

CBP Climate Model Support of WQGIT Narrative Request

Climate Resiliency Workgroup

April 19, 2021

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Science, Restoration, Partnership



Phase 6 Climate Change Model Elements

Model
Data Set
Endpoint
Project/Decision

Complete

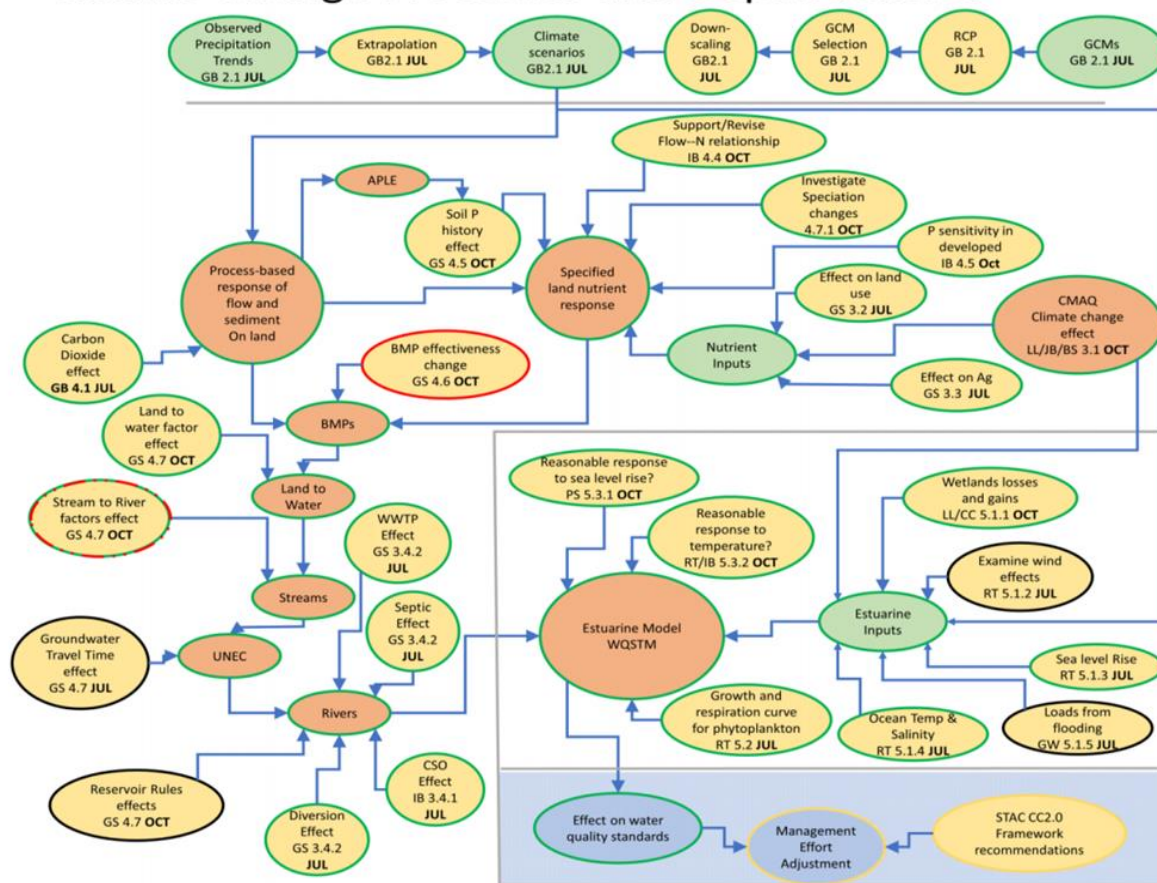
In Process

Not included
But important

Not included
minor

Initials indicate
the responsible person
Numbers
indicate the
section of the
documentation

Climate Change Processes and Dependencies



Climate

Watershed

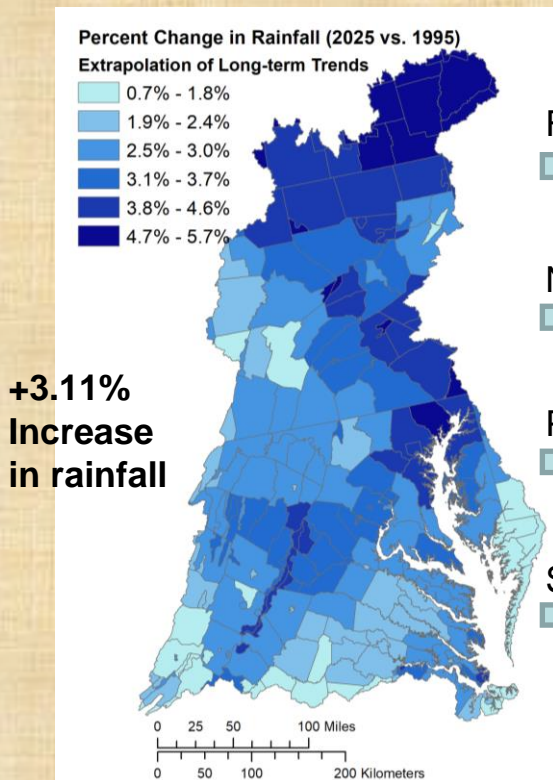
Estuary

Management



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Elements of 2025 Climate Change (1995-2025)



Phase 6 Watershed Model

Flow
→
2.4% Increase

Nitrogen Load
→
2.6% Increase

Phosphorus Load
→
4.5% Increase

Sediment Load
→
3.8% Increase

Air-temperature increase: 1.06 °C

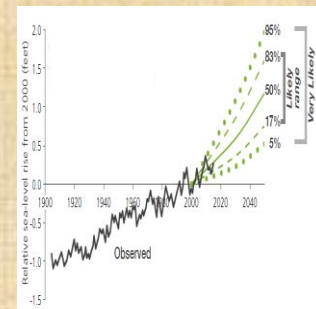
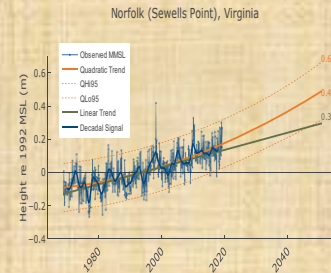


Model: CH3D-ICM
400m-1km Resolution

Sea Level Rise: 0.22m



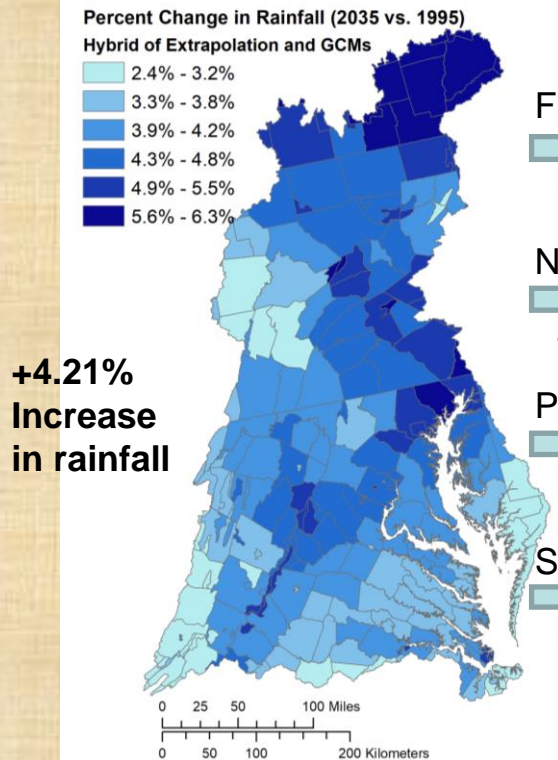
Open boundary:
Temperature: +0.95 °C;
Salinity: +0.18 psu
(Thomas et al., 2017)





Elements of 2035 Climate Change (1995-2035)

**Air-temperature
increase: 1.39 °C**



Flow

3.7% Increase

Nitrogen Load

4.7% Increase

Phosphorus Load

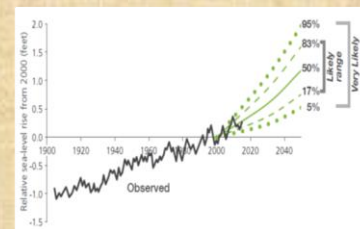
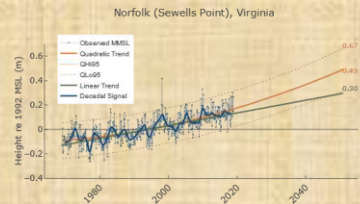
9.9% Increase

Sediment Load

8.5% Increase



Model: CH3D-ICM
400m-1km Resolution



**Sea Level
Rise:
0.31m**

**Open boundary:
Temperature: +1.32 °C;
Salinity: +0.25 psu
(Thomas et al., 2017)**

**Phase 6 Watershed
Model**

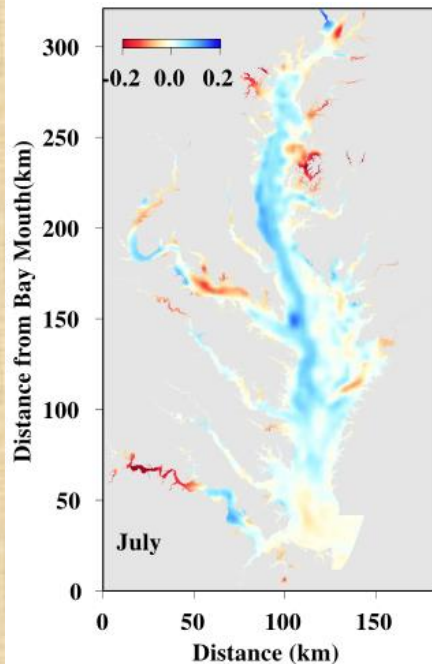


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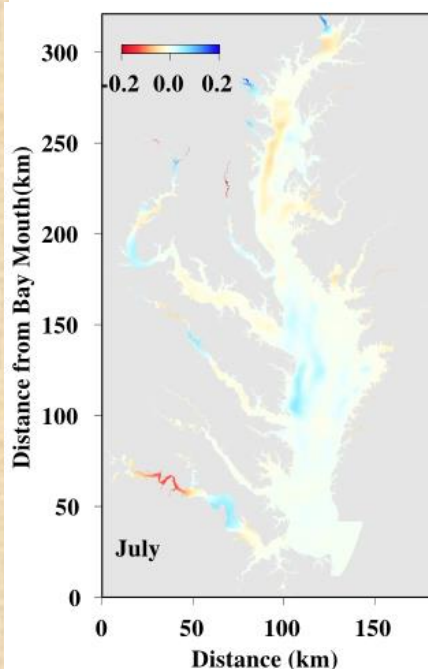
Bottom DO Change: 1995 to 2025

Keeping all other factors constant, sea level rise and increased watershed flow reduce hypoxia in the Bay, but the predominant influence are the negative impacts of increased water column temperature.

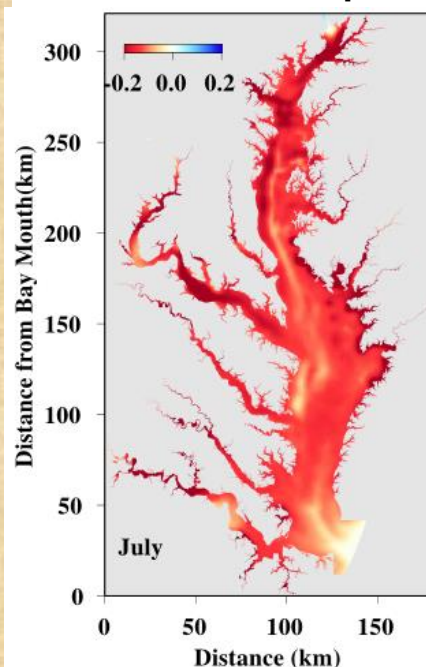
Sea Level Rise



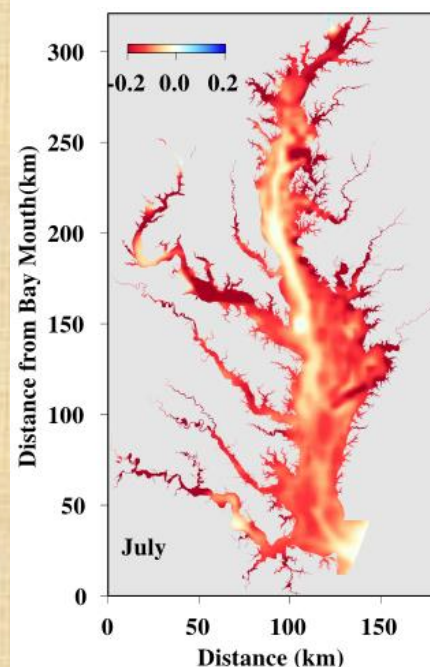
Watershed Flow



Increased Temp.



All Factors



CBP Decision on 2025 Climate Change Load Reduction Needed

State	2025 Climate N	2025 Climate P
DC	0.007	0.001
DE	0.039	0.003
MD	1.142	0.111
NY	0.399	0.044
PA	1.811	0.095
VA	1.589	0.337
WV	0.000	0.009
Total	4.986	0.599

Source: Management Board October 15, 2020 Actions/Decisions



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Bay Model Timeline: 2021 to 2022

2021
RFA
Completed.
Teams in
place.
Initial Main Bay
and Trib.
Model
Work

- Get initial CBP Bay Model structure in place with Main Model and Nested Fine Scale Tributary Models.
- Work on shallow water DO, clarity, and chlorophyll simulation begins.

2022
Main and
Tributary
Model
Development

- Main and Tributary model structure and boundaries determined.
- Decision rules for regulatory model calibration established.
- Begin Trib Models and semiannual Trib Model PI meetings.
- Examine use of linked watershed to tidal water hydrology inputs from Phase 7.



Bay Model Timeline: 2023 to 2024

2023

Refine shallow water DO, clarity/SAV, chlorophyll for WQ standard assessment

- Use Phase 7 WSM inputs of hydrology, sediment, and nutrients. (Phase 7 Model complete and fully operational in December 2023).
- Continue semiannual Trib Model PI meetings.
- Demonstrate improved simulation of shallow water DO, clarity/SAV, chlorophyll with unstructured grid Main Bay and Trib Models.
- Demonstrate sea level rise and tidal wetland simulation capability.

2024

Unstructured Grid Bay Model fully operational December 2024

- Adjust for input load changes from hydrology, sediment, and nutrients due to final reviewed version of Phase 7 model.
- Continue Trib Models and semiannual Trib Model PI meetings.
- Complete shallow water DO, clarity/SAV, chlorophyll refinements
- Unstructured grid Bay Model fully operational December 2024.



Bay Model Timeline: 2025 to 2026

2025
Apply
Unstructured
Grid Bay Model
to 2035 climate
change risk to
Chesapeake
water quality
standards

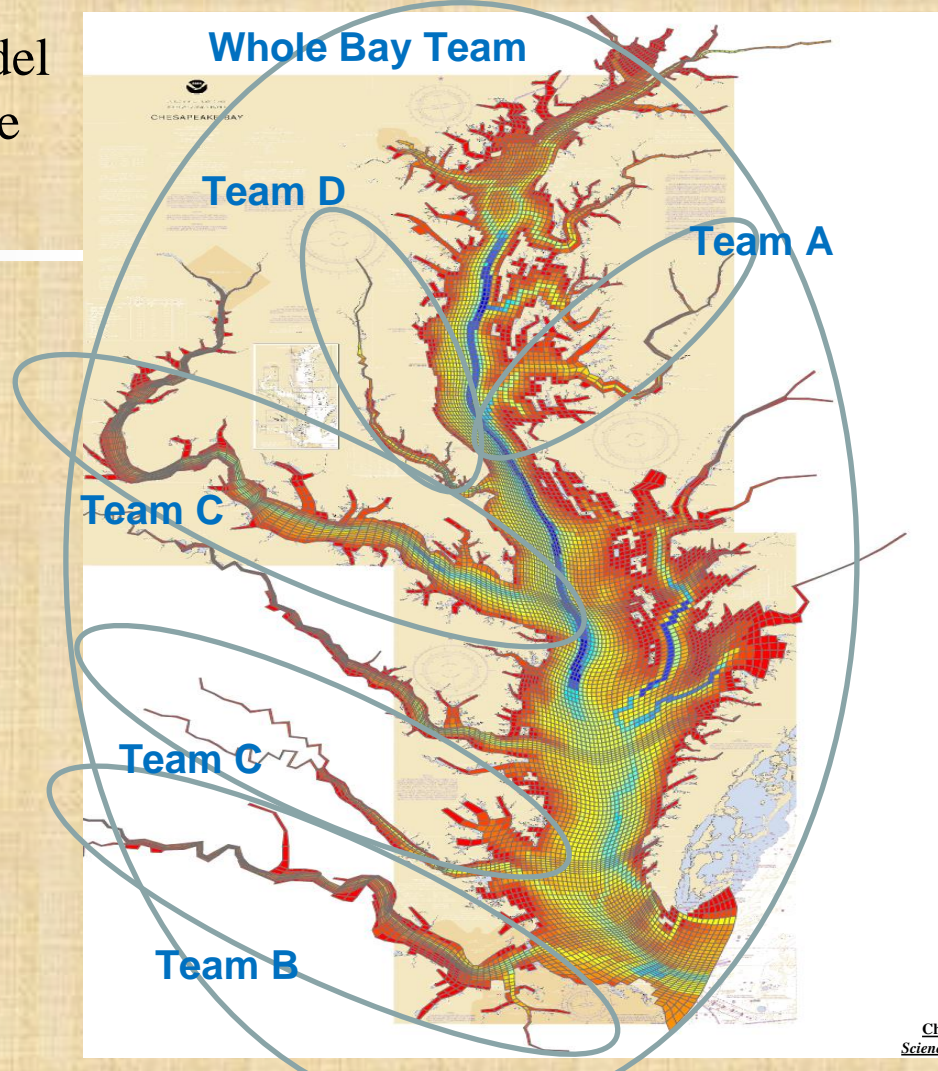
- Apply the 2025 Unstructured Grid Model to 2035 climate change risk.
- Determine the carrying capacity the Bay has for nutrient loads under 2025, 2035, 2045, and 2055 conditions.
- Examine in detail Open Water DO, clarity/SAV, and chlorophyll water quality standards under scenario conditions for Bay and Tribs.
- Develop nitrogen/phosphorus tradeoffs for tidal waters.

2026
Confirm and
support CBP
decision makers
with 2035
climate change
risk assessment

- Develop tributary and local tidal water assessments as requested by CBP Partners.
- Update local tidal water TMDLs, e.g., James Chlorophyll TMDL as requested by CBP.
- Main Bay Model “frozen” until 2035 but continue Trib Models and semiannual Trib Model PI meetings through 2025 and 2026.

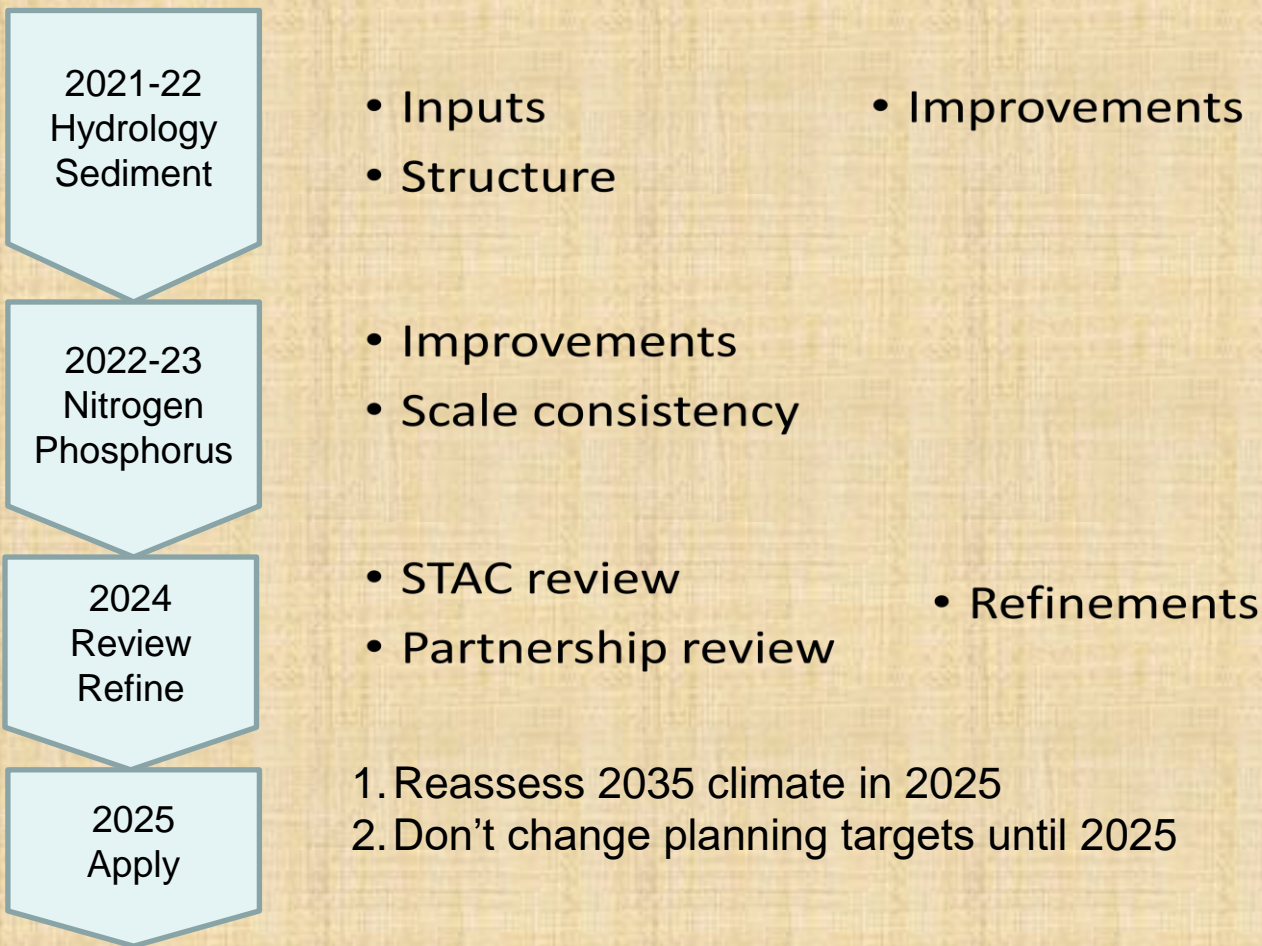
How an Unstructured Grid Model in the Chesapeake with Multiple Model Teams Could Work

- Main Bay Model of all tidal waters used for integration of tributary model findings and for management scenarios.
- Multiple model teams working in tributaries and sharing collaboratively information with all model teams on a regular basis.
- Similar to CMAQ multiple model approach





Watershed Model Phase 7 Timeline



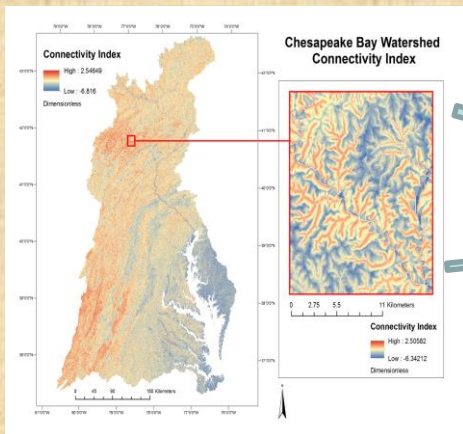
PSC
directives



Watershed Model Phase 7– Calibration Mode

10m
pixel

Distributed
Static
Model7

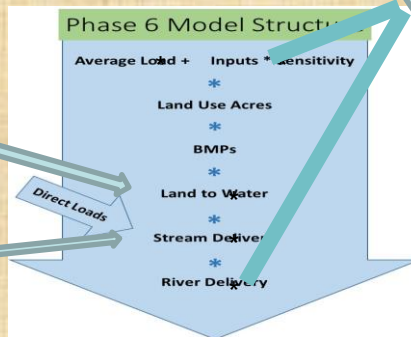


Generation of
summarized loading
parameters for flow, N,
P, and S

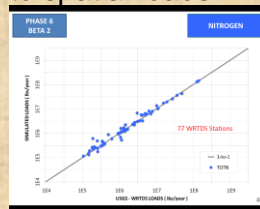
Potential
feedback

NHD
100k

CalCAST7



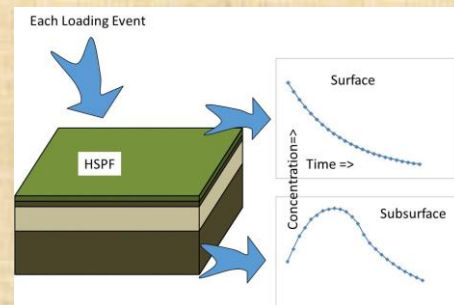
Calibration of
meta-parameters
to spatial loads



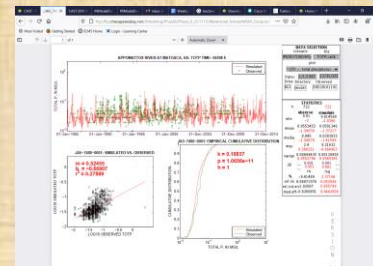
Potential
feedback

NHD
100k

Dynamic
Model7



Temporal
calibration



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Source: Management Board October 15, 2020 Actions/Decisions



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Direction from the PSC

- Jurisdictions are 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.
- Jurisdictions are expected to include a narrative in the 2022-2023 Milestones that describes the current understanding of 2035 climate change conditions, to the effect that: “Preliminary estimates for the climate impact through 2035 indicate a doubling of the 2025 load effect. The effect of climate change on our ability to meet the Bay’s water quality standards is a significant and increasing concern.”
- In 2025, 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 2035 load estimates are needed.



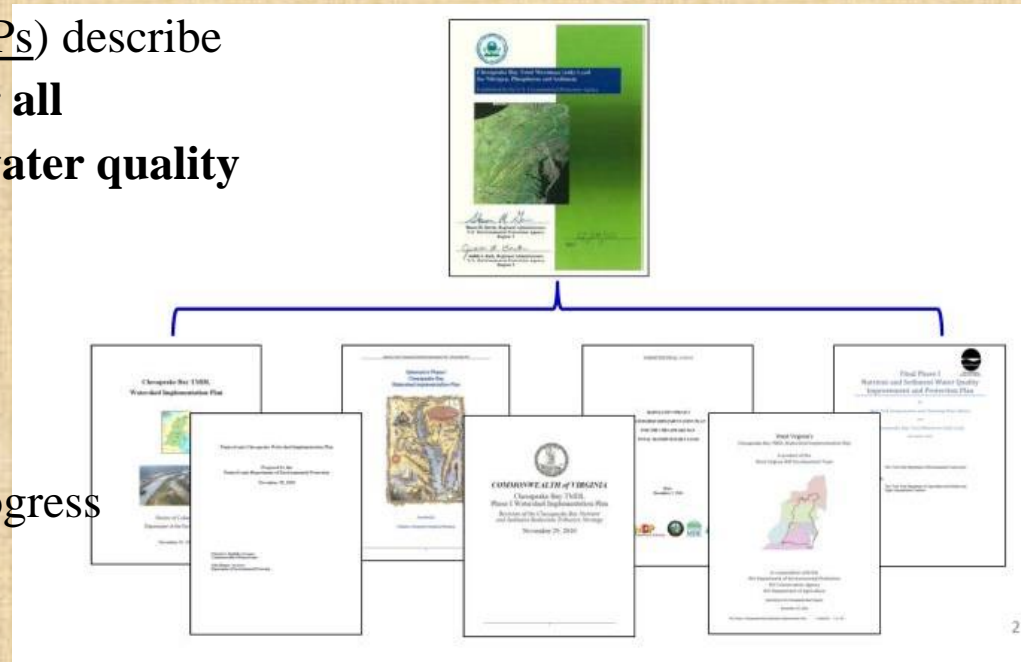
What do these results mean for jurisdictions?

Table 6-5: Final jurisdiction-basin planning targets for the 2017 Midpoint Assessment.

StateBasin	2018 Planning Targets approved by PSC		2019 Planning Targets with Exchanges and Sediment			2020 Climate Adjustments		2020 Planning Targets with Climate reductions	
	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Sediment	Nitrogen	Phosphorus	Nitrogen	Phosphorus
DC Potomac	2.42	0.130	2.42	0.130	41.9	0.01	0.001	2.42	0.129
DE Eastern Shore	4.55	0.108	4.55	0.108	26.7	0.04	0.003	4.51	0.105
MD Eastern Shore	15.21	1.286	15.60	1.290	2903.4	0.37	0.032	15.23	1.258
MD Patuxent	3.21	0.301	3.21	0.300	437.7	0.11	0.019	3.09	0.281
MD Potomac	15.30	1.092	15.80	1.090	1928.0	0.21	0.033	15.59	1.057
MD Susquehanna	1.18	0.053	1.60	0.050	113.8	0.14	0.007	1.46	0.043
MD Western Shore	10.89	0.948	9.63	0.950	2959.9	0.31	0.020	9.32	0.929
NY Susquehanna	11.53	0.587	11.53	0.587	532.7	0.40	0.044	11.13	0.543
PA Eastern Shore	0.45	0.025	0.46	0.022	27.4	0.05	0.005	0.41	0.017
PA Potomac	6.11	0.357	6.14	0.338	295.5	0.04	0.008	6.11	0.330
PA Susquehanna	66.59	2.661	66.87	2.544	1838.2	1.72	0.082	65.14	2.462
PA Western Shore	0.02	0.001	0.02	0.001	0.3	0.00	0.000	0.02	0.001
VA Eastern Shore	1.43	0.164	1.83	0.152	473.3	0.01	0.000	1.82	0.152
VA James	25.92	2.731	21.81	2.241	2015.2	0.30	0.143	21.51	2.097
VA Potomac	16.00	1.892	16.51	1.823	1929.7	0.56	0.073	15.95	1.750
VA Rappahannock	6.85	0.849	7.09	0.819	1505.1	0.54	0.102	6.54	0.717
VA York	5.52	0.556	5.71	0.548	949.1	0.17	0.018	5.54	0.530
WV James	0.04	0.005	0.05	0.006	13.0	0.00	0.000	0.05	0.006
WV Potomac	8.18	0.427	8.18	0.427	595.9	0.00	0.008	8.18	0.418

Chesapeake Partnership Accountability Framework

- 7 Watershed Implementation Plans (WIPs) describe what amount, how, where, and when for **all implementation required to achieve water quality standards by 2025**.
 - Phase I in 2010
 - Phase II in 2012
 - **Phase III in 2019**
- 2-Year Milestones ensure short term progress



By the 2022-2023 milestones there will be quantifiable reductions applied to defend water quality standards from future (2025) climate risk.



Example Climate Narrative WQGIT November 2020

In February 2020, the Chesapeake Bay Program's Water Quality Goal Implementation Team (WQGIT) decided to offset impacts from climate change during the period 1995 through 2025 by asking the seven watershed jurisdictions (Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia) to have additional nitrogen and phosphorus (nutrients) pollutant reduction practices in place across the watershed by 2025. This decision was approved by the Management Board in October 2020.

The WQGIT reviewed modeling scenarios to provide insight on how climate change will impact the Chesapeake Bay watershed in the future. Scenarios were run for the years 2035, 2045, and 2055, while showing the impacts from different competing climatic influences, e.g., sea-level rise and temperature changes. The overall assessment predicts that future climate change impacts will continue over the near-term, increasing the need for additional pollutant reduction efforts.

As a result of these findings, the WQGIT decided that the current 2035 estimates should be documented and quantified at the watershed-scale in each jurisdiction's 2022-23 milestones. During this time, the partnership will continue to refine its climate modeling and assessment framework in order to update the 2035 estimates in 2025.



Example Climate Narrative WQGIT November 2020 (cont.)

For **CBP Partner C** what is needed to offset these additional pollutant loads due to the climate change impacts from 1995-2025 on water quality require addressing an additional reductions of x million pounds of nitrogen, y million pounds phosphorus, and z million pounds sediment reductions beyond what is called for in the 2019 Planning Targets (PSC, December 2020).

For **Partner C** the additional load reductions are estimated to be divided among basins s , t , and v as shown in Table W , however, *Partner C is free to apportion the additional reductions anywhere among its basins.*

In 2035, this amount will grow by a currently estimated q, r, s , million pounds (Table W) that needs to be offset for nitrogen phosphorus and sediment, respectively, which is a factor of d the amount required by 2025. Beyond 2035, the 2025-2035 increase rate of m million additional pounds is expected to continue for each subsequent decade. Based on this current estimate, substantive efforts are needed after 2025 to address how climate change will impact Chesapeake Bay water quality.



Example Climate Narrative WQGIT November 2020 *(cont.)*

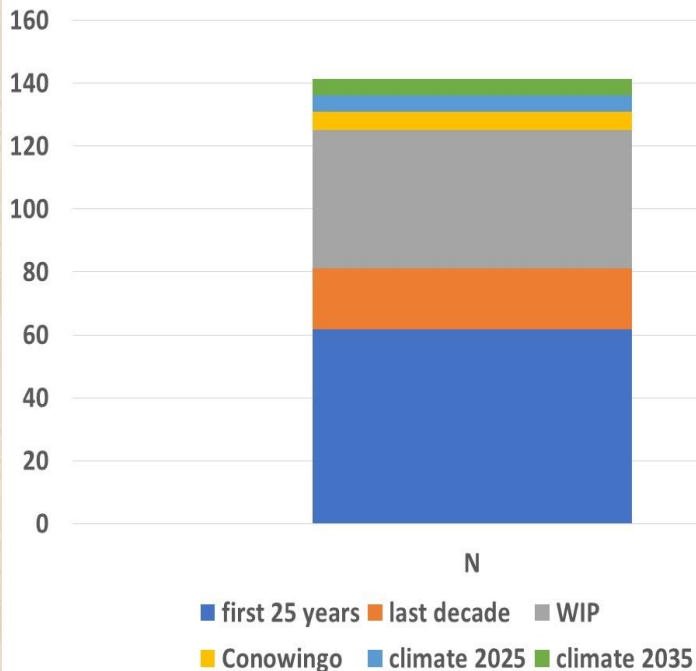
When the 2035 estimates are reassessed in 2025, they will benefit from updated tools, methods, and data, as well as a shorter projection into the future for impacts such as temperature, precipitation, and sea-level rise. The Partnership expects that an improved capability to assess shallow water and open water designated use will be available by this time. Additionally, revisions to the water quality standard may be considered, which would impact attainment assessments.

Revisions to the Watershed Model and the 2035 climate impact assessment will be accomplished by the Chesapeake Bay Program's Modeling Workgroup, along with input from myriad workgroups across the partnership and other experts. The results will be presented to the WQGIT in 2025, and at that time, the group will explore all available and practical approaches in allocating additional pollutant loads while pursuing consensus-based implementation recommendations.

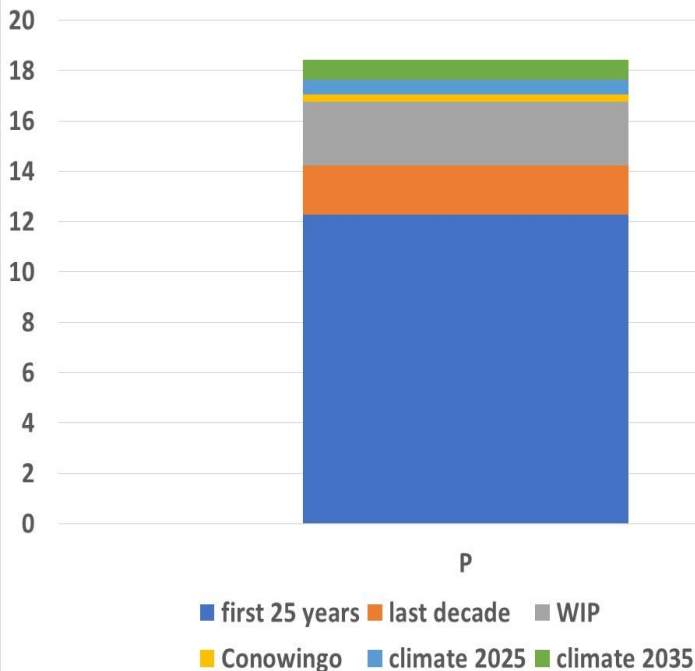


Putting Climate Effects Into Perspective

Nitrogen Reductions in the CB watershed



Phosphorus Reductions in the CB watershed



Source: Load reductions from CAST-2019
(current version of the CBP watershed model)²⁰



Next Steps

- Develop draft versions of Climate Narrative for the WQGIT.
- Present drafts to WQGIT at their May meeting for comment.
- WQGIT will present their recommended Climate Narratives to the MB for consideration in the 2022-2023 Milestones
- Provisions for Climate Narratives being made available to the CBP Partnership for the 2022-2023 Milestones.

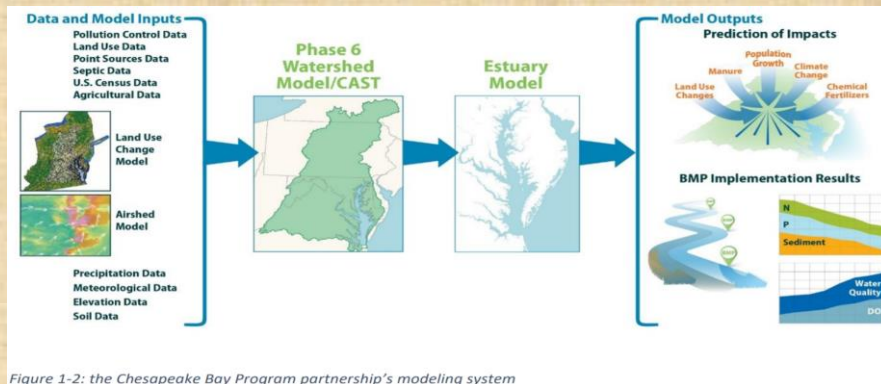


Figure 1-2: the Chesapeake Bay Program partnership's modeling system



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