0.991	0.912	0.966	0.979	0.998	0.999	0.991	0.930	0.998	0.974
Frederick	0.995	0.952	0.978	0.988	0.997	0.998	0.991	0.961	0.997	0.984
Garrett	0.994	0.943	0.971	0.986	0.995	0.889	0.986	0.954	0.995	0.968
Harford	0.996	0.957	0.992	0.990	1.004	1.003	1.005	0.968	1.004	0.991
Howard	0.996	0.957	0.992	0.990	1.004	1.003	1.005	0.968	1.004	0.991
Kent	0.995	0.956	0.972	0.989	0.993	0.995	0.983	0.963	0.993	0.982
Montgomery	0.995	0.949	0.982	0.988	1.000	1.000	0.996	0.960	1.000	0.985
Prince George's	0.996	0.955	0.987	0.989	1.002	1.001	1.000	0.965	1.002	0.989
Queen Anne's	0.991	0.912	0.966	0.979	0.998	0.999	0.991	0.930	0.998	0.974
St. Mary's	0.995	0.949	0.985	0.988	1.002	1.001	1.000	0.961	1.002	0.987
Somerset	0.990	0.896	0.962	0.975	0.999	0.999	0.992	0.918	0.999	0.970
Talbot	0.991	0.912	0.966	0.979	0.998	0.999	0.991	0.930	0.998	0.974
Washington	0.995	0.952	0.978	0.988	0.997	0.998	0.991	0.961	0.997	0.984
Wicomico	0.990	0.896	0.962	0.975	0.999	0.999	0.992	0.918	0.999	0.970
Worcester	0.990	0.896	0.962	0.975	0.999	0.999	0.992	0.918	0.999	0.970

[1] This county cost adjustment index is based on average overall cost differences of 9 stormwater BMPs estimated using the Water Environmental Research Foundation (WERF) model and the Means input cost indices. (Both are listed in References.)

Table 4

General Factors That Affect County Costs of SWBMPs

- Up-front Effort required to locate, compare, gain access to project sites and get projects designed and permitted.
- Land Value/Needs - Private or public, developable or not.
- Landscape Context – Rural vs. urban vs. ultra-urban
- Site Conditions – Land cover, structures, soil type. etc.
- Project Scale – Project size in acres or cubic feet of water capacity
- Project Capacity - Acres of land or impervious area treated
- Number of Projects – Few or many similar projects within a county
- Type of Project - Newly built or retrofit
- Site Access for surveying, construction, and maintenance
- Importance of Aesthetics - Attractive vs ugly detention pond
- Safety and Public Health - Stagnant water, attractive nuisance, etc

Table 5

Integrating Unit SWBMP Costs with MAST Output

Planning Level Unit Cost Development for Stormwater Best Management Practices (BMPs)

Part 4: Integrating Unit Stormwater BMP Costs with MAST Output

Stormwater BMP		Reduction in Emissions per acre treated by each Stormwater BMP						Cost per Impervious Acre Treated			
								County-based Costs		Lifetime Costs	
		(1) Nitrogen	(2) Phosphorus	(3) Sediment	(4) Available Acres	(5) % of Available Acres Treated (County Decision Variable)	(6) Number of Acres Treated	(7) Initial Cost	(8) Average Annual Maintenance Cost	(9) Total (Over 20 Years)	(10) Annual Costs (Over 20 Years)
Impervious Urban Surface Reduction							0	$ 146,250	$ 885	$ 163,957	$ 8,198
Urban Forest Buffers							0	$ 33,000	$ 1,210	$ 57,207	$ 2,860
Urban Grass Buffers							0	$ 23,650	$ 870	$ 41,057	$ 2,053
Urban Tree Planting							0	$ 183,000	$ 1,210	$ 207,207	$ 10,360
Wet Ponds and Wetlands (New)							0	$ 26,115	$ 763	$ 41,368	$ 2,068
Wet Ponds and Wetlands (Retrofit)							0	$ 65,998	$ 763	$ 81,251	$ 4,063
Dry Detention Ponds (New)							0	$ 44,000	$ 1,231	$ 68,620	$ 3,431
Hydrodynamic Structures (New)							0	$ 42,000	$ 3,531	$ 112,620	$ 5,631
Dry Extended Detention Ponds (New)							0	$ 44,000	$ 1,231	$ 68,620	$ 3,431
Dry Extended Detention Ponds (Retrofit)							0	$ 72,500	$ 1,231	$ 97,120	$ 4,856
Infiltration Practices w/o Sand, Veg. (New)							0	$ 63,450	$ 866	$ 80,770	$ 4,039
Infiltration Practices w/ Sand, Veg. (New)							0	$ 66,250	$ 906	$ 84,370	$ 4,219
Filtering Practices (Sand, above ground)							0	$ 54,000	$ 1,431	$ 82,620	$ 4,131
Filtering Practices (Sand, below ground)							0	$ 56,000	$ 1,631	$ 88,620	$ 4,431
Erosion and Sediment Control							0	$ 26,000	$ 10	$ 26,207	$ 1,310
Urban Nutrient Management							0	$ 61,000	$ 31	$ 61,620	$ 3,081
Street Sweeping							0	$ 6,049	$ 451	$ 15,079	$ 754
Urban Stream Restoration							0	$ 64,500	$ 891	$ 82,320	$ 4,116
Bioretention (New - Suburban)							0	$ 49,875	$ 1,531	$ 80,495	$ 4,025
Bioretention (Retrofit - Highly Urban)							0	$ 186,750	$ 1,531	$ 217,370	$ 10,869
Vegetated Open Channels							0	$ 26,000	$ 610	$ 38,207	$ 1,910
Bioswale (New)							0	$ 44,000	$ 931	$ 62,620	$ 3,131
Permeable Pavement w/o Sand, Veg. (New)							0	$ 239,580	$ 2,188	$ 283,347	$ 14,167
Permeable Pavement w/ Sand, Veg. (New)							0	$ 335,412	$ 3,060	$ 396,603	$ 19,830
Overall reduction for all Stormwater BMPs		0	0	0		Cost for all Stormwater BMPs				$ 2,539,274	$ 126,964
						Cost per County Resident				#DIV/0!	#DIV/0!
						Cost per County Household				#DIV/0!	#DIV/0!
						Total Cost per 1,000 sq ft Impervious Area				#DIV/0!	#DIV/0!
County Population (2010)	0										
Number of Households (2010)	0										
Impervious Area (2010)	0										

Table 6

Using Total SWBMP Cost Estimates to Assess and Compare Financing Options

(For Illustration Only, based on some actual figures for Anne Arundel County, MD)

County Stormwater BMP Costs			Financing Strategy				
			Option A - Impervious Area Fee			Option B - Property Tax Increase	
Annual County Costs of SW BMPs	$60M		Annual Fee Per ERU*	$48	2,725 sq. ft.	County Assessed Property Value	$89.6B
Contribution to County SW Costs						County Tax Rate (per $100)	
Federal	$4M	7%	Impervious Area in County	Revenue	# of Acres	All county	0.0091
State	$6M	10%	Residences	$20.6M	22,560		
Regional (Multi county)			Commercial	$10.6M	11,540		
Annual County SW Cost Burden	$50M	83%	Industrial	$5.5M	6,050	Annual County Property Tax Revenues	$766.2M
			Schools/Parks	$11.5M	12,877	Average Single Family Home Prop Tax	$3,278
			Churches	$1.5M	1,633	Required Increase in Property Tax Rate	
			Subtotal	$50M	54,660	All county	6.5%
			Average Annual Cost per Single Family Home	$48		Average Annual Cost per Single Family Home	$213

*An ERU value of 1.0 is defined as the stormwater run-off and pollutant loads from a standard residential family dwelling parcel.

Source: Maryland Department of Assessment and Taxation_2011-2012 County Tax Rates, Anne Arundel County Budget FY2010, Chamber of Commerce_Stormwater Quality Enterprise Fund 2006, Maryland Property View 2009

Typical Approach - Impervious Area Fee

Step 1: Estimate annual county stormwater costs
Step 2: Determine impervious area in county
Step 3: Calculate annual stormwater costs per acre of impervious area
Step 4: Establish "Equivalent Residential Unit" or ERU based on impervious area per average single family home
Step 5: Establish impervious area fee based on # of ERUs in county

County Illustration

Annual stormwater management costs **$50 million**
Impervious area in county 54,660 acres
Annual revenue needs per acre of imp. area **$915**
ERU= 2,275 sq. ft or .0522 acres.….therefore.....ERU Fee = **$48 per avg. residence**

Average Annual Cost per Single Family Household = $48

Typical Approach - Intensity of Development (Property) Tax

Step 1: Determine annual county stormwater costs
Step 2: Estimate stormwater revenue required per $100 of appraised property value
Step 3: Estimate required increase in property tax rate
Step 4: **Then**…increase property tax rate by that amount

County Illustration

Appraised value of all property in county $89 billion
Appraised value of non-government property $84.2 billion
Current county property tax rate 0.91%
Annual county property tax revenues $766.2 million
Average property tax per household $3,278

Annual stormwater management costs **$50 million**
Stormwater revenues needed per $100 of appraised value **$.561**
Required increase in county property tax rate **from 0.91% to 0.97%**
Required increase in average property tax per household **$213 or 6.5%**

Average Annual Cost per Single Family Household = $213

Table 7

SWBMP Unit Costs Per Acre of Impervious Area Do Not Reflect BMP Efficiencies (Numbers are for illustration only)

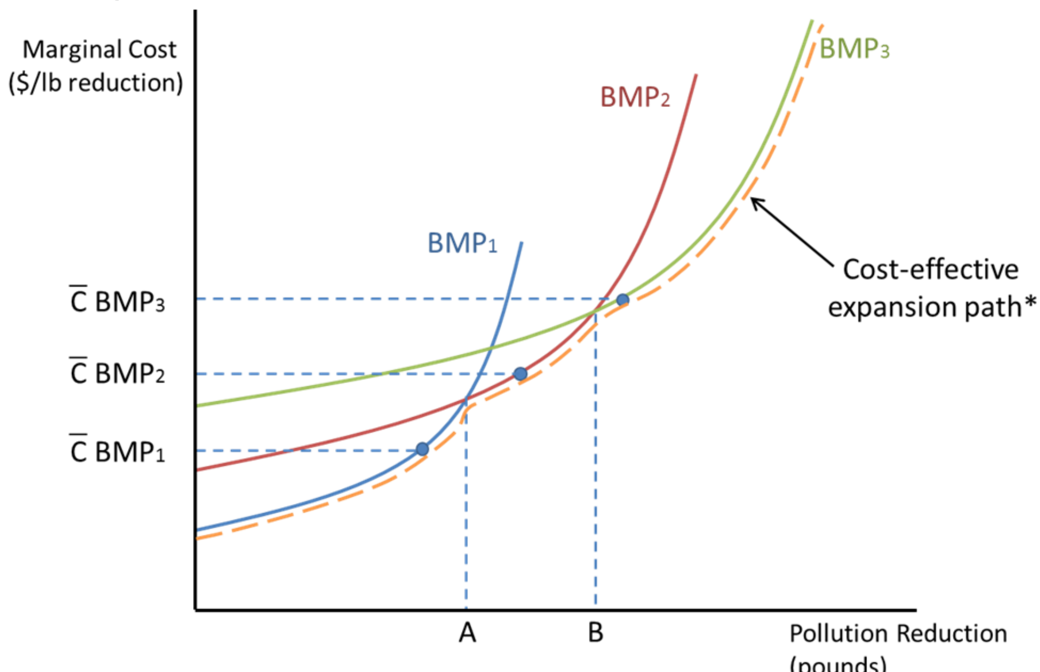
		Stormwater BMP 1	Stormwater BMP 2
Unit Cost Per Impervious Area Treated		$ 20,000	$ 100,000
(Illustrative – based on cost analysis)			
Average Pound Reduction Per Impervious Area Treated			
(Illustrative - based on BMP efficiencies)			
	Nitrogen	5	50
	Phosphorus	10	20
	Sediment	15	70
Cost per Pound of Reduction			
	Nitrogen	$ 4,000	$ 2,000
	Phosphorus	$ 2,000	$ 5,000
	Sediment	$ 1,300	$ 1,400

Results:

- Lowest Cost per pound of Nitrogen discharge reduction is BMP 2
- Lowest Cost per pound of Phosphorus discharge reduction is BMP 1
- Cost per pound of Sediment discharge reduction is about the same

Figure 1

Choosing A Cost-Effective Portfolio of County SWBMPs



Legend:

BMP_1 = Marginal cost of pollution reduction for BMP_1 — $\bar{C}$ BMP_1 = Average unit cost per pound reduction for BMP_1

BMP_2 = Marginal cost of pollution reduction for BMP_2 — $\bar{C}$ BMP_2 = Average unit cost per pound reduction for BMP_2

BMP_3 = Marginal cost of pollution reduction for BMP_3 — $\bar{C}$ BMP_3 = Average unit cost per pound reduction for BMP_3

*Cost effective expansion path is the envelop of lowest marginal cost options for reducing pollution discharge. This is illustrated here to include the lowest cost options available for BMPs with high estimated average unit costs and to include some high cost options of BMPs with low average unit costs.

13. Appendices

13.1. Appendix A: Definitions of SWBMPs from MAST

BMP	Sector	BMP Description
Bioretention with underdrain	Urban	An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the storm water runoff is temporarily ponded and then treated by filtering through the bed components, and through biological and biochemical reactions within the soil matrix and around the root zones of the plants.
Bioswale	Urban	With a bioswale, the load is reduced because, unlike other open channel designs, there is now treatment through the soil. A bioswale is designed to function as a bioretention area.
Dry Detention and Extended Detention Basins	Urban	Dry extended detention (ED) basins are depressions created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. Dry ED basins are designed to dry out between storm events, in contrast with wet ponds, which contain standing water permanently. As such, they are similar in construction and function to dry detention basins, except that the duration of detention of stormwater is designed to be longer, theoretically improving treatment effectiveness.
Dry Detention Ponds/Hydrodynamic Structures	Urban	Dry Detention Ponds are depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. Hydrodynamic Structures are devices designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads that are designed to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff.
Impervious Surface Reduction	Urban	Reducing impervious surfaces to promote infiltration and percolation of runoff storm water.
Permeable Pavement with sand/vegetation	Urban	Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. When sand and vegetation are present, high reduction efficiencies can be achieved.
Permeable Pavement without sand/vegetation	Urban	Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain.

Street Sweeping	Urban	Street sweeping and storm drain cleanout practices rank among the oldest practices used by communities for a variety of purposes to provide a clean and healthy environment, and more recently to comply with their National Pollutant Discharge Elimination System stormwater permits. The ability for these practices to achieve pollutant reductions is uncertain given current research findings. Only a few street sweeping studies provide sufficient data to statistically determine the impact of street sweeping and storm drain cleanouts on water quality and to quantify their improvements. The ability to quantify pollutant loading reductions from street sweeping is challenging given the range and variability of factors that impact its performance, such as the street sweeping technology, frequency and conditions of operation in addition to catchment characteristics. Fewer studies are available to evaluate the pollutant reduction capabilities due to storm drain inlet or catch basin cleanouts.
Tree Planting	Urban	Urban tree planting is planting trees on urban pervious areas at a rate that would produce a forest-like condition over time. The intent of the planting is to eventually convert the urban area to forest. If the trees are planted as part of the urban landscape, with no intention to covert the area to forest, then this would not count as urban tree planting
Urban Filtering Practices	Urban	Practices that capture and temporarily store runoff and pass it through a filter bed of either sand or an organic media. There are various sand filter designs, such as above ground, below ground, perimeter, etc. An organic media filter uses another medium besides sand to enhance pollutant removal for many compounds due to the increased cation exchange capacity achieved by increasing the organic matter. These systems require yearly inspection and maintenance to receive pollutant reduction credit.
Urban Forest Buffers	Urban	An area of trees at least 35 feet wide on one side of a stream, usually accompanied by trees, shrubs and other vegetation that is adjacent to a body of water. The riparian area is managed to maintain the integrity of stream channels and shorelines, to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals.
Urban Grass Buffers	Urban	This BMP changes the land use from pervious urban to pervious urban. Therefore, there is no change and no reduction from using this BMP.
Urban Growth Reduction	Urban	Change from urban to non-urban landuse in forecasted conditions.
Urban Infiltration Practices with sand/vegetation	Urban	A depression to form an infiltration basin where sediment is trapped and water infiltrates the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration. Design specifications require infiltration basins and trenches to be build in good soil, they are not constructed on poor soils, such as C and D soil types. Engineers are required to test the soil before approved to build is issued. To receive credit over the longer term, jurisdictions must conduct yearly inspections to determine if the basin or trench is still infiltrating runoff.
Urban Infiltration Practices without sand/vegetation	Urban	A depression to form an infiltration basin where sediment is trapped and water infiltrates the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration.

Urban Nutrient Management	Urban	Urban nutrient management involves the reduction of fertilizer to grass lawns and other urban areas. The implementation of urban nutrient management is based on public education and awareness, targeting suburban residences and businesses, with emphasis on reducing excessive fertilizer use.
Urban Stream Restoration	Urban	Stream restoration in urban areas is used to restore the urban stream ecosystem by restoring the natural hydrology and landscape of a stream, help improve habitat and water quality conditions in degraded streams.
Volume Reduction and/or Retention Standard (Interim)	Urban	This BMP credits efforts to increase the retention of stormwater on site or reduce the volume of stormwater entering the edge of stream. DC used a 1.2 inch retention standard and NY's WIP included a 50% volume reduction of stormwater on some urban acres. This is modeled as a conversion of impervious urban acres to urban acres that achieve a known volume reduction. Each jurisdiction has its own average and this was used to achieve a specified benefit. A similar practice with an implicit model reduction is known as impervious surface reduction.
Wetlands and Wet Ponds	Urban	A water impoundment structure that intercepts stormwater runoff then releases it to an open water system at a specified flow rate. These structures retain a permanent pool and usually have retention times sufficient to allow settlement of some portion of the intercepted sediments and attached nutrients/toxics. Until recently, these practices were designed specifically to meet water quantity, not water quality objectives. There is little or no vegetation living within the pooled area nor are outfalls directed through vegetated areas prior to open water release. Nitrogen reduction is minimal.
Forest Conservation	Urban	Urban forest conservation applies only to Maryland at this time. This BMP in Maryland is the implementation of the Maryland Forest Conservation Act that requires developers to maintain at least 20% of a development site in trees (forest condition). This is actually a preventative type of BMP which alters the rate of urban conversion. The acreage is calculated from the annual urban increase (population based). The 20% is specific to the Maryland Act and could be different for each jurisdiction or various locations within a jurisdiction.
Adapted from:	USEPA (U.S. Environmental Protection Agency). 2010d. Estimates of County Level Nitrogen and Phosphorus Data for Use in Modeling Pollutant Reductions. December 2010. U.S. Environmental Protection Agency, Region 3 Chesapeake Bay Program Office, Annapolis, MD.	

13.2. Appendix B: Maryland County/Regional and Location-Specific Cost Adjustment Factors*

Introduction

Table 4 of this report lists general factors that influence the cost of designing, implementing, and maintaining SWBMPs that may be used to adjust the planning level unit cost estimates presented in Tables 2a, 2b, and 2c. A list of qualitative considerations and generalized quantitative construction cost adjustments factors are provided in this appendix to help counties determine if and how to make cost adjustments. Until county stormwater experts can review and refine their own cost data for pre-construction, construction, and post-construction costs for comparison to the costs shown in Tables 2a, 2b, and 2c of this report these cost adjustment factors can be considered and applied to better reflect unique local conditions to help support the WIP planning and budgeting process.

Maryland Regions

The 23 Maryland Counties and Baltimore City can generally be separated into four (4) regional and two (2) land use specific categories based on the similarity of natural resources, landscape conditions, and land use characteristics; the physiographic provinces in which they are located; and/or their population densities and existing development characteristics. These six (6) regional/land use categories and the counties or municipalities included in each are:

- **Mountain Region (Appalachian Plateaus, Ridge and Valley, and Blue Ridge Provinces)** – eastern Garrett, Allegany, Washington, western Frederick Counties;
- **Piedmont Plateau Province Region (Suburban and Rural areas)** – eastern Frederick, Carroll, western Howard, western Montgomery, northern Baltimore, northern Harford, northern Cecil Counties;
- **Western Shore Region of Coastal Plain Province (Suburban and Rural areas)** – Prince George's, Charles, St. Mary's, Calvert, Anne Arundel, southern Baltimore, southern Harford, southwestern Cecil Counties;
- **Delmarva Peninsula Region of Coastal Plain Province (Suburban and Rural Areas)** – south-eastern Cecil, Kent, Queen Anne's, Caroline, Talbot, Dorchester, Wicomico, Somerset, and western Wicomico Counties;
- **Urban Areas (40K to 150K population)** – Frederick, Columbia/Ellicott City, mid to southern Harford County (Bel Air, Abingdon, Joppatowne, Edgewood, Aberdeen, Havre de Grace), Hagerstown, Waldorf/LaPlata, Salisbury, Westminster, Elkton, Cumberland; and
- **Ultra-Urban Areas (> 150K population)** – Baltimore City and Metro area in southern Baltimore County and northern Anne Arundel County, DC Metro area of Montgomery County, DC Metro area of Prince George's County, Annapolis and Metro area in Anne Arundel County.

While economies of scale play a significant role in lowering the costs of certain BMPs, other site-specific factors that influence the process for selecting appropriate BMPs or groups of BMPs for projects are also important and should be considered in adjusting costs up or down from the "typical" planning level costs provided in Tables 2a, 2b, and 2c. These factors are described in greater detail in *Chapter 4.0 – A Guide to BMP Selection and Location in the State of Maryland* of the 2000 Maryland Stormwater Design Manual (MDE 2000). They include factors related to: watershed location/conditions; terrain and geology; stormwater treatment suitability; physical site feasibility; community and environmental issues; and general location, type of land use, site access, existing utilities, and permitting issues. In general, the higher the number of these screening factors that affect a site, the more likely costs associated with the pre-construction planning/design/permitting and the construction phases of a project will be different from the average or typical costs of SWBMP. Of course, the effects of some factors could wash each other out resulting in cost being relatively close to the average.

Some qualitative adjustment factors that may affect initial costs for: 1) pre-construction planning/site selection, engineering, design, permitting, and land acquisition, 2) construction, and 3) post-construction maintenance are listed in Table B-1 below. In addition to affecting project costs, some of the factors listed in the table may also limit the potential use and applicability or effectiveness of certain BMPs in particular regions.

*****This appendix was prepared by EA Engineering, Science, and Technologies, Inc. under a sub contract with UMCES.

Table B-1.

Quantitative Adjustment Factors by Region/Site	Mountain Region	Piedmont Plateau Region	Western Shore Coastal Plain	Delmarva Peninsula Coastal	Urban Areas	Ultra-Urban Areas
General MDE BMP Site Selection Considerations						
Watershed Factors (2 or more)	+	S	+	+	S	S
Terrain Factors	+	S	S	+	S	S
Stormwater Treatment Suitability Factors	S	S	S	S	S	+
Physical Feasibility Factors (2 or more)	+	S	S	+	S	+
Community and Environmental Factors (2 or more)	+	S	S	S	+	+
Location and Permitting Factors (2 or more)	S	S	S	S	+	+
Specific Pre-Construction Considerations						
Quality of streams, wetlands, forests, and other natural or cultural resources to be impacted	+	S	S	S	-	-
Geotechnical issues (karst, sinkholes, urban fills, etc.)	+	S	-	-	S	+
High water table/poorly drained soils	S	S	S	+	S	S
Potential for habitat uplift	S	S	S	S	+	+
Difficulty gaining agency/property owner approvals	S	S	S	S	+	+
Number of utility and other infrastructure conflicts	-	S	S	-	+	+
Community input and acceptance / Public outreach and education	S	-	-	S	+	+
General land costs for purchases	-	+	S	-	+	+
Number of property owners to negotiate with for ROW or easement acquisition	-	S	S	-	+	+
Potential for work on publicly-owned lands	-	S	S	-	+	+
Size potential of projects to reduce overall unit costs	-	S	-	-	+	+
Site access for surveying and environmental/engineering studies	+	S	S	S	+	+
Competition between existing and proposed land uses (i.e., developable or agricultural parcels vs. BMP use)	S	+	+	S	+	S
Construction Considerations						
Narrow LODs / limited construction space for staging and laydown areas	-	-	-	-	+	+
High mobilization costs (i.e, material delivery costs, traffic control, work time restrictions)	S	S	S	S	+	+
Heavily disturbed underlying soils or bedrock	+	S	S	S	+	+
Potential for hazardous materials/pollutants	S	S	S	S	S	+
Level of competition from qualified contractors for bidding	+	-	-	+	-	-

Availability of skilled local labor	+	-	-	+	-	-
Local labor wage rates	-	S	S	-	+	+
Availability of adequate energy and water	+	-	S	+	-	-
Availability of suitable materials for re-use on the site	-	S	S	S	+	+
Local availability of materials (e.g. rock, sand, plants, etc.) to be shipped to site	+	S	S	S	S	+
Level of construction oversight (regulatory agencies, required environmental monitor, etc.)	S	S	S	S	+	+
Initial landscaping protection needs	+	+	S	S	+	S
Time of Year Restrictions	S	S	S	S	-	-
Security and public safety issues	S	S	S	S	+	+
Post-Construction Considerations						
Frequency of maintenance related to:						
Site damage/vandalism	-	S	S	-	+	+
Trash and debris accumulation	-	S	S	-	+	+
Landscape materials protection/replacements	S	S	S	S	S	+
Safety and public health issues/attractive nuisance	-	S	S	-	+	+
Other aesthetics	-	S	S	-	+	+
Frequency of BMP clean-outs	-	S	S	-	+	+
Potential for catastrophic failures	+	S	S	-	S	+

NOTES:

"+" - factor likely to increase costs

"-" – factor likely to decrease costs

"S" – factor is very site specific to region

13.3. Appendix C: Overview of Research Tasks Undertaken to Estimate Planning Level Unit Costs

Task 1	Review pervious SW Management Cost Studies
Task 2	Review Maryland County MS4 Reports
Task 3	Review selected Maryland Stormwater Cost Estimates (e.g. City of Rockville, Montgomery County)
Task 4	Apply SW cost estimating software (WERF model for MD counties
Task 5	Interview institutional SW experts (CSN, WERF, etc.)
Task 6	Use results of 1 through 5 to prepare table of available cost estimates for each BMP
Task 7	Use results of 6 to develop "best available" preliminary unit cost estimates for each BMP
Task 8	Review preliminary cost estimates with Maryland county SW experts
Task 9	Review preliminary cost estimates with Maryland-based SW technology vendors
Task 10	Modify cost estimates based on county input
Task 11	Prepare final draft BMP unit cost estimates
Task 12	Prepare Draft of Part 1 (Cost Section) of project report
Task 13	Respond to reviewer comments on draft and prepare final project report

Sustainable Financing for Stormwater Management

Prepared by the Environmental Finance Center, University of Maryland

October 2011

Introduction

Stormwater management is one of the most daunting issues local-level decision-makers currently face. These programs have evolved from what were once essentially flood control programs into sophisticated local efforts to protect water and stream quality. With more aggressive enforcement of state and federal pollutant discharge laws, local governments must implement potentially expensive Best Management Practices (BMPs) with limited fiscal resources.

In many communities, the stormwater system can be described as a "forgotten investment." This is, in part, due to the fact that stormwater management and infrastructure are "hidden." In a literal sense, the initial infrastructure designs of stormwater systems were to move rainwater quickly and, as unobtrusively as possible, away from the built environment.

The costs and benefits of stormwater management are also hidden and often not apparent to many sectors of the public, creating public opposition and/or apathy toward funding for stormwater management. The public is accustomed to paying meter-based user fees, for example, for drinking water and sewer, and views metering as both acceptable and equitable. However, the public may have difficulty seeing stormwater management as an equal necessity. Finally, allocations for stormwater management, if present at all, may be hidden in flood control and transportation budgets.

Sustainably Financing Stormwater Management

The drivers behind the desire for an improved level of stormwater management are diverse. Although the nutrient reduction requirements associated with the pending Watershed Implementation Plans present a pressing need, communities throughout the state are also facing water shortages, flooding, and failing infrastructure in addition to their water quality issues. There is great potential, therefore, for "multi-objective watershed management" but this necessitates a multi-pronged finance approach, as well.

Before determining how to pay for stormwater management, a community needs a solid sense of exactly "what" needs to be funded. Determining program goals, and then assessing and prioritizing the specific activities that will need to be a part of the program with an eye to the long-term is a critical first step, and one that should include the opportunity for broad-scale community engagement. Consideration should be given to all of the many components of a comprehensive stormwater management program, including areas such as administrative, planning and engineering, water quality management, operations and maintenance, capital improvement, and GIS mapping needs.

As older stormwater programs evolve beyond flood control to incorporate natural resource management and environmental protection, the costs of repairing and retrofitting local stormwater management systems will only be compounded. In addition, new development has the financial burden of attaining the standards set by codes, as well as the future cost of maintenance long after initial compliance is met. The question quickly becomes, "How will our community pay for our stormwater management needs?"

The answer comes in the form of a sustainable financing strategy. Developing and drawing on partnerships at a variety of levels and establishing a diverse financial base is critical to crafting a financing strategy that will support stormwater program goals in a sustainable manner. Dependency on a single funding source can lead to quick gains and quick declines. As foundation programs change focus and competition for declining federal grant dollars increases, communities must be strategic in developing their financing plans.

Although grant funds can be an effective way to launch programs and build momentum, there is not, never has been and never will be enough grant funds, either public or private, to achieve all of a community's stormwater management goals. A combination of cost reducing measures and additional revenue streams make for the most effective long-term financing strategies.

It is important to differentiate the terms "funding" and "financing". While funding provides revenue toward paying for a program or project, it is generally short-term, unreliable, and unsustainable. Financing, on the other hand, is a process for acquiring, investing, and managing fiscal resources with a goal of leveraging sustainable, dedicated revenue streams.

Generating Revenue

A dedicated revenue stream for wet-weather management activities can vastly improve the level of Service derived from a stormwater program. A steady, reliable income source can be used to address a community's backlog of repair requests, retrofit and replace deteriorating pipes, build a long-term operations and maintenance program, install best management practices like storm drain interceptors, catch basin inserts, and the like, and conduct outreach to residents, businesses, and visitors.

Communities have used a number of revenue streams, and combinations thereof, to address their stormwater management needs. These can include:

- General Funds
- Revenue bonds
- Revolving loans
- Construction fees
- Tax allocation
- Development fees
- Grants
- Stormwater Utility

Although the idea of a new fee may not initially sound like a solution that would be pleasing to the community at-large, stormwater utilities have become an increasingly popular mechanism for financing stormwater programs. Outreach and education that explain the importance of this type of community investment are critical to achieving public support.

These programs are often seen as more equitable than other financing solutions, since the fee paid is usually tied the extent to which a property contributes to the stormwater problem. In addition, because the utility is dedicated, the revenue stream is more reliable. A fee-based system also enables a community to offer incentives to change personal behaviors, such as rebates or reduced fees for on-site management practices that reduce runoff. The table below offers a few examples of utilities operating in the region.

Comparison of regional stormwater fees				
City, State	**Year Stormwater Fee Established**	**Population**	**Fee Structure**	**Revenue Generated Per Year**
Lewes, DE	2010	2,932	$5/month Residential $10/month Commercial $20/month Industrial	$200,000
Takoma Park, MD	1996	18,027	$4/month Single Family $4/month/ERU* Commercial and Multifamily* (*1 ERU = 1,228 sq/ft impervious surface	$350,000
Rockville, MD	2009	60,734	$4.10/month Single Family $4.10/ERU/month* All Other Properties (*1 ERU=2,330 sq/ft impervious surface)	$1,927,928
Suffolk, VA	2005	83,659	$5.24/month Single Family $5.24/ERU/month* All Other Properties (*1 ERU=3,200sq/ft impervious surface)	$4,056,979
Virginia Beach, VA	1993	433,746	$7.23/month Single Family $7.23/ERU/month* All Other Properties (*1 ERU=2,269 sq/ft impervious surface)	$21,058,267
Washington, DC	2007	599,657	$2.67/ERU/month* All Properties (*1 ERU=1,000 sq/ft impervious surface)	$13,000,000

The EFC's Stormwater Financing and Outreach Unit

Even with this knowledge, as a community with limited resources and capacity, it can be difficult to know where to start. The University of Maryland Environmental Finance Center (EFC) is a university-based center that works to assist communities in identifying sustainable implementation and financing solutions to their resource management priorities. The EFC works to strengthen the capacity of local-level decision-makers to analyze environmental problems and develop innovative and effective methods of implementing and sustainably financing solutions.

With generous support from the Maryland Department of Natural Resources and the Town Creek Foundation, the EFC recently launched a Stormwater Financing and Outreach Unit that focuses specifically on the needs of communities struggling to address stormwater management issues. The EFC recognizes that communities vary in terms of geography, population, political climate, capital budget, capacity, and stormwater management requirements; there is no one-size-fits-all solution to financing stormwater management. The Stormwater Financing and Outreach Unit provides direct technical assistance to communities to develop locally appropriate and sustainable stormwater financing strategies.

For more information:

Joanne Throwe
EFC Stormwater Financing and Outreach Unit
301-405-5036 or jthrowe@umd.edu
http://www.efc.umd.edu/SFOU.html

EFC