UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 3
CHESAPEAKE BAY PROGRAM OFFICE
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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's (STAC) workshop on *Cracking the WIP: Designing an Optimization Engine to Guide Efficient Bay Implementation.*

The ability of the Chesapeake Bay Program Partnership to guide restoration of the Chesapeake Bay is dependent in part on the capacity to design and compare efficient strategies of Best Management Practice (BMP) implementation for achieving target loads of nitrogen, phosphorous, and sediment. The Chesapeake Assessment Scenario Tool (CAST) directly supports this activity by its numeric representation of the interactions and effects of BMPs throughout the watershed, and thus assists Bay Program Partners in the evaluation and development of implementation plans. However, due to the large number of decision variables, the complexity of interactions, and time it takes to become an expert user of the system, the full potential of CAST has been unrealized by many Partners that would benefit from insights achievable through systematic examination of CAST scenarios. An optimization engine that algorithmically performs such examinations and presents cost-effective implementation strategy possibilities will enhance the utility of CAST while also increasing its ease of use, thus enabling interested Partners to focus their efforts on making policy decisions critical for restoring the Bay. Optimization analysis is critically necessary to meet the challenges associated with the need to accelerate nitrogen reductions, address anticipated loss of BMP efficiency with climate change and development, and address additional Conowingo reductions.

The recommendations of the STAC workshop provide useful guidance for the development of such an optimization engine and identify important technical challenges stemming from the large number of decision variables and the non-linear cascading effects of Best Management Practices (BMPs), which are essential for CAST to accurately reflect policy and management considerations of the Partnership. The overarching recommendation was for the Partnership to "develop a Bay Optimization System that facilitates development of implementation scenarios that minimize lifecycle costs and maximize the achievement of the broader Bay Watershed Agreement goals and other potential co-benefits while accounting for

nonlinear interactions of BMPs and the spatial variability of a complex watershed." The first corollary to this recommendation was that this development work "...should be on a timeline compatible with the mid-point assessment, Phase 3 WIP and ongoing milestone planning." Following the recommendations of the STAC workshop report, development of the Bay Optimization System has begun. Although the optimization system won't be complete before the Phase 3 WIP development time period, it is anticipated to be available for ongoing milestone planning.

The STAC workshop report also recommended that "[t]he Bay Optimization System should be integrated into our existing suite of decision-support tools, likely through CAST." Key steps in the developmental progression, from BMP screening, to simulation, and to optimization, were described in the report, and the first five steps [(1) gathering feedback, (2) retaining the services of an expert team, (3) identifying dominant BMPs, (4) establishing limited scenario suite templates, and (5) deploying the single-objective optimization system] were emphasized. In addition to these major sequential development steps, the report described three priorities for features of the Bay Optimization System. The priority was the minimization of lifecycle costs to achieve nitrogen, phosphorous, and sediment target loads using a select and constrained set of BMPs, with reporting on a short list of quantified co-benefits after the fact. The second priority was the factoring in of co-benefit scoring early on in the optimization process. The third priority was driving towards true multiple objective optimization to maximize co-benefits as well as minimize lifecycle costs. In addition to the programmatic recommendations, the report outlined a potential formulation of optimization problem objectives, decision variables, and constraints.

Several specific steps have been taken by the CBP to follow the recommendations of STAC, and as work on the optimization system progresses, the key steps and priorities described in the report are being incorporated into the development process as applicable. A request for proposals (RFP) was issued by CBP, and a cooperative agreement was awarded to the Chesapeake Research Consortium (CRC) on 9 December 2016. An advisory and support committee (ASC) was established to recruit, advise, and mentor the best-qualified applicant to serve the CBP as an optimization expert. Prior to identifying a suitable optimization expert, one of the ASC members began crafting a prototypical optimization formulation for CAST and identified a list of details to work through in order to implement such an approach, including: composing efficient data structures, assessing BMP groups, and identifying problematic BMPs. After these interim activities were terminated, a candidate for the full-time position was hired as a Research Scientist to lead development of the Bay Optimization System.

Programming of the optimization software is underway, with a focus on the automated and systematic generation of CAST scenarios so that details of the necessary software can be tested and refined. This prototype software queries the CAST source data and generates potential collections of decision variable values. During this initial drafting of the software, preliminary graphical interface components are also being tested, such as options for selecting metadata, decision variable groups, and constraints. In addition, the optimization prototype software is

being tested for compatibility with the CBP cloud server platform, toward which the majority of computationally intensive CBP resources are currently moving. Along with the optimization engine development, CAST is being refactored to increase the speed of a single run of CAST, to enable multiple parallel runs of CAST, and to facilitate efficient communication between the scenario-running components and the optimization-analysis components.

So far, progress updates have been provided and feedback gathered from the Water Quality Goal Implementation Team, the Scientific, Technical assessment & Reporting team, and four workgroups (Watershed Technical Workgroup, Modeling Workgroup, Wastewater Treatment Workgroup, Urban Stormwater Workgroup).

On behalf of the Management Board, please extend my thanks to the workshop steering committee and participants for their time and effort in developing the report *Cracking the WIP: Designing an Optimization Engine to Guide Efficient Bay Implementation.* We remain, as always, very appreciative of STAC's role in providing independent reviews and guidance for improving our management of the Chesapeake Bay TMDL and restoration effort.

Sincerely,

Dana Aunkst, Chair
Management Board