Date: July 2, 2012

To: Urban Stormwater Workgroup and Expert Panels

From: Tom Schueler, CSN

Re: Resolution of Technical Issues Related to the Urban Retrofit and Performance Standards Expert Panel Recommendations

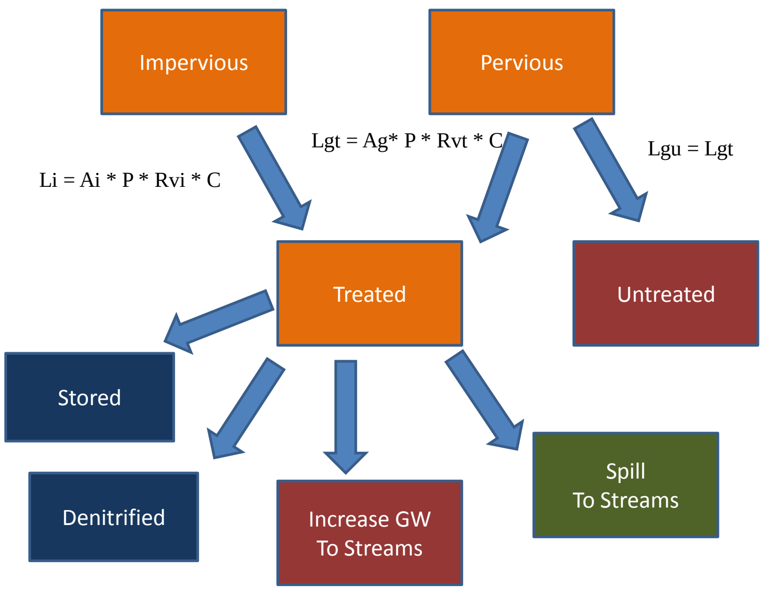
Background:

The Urban Stormwater Workgroup (USWG) accepted the recommendations of the two expert panels at its April 30 meeting. The recommendations were then transmitted to the CBP Watershed Technical Work Group (WTWG) at its May 29 meeting, which endorsed the two final reports, subject to four proposed revisions to ensure consistency with the CBWM and other scenario assessment tools.

After consulting with Gary Shenk (CBPO), I drafted a memo on 6/6/12 on an approach to incorporating these revisions, which was sent to both expert panels and the USWG. The USWG met on June 12 to discuss the memo. Whereas there was consensus to accept revisions 2 through 4, the USWG could not reach consensus on the nitrate base flow issue raised by WTWG (see meeting minute excerpts in Appendix A). At the request of the USWG chair, Gary Shenk drafted a response to the USWG (which is included in Appendix B), and the states were given a week thereafter to provide written comments (summarized in Appendix C). Based on the feedback I received, I have revised the 6/6/12 memo and offer a proposed resolution to the nitrate base flow issue, as follows:

Revision 1. Revising TN Adjustor Curve to Reflect Base flow Nitrate Movement in Urban Watersheds.

Issue: 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 reflect direct leaching of nitrate into groundwater in pervious areas that is not captured or treated by a down-gradient retrofit or BMP, or it may reflect nitrate that is exits a runoff reduction or stormwater treatment practice via infiltration into soil, or slow release through an under drain (e.g., bioretention). See Figure 1 below:



In the context of the CBWM, BMP removal rates are applied to the total nitrogen load that is generated by surface runoff and groundwater flows (i.e., when watershed modelers say 'runoff' they mean total surface and groundwater export from the land. When stormwater managers say 'runoff' they mean the surface runoff or interflow only that is captured by a retrofit or BMP). On pervious lands, as much as 25 to 40% of the simulated nitrogen load is coming through the groundwater (some fraction may also be delivered by downstream sources such as septic systems or illicit discharges).

If overland flow is diverted to groundwater, the overall load is reduced by using the ground as a filtering medium, but not eliminated. While ongoing research has indicated that it may be possible to enhance subsurface de-nitrification through certain design factors, we lack, as of now, definitive evidence for this effect.

Therefore, the WTWG concluded that current TN adjustor curves may over-estimate TN removal rates, and should be discounted to reflect the movement of untreated nitrate into streams, at the scale of the small watershed. This discounting is not needed for TKN, TP or TSS as these pollutants are not mobile in urban groundwater.

Rationale:

The ultimate fate of nitrogen in urban groundwater has been an ongoing concern from MDE representatives on both expert panels, but no panelist could identify a method or work around to satisfactorily address it in the context of CBWM.

Proposed Resolution:

The proposed resolution is to develop a discount factor to the existing panel protocols to account for groundwater nitrate migration from runoff reduction practices.

The USWG acknowledges that there is a potential need for a second discount factor to account for "escaped" nitrate up gradient and down gradient of the BMP that is not effectively captured by the BMP. However, the USWG does not feel there is a technical support for a work-around at this point in time and with this version of the CBWM. It recommends that the 2017 model refinements attempt to better characterize more specific contributions of different urban nitrate sources and their relative position in the urban landscape relative to the CBWM river basin segments.

Derivation of discount factor for nitrate loss exiting from runoff reduction practices

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) analyzed more than 3000 storm events, and the nitrate : TN fraction consistently around 0.3. This sets an upper boundary on the fraction of the inflow 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 1. 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 1). 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 removal is likely after the nitrate exits the BMP and moves down-gradient through soils on the way to the stream.

Given the 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 2.

Table 1: 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
Perm Pavers	-50% [4]	6	NA	IBSD, 2010
Perm 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

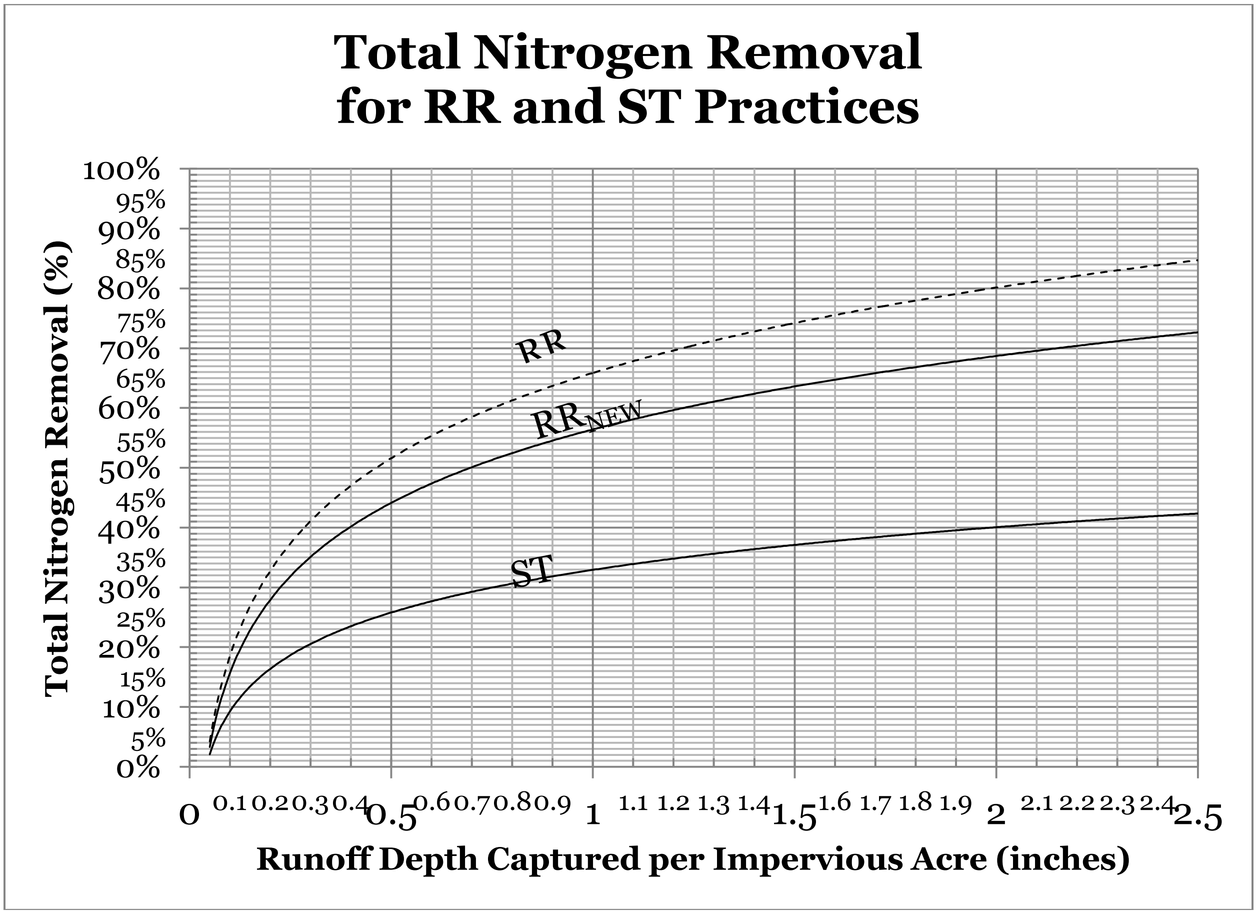
[4] A negative removal rate occurs when organic forms of nitrogen are nitrified to produce additional nitrate which is

[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 2. Revised TN Adjustor Curve



Option 1 Action: The USWG supports the modified resolution as provided above, and that the revised N removal rate adjustor curve shown above replace the current one. Design examples would be modified accordingly, and the preceding technical discussion be added to the appropriate appendix that describes how the adjustor curves were derived.

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.

Option 2 Action: Stick with both nitrate discount factors as originally outlined in the 6/6/12 Schueler memo. Revise expert panel memos accordingly.

Revision 2. Make a Short Term and Long Term Recommendation on how the new removal rate protocols can be better integrated into CAST.

Issue: The WTWG committee inquired how the project-specific removal rates developed by the expert panels could be incorporated into watershed assessment tools such as CAST and scenario builder. If each development site or retrofit project has a unique removal rate, how can this variability be addressed in the watershed assessment tools that localities and states use in their watershed implementation efforts?

Rationale: It may take a year or more to incorporate the adjustor curves into the CAST modeling framework, although the CBPO modeling team has expressed a willingness to do so. Until these refinements are made, how should retrofits and new BMPs be expressed in state tools (CAST/VAST/MAST etc.)

Resolution: Since these tools are used for planning, and evaluation of alternate BMP scenarios, it is reasonable for the states to select a single rate to characterize the performance of a generic retrofit or a BMP system used to meet new performance standards at a new or redevelopment site. For example:

> *For retrofits:* Assume the retrofits are a 50/50 blend of RR and ST practices and treat 1 inch of impervious area, and then use that generic rate for planning purposes, and then focus on the total drainage area treated by a group of retrofits.
>
> *For new development*: Assume that the projects fully meet the performance standard, and then assign the derived removal rate to the aggregate drainage area. The resulting load can be compared against the pre-development load to determine if the Project is nutrient neutral. States may also want to include options whereby full compliance with the standard is not possible so localities can forecast how these might change their baseline load allocation.
>
> *For Redevelopment*: Assume that the redevelopment project fully meet the performance standard, and then assign the derived removal rate to the aggregate impervious area that is treated. Since pre and post development land use is impervious, it will provide a quick estimate of the load reduction possible under different future redevelopment scenarios.

As noted, each state would elect to develop its own scenarios to be consistent with their unique requirements

Action: The USWG fully supports the recommended resolution.

Revision 3. Report Stormwater Performance Standards for Redevelopment Removal Credit as impervious acres treated and not pounds of nutrients reduced

Issue: It is more precise to have the CBWM compute the actual reduction associated with redevelopment stormwater then to have the state or locality estimate it based on the simple method or the state-wide unit loading rates from the CBWM.

Rationale: Reporting the rates and the impervious acreage treated requires less effort by local and state government, and provides more consistent estimates of load reduction via the CBWM. This approach also protects local government if the unit loads change in future versions of the CBWM (e.g., 2017).

Resolution: Accept the proposed revision, but still allow localities to estimate their load reductions using the two existing methods referenced in the Appendices. Localities, however, would not report their load reductions to the state for CBWM input deck.

Action: The USWG fully supports the recommended resolution.

Revision 4. Additional Qualifying Condition for the BMP Restoration credit

Issue: The WTWG requested that the BMP restoration credit have an additional qualifying condition that the proposed restoration activities be significant enough to achieve the intent of the original water quality design criteria in the era it was built (e.g., sediment cleanouts would need to be sufficient to recover the full water quality storage capacity that was originally approved for the BMP, under historically less stringent standards, regardless of whether the BMP was reported in the CBWM input deck.

Rationale: On-going concern that this restoration option was susceptible to gaming, and to have a firmer threshold that the restorative actions bring things back at least to the old design standard.

Resolution: add language to the retrofit memo that "the proposed BMP restoration activities be significant enough to achieve the intent of the original water quality design criteria in the era it was built"

Action: The USWG fully supports the recommended resolution

.

Appendix A:
Excerpts from June 12 USWG Meeting Minutes

WTWG Recommended Revisions on Expert Panel Reports: Tom Schueler

- See also memo: Proposed Revisions to Urban BMP Expert Panel Reports.
- Watershed Technical WG endorsement of the expert panels' retrofit and state performance standards recommendations, pending modifications.
  - WTWG key revisions include making nitrate leaching from pervious land more consistent with the CBP models.
- Reduced N rates also reflect many expert panelists' concerns that the N rates were too generous because of the use of the unitization equation.
- 2 other recommendations from the WTWG:
  - Redevelopment removal rate reporting units changed to impervious acres from pounds reduced
  - States provide generic retrofit and new BMP removal rate for use in CAST and MAST for the short term, and modelers have agreed to develop integration of these tools into the Model for the long-term approach.
  - Qualifying condition that the BMP must at least be restored to the original design/effectiveness of the era constructed.
- Majority of the expert panelists are generally accepting of the changes recommended by the WTWG.
  - These modifications are still under review
  - Next steps to be determined

Discussion:

- Norm Goulet- Split feelings on these recommendations. Concerned that this will be a big hit to the removal rates
  - Recommendations may be beyond the extent of current knowledge of the BMP.
- Ken Murin – Finds the WTWG recommendations problematic due to:
  - The orders of magnitude difference between tracking stormwater on the ground (site-by-site basis) and what the Model does. Concerned about accuracy.
  - Wrong message about encouraging BMP implementation and BMPs effects due to overly conservative numbers. Dilutes credits and message about stormwater BMPs.
  - Feels this approach is not consistent with work conducted in other sectors (e.g. other sectors' BMPs are not corrected to this extent in the Model).
- Stu Comstock – Feels these recommendations are a step in the right direction for N removal rates.
  - Similar approach to transport evaluations for loss from drain fields to edge of stream for septic systems.
  - Requests more time to review WTWG recommended modifications.
- Scott Crafton – Tom included a paragraph about the distinction between making this change to improve model results vs. downgrading new BMP specifications. But this distinction? is still not clear.

    - Significant investment in BMP specifications, both financially and in presenting to public.
        - Concern if performance of BMPs is lowered, this will send the wrong message to the public at a critical juncture of local implementation.
    - Feels that other sectors are not held to these standards of refinement.
    - Issues of states making investments, then BMP credits are decreased by EPA.
- Bill Stack – Studies indicate this issue of leakage, but question of where to make the adjustments remains. At or after the BMP level?
- Gary Shenk: Other sectors are also considering these changes in loading rates, as loading is not just from surface runoff, but total runoff including groundwater.
    - Certain amount enters the BMPs; ~30% leaves the BMP through normal flow out of BMP.
        - ~50% of pervious load never reaches the BMP; therefore, shouldn't be reduced by the BMP
        - If specifically designing BMPs to put more water into the ground, it will have some [N].
    - Important to understand that Model is predicting the total load coming off a land use, and these BMPs are only treating a certain amount of that load.
        - For accurate accounting, certain assumptions must be made to avoid biased high estimates.
    - Open to other suggestions, but must conceptually account for the other streams of loading.
- Ken Murin – Feels that other sectors may be looking at this, but not at the same level proposed here.
    - Concerned about adding an additional layer of conservative values.
    - This will decrease interest in stormwater BMP implementation.
    - Doesn't want the Model driving bad decisions.
- Norm Goulet – Agreement on non-Nitrate issues?
    - Ken Murin – Not prepared to vote on other recommendations at this time.

ACTION: Gary Shenk will provide examples of how other sector BMPs are handling nitrate leaching issues and evaluations.

ACTION: Members will send written comments to Molly Harrington 1 week after receipt of Gary Shenk's information on methods used in other sectors.

- Compiled comments will be reviewed again by the WTWG; options will be developed and presented for the WQGIT's final vote.

Appendix B
Gary Shenk Response on groundwater and BMPs.

On the Urban Stormwater Workgroup call of 6/12, two concepts were introduced reducing the estimated effectiveness of BMPs. The first concept was that groundwater nitrogen from pervious areas bypassed stormwater BMPs. The second concept was that BMPs that increased infiltration also increased the flow of nitrate through the groundwater. The challenge to these points were that (1) this concept was too detailed and not worth the effort, (2) that it took a big reduction from the effectiveness of the BMPs, (3) it didn't fit with current messaging and the desire to implement more BMPs, and (4) other sectors did not consider groundwater in their BMP efficiencies.

The first three are not technical arguments against incorporation of the bypass concepts. The fourth could be a technical argument in that the modeling will be used to choose between implementation in the different sectors. The workgroup chair requested documentation of groundwater consideration in the BMPs of other sectors.

The 2009 Simpson and Weammert document on which many BMP efficiencies are based, Developing Best Management Practice Definitions and Effectiveness Estimates for Nitrogen, Phosphorus, and Sediment in the Chesapeake Bay, offers numerous examples of consideration of groundwater.
http://archive.chesapeakebay.net/pubs/BMP_ASSESSMENT_REPORT.pdf

Charge to expert panels
Page 13 – "Experts were also asked to discuss the relative importance of surface water and groundwater flow paths in controlling BMP effectiveness."
Page 24 – "As discussed, the expected spatial and temporal variability for a practice was estimated based on available science and knowledge of the geographic extent of implementation of the practice.
Different reduction efficiencies were established for practice implementation across different physiographic, geomorphic or hydrologic settings. Where possible, efficiencies were adjusted for
surface water and groundwater interactions (permeability), along with geology and soil types
(slope, seeps, floodplain, etc.)."

A few specific BMP examples – others exist in the document
Page 101 – the cover crop benefit is primarily a benefit to groundwater nitrate
Page 107-8 – table of cover crop measurements of groundwater changes
Page 121 – discussion of literature on the effect of cover crops on groundwater
Page 325 – forestry groundwater discussion
Page 474 – riparian buffers with explicit consideration of groundwater

Urban Discussion
Page 350 – discussing urban runoff reduction BMPs:
"* The proportion of nitrate removal from infiltration and filtration practices is extremely low and the fate of leached nitrate is unknown. Thus, TN removal is low to

account for the lack of nitrate removal via infiltration." The discussion continues mentioning groundwater several more times.
Interestingly, the urban storage BMPs did not consider groundwater, but still came out with significantly lower values based on published literature.

Directly-Modeled BMPs –
The phase 5 watershed model has a direct simulation of effects that change the application of nutrients, most notably nutrient management and atmospheric deposition. Since groundwater is explicitly simulated, these changes affect both surface and groundwater runoff.

Groundwater is considered throughout the modeling and BMP processes. For the sake of consistency and to aim toward a fair comparison between BMPs in different sectors, groundwater bypass of BMPs should be considered in assigning an overall efficiency to the total loads from a land use.

Appendix C
Summary of State Comments Received on Nitrate Base flow Issue

Scott Crafton, VA DCR

Virginia agrees with the position that Randy Greer and Stu Comstock have stated regarding the 2nd proposed adjustment factor for stormwater BMP N removals. We believe as well that soluble N leaching may not be a significant problem in well-established turf areas and that most of the pollutant load from turf lawns is associated with runoff during saturated or frozen conditions. The other adjustments are okay with us.

Joe Kelly, PA DEP

Thank you for the opportunity to comment on the Revisions to Expert Panel Reports based on the WTC Comments. Based upon the information provided in the 6/6/12 memo from Tom Schuler regarding WTC responses to the Final Reports and the 6/12/12 teleconference regarding the four WTC comments, PA-DEP does not object to revisions 2 through 4, however, we do have reservations and concerns regarding recommended revision # 1.

As with other jurisdictions on the Expert Panel, PA views the original CPB Model input deck as a more realistic representation of N in groundwater than the alternative in the WTC's proposed revision 1. We do not believe that the WTC's concern of "BMP bypassing" applies to PA because our stormwater regulations require design for no discharge from approximately 2.8" (2yr/24hr) rainfall. In PA we are very careful about "loading ratios" to distribute these runoff, volume and nutrient loads for all BMPs, especially ones that utilize infiltration. For example, a 25 or 40 acre site gets diffused to several BMPs. It is not allowable, with our current regulations, to send an entire drainage area on a 25 or 40 acre site to just one big basin or similar BMP. There are a number of variables that could lead to inaccuracies and should be accounted for before revising the TN adjuster curve as suggested in revision #1, such as the type of BMP, characteristics of the drainage area and BMP failure and maintenance.

As stated during our conference call, we are concerned that the assumptions are too conservative. It is our understanding that there are BMPs in other sectors, such as septic connections, that simply remove loads out of the model. It seems unreasonable to hold urban stormwater to a different higher standard than what is expected in other sectors. In addition, the temporal scale of the model is a limitation that will not be adequately adjusted by the recommended change proposed in the WTC recommended revision #1, and we suggest continuing with the efficiencies that best characterize what is flowing out of the unit as a function of hydrology as the best and appropriate representation of our delivered stormwater loads.

We believe PA BMPs are based on pragmatic presumptions, plus these conservative values are leading us down a path where the BMPs will not provide an accurate representation on the ground via the model.

Stew Comstock (MDE)

I support the proposed revision to the TN adjustor curve to reflect base flow nitrate movement (the first discount factor). However, I am going to echo Randy Greer's position on the second discount factor. There doesn't need to be a further reduction factor for runoff from pervious areas that bypass a BMP. First, as Randy Greer points out, this is not as significant a problem. Also, applying yet another adjustment to the system further weakens and muddies the approach. This was supposed to be simple. This second discount factor accounts for "escaped nitrate" from pervious areas that bypass BMPs and/or nitrate derived from "non-stormwater sources" that enter into groundwater. How these are sorted out in the reporting shouldn't be fixed by another "fudge" factor. Thanks! Stew C.

Randy Greer Delaware

I generally support the proposed revisions to the original Performance Standards Experts Panel Report, with one exception. I don't necessarily agree that a portion of the runoff from pervious areas that bypasses a BMP requires yet another adjustment using the "Reduction Multiplier". The article "Lawns as a Source of Nutrient Runoff in Urban Environments" from the Fall 2011 Watershed Science Bulletin notes that turf areas are a permanent ground cover that have the ability to use N earlier in the Spring and later in the Fall than either forests or agricultural crops. One of the studies cited in this article found that cool-season turf grass is able to absorb 70% to 80% of the soluble N within 24 hours of fertilizer application and nearly all of it within 48 hours. Assuming soluble N associated with precipitation itself would have a similar fate, this article seems to imply that soluble N leaching may not be a significant problem in well-established turf areas. In fact, the authors concluded that the data suggests most of the pollutant load from turf lawns is associated with runoff during saturated or frozen conditions.

Jenny Tribo, Hampton Roads Planning District Commission

While I appreciate Gary Shenk's response to the concerns expressed on the June 12th Urban Stormwater Workgroup call, I believe he failed to mention/address one of the major concerns I heard expressed on that phone call: a lack of available data to accurately calculate the adjustments necessary to account for 1) increased flow of nitrate through infiltration BMPs to groundwater; and 2) bypass of nitrogen from pervious areas to groundwater.

On the first issue, nitrate loss within the BMP to groundwater, the July 6, 2012 memo from Tom Schueler provides no references to support the 40% nitrate retention within BMPs. The memo does make a case that this seems to be a reasonable number, but I believe the workgroup expressed concern on the June 12 call that this was not supported by references. I would still like to see some references to support this adjustment. This reduction in efficiency for runoff reduction BMPs could significantly impact the number of BMPs a locality may have to implement to meet their urban nutrient reduction goals of the TMDL. Since this change could significantly increase local costs to meet reduction targets, it must be well supported and justified by existing research. In addition, I think it is imperative that the Bay Program and the urban stormwater workgroup commit to considering a third curve if research shows denitrification occurs due to addition of particular design features, as mentioned in the "Notes" section of the June 6 memo. The Bay Program should encourage/fund this type of research given it is one of the few ways to reduce nitrate delivery to the Bay aside from reductions from air deposition and fertilizer use.

On the second issue, bypass of nitrogen from pervious areas, I think Randy Greer's response highlights at least one of the issues with the proposed adjustment. The July 6 memo only addressed the estimated the volume of rainfall flowing to groundwater from pervious areas, it did not include any discussion on the nitrogen cycling occurring during that infiltration process. According to Tom Schueler's July 6, 2012 memo, "in the context of the CBWM, BMP removal rates must be applied to the total nitrogen load that is generated by surface runoff and groundwater flows." Local stormwater managers do not know that the Bay model assumes that BMPs 'treat' groundwater. If the model cannot realistically simulate the volume of water treated by BMPs, then documentation on the BMP efficiencies should clearly explain the model assumptions and calculations. Stormwater BMPs are not designed to treat groundwater flow, they are designed to treat surface runoff. If the Model assumes that BMPs are treating groundwater flows when they are not, then the BMP efficiencies need to be downgraded; however, this could be confusing to stormwater practitioners who will be installing and reporting these practices. Perhaps this is an issue that could be resolved in the revisions to develop the Phase 6 Watershed Model.

I appreciate the Bay Program's attempt to accurately account for all sources and delivery mechanisms for nitrate, but I think this issue raises more questions about how the model treats "runoff" and transport between surface water and groundwater. Comments regarding the treatment of groundwater by the Bay Model were common during the TMDL review process. However, this question was not adequately addressed by EPA's response to comments. The following response is an example, "EPA agrees that the U.S. Geological Survey (USGS) estimates that approximately 50% of the nitrogen that reaches the tidal water flows through the groundwater at some point in its path to the Chesapeake Bay. Groundwater delivery of water and nutrients is simulated in the Phase 5.3 watershed model. Please see the Phase 5.3 Chesapeake Bay Watershed Model report at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169 for more details."

The watershed model documentation does contain some discussion of how the model deals with interactions between surface water and groundwater in the Hydrology section, but it does not cover the transport of nitrate. If local governments are expected to implement stormwater controls that reduce nitrogen, phosphorus, and sediment, then they must have a thorough understanding of how the model defines runoff, how that runoff is transported to a BMP, and why model efficiencies might be different that State design manual efficiencies. Without this information, local governments will not have the tools necessary to select the proper BMPs for their area or justify to elected officials and citizens the large expenditures of tax payer dollars needed to fund construction of these BMPs. The Bay Program has an opportunity now during the development of the Phase 6 watershed model to adequately explain to local government stakeholders how the revised model differs from Phase 5 and how it will simulate groundwater/surface water interactions. I suggest that EPA work with Jurisdictions and appropriate Bay Program work groups to develop a series of fact sheets or white papers on key model issues that can be distributed to local government partners

Appendix D
Groundwater nitrate loss from pervious areas that are not captured by BMPs.

This appendix excerpts the discussion on groundwater nitrate loss from pervious areas that are not captured by urban BMPs. The WTWG raised this issue in this manner to prevents the possibility for double counting with TN reductions associated with other urban BMPs applied to pervious lands in the context of CBWM. This may occur when downstream BMPs are applied, such as enhanced urban fertilizer management practices, septic system upgrades, stream buffers and elimination of illicit discharges.

It is important to note that the proposed second discount to resolve the urban nitrate groundwater issue is more about a proper accounting of urban N sources and pathways in the urban landscape, and less about a "downgrade" of the performance of the new runoff reduction BMP technologies (i.e., what a urban BMP does not capture, and cannot treat).

The 6/6/12 Schueler memo outlined a proposed "work around" method to account for groundwater nitrate loss from pervious areas that are not captured by BMPs (e.g., "escaped nitrate" that is not effectively captured by the BMP (i.e. because it infiltrates into soil (and into groundwater) up gradient of the BMP and effectively by-passes it OR it is nitrate is derived from another non-stormwater source and moves into the stream via groundwater down gradient of the BMP

Gary Shenk has proposed a simple method to define the untreated discounts based on runoff coefficients and urban hydrology. The nitrate load to the BMP treatment area (either RR or ST) is computed as the produce of drainage area * precipitation * runoff coefficient * concentration.

Given that the NSQD (Pitt, 2009) database shows very little difference in nitrate concentration among land uses, concentration can be assumed to be constant. Therefore, the discount factor can be estimated by comparing the hydrology mass balance on pervious urban land as modeled by the CBWM at the river segment scale.

In general, the CBWM simulates, on average, a pervious runoff coefficient of about 20%.m with about 50% of the annual rainfall volume going to ET, which leaves about 30% to move through groundwater.

Assuming there is a rough split between treated and untreated pervious land, a multiplier can be derived to reduce the efficiency for the part that is never treated, using the equation:

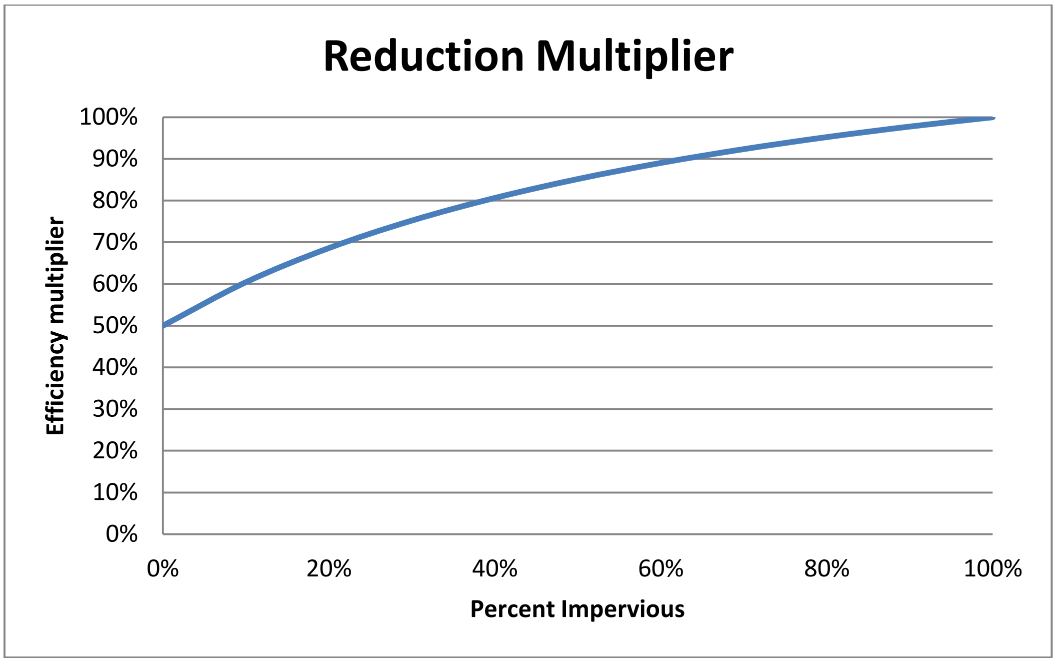
$$\text{Treated fraction} = (Li + Lgt) / (Li + Lgt + Lgu)$$

Reducing this by cancelling P and C from each term you get

(%I * Rvi + %P * Rvt) / (%I * Rvi + 2 * %P * Rvt)

As shown in Figure 3, the multiplier would be 1.0 for a practice with a 100% impervious drainage area, and 0.5 for a facility that is 100% pervious. This multiplier is then used to adjust the removal rate determined from the new TN adjustor curve.

Figure 3: Proposed reduction Multiplier for TN removal Rate based on % pervious area into the drainage area to a retrofit or a new stormwater BMP



Some scientific corroboration of the Shenk modeling approach can be found in an analysis of urban stream nitrate loads taken from Baltimore county, which compare the ratio of base flow nitrate loads to total annual loads (See Figure 4, from Stewart et al, 2005)

Therefore, the user would use the following equations to adjust the TN removal rate obtained from Figure 2 to compute the final adjusted rate.

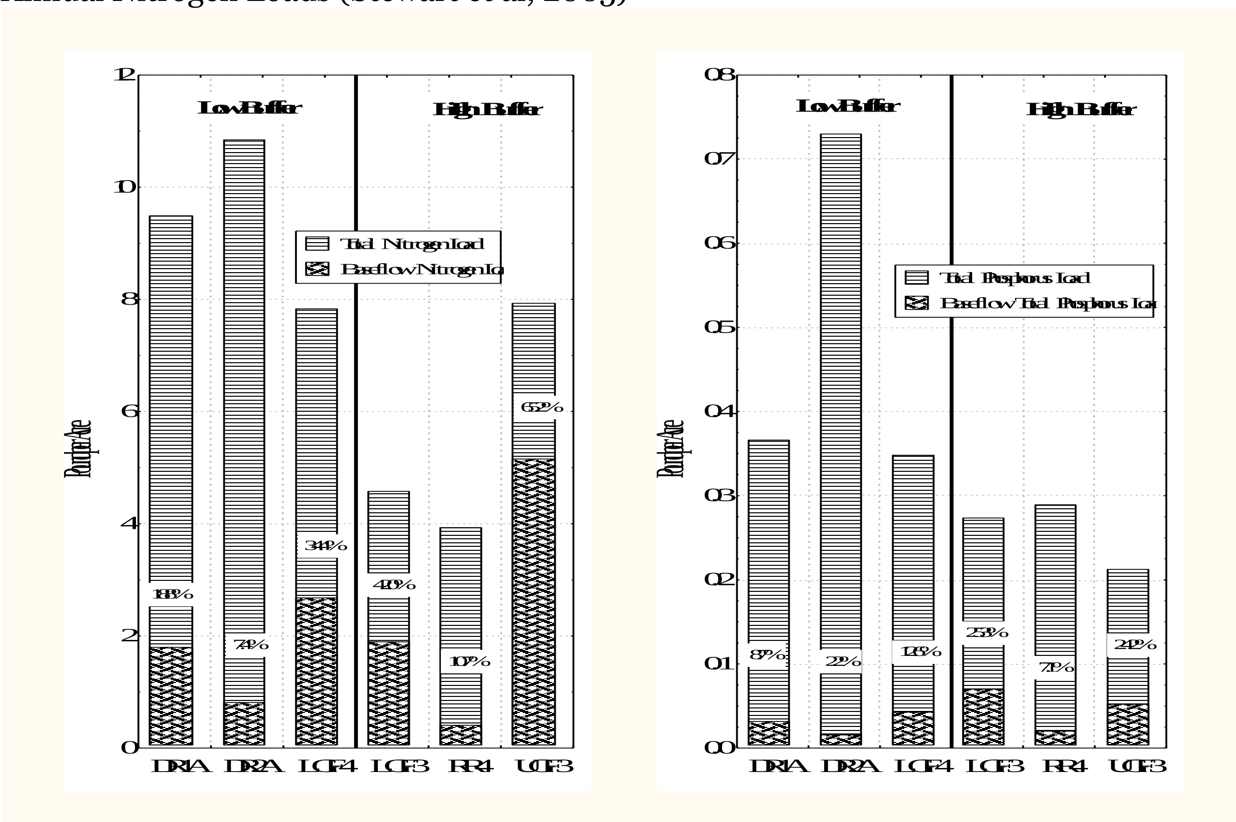
$$\mathbf{N_{adj} = RR_{NEW} \ x \ (1 - P/2)}$$

$$\mathbf{N_{adj} = ST \ x \ (1 - P/2)}$$

Where P = pervious fraction of site area

If it conservatively assumed that all of the base flow nitrate monitored in urban streams represents untreated base flow, and the ratio of the annual base flow nitrate load to total annual stream total nitrogen load represents the discount factor. These watersheds are in the 25 to 50% IC range, so the average ratio of base flow nitrate to total nitrogen load of around 20 to 30% is reasonably consistent with the Shenk multiplier equation (the one stream value of 54%ais an outlier, and appears to reflect the impact of dry weather sewage discharges via illicit discharges and/or sanitary sewer overflows).

Figure 4: Baltimore County Stream Monitoring Data for Base flow Nitrate and Total Annual Nitrogen Loads (Stewart et al, 2005)



References Cited:

CWP. 2007. *National Pollutant Removal Performance Database Version 3.0*. Center for Watershed Protection, Ellicott City, MD.

CWP and Chesapeake Stormwater Network (CSN). 2008. *Technical Support for the Bay wide Runoff Reduction Method*. Baltimore, MD www.chesapeakestormwater.net

Collins, K.A., Hunt, W.F., and Hathaway, J.M. 2008b. Nutrient and TSS removal comparison of four types of permeable pavement and standard asphalt in eastern North Carolina.

International Stormwater BMP Database (ISBD). 2010. International stormwater best management practice database pollutant category summary: nutrients. Prepared by Geosyntec Consultants and Wright Water Engineers.

Kim, H., E. Seagren, and A. Davis. 2003. Engineering bioretention for removal of nitrate in stormwater, Water Environment Research 75(4);355-367

Long, B., S. Clark, K. Baker, R. Berghage. 2006. Green roof media selection for minimization of pollutant loadings in roof runoff. Center for Green Roof Research. Penn State University.

North Carolina State University. 2009. Designing bioretention with an internal water storage layer. Urban Waterways

Pitt, R., T. Brown and R. Morchque. 2004. *National Stormwater Quality Database. Version 2.0*. University of Alabama and Center for Watershed Protection. Final Report to U.S. Environmental Protection Agency.

Stewart, S., E. Gemmill and N. Pentz. 2005. An evaluation of the functions and effectiveness of urban riparian forest buffers. Baltimore County Dept. of Environmental Protection and Resource Management. Final Report Project 99-WSM-4. For Water Environment Research Foundation

UNH. 2009. University of New Hampshire Stormwater Center. 2009 Annual Report. Durham, NH.

Weiss, P., J. Gulliver, A, Erickson, 2010. The performance of grass swales as infiltration and pollution prevention practices. A Literature Review. University of Minnesota. Stormwater Center