Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards

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List of common acronyms used throughout the text

BMP	Best Management Practices
CAST	Chesapeake Assessment Scenario Tool
CBP	Chesapeake Bay Program
CBWM	Chesapeake Bay Watershed Model
ESD	Environmental Site Design
GIS	Geographic Information Systems
GPS	Global Positioning System
LID	Low Impact Development
RR	Runoff Reduction
ST	Stormwater Treatment
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USWG	Urban Stormwater Workgroup
WIP	Watershed Implementation Plan
WQGIT	Water Quality Group Implementation Team
WTM	Watershed Treatment Model

Summary of Panel Recommendations

All of the Bay states are shifting to a new paradigm for managing urban stormwater runoff from both new development and redevelopment projects. The new paradigm is reflected in new performance standards that require greater levels of stormwater treatment using Low Impact Development (LID) and site design practices to mimic predevelopment hydrologic conditions.

The Panel noted that this new stormwater paradigm has increased capability to reduce runoff and pollutant loads generated by future development and redevelopment that occurs across the Chesapeake Bay watershed. The Panel also wrestled with the fact that each state has adopted (or will soon adopt) unique regulations, performance standards, compliance models and design criteria to implement the new stormwater paradigm.

Given this diversity, the Panel decided that assigning a single universal removal rate for BMPs designed to the new standards was not practical or scientifically defensible. Instead, the Panel elected to develop a protocol whereby the removal rate for each individual development project is determined based on the amount of runoff it treats and the degree of runoff reduction it provides. The Panel conducted an extensive review of recent BMP performance research and developed a series of new BMP adjustor curves to define sediment, nitrogen and phosphorus removal rates.

The Panel then developed specific calculation methods tailored for different development situations. Local governments will only need to report the number of acres treated under the new performance standards and the acreage of non-complying projects. They will no longer have to report a pollutant removal efficiency for each individual BMP or site design credit installed at each development project, which should greatly reduce the administrative burden on local and state agencies. To assist local users (and state verifiers), the Panel has included numerous design examples to illustrate how the removal rates are calculated

The Panel also developed a method to account for pollutant load reduction associated with the implementation of more stringent redevelopment stormwater requirements on existing sites with untreated impervious cover. While stormwater standards for redevelopment tend to be lower than for new development, they have the potential in the long run to incrementally reduce pollutant loads from untreated urban areas as redevelopment progresses. Larger communities with high redevelopment rates could be expected to attain substantial pollutant reductions in the next several decades.

The Panel also stressed that verification of BMP installation and subsequent maintenance is critical to ensure that pollutant reductions are actually achieved and maintained across the watershed. To this end, the Panel recommended that the pollutant removal rates are initially limited to a duration of 6 to 10 years, and can be renewed after a field inspection verifies the BMPs still exist, are adequately maintained and are operating as designed.

Section 1
The Expert Panel and its Charge

EXPERT BMP REVIEW PANEL New Stormwater Performance Standards	
Panelist	**Affiliation**
Stewart Comstock	Maryland Department of the Environment
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Facilitator, Tom Schueler	Chesapeake Stormwater Network
The Panel would like to acknowledge the following additional people for their contribution: Norman Goulet, Chair Urban Stormwater Workgroup Lucinda Power, U.S. Environmental Protection Agency, Chesapeake Bay Program Office Davis Montalli, West Virginia Department of Environmental Protection Joe Kelly, Pennsylvania Department of Environmental Protection	

The Panel was charged to review all of the available science on the pollutant removal performance and runoff reduction capability of BMPs that are used to comply with the new state-wide performance standards for new development and redevelopment.

The Panel was initially charged to evaluate:

(a) Whether full implementation of each new state stormwater performance standard can achieve sufficient nutrient and sediment removal at a new development site, and qualify as being "nutrient neutral" with respect to the Bay TMDL.

(b) How to assess situations at new development projects that only partially achieve the standard.

(c) What, if any, pollutant load reduction should be offered when the standards are applied to redevelopment projects that treat existing impervious cover that was not previously treated by any BMP.

(d) What are the proper units that local governments will report to the state to incorporate into the Chesapeake Bay Watershed Model.

Beyond this general charge, the Panel was asked to:

- Determine whether to recommend if an interim BMP rate be established prior to the conclusion of the panel for WIP planning purposes.

- Provide a specific definition of how the performance standard approach is applied in each state, including runoff capture volume, degree of runoff reduction, and the potential situations where development projects may not fully comply with the standard.

- Recommend procedures for reporting, tracking and verifying the removal rates achieved under the new performance standards.

- Critically analyze any unintended consequence associated with the removal rates and any potential for double- or over-counting of load reductions.

While conducting its review, the Panel followed the procedures and process outlined in the WQGIT BMP review protocol (WQGIT, 2010) to ensure rates are consistent, transparent and scientifically defensible. The panel recommendations will be reviewed by the Urban Stormwater Workgroup (USWG), and other CBP management committees before they are officially adopted by the Chesapeake Bay Partners. Appendix F documents the process by which the expert panel reached consensus, in a series of meeting minutes.

Section 2
Background on Bay State Stormwater Performance Standards

In the last 5 years, all of the Bay states have worked to revise their regulations to improve the performance of the stormwater practices applied to development sites. All of the states have increased the volume of runoff that must be treated on-site and either require or strongly encourage the use of runoff reduction practices and environmental site design. This represents a sharp departure from the "pipe to pond" stormwater paradigm used in the 1990's.

The new approach utilizes many different Low Impact Development (LID) practices distributed across the development site rather than a single centralized facility. In addition, the Bay states have all adopted more stringent design criteria to improve the performance and longevity of individual LID practices, with a greater emphasis on design features that can enhance pollutant removal capability.

A comparative summary of the stormwater performance standards for new development sites is provided in Table 1 for each Bay jurisdiction. It should be noted that the engineering design criteria underlying each set of individual state standards is too complex to fit into a single table. Readers should consult the more detailed descriptions in Appendix A to gain a more complete understanding of state requirements (or directly access the state stormwater agency web links provided in Table 2).

Also, most Bay states only require redevelopment projects to treat a fraction of the runoff volume required at new development sites. Performance standards for redevelopment sites are discussed separately in Section 4 of this report.

As can be seen in Table 1, there are considerable differences among the Bay states in the terminology they use to describe their new stormwater performances standards including terms such as environmental site design, low impact development, runoff reduction, on-site retention, resource protection events and the water quality volume.

While it is tempting to compare the state performance standards in terms of the rainfall depth controlled, this can be misleading because of differences in the models used to compute runoff and technical assumptions regarding the pre-development hydrology baseline. Some states use a curve number (CN) approach, whereas others use a runoff coefficient (R_v) approach. The CN approach yields different runoff volumes, depending on the existing hydrologic soil group, the pre-existing land cover, and the change in impervious cover.

Table 1 lists the performance standard for new development sites in each jurisdiction across the Bay along with any qualifying conditions. The rain depth column indicates the rainfall depth that must be managed on the site.

The baseline column refers to the fact that each state requires stormwater to be treated to a different predeveloped hydrologic baseline. That baseline often reflects the runoff prior to development based on the specified land cover and hydrologic soil groups present at a site. In other cases, a state may simply require a basic stormwater treatment volume independent of the predevelopment condition.

The next column addresses the question of what method is used in each state's compliance tool or model to calculate the runoff volume produced at a site. Most states employ either the Curve Number (CN) or Runoff Coefficient (Rv) approach. The RR or LID column indicates whether state stormwater regulations specifically require or encourage the use of Runoff Reduction (RR) or Low Impact Development (LID) practices for stormwater management.

Finally, the Manual column addresses when the stormwater manual for each jurisdiction was released and/or whether or not it is currently being updated (U).

Table 1
Comparison of Bay State Stormwater Performance Standards for New Development Sites [1] [2]

STATE	Performance Standard	Rain Depth	Base-line	Model	RR or LID?	Manual
DC	Retain runoff volume on-site	1.2 in	Zero	R_v	R	2012
DE	Provide runoff reduction to have zero effective impervious for RPE	2.7 in	Open Space	CN	R	2012-U
EPA	Control 95% storm event on-site using RR to METF	1.4 - 1.7 in	Varies	Varies	R	2010
MD	Use ESD to the MEP to achieve runoff for woods in good condition	2.7 in	Woods in good condition	CN & R_v	R	2009
NY	Provide runoff reduction for a fraction of WQv for 90% rain event	0.8 - 1.2 in	Zero	R_v	R	2010
PA	No increase in total runoff volume for all events up to the two year storm	2.8 in	Meadow or better	CN	E	2006
VA	TP load from new development may not exceed 0.41 lbs/ac/yr	1.0 in	Zero	R_v	E	2012
WV	Provide on-site runoff reduction	1.0 in	Zero	Rv	R	2012

[1] for redevelopment comparison, see Section 4
[2] Please consult Appendix A to get a more detailed description of state stormwater performance standards

CN = Curve Number using TR 55
ESD = Environmental Site Design
LID = Low Impact Development
RPE = Resource Protection Event
RR = Runoff Reduction
R_v = Runoff coefficient
MEP = Maximum Extent Practicable
METF = Maximum Extent Technically Feasible
TP = Total Phosphorus
WQv = Water Quality Volume

R= Required E= Encouraged U= Update of Existing Manual

In addition, the Bay states differ with respect to the years that their new stormwater performance standards will take effect. Implementation within a state may also be staggered due to delayed local ordinance approval, exemptions, grandfathering provisions and a host of other factors. In addition, certain development sites may not need to fully comply with the standards if they can demonstrate they have tried to the maximum extent practical or technically feasible.

The practical implication is that many localities may end up with a mix of practices designed under the old and new standards from approximately 2009 to 2014, which complicates efforts to track the net change in nutrient loads from new development going forward.

The Panel concluded that these "apples to oranges" problems meant that (a) any general protocol had to be specifically adapted for each Bay state to reflect its unique performance standard formulation and (b) the protocol had to account for the differential rates for development projects built under old and new performance standards.

Table 2 Key Web Links for State and Federal Stormwater Agency Regulations[1]	
EPA	http://cfpub.epa.gov/npdes/home.cfm?program_id=6
DC	http://ddoe.dc.gov/stormwater
DE	http://www.dnrec.delaware.gov/swc/pages/sedimentstormwater.aspx
MD	http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/SedimentandStormwaterHome/Pages/Programs/WaterPrograms/sedimentandstormwater/home/index.aspx
NY	http://www.dec.ny.gov/chemical/8468.html
PA	http://www.pacode.com/secure/data/025/chapter102/chap102toc.html
VA	http://www.dcr.virginia.gov/stormwater_management/stormwat.shtml
WV	http://www.dep.wv.gov/WWE/Programs/stormwater/Pages/sw_home.aspx
1 links current as of 3.19.2012	

Section 3
Protocol for Defining Removal Rates for New Development Projects

Basic Approach

Given the diversity in state stormwater performance standards, the Panel decided that assigning a single universal removal rate for BMPs designed to the new standards was not practical or scientifically defensible. Instead, the Panel elected to develop a protocol whereby the removal rate for each individual development project is determined based on the amount of runoff it treats and the degree of runoff reduction it provides. The Panel conducted an extensive review of recent BMP performance research to develop this new protocol which is summarized in Appendix B.

The Panel initially developed a new BMP removal rate adjustor table that provides increasing sediment and nutrient removal rates for new development projects that treat more runoff and/or employ runoff reduction practices. For ease of use, the adjustor table was converted into a series of three curves, which are portrayed in Figures 1 to 3. Readers that wish to see the technical derivation for both the adjustor table and the curves should consult Appendix C. The new BMP removal rate curves make it easy to determine pollutant removal rates for new development. The designer first defines the runoff volume captured by the project (on the x-axis), and then determines whether the project is classified as having runoff reduction (RR) or stormwater treatment (ST) capability (from Table 4). The designer than goes upward to intersect with the appropriate curve, and moves to the left to find the corresponding removal rate on the y-axis (see example in Figure 1).

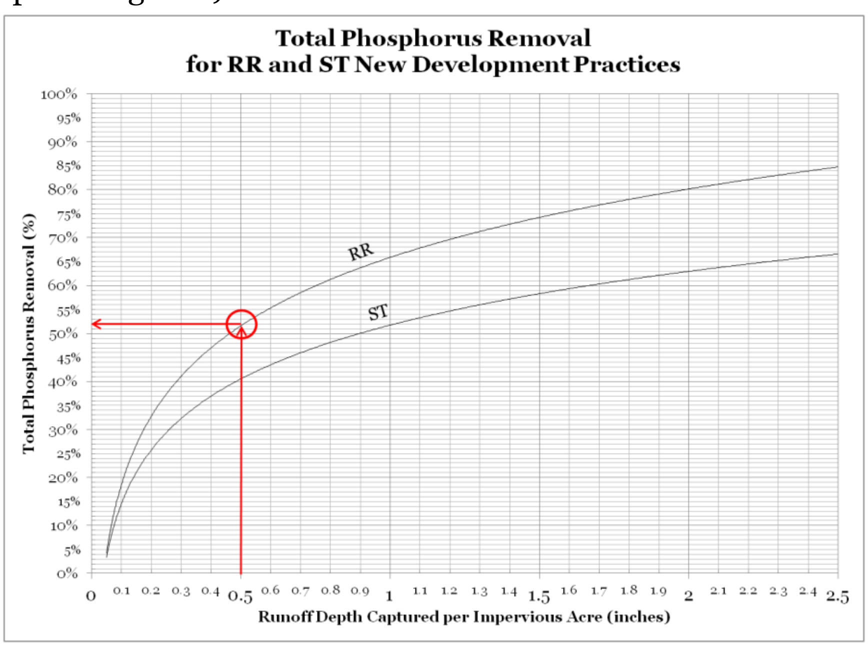

Figure 1. New BMP Removal Rate Adjustor Curve for Total Phosphorus

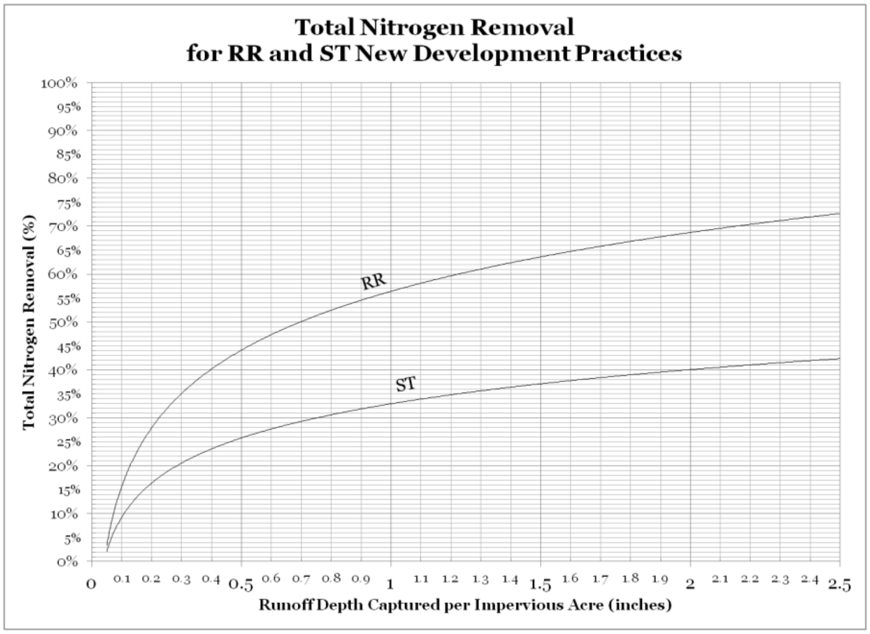

Figure 2. New BMP Removal Rate Adjustor Curve for Total Nitrogen

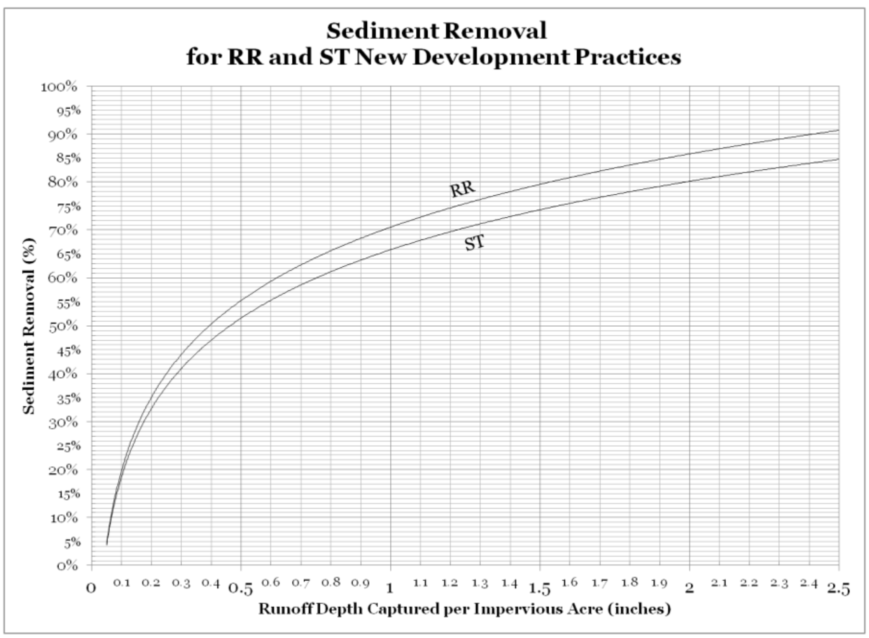

Figure 3. New BMP Removal Rate Adjustor Curve for Sediment

In the rare cases that the runoff volume captured by the practice exceeds 2.5 inches, simply use the pollutant removal values associated with 2.5 inches.

Table 3 **How to Define Runoff Capture for New Development in Each Bay State**		
	Specific Engineering Parameter (EP) Defining Runoff Volume Captured	**Source**
DC	Divide SWRv (stormwater retention volume, cubic feet) by 43,560 and insert into Equation X	Cell C-30 in 2012 DDOE Compliance Spreadsheet
DE	Runoff Reduction Depth (inches)	Directly from DE DURMM v. 2 Model Output
FED	D (95% rainfall depth, inches) less initial abstraction for predevelopment condition	EPA, 2009 and DOD, 2010
MD	Divide ESD Runoff Volume (cubic feet) by 43,560 and insert into Equation X	Cell C-66 in MD ESD TO MEP Spreadsheet (2012)
NY	Insert WQv (water quality volume, acre-feet) into Equation X	See 2010 Design Manual
PA	Divide 2-year Volume Increase of Runoff Volume between the proposed conditions and the existing conditions (cubic feet) by 43,560 and insert into Equation X	Cell C-51 in Tab WS4 of 2012 CSN PA Stormwater Spreadsheet
VA	Post Development treatment volume (acre-feet) inserted into Equation X	Cell B-49 on Site Data page (tab 1) in 2012 VA DCR Compliance Spreadsheet
WV	Target Tv (treatment volume, acre-feet) inserted into Equation X	Cell A-80 in 2011 WVDEP Compliance Spreadsheet

Equation X is a site specific conversion factor equation:

$$= \frac{(12 * EP)}{IA}$$

Where:

EP = State-Specific Engineering Parameter (in acre-feet)
IA = Impervious Area (acres)

Runoff reduction is defined as the total post-development runoff volume that is reduced through canopy interception, soil amendments, evaporation, rainfall harvesting, engineered infiltration, extended filtration or evapo-transpiration. Stormwater practices that achieve at least a 25% reduction of the annual runoff volume are classified as providing runoff reduction (RR), and therefore earn a higher net removal rate. Stormwater practices that employ a permanent pool, constructed wetlands or sand filters have less runoff reduction capability, and their removal rate is determined using the stormwater treatment (ST) curve.

Table 4 assigns all of the stormwater practices referenced in Bay State stormwater manuals into the ST or RR category, so that designers can quickly determine which curve they should use based on the primary treatment practice(s) employed at their site. In situations where a mix of ST and RR practices are used within the same development project, the designer should use the curve based on either the largest single practice used in the project or the one(s) that provide the majority of the runoff capture volume.

Table 4 Classification of BMPs based on Runoff reduction capability[1]	
Runoff Reduction (RR) Practices	*Stormwater Treatment (ST) Practices*
Non-Structural Practices	*Practices*
Landscape Restoration/Reforestation	Constructed Wetlands
Riparian Buffer Restoration	Dry Detention Ponds
Rooftop Disconnection (aka Simple Disconnection to Amended Soils, to a Conservation Area, to a Pervious Area, Non-Rooftop Disconnection)	Dry Extended Detention Ponds
Sheetflow to Filter/Open Space* (aka Sheetflow to Conservation Area, Vegetated Filter Strip)	Filtering Practices (aka Constructed Filters, Sand Filters, Stormwater Filtering Systems)
Non-Structural BMPs, PA 2006 BMP Manual, Chapter 5	Proprietary Practices (aka Manufactured BMPs)
Practices	Wet Ponds (aka Retention Basin)
All ESD practices in MD 2007	Wet Swale
Bioretention or Rain Garden (Standard or Enhanced)	
Dry Swale	
Expanded Tree Pits	
Grass Channels (w/ Soil Amendments, aka Bioswale, Vegetated Swale)	
Green Roof (aka Vegetated Roof)	
Green Streets	
Infiltration (aka Infiltration Basin, Infiltration Bed, Infiltration Trench, Dry Well/Seepage Pit, Landscape Infiltration)	
Permeable Pavement (aka Porous Pavement)	
Rainwater Harvesting (aka Capture and Re-use)	
*May include a berm or a level spreader [1]Refer to DC, MD, PA, VA or WV State Stormwater Manuals for more information	

Protocol for New Development Projects

To determine the sediment and nutrient removal rate for an individual new development project, the designer should go the appropriate curve and find the unique rate for the combination of runoff treatment and runoff reduction that is achieved. The designer should also estimate the total number of acres that are collectively treated by the system of BMPs.

The removal rates determined from the new BMP removal rate adjustor curves are applied to the entire site area, and not just the impervious acres. Also, the reporting unit is the entire treated area of the site, regardless of whether it is pervious or impervious. Several examples are provided in Section 6 to illustrate how the protocol is applied.

What to Submit to the State

Localities should check with their state stormwater agency on the specific data to report for individual new development projects. Some typical data they may be asked to report includes:

a. List of practices employed
b. GPS coordinates
c. Year of installation
d. 12 digit watershed in which it is located
e. Total drainage area treated
f. Runoff volume treated and BMP "type" (i.e., whether the BMP system is classified as ST or RR)
g. Projected sediment, nitrogen and phosphorus removal rates

The Baseline Load Issue

The Panel decided that localities do not need to calculate a pre-development baseline load when it comes to reporting new BMPs that serve future new development or redevelopment sites to their appropriate state TMDL agency. The precise load reduction achieved under the new performance standards is computed by the Chesapeake Bay Watershed Model. Localities need only report the removal rate derived from the new BMP removal rate adjustor curves and the total treated acres for each individual development project.

The Panel acknowledges that many localities may want to estimate pre-development baseline loads so they can track the aggregate impact of the implementation of stormwater practices on pollutant loads from the developed land sector over time. This local tracking effort can estimate pollutant load reductions that occur when the new performance standards are applied to redevelopment sites. In addition, this tracking system can estimate the pollutant removal benefits associated with BMP implementation at new development sites. Most importantly, local load tracking can help communities forecast trends in local loads due to land use change (and BMP implementation) in the future. Such information can be useful to include in:

1. Local watershed implementation plans
2. Comprehensive land use plans
3. MS4 permit annual reports

Therefore, the Panel recommended several options that are suitable for planning level analyses to track how pollutant loads change in response to growth and development over time. These include the:

1. Generic state-wide CBWM urban unit loading rates
2. Simple Method
3. The Watershed Treatment Model

These options are described in greater detail in Appendix D. The Panel noted that there are pros and cons associated with each option, and that localities should check with their state stormwater agency to see which one(s) are preferred when it comes to any state MS4 permitting requirements.

Analyzing New BMPs in the Context of CAST, SB and the CBWM

The Panel acknowledges that the new BMP removal rate protocol may require adjustments in the BMP assessment and scenario builder tools recently developed to assist states and localities to evaluate BMP options to develop watershed implementation plans (i.e., each development project has a unique removal rate and consequent load reduction, while the CAST tools apply a universal rate for each type of BMPs).

The CBPO modeling team has expressed a willingness to incorporate the adjustor curves into the CAST modeling framework in the next year or so. Until these refinements are made, the Panel felt that it was reasonable for each state to select a single removal rate to characterize the performance of a generic BMP system used to meet new performance standards at a new or redevelopment site. This generic rate can be used for planning purposes to allow localities to analyze the loading impact from alternate future land use and stormwater management scenarios. For example:

A locality might assume that their future new development projects will fully meet the performance standard, and then use the curves to derive a standard removal rate for the aggregate drainage area expected to be treated in the future. The resulting load can be compared against the pre-development load to determine if future development will be nutrient neutral or not. Localities may also want to run scenarios whereby full compliance with the performance standard is not achieved to get a better sense of how this might impact their baseline load allocation.

A locality might also assume that their future redevelopment project fully meet the performance standard, and then assign the derived removal rate to the aggregate impervious area that is expected to be redeveloped over a defined time horizon. Since pre and post development land use are both impervious, this will provide a quick estimate of the load reductions possible under different redevelopment scenarios in the future.

As noted, each state is encouraged to work with localities to develop new and redevelopment stormwater scenarios that are consistent with their unique scenario assessment tools.

Important Note on State Pollutant Load Calculations

Several states in the Bay watershed require a site-based spreadsheet pollutant load calculation as part of stormwater review for individual development projects. The calculations require designers to achieve target post development loads using a series of removal efficiencies for individual LID and site design practices at the development site. Examples include the Maryland Critical Area Phosphorus compliance spreadsheet (CSN, 2011), the Virginia state-wide stormwater compliance spreadsheet (VA DCR, 2011), and the Pennsylvania stormwater manual worksheets (2006).

The Panel considers the technical and scientific basis for these site-based tools to be sound and appropriate for the scale of individual site analysis and BMP design. The Panel strongly emphasizes that the pollutant removal protocol it has recommended for Bay TMDL tracking in no way supersedes these site-based compliance tools. The regulated community must still meet their state's stormwater regulatory requirements established by regulations, permits, and/or design manuals.

The Panel agreed on the continuing need to monitor the effectiveness of stormwater BMPs at both the project and watershed scale to provide greater certainty in the removal rate estimates. The Panel also noted the importance of monitoring both runoff reduction and stormwater treatment BMPs in varied applications, terrain and climatic conditions.

Section 4
Protocol for Estimating Redevelopment Load Reduction

Background on Redevelopment and the Bay

Redevelopment is generally defined as the process whereby an existing development is adaptively reused, rehabilitated, restored, renovated, and/or expanded, which results in the disturbance of a defined footprint at the site. Redevelopment normally occurs within urban watersheds that are served by existing water, sewer and public infrastructure. When redevelopment is done properly, it is a key element of smart growth, sustainable development and urban watershed restoration (US EPA, 2005, 2006 and CSN, 2011a).

Historically, new development in the suburbs and rural areas of the Chesapeake Bay watershed has far exceeded the amount of redevelopment, in terms of land consumed and new impervious cover created. In recent years, however, there is evidence that urban sprawl may be cresting as a result of high energy prices, road congestion, falling housing prices, reduced job mobility and other economic forces, including the recent recession. Recent land use statistics show a slowdown in the rate of land conversion for sprawl development in the last five years.

At the same time, there is some evidence that redevelopment is increasing as a share of total development, at least in some portions of the watershed. More recent statistics show a sharp increase in residential redevelopment projects in core cities and inner suburbs of major metropolitan areas, including five in the Bay watershed (US EPA, 2010b).

The trend is being driven by increasing numbers of urbanites seeking the amenities of city life. This “back to the city” trend is reinforced by surveys of real estate investors that forecast increasing infill and redevelopment activity in coastal cities (ULI, 2010). In any event, the increasing age of existing residential and commercial development in metropolitan areas suggest that much of it will need to be rehabilitated or redeveloped in the future (Jantz and Goetz, 2008).

Stormwater Performance Standards for Redevelopment in the Bay States

Most jurisdictions in the Bay watershed have traditionally waived, exempted, relaxed or otherwise avoided stormwater requirements for redevelopment projects (with some notable exceptions). Most Bay states, however, have applied more stringent stormwater performance standards for redevelopment projects in the last few years. A comparative summary of the stormwater redevelopment requirements is shown in Table 5.

Most Bay states only require redevelopment projects to treat a fraction of the stormwater volume required at "green-field" development sites, in recognition of the challenging design constraints in urban areas, and to create an incentive for smart growth. As can be seen from Table 5, most states allow for offsets if full on-site compliance is not feasible. Most Bay states provide a credit for reducing existing impervious cover as part of the redevelopment design process, and some states "penalize" redevelopment projects that create more impervious cover than the predevelopment condition (i.e., the new increment of impervious cover is subject to the new development performance standard). There are two notable exceptions: the District of Columbia and Federal Facilities require the same runoff reduction volume for both new and redevelopment projects.

Table 5
Examples of Redevelopment Stormwater Requirements in the Chesapeake Bay Watershed [1]

Jurisdiction	Redevelopment Requirement	Min. Area (sf)	Offset?	Status*
District of Columbia	On-site retention of runoff from the 1.2 rainfall event	5,000	Yes	2012
Delaware	50% reduction in existing effective impervious for the site	5,000	Yes	2012
Federal Facilities	On-site runoff reduction for the 95% rainfall event	5,000	Yes	2010
Maryland	Reduce existing imperviousness by 50%, or treat runoff from 1.0 inch of rainfall, or combination	5,000	Yes	2009
New York	Reduce by 25% through IC reduction, BMPs or alternative practices	43,560	Yes	2010
Pennsylvania	20% WQ treatment for the site	43,560	UD	2008
Virginia	Reduce existing phosphorus load by 10 to 20% depending on disturbed area	43,560[3]	Yes	2011
West Virginia	0.25 - 0.8 inch of on-site runoff reduction [2]	43,560	Yes	2011

[1] Some states and localities may also impose further stormwater storage or runoff reduction volumes for channel protection or flood control purposes, depending on downstream conditions and how much new impervious cover is created at the redevelopment site.
[2] Depth varies depending on the number of redevelopment credits the project qualifies for thresholds for land use intensity and/or vertical density, involvement of brown-field remediation, or inclusion of mixed use or transit oriented development elements (WV DEP, 2009).
[3] May be smaller in the Chesapeake Bay Preservation Area
* Refers to the projected year that the redevelopment requirement will be adopted; the actual effective date for individual projects is likely to extend beyond that.

UD = Under development

Protocol for Defining Redevelopment Pollutant Removal Rates

This protocol is used to account for nutrient reduction associated with the implementation of more stringent redevelopment stormwater requirements on existing, untreated impervious cover. While the stormwater standards tend to be lower than for new development, they have the potential to incrementally reduce pollutant loads from untreated impervious areas during the redevelopment process. In particular, large cities and counties with high forecasted redevelopment rates can expect substantial pollutant reductions over the next 15 years, which can be deducted from their baseline pollutant load allocation target.

The protocol applies to individual redevelopment projects that meet the new redevelopment standards from 2010 and going forward. The protocol is fairly similar to the protocol for new development, but has several nuances. For example, the designer:

- Needs to confirm that the project is properly classified as redevelopment and is not served by any prior stormwater treatment practices.
- Tracks the acreage of *impervious cover* that is either treated or reduced during the redevelopment process. This is different from the reporting unit for new development which is *total site area*.
- Determines the runoff capture volume and degree of runoff reduction achieved by the combination of LID practices used to meet the redevelopment standard. As noted earlier, the runoff capture volume will usually be lower than that achieved at new development sites. Most Bay states have a separate compliance computation or spreadsheet that applies strictly for redevelopment situations (See Table 6 for state-specific parameters).
- Estimates the pollutant removal rates using the appropriate new BMP adjustor curves (Figures 1 to 3).

Table 6 **How to Define Runoff Capture for Redevelopment in Each Bay State**		
	Specific Engineering Parameter (EP) Defining Runoff Volume Captured	**Source**
DC	Divide SWRv (stormwater retention volume, cubic feet) by 43,560 and insert into Equation Y	Cell C-30 in 2012 DDOE Compliance Spreadsheet
DE	Runoff Reduction Depth (inches)	Directly from DE DURMM Model Output
FED	D (95% rainfall depth, inches) less initial abstraction for predevelopment condition	EPA, 2009 and DOD, 2010
MD	Divide Redevelopment treatment volume requirements (cubic feet) by 43,560 and insert into Equation Y	Cell F-44 in MD ESD TO MEP Spreadsheet (2012)
NY	Insert WQv (water quality volume, acre-feet) into Equation Y	See 2010 Design Manual
PA	Divide 2-year Volume Increase (cubic feet) by 43,560 and insert into Equation Y	Cell C-51 in Tab W4 of 2012 CSN PA Stormwater Spreadsheet
VA	Post Development treatment volume (acre-feet) inserted into Equation Y	Cell F-57 on Site Data page (tab 1) in 2012 VA DCR Redevelopment Compliance Spreadsheet
WV	Target Tv (treatment volume, acre-feet) inserted into Equation Y	Cell B-80 in 2011 WVDEP Compliance Spreadsheet

Equation Y is a site specific conversion factor equation:

$$= \frac{(12 * EP)}{SA}$$

Where:

EP = State Specific Engineering Parameter (acre-feet)
SA = Redevelopment Site Area (acres)

Section 5
Protocol for Non-Conforming Projects

What Are Non-Conforming Projects?

Non-conforming projects include new development or redevelopment projects installed after 2011 that are:

- Designed under old state stormwater performance standards due to grandfathering provisions, gradual rollout of new standards, waivers or delayed local adoption of stormwater ordinances or review procedures, or
- Designed under the new state stormwater standards, but only partially meet them due to site constraints, waivers, exemptions, etc. AND are not mitigated by an acceptable stormwater offset

Why are Non-Conforming Projects an Issue?

The transition to more stringent stormwater performance standards will not be a hard and fast event in most Bay states. Through 2017, many localities will need to keep two sets of BMP books to reflect the simultaneous implementation of BMPs under the old and new standards.

At the same time, localities are seeing a shift to a mix of LID and site design practices in many projects, even if they are not sized according to the new standards. Many of these new LID BMPs are not easily classified under the existing CBP-approved urban BMP rates. Simple BMP reporting mechanisms are needed to accurately account for the differential nutrient reduction achieved during this transition period.

Recommended Process for Reporting Non-Conforming BMPs

If the development project is served by a single BMP that can be classified under an existing CBP-approved BMP category, then use the appropriate existing removal rate.

If the project is served by multiple BMPs, determine the runoff treatment volume per impervious acre and whether the BMPs achieve RR or ST, and enter the appropriate removal rate from Figures 1 to 3. In addition, the following site data should be reported: year installed, treated drainage area, % IC, predevelopment land cover and GPS coordinates.

If a project does comply with the applicable standard due to the use of a stormwater offset or mitigation fee, the locality should track the aggregate equivalent impervious acreage which must be mitigated in the future, and the status of offset retrofit project construction. Any BMP built under a local offset program to meet state performance standards is not eligible for any additional load reduction (i.e., beyond the load reduction they are credited for meeting the state stormwater performance standard for the site).

Section 6
Design Examples

This section presents examples on how to apply the new BMP protocol to estimate nutrient and sediment removal rates for four development scenarios, as interpreted under different state stormwater performance standards. The examples include a low density residential subdivision, a planned unit development and a high density "big box" retail project, as well as an urban redevelopment project.

It should be noted that the design examples simply illustrate how nutrient and sediment removal rates are calculated in the context of the Chesapeake Bay TMDL. Designers must still follow the appropriate stormwater sizing, design criteria and compliance tools established by each state to implement its new performance standards.

Common Scenario #1 – Low Density Residential Subdivision

A developer plans to develop a 25 acre site into a half-acre lot residential subdivision in Pennsylvania. The predevelopment land cover is 50% forest and 50% meadow and has 100% C soils. After development the site will be 25% impervious, 50% turf and 25% forest. The developer will install a mix of LID and site design practices that qualify as RR practices. The calculation for PA is shown below as an example.

Using the site data above and the PA stormwater compliance worksheets, we can determine the target runoff reduction volume (in acre-feet) for this site. The rainfall depth to be controlled is assumed to be 2.8 inches. Once the EP has been calculated, it is then entered into Equation X to determine the site runoff capture depth.

$$Equation\ X = \frac{(12 * EP)}{IA}$$

$$Equation\ X_{PA} = \frac{(12 * 1.16)}{6.25} = 2.23\ in$$

State	Engineering Parameter (acre-feet)	Runoff Captured (inches)
PA	1.16	2.23

Once the runoff capture depth has been defined, the designer then uses the New BMP Adjustor Curves (Figures 1-3) to determine the associated pollutant removal values. One starts with the runoff capture depth on the x-axis and draws a line vertically until the curve for the practices is intercepted. From there, a horizontal line drawn back to intersect the y-axis will yield the pollutant removal rate.

State	TP	TN	TSS
PA	82%	70%	88%

Common Scenario #2 – Residential Planned Unit Development

A 100-acre site is built with a mix of single-family homes, apartments and townhouses in Maryland. The existing land cover consists of 100% forest with C soils. The new residential development will result in 50% impervious cover and 50% turf cover. After review of Table 4, it was determined that the stormwater management practices employed at the site should be classified as ST practices.

Entering the site data above into the MD stormwater compliance spreadsheet, one can quickly determine the EP (in acre-feet) for the site. The EP can then be used in Equation X to determine the amount of runoff in inches that needs to be captured.

$$Equation\ X_{MD} = \frac{(12 * 7.5)}{50} = 1.80\ in$$

State	Engineering Parameter (acre-feet)	Runoff Captured (inches)
MD	7.50	1.80

Once the runoff capture depth for the site is known, the New BMP Adjustor Curves (Figures 1-3) are used to determine the associated pollutant removal rate, as shown below.

State	TP	TN	TSS
MD	61%	39%	78%

Common Scenario #3 – Commercial Retail

An existing 10-acre site is developed into a big-box retail store in Virginia. The new site will have 80% impervious cover and 20% turf cover, which will replace the predevelopment meadow cover. The site has 100% B soils. After consulting Table 4, the reviewer determines that the stormwater practices employed at the site qualify as ST practices. The calculations for VA have been done as an example.

The above site data is entered into the Virginia stormwater compliance spreadsheet to quickly determine the EP (in acre-feet) for the site. The EP can then be used in Equation X to determine the amount of runoff in inches that needs to be captured.

$$Equation\ X_{VA} = \frac{(12 * 0.67)}{8} = 1.01\ in$$

State	Engineering Parameter (Acre-feet)	Runoff Captured (inches)
VA	0.67	1.01

Once the runoff capture depth for the site is known, the New BMP Adjustor Curves (Figures 1-3) are used to determine the associated pollutant removal rate, as follows.

State	TP	TN	TSS
VA	52%	33%	66%

Common Scenario #4 – Redevelopment Project

A developer is redeveloping a 2-acre facility to build a new warehouse in the District of Columbia. The predevelopment conditions are 50% impervious and 50% turf land cover. The redeveloped site will also consist of 50% impervious and 50% turf land cover. There are 100% D soils at the site and the site will be developed using RR practices. The District of Columbia's calculations have been done for demonstration below.

Table 6 tells us how we can calculate the runoff reduction volumes for redevelopment in each Bay state. In this case, the project data is entered into the DDOE stormwater compliance spreadsheet to determine the EP value for the site. Equation Y is then used to calculate the target runoff reduction volume (inches).

$$Equation\ Y = \frac{(12 * EP)}{SA}$$

$$Equation\ Y_{DC} = \frac{(12 * 0.12)}{2} = 0.72\ in$$

State	Runoff Captured (Acre-feet)	Runoff Captured (inches)
DC	0.12	0.72

Once the runoff capture volume is known, we can refer to the New BMP Adjustor Curves (Figures 1-3) to determine the associated pollutant removal values.

State	TP	TN	TSS
DC	59%	51%	63%

Section 7
Accountability Procedures

The Panel concurs with the conclusion of the National Research Council (NRC, 2011) that verification of BMP installation and subsequent performance is a critical element to ensure that pollutant reductions are actually achieved and sustained across the watershed. The Panel also concurred with the broad principles for urban BMP reporting, tracking and verification contained in the revised memo to the Urban Stormwater Workgroup (CSN, 2012). The Panel developed the following specific reporting and verification protocols for BMPs installed to comply with new state performance standards at new development and redevelopment projects.

Basic Reporting Unit. Local governments will track the number of treated acres each year that fully meet the state's new performance standard. The typical duration for the BMP system removal rate for new development will be twice the prescribed MS4 inspection cycle, which ranges from 6 to 10 years. The removal rate can be extended if a field inspection verifies the BMP(s) are still performing.

State BMP Reporting Systems. Each state has a unique system to report BMPs as part of their MS4 permit. In some cases, states are still developing and refining their BMP reporting systems. To get credit for load reductions in the context of CBWM progress runs, states will need to report BMP implementation data using CBP-approved rates or methods, reporting units and geographic location (consistent with NEIN standards), and periodically update data based on the local field verification of BMPs.

Local Reporting to the State. Localities will need to submit basic spreadsheet documentation to the state once a year as part of their MS4 annual report. The spreadsheet can be used to tabulate the aggregate acres of new development and redevelopment that were treated to the standard. Localities should check with their state stormwater agency on the specific data to report. Some typical data they may be asked to report includes:

- Whether the project is classified as new development or redevelopment
- Total drainage area treated (acres)
- Post development site land cover (e.g., % forest, % turf, % impervious cover)
- Pre-development land cover (e.g., % forest, % turf, % impervious cover)
- Year installed
- GPS coordinates (lat/long) and the 12 digit watershed in which it is located (optional)

Initial Verification of BMP Installation. Localities will need to verify that urban BMPs are installed properly, meet or exceed the design standards for its CBP BMP classification, and are functioning hydrologically as designed prior to submitting the BMP for load reduction credit in the state tracking database. This initial verification is provided either by the BMP designer or the local inspector as a condition of project acceptance, as part of the normal local stormwater BMP plan review process. From a reporting standpoint, the MS4 community would simply indicate in its annual report whether or not it has BMP review and inspection procedures in place and adequate staff to implement them.

Local Record-Keeping. Localities should maintain an extensive project file for each new development project (i.e., LID locator map showing all LID and site design practices employed, construction drawings, as-built survey (for larger practices), digital photos, inspection records, and maintenance agreement). The file should be maintained for the lifetime for which the BMP removal rate will be claimed. Localities are encouraged to develop a GIS-based BMP tracking system in order to schedule routine inspections and maintenance activities over time.

Non-Conforming Projects. Local governments should also keep track of any future development projects that are designed under the old standard, or cannot fully comply with the new standards. The lower nutrient removal rate for each non-conforming project can be computed using the new BMP removal rate adjustor curves, and reported separately to the state. The state may elect to use CAST or other similar tools to determine the aggregate nutrient increase associated with non-conforming projects in a locality, and increase their local load allocation target.

Periodic BMP Inspections. Simple visual indicators are used during routine maintenance inspections to verify that the system of practices still exists, is adequately maintained and is operating as designed. It is recommended that these rapid investigations be conducted as part of every other routine stormwater BMP inspection required under their MS4 NPDES permits.

Appendix E provides an example of an inspection form to quickly assess urban BMP performance in the field using simple visual indicators. This approach was refined and tested through an extensive analysis of hundreds of BMPs located in the James River Basin of the Chesapeake Bay watershed. More detail on the methods and results can be found in Hirschman et al (2009).

The basic form in Appendix E can be modified, simplified or customized to meet the unique BMP terminology and design criteria employed in each Bay state. Each state may elect to develop or adapt their own indicators, checklists and field inspection procedures. In some situations, localities can reduce the inspection effort by sub-sampling a representative fraction of BMPs at new development sites designed to the new standard to calculate the proportion of their BMPs that are performing or not performing.

Local inspectors should evaluate BMPs once every other inspection permit cycle, as mandated in their MS4 permit to assure that individual LID and site design practices are still capable of removing nutrients/sediments.

Suggested Process for BMP Downgrades. If the field inspection indicates that a BMP system is not performing to its original design, the responsible party would have up to one year to take corrective maintenance or rehabilitation actions to bring it back into compliance. If the facility is not fixed after one year, the pollutant reduction rate for the BMP would be eliminated, and the locality would report this to the state in its annual MS4 report. If corrective maintenance actions were verified for the BMP system at a later date, the locality could take credit for the load reduction at that time.

Special Procedures for Urban BMPs Installed in Non-MS4s. Several states such as PA and WV are expected to have considerable development occurring in non-MS4 communities, which tend to be very small in size and fairly new to stormwater BMP review. It is acknowledged that these non-MS4s may not currently have the budget and/or regulatory authority to fully meet the new BMP verification protocol. A committee of the Urban Stormwater Work Group will recommend alternative verification procedures in 2012 for non-MS4 communities.

Stormwater Offsets and Mitigation. The full site pollutant reduction rate for non-conforming sites is allowed if a new stormwater practice(s) is built (and verified) that fully offsets, compensates or otherwise mitigates for a lack of compliance with new development stormwater performance standards. It should be noted that no additional load reduction may be taken for a retrofit when a stormwater offset is provided.

Appendix A
Summary of State Stormwater Performance Standards

District of Columbia

1. Status of Standard
    a. Stormwater regulations expected to be rolled out in 2012 and take effect in June 2013
2. Performance Standard for New Development
    a. On-site retention of runoff from the 1.2 inch rainfall event
    b. Onsite retention and/or treatment of the first 1.0 inch and treatment or retention of additional flows up to the 2 year, 24 hour storm event in Anacostia Watershed
3. Performance Standard for Redevelopment
    a. On-site retention of runoff from the 1.2 inch rainfall event
    b. An additional requirement of 0.8 inches is being proposed for "significant alterations" properties over 5,000 sq. ft. that spend greater than 50% of the assessed value on construction costs
4. Applicability
    a. Disturbances greater than 5,000 square feet
5. Manual Status
    a. Under development by the Center for Watershed Protection - due out in 2012
6. Predevelopment Baseline
    a. No predevelopment baseline
7. Prescribes or Encourages LID or RR
    a. Yes, LID practices are required to achieve onsite retention and runoff reduction
8. Situations where the performance standard does not apply
    a. Public Right-of-Way projects have an MEP standard, they are not required to participate in the offsite retention program.
9. Offset
    a. Yes - Under the planned regulations, which the MS4 permit requires to be in effect by July 22, 2013, a regulated site would have the option of meeting a portion of its required stormwater retention volume (SWRV) off site, after retaining a minimum amount on site.
    b. The two options for off-site retention are use of Stormwater Retention Credits (SRCs) traded on the private market, or payment of an in-lieu fee to the District. An SRC and the in-lieu fee rate correspond to one gallon of retention for one year. A regulated site that elects to use off-site retention to achieve a portion of its SWRV would have an ongoing obligation to use SRCs and/or in-lieu fee to continue to meet that obligation, just as that site would have an obligation to maintain the practices that were installed on site to achieve the minimum on-site retention volume.
10. Compliance Tool

   a. D.C. spreadsheet being developed by the Center for Watershed Protection (Rv based)

Delaware

1. Status of Standard
   a. Public Hearing held March 1, 2012
   b. Anticipated effective date of August 1, 2012.
2. Performance Standard for New Development
   a. Reduce Runoff from 2.7 inches of rainfall down to an equivalent of 0% Effective Imperviousness. This basically requires the equivalent of an "open space" post-developed condition.
   b. For disturbed areas that were wooded or meadow in the pre-developed condition, reduce runoff from 2.7 inches of rainfall down to an equivalent wooded condition.
3. Performance Standard for Redevelopment
   a. Reduce Runoff from 2.7 inches of rainfall down to an equivalent of 50% of the existing imperviousness.
   b. Any increase in impervious area would be treated like new development.
   c. Brownfield sites may comply without runoff reduction if a Department-approved remediation plan is implemented.
4. Applicability
   a. Disturbances greater than 5,000 square feet
5. Manual Status
   a. Draft Post-Construction SW BMP Standards & Specifications currently released for comment.
6. Predevelopment Baseline
   a. Equivalent 0% effective imperviousness (open space post-developed) for non-wooded/non-meadow
   b. Equivalent wooded condition for existing wooded or meadow disturbed areas.
7. Prescribes LID or RR
   a. Runoff Reduction/LID practices are required for compliance.
8. Situations where the performance standard does not apply
   a. Limited to re-construction projects that return the site to the pre-developed hydrologic condition as the result of fire, flood, natural disaster, etc.
9. Offset
   a. Yes - If the runoff reduction cannot be met on-site due to soils, water table or other similar site restraints, an offset must be provided. Offset options include off-site retrofits, banking, trading, fee-in-lieu, etc.
   b. Offset requirement can be reduced by installing additional SW treatment practices; reduction based on total equivalent TN reduction.
10. Compliance Tool
   a. DE DURMM Model (CN based using WinSLAMM equations)

Federal Facilities

1. Status of Standard
    a. Requirement is in effect but federal agencies are just beginning to implement it
2. Performance Standard for New Development
    a. Onsite retention of the 95th percentile rainfall event. Rain depth varies from 1.4 – 1.7 inches based on geographic region.
3. Performance Standard for Redevelopment
    a. Onsite retention of the 95th percentile rainfall event. Rain depth varies from 1.4 – 1.7 inches based on geographic region.
4. Applicability
    a. Disturbances greater than 5,000 square feet
    b. Construction of new facilities and redevelopment of existing facilities
5. Manual Status
    a. Section 438 – 2010
    b. Agencies have developed different guidance with the Department of Defense's (2010), being the most commonly applied.
6. Predevelopment Baseline
    a. Variable
7. Prescribes LID or RR
    a. Yes runoff reduction or LID practices are prescribed.
8. Situations where the performance standard does not apply
    a. Existing facilities.
9. Offset
    a. Yes
10. Compliance Tool
    a. No compliance tool as of yet.

Maryland

1. Status of Standard
    a. Accepted in 2009 and takes effect for projects submitted after May 2010
2. Performance Standard for New Development
    a. Environmental Site Design (ESD) to the Maximum Extent Practical (MEP) for the 1-year 24 hour storm event which is 2.7 inches.
3. Performance Standard for Redevelopment
    a. Defined as a site with existing imperviousness of greater than or equal to 40%
    b. Reduce existing imperviousness by 50%, or
    c. Provide water quality treatment (i.e., runoff from 1" of rainfall) for 50% of existing imperviousness, or
    d. Combination of the two, and
    e. All new imperviousness must meet new development performance standards
4. Applicability
    a. Applies to projects disturbing an area greater than 5,000 square feet
5. Manual Status
    a. Complete, updated in May 2009

6. Predevelopment Baseline
    a. Woods in good condition
7. Prescribes LID or RR
    a. Yes. Maryland defines a series of environmental site design techniques and practices that reduce runoff and mimic existing hydrology. Many of these techniques and practices are similar to those low impact development practices encouraged in other areas. In Maryland the primary goal is to use ESD to the MEP to reduce runoff to reflect forested conditions.
8. Situations where the performance standard does not apply
    a. Projects that have approved Erosion and Sedimentation control plans and Stormwater Management plans before May 2010
    b. Have preliminary approval prior to May 2010 provided final approval is granted prior to May 2013
    c. Are phased with Stormwater Management systems built before May 2010 - all reasonable efforts to use ESD in future phases must be demonstrated
    d. Have a direct discharge to tidal waters - ESD to the MEP still required. Waivers may be granted on a case-by-case. Also, other State programs (e.g., Critical Areas) may require more treatment where warranted.
9. Offset
    a. Yes – For redevelopment only – if reduction of imperviousness and/or water quality treatment is not practicable, local approval authorities may accept alternatives including retrofitting of existing imperviousness or upgrades to existing BMPs.
10. Compliance Tool
    a. Computations and plans are used to demonstrate compliance. Tools like the Chesapeake Stormwater Network ESD-MEP spreadsheet may be used to facilitate design, but final computations must be submitted with plans. MDE (not the local government) must approve any tools used for stormwater management design and the application of ESD to the MEP.

New York

1. Status of Standard
    a. Now in effect since Augusts 2010.
2. Performance Standard for New Development
    a. Provide volumetric control of the 90th percentile rainfall event which equates to 0.8 – 1.2 inches of rainfall
    b. Provide runoff reduction for a minimum fraction of the WQv based on the hydrologic soil group for the 90% rain event. Specific reduction factors for the HSGs are as follows:
        i. HSG A = 0.55
        ii. HSG B = 0.40
        iii. HSG C = 0.30
        iv. HSG D = 0.20
3. Performance Standard for Redevelopment
    a. Treatment of 25% of WQv through runoff reduction, impervious cover reduction, or BMPs; or

    b. Treatment of 75% of WQv by the use of alternative practices (Chapter 10, p. 10-19)
4. Applicability
    a. Disturbances of 1 acre or more
5. Manual Status
    a. Complete – updated in 2010
6. Predevelopment Baseline
    a. No predevelopment baseline
7. Prescribes LID or RR
    a. Yes, prescribes runoff reduction practices.
8. Situations where the performance standard does not apply
    a. Runoff reduction requirement is waived for plans that were already before local planning board by March 2010.
9. Offset
    a. Yes – Existing authorization only in MS4 areas where the MS4 has developed a qualifying offset program.
10. Compliance Tool
    a. No official compliance tool, localities have own submission requirements.

Pennsylvania

1. Status of Standard
    a. Performance standard was established in 2006 when the new stormwater BMP Manual was finalized and the MS-4 and Construction General Permit required that the standard be implemented.
2. Performance Standard for New Development
    a. No net change of volume for all events up to the two year storm which equates to approximately 2.8 inches of rainfall.
3. Performance Standard for Redevelopment
    a. Treat 20% of existing impervious cover as though it were meadow condition.
4. Applicability
    a. Volume control is applicable to any NPDES construction activity one acre or greater.
    b. Alternative Volume Control requires approval by DEP and is applicable to:
        i. regulated activities smaller than 1 acre
        ii. projects requiring design of stormwater storage facilities
5. Manual Status
    a. Currently PA DEP is initiating a review of the 2006 Stormwater BMP Manual; the completion date is currently unknown.
6. Predevelopment Baseline
    a. Meadow in good condition or better.
7. Prescribes LID or RR
    a. Yes
8. Situations where the performance standard does not apply
    a. The performance standard applies to all activities requiring MS4 permits, NPDES Construction permits or other state permits authorized by Chapter 102 and any ordinance developed under Act 167. In addition, an

alternative standard known as Control Guidance #2 (CG2) may be used, as outlined in the 2006 PA Stormwater BMP Manual.

9. Offset
   a. Yes – The Commonwealth is currently developing stormwater offsetting guidance. Continuing efforts of a workgroup including representatives of academia, the development community as well as conservation groups and municipalities have been meeting on a regular basis to provide input to the Department regarding a potential stormwater offsetting program. It is anticipated that this guidance will be ready to publish for public comment by the fall of 2012.
10. Compliance Tool
    a. Draft spreadsheet tool in existence developed by Chesapeake Stormwater Network and Center for Watershed Protection based on a series of paper worksheets found in the PA DEP Stormwater Manual (CN based).

Virginia

1. Status of Performance Standard
   a. Modified regulations have been adopted but will not take effect until July of 2014. Until then, the current regulatory requirements will be in effect. The following criteria are those in the *modified* regulations.
2. Performance Standard for New Development
   a. Reduce Runoff from 1.0 inches of rainfall
   b. Total Phosphorus in site runoff may not exceed 0.41 lb/ac/yr; excess TP must be reduced through implementation of BMPs
   c. Stream channel protection criteria, situationally based on either the 1- or 2-year 24-hour storm event, apply to ensure continued receiving channel stability and minor flood protection. A new Energy Balance calculation, based on both peak discharge and volume, results in reduced impact on the stream channel and, ultimately, reduced sediment discharge and transport in the channel.
3. Performance Standard for Redevelopment (development on "prior developed lands")
   a. The "predevelopment" baseline is the conditions that exist at the time that plans for the land development of tract of land are submitted to the plan approval authority. Where phased development or plan approval occurs (preliminary grading, demolition of existing structures, roads and utilities, etc.), the existing conditions at the time prior to the first item being submitted shall establish predevelopment conditions.
   b. 20% reduction in Phosphorus from pre-development load (>1 acre and no increase in impervious cover); 10% reduction in Phosphorus load when site is <1 acre and there is no increase in impervious cover
   c. Projects with an increase in impervious cover (no size threshold), new impervious cover subject to 0.41 lb/ac/yr load limit, and remainder of site complies with either 10% or 20% reduction depending on disturbed area (< or > 1 ac)
4. Applicability
   a. Disturbances greater than 1.0 acre or,

    b. Disturbances greater than 2,500 square feet within a locally designated Chesapeake Bay Preservation Area (CBPA) (however, these smaller sites not required to get a General Construction Permit)
    c. Land disturbing activities that are part of a common plan of development or sale, no matter whether inside or outside of a CBPA
5. Manual Status
    a. Completed in summer 2012
6. Predevelopment Baseline
    a. No predevelopment baseline
7. Prescribes LID or RR
    a. No, doesn't technically prescribe the use of LID or runoff reduction however, it is difficult to meet the performance standard without utilizing runoff reduction practices.
8. Situations where the performance standard does not apply
    a. Disturbances less than 1.0 acre outside of the a CBPA
    b. A site that, prior to July 1, 2012, has (1) a local approval (e.g., subdivision plat, rezoning, site plan approval, etc.), (2) a layout, and (3) sufficient information provided to ensure compliance with Virginia's *current* post-development design criteria is grandfathered.
9. Offset
    a. Yes – Offsets (various kinds, including fee-in-lieu, off-site mitigation, nutrient trading, etc.) authorized *only* for projects within the Chesapeake Bay watershed, based on a pound-for-pound load *delivered* to the Bay, and any offset granted must be acknowledged in the General Construction Permit
    b. DCR is still working out the process
10. Compliance Tool
    a. VA DCR compliance spreadsheet developed by the Center for Watershed Protection (Rv based for 1-inch rainfall and three land covers – forest/conserved open space; managed turf; and impervious cover).

West Virginia

1. Status of Standard
    a. The MS4 permit was reissued on June 22, 2009, but MS4s have up to four years for approval of the stormwater management program to implement the performance standard. The performance standard is only contained in the MS4 general permit. WV does not have statewide stormwater management regulations.
2. Performance Standard for New Development
    a. Provide on-site runoff reduction for first 1.0 inch of rainfall
3. Performance Standard for Redevelopment
    a. Also 1.0 inches however, a reduction of 0.2 inches from the standard is applicable in any of the following situations:
        i. Redevelopment
        ii. Brownfield redevelopment
        iii. High density (>7 units per acre)

        iv. Vertical Density, (Floor to Area Ratio (FAR) of 2 or >18 units per acre)
        v. Mixed use and Transit Oriented Development (within ½ mile of transit)
    b. Reductions are additive up to a maximum reduction of 0.75 inches for a project that meets four or more criteria. The permittee may choose to be more restrictive and allow a reduction of less than 0.75 inches if they choose. In no case will the reduction be greater than 0.75 inches.
4. Applicability
    a. Disturbance of 1 acre of land or greater for MS4 areas.
    b. Significant development activity takes place in localities that are not MS-4s yet are in the Chesapeake Bay drainage area. Some localities have developed or are developing their own ordinances with similar or more stringent standards.
5. Manual Status
    a. Being developed by Center for Watershed Protection, due out in the fall of 2012.
6. Predevelopment Baseline
    a. No predevelopment baseline
7. Prescribes LID or RR
    a. Yes, prescribes runoff reduction and LID practices only in MS4's.
8. Situations where the performance standard does not apply
    a. There are some site and terrain conditions where the standard may not be technically feasible. These conditions include the following:
        i. A site with too small a lot outside of the building footprint to create the necessary infiltrative capacity even with amended soils
        ii. A site with soil instability as documented by a thorough geotechnical analysis;
        iii. A site use that is inconsistent with capture and reuse of stormwater;
        iv. A site with too much shade or other physical conditions that preclude adequate use of plants;
9. Mitigation or Payment in lieu
    a. Yes – For projects that cannot meet 100% of the runoff reduction requirement, mitigation or payment in lieu are options if the permittee chooses.
    b. Mitigation or payment in lieu must occur at a 1:1.5 ratio. Mitigation projects must occur in the same sewershed/watershed as the original project. Payment in lieu may be made to the permittee (MS4), who will apply the funds to a public stormwater project. Permittees (MS4s) are required to maintain a publicly accessible database of approved in lieu projects.
10. Compliance Tool
    a. West Virginia spreadsheet tool was developed by the Center for Watershed Protection (Rv based) and was released on October 6, 2010.
    b. West Virginia Stormwater Management Design and Guidance manual is currently under development by the Center for Watershed Protection and

is expected to be released the fall of 2012. The manual will contain stormwater runoff reduction practices.

Appendix B
Evolution of Stormwater BMP Removal Rates

The Panel agreed that the performance of new stormwater BMPs could only be inferred by analyzing previous studies that have looked at pollutant removal and runoff reduction data for groups of stormwater BMPs.

Over the past three decades, considerable research has been undertaken to understand the nutrient removal dynamics of urban stormwater practices and translate these into generic removal rates that can be used by watershed managers. This appendix begins with a brief review of how our understanding about BMP performance has evolved in response to new monitoring data and shifts in stormwater technology. This background is needed to interpret the many different (and sometimes conflicting) removal rates that have been assigned to BMPs over time.

Evolution of the Science of Stormwater BMPs

Stormwater managers have been grappling to define nutrient removal rates for stormwater practices, with at least ten different sets of rates published in the last 25 years (MWCOG, 1983, Schueler, 1992, Brown and Schueler, 1997, Winer, 2000, Baldwin et al, 2003, CWP, 2007, CWP and CSN, 2008, Simpson and Weammert, 2009, ISBD, 2010, and CSN, 2011). It is no small wonder that managers are confused given that the nutrient removal rates change so frequently.

Each new installment of published BMP removal rates reflects more research studies, newer treatment technologies, more stringent practice design criteria and more sophisticated meta-analysis procedures.

For example, the first review involved only 25 research studies and was exclusively confined to stormwater ponds and wetlands, most of which were under-sized by today's design standards. The monitoring design for this era of BMP assessment evaluated the change in nutrient concentration as storms passed through individual practices. Analysis of individual performance studies showed considerable variability in nutrient removal efficiency from storm to storm (negative to 100%), and among different practices in the same BMP category.

The variability in removal rates was normalized by computing a median removal rate for each individual practice and then computing a group mean for all the practices within the same group. This enabled managers to develop a unique "percent removal rate" for each group of BMPs.

By the turn of the century, about 80 research studies were available to define BMP performance, which expanded to include new practices such as grass swales, sand filters and a few infiltration practices. The number of BMP research studies available for analysis had climbed to nearly 175 by 2007. Table B-1 portrays the percent removal rates for nutrients for different groups of stormwater practices. The percent removal approach provides general insights into the comparative nutrient capability of different BMP groups, both in terms of total and soluble nutrient removal. For example, wet ponds and filtering systems are clearly superior to dry ponds when it comes to TN and TP removal, but wet ponds do a much better job than filtering systems in removing soluble N and P.

Table B-1
Typical Percent Removal Rates for Total and Dissolved Fractions of Phosphorus and Nitrogen (N=175)

Practice Group	***TP (%)***	***Sol P (%)***	***TN (%)***	***Nitrate-N(%)***
Dry Ponds	20	- 3	24	9
Wet Ponds	52	64	31	45
Wetlands	48	24	24	67
Infiltration	70	85	42	0
Filtering Systems	59	3	32	-14
Water Quality Swales	24	-38	56	39
Source: CWP, 2007				

At about the same time, researchers began to recognize the limits of the percent removal approach. First, percent removal is a black box approach that provides general performance data, but little or no insight into the practice design features that enhance or detract from nutrient removal rates (Jones et al, 2008). Second, new data analysis showed that there were clear limits on how much any BMP could change nutrient concentrations as they passed through a practice. Extensive analysis of the nutrient levels in BMP effluent indicated that there appeared to be a treatment threshold below which nutrient concentrations could not be lowered.

This threshold has been termed the “irreducible concentration”. The nutrient concentration limits for each group of practices is shown in Table B-2, and are caused by pass-through of fine particles, internal re-packaging of nutrients, biological activity and nutrient leaching and/or release from sediments.

The third critique of the percent removal approach was that the population of monitoring studies upon which it is based is biased towards newly installed and generally well-designed practices. Very few monitoring studies have been performed on older practices or practices that have been poorly installed or maintained. The clear implication is that the ideal percent removal rate may need to be discounted to reflect these real world concerns, and several BMP reviews (Baldwin et al, 2003 and Simpson and Weammert, 2009) have derived more conservative rates in order to account for them.

Table B-2 "Irreducible" Nutrient Concentrations Discharged from Stormwater Practices				
Stormwater Practice Group	Total Phosphorus	Soluble Phosphorus	Total Nitrogen	Nitrate Nitrogen
	mg/l			
Dry Ponds	0.19	0.13	ND	ND
Wet Ponds	0.13	0.06	1.3	0.26
Wetlands	0.17	0.09	1,7	0,36
Filtering Practices	0.16	0.06	1.1	0.55
Water Quality Swales	0.21	0.09	1.1	0,35
Untreated Runoff	0.30	0.16	2.0	0.6
Source: Winer (2000)				

The most serious critique, however, of the percent removal approach is that it focuses exclusively on nutrient concentrations and not flow reductions. This was not much of an issue with the first generation of BMPs (ponds, wetlands, and sand filters) since they had little or no capability to reduce runoff as it passed through a practice (ISBD, 2010). With the emergence of new research on LID practices, however, the importance of runoff reduction in increasing the mass nutrient removal rate became readily apparent.

Nearly 50 new performance studies on the pollutant and runoff reduction capability of LID practices have been published in the last five years. Collectively, this new research has had a profound impact on how nutrient reduction rates are calculated, and in particular, isolating the critical practice design and site variables that can enhance rates. CWP and CSN (2008) synthesized the runoff reduction research and calculated new (and higher) mass nutrient removal rates for both traditional and LID stormwater practices.

A key element of the new runoff reduction approach is that it prescribes two design levels for each practice, with each level having a different nutrient removal rate. An example of the two level design approach for bioretention is shown in Table B-3. The table reflects recent research that indicates which design features, soil conditions and performance standards can boost TN and TP removal. Some of these include:

- Increased depth of filter media
- No more than 3-5% carbon source in the media
- Create an anoxic bottom layer to promote denitrification
- Increased hydraulic residence time through the media (1-2 in/hr)
- Test the media to ensure soils have a low phosphorus leaching risk

Designers that meet or exceed the Level 2 design requirements are rewarded with a higher nutrient mass reduction rate.

Table B-3 Example of Two Level Design Approach for Bioretention	
LEVEL 1 DESIGN	**LEVEL 2 DESIGN**
RR = 40% TP = 55% TN = 64%	RR= 80% TP= 90% TN = 90%
Treats the 90% storm	Treats the 95% storm
HSG C and D soils and/or under drain	HSG A and B soils OR has 12 inch stone sump below under drain invert
Filter media at least 24" deep	Filter media at least 36" deep
One cell design	Two cell design
Both: Maximum organic material in media of 5% and hydraulic residence time of 1-inch per hour through the media	

The basics of the runoff reduction method and/or design level approach are now being incorporated into stormwater design manuals and compliance tools in Virginia, West Virginia, District of Columbia, Delaware and the Maryland Critical Area. Table B-4 summarizes the mass nutrient removal rates developed to implement the new Virginia stormwater regulations.

The runoff reduction method enables designers to achieve high removal rates when a mix of site design credits, LID practices and conventional stormwater practices are combined together to meet a specific phosphorus performance standard. In many cases, the aggregate nutrient reduction achieved by a mix of LID practices at a site exceeds the existing CBP approved rate for the individual practices (which reflects the higher treatment volume, better soil conditions and more stringent design criteria). In summary, urban BMP nutrient removal rates have constantly evolved over time in response to new performance research, changing stormwater practices and paradigms, and more stringent design criteria and regulations.

Approved Removal Rates for Urban BMPs in the Chesapeake Bay

Given the proliferation of removal rates described in the preceding section, the Chesapeake Bay Program has established a peer-review process to derive standard and consistent removal rates for a wide range of urban BMPs. These rates are used for the purpose of defining the aggregate nutrient and sediment reduction associated with BMP implementation in the context of the Chesapeake Bay Watershed Model. Since 2003, about 20 urban BMP rates have been established, with the supporting documentation provided in Baldwin et al (2003) and Simpson and Weammert (2009). The most current CBP-approved efficiency rates that relate to stormwater BMPs are provided in Table B-5.

Table B-4 Mass Nutrient Removal Rates for Stormwater Practices			
Practice	**Design Level[1]**	**TN Load Removal[4]**	**TP Load Removal[4]**
Rooftop Disconnect [5]	*1*	*25 to 50*	*25 to 50*
	2 [6]	*50*	*50*
Filter Strips [5]	*1*	*25 to 50*	*25 to 50*
	2 [6]	*50 to 75*	*50 to 75*
Green Roof	*1*	*45*	*45*
	2	*60*	*60*
Rain Tanks & Cisterns [7]	*1*	*15 to 60*	*15 to 60*
	2	*45 to 90*	*45 to 90*
Permeable Pavers	*1*	*59*	*59*
	2	*81*	*81*
Infiltration Practices	*1*	*57*	*63*
	2	*92*	*93*
Bioretention Practices	*1*	*64*	*55*
	2	*90*	*90*
Dry Swales	*1*	*55*	*52*
	2	*74*	*76*
Wet Swales	*1*	*25*	*20*
	2	*35*	*40*
Filtering Practices	*1*	*30*	*60*
	2	*45*	*65*
Constructed Wetlands	*1*	*25*	*50*
	2	*55*	*75*
Wet Ponds [8]	*1*	*30 (20)*	*50 (45)*
	2	*40 (30)*	*75 (65)*
ED Ponds	*1*	*10*	*15*
	2	*24*	*31*

Notes

[1] See specific level 1 and 2 design requirements within each practice specification
[2] Annual runoff reduction rate (%) as defined in CWP and CSN (2008)
[3] Change in nutrient event mean concentration in and out of practice, as defined in CWP and CSN (2008)
[4] Load removed is the product of annual runoff reduction rate and change in nutrient EMC
[5] Lower rate is for HSG soils C and D, Higher rate is for HSG soils A and B
[6] Level 2 design involves soil compost amendments, may be higher if combined with secondary runoff reduction practices
7 Range in RR depends on whether harvested rainwater is used for indoor, outdoor or discharged to secondary runoff reduction practice. Actual results will be based on spreadsheet
[8] lower nutrient removal parentheses apply to ponds in coastal plain terrain

Table B-5 Approved CBP BMP Efficiency Rates for Stormwater BMP Analysis [1, 2, 3]				
URBAN BMP		**Total Nitrogen**	**Total Phosphorus**	**TSS**
		MASS LOAD REDUCTION (%)		
Wet Ponds and Constructed Wetlands		20	45	60
Dry Detention Ponds		5	10	10
Dry Extended Detention Ponds		20	20	60
Infiltration		80 (85) [4]	85	95
Filtering Practices (Sand Filters)		40	60	80
Bioretention	C & D w/UD	25	45	55
	A & B w/ UD	70	75	80
	A & B w/o UD	80	85	90
Permeable Pavement	C & D w/UD	10 (20)	20	55
	A & B w/ UD	45 (50)	50	70
	A & B w/o UD	75 (80)	80	85
Grass Channels	C & D w/o UD	10	10	50
	A & B w/o UD	45	45	70
Bioswale	aka dry swale	70	75	80

[1] In many cases, removal rates have been discounted from published rates to account for poor design, maintenance and age, and apply to generally practices built prior to 2008
[2] Current Practices are designed to more stringent design and volumetric criteria, and may achieve higher rates –see Table B-4
[3] Some practices, such as forest conservation, impervious cover reduction, tree planting are modeled as a land use change. Urban stream restoration is modeled based on a reduction per linear foot of qualifying stream restoration project
[4] Numbers in parentheses reflect design variation with a stone sump to improve long term infiltration rates

A quick glance at Table B-5 reveals that the rates for ponds and wetlands tend to be fairly conservative, which reflects the concern that ideal or initial removal rates should be discounted due to real world implementation issues such as poor design, installation and maintenance, or simply the age of the practice. The removal rates for newer LID practices, by contrast, are not discounted.

Appendix C
Documentation of New BMP Removal Rate Adjustor Curves

The Panel started by noting the strong relationship between the runoff volume treated and the degree to which runoff reduction is achieved at individual BMPs. The primary source was a comprehensive analysis of runoff reduction and pollutant event mean concentration reduction data for a wide range of BMPs that are typically applied in new development (CWP and CSN, 2008).

CSN (2011) developed a general table to determine nutrient removal rates for all classes of stormwater BMPs, and this approach was used as a starting point. The basic technical approach defines an "anchor" rate for composite ST and RR practices for one inch of runoff treatment (see Table C-1). The RR category is comprised of six different LID practices including bioretention, dry swales, infiltration, permeable pavement and green roofs/rain tanks.

The composite for ST practices included wet ponds, constructed wetlands, sand filters and wet swales. Dry ponds and Dry ED ponds were omitted from ST categories since they have such low removal rates that they are not encouraged or promoted as practices under new state stormwater performance standards. The annual mass nutrient removal rates associated with each practice presented in Table B-4 was averaged for the composite practices, as shown in Table C-1 below.

Table C-1 Composite Approach to Derive Nutrient Mass Load Reductions for RR ad ST Practices [1, 2]

PRACTICE	TP Mass Reduction (%)	TN Mass Reduction (%)
Bioretention	73	77
Dry Swale	66	63
Infiltration	75	78
Permeable Pavers	70	70
Green Roof/Rain Tank	55	55
Average RR	**70**	**70**[2]
Wet Ponds	63	35
Const. Wetlands	63	40
Filtering Practice	63	38
Wet Swale	30	30
Average ST	**55**	**35**

[1] Source: Table B-4, nutrient rates computed using the average mass reduction for both Design Level 1 and Level 2.
[2] This value was subsequently discounted by 18% to reflect the impact of nitrate migration from runoff reduction practices described later in this appendix.

The next step involved using a rainfall frequency spreadsheet analysis from Washington, DC to estimate how the anchor removal rate would change based on different levels of runoff capture by the composite practice. The percent of the annual rainfall that would be captured by a practice designed for a specific control depth, was estimated by summing the precipitation for all of the storms less than the control depth, plus the product of the number of storm events greater than the control depth multiplied by the control depth. This sum was then divided by the sum of the total precipitation. A visual representation of this may be helpful and can be seen as follows:

$$\% \, Annual \, Rainfall = \frac{(SUM \; P_{<CD} + \; CD(in) * (\# \, of \, Storms \; P_{>CD}))}{Sum \, of \, Total \, Precipitation \, (inches)}$$

Where:

$P_{<CD}$ = Precipitation of Storms less than Control Depth (inches)
$P_{>CD}$ = Precipitation of Storms greater than Control Depth (inches)
CD = Control Depth (inches): the depth of rainfall controlled by the practice

Once the percent annual rainfall has been determined for a specific control depth, we can use this along with the anchor pollutant removal rates to determine the pollutant removal values associated with a specific control depth. For example:

$$Pollutant \, Removal_{\,CD} = \frac{(Pollutant \, Removal \, Value_{AR} * \% \, Annual \, Rainfall_{CD})}{\% \, Annual \, Rainfall_{AR}}$$

Where:

Pollutant Removal Value $_{AR}$ = The anchor rates for N, P or TSS and ST or RR practices per 1.0" of Control Depth (~88% Annual Rainfall)

Phosphorus		Nitrogen		Sediment	
ST	RR	ST	RR	ST	RR
55%	70%	35%	60%	70%	75%

% Annual Rainfall $_{CD}$ = The % Annual Rainfall for a specific Control Depth as determined by the previous equation

% Annual Rainfall $_{AR}$ = This will always be 88%

The same basic approach was used to define maximum mass nutrient reduction rates for storms above the anchor rate, up to the 2.5 inch storm event. In general, no BMP performance monitoring data is available in the literature to evaluate removal for runoff treatment depths beyond 1.5 inches, so this conservative approach was used for the extrapolation. The Panel had limited confidence in removal rates in the 1.5 to 2.5 inch range, although it was not overly concerned with this limitation, since few of any stormwater BMPs are sized to capture that much runoff. A spreadsheet that defines how the anchor rates and bypass adjustments were derived can be obtained from CSN.

The tabular data was converted into a series of curves to make it easier for users to define a rate for the unique combination of runoff capture volume and degree of runoff reduction. This was done by fitting a log-normal curve to the tabular data points, which came within a few percentage points of the tabular values for a wide range of runoff capture depths and removal rates.

A 0.05 inch runoff capture volume was established as the cut-off point for getting any pollutant removal rate, since this roughly corresponds to the depth of initial abstraction that occurs on impervious surface. It should be noted that stormwater BMPs in this small size range will require very frequent maintenance to maintain their performance over time.

The Panel concluded that the generalized new BMP removal rate adjustor curves were a suitable tool for estimating the aggregate pollutant load reductions associated with hundreds or even thousands of future new development projects at the scale of the Bay watershed and the context of the Chesapeake Bay Watershed Model.

Notes on the Unitization Equation

The new BMP storage volume for each new development site must be adjusted using a "unitization" equation that converts the storage volume into a unit depth per impervious acre at each site.

The basic rationale for the equation is that the Rainfall Frequency Analysis method used to derive the curve above and below the anchor points is based on the assumption that the runoff delivered to a practice is generated from a unit impervious acre.

The runoff storage volumes achieved for new BMPs, however, are unique, based on the target rainfall depth, land cover, soils and hydrologic assumptions used in each state performance standard. Consequently, the Engineering Parameter (EP) calculated for each state must be adjusted to get a standard depth of runoff treatment per unit impervious cover to use the curves.

By dividing each site's EP by the impervious cover acreage, we are able to define inches of runoff captured per unit impervious acre, and use this value to define the removal rate from the curves. The new development unitization equation is used to get the correct depth to use on the x-axis of the new BMP adjustor curves, as follows:

$$= \frac{(12 * EP)}{IA}$$

The removal rates determined from the new BMP removal rate adjustor curves are applied to the <u>entire</u> new development or redevelopment site area, and not just the impervious acres. Also, the reporting unit for the site is the entire treated area of the site, regardless of whether it is pervious or impervious.

The unitization equation is not needed for redevelopment projects because the EP defined under each state redevelopment standard is computed solely based on site impervious cover (i.e., runoff from pervious cover is not a factor in defining EP at a redevelopment site, which means IA = SA). Therefore, redevelopment sites will use the following equation:

$$= \frac{(12 * EP)}{SA}$$

Notes on the Derivation of Sediment Removal Rates

The original new BMP removal rate adjustor table (CSN, 2011) did not include estimates for sediment removal. They were derived in January of 2012 after a detailed analysis of BMP sediment removal rates drawn from the following sources – Brown and Schueler, (1997), Winer (2000), Baldwin et al, (2003), CWP (2007), Simpson and Weammert, (2009), and ISBD (2011a). Collectively, these BMP performance research reviews analyzed more than 200 individual urban BMP performance studies conducted both within and outside of the Chesapeake Bay watershed. The following general conclusions were drawn from the analysis.

Sediment removal by both traditional BMPs and LID practices was consistently higher and less variable than nutrient removal. This is attributed to the particulate nature of sediment, which makes it easier to achieve reductions through settling, trapping, filtering and other physical mechanisms.

The analysis began with an examination of existing CBP-approved rates (see Table B-5). Two important trends were noted. First, TSS removal always exceeded TP and TN rates for every category of urban BMP. Second, nearly all the rates were within a fairly narrow range of 60% to 90% (Table B-5).

The same composite BMP method was employed using the CBP-approved rates to define sediment removal rates for RR and ST practices. The ST practice category included wet ponds, constructed wetlands and sand filters, which collectively had a TSS removal rate of 70%. The RR category included all design variations of bioretention, permeable pavement, infiltration and bio-swales in Table B-5, and had a slightly higher composite TSS removal rate of 75%.

Other BMP performance reviews have also noted that TSS removal rates exceed TP or TN removal rates for all individual studies of traditional urban BMPs (up to 1.0 inch of runoff treated, Winer, 2000 and CWP, 2007).

The sediment removal rate for traditional BMPs is ultimately limited by particle size considerations. Studies have shown that there is an irreducible concentration of around 15 to 20 mg/l associated with the outflow from traditional BMPs (Winer, 2000 and NRC, 2008) which reflects the limits of settling for the most fine-grained particles. In practical terms, this sets an upper limit on maximum sediment removal of around 70% to 80% for the range of monitored BMPs (i.e., sized to capture 0.5 to 1.5 inches of runoff).

Additional analysis was done to examine whether sediment removal rates for LID practices (i.e., RR practices) would achieve high rates of runoff reduction. Recent sediment mass removal rates were reviewed for bioretention, permeable pavers, green roofs, rain tanks, rooftop disconnection and bioswales (Simpson and Weammert, 2009, ISBD, 2011a, and a re-analysis of individual studies contained in CWP and CSN, 2008). The following general conclusions about LID sediment removal rates were drawn from the analysis:

- Most LID practices had lower TSS loadings than traditional BMPs, primarily because there was either no major up-gradient sediment source area (e.g., green roofs, rain tanks, permeable pavers, rooftop disconnection) or a small contributing drainage area (bioretention, bio-swales).

- In general, LID practices had a slightly lower outflow sediment concentration than their traditional BMP counterparts (around 10 mg/l – ISBD, 2011a).

- The ability of LID practices to change the event mean concentration of sediment as it passed through a practice differed among the major classes of LID practices. For example, nearly a dozen studies showed that bioretention and bioswales could achieve significant reduction in sediment concentrations. On the other hand, permeable pavers and green roofs generally produced low or negative changes in sediment concentrations through the practice. This finding was not deemed to be that important given how low the sediment inflow concentrations were.

Based on these conclusions, the Panel took a conservative approach and did not assign higher sediment removal rates for LID practices that achieved a high rate of runoff reduction, at least for facilities designed to capture less than one inch or more of runoff. Beyond that point, the Panel did assign a modest increase in sediment removal rate for LID practices under the assumption that the combination of high runoff capture and reduction would work to reduce or prevent accelerated downstream channel erosion. The Panel notes that the extra sediment removal rate for this range of LID practices is an untested hypothesis that merits further research.

Notes on Revising TN Adjustor Curve to Reflect Base flow Nitrate Movement in Urban Watersheds

The adjustor curves are used to define a removal rate that applies to both the pervious and impervious areas in the contributing drainage areas for the stormwater treatment practices. The removal rates properly apply to surface runoff and some portion of the interflow delivered to the stream, but may not properly apply to groundwater export of nitrate-nitrogen from the urban landscape. The "missing” nitrate may be nitrate that exits a runoff reduction practice via infiltration into soil, or slow release through an under drain (e.g., bioretention).

Once stormwater runoff is diverted to groundwater, the overall load is reduced by using the ground as a filtering medium, but not eliminated. Therefore, the WTWG concluded that the original TN adjustor curves developed by the expert panel may over-estimate TN removal rates, and should be discounted to reflect the movement of untreated nitrate from runoff reduction BMPs. This discounting is not needed for TKN, TP or TSS as these pollutants are not mobile in urban groundwater.

The USWG concurred with this approach and developed the following procedure to derive a new TN adjustor curve to account for groundwater nitrate migration from runoff reduction practices. The basic approach is documented in Schueler (2012a and 2012b).

This discount factor is fairly straight forward to calculate and is simply based on the ratio of nitrate in relation to total nitrogen found in urban stormwater runoff. Stormwater runoff event mean concentration data from the National Stormwater Quality Database (Pitt et al, 2006) was analyzed for more than 3000 storm events, and the nitrate:TN fraction was consistently around 0.3. This sets an upper boundary on the fraction of the inflow nitrate concentration to the BMP which could be lost to groundwater or under drains at about 30%.

The next step is to account for any nitrate loss within the BMP due the combination of either plant uptake and storage and/or any de-nitrification within the BMP. Most runoff reduction practices employ vegetation to promote ET and nutrient uptake, whereas the de-nitrification process is variable in both space and time.

Over 70 performance studies have measured nitrate removal within runoff reduction BMPs. A summary of the national research is shown in Table C-2. Clearly, there is a great deal of variability in nitrate reductions ranging from nearly 100% to negative 100% (the negative removal occurs when organic forms of nitrogen are mineralized/nitrified into nitrate within the BMP).

Some well studied runoff reduction practices, such as bioretention and bioswales, have a median nitrate removal ranging from 25 to 45%, presumably due to plant uptake. Initial results for green roofs indicate moderate nitrate reduction as well. Non-vegetative practices, such as permeable pavers and a few infiltration practices, show zero or even negative nitrate removal capability (Table C-2). Submerged gravel wetlands that create an aerobic/anaerobic boundary that promotes denitrification appear capable of almost complete nitrate reduction.

Therefore, it is recommended that maximum nitrate removal within runoff BMPs be assumed to be no more than 40%. Although this value may seem generous, it should be noted that some additional nitrate reduction occurs as the nitrate moves down-gradient through soils on the way to the stream. Under this conservative approach, no additional nitrate reduction is assumed after it exits the BMP and migrates into groundwater.

Given the nitrate inflow concentrations, the potential groundwater/under drain nitrate loss would be (0.3)(0.60) = 0.18, or a discount factor of 0.82

The discount factor is then applied to the anchor rates used to derive a new N adjustor curve. The anchor rate for RR practices would be adjusted downward from the current 70% to 57%, and the existing runoff frequency spectrum equation would be used to develop a new, lower curve for TN removal. An example of the how this discount influences the existing N adjustor curve is shown in Figure C-1.

Table C-2 Nitrate Removal by Runoff Reduction Practices [1]

Practice	Median Removal Rate	No. of Sites	Range	Source
Bioretention [2]	43%	9	0 to 75	CWP, 2007
Bioretention [2]	44%	1	NA	UNH, 2009
Bioretention [2]	24%	10	NA	ISBD, 2010
Bioswales	39%	14	-25 to 98	CWP, 2007
Bioswales	7%	18	NA	ISBD, 2010
Infiltration [3]	0	5	-100 to 100	CWP,2007
Permeable Pavers	-50% [4]	6	NA	IBSD, 2010
Permeable Pavers	0	4		Collins, 2007
Green Roof [5]	Positive	4	NA	Long et al 2006
Gravel Wetland	98%	1	NA	UNH, 2009

Notes:
[1] As measured by change of event mean concentration (EMC) entering device and final exfiltrated EMC, and involves either or plant uptake or denitrification
[2] For "conventional" runoff reduction practices only, i.e., no specific design features or media enhancements to boost nitrate removal
[3] Category includes several permeable paver sites
[4] A negative removal rate occurs when organic forms of nitrogen are nitrified to produce additional nitrate which is
[5] Test column study

It is also noted that no nitrate loss parameter needs to be defined for stormwater treatment (ST) practices, since inlet and outlet monitoring of these larger facilities already takes this into account (and is a major reason why the ST curve is so much lower than the RR curve).

The de-nitrification process can be enhanced through certain design features (inverted under drain elbows, IWS, enhanced media). Several good research reviews indicate that these design features show promise in enhancing nitrate removal (Kim et al, 2003, NCSU, 2009, Weiss et al, 2010), these features are not currently required in Bay state stormwater manuals. Should future research confirm that these features can reliably increase nitrate removal through denitrification and/or plant uptake, it is recommended that a future expert panel revisit the existing nitrogen adjustor curve.

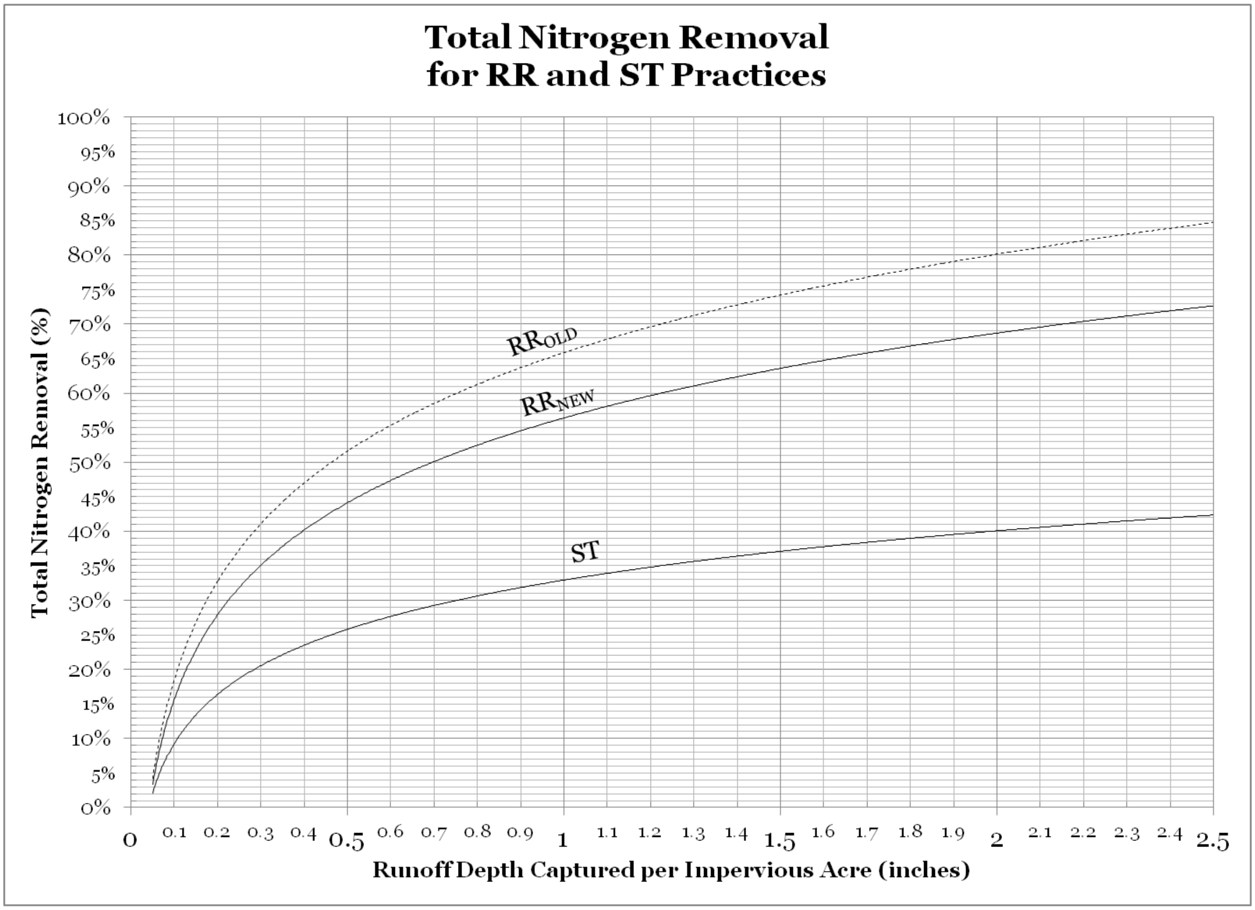

Figure C-1. Revised TN Adjustor Curve

Text would be added to memos that acknowledge the "escaped nitrate" issue up gradient and down gradient of the BMP that might not be effectively captured by the BMP, but indicate that this should be resolved in the next version of CBWM.

Appendix D
Methods to Calculate Local Baseline Loads

The Panel decided that localities do not need to calculate a pre-development baseline load when it comes to reporting new BMPs that serve future new development or redevelopment sites to their appropriate state TMDL agency. The precise load reduction achieved under the new performance standards is computed by the Chesapeake Bay Watershed Model. Localities need only report the removal rate derived from the new BMP removal rate adjustor curves and the total treated acres for each individual development project.

The Panel acknowledges that many localities may want to estimate pre-development baseline loads so they can track the aggregate impact of the implementation of stormwater practices on pollutant loads from the developed land sector over time. This local tracking effort can estimate pollutant load reductions that occur when the new performance standards are applied to redevelopment sites. In addition, this tracking system can estimate the pollutant removal benefits associated with BMP implementation at new development sites. Most importantly, local load tracking can help communities forecast trends in local loads due to land use change (and BMP implementation) in the future. Such information can be useful to include in:

1. Local watershed implementation plans
2. Comprehensive land use plans
3. MS4 permit annual reports

Therefore, the Panel recommended several options that are suitable for planning level analyses to track how pollutant loads change in response to growth and development over time. These include the:

1. Generic state-wide CBWM urban unit loading rates
2. Simple Method
3. The Watershed Treatment Model

The Panel noted that there are pros and cons associated with each option, and that localities should check with their state stormwater agency to see which one(s) are preferred when it comes to any state MS4 permitting requirements. The remainder of this memo outlines the proper use of these planning tools.

Generic state-wide CBWM urban unit loading rates

The first option is to use the average state-wide unit loading rates for pervious and impervious areas, as derived from the most recent version of the Chesapeake Bay Watershed Model (CBWM, version 5.3.2). The unit loads for sediment, nitrogen and phosphorus can be found in Table D-1, which differ from state to state.

Designers can quickly calculate the baseline load delivered to the BMP system by measuring the number of pervious and impervious acres in the post development drainage area and multiplying them by the appropriate unit load value for their state. Once the baseline load has been computed, it is a simple matter to multiply it by the project removal rate (derived from the new BMP removal rate adjustor table) to determine the actual load reduced.

Table D-1
Edge of Stream Unit Loading Rates for Bay States Using CBWM v. 5.3.2
No Action Run, State-wide Average Loading Rates, average of regulated and unregulated MS4 areas

BAY STATE	Total Nitrogen		Total Phosphorus		Suspended Sediment	
	Pounds/acre/year				Pounds/acre/year	
	IMPERV	PERV	IMPERV	PERV	IMPERV	PERV
DC	13.2	6.9	1.53	0.28	1165	221
DE	12.4	8.7	1.09	0.25	360	42
MD	15.3	10.8	1.69	0.43	1116	175
NY	12.3	12.2	2.12	0.77	2182	294
PA	27.5	21.6	2.05	0.61	1816	251
VA	13.9	10.2	2.21	0.60	1175	178
WV	21.4	16.2	2.62	0.66	1892	265

Source: Spreadsheet output provided by Chris Brosch, CBPO, 1/4/2012

The Simple Method

The Simple Method is an empirical equation developed by Schueler (1987) to estimate annual nutrient loads in stormwater runoff using easily derived parameters. It computes loads for storm events only, and is best applied to individual drainage areas or catchments. The basic equation is:

$$L = [\ P * Pj * Rv / 12\ ]\ [\ C * A * 2.72]$$

Where:

L = Annual load (lbs)
P = Annual rainfall (in)
Pj = Fraction of storms producing runoff (0.9)
Rv = Site runoff coefficient, based on impervious cover equation

C = Median event mean concentration (mg/l) TN= 2.0, TP= 0.3
A = Site Area (acres)
2.72 = Unit conversion factor

A modified version of the Simple Method has been developed to account for the differential impact of turf and forest cover in generating runoff from a site (CWP and CSN, 2008). The modified equation has been incorporated into the Virginia DCR site compliance spreadsheet, and uses a composite runoff coefficient to reflect the forest, turf, and impervious cover present at the site, as shown in the equation below.

$$Rvc = (Rv_I * \%I + Rv_T * \%T + Rv_F * \%F)$$

Where

Rv_I = runoff coefficient for impervious cover
Rv_T = runoff coefficient for turf cover or disturbed soils
Rv_F = runoff coefficient for forest cover
% I = percent of site in impervious cover
%T = percent of site in turf cover
%F = percent of site in forest cover

The appropriate runoff coefficients for each hydrologic soil group are provided in Table D-2

Table D-2 Site Cover Runoff Coefficients

Site Cover Condition	Hydrologic Soil Group			
	HSG A	HSG B	HSG C	HSG D
Forest Cover	0.02	0.03	0.04	0.05
Disturbed Soils	0.15	0.20	0.22	0.25
Impervious Cover	0.95	0.95	0.95	0.95

Despite its simplicity, these equations provide reasonably accurate estimates of annual nutrient loads in urban areas when compared to more sophisticated continuous simulation models.

Watershed Treatment Model

The Watershed Treatment Model (WTM) is a spreadsheet model first developed by Caraco (1999) and recently updated (CWP, 2010). The WTM incorporates the Simple Method for urban loads, but also computes non-urban loads and secondary loads for small watersheds. The WTM was expressly designed to enable users to evaluate the effect of a broad range of urban BMPs in reducing nitrogen, phosphorus and sediment loads. The WTM works well when localities possess good land use/land cover and has been successfully used in many watershed plans and TMDL assessments. The WTM is a particularly versatile tool to track changes in pollutant load over time as land is developed or redeveloped and more effective BMPs are installed.

Appendix E
Example of Visual Indicators Used to Verify BMP Performance
Adapted from Hirschman et al (2009)

The Center for Watershed Protection has updated a form to quickly assess urban BMP performance using simple visual indicators. This approach was refined and tested through an extensive analysis of hundreds of BMPs located in the James River Basin of the Chesapeake Bay watershed. More detail on the methods and results can be found in Hirschman et al (2009).

It is recommended that these rapid investigations be conducted during every other routine stormwater BMP inspection conducted by a locality in order to verify BMP performance. In many cases, the locality may choose to sub-sample their existing inventory of stormwater practices to gain better information.

This basic form can be modified, simplified or customized to meet the unique BMP terminology and design criteria employed in each Bay state. Each state may elect to develop or adapt their own indicators, checklists and field inspection procedures
.

FACILITY ID: ______________________	**DATE:** ___/_____/___	**ASSESSED BY:**

NAME: ____

ADDRESS: ____

PHOTO IDS: ______________________________

HANDHELD/ GPS ID:

SECTION 1- BACKGROUND INFORMATION (GIS)

BMP TYPE :

☐ Dry Detention Pond ☐ Dry Swale ☐ Wetland
☐ Extended Detention Pond ☐ Wet Swale ☐ Level Spreader
☐ Wet Pond ☐ Grass Channel ☐ WQ Inlet
☐ Filter (specify: _______________) ☐ Dry Well ☐ Proprietary Device
☐ Infiltration (specify:_____________) ☐ Permeable Pavement ☐ Other _______________
☐ Check if structure is underground ☐ Bioretention

YEAR CONSTRUCTED: __________

OWNERSHIP
☐ Public ☐ Private ☐ Unknown

SITE CHARACTERIZATION

DRAINAGE AREA: _____(acres) **IMPERVIOUS COVER:** _____(acres) Discerned from: ☐ Plan ☐ County Data ☐ GIS ☐ Field

CONTRIBUTING DRAINAGE AREA (% land use): *Note – All percentages should sum up to 100%.*

_____Industrial _____Commercial _____Urban/Residential _____Suburban/Res
_____Forested _____Institutional _____Golf course _____Park
_____Crop _____Pasture _____Other: __________

WATER QUALITY VOL (FROM DESIGN PLAN): _____(ft^3)

SECTION 2- FIELD VISIT

Rain in last 48 hrs? ☐ Yes ☐ No

Evidence of high water table (e.g., excessive soil saturation)? ☐ Yes ☐ No

DESIGN ELEMENTS

FACILITY SIZE:
Length: _____(ft)
Width: _____(ft)
Surface Area: _____(ft^2)
Depth of WQ storage _____(ft)

OBSERVED WQ STORAGE VOL:
_____(ft^3)

HYDRAULIC CONFIGURATION
☐ On-line Facility
☐ Off-line Facility

DESIGN STORM(S):
☐ Water Quality
☐ Flood Control
☐ Channel Protection
☐ Unknown

BMP SIGNAGE: (check all that apply)
☐ None ☐ Flood Warning ☐ Stormwater Education ☐ No Trespassing ☐ Wildlife Habitat
☐ Public Property ☐ Do Not Mow ☐ Other: ______________________________

OUTLET CHARACTERISTICS

PRIMARY OUTLET STRUCTURE: ☐ N/A – infiltration w/ no outlet ☐ Pipe ☐ Riser ☐ Weir ☐ Large Storm Overflow ☐ Open channel ☐ Large Storm By-pass ☐ Other: __________

OUTLET FEATURES: ☐ N/A ☐ Trash Rack ☐ Pond Drain ☐ Inverted outlet pipe ☐ Hooded outlet ☐ Anti-vortex device ☐ Perforated pipe ☐ Gravel Diaphragm ☐ Micropool outlet ☐ Multiple outlet levels
Outlet includes restrictor? ☐ Yes ☐ No

OUTLET STRUCTURE CONDITIONS:
Erosion at Outlet: ☐None ☐Slight ☐Moderate ☐Severe
Outlet Clogging: ☐None ☐Slight ☐Moderate ☐Severe
Structural Problems: ☐None ☐Slight ☐Moderate ☐Severe

CONDITIONS AT OUTFALL: ☐ Stream ☐ Closed storm sewer ☐ Surface channel ☐ Road ditch ☐ Other: __________ ☐Unknown

Active Erosion: ☐None ☐Slight ☐Moderate ☐Severe
Trash: ☐None ☐Slight ☐Moderate ☐Severe
Sedimentation: ☐None ☐Slight ☐Moderate ☐Severe
Odor: ☐None ☐Slight ☐Moderate ☐Severe
Algae: ☐None ☐Slight ☐Moderate ☐Severe
Other WQ Problems: ☐None ☐Slight ☐Moderate ☐Severe

Emergency Spillway Type: ☐ Channel ☐ Riser Overflow ☐ Weir ☐ Other: __________

SOIL OR FILTER MEDIA

TYPE OF FILTER/INFILTRATION MEDIA: (check all that apply)
☐ Soil mix _________(in) ☐ Sand _________(in) ☐ Gravel _________(in) ☐ Large Stone _________(in)
☐ Organic material _________(in) ☐ Other_________ ☐ N/A ☐ Unknown
Avg. depth of sediment build-up on surface?_____(in)

SOIL MEDIA SAMPLE: *Note – Complete during site investigation, if applicable*
Dominant Soil Type ☐ Clay ☐ Loam ☐ Sand ☐ Sand/Loam
Is the soil homogenous? ☐ Yes ☐ No

Comments:

VEGETATION

GENERAL OBSERVATIONS:
☐ Landscaped
☐ Aquatic Bench
☐ Invasive Species
☐ Plant Diversity

TYPE OF GROUND COVER (% of Surface Area in Plan View up to low Outlet)**:**
Note – All percentages should sum up to 100 %.

_____Trees	_____Grasses/Perennials	_____ Ponded water	_____ Other: _____
_____ Managed Turf	_____ Bare Soil	_____Shrubs	_____ N/A
_____ Gravel/stone	_____ Mulch	_____ Emergent wetland	

Depth of mulch, if present: ☐ Hardwood _____(in) ☐ Pine Straw _____ (in) ☐ Other_________ (in)
Rate degree of shading of BMP Surface Area by trees: ☐ Well Shaded ☐ Some Shading ☐ No Shading ☐ N/A

INLET CHARACTERISTICS

INLET #1:
Diameter/Width: _____(in)

TYPE OF INLET: ☐ Open Channel ☐ Closed Pipe
☐ Sheet Flow ☐ Curb Cut ☐ Other: __________

Elevation difference between bottom of inlet and BMP surface: _____ (in)

INLET SUBMERSION:
☐ Complete
☐ Partial
☐ None

INLET CONDITIONS:

Inlet Erosion	☐None	☐Slight	☐Moderate	☐Severe
Inlet Clogging	☐None	☐Slight	☐Moderate	☐Severe
Structural Problems	☐None	☐Slight	☐Moderate	☐Severe

Comments:

INLET #2:
Diameter/Width: _____(in)

TYPE OF INLET: ☐ Open Channel ☐ Closed Pipe
☐ Sheet Flow ☐ Curb Cut ☐ Other: __________

Elevation difference between bottom of inlet and BMP surface: _____ (in)

INLET SUBMERSION:
☐ Complete
☐ Partial
☐ None

INLET CONDITIONS:

Inlet Erosion	☐None	☐Slight	☐Moderate	☐Severe
Inlet Clogging	☐None	☐Slight	☐Moderate	☐Severe
Structural Problems	☐None	☐Slight	☐Moderate	☐Severe

Comments:

PRETREATMENT

TYPE OF PRETREATMENT *(check all that apply)*
☐ None
☐ Sediment Forebay (_____ ft^3)
☐ Grass Channel
☐ Riprap Channel or Apron
☐ Grass Filter Strip
☐ Plunge Pool?
☐ Stone Diaphragm
☐ Other: __________

PRETREATMENT FUNCTION ☐ By design ☐ Incidental
Is pretreatment functioning? ☐ Yes ☐ No
Is sediment removal necessary? ☐ Yes ☐ No
Signs of pretreatment bypass? ☐ Yes ☐ No
Signs of flow of sediment from pretreatment to BMP? ☐ Yes ☐ No
Severity: ☐ Slight ☐Moderate ☐Severe

GENERAL DESIGN

BMP FEATURES (check all that apply)
☐ Maintenance Access
☐ Fence
☐ Multi-cell
☐ Micropool
☐ Impermeable Liner
☐ Underdrain
☐ Clean Out
☐ Observation Well
Is water present in observation well?
☐ Yes ☐ No Depth: ______ ft
☐ Pond Drain
☐ Other:_______________

CONVEYANCE THROUGH BMP
☐ No Defined Channel
☐ Low Flow Channel
☐ Concrete ☐ Eroded ☐ Earthen ☐ Other ____________
Length of Shortest Flow Path: _________(ft)

Is BMP designed with a Permanent Pool? ☐ Yes ☐ No

PERFORMANCE

GENERAL PROBLEMS: (check all that apply)

☐ Maintenance Needed	☐ Erosion at Embankments	☐ Permanent Pools not stable
☐ Water Bypass of Inlet	☐ Erosion within Facility	☐ Inadequate vegetation
☐ Water Bypass of Outlet	☐ Deposition within Facility	☐ Dead or Diseased Vegetation
☐ Incorrect Flow Paths	☐ Inappropriate Ponding of Water	☐ Too many invasive plants
☐ Short-circuiting of treatment mechanism	☐ Clogged Pond Drain/Underdrain	☐ Trees on Embankment
☐ No or ineffective treatment	☐ Clogged Media	☐ Failing structural components
☐ Ineffective pretreatment	☐ Inappropriate media material	☐ Safety issue (Note:________________)
☐ Others ________________________ __	☐ Inappropriate underlying soil (infiltration)	

WATER QUALITY IN FACILITY: ☐N/A

Algae	☐None	☐Slight	☐Moderate	☐Severe
Odor	☐None	☐Slight	☐Moderate	☐Severe
Turbidity	☐None	☐Slight	☐Moderate	☐Severe
Color	☐Normal	☐Abnormal: ___________		

EVIDENCE OF:

☐ Geese
☐ Animal Burrows
☐ Mosquitoes
☐ BMP Alteration

PROBLEM		1=NONE	2 - FEW	3 – SEVERAL	4-SEVERE
TRASH		No evidence of trash	A few pieces of trash throughout BMP	Trash accumulation near inlet/outlet	Lots of trash in BMP or BMP used for storage
BMP BANK EROSION		No noticeable erosion	Slight erosion < 5% of bank affected	Moderate erosion ~15% of bank affected	Banks severely eroded, >25% of bank affected
SEDIMENT DEPOSITION		No sediment deposition	Areas of minor sediment deposition	Areas of some deposition, may be severe near inlet/outlets	Lots of deposition resulting in pond bottom clogging
SURFACE SLOPE		0-1% BMP surface slope	1-3% BMP surface slope or steeper slopes with check dams,	3-5% BMP surface slope with no check dams,	>5% surface slope;
SIDE SLOPES		BMP side slopes 3:1 or flatter	BMP side slopes 2:1	Steep BMP side slopes	Risk of side slope failure
STRUCTURAL		No evidence of structural damage	Minor problems (e.g., bank slump, eroded channels)	Moderate structural problems –failure pending	Structural failures (e.g., bank failure, blowout)
VISIBILITY		High visibility, near high-traffic areas	Some visibility, near traffic areas	Limited visibility, near low traffic areas	No visibility, behind buildings or fences
ACCESSIBILITY		Maintained access area for vehicles	Access area designated, but not maintained	Access for vehicles not designated	Access for vehicles not possible
VEG COVER		No mowing in/around BMP	Mowing along BMP edges but areas of no mow in BMP bottom	Mowed turf vegetation	BMP bottom has large areas of bare soil
		Dense plant cover (>75%)	Plant cover, 50-75%	Some plant cover, 25-50%	Sparse vegetative cover (<25%),
VEG HEALTH	TREES	Healthy and established	Slightly stressed	Stressed	Dead
	GROUND COVER	Healthy and established	Slightly stressed	Stressed	Dead
	SHRUBS	Healthy and established	Slightly stressed	Stressed	Dead
	EMERGENT WETLAND	Healthy and established	Slightly stressed	Stressed	Dead

OVERALL PERFORMANCE SCORE (circle one number)

Excellent design and function, no general problems with performance			BMP is well designed, but is undersized or has a few performance problems		BMP is adequately designed, several problems with performance are noted			Poor BMP design, severe performance problems or failure	
10	9	8	7	6	5	4	3	2	1

Field Notes

Good or Interesting Design Features:
Photo #'s:

Poor or Problematic Design Features:
Photo #'s:

SECTION 3 – Design Plan Verification

Plan Available: ☐ As-built ☐ Other: _____

Do field observations match design plans/as-builts? Describe any differences.

Soil type in facility ☐ N/A ☐ Yes ☐ No If no, describe:

Pretreatment type and size ☐ N/A ☐ Yes ☐ No If no, describe:

Signage ☐ N/A ☐ Yes ☐ No If no, describe:

Low-flow channel ☐ N/A ☐ Yes ☐ No If no, describe:

Dimensions/volume ☐ N/A ☐ Yes ☐ No If no, describe:

Inlet type, #, and sizing ☐ N/A ☐ Yes ☐ No If no, describe:

Outlet type, #, and sizing ☐ N/A ☐ Yes ☐ No If no, describe:

Vegetation composition ☐ N/A ☐ Yes ☐ No If no, describe:

Other features ☐ N/A ☐ Yes ☐ No If no, describe:

Appendix F
Expert Panel Meeting Minutes

Performance Standard BMP Review Panel
Thursday October 20, 2011

Members Present

Panelist	Affiliation	Present
Stewart Comstock	MDE	Briefed
Randy Greer	DE DNREC	No
Shoreh Karimpour	NYDEC	Yes
Sherry Wilkins	WVDEP	Yes
Fred Rose	Fairfax County	Yes
Peter Hill	DDOE	No
Dave Hirschman	CWP	Yes
Ken Murin	PADEP	No
Scott Crafton Virginia Snead	VA DCR	Yes
Jeff Sweeney	EPA	No
Tom Schueler (Facilitator)	CSN	Yes
Non-Panelists		
Linda Power, US EPA CBP. Norman Goulet, NVRA, Chair USWG		

Call to Order and Panelist Introductions

Each of the panelists introduced themselves and explained their background in developing or addressing new performance standards in their jurisdiction. Tom briefly outlined the protocol by which the Panel would conduct its business, and asked the Panel whether they understood their role and had any questions about the protocol.

Tom then outlined that his role was to facilitate the Panel, organize the research and methods, and document its progress, but not be involved in the decision-making process.

Review of the Charge for the Panel, the BMP Panel Review Process and Panel Member Responsibilities

Bay states have requested assistance on how to report efficiencies for individual BMPs within a system of BMPs that are applied to new and redevelopment projects under their new stormwater performance standards. Since nearly all states have runoff reduction requirements, the main thrust behind a performance based approach is that it doesn't matter what component practice you use, you are capturing the reduction value. With almost all new state stormwater standards underway, they presume a system of practices used at the development site. Going forward, the Panel is asked to assess a composite removal rate or efficiency that would apply to all the practices on a development site. We're not talking about assessing the efficiency rates of each individual practice.

Tom proposed a draft charge for the Panel to ensure that it has reviewed all of the available science on the pollutant removal performance of LID/ESD practices.

The initial charge of the Panel is to evaluate:

(a) Whether full implementation of each new state stormwater performance standard can achieve sufficient nutrient and sediment removal at a new development site to qualify as being nutrient neutral with respect to the Bay TMDL,

(b) How to assess situations at new development projects that only partially achieve the standard,

(c) What, if any, pollutant load reductions are offered when the standards are applied to re-development,

(d) What are the proper units that local governments would report to the state to incorporate into the model.

Beyond this general charge, the Panel is asked to:

- Determine whether to recommend whether an interim BMP rate be established prior to the conclusion of the panel for WIP planning purposes

- Provide a specific definition of how the performance standard approach would be applied in each state

- Recommend procedures for reporting, tracking and verifying the load reduction achieved by the BMP systems.

- Critically analyze any unintended consequence associated with the removal rates and any potential for double or over-counting of load reductions achieved

Action*: The Panel requested that Tom draft a written version of the charge for the Panel and EPA CBP staff, and provide review and comment to Tom by the first week of November.*

Review of Existing BMP Performance Data *(Attachment B/C)*

The Panel was provided a summary review of recent stormwater research and asked to review the existing data and protocols and determine whether they reflect available data, or whether additional studies or research is needed to define the performance of new BMPs designed and installed under new state stormwater performance standards for new and redevelopment.

Action*: Tom will distribute source research studies, including tech memo on runoff reduction, international stormwater database on pollution reduction removal rates to the Panel.*

Action*: Panelists are requested to provide any additional research studies, performance data or reports to Tom Schueler, who will send them to the entire Panel.*

Action*: Submit any comments on Technical Bulletin #9 and the MDE document to Tom Schueler. All comments received will be distributed to the Panel.*

Scoping of Technical Issues to Address

The Panel discussed the technical issues that need to be resolved to define expected removal rates for sites that fully or partially comply with new stormwater performance standards. The following were the highlights of the discussion:

- *Review the basic "acceptable loads" method* – This method takes the entire land based nutrient load from each state and divides it by its acreage and comes up with unit area load in terms of pound per acre per year for N and P. If all of the land area in a particular state had that loading, you would meet water quality standards in the Bay. You have to set the benchmark if you're going to be nutrient neutral. The Panel has been asked to look at this method and do some calculations of how using this approach would work for them and the part of their state that's covered within the Bay watershed.

- *Evaluate methods to define baseline loads from new and redevelopment* – There are a couple choices: Use the Simple Method or an alternative approach that would take the state average of impervious/pervious areas from the Watershed Model and use those unit rates based on the relative amount of cover at a 25 acre site. Tom has requested that the Panel look into these methods.

- *Assess protocols for reporting, tracking, and verifying BMP removal rates* – Examples of these protocols can be found in the Technical Bulletin #9 excerpts. Right now we assign permanence to a structural BMP that is installed. Should there be some system in place with new performance standards where we certify on a 5 or 10 year-cycle that the system of practices is still working as intended?

This is an important concept to look at because it would be hard to justify a higher rate without an accountability mechanism.

- *How to deal with partial compliance at sites with new standards* – It would be ideal if every development/redevelopment site met the applicable state's performance standard. However, there are many situations where there is a waiver, grandfathering, or a roll out that might not happen until further down the line. Currently, with the exception of MD and NY, most are gradually phasing in new performance standards. Consequently, how do we handle these situations? Partial compliance based on an old standard? The Panel has been asked to think about this.

- Other key issues from panel – Using Table 23 from Technical Bulletin #9, the Panel has been asked to conduct their own acceptable load analysis to determine if their own stormwater performance standards will achieve nutrient neutrality.

Set Next meeting Date and Assign Action Items to the Panel (15 min)

Each state was asked to do perform the following in the next three weeks:

Action: Panel has been asked to conduct an acceptable loads analysis, provide a short narrative of their performance standards for new and redevelopment, and determine whether these standards can be expressed in terms of rainfall/runoff capture and runoff reduction as shown of Table 23 in Technical Bulletin #9.

Action: Panel has been asked to develop some bullets that outline the situations where full compliance is not expected at development sites (e.g., grandfathering, waivers, exemptions, technical feasibility, brownfields, etc) and any provisions for offsets.

Second Meeting
Performance Standard BMP Review Panel
Friday, November 18, 2011

Members Present

Panelist	Affiliation	Present
Stu Comstock	MDE	X
Randy Greer	DE DNREC	X
Shoreh Karimpour	NYDEC	X
Sherry Wilkins	WVDEP	X
Fred Rose	Fairfax County	X
Peter Hill	DDOE	
Dave Hirschman	CWP	X
Ken Murin	PADEP	X
Scott Crafton	VA DCR	X
Jeff Sweeney	EPA	
Tom Schueler (Facilitator)	CSN	X
Non-Panelists		
Rachel Streusand, CBPO. Norman Goulet, NVRA, Chair USWG		

Action: Stew Comstock to send some edits to CSN on the expert panel charge by December 1.

Action: Tom to meet with Randy Greer and D. Hirschman on how to adjust Table 23 so that it properly reflects actual runoff volume captured by each state stormwater performance. This may entail developing two tables, depending on whether the standard specifies a runoff capture volume or a rainfall depth that must be captured, relative to a predevelopment baseline.

Action: Tom to knit together the performance standard information submitted by DE, MD, and PA. Scott Crafton (VA), Peter Hill (DC), Shoreh (NY) and Sherry (WV) to send their relevant summaries to Tom by December 10.

Action: Tom to follow up with Dave Hirschman about his work on visual indicators to verify BMP performance and have him speak at the next panel meeting.

Action: Next panel meeting scheduled for 10 to 12 AM on Thursday, January 12.

Action: Tom to present summary of panel progress at December 13 USWG meeting.

Review of the Charge for the Panel and Review of Meeting Minutes

Consensus: The expert panel formally approved the panel charge and the meeting minutes from the first teleconference.

Closure on BMP Pollutant Removal and Runoff Reduction Research Review

Consensus: The Panel affirmed that the summary of research provided was adequate for their purposes, although **Fred Rose** noted that the Panel should account for how performance may diminish with age. Tom noted that this may be possible using BMP verification procedures.

State Reports on their Stormwater Performance Standards

Each of the states provided a report on their state performance standards.

Randy Greer (DE) provided a series of slides that showed the acceptable load analysis for DE. Randy found that the Table 23 approach did not work well for DE because of how their performance standards work. His analysis indicated that many sites on A, B, and some C soils could be nutrient neutral, but seldom for sites on D soils, or any site with on-site septic systems.

Scott Crafton (VA DCR) noted that he was not sure whether the edge of stream or delivered loads should be used for the basis of the acceptable loads analysis, and that the ability of the Virginia standard to meet nutrient neutrality largely depended on this issue. He described offset procedures, and will continue to work on his state documentation.

Stewart Comstock (MDE) presented a series of slides that explained the ESD to MEP regulatory framework and showed the acceptable loads analysis for MDE. He concluded that new development sites that fully complied with the MDE standard would be nutrient neutral. He also described some limited conditions where local compliance might not be possible under the ESD to MEP framework.

Ken Murin (PA DEP) also presented a series of slides on the implementation of their state performance standard, and his initial work on defining the acceptable loads analysis. Based on his preliminary analysis, full compliance with the standard would ensure nutrient neutrality.

Sherry Wilkins (WV DEP) presented preliminary analysis that indicated that sites that met the MS4 performance probably would be nutrient neutral, depending on some technical assumptions. However, she noted that MS4s represent only a fraction of the land being developed in the eastern Panhandle, and that local ordinances are needed for full implementation there. She indicated that WV DEP is tracking changes in re and post development land cover for new development projects in order to ensure they can hold the line on stormwater nutrient discharges.

Shoreh K (NY DEP) described the current NY performance standard, and indicated she plans on performing additional analysis in December.

No one from **DDOE** was present on the call, so it is requested **Peter Hill** provide his analysis on the next conference call

Dave Hirschman noted that there were several idiosyncrasies in each state performance standard that makes it difficult to do an "apples to apples" comparison against a single metric such as rainfall depth captured, and the Panel agreed with this view.

Action Item The Panel also directed Tom to consult with the Bay modeling staff to provide clarification on the issue of edge of stream versus delivered loads, and how the Panel should interpret these in its analyses.

Potential Methods for Assessing Effect of Standards on Loads from New Development and Redevelopment

Tom briefed the Panel on the technical basis for the proposed methods for analyzing how loads change as a result of state performance standards. The Panel came to consensus on several points:

The methods presented need to show sediment reduction rates. **Tom and Dave Hirschman** indicated they would look at sediment performance data in the runoff reduction studies and CWP BMP performance database, and make recommendation for next meeting.

There was general support for the concept of (Table 23), but several refinements were needed to make it a useful tool

1) Add in sediment removal rates described above.

2) Drop or italicize the nutrient and sediment reduction projections above 1.5 inch since there is much less research to support them and the removal rates for the 2.0 to 2.5 inch range is extremely high.

3) Investigate whether two tables are needed, one for states that define a rainfall capture depth above a predevelopment runoff baseline, and one for those that define a straight runoff reduction volume.

Consensus: The Panel directed Tom to revise the approach for consideration at the next panel meeting.

Discussion of How to Handle Non-Conforming Projects

This discussion was subsumed into the discussion in agenda item No. 6.

Protocols for Reporting, Tracking and Verifying New BMPss

Tom provided a general summary of options for reporting BMPs from new and redevelopment projects, and subsequent protocols for tracking and verification.

Consensus: Overall, the Panel felt that overall framework for BMP reporting, tracking and verification was useful and it struck a good balance between reducing local administrative burden while not sacrificing real world BMP accountability.

The Panel felt the protocols should be modified as follows:

- For the sake of equity, redevelopment verification procedures should be no more stringent than procedures for new development.

- The local PE certification requirement for BMP performance is probably overkill.

- The duration of the BMP removal rates should be linked to the enforceable maintenance requirements.

- Need clearer definition of what is meant by visual indicators of BMP performance. Dave Hirschman volunteered to present on this topic at the next meeting.

Panel requested Tom revise Attachment C to reflect these comments, and provide in advance of next meeting.

NEW LID Performance Standards Review Panel
Third Teleconference
Thursday, January 12, 2012

Panelist	Affiliation	Present
Stewart Comstock	MDE	
Randy Greer	DE DNREC	X
Shoreh Karimpour	NYDEC	X
Sherry Wilkins	WVDEP	X
Fred Rose	Fairfax County	X
Peter Hill	DDOE	
Dave Hirschman	CWP	X
Joe Kelly	PADEP	X
Scott Crafton	VA DCR	X
Jeff Sweeney	EPA	
Tom Schueler (Facilitator)	CSN	X
Non-Panelists	Dave Montalli (WVDEP), Nick Shell	
Rachel Streusand, CBPO. Norman Goulet, NVRA, Chair USWG		

Action Item: Tom to draft technical memo describing consensus of the panel by end of January and distribute to panel for their extensive review by Feb 20, in track changes. Special attention should be placed on checking the sediment removal rate documentation, and MD/DE/PA/VA checking the math in the new BMP convertor table, and if needed, preparing a new state convertor table.

Call to Order and Review of November 18 Meeting Minutes

The meeting was called to order @ 10:02 AM. Tom commended the Panel for its hard work in completing its action items from the last meeting. The meeting minutes of the November 18 call were approved, subject to revisions proposed by **Sherry Wilkins**. Tom will revise the minutes and include them in the final technical memo. Tom also noted that **Shoreh K** from NY has accepted a new job, and will no longer be part of the Panel after today. The Panel was sorry to see her leave and congratulated her on her new job.

More State Reports on their Stormwater Performance Standards

VA and NY provided a numeric summary of their performance standards for new and redevelopment, and indicated how they express their standards in terms of runoff capture volume and degree of runoff reduction. These materials will be incorporated in the final technical memo.

Consensus: Methods for Assessing Effect of Standards on Loads from New Development and Redevelopment.

Tom presented a revised version of the new BMP removal rate adjustor table that includes new sediment removal rates, and incorporates other changes recommended and defines rates based on runoff reduction and runoff volume treated. The Panel asked to see more written documentation on the sediment removal rates. The Panel generally concurred with the new BMP removal rate adjustor table, but wanted to see examples for each state in the final technical memo so that local users would be able to understand how to compute rates for projects that are conforming with the state performance standard.

Dave noted a typo in the table that needed to be corrected. The Panel also indicated they wanted to see a table that defined which BMPs would be classified as RR or ST practices, and also be clear that the computed removal rate applies to the entire drainage area to the new or redevelopment project, and not just the impervious acres.

Tom introduced the concept of the state performance standard convertor table which converts the various rainfall depths in several state performance standards (PA/DE/MD) to a runoff depth treated (so that a site can be subsequently analyzed using the new BMP removal rate adjustor table. This was the "apples to oranges" problem discussed at the last call.

Randy and **Dave** provided comments on the convertor table that Tom prepared. The Panel felt that the convertor table approach was useful to provide a unified basis for comparison among states. MD, PA and DE were requested to review the draft convertor table to make sure it is consistent with their state standards for rainfall capture, pre-development baseline, and curve numbers. They can reserve the option to prepare their own convertor table.

The Panel continued its discussions on the proper method(s) to define baseline loads for the purpose of defining nutrient neutrality, including the Simple Method and generic CBWM urban unit loading rates (Attachment C). After considerable discussion, the Panel elected not to recommend a method for defining baseline loads for individual development projects, when it comes to reporting individual projects to state TMDL agencies. The notion that nutrient neutrality could be defined on the basis of “acceptable loads analysis” discussed in the last call was rejected by the Panel for several technical reasons.

Instead, localities would simply report the removal rates computed from the new BMP adjustor table and the contributing drainage area for each project. The Panel also indicated that states could decide whether to use the Simple Method, CBWM unit loads or other suitable methods when conducting local watershed analyses to track changes in pollutant loadings and for MS4 permit reporting. They also indicated that both methods should be included as an appendix in the technical memo.

The Panel also felt that it would be wise for localities to track aggregate changes in pre and post development land cover associated with new development and redevelopment projects within their jurisdiction over time. This may provide useful data to account for future loading changes as a result of land use change due to development/redevelopment (e.g., in MS4 permits).

Consensus: How to Handle Non-Conforming Projects

Tom described a brief proposal on how to compute and report removal rates for projects that cannot fully comply with their relevant new performance standard (Attachment C). The issue is important for localities between now and the future date when plans using the new standards are actually approved. The Panel discussed and approved the approach, subject to several edits.

Presentation: Field Methods to Verify BMP Performance:

Norm G started the discussion by describing the forthcoming Bay program initiative to improve urban BMP reporting, tracking and verification in the context of the Bay TMDL.

Dave H (CWP) made a short presentation on inspection methods and visual indicators to verify BMP performance in the field, based on his prior experience in assessing existing BMPs in Virginia and other Bay states. The Panel indicated that the CWP approach embodied in the two documents (Attachment F-1 and F-2) was an excellent template to help define what constitutes "installed properly, meets or exceeds state design standards and is functioning hydrologically as designed" in post-construction inspections to verify BMP performance (see next agenda item). Dave volunteered to provide the Panel an updated version of the performance inspection field sheet, and the Panel felt it would be useful to refer to it in the memo, and provide as an example in the Appendix.

Consensus: Protocols for Reporting, Tracking and Verifying New BMPs

The Panel discussed the revised general framework for RTV (Attachment D) and adopted it subject to the following modifications:

- Provide more specific guidance as to what constitutes "installed properly, meets or exceeds state design standards and is functioning hydrologically as designed" so that it can be physically defined in the field.

- Change certification to verification.

- Simplify the local BMP reporting requirements by dropping the baseline load requirement, but recommended localities also provide a list of the LID practice(s) employed at the site.

The Panel will be asked to review the revised general framework for reporting tracking and verifying the BMPs installed under the new performance standards, and decide whether it needs further refinement.

Recap Consensus Achieved and Structure for Panel Report

Tom described the proposed structure for the Performance Standard Removal Rate Technical Memo that documents the consensus of the Panel (Attachment E). The Panel concurred with the outline, and authorized Tom to produce a draft for track change review in two weeks. Based on panel comments, the group may elect to have a short teleconference to resolve any outstanding comments, and then transmit it to the Urban Stormwater Workgroup to initiate the WQGIT BMP protocol review process.

The panel adjourned at 3:58 PM

Combined Meeting Minutes
State Stormwater Performance Standard Expert Panel
Final Review Teleconferences

March 13, 2012
and
April 3, 2012

Panelist	Affiliation	March 13 ?	April 3?
Stu Comstock	MDE	X	C
Randy Greer	DE DNREC	X	X
Shoreh Karimpour	NYDEC	R	R
Sherry Wilkins	WVDEP	X	X
Fred Rose	Fairfax County	X	X
Peter Hill	DDOE	X	C
Dave Hirschman	CWP	X	C
Joe Kelly	PADEP	X	X
Scott Crafton	VA DCR	X	X
Jeff Sweeney	EPA		
Tom Schueler (Facilitator)	CSN	X	X
Norman Goulet	Chair USWG	X	X
X = present, C= Checked in prior to meeting, R= resigned from panel			

The Panel held two calls and provided extensive written and verbal comments on the Feb 21 and March 13 drafts of the final panel memo. These minutes summarizes the key technical changes made to the method by CSN during this review period, as well as a providing a record for how the Panel resolved its more substantive comments. Based on this, the Panel voted 9-0 to tentatively adopt the final memo, subject to a two week period for errata and state-specific comments, and report out on its final recommendations at the April 30 USWG meeting.

1. Key Technical Changes to the Method

Changes after First draft

1. *Dropped reference to the Original New BMP Adjustor Table and replaced with curves*. The tabular data was converted into a series of curves to make it easier for users to define a rate for the unique combination of runoff capture volume and degree of runoff reduction. This was done by fitting a log-normal curve to the tabular data points, which came within a few percentage points of the tabular values for a wide range of runoff capture depths and removal rates

2. *The technical basis for defining the anchor rate was provided in a New Table in Appendix C*

3. *More Accurate Estimates of Runoff Capture Were Derived Using Explicit an Explicit rainfall frequency spectrum equation, and this supplemental documentation was incorporated into Appendix C.* The new more accurate method has the result of flattening the removal curves for higher depths of runoff capture.

4. *Suitability of Method*. The Panel concluded that the generalized new BMP removal adjustor curves were a suitable tool for estimating the aggregate pollutant load reductions associated with hundreds or even thousands of future BMPs at the scale of the Bay watershed and the context of the Chesapeake Bay Watershed Model.

Changes After 2nd Draft

1. *Modify HI/LO Designation*. Change the HI runoff reduction designation to RR (runoff reduction) and the LO designation to ST (stormwater treatment). DE recommended this clarification as it is more consistent with how these practices are treated in state stormwater manuals. This would be reflected in the text and on the curve labels in the memo, however, there would be no change in how the current list of stormwater practices are categorized (i.e., Table 4)

2. *Make the following clarifications in the methods section*:

- Clearly define the x-axis as being "depth of runoff captured by practice per impervious acre."

- Clearly state that the new BMP storage volume for each site must be adjusted using a "unitization" equation that converts the storage volume into a unit depth per impervious acre at each site.

- Note that the corresponding removal rate determined from the appropriate curve applies to the entire drainage area (i.e., the new development or redevelopment site).

3. *Why We Use the Unitization Equation for New Development Projects*

In order to compare the impact of performance standards of all the Bay states, a unitization equation is used that divides runoff storage volume for the site, by the fraction of the site that is impervious.

$$= \frac{(12 * EP)}{IA}$$

The primary reason is that each state's Engineering Parameter (EP) is calculated as a function of several factors including land cover, hydrologic soils group, predevelopment hydrology baseline and target rainfall depth. This means that each individual site within a state will have a unique EP storage volume over its drainage area. As a result, we need to adjust each unique site EP to get a standard depth of treatment per unit impervious cover to use the curves. By dividing each site's EP by the impervious cover acreage, we are able to define inches of runoff captured per unit impervious acre, and use this value to define the removal rate from the curves.

The removal rates determined from the new BMP removal rate adjustor curves are applied to the <u>entire</u> site area, and not just the impervious acres. Also, the reporting unit for the site is the entire treated area of the site, regardless of whether it is pervious or impervious.

4. *Why We Don't Use the Unitization Equation for Redevelopment Projects:*

   The unitization equation is not needed for redevelopment projects because the EP defined under each state redevelopment standard is computed solely based on site impervious cover (i.e., runoff from pervious cover is not a factor in defining EP at a redevelopment site, which means IA = SA).

$$= \frac{(12 * EP)}{SA}$$

5. *Change Design Examples*: The original design examples provided data for each of the six Bay states for common development scenarios. The Panel felt that the comparison provided some counter-intuitive (but accurate) results, and indicated that these comparisons served no useful purpose. It was agreed that to prevent confusion, only one state would be utilized per design example, and re-iterate the point that the runoff capture volume derived for the curves will be different from the runoff volume computed (EP) under each state's performance standard.

6. *Provide More Documentation on Unitization Equation*. Add a section in the Appendix C that documents why the unitization for impervious area is needed to provide a common basis of comparison among states and drainage areas. The basic reason is that the Rainfall Frequency analysis used to derive the curve above and below the anchor points is based on the assumption that the runoff delivered to a practice is generated from a unit impervious acre. The runoff storage volumes achieved for individual retrofits, however, are unique, based on the land cover, soils and hydrologic assumptions used in each state. Therefore, these volumes must be adjusted by a unitization equation to get the correct depth to use on the x-axis of the curve.

2. Resolving Key Comments From the Panel

General Comments:

In general, the Bay states wanted to ensure that the memo would protect state prerogatives with respect to their existing and/or future BMP reporting and tracking systems.

To prevent confusion, the memo should be carefully screened to reduce the use of the term "credit" as this has implications for trading and offsets. The term "site design credits" will be employed to refer to runoff reduction achieved through non-structural stormwater practices, such as disconnections and sheet flow.

Methods Section:

Comment: MDE and others noted that some runoff reduction practices take surface stormwater and shift it to groundwater, so that it is possible that some fraction of the nitrogen entering a runoff reduction practice may ultimately end up in a stream, and that the nitrogen removal rates shown on the curve may not be as high in the real world.

Resolution: The Panel acknowledged the potential for this, but did not have any data to confirm or refute that it exists. The Panel agreed that this issue should be a top stormwater research priority, and indicated that the following statement be added to the existing section on research collaboration: "The Panel expressed a particular interest in defining the fate of nitrogen in retrofits that rely heavily on infiltration or extended filtration to provide runoff reduction"

Comment: Several Bay states require pollutant load reductions design computations as an integral part of the implementation and compliance of their stormwater performance standard, and were concerned that the proposed method would supersede them

Resolution: The Panel agreed that this is not the intent for the protocol to replace or supersede state design standards, and added the following language to stress that point.

Several states in the Bay watershed require a site-based spreadsheet pollutant load calculation as part of stormwater review for individual development projects. The calculations require designers to achieve target post development loads using a series of removal efficiencies for individual LID and site design practices at the development site. Examples include the Maryland Critical Area Phosphorus compliance spreadsheet (CSN, 2011), the Virginia state-wide stormwater compliance spreadsheet (VA DCR, 2011), and the Pennsylvania stormwater manual worksheets (2006).

The Panel considers the technical and scientific basis for these site-based tools to be sound and appropriate for the scale of individual site analysis and BMP design. The Panel strongly emphasizes that the pollutant removal protocol it has recommended for Bay TMDL tracking in no way supersedes these site-based compliance tools. The regulated community in each Bay state must still meet the stormwater regulatory requirements established in each state's stormwater regulations, permits, and design manuals.

Design Examples Section

Comment: PA indicated that there should be a disclaimer at the beginning of the section to reinforce the point that the design examples simply show how nutrient and sediments removal rates are calculated in the context of the Chesapeake Bay TMDL, and that designers must still follow the appropriate stormwater sizing, design criteria and compliance tools established by each state to implement its new performance standards.

Resolution: The Panel agreed that this disclaimer should be added.

Accountability Section

Comment: Various states indicated that their BMP reporting systems are unique, and they did not want a "one-size fits all" approach to new stormwater BMP reporting.

Resolution: The Panel agreed that states will need to aggregate data on the location of BMP systems, year installed, and removal rate to report to EPA, and also have the capacity to remove BMPs that are no longer functioning. However, the Panel agreed the following language should be added to the memo:

"Localities must submit basic documentation to the state stormwater or TMDL agency to document the nutrient/sediment reduction claimed for each system of urban BMPs that are actually installed. Localities should check with their state stormwater agency on the specific data to report for individual projects. Some *typical* information that may be reported includes"

State BMP Reporting Systems. Each state has a unique system to report BMPs as part of their MS4 permit. In some cases, states are still developing and refining their BMP reporting systems. To utilize the removal rates in the context of CBWM progress runs, states will need to report BMP implementation data using CBP-approved rates or methods, reporting units and geographic location (consistent with NEIN standards), and periodically update data based on the local field verification of BMPs.

Local Reporting to the State. Localities will need to submit basic spreadsheet documentation to the state once a year as part of their MS4 annual report. The spreadsheet can be used to tabulate the aggregate acres of new development and redevelopment that were treated to the standard. Localities should check with their state stormwater agency on the specific data to report. Some typical data they may be asked to report includes:

Comment: Several states and localities on the panel indicated concerns over the language on initial verification/certification of the performance of BMP systems at new or redevelopment sites. The concerns ranged from effect on local resources, and that localities should be able to use the existing annual MS4 annual reports as an alternative.

Resolution: The Panel agreed and re-drafted the section as follows: Localities will need to verify that urban BMPs are installed properly, meet or exceed the design standards for its CBP BMP classification, and is functioning hydrologically as designed prior to submitting the BMP for pollutant reduction in the state tracking database. This initial verification is provided either by the BMP designer or the local inspector as a condition of project acceptance as part of the normal local stormwater BMP plan review process. From a reporting standpoint, the MS4 community would simply indicate in its annual report whether or not it has BMP review and inspection procedures in place and adequate staff to implement them.

Comment: Several panelists questioned the process for down-grading individual BMPs, noting that as long as a local jurisdiction has a regular inspection and maintenance program/procedures in place to correct under or non-performance of retrofits, then removal and replace of credits should be rare. This requirement could be excessively burdensome and subject of error and confusion not only at the local level, but also at the level of the Bay Program modelers.

Resolution: The Panel agreed that downgrading based on field inspection was an important component of BMP verification. The Panel drafted language on a reasonable time frame for corrective action and that downgrades only need to be reported through MS4 permit annual reports, as follows: If the field inspection indicates that the BMP system is not performing to its original design, the responsible party would have up to one year to take corrective maintenance or rehabilitation actions to bring it back into compliance. If the facility is not fixed after one year, the pollutant reduction rate for the BMP system would be eliminated, and the locality would report this to the state in its annual MS4 report.

Comment: Several states noted that the BMP visual indicators checklist referenced in the text and provided in Appendix E may not be applicable in their state, and they wanted to reserve the right to develop their own indicators and checklists.

Resolution: The Panel agreed, and indicated the intent was to provide a model for what kind of visual indicators are worth looking at in the field, and not prescribe a Bay-wide template. Additional language to be added to address this point.

Comment: Several states were concerned that the BMP reporting and verification procedures need to be specially adapted to meet the unique situation of non-Ms4s communities.

Resolution: The Panel agreed with the general comment, but felt that this was a larger verification issue that should be addressed by the entire USWG in the coming year. It agreed on the following language to add.

Special Procedures for Urban BMPs Installed in Non-MS4s. Several states such as PA and WV are expected to have considerable development occurring in non-MS4 communities, which tend to be very small in size and fairly new to stormwater BMP review. It is acknowledged that these non-MS4s may not currently have the budget and/or regulatory authority to fully meet the new BMP verification protocol. A committee of the Urban Stormwater Work Group will recommend alternative verification procedures in 2012 for non-MS4 communities

Comment: If these protocols are accepted by the CBP, then the CAST, MAST, VAST will need to be modified as well. There will be no utility to these programs if they don't effectively predict CBP model results. Coordination with CAST needs to be a priority that should happen in concert with the update of urban BMP removal rates and not as an afterthought.

Resolution: The Panel agreed with this, and instructed CSN to share the final memo with the CB Modeling Team to ensure procedures were in place to prior to USWG meeting to address these concerns. They also added the following language to the text:

The Panel acknowledges that the new BMP removal rate protocol may require adjustments in the BMP assessment and scenario builder tools recently developed to assist states and localities to evaluate BMP options to develop watershed implementation plans (i.e., each development project has a unique removal rate and consequent load reduction, while the CAST tools apply a universal rate for each type of BMPs).

The Panel noted, that with the exception of the redevelopment load reduction, most localities will not need to employ CAST to track implementation of new BMPs associated with future growth and development. CSN will work with ICPRB and Bay Partners to make improvements to future versions of CAST and CBWM to improve its ability to handle stormwater BMP systems associated with both new and redevelopment. In addition, CSN will check with the Bay modeling team to ensure that the new removal rates are properly applied to urban lands in the context of CBWM, and in particular, the appropriate pervious and impervious areas.

Appendix C

Comment: It was noted that a Table in Appendix C had incorrect units for sediment loading rate from CBWM.

Resolution: Table Corrected

Comment: A locality noted that when it comes to defining baseline loads from which the removal rates are applied, the two methods in Appendix C can give different loads for the same scenario (e.g., Simple Method cs. CBWM unit loads). The main issues is that Simple Method computes load solely based on IC, where the CBWM unit load method has employs both IC and pervious cover to compute baseline loads. Depending on the method, this could result in an over-estimate of load removed.

Resolution: The Panel noted that the actual BMP load reductions are calculated for each project based on the NEIN location on the CBWM. The Panel noted that each Bay state should provide guidance to their MS4 localities on which of the two methods they prefer, to assure consistency in their MS4 permit reports.

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