Chesapeake Bay Program
A Watershed Partnership

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Dr. Lisa Wainger, Chair
Scientific and Technical Advisory Committee
Chesapeake Bay Program
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Dear Dr. ~~Wainger~~ Lisa:

Thank you for the opportunity to respond to the Scientific and Technical Advisory Committee's (STAC) report entitled "The Development of Climate Projections for Use in Chesapeake Bay Program Assessments".

In 2012, the CBP partnership identified climate change as one of the key priorities of the Bay TMDL's Midpoint Assessment. As a result, the partnership began the development of tools and procedures to quantify the effects of climate change on watershed flows and pollutant loads, storm intensity, increased estuarine temperatures, sea level rise, and ecosystem influences, including loss of tidal wetland attenuation, as well as other ecosystem influences in the Chesapeake Bay watershed. As you are aware, current modeling efforts are underway to frame a range of future climate change scenarios based on estimated 2025 and 2050 conditions. The recommendations outlined in the STAC workshop report have provided valuable information to guide the development and implementation of the modeling and policy decision-making process thus far.

A major component of the Midpoint Assessment is enhancing the CBP partnership's decision support tools, including the Phase 6 Watershed Model (WSM) and the Chesapeake Bay Water Quality Sediment Transport Model (WQSTM). The incorporation of key elements of the latest science on climate change is one of the more significant refinements to this modeling effort being conducted as part of the Midpoint Assessment. For the 2025 and 2050 climate scenarios, estimated attainment of water quality standards under 2025 and 2050 watershed loads, temperatures, hydrodynamics, tidal wetland attenuation, and sea level rise will be quantified. The report recommendations are clearly and concisely stated and the CBP is committed to working to implement these recommendations and associated guidance on the application of climate data and information throughout the Midpoint Assessment modeling development process. While the work is currently underway, we are addressing the specific STAC report recommendations as follows.

1. ***For the 2017 Midpoint Assessment, use historical (~100 years) trends to project precipitation to 2025 as opposed to utilizing an ensemble of future projections from GCMs. Shorter term climate change projections using GCMs have large uncertainties because climate models are structured to look further out and at much larger scales.***

For the 2025 climate change analysis in the Midpoint Assessment, the CBP will apply the CBP ten-year average hydrology of 1991 to 2000 used in the 2010 TMDL and adjust the rainfall and temperature hourly time series with factors derived from observed long term trends for 2025 conditions.

For the year 2025, the relative change in precipitation is derived from trends estimated from an 87 year record of precipitation in the Chesapeake watershed developed by Karen Rice, USGS, as described in the workshop report. The methodology is fully operational and has been tested in early versions of the WSM.

2. ***The Partnership should carefully consider the representation of evapotranspiration in Watershed Model calibration and scenarios, due to its strong influence on future water balance change.***

Several different approaches to estimate evapotranspiration are being examined including Hamon[i], Hargreaves[ii], and Penman–Monteith[iii], among others. Where practicable, the CO_2 correction for stomatal resistance as described by Butcher et al., 2014[iv] will be applied. Further application of potential evapotranspiration corrections based on Johnson, T.E., et al, 2012[v] will also be applied. By March, 2017, the CBP is committed to applying improved evapotranspiration methods to Phase 6 analysis of climate change influence on Chesapeake water quality.

3. ***For any 2050 assessment, use an ensemble or multiple global climate model approach, selecting model outputs that bound the range of key climate variables for the Chesapeake Bay region. Additionally, use multiple scenarios covering a range of projected emissions.***

For the 2050 assessments, an ensemble of 32 downscaled models have been used to produce a median temp/precipitation projection under low (RCP 2.6), medium (RCP 4.5) and high (RCP 8.5) CO_2 emission scenarios called representative concentration pathways (RCPs).[vi] The socio-economic assumptions and associated concentration levels of RPC 4.5 assumes that an increase in average global radiative forcing will reach 4.5 Wm^{-2} by the year 2100, and is considered to be a moderate future climate condition compared to RCP 8.5. Conditions under RCP 8.5 assume little to no reduction in greenhouse gas emissions over time leading to high greenhouse gas concentration levels and significant radiative forcing of 8.5 Wm^{-2} by the year 2100. The RCP 2.6 scenario assumes greater initiatives set forth for the reduction of greenhouse gas emissions, resulting in a globally averaged radiative forcing of 2.6 Wm^{-2} by the year 2100. The median projection for each RCP is applied to precipitation and temperature inputs within the WSM to produce watershed loads under a potential future climate scenario. Between October – December, 2016, preliminary results of the watershed loads projected based on the median RCP 4.5 value were presented to the WQGIT, the Management Board and the Principal Staff Committee. The RCP 8.5 scenarios have also been run but were not presented, and the RCP 2.6 scenarios are planned for the future. Additional runs are planned which take the median projection. Also, estimated precipitation intensity will be examined by additional scoping scenarios. e

4. ***Select an existing system to access GCM downscaled scenario data (such as 'LASSO' described in more detail in Section II) in lieu of conducting a tailored statistical climate downscaling process for the Chesapeake Bay watershed.***

Based on this recommendation, the CBPO reviewed available systems to deliver downscaled GCM scenarios data and utilized the U.S. Climate Resilience Toolkit[vii] as a basis for guidance in the selection of downscaled methodology and models because of its completeness of available scenarios.

5. ***Beyond the 2017 Midpoint Assessment, it is recommended that the CBP use 2050 projections for best management practice (BMP) design, efficiencies, effectiveness, selection, and performance – given that many of the BMPs implemented now could be in the ground beyond 2050.***

In addition to the sound guidance provided by STAC, the CBP Climate Resiliency Workgroup (CRWG) has also provided input on scientific and technical aspects of the climate components of the Midpoint Assessment modeling and decision-making process. In May, 2016, the CRWG developed written recommendations on two specific climate-related data inputs and assessments, sea level rise projections and future tidal wetland loss, to inform the Midpoint Assessment modeling effort. These recommendations built off the foundation established and documented in the STAC Workshop Report. Additionally, the CRWG presented the briefing paper, "Guiding Principles and Options for Addressing Climate Change Considerations in the Jurisdictions' Phase III Watershed Implementation Plans (October, 2016)," to the Chesapeake Bay Program leadership for consideration.

Two of the guiding principles recommended by the CRWG speak to the use of climate projections for use in best management practice (BMP) design, efficiencies, effectiveness, selection, and performance. The first is to "reduce vulnerability" by siting and designing BMP's to reduce future impact of sea level rise, coastal storms, increased temperature, and extreme events on BMP performance over time. Vulnerability should be evaluated based on the factor of risk (i.e. consequence x probability) in combination with determined levels of risk tolerance, over the intended design-life of the proposed practice. The second is to "build in flexibility and adaptability" during implementation to allow for adjustments in BMP implementation in order to consider a wider range of potential uncertainties and a richer set of response options (load allocations, BMP selections, BMP redesign). A full range of options for addressing climate change considerations in the Jurisdictions' Phase III Watershed Implementation Plans was presented to the Water Quality Goal Implementation Team for consideration and approval in October, 2016, to the Management Board in November, 2016 and to the Principal Staff Committee on December 13, 2016. Some combination of these options that take into account the two guiding principles recommended by the CRWG will most likely be the end result of these discussions.

6. ***Looking forward, the 2050 timeframe is more appropriate for selecting and incorporating a suite of global climate scenarios and simulations to provide long-term projections for the management community, and an ongoing adaptive process to incorporate climate change into decision-making as implementation moves forward.***

Recognizing time and resource limitations to model climate effects for 2025 and 2050 as an element of the Midpoint Assessment modeling effort, the CBP has prioritized the selection and application of climate variables for the year 2025. However, the CBP modeling team is also conducting several 2050 runs for use as scoping scenarios. That said, the CBP is committed to conducting a more comprehensive analysis of the effects of climate change within the watershed and estuary in late 2017 and into 2018. Climate variables for input into this process are listed in the table below. Looking beyond the Midpoint Assessment, the CBP will work to stay abreast of emerging climate and sea level rise science as well as the application of the latest findings in CBP assessments and decision-making processes. The CBP will undoubtedly seek additional guidance and input from STAC as climate data and science evolves over time.

Table 1. Proposed 2050 Climate Variable Inputs

Year	Variable	Input	Parameter
2050	CO_2	487 ppm	Stomatal resistance
	Potential Evapotranspiration	Hamon Method	PET with high temperature response
		Hargreaves Method	PET with moderate temperature response
	Temperature	RCP 2.6	Monthly median of 32 member ensemble of climate change models
		RCP 4.5	Monthly median of 32 member ensemble of climate change models
		RCP 8.5	Monthly median of 32 member ensemble of climate change models
	Precipitation	RCP 2.6*	With Observed Intensity
			Without Intensity
		RCP 4.5*	With Observed Intensity
			Without Intensity
		RCP 8.5*	With Observed Intensity
			Without Intensity
	Sea Level Rise	0.3 m	Bay Hydro Model
		0.5 m	Bay Hydro Model
		0.8 m	Bay Hydro Model

*Each 2.6, 4.5 and 8.5 RCP scenario for 2050 is generated from a 32-member ensemble of climate change models with 10 percentile precipitation, median precipitation, and 90 percentile precipitation.

On behalf of the Management Board, I want to thank you for your timely and concise recommendations. Please extend our gratitude to STAC and the workshop steering committee for the time and effort involved in the production of this report. In addition to this workshop, the STAC is scheduled to conduct an independent peer review of the Phase 6 WSM and the WQSTM which includes a review of the approach being taken to model the effects of climate change. The reviews of the Phase 6 WSM and the WQSTM will take place in the winter of 2017. We greatly appreciate the ongoing role of STAC in serving as an independent review body directly towards continually improving our overall management of the Chesapeake Bay and watershed restoration efforts.

Most sincerely,

Nick DiPasquale

Nicholas A. DiPasquale, Chair
Management Board

Ec: Management Board Members

References

[i] Hamon, W. Russell. *Estimating potential evapotranspiration.* Diss. Massachusetts Institute of Technology, 1960.

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[iv] Butcher, Jonathan B., et al. "Incorporating the effects of increased atmospheric CO 2 in watershed model projections of climate change impacts." *Journal of Hydrology* 513 (2014): 322-334.

[v] U.S. EPA. Watershed Modeling to Assess the Sensitivity of Streamflow, Nutrient, and Sediment Loads to Potential Climate Change and Urban Development in 20 U.S. Watersheds (External Review Draft). U.S. Environmental Protection Agency, Washington, DC, 2013.

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