Water Quality Issues and Water Quality Modeling in the Albemarle-Pamlico Waters

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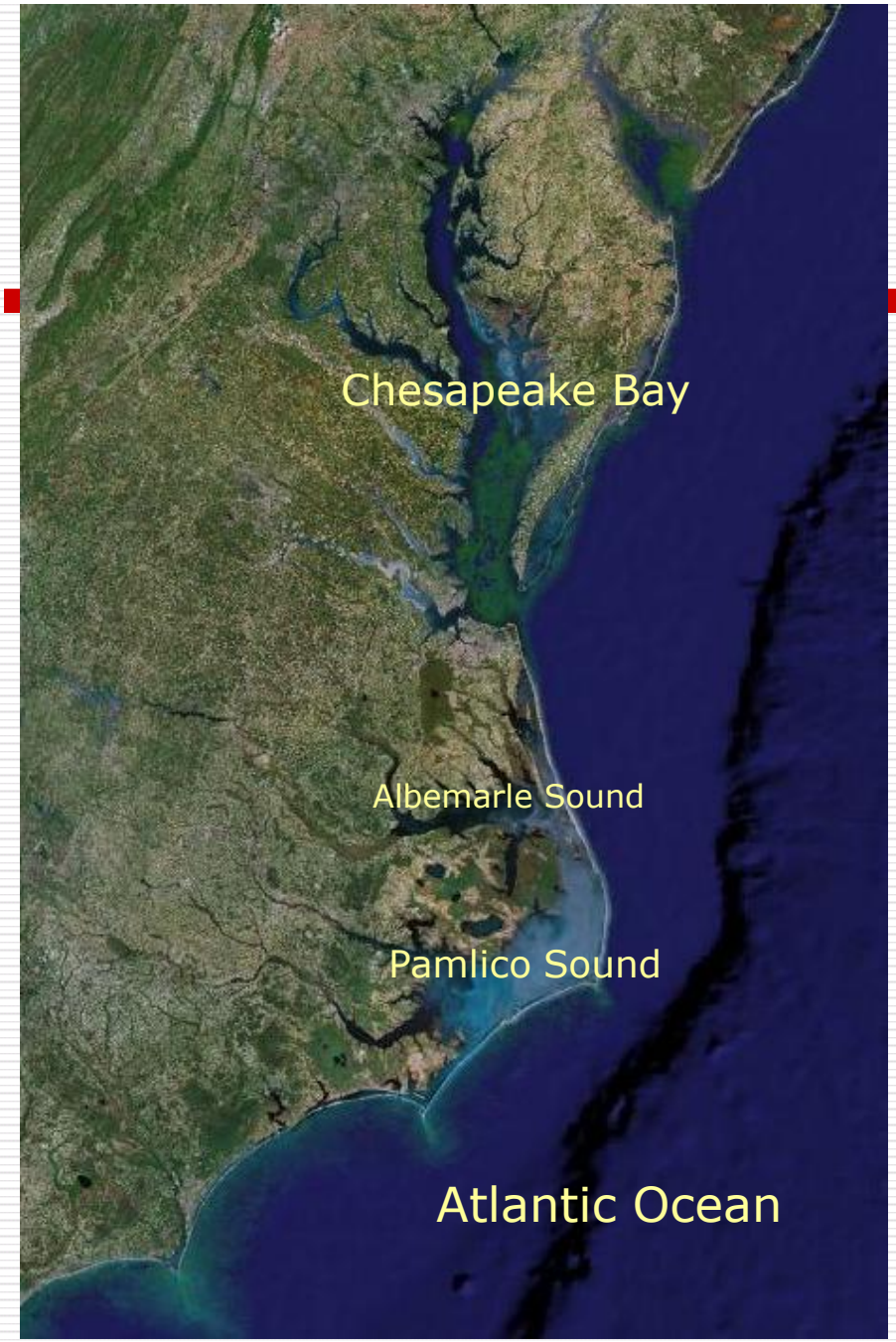
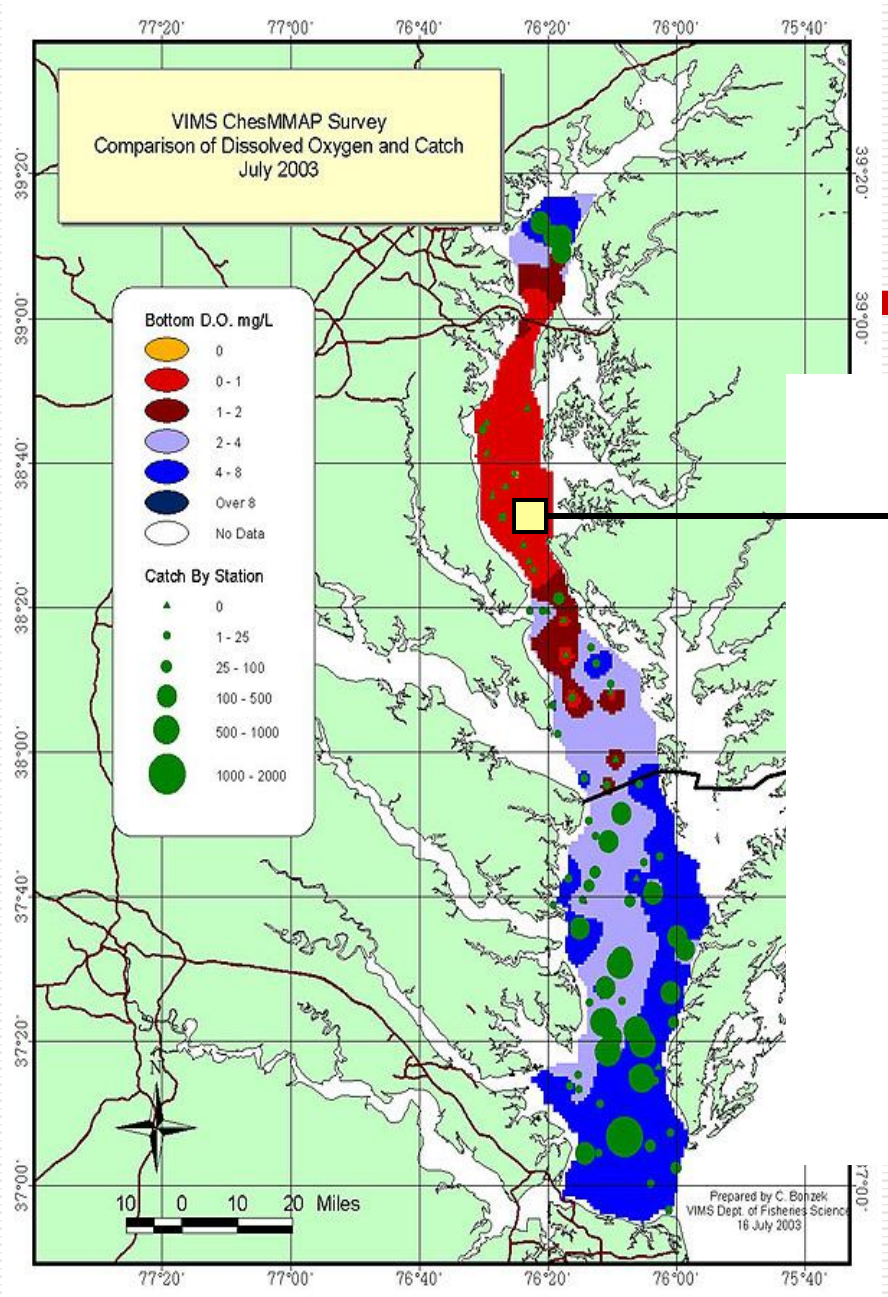


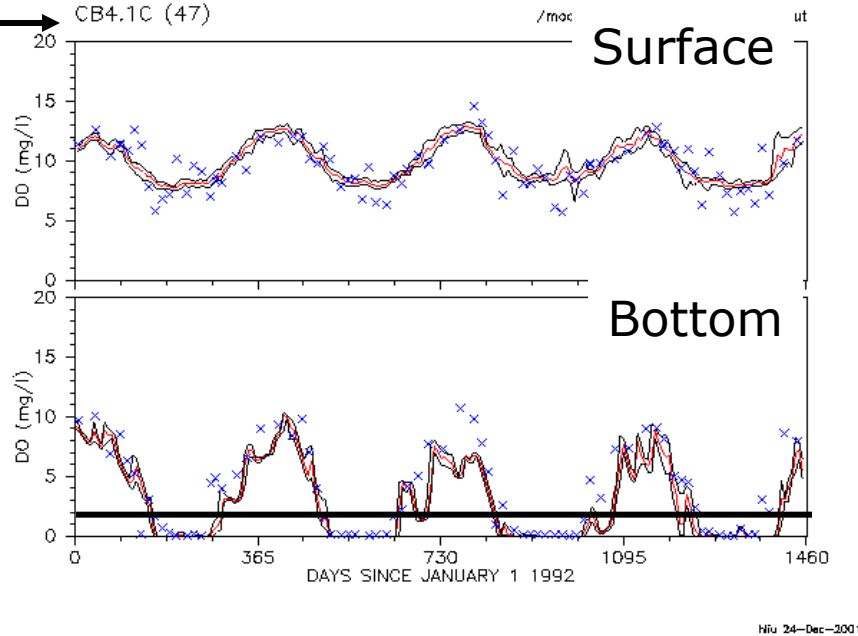
Chesapeake Bay:
Watershed area: 64,000 mile^2
~~Surface area: 2,500 mile^2~~
Averaged depth: ~7.6 m
Greatest depth: ~53 m
Micro-tidal estuary
7-month residence time (Paerl et al., 2002)

Albemarle-Pamlico Sound Estuarine System (APES):
Watershed area: 30,880 mile^2
Surface area: 2,047 mile^2
Averaged depth: ~4.5 m
Greatest depth: ~7.5 m
11-month flushing rate (Pietrafesa et al., 1986)

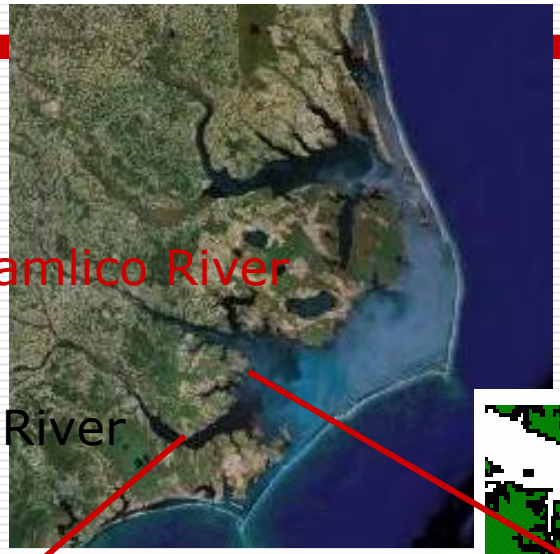
Chesapeake Bay



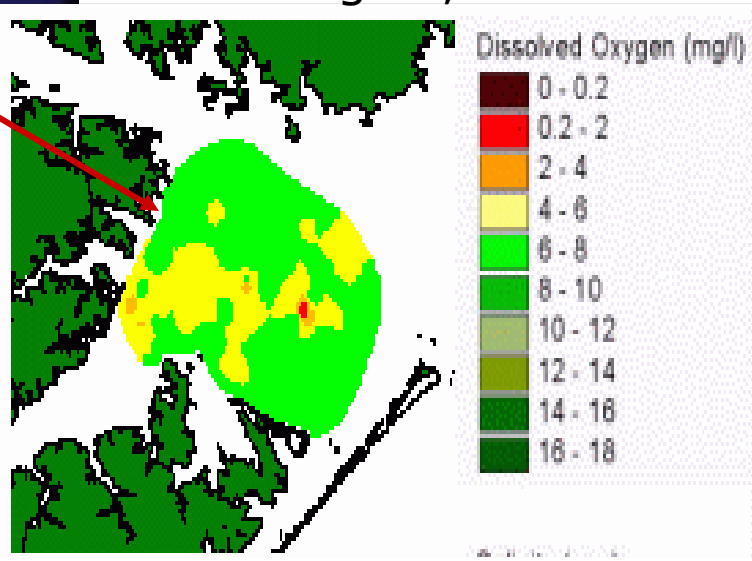
Eutrophication Model Results: DO

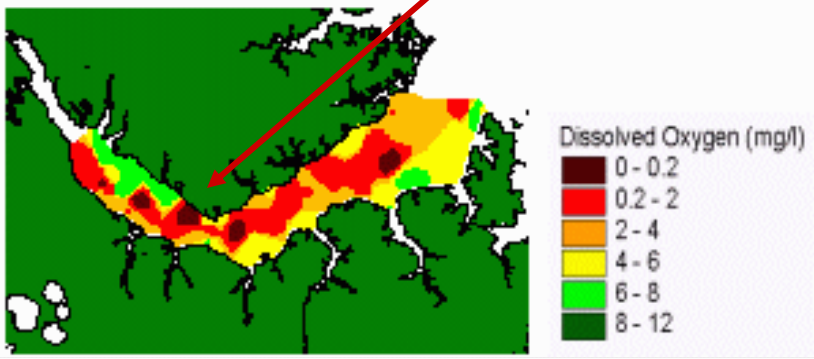


Pamlico Sound



August, 2001

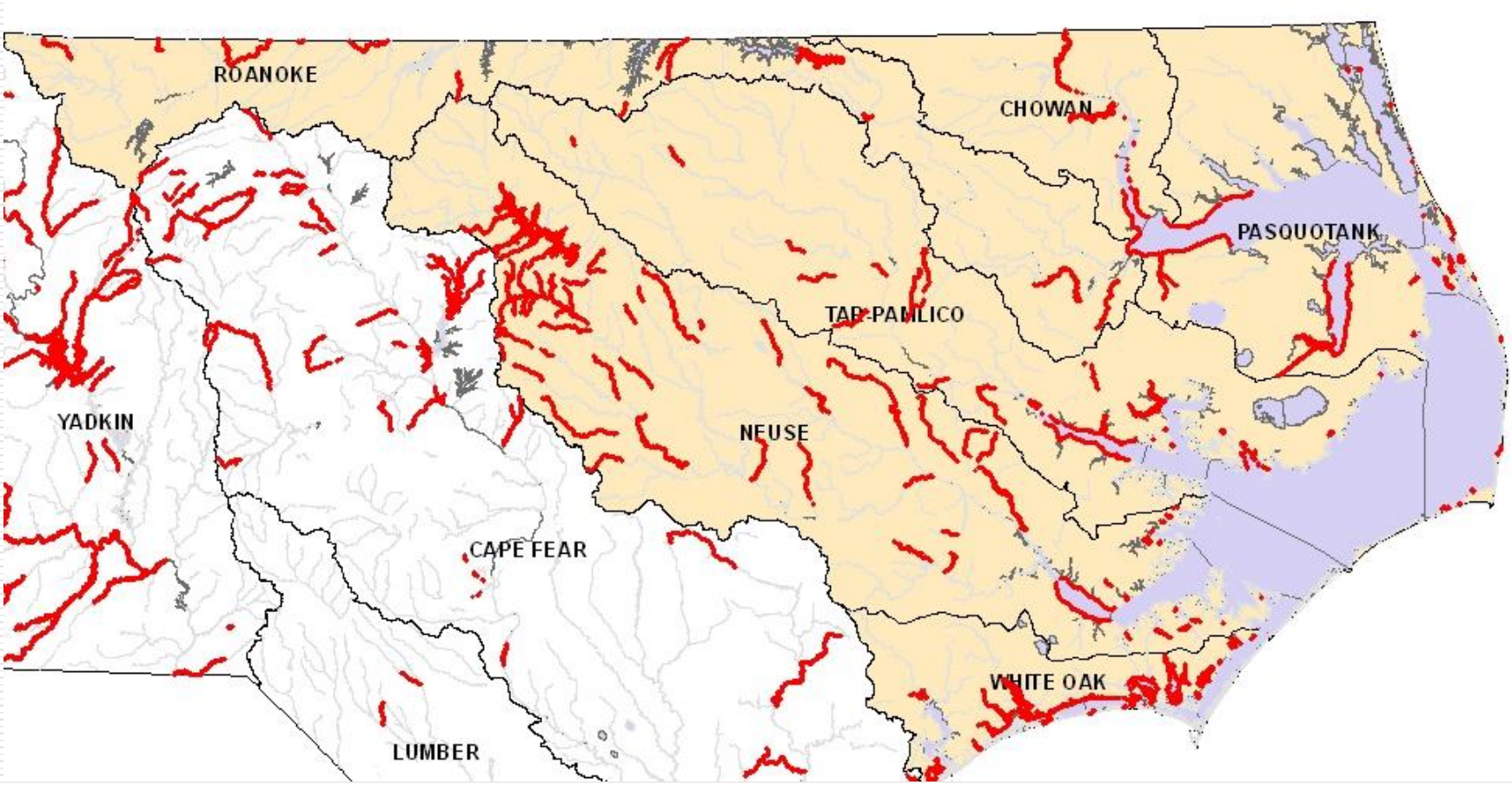




July, 2001

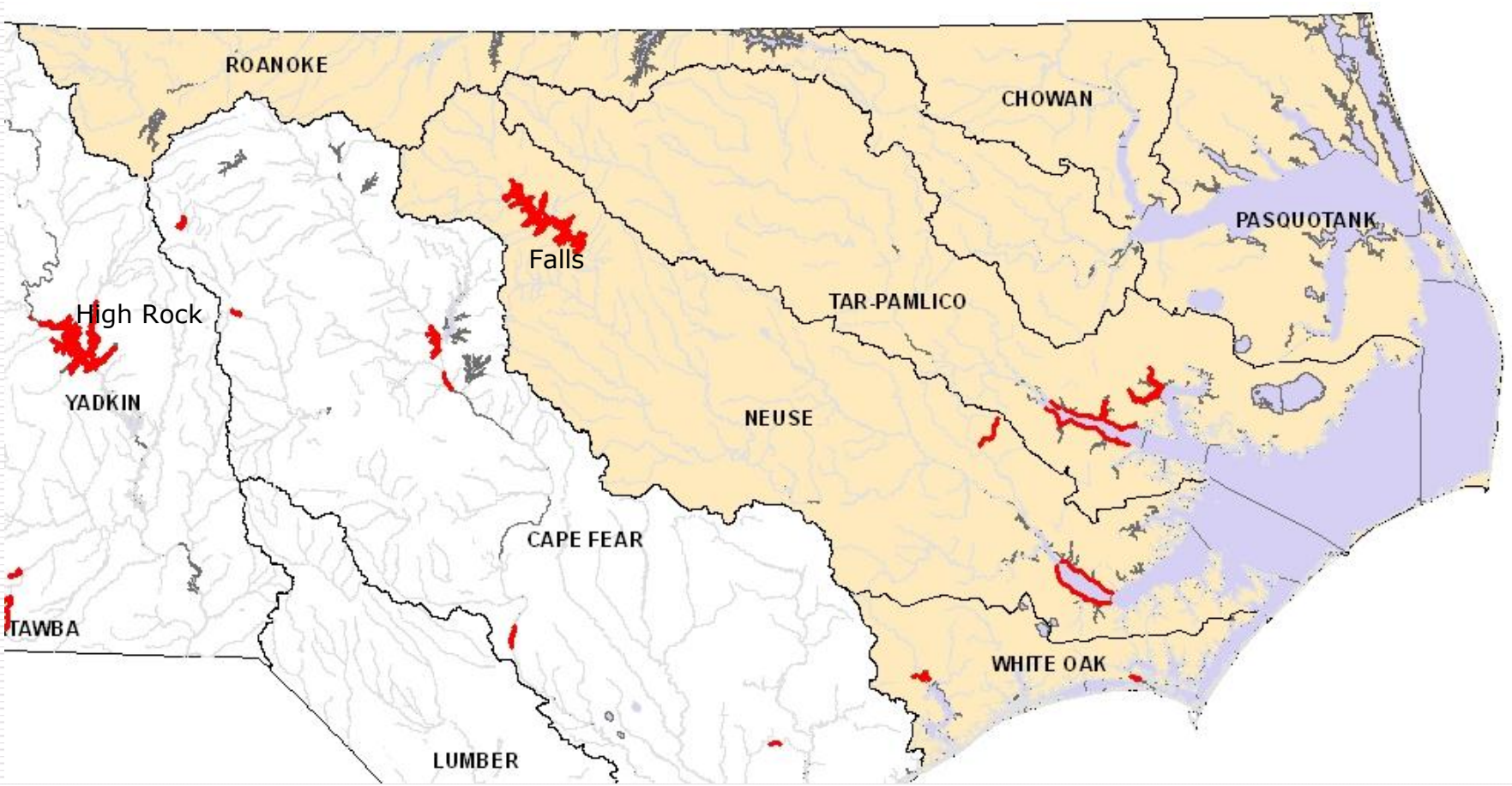
http://moray.ml.duke.edu/faculty/crowder/research/neuse/

NC Impaired Waters (mercury not included)



(2008 draft)

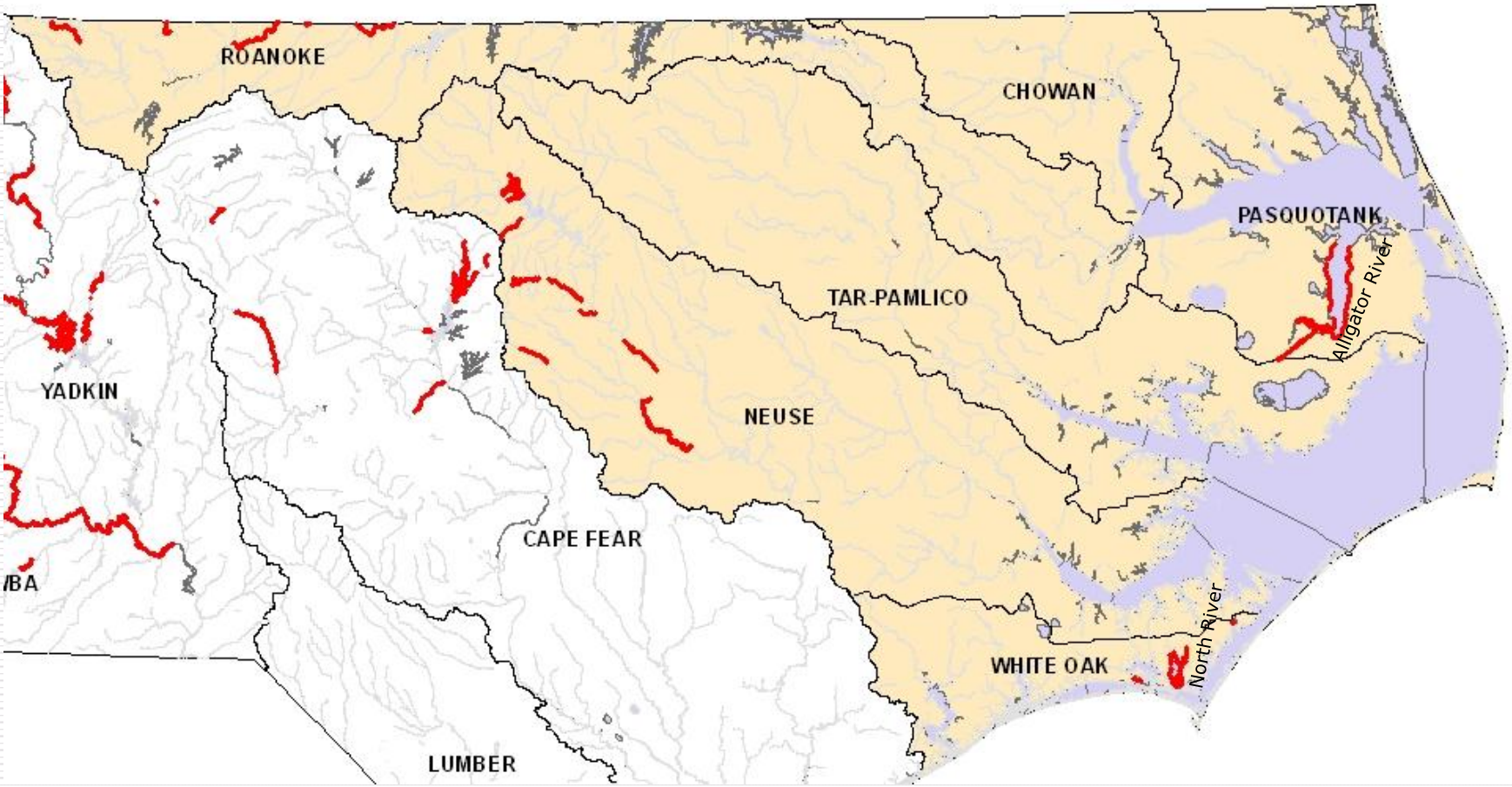
NC Impaired Waters (Chl a & pH)



(2008 draft)

"To preserve, protect and enhance North Carolina's water..."

NC Impaired Waters (turbidity)



(2008 draft)

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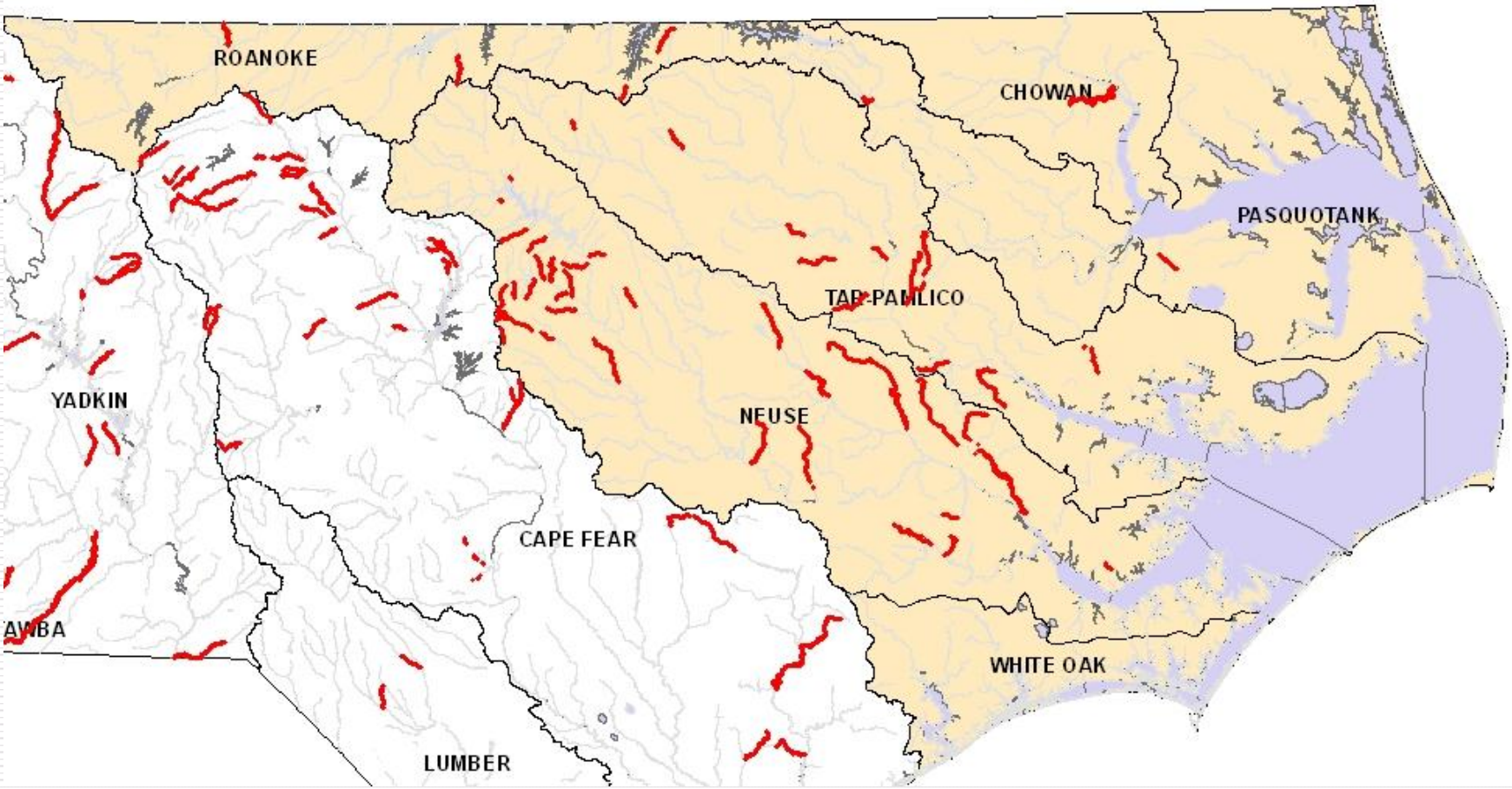
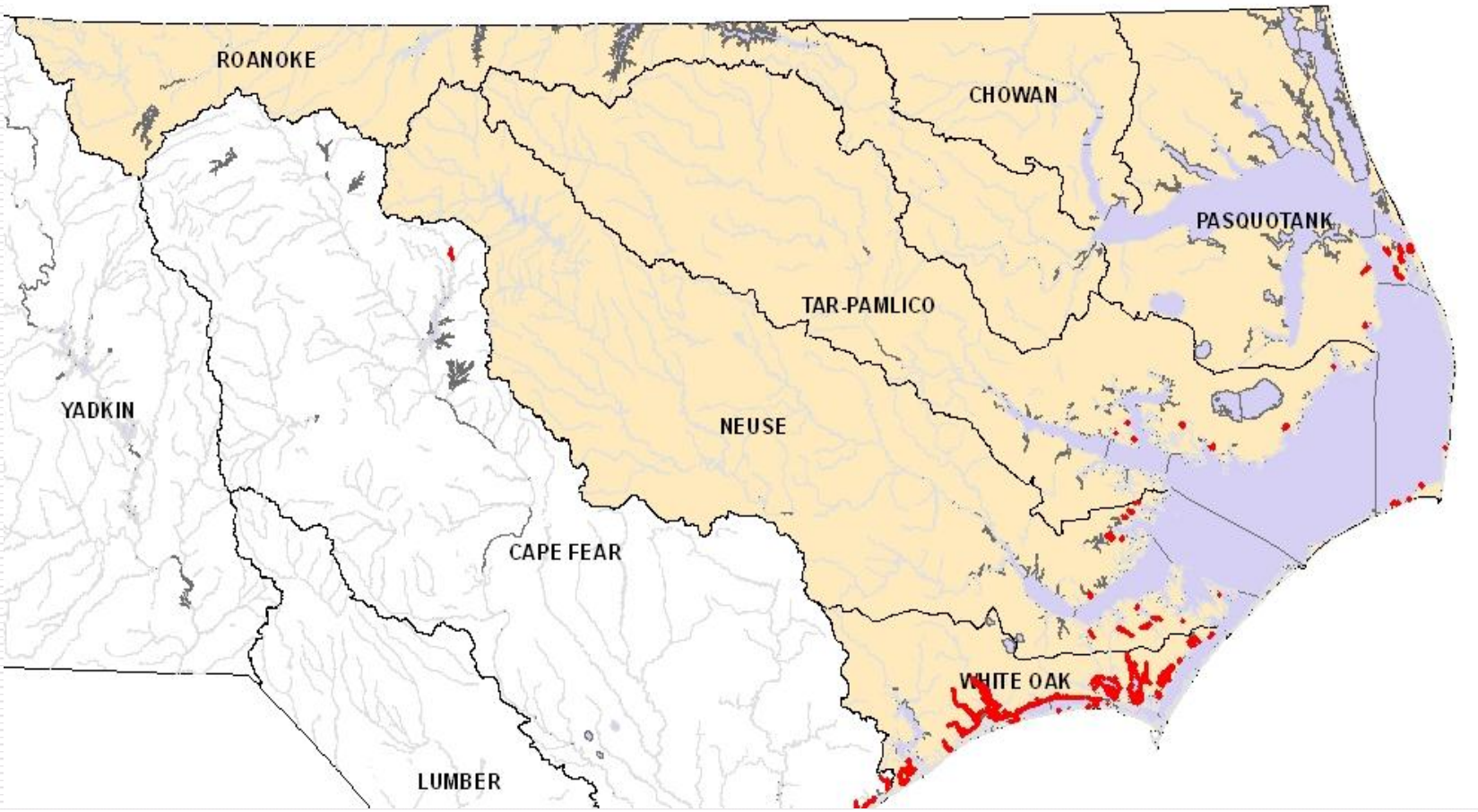
NC Impaired Waters
(ecological/biological integrity benthos)



(2008 draft)

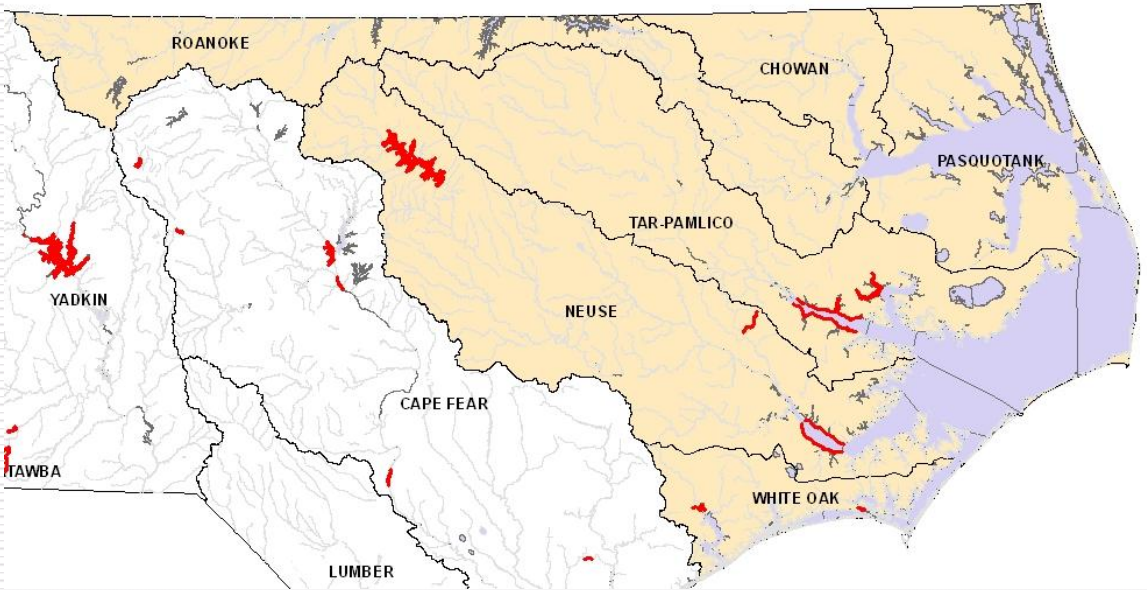
NC Impaired Waters (Fecal Coliform)



(2008 draft)

Nutrient TMDLs and WQ modeling

- Tar-Pamlico (1995)
- Neuse (2002)
- Falls Lake



Tar Pamlico River nutrient TMDL

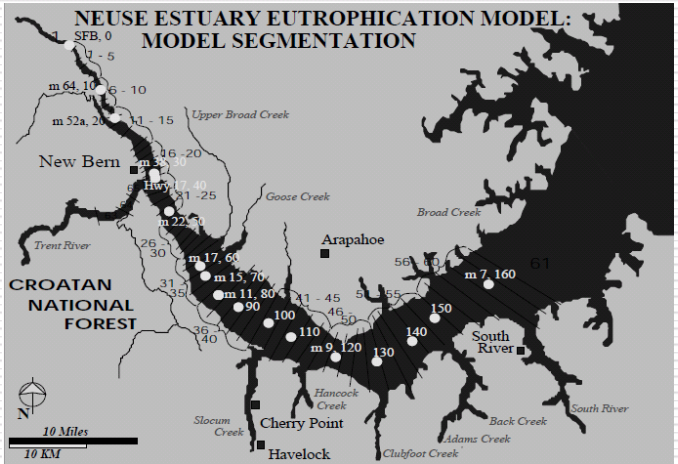
- QUAL2E was used
  - 2-dimensional laterally averaged
  - HydroQual
  - Model calibration year: 1991
  - Model domain: from Greenville to Pamlico Point ~ 60 miles
- Model suggested
  - Washington is critical region
  - Chl a was violated 18% of the time at Washington
  - Chl a could reach 70 ug/l

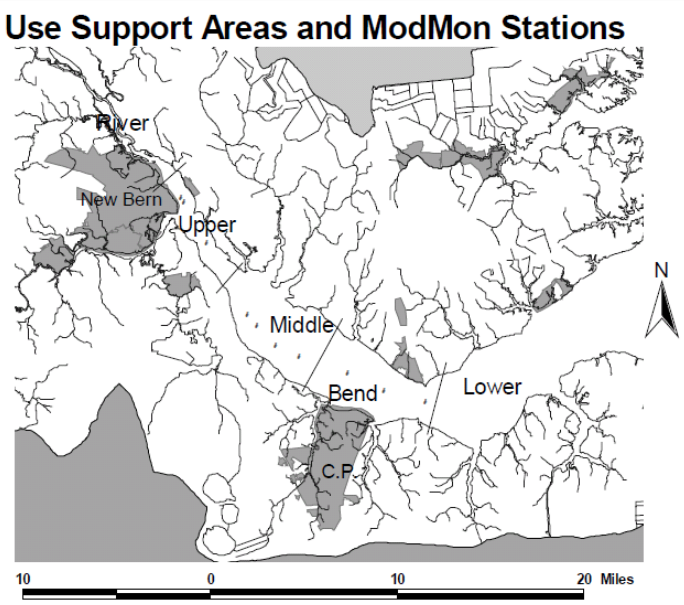
Tar Pamlico River nutrient TMDL

- Model suggested 45% TN reduction needed for no Chl a violation
- Consider model uncertainty, PS treatment technology, and BMP feasibility
- TMDL: 30% TN reduction and no increase in TP

Neuse River nutrient TMDL (II)

- CE-Qual W2 (NEEM)
- Bayesian Ecological Response Network (Neu-BERN)
- Water Analysis Simulation Program (WASP)





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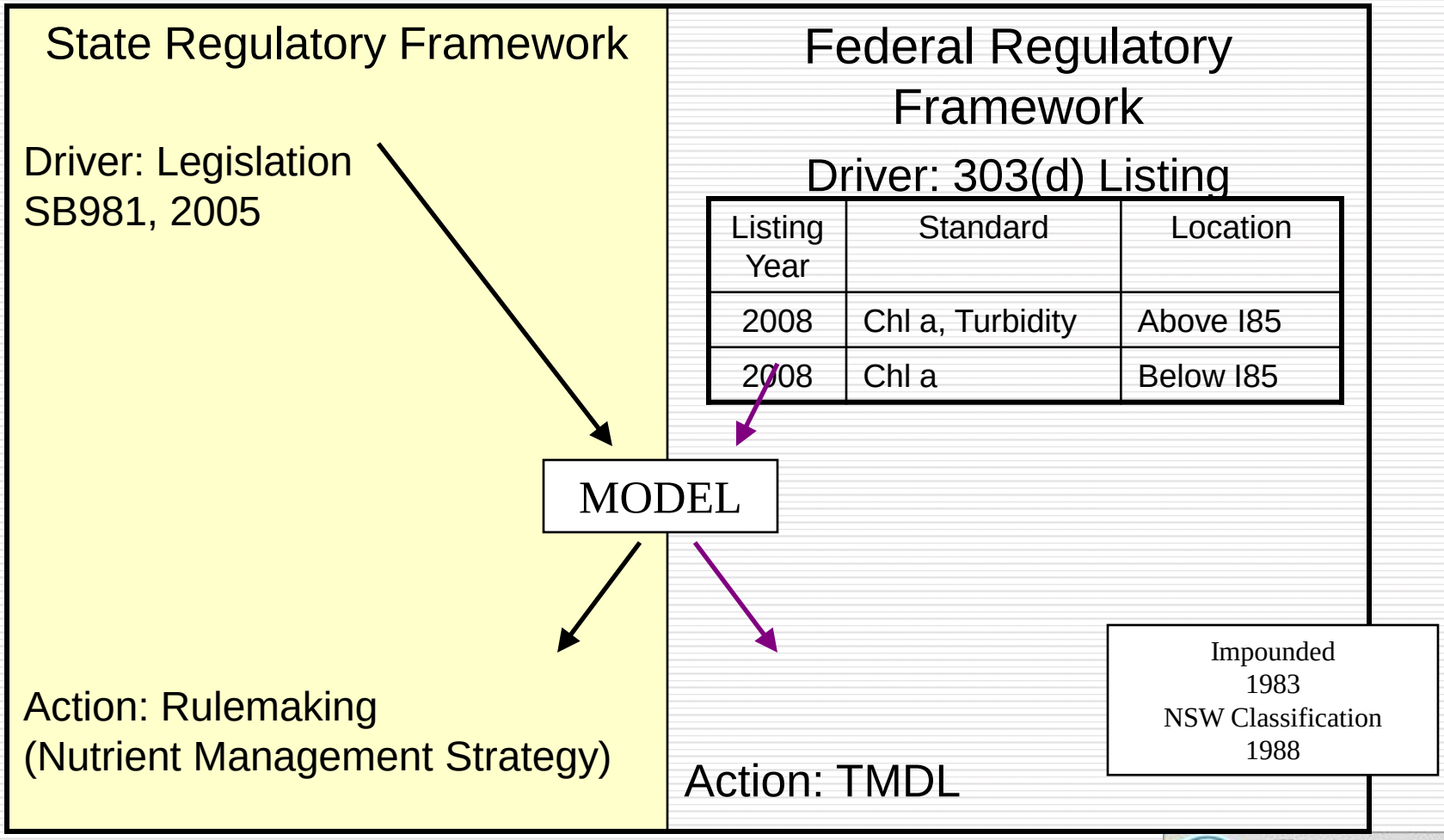
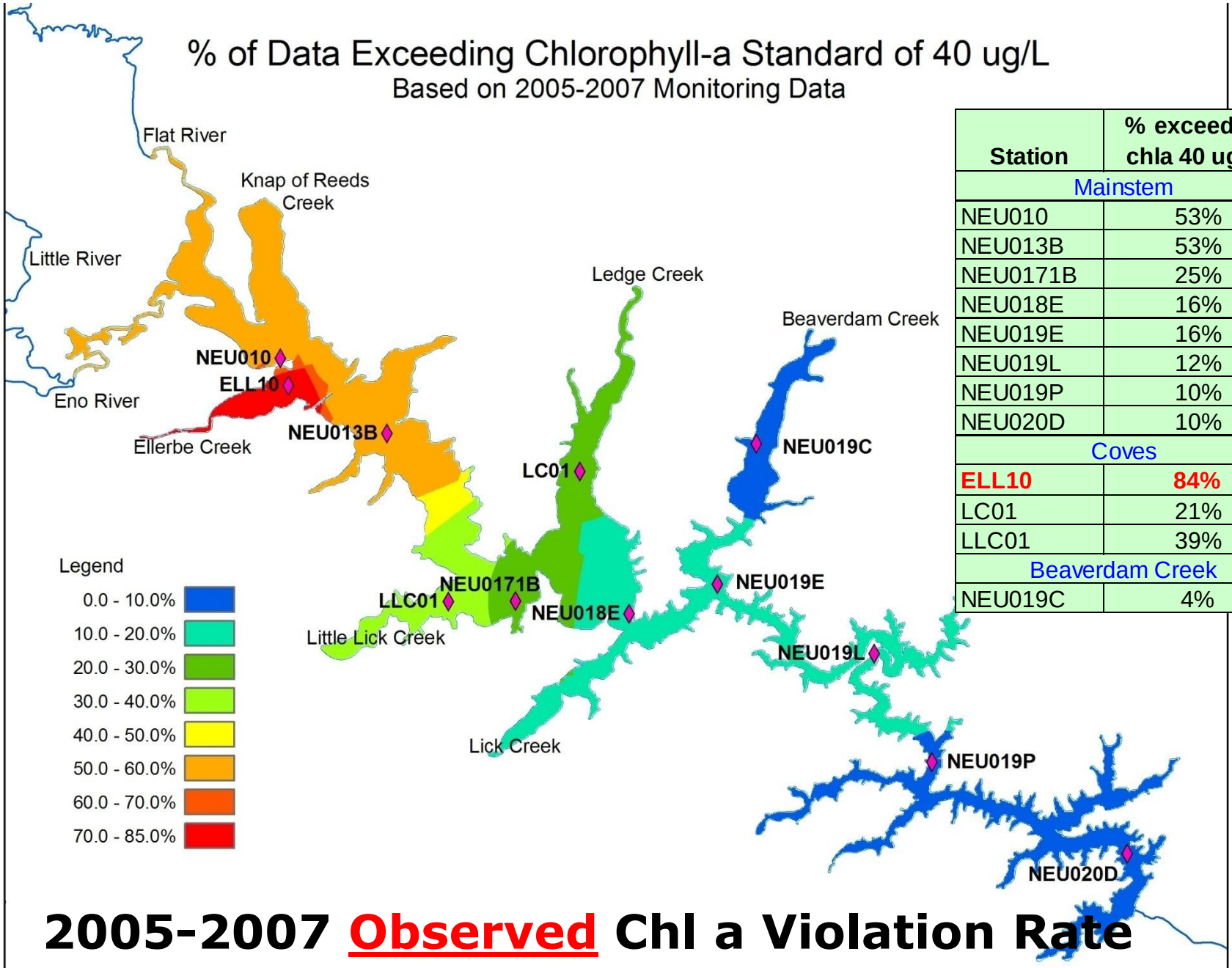
Neuse River nutrient TMDL (II)

- Neu-BERN: Reduction needed from 1995 loads ranges 0-45%
- NEEM: Reduction needed from 1998-2000 loads is 5%
- WASP: Reduction needed from 1998-2000 loads is 0%
- Data: 1998-2000 chl a violation occurred < 10%
- Reduction target: 30% from 1991-1995 baseline TN loading

Falls Lake Nutrient Response Model





Station	% exceeding chla 40 ug/L*
Mainstem	
NEU010	53%
NEU013B	53%
NEU0171B	25%
NEU018E	16%
NEU019E	16%
NEU019L	12%
NEU019P	10%
NEU020D	10%
Coves	
ELL10	84%
LC01	21%
LLC01	39%
Beaverdam Creek	
NEU019C	4%

2005-2007 Observed Chl a Violation Rate

Data Review - Temporal Variations: Chl a

- Maximum Conc.

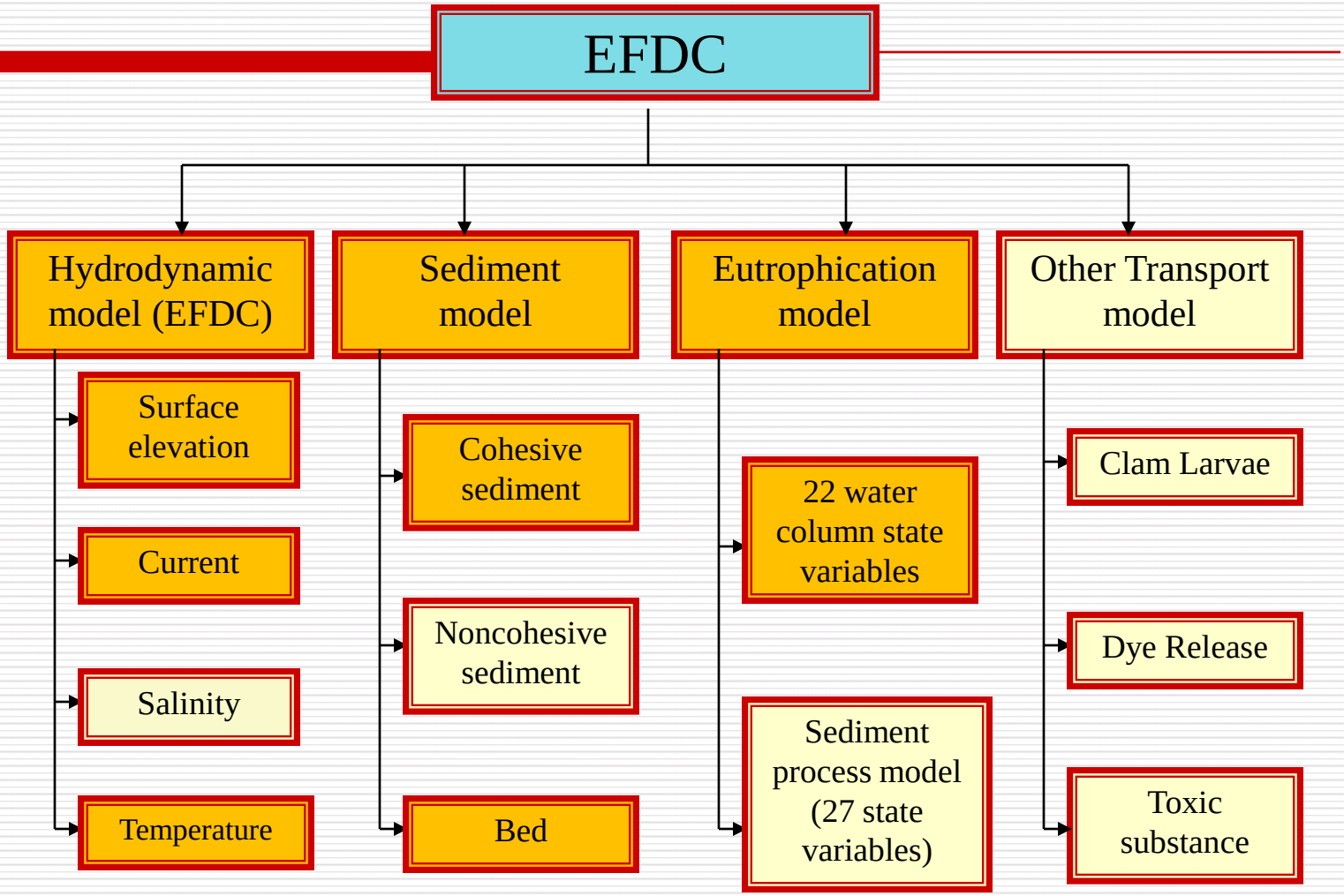
	Time	Station	Chl a Conc.
05-07	08/09/07	ELL10	230
83-01	07/16/86	NEU013	280

- Seasonal (05-07)

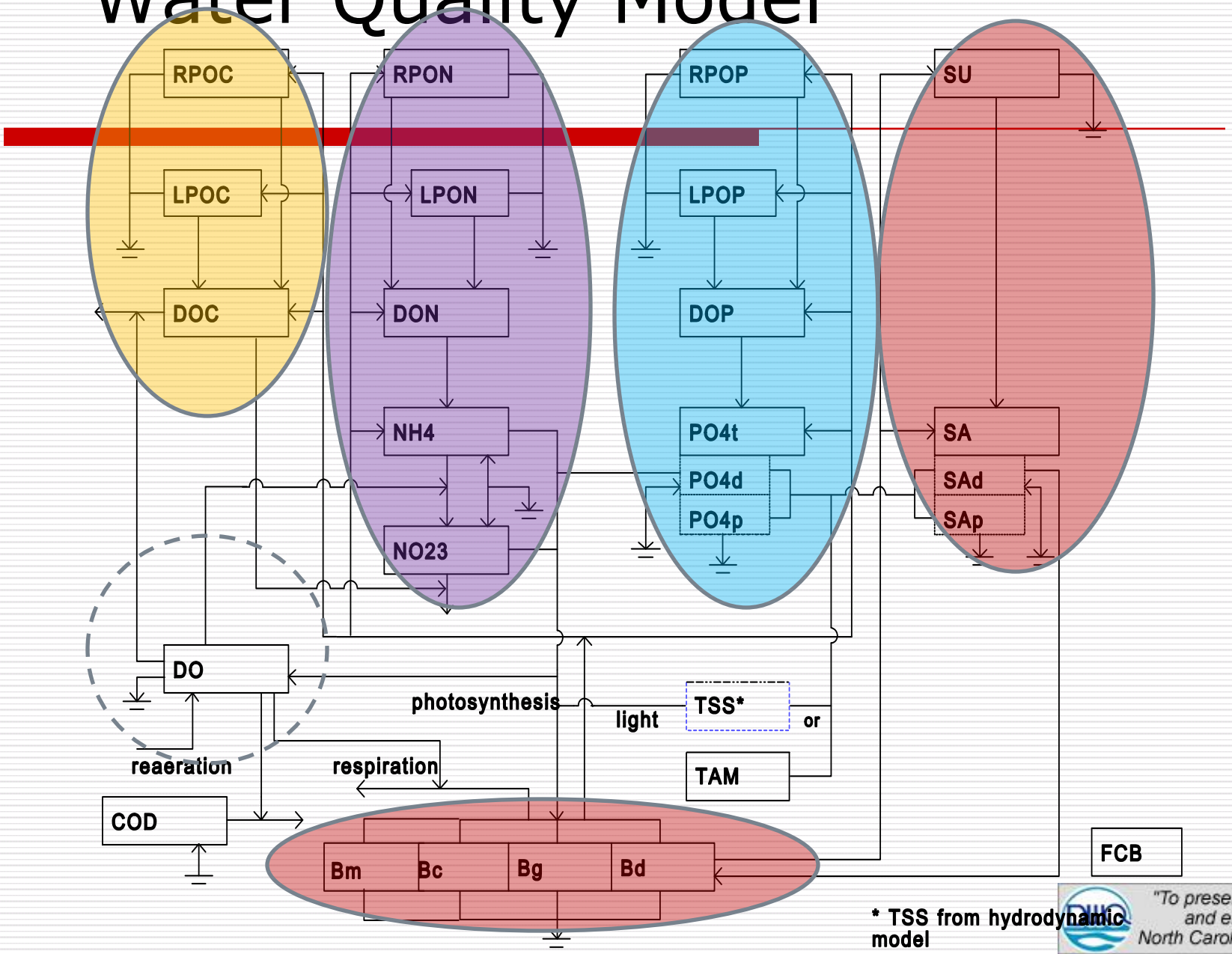
	Time	Station	Chl a Conc.
Earliest (> 40)	01/04 /2007	ELL10	57
Latest (> 40)	11/15/2005	NEU010/013	51

*Courtesy of ISU for historical data

Model Package-EFDC



Water Quality Model



* TSS from hydrodynamic model

Model Configuration- Grid

Flat R.

Knap of Reeds

Little & Eno R.

Ellerbe Cr.

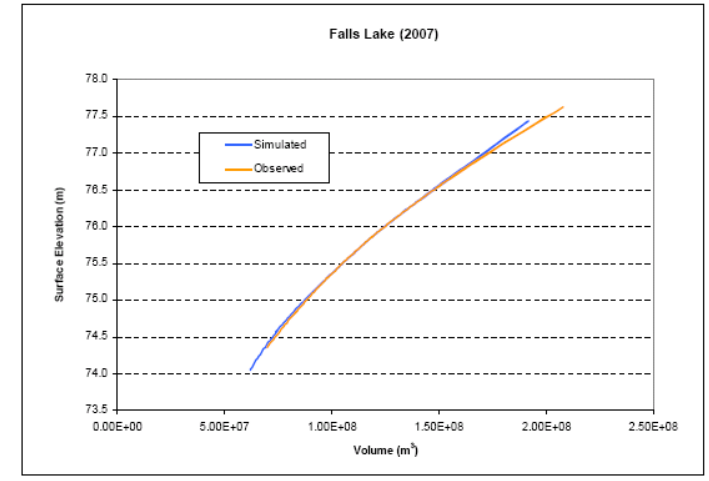
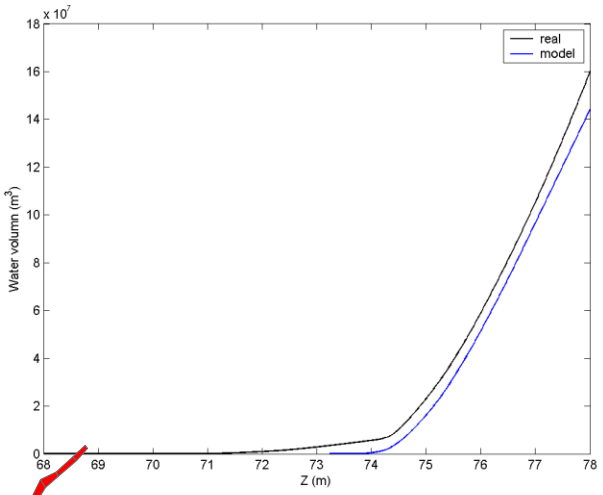
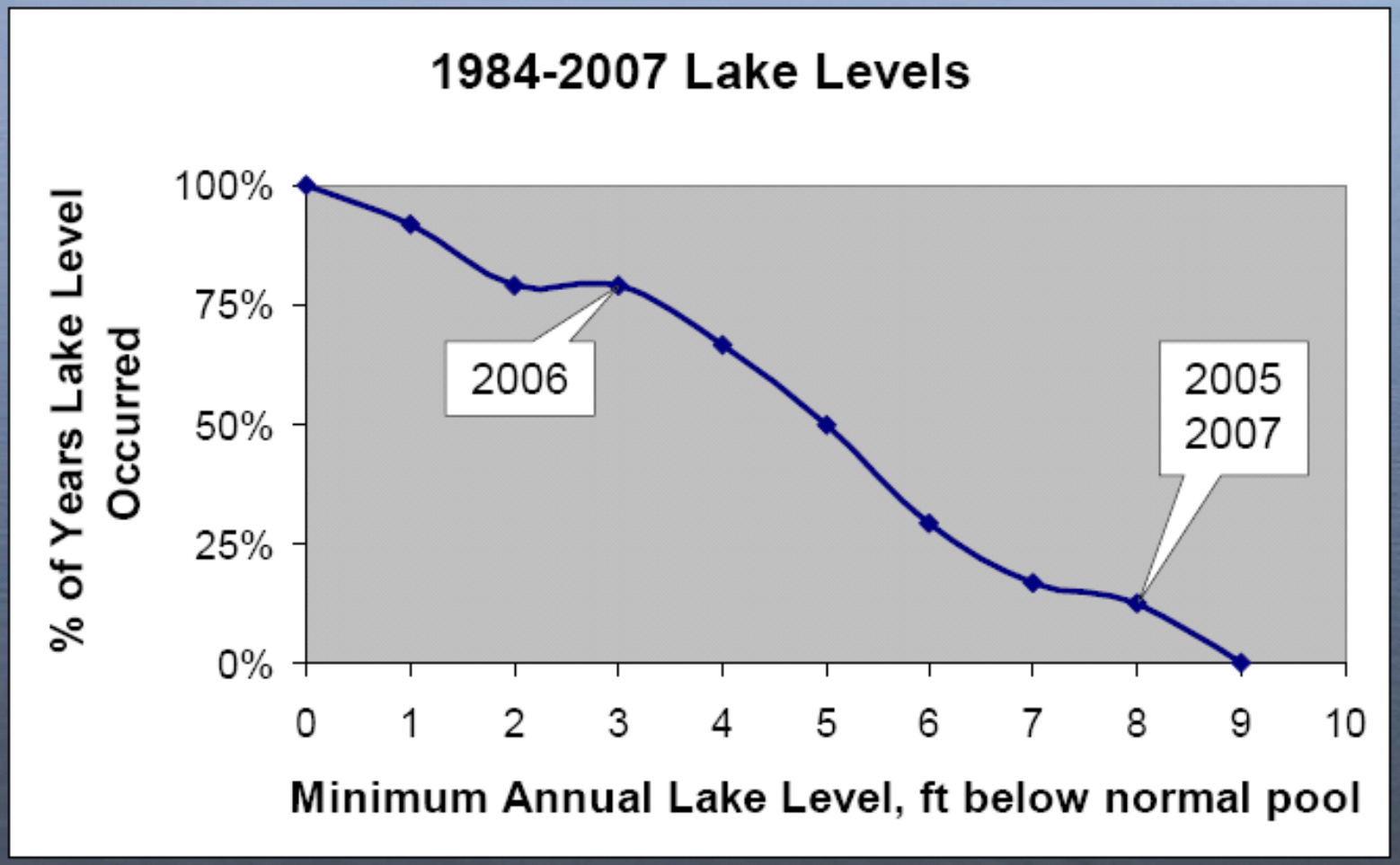


Figure 3. Comparison of Stage-Storage Relationships for Falls Lake



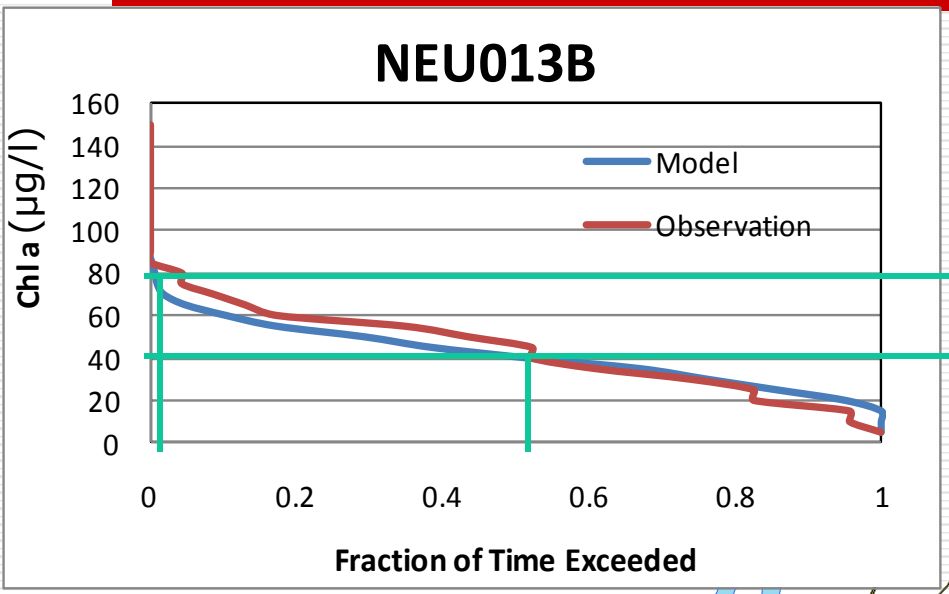
Horizontal Cell: 519
Vertical: 4 layer
Horizontal Cell Size: 60m -1km

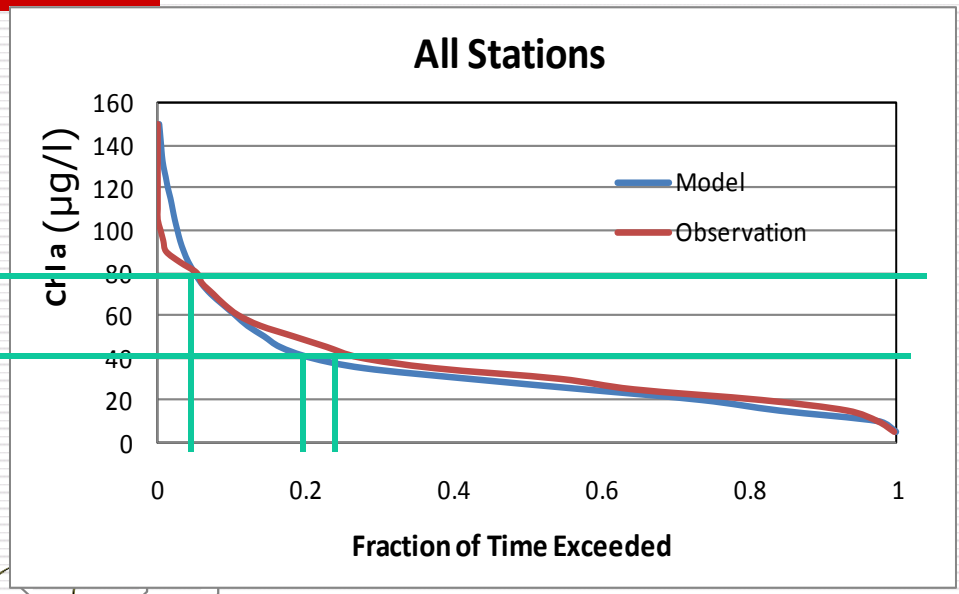
How representative are the model baseline years?

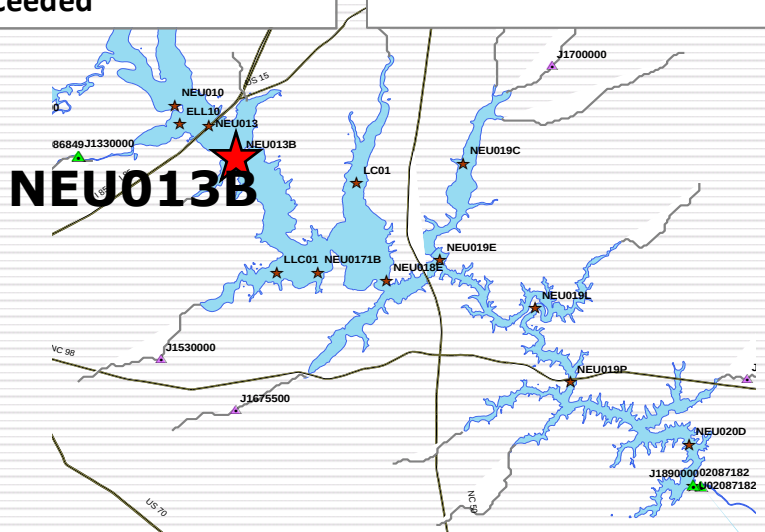


Courtesy of Peter Caldwell

Fraction of Time Chl a Exceeded (2006)







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Model Results Statistics

- Model calibration and validation also met the criteria set by TAC for water level, temperature, Chl *a*, TN, and DO simulations

Water Level Statistics

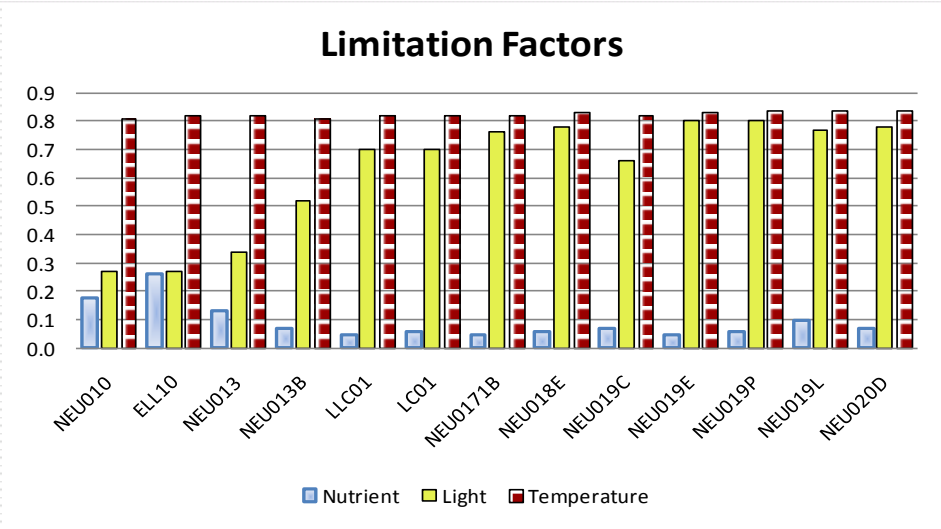
	Relative Error (RE)	Average Error (AE)	RMSE	Standard Deviation (SD_{obs})	RMSE /SD_{obs}	R^2	Coeff. of Efficiency (CE)	Percent Bias (PBIAS)
2005	0.001	0.09	0.15	0.89	0.17	0.99	0.97	0.12%
2006	0.0005	0.04	0.20	0.50	0.40	0.89	0.84	0.05%
2007	-0.14	-0.06	0.12	0.71	0.18	0.98	0.97	-0.1%

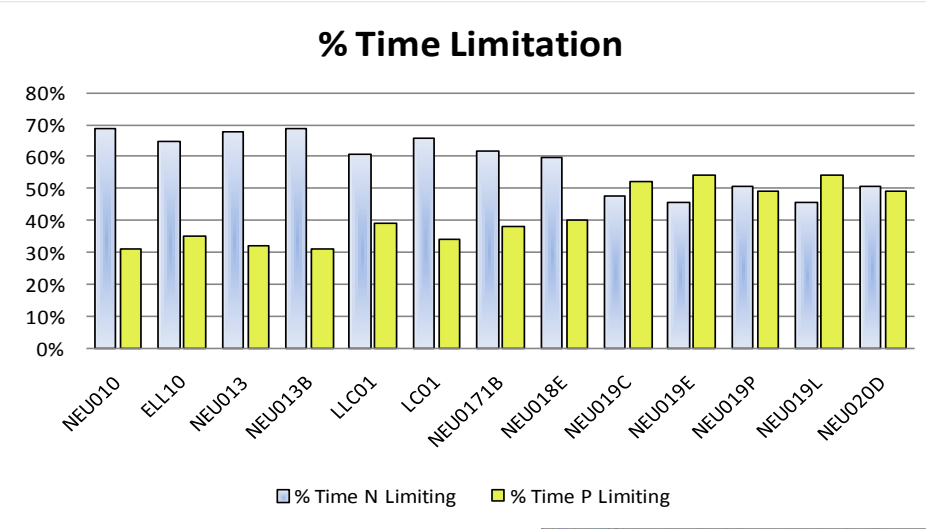
Chl a Statistics

	RE	AE	SD_{obs}	R^2	RMSE	RMSE/SD_{obs}	CE	pBias
2005	-0.12	-3.54	15.64	0.08	16.81	1.07	-0.16	-11.8%
2006	-0.10	-3.57	19.07	0.40	17.89	0.94	0.12	- 10.0%
2007*	-0.15	-6.24	29.52	0.37	24.51	0.83	0.31	-15.3%

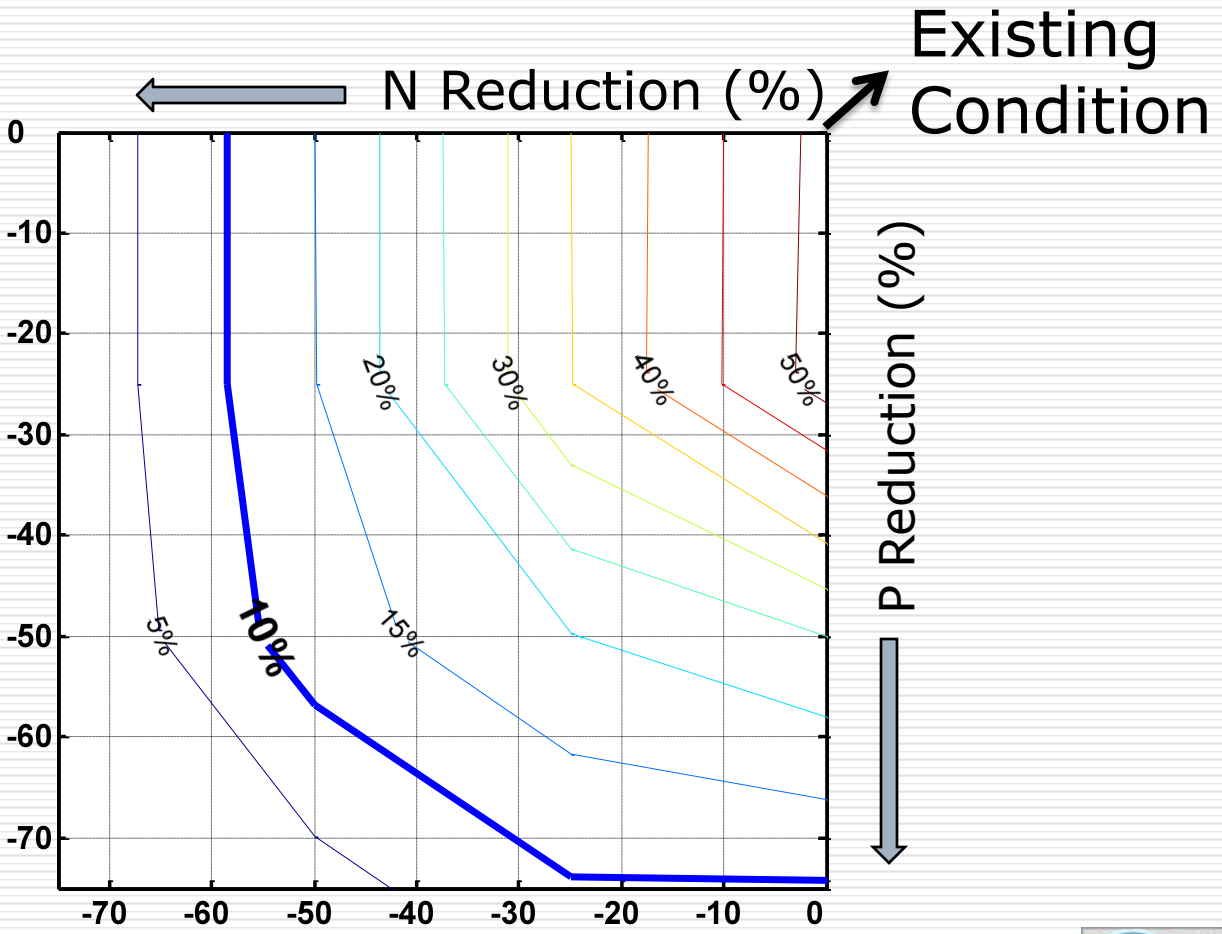
Algae Growth Limitation

- Algae growth is limited by both **nutrient** and **light** at the upstream and mostly by **nutrient** at the downstream of the Falls Lake
- Algae growth limitation is dominated by nitrogen limitation around 60-70% of time (P limitation 30-40% of time) upstream and around 50% of time downstream





Model Result



Thank you