South Carolina Surface Water Quantity Modeling Project

Catawba-Wateree Basin Meeting No. 2 – Introduction to the Draft Model

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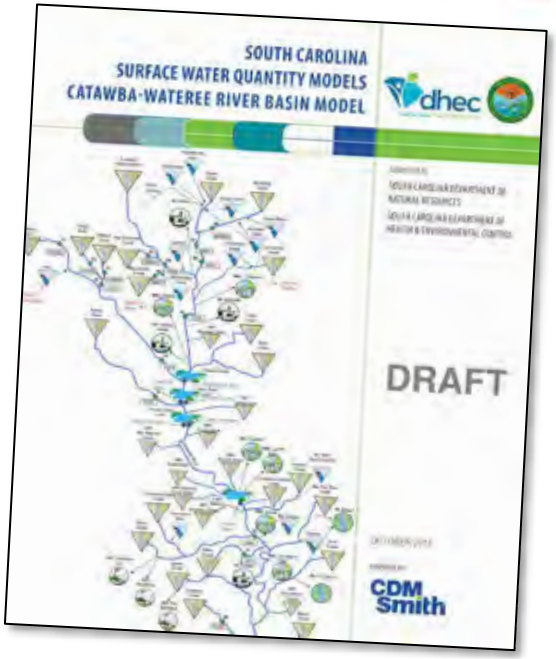
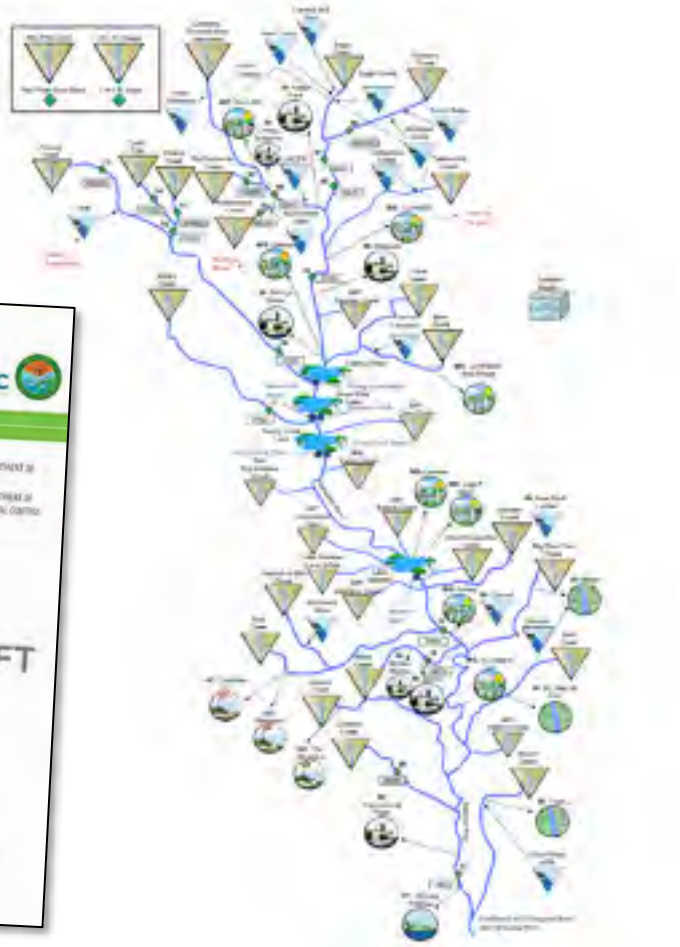
Nina Caraway

Nov 2, 2016





CDM Smith

Presentation Outline

- Project background and status
- Model calibration/verification
  - Calibration/verification philosophy and approach
  - Calibration results and discussion
- Overview and demonstration of the model

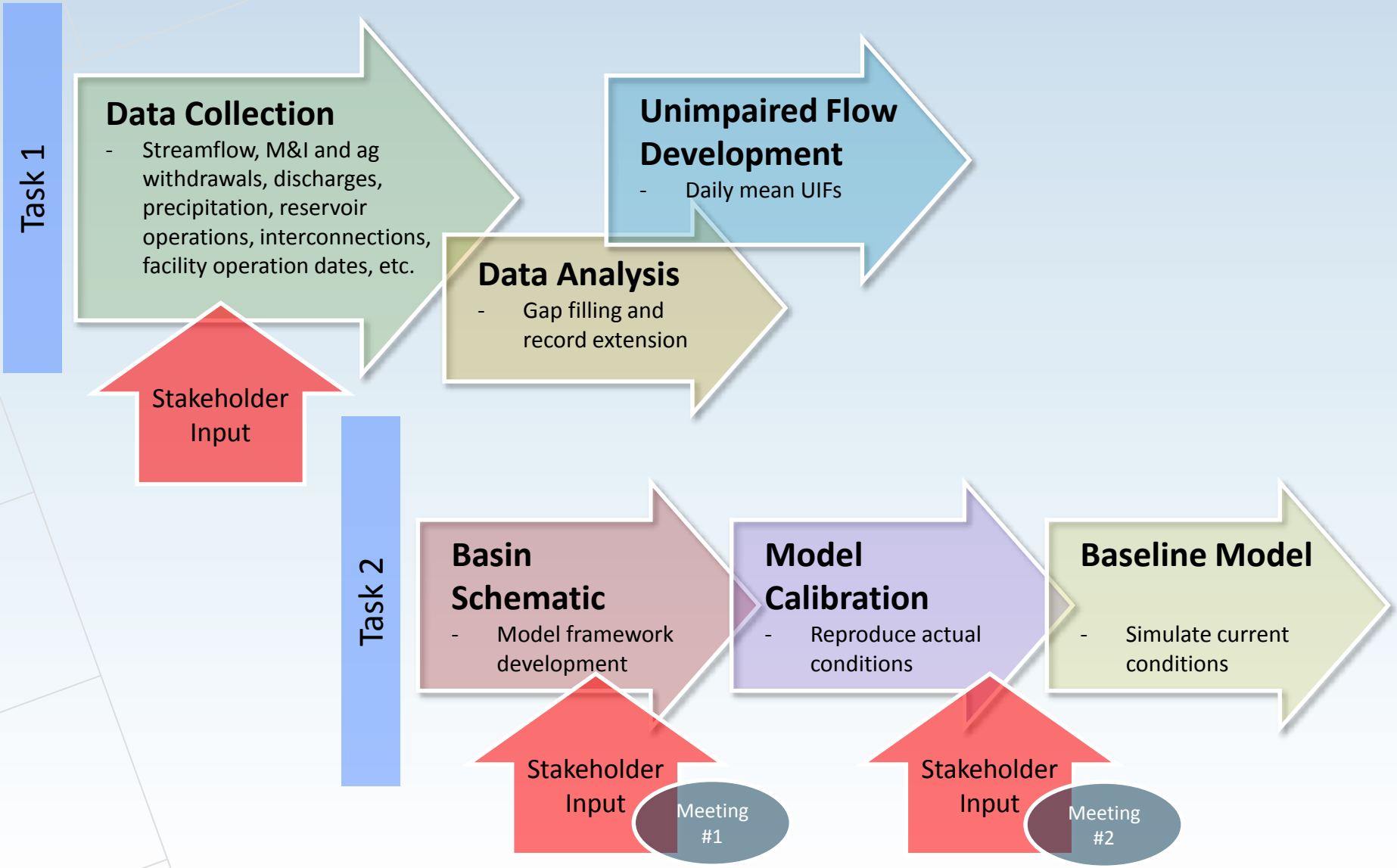
Project Purpose

- Build surface water quantity models capable of:
  - Accounting for inflows and outflows from a basin
  - Accurately simulating streamflows and reservoir levels over the historical inflow record
  - Conducting “What if” scenarios to evaluate:
    - future water demands
    - management strategies
    - system performance

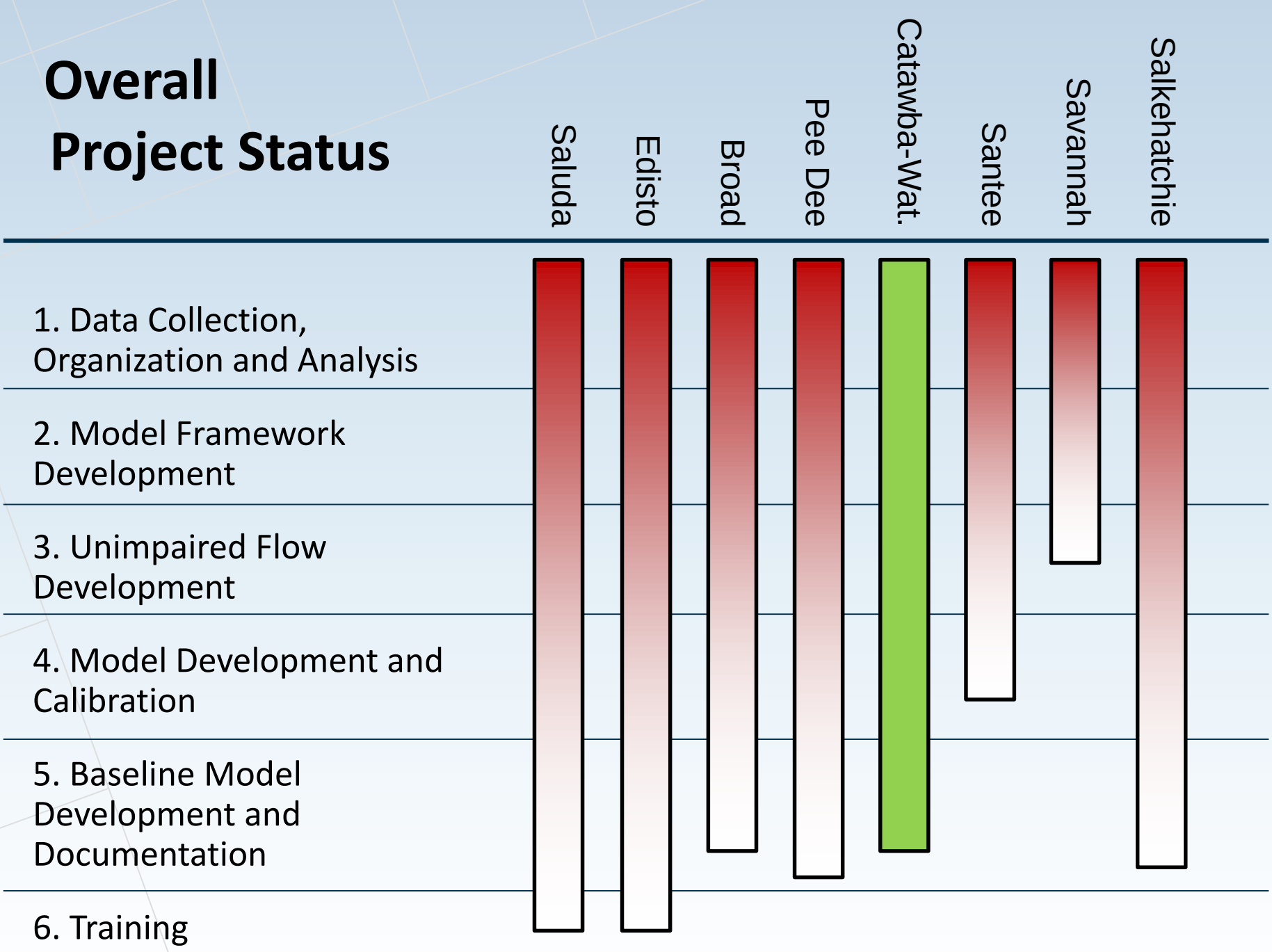
The Simplified Water Allocation Model is…

- A water accounting tool
  - *Calculates physically and legally available water*
  - *Traces water through a natural stream network, simulating withdrawals, discharges, storage, and hydroelectric operations*
- Not a precipitation-runoff model (e.g., HEC-HMS)
- Not a hydraulic model (e.g. HEC-RAS)
- Not a water quality model (e.g., QUAL2K)
- Not an optimization model
- Not a groundwater flow model (e.g., MODFLOW)

Project Status – Catawba-Wateree Basin



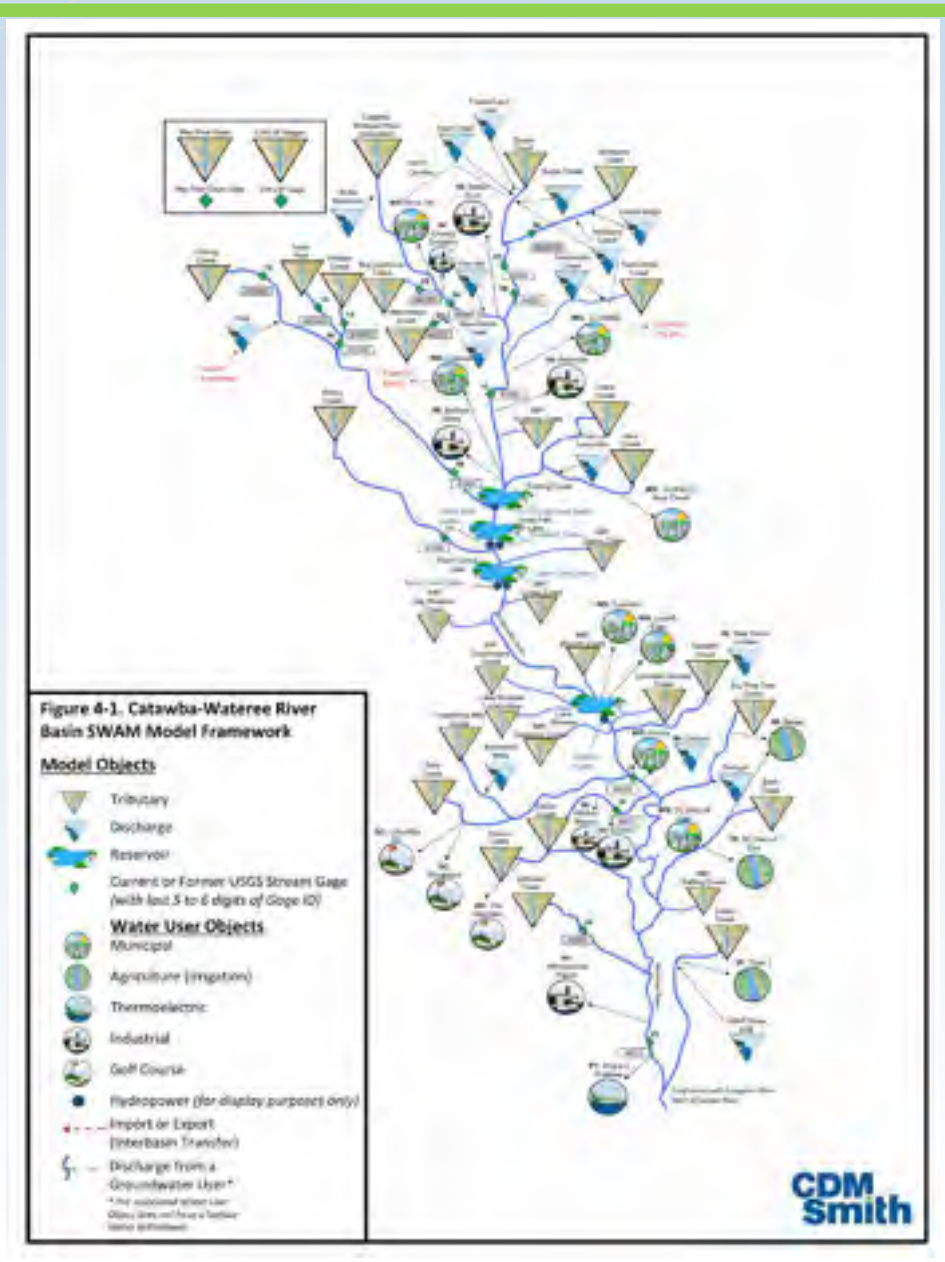
Overall Project Status



Calibration vs. Baseline Model

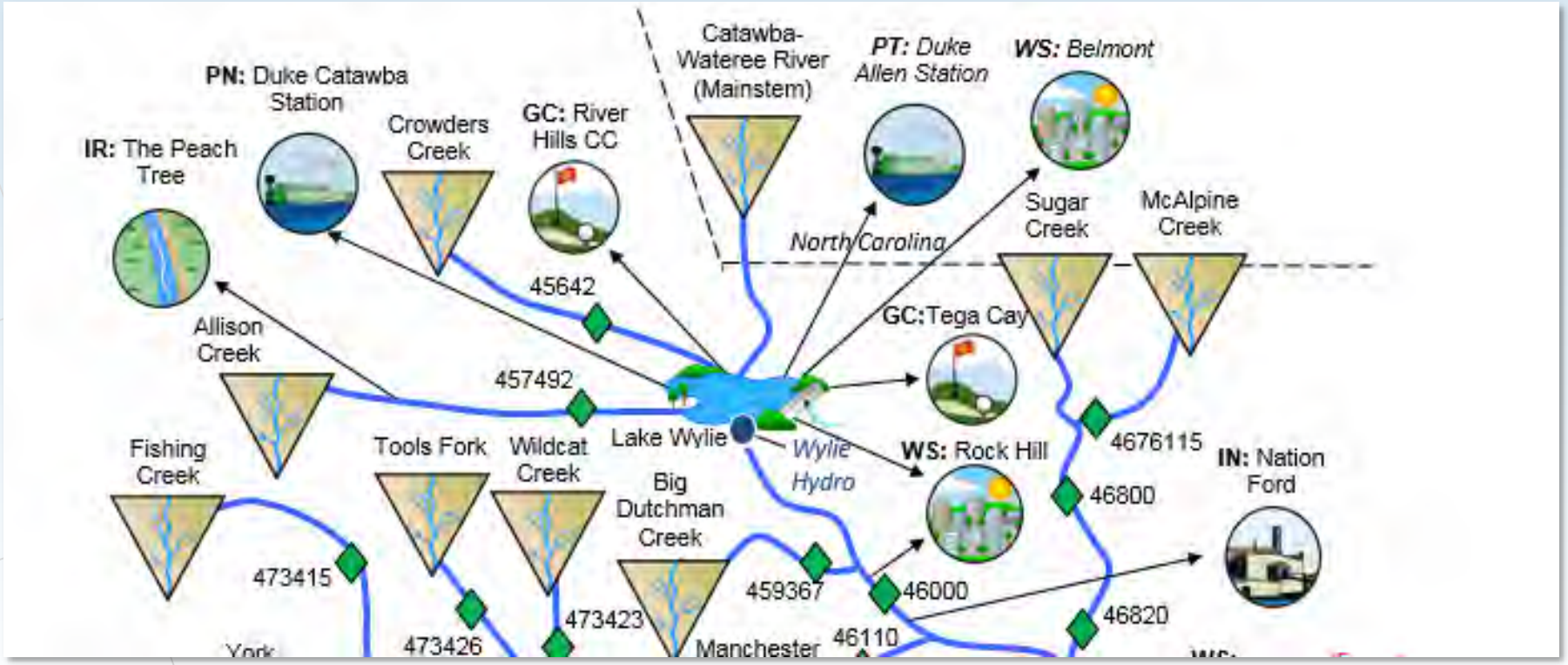
- **Calibration Model**
  - Purpose: confirm models ability to accurately simulate river basin flows and storage amounts
  - Uses recent withdrawal, discharge and flow records
- **Baseline Model**
  - Purpose: Evaluate water availability under future conditions
  - Uses entire record of flow and most current withdrawals and discharges
- Both models are used coordination with CHEOPS model to obtain flows from NC portion of the system (outflow from Lake Wylie)

Catawba-Wateree Basin – SWAM Framework



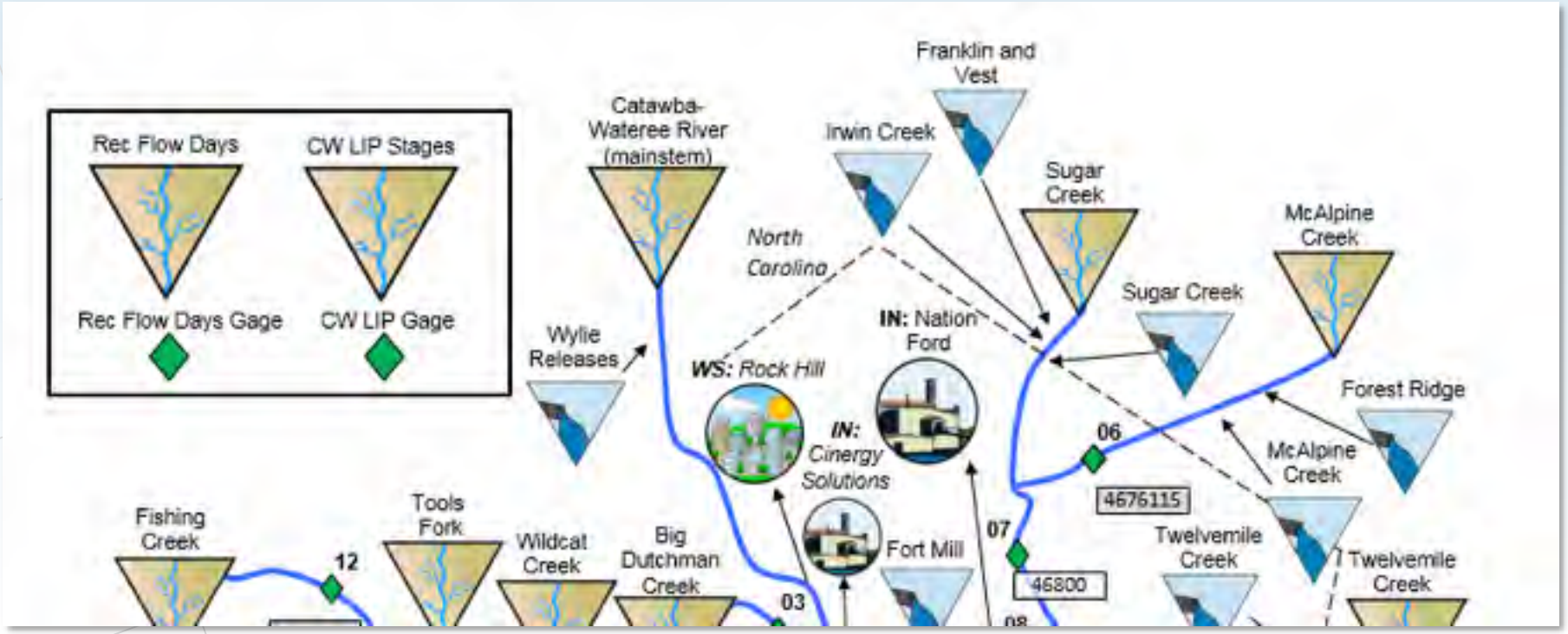
Framework Changes

- Original Framework included Lake Wylie and its major tributaries



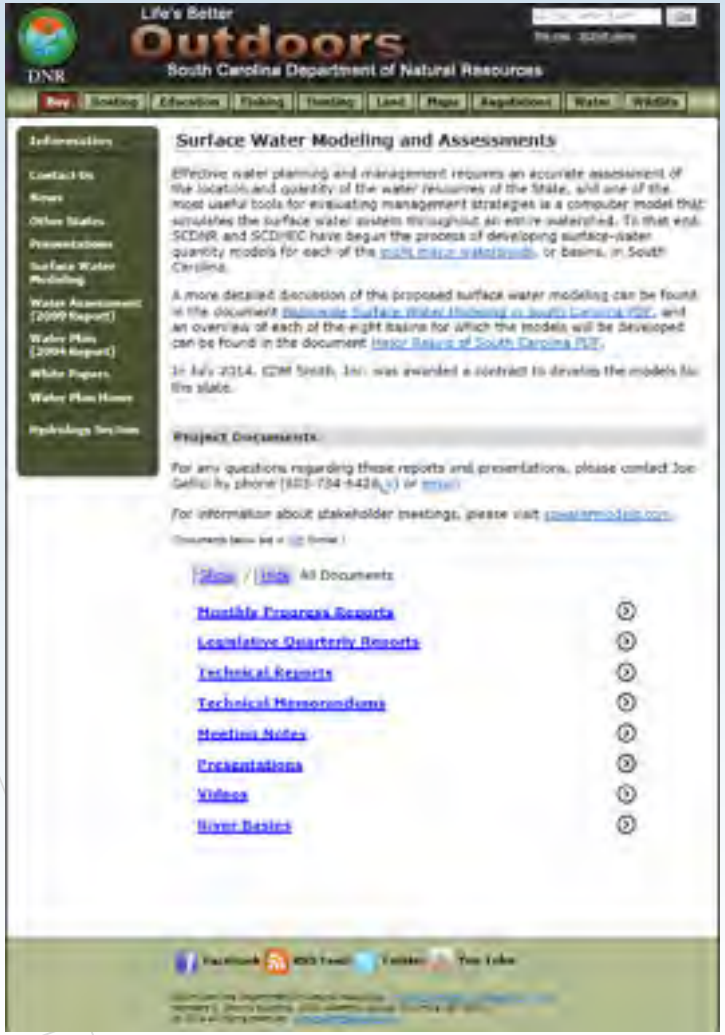
Framework Changes

- Revised Framework begins at the outlet to Lake Wylie
- Wylie releases are specified as a discharge object and mainstem headwater flows are scaled from the inflow dataset
- Major NC dischargers were added on Sugar and McAlpine creeks



Modeling Report and Other Documents

- http://www.dnr.sc.gov/water/waterplan/surfacewater.html



Catawba-Wateree River Basin

MODEL CALIBRATION/VERIFICATION

Calibration Objectives

1. Extend hydrologic inputs (headwater UIFs) spatially to adequately represent entire basin hydrology by parameterizing reach hydrologic inputs
2. Refine initial parameter estimates, as appropriate
   - E.g., reservoir operating rules and %Consumptive Use assumptions
   - Gain confidence in the model as a predictive tool by demonstrating its ability to adequately replicate past hydrologic conditions, operations, and water use
   - Avoid being overly prescriptive

Potential Sources of Model Error and Uncertainty

- Gaged flow data (± 20%)
- Gaged reservoir levels (± ?%)
- Reported withdrawal data
- Consumptive use percentages
- Return flow lag times (if applicable, e.g. outdoor use)
- Basin climate and hydrologic variability
- *Reservoir operations (operator decision making)*
- *Reach hydrology: gains, losses, local runoff and inflow*

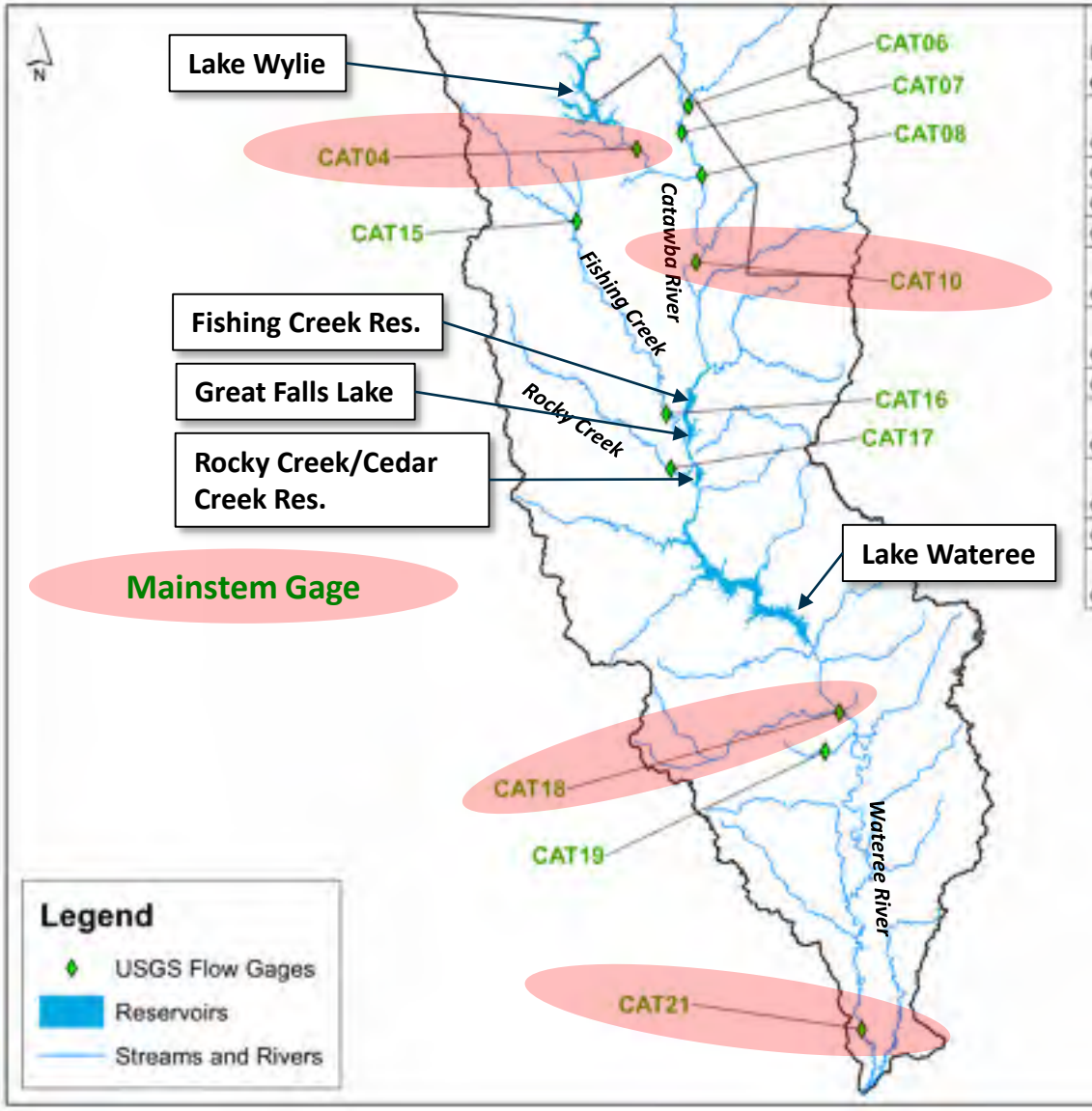
Calibration/Validation General Approach

- Two hindcast periods
  - 1983 – 2010 for **tributaries**
    - Includes droughts in both early and late 2000's
  - 2006 – 2010 on **mainstem** to reflect operating rules in the Comprehensive Relicensing Agreement (CRA)
    - Particular focus on 2007-2008 drought years
- Comparison to gaged (measured) flow or reservoir data
  - Operations and impairments are implicit in that data
- LIP Timeseries was included from CHEOPS model
  - Not exact match to actual historical LIP timeseries likely due slight differences in model vs. actual storage and the impact on storage index calculations which are a LIP trigger

Calibration/Validation General Approach

- Assess performance at (subject to gage data availability):
  - Multiple mainstem locations
  - All tributary confluence locations
  - Major reservoirs (where levels/storage are available)
- Multiple model performance metrics, including:
  - Timeseries plots (monthly and daily variability)
  - Annual and monthly means (water balance and seasonality)
  - Percentile plots (extremes and frequency)

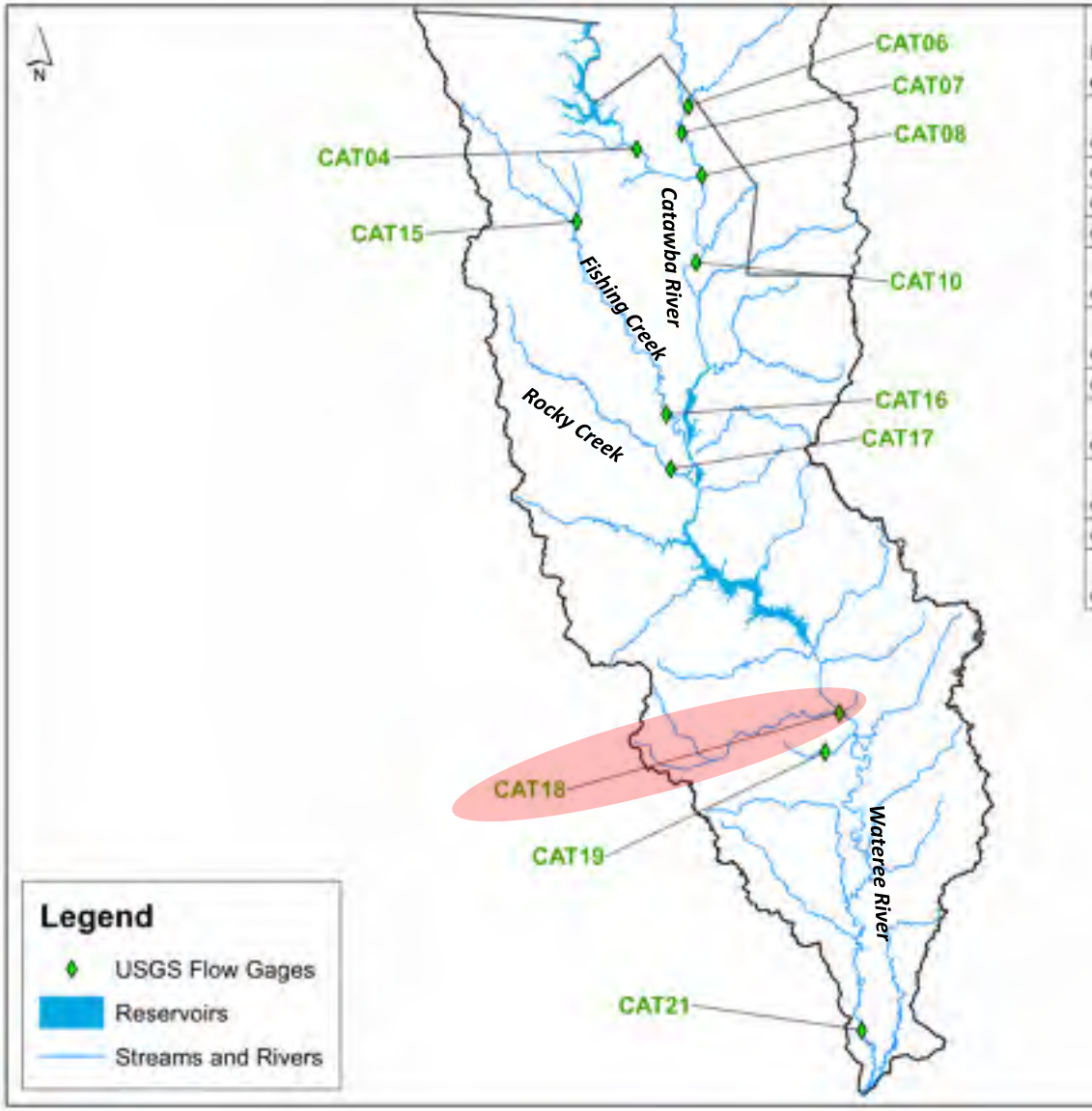
Calibration/Validation Locations



Project Gage ID	USGS Number	Tributary Object	Periods of Record	Basin Area (sq. mi.)	River Mile
CAT04	02146000	Mainstem	4/1942 - 8/1995 10/1995 - 12/2010	3048	4
CAT06	0214676115	McAlpine Creek	10/2005 - 12/2010	95	15
CAT07	02146800	Sugar Creek	4/2006 - 12/2010	263	24
CAT08	02146820	Sugar Creek	5/2001 - 9/2002	275	30
CAT10	02147020	Mainstem	1/1992 - 9/1994 10/1995 - 12/2010	3538	20
CAT15	021473428	Wildcat Creek	8/1998 - 6/2001 1/2006 - 12/2010	30	4
CAT16	02147403	Fishing Creek	2/2001 - 10/2003	280	40
CAT17	02147500	Rocky Creek	3/1951 - 9/1981 8/1986 - 12/2010	196	24
CAT18	02148000	Mainstem	10/1929 - 9/1983 5/1984 - 12/2010	5057	738
CAT19	02148071	Gillies Creek	4/1994 - 9/1997	8	3
CAT21	02148315	Mainstem	7/1968 - 2/1983 5/1983 - 12/2010	5554	131

Wateree River near Camden

USGS Gage 02148000



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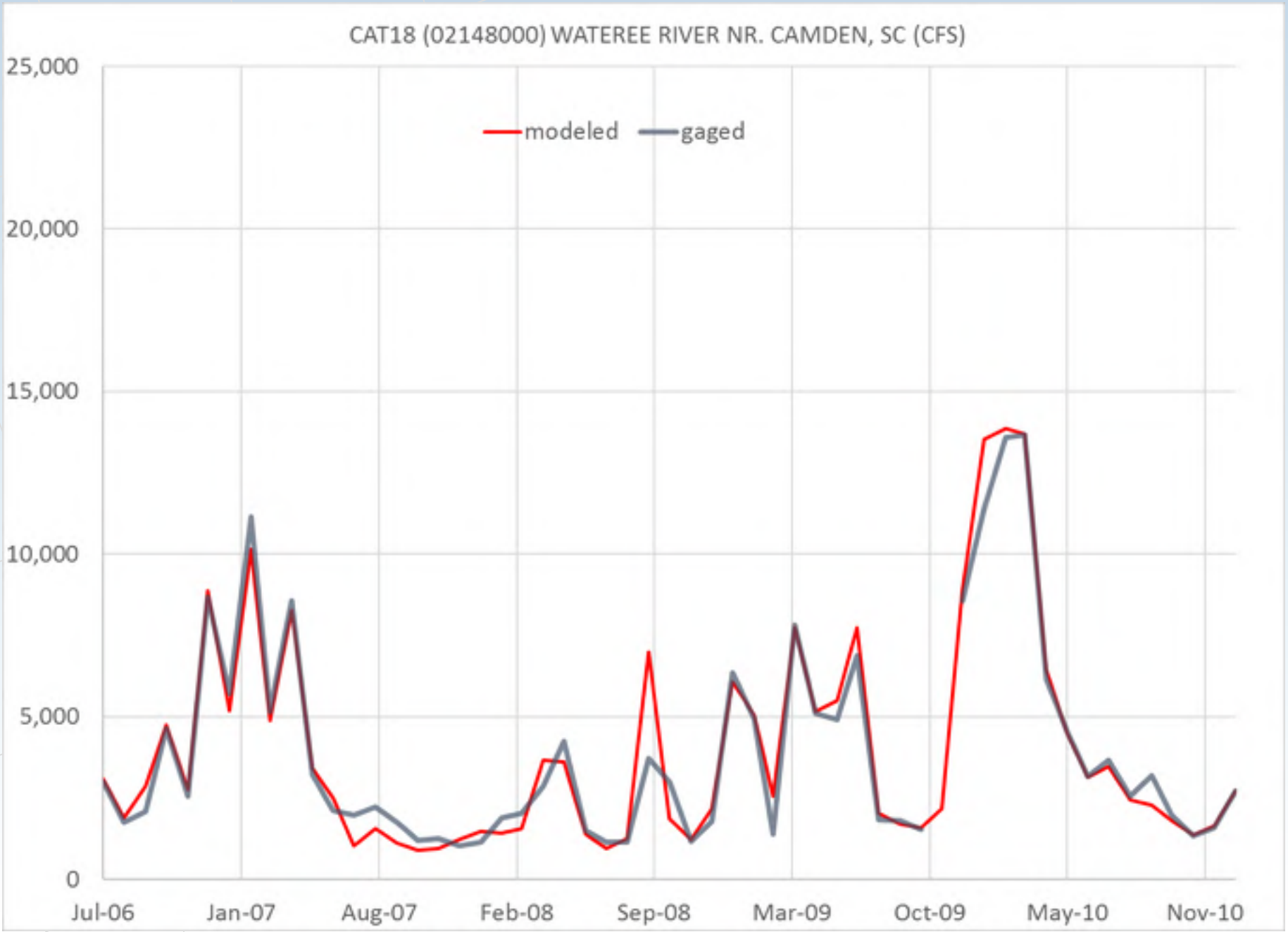
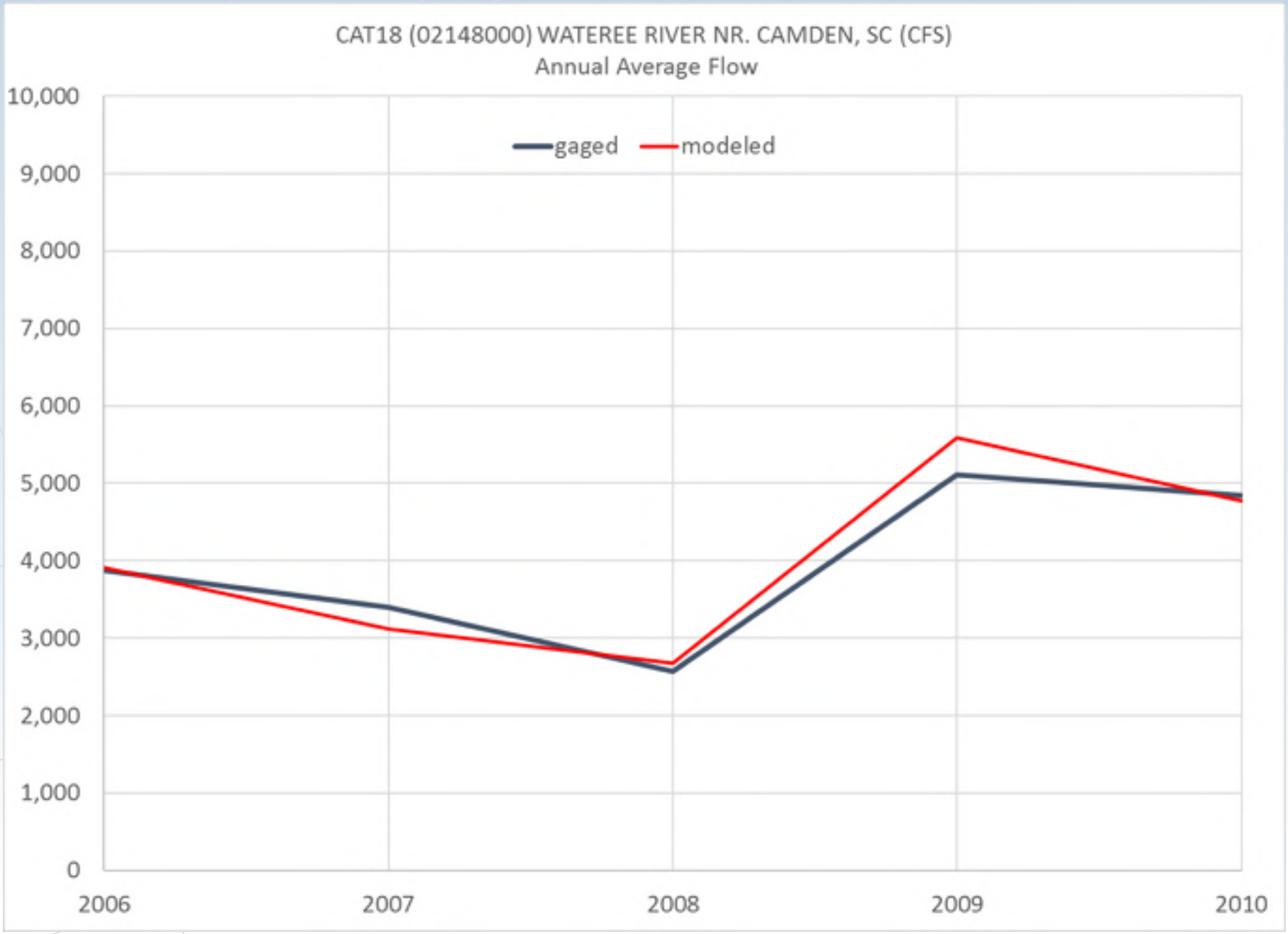
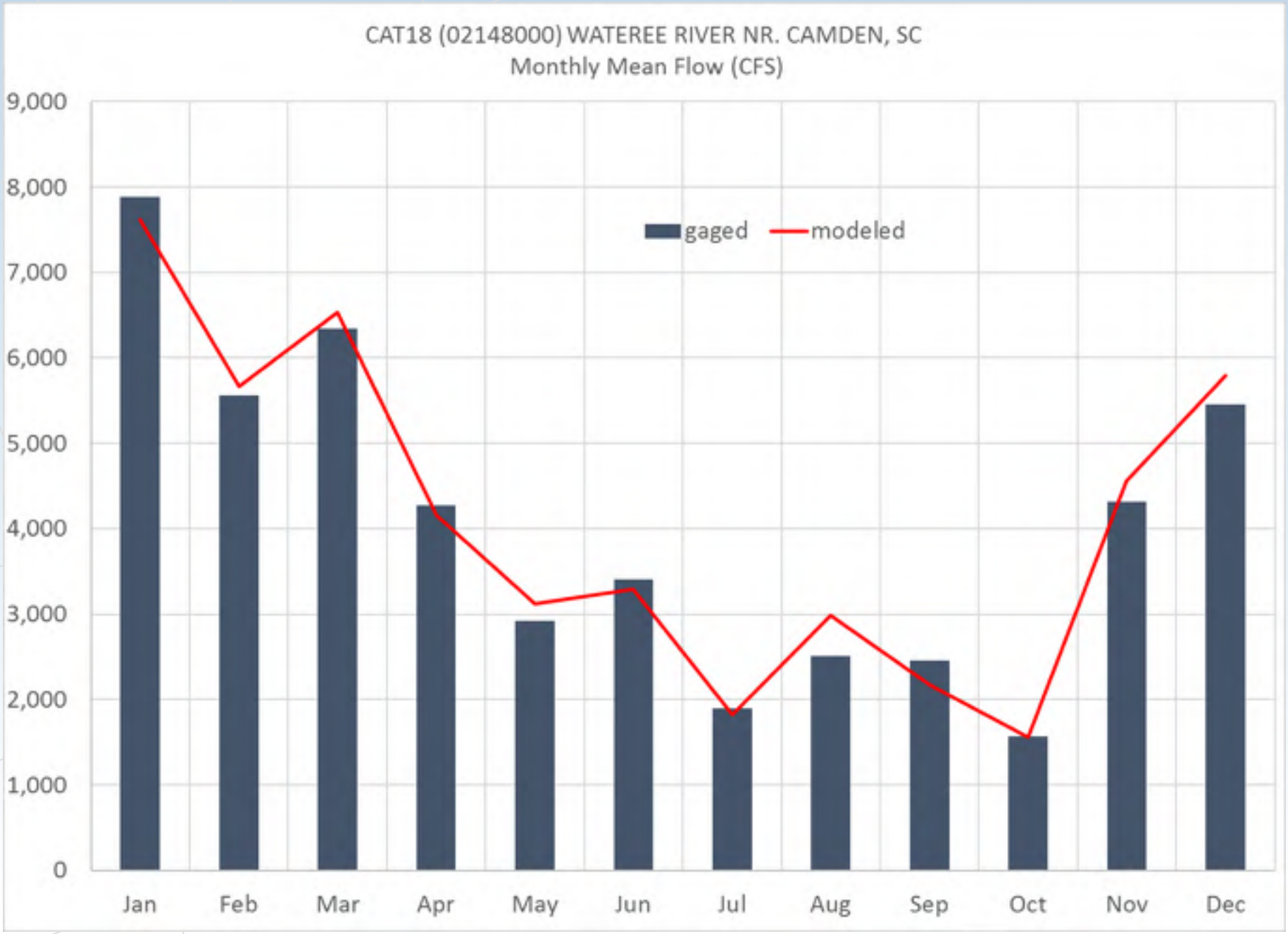
Monthly Flow Comparison



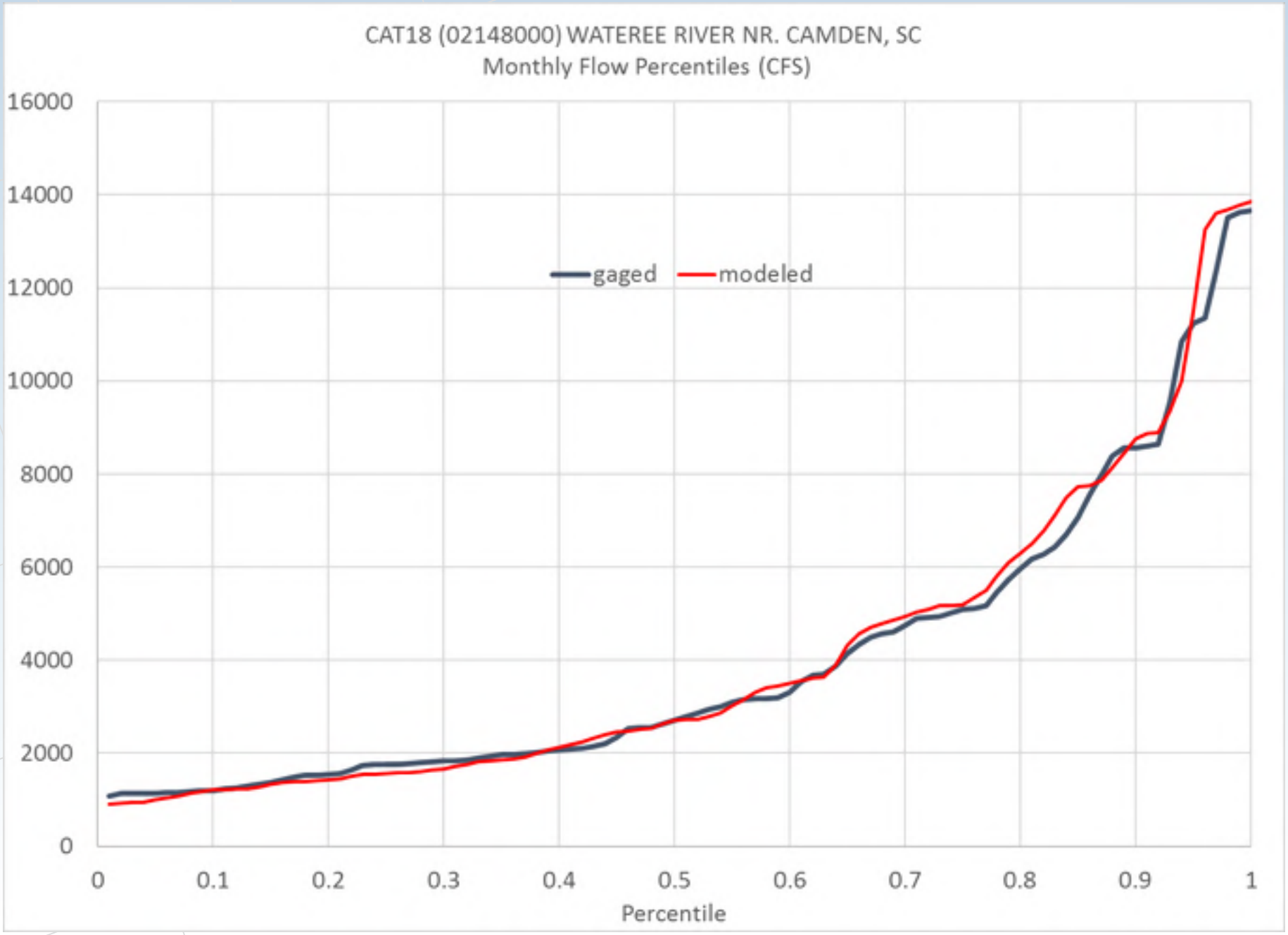
Annual Average Flow Comparison



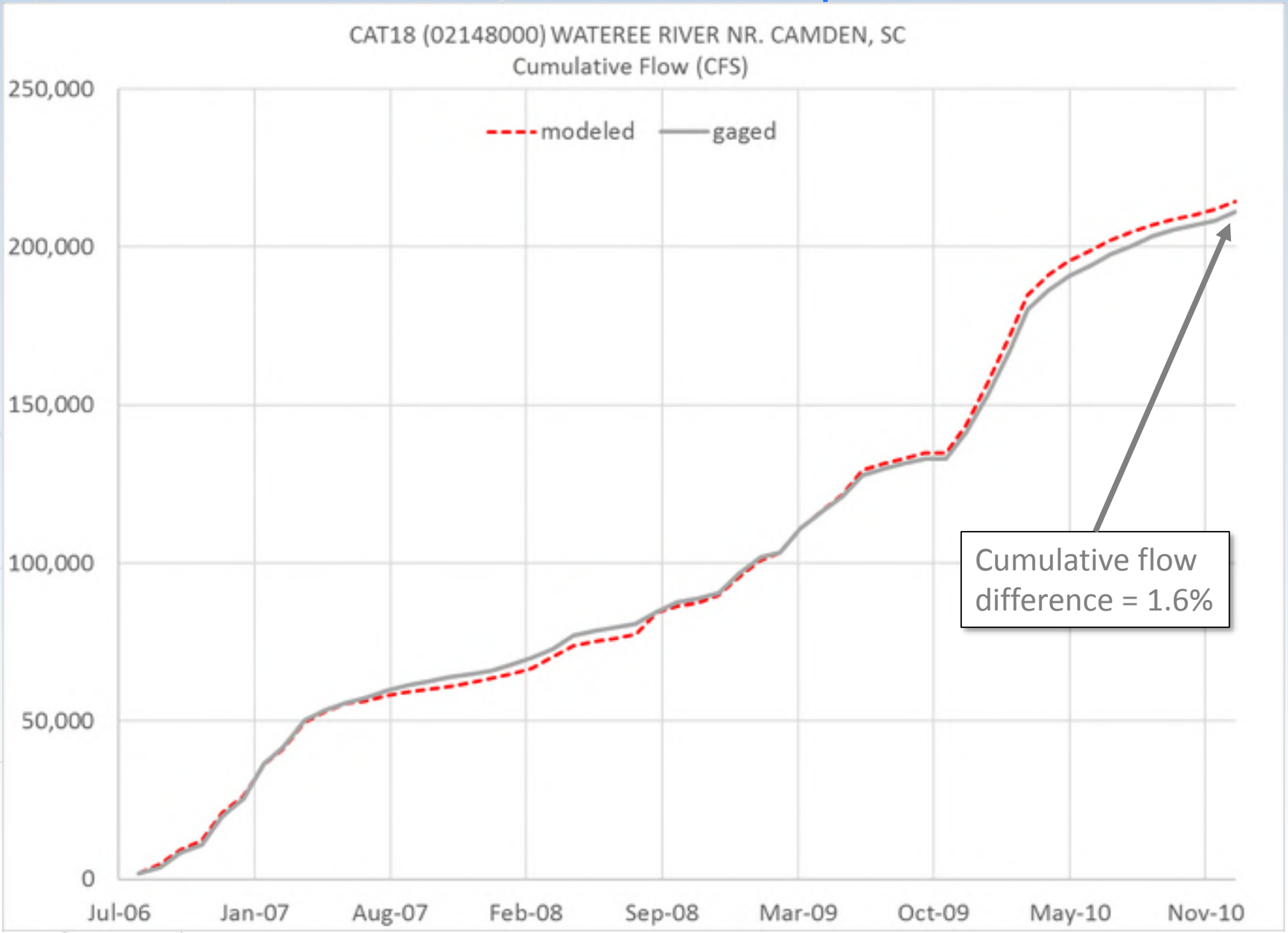
Monthly Mean Flow Comparison



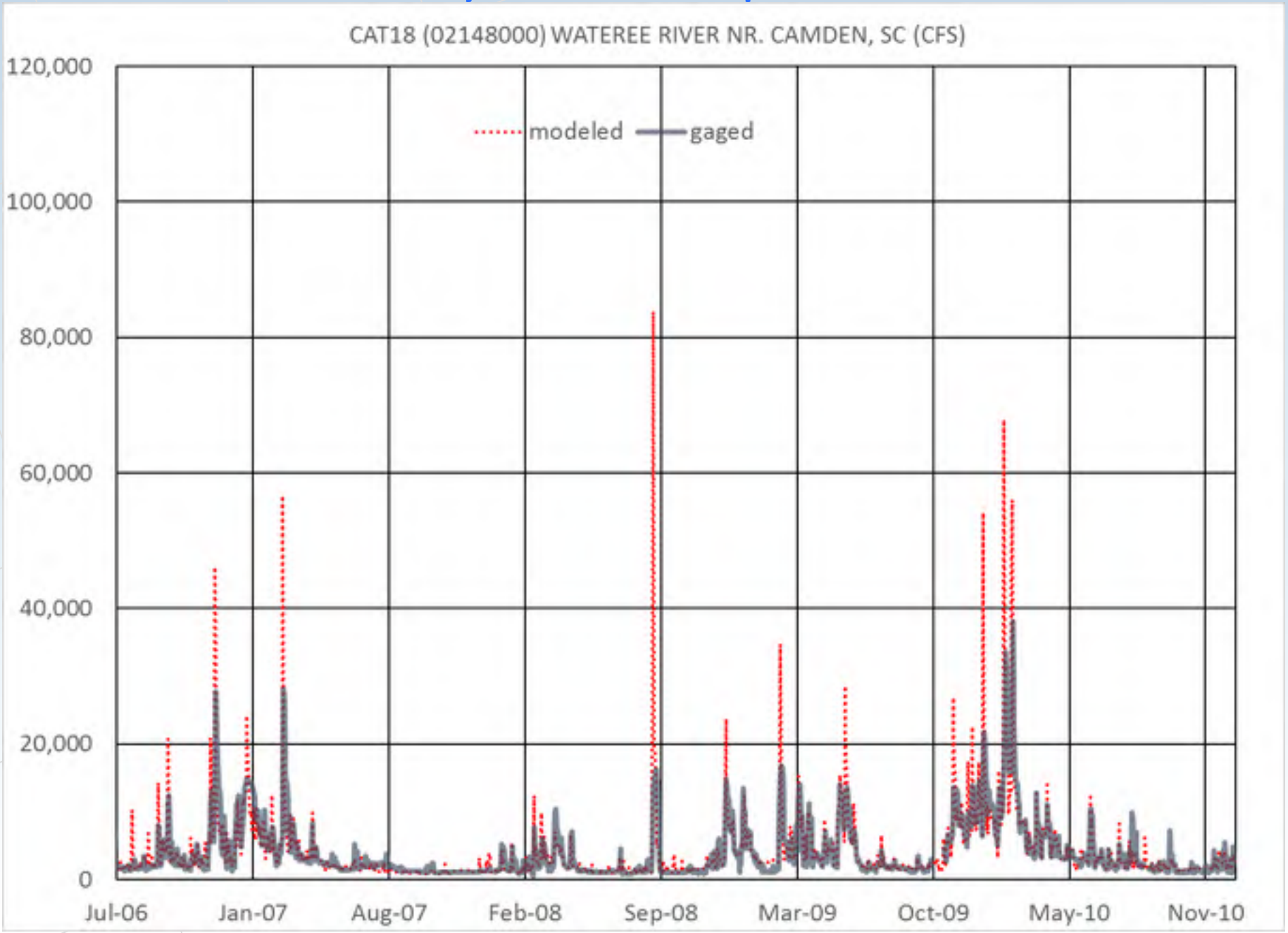
Monthly Flow Percentiles Comparison



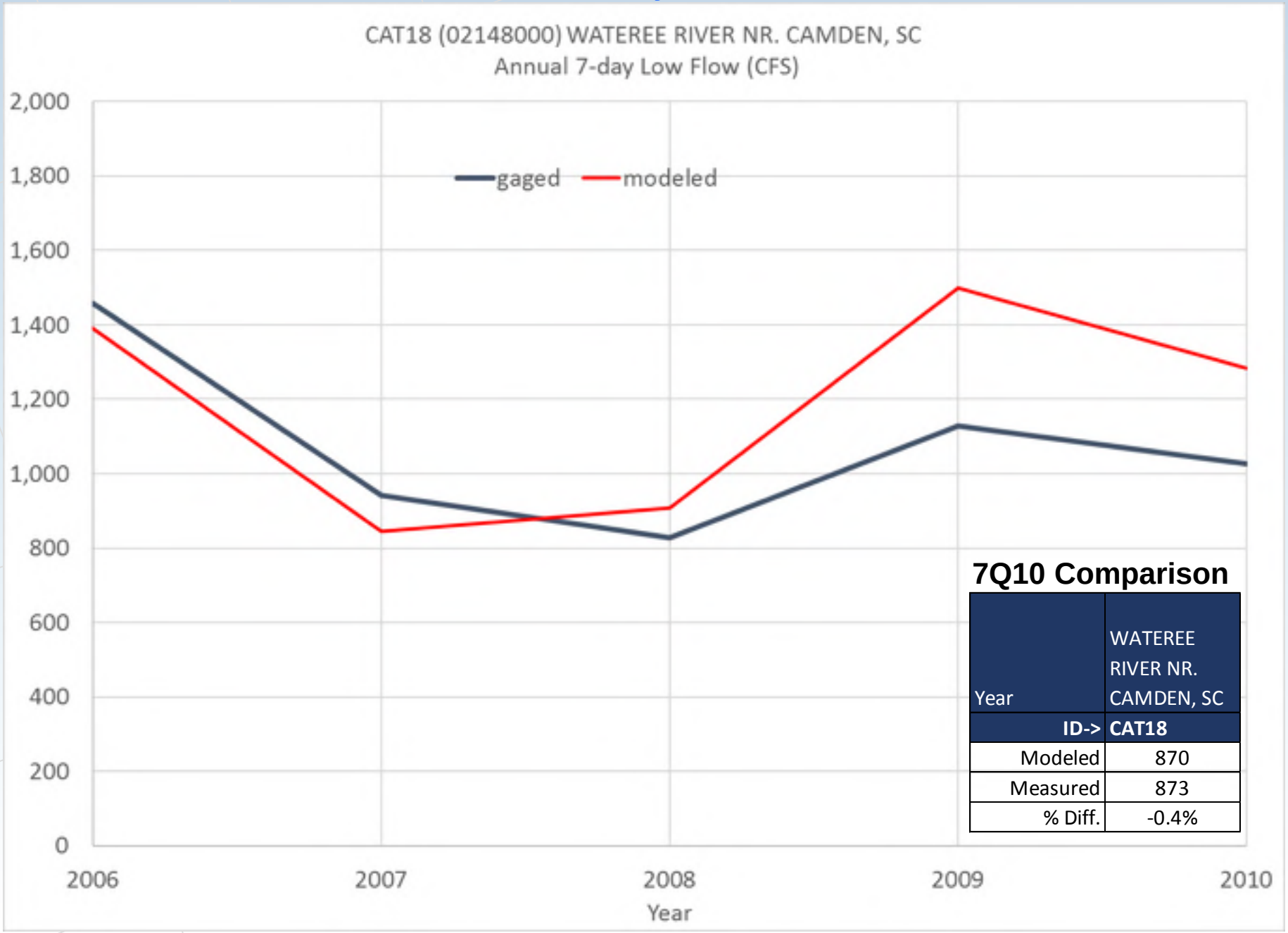
Cumulative Flow Comparison



Daily Flow Comparison



Annual 7-Day Low Flows



7Q10 Comparison

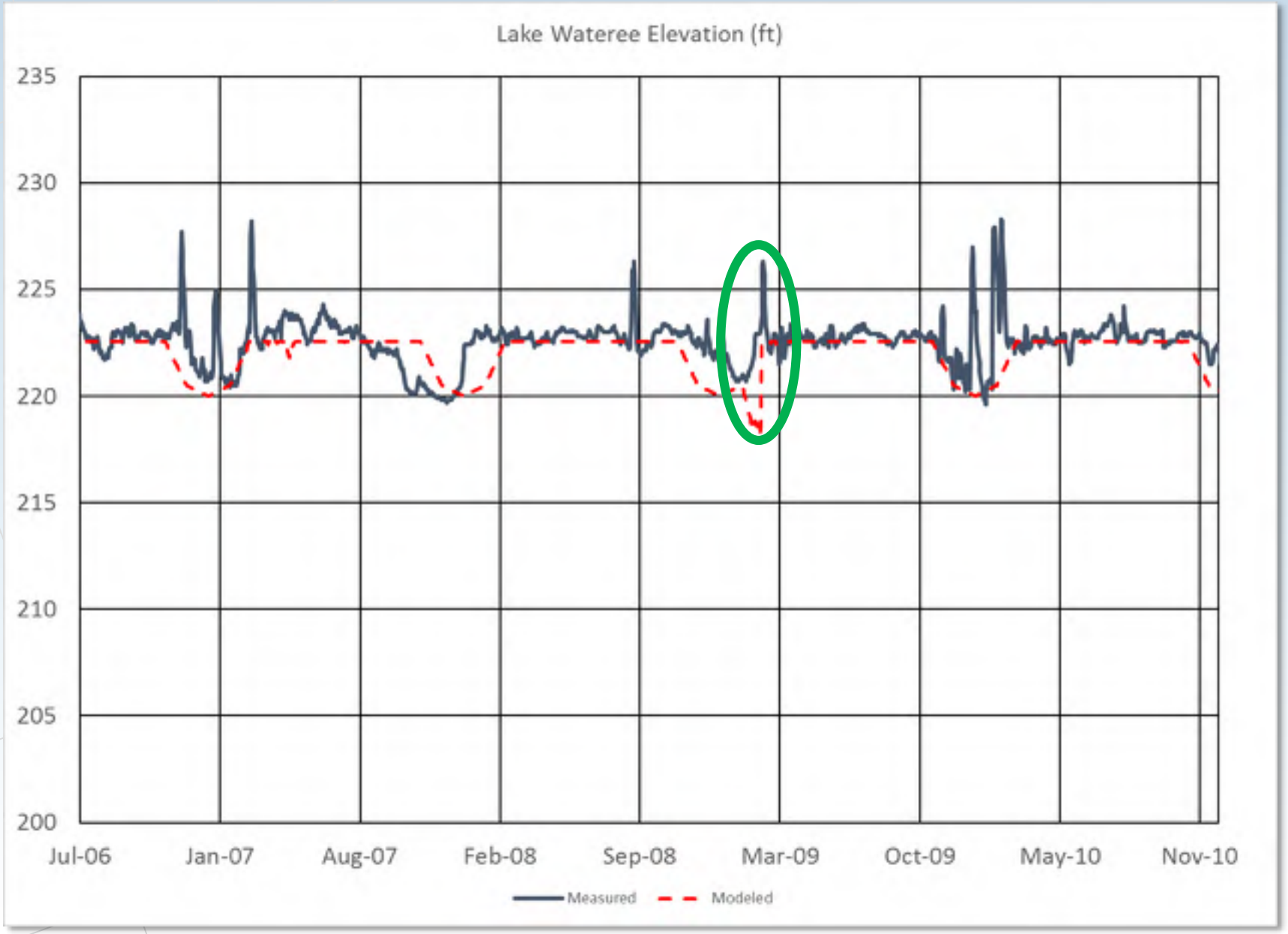
Year	WATEREE RIVER NR. CAMDEN, SC
ID->	**CAT18**
Modeled	870
Measured	873
% Diff.	-0.4%

SWAM Calibration/Validation Summary

- For most sites, modeled mean flow values, averaged over the full period of record, are within 2% of measured mean flows

Project ID	Station	Modeled Average	Measured Average	% Diff Average	Years of Record	
CAT07	SUGAR CREEK NEAR FORT MILL, SC	359	384	-6.5%	5	>5% difference
CAT16	FISHING CREEK BELOW FORT LAWN, SC	240	248	-3.1%	3	5% or less diff.
CAT10*	CATAWBA RIVER BELOW CATAWBA, SC	3,259	3,353	-2.8%	19	
CAT17	ROCKY CREEK AT GREAT FALLS, SC	147	149	-1.5%	25	
CAT15	WILDCAT CREEK BELOW ROCK HILL, SC	19	19	-1.1%	9	
CAT04*	CATAWBA RIVER NEAR ROCK HILL, SC	2,726	2,749	-0.9%	28	2% or less difference
CAT21*	WATEREE R. BL EASTOVER, SC	2,816	2,829	-0.5%	28	
CAT06	MCALPINE CREEK AT SR2964 NR CAMP COX, SC	111	112	-0.4%	6	
CAT19	GILLIES CREEK NEAR LUGOFF, SC	13	13	1.3%	4	
CAT18*	WATEREE RIVER NR. CAMDEN, SC	4,010	3,956	1.4%	28	
CAT08	SUGAR CR. NR FT. MILL, S.C.	241	230	4.9%	2	5% or less diff.

SWAM Calibration/Validation Summary



SWAM Calibration/Validation Summary

- Monthly mean flows percentile deviations are all generally within 5%-10% with no clear seasonal bias
- Modeled low flow values (as represented by 7Q10 flows) are within:
  - 0.4% and 7.2% on the Catawba-Wateree River
  - Rocky Creek (1.1 cfs modeled, 0.03 cfs observed)
- Modeled cumulative flows are within 0.1% and 2.1% of gaged flows for mainstem
- Modeled cumulative flows are within 0.5% and 6.3% of gaged flows for tributaries
- The model adequately hindcasts delivered water supply for each water user in the model (no significant shortfalls)

Catawba-Wateree River Basin

BASELINE MODEL AND USES

Baseline Model

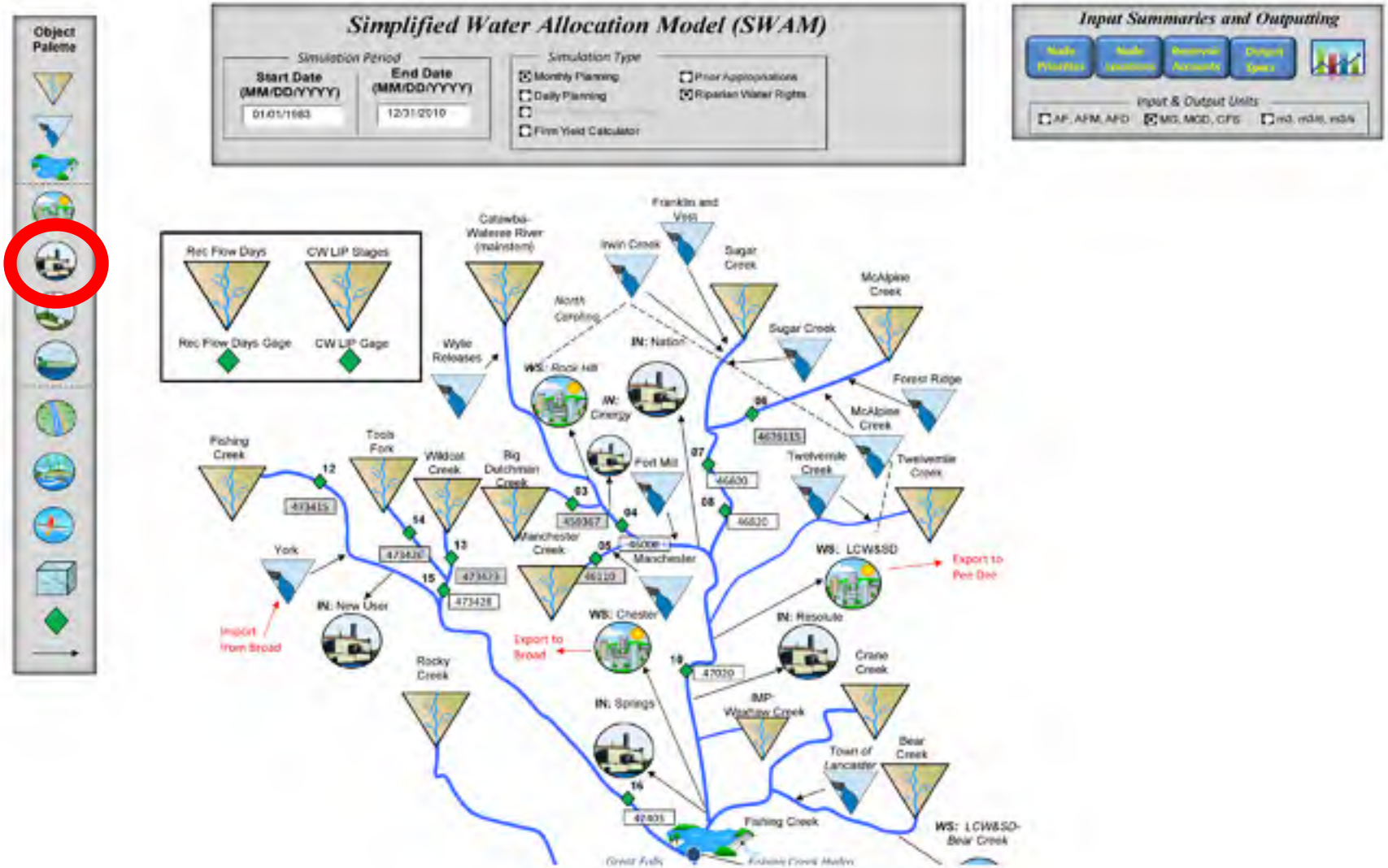
- Will represent current demands and operations combined with an extended period of estimated hydrology
  - Most demands reflect 2004-2013 averages
  - Estimated hydrology from 1951 to 2010
  - Inactive users are not included
- The baseline model serves as the starting point for future predictive simulations
- Must be used in coordination with CHEOPS model to obtain flows from NC portion of the system (outflow from Lake Wylie)

Example Use
Adding a New User

- Add a new M&I permittee on Fishing Creek
  - Demand = 15 mgd
  - Consumptive Use = 50%
    (return to Fishing Creek)

- *Is there enough water to support the new user?*

Add an Industrial Water User Object from the Palette



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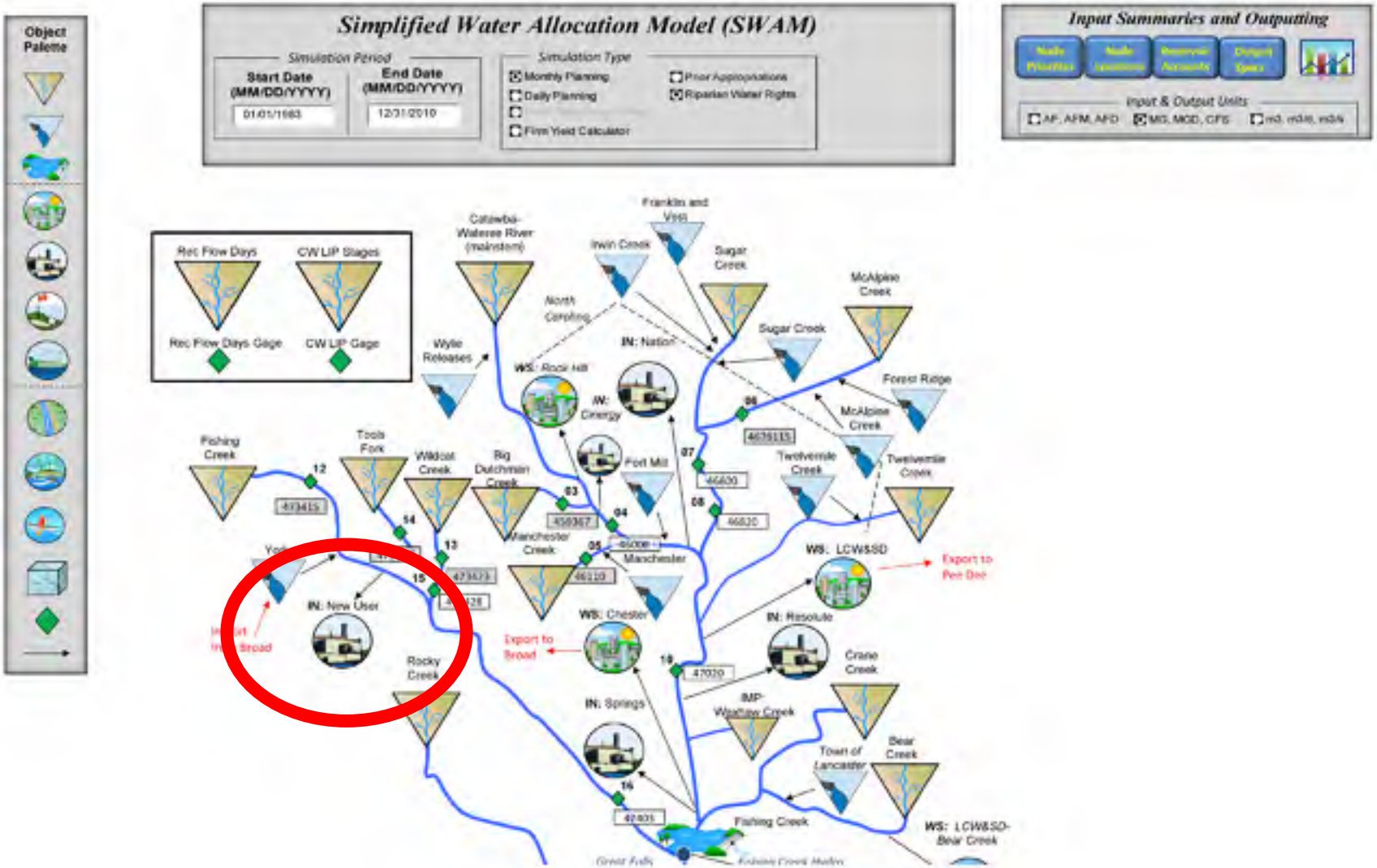
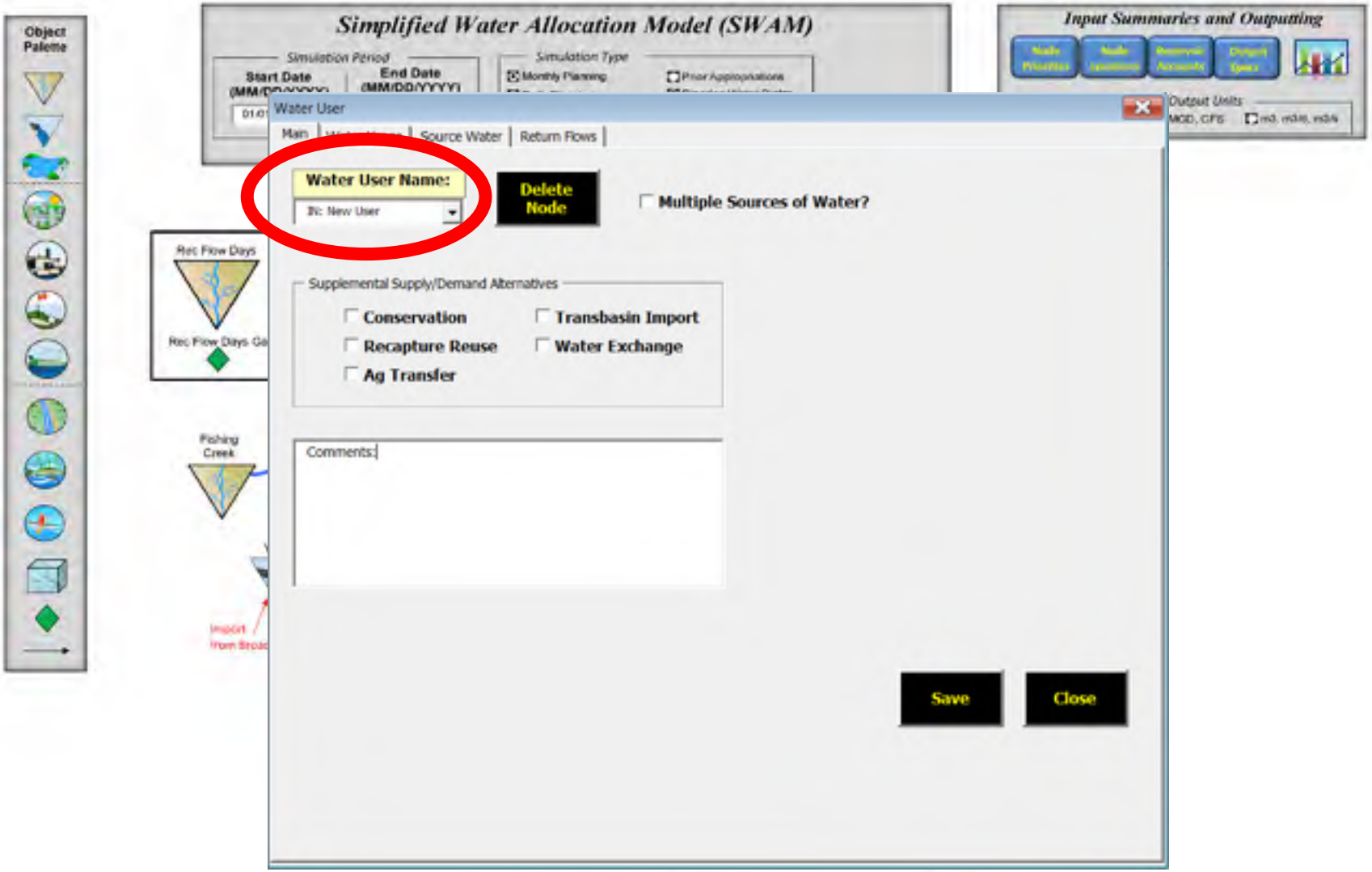
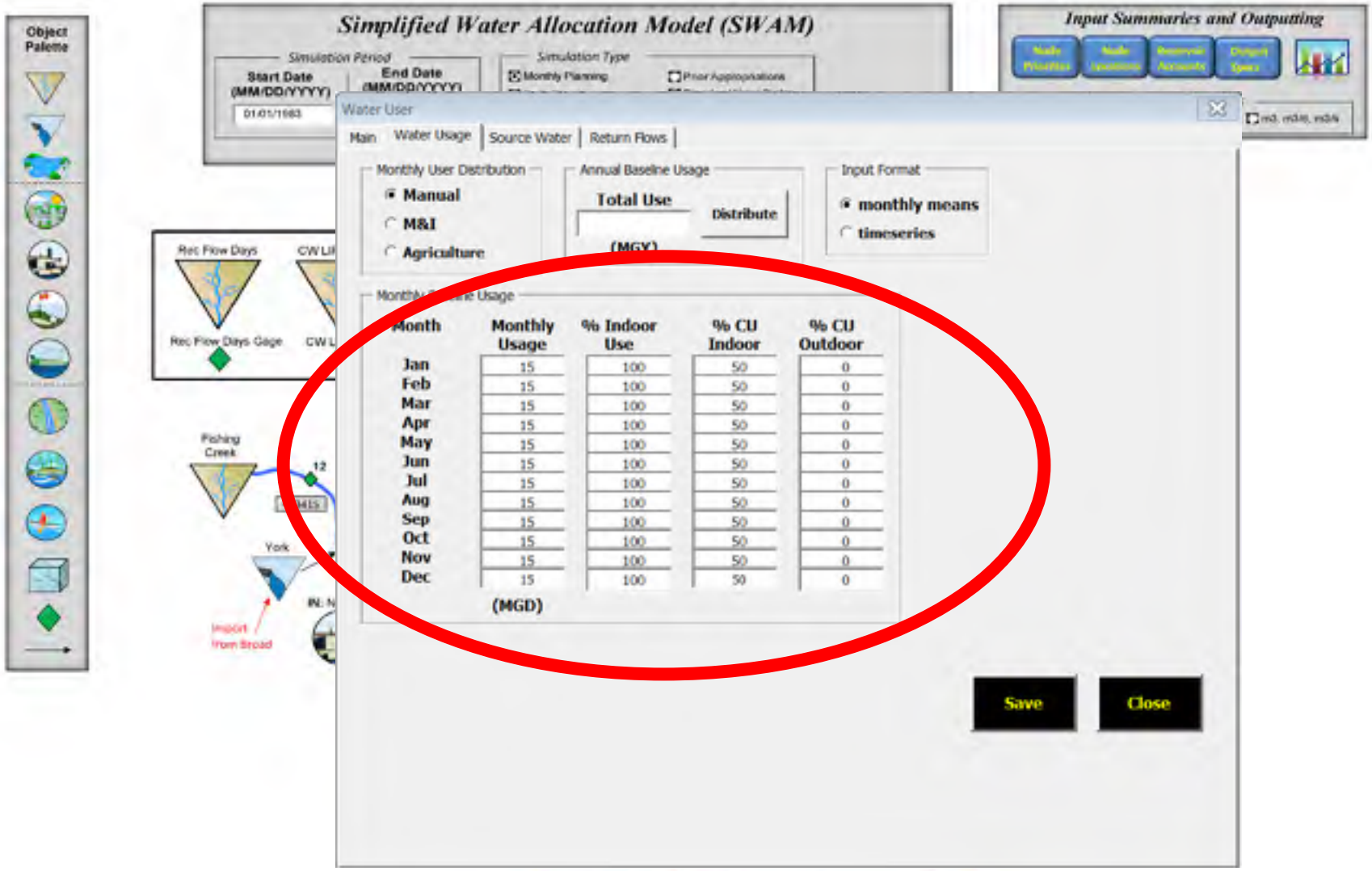


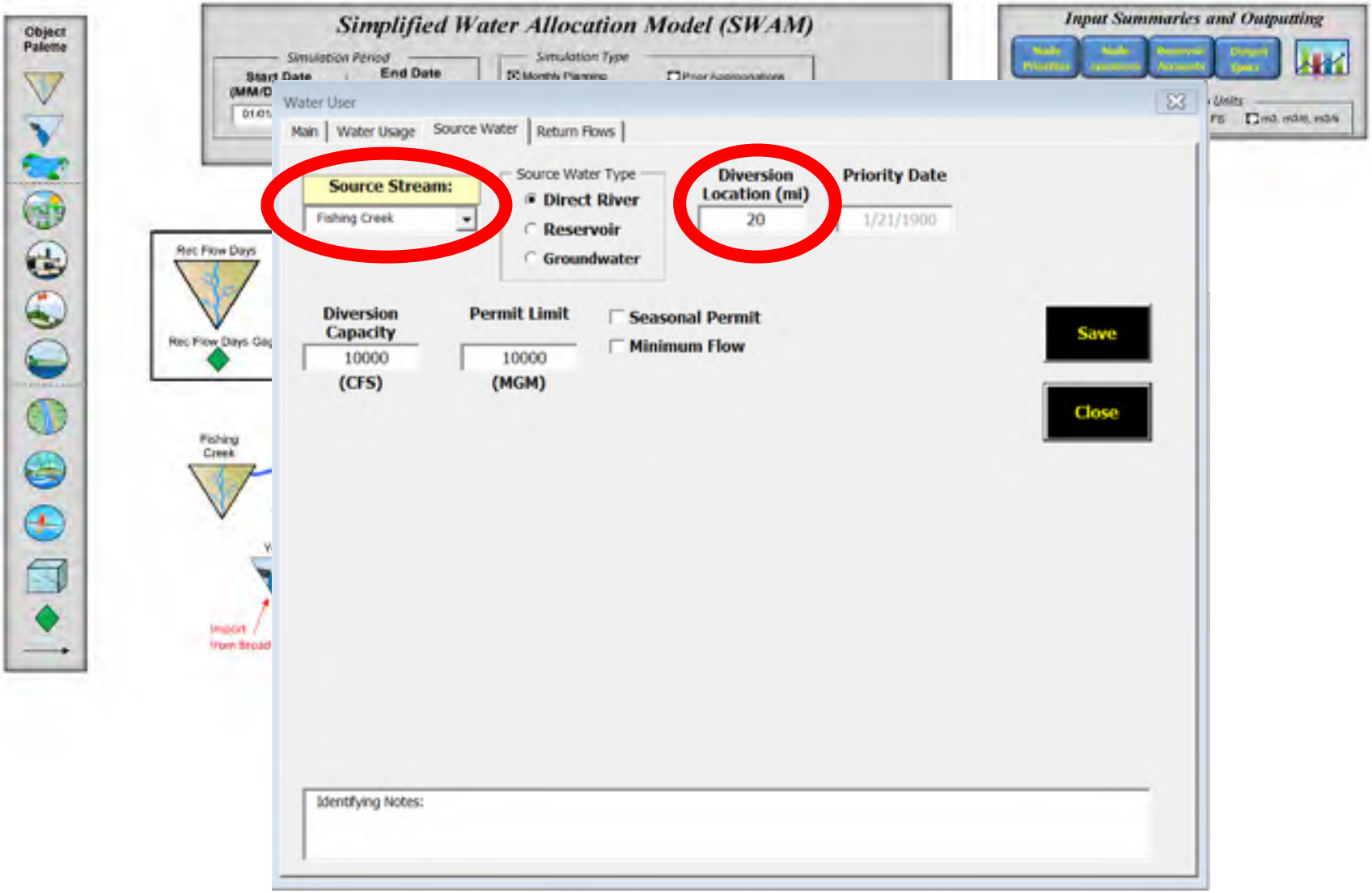
Add the New User in the Water User Dialogue



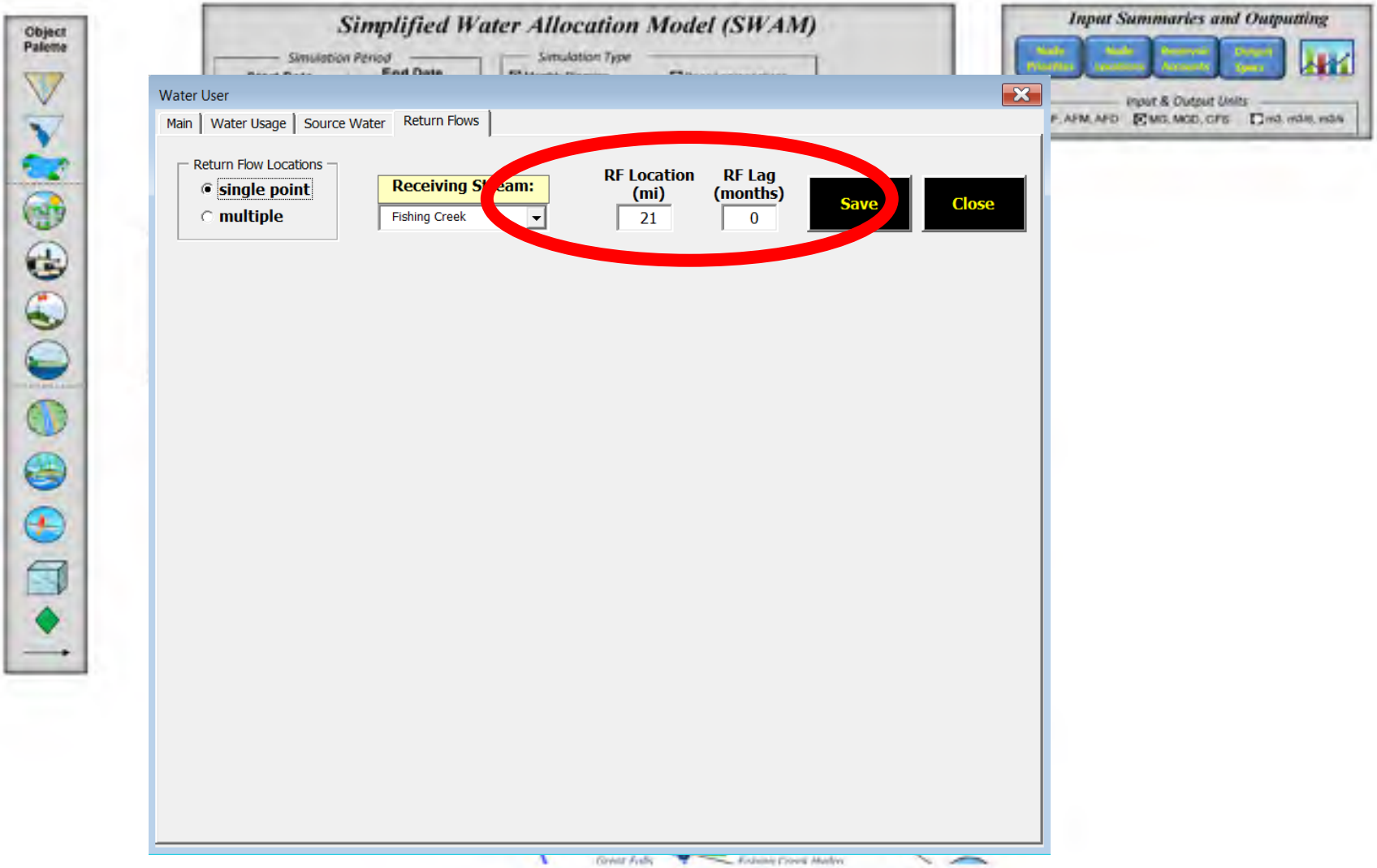
Specify Water Use



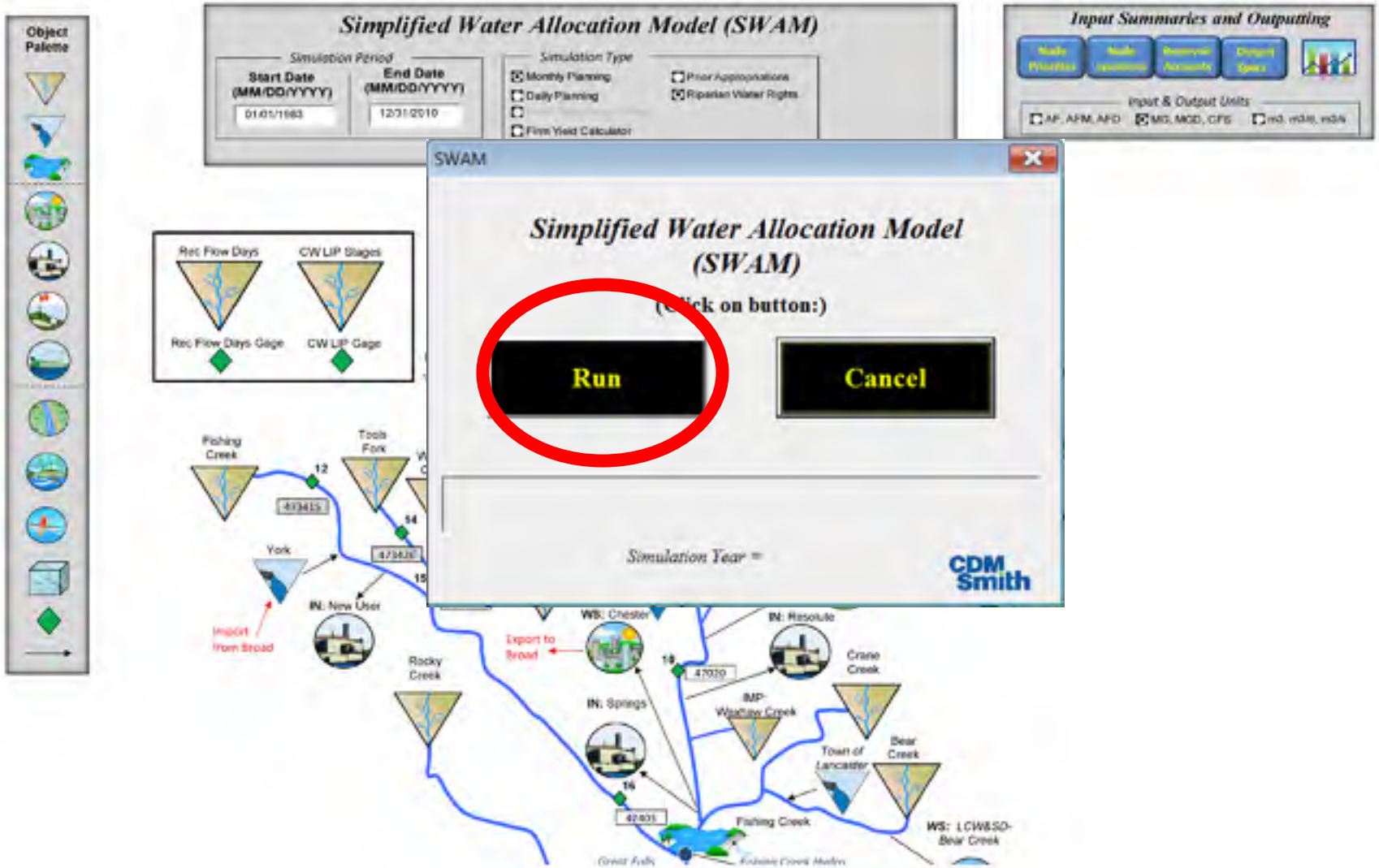
Specify Source and Withdrawal Location



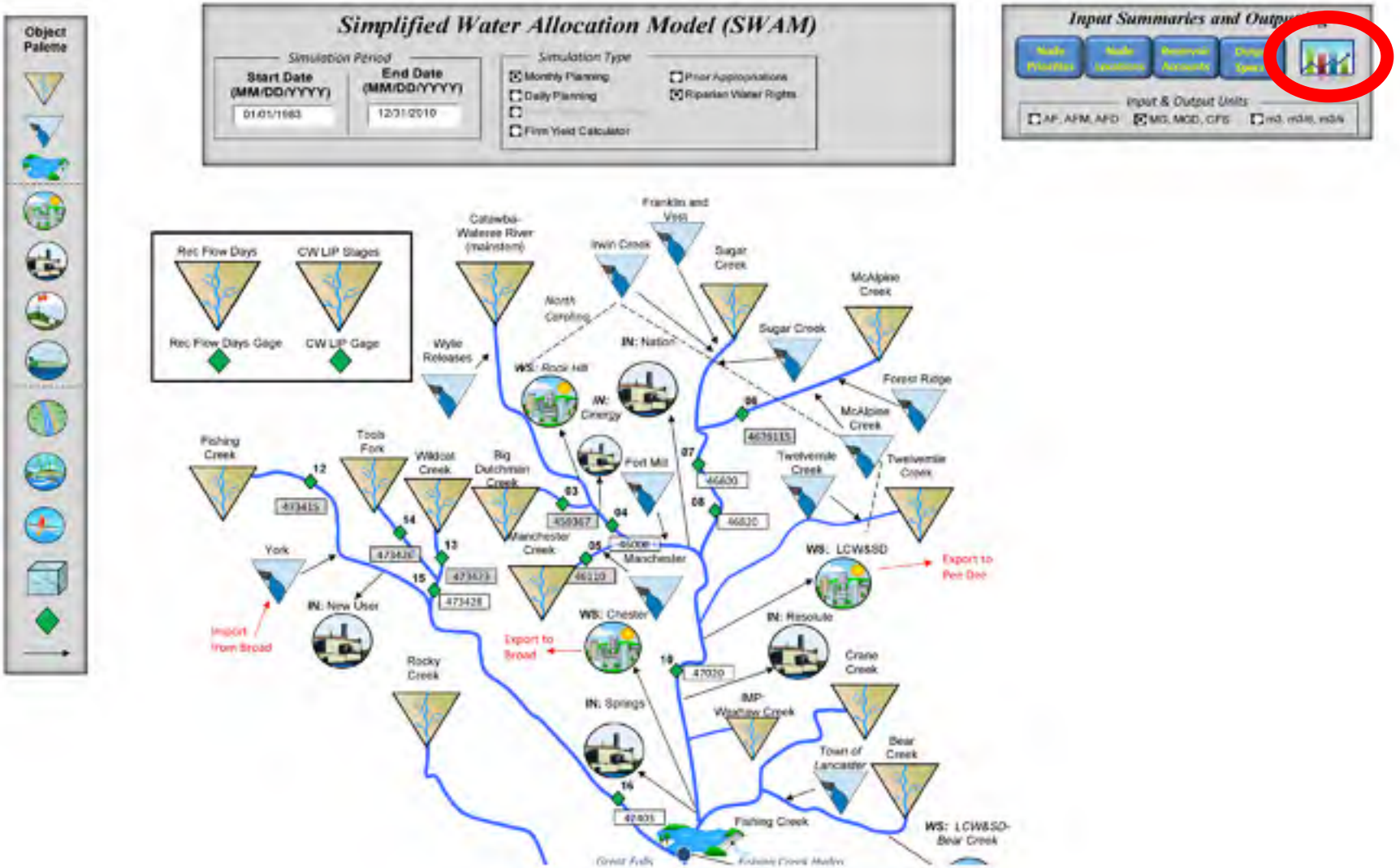
Specify Return Location



Run Model Scenario



Build a Shortage Plot for the New User



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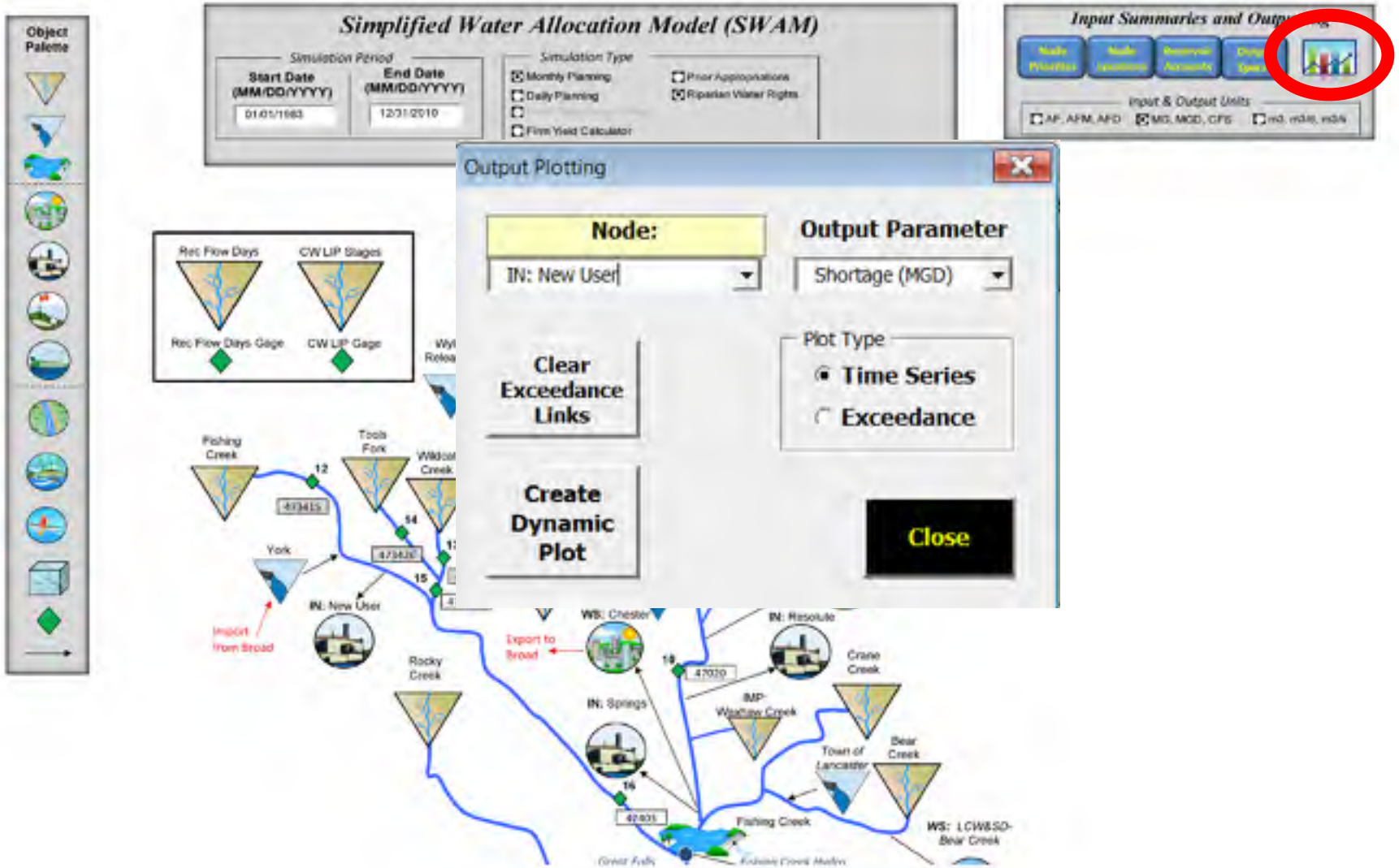

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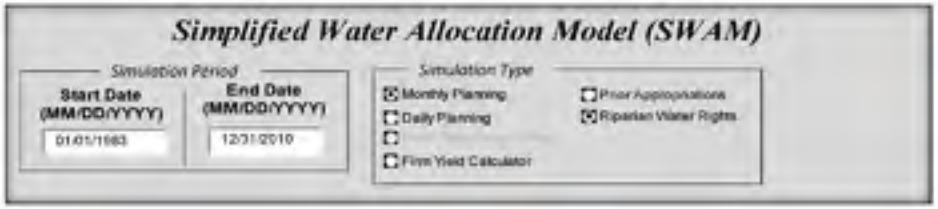
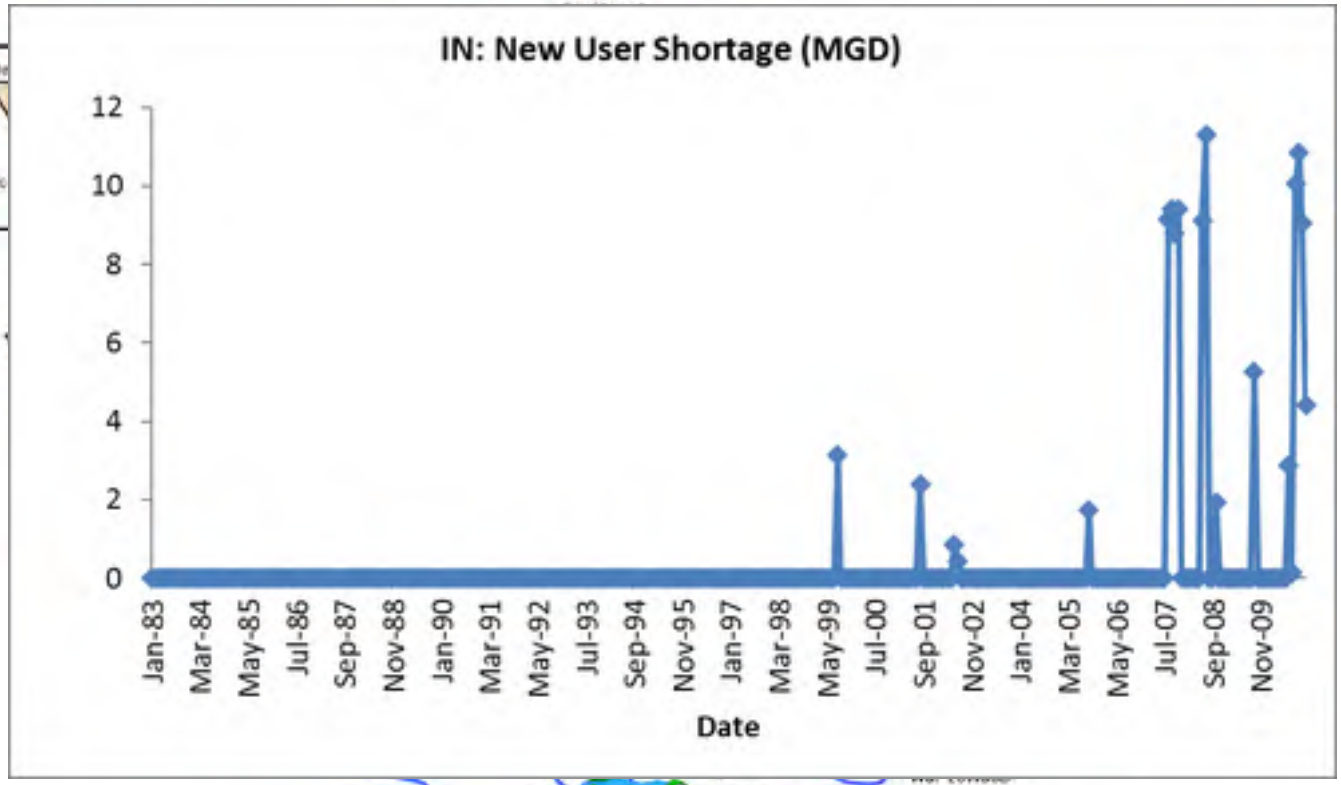
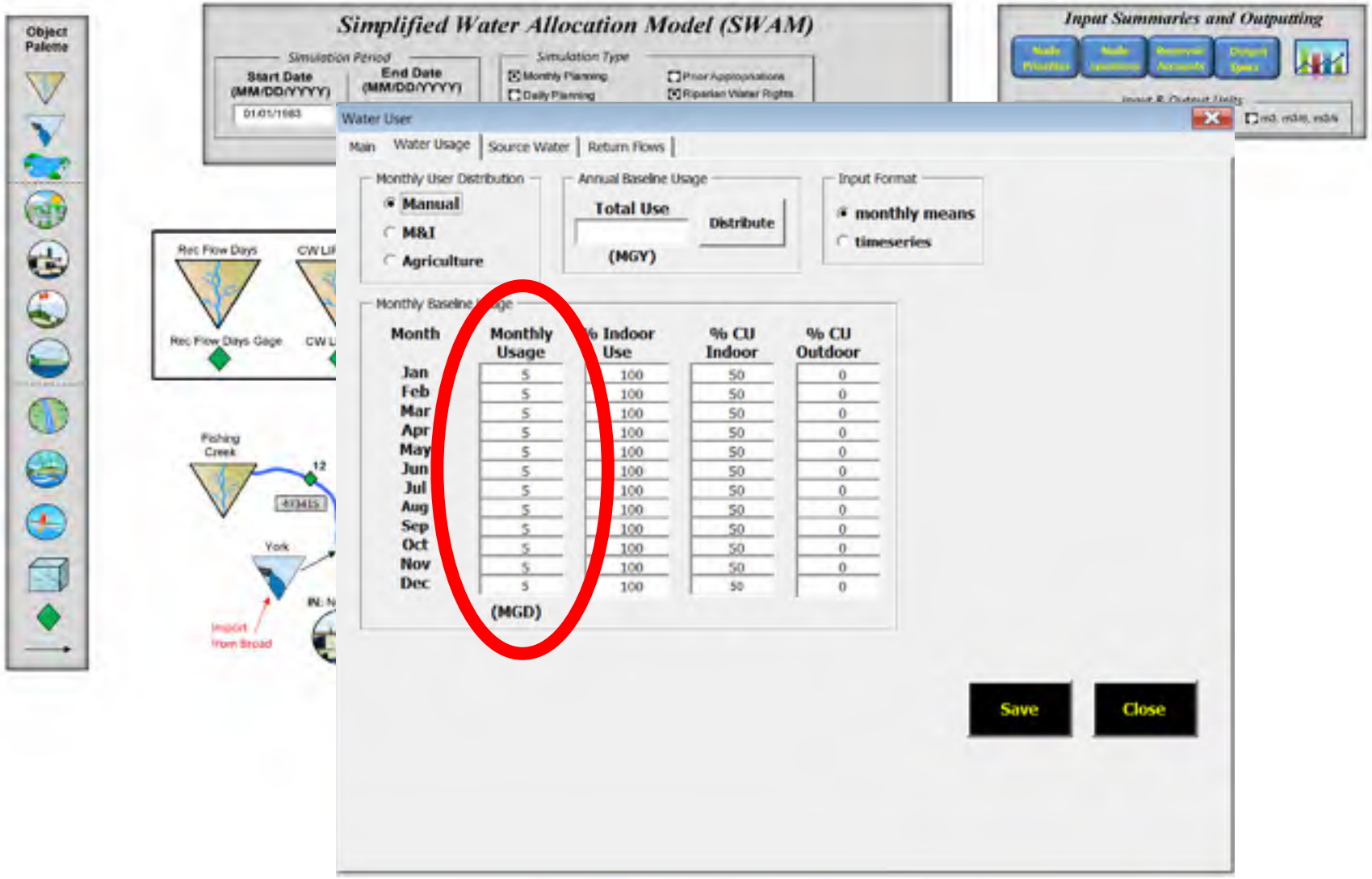




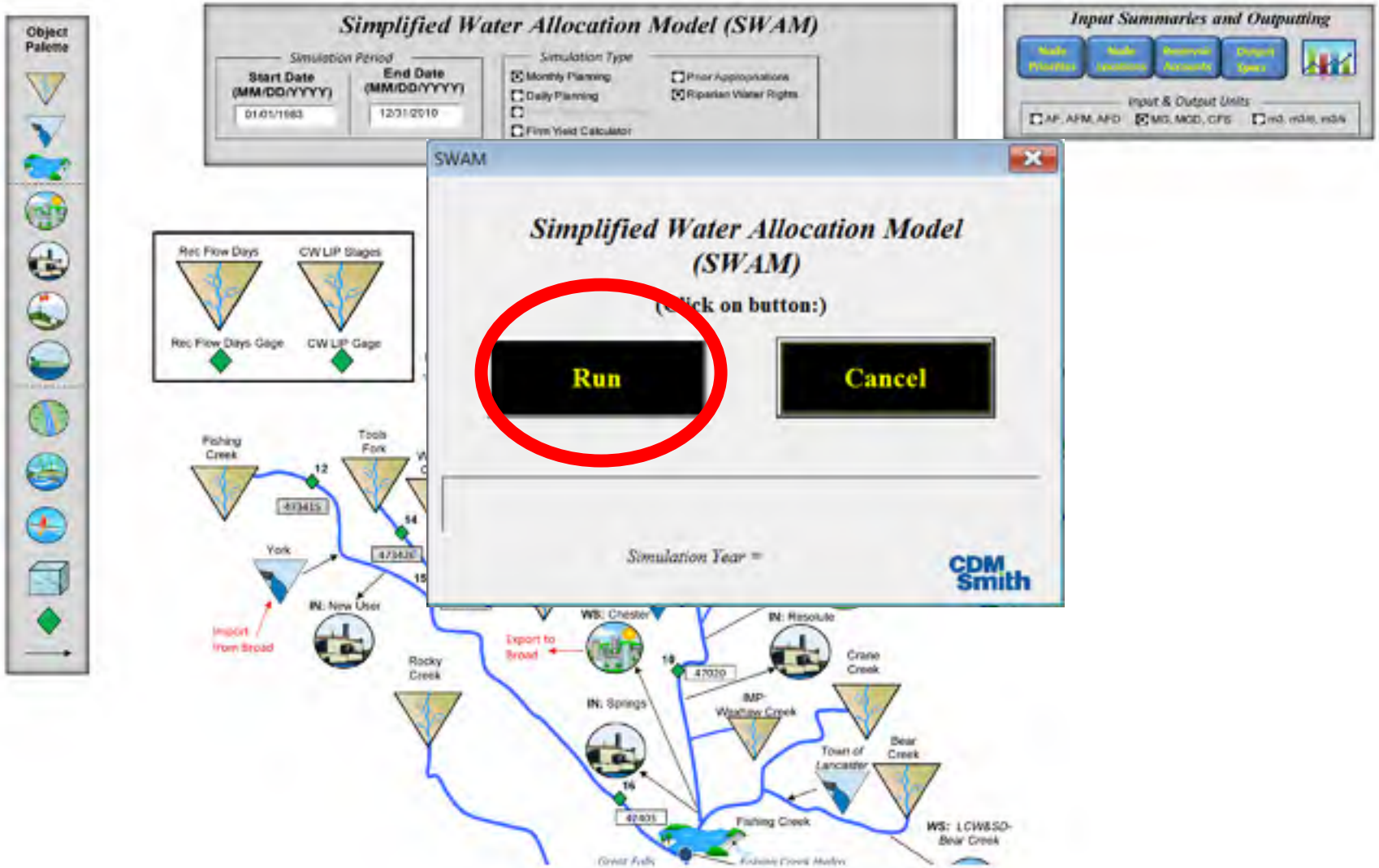
Shortages are Also Listed in the Node Output Table

Output									
		IN: New User	Priority Rank *22*	Reach *ishing Cree*	Location *20*	Permit Limit (MGM) *10000*	Diversion Capacity (CFS) *10000*	Storage Capacity (MG) *0*	Reservoir Withdrawal Permit (MGM)
	Date	Physically Avail. (MGD)	Legally Avail. (MGD)	Demand (MGD)	River Withdrawal (MGD)	Storage (MG)	Groundwater Withdrawal (MGD)	Shortage (MGD)	Return Flow (MGD)
	Min	4	4	15	4	0	0	0	2
	Max	744	357	15	15	0	0	11	8
	Avg	89	87	15	15	0	0	0	7
	9/30/06	58	58	15	15	0	0	0	8
	10/31/06	26	26	15	15	0	0	0	8
	11/30/06	226	226	15	15	0	0	0	8
	12/31/06	75	75	15	15	0	0	0	8
	1/31/07	104	104	15	15	0	0	0	8
	2/28/07	68	68	15	15	0	0	0	8
	3/31/07	140	140	15	15	0	0	0	8
	4/30/07	71	71	15	15	0	0	0	8
	5/31/07	20	20	15	15	0	0	0	8
	6/30/07	27	27	15	15	0	0	0	8
	7/31/07	20	20	15	15	0	0	0	8
	8/31/07	6	6	15	6	0	0	9	3
	9/30/07	6	6	15	6	0	0	9	3
	10/31/07	6	6	15	6	0	0	9	3
	11/30/07	6	6	15	6	0	0	9	3
	12/31/07	32	32	15	15	0	0	0	8
	1/31/08	28	28	15	15	0	0	0	8
	2/28/08	55	55	15	15	0	0	0	8
	3/31/08	112	112	15	15	0	0	0	8

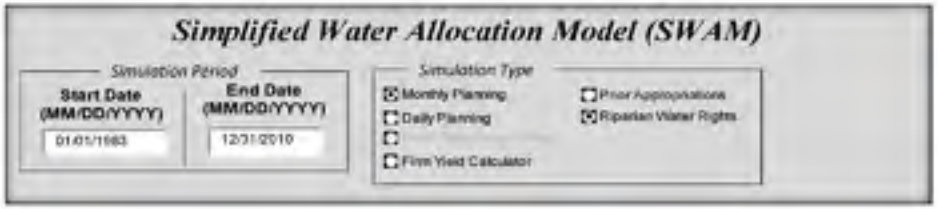
Reduce the New User's Total Water User to 5 mgd

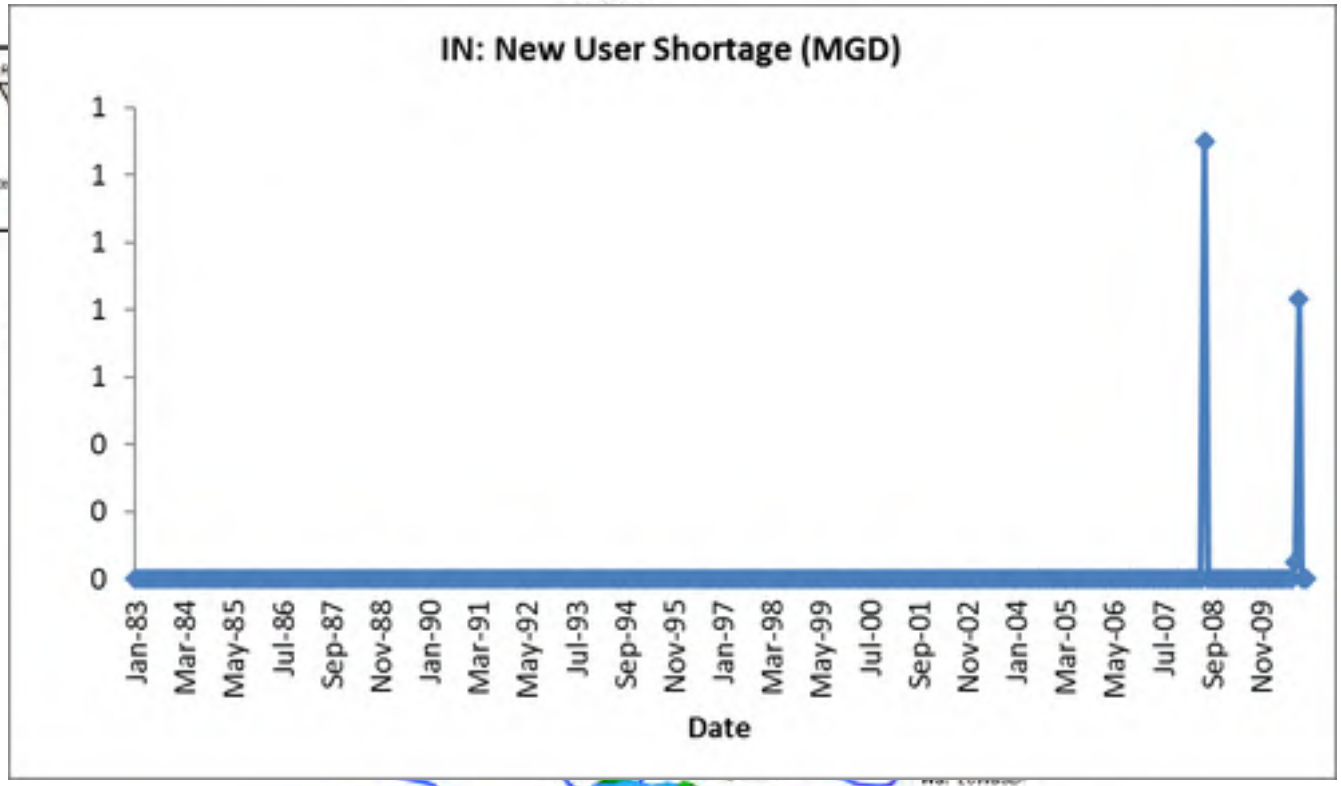


Rerun Model Scenario



Dynamic Shortage Plots Update Automatically





Demonstrations and Q&A

- Stations 1 (Nina) and 2 (John)

  Add a new user and incorporate conservation measures

  Explore impact of LIP adjustments

Catawba-Wateree River Basin

THANK YOU