Climate Change, Marsh Erosion and the Chesapeake Bay TMDL

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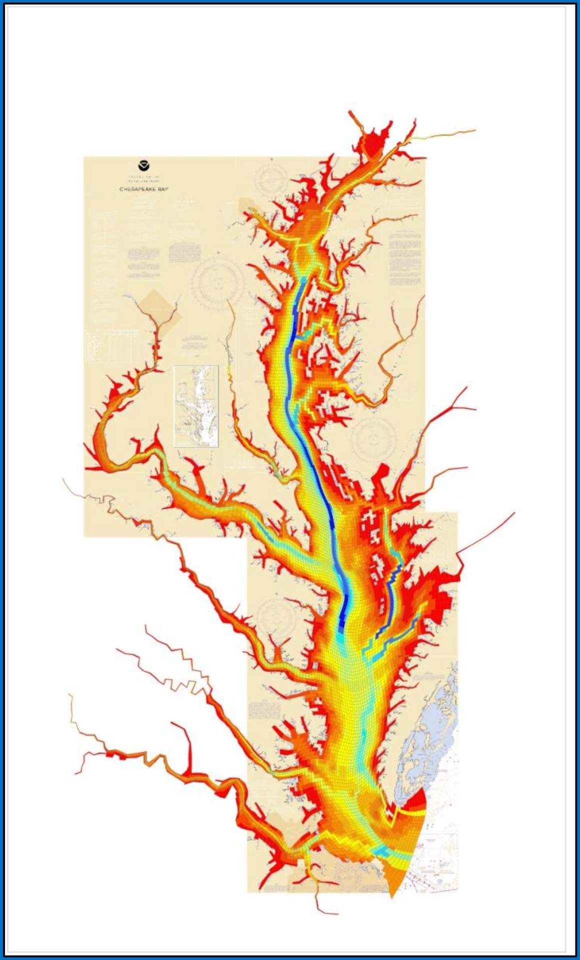
Study Features

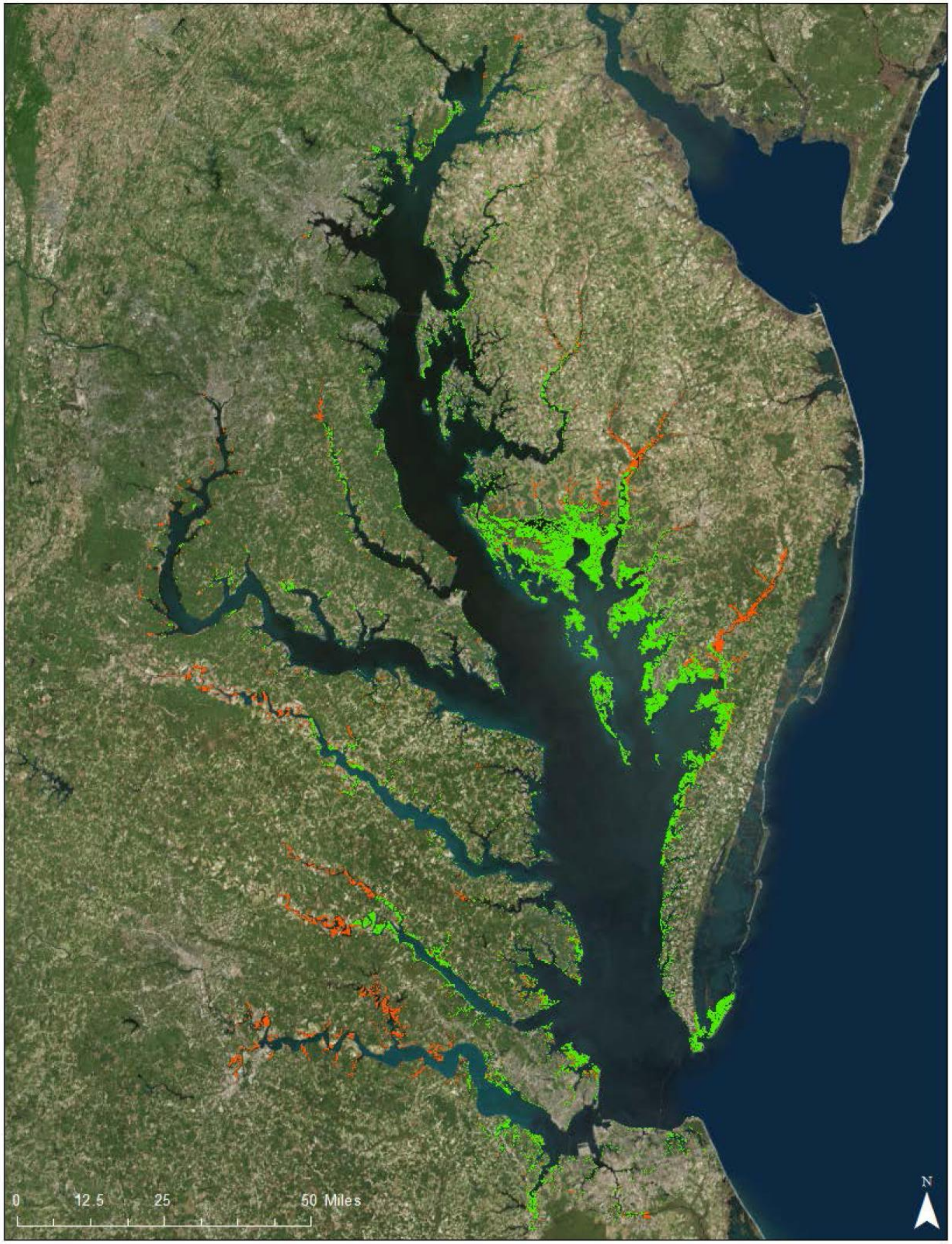
We are examining the potential impact of tidal wetlands loss through a three-phase program including:

- Phase I – Estimate marsh loss and transition due to sea level rise
- Phase II – Investigate the reactivity and impact of material eroded from marshes and released to Chesapeake Bay waters
- Phase III – Quantify effects of marsh loss on water quality and examine implications for TMDL

Chesapeake Bay Water Quality and Sediment Transport Model



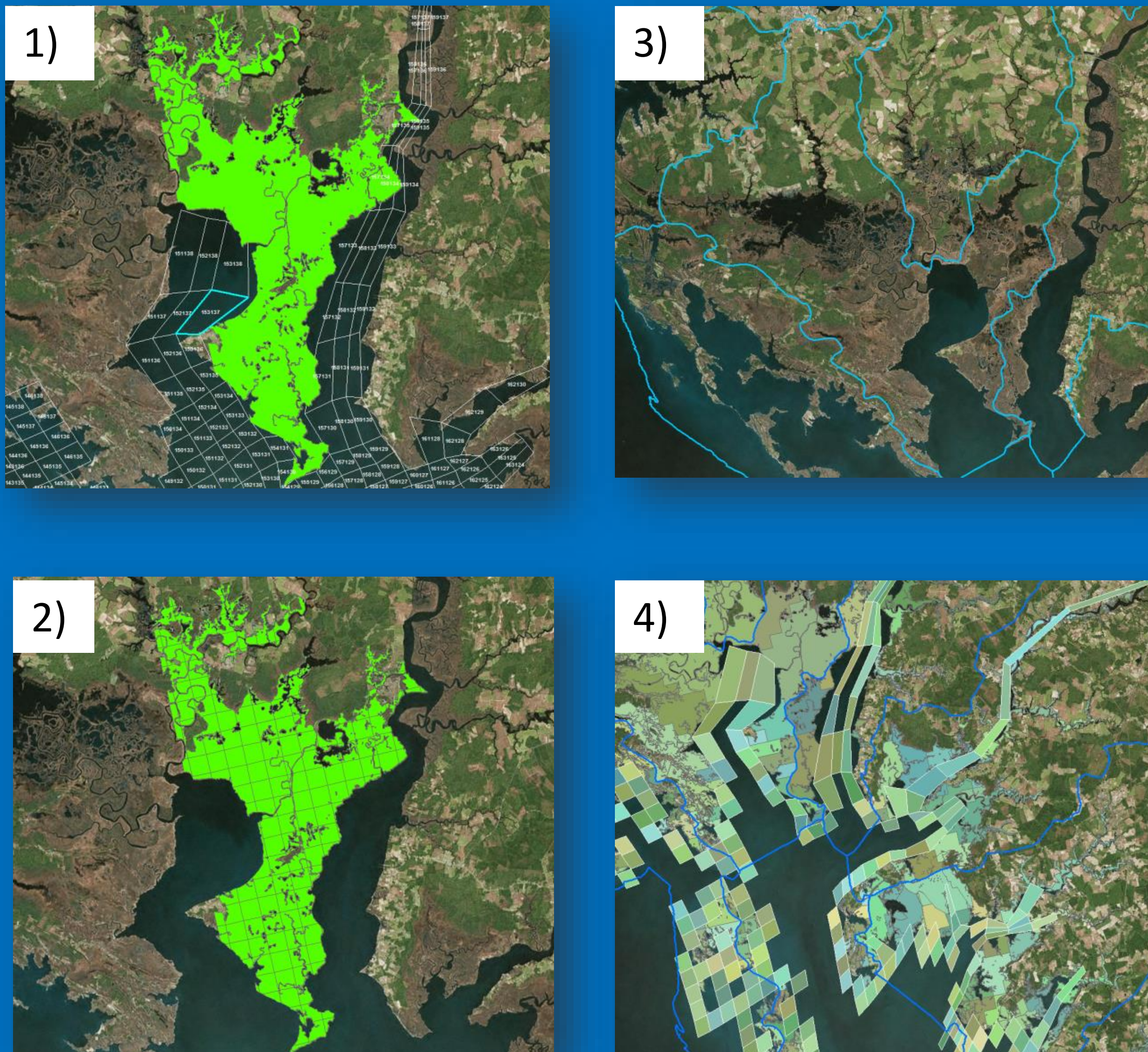
- Simulates water quality, sediment, and living resources in three dimensions in 50,000 discrete cells.
- For the TMDL, emphasis on chlorophyll, water clarity, and dissolved oxygen.
- Operational for 1985 – 2011.



Chesapeake Bay Tidal Wetlands

- Extent form National Wetlands Inventory.
- Determined largely from vegetation perceived via aerial photography.
- 190,000 hectares of estuarine (green) and tidal fresh (red) wetlands.
- Shape files provided by Quentin Stubbs and Peter Claggett, EPA Chesapeake Bay Program.

Assign Wetlands Areas to Model Cells



1. Wetlands polygon.
2. Divide polygon into "fishnet."
3. Overlay 10-digit HUC boundaries.
4. Assign wetlands areas to model cells based on proximity and local watershed boundaries.
5. Thank you, Scott Bourne, ERDC.

Effects of Wetland Loss

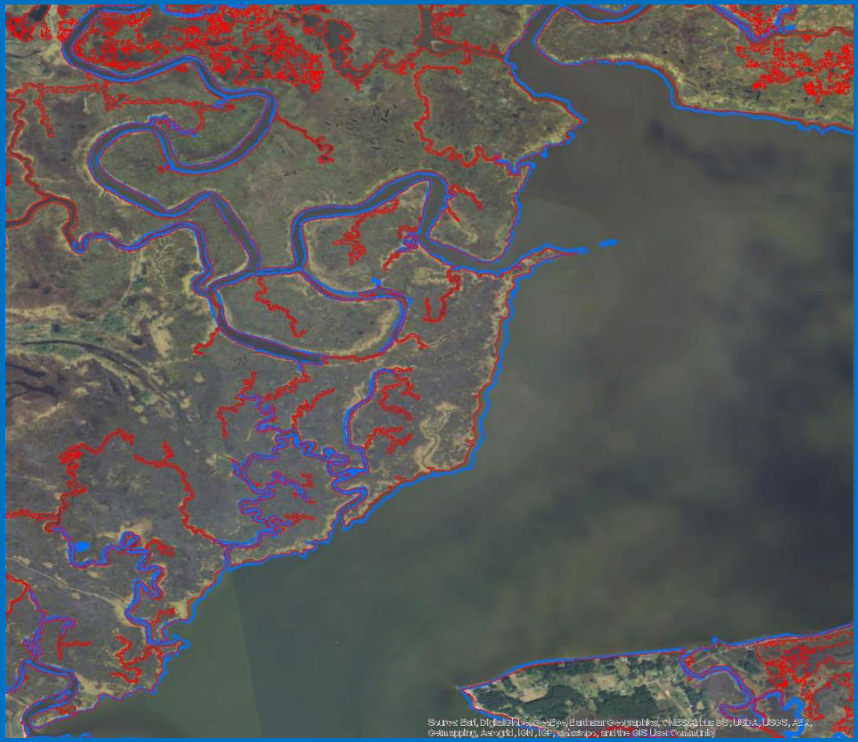
- We want to quantify the effects of wetlands loss due to sea level rise on the Chesapeake Bay TMDL.
- We have shoreline erosion loads of solids and nutrients from a previous study.
- We are working on a wetlands function module. We will incorporate functions (solids removal and burial, nutrient removal and burial, denitrification, respiration, etc.) into present model. Loss of wetlands functions will be accounted for explicitly.
- Meanwhile …..
- The Water Quality Goal Implementation Team allows credits for wetlands restoration.
- The credits are 85 lbs N/acre/yr removed through denitrification and 5.3 lb P/acre/yr removed through burial.
- For those who respect the Enlightenment, 0.26 kg/hectare/day N, 0.016 kg/hectare/day P.
- Assume that wetland loss is the equivalent of adding his much N and P to the TMDL loads.
- These become new wetlands loss loads input to the model as particulate N and P.

Wetlands Loss Projections

- Bilkovic et al. (2009) “Vulnerability of shallow tidal water habitats in Virginia to climate change”: 12-52% loss of tidal wetlands, 38% of wetlands at risk b/c of adjacent development limiting landward transgression.
- Glick et al. (2008) “Sea level rise and coastal habitats in the Chesapeake Bay region”: In Cambridge and surrounding peninsula, irregularly flooded marsh will decrease from 35,000 to 12,000 hectares but saltmarsh will increase from 168 to 17,000 hectares.
- Craft et al. (2009) “Forecasting the effects of accelerated sea-level rise on tidal marsh ecosystem services”: Saltmarshes along the Georgia coast will decline by 20% by 2100 under mean estimates of sea level rise.

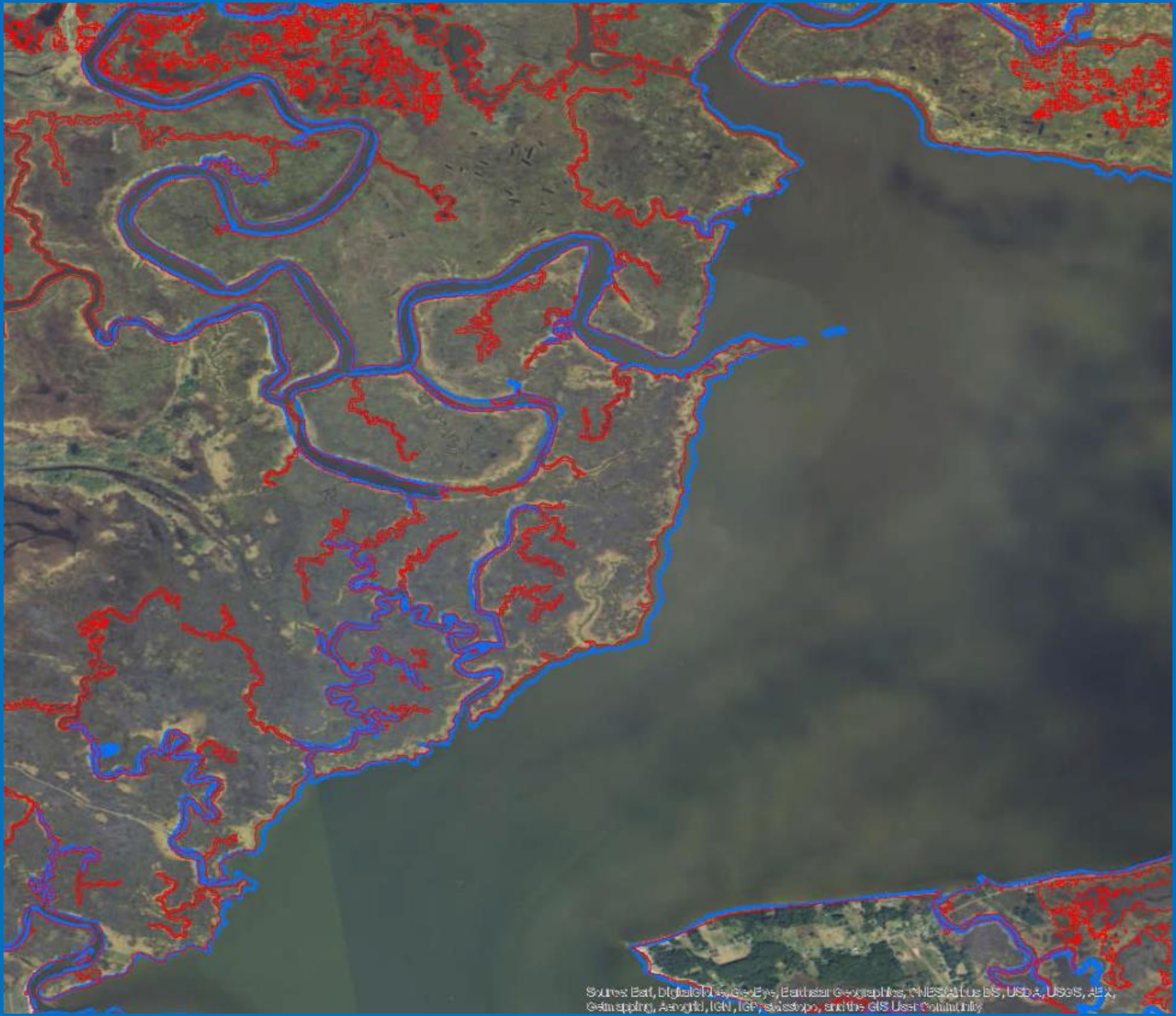
Wetlands Loss Projections

- We are working with NOAA projected MHHW levels under various scenarios (1 ft, 2ft, 3 ft sea level rise).
- We are mapping local wetlands loss to model cells.
- Meanwhile ….. Test 40% loss of estuarine wetlands, 25% loss of tidal freshwater wetlands.



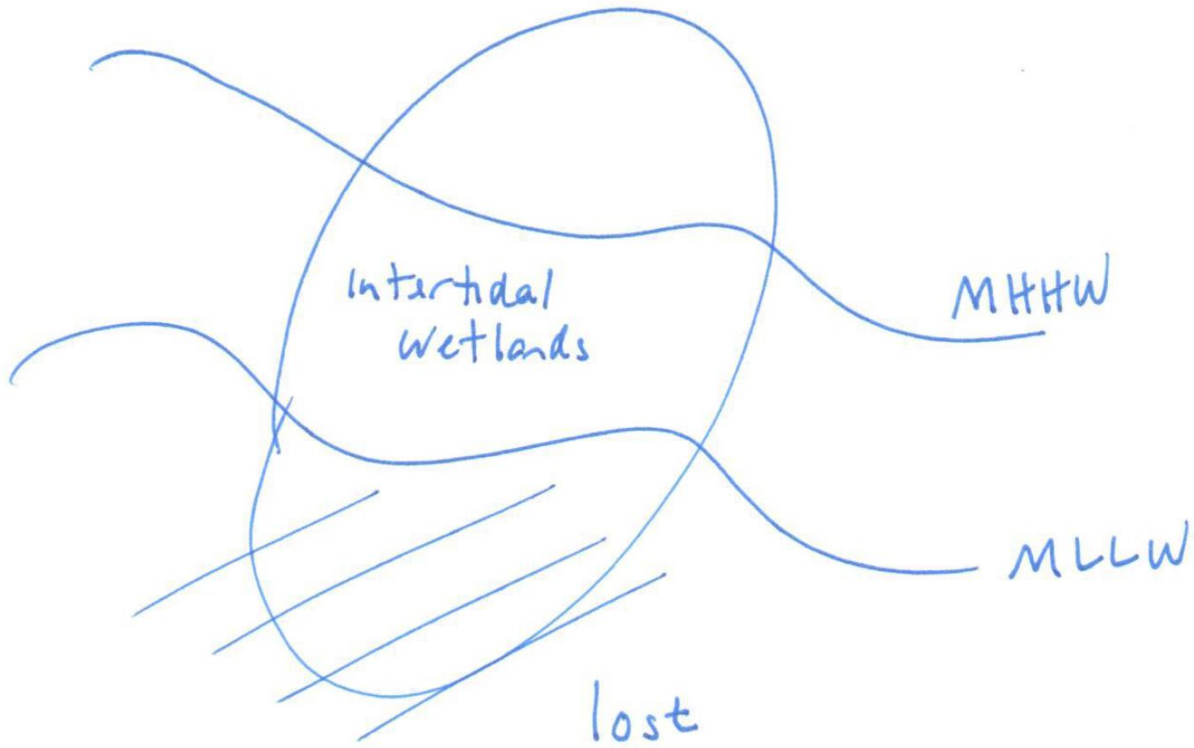
Here's What We Have

- NWI wetlands polygons. These are from photography and are not referenced to any datum.
- Detailed NOAA projections of MHHW for 0, 1, 2, 3 ft sea level rise
- MLW from CBP. These were used for delineating SAV habitat. The line might be MLW minus 1 m?


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

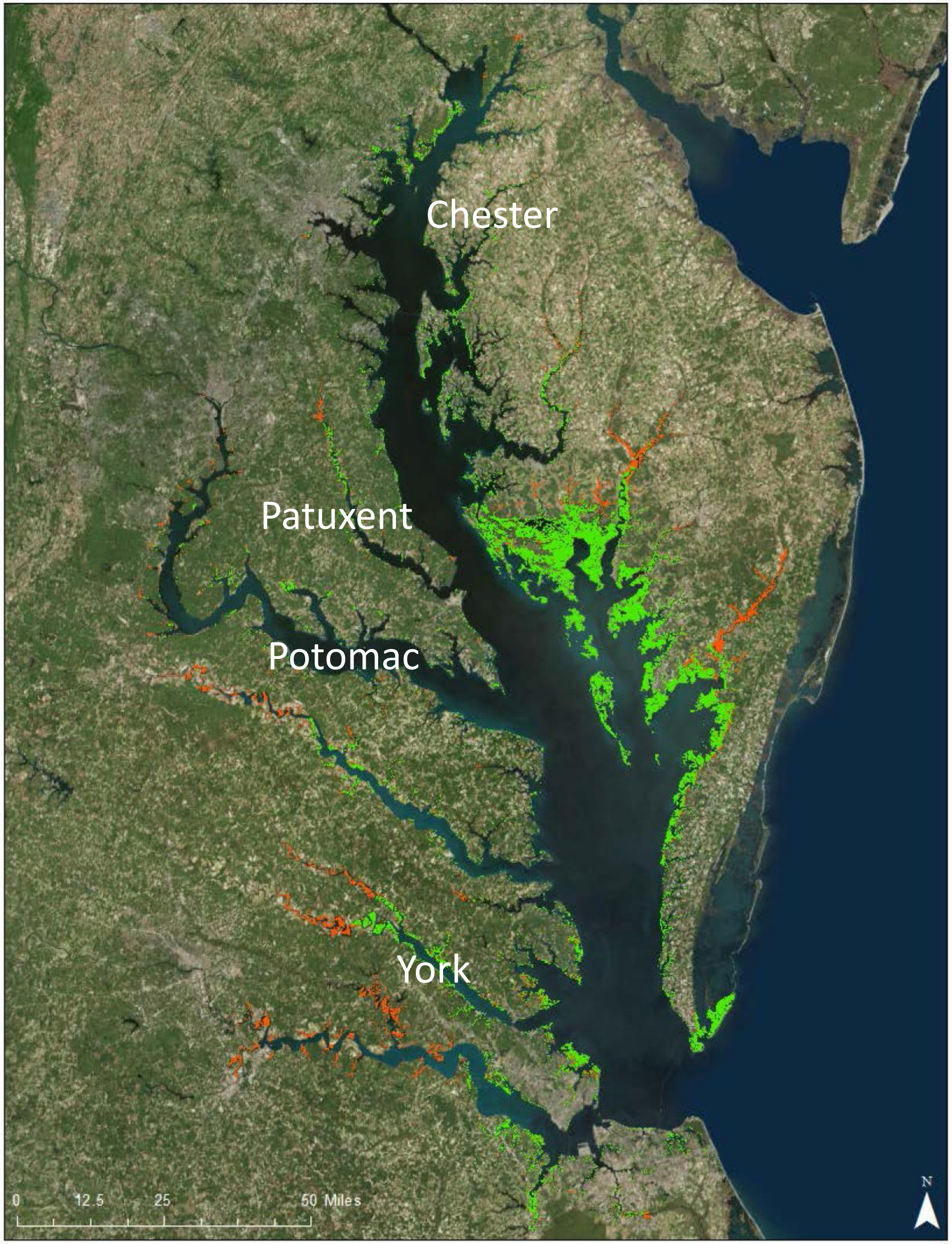
One Thing We Can Do

- Assume intertidal wetlands fall between MHHW and MLLW.
- Obtain a digital elevation map that includes topography from MLLW to local maximum elevation above sea level.
- Obtain estimates of tide range around perimeter of Chesapeake Bay.
- Use NOAA projections of MHHW and tide range to delineate MLLW.
- Wetlands areas below MLLW are subtidal and are lost.


Intertidal
Wetlands
MHHW
MLLW
lost

Another Thing We Can Do

- Assume intertidal wetlands fall between MHHW and MLLW.
- Obtain a digital elevation map that includes topography from MLLW to local maximum elevation above sea level.
- Be certain that we have CBP estimates of existing MLW (Not SAV habitat, also identify if this is MLW or MLLW).
- Add 1 ft, 2 ft, 3 ft to MLW to project MLW under sea level rise scenarios.
- Wetlands areas below MLW are subtidal and are lost.



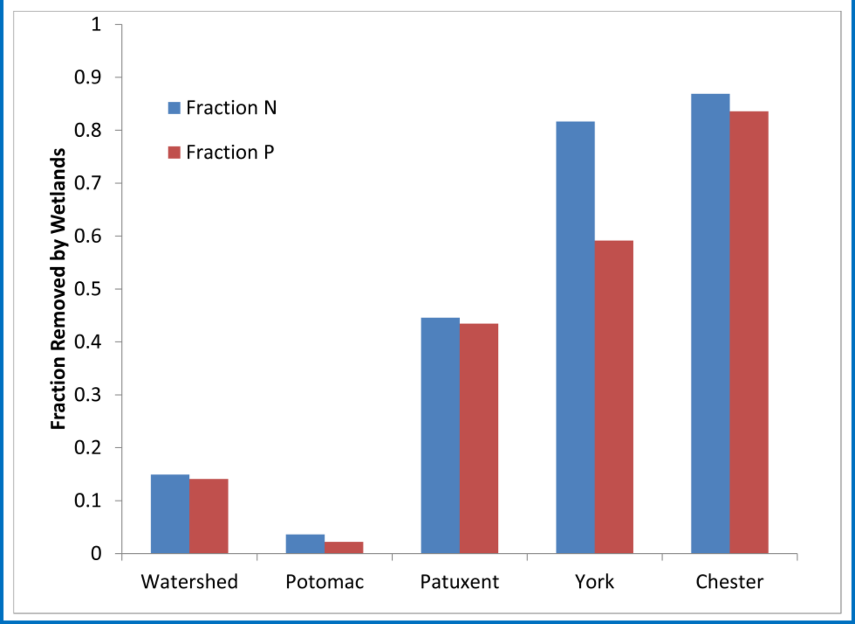
Lets Compare the WQGIT Removal Estimates to System-wide and Sub-system Loads.

- 1991-2000 loads from Phase 5.3.2 CBP Watershed Model.
- TMDL loads from Phase 5.3.2 CBP Watershed Model.

Wetlands and 1991-2000 Loads

Loads (kg/d)

	N Load	Denit	P load	Burial
Watershed	332,445	49,663	22,010	3,102
Potomac Fall-Line	56,311	2,034	5,765	127
Patuxent Fall-Line	2,023	902	130	56
York Fall-Line	3,906	3,189	337	199
Chester Fall-Line	719	625	47	39

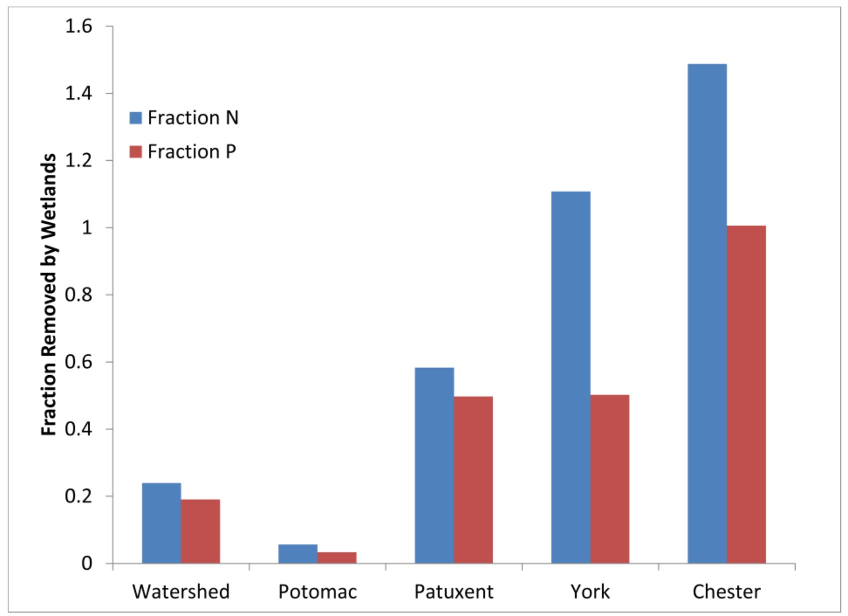


“The tidal marsh-oligohaline estuary removed about 46% and 74% of total annual upland N and P inputs” (Boynton et al., 2008, Nutrient budgets in the Patuxent River estuary)

Wetlands and TMDL Loads

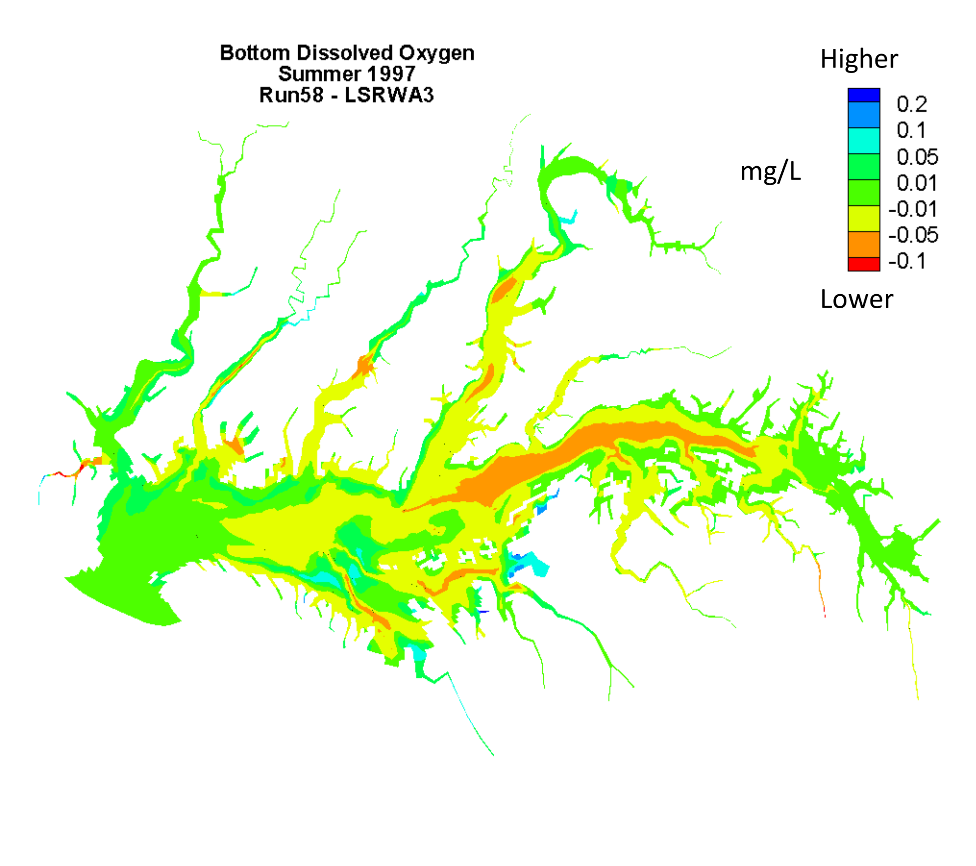
Loads (kg/d)

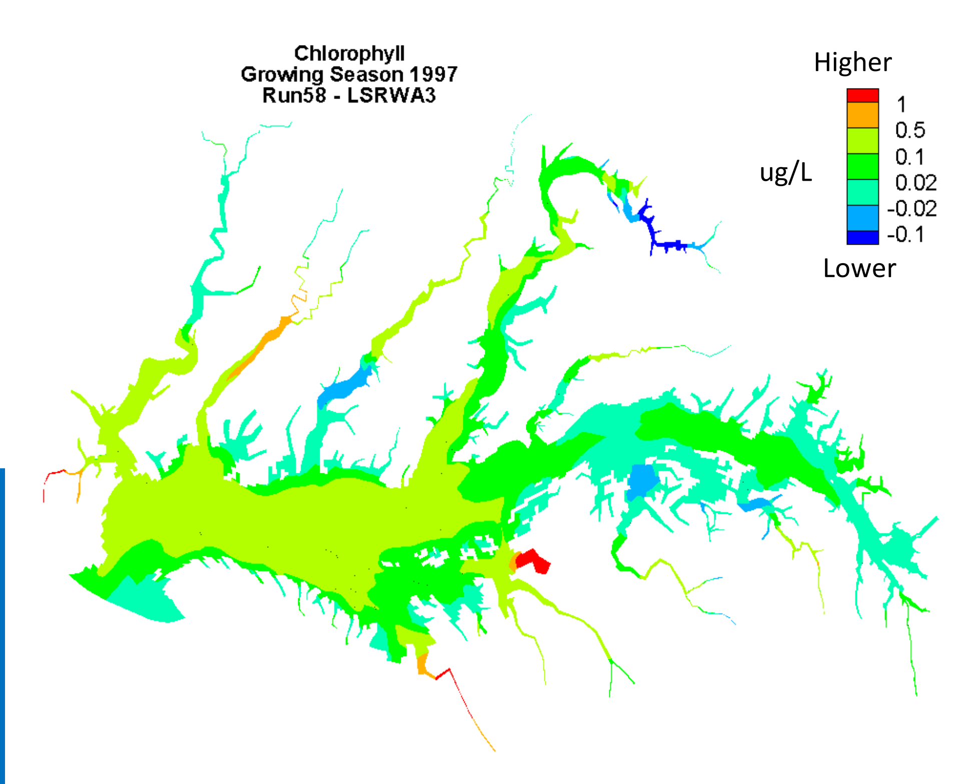
	N Load	Denit	P load	Burial
Watershed	207554	49663	16285	3102
Potomac Fall-Line	36254	2034	3800	127
Patuxent Fall-Line	1547	902	113	56
York Fall-Line	2879	3189	397	199
Chester Fall-Line	420	625	39	39



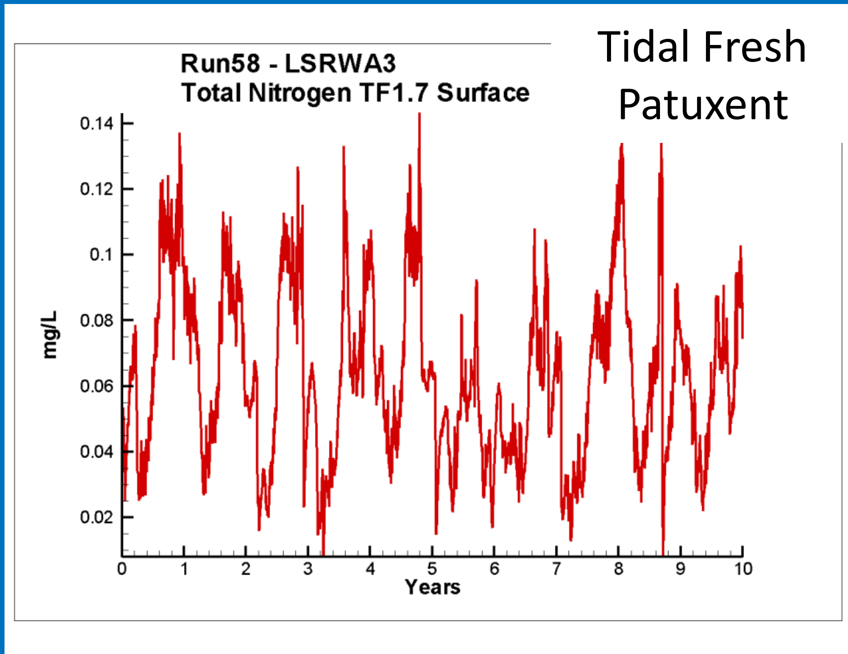
A 40% loss in estuarine wetlands combined with 25% loss in tidal fresh wetlands corresponds to a load increase of 18,219 kg N/d, 1,138 kg P/d.

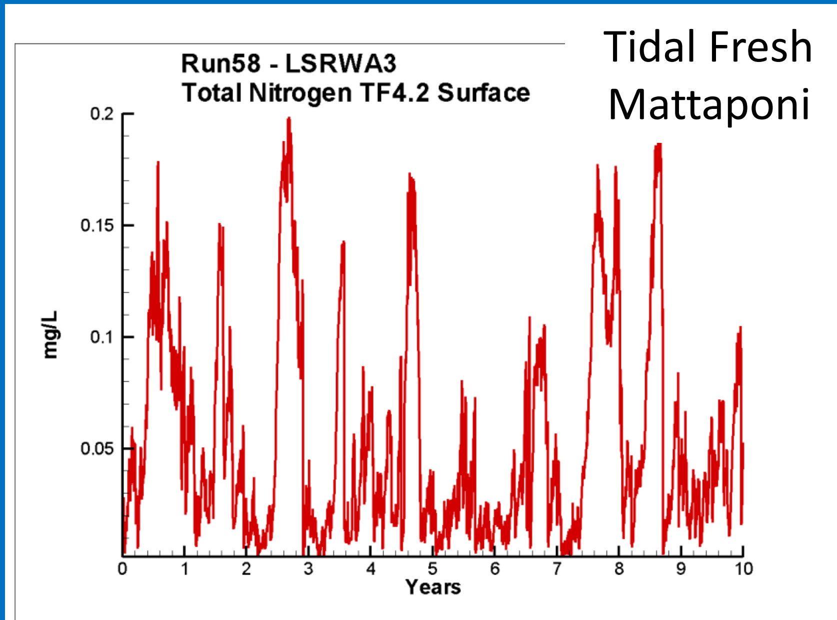
Marginal Effect of Wetlands Loss on TMDL Conditions

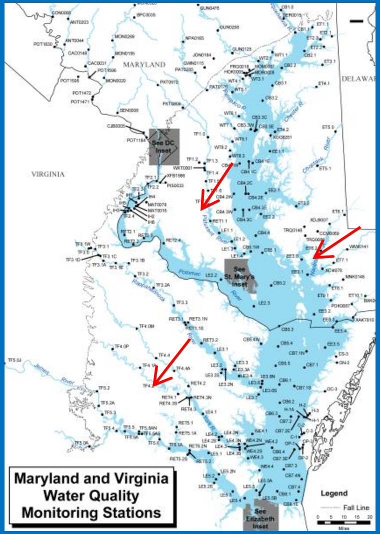


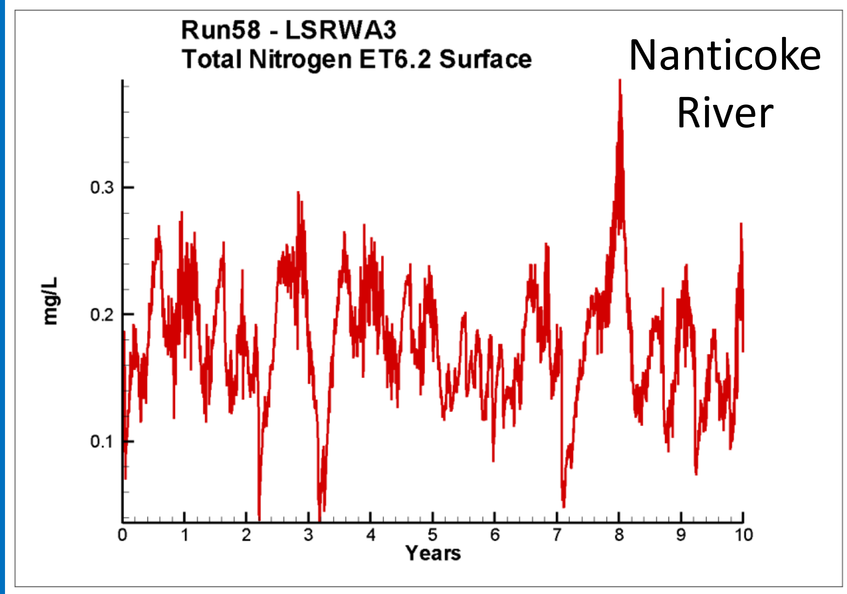


Marginal Increase in Nitrogen Concentration

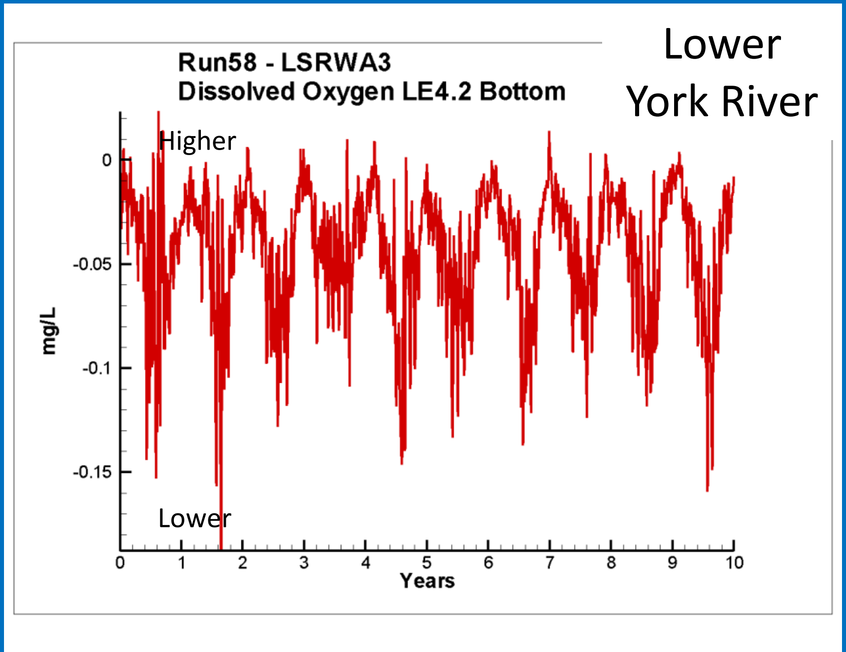


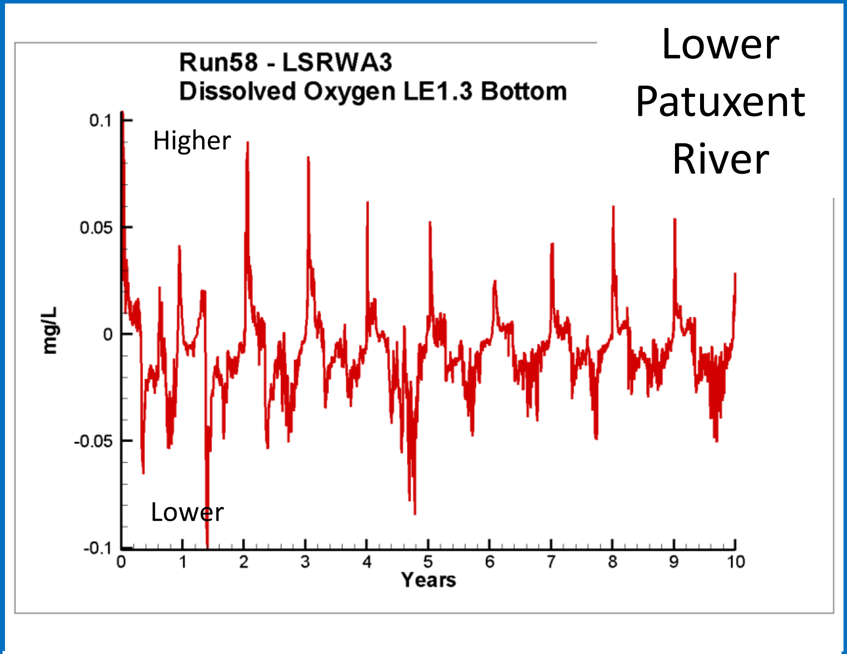


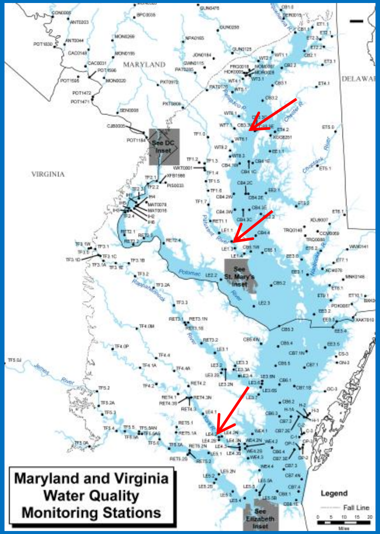


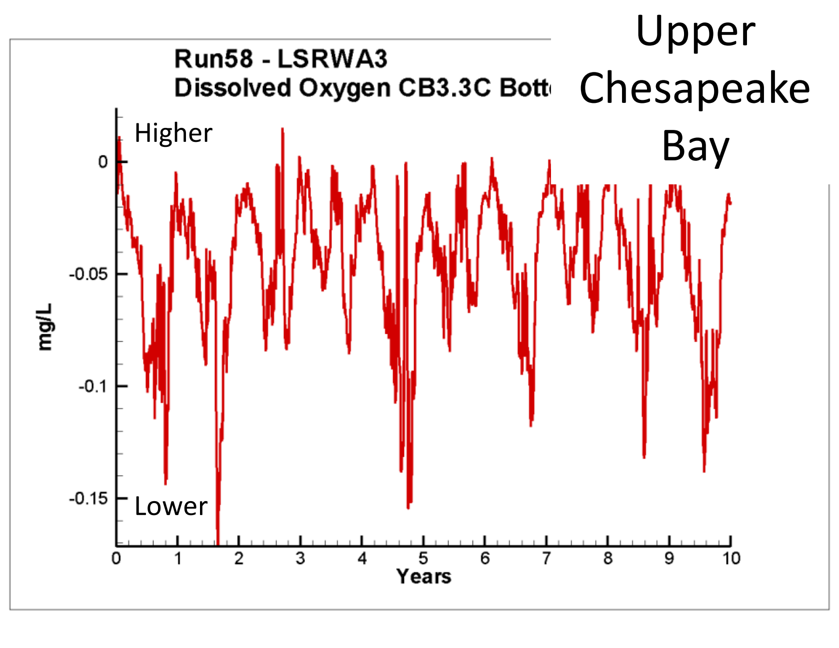


Marginal Decrease in Bottom DO Concentration









Conclusions – Future Directions

- Wetlands loss has the potential to increase nutrient and chlorophyll concentrations at locations distant from major loading sources.
- Dissolved oxygen declines, however, are projected at the usual problem areas.
- Declines in bottom-water DO roughly 0.1 mg/L are projected for a 40% loss in estuarine wetlands, 25% loss in tidal fresh wetlands. This concentration can be significant from a TMDL perspective.
- Our next step is to obtain quantitative, local projections for various sea level rise scenarios.