Chesapeake Bay Program Climate Change Modeling 2.0

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Outcomes of December 2017 PSC Meeting

- Directed the CBP to update the methods, techniques, and studies and revisit existing estimated loads due to climate change to determine if any updates to those load estimates are needed

- Expected that jurisdictions will 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

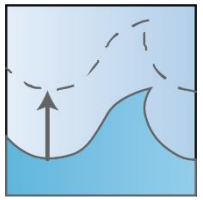
Initial Questions

- How does the CBP Watershed Model (WSM) and Water Quality Sediment Transport Model (WQSTM) response to future climate forcing compare to other comparable modeling efforts and frameworks?
- What additional or different climate change approaches and methods should be incorporated into the WSM and WQSTM?
- How can CBP modeling efforts account for potential impacts of larger landscape-level changes (e.g., changes in land use or agricultural systems) on nutrients and sediments loads?
- What ranges of inputs should be used for the WQSTM for water column temperature and ocean boundary changes?
- How does the relative rate of increasing precipitation, temperature, and sea level rise influence Chesapeake water quality in 2030, 2035, 2040, and other future years? In other words, are trends in the impacts of climate change increasing or changing going forward beyond 2025?
- What new and/or refined methods and modeling techniques could be used to better assess projected impacts on watershed loads and estuarine impacts for a range of future scenarios?
- What improvements could be made to the methodology used to develop jurisdiction-specific nutrient pollutant loads due to 2025 climate change conditions and beyond?
- What are the remaining research gaps and highest priority information needs (e.g., data, research, modeling methods and techniques, programmatic efforts)?

Breakout Groups

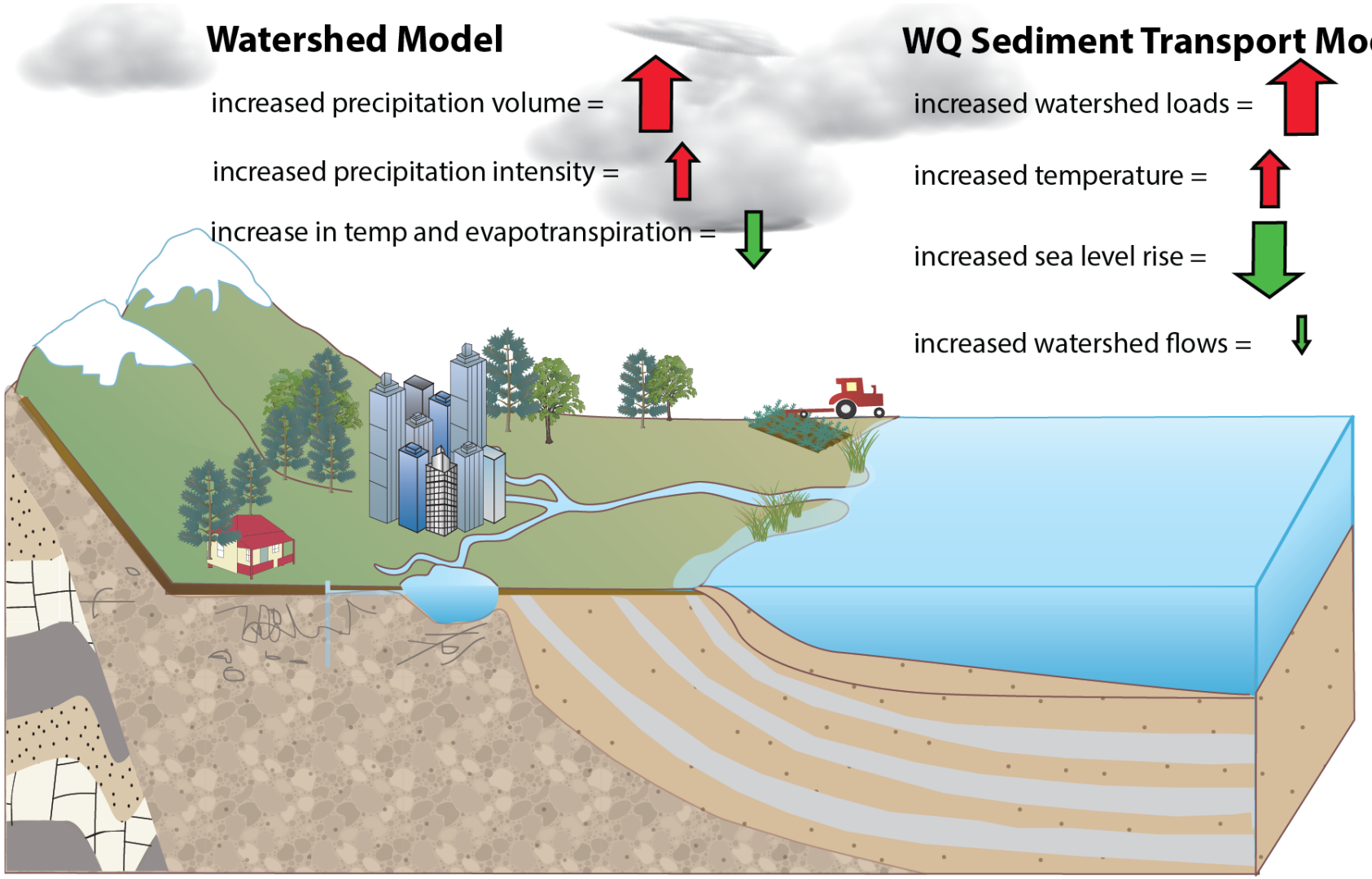
- Group 1: Simulation of Climate Change Processes and land management in the Phase 6 Watershed Model Influencing Chesapeake Water Quality
- Group 2: Simulation of Climate Change Processes in the WQSTM Influencing Chesapeake Water Quality
- Group 3: Assessment of the overall CBP framework of climate change analysis

Major Climate Variables: 2025 Projections

 Relative Sea Level Rise	17 centimeters	Extrapolation of NOAA observed sea level trends (Swells Point, VA)
 Temperature Increase	1.98° F / 1.1° C Increase	Downscaled climate projections (RCP 4.5)
 Precipitation Change	3.1% Increase	Observed trends in 88-years of annual PRISM[1] data

Accounting for Changing Conditions

Cumulative Assessment of Bay Low Dissolved Oxygen Impacts



In the Summer of 2017 Our Message was Climate Change Effects by 2025 were Projected to be Minimal as the Different Effects were Largely Counteracting Each Other

Summer 2017 Assessment: Deep Water Dissolved Oxygen in Balance

Watershed Loads Increase

Water Temperature in Bay Increases

Sea Level Rise Increases

Decreased Oxygen In Deep Waters of the Bay

Increased Oxygen In Deep Waters of the Bay

So What Changed Between the Summer 2017 Assessment of Projected Climate Change Impacts and what was Presented to the PSC at the December 19-20 Meeting?

Estimated Sea Level Rise Decreased

- Partnership originally used a predicted sea level rise of 30 centimeters (1 foot) between the 1990s and 2025

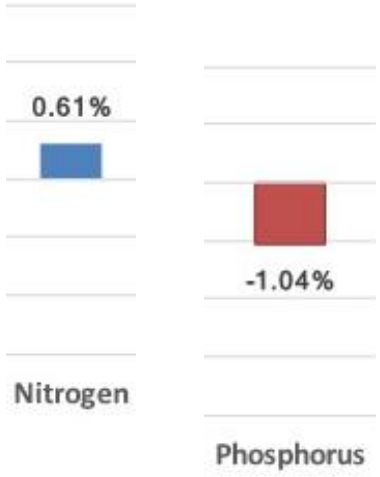
- Better scientific understanding brought forth by Partners
  - NOAA released new sea level rise projections for the Chesapeake Bay
  - VIMS also provided updated sea level rise projections

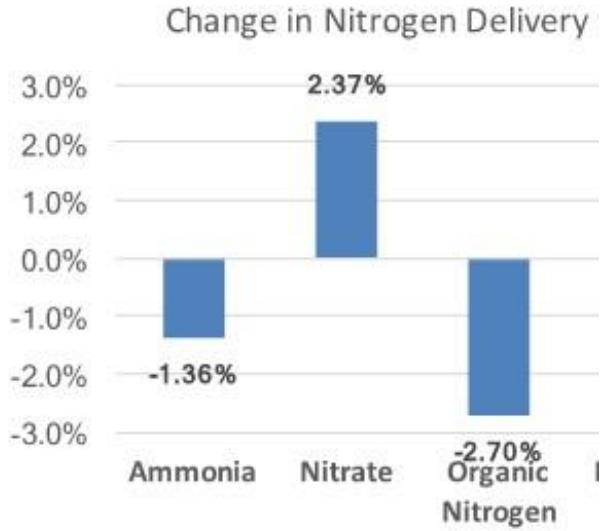
- Based on new science, the CBP Climate Resiliency Workgroup recommended using a projection of 17 centimeters
  - Consistent with long term trends at the Sewells Point, VA tide gauge at Bay mouth

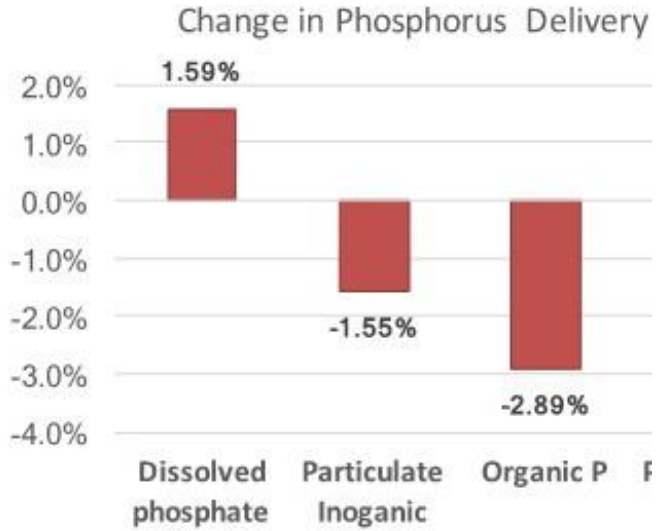
- **Result**: less influx of colder, oxygen-rich ocean water causing less ventilation of low dissolved oxygen waters in the deepest portions of the Bay

Climate Change Effects on Loading of Different Types of Nutrients Better Understood

- Total nitrogen and phosphorus are expected to stay about the same
- Dissolved nitrate and phosphate have a strong effect on dissolved oxygen and increase with climate change
- Ammonia decreased as a percentage, but the absolute amount is small
- Particulate and organic nutrients decrease, but they have a weak effect on dissolved oxygen







December 2017 Assessment: Deep Water Dissolved Oxygen Not in Balance

Watershed Loads Increase

Water Temperature in Bay Increases

Sea Level Rise Increases

Decreased Oxygen In Deep Waters of the Bay

Increased Oxygen In Deep Waters of the Bay

Nutrient Load Reductions Needed to Account for Reduced Oxygen Due to Climate Change

- We can choose to reduce nitrogen, phosphorus, or both
- Since most BMPs apply to both nutrients, a balanced approach is more efficient than just focusing on one or the other
- Raising the level of effort for all jurisdictions using the approved planning target method results in an estimate of 9.1 million pounds of nitrogen and 490,000 pounds of phosphorus basin-wide
- Those are the nutrient loads reductions necessary to counteract the projected climate change induced lower oxygen conditions

Climate Change Loads: Nitrogen

Jurisdiction	1985 Baseline	2013 Progress	Climate Change	Phase III Planning Target
NY	18.71	15.44	0.400 (3.8%)	10.62
PA	122.41	99.28	4.135 (5.7%)	72.99
MD	83.56	55.89	2.194 (4.8%)	45.39
WV	8.73	8.06	0.236 (3.7%)	6.36
DC	6.48	1.75	0.006 (0.3%)	2.25
DE	6.97	6.59	0.397 (8.5%)	4.66
VA	84.29	61.53	1.722 (3.1%)	56.37
Basinwide	331.15	248.54	9.09 (4.6%)	198.64

*Units: millions of pounds

Climate Change Loads: Phosphorus

Jurisdiction	1985 Baseline	2013 Progress	Climate Change	Phase III Planning Target
NY	1.198	0.710	0.014 (2.9%)	0.491
PA	6.282	3.749	0.141 (4.7%)	3.012
MD	7.495	3.942	0.114 (3.2%)	3.553
WV	0.902	0.617	0.019 (3.9%)	0.493
DC	0.090	0.062	0.001 (0.8%)	0.120
DE	0.225	0.116	0.006 (5.1%)	0.116
VA	14.244	6.751	0.193 (3.0%)	6.411
Basinwide	30.44	15.95	0.489 (3.4%)	14.20

*Units: millions of pounds

December 19-20 PSC Policy Decisions

1. **Incorporate Climate Change in the Phase III WIPs**

Include a narrative strategy in the Phase III WIPs that describes the jurisdictions current action plans and strategies to address climate change, as well as the jurisdiction-specific nutrient and sediment pollution loadings due to 2025 climate change conditions, while incorporating local priorities and actions to address climate change impacts.

2. **Understand the Science**

Address the uncertainty by documenting the current understanding of the science and identifying research gaps and needs.

3. **Incorporate into Milestones**

Starting with the 2022-2023 milestones, determine how climate change will impact the BMPs included in the WIPs and address these vulnerabilities in the two-year milestones.

Understanding the Science: Proposed Next Steps

2018

- STAC Workshop to examine current results, assess lessons-learned and recommend next steps.
- Climate Resiliency Workgroup will incorporate actions in its 2018-2020 workplan to develop a better understanding of BMP responses, including new or other emerging BMPs, to climate change conditions.

2019

- Following the direction of the PSC, the Modeling and Climate Resiliency Workgroups, working with other key Chesapeake Bay Program groups, will develop and implement a complete and fully operational climate change modeling and assessment system in 2019.

2020

- In 2020, the CBP partners will complete a technical review and process for approval of the new refined climate change modeling and assessment system as well as the scientific and technical findings from its management applications.

2021

- In 2021, the policy implications for including targets adjusted for the influence of climate change into the 2022-2023 milestones will be considered by the Partnership.
- By the close of 2021, the refined findings on climate change will be implemented into the jurisdictions' 2022-2023 milestones.

Today's Requested Policy Decisions

1) Approve the proposed next steps and overall schedule for addressing uncertainty by documenting the current understanding of the science and identifying research gaps and needs

Today's Requested Policy Decisions

2) Agree to use our current estimated nutrient and sediment load reductions needed to address projected climate change impacts on Bay water quality by 2025 as the starting point for proceeding forward the Partnership multi-year schedule for factoring changing climate conditions into the jurisdictions' Phase III Watershed Implementation Plans