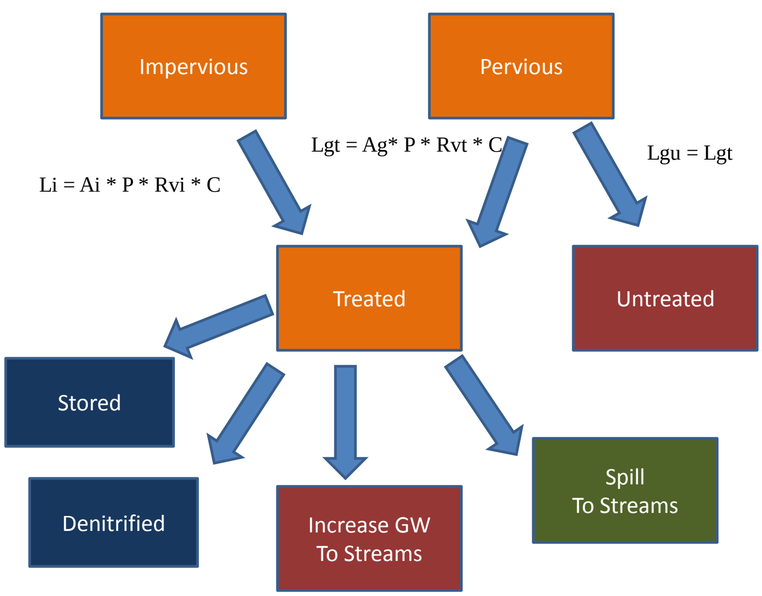
Date: June 6, 2012
To: Retrofit and Performance Standard Expert Panels
From: Tom Schueler, CSN
Re: Watershed Technical Committee Response to the Final Reports

The good news is that the CBP Watershed Technical Committee (WTC) approved the two final recommendation reports at its May 29 meeting, subject to your consideration of four proposed revisions. In general, the WTC was very impressed with the quality of your work, and just wanted to make sure your protocols would be consistent with the CBWM and other scenario assessment tools. I have been working with Gary Shenk of the modeling team on how to address the issues they raised. This memo summarizes the four technical issues they have raised, and the recommended resolution

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 must be 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 illicit discharges)

If you are diverting overland flow to groundwater, you are probably reducing the overall load by using the ground as a filtering medium, but you are not eliminating it. 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 WTC 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. CSN and Gary Shenk have met several times since the panel concluded, and have proposed a simple resolution to the issue.

By addressing the urban nitrate issue in this manner, it prevents the possibility of the potential for double counting with TN reductions associated with other urban BMPs applied to pervious lands, including enhanced urban fertilizer management practices, septic system upgrades, stream buffers and elimination of illicit discharges.

It is important to note that the proposed technical resolution of 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

Proposed Resolution:

The proposed solution is to develop two discounts to the existing protocols to reflect (1) a factor to account groundwater nitrate migration from runoff reduction practices, and (2) a factor to account for escaped nitrate up gradient and down gradient of the BMP that is not effectively captured by the BMP.

(1) Nitrate loss from runoff reduction practices

The first 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, 2009) 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% (in general, the amount of mineralization and nitrification that could create additional nitrate within the BMP itself is negligible due to their relatively short residence times).

The next step is to account for any nitrate loss within the BMP due a combination of either plant uptake and storage within the BMP and/or any de-nitrification within the BMP or down-gradient on the way to the stream. Most runoff reduction practices employ vegetation to promote ET and nutrient uptake, whereas the de-nitrification process is variable in both space and time. Although recent research has shown that the de-nitrification process can be enhanced through certain design features (inverted under drain elbows, IWS), these design features are not currently required in any bay state stormwater manuals.

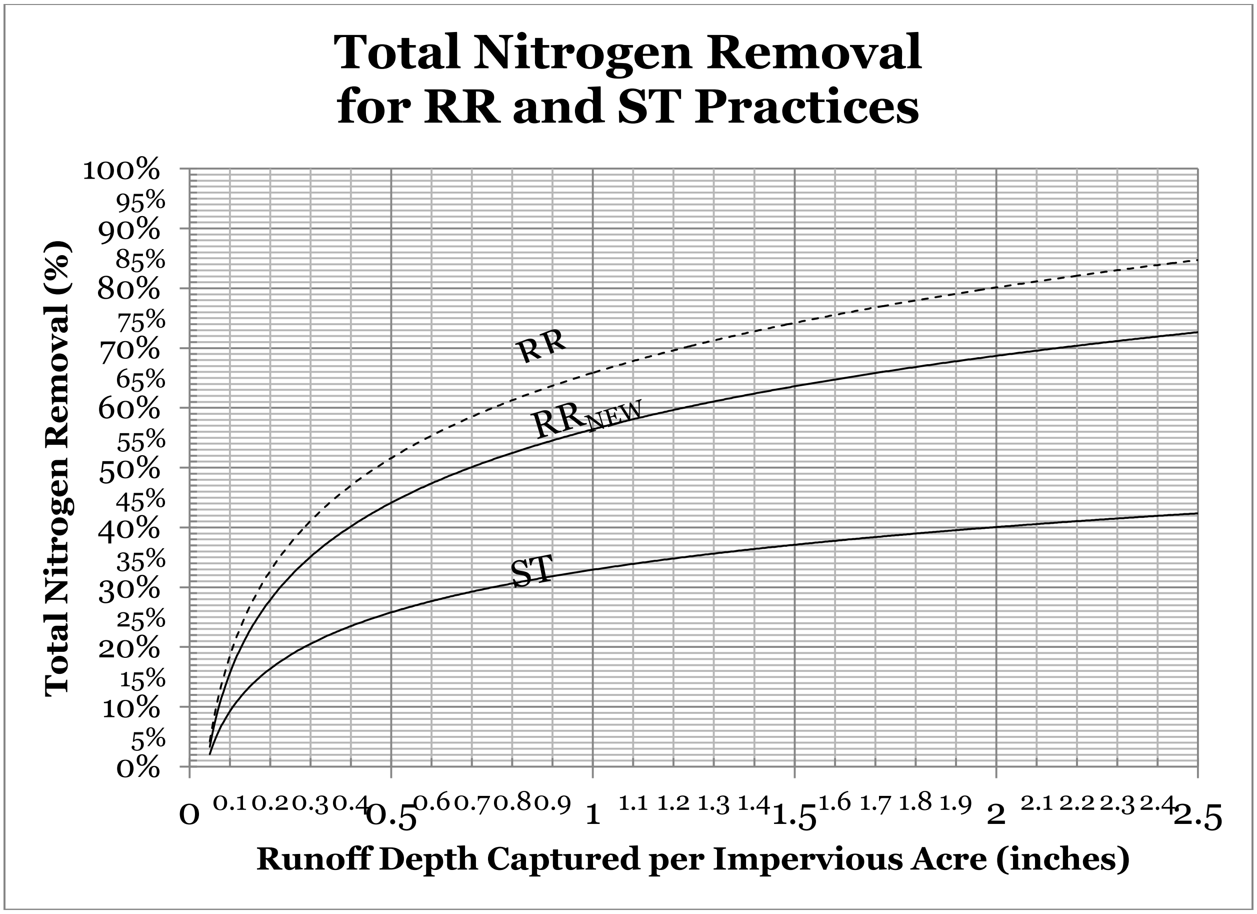
As the panels noted in their original deliberations, there is not a great deal of research to define nitrate retention within runoff reduction BMPs due to these mechanisms. Field studies and laboratory column studies have indicated changes in nitrate EMCs from 25 to 50% from the top of the BMP to the invert of the practice or the under drain (TRS to provide more references), but do not account for any down-gradient nitrate losses. For septic systems, these losses are assumed to be 60%, but that appears to be generous. Therefore, it is recommended that nitrate retention within BMPs be assumed to be no more than 40%, until more substantive data is available.

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.

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)

Figure 2. Revised TN Adjustor Curve



(2) Groundwater nitrate loss from pervious areas that are not captured by BMPs.

The second discount factor accounts for "escaped nitrate" up gradient and down gradient of the BMP that is not effectively captured by the BMP (i.e. because it infiltrates into soil and into groundwater and effectively by-passes the BMP. In other cases, the nitrate is derived from another non-stormwater source and moves into the stream via groundwater.

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:

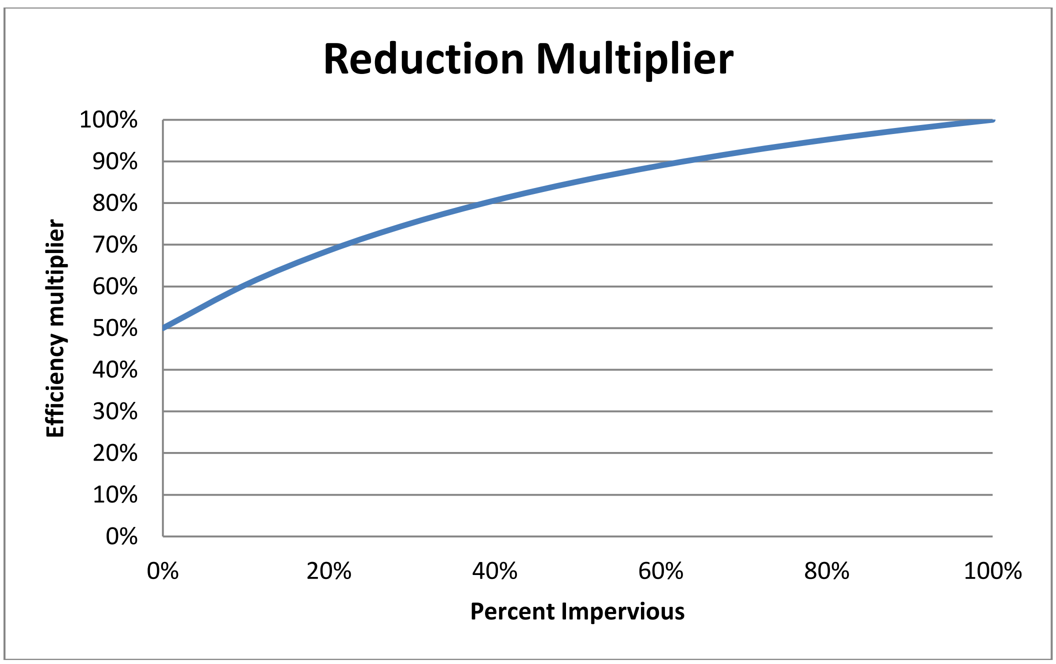
Treated fraction = (Li + Lgt) / (Li + Lgt + Lgu)

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 baseflow nitrate loads to total annual loads (See Figure 4, will get the source, but I think it is Baltimore LTER)

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

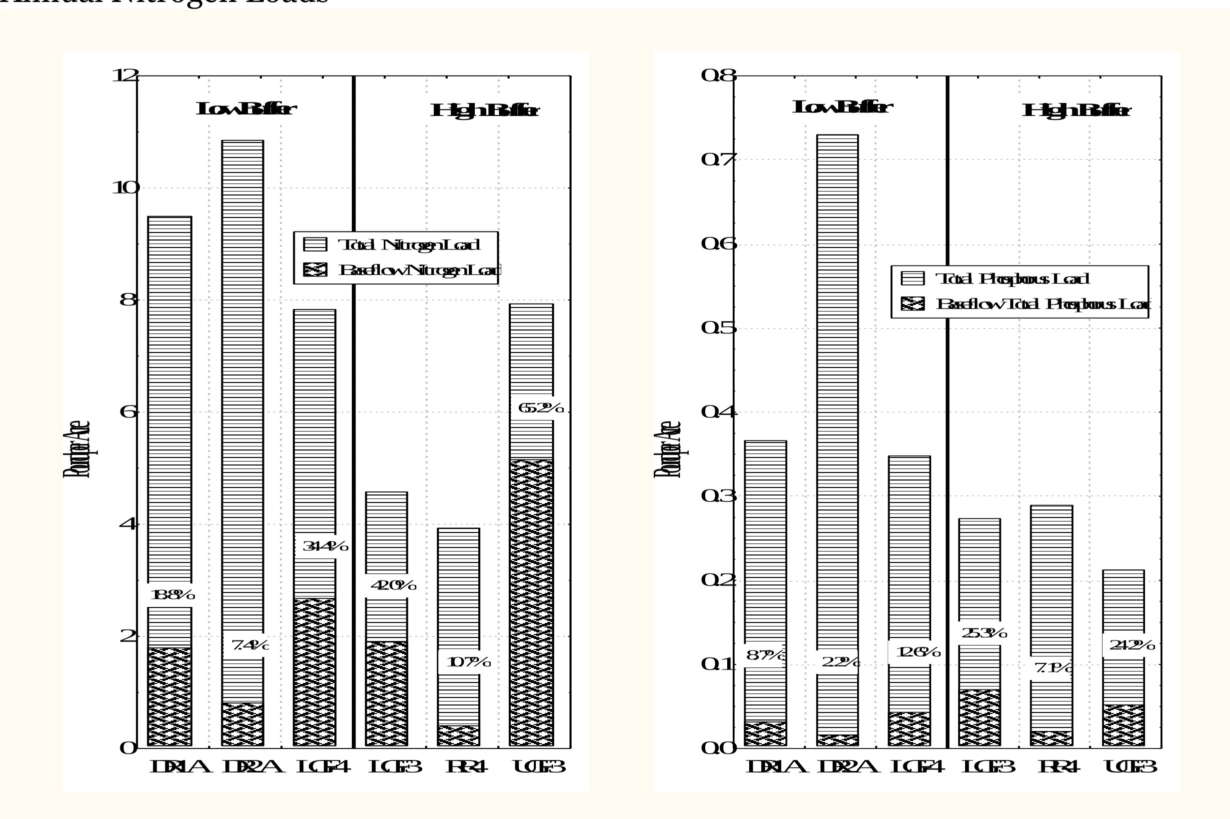
$$\mathbf{N_{adj} = RR_{NEW} \times (1 - P/2)}$$

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

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 baseflow 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 Baseflow Nitrate and Total Annual Nitrogen Loads



Other Notes:

The text would be amended to contain a note that a third, higher, "enhanced RR curve" could be developed by a future expert panel if research showed in-situ de-nitrification was occurring due to new design features.

The text would also note on other BMPs that could increase nitrogen removal from urban pervious areas (septic systems, illicit discharges, reduce N applications, stream buffers, etc). CSN will work with these upcoming expert panels to ensure that the groundwater nitrate issue is consistently addressed.

The text of the expert panel memos will be revised to include new design examples to show the revised protocol, and the preceding discussion would be added as an appendix

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 WTC 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

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 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 Appendix. Localities, however, would not report their load reductions.

Revision 4. Additional Qualifying Condition for the BMP Restoration credit

Issue: The WTC 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: get feedback from Retrofit Expert Panel on whether this is a workable qualifying condition, or whether an alternate qualifying condition needs to be developed.