CPF Intensive Monitoring Project

Upper Cape Fear River Basin Coalition

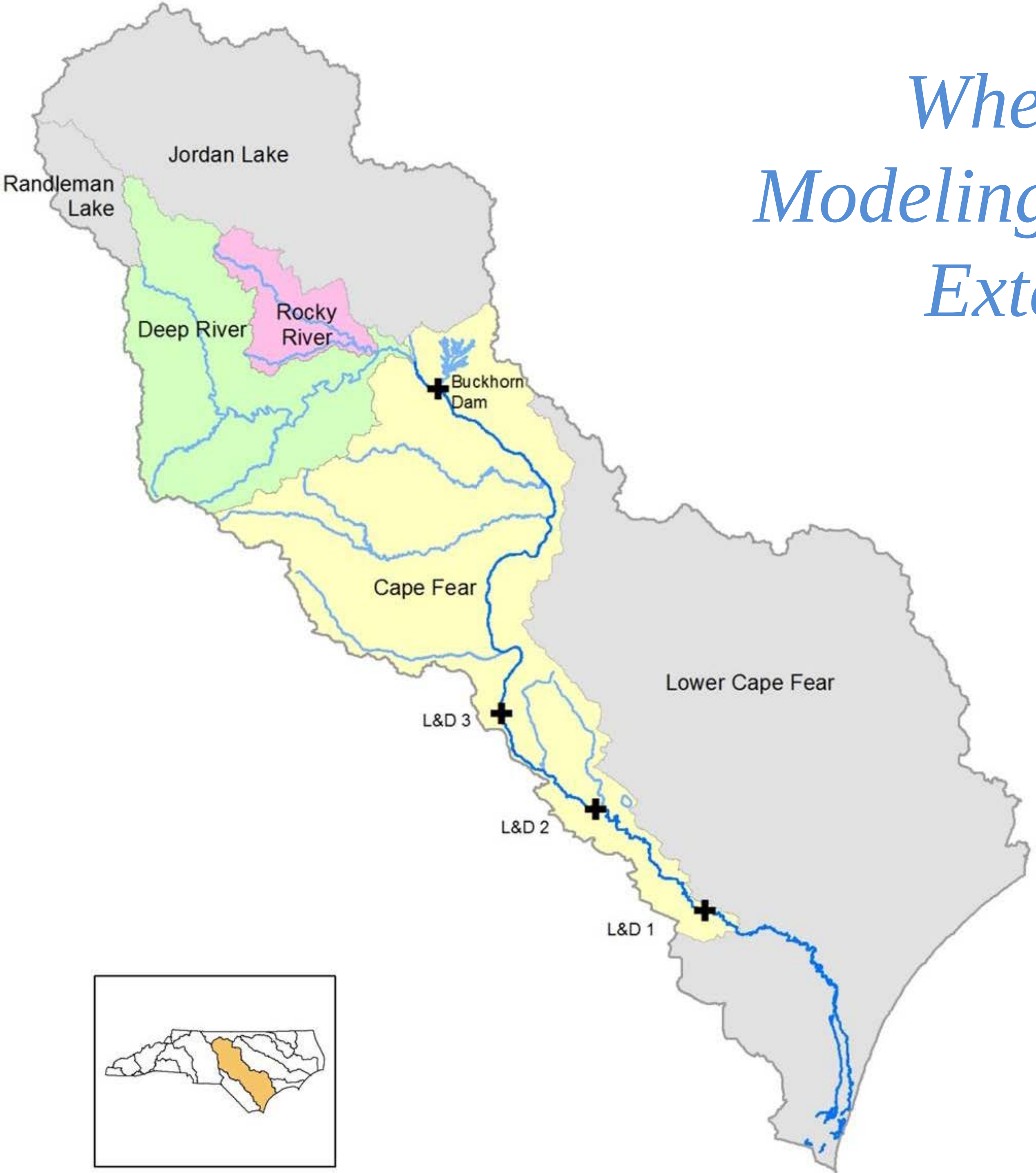
January 23, 2018

Department of Environmental Quality

Nothing Compares

NORTH CAROLINA

Where? Modeling Spatial Extent



WHAT is this project?

- Previously presented to UCFRBA in April 2015
- Presented Rocky River preliminary modeling to UCFRBA in July 2017
- Intensive monitoring of Deep/Rocky Rivers and Middle Cape Fear River
- Monitoring data will be used to develop water quality models focused on DO and nutrients
- Different purpose than Jordan, Falls, or High Rock Lakes, may or may not result in NMS

WHY?

1. **Support NPDES permitting for nutrients.**
2. Potentially support nutrient criteria, as described in the North Carolina Nutrient Criteria Development Plan (NCDP).
3. Potentially provide information on existing impaired waters.

Cape Fear River Basin Modeling

- Parts of Cape Fear River have long shown signs of nutrient over-enrichment
- Algal blooms in recent years
- A tool is needed to support effective nutrient permitting of discharges in Cape Fear River Basin

How are discharges currently impacted by lack of modeling?

- Expanding discharges
  - Loads are frozen
- New discharges
  - Need to perform their own modeling to demonstrate impact
- Without a model, permit writers have no way to determine what limitations are sufficiently protective, and this uncertainty continues to result in delays in permitting decisions

Monitoring Gap Analysis

- Goal: Balance need to reduce model uncertainty with additional monitoring costs
- Applied lessons learned from previous modeling projects
- Started with Western Wake Nutrient Modeling and Monitoring Plan (CH2M Hill, 2011)
- SWAT model already developed for Rocky River identified gaps

Targets:

1. Calibration and validation at critical sub watersheds
2. Calibration at headwater steams: characterize headwater conditions
3. Characterize tributary inputs

Parameters of Interest

- Nutrients (primarily nitrogen and phosphorus)
- Chlorophyll-a
- Dissolved Oxygen (DO)
- Turbidity – indirect modeling
- Algal blooms – indirect modeling
- Total Organic Carbon (TOC)

Monitoring Gaps Analysis Results

1. Two year study
2. **Proposed start date: January 2019**
3. 9 new/temporary monitoring locations identified
4. Increased frequency at selected existing stations
5. Additional parameters at selected existing stations
6. Written plan prioritizes monitoring locations

Desired Outcome of Monitoring

- Provide enough information to adequately characterize and represent water quality in Cape Fear
- Reduce model uncertainty
- Avoid need to remodel (e.g. Falls Lake)

DWR Resource Impacts

1. 9 ambient stations – all require extra trips – Reg Offices
2. 9 new/temporary stations – Reg Offices
3. 6 storm event stations – Intensive Survey
4. Phytoplankton Assemblage analysis at 5 stations (monthly)

Coalition Resource Impacts

- Upper Cape Fear – 3 existing stations identified for additional monitoring (0 would require extra trips)
- Middle Cape Fear – 18 existing stations identified for additional monitoring (3 would require extra trips)

Upper Cape Fear Coalition Additional Monitoring Request

- Upper Cape Fear – 3 existing stations identified for additional monitoring (0 would require extra trips), all are high priority

1. B480 – Deep Riv at SR 2122/2128 Worthville Rd at Worthville
   - Establish upper Deep River boundary conditions (below Randleman Lake)
2. B595 Rocky Riv at US 64 near Siler City
   - Watershed calibration station (co-located with USGS gage 02101726)
3. B408 Haw Riv at SR 1011 Old US 1 nr Haywood
   - Establish boundary conditions to characterize Haw River inputs to Cape Fear River

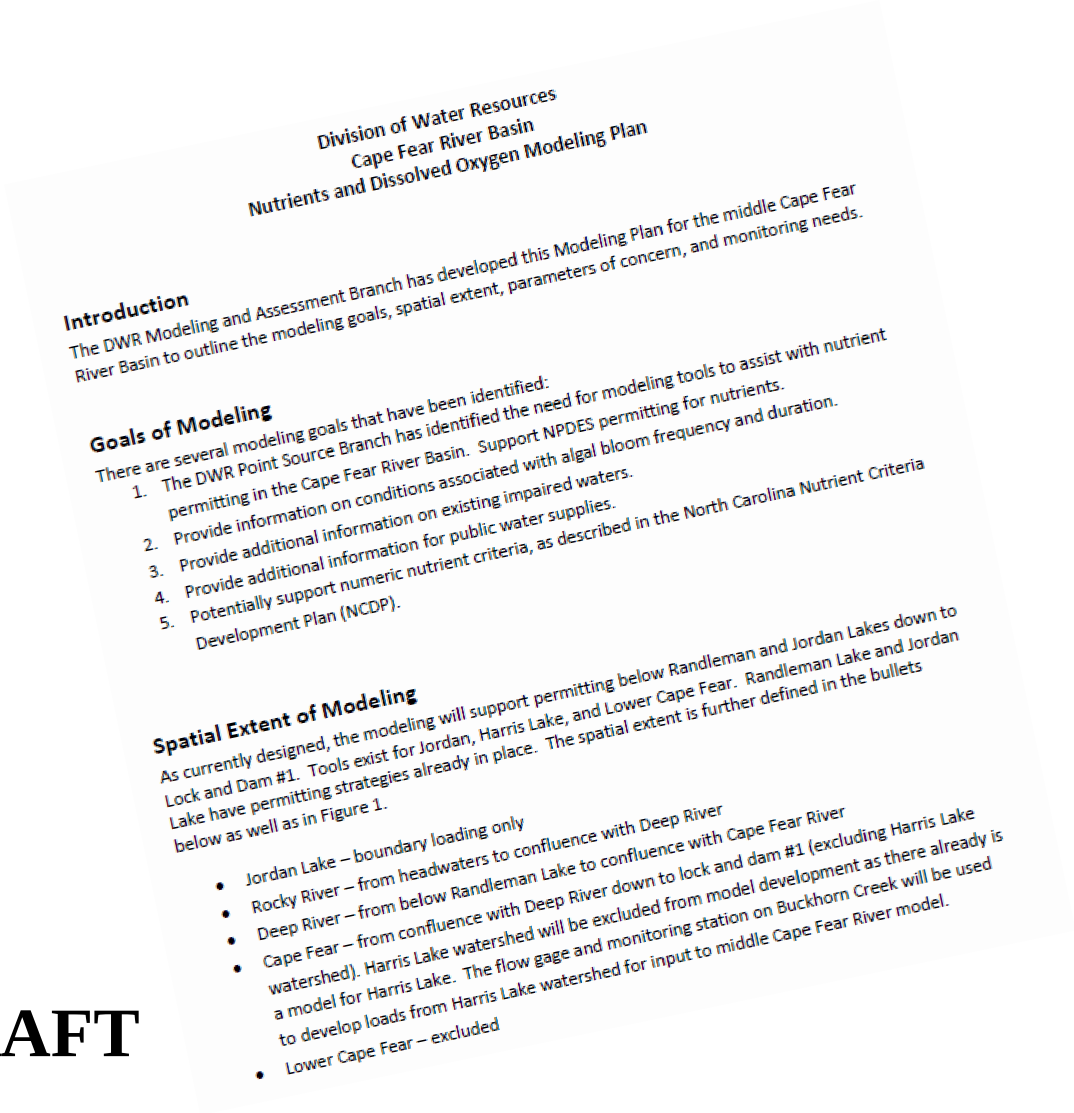
Existing Models - CPF Basin

Models	Developed Year	Domain	Target
1. Hydrodynamic			
3D EFDC-WQ	2009	LCFR	DO
3D EFDC-WASP	2007	Jordan Reservoir	Chlorophyll a
2D CE-QUAL-W2	2010	Harris Lake	Chlorophyll a
2. Eutrophication			
BATHTUB	2004	Roberson Creek	TP
WASP	2003	Jordan Lake	Chlorophyll a
CE-QUAL-W2	2010	Harris Lake	Chlorophyll a
3. River/Stream			
QUAL2e/QUAL2K	2008	CFR up to L&D1	DO
4. Hydrologic			
Cape Fear/Neuse Combined OASIS	2015	CFR up to L&D1	Water Balance
5. Watershed			
SWAT	2008	Northeast CFR	TN and TP
GWLF	2007	Jordan Lake Watershed	TN and TP
BASINS-HSPF	2004	Upper N Buffalo Creek	Fecal Coliform
SWAT	2004	Roberson Creek	TP
CRAP	2003	Northeast Creek	Fecal Coliform
BASINS-NPSM	2002	Little Troublesome Creek	Fecal Coliform
SWAT	2015	Rocky River Watershed	TN and TP
SWAT - TNC	2015	Middle Cape Fear	TN and TP
LSPC	2013	Jordan Lake Watershed	TN and TP

Model Selection – Important Considerations

- Parameters of interest
- Data availability
- Modeler expertise
- Ability to represent impoundments
- EPA supported
- User interface

Documentation



Division of Water Resources
Cape Fear River Basin
Nutrients and Dissolved Oxygen Modeling Plan

Introduction

The DWR Modeling and Assessment Branch has developed this Modeling Plan for the middle Cape Fear River Basin to outline the modeling goals, spatial extent, parameters of concern, and monitoring needs.

Goals of Modeling

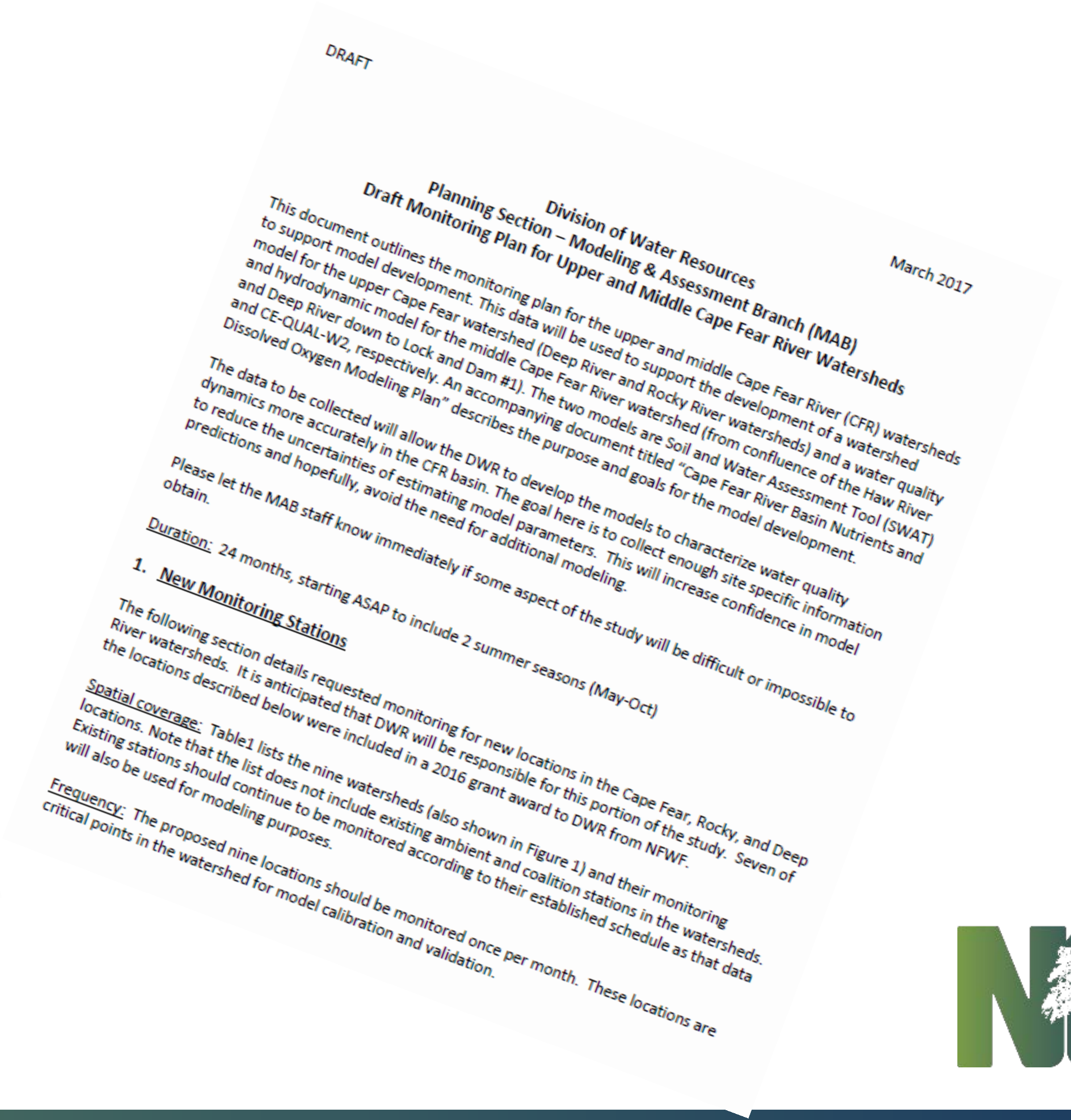
There are several modeling goals that have been identified:

1. The DWR Point Source Branch has identified the need for modeling tools to assist with nutrient permitting in the Cape Fear River Basin. Support NPDES permitting for nutrients.
2. Provide information on conditions associated with algal bloom frequency and duration.
3. Provide additional information on existing impaired waters.
4. Provide additional information for public water supplies.
5. Potentially support numeric nutrient criteria, as described in the North Carolina Nutrient Criteria Development Plan (NCDP).

Spatial Extent of Modeling

As currently designed, the modeling will support permitting below Randleman and Jordan Lakes down to Lock and Dam #1. Tools exist for Jordan, Harris Lake, and Lower Cape Fear. Randleman Lake and Jordan Lake have permitting strategies already in place. The spatial extent is further defined in the bullets below as well as in Figure 1.

- Jordan Lake – boundary loading only
- Rocky River – from headwaters to confluence with Deep River
- Deep River – from below Randleman Lake to confluence with Cape Fear River
- Cape Fear – from confluence with Deep River down to lock and dam #1 (excluding Harris Lake watershed). Harris Lake watershed will be excluded from model development as there already is a model for Harris Lake. The flow gage and monitoring station on Buckhorn Creek will be used to develop loads from Harris Lake watershed for input to middle Cape Fear River model.
- Lower Cape Fear – excluded



DRAFT

March 2017

Division of Water Resources
Planning Section – Modeling & Assessment Branch (MAB)
Draft Monitoring Plan for Upper and Middle Cape Fear River Watersheds

This document outlines the monitoring plan for the upper and middle Cape Fear River (CFR) watersheds to support model development. This data will be used to support the development of a watershed model for the upper Cape Fear watershed (Deep River and Rocky River watersheds) and a water quality and hydrodynamic model for the middle Cape Fear River watershed (from confluence of the Haw River and Deep River down to Lock and Dam #1). The two models are Soil and Water Assessment Tool (SWAT) and CE-QUAL-W2, respectively. An accompanying document titled "Cape Fear River Basin Nutrients and Dissolved Oxygen Modeling Plan" describes the purpose and goals for the model development.

The data to be collected will allow the DWR to develop the models to characterize water quality dynamics more accurately in the CFR basin. The goal here is to collect enough site specific information to reduce the uncertainties of estimating model parameters. This will increase confidence in model predictions and hopefully, avoid the need for additional modeling.

Please let the MAB staff know immediately if some aspect of the study will be difficult or impossible to obtain.

Duration: 24 months, starting ASAP to include 2 summer seasons (May-Oct)

1. **New Monitoring Stations**

The following section details requested monitoring for new locations in the Cape Fear, Rocky, and Deep River watersheds. It is anticipated that DWR will be responsible for this portion of the study. Seven of the locations described below were included in a 2016 grant award to DWR from NFWF.

Spatial coverage: Table1 lists the nine watersheds (also shown in Figure 1) and their monitoring locations. Note that the list does not include existing ambient and coalition stations in the watersheds. Existing stations should continue to be monitored according to their established schedule as that data will also be used for modeling purposes.

Frequency: The proposed nine locations should be monitored once per month. These locations are critical points in the watershed for model calibration and validation.

DRAFT

Other Special Studies?

- SOD – completed 2016 by EPA
- Bathymetry – ongoing
- Periphyton - universities
- Others as identified?

Stakeholder Involvement?

- YES
- DWR will involve stakeholders at key points in model development
- DWR will invite stakeholders to review model after development
- Any resulting rulemaking/permitting changes will also include stakeholder input

Model Education Meeting

Goal: improve understanding of why division needs additional data, how models are developed/used

- Involve both UCF and MCF Coalitions
- 1 3-hour meeting
- April/May timeframe

Summary

- Will provide a permitting tool to allow for future growth
- NCDP SAC work may add additional areas of focus
- May or may not result in reduction requirements/nutrient management strategy
- Modeling resources in-house
- Division is requesting monitoring assistance from coalitions to ensure adequate data coverage to address model uncertainty

Thank You!

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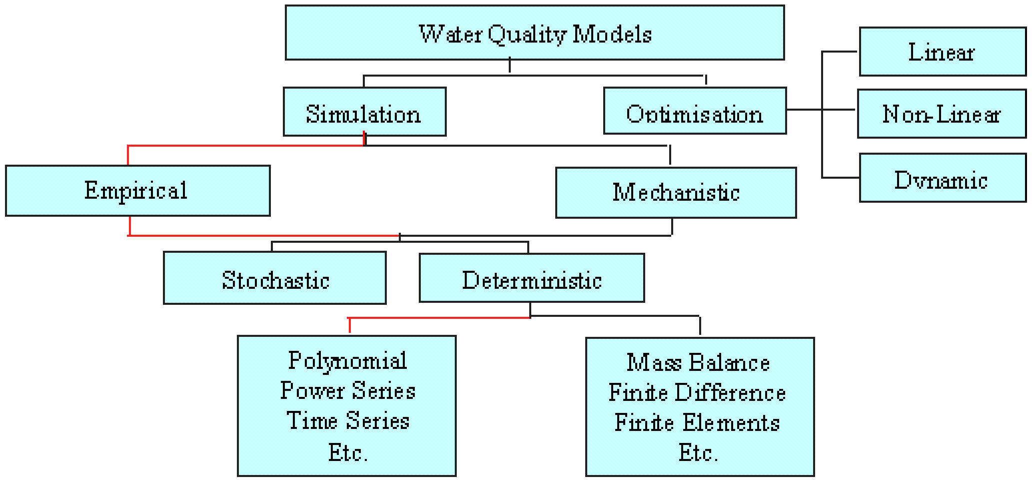
Modeling and Assessment Branch

NC Division of Water Resources - Water Planning

Model Selection Considerations for Middle Cape Fear River

Types of Models

- Process-based Models
  - Watershed Models (e.g. HSPF for High Rock, WARMF for Falls)
  - Receiving Water Models
    - Hydrodynamic Models (e.g. EFDC for Falls and High Rock)
    - Water Quality Models (e.g. WASP for HRL)
- Statistical Models
  - Empirical Models
  - Bayesian Network
  - Stochastic Models

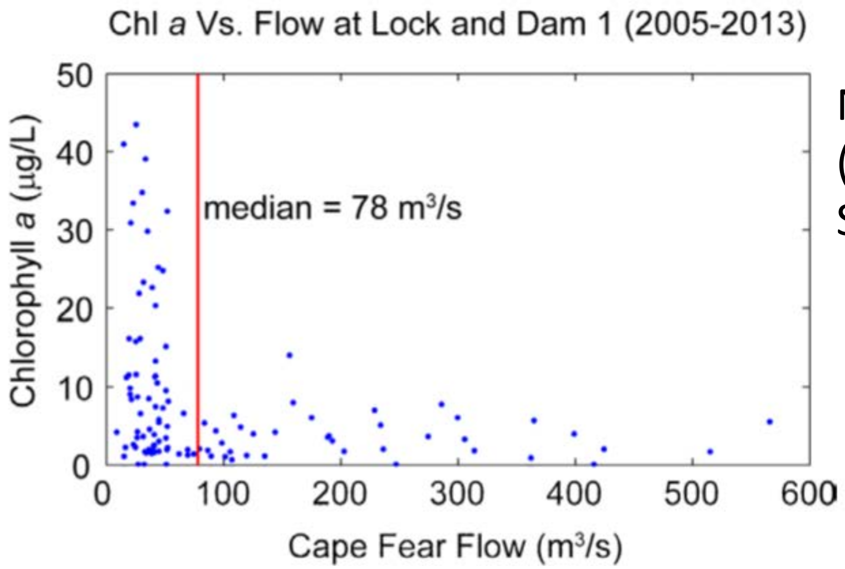


VICAIRE (VIrtual CAmpus In hydrology and water REsources management)

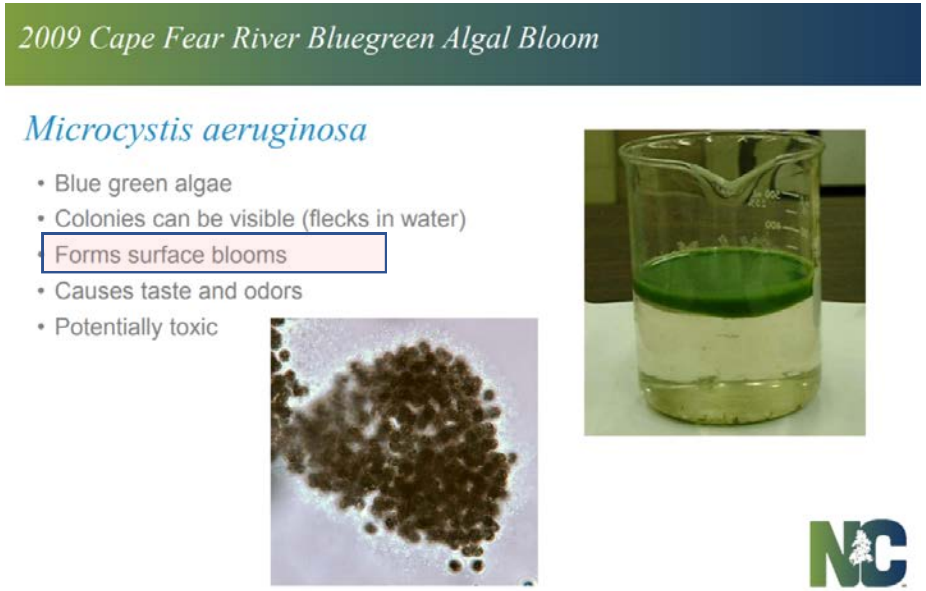
Types of Process-based Models

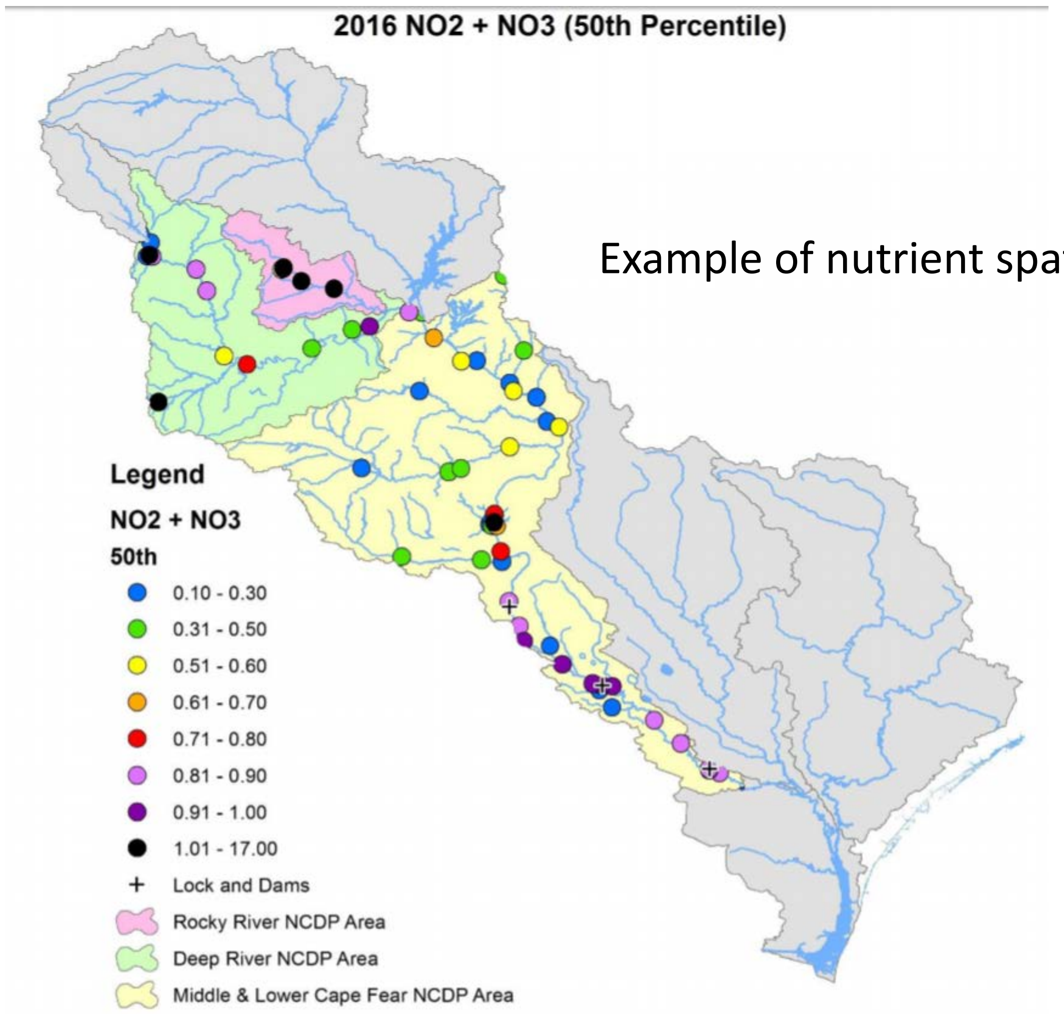
- Spatial Resolutions of *Receiving water* models
  - 0-dimensional
  - 1-dimensional (x or z) (e.g. QUAL2E/K)
  - 2-dimensional (x-y or x-z) (e.g. CE-QUAL-W2)
  - 3-dimensional (x-y-z) (e.g. EFDC)
- Temporal Resolutions
  - Steady- State Models (e.g. QUAL2E/K)
  - Dynamic Models (e.g. CE-QUAL-W2 and EFDC/WASP)

Relevant Findings of Cape Fear Water Quality



Nathan Hall (April, 2016 SAC Meeting)





Example of nutrient spatial variability

DWR (April, 2016 SAC Meeting)

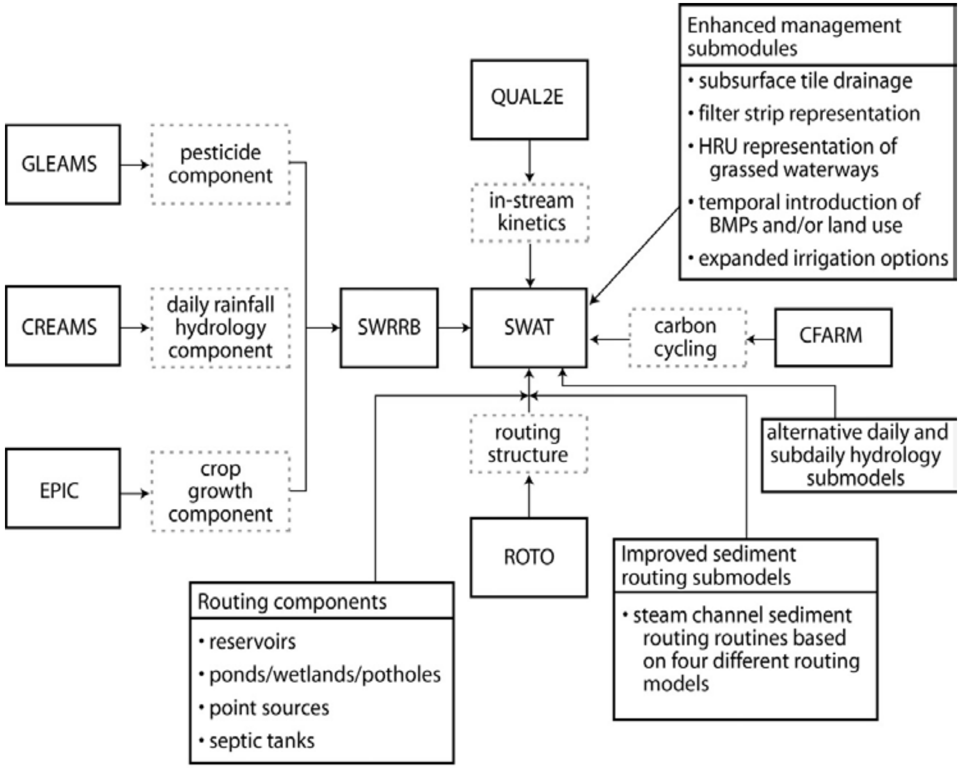
Major Processes to be Represented in the Middle Cape Fear Model

- Hydrological/Hydrodynamic Processes
  - Longitudinal and temporal variation of flow
  - Hydraulic Structures such as Lock&Dam
  - Stratification/vertical mixing
- Biogeochemical Processes
  - Algae – nutrients
  - DO – CBOD, NBOD, and SOD
  - Point sources / nonpoint sources

Current Model Selection for Deep and Rocky River

SWAT; LSPC/WASP

- SWAT
  - Already developed for Rocky (will need to be extended to Deep)
  - Can handle parameters of interest
- LSPC/WASP
  - Basic Framework has been set-up
  - Can handle parameters of interest
  - EPA support



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Current Model Selection for Middle Cape Fear River

SWAT with CE-QUAL-W2

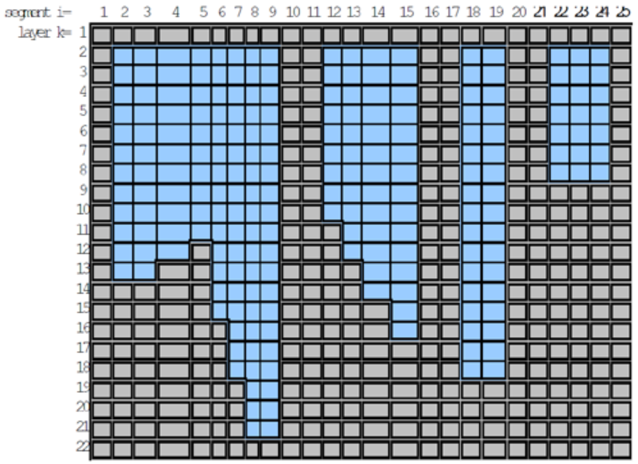

Figure 1. Sample computational grid in the x-z plane showing active and inactive cells.

- SWAT
  - Already developed for CFR (need to be extended)
  - Provides nutrient/sediment loading assessment from the watershed
- CE-QUAL-W2
  - 2-dimentional Approach (x-z)
  - Dynamic model (not steady-state)
  - Good representation of hydraulic structures
  - Has been applied to NC waters (e.g. Neuse River)
  - Can handle parameters of interest

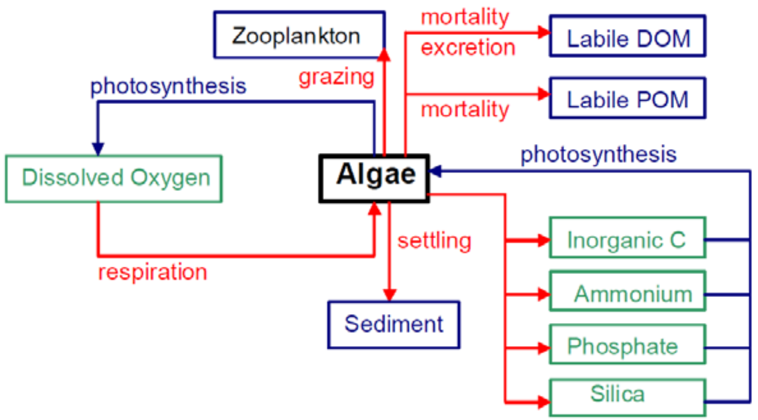

Figure B-9. Internal flux between algae and other compartments.

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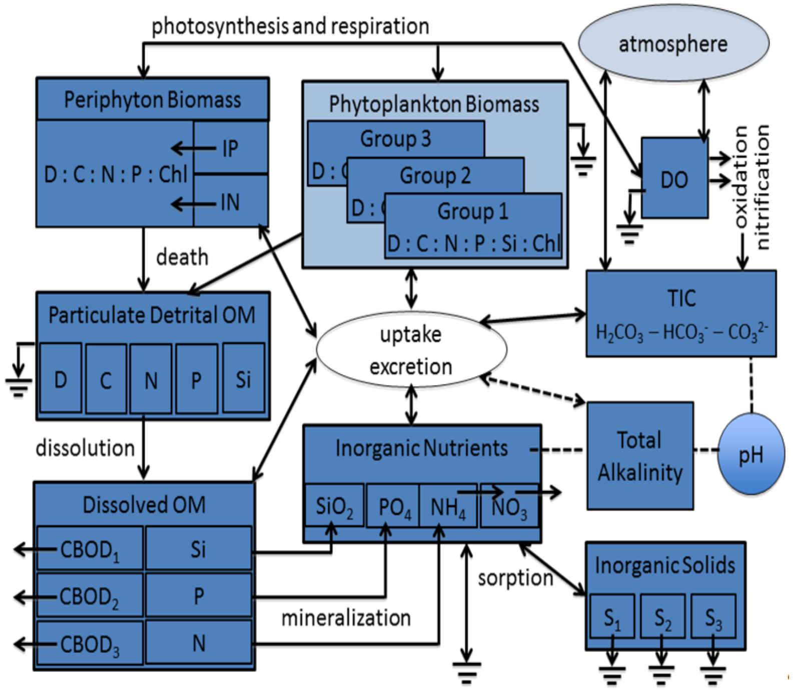
Alternative Model for Middle Cape Fear River

LSPC with EFDC/WASP

- EFDC Potentially 3-D approach and dynamic model
- Has been applied to NC waters (e.g. Jordan)
- Supported by EPA, recommended by T. Wool



WQ variables and processes simulated in WASP

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Data Needs and Challenges with Process-based Models

- Model Setup
  - Bathymetry -- model grid
  - River Boundary Condition
  - Outflow Boundary Condition
  - Climate Data
  - Benthic Flux
  - Point Sources / Nonpoint Sources
- Model Calibration
  - Spatial and temporal representation of flow
  - Spatial and temporal representation of instream WQ parameters
  - Parameterization of various biogeochemical processes represented in the model