Introduction to the Santee River Basin Surface Water Quantity Model

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Agenda Item 9

What is a Model?

A ***numerical model*** is a representation of a real-world system that can be solved with computation methods

Numerical models allow us to explore and consider **possible futures**

Models should be as **simple** as possible and as **complex** as needed.

"All models are wrong, some are useful"

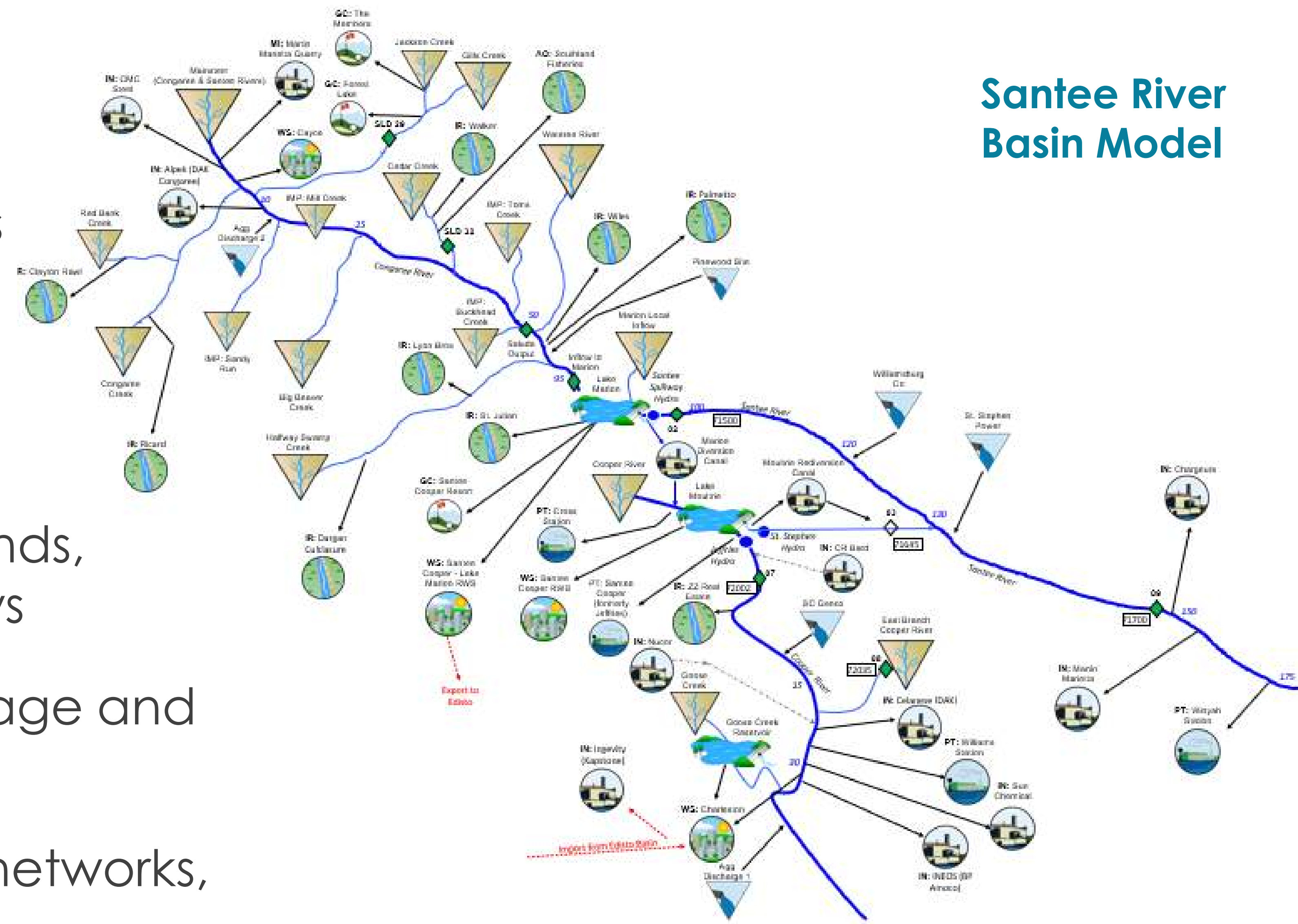
George Box, 1976
British Statistician

Box's point was that we should focus more on whether something can be applied in a useful manner rather than debating endlessly if an answer is correct in all cases

Surface Water Model Overview

Water Allocation Modeling ***is***:

- Water balance calculations of physical flow
- Water rights calculations of legally available flow
- Accounting of water demands, withdrawals, and return flows
- Accounting of reservoir storage and loss to evaporation
- A representation of stream networks, multiple “nodes”
- Data intensive



Santee River Basin Model

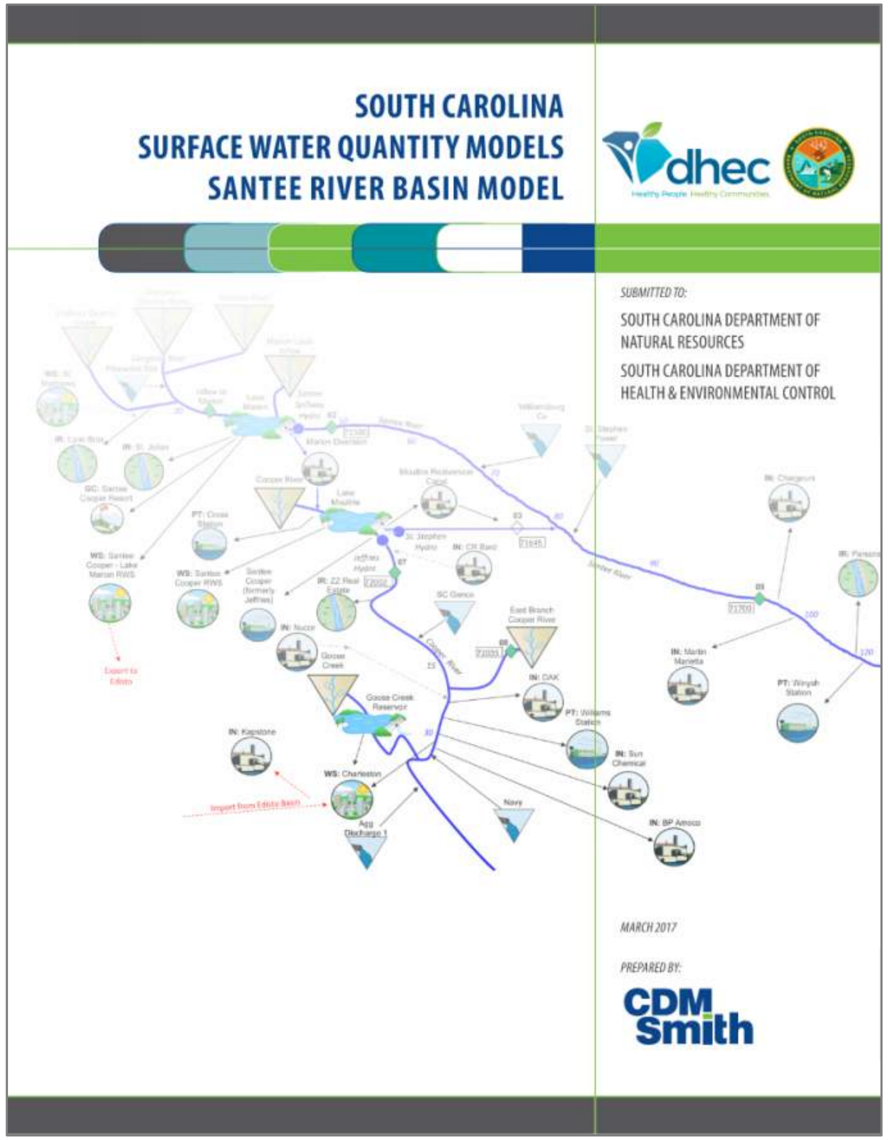
Surface Water Model Overview

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

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

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
- Updates to the Santee model are being completed now



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

- Assess current supply availability and shortages across a range of hydrologic conditions
- Assess a range of future potential scenarios with respect to changes in water demand
- Assess potential impacts of a "full allocation" scenario
- Compare managed flows to natural flows
- Evaluate drought management plans
- Test, evaluate and help prioritize water management strategies

Model Inputs and Supporting Information

Model Inputs

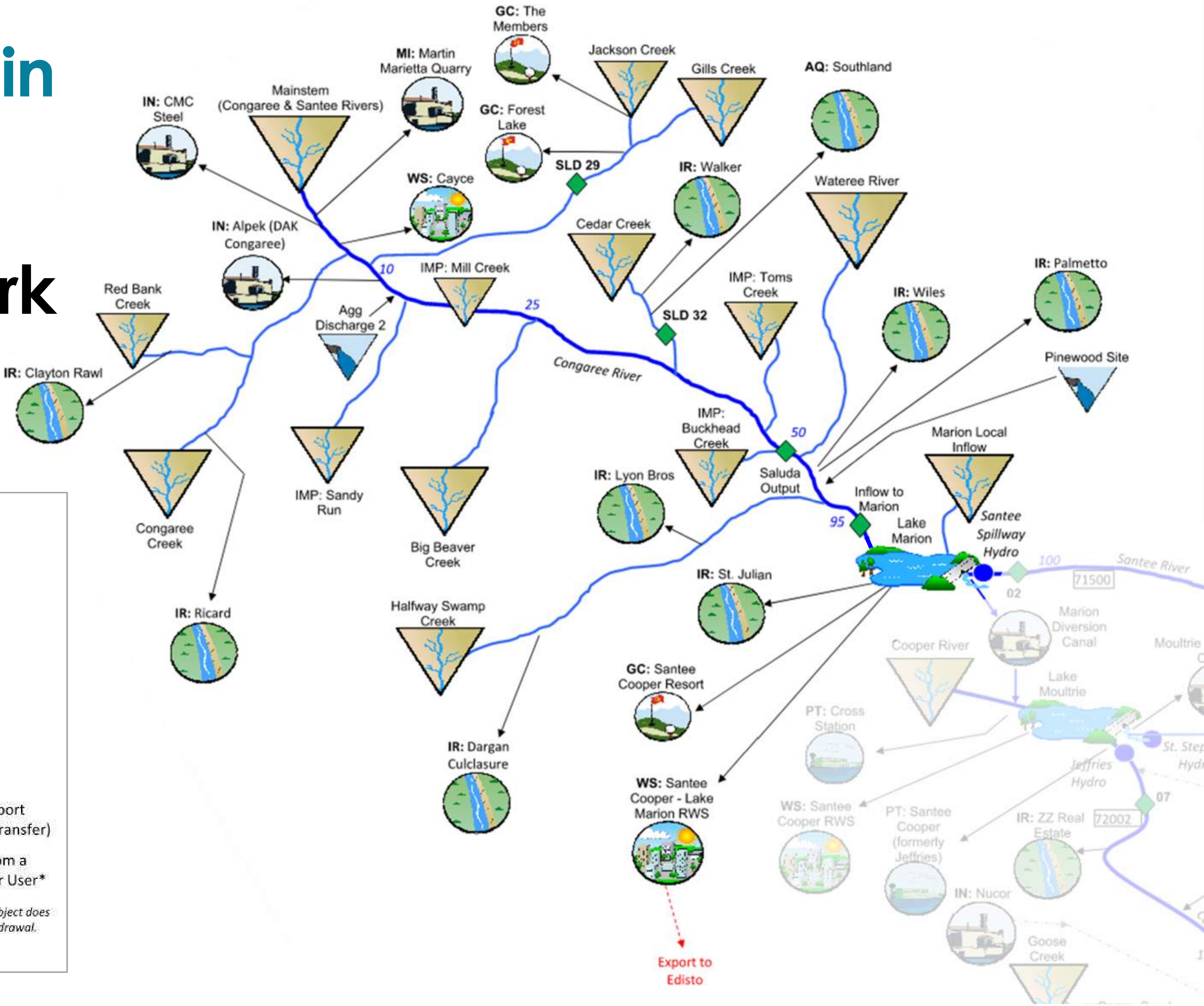
- USGS daily flow records
- Historical operational data
  - Withdrawals (municipal, industrial, thermoelectric, agricultural, golf courses, hatcheries)
  - Wastewater discharges and return flows
  - Transfers in and out of the basin
- Reservoir characteristics and operating rules

Supporting Information

- Subbasin characteristics
  - Drainage area, land use, and slope

USGS Streamflow Gaging Station

Santee River Basin (Upper Portion) Surface Water Model Framework



Model Objects

Tributary

Discharge

Reservoir

Current or Former USGS Stream Gage *(with last 5 to 6 digits of Gage ID)*

Water User Objects

Municipal

Agriculture (Irrigation)

Thermoelectric or Nuclear

Industrial or Mining

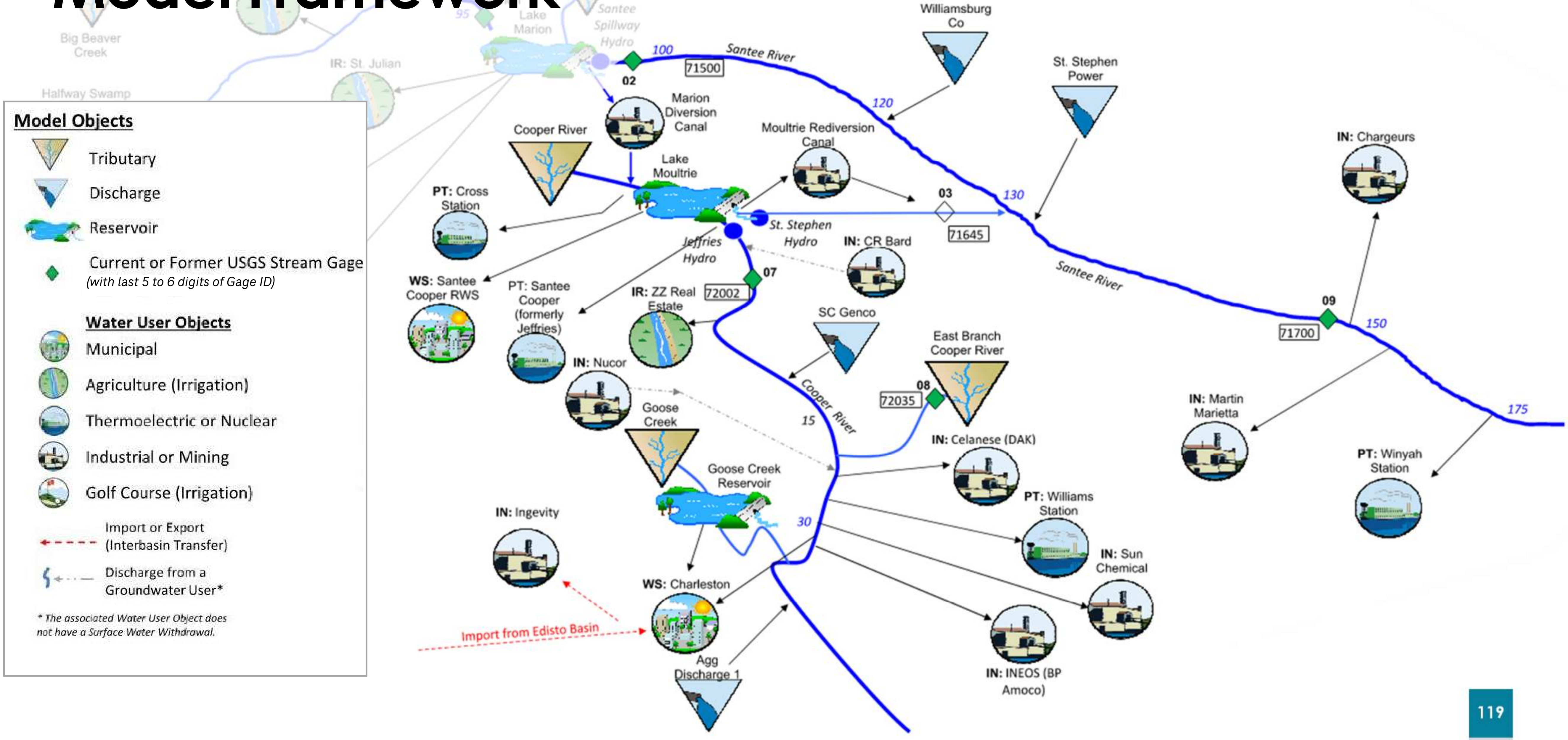
Golf Course (Irrigation)

Import or Export (Interbasin Transfer)

Discharge from a Groundwater User*

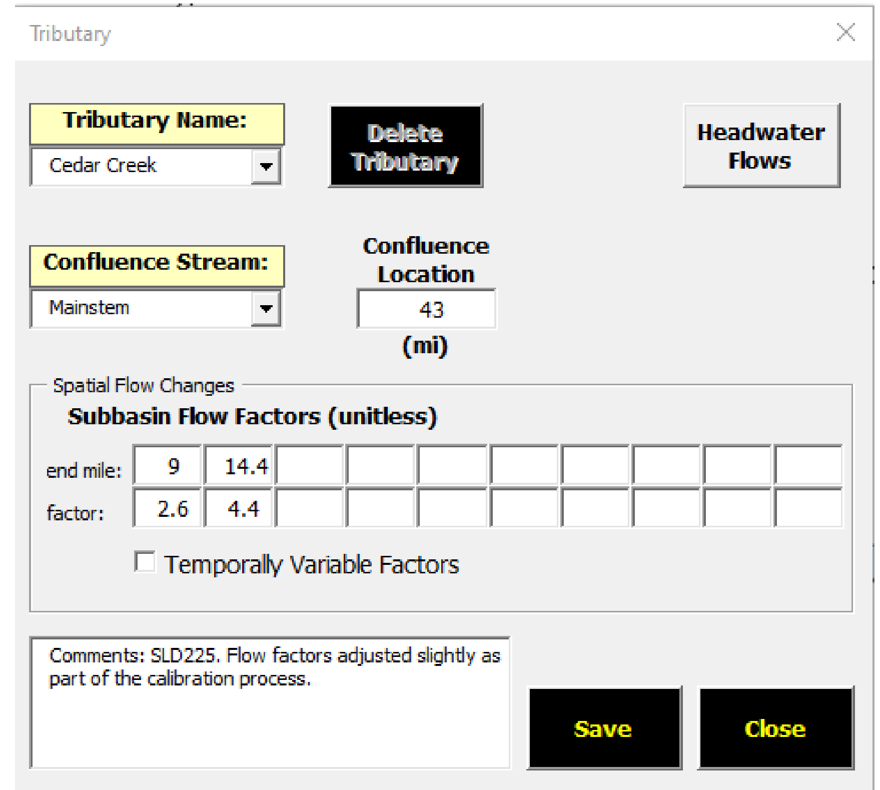
** The associated Water User Object does not have a Surface Water Withdrawal.*

Santee River Basin (Lower Portion) Surface Water Model Framework



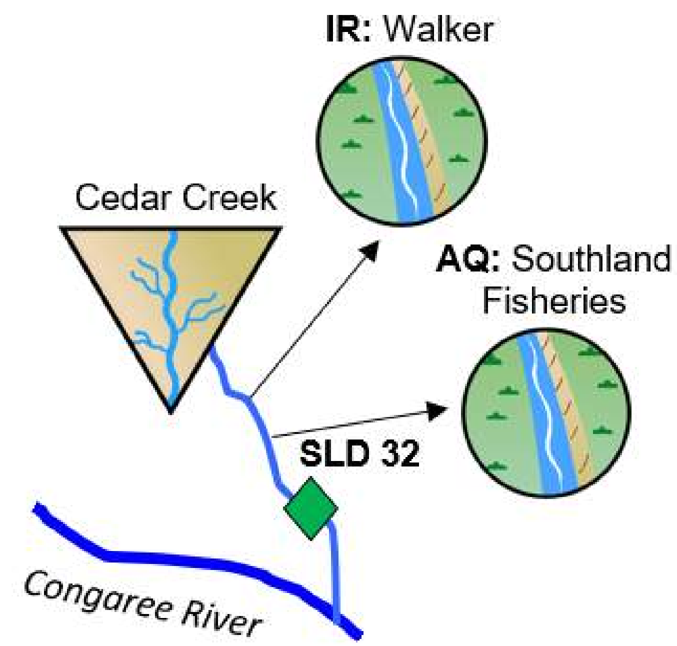
SWAM Calculations: Supply

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



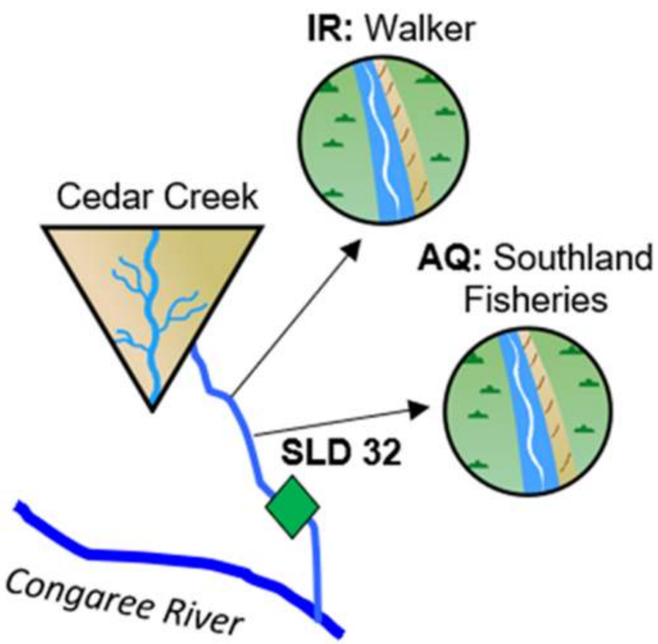
Cedar Creek Headwater Flows

Year (YYYY)	Month (MMM)	Monthly Flow (CFS)
1980	Jan	36.0
1980	Feb	40.8
1980	Mar	86.4
1980	Apr	71.1
1980	May	27.3
1980	Jun	18.8
1980	Jul	17.1
1980	Aug	11.6
1980	Sep	11.5
1980	Oct	23.8
1980	Nov	18.3
1980	Dec	18.3
1981	Jan	15.4
1981	Feb	24.0
1981	Mar	17.9
1981	Apr	11.3
1981	May	7.9
1981	Jun	16.7
1981	Jul	9.5

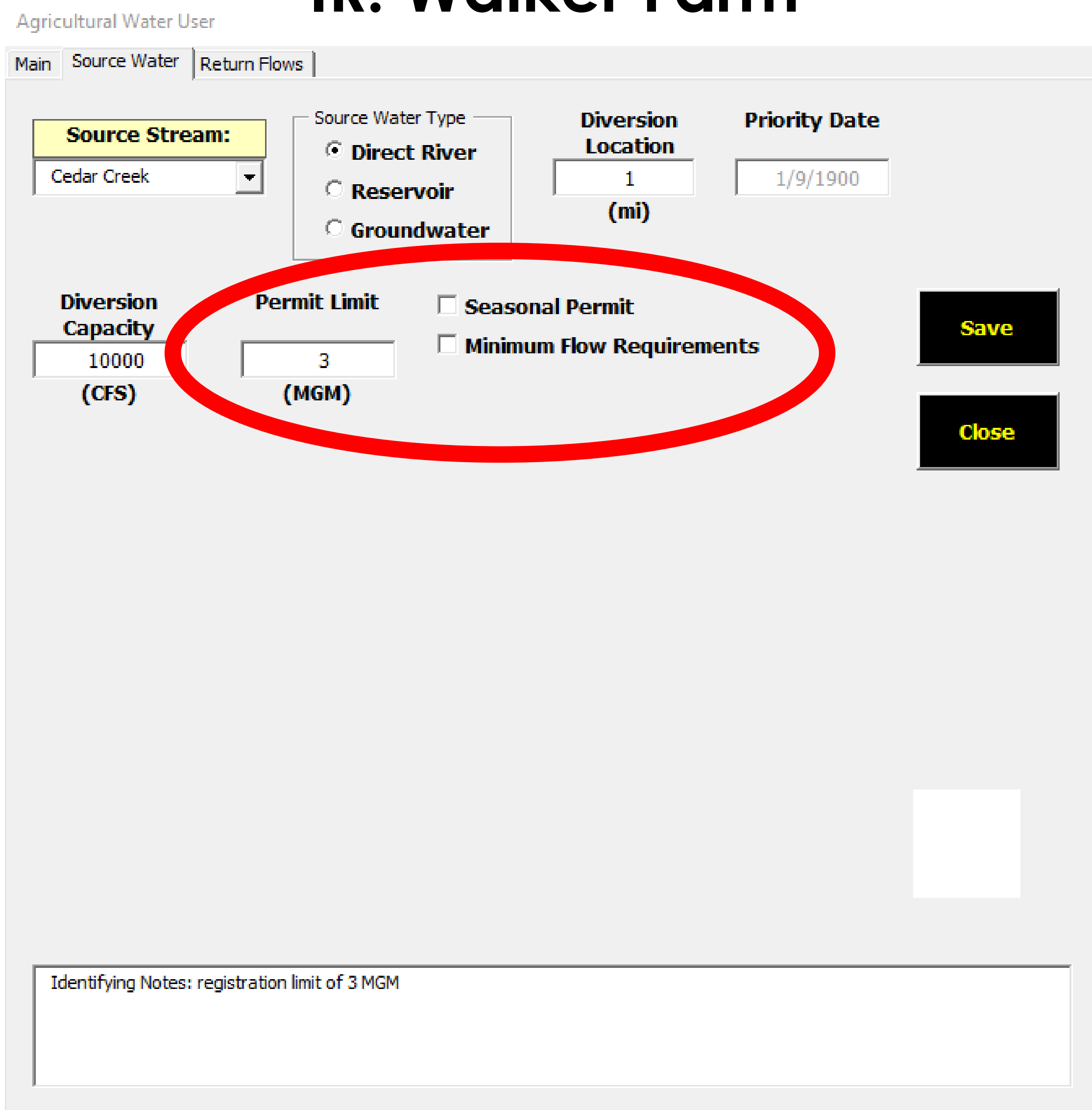


SWAM Calculations: Supply

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



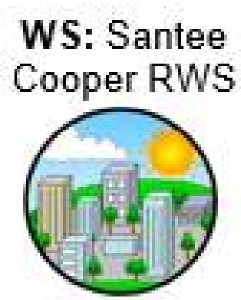
IR: Walker Farm

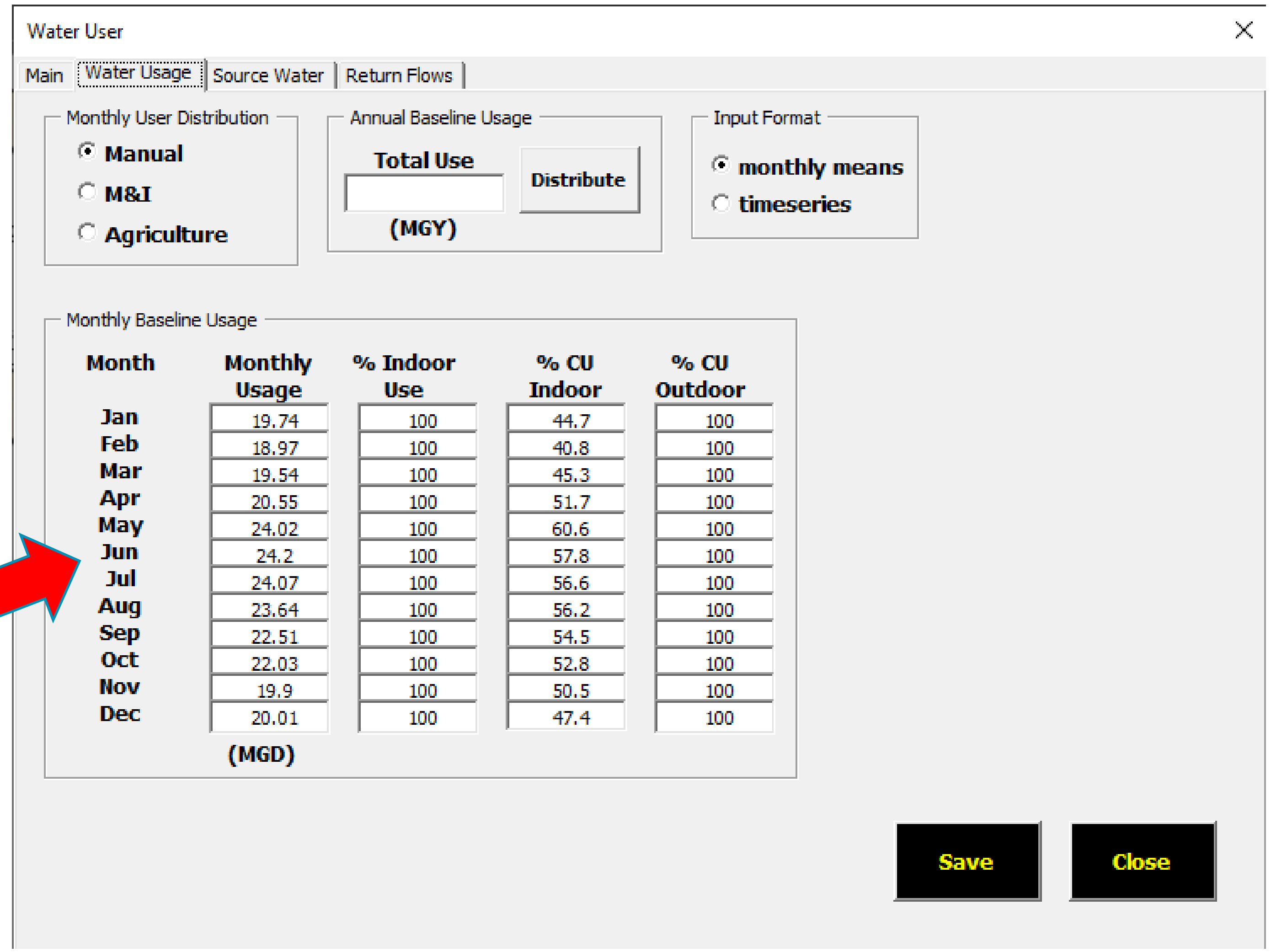


SWAM Calculations: Demand

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

WS: Santee Cooper RWS

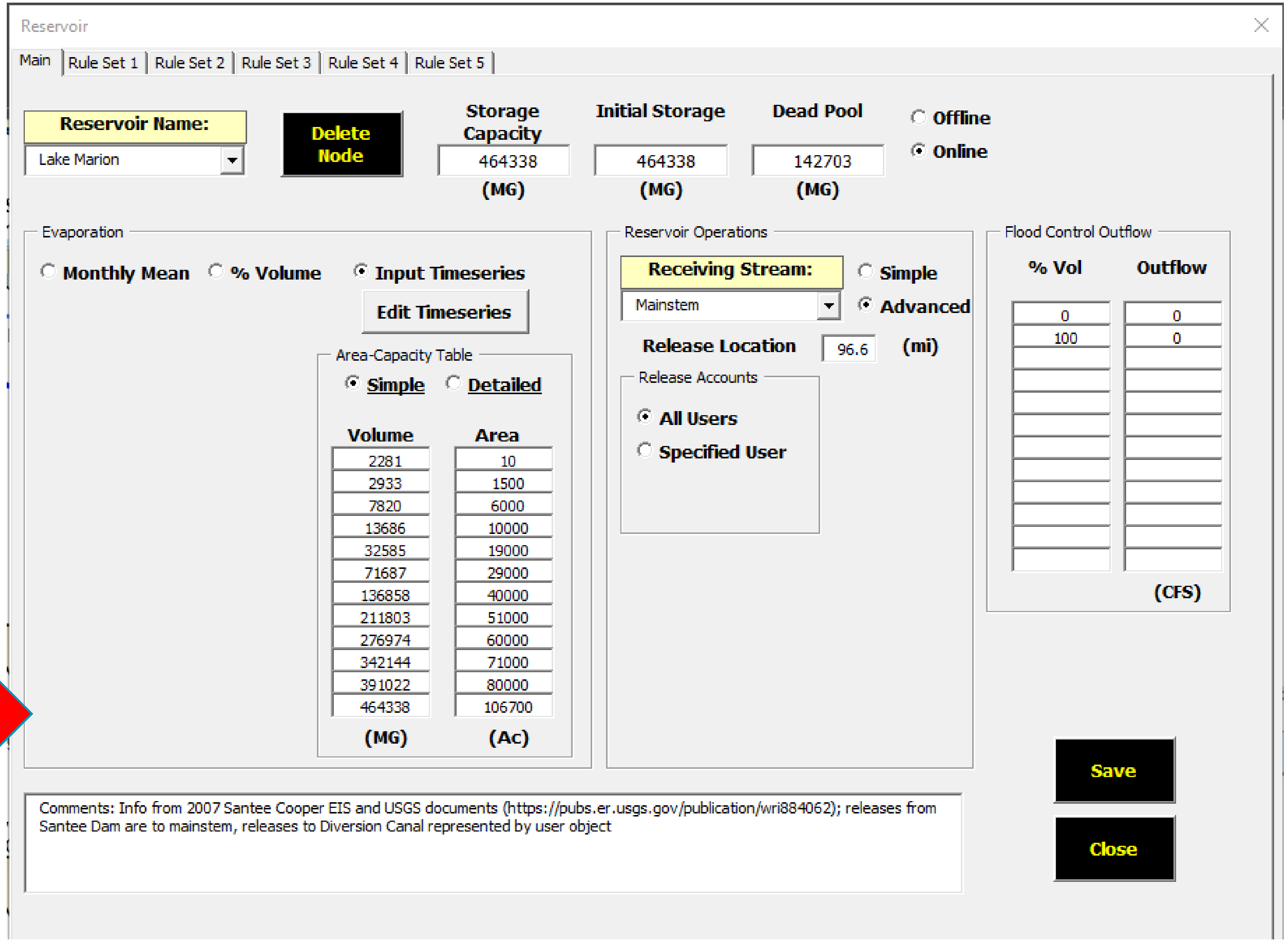




SWAM Calculations: Reservoirs

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

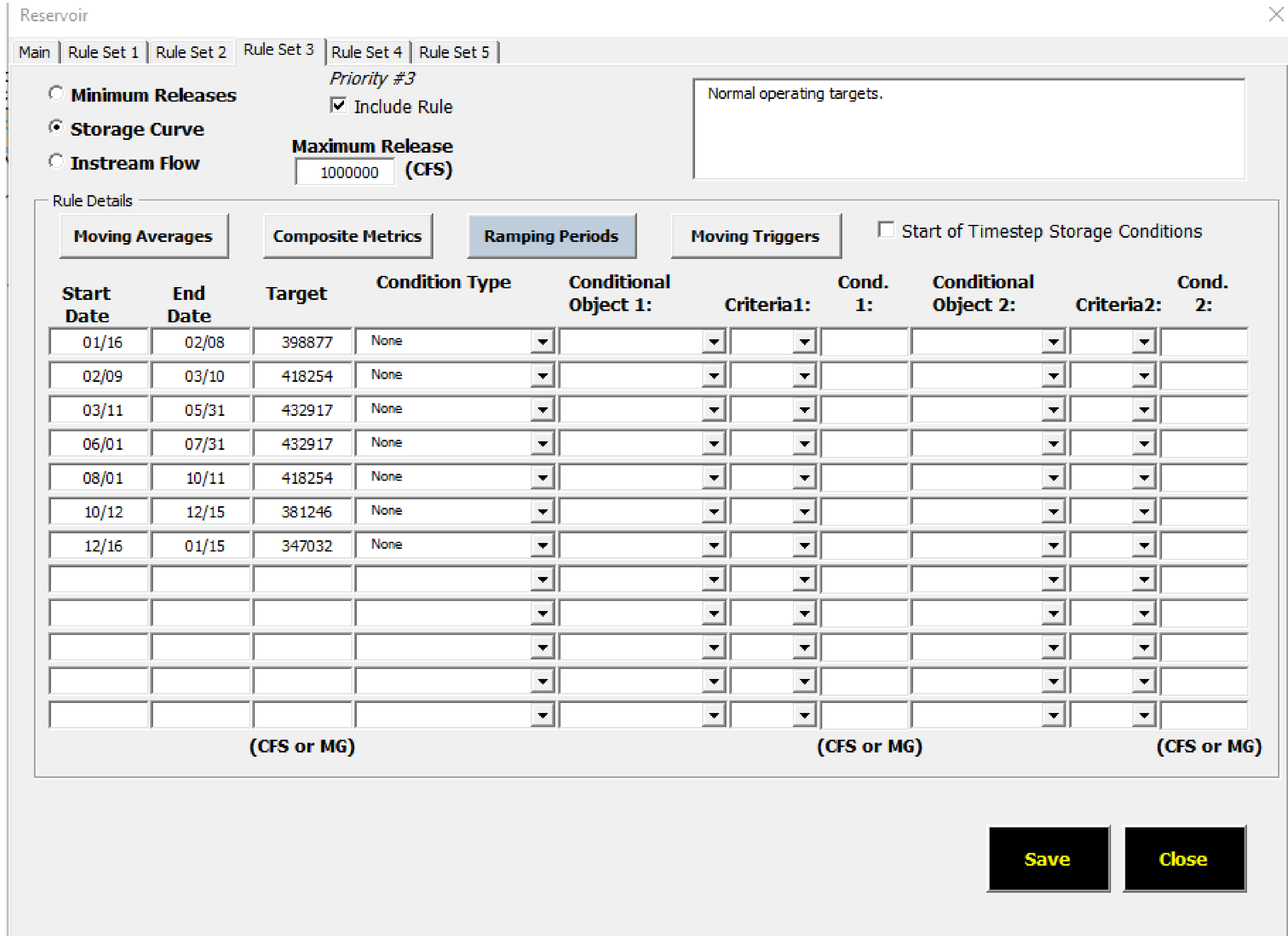
Lake Marion



SWAM Calculations: Reservoirs

- **Reservoir Object:**
  - Example operating rule: Lake Marion normal operating target volumes (Rule Set 3)

Lake Marion



Model Time Steps

- Model simulations may use a **daily** or **monthly** timestep
- A **monthly timestep** will be used to look for shortages, test and compare management strategies, and compare flows at strategic nodes.
- A **daily timestep** will be used for comparison to minimum instream flows and for determining changes in risk in ecological-flow relationships.

Model Calibration

- Calibration performed for multiple sites across a wide range of hydrologic conditions
- ***Calibration Targets:*** USGS streamflow gage records
- ***Key calibration parameters:*** reach gain/loss and sub-basin flow factors
- ***Performance metrics:***
  - Annual avg flows (overall water balance)
  - Monthly avg flows (seasonality)
  - Flow percentile distributions (variability, extreme events)
  - Flow timeseries (specific timings, operations)
  - Cumulative flows over entire calibration period
  - Reservoir storage timeseries
  - Achieving representative demands for the canal Water User objects

FOCUS (Reservoir storage timeseries; Achieving representative demands for the canal Water User objects)

A0 I think these are probably the same for Santee? The language is slightly different in Savannah report vs. Santee report.

Savannah:
A number of performance metrics were used to assess the model's ability to reproduce past basin hydrology and operations. These include: monthly and daily water user supply delivery and/or shortfalls, monthly and daily timeseries plots of both river flow and reservoir levels, annual and monthly mean flow values, monthly and daily percentile plots of river flow values, annual 7-day low flows with a 10-year recurrence interval (7Q10), and mean flow values averaged over the entire period of record.

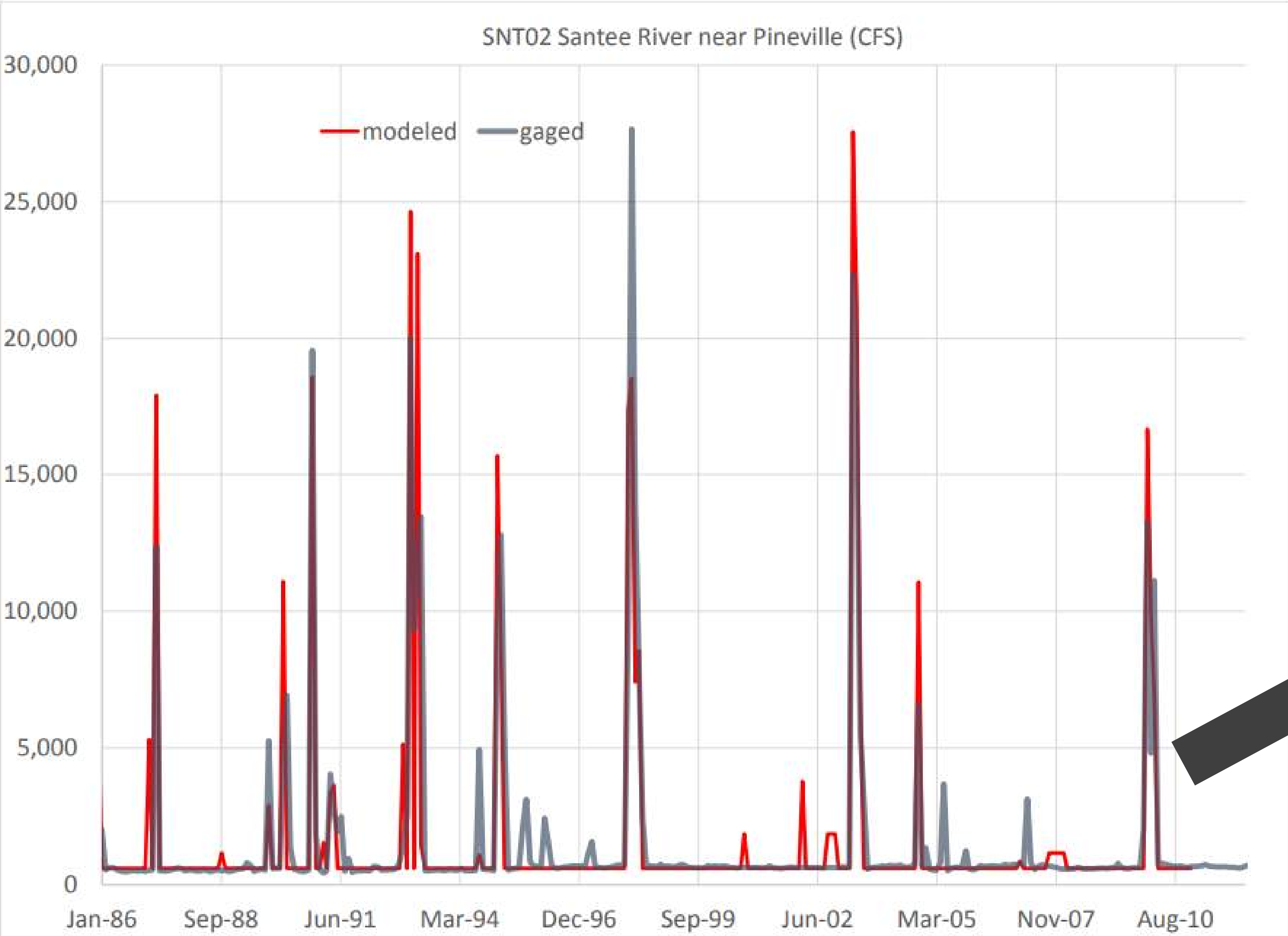
Santee:
A number of performance metrics were used to assess the model's ability to reproduce past basin hydrology and operations. These include: monthly and daily water user supply delivery and/or shortfalls; monthly and daily timeseries plots of both river flow and reservoir levels; annual and monthly mean flow values; monthly and daily percentile plots of river flow values; and mean flow values averaged over the entire period of record. . As emphasized in the calibration sequence outlined in Section 7.2.1, the focus of calibration was on reproducing historic patterns of reservoir storage/elevation and achieving representative demands for the canal Water User objects such that historic variability is preserved while still maintaining predictive potential. The other calibration metrics can offer important context, but as this is no longer a strictly hydrologic calibration, cannot be construed with as much weight as in previous basins.

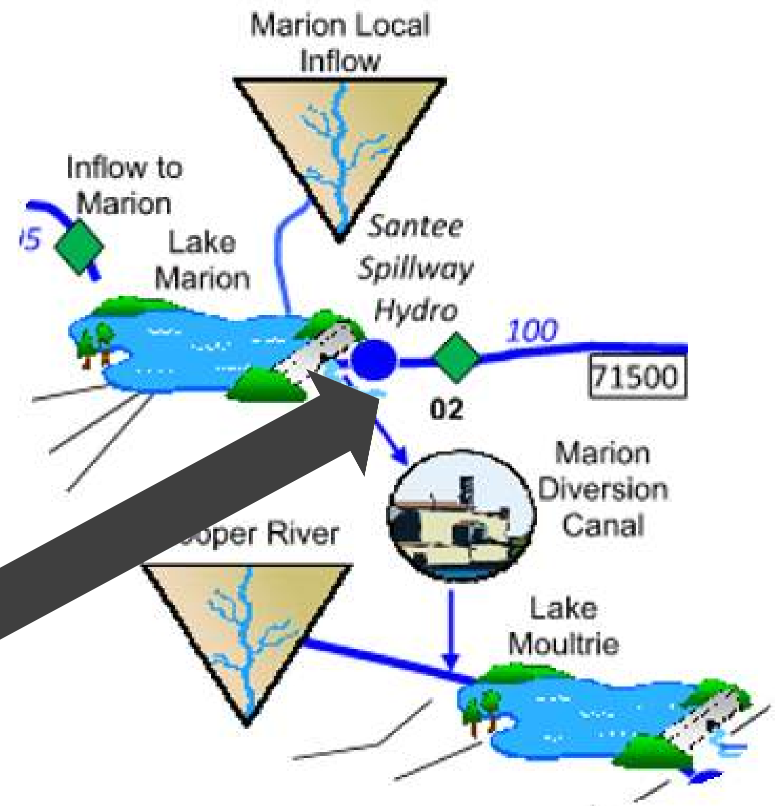
Author, 2025-02-05T21:36:36.324

A1 Changed from reach gain/loss factors

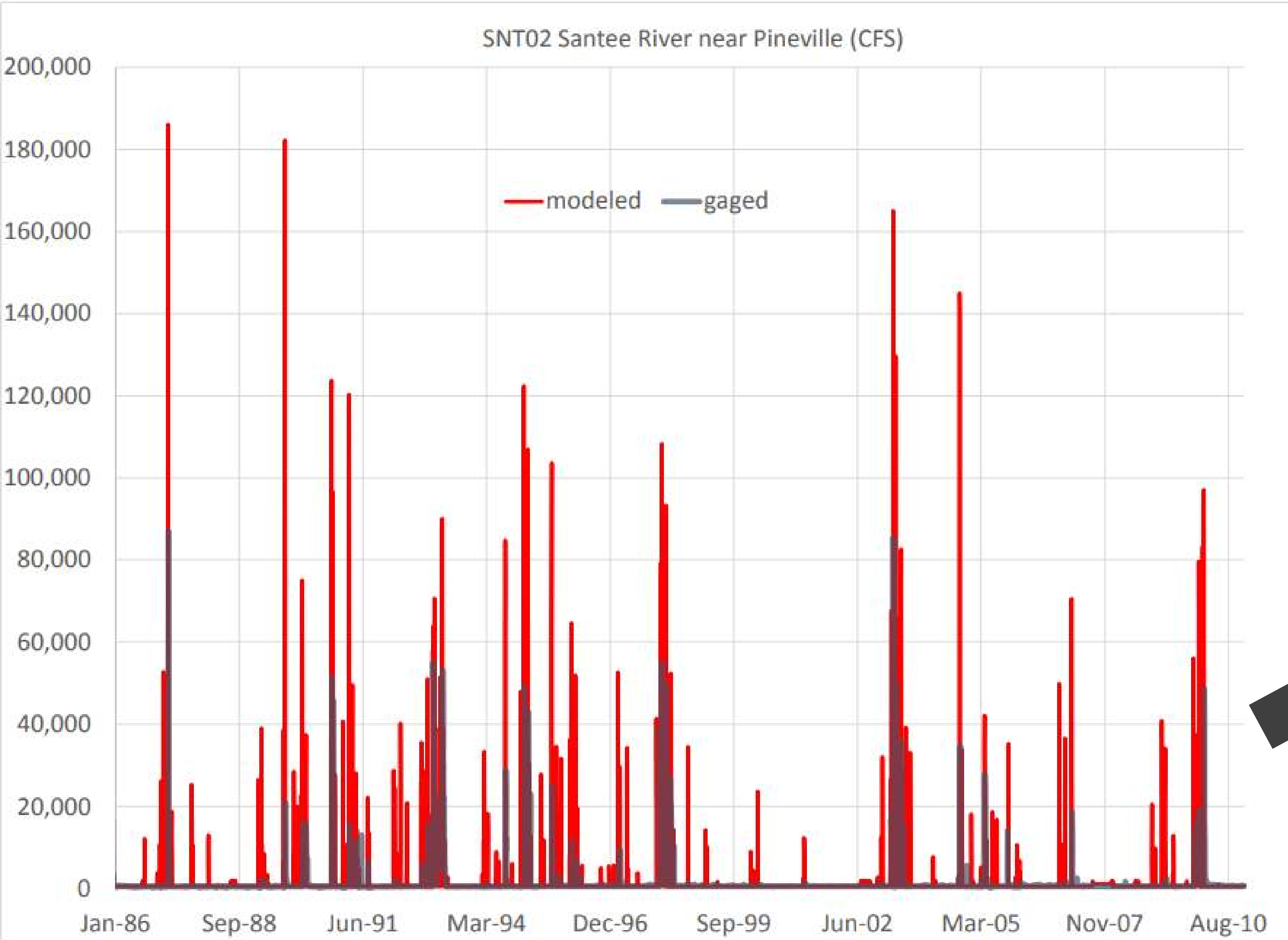
Author, 2025-02-05T21:39:36.652

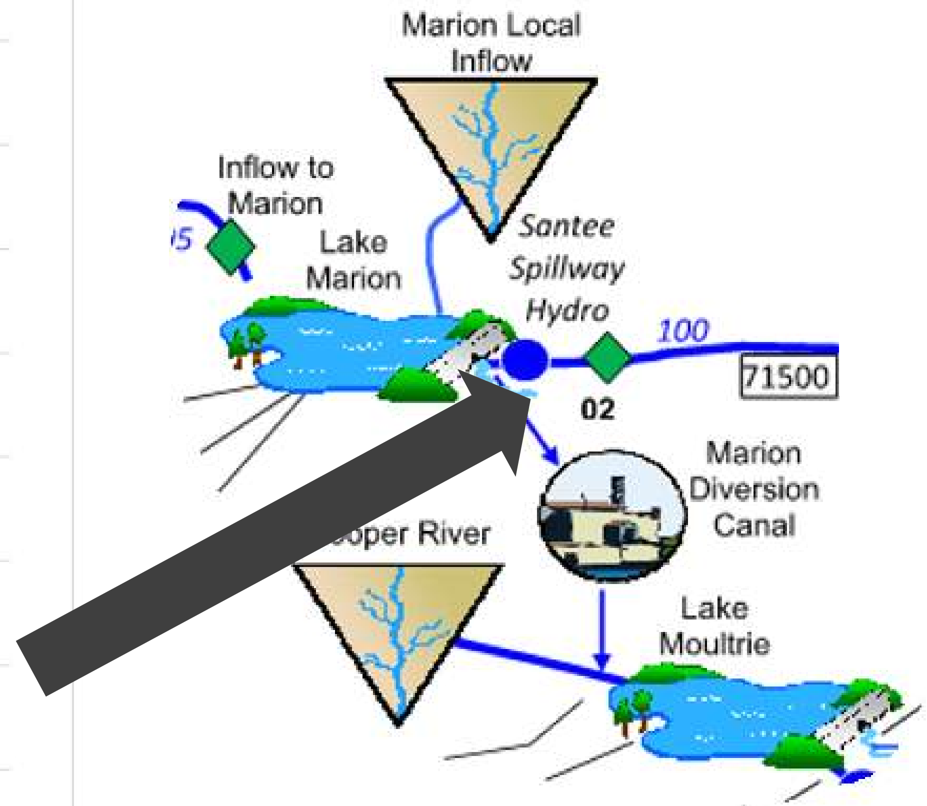
Comparison of Monthly Gaged and Modeled Flows





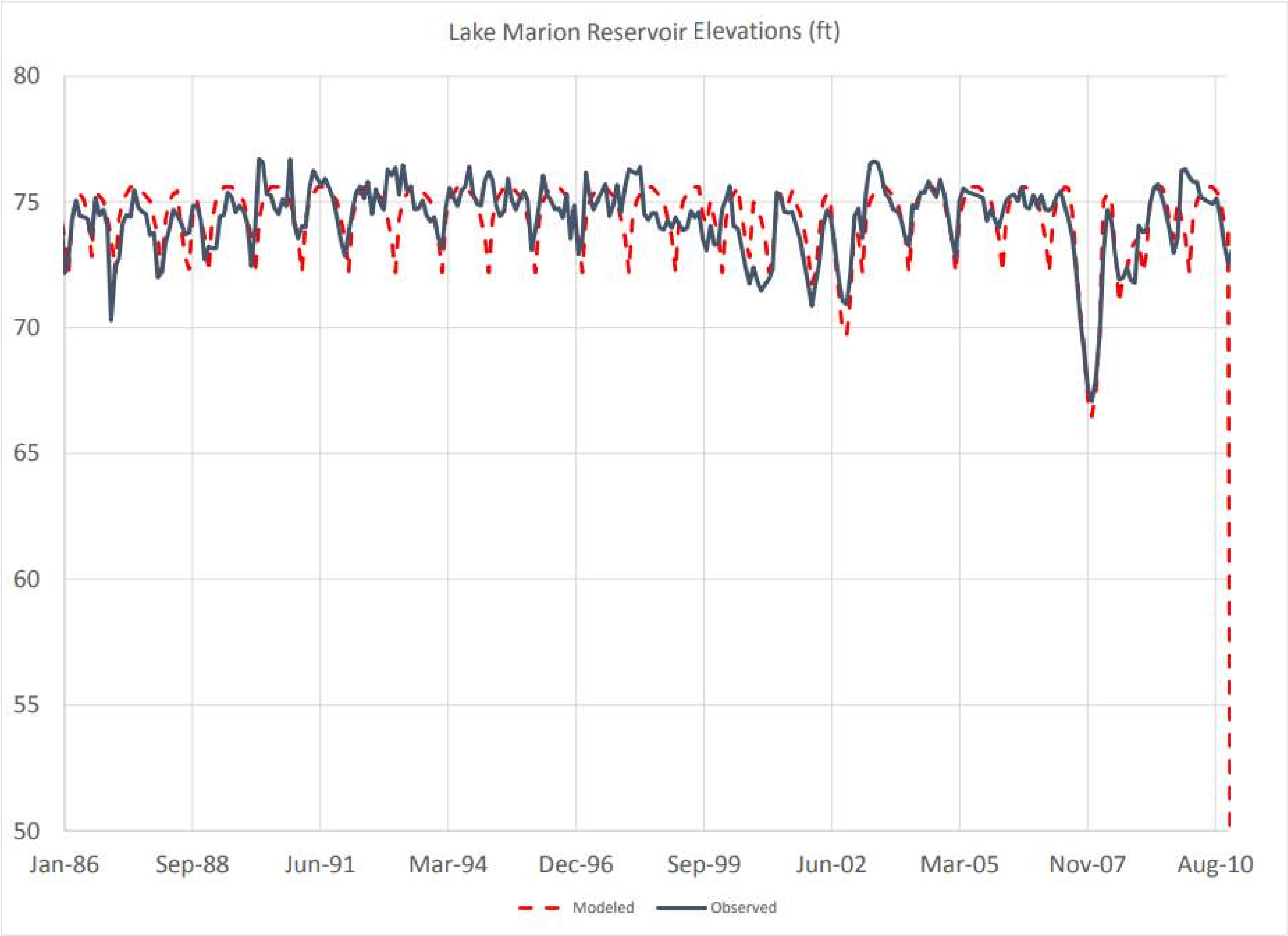
Comparison of Daily Gaged and Modeled Flows





Comparison of Measured and Modeled Lake Levels

Lake Marion

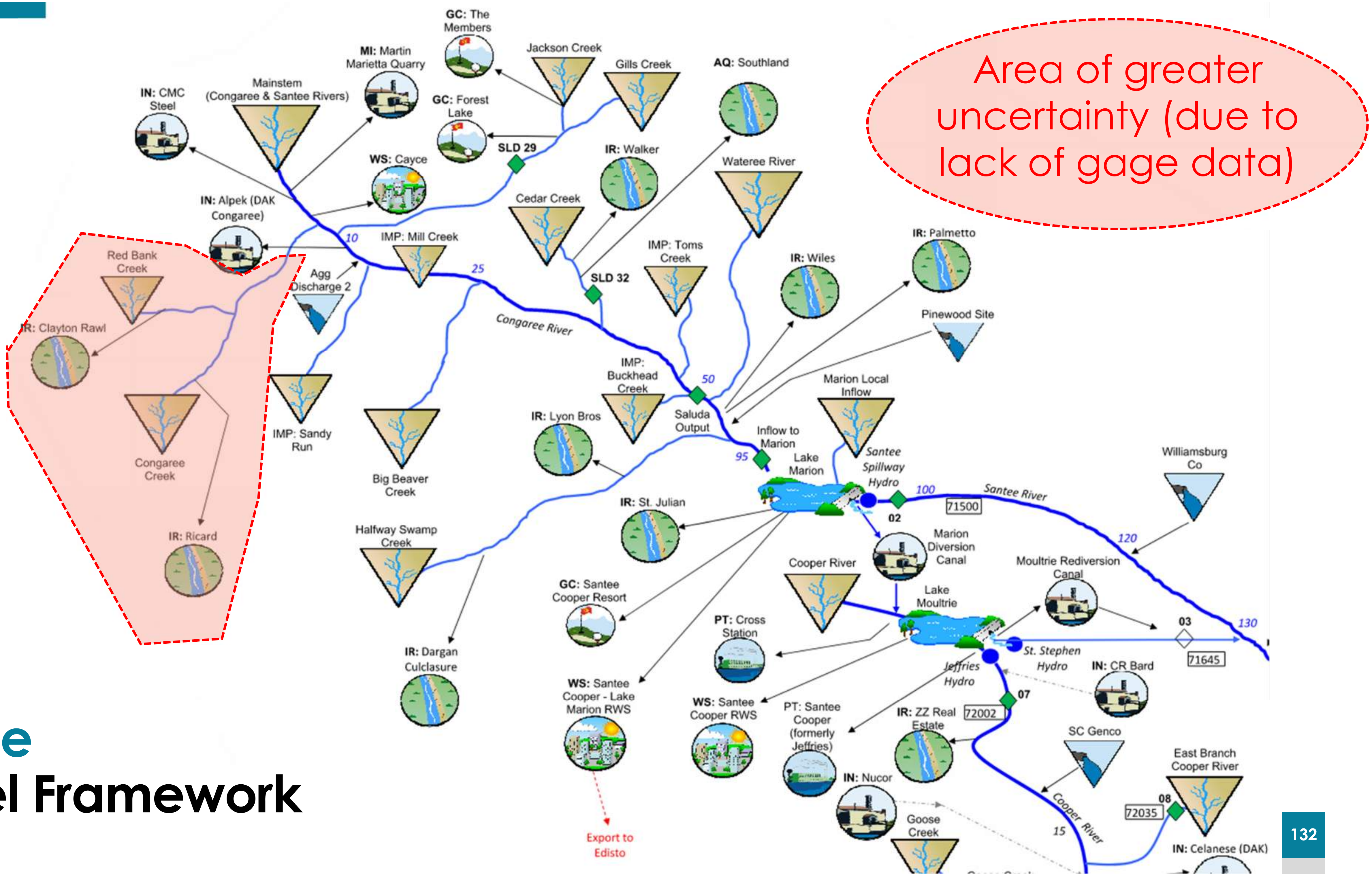


2024 Surface Water Model Updates

- Extended baseline hydrology
- Updated monthly mean water demands based on recent water use data
- Updated permit and intake location information
- Removed inactive permittees
- Added new registrations
- Software updates

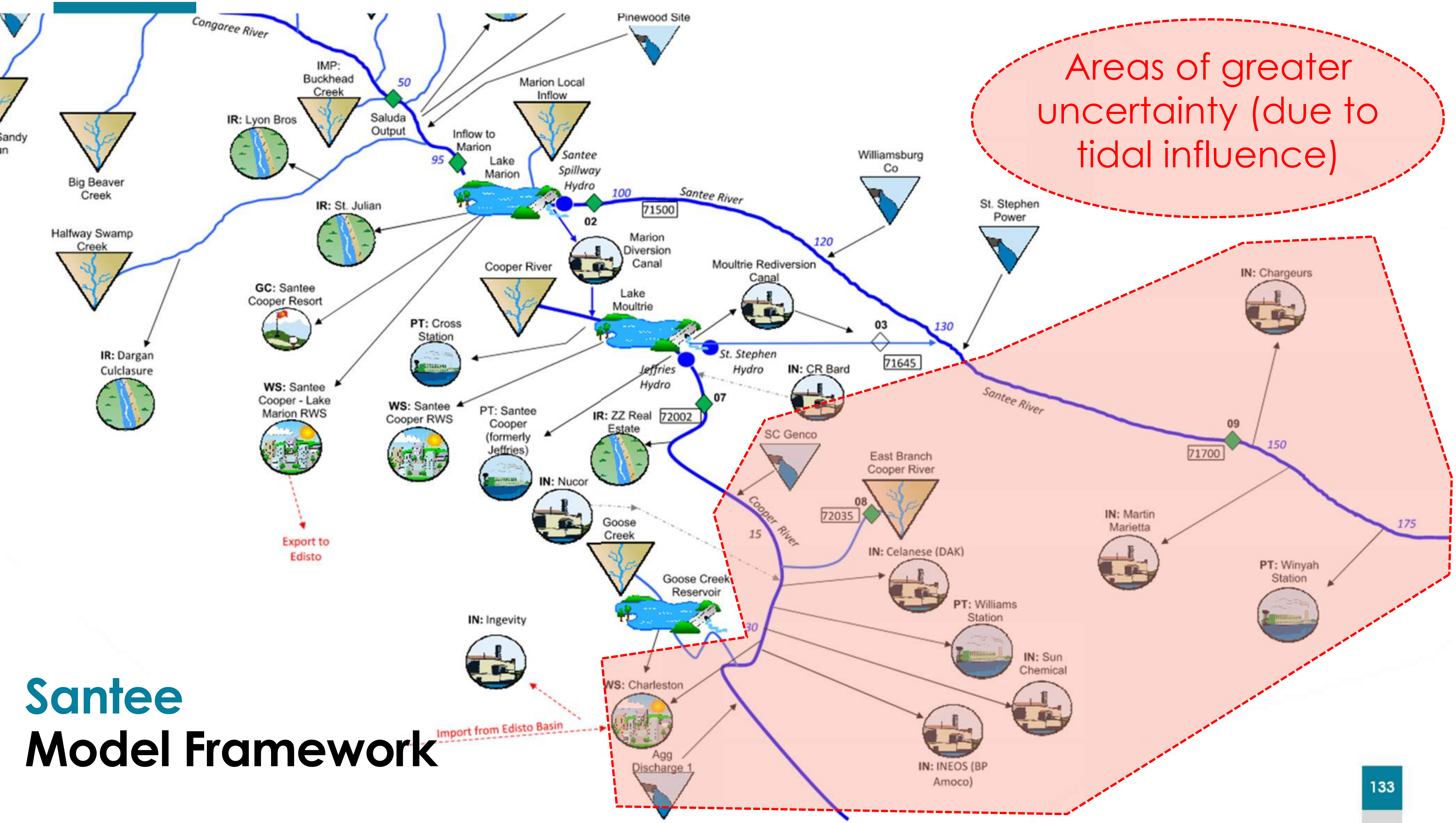
Model Limitations

- Greater uncertainty in predictions for ungaged reaches compared to gaged
- Model not designed for reach routing of flow changes at a 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. irrigation ponds
- Baseline model assumes past hydrologic variability is representative of future hydrologic variability (stationary climate)



Santee
Model Framework

Santee
Model Framework



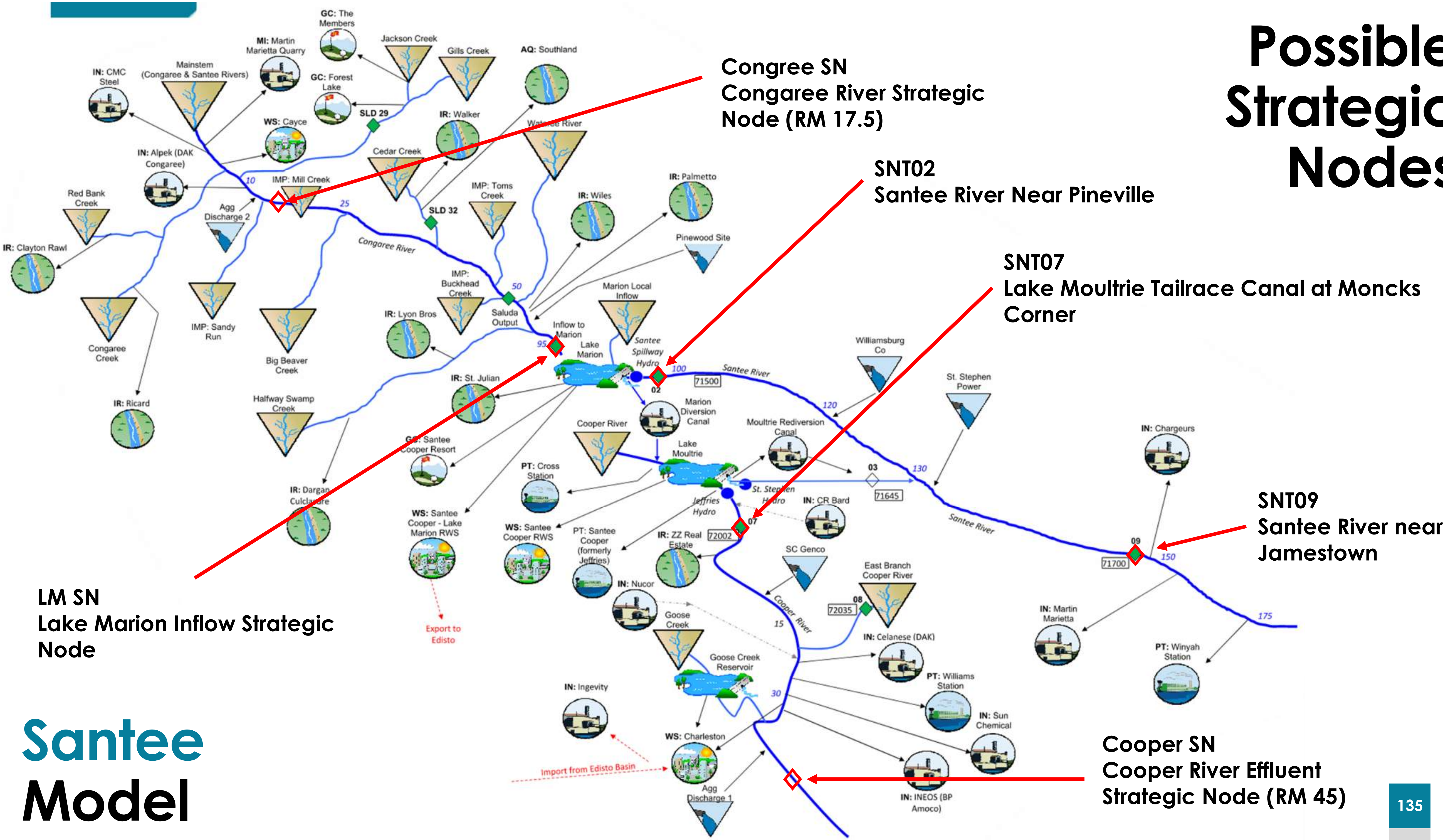
Performance Measures

Assessment of simulation results will focus on quantifying key performance measures for strategic nodes and 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 that experience a shortage
- Change in the average frequency of shortage
- Percent of time recreational facilities were unavailable on a stream reach

Possible Strategic Nodes



Santee Model