Ohio's Development of a State Nutrient Reduction Strategy and Nutrient Water Quality Standards

There is little doubt that water pollution attributed to excess nutrients is a serious and growing problem. The challenge facing federal, state and local governmental agencies is devising effective programs that restore impaired waters. This paper offers some observations regarding the roles of regulatory and supporting agencies in efforts adopt nutrient criteria. It also presents a summary of the steps Ohio has undertaken to develop a State nutrient reduction strategy and to adopt nutrient water quality standards (WQS).

Ohio's Monitoring and Assessment Experience

U.S. EPA Region 5 and Ohio have enjoyed a generally good working relationship on matters relating to water quality monitoring and WQS since the 1980s. This was a result of a series of events that focused on the major water quality issues of the time. In the 1970s and early 80s the need to have extensive justifications for every advanced wastewater treatment plant built using federal construction grants dollars provided the impetuous and the funding to expand a fledging biological monitoring program. Water quality and biological surveys provided the data necessary to determine attainable aquatic life uses and to demonstrate that advance wastewater treatment, as opposed to secondary treatment, would be required to achieve the in-stream standards. The work done during those years laid the groundwork for later cooperative ventures with U.S. EPA including whole effluent toxicity case studies, stream regionalization and numerous national water body surveys. The stream regionalization project and long-term monitoring at reference locations allowed the development of numeric bio-criteria based on fish and macroinvertebrate assemblages. In 1990, the bio-criteria were adopted into State WQS regulations as the means to measure attainment of Ohio's tiered aquatic life uses. Bio-criteria serve as the cornerstone of Ohio's Section 303(d) and 305(b) reporting methodology and, combined with the shear number of locations sampled (nearly 10,000 sampling sites since 1980) it provides a robust assessment of water quality. The program has documented dramatic improvements in aquatic life attainment in Ohio's large rivers that is attributed to pollution controls at point sources and sediment reduction from non-point source runoff. In the 1980s only 21% of Ohio's large rivers attained aquatic life standards; today 89% of large rivers fully meet their aquatic life uses. While conditions in smaller rivers and streams have improved, approximately 40% of these smaller watersheds do not meet standards and nutrients are a significant cause of non-attainment more than half of the time.

These accomplishments in water quality were the result of an effective State-federal co-regulator relationship borne from several key ingredients: 1) scientifically sound, cost effective water quality assessment methods; 2) standardized information about the problem and issues; 3) the programs ability to demonstrate water quality improvements; 4) continuity in staffing and management; and 5) mutual trust. We intend to continue using this State-led co-regulatory

model to address nutrient pollution. A summary of the ongoing work on strategy and criteria development is described in the following sections.

Ohio's Nutrient Strategy

The resurgence of nutrient pollution was evident in Ohio in the late 1990s. In response, the Ohio EPA created a written protocol describing how the State's narrative water quality criteria could be applied in total maximum daily loads (TMDLs) and the management of nutrient sources. Here is an excerpt.

> "The establishment of in-stream numeric targets is a significant component of the total maximum daily load (TMDL) process. The numeric targets serve as measures of comparison between observed in-stream conditions and conditions that are expected to restore the designated uses of the water body. The TMDL identifies the load reductions and other actions that are necessary to meet the target, thus resulting in the attainment of applicable water quality standards. Numeric targets are derived directly or indirectly from narrative or numeric water quality standards contained in Chapter 3745-1 of the Ohio Administrative Code (OAC).
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> This guidance summarizes Ohio EPA's authority for regulating the discharge of nutrients and developing TMDL implementation plans for nutrients, focusing on nitrogen and phosphorus in river/stream environments. This guidance was written at this time to address the immediate need to regulate discharges of nutrients through the TMDL program. U.S. EPA has identified state adoption of numeric water quality standards for nutrients as a priority and is in the process of developing recommendations. ….. Adoption of specific numeric water quality standards for nutrients in Ohio rules is probably two to four years away. In the meantime, the existing water quality standards provisions can be used to regulate the discharge of nutrients. The existing rule requirements for nutrients are general in nature and, therefore, must be applied on a case-by-case basis." (Ohio EPA 2000).

The day-to-day application of this WQS guidance document drew upon an analysis of over 15 years of data available from the monitoring and assessment program, the network of least impacted reference sites and the stream regionalization project. A system of tiered aquatic life uses linked directly to numeric bio-criteria adopted in rule was also important an element. Although not labeled a strategy as such, the report entitled "Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams" (Ohio EPA 1999) was the de-facto nutrient reduction strategy used by Ohio EPA for nearly 15 years. This report contained an analysis of nutrient chemistry, bio-criteria scores and habitat data from least impacted regional reference sites and other sites impacted by a variety of causes. It applied the results to develop the TMDL target values for total phosphorus and nitrogen (nitrate plus nitrite) in Ohio's five ecoregions.

Since 2001, Ohio has used its narrative WQS standard and the associated TMDL target values to generate nutrient load reductions in 40 of 64 watershed scale TMDL reports approved by U.S. EPA. Ohio EPA can also show real world river responses to some of the early phosphorus load reductions mandated by these TMDLs. One example is the Upper Little Miami River in southwest Ohio. Based upon fieldwork conducted in 1998, the Exceptional Warmwater Habitat aquatic life use of the river was impaired or threatened due to excessive nutrients. The TMDL approved in 2002 called for a 60% reduction in total phosphorus loading and effluent limits were imposed on the major sewage plants. Follow up monitoring done in 2011 showed compliance with permit limits, lowered in-stream phosphorus concentrations and a river in full attainment of it aquatic life use. Complete stream survey reports for these and other studies are available on line at http://www.epa.state.oh.us/dsw/document_index/psdindx.aspx.

In 2009, Ohio initiated work on a more comprehensive nutrient reduction strategy in response to the recommendations of the Gulf Hypoxia Action Plan 2008 (Hypoxia Task Force 2008). Once again U.S. EPA Region 5 provided valuable assistance in laying the groundwork to effectively coordinate with the other State resource agencies in Ohio (Ohio Department of Agriculture and Ohio Department of Natural Resources). As the lead agency for water quality, Ohio EPA prepared the initial drafts for review and input by others. The document was further revised in 2012 to address the eight-point framework for State nutrient strategies laid out in guidance issued by U.S. EPA (2011). The final Ohio Nutrient Reduction Strategy was submitted in June 2013 (Ohio EPA 2013). Upon review by and at the request of U.S. EPA Region 5, Ohio EPA has prepared a 2-year action plan to address the 11 significant issues raised in U.S. EPA's comments on the final submittal. The most challenging gaps to fill concern the adoption of numeric nutrient criteria, describing how water quality based effluent limits are phased into National Pollutant Discharge Elimination System (NPDES) permit limits and the inclusion of logical adaptive management scenarios that are dependent upon the attainment of all designated water body uses.

Ohio's Trophic Index Criterion

Most existing numeric aquatic life water quality criteria are built on a sound technical basis owing to well-defined, dose-response relationships between individual pollutants and aquatic organisms. These relationships are so well defined as to allow confident predictions of environmental outcomes; hence, our administrative and regulatory infrastructure is largely predicated on tabular or algorithmic numeric criteria. However, unlike toxicants and oxygen demanding materials, the effects of nutrient pollution on fish or macroinvertebrates are indirect, and therefore not predictable through simple dose-response curves, or highly deterministic models.

The published literature provides evidence of a reasonably predictable and consistent response between increasing nutrient concentrations and periphyton (reviewed by Hillebrand 2002), and between periphyton and dissolved oxygen concentrations (Morgan et al. 2006, Huggins and

Anderson 2005, Miltner 2010). Ohio EPA conducted a nutrient criteria study predicated on tracing the steps from nutrients to periphyton (as given by chlorophyll-a), from periphyton to dissolved oxygen, and from dissolved oxygen to macroinvertebrates and fish. The objective was to identify benchmarks or thresholds at each step that would help define where a given water body is positioned along a continuum of enrichment. Results were published by Miltner (2010) and further explored in the context of Ohio EPA's water quality management system (Miltner 2011).

U.S. EPA Region 5 and Ohio EPA collaboratively developed the Trophic Index Criterion (TIC) - a composite index that brings together the measures of nutrients, periphyton, dissolved oxygen, and biological assemblages by awarding points to successive ranges of each indicator, where the ranges are defined by benchmarks identified in the nutrient study. Hence, the TIC provides a structured method of aggregating data collected on Ohio's streams and rivers into a nominal scale that is essentially a translator for the condition of a water body relative to nutrient enrichment. As such, it can be applied independently to dictate the imposition of appropriate nutrient management programs including NPDES permits and TMDLs. Tables 1 and 2 present some details on the metric scoring system. Waters scored as threatened or impaired have total phosphorus TMDLs target concentrations set according to their habitat conditions and designated tiered aquatic life use (values range from 60 ppb to 300 ppb total phosphorus).

Remaining Challenges

The political realities of today being what they are, environmental regulations are seldom adopted without a great deal of initial opposition. Here are the steps being taken in Ohio to build consensus. Information about all these activities can be accessed on line at http://www.epa.state.oh.us/dsw/wqs/NutrientReduction.aspx.

1. Formation of ad hoc work groups on the important issues. Examples include:
    a. Ohio Lake Erie Phosphorus Task Force, Parts 1 and 2
    b. Director's Agricultural Nutrient Water Quality Working Group
    c. Point Source Urban Runoff Work Group
2. Ohio Nutrient Forum – a visioning workshop open to the public with over 200 participants held in November 2011.
3. Early Stakeholder Outreach on Developing Rules to Reduce the Impacts of Nutrients in Surface Waters (public comments invited April – May 2013)
4. Technical Advisory Group for Nutrient Water Quality Standards (formed in November 2013)

There have been tangible results attributable to these outreach efforts. The public and media attention drawn to western Lake Erie's deteriorating water quality and the work of the Lake Erie Phosphorus Task Force prompted the General Assembly to pass the Ohio Clean Lakes Initiative which provided modest funding for innovative agricultural best management practices (BMPs) in

a 5 county area of northwest Ohio. The General Assembly is currently debating a bill that includes recommendations from the Director's Agricultural Nutrient Water Quality Working Group (includes licensure of fertilizer applicators and more complete record keeping). Ohio's farm community has collectively and publicly taken some ownership in the problem through educational campaigns and through funding research.

The Early Stakeholder Outreach on nutrient criteria rules provided an opportunity for point source aligned interest groups to express general support for the TIC while urging additional further consultation. That led directly to the formation of a 12 member Technical Advisory Group (TAG) with representation from point sources, the farm community, Lake Erie economic interests and environmental groups. The TAG is charged with advising Ohio EPA as it drafts nutrient WQS rule and implementation language over the next year.

Conclusions

Although Ohio's TIC does not fully equate to the classic interpretation of numeric nutrient criteria, it is an important refinement to Ohio's nearly 15 year application of the existing narrative WQS criteria. By constructively engaging key stakeholders in drafting new rule language Ohio has the opportunity to create a widely accepted diagnostic tool for nutrient impairment of aquatic life uses and the specific numeric TMDL targets upon which to assign load reductions. The long running support for Ohio's monitoring and WQS program at U.S. EPA Region 5 and more recently U.S. EPA headquarters is important and appreciated. Still, the continued national program emphasis on adoption of numeric nutrient criteria is concerning to Ohio. A more complete measure of program accountability and success should account for the overall effectiveness of a State's nutrient pollution abatement efforts. U.S. EPA must continue to place State agencies in the fore of adopting WQS that fit their unique circumstances regardless of whether a numeric or narrative methodology is applied.

Table 1. The Trophic Index Criterion (as currently proposed in draft form).

Biological Assemblages	Dissolved Oxygen	Benthic Algae	Nutrients†	Trophic Index Criterion
Meet applicable biocriteria (12)	Normal variation‡ <6 mg/l (12)	<107 mg/m^2 (8)	Concentrations typical of low disturbance systems (6)	**Acceptable (38-22)**
	Modest swings >6 mg/ (6)	107-183 mg/m^2 (4)	Concentrations typical of healthy streams in working landscapes (3)	
Within the range of non-significant departure (6)	Wide swings >7 mg/l (1)	Enriched 183-320 mg/m^2 (1)	Concentrations observed with high-intensity land use and WWTP loadings (1)	**Threatened 21-14**
Fail biological criteria (0)	Extreme swings >9 mg/l or swings >7 mg/l and minimum D.O. <WQS (0)	Thick to nuisance levels >320 mg/m^2 (0)	Concentrations typical of highly disturbed systems; effluent domination; >50% chance of biological impairment (0)	**Impaired 13-0**

†See Table 2 for nutrient concentration ranges

‡Measured as the difference between the daytime maximum concentration and the morning minimum

Table 2. Trophic Index Criterion scoring for the nutrient component.

Total Phosphorus (mg/l)	Dissolved Inorganic Nitrogen (mg/l)				
	≤0.44	0.44-1.10	1.10-3.60	3.60-6.70	≥6.70
≤0.04	6	3	3	1	0
0.04-0.08	3	3	3	1	0
0.08-0.13	3	3	1	1	0
0.13-0.40	1	1	1	0	0
≥0.40	0	0	0	0	0

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