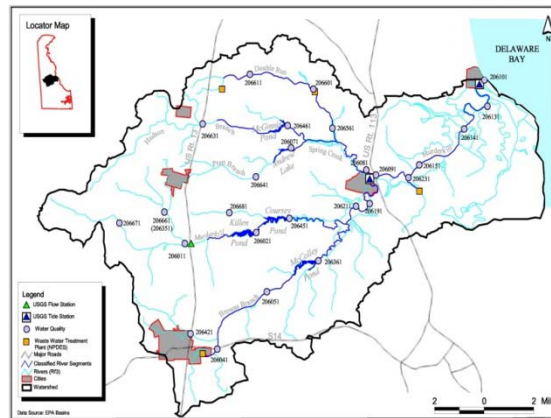


A Use Attainability Analysis (UAA) Based Alternative Dissolved Oxygen Criteria for Wetland-dominated Tidal Portions of Murderkill River, Delaware

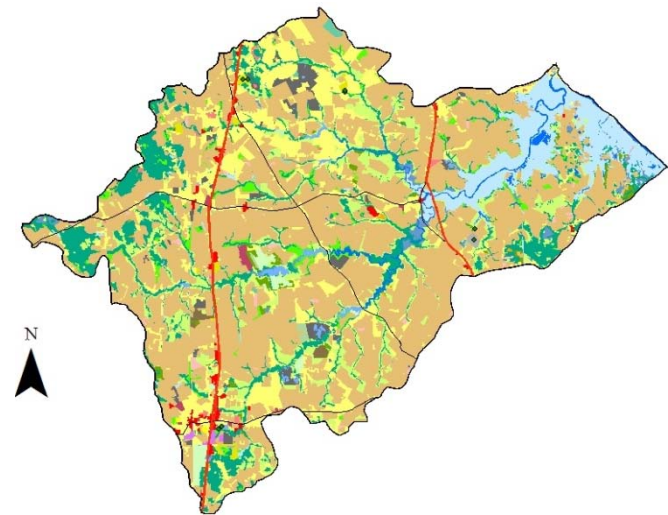
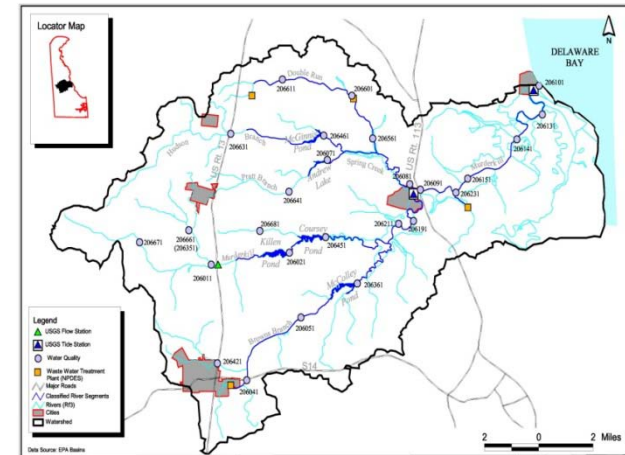


Hassan Mirsajadi
Watershed Assessment and Management Section
Delaware DNREC



Murderkill River Watershed

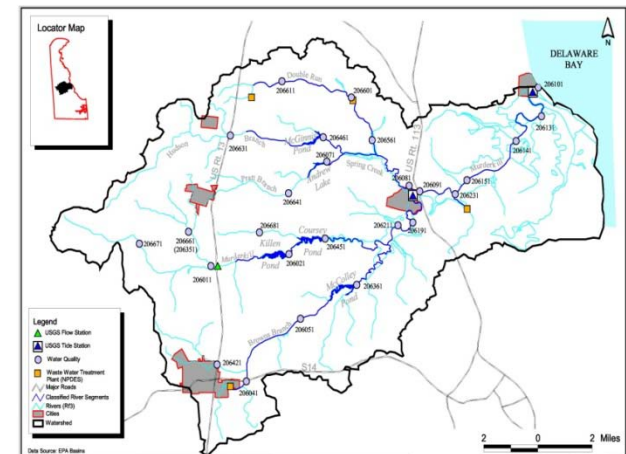
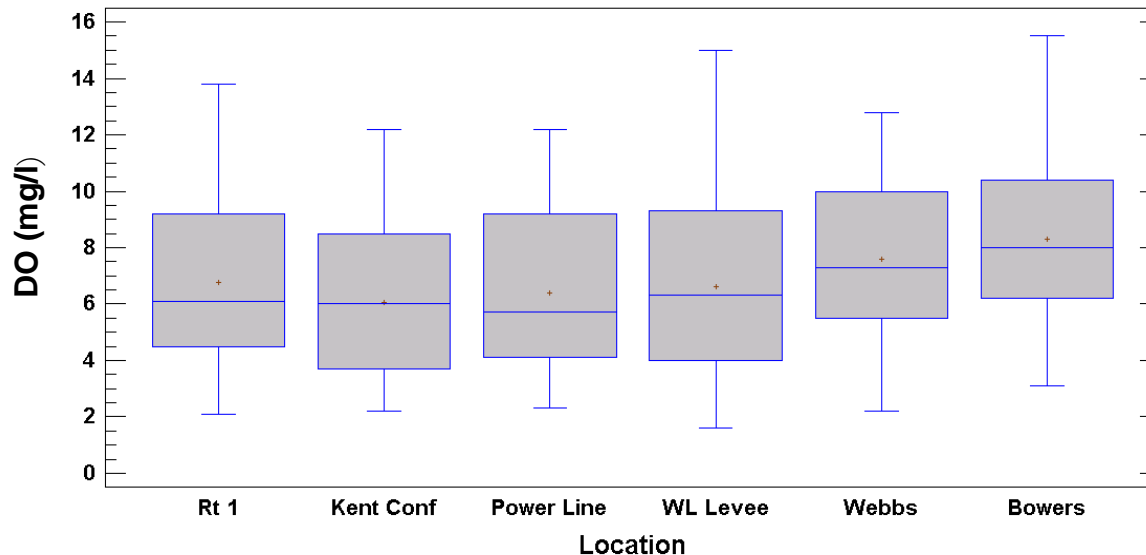
- Area: 107 square miles
- Major land use/land cover:
 - Agriculture (52%)
 - Wetland (17%)
 - Residential (16%)
- Single Point Source: Kent County Facility
 - Discharge started in 1972
 - Design capacity: 16.5 mgd
 - Current Discharge flow: 12 mgd



Background and Motivation for Establishing Alternative DO criteria

- Waters of the Murderkill River were listed for high level of nutrients and low dissolved oxygen in the State's 303(d) List of impaired waters.

Dissolved oxygen (2001-2011)



Background and Motivation for Establishing Alternative DO criteria

- A nutrient and DO TMDL was established for the watershed in 2001.
- Kent County Government, which owns and operates Kent County Facility, appealed the TMDL questioning, among other things, if the dissolved oxygen criteria is appropriate for tidal portions of the Murderkill River, which is dominated by tidal wetlands.



Background and Motivation for Establishing Alternative DO criteria

- As part of negotiations between DNREC and Kent County, it was agreed to conduct a jointly-funded study with the goal of:
 - Addressing scientific questions that were raised by the Kent County
 - Establishing site-specific DO criteria for tidal Murderkill River
 - And, if necessary, amend the TMDL

Monitoring, Research, and Modeling Studies

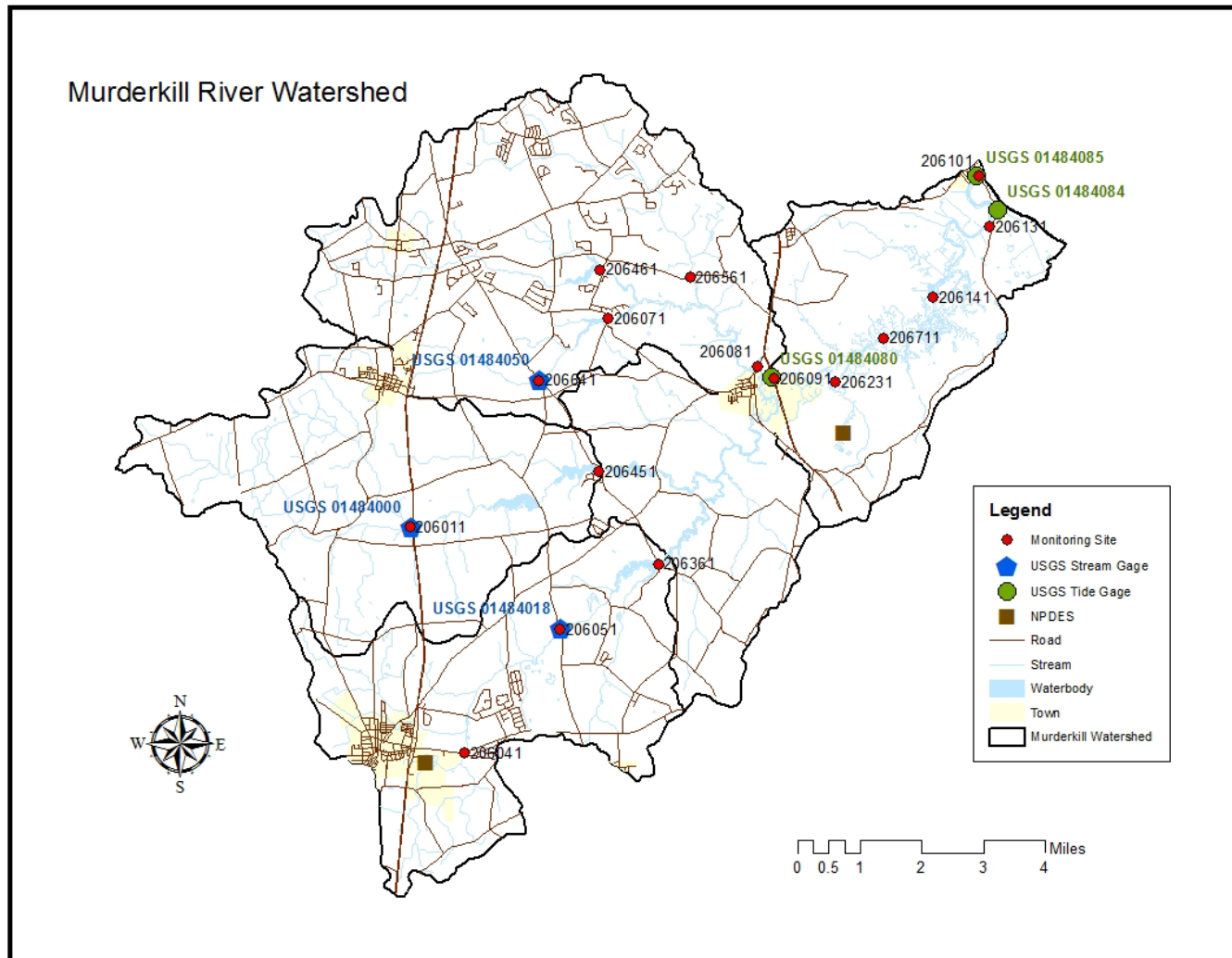
- In 2007, a Study Team was formed with representatives from DNREC, Kent County, University of Delaware, University of Maryland, Stroud Water Research Center, Academy of Natural Sciences, USGS, and others
- The team was tasked with developing plans for collecting data, conducting research, and developing models with the ultimate goal of establishing a scientifically-defensible DO criteria for tidal Murderkill River
- Time schedule: 3 years (2007-2010)
- Budget : About \$1.2 million, to be shared by DNREC and Kent County on a 50/50 basis

Study Elements and Timeline

– Monitoring (2007-2008)

- Monthly water quality sampling at 16 sites
- YSI Continuous monitoring of DO, temp., salinity, and pH at 3 sites
- Stream gages at 3 tributaries
- Tide gages and ADCP units at 3 sites

Water Quality and Hydrologic Monitoring Sites



Bowers Beach



Webb's Marsh



Rt. 1 Bridge

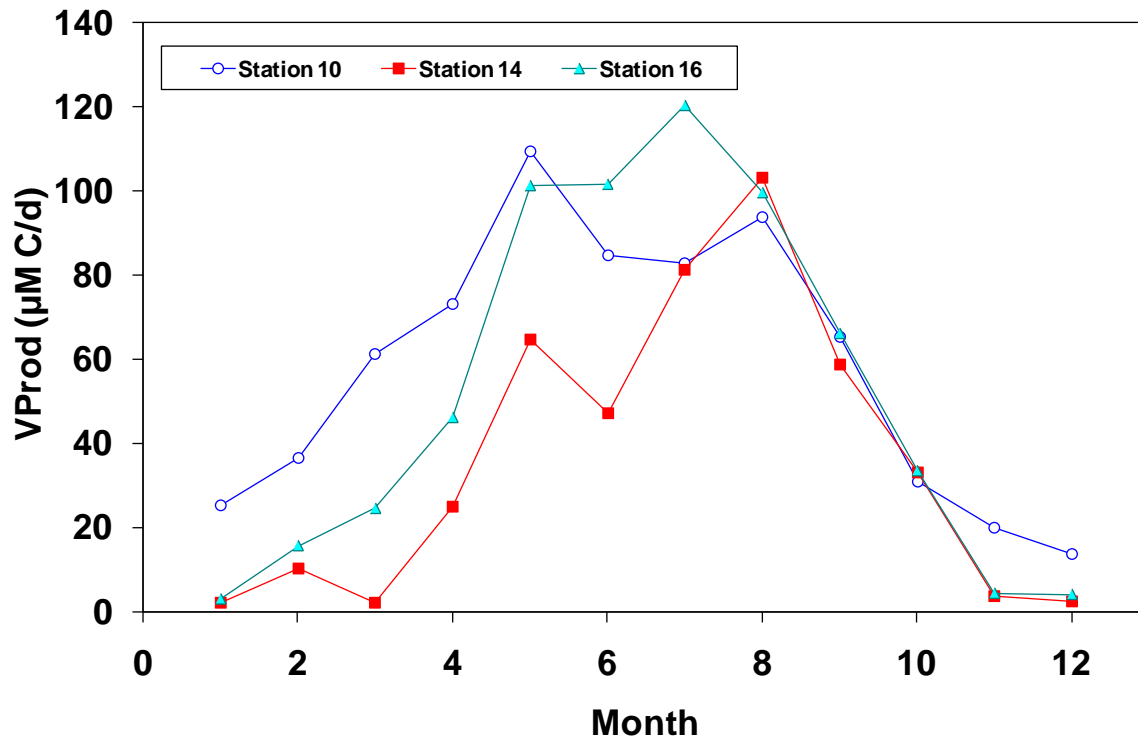
Research Studies

2007-2010

Primary Production Study

(Dr. Jonathan Sharp, University of Delaware)

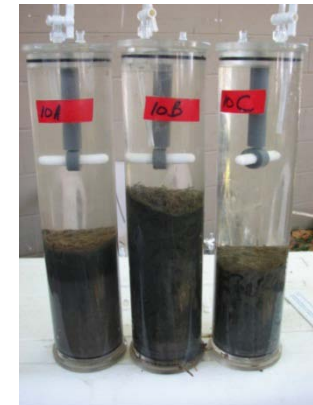
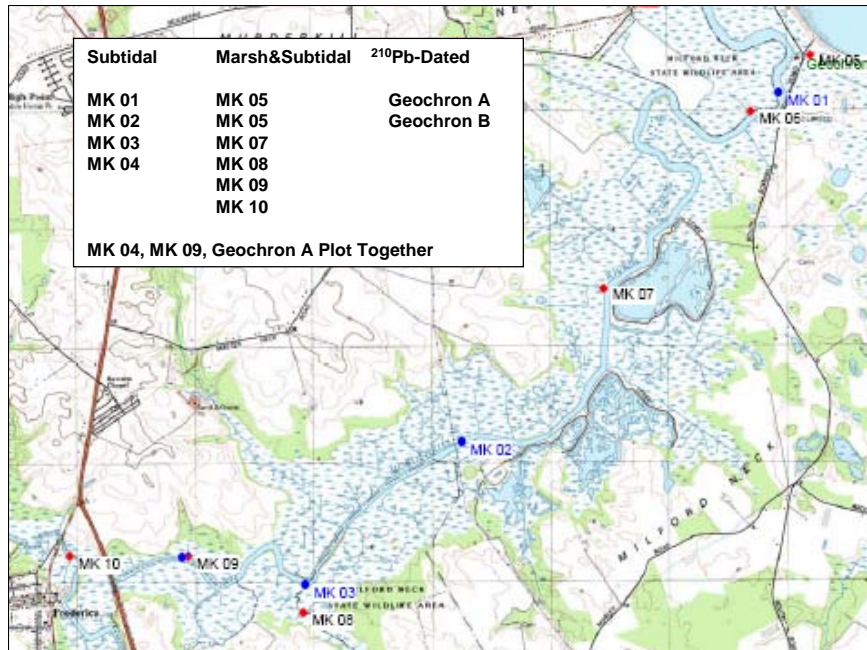
- This study was conducted to determine the rate of nutrient uptake in the River through photosynthesis processes



Sediment Flux Survey

(Drs. Jeff Cornwell and Mike Owens, University of Maryland)

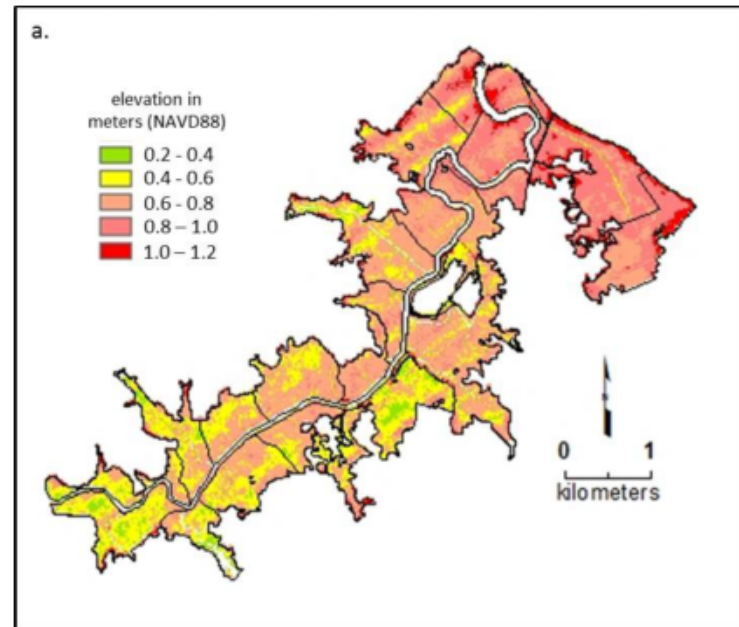
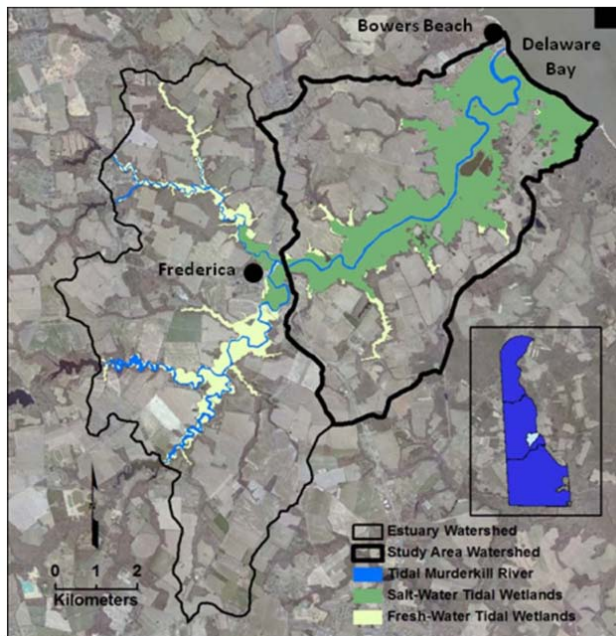
- This study was conducted to measure nutrients and dissolved oxygen fluxes from sediment to the water column (in the river and in marsh)



Study of Tidal Marsh inundation

(Dr. Tom McKenna of Delaware Geological Survey)

- This study was conducted to identify the areas of the tidal marsh that is inundated during each tide cycle.



Study of Exchanges of nutrients and DO between the River and Tidal Marsh

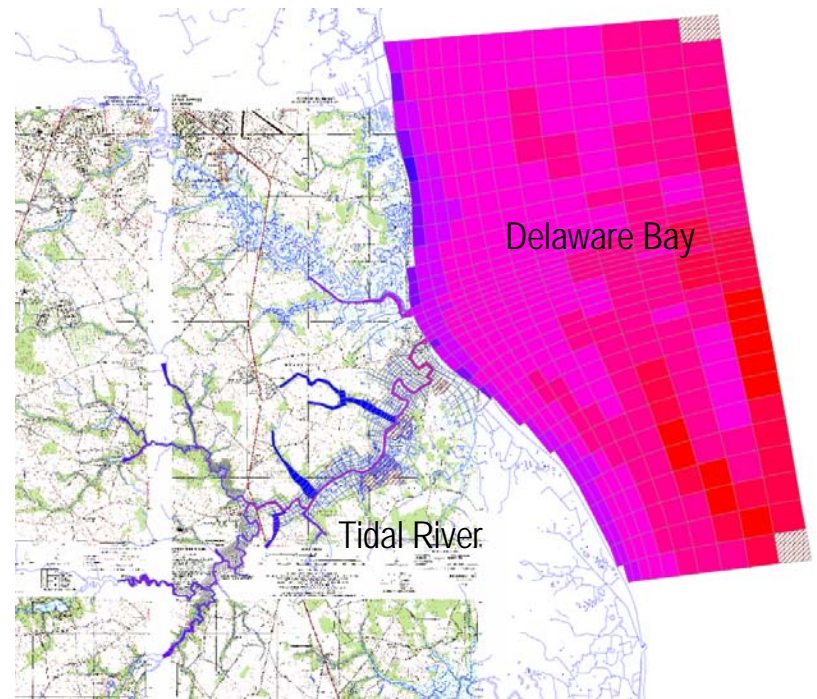
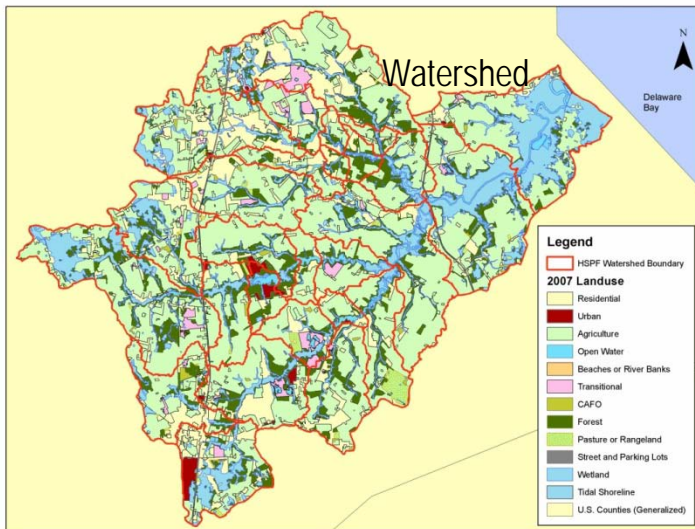
(Drs. William Ullman of UD and Anthony Aufdenkampe of Stroud)

- This study was conducted to quantify the exchange of nutrients, organic matter, and dissolved oxygen between the River and its tidal marsh



Watershed and Hydrodynamic/Water Quality Modeling (HDR|HydroQual)

- Data collected during monitoring and research studies were used to build and calibrate a watershed and a hydrodynamic/water quality model.



What is Causing Low DO Levels in tidal Murderkill River?

To answer this question, we used the calibrated watershed and tidal river models and evaluated many scenarios. The two scenarios that provided most insight into DO dynamics in tidal Murderkill were:

- Natural-background scenario
- No Marsh load scenario

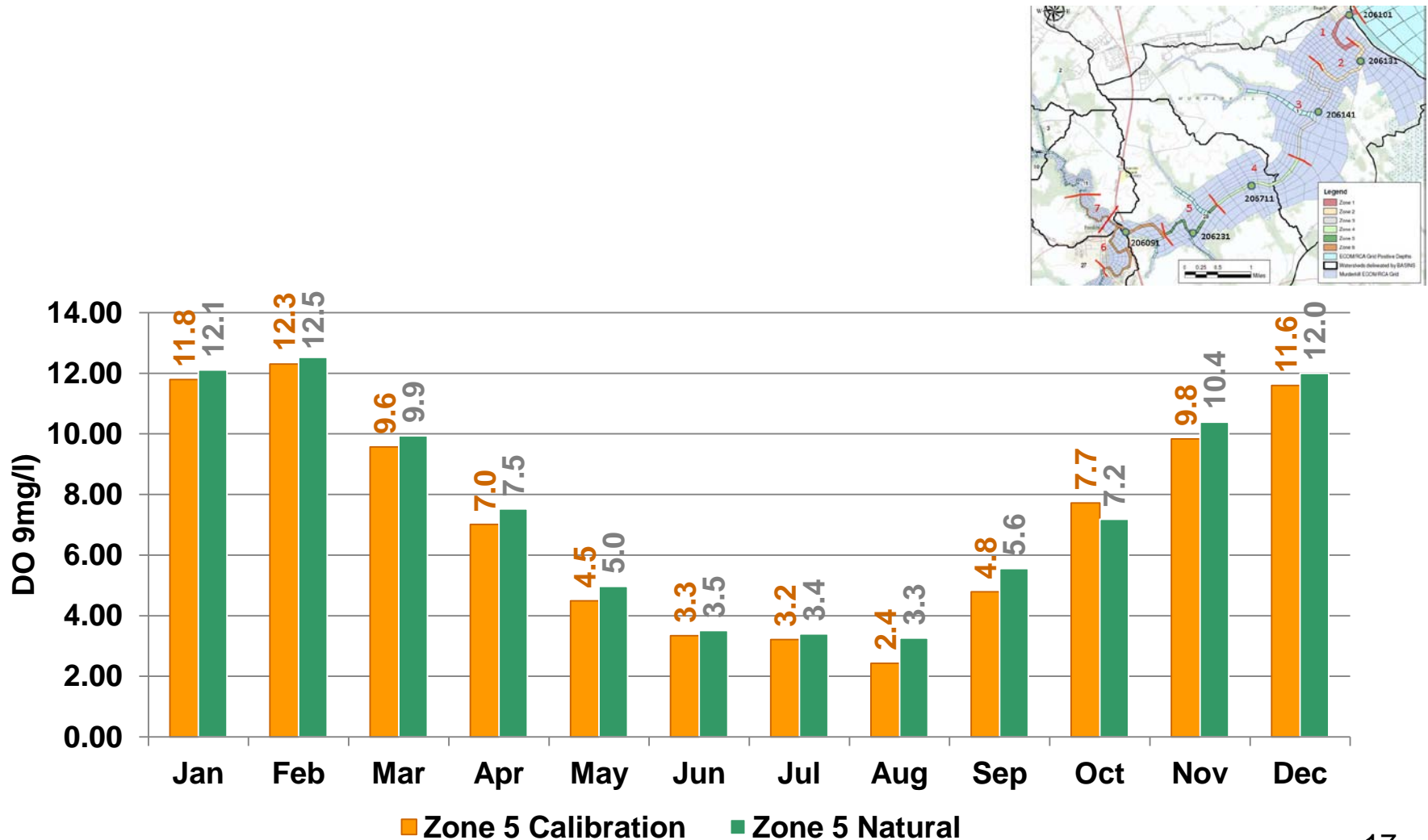
What is Causing Low DO Levels in tidal Murderkill River?

Natural-background scenario

- For this scenario, all loads associated with human activities in the watershed were removed
- Model results showed that dissolved oxygen concentration in the river increased only by 0.2-0.5 mg/l

DO Concentration in the River

Calibration (existing condition) vs. Natural-background



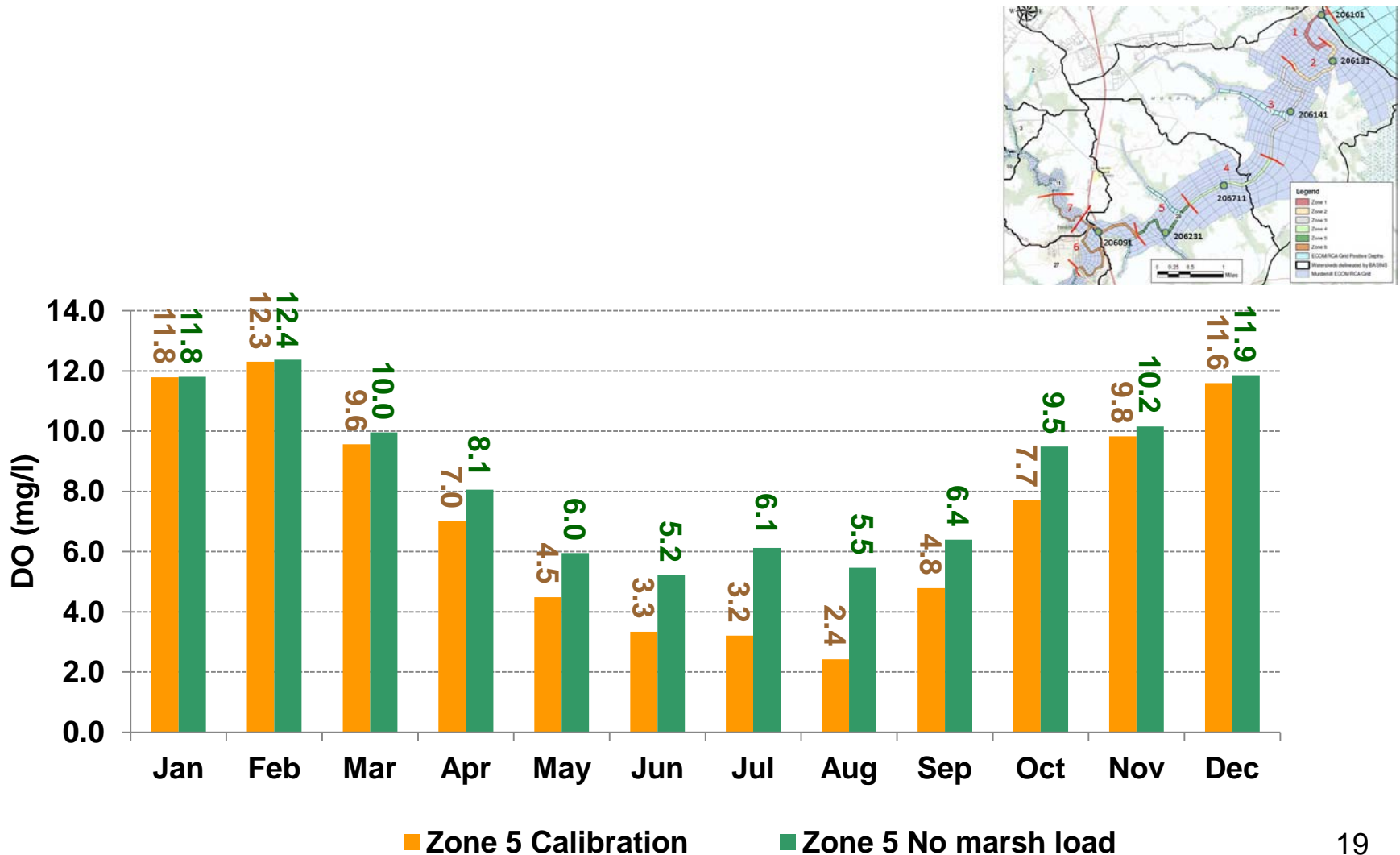
What is Causing Low DO Levels in tidal Murderkill River?

No marsh load scenario

- For this scenario, all loads associated with tidal marshes were removed while other loads were set at the existing (2007-2008) levels.
- Model results showed that dissolved oxygen in the river increased by about 2.0 mg/l.

DO Concentration in the River

Calibration (existing condition) vs. No Marsh Load Scenarios

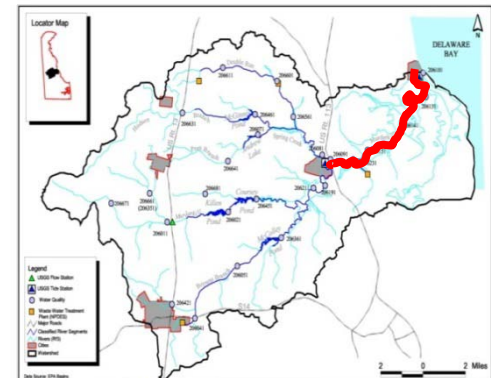


Conclusions from Modeling and Research Studies

- Evaluation of many loading scenarios showed that organic carbon and low DO waters contributed by tidal marshes are the main cause of low DO levels in tidal Murderkill River
- Following extensive discussions with the EPA Region 3 and Headquarters, we defined a new designated use as “wetland dominated tidal river” for lower portions of the Murderkill River and adopted a new DO criteria for it (UAA based criteria).

DO Criteria for wetland-dominated tidal waters of the Murderkill River (seasonal)

- For the period of May 16 thru Sept. 30
 - Daily average DO - 3.0 mg/L
 - 1-hour minimum DO - 1.0 mg/L
- For the period of Oct. 1 thru May 15
 - 5.0 mg/L (daily average)
 - 4.0 mg/L (minimum at any time)



Current Status

- A Public Hearing was held last April for the new designated use and DO criteria for tidal Murderkill River. No adverse comment was received.
- Last August, DNREC Secretary adopted the new designated use and DO criteria.
- We have submitted the new criteria and all technical supporting documents to the U.S. EPA Region 3 for their review.

Next Steps?

- Many tidal rivers in Delaware have similar situation as the Murderkill River. They have extensive tidal marshes, are very turbid, and experience very low DO concentrations during summer time.
- DNREC may initiate additional monitoring and modeling studies for those rivers to see if it is justifiable to assign a similar designated use and DO criteria.