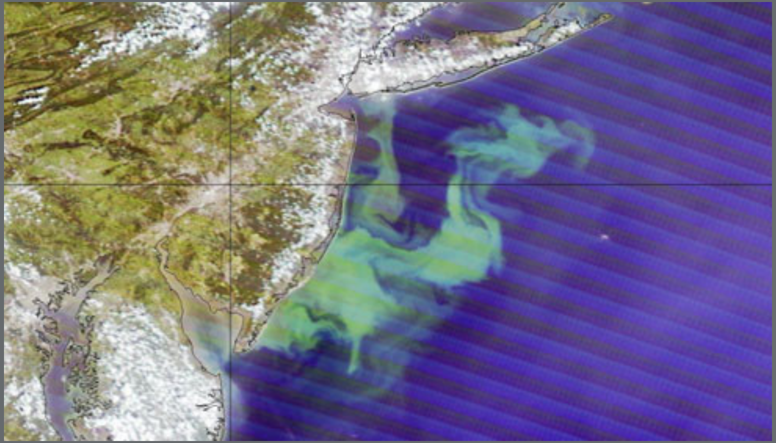
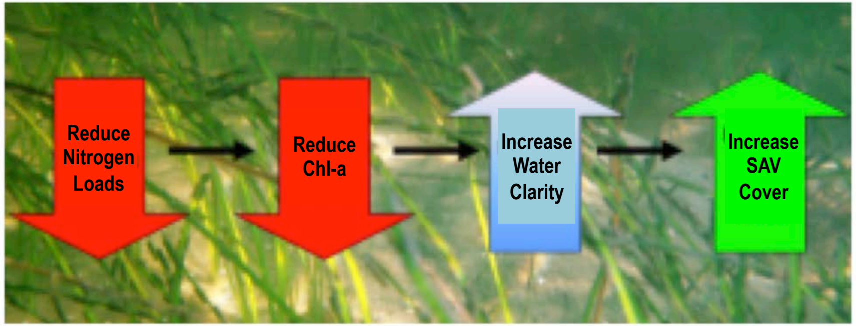


ASSESSING SURFACE WATER NUTRIENT IMPACTS & IMPLICATIONS ON WASTEWATER REMOVAL

Andy Thuman, P.E.

HDR

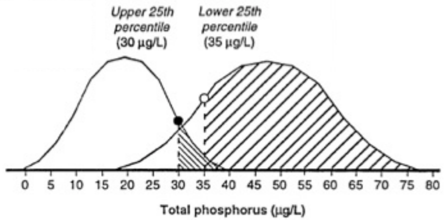

SKIP THE
FERTILZR
GO FISHN


Reduce
Nitrogen
Loads
Reduce
Chl-a
Increase
Water
Clarity
Increase
SAV
Cover

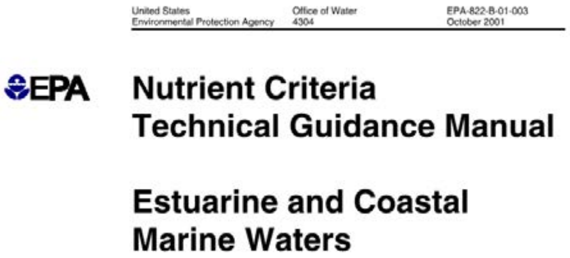
NUMERIC NUTRIENT CRITERIA (NNC)

- EPA started developing NNC guidance & recommendations in 2000-2001 for rivers, lakes & estuaries

- Range in methods varies
  - Gather all TN/TP data for an ecoregion & select the 25th percentile
  - Gather "unimpacted" TN/TP data for an ecoregion & select 75th percentile
  - Correlations between biological effects & nutrients
    - Algae (chlorophyll-a), macro-invertebrate metrics
  - Reference conditions / sites
  - Water quality modeling



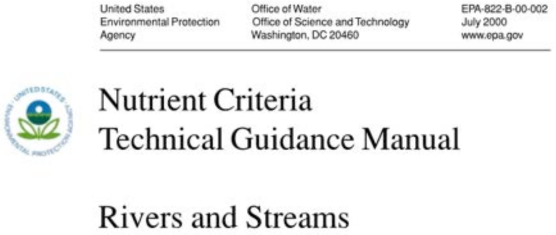
- Summary of correlation methods
  - Lakes – OK, River/Streams – Not OK, Estuaries - Complicated


United States Environmental Protection Agency | Office of Water 4304 | EPA-822-B-01-003 October 2001

EPA

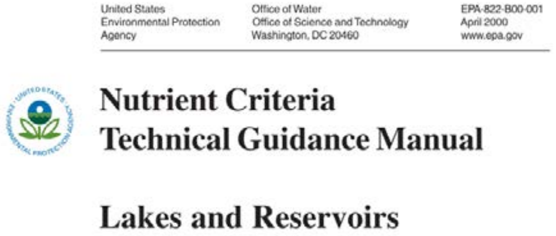
Nutrient Criteria Technical Guidance Manual

Estuarine and Coastal Marine Waters


United States Environmental Protection Agency | Office of Water Office of Science and Technology Washington, DC 20460 | EPA-822-B-00-002 July 2000 www.epa.gov

Nutrient Criteria Technical Guidance Manual

Rivers and Streams

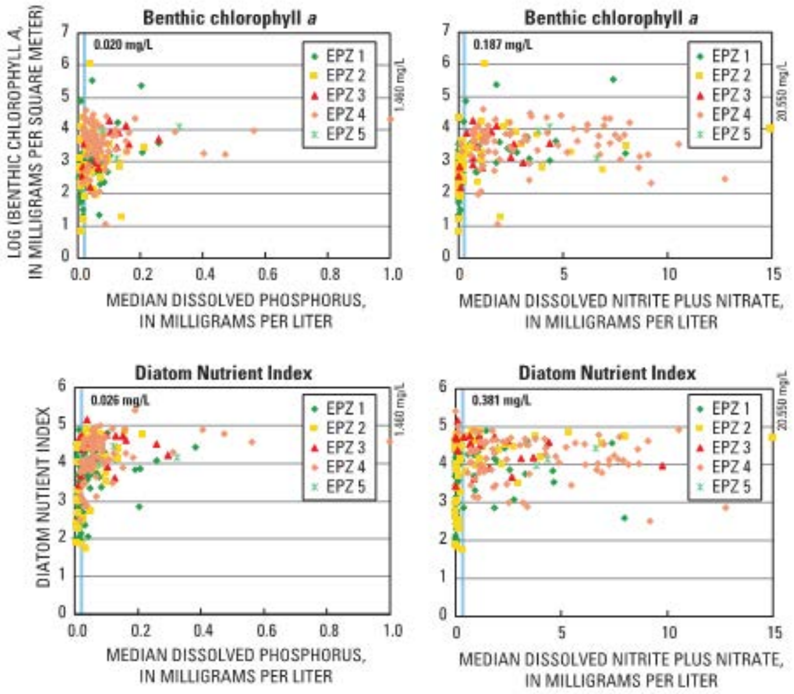

United States Environmental Protection Agency | Office of Water Office of Science and Technology Washington, DC 20460 | EPA-822-B00-001 April 2000 www.epa.gov

Nutrient Criteria Technical Guidance Manual

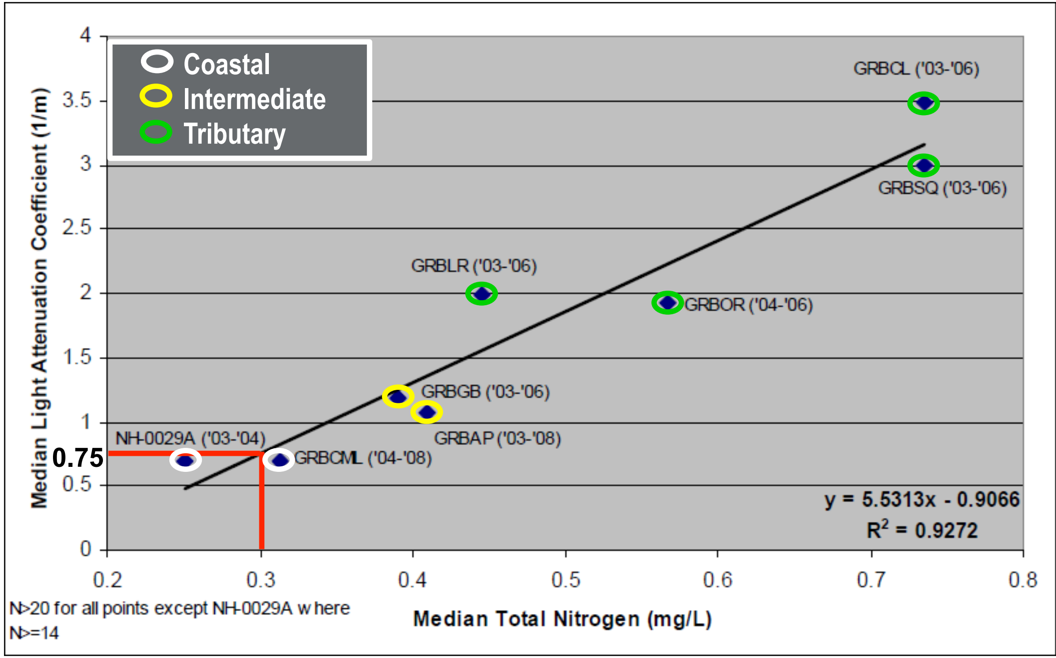
Lakes and Reservoirs

CORRELATION FAILURES

Wadeable streams (WI)



Great Bay Estuary (NH)

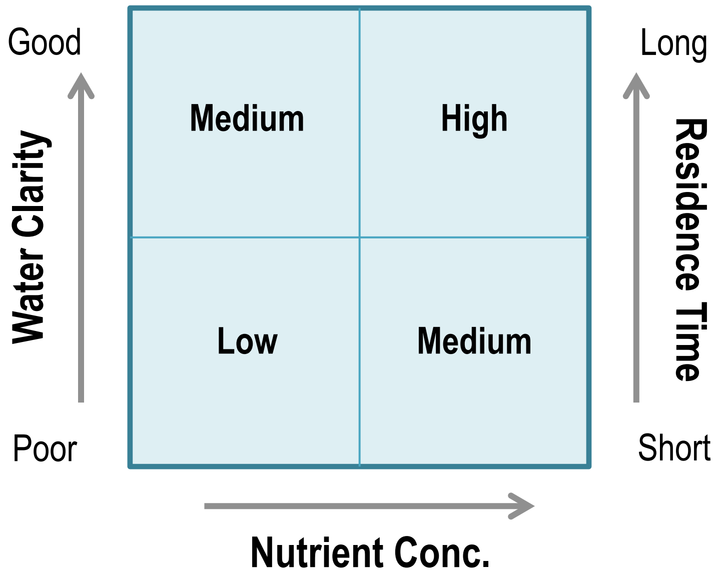


DIFFICULTY IN SETTING NNC

- Nutrients cannot be treated as a toxic substance to develop NNC
  - Except for ammonia, which does cause aquatic toxicity

- Because nutrient effects do not follow a dose-response relationship
  - Many “other” factors affect nutrient effects in water bodies

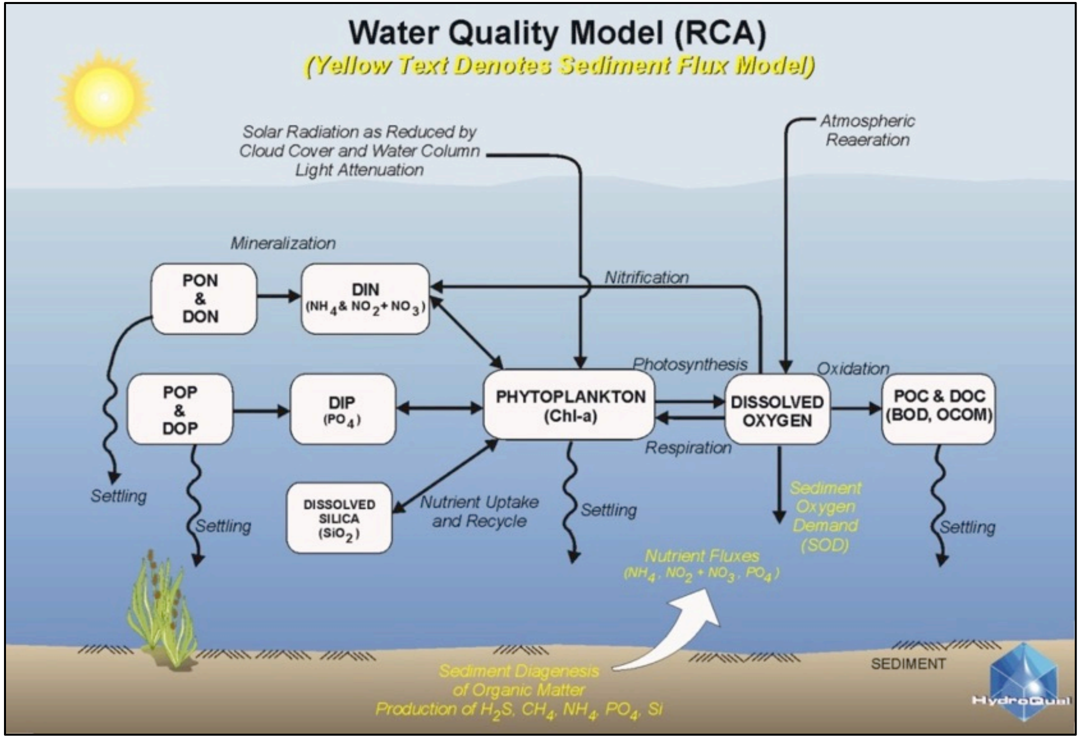
- “Other” factors include:
  - Residence time
  - Available light (affected by turbidity/color/algae)
  - Temperature
  - TSS, toxics, habitat, flow, etc.



WATER QUALITY MODELS – ROLE IN NNC PROCESS

- Models provide a quantitative framework for determining water body response to many factors
  - Water movement (circulation)
  - External loads (PS & NPS)
  - Internal nutrient cycling (algal growth, sediment interactions)
  - Meteorology (wind, climate change)

- By setting a nutrient “effects” criteria
  chl-a, DO, % bottom light),
  quality models can be used to
  and allowable
  TMDL, WLA)



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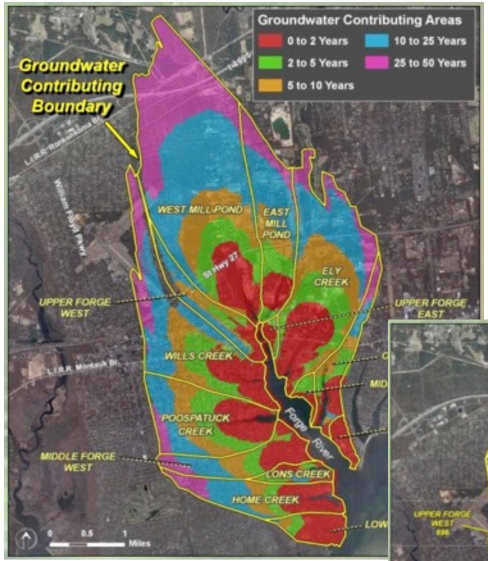
FORGE RIVER (NY - LI)

FORGE RIVER TMDL (TOWN OF BROOKHAVEN)

- Much of LI (Suffolk County) is still un-sewered which results in large nitrogen loadings to the surrounding coastal water bodies

- Forge River watershed (~570 acres)
  - High density of on-site septic systems
  - Groundwater inflow is ~60-80% of total freshwater flow to river
  - 50% built-up, 24% vacant, 15% transportation, 11% ag/open
  - WQ issues: algal blooms, low DO, high NO_2+NO_3

- 3rd Party TMDL completed to support NYSDEC
  - Partnered with CDM Smith
  - TMDL developed for nitrogen to meet DO water quality standard



EXISTING NITROGEN LOADS

- Pre-TMDL watershed characterization study
  - Identified nitrogen sources, groundwater/OWTS role, existing water quality assessment, reduction options
  - Set groundwork for completing the nitrogen TMDL

Existing Nitrogen Contributions (lbs/day)

Lower Forge West	1.73
Home Creek	137.61
Lons Creek	75.18
Middle Forge West	49.05
Poospatuck Creek	164.01

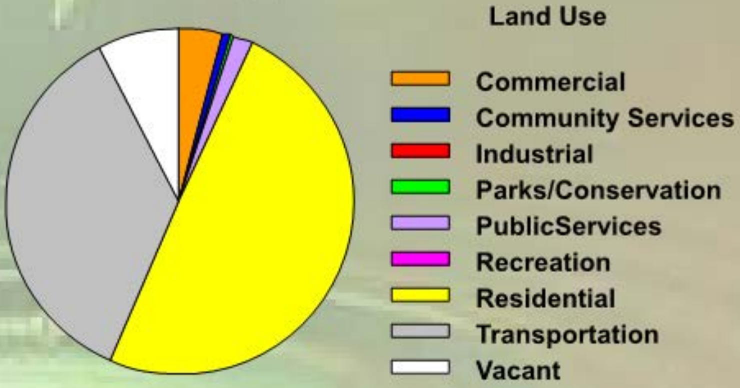
Wills Creek	173.20
Upper Forge West	41.82
West Mill Pond	301.25
East Mill Pond	41.83
Upper Forge East	3.59

Ely Creek	97.57
Middle Forge East	3.83
Old Neck Creek	148.31
Lower Forge East	5.55

Subwatershed Summary – Wills Creek

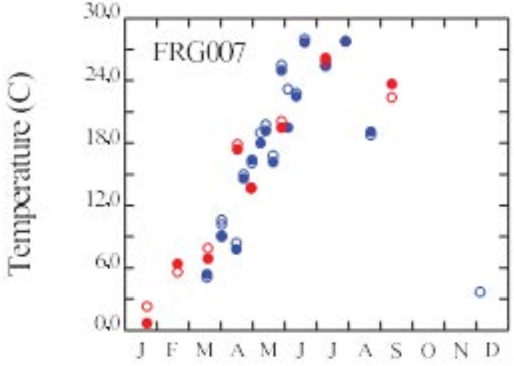
Nitrogen Contributions (lb/day)		
Inputs	Existing	Build-out
Fertilizer	10.04	10.08
Atmospheric	10.06	10.06
On-Site Wastewater	127.01	130.19
WWTP Effluents	0.00	0.00
Benthic Flux	26.09	26.09
Total	**173.20**	**176.42**

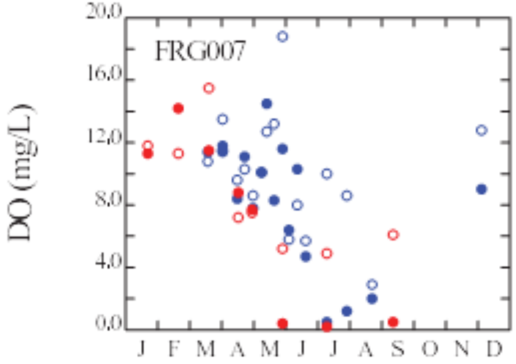
Source: Project team estimates and Benthic flux methodology by *SUNY SOMAS

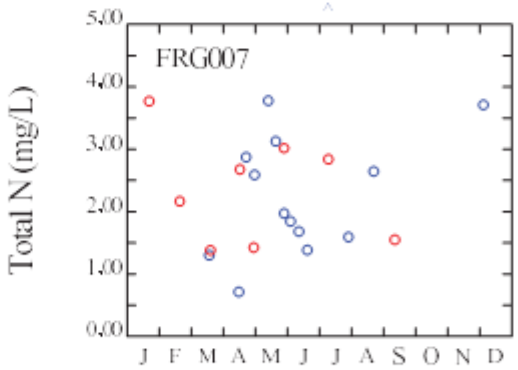


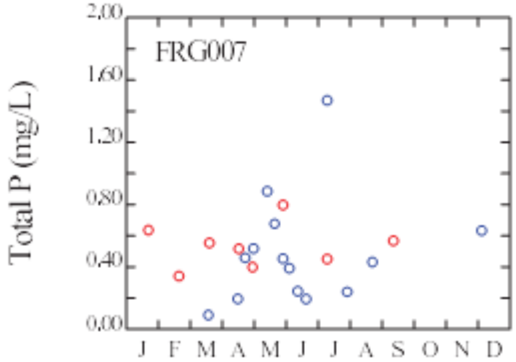
- 2,404 On-Site Wastewater Treatment Systems
- Residential is majority of land use
- Transportation (Airport) is second largest use

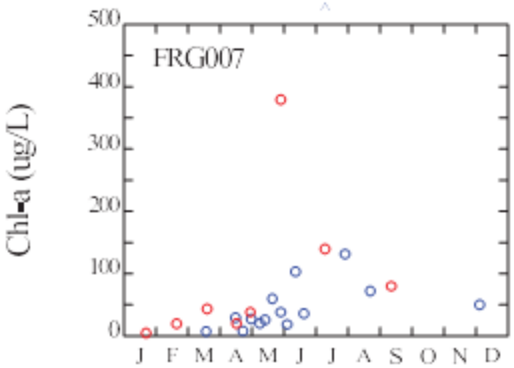
EXISTING WATER QUALITY DATA





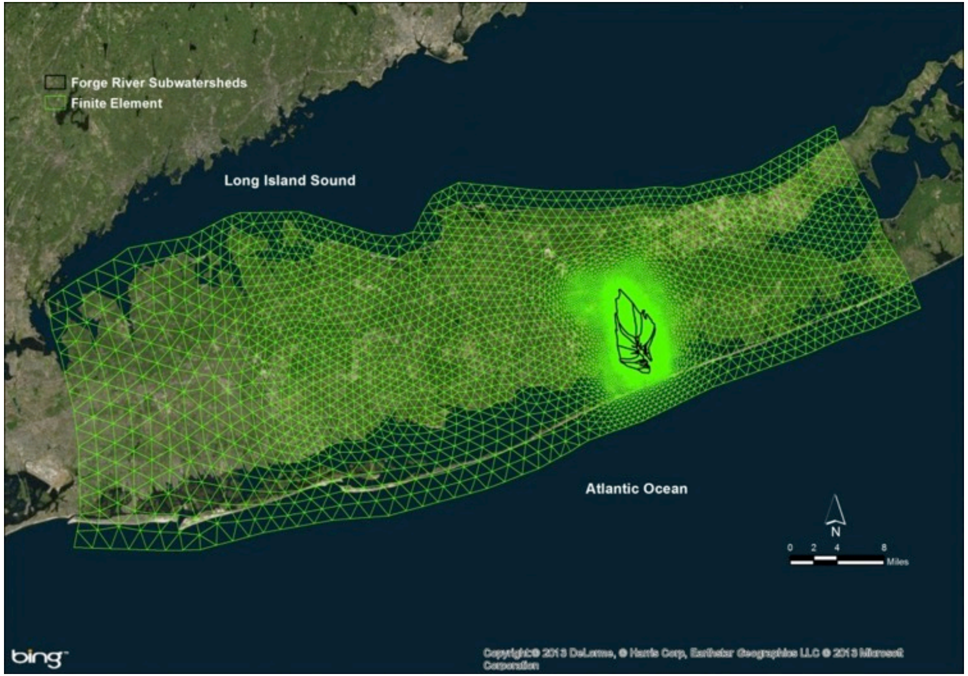


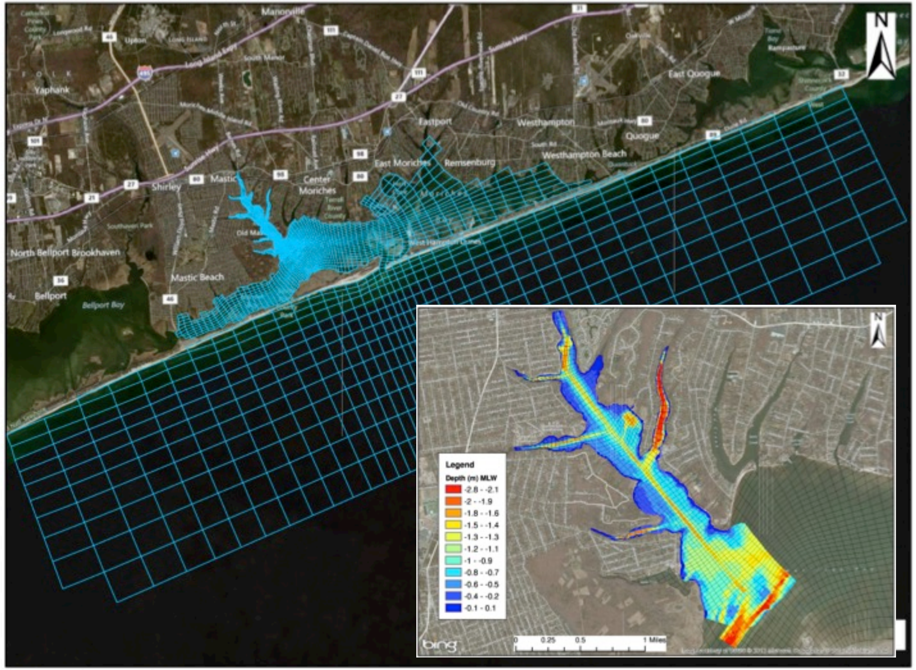




MODELING TOOLS
(GROUNDWATER & SURFACE WATER)

- Surface water models include hydrodynamic (circulation) & eutrophication (nutrient/algal/DO)





TMDL RESULTS

- NYSDEC tiered DO standard (daily average – 4.8 mg/L, minimum – 3 mg/L)

- Closing of Duck Farm at top of watershed
  - Significantly reduced TN & TP in the river upstream
  - Reduction in algae (chl-a) & improved DO levels observed

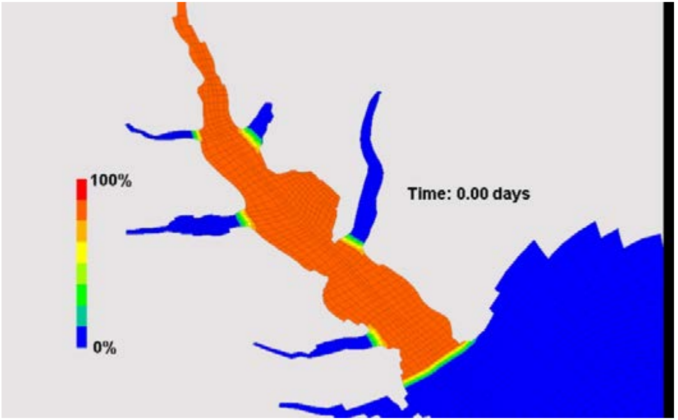
- Groundwater nitrogen load was main focus of TMDL & examined with the models
  - Investigated differing levels of sewering & new WWTP with discharge to GW of 5 mg/L
    - Resulted in ~17-26% TN load reduction but did not result in full DO standards attainment
  - Additional GW load reductions evaluated (up to 90%) to represent additional sewering
    - 80-90% GW nitrogen reductions show just about complete attainment of DO standards
    - Resulting TMDL is 74 lb/d TN

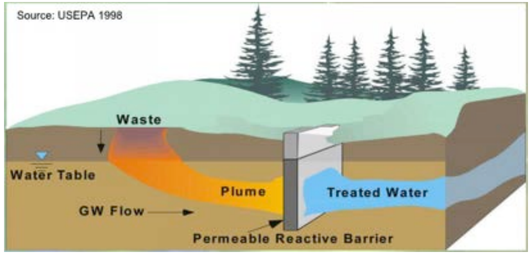
SUMMARY

- Importance of considering GW nitrogen sources to properly account for all loads

- Modeling tools allow for evaluation of load reduction alternatives
  - Focused/adaptive implementation (i.e., phased sewering)
  - Impacts of phased load reductions on water quality

- Provides assessment of whether DO standard can be attained
  - Low bottom water DO may not be fixed by nitrogen reduction alone
  - Due to bathymetry (holes/sills) & past dredging activities





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GREAT BAY (NH)

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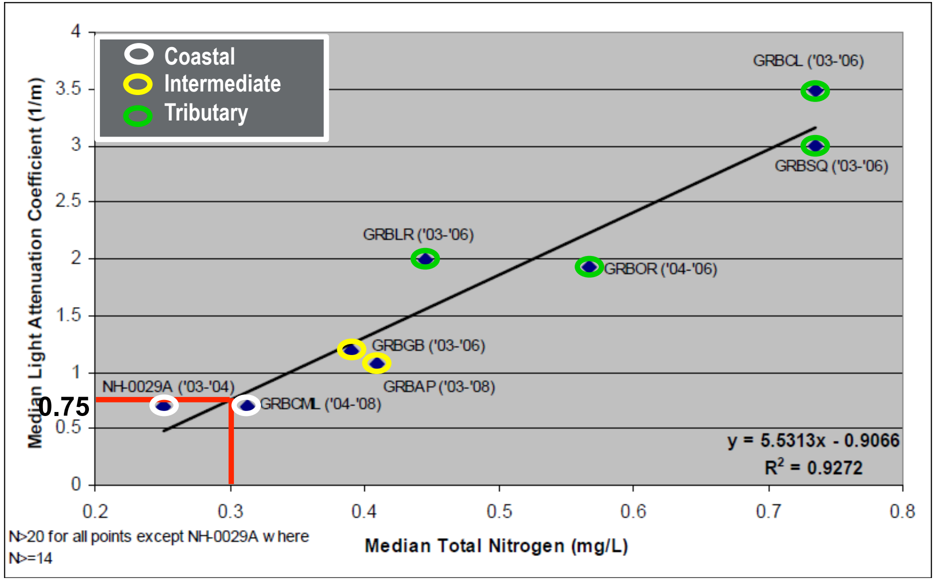
GREAT BAY TN CRITERIA & MODELING

- TN criteria developed by NHDES based on providing sufficient light for eelgrass restoration
  - Good reason for setting NNC but sound relationship between TN & light is required
  - Goal is to provide sufficient light for eelgrass restoration to a target depth of 2 meters

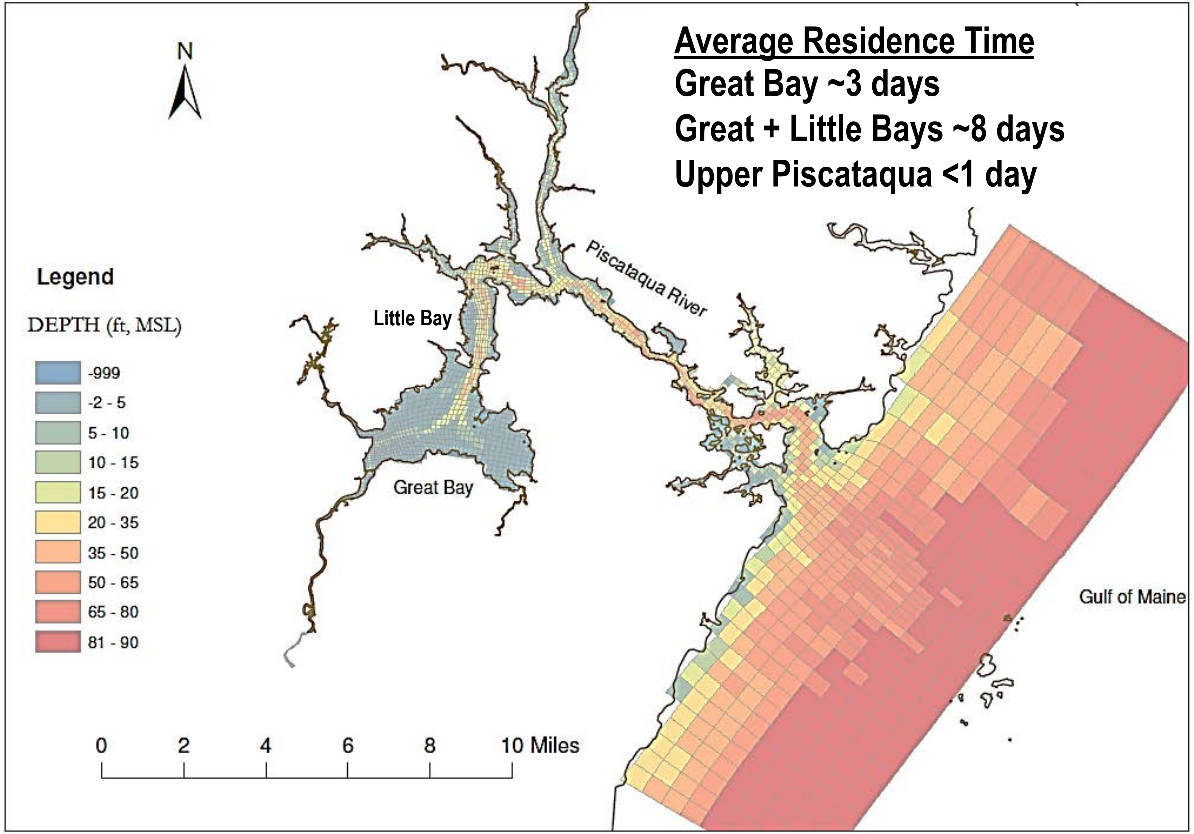
- TN criteria of 0.3 mg/L proposed in the bay
  - But approach mixed light attenuation from different parts of the bay with varying turbidity/color levels
  - TN co-varied with turbidity/color

- Initial WWTP TN effluent limits of 3 mg/L set by EPA
  - But WWTP contributions to bay TN levels were not considered



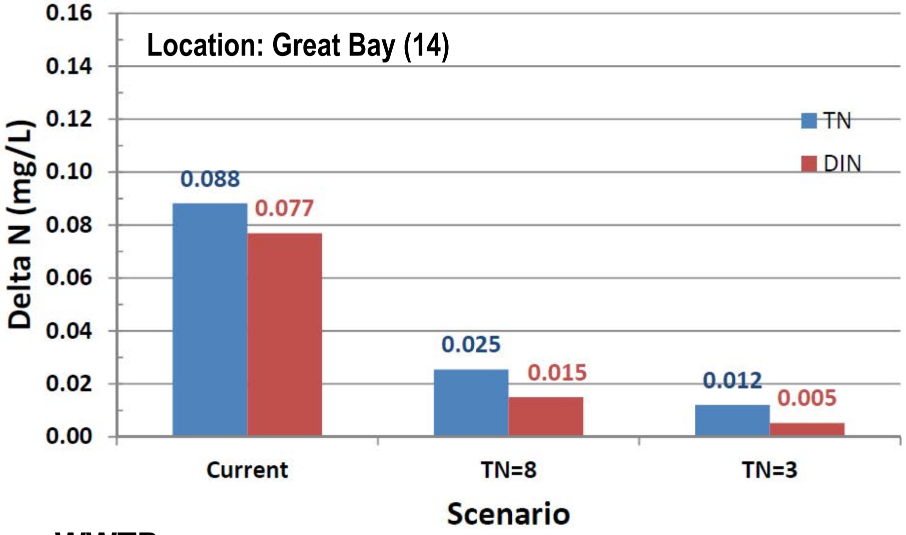
GREAT BAY ESTUARY HYDRODYNAMIC MODEL

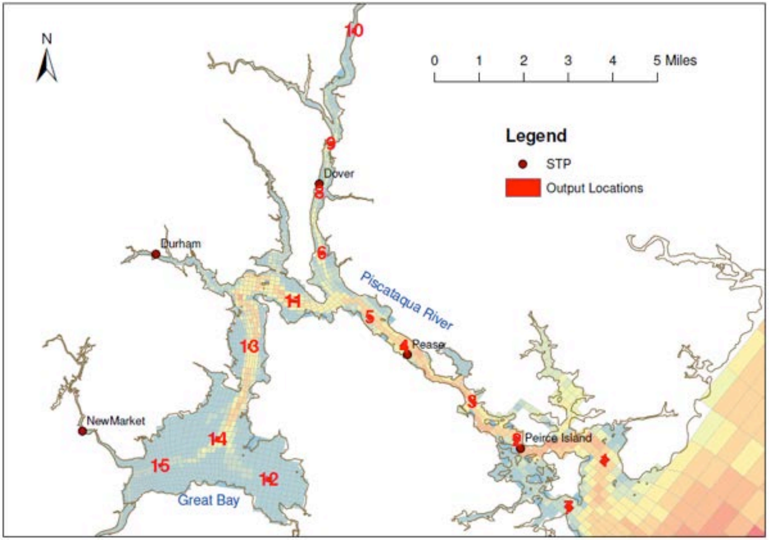
- Model calculates water circulation due to tides, freshwater flow, density & meteorology (wind)
- For each WWTP, it also calculates effluent dilution throughout the bay system
- This provides an estimate of how WWTP effluent TN contributes to bay levels
    - All WWTPs do not contribute equally throughout the bay system (location & flow matters)

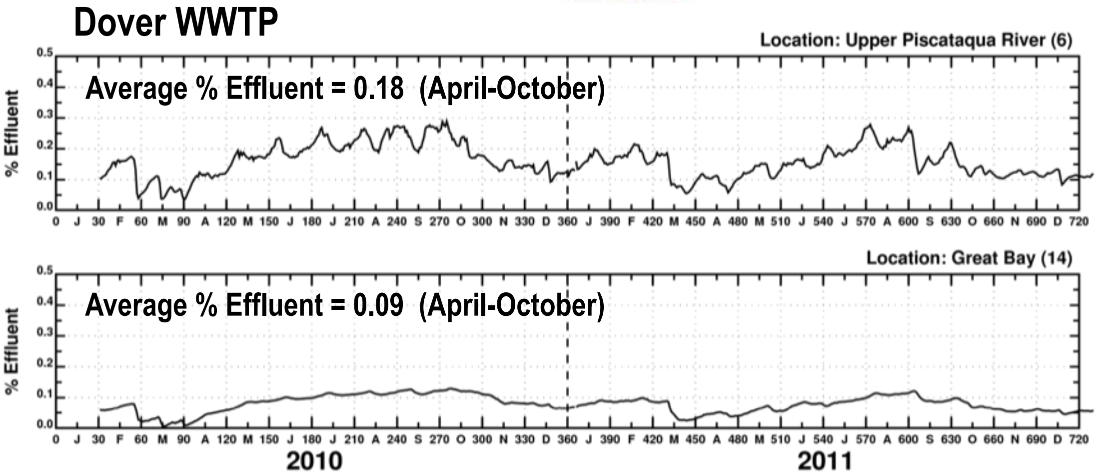


MODELING RESULTS

- % effluent calculated at different locations
- Delta TN for all WWTPs
  - Dover, Rochester, Portsmouth, Exeter, Durham, New Market

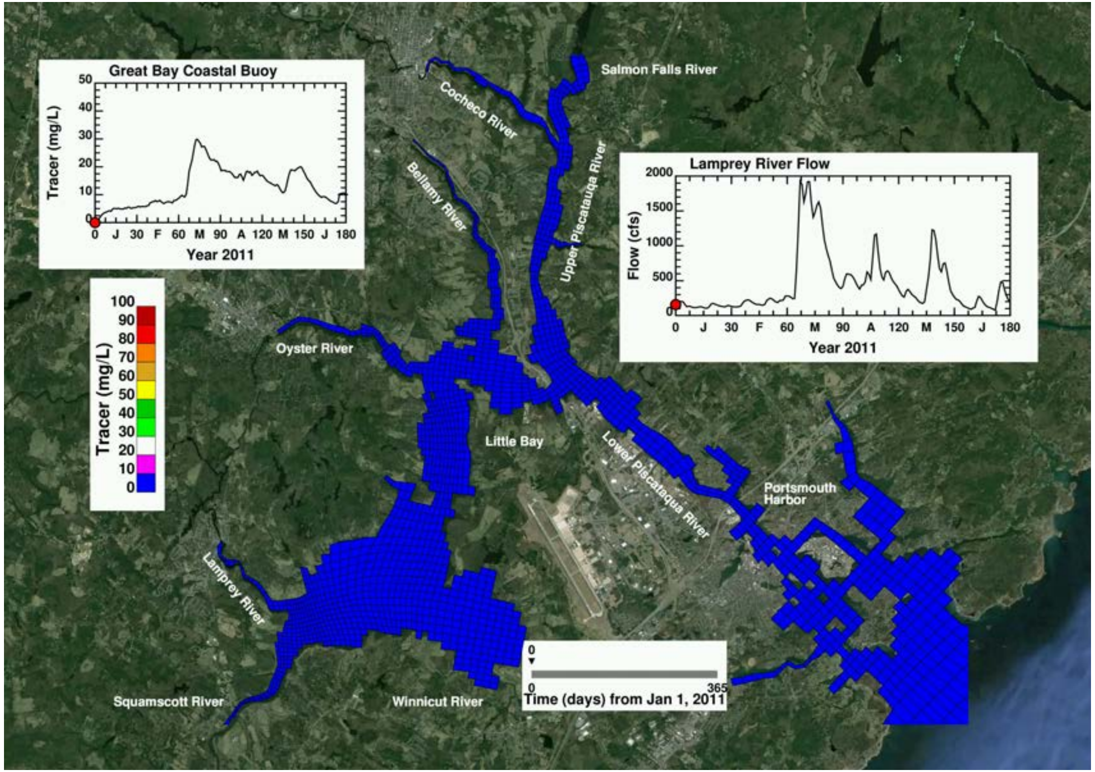






SUMMARY

- Set criteria based on complete understanding of circulation & competing effects of “other” nutrient related parameters (turbidity/color)
- Models allow for tidal circulation to be considered in assessing the relative impact of WWTPs
- Different bathymetric features can also be considered
  - Great Bay shallow with tidal flats other areas are deeper



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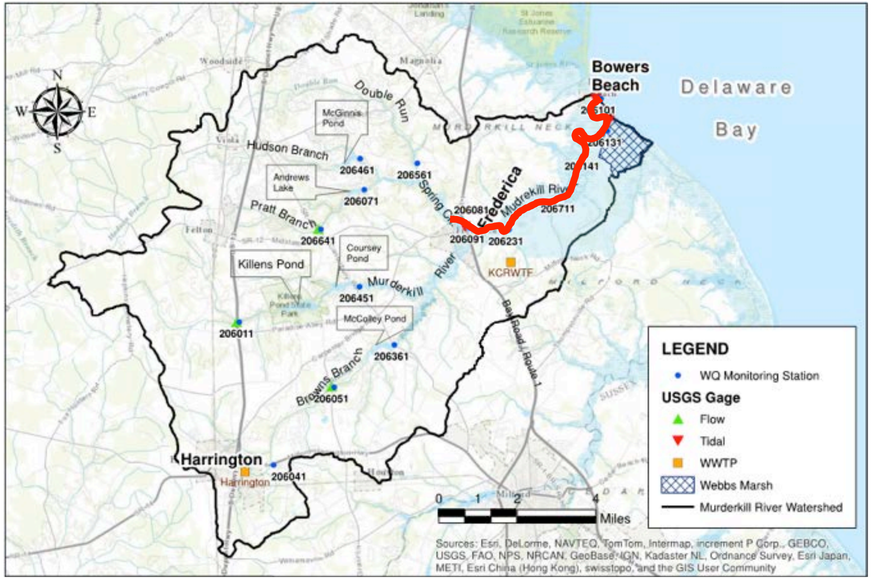
MURDERKILL RIVER (DE)

MURDERKILL RIVER TMDL (DE)

- Long history of low DO in tidal river (from 1970s to present with nominal improvements over time)
  - But WW treatment has improved over time
- Murderkill River watershed (~62,000 acres)
  - Primarily agriculture land use but includes WWTP
  - 57% ag, 17% residential, 15% wetland, 11% forest
  - Primary WQ issues: low DO & bacteria
- 3rd Party TMDL completed collaboratively with DNREC & KCDPW
  - Original TMDL did not include effects of tidal wetlands

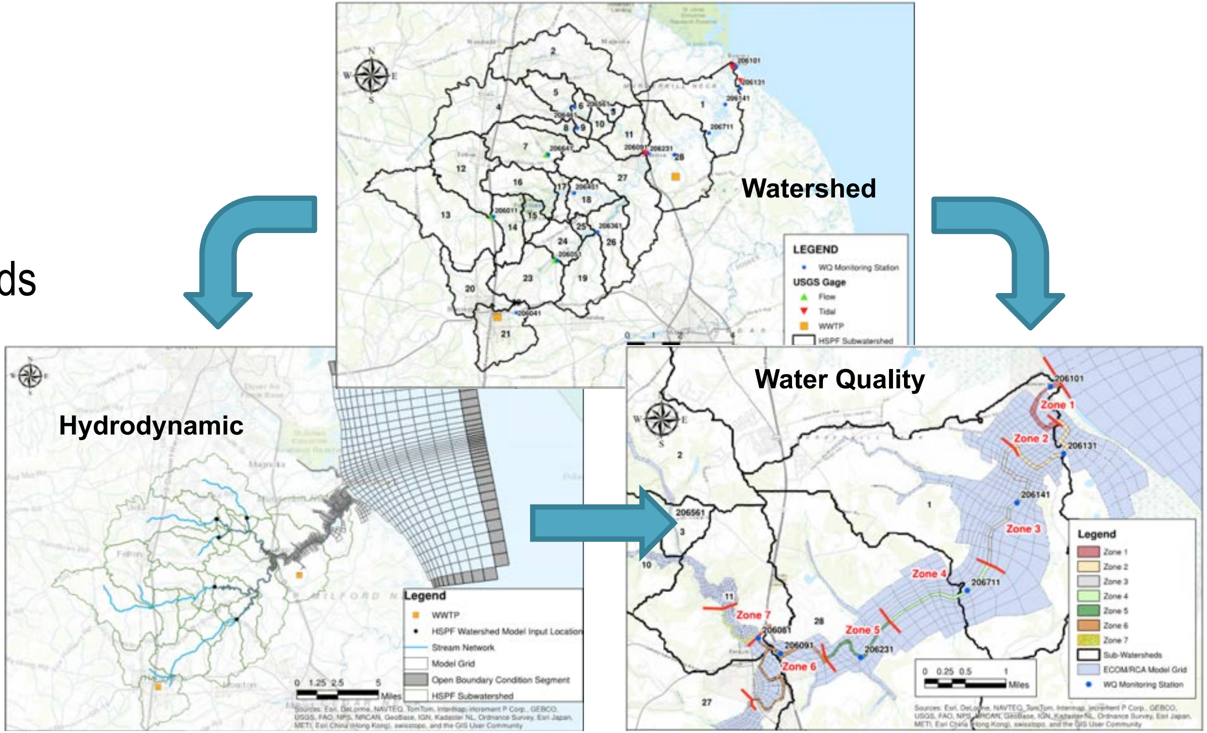


COUPLED MODELS

- Watershed, hydrodynamic & water quality models developed for TMDL

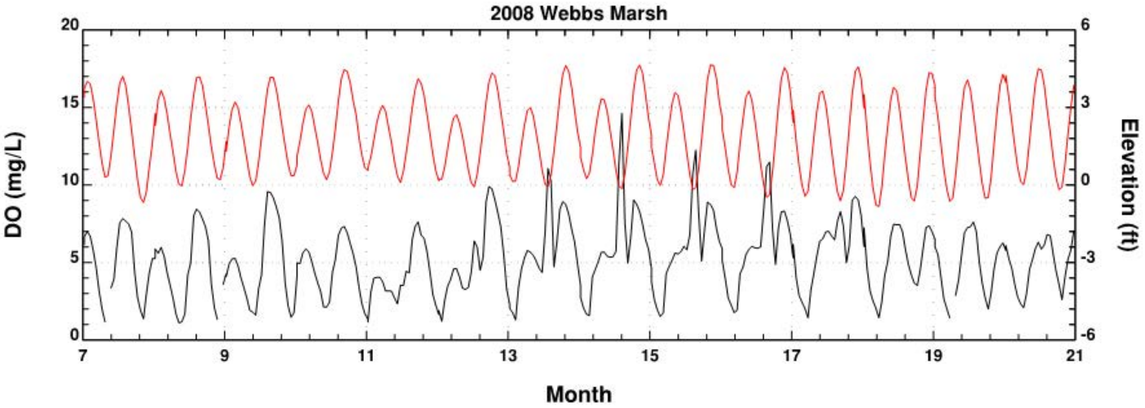
- Tidal models included the river interaction with the adjacent wetlands
  - Tidal storage volume
  - Water quality interactions

- Wetland water quality impacts
  - Large DO consumption
  - Denitrification (N loss)
  - Particulate organic matter (source)



UNCONTROLLABLE SOURCES & BACKGROUND
(MODEL SCENARIOS)

- Tidal marshes considered natural & not manageable
  - TN increase (lost denitrification), small TP & Chl-a changes
  - DO decrease due to tidal marshes of ~1-2 mg/L from existing levels depending on location
- “Natural” background condition also assessed (forested watershed, no PS, GW reductions)
  - Large TN & TP decreases, Chl-a decreases (8-15 µg/L)
  - Only DO increase of ~0.2-0.5 mg/L



UAA & REVISED DO CRITERIA FOR TIDAL RIVER

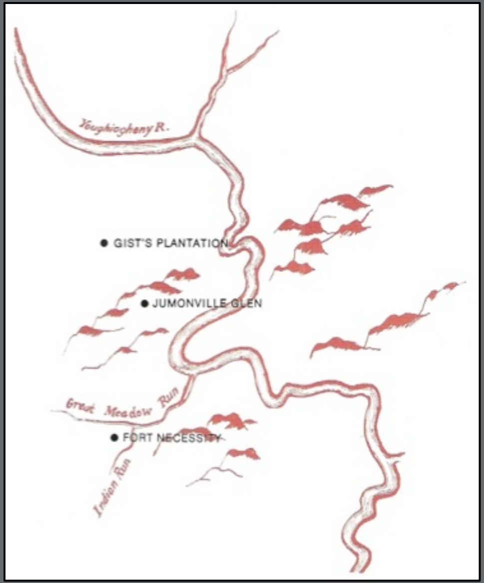
- Tidal marshes determined to be main factor controlling DO levels in the river
- Models used to guide development of Use Attainability Analysis (UAA)
  - New sub-category to the DNREC aquatic life use established
  - "Tidal Marsh Influenced Aquatic Life" Use sub-category

4.1.2.5	The Murderkill River from the Route 1 Bridge to the mouth at Bowers Beach
4.1.2.5.1	Tidal Marsh Influenced Aquatic Life use DO standards for the period from May 16 to September 30:
4.1.2.5.1.1	Daily average shall not be lower than 3.0 mg/L
4.5.2.5.1.2	Minimum one hour average shall not be less than 1.0 mg/L
4.5.2.5.2	For the period from October 1 to May 15 applicable criteria for all waters of the state shall apply

- TMDL followed that resulted in 30-50% reduction in NPS N/P/C loads & ENR at the KCRWTF

CONCLUSIONS

- Many factors control nutrient effects in water bodies
  - Nutrient source (GW), residence time, available light, “other” factors
- Water quality models are valuable in assessing the effects of nutrient loading
  - Models can include the “other” factors affecting nutrient effects
- Nutrient management of PS & NPS sources requires a modeling tool due to the high cost associated with nutrient removal



Fort Necessity (Natural Background?)
“He placed his wagons and pitched his tents between two shallow gullies that might serve as natural entrenchments. **The ground was marshy in spots. Great Meadows Run, a twisting, weed grown stream some 10 feet wide in places**, and a smaller branch later known as Indian Run, crossed the area.”

George Washington, 1754

HDR