

## Assessing the Environment In Outcome Units (AEIOU): Using Eutrophying Units for Management – a Proactive STAC Workshop Proposal

### Steering committee members – all have agreed to serve

1. Co-chair: Lisa Wainger UMCES (STAC)
2. Co-chair: Gary Shenk USGS
3. Paul Capel, USGS (fate and transport modeling)
4. Marjy Friedrichs, VIMS, (physical and biogeochemical estuarine processes)
5. Jason Hubbart, WVU, (STAC) (watershed modeling w/ field verification)
6. Antti Iho, Natural Resource Institute Finland (agricultural modeler & economist)
7. Peter Kleinman, USDA ARS, (STAC) (ag management practices + water quality)
8. Kevin Sellner, itinerant ecologist, (phytoplankton ecologist)
9. Kurt Stephenson, VA Tech (STAC) (economist)

### Workshop objectives and problems addressed

The Chesapeake Bay TMDL sets a cap on total average annual nutrients without regard to the bioavailability or timing of different nutrient species deliveries to the Bay. While this approach creates a metric for the TMDL that is relatively simple for accounting and communication, lumping nutrient species into a total annual average creates inefficiencies and inconsistencies when allocating scarce resources to improve water quality. Specifically, inorganic nutrients may have a greater impact on eutrophication compared to organic forms. In addition, management options may have varying, even conflicting, effects on the fate of different forms of nutrients. Therefore, more direct accounting of nutrient species or fractions could lead to more cost-effective management by making explicit the effects of practices or their location on water quality outcomes.

The TMDL has specific endpoints of dissolved oxygen, water clarity, and chlorophyll, which are related to other important endpoints such as harmful algal species and fish habitat quality. The relationships of nutrient species and timing to water quality and biotic responses can depend on a variety of co-variables including salinity, temperature, sediment load, and soil and aquifer properties in the runoff pathway. The objective of this workshop will be to explore whether the science is ripe and appropriate for calculating *eutrophying units* as a common currency that can be used to compare alternative restoration strategies. Eutrophying units would be comprised of the combined species concentrations of nitrogen (N) and phosphorus (P) using transfer functions that depend on their effect on environmental outcomes. The workshop will facilitate synthesizing the state of knowledge and organizing approaches for developing eutrophying units, reflecting spatial and temporal conditions of the Bay and its watershed.

### Background

Conditions within the watershed and the CB partnership support the need for this workshop and an outcome-based (AEIOU) approach to management priorities. Analysis of River Input Monitoring data shows statistically significant differences in flow-normalized trend *direction* for total P and ortho-P (the most bioavailable form of P) for four of nine river input stations. In some areas of the Chesapeake Bay, ortho-P is increasing, despite or even as a side effect of management efforts, and this issue is common to large watersheds throughout the world. Currently, watershed modeling does not fully capture the influence of headwater systems on nutrient dynamics and conditions in downstream receiving waters. Headwater streams integrate processes including flow dynamics, land use practices and nutrient spiraling in which stream communities assimilate and chemically transform nutrients and thereby prevent hypoxic conditions in downstream waters. As a result of these water quality trends and known modeling gaps, synthesizing what is known about bioavailable forms of nutrients has the potential to improve the CBP's ability to quantify effects of management efforts under a variety of conditions that control nutrient transformations to ensure efforts are ultimately effective at restoring water bodies.

Nutrient speciation matters to water quality outcomes because it affects total phytoplankton biomass and can cause preferential growth of some phytoplankton groups and taxa in tidal waters. Some literature suggests that the ratio of N to P (N/P) or dissolved fractions (DIN/DIP) can determine phytoplankton species composition. In some systems, a low N/P ratio selects for nitrogen-fixing cyanobacteria and several known toxin producers. Hence, nutrient species, concentrations, and ratios, along with mixing, can govern species composition and water quality outcomes in many water bodies.

Chesapeake Bay managers are already somewhat comfortable with the concept of different N and P fractions and are receptive to expanding this concept because of the potential to use such knowledge to select the nutrient reduction strategies that are most protective of water quality and human health. The Chesapeake Bay Modeling Suite already explicitly simulates the effect of nutrient species on TMDL outcomes of dissolved oxygen, clarity, and chlorophyll in the Bay. However, such information is not easily accessible for planning. Managers are also interested in the potential to use fractions to trade off N and P reductions, as has been used by jurisdictions since 2010 to achieve combined caps. Initial work on this issue resulted in weight assignments to particulate P and ortho-P according to their short- and long-run contributions to algae growth, but further evaluation is warranted to ensure the best feasible science is being used.

#### Management relevance and urgency

Adoption of eutrophying units by the CBP has significant management relevance since the outcomes have the potential to greatly reduce costs and increase effectiveness of the states' watershed implementation plans, which are in preparation. Although workshop results will not be available for use in the implementation plans due at the end of this year, they will be available to inform allocation of effort as plans evolve through the 2-year milestone process. The results are expected to be useful for guiding operation of wastewater treatment plants, BMP selection and siting, and design of BMP systems to preferentially control nutrient species with higher eutrophying potential.

#### Why a STAC workshop

Researchers currently working on eutrophying units and watershed processes are widely distributed geographically and the group will benefit from an opportunity to discuss the applicability and transferability of approaches that have been used elsewhere. A workshop format will also provide an opportunity to elicit different perspectives on potential outcome units and watershed and estuarine processes that should be considered.

#### Questions to address

- Does nutrient speciation and timing of delivery to the bay depend strongly on BMPs, land use, watershed characteristics, and the presence or reservoirs?
- To what extent do in-stream transformations and spiraling dominate the speciation and timing of nutrient delivery to the Bay?
- How do nutrient pathways (groundwater, shallow underground flow, surface flow) affect speciation and timing of nutrient delivery to the Bay?
- How do endpoints and outcomes associated with the CBP TMDL or other environmental goals respond to changes in nutrient species and timing and what practical strategies could be used to incorporate such science into BMP performance?
- How do all of the above vary with by salinity, stratification, energy regime, or climate?

#### Potential speakers

James Davis-Martin

VA DEQ

Stakeholder concerns

Andrew Sharpley	U of Arkansas	BMP effects on nutrient species
Helen Jarvie	Natural Environment Research	BMP effects on nutrient species
Jennifer Tank	Notre Dame	Spiraling – stream recycling and transformations
Bern Sweeney	Stroud Water Research Center	Spiraling – stream recycling and transformations
Antti Iho	Natural Resource Institute	Baltic approach to eutro units
Mark Munn	USGS, WA	Stream Ecology
Jason Hubbart	WVU	Freshwater hydro-biogeochemistry
Pat Glibert	UMCES	HAB species preferences for nutrient species and ratios
Dave Secor	UMCES	Fish food preferences
Petri Ekholm	Finnish Environment Institute	Long term P release from anoxic sediments
Risto Uusitalo	Natural Resources Institute	Ag soil P processes, vertical stratification of soil P
Charles Bott	HRSD	WWTP, Chemistry of WWTP discharge

### Expected outcomes

The initial product of this workshop will be a report summarizing the state of the science for developing eutrophying units and recommendations for implementing eutrophying units in CBP models and policies supported by science. We expect to generate initial ideas for integrating bioavailability of nutrient fractions into BMP panel guidance and CBP models. We will document understanding gained regarding watershed production and spiraling of nutrient species, the relative bioavailability of fractions of nutrients, their effects on water quality and possible food web and biogeochemical processes, and the temporal and spatial heterogeneity of such effects. We will, individually and through STAC, continue to work with CBP on an initial implementation approach for these ideas. We anticipate that additional research will be needed to implement such an approach. Given the representation of federal agencies and research institutions within the steering committee, the team is well-positioned to apply workshop findings to the development of research proposals and management approaches.

### Past outcomes

The co-chairs (Wainger and Shenk) and several steering committee members (Friedrichs, Kleinman, and Stephenson) have all received prior STAC workshop funding as either chairs or steering committee members. In all cases, the workshop teams have produced reports that were shared with the management board, various CBP workgroups and goal teams, and the scientific community. The impact of these outputs has been substantial and has included uptake by the CBP modelers and follow-on work within the partnership. For example, the multiple modeling workshops in 2012 and 2014 were highly successful in convincing the CBP to begin to implement multiple models and understand the benefits and the optimization workshop in 2016 resulted in a new CBP project to implement WIP optimization.

### Logistics

Planning will start immediately upon approval by STAC with the workshop being anticipated in January of 2019 in an Annapolis area hotel. Timing of the workshop is flexible. We will seek \$5,000 from USDA ARS in general workshop support which would reduce the cost to STAC from \$10,000 to \$5,000. The report will be submitted **within 90 days** of workshop completion. We anticipate around 30 participants. Up to three Finnish participants will be supported through a fellowship of the Finnish government

### Budget

Category	Estimated Cost
Venue - room rental fees	\$500
Catering, A/V, service charges	\$6,500
Participant travel	\$3,000
<b>Total</b>	<b>\$10,000</b>