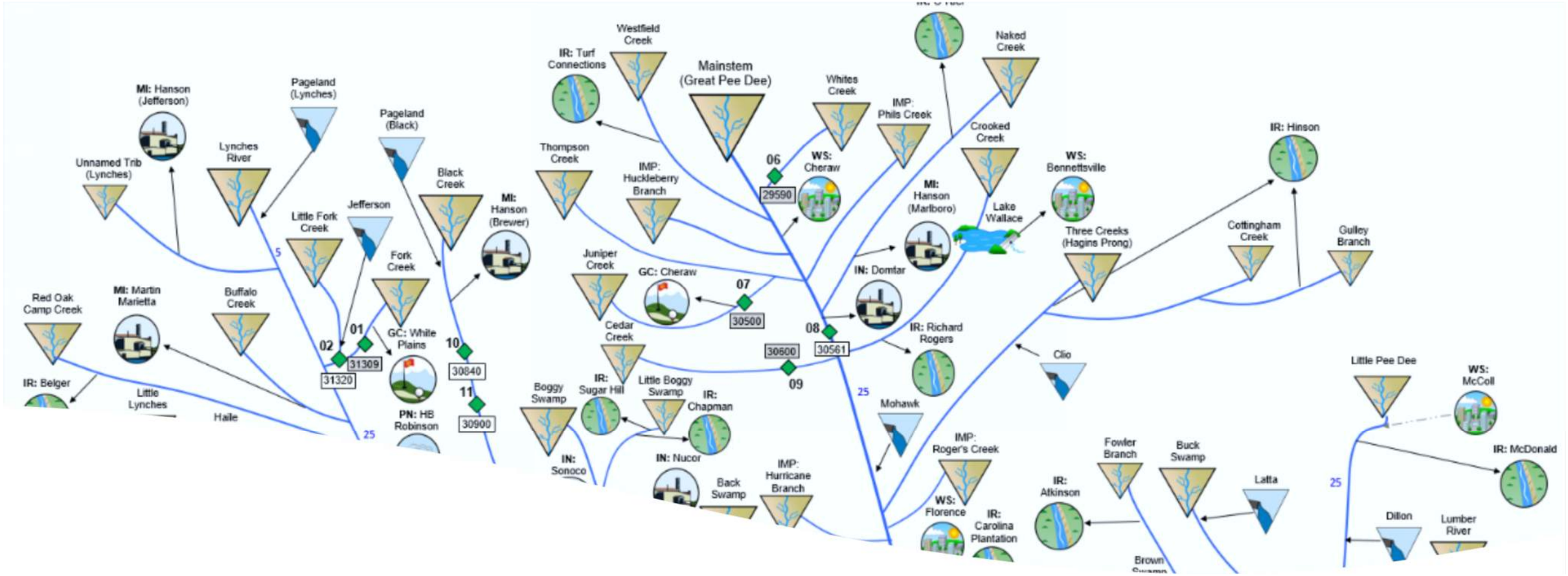
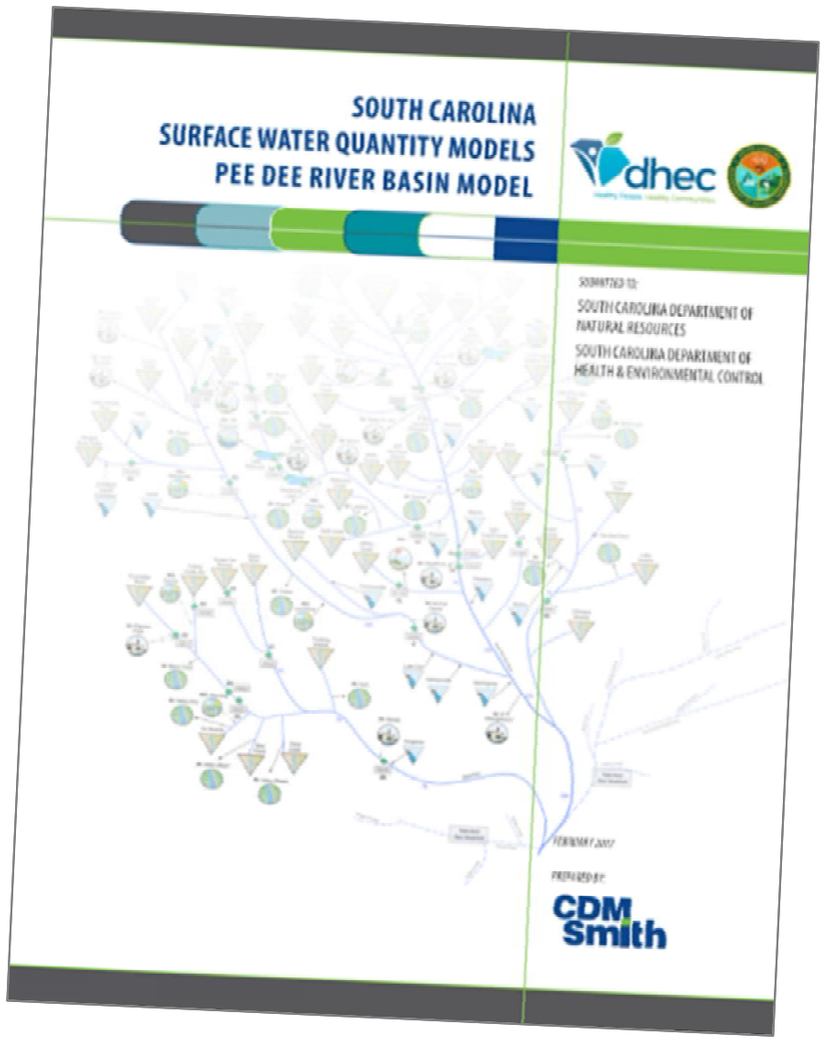


Overview of the Pee Dee Basin Surface Water Quantity Model

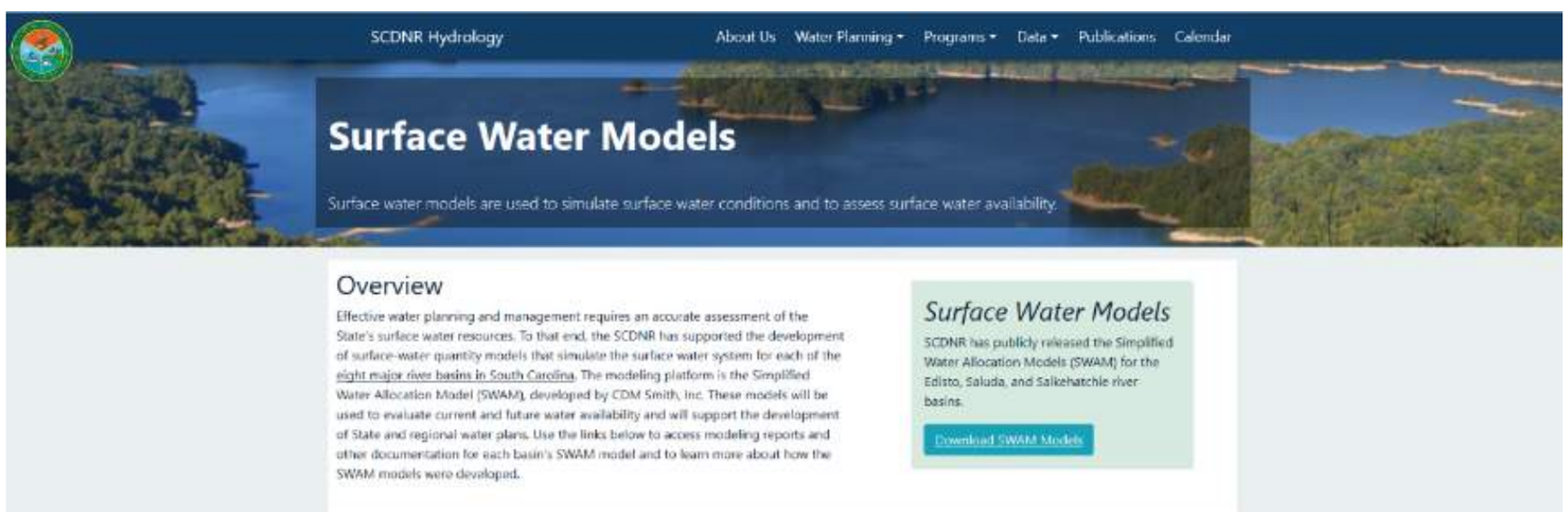
Simplified Water Allocation Model (SWAM)

- Developed as a desktop tool to facilitate regional and statewide water planning and allocation
- SWAM calculates physically and legally available water, diversions, storage, consumption and return flows at user-defined nodes
- From 2014 to 2017, all eight South Carolina surface water quantity models were built in the SWAM platform
- Model updates were performed in 2021



Surface Water Model Access

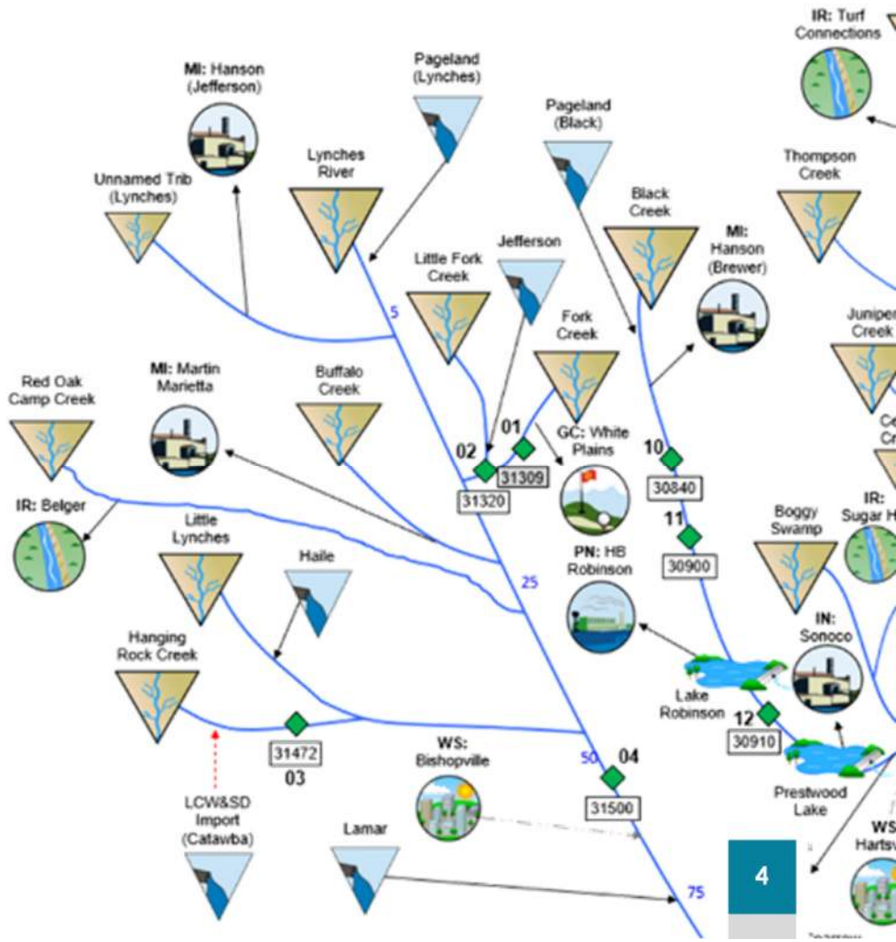
- Available for download at: http://hydrology.dnr.sc.gov/surface-water-models.html
- Also available for download:
  - SWAM User's Manual
  - Model reports for each basin
  - Supplementary technical memoranda



Pee Dee Basin Surface Water Model Overview

Water Allocation Modeling ***is***:

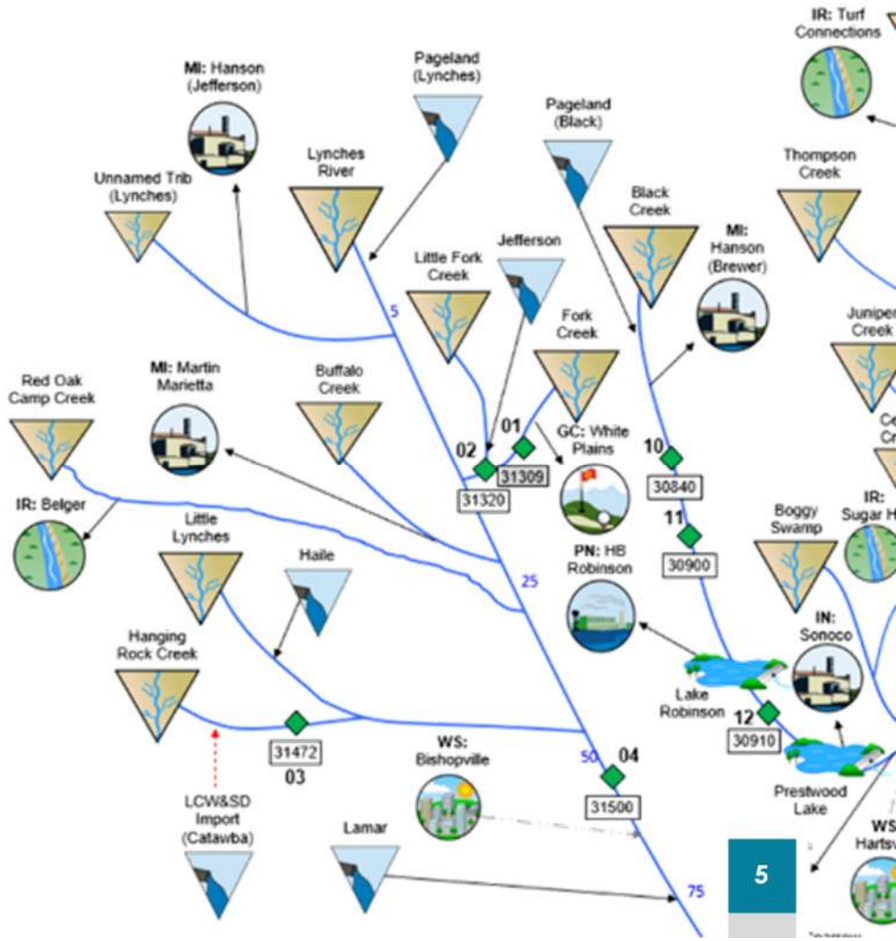
- Water balance calculations of physical flow
- Water rights calculations of legally available flow
- Demands, withdrawals, and return flows
- Reservoir storage
- Stream networks, multiple “nodes”
- Data intensive



Pee Dee Surface Water Model Overview

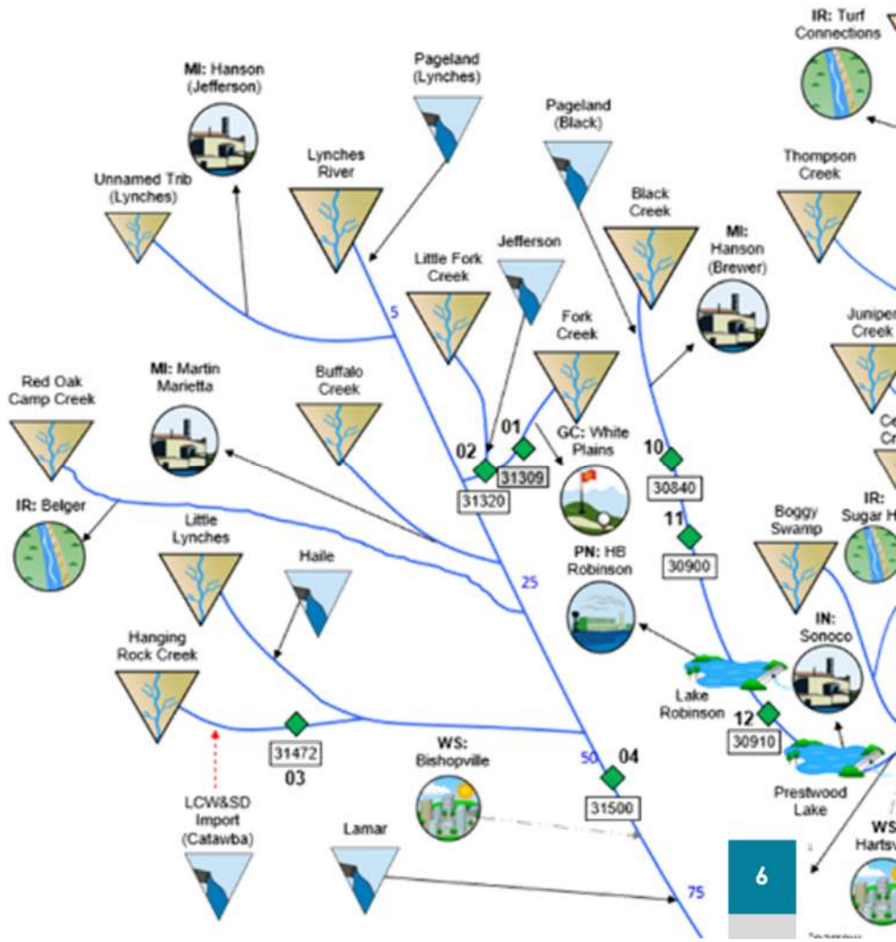
Water Allocation Modeling ***is not***:

- Rainfall-runoff calculations
- Hydrologic routing calculations
- Groundwater hydrology modeling
- Water quality modeling



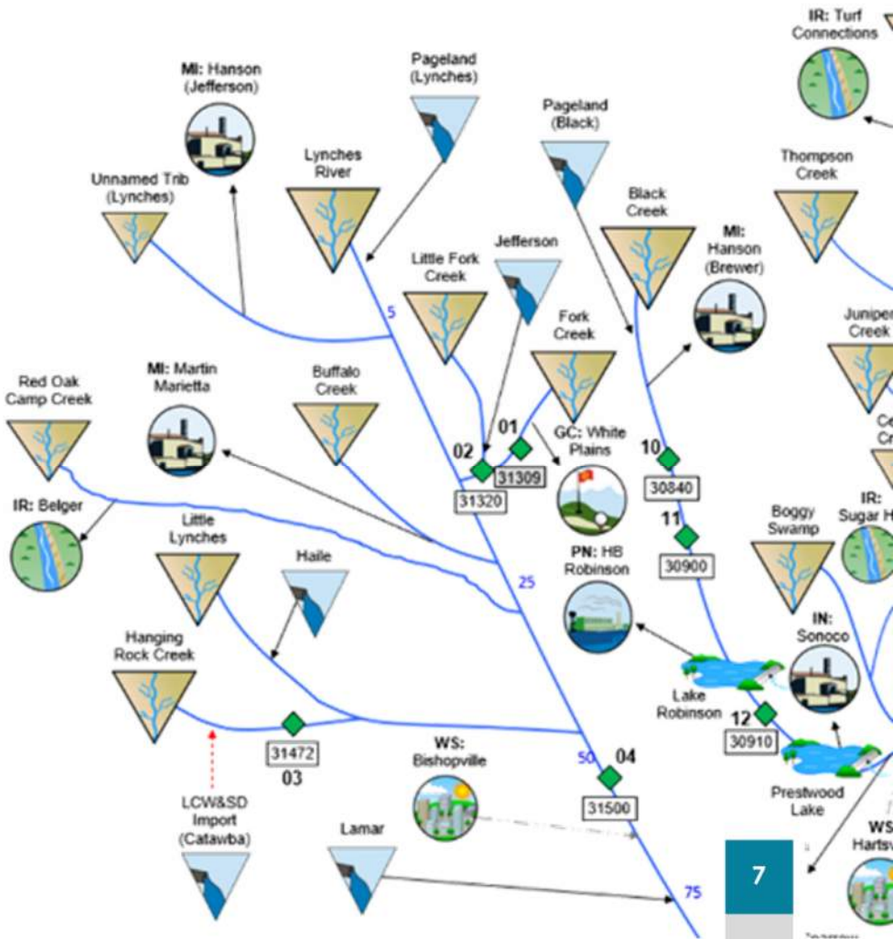
In Support of Pee Dee River Basin Planning, the Model Will be Used to:

- Assess current supply availability and shortages across a range of hydrologic conditions (1929 through 2018)
- Assess a range of future potential scenarios with respect to changes in growth
- Assess potential impacts of a "full allocation" scenario
- Test, evaluate and help prioritize water management strategies

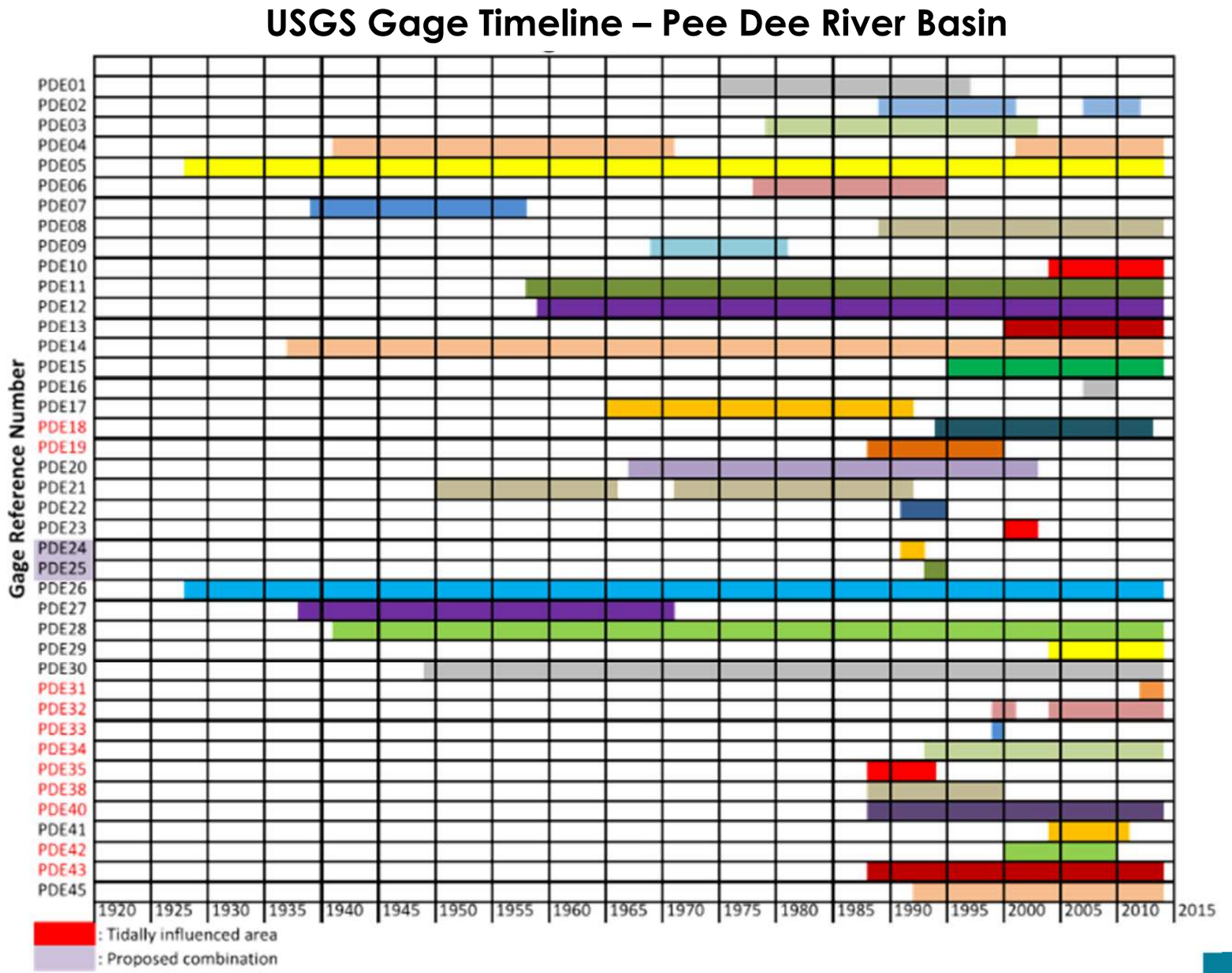


Pee Dee Model Inputs and Supporting Information

- USGS daily flow records
- Historical operational data
  - Withdrawals (municipal, industrial, thermoelectric, agricultural, golf courses, hatcheries)
  - Wastewater discharges and return flows
  - Transfers in and out of the basin
- Reservoir characteristics and operating rules
- Subbasin characteristics
  - Drainage area, land use, and slope

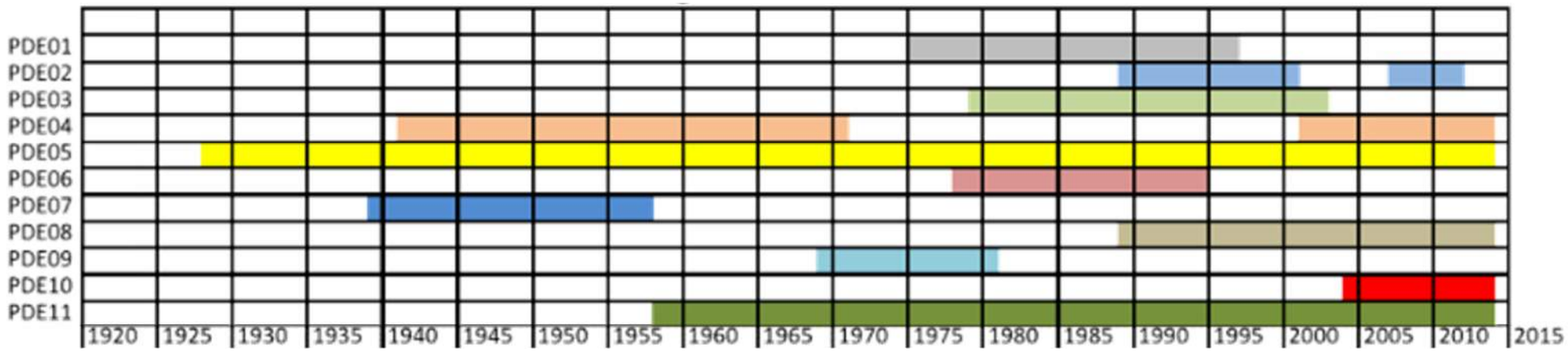


Timeline of Daily Flow Records in the Pee Dee Basin

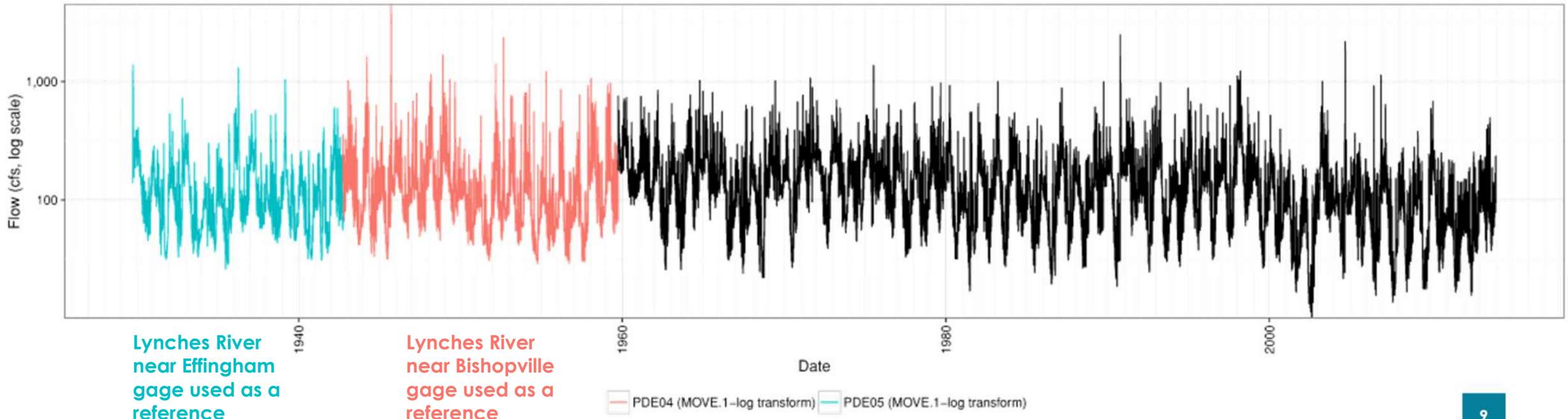


Filling in Gaps in Flow Data

USGS Gage Timeline – Pee Dee River Basin



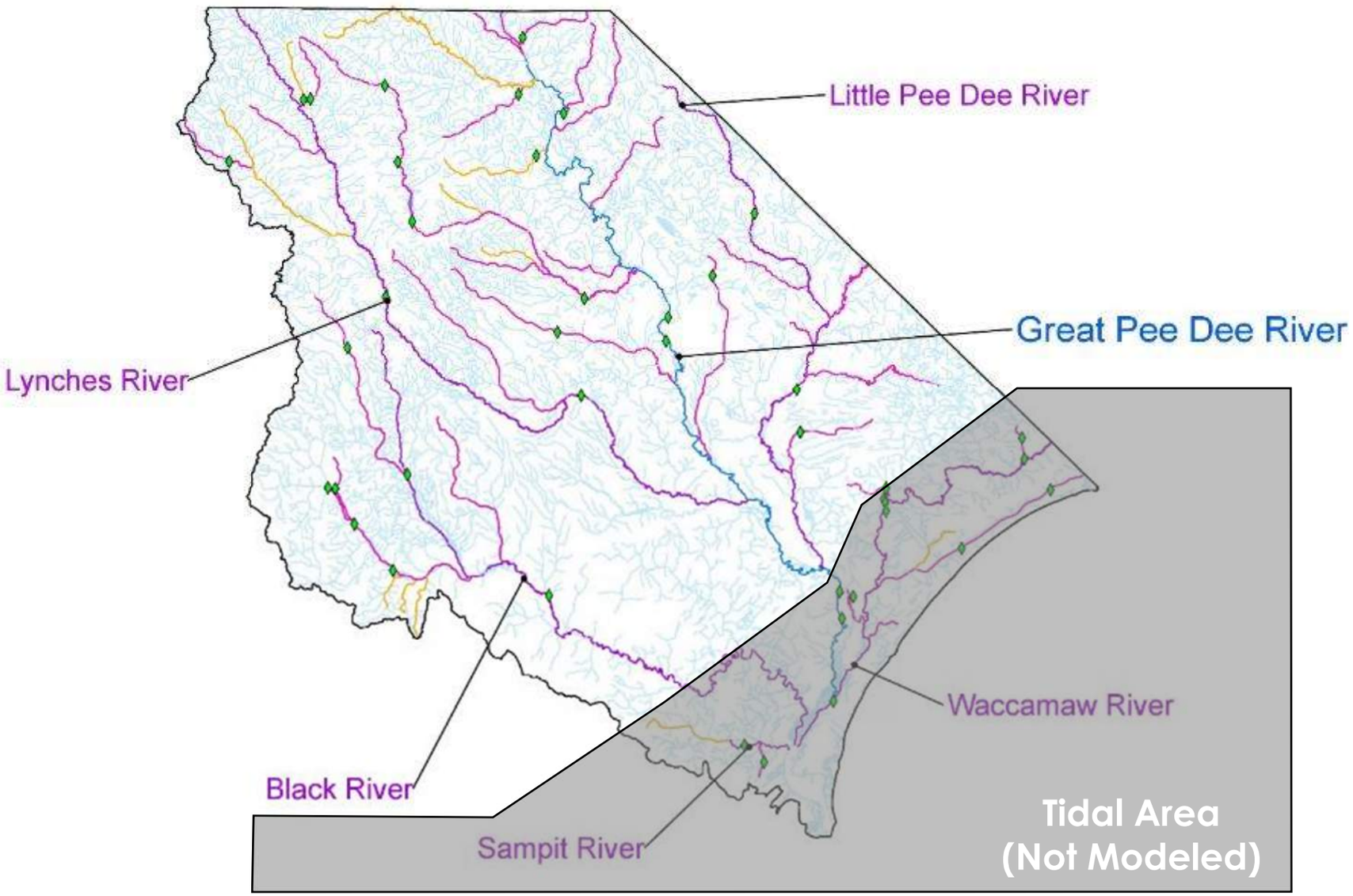
Extended Timeseries for PDE11 (Black Creek near McBee Gage)



Lynches River near Effingham gage used as a reference

Lynches River near Bishopville gage used as a reference

Main Stem and Major Branches



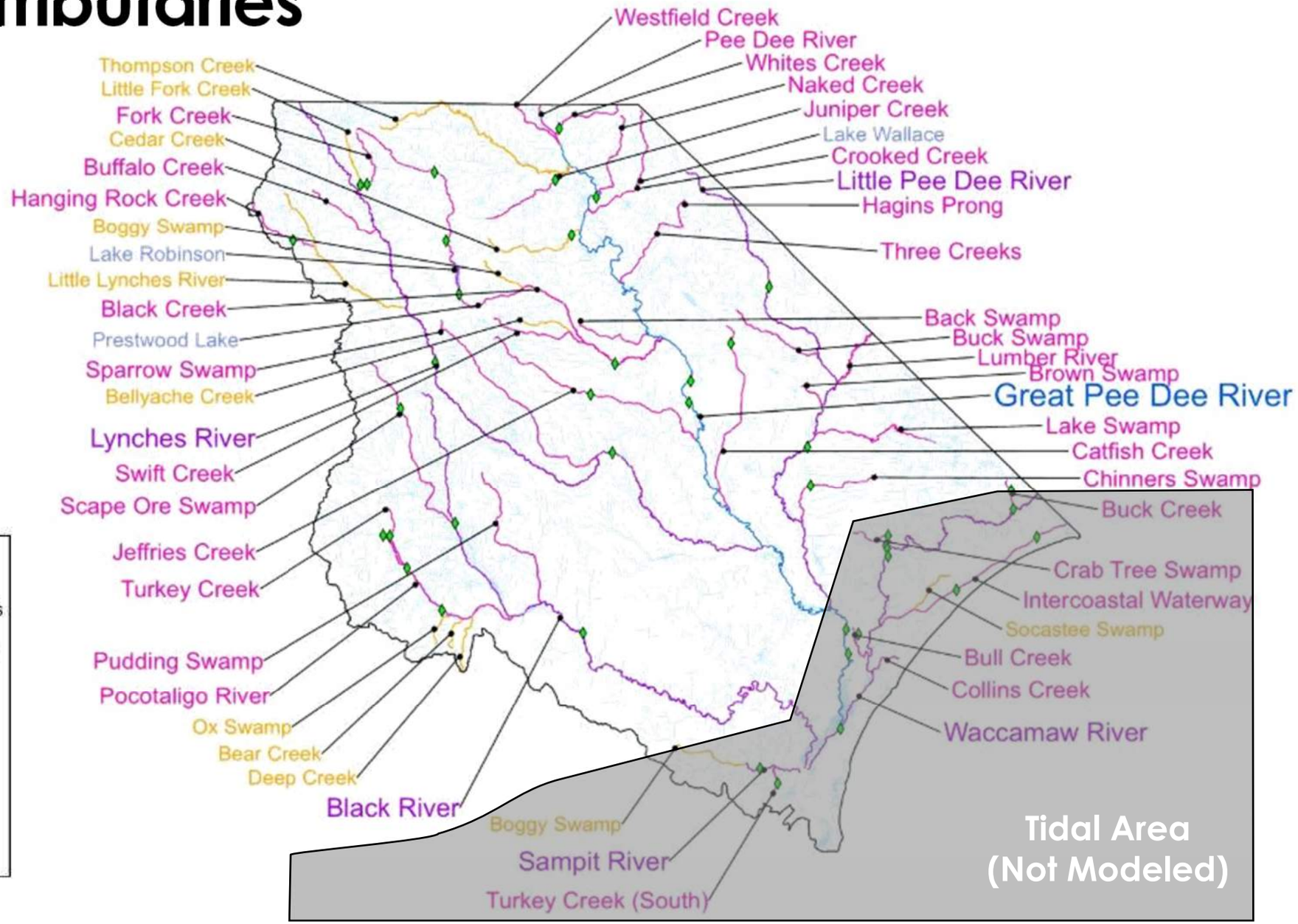
Legend

- Pee Dee USGS Gages

Model Tributary Objects

- Pee Dee
- Major Branch
- Primary
- Secondary
- Higher Order Tribs

Primary Tributaries



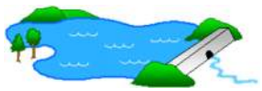
Legend

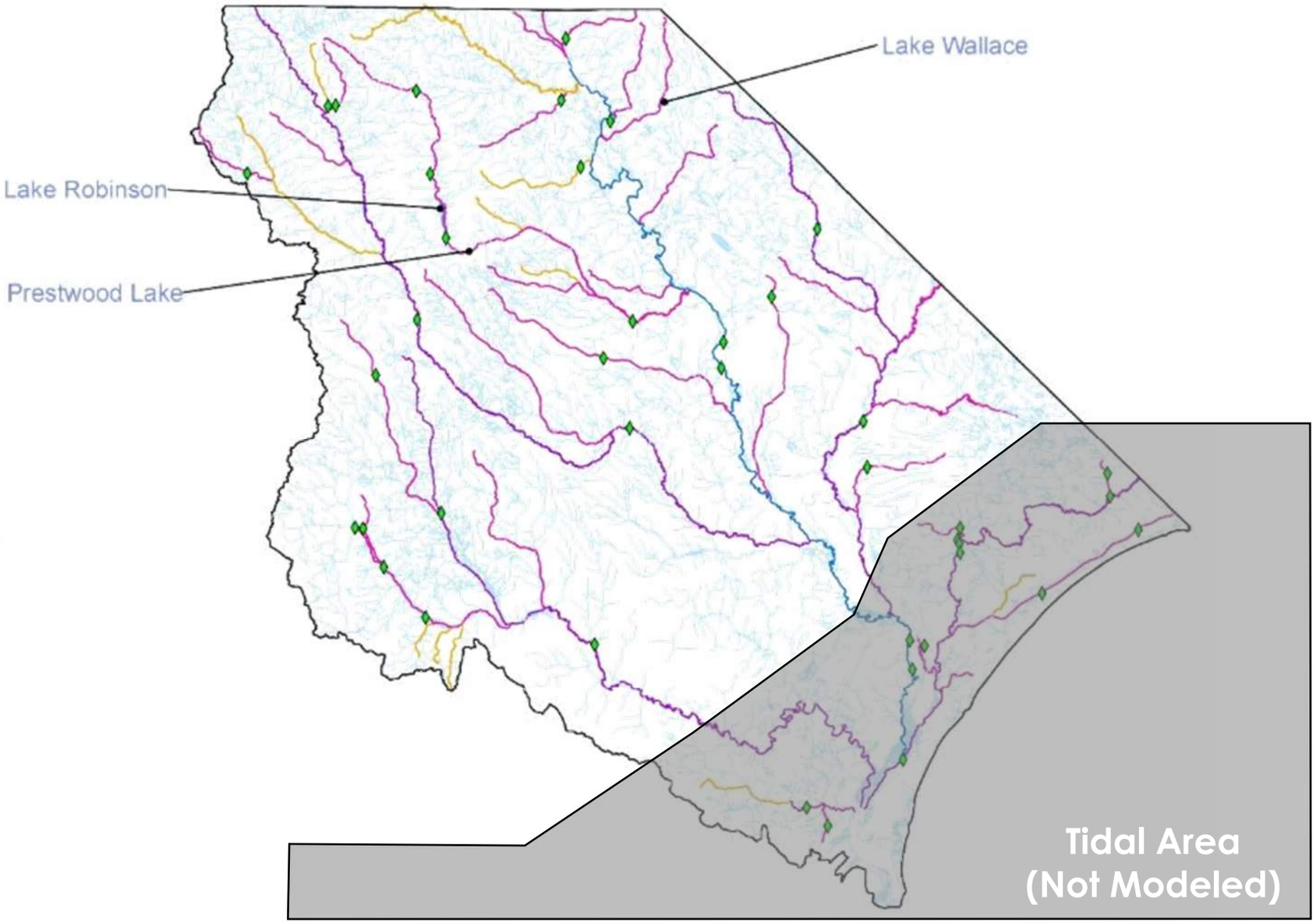
- Pee Dee USGS Gages

Model Tributary Objects

- Pee Dee
- Major Branch
- Primary
- Secondary
- Higher Order Tribs

Reservoirs





Legend

- Pee Dee USGS Gages

Model Tributary Objects

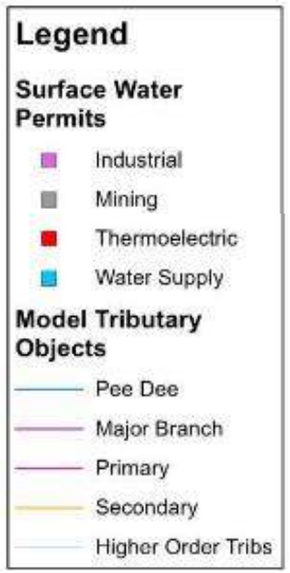
- Pee Dee
- Major Branch
- Primary
- Secondary
- Higher Order Tribs

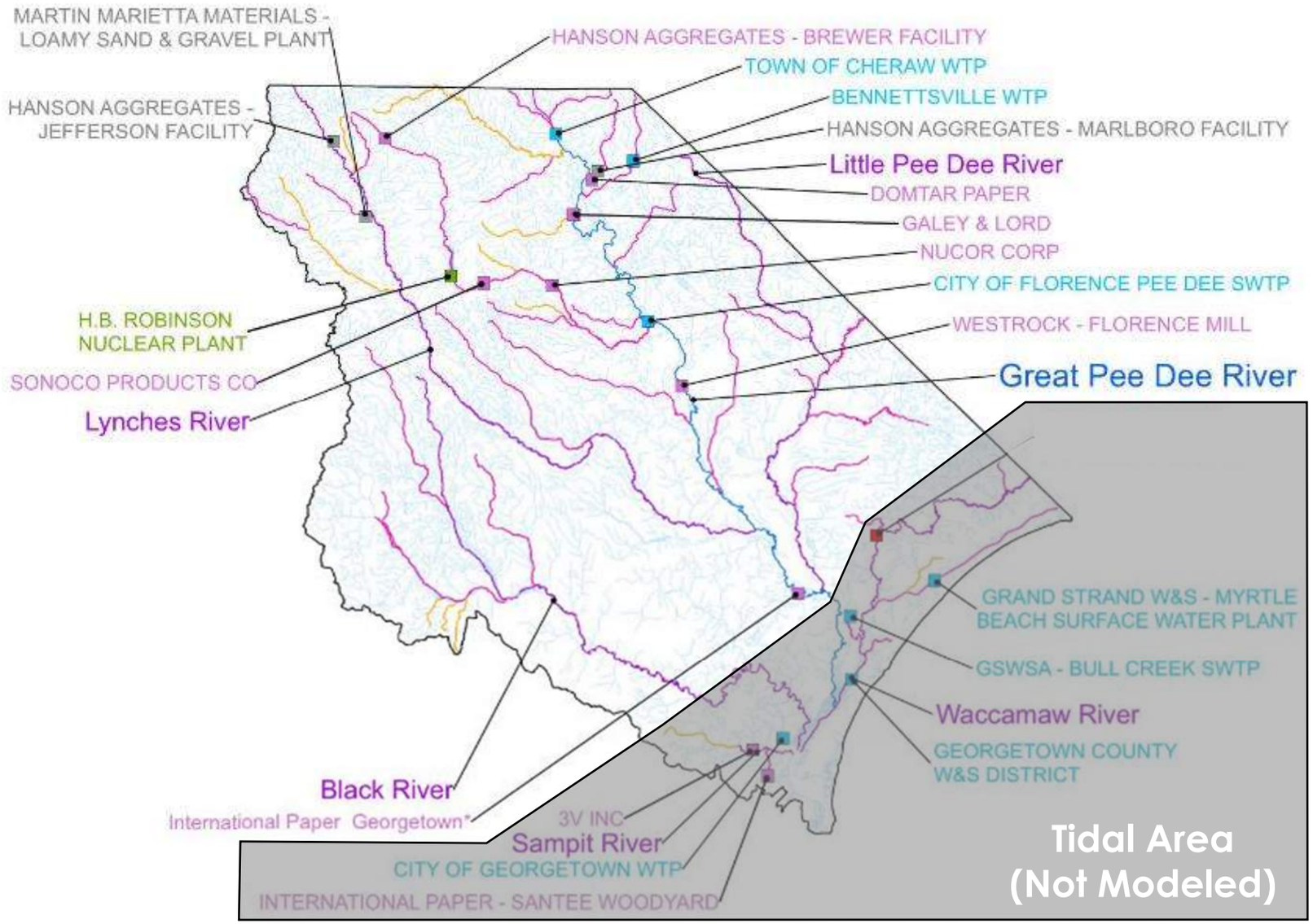
Municipal, Industrial, and Thermoelectric Withdrawals

MUNICIPAL

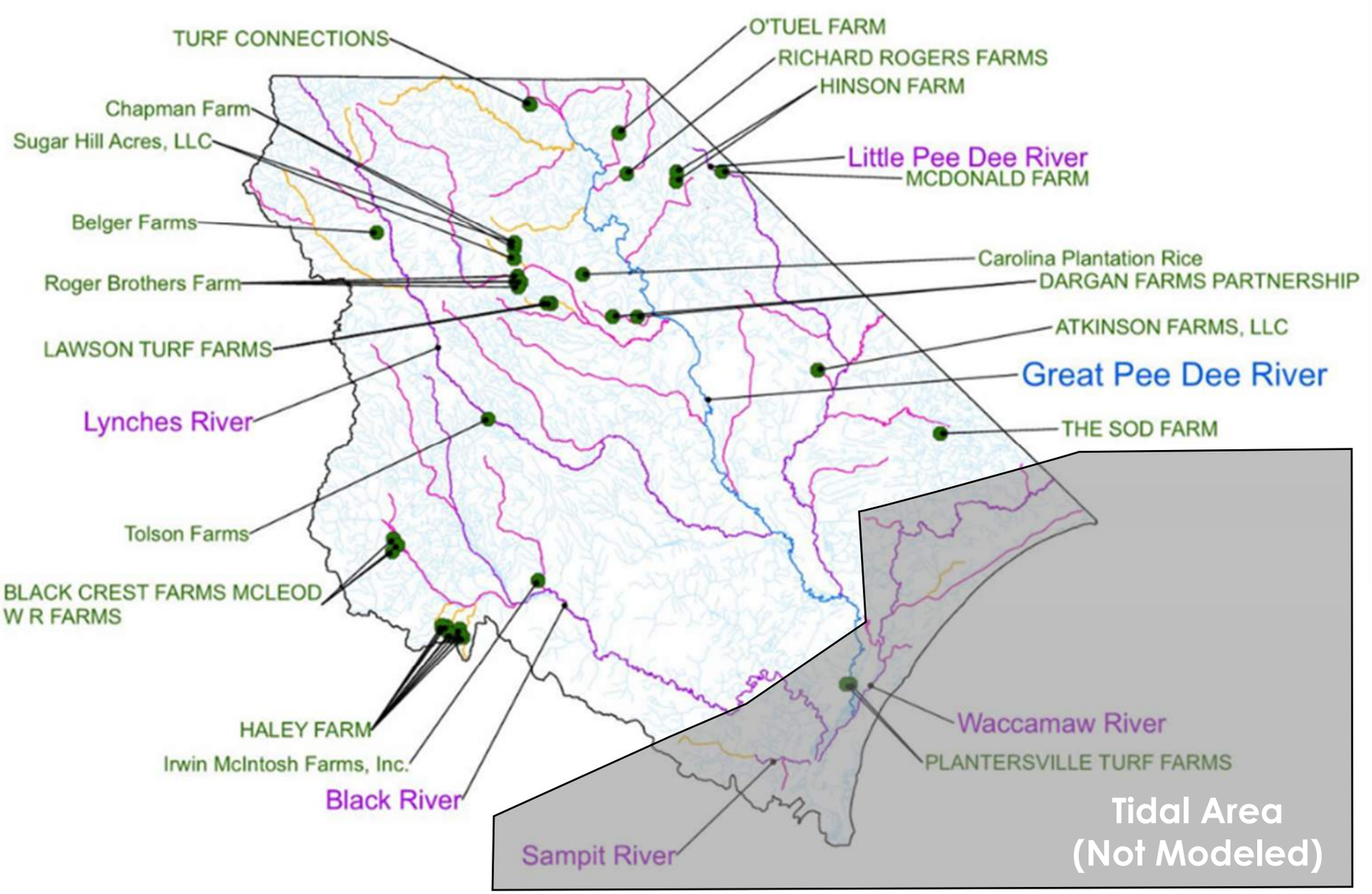
INDUSTRIAL/
MINING

THERMO-
ELECTRIC





Agriculture Withdrawals



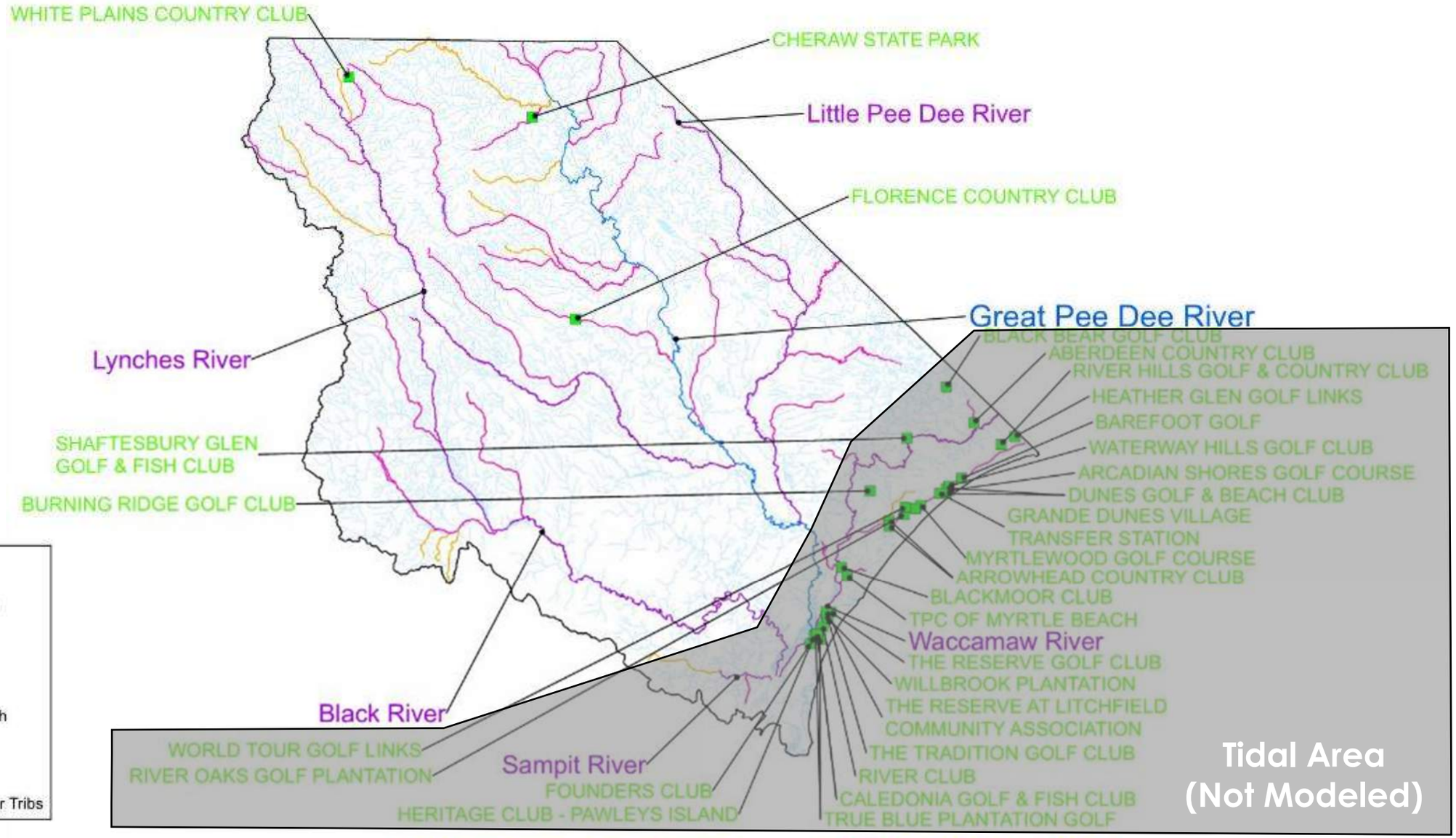
Legend

- Registered Agriculture

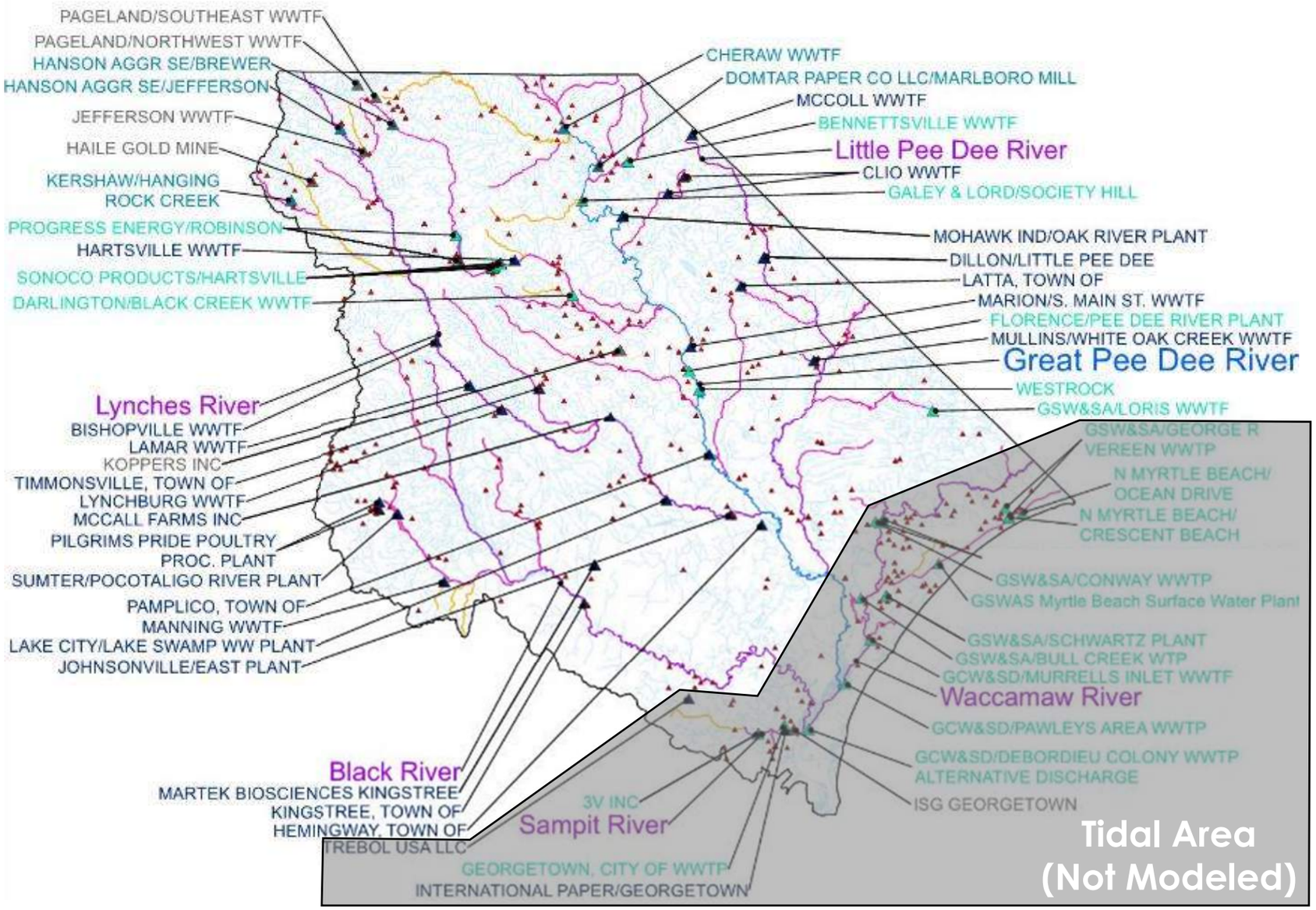
Model Tributary Objects

- Pee Dee
- Major Branch
- Primary
- Secondary
- Higher Order Tribs

Golf Course Withdrawals



Discharges to Surface Water



Legend

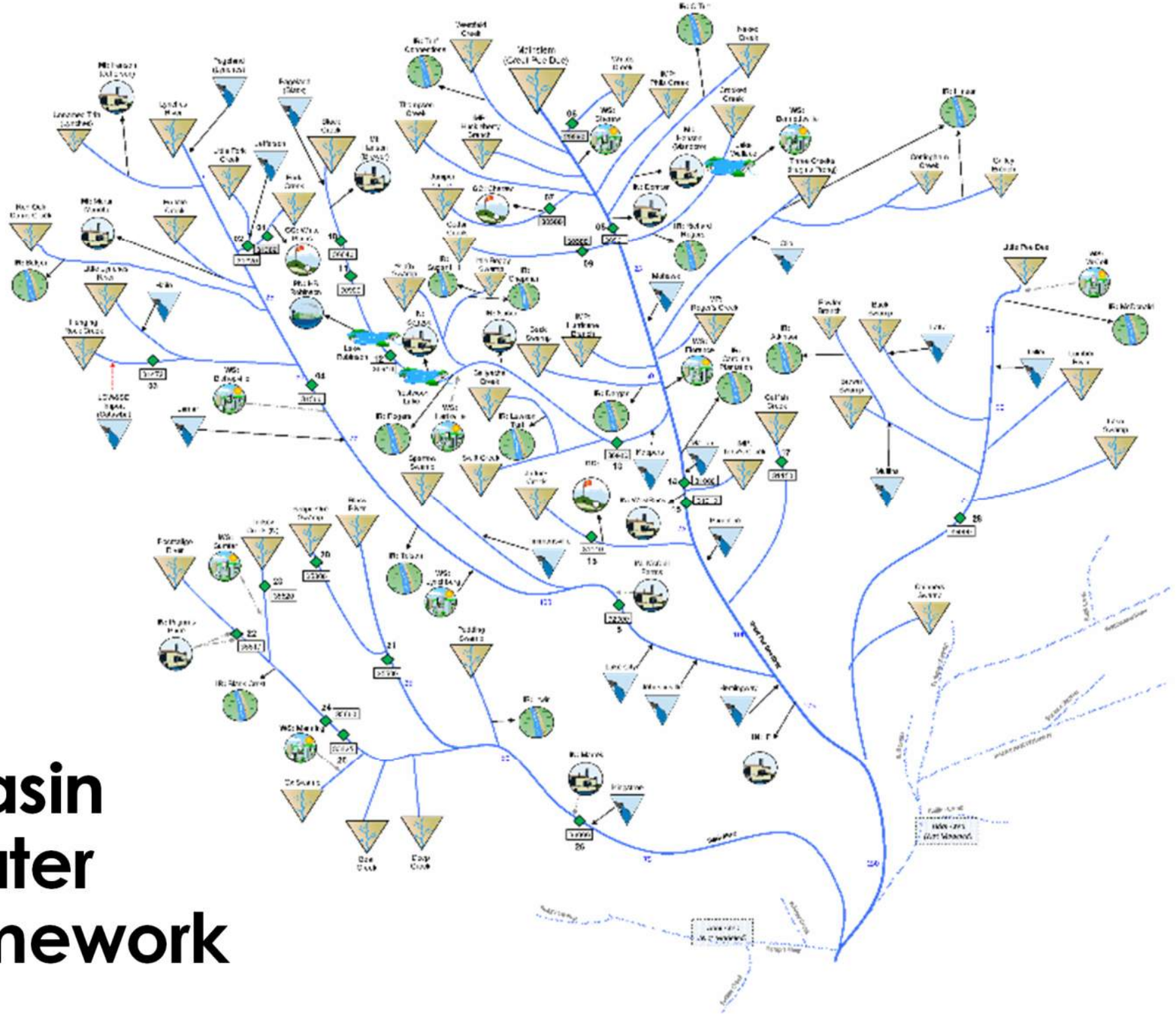
Significant Dischargers

- Not Included, Insignificant
- Included, No Withdrawal Permit or Registration
- Included, Has GW Withdrawal Registration
- Included, Has SW Withdrawal Permit
- Included, Has both SW Withdrawal Permit & GW Withdrawal Registration

Model Tributary Objects

- Pee Dee
- Major Branch
- Primary
- Secondary
- Higher Order Tribs

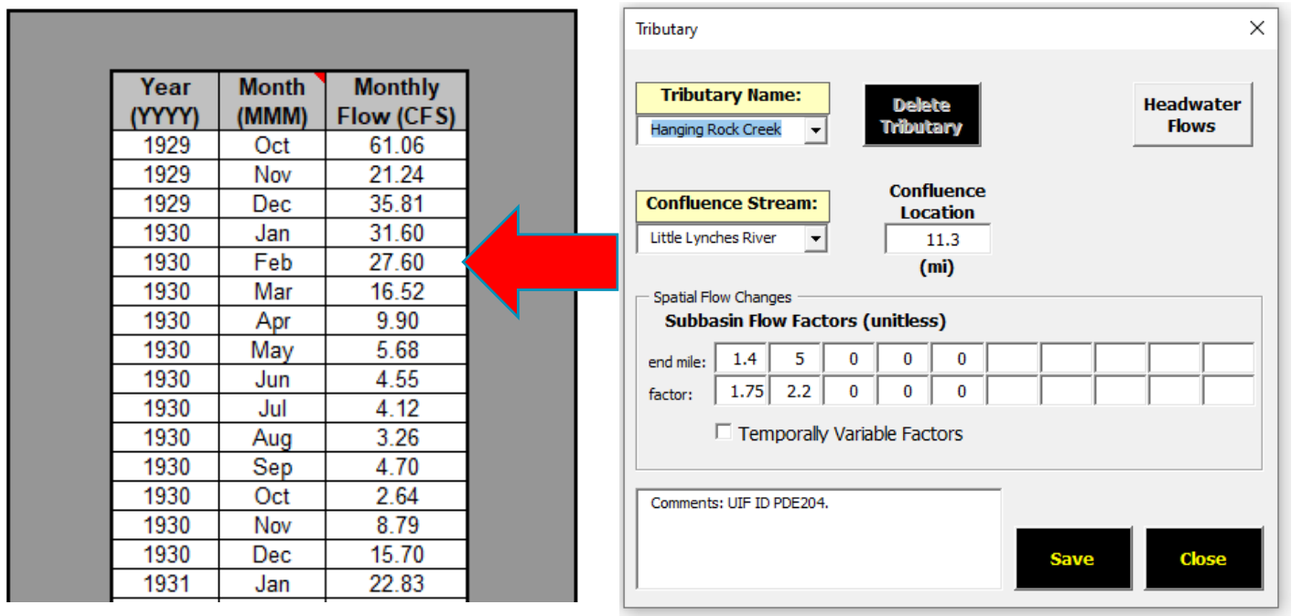
Pee Dee Basin Surface Water Model Framework

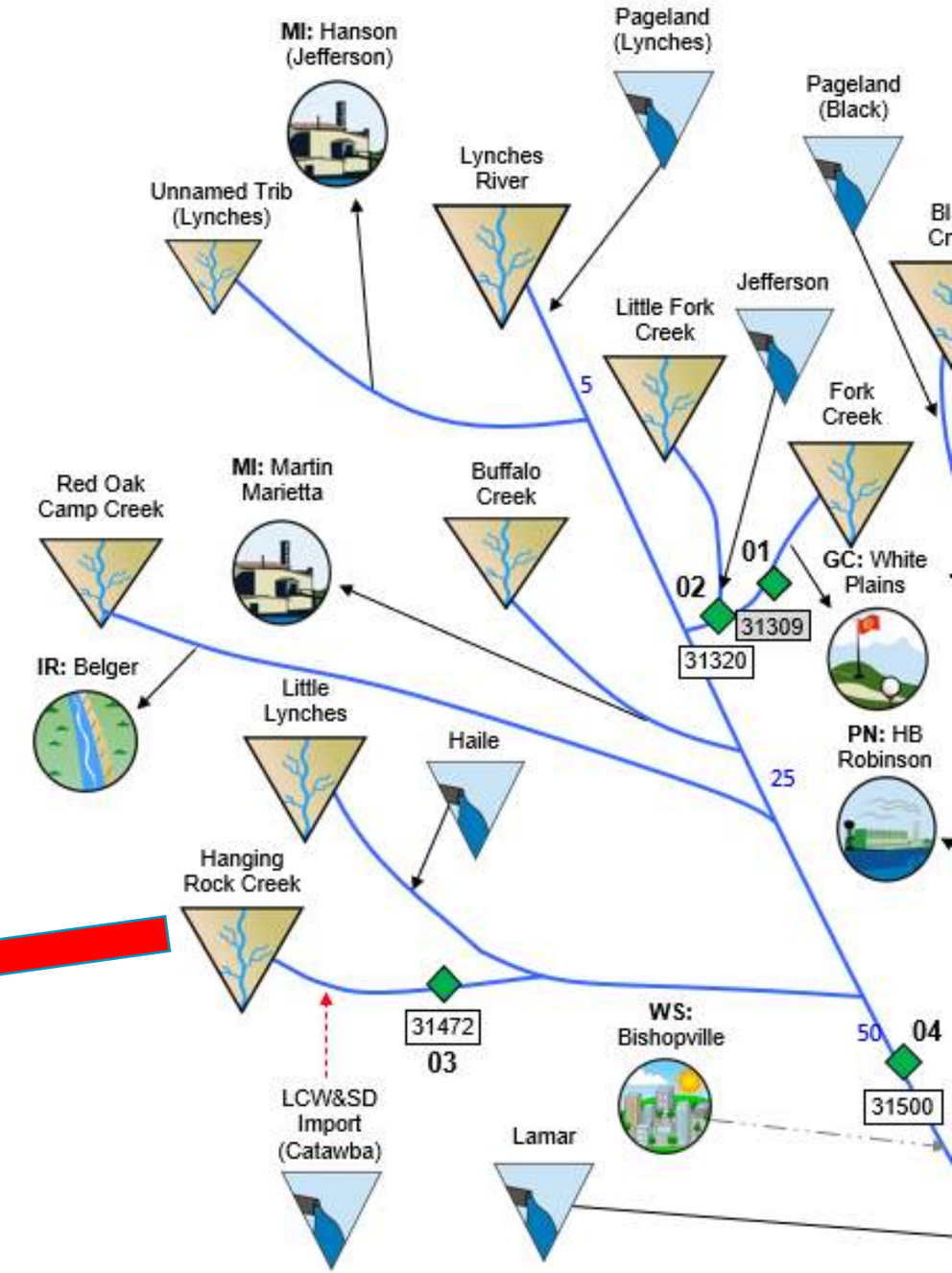


SWAM Calculations: Supply

- **Physically available** flow is a function of:
  - upstream tributary inflows,
  - reach gains and losses,
  - upstream diversions, withdrawals, returns, and storage

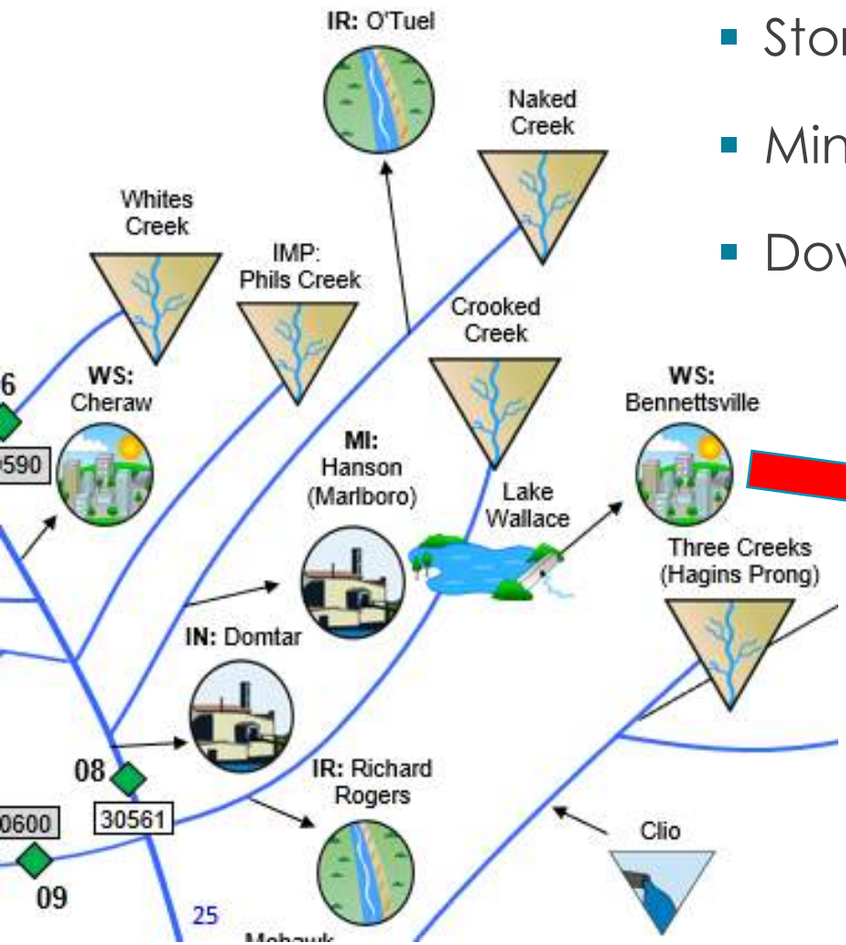
Year (YYYY)	Month (MMM)	Monthly Flow (CFS)
1929	Oct	61.06
1929	Nov	21.24
1929	Dec	35.81
1930	Jan	31.60
1930	Feb	27.60
1930	Mar	16.52
1930	Apr	9.90
1930	May	5.68
1930	Jun	4.55
1930	Jul	4.12
1930	Aug	3.26
1930	Sep	4.70
1930	Oct	2.64
1930	Nov	8.79
1930	Dec	15.70
1931	Jan	22.83

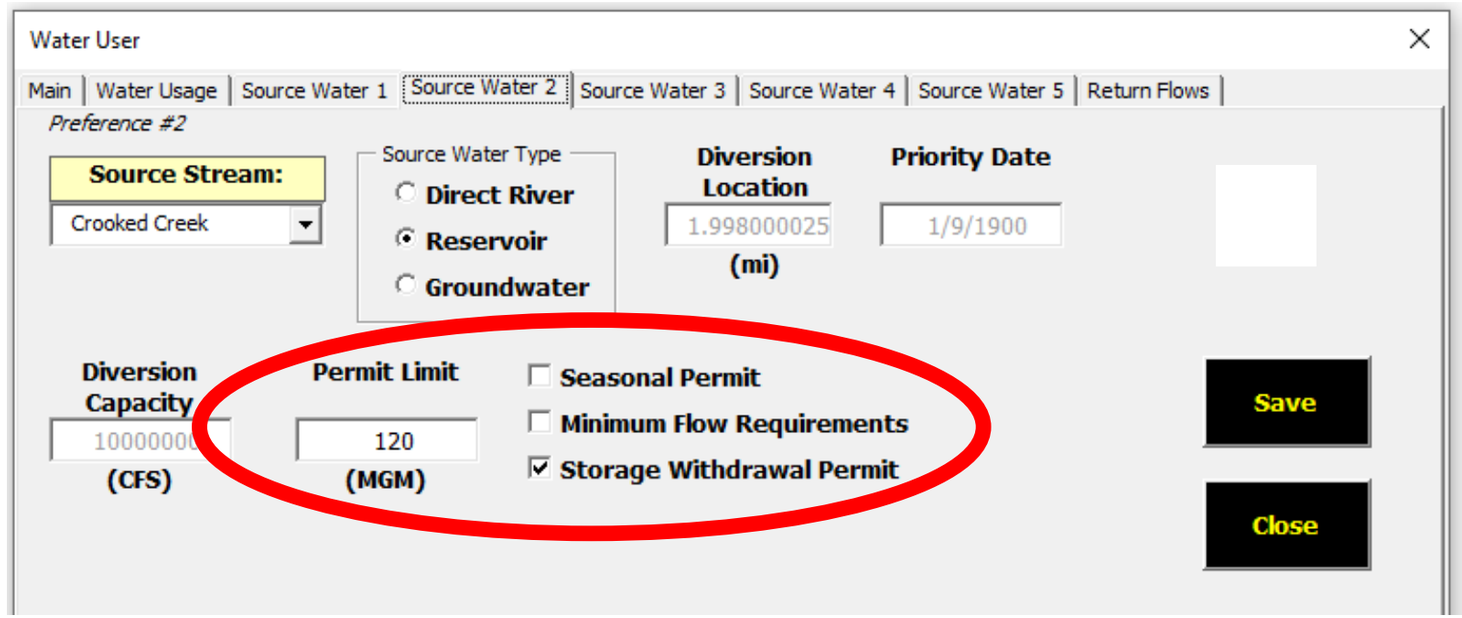




SWAM Calculations: Supply

- **Legally available** flow is a function of:
  - Permit limits / water rights
  - Storage rights
  - Minimum Instream flow requirements
  - Downstream priority water uses





SWAM Calculations: Demand

- **WS: User Object:**
  - Node based withdrawals and returns
  - Municipal water demands (prescribed monthly mean)

Water User

Main | Water Usage | Source Water 1 | Source Water 2 | Source Water 3 | Source Water 4 | Source Water 5 | Return Flows

Monthly User Distribution
- (•) Manual
- ( ) M&I
- ( ) Agriculture

Annual Baseline Usage
Total Use: 5184.68 (MGY) [Distribute]

Input Format
- (•) monthly means
- ( ) timeseries

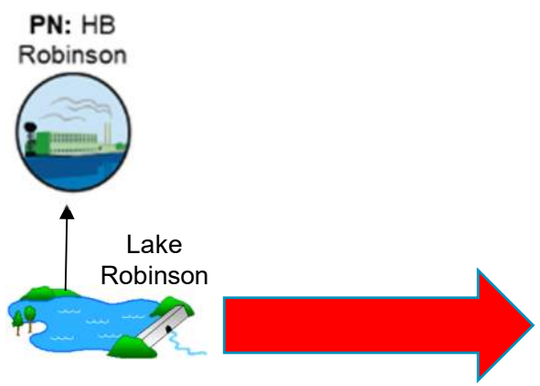
Monthly Baseline Usage

Month	Monthly Usage	% Indoor Use	% CU Indoor	% CU Outdoor
Jan	13.95	100	19	100
Feb	13.68	100	10	100
Mar	13.37	100	8	100
Apr	13.61	100	11	100
May	14.26	100	21	100
Jun	15.22	100	29	100
Jul	15.39	100	30	100
Aug	15.24	100	31	100
Sep	14.97	100	30	100
Oct	14.05	100	25	100
Nov	13.5	100	23	100
Dec	13.18	100	17	100
	(MGD)			

[Save] [Close]

SWAM Calculations: Reservoirs

- **Reservoir Object:**
  - Dynamic water balance, water supply pool, customized operating rules



Reservoir

Main

Reservoir Name: Lake Robinson

Delete Node

Storage Capacity: 10101 (MG)

Initial Storage: 10000 (MG)

Dead Pool: 0 (MG)

Offline / Online

Evaporation

Monthly Mean / % Volume / Input Timeseries

Edit Timeseries

Area-Capacity Table

Simple / Detailed

Volume (MG)	Area (Ac)
0	0
10101	2250

Reservoir Operations

Receiving Stream: Black Creek

Simple / Advanced

Release Location: 38.5 (mi)

User Defined Releases

Month	Min. Release (CFS)
Jan	0
Feb	0
Mar	0
Apr	0
May	0
Jun	0
Jul	0
Aug	0
Sep	0
Oct	0
Nov	0
Dec	0

Flood Control Outflow

% Vol	Outflow (CFS)
0	0
100	0

Comments: Lake Robinson reservoir came online in 1960. Supports withdrawal from H.B. Robinson Nuclear Plant (Permits 16PN001S2 and -S01). No minimum releases or storage targets. Evap rates extended and updated in 2020.

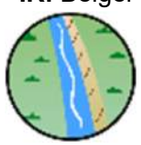
Save

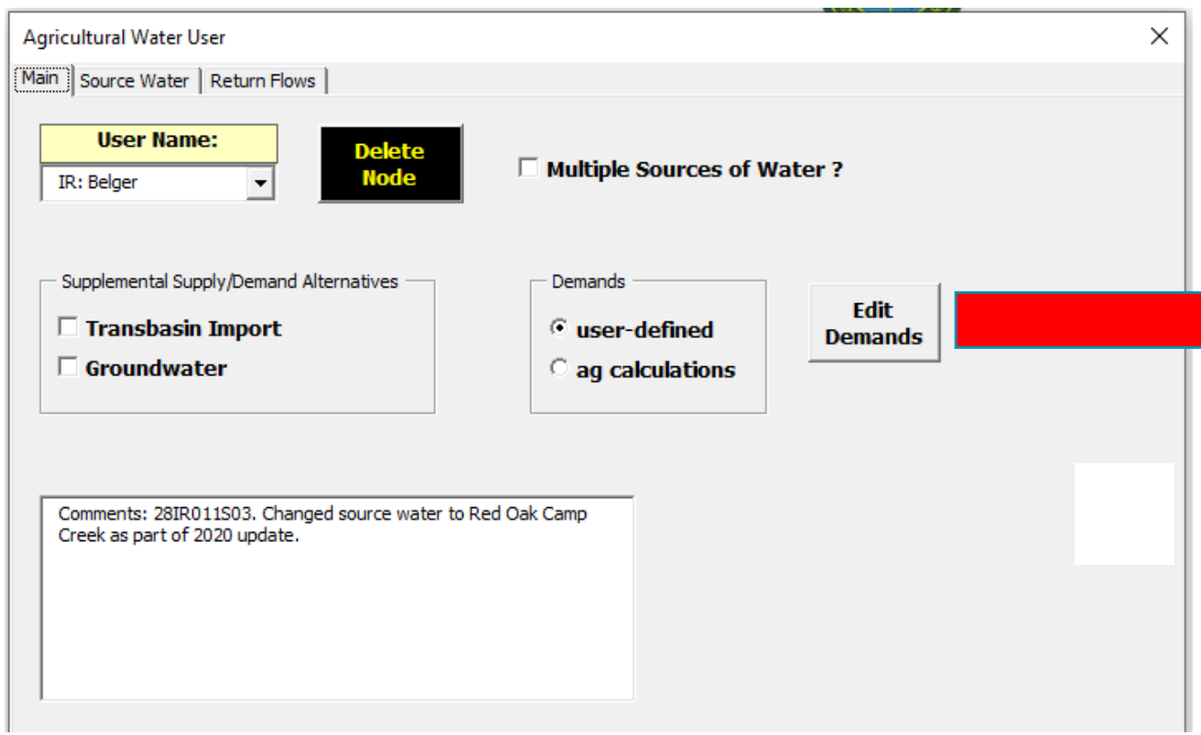
Close

SWAM Calculations: Demand

- **Ag User Object:**
  - Agricultural water demands (prescribed monthly mean – repeated time series)

IR: Belger

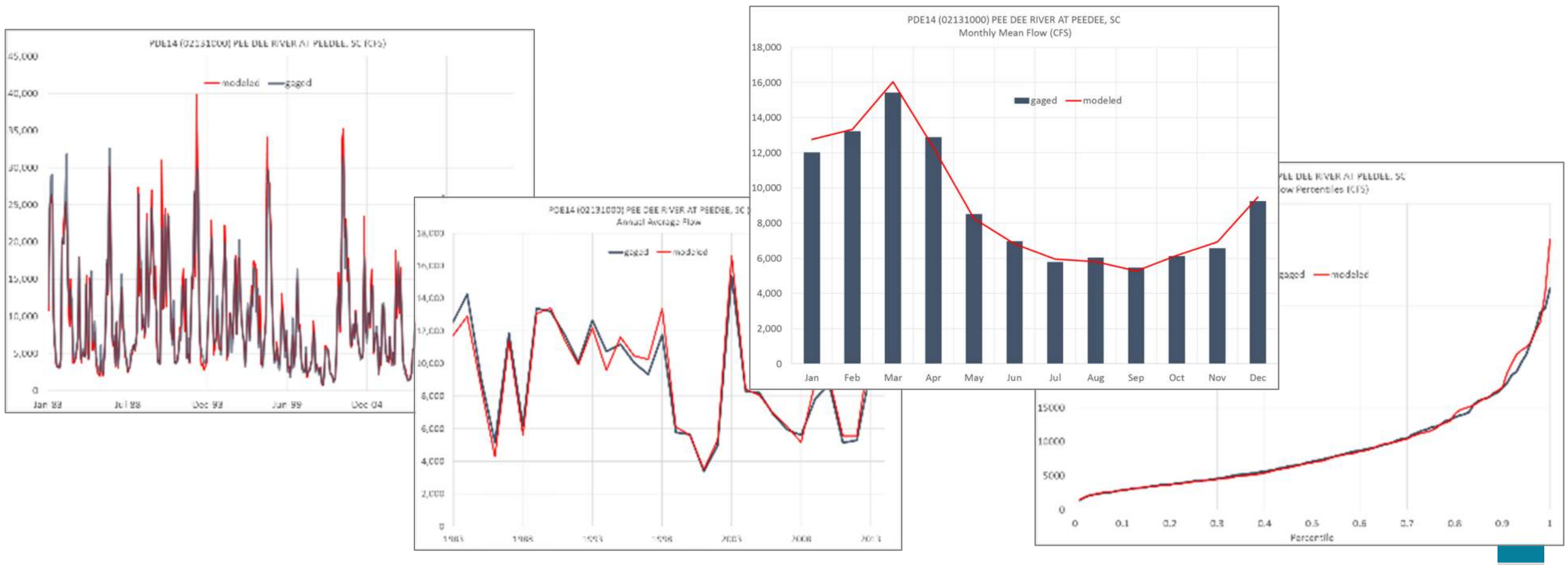




Year (YYYY)	Month (MMM)	Monthly Demand (MGD)
1929	Jan	0.00
1929	Feb	0.00
1929	Mar	0.00
1929	Apr	0.00
1929	May	0.00
1929	Jun	0.00
1929	Jul	0.00
1929	Aug	0.00
1929	Sep	0.00
1929	Oct	0.00
1929	Nov	0.00
1929	Dec	0.00
1930	Jan	0.00
1930	Feb	0.00
1930	Mar	0.00
1930	Apr	0.00
1930	May	0.00

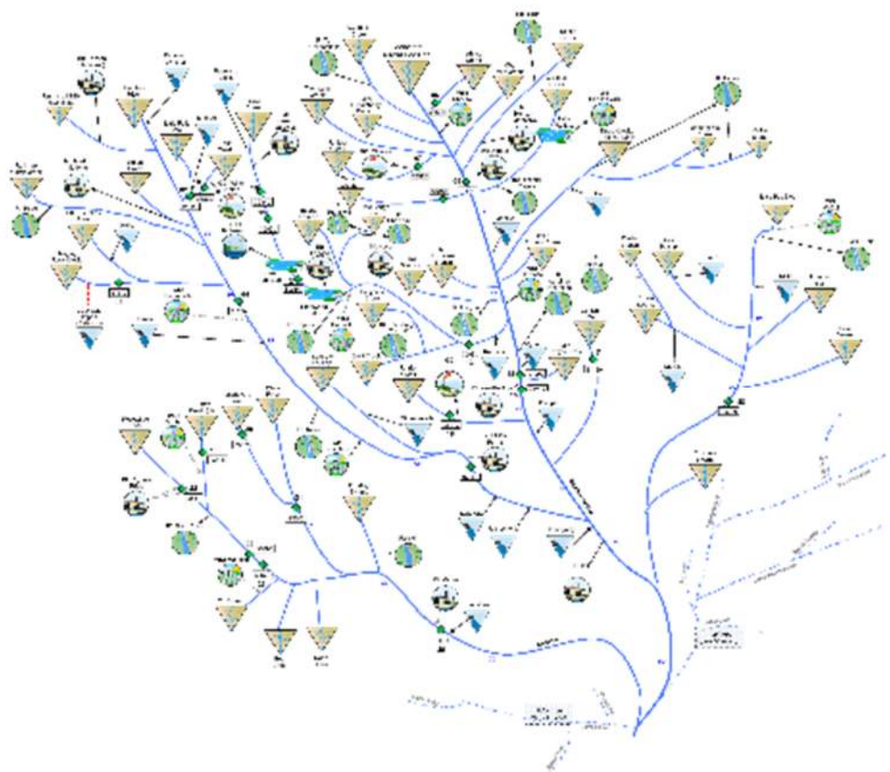
Model Calibration

- Calibration performed for multiple sites across wide range of hydrologic conditions
- Key calibration parameters = reach gain/loss factors (hydrology)



2021 Surface Water Model Updates

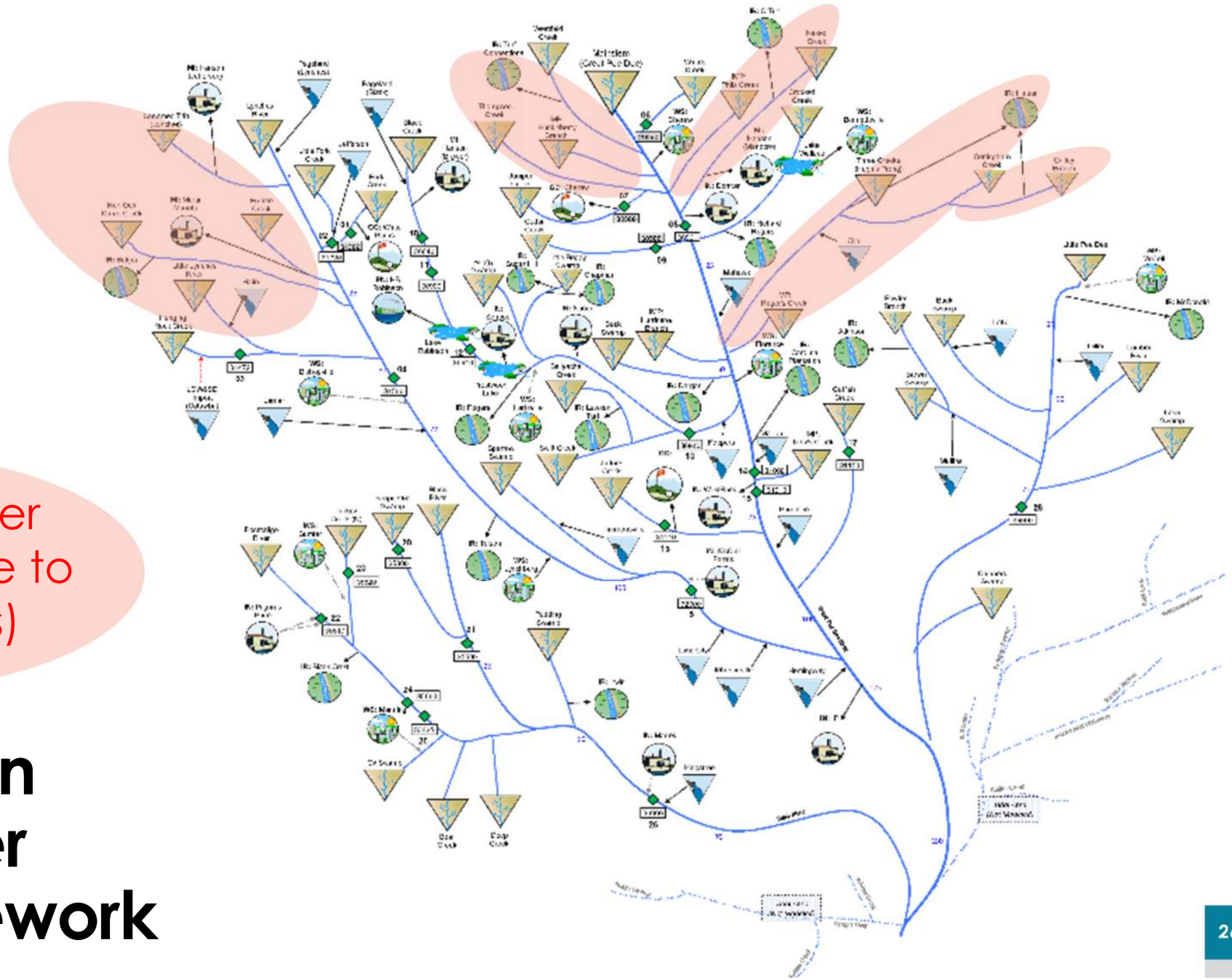
- Extended baseline hydrology through 2018 (added 5 years)
- Updated monthly mean water demands based on recent water use data
- Updated permit and intake location information
- Removed inactive permittees
- Added new registrations
- Software update



Model Limitations

- Greater uncertainty in predictions for ungaged reaches compared to gaged
- Model not designed for reach routing of flow changes at a daily or sub-daily timestep
- Greater uncertainty in supply availability (and "shortage") predictions associated with small stream withdrawals compared to larger river and reservoir withdrawals
  - e.g. offline irrigation ponds
- Baseline model assumes past hydrologic variability is representative of future hydrologic variability (stationary climate)

Areas of greater uncertainty (due to lack of gages)



Pee Dee Basin Surface Water Model Framework

Surface Water Scenarios

Base Scenarios

- Current Surface Water Use Scenario
  - *Uses most recent 10-yr average withdrawals (as reported by month)*
- Permitted and Registered Surface Water Use Scenario
  - *Uses current fully-permitted and registered amounts*
- Business-as-Usual Water Demand Projection Scenario
  - *Future water demand projection based on moderate growth and normal climate*
- High Water-Demand Projection Scenario
  - *Future water demand projection based on high growth and hot/dry climate*

Additional scenarios may be identified and requested by the RBC

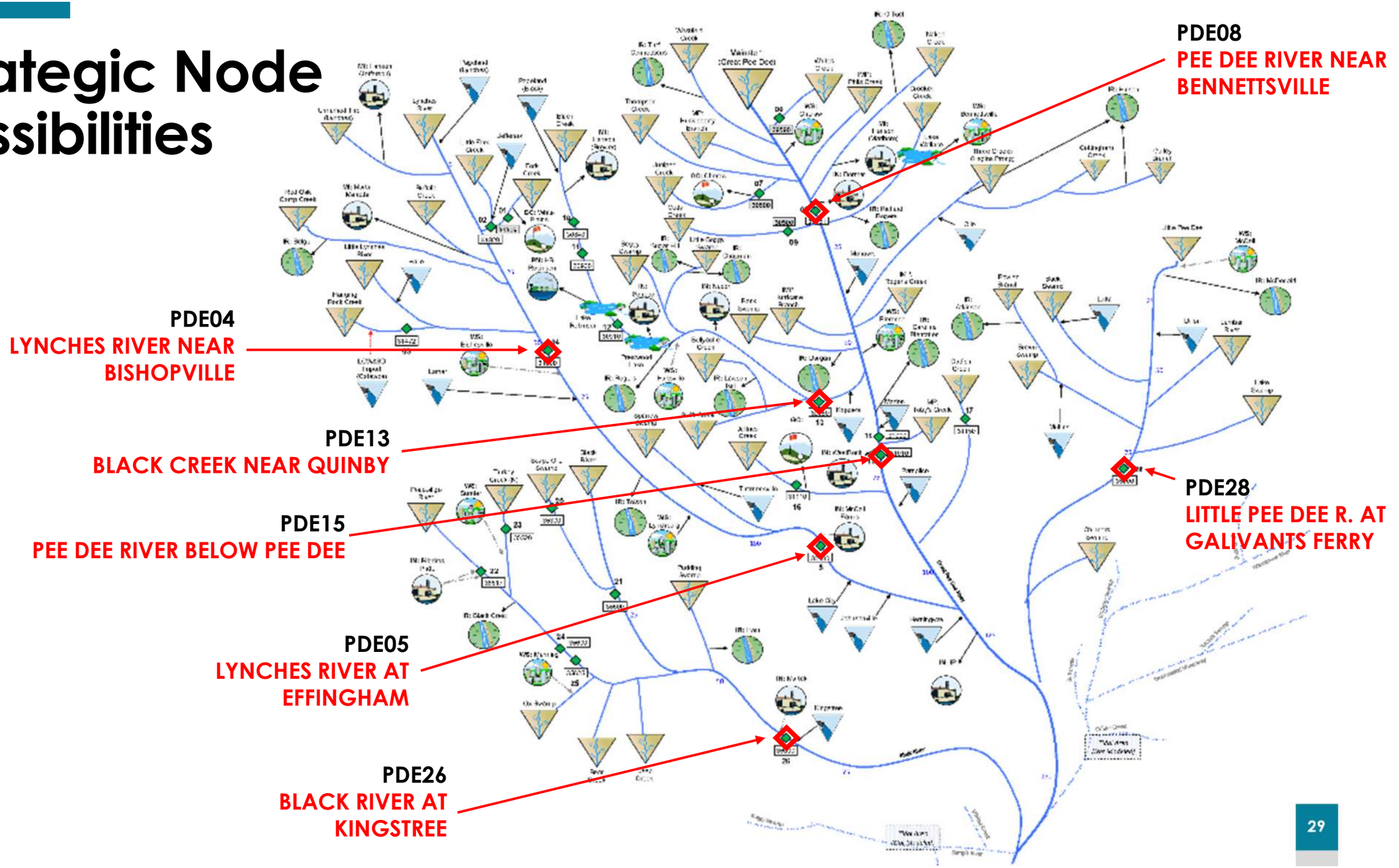
Performance Measures

Assessment of simulation results will focus on quantifying key performance measures for multiple reaches of interest across the basin.

Example / Suggestions:

- Percent change in a monthly minimum flow, 5th percentile flow, mean, and/or median flow
- Percent change in seasonal or monthly flows
- Percent change in surface water supply
- Percent change in mean annual shortage or mean percent shortage
- Change in the number and magnitude of excursions below 20, 30 and 40 percent mean annual daily flows and/or 7Q10 flow
- Change in number of water users experience a shortage
- Change in the average frequency of shortage
- Percent of time recreational facilities were unavailable on a stream reach

Strategic Node Possibilities



Reaches of Interest

Specific stream reaches that may have no identified *Surface Water Shortage* but experience undesired impacts, environmental or otherwise, determined from current or future water-demand scenarios or proposed water management strategies.

Could be related to:

- Recreational flows
- Ecological / in-stream flows
- Designation as a Scenic River

Training

- Training for interested RBC members will be offered in early January
- RBC Preferred Dates?