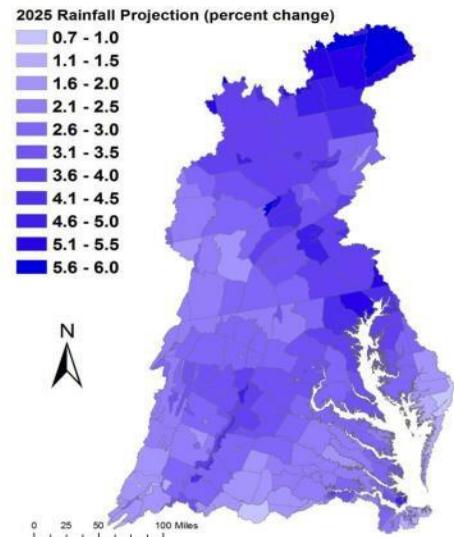


## Modeling of Climate Change Consequences for Phase III Watershed Implementation Plans

*STAC Workshop: Chesapeake Bay Program Climate Change Modeling 2.0  
September 24-25, 2018*

The consequences of global climate change are already evident in the Chesapeake Bay and watershed – at least in terms of warmer water temperatures and sea-level rise – and will influence virtually every aspect of the structure and function of the ecosystem in the coming decades. The 2014 [Chesapeake Watershed Agreement](#) set a new goal for climate resiliency to withstand adverse impacts from changing climate conditions. Since then, an important focus has been to estimate, using the Chesapeake Bay Program’s (CBP) management [models](#) of the watershed, airshed, and the estuary, the effects of future climate change risk on achieving Chesapeake tidal water quality standards. Based on these estimates, the task was to determine any adjustments that should be considered in the nutrient load reductions included in the Phase III Watershed Implementation Plans ([WIPs](#)) to achieve the Agreement’s 2025 [TMDL commitments](#). The most recent results were [presented](#) at the Modeling Workgroup September 11, 2018 meeting.

The modeling assumed specific projections of increased temperature, changes in precipitation, and a rise in mean sea level based on guidance from scientific community, including a 2016 STAC workshop [report](#). Projections made for 2025, from a 1991-2000 reference period, were: relative sea-level rise of 17 cm (extrapolated from tide gauge trends at Sewells Point), temperature increase of 1.1°C (based on downscaled climate model projections of annual air temperature), and an overall 3.1 percent increase in precipitation (based on extrapolation of trends observed in the 88-year annual [PRISM data](#) for major basins of the watershed). A single set of precipitation assumptions based on long term trends was used rather than scenarios or ranges.

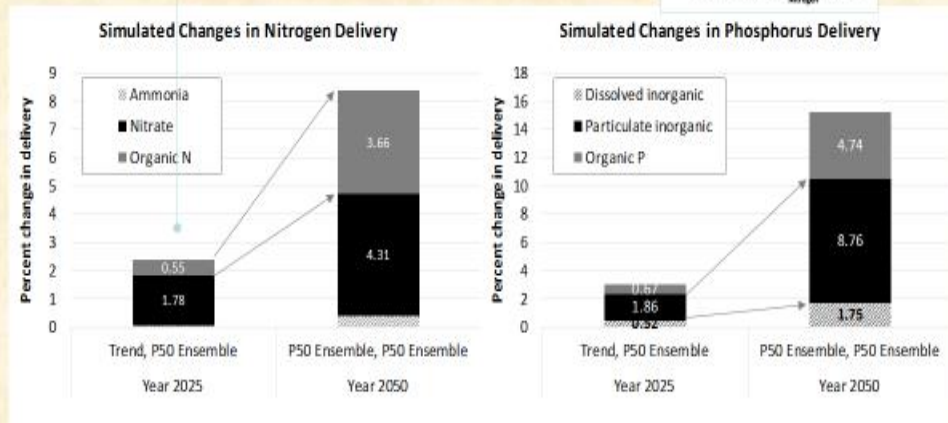


The focus in model outcomes was the effect on hypoxia in the deep channel of the mainstem Bay, because that is the most recalcitrant impairment of water quality. The basic question was, given the assumed climate changes, what would be the variance in hypoxia from the TMDL 2025 objective for achieving dissolved oxygen standards, i.e., if nutrient loads were reduced consistent with the present WIPs by 2025? Directionally, hypoxia would be expected to increase with increased temperature because of the decrease in oxygen saturation of warmer waters and the increase in rates of metabolic consumption of dissolved oxygen. Hypoxia would be expected to worsen with increased precipitation that would yield more freshwater runoff and deliver more nutrients. On the other hand, sea-level rise would likely result in some alleviation of hypoxia as the estuary would deepen and have greater inflows of cooler and more oxygen-rich ocean water.

## September 2018 results Nitrogen and phosphorus species

September 2018 results

Year 2025 results in December 2017 (with error)



Arrows show relatively more increase in organic nitrogen in 2050 estimates as compared to inorganic DIN.

Arrows show relatively more increase in particulate phosphorus in 2050 estimates as compared to DIP.

Using the assumptions listed above, the models estimated that, on balance, the total nitrogen and total phosphorus loads would change by 2.4 percent and 3.1 percent, respectively, with nitrate and dissolved phosphate loads increasing by 1.8 percent and 0.5 percent, respectively (September 2018 model estimates). This, plus the warmer temperatures, would be sufficient to decrease dissolved oxygen criteria attainment by an estimated 2 percent, which was estimated in December 2017 to require an equivalent reduction of nitrogen and phosphorus on the order of about 9 million pounds and 0.5 million pounds, respectively, to achieve 2025 Chesapeake water quality standards under future climate risk. The additional climate-change offsets for nitrogen that would have to be reduced are not insignificant with respect to the reductions from 2013 levels yet to be reduced over the next seven years for several of the jurisdictional WIPs.

In considering this advice, the CBP's Principals' Staff Committee (PSC) was struck by how rather small changes in assumptions on climate changes affected these estimates. Preliminary model estimates that had been provided earlier in 2017 had suggested that the extent of hypoxia would decrease (improve) with climate change. The rather substantial change in the assessment then provided in December 2017 resulted principally from a reduction in the assumed sea-level rise from 30 cm to 17 cm, and also consideration of the form of the additional nutrient loads, disproportionately more soluble nitrate and orthophosphate (small insert box in figure above). Current September 2018 estimates continue to estimate somewhat disproportionately more soluble nitrate loads (figure above).

The PSC indicated that it would also like to consider information on how modifying "best management practices" could affect nutrient loads under the changing climate. The PSC directed the CBP to work to better understand the science by documenting the current understanding, identifying research gaps and needs, and addressing uncertainty.

Specifically, the CBP was to

- “Develop an estimate of pollutant load changes (N, P, and S) due to climate change conditions [so that] starting with the 2022-2023 milestones, [the CBP will] determine how climate change will impact the BMPs included in the WIPs and address these vulnerabilities in the two-year milestones.
- Develop a better understanding of the BMP responses, including new or other emerging BMPs, to climate change conditions.
- In 2021, the Partnership will consider results of updated methods, techniques, and studies and revisit existing estimated loads due to climate change to determine if any updates to those load estimates are needed.
- Jurisdictions will be expected to account for additional nutrient and sediment pollutant loads due to 2025 climate change conditions in a Phase III WIP addendum and/or 2-year milestones beginning in 2022.”

## Next Steps Directed by the PSC: Understanding the Science and Refining the Model Estimates

