A Tidal Model for the Assessment of 2035 Climate Change Risk to the Chesapeake TMDL

Modeling Quarterly Review

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Chesapeake Bay Program

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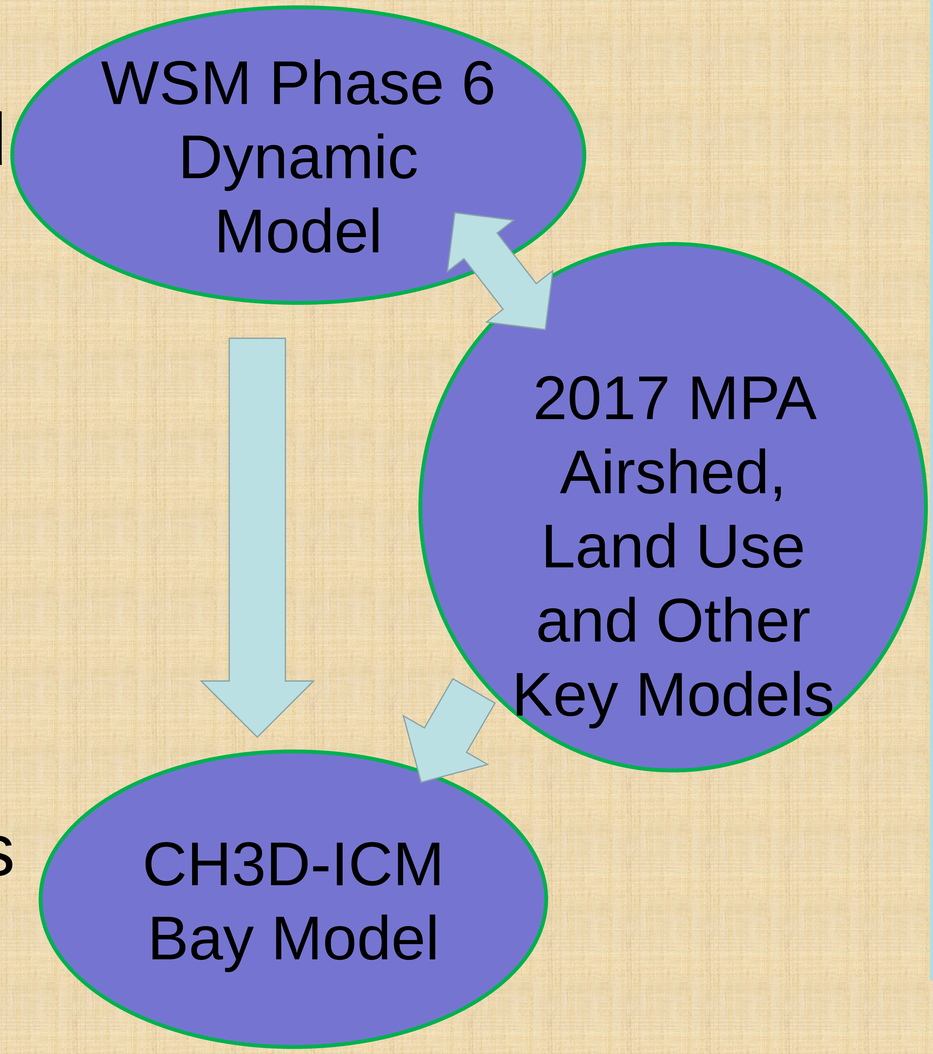
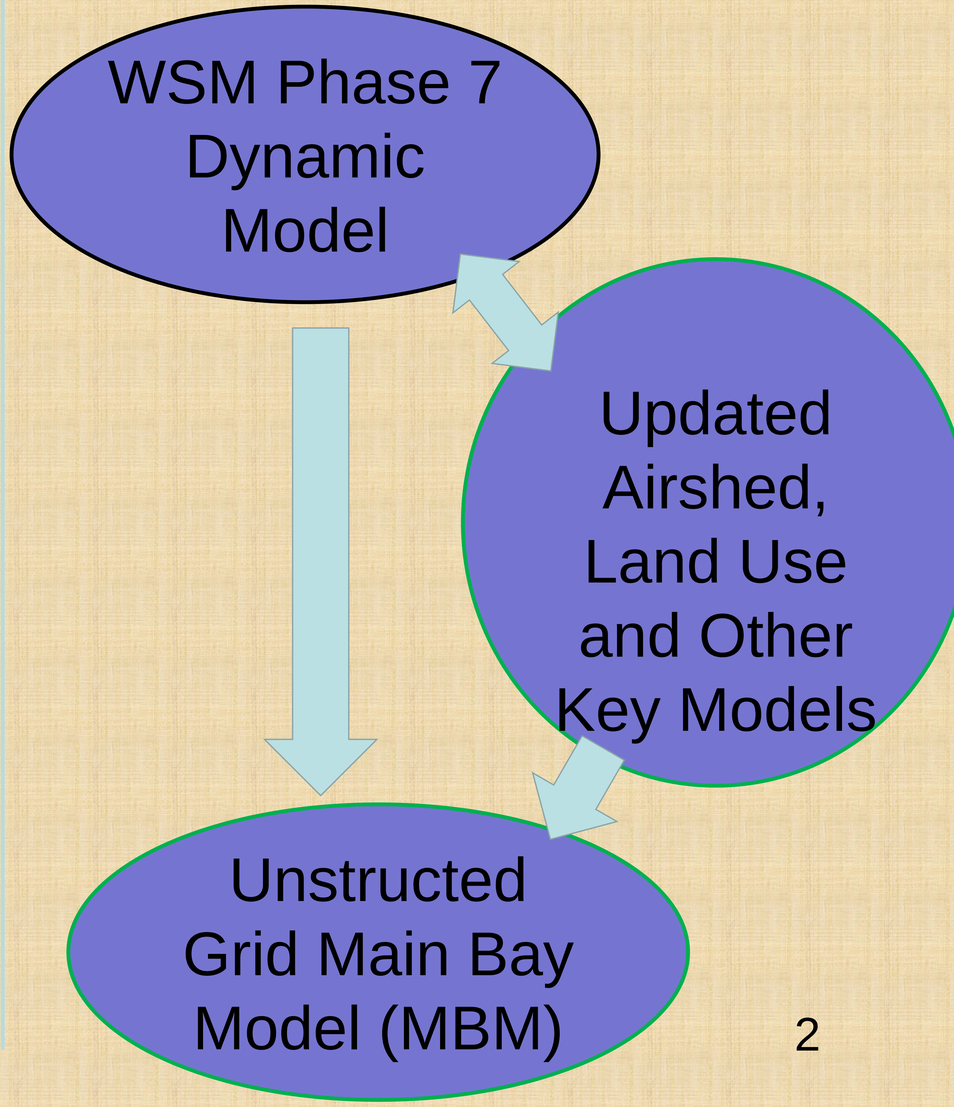
CBP Bay Model Products: Main Bay Model

Main Bay Model for 1) allowable estuarine loading and carrying capacity for Bay TMDL,
2) ancillary Bay model studies and information/ collaboration with CBP research community, and
3) regulatory scenarios and ancillary management tools (N-P and B2B exchanges etc.).

CBP Phase 6 Model application from 2017 Midpoint Assessment (MPA) to 2025 assessment of progress.

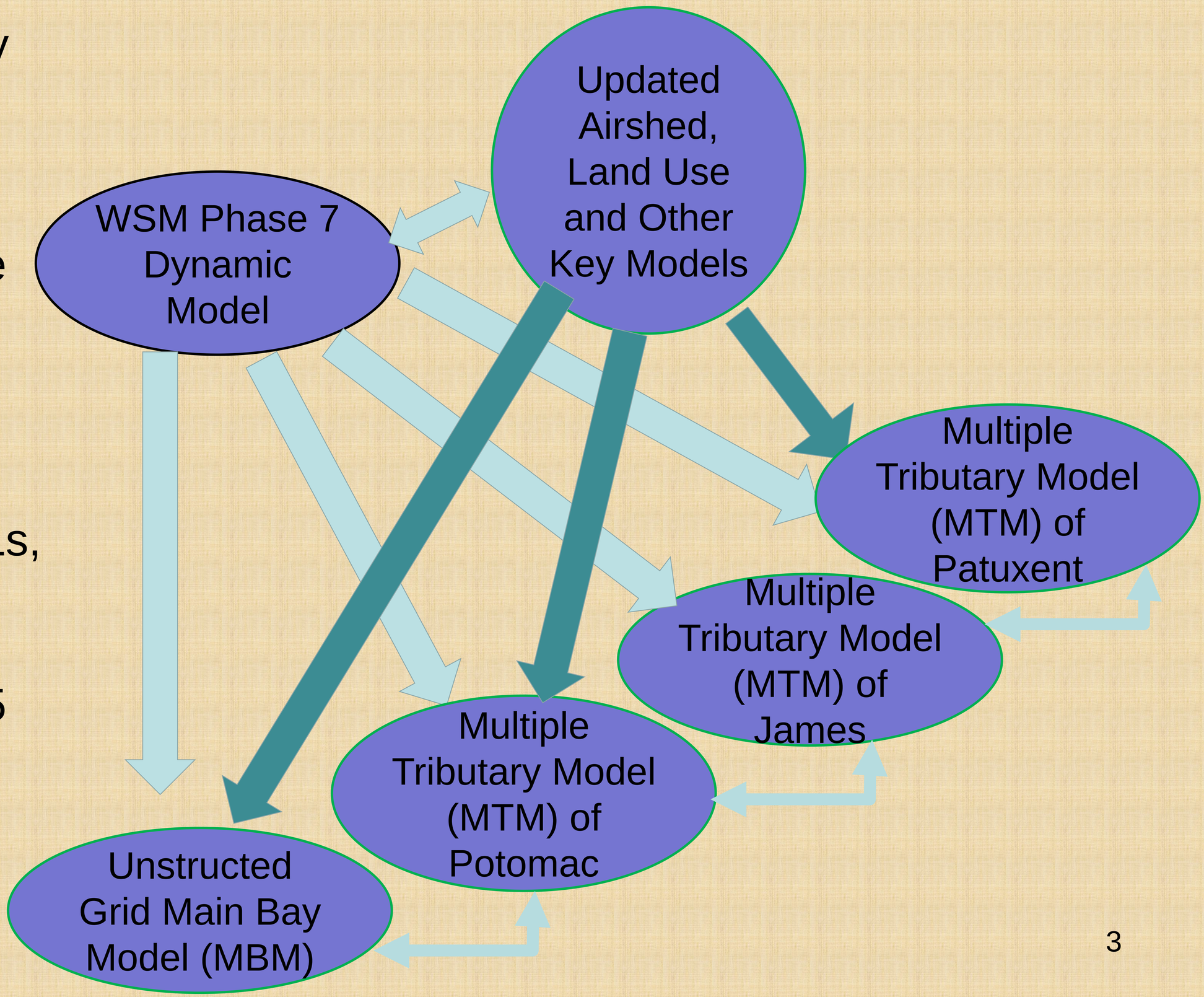


Application of Phase 7 in 2025 for 2035 Climate Change Risk Assessment.



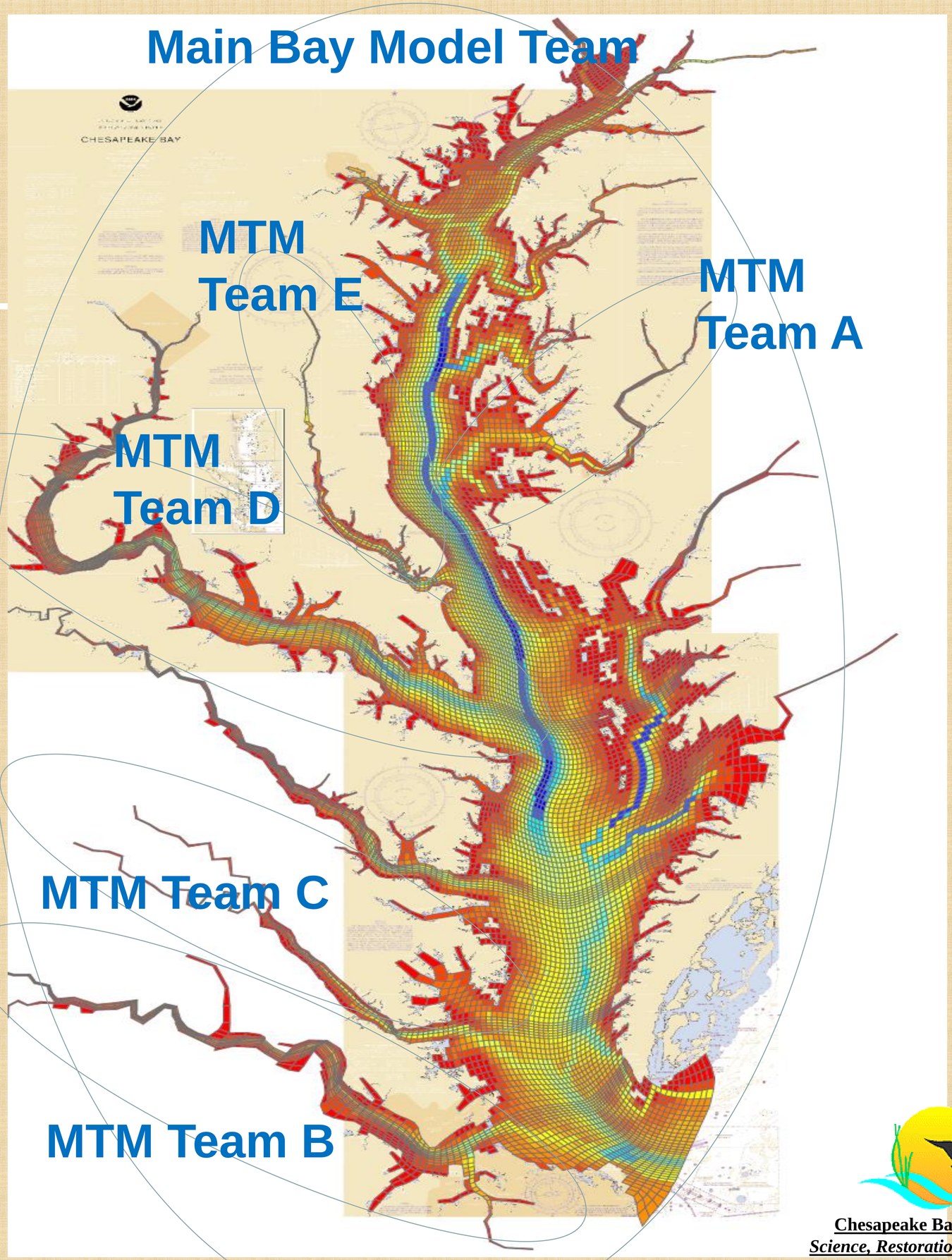
CBP Bay Model Products: Multiple Tributary Models

Multiple Tributary Models for:
1) bringing more expertise and knowledge to the table
2) providing a consistent high-grade simulation for all tidal TMDLs,
3) updating all tidal TMDLs to current and 2035 climate change conditions.



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

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



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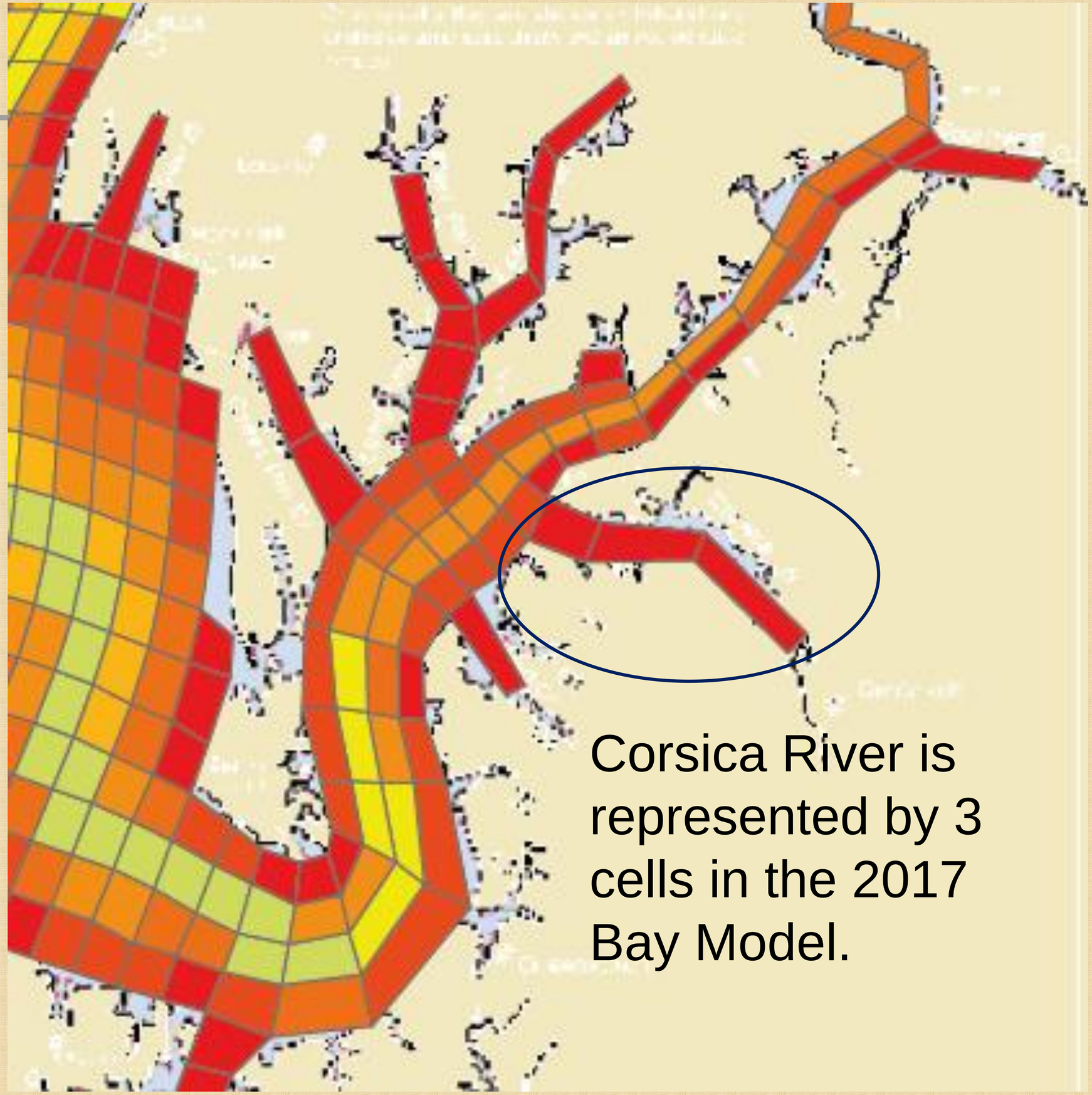
The Next Generation Bay Model:

- Allows for model development, application, and collaboration with “many eyes” though Main Bay Model (MBM) and Multiple Tributary Model (MTM) scientists and principal investigators (about a six-fold increase in tidal model practitioners).
- Fine scale MTMs will provide a high-grade simulation and analysis for all tidal TMDLs in Virginia, Maryland, and DC that will be completely consistent with one another and provide updates to current and 2035 climate change conditions.
- Replaces a highly successful Bay Model that CBP has used for three decades.

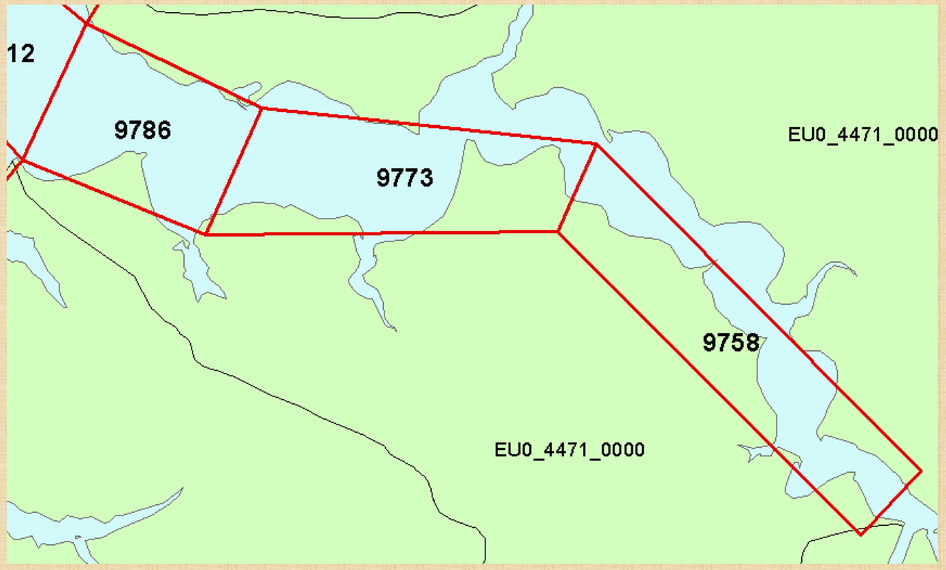
An Example From the Corsica Model Testbed for Shallow Water Processes Simulated by a MTM Prototype



Corsica River is represented by 3 cells in the 2017 Bay Model.

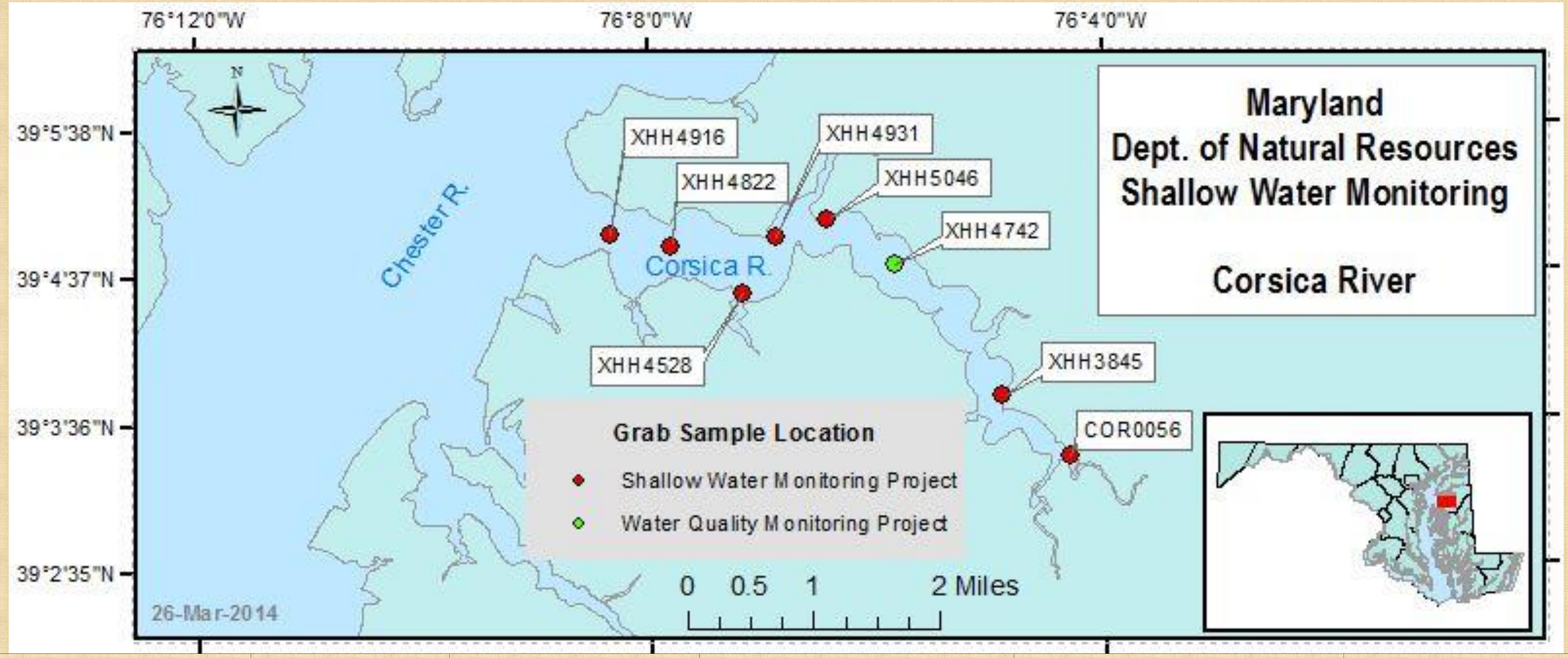
Corsica Grid

20m resolution on coast, 100m at the mouth; 5029 cells, 5 layers



Source: Jeremy Testa - Corsica River Shallow Water Modeling, CBP April Modeling Quarterly Review, April 2021.

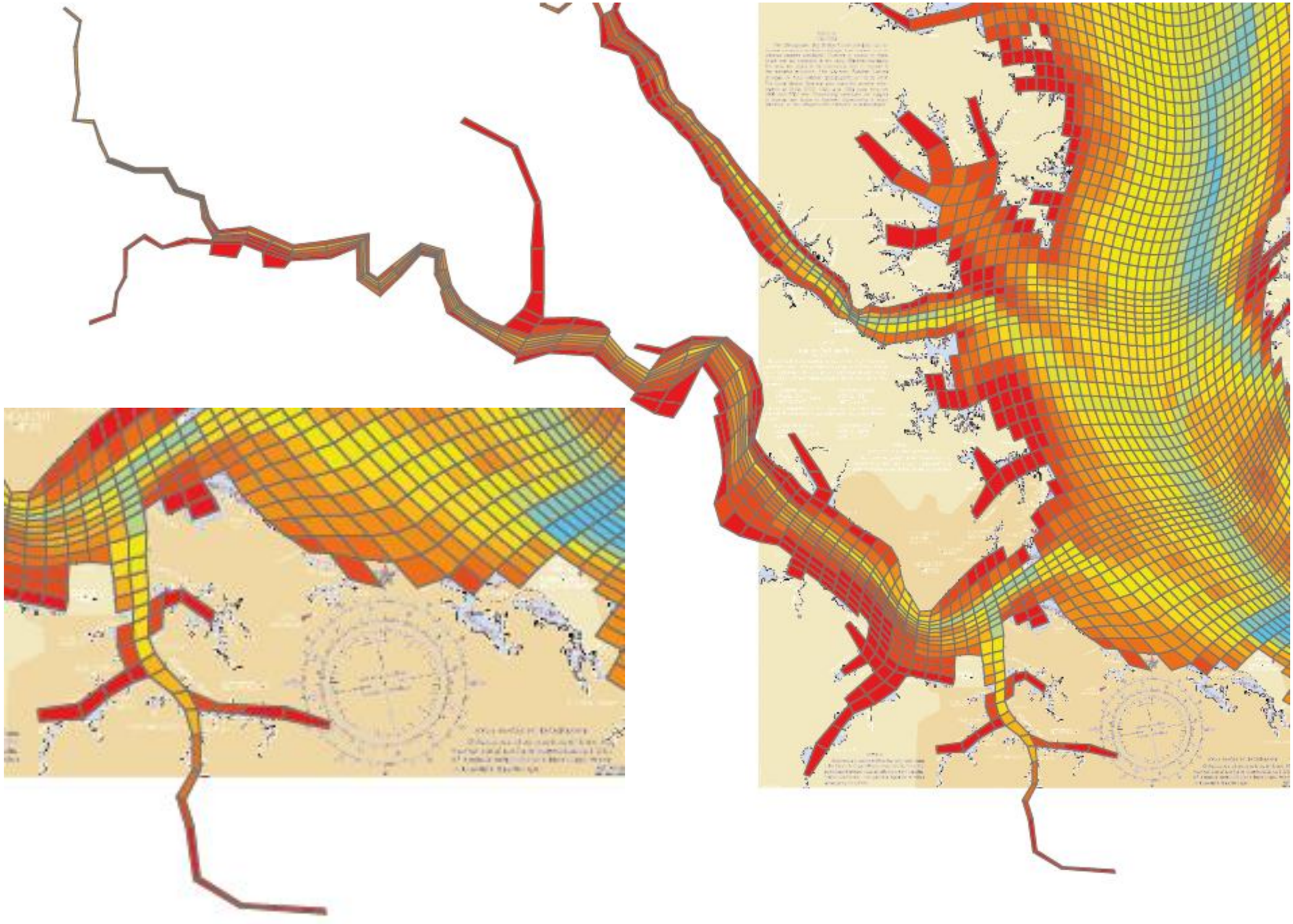
DNR monitoring stations in Corsica R.



Station	Cmon	Dflow	Tributaries	CMON yrs	Dflo yrs
XHH3851	x	x		2005 - 2013	2005 - 2013
XHH4528		x			2006 - 2013
XHH4742			x		
XHH4822		x			2003 - 2005
XHH4916	x	x		2006 - 2011	2006 - 2013
XHH4931	x	x		2006 - 2013	
XHH5046	x			2005 2006	2006 - 2013

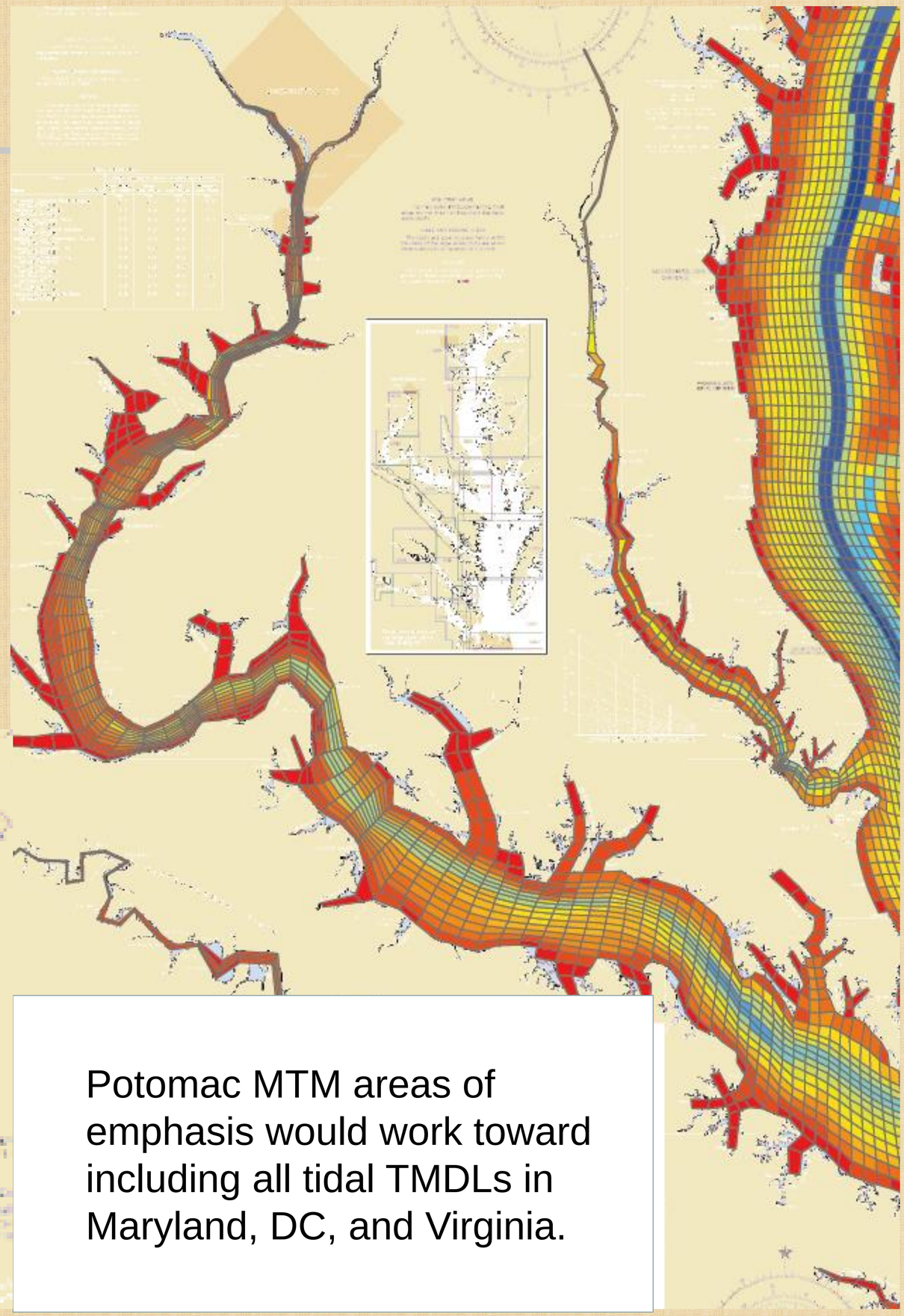
Source: Jeremy Testa - Corsica River Shallow Water Modeling Presentation, CBP Modeling April Quarterly Review April 2021.

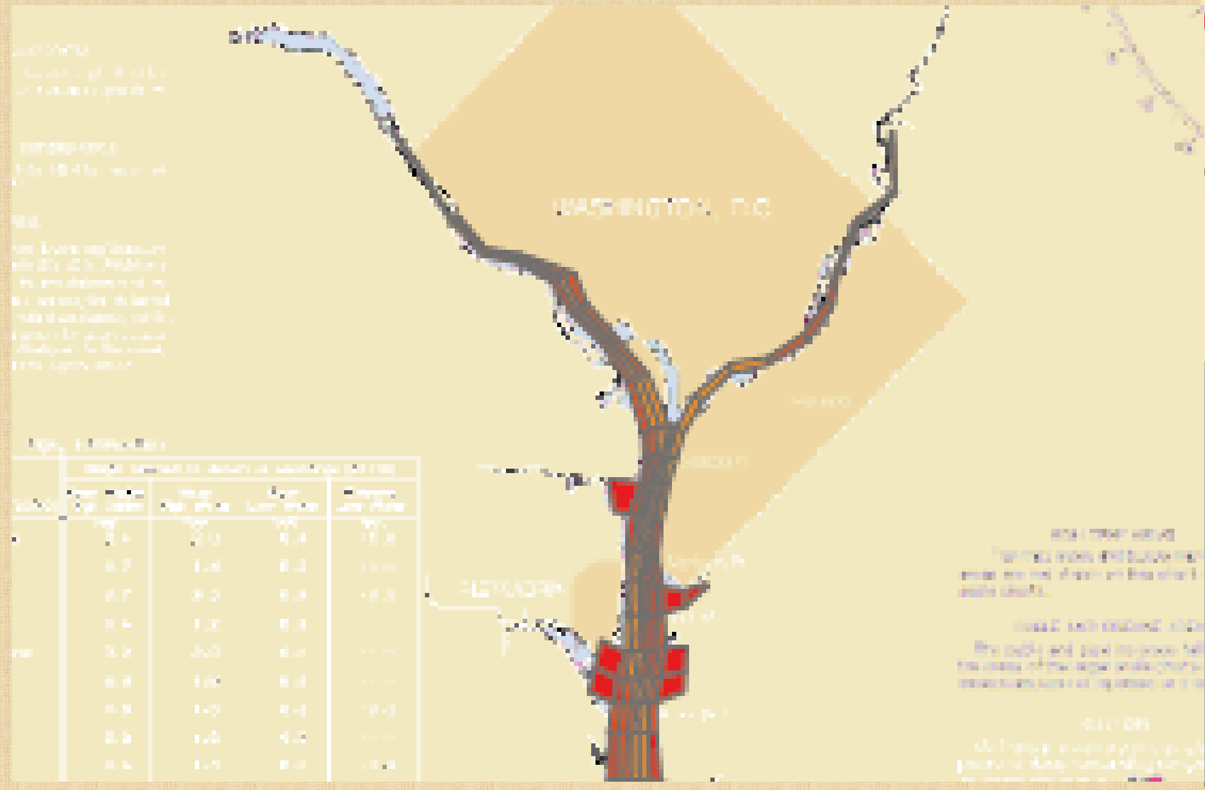
Example of a James River Prototype Having Particular Focus on the Chlorophyll TMDL and the Elizabeth and Lynnhaven Rivers



Potomac Prototype MTM

Having Particular Focus
on the Anacostia River,
the Washington Channel,
and selected Virginia
embayments.

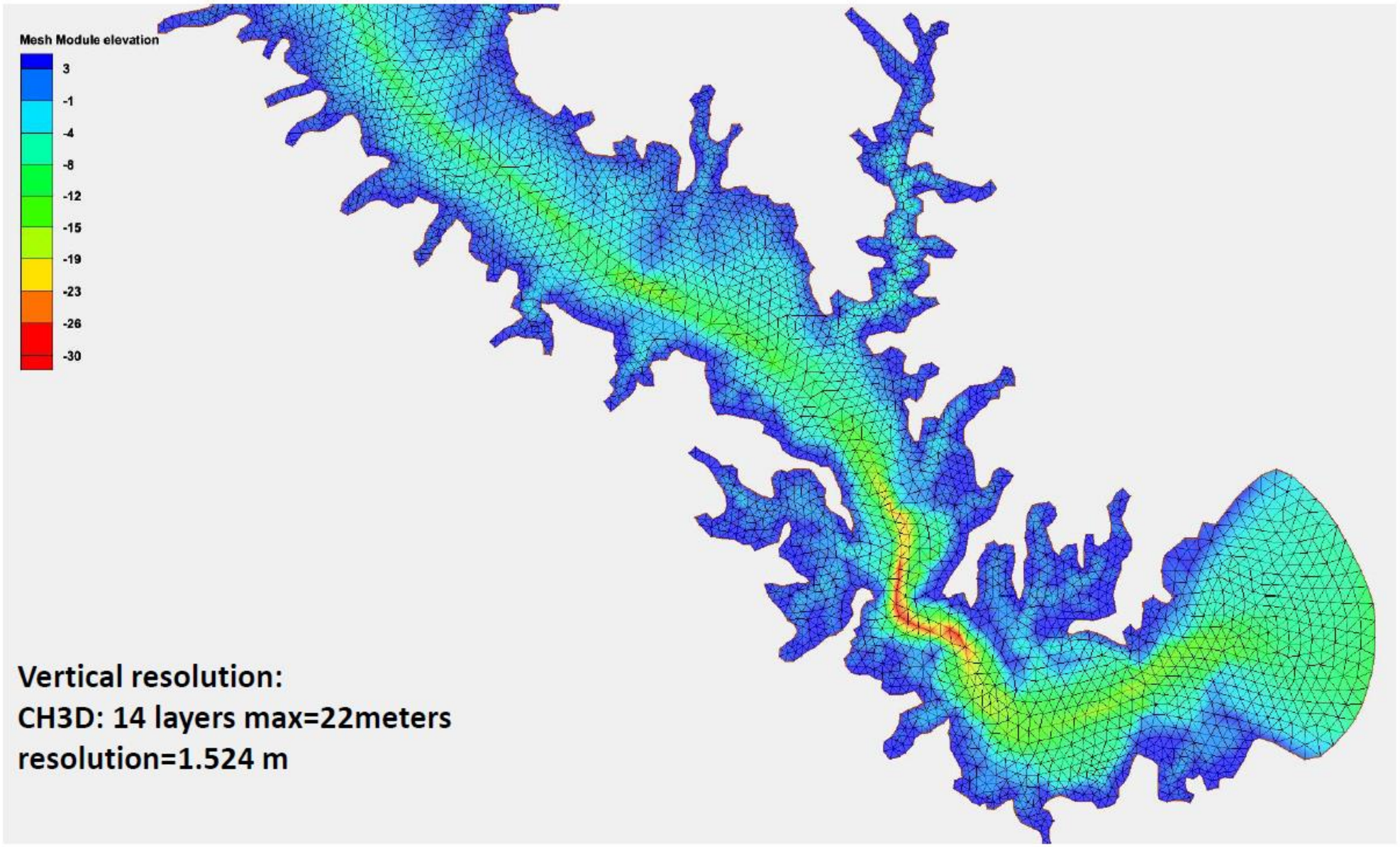




Potomac MTM areas of emphasis would work toward including all tidal TMDLs in Maryland, DC, and Virginia.

Initial Work on Patuxent Prototype MTM

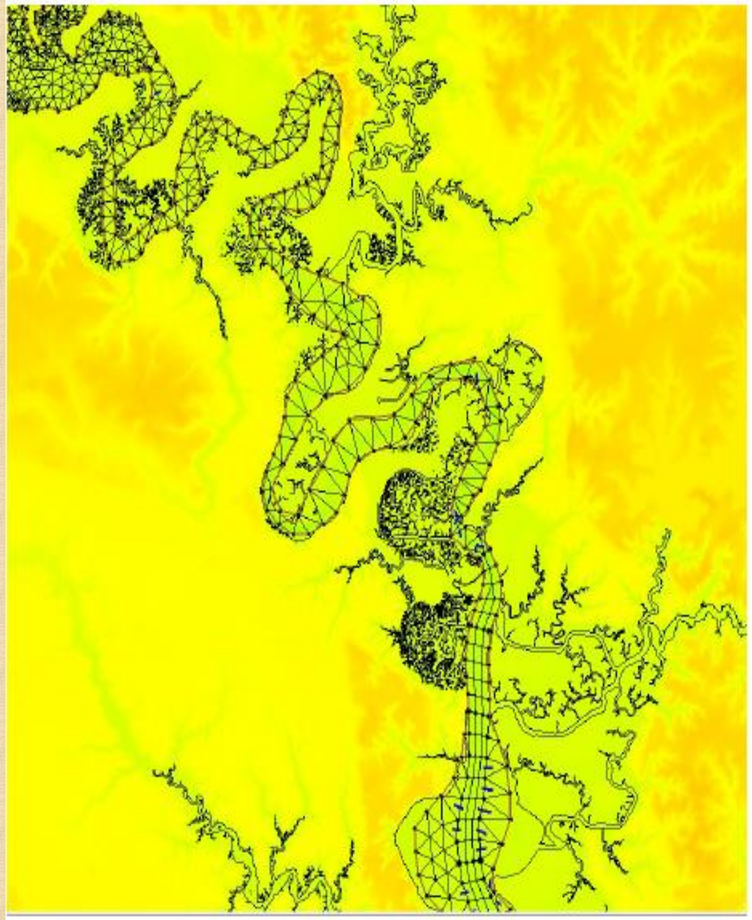
Bathymetry interpolation using the nearest neighbor method

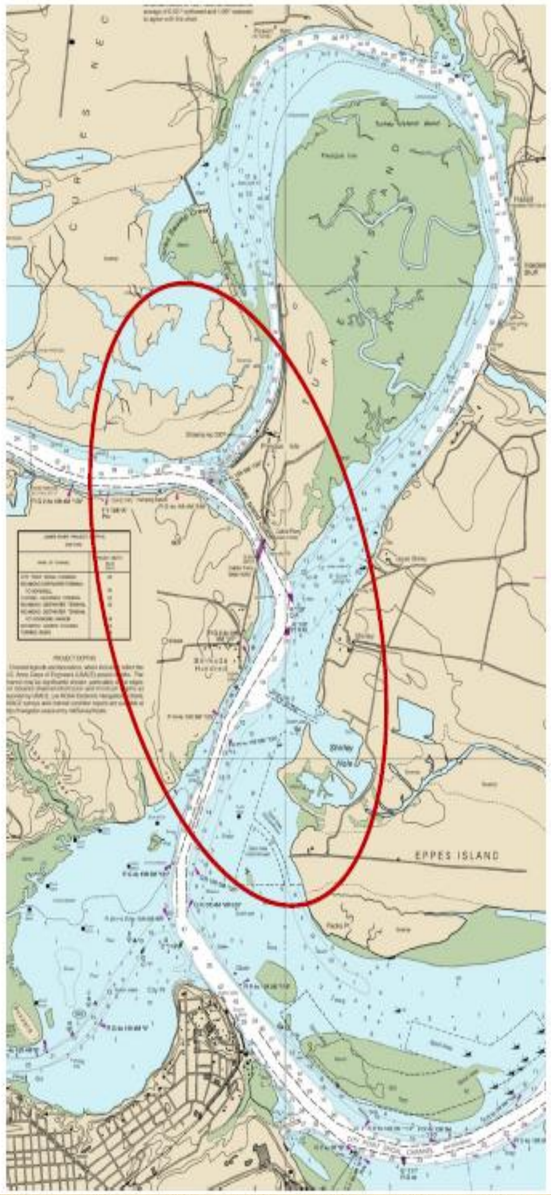


Vertical resolution:
CH3D: 14 layers max=22meters
resolution=1.524 m

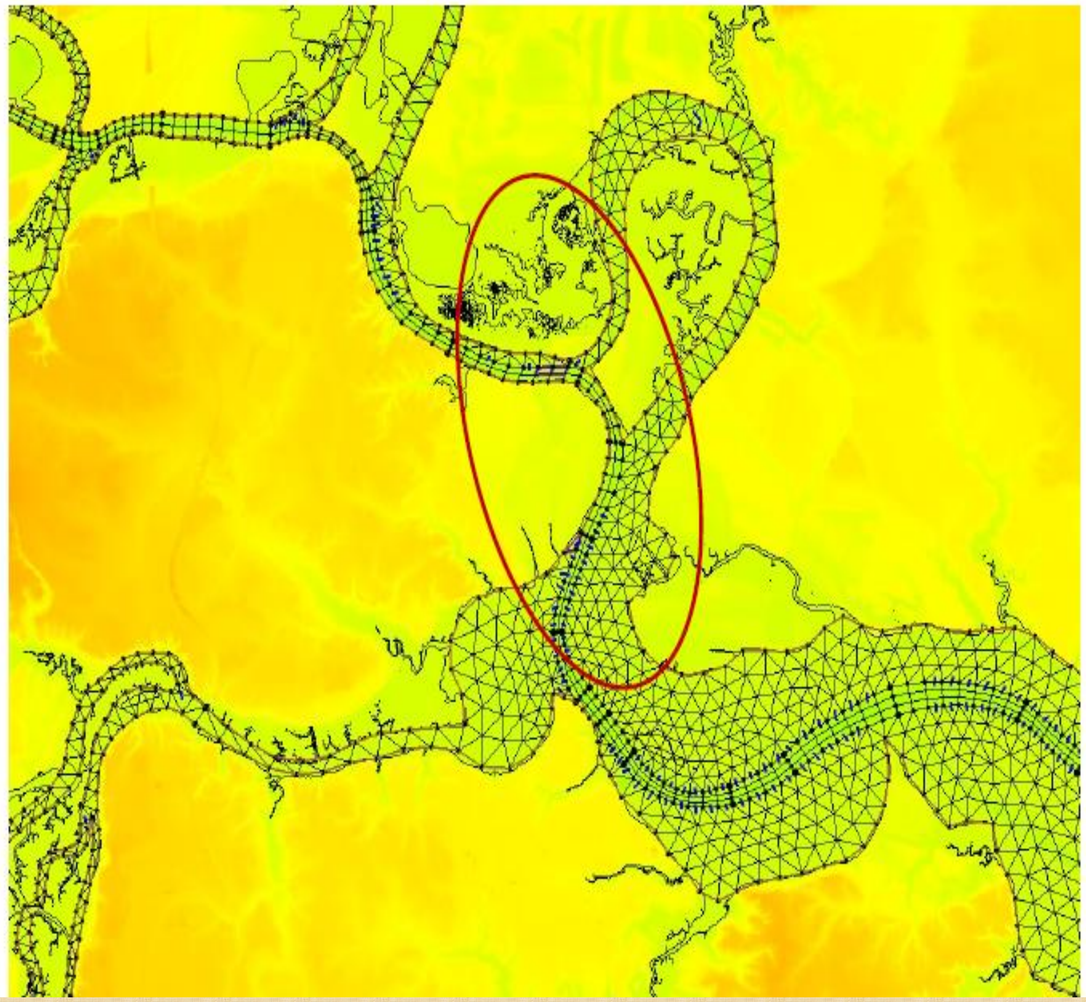
Initial Work on James Prototype MTM

Local refinements -- excluding wetlands for current phase





- The grid covers shoals and major channels within the 0 m contour
- Tidal wetlands are not included so far.
- This version of grid will serve as a base for the next level of developments.



What We're Learning From Prototype MTMs

Decision Rules for MTM Development

- The Main Bay Model (MBM) and all Multiple Tributary Models (MTMs) must have a run time for ten years of water quality simulation of less than a day and preferably to be able to complete in about 12 hours to provide timely and sufficient support to CBP decision-makers.

- When running the MBM or MTMs in scenario mode, only run the water quality simulation along with an appropriate and vetted pre-run hydrodynamic model.

- The boundary conditions between the MBM and the MTMs will be fixed and constant.

What We're Learning From Prototype MTMs *(continued)*

Decision Rules for MTM Development

- Quarterly meetings, coincident with the CBP Modeling Quarterly Reviews, will be set up as forums for model development, analysis, and application among the MBM and MTM PIs.

- The MBM and all MTMs will use the same state variables and will prefer a robust and consistent user-supplied value for state variables, i.e., specification of algal-temperature growth curves. Exceptions can be provided given sufficient PI justification, documentation and consensus agreement in MBM-MTM Quarterly Meetings.

- When gridding the model for shipping channels always use the channels "control depth" found on nautical charts because maintenance dredging is regularly applied to maintain the control depth.

Timeline: 2021 to 2022

2021
RFA Completed for Main Bay Model (MBM). MBM Team begins work.

- Get initial CBP Main Bay Model (MBM) structure in place with Main Bay Model *Request for Assistance* (RFA).
- Initial foundational work begins on shallow water DO, clarity, and chlorophyll simulation for MBM and MTMs.

2022
RFA Completed for Multiple Tributary Models (MTMs). MTM Teams begin work. Link MBM and TMT model development.

- 2022 RFA for MTMs complete. MBM and MTMs structure and boundaries determined.
- Decision rules for regulatory model calibration established.
- Continue foundational work on Multiple Tributary Model (MTM) structure and shallow water DO, clarity, and chlorophyll simulation.
- Quarterly MBM and MTM PI meetings begin.
- Examine use of linked watershed to tidal water hydrology inputs from Phase 7.

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 Quarterly MBM and MTM PI meetings.
- Demonstrate improved simulation of shallow water DO, clarity/SAV, chlorophyll with unstructured grid MBM and MTMs.
- 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 Quarterly MBM and MTM PI meetings.
- Complete shallow water DO, clarity/SAV, chlorophyll refinements
- Unstructed grid Bay Model (MBM and MTMs) fully operational December 2024.

Timeline: 2025 to 2026

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

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

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.
- Main Bay Model “frozen” until 2035 but continue quarterly MBMs and MTMPI meetings through 2025 and 2026.

Next Steps

- Proposals for the MBM RFA have been received and are being evaluated.
- In the third quarter of 2021 the MBM Team will be selected.
- Continue foundational work on MBM and MTMs in anticipation of full MBM and MTM Teams in place in 2022.

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