Application of Main Bay Model (MBM) and Multiple Tributary Models (MTMs) to Support Chesapeake TMDL

Phase 7 Model Office Hours Meeting

February 5, 2024

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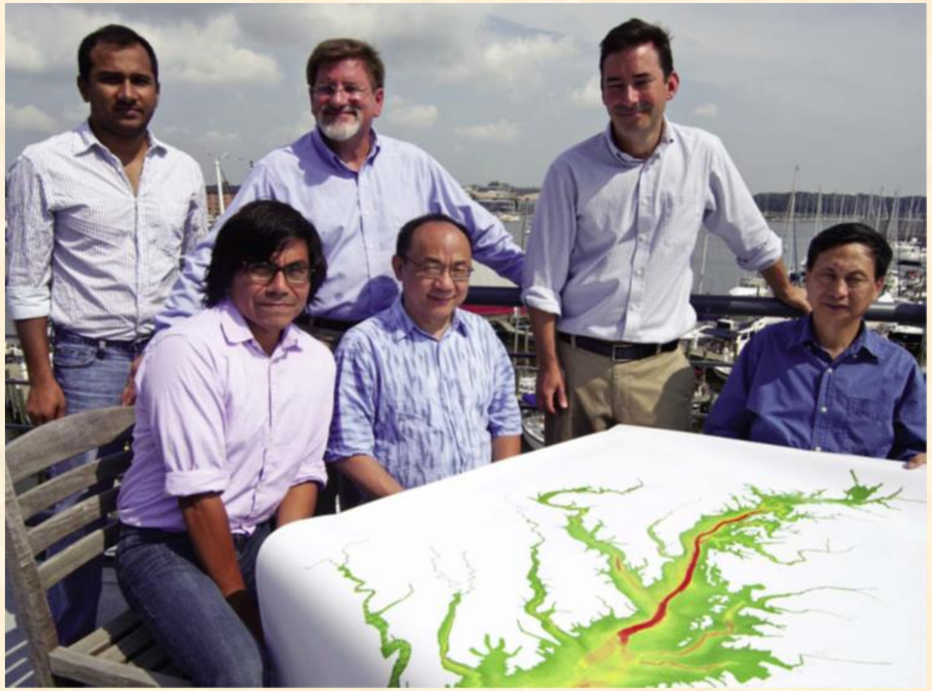

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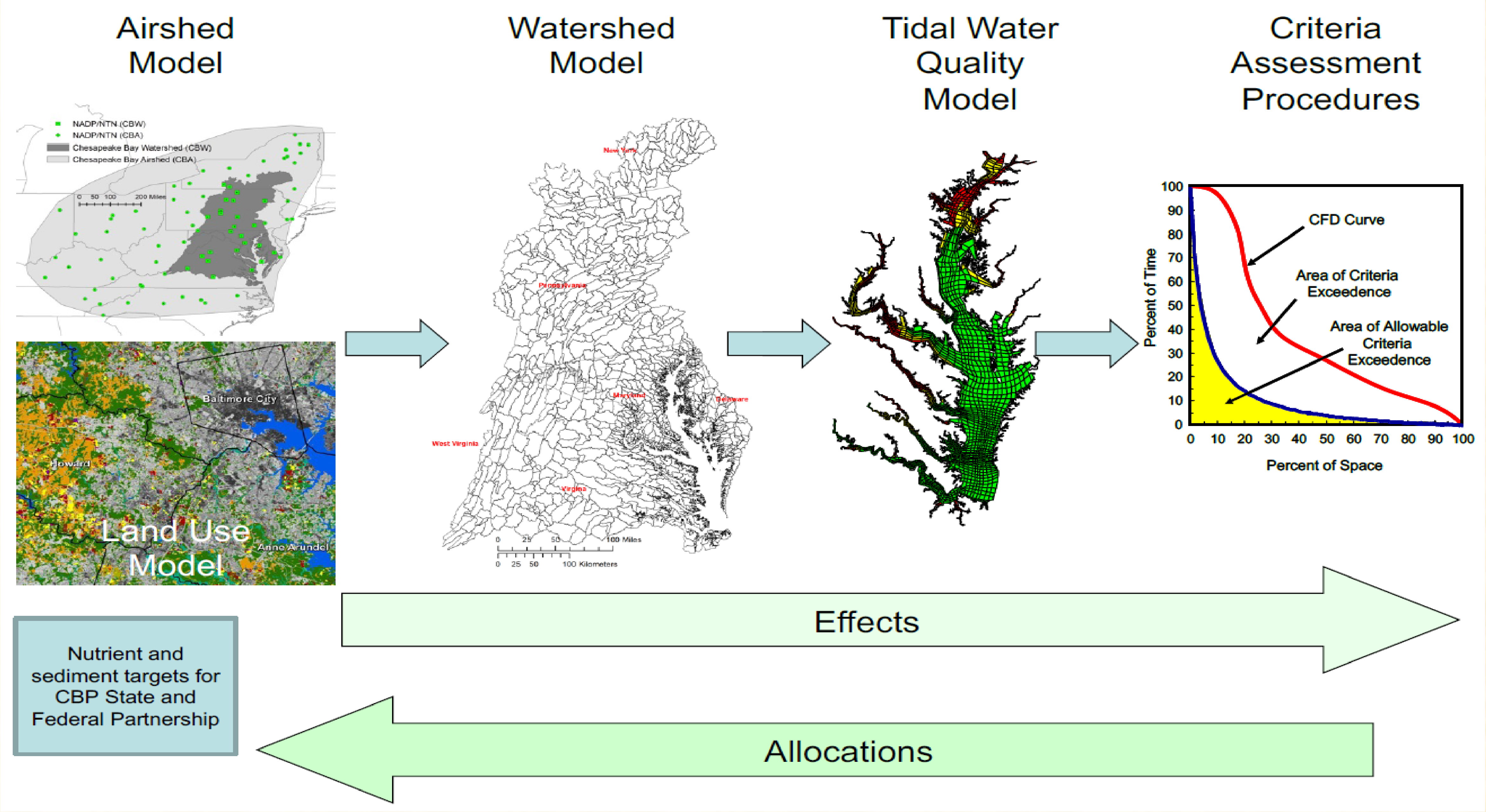
The CBP Climate Change Assessment



Elements of Chesapeake Water Quality Climate Risk Assessment

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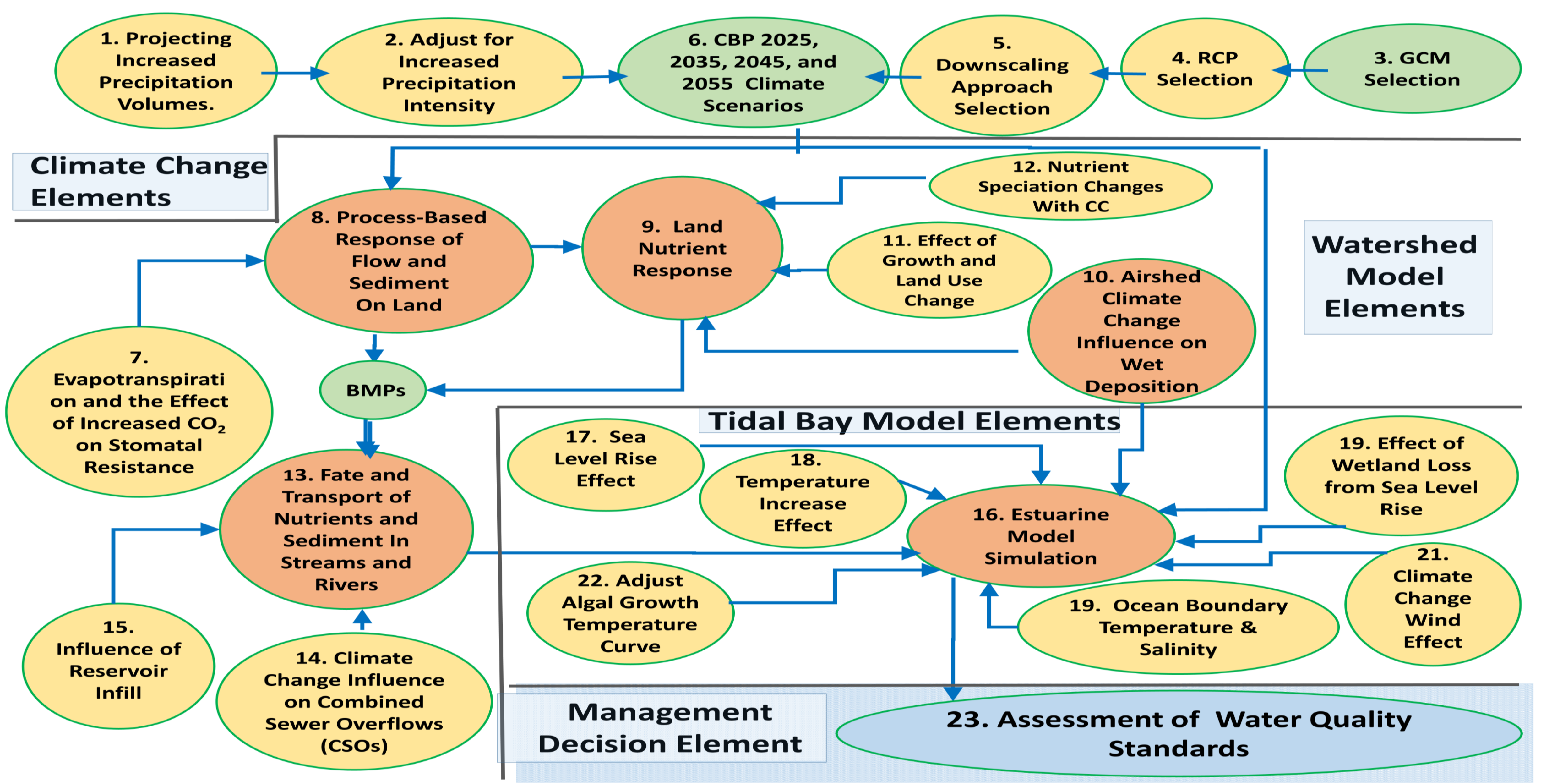

Elements of 2025 Climate Change (1995-2025)

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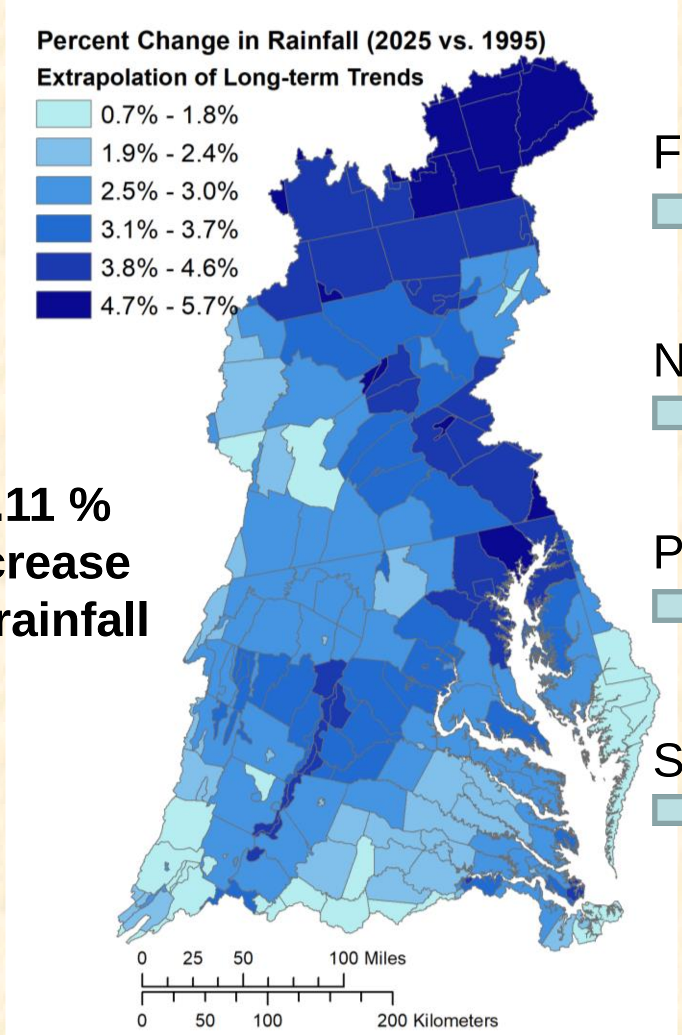
Air-temperature increase: 1.06 °C

+3.11 % Increase in rainfall



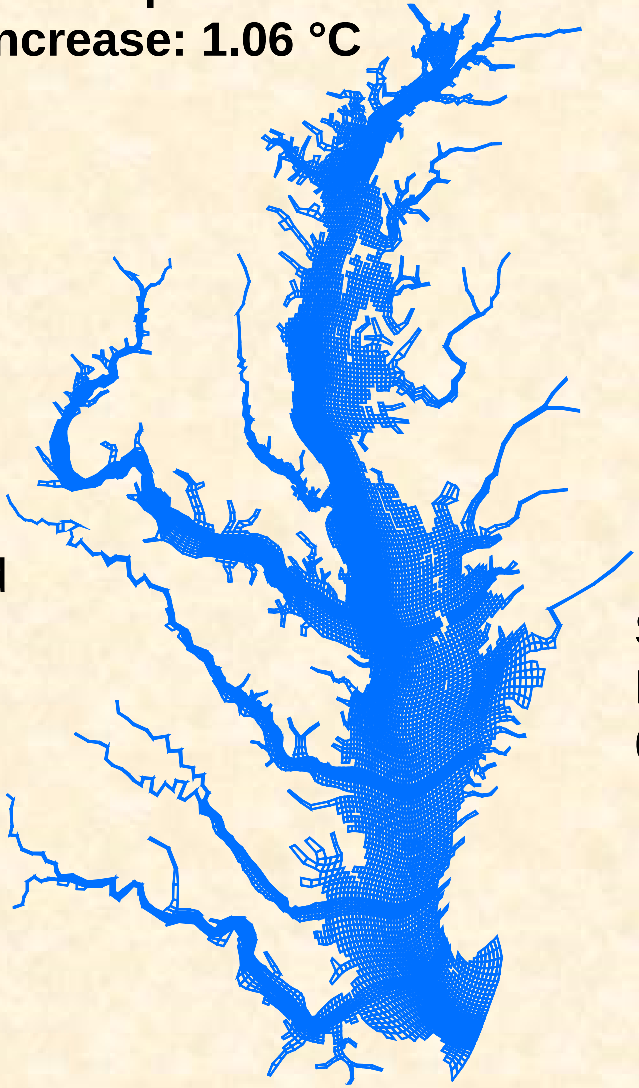
Phase 6 Watershed Model

Flow
2.4% Increase

Nitrogen Load
2.6% Increase

Phosphorus Load
4.5% Increase

Sediment Load
3.8% Increase



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)

Recommendations of STAC's Chesapeake Bay Program Modeling in 2025 and Beyond: A Proactive Visioning Workshop

- Potential future development of the hydrodynamic and biogeochemical models should focus on transition to a hydrodynamic model with an unstructured grid that can provide much greater resolution in the shallow tributaries of the Bay.
- The current living resource simulation in the CBP water quality model, which includes submerged aquatic vegetation (SAV) and oysters, should continue to be developed with the goal of improving these models.
- The approaches, processes, and parameterizations used in the CBP models for estimating the impacts of climate change and sea level rise on the TMDL should be reexamined in detail.
- The CBP partnership models should strive to provide outputs related to local ecosystem services and economic impacts that are of direct interest to local stakeholders.

Hood, R.R., G. Shenk, R. Dixon, W. Ball, J. Bash, C. Cerco, P. Claggett, L. Harris, T.F. Ihde, L. Linker, C. Sherwood, and L. Wainger. 2019. Chesapeake Bay Program Modeling in 2025 and Beyond: A Proactive Visioning Workshop. STAC Publication Number 19-002, Edgewater, MD. 62 pages.

Recommendations of STAC's Chesapeake Bay Program Modeling in 2025 and Beyond: A Proactive Visioning Workshop

- The CBP should continue to <u>work toward strengthening its ties with the scientific community</u> and it should continue to support adaptive management.
- <u>Future model development should continue to be driven by management needs</u> and future models must support time-certain management deadlines.
- <u>The 2025 next generation CBP suite of models should provide support of better understanding across a wide range of scales</u>. Models that use unstructured grids are particularly well suited to cover this wide range of scales.

Hood, R.R., G. Shenk, R. Dixon, W. Ball, J. Bash, C. Cerco, P. Claggett, L. Harris, T.F. Ihde, L. Linker, C. Sherwood, and L. Wainger. 2019. Chesapeake Bay Program Modeling in 2025 and Beyond: A Proactive Visioning Workshop. STAC Publication Number 19-002, Edgewater, MD. 62 pages.

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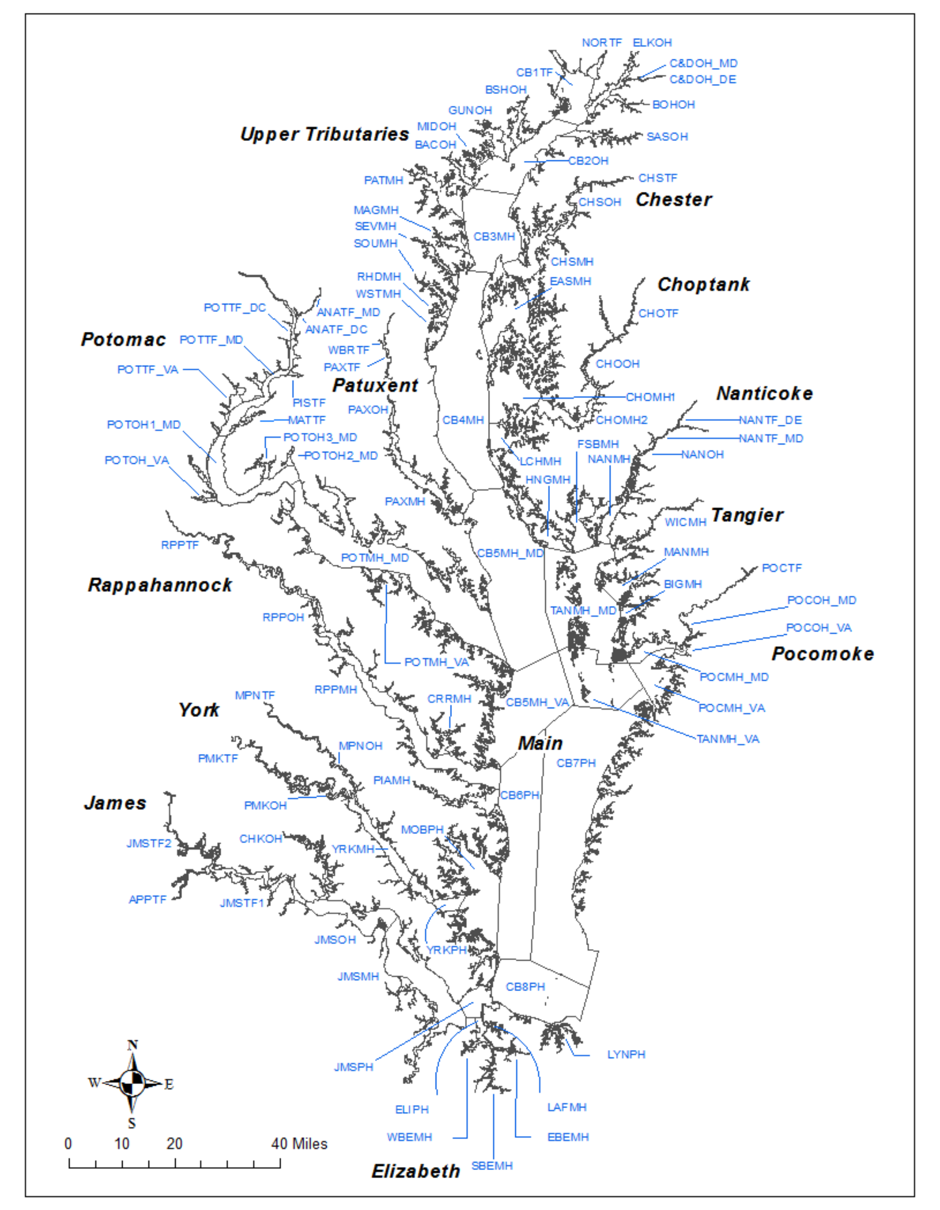
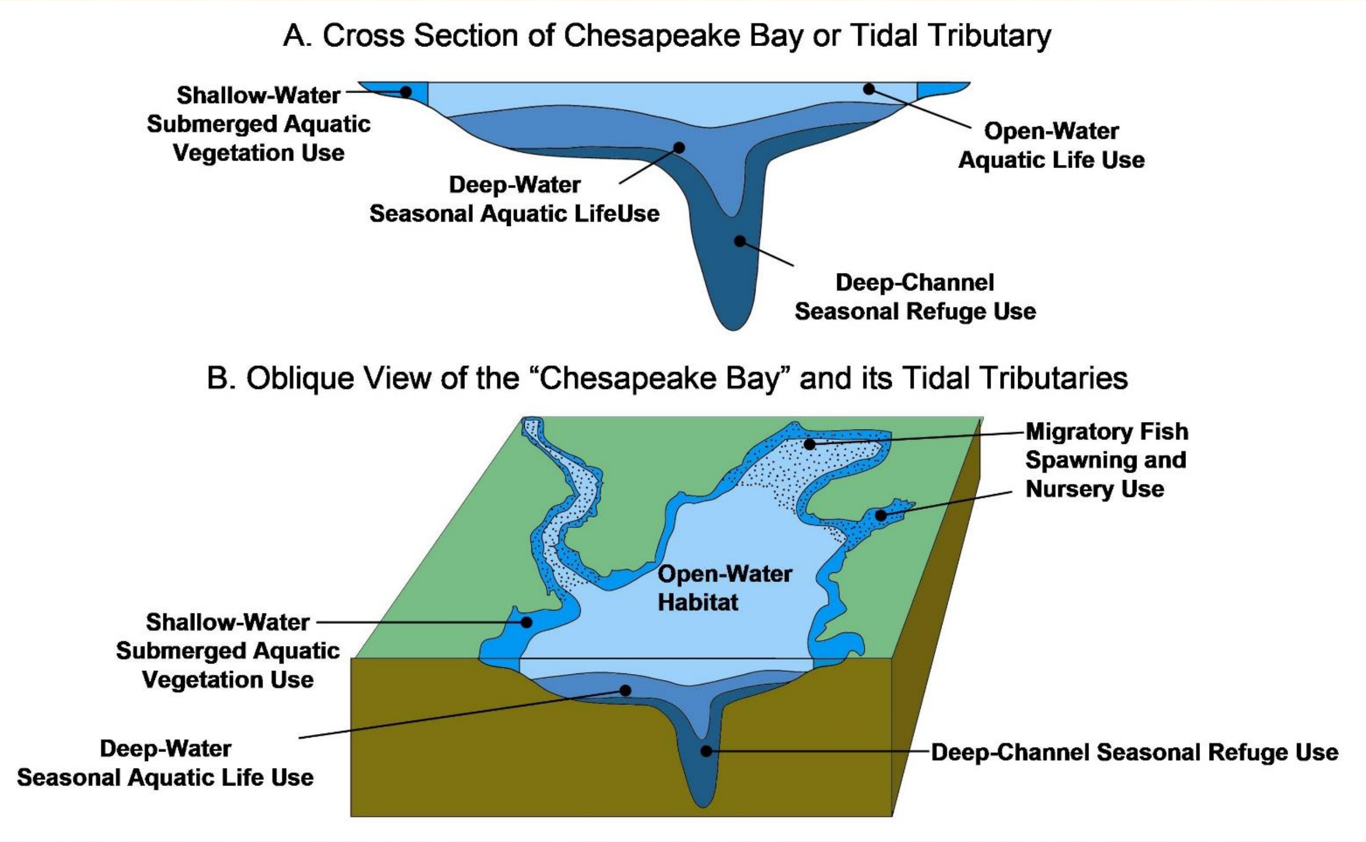
Overview of Bay Designated Uses



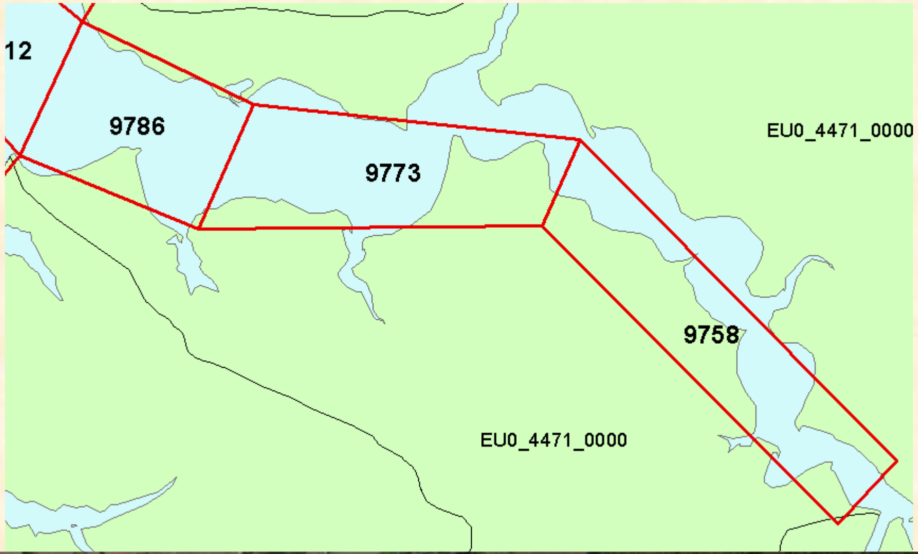


Motivation for Development and Application of MTMs

Improved Assessment of Shallow Water Processes. The MTMs will be able to better assess shallow water processes in the shallow Open-Water regions of the Bay. The majority of the 93 Chesapeake TMDL segments, also called CB-segments or designated uses, have only an Open-Water DO water quality standard and lack Deep-Water or Deep Channel DO standards. The Phase 6 2017 CBP Bay Model was unable to effectively simulate shallow water (< 2 m) Open-Water DO standards under climate change conditions. With the Phase 7 MBM and MTMs the shallow water processes are only now being understood and are beginning to be effectively modeled. The MTM models will provide the CBP partners with enhanced decision support tools for determining how to best restore and protect the Bay's extensive shallow water habitats.

Improved Assessment of Shallow Water Processes

The 2017 Bay Model had a three segment Corsica River. The Corsica River Shallow Water Test Bed for the MBM and MTMs has 5,029 cells with up to 20 m resolution and 5 sigma layers of depth.



The Watershed Model loading to the Corsica River in 2017 was on an order of a 30 square mile watershed that in Phase 7 will be quantified at about a one square mile watershed.

Motivation for Development and Application of MTMs

Resolving Special Issues - James River Chlorophyll Assessment. The MTMs will be able to resolve special issues like the James Chlorophyll Assessment. The James River chlorophyll Assessment is currently oriented to 2025 climate change conditions but there is an interest in updating the assessment for climate change conditions anticipated beyond 2025. With the MTMs this can be done by taking advantage of the CBP work in the assessment of 2035 conditions with updated watershed, airshed, and estuary models and in leveraging the combined analysis to provide the most complete assessment available for the James Chlorophyll Assessment at least cost.

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Overview of the Main Bay Model (MBM) and Multiple Tributary Model (MTM) Workplan: Interim Development Phase (2023-2024)

Calendar Year		2023				2024				2025			
Calendar Quarter		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Project Year		Year 2				Year 3				Year 4			
Task 2 Interim MBM and MTM Development (2023 – 2024)	Task 2	■	■	■	■	■	■	■	■				
2-1. Initiate MTM activities (Q1-Q2: 2023).	Task 2.1		■	■									
2-2. Kick-off joint meetings of MBM and MTM Teams with Mod WG (Q1-Q2: 2023)	Task 2.2	■	■										
2-3. Conduct full initial calibration and verification of hydrodynamic and WQ model output (Q3-Q4: 2024).	Task 2.3							■	■				
2-4. Address important knowledge gaps in ICM (All Qs: 2024).	Task 2.4	■	■	■	■	■	■	■	■				
2-5. Begin completion of work to improve shallow water dynamics in MBM (All Qs: 2024).	Task 2.5			■	■	■	■	■	■				
2-6. Begin completion of work to improve shallow water dynamics in MTMs (All Qs: 2024).	Task 2.6			■	■	■	■	■	■				
2-7. Completion of work on basic living resource linkages of refined chlorophyll, wetland, and SAV simulation an	Task 2.7				■	■	■	■	■				
2-8. Completion of work using MBM and MTMs to better resolve CBP problem segments (All Qs: 2024).	Task 2.8					■	■	■	■				
2-9. Completion of work examining CC influence on SAV, shallow water, & phenology of CC watershed loads anc	Task 2.9					■	■	■	■				
Task 3 Final MBM and MTM Development (2005)	Task 3									■	■	■	■
3-1. Provide a fully operational MBM that meets the needs of CBP (Q2-Q3: 2025).	Task 3.1										■	■	
3-2. Finish documentation on the software package in a report that will include detailed documentation on model st	Task 3.2												■
3-3. Demonstrate feasibility and utility of using a state of the science UG model to better estimate Chesapeake WQ	Task 3.3									■	■	■	■
3-4. Transfer the software package to CBPO for operational testing, and work with CBPO personnel to test the moc	Task 3.4											■	■
3-5. All MBM and MTMs fully operational (Q4: 2025).	Task 3.5												■

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Overview of the MBM & MTM: Final Model Development (2025)

Calendar Year			2025			
Calendar Quarter			Q1	Q2	Q3	Q4
Project Year			Year 4			
Task 3 Final MBM and MTM Development (2005)		Task 3				
3-1. Provide a fully operational MBM that meets the needs of CBP (Q2-Q3: 2025).		Task 3.1				
3-2. Finish documentation on the software package in a report that will include detailed documentation on model st		Task 3.2				
3-3. Demonstrate feasibility and utility of using a state of the science UG model to better estimate Chesapeake WQ		Task 3.3				
3-4. Transfer the software package to CBPO for operational testing, and work with CBPO personnel to test the mod		Task 3.4				
3-5. All MBM and MTMs fully operational (Q4: 2025).		Task 3.5				
3-6. Conduct full review of al MBM and MTMs with CBP technical and management groups and with STAC (All (		Task 3.6				
3-7. Review all recent studies related to Bay WQ processes and work with CBP and Mod-WG to identify key miss		Task 3.7				
3-8. Provide estuarine models, analysis tools, and initial scoping scenarios, final code version and other materials		Task 3.8				
3-9. Finalize work to improve shallow water dynamics in MBM (Q1-Q2: 2025).		Task 3.9				
3-10. Finalize work to improve shallow water dynamics in MTMs (Q1-Q2: 2025).		Task 3.10				
3-11. Finalize work on basic living resource linkages of refined chlorophyll, wetland, and SAV simulation and pot		Task 3.11				
3-12. Finalize work using MBM and MTMs to better resolve CBP problem segments (Q1-Q2: 2025).		Task 3.12				
3-13. Finalize work examining CC influence on SAV, shallow water, and phenology of CC watershed loads and tid		Task 3.13				

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MBM and MTM Review (2026) and Application (2027)

	2026				2027			
Calendar Year	2026				2027			
Calendar Quarter	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Project Year	Year 5				Year 6			
Task 4. MBM and MTM Review (2026) and Application (2027)								
4-1. Provide final estuarine models, analysis tools, model documentation and other materials to CBPO (Q1:2026).								
4-2. Improve the CBP management decisions through the successful application of developing quantitative assessments c								
4-3. Provide initial (2026) and final (2027) scoping scenarios, analyses, and other materials to support Chesapeake prot								
4-4. Develop user-friendly interfaces with model software and technical transfer training so that a variety of stakeholder								
4-5. Develop and apply 2035 CC and all other management MBM and MTM scenarios as determined by CBP decision r								
4-6. Document the findings and recommendations in the final report (Yr 6: 2027).								
4-7. Provide final TMDL scenario simulation results to address the needs and requirements of CBP decision makers and								

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MBM and MTM Continuous Activities (2022 - 2027)

Calendar Year		2026				2027			
Calendar Quarter		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Project Year		Year 5				Year 6			
Task 5. Continuous Activities	Task 5								
5-1. Support the Modeling Workgroup, WQGIT, and other technical and management/policy CBP groups as needed (All	Task 5.1								
5-2. Host a dedicated web site for the new Main Bay Model (MBM) (All Qs: 2022 2027 with final deliverable Q3 202	Task 5.2								
5-3. Submit annual reports with detailed documentation on model structure, major code changes, validation, and calibrat	Task 5.3								
5-4. Disseminate research findings & experiences via 1-2 journal papers/year (All Qs: 2022-2027).	Task 5.4								
5-5. Coordination/collaboration meetings among MBM and MTM Teams (All Qs: 2023-2027 coincident with CBP Moc	Task 5.5								

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Summary: MBM and MTM Outcomes

1. Nitrogen, phosphorus, and sediment loads delivered to tidal Bay waters appropriate to respond to 2035 and future climate change and achieve Bay water quality standards.

2. Amount of habitat restored as represented by achievement of the Chesapeake living-resource-based water quality standards and direct simulation, e.g., oysters, SAV, or linkages to higher trophic levels, e.g., finfish.

3. Improved knowledge about the critical load of nutrients that the Chesapeake Bay would have under 2035 and future climate change via ensemble simulations.

4. Improved CBP decision making and leadership in responding to future climate change conditions through a flexible MBM-MTM modeling framework

5. Providing improved community model and analysis tools to serve both scientific community and stakeholders by supporting a large user community (many eyes).

6. Training of next-generation scientists including graduate students in Bay ecology, hydrodynamics, and biogeochemistry toward increasing scientific capacity for environmental problem solving in the region, by leveraging the education capacity in PIs' home institutes (many hands).