Missouri Department of Natural Resources

MEETING SUMMARY
Stream Nutrient Criteria Stakeholder Group
Bennett Springs Conference Room
Elm Street Conference Center
Jefferson City, MO
November 16, 2010
10:00 am

Attendees:
Bob Bacon, ERC; Dorris Bender, City of Independence; Brandy Bergthold, MDNR; Todd Blanc, MDNR; Kurt Bordewick, KCMO-WSD; Robert Brundage, Newman, Comley & Ruth; Cindy DiStefano, MDC; Frank Dolan, Eric Dove, Olsson Associates; Gredell Engineering Resources Inc; Suzanne Femmer, USGS; Ed Galbraith, Barr Engineering; Peter Goode, WASHU/Missouri Coalition for the Environment; Judy Grundler, MDA; Leslie Holloway, MO Farm Bureau; Chris Klinkler, MDA; Cindy LePage, MDNR; John Lory, University of Missouri; Pat McCole, Carollo Engineers; Dave Michaelson, DNR-ESP; Rebecca O'Hearn, MDC; Colleen Meredith, MDNR; Mark Osborn, MDNR; Kevin Perry, REGFORM; Chris Riggert, MDC; Mike Pessina, HDR Archer; John Reece, Little Blue Valley Sewer District; Tim Rielly, MDNR; Trish Rielly, MDNR; John Rustige, MDNR; Buffy Santel, St Louis MSD; John Schumacher, USGS; Tom Simmons, Missouri American Water; Trent Stober, Geosyntec; Steve Taylor, MO AG; Scott Totten, MDNR; John Waitman, City of Springfield; Carl Wakefield, MDNR; Phil Walsack, MPUA ; Mary West, Jacobs Engineering; Bob Williamson, KCMO-WSD; Chris Zell, Geosyntec.

Rulemaking: Current Status for Nutrient Criteria

Mark Osborn informed the group that EPA had promulgated a nutrient rule for the State of Florida the previous day. It applies to lakes, streams, and springs. Details can be found at the EPA web site.

Mark also discussed the status of the nutrient rule as it pertains to lakes and reservoirs. The most recent revision to the State's Water Quality Standard, after approval by the Clean Water Commission, was entered into the books with the Secretary of State a little over a year ago. However EPA, which is mandated by the Clean Water Act to approve or deny state water quality standards, has yet to take any action on this update. From meetings between DNR and EPA staff, it has been determined that EPA has issues with the lake nutrient portion of the rule. This is despite their participation in the stakeholder process from which the rule was developed.

Because of this, DNR staff has made the decision to hold off on submitting any other nutrient related material for rule making until the lakes issue is resolved with EPA. Consequently, it is unlikely that a rule for streams will be ready for submittal during the current triennial cycle, which terminates in 2012.

Question: How can the stakeholders be involved in this process?
Answer: At this point, DNR has not been formally advised by EPA of any decision on their part, so all that can be done is to wait.

Question: When will a TMDL be completed to address hypoxia in the Gulf of Mexico?
Answer: It is not known at this time. We can look at the Chesapeake Bay as a possible example to follow.

Algae Response to Nutrients in the Ozarks

Suzanne Femmer described her analysis of Ozark data collected through the USGS National Water Quality Assessment (NAWQA) program. The study included 59 algae and nutrient samples from 44 sites collected from July through early November in 1993-1995 and 2006-2007. Times of year for collection were intended to capture low flow conditions. Other parameters, including macro-invertebrate and fish data were also collected. The algae community metrics showed the strongest relationship. This was consistent with work published in 2009 by Justus et al. Total Nitrogen (TN) concentrations ranged from 0.04 to 4.85 mg/L and Total Phosphorus (TP) concentrations ranged from <0.004 to 1.14 mg/L.

All sites sampled were in riffle/pool stream segments. The dominant substrate was cobble/gravel. Drainage areas for sample sites ranged from 18 to 4,318 square kilometers. Data analyses were performed by community structure and by algal metrics. The following metrics had the strongest correlations with nutrients:

- Organic nitrogen tolerance
- Oxygen tolerance
- Bahl's Pollution Index
- Saprobien Index

Analyses of these metrics indicated a significant shift in the algae community structures in the range of the 75th to the 80th percentiles for nutrient concentration in the dataset. For TN, this range was between 0.47 and 0.68 mg/L. For TP, it was between 0.031 and 0.035 mg/L. These relationships were displayed in multi-dimensional scaling graphs (for the organic nitrogen metric), in which the contrasts between the lowest quartile (<25%) and the upper fifth (>80th percentile) were very clear for both TN and TP. This was also shown in a series of box plots in which the metric distributions were displayed per quartile of the TN data. Box plots from the same dataset were also classified by three ranges of TN data, using the 25th and 80th percentiles as breakpoints.

These concentrations serve as guidelines and starting points for nutrient criteria in the Ozarks. Questions from participants brought out a number of points and issues:

- Macro-invertebrate response was not as strong an indicator as algae.
- Is achievement of natural background conditions desirable?
- Data for the region goes back to the 1920's and 30's.
- Breakpoints in algae response were determined by first examining quartiles. At the low end, there was no significant difference between the 10th and 30th percentiles. The strongest break point was found to be around the 80th percentile.
- Quantity of algae per sample was not considered. This was because it is influenced by grazer activity, substrate, and shading. Algae community structure is a more reliable indicator. It is resistant to the influence of these factors.
- Nutrient concentration has greater influence on algae community structure than does watershed size.
- Site selection considerations included the avoidance of springs and point sources.

Macro-Invertebrate Response to Nutrients in the Plains

Mark Osborn described his work with macro-invertebrate response to nutrient concentrations in the Plains regions of the State. A caveat is that, as mentioned in the previous presentation, macro-invertebrate response is not as reliable an indicator as is algae community structure. But algae data are not available for this region, and macro-invertebrate data are.

The area under consideration includes five Ecological Drainage Units (EDU) that constitute the northern and west central regions of the state: Blackwater/Lamine, Cuivre/Salt, Grand/Chariton, Nishnobotna/Platte, and Osage/South Grand. The Environmental Services Program (ESP) has calculated biological criteria that are unique for each EDU and that fluctuate between fall and spring as well as between glide/pool and riffle/pool stream types. (In the Ozarks, there is further distinction between warm water and cold water streams. In the plains, they are all warm water.)

There are four biological metrics that ESP uses for macro-invertebrates: Taxa Richness, Ephemeroptera/Plecoptera/Trichoptera (EPT), Biotic Index (BI), and Shannon Diversity Index. For each macro-invertebrate sampling event, scores for these metrics are aggregated to produce the Stream Condition Index, from which a site is classified as fully supporting, partially supporting, or not supporting aquatic life. ESP staff recommended that for measuring response to nutrient concentration, BI would be the most appropriate metric, as it was designed to measure the effects of organic loading.

BI takes into account the number of individuals within each species collected per sample, a tolerance value for each species, and the total number of organisms per sample. Scores range between 1 and 10 on a continuous scale, inversely to water quality. That is, a higher score indicates greater impairment.

The number of data points used for the analysis was restricted by several considerations. A single nutrient reading per sample was not considered sufficient to assess the overall nutrient regime for any given site. For a sample to be included in the analysis there had to be at least three nutrient samples taken within two years and within two miles of the biological sample. There could be no point sources between nutrient and biological sample locations. Biotic data were further restricted to those samples taken during the autumn. Because of the small number of samples taken in riffle/pool streams, the analysis addressed only those taken in glide/pool streams, which are more predominant in the region.

Target scores for BI were initially based on criteria that ESP had determined for each of the EDUs which, for glide/pool habitat in autumn, ranged from 6.8 to 7.7. However, the small number of data points spread across the region was insufficient to address conditions in each EDU. A target was set after reviewing all BI data in the region for samples taken from reference streams which had BI scores that indicated full support. The 75th percentile score was 7.1, and that was selected as the target.

Given the multiple complexities that affect biological integrity, the next step was to account for all causative parameters for which data were available. These included TN, TP, flow, watershed area, watershed area in row crops, point source flow, stormwater permits and animal units. A stepwise regression was performed, with BI as the dependent variable.

This eliminated all factors except for TN, watershed area, stormwater permits, and animal units. The probable reason that TP was eliminated as a factor was that, at least for this dataset, TN/TP ratios tended to be relatively low, making TN the most limiting nutrient. The resulting equation had an R-squared value of 68.7 percent. Which may seem impressive, but caution is warranted. The coefficient for animal units is almost non-existent, as well as going in the opposite direction from what would be expected. Also, data for stormwater permits as well as animal units could not be normalized, so their actual effect is statistically questionable.

The regression was therefore simplified to only include TN and watershed area. This resulted in an equation with the R-squared reduced to 41.9 percent. When watershed area was eliminated as a factor R-squared was 23.3 percent. However, the p-value was calculated at 0.004, indicating that there is still a significant relationship.

Using the target BI of 7.1, back calculation of the regression equations yielded the following results: For the first and second regressions, the watershed size in the interquartile range was between 98 and 259 km^2. Setting the coefficients for animal units and stormwater permits at zero, total nitrogen concentration ranged from 634 to 1291 µg/L. For the second equation, this range was narrowed to between 722 and 1012 µg/L. For the third, most simplified equation, the result was 931µg/L. These results are generally consistent with proposed criteria for the region as suggested by RTAG recommendations, statistical reviews of data, and literature recommendations.

The scope of this study was limited, and a few caveats are in order. The linear regressions provide a partial, but not complete interpretation of biological response to nutrient concentrations. Watershed size and other factors also influence biological response. The range in watershed size used in this analysis was limited. The linkage between TN and biological response is not conclusively proven by this analysis. It is to be treated as a line of evidence.

Question: Was there an effort made to limit samples to base flow conditions?
Answer: Restriction of the analysis to biological samples taken during autumn was intended to approximate that.

Question: Is there a mechanism in mind to address the effects of watershed size in the rule?
Answer: At this point there is not.

Statistical Analysis of Statewide Nutrient Data

John Schumacher presented a review of USGS compilation of statewide data. There were three data sets from which data were drawn. They are described in the following table:

Agency	# sites	# samples	Other information
MDNR	~2,000	~38,000	Includes data from 44 agencies or labs, compiled by MDNR
USGS	~460	~12,568	
MDC (RAM)		~390	RAM = Resource Assessment Monitoring program. Includes 187 samples from EPA.

USGS took a number of steps to compile and clean up the data. MDNR data and location files were merged. Ambiguous and duplicate sites were reconciled. A master database was created that included data from all sources listed above. It was reviewed by iteration at the site and sample level. All sites were rated according to the following characteristics: G – good; R – rejected; P – provisional; L – large river; LK – lake; S – spring. Sites were rejected if they were within one mile below point sources. Other sites that were rejected included some sequential downstream sites and sites with unconfirmed locations. All data from before 1990 were also rejected.

Parameters that were reviewed for quality assurance included Kjeldahl nitrogen, ammonia, nitrate, orthophosphate, total phosphorus and field measurements such as flow, specific conductivity, and dissolved oxygen. The focus of the review was on TN and TP.

The big issue in data compilation was the large amount of censored data, that is, data for TN and TP that were listed as less than a specified detection limit. These detection limits varied, and some were relatively high. Limits for censor threshold were set at 0.3 mg/L for TN and 0.05 mg/L. All samples that were censored due to higher detection limits were rejected. This included 182 values for TN and 1,198 values for TP.

There were several other actions taken to make the dataset more meaningful. Where TN data were missing, they were calculated by adding Kjeldahl nitrogen and nitrate nitrogen. Several blocks of high density data (such as the large set on the East Fork of the Black River following the Taum Sauk disaster) were removed. Stream orders and drainage areas were assigned. Some data had to be revised due to evident inconsistency with the units used (µg/L vs mg/L). Also, data with concentrations of TN greater than 10 mg/L and TP greater than 2 mg/L were removed. These are considered to be extremely high concentrations and not representative of streams in Missouri. The final dataset consisted of 22,632 samples from 1,766 sites. Of these, 18,027 samples included data for TN and 21,755 included data for TP.

Statistics for the dataset were calculated by EDU, using the 75th percentile from reference site samples and the 25th percentile of all samples. These calculations were done first using all samples and then using single values for each site. The latter approach was considered as more representative, as there were some sites which had large numbers of samples, which would tend to skew the data. Site values were calculated using the mean, geomean, and median values. The median values were determined to be the most accurate.

Several approaches to calculating from the remaining censored data were considered, and two were adopted: multiple substitution and Kaplan-Meier. Multiple substitution is the replacement of each censored value with one half of the listed detection limit. Kaplan-Meier is a non-parametric statistics package which does analysis on multiple censoring levels. It is a robust program that has been used extensively by the CDC to examine right-censored data (e.g. too many pathogens to count).

Data for the different EDUs within each of the broad regions of the State (Central Plains, Ozarks, Mississippi River Alluvial Valley) were compared using Kruskal-Wallis and Tukey's multiple comparison tests. Adjacent EDUs where these tests indicated no significant differences were combined into "super EDUs".

A summary of statistical methods was presented as a flow chart. The total sample base was classified by EDU and also by super EDU. Within each of these classifications, statistics were run for all samples and for reference samples. Censored data were accounted for using both Kaplan-Meier and substitution. For the site based approach, medians and geomeans for all sites and reference sites were calculated, and sorted by EDU and super EDU.

Statewide maps showing sample site distributions and the numbers of samples per site were shown, as were box plots that indicated sample based distributions within EDUs. Letter classifications derived from Tukey's multiple comparisons for the box plots illustrated the rationale for grouping them into super EDUs. A bar chart illustrated variations within each EDU from the following calculations for TP, all of which were based on the substitution method for censored data: 25^{th} percentile of total and 75^{th} percentile of reference samples using the sample-based approach and the 25^{th} percentile of total and 75^{th} percentile of reference sites using the site-based approach. A notable tendency of these comparisons is that, within many, though not all, of the EDUs, the 75^{th} percentile for reference streams appeared to be significantly higher than the 25^{th} percentile of the entire population.

Most of the data indicate low TN/TP ratios. However, there are some regions, particularly the southwestern part of the state where the ratio is higher.

Question: If high values of TN (>10 mg/L) and TP (>2 mg/L) were removed from the dataset, why was the same not done for low values?
Answer: Values below detection limits are generally representative of natural background conditions, whereas the high values are considered to be in extreme excess of the norm. They are indicative of artificial loading from some source. The cutoff points were chosen based on Best Professional Judgment after examining many years' worth of data. In locations that were not affected by point sources, TN concentration rarely exceeded 5 mg/L. Doubling that appeared to be an appropriate cutoff point.
Comment: Treatment for TN can cost $15 per gallon. This can have a huge monetary impact on communities, particularly in the Central Plains. We just want to know if the low end data is in compliance.

Proposed Rule and Discussion

Mark explained how the proposed rule was drafted. Following the data provided in the matrix of summary statistics, and lines of evidence, and after consultation with the technical subcommittee and with EPA, the state was divided into five nutrient zones, based largely on groupings of EDUs. The exception was Zone IV, which is the drainage area for the Current and Jack's Fork Rivers. This area constitutes a portion of EDU 21, the Ozark/Black/Current.

The other zones are aggregations of adjacent EDUs. Zone I includes all the Central Plains EDUs plus the Ozark/Neosho, which is a bit of an anomaly that has some characteristics of the Central Plains, including substantially higher nitrogen concentrations than the rest of the Ozark region. Zones II and III represent the border and central Ozark regions respectively. And Zone V is the Bootheel, for which there is insufficient biological data for a meaningful analysis. Therefore, proposed criteria for that zone are based entirely on nutrient statistics.

Question: What designated uses are these criteria designed to protect?
Answer: Aquatic Life Protection.

Question: Are we trying to make all streams as pristine as those listed as reference streams?
Answer: Reference conditions are a consideration, as is biological response, whether it is algae or macro-invertebrates.

Comment: Zone IV has highly restrictive criteria. It should be recalled that there are people living in the area, and it may be impossible for treatment plants to comply. Implementation needs to be considered.
Response: Our task is to first look at the science. We realize that there is an ongoing tension between the goals of the Clean Water Act and some practical considerations. The way to address

it is development of the Regulatory Impact Report (RIR), which is currently planned for the 2015 rulemaking schedule.

Question: Since biological data were collected only during late summer and fall, would nutrient criteria only apply during that time of year?
Answer: Biological response is a reflection of long term conditions and not just the concentrations during the time of sampling.

Question: Why were macro-invertebrate data collected during spring not considered in the analysis?
Answer: Spring time macro-invertebrate assemblages are generally quite different from those in the fall. Spring time data are likely be skewed by scouring that follows the high flow events that are more frequent during that time of year.

Question: The data seem to indicate that more than 70 percent of streams will be in violation of the proposed criteria. How do we move forward?
Answer: Listing methodology has yet to be determined. If, for example, a stream's status is determined by the geomean of nutrient data over a period of time (rather than the mean or the maximum concentrations), the result could be a greater likelihood of compliance.

Comment: Application of this rule to all Waters of the State may result in a lot of intermittent and effluent dominated streams being listed. This could be overwhelming.
Response: We may change the rule to apply only to classified waters. However, the definition of classified waters is also under discussion and may be expanded.

Question: What is the likelihood of the Florida scenario being imposed on Missouri?
Answer: We don't know.

Comment: In Ohio, they have established a weight of evidence approach. Nutrient criteria are in place, but they are only enforced when other indications of impairment are evident.
Response: We will look into that.

Question: Is there an implementation strategy in place for the lake nutrient criteria?
Answer: That will be addressed at the next stakeholder meeting.