Stormwater Runoff Water Quality Newsletter
Devoted to Urban/Rural Stormwater Runoff
Water Quality Management Issues
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This edition of the Newsletter focuses on the regulation of concentrations of nutrients (nitrogen and phosphorus) that produce excessive growth of aquatic plants that impair water quality/beneficial uses of waterbodies. Included is information on the US EPA Science Advisory Board's (SAB) review of the US EPA's proposed statistics-based national nutrient criteria, the US EPA's proposed approach for developing nutrient criteria for Florida's waterbodies, and the approach that the state of Minnesota is following in developing a phosphorus-based TMDL for the purpose of controlling excessive fertilization in Lake Shaokatan in western Minnesota. Information is presented on a National Research Council review of the nutrient control program for Chesapeake Bay that has been in place for several decades. An update is also provided on the anoxia situation in the Gulf of Mexico.

SAB Review of US EPA's Efforts to Develop
Statistics-Based Numeric Nutrient Criteria

On April 27, 2010 the US EPA Science Advisory Board (SAB) released its final report, "SAB Review of Empirical Approaches for Nutrient Criteria Derivation." That report is available at:
http://yosemite.epa.gov/sab/sabproduct.nsf/0/E09317EC14CB3F2B85257713004BED5F/$File/EPA-SAB-10-006-unsigned.pdf. Background information provided by the US EPA is available at:
http://yosemite.epa.gov/sab/sabproduct.nsf/0/5972E2A88464D45E85257591006649D0?OpenDocument

Following in an excerpt from the Executive Summary of the SAB report:
"*In general, we find that the scope, limitations, and intended use of the Guidance should be more clearly described. The Guidance addresses only one type of "empirical" approach for derivation of numeric nutrient criteria (i.e., the stressor-response framework). As illustrated in many of the examples in the Guidance, considerable unexplained variation can be encountered when attempting to use the empirical stressor-response approach to develop nutrient criteria. The final Guidance should clearly indicate that such unexplained variation presents significant problems in the use of this approach. Further, the final document should clearly state that statistical associations may not be biologically relevant and do not prove cause and effect. However, when properly developed, biologically relevant statistical associations can be useful arguments as part of a weight-of-evidence approach (further discussed in Section 3.3, recommendation #7 of this advisory report) to criteria derivation. Therefore, the final Guidance should provide more information on the supporting analyses needed to improve the basis for conclusions that specific stressor-response associations can predict nutrient responses with an acceptable degree of uncertainty. Such predictive relationships can then be used with*

mechanistic or other approaches in a tiered weight-of-evidence assessment including cause and effect relationships to develop nutrient criteria."

Lee and Jones-Lee discussed a number of the key technical deficiencies in the statistics-based approach used that render it inappropriate for the development of technically reliable nutrient criteria in:

> Lee, G. F., and Jones-Lee, A., "Comments on 'US EPA "Empirical Approaches for Nutrient Criteria Derivation" Prepared by US EPA, Office of Water, Office of Science and Technology, Science Advisory Board Review, Draft August 17, 2009'," Report of G. Fred Lee & Associates, El Macero, CA, September 4 (2009).
> http://www.gfredlee.com/Nutrients/EPA_Empirical_CritDevel.pdf

The basic problem with the US EPA's proposed statistical approach is that it is not founded in a cause-and-effect coupling between nutrient concentration-load and eutrophication-related water quality. The SAB review of these US EPA proposed criteria mentioned above included comments on the lack of cause-and-effect considerations in the statistical approach.

Previous issues of the Stormwater Runoff Water Quality Newsletter have discussed significant problems with the approaches that the US EPA has employed in its attempts to develop nutrient criteria in NL1-3, 5-1, 9-1/2, 9-8, 10-4, 10-5, 10-6, 10-7, 10-13, 11-2, 11-5, 11-9, 12-3, 12-5, 12-6, 12-7/8. As discussed, the agency has had chronic problems in developing numeric criteria for nitrogen and phosphorus as aquatic plant nutrients that cause excessive fertilization that impairs the waterbodies' water quality/beneficial uses. These problems are rooted in its trying to develop short-cut, one-size-fits-all approaches that ignore or disregard good science.

Problems with US EPA's Proposed Approach for Developing Nutrient Criteria for the State of Florida

The US EPA is proposing numeric nutrients water quality criteria in the state of Florida for the protection of aquatic life in lakes and flowing waters, including canals, within the state, and regulations to establish a framework upon which Florida would develop "restoration standards" for impaired waters. Page 16 of the Executive Summary of that proposed rule states,
"*Overall, EPA is soliciting comments and data regarding EPA's proposed criteria for lakes and flowing waters, the derivation of these criteria, the protectiveness of the streams and rivers criteria for downstream waters, and all associated alternative options and methodologies discussed in this proposed rulemaking*." The draft nutrient criteria are available at http://www.epa.gov/waterscience/standards/rules/florida/.

In response to that request for comments, Lee and Jones-Lee submitted,
Lee, G. F., and Jones-Lee, A., "Comments on 'Environmental Protection Agency 40 CFR Part 131 [EPA-HQ-OW-2009-0596; FRL-XXXX-X] [RIN 2040-AF11] Water Quality Standards for the State of Florida's Lakes and Flowing Waters,'" Submitted to US EPA Docket ID No. EPA-HQ-OW-2009-0596, by G. Fred Lee & Associates, El Macero, CA, April 7 (2010).
http://www. gfredlee.com/Nutrients/FL-Nutrient-Std.pdf

In the "Overall Finding on Proposed Nutrient Standards" section of their comments, Lee and Jones-Lee reported,

"*The technical foundation of the US EPA's nutrient criteria development is invalid; the application of the proposed nutrient criteria can be expected to result in unjustified waste of money in controlling nutrients that are not responsible for excessive fertilization of receiving waters.*

"The basis for the US EPA's nutrient criteria is what is well-recognized to be an unreliable statistical approach that can be founded in spurious correlations. It is not based on a technically sound quantitative cause-and-effect relationship between nutrient concentrations and planktonic algal chlorophyll or other aquatic plant biomasses, which is paramount if there is to be any expectation, much less a quantitative expectation, that reducing the "cause" will reduce the "effect." The Florida nutrient criteria are based on statistical analysis of TP and TN lake P and N concentration data. The nutrient criteria should be based on water quality impact of phosphorus and/or nitrogen on the waterbodies nutrient related water quality such as planktonic algal chlorophyll, chlorophyll impacted water clarity as measured by Secchi depth, and or the area extent and density of macrophytes etc. While for many waterbodies there is a correlation between phosphorus concentration in a waterbody and the water quality impacts of phosphorus there are waterbodies where this relationship is not valid.

"Those fundamental defects are compounded by the inclusion of total nitrogen as a parameter presumed to be controlling the amount of planktonic algal biomass in a subject waterbody. Including total nitrogen in the constituents that must be controlled for all waterbodies when the focus is eutrophication-related water quality will for many waterbodies result in the expenditure of large amounts of money for nitrogen control in runoff and discharges with little or no impact on a lake's planktonic algal chlorophyll beyond that which could be achieved by controlling available phosphorus loads to the waterbody."

On page 54 of the US EPA's proposed nutrient criteria for Florida waters, the following description of the basis for the nutrient criteria was given:
"*(c) Methodology for Proposed Total Phosphorus (TP) and Total Nitrogen (TN) Criteria in Lakes EPA proposes TP and TN criteria for each of the classes of lakes described in Section* 9 *III.B(2)(a). The proposed TP and TN criteria are based principally on independent statistical correlations between TN and chlorophyll a, and TP and chlorophyll a for clear and colored lakes in Florida Each data point used in the statistical correlations represents a geometric mean of samples taken over the course of a year in a particular Florida lake After establishing the protective levels of chlorophyll a as 20 µg/L for colored lakes and clear alkaline lakes and 6 µg/L for clear acidic lakes, EPA evaluated the data on TN and TP concentrations associated with these chlorophyll a levels and the statistical analyses performed by FDEP in support of the State's efforts to develop numeric nutrient criteria."*

Lee and Jones-Lee stated in their comments,
"*Based on our experience, the technical literature, and the OECD eutrophication study results, the approach described is not technically valid. Total nitrogen should not be incorporated into the criterion focused on achieving a planktonic algal chlorophyll concentration in waterbodies. "Independent statistical correlations" between total nitrogen and chlorophyll are not founded in a demonstrated and quantitative cause-and-effect relationship, but rather can be based on spurious correlations. Including total nitrogen in the constituents that must be controlled for the*

purpose of limiting planktonic algal biomass in all waterbodies can force large expenditures for nitrogen control in runoff/discharges that can be expected to result in little or no improvement in many lake's planktonic algal chlorophyll beyond that which can be achieved by controlling available phosphorus loads to the waterbody."

The technical foundation for those findings is included in their comments submitted to the US EPA. The deadline for submission of comments on the US EPA's proposed criteria is April 28, 2010. The US EPA has indicated that in time, it will post all the comments it receives concerning the Florida nutrient criteria development. on its website at http://www.epa.gov/waterscience/standards/rules/florida/.

Development of a Phosphorus TMDL for Lake Shaokatan, MN

The state of Minnesota Pollution Control Agency (MPCA) has proposed a concentration-based phosphorus TMDL for Lake Shaokatan, a small rural lake in western Minnesota. The proposed TMDL, developed for the purpose of improving the eutrophication-related water quality of the lake, is directed at the control of phosphorus in runoff from agricultural lands. Information on that proposed TMDL is available in the report, "Minnesota's Impaired Waters and Total Maximum Daily Loads Project: Lake Shaokatan TMDL – Excess Nutrients," available at http://www.pca.state.mn.us/water/tmdl/project-lakeshaokatan.html. The "Final Lake Shaokatan Phosphorus Total Maximum Daily Load [TMDL] Report" was released in December 2009.

Because the designation of a P TMDL for Lake Shaokatan will have a marked impact on the agricultural activities in that lake's watershed, and arguably on agricultural practices elsewhere in the state, it is paramount that those regulatory limitations have a sound technical basis. It is also important that there be a technically sound basis for a reasonable expectation that the implementation of such limits will effect the desired and anticipated improvement in water quality of the lake. In response to a request by the Minnesota Agricultural Water Resources Coalition, Lee and Jones-Lee reviewed the technical basis for the proposed TMDL and prepared the following reports.

> Lee, G. F., and Jones-Lee, A., "Comments on 'Lake Shaokatan Phosphorus Total Maximum Daily Load Report' Prepared for the Yellow Medicine River Watershed District 2009, by David J. Schuler, Schuler Environmental Engineering, dated 12/02/2009," Comments prepared for and submitted to Minnesota Agricultural Water Resources Coalition, by G. Fred Lee & Associates, El Macero, CA, March 7 (2010). http://www.gfredlee.com/Nutrients/TMDL_Shaokatan_Com.pdf
>
> Lee, G. F., and Jones-Lee, A., "Review of the Characteristics of Lake Shaokatan, MN," Report submitted to Minnesota Agricultural Water Resources Coalition, by G. Fred Lee & Associates, El Macero, CA, March 7 (2010). http://www.gfredlee.com/Nutrients/Shaokatan_MN.pdf

Lee and Jones-Lee identified and discussed a number of technical issues that need to be addressed before adoption of a P TMDL for that waterbody. They reported,

"Normally, the year-to-year variations in weather, rainfall, runoff, and nutrient inputs, and lake responses to those variations necessitate an appropriately encompassing, several-year study of the lake and its watershed to adequately characterize the sources of P and quantify how

contributions of P from those sources impact water quality. Such an understanding is essential for the development of a reliable TMDL sufficiently broad to have applicability to the range of conditions likely to occur. The TMDL was based on a limited set of data developed from routine monitoring for part of one year, 2005; the monitoring was not focused on collection of the necessary data for the development of a technically sound TMDL. It is therefore important to consider not only the adequacy of the technical approach used in the development of the TMDL, but also how representative the database used to establish the TMDL is of the broader range of normal conditions to which the TMDL will be applied over time.

"*Another area of focus in the Lee and Jones-Lee review was the relationship between P load to the lake and the resultant eutrophication-related water quality. The Draft TMDL drew conclusions about that relationship based on the 2005 database and noted a number of key limitations in the data available. Lee and Jones-Lee examined the relationship between P load and response from the 2005 database as well as from the results of the MPCA study in 2008, and some limited data collected in 2009. This has enabled them to consider how "normal" a year 2005 may have been to serve as a foundation for a TMDL, as well as how the load–response relationships for Lake Shaokatan compare to those in other waterbodies worldwide. It also provides insight into particular characteristics of Lake Shaokatan and its use of nutrients in the production of algae and aquatic macrophytes/rooted water weeds that call into question the appropriateness of a TMDL approach for regulating phosphorus input into this lake.*

Their reports provide details of their review on these and related issues. The comments on the proposed TMDL are under review by the MPCA.

Evaluation of Chesapeake Bay Program Implementation
for Nutrient Reduction to Improve Water Quality

The National Academy of Science (NAS), Division on Earth and Life Studies, Sub Unit: Water Science and Technology Board, Board on Agriculture and Natural Resources, Ocean Studies Board, the National Research Council (NRC) DELS-WSTB-09-08

"*proposes to evaluate and provide advice on Chesapeake Bay Program (CBP) nutrient reduction efforts. To carry out this work, the NRC will appoint a multidisciplinary committee of experts that will provide advice to the U.S. Environmental Protection Agency, the six states in the Chesapeake Bay watershed, the District of Columbia, other federal agencies, and other interested parties. The committee will review the CBP, identify technical and strategic shortcomings, and recommend options for improving the effectiveness of its nutrient reduction program in order to accelerate reaching the overall goals to protect and restore the Chesapeake Bay."* Information on that NRC review is available at http://www8.nationalacademies.org/cp/projectview.aspx?key=49141.

According to the Water Environment Federation WE&T Magazine March 2010, Vol. 22, No. 3 article entitled, "US EPA Sets 15-Year Schedule for Chesapeake Bay Cleanup,"

"EPA established preliminary maximum target loads to the bay of 200 million lb/yr (90 million kg/yr) of nitrogen and 15 million lb/yr (7 million kg/yr) of phosphorus. Following submission of the implementation plans, each jurisdiction's progress in meeting its reduction targets will be measured "through benchmarks" every 2 years, "and EPA may impose federal consequences for inadequate plans or failure to meet the performance milestones."

Specifically, the NRC committee reviewing the nutrient control program for Chesapeake Bay will address the following questions*:*
Evaluation Theme I: Tracking and Accountability
1. Does tracking for implementation of nutrient and sediment point and non-point source pollution (including air) best management practices appear to be reliable, accurate, and consistent?
2. What tracking and accounting efforts and systems appear to be working, and not working, within each state (i.e., the six states in the watershed and DC), including federal program implementation and funding? How can the system be strategically improved to address the gaps?
3. How do these gaps and inconsistencies appear to impact reported program results?
CBP Evaluation Theme II: Milestones
4. Is the two year milestone strategy, and its level of implementation, likely to result in achieving the CBP nutrient and sediment reduction goals for this milestone period?
5. Have each of the states (i.e., the six states in the watershed and DC) and the federal agencies developed appropriate adaptive management strategies to ensure that CBP nutrient and sediment reduction goals will be met?
6. What improvements can be made to the development, implementation, and accounting of the strategies to ensure achieving the goals?
The project is sponsored by the U.S. Environmental Protection Agency.
The approximate start date for this project is July 21, 2009.
A report will be issued at the end of the project in approximately 21 months

Contact the Johnson, Stephanie, *Public Access Records Office to make an inquiry, request a list of the public access file materials, or obtain a copy of the materials found in the file."*

Hypoxia in the Gulf of Mexico and Long Island Sound
In March 2010 the US EPA released an updated report entitled, "Hypoxia in the Gulf of Mexico and Long Island Sound," that summarizes the low-DO conditions in those waterbodies that is attributed to the input of excessive amounts of aquatic plant nutrients. That report is available at http://cfpub.epa.gov/eroe/index.cfm?fuseaction=detail.viewInd&showQues=Ecological%20Condition&ch=47,50&lShowInd=0&subtop=315&lv=list.listByQues&r=201562

According to the "Introduction" of that reports,
"*Nutrient pollution is one of the most pervasive problems facing U.S. coastal waters, with more than half of the nation's estuaries experiencing one or more symptoms of eutrophication (Bricker et al., 1999; NRC, 2000; U.S. Commission on Ocean Policy, 2004). One symptom is low levels of dissolved oxygen (DO), or hypoxia. Hypoxia can occur naturally, particularly in areas where natural physical and chemical characteristics (e.g., salinity or mixing parameters) limit bottom-water DO. The occurrence of hypoxia in shallow coastal and estuarine areas appears to be increasing, however, and is most likely accelerated by human activities (Jickells, 1998; Vitousek et al., 1997).*

"This indicator tracks trends in hypoxia in the Gulf of Mexico and Long Island Sound, which are prime examples of coastal areas experiencing hypoxia. For consistency, this indicator focuses on

occurrences of DO below 2 milligrams per liter (mg/L), but actual thresholds for "hypoxia" and associated effects can vary over time and space. Hypoxia often is defined as a concentration of DO below saturation, and because saturation levels vary with temperature and salinity, the concentration that defines hypoxia will vary seasonally and geographically. Effects of hypoxia on aquatic life also vary, as some organisms are more sensitive to low DO than others. As a general rule, however, concentrations of DO above 5 mg/L are considered supportive of marine life, while concentrations below this are potentially harmful. At about 3 mg/L, bottom fishes may start to leave the area, and the growth of sensitive species such as crab larvae is reduced. At 2.5 mg/L, the larvae of less sensitive species of crustaceans may start to die, and the growth of crab species is more severely limited. Below 2 mg/L, some juvenile fish and crustaceans that cannot leave the area may die, and below 1 mg/L, fish totally avoid the area or begin to die in large numbers (Howell and Simpson, 1994; U.S. EPA, 2000).

"The Gulf of Mexico hypoxic zone on the Texas-Louisiana Shelf is the largest zone of coastal hypoxia in the Western Hemisphere (CAST, 1999). It exhibits seasonally low oxygen levels as a result of complicated interactions involving excess nutrients carried to the Gulf by the Mississippi and Atchafalaya Rivers; physical changes in the river basin, such as channeling, construction of dams and levees, and loss of natural wetlands and riparian vegetation; and the stratification in the waters of the northern Gulf caused by the interaction of fresh river water and the salt water of the Gulf (CENR, 2000; Rabalais and Turner, 2001). Increased nitrogen and phosphorus inputs from human activities throughout the basin support an overabundance of algae, which die and fall to the sea floor, depleting oxygen in the water as they decompose. Fresh water from the rivers entering the Gulf of Mexico forms a layer of fresh water above the saltier Gulf waters and prevents re-oxygenation of oxygen-depleted water along the bottom."

As discussed in previous Newsletters (NL 9-1/2, 9-10, 10-1, 12-5, 12-7/8) this situation has important implications for nutrient dischargers, such as municipalities and agriculture, throughout the Mississippi River watershed including the watersheds of the Ohio and Missouri Rivers. The US EPA and states are beginning to implement programs to require nutrient control from sources in a broad construct of the Gulf of Mexico "watershed." While there is no doubt that excessive nutrient discharges to the Gulf is the cause of the low-DO problem, at this time there is inadequate information to reliably and quantitatively tie nutrient discharges in the watersheds of the Ohio and Missouri Rivers and other Mississippi River tributaries to the low-DO problems that occur in the Gulf of Mexico. Such a cause-and-effect coupling needs to be reliably quantified before a technically valid assessment can be made of the improvement in the low-DO problem in the Gulf of Mexico that could reasonably be expected to result from given nutrient control measures in those upper reaches of the Gulf watershed. This is especially important before consideration of Gulf-focused nutrient control measures in areas substantially removed from the Gulf. Without such information, large amounts of money could be spent for nutrient control with limited, if any, improvement in the low-DO conditions in the Gulf.

General Comment on Development of Nutrient Control Programs

As discussed in this Newsletter, there is renewed and rather frenzied attention being given to the control of water quality impacts of aquatic plant nutrients. It is, in some ways, reminiscent of the interest in nutrient control in the Upper Midwest, US–Canadian Great Lakes, and some other areas of the US in the 1960s. At that time, however, the FWPCA (predecessor of the US EPA)

had a strong, basic science-based research program that established the technical foundation for formulating nutrient control programs. That foundation reliably established that it is not possible to develop technically valid, generally applicable, numeric water quality criteria for nutrients. In the late 1970s the US EPA abandoned it support of effective research on nutrient impacts and technically reliable control programs and shifted its focus to Priority Pollutant issues.

Beginning in the late 1980s the Agency embarked on a nutrient criteria development program that has largely ignored the large amount of high-quality information developed in the 1960s and early 1970s that described and quantitatively defined the relationships between nutrient loads and impacts. Instead, it has focused on more expedient and trendy statistical models and spurious empirical approaches that ignore or inadequately incorporate the fundamental tenant of first establishing and defining the cause-and-effect relationship between chemical and impact in developing water quality criteria. Without a technically sound and well-defined cause-and-effect relationship between contaminant input and water quality response, there can be no reasonable expectation that expending funds to reduce nutrient input to achieve a water quality criterion/standard will, in fact, effect anticipated water quality improvement. Waterbody-specific cause-and-effect definition is especially important in managing nutrients loads that are responsible for significant water quality problems. Many "old timers" in the nutrient impact control field have great difficulty with the US EPA's largely empirical approach for developing nutrient criteria.

In addition, the regulation of nutrients is not like the regulation of toxic chemicals for which numeric, worst-case-based water quality criteria can be established and then adjusted for specific waterbody conditions that alter the cause-and-effect relationships. While excessive nutrient input can significantly adversely impact a waterbody's water quality, some level of nutrient input is needed by the waterbody to maintain a healthy ecosystem. The development of appropriate nutrient loads must balance nutrient's adverse impacts with their benefits to the ecosystem. Thus, nutrient criteria have to incorporate reliable definition of not only the cause-and-adverse impact, but also cause-and-beneficial impact.

The effort in nutrient regulation for Lake Shaokatan in Minnesota mentioned above illustrates some of the problems encountered when a very limited study of nutrient sources and impacts is used to formulate a phosphorus control TMDL. Their proceeding in TMDL development without an adequate information base, however, is an outgrowth of the current efforts by the US EPA to force states into developing TMDLs without regard to the adequacy of the understanding and quantification of the various factors that must be considered in controlling nutrient sources. This will not lead to cost-effective nutrient control programs that can be expected to achieve desired water quality characteristics. Instead, it will result in large expenditures for "control" of nutrients and watershed practices without reliable understanding of the effects of that control on water quality characteristics.

Municipal domestic wastewater and stormwater dischargers, agricultural interests, and the public who will eventually be paying for the control, should be reliably informed of the nutrient-related beneficial use improvements that will occur from given degrees of nutrient control in their discharges. There is an urgent need to return to the fundamentals of accessing nutrient impacts on a waterbody-specific basis employing an adequate and reliable database for formulating

TMDLs for nutrient control. Because of the complexity of these issues, an adaptive implementation approach, such as that described by Shabman et al. (2007) should be followed in developing nutrient TMDLs for waterbodies.

> Shabman, et al., "Adaptive Implementation of Water Quality Improvement Plans: Opportunities and Challenges," Report Prepared for the Nicholas Institute for Environmental Policy Solutions, September (2007) available at http://nicholas.duke.edu/institute/adaptive-water.pdf

Briefly, based on the Shabman et al discussion of issues such an approach should include the following components:

1. Establishment of quantitative, nutrient-related water quality goal for the waterbody being evaluated based on beneficial uses.
2. Assessment of compliance with the goals.
3. Determination of the need for a TMDL to achieve the goal.
4. Definition and documentation of quantitative relationship between nutrient input and water quality response.
5. Development of the preliminary TMDL.
6. Implementation of controls to restore uses by meeting nutrient related water quality goal.

This is to be an iterative process; several passes through these steps may be needed to ultimately develop the appropriate nutrient discharge limits for the sources of nutrients for the waterbody. Lee and Jones-Lee provided guidance on development of nutrient TMDLs for waterbodies in

> Lee, G. F. and Jones-Lee, A., "Developing Nutrient Criteria/TMDLs to Manage Excessive Fertilization of Waterbodies," Proceedings Water Environment Federation, TMDL 2002 Conference, Phoenix, AZ, November (2002). http://www.gfredlee.com/Nutrients/WEFN-Criteria.pdf

That paper discusses the problems with the empirical approach that the US EPA had proposed at that time in developing nutrient criteria and provides guidance on components and approaches critical to establishing technically reliable the nutrient-related water quality goals and controls.