



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 3

CHESAPEAKE BAY PROGRAM OFFICE

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ANNAPOLIS, MD 21403

August 23, 2019

Dr. Brian Benham, Chair
Scientific and Technical Advisory Committee
Chesapeake Bay Program
645 Contees Wharf Road
P.O. Box 28
Edgewater, Maryland 21037

Dear Dr. Benham:

Thank you for the opportunity to respond to the *Scientific and Technical Advisory Committee Chesapeake Bay Watershed Model Phase 6 Review*. As you are well aware, the Phase 6 Watershed Model is the most recent in a series of watershed models produced by the Chesapeake Bay Program (CBP) partnership for use in management on nitrogen, phosphorus, and sediment dating to the early 1980s. The Phase 6 Model differs in structure from previous models in that its physical simulation components are greatly simplified. This structure allows for better stakeholder understanding of the processes, speeds up computations, and resulted in a demonstrably better agreement with water quality observations. The Phase 6 Model was built with a stakeholder-driven process through the CBP's Modeling Workgroup and Water Quality Goal Implementation Team.

In the course of the normal business processes of STAC and the larger CBP, there has been significant opportunity to discuss the major themes, findings, and recommendations from this important review. The reviewers and Phase 6 Model practitioners made presentations to STAC and the Modeling Workgroup where the uncertainty issues were highlighted with possible solutions discussed. For example, the STAC workshops on BMP uncertainty and on the future of CBP modeling were able to build on the content of this review.

We are addressing the major recommendations as follows.

A more detailed and comprehensive description and rationale of model structure and linkages is needed to support decision-making. The precise role that multiple models play in influencing P6 WSM results and the methodology that is used to accommodate multiple models needs to be clarified.

We appreciate the comments on documentation and communication made in writing and verbally during the in-person review. It is in the best interest of the CBP and the CBP modeling team to have clear documentation of the rationale driving change in the watershed model and the structure that arose to meet stakeholder and scientific needs. We have moved discussions on the physical watershed and model segmentation out of the introductory section of the documentation so that it could be devoted to communicating the rationale and structure of the Phase 6 Model. Language was added to the introductory section to clarify how multiple parallel models are currently used in Phase 6. Additionally, the discussion regarding multiple models was expanded in Section 2 dealing with average loads and Section 4 on model sensitivities.

An accuracy or skill assessment of the underlying individual models used in the multiple model approach is warranted to better constrain model uncertainty.

We agree that a skill assessment for the underlying models is a desirable step in estimating the uncertainty of the Phase 6 Watershed Model. A skill assessment that includes an estimation of the uncertainty of parameters for the statistical SPARROW model is now included in the documentation. The Phase 5.3.2 Model has a skill assessment available, however the evaluation of prediction and observation does not easily translate to the estimate the uncertainty of the Phase 5.3.2 Model outputs used in the Phase 6 Model. The same is true for the APLE model. The Chesapeake CEAP Model documentation does not include a skill assessment.

The panel encourages the CBP to transition from a multi-level model approach (e.g., several models providing a single point of input to the larger watershed model, which results in a single model realization) to a true ensemble model approach, which would allow for a Bayesian model analysis and a more thorough quantification of uncertainties.

We appreciate this recommendation and the extensive comments from the panel with suggestions for implementation. A Bayesian model structure will require estimation of uncertainty for all model inputs. The CBP is beginning the process of estimating some of the necessary uncertainties and it will take a significant effort to estimate sufficient numbers of input distribution. Bayesian methods would also require many thousands of runs of the Phase 6 Model. The CBP is now running the model on the cloud and working on methods of parallelization as part of the optimization effort that will enable the necessary capability.

Uncertainty analyses should be developed for each P6 WSM model component; the panel believes this would be a natural extension of the ensemble model approach.

As mentioned above, it will take a significant effort to estimate the uncertainties of all of the components of the Phase 6 Model. Some parts of the Phase 6 Model, such as the land-to-water factors and stream delivery factors, have explicit estimations of uncertainty from the underlying models or information. Other components, such as river delivery or average loads will have uncertainty distributions that are more difficult to estimate.

Use of expert panels for establishing BMP (best management practices) efficiencies should develop an explicit basis/approach to evaluating and applying uncertainty.

Given that the primary function of the Phase 6 Model is to estimate the aggregate effectiveness of BMPs, the most important component to estimate the confidence around would likely be BMP effectiveness. The STAC workshop report *Consideration of BMP Performance Uncertainty in Chesapeake Bay Program Implementation* asks the CBP to modify the BMP panel protocol document so that future panels will incorporate uncertainty estimation.

The CBP should commit to a process for improving the model's capability to represent processes of particle transport, storage, and reworking in the Chesapeake Bay watershed, as the Revised Universal Soil Loss Equation 2 (RUSLE2) foundation is questionable at the river basin scale.

The need for a revised sediment modeling capability was discussed and highlighted in the STAC workshop report *CBP Modeling in 2025 and Beyond*. Results of sediment breakout group

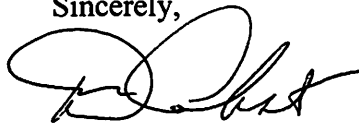
recommendations from the workshop include both short-term and long-term recommendations. In the next few years, alternatives to RUSLE can be evaluated and perhaps implemented in the next version of the CBP watershed model along with other evolutionary steps. In the longer term, participants at the workshop described the need for new conceptual models that would eventually result in revised numerical models.

The CBP should encourage the development of sub-models that attempt to down-scale the watershed models while also exploring process-based mechanisms affecting water quality to help inform local decisions to target conservation and manage inputs.

The water quality managers in the CBP partnership agree that finer scale models that assist local decision makers would be a great benefit to the partnership. Many of the datasets describing physical transport of nutrients are currently available on a finer scale, so some down-scaling could be done relatively simply. Other data sets describing management are limited in scale by policies or funding. The CBP partners will continue to work toward the long-term goal of developing finer-scale models that are consistent with the larger CBP partnership model.

On behalf of the Management Board, I want to thank you for STAC's thorough review and forward-looking recommendations. Please extend our gratitude to STAC and particularly the review panel for the time and effort involved in the production of the report: *Scientific and Technical Advisory Committee Chesapeake Bay Watershed Model Phase 6 Review*. We greatly appreciate the ongoing role of STAC in serving as an independent review body directed towards continually improving our overall management of the Chesapeake Bay and watershed restoration efforts.

Sincerely,

A handwritten signature in black ink, appearing to read 'Dana Aunkst', with a large, stylized flourish at the end.

Dana Aunkst, Chair
Management Board