South Carolina Surface Water Quantity Modeling Project

Saluda Basin Meeting No. 2 – Introduction to the Draft Model

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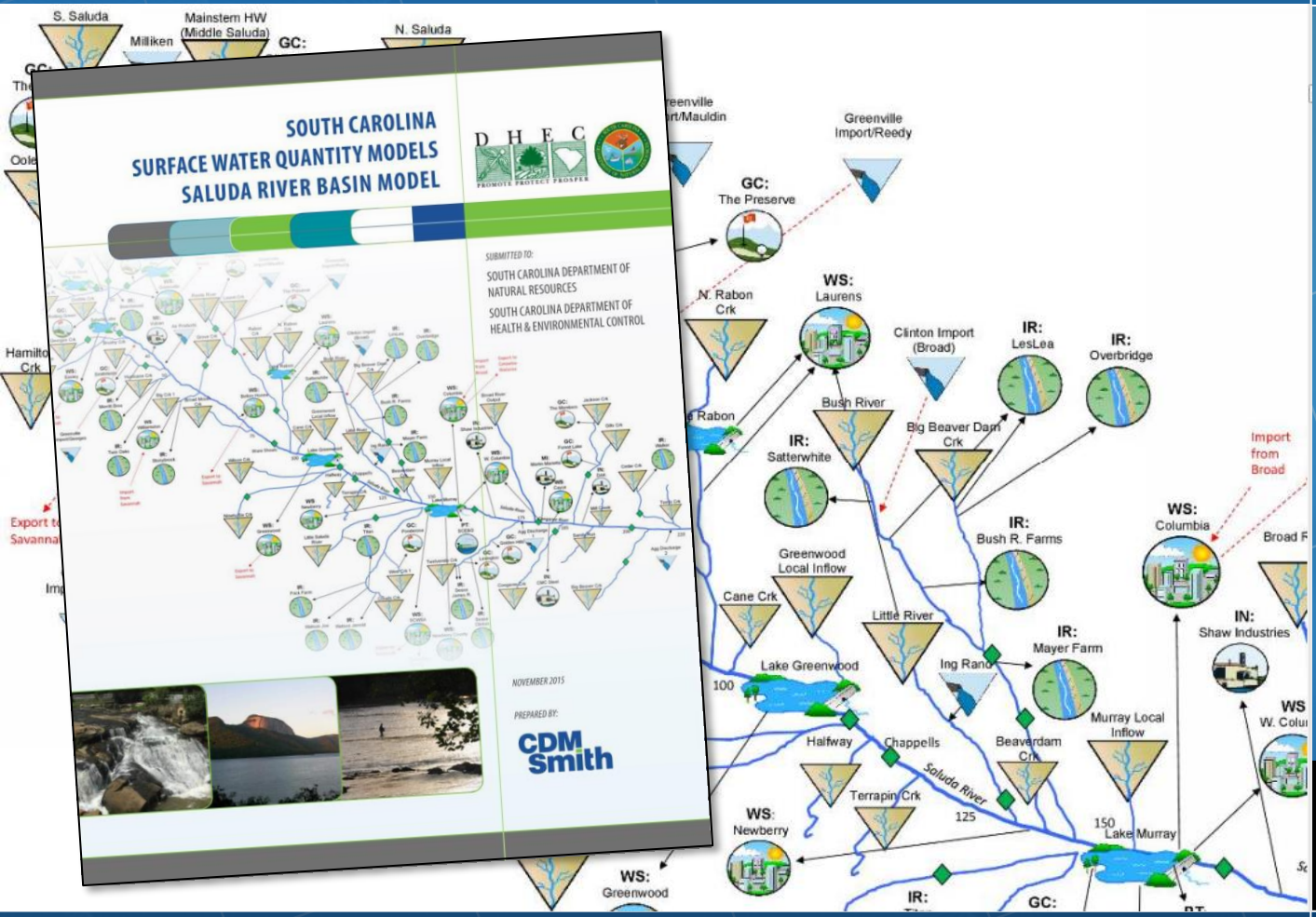

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Presentation Outline

- Project Background and Status
- Model Calibration/Verification
  - Calibration/Verification Philosophy and Approach
  - Calibration Results and Discussion
- Saluda Baseline Model
  - Overview and Uses

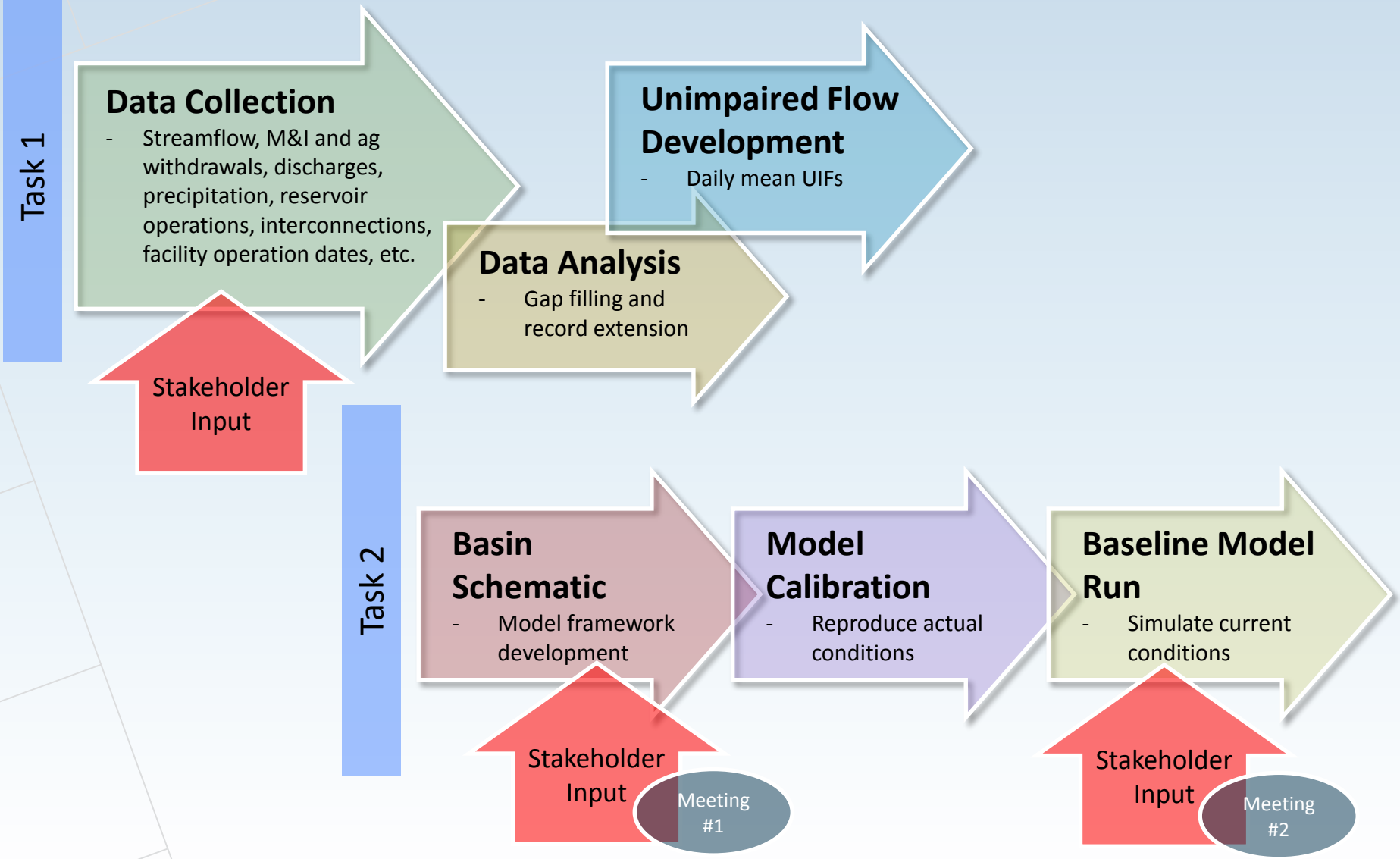
Project Purpose

- 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 and 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 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 – Saluda Basin

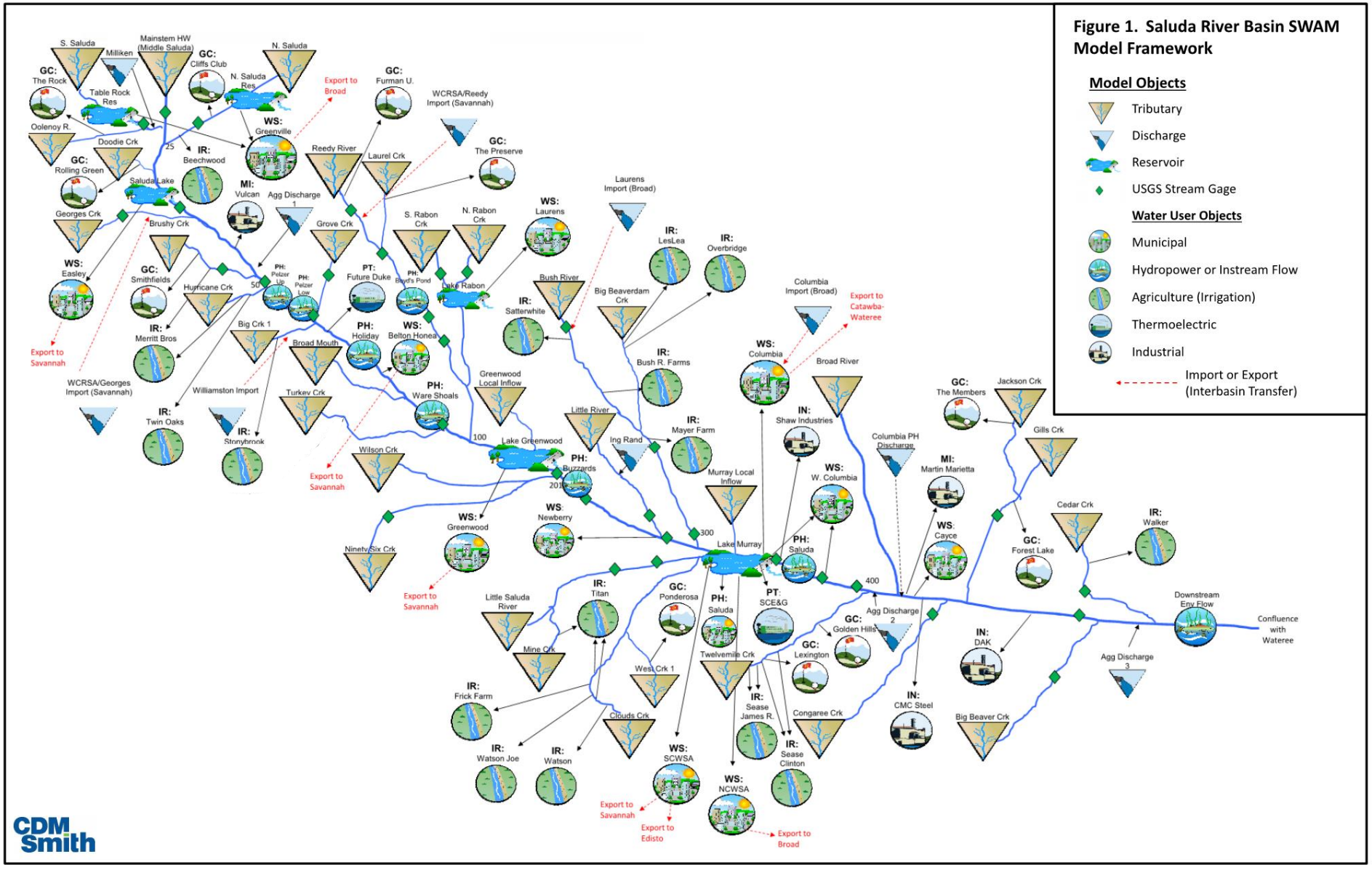


Calibration vs. Baseline Model

- **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

Saluda Basin – SWAM Framework



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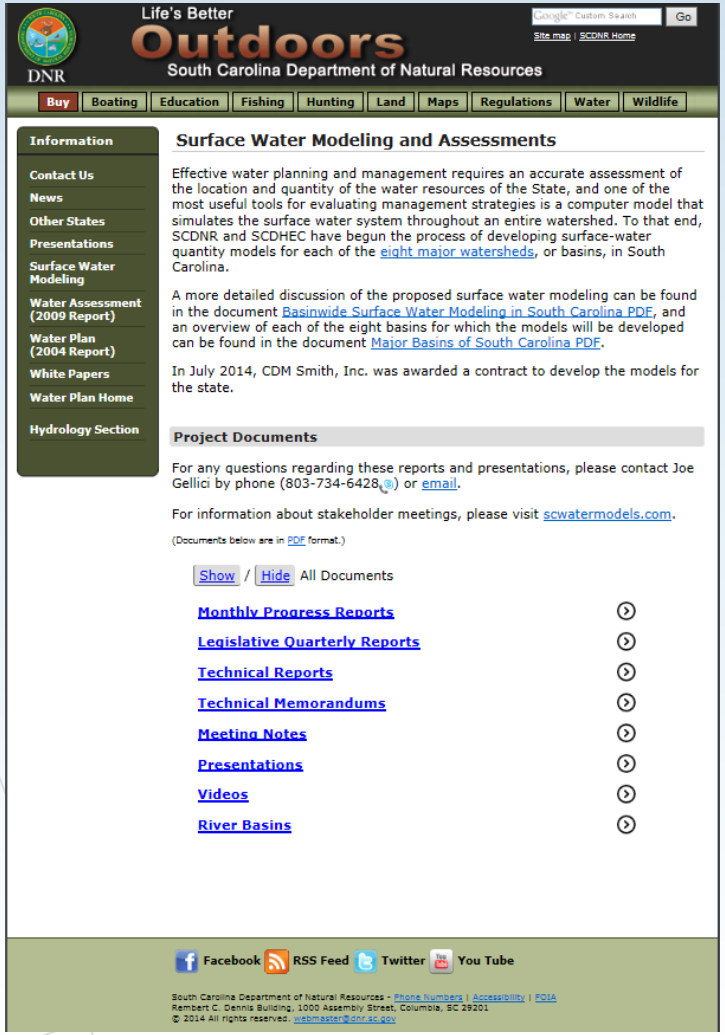
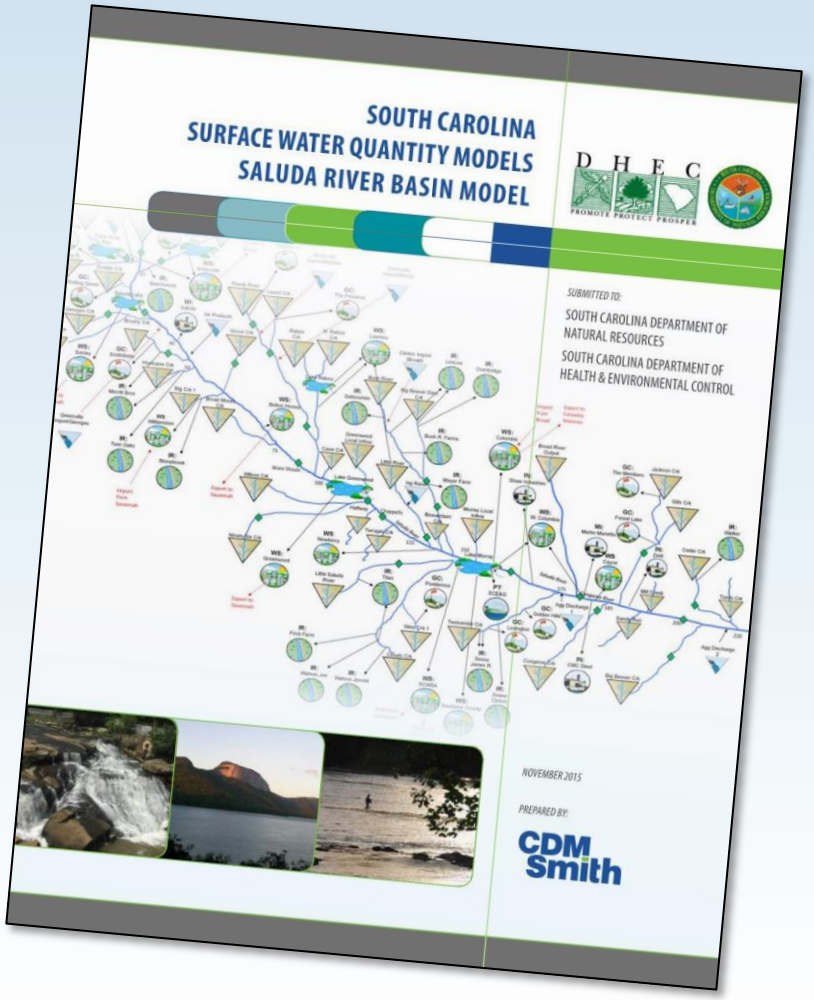
Modeling Report and Other Documents

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





Saluda 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, %Consumptive Use assumptions, return flow locations
3. Gain confidence in the model as a predictive tool by demonstrating its ability to adequately replicate past hydrologic conditions, operations, and water use
   - **without being overly prescriptive**

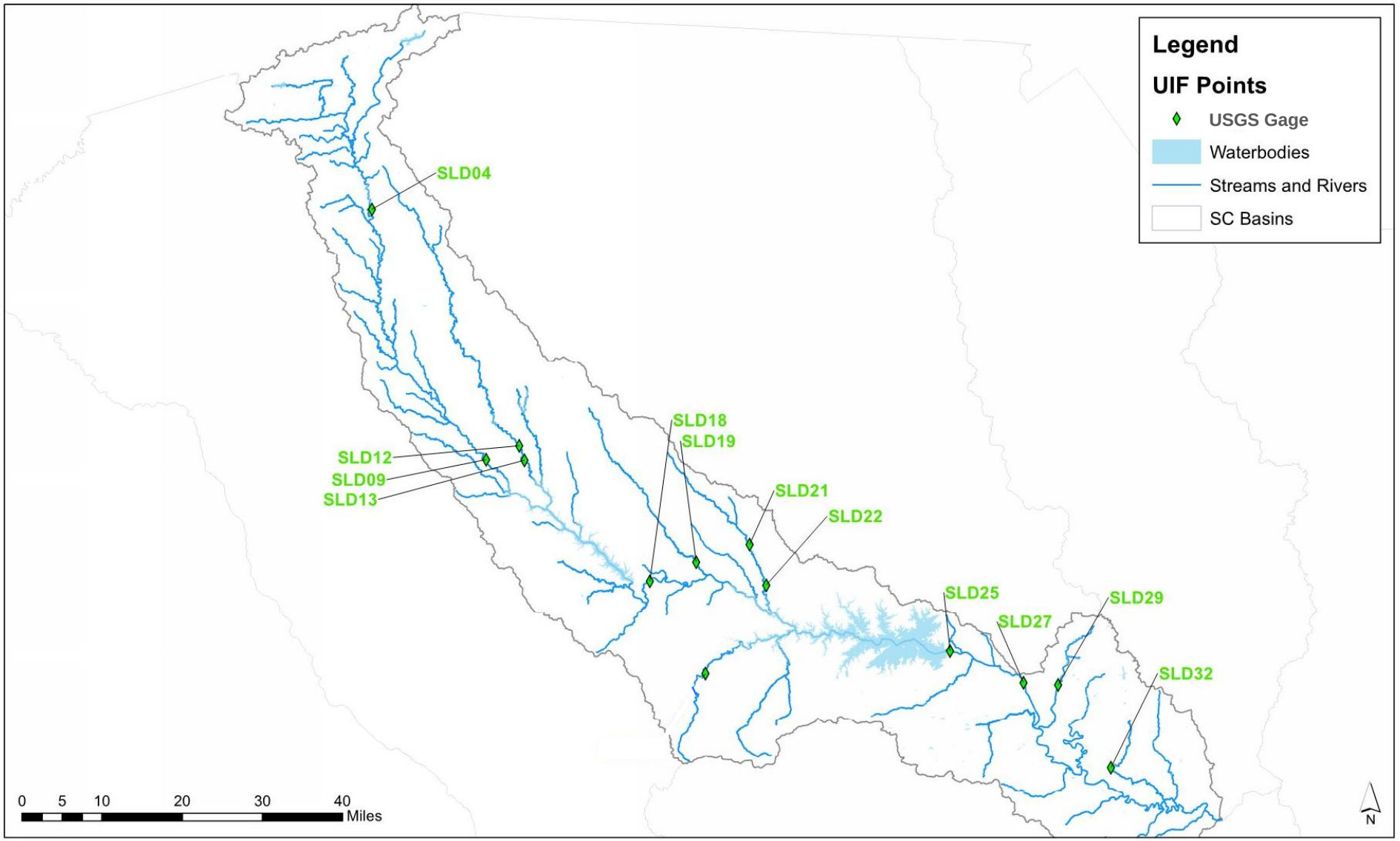
Potential Sources of Model Error and Uncertainty

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

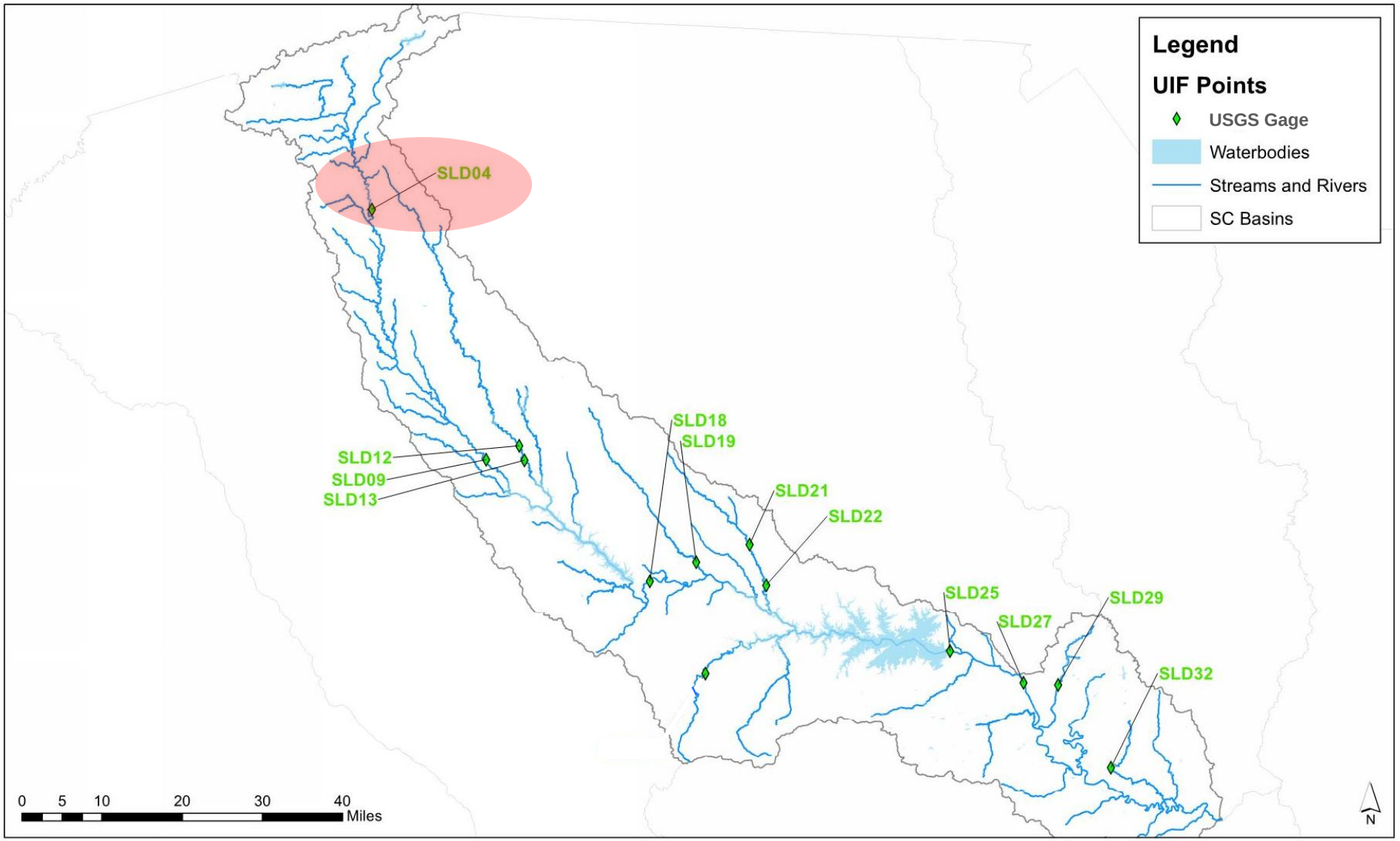
Calibration/Validation General Approach

- 1983 – 2013 hindcast period; monthly timestep
  - Includes droughts in both early and late 2000's
- Comparison to gaged (measured) flow data only
  - operations and impairments are implicit in that data
- Assess performance at (subject to gage data availability):
  - multiple mainstem locations
  - all tributary confluence locations
  - major reservoirs
- Multiple model performance metrics, including:
  - timeseries plots (monthly and daily variability)
  - annual and monthly means (water balance and seasonality)
  - percentile plots (extremes and frequency)

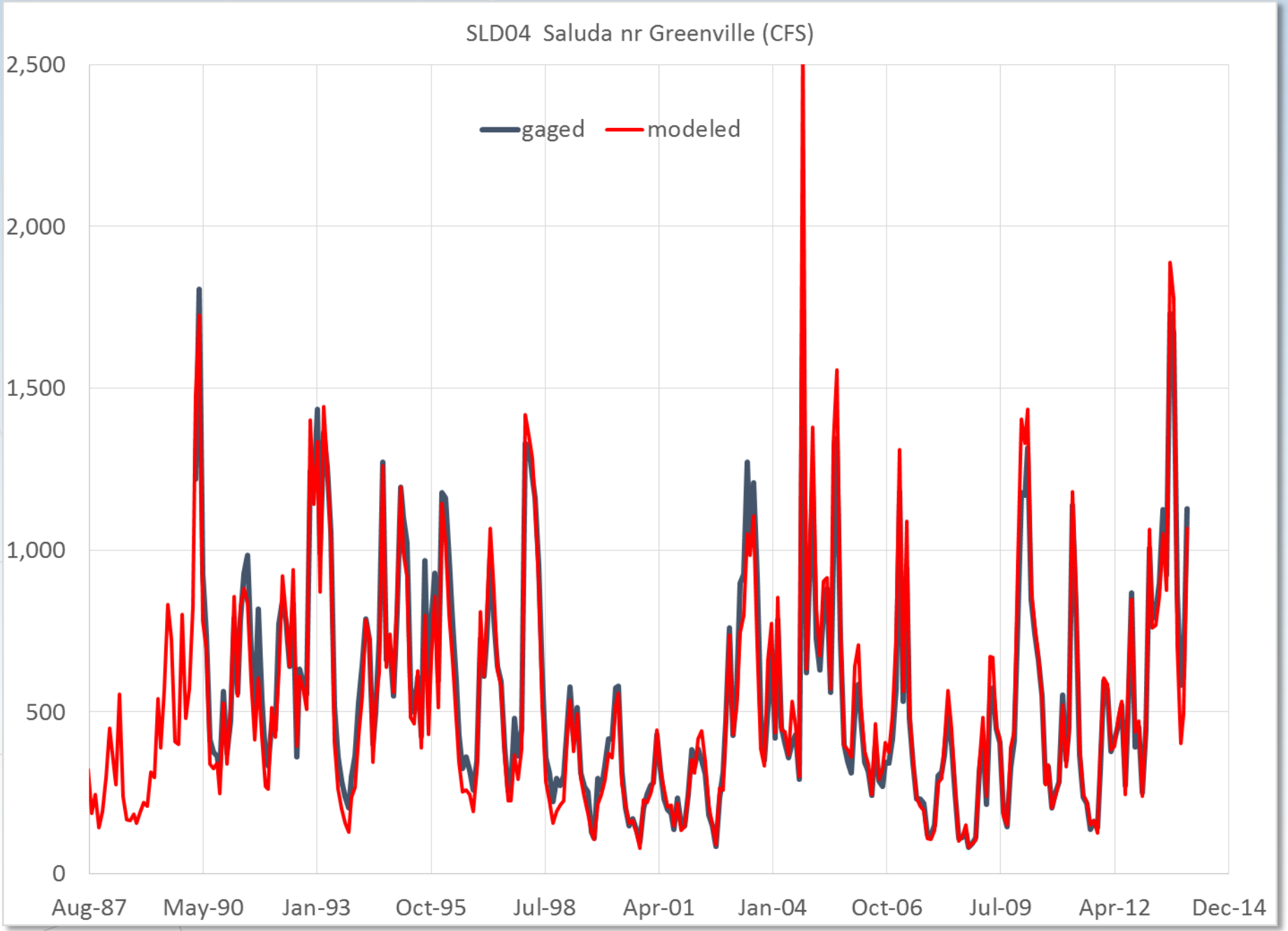
Calibration/Validation Locations



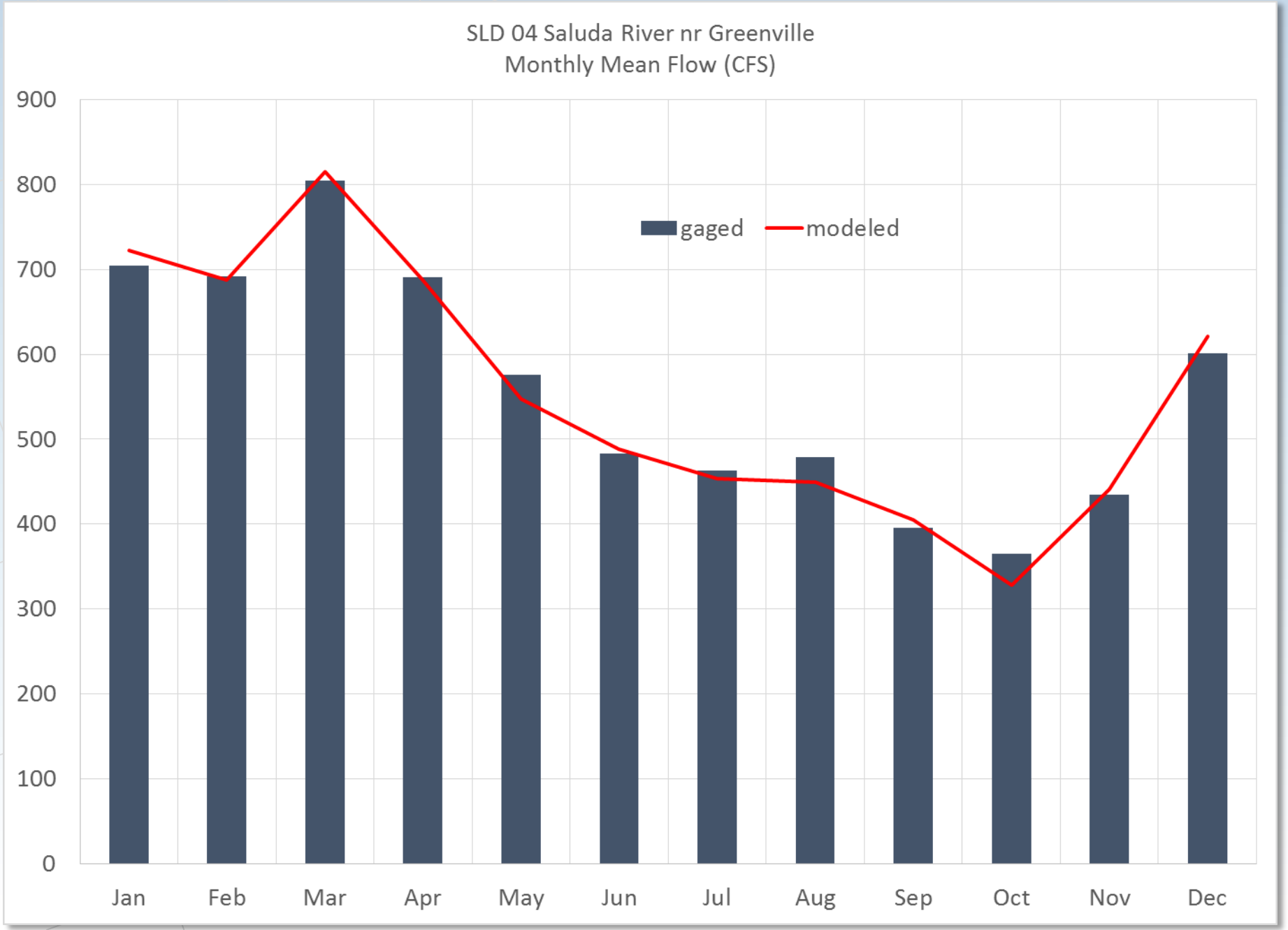
Saluda River Near Greenville



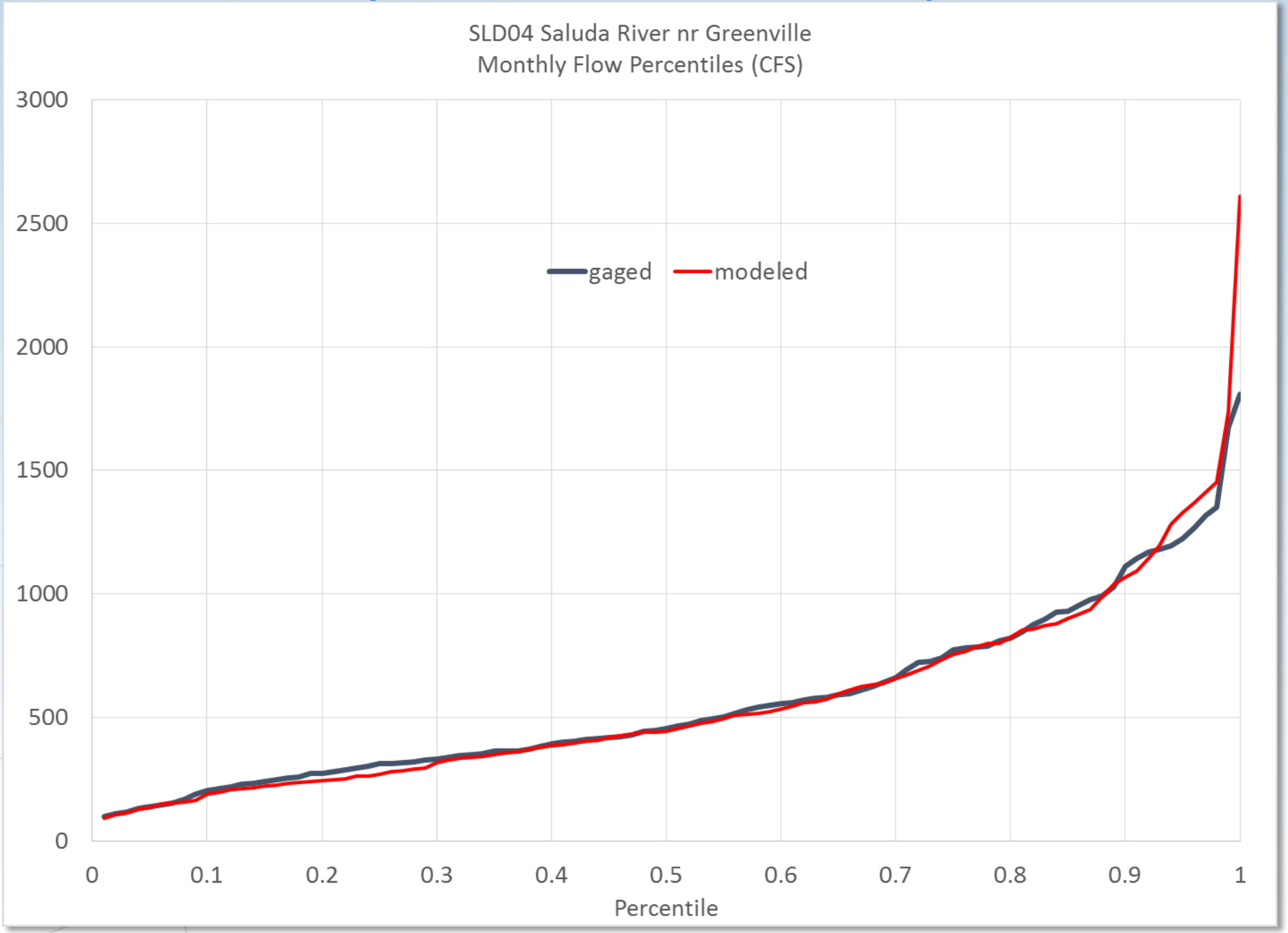
Monthly Flow Comparison



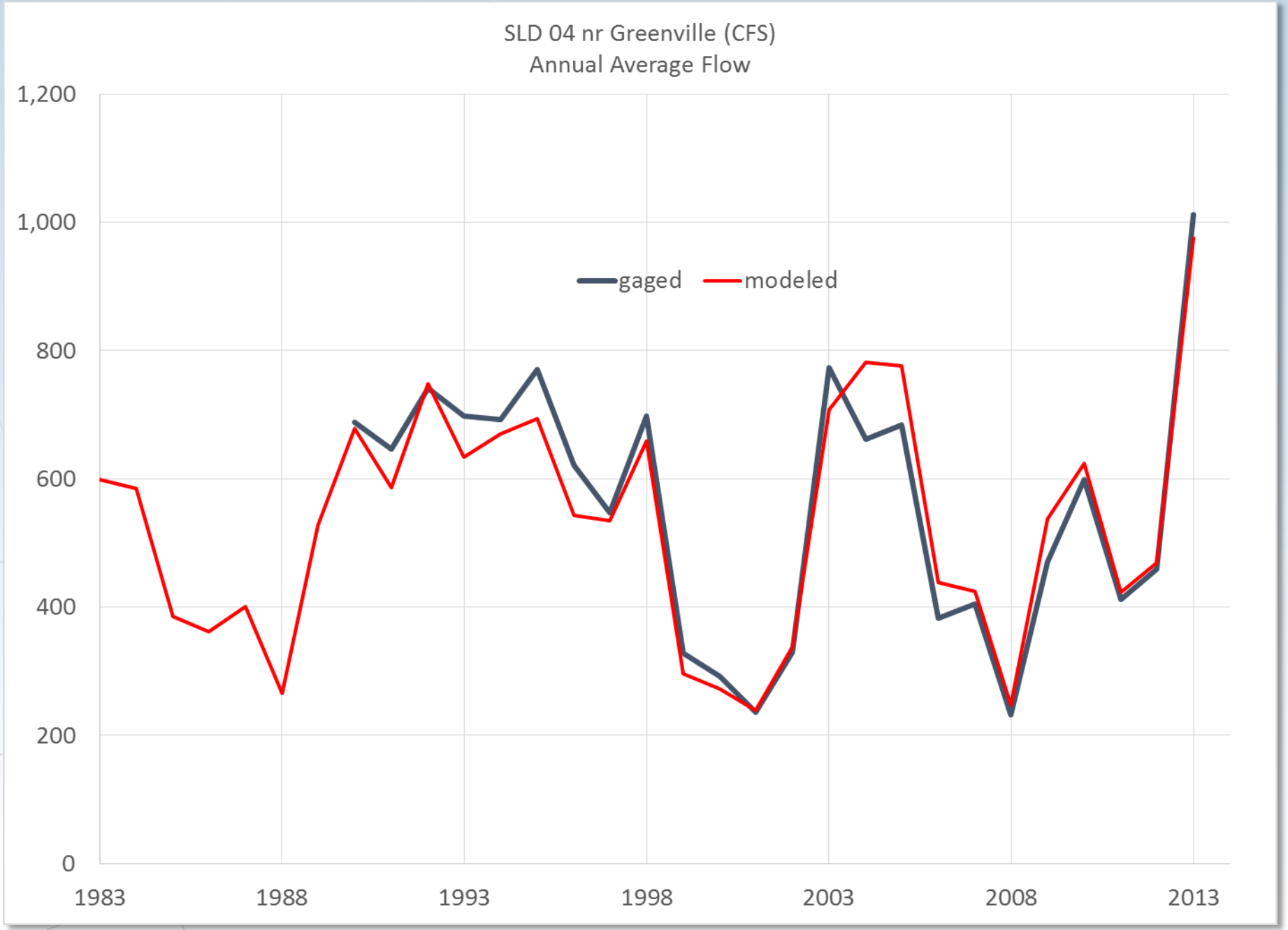
Monthly Mean Flow Comparison



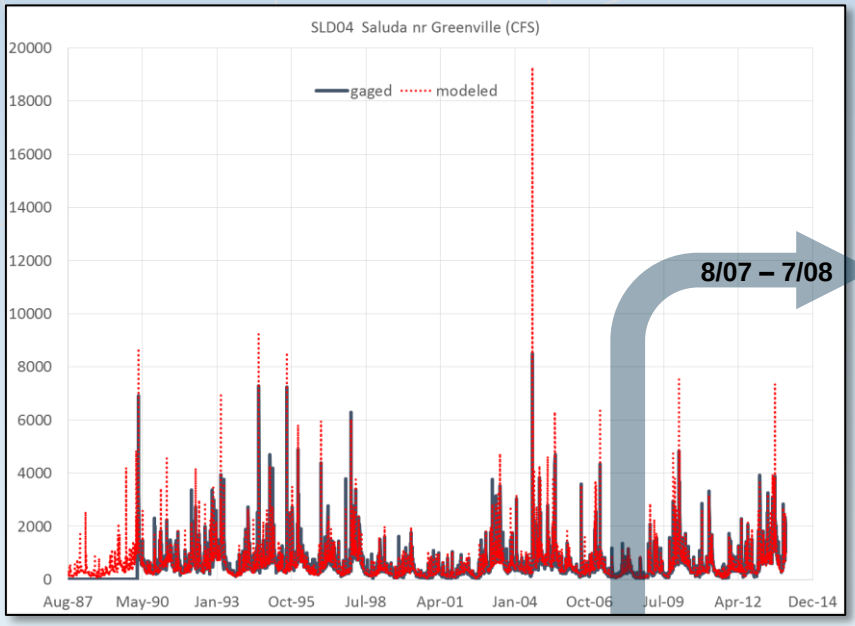
Monthly Flow Percentiles Comparison



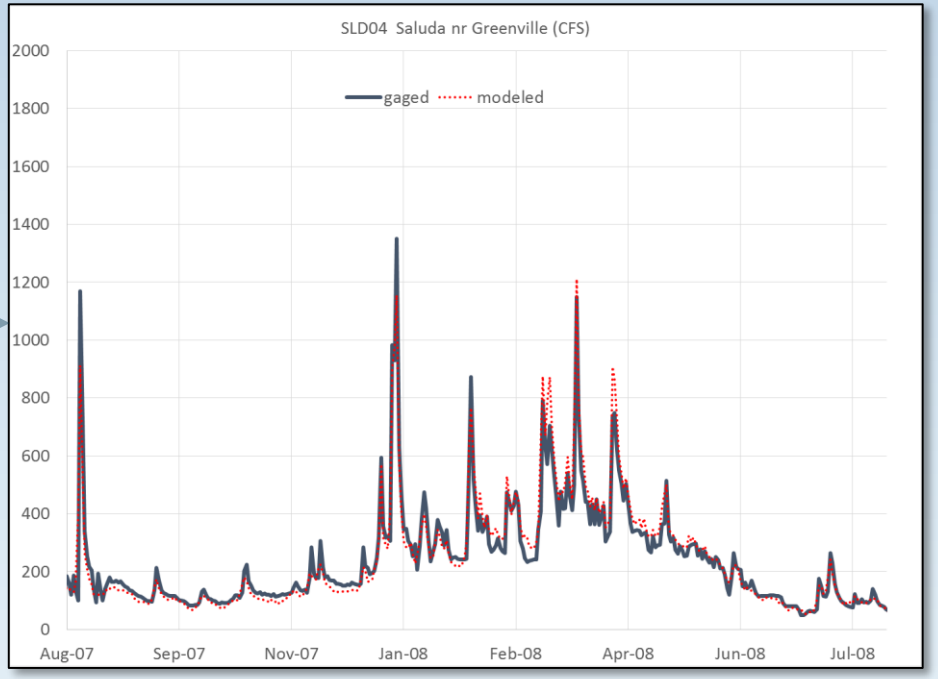
Annual Average Flow Comparison

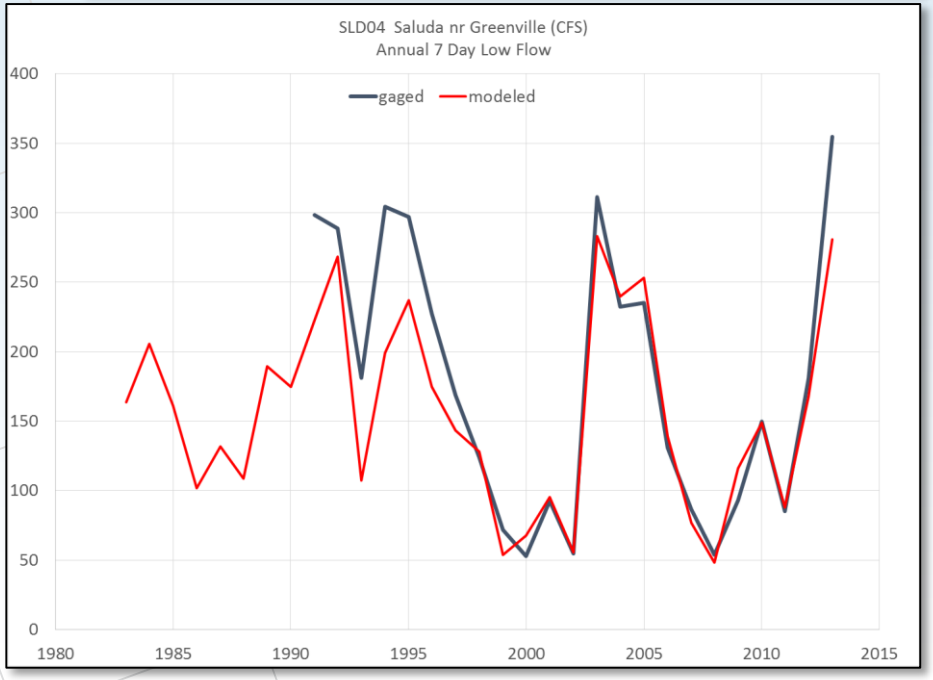


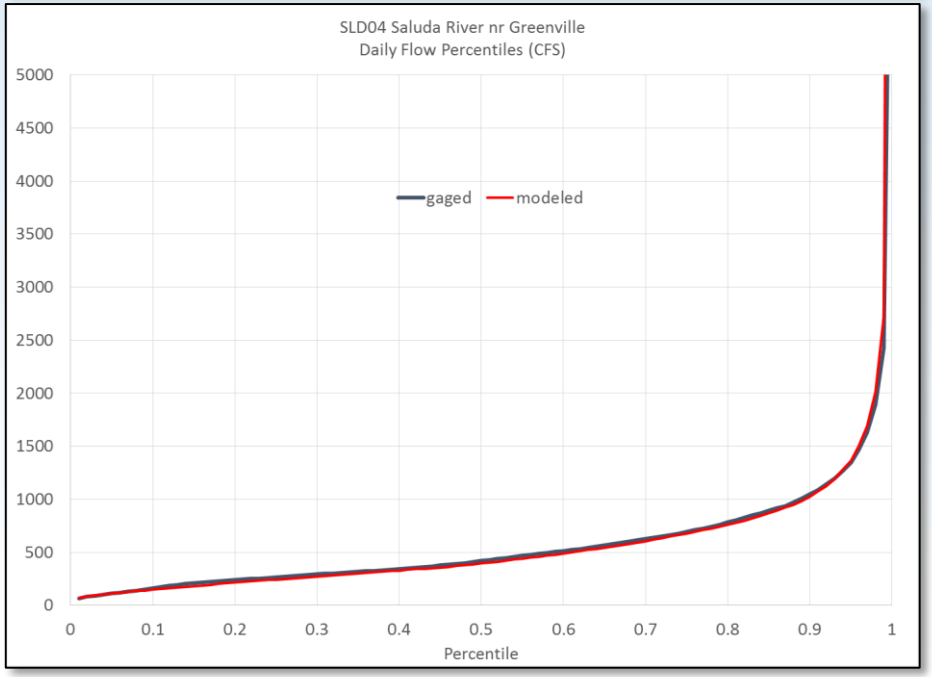
Daily Comparison



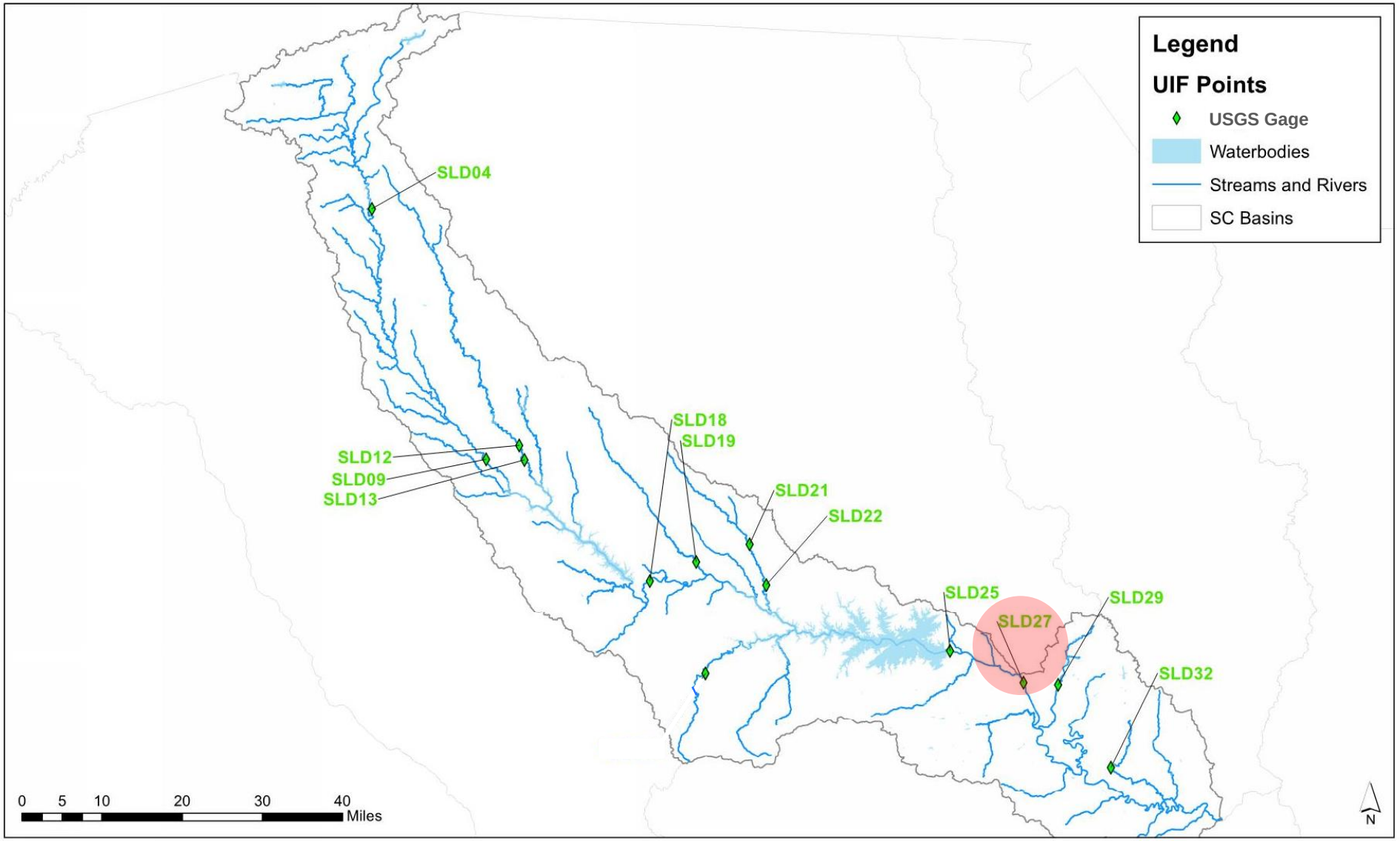
8/07 – 7/08



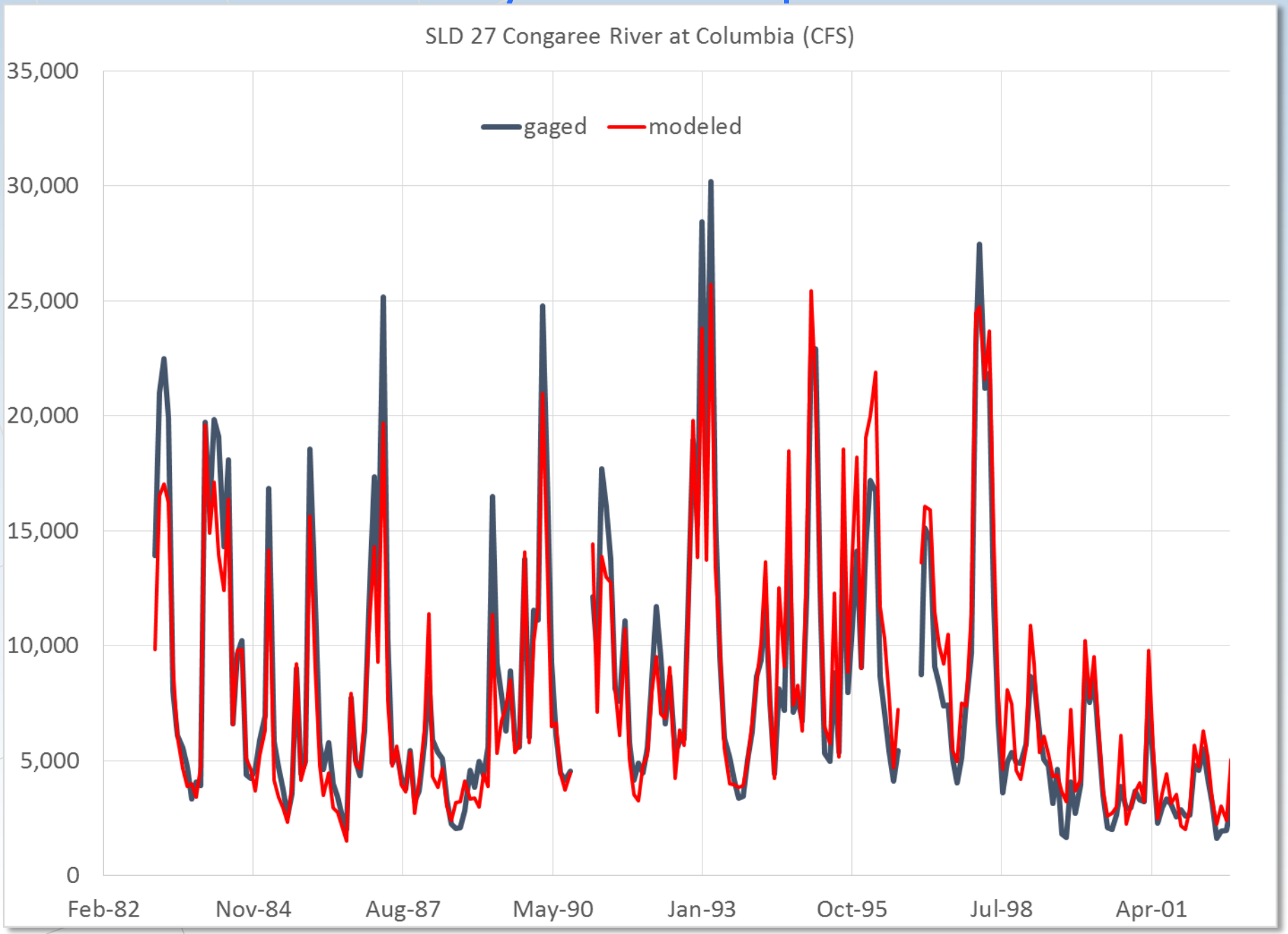




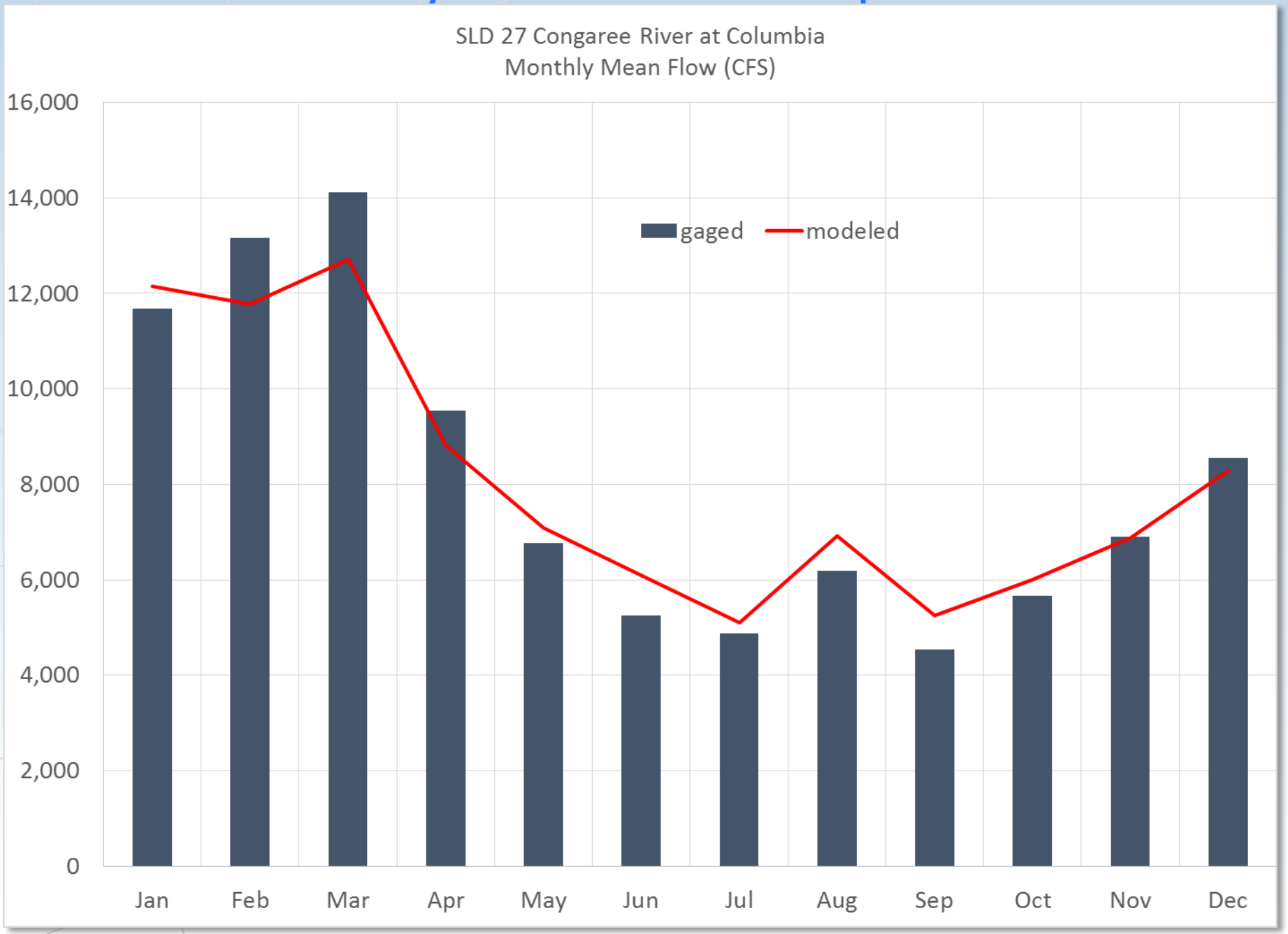
Congaree River at Columbia



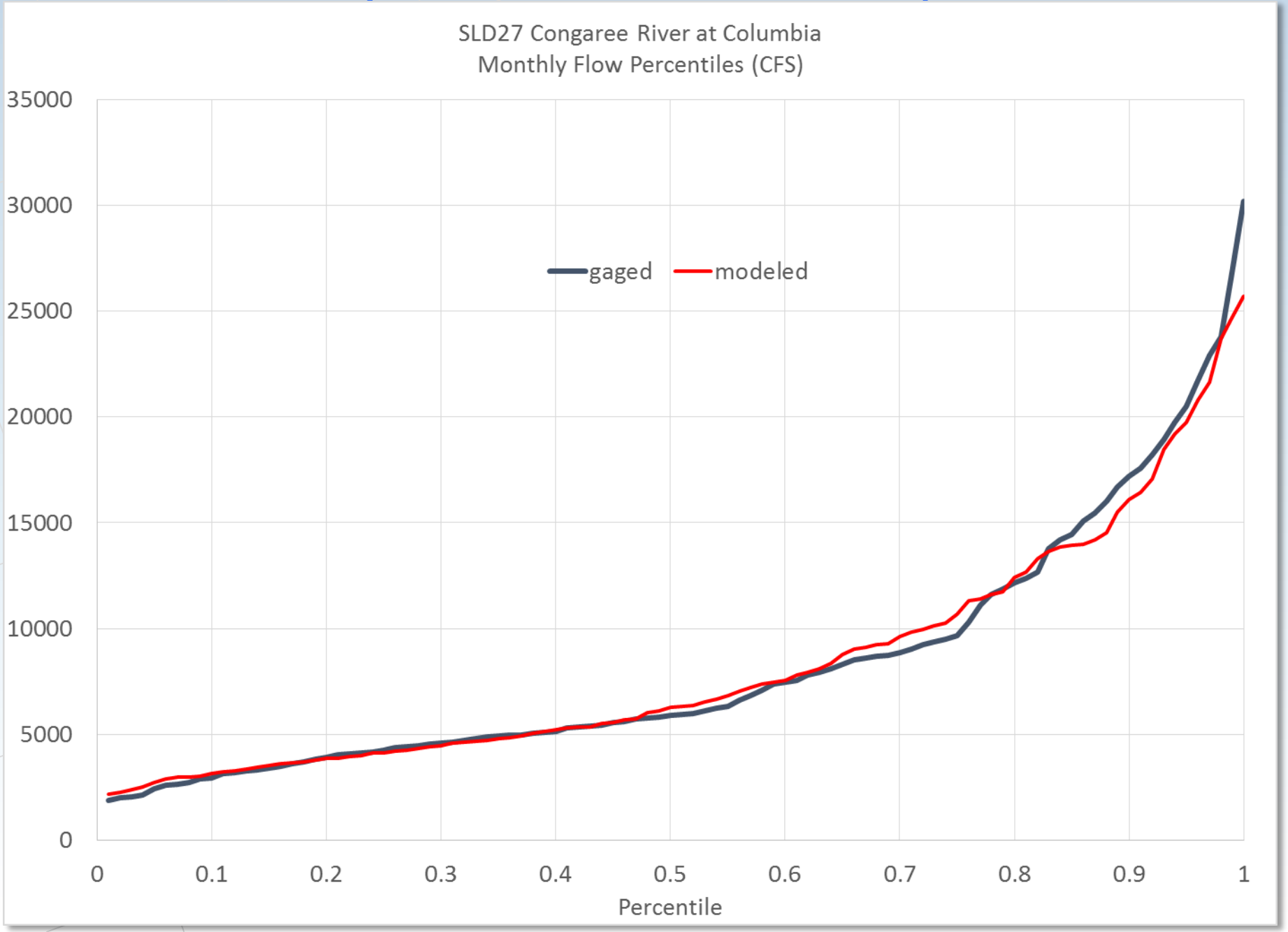
Monthly Flow Comparison



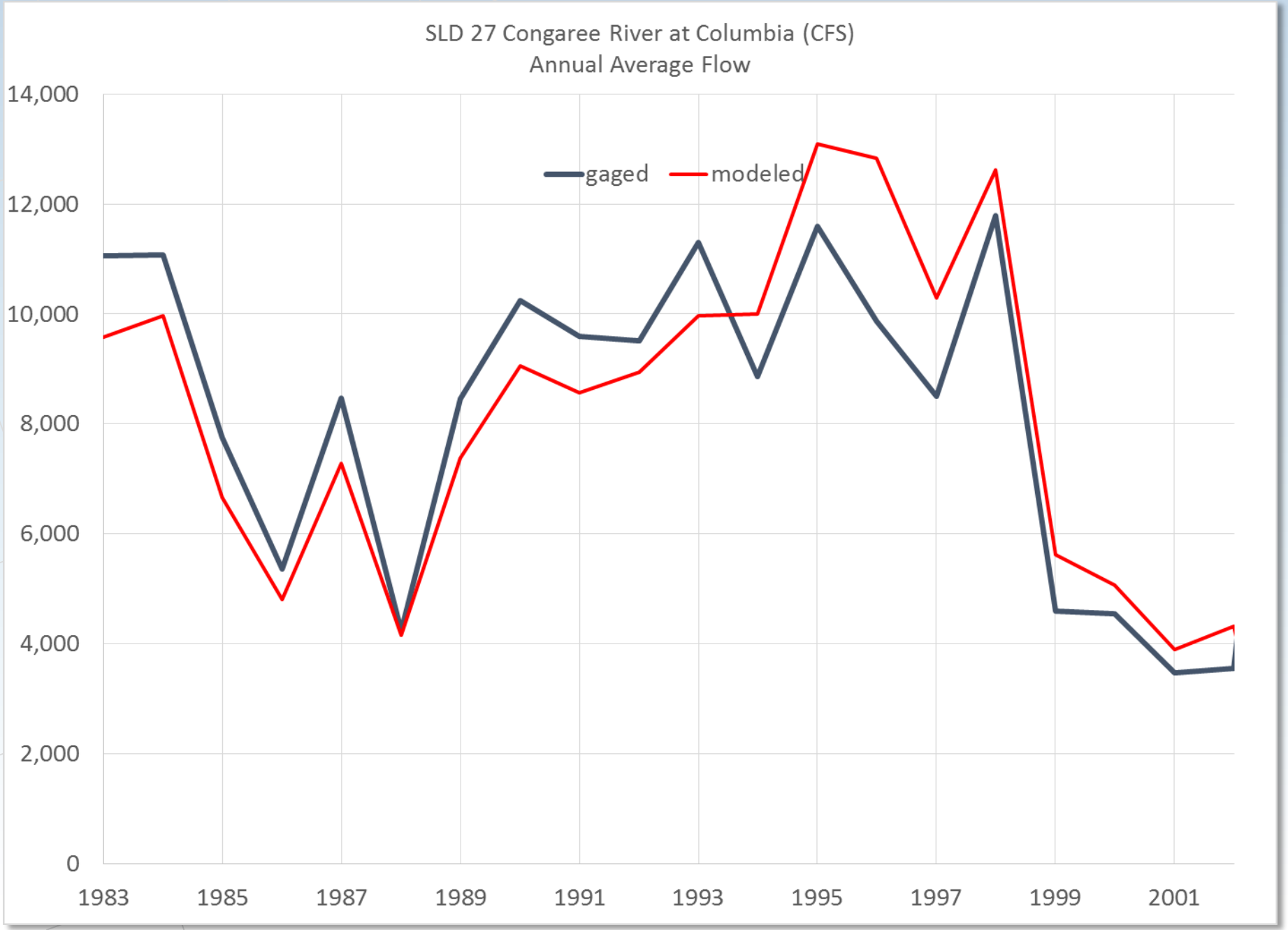
Monthly Mean Flow Comparison



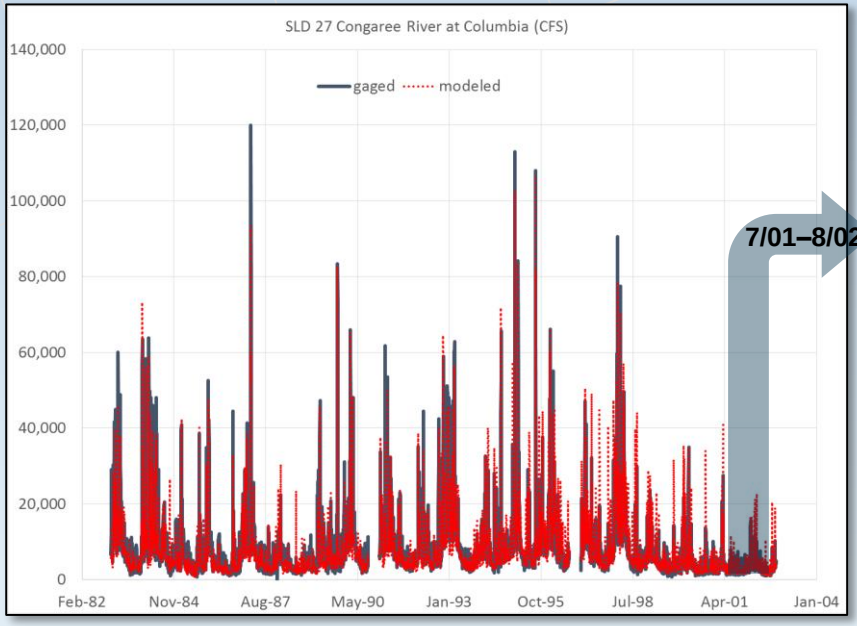
Monthly Flow Percentiles Comparison



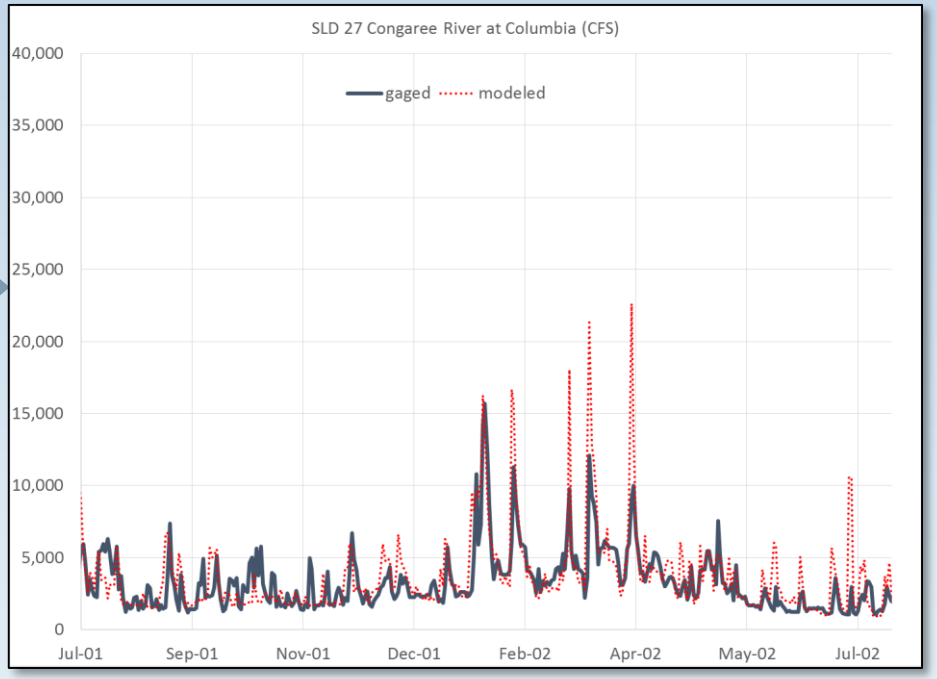
Annual Average Flow Comparison

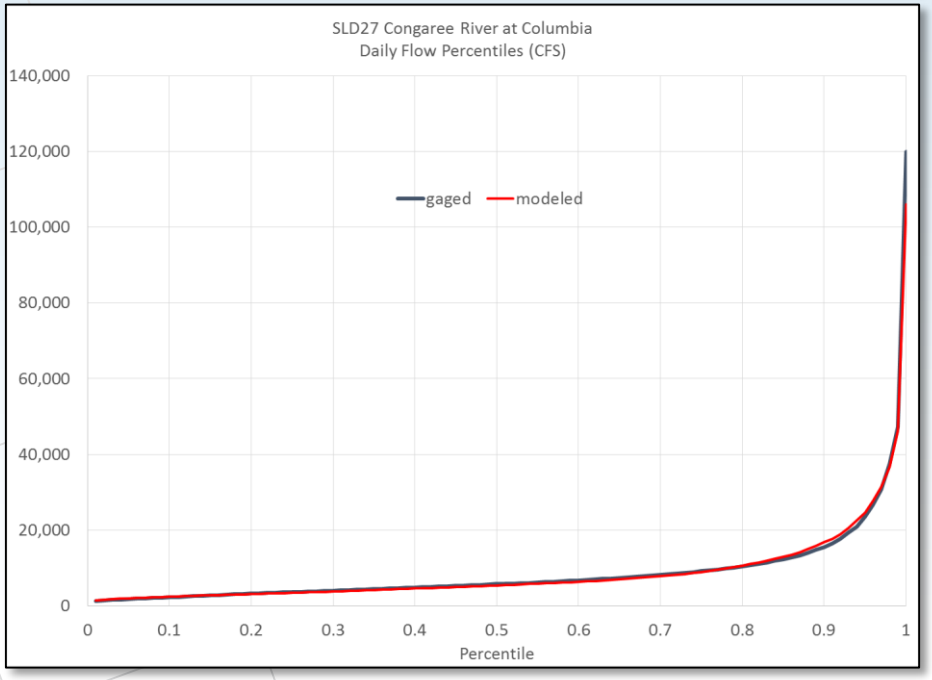


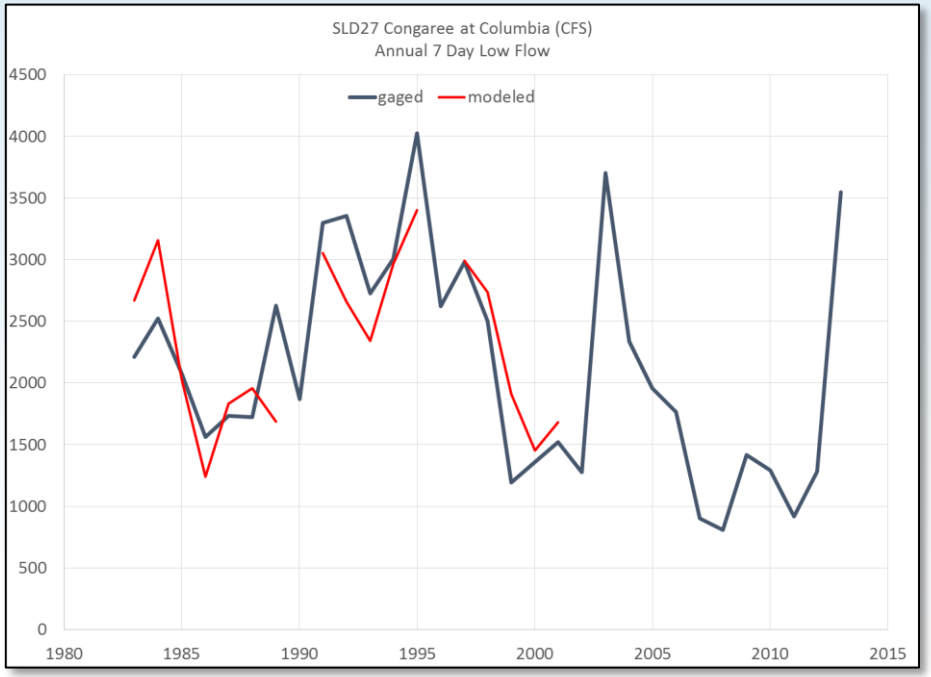
Daily Comparison



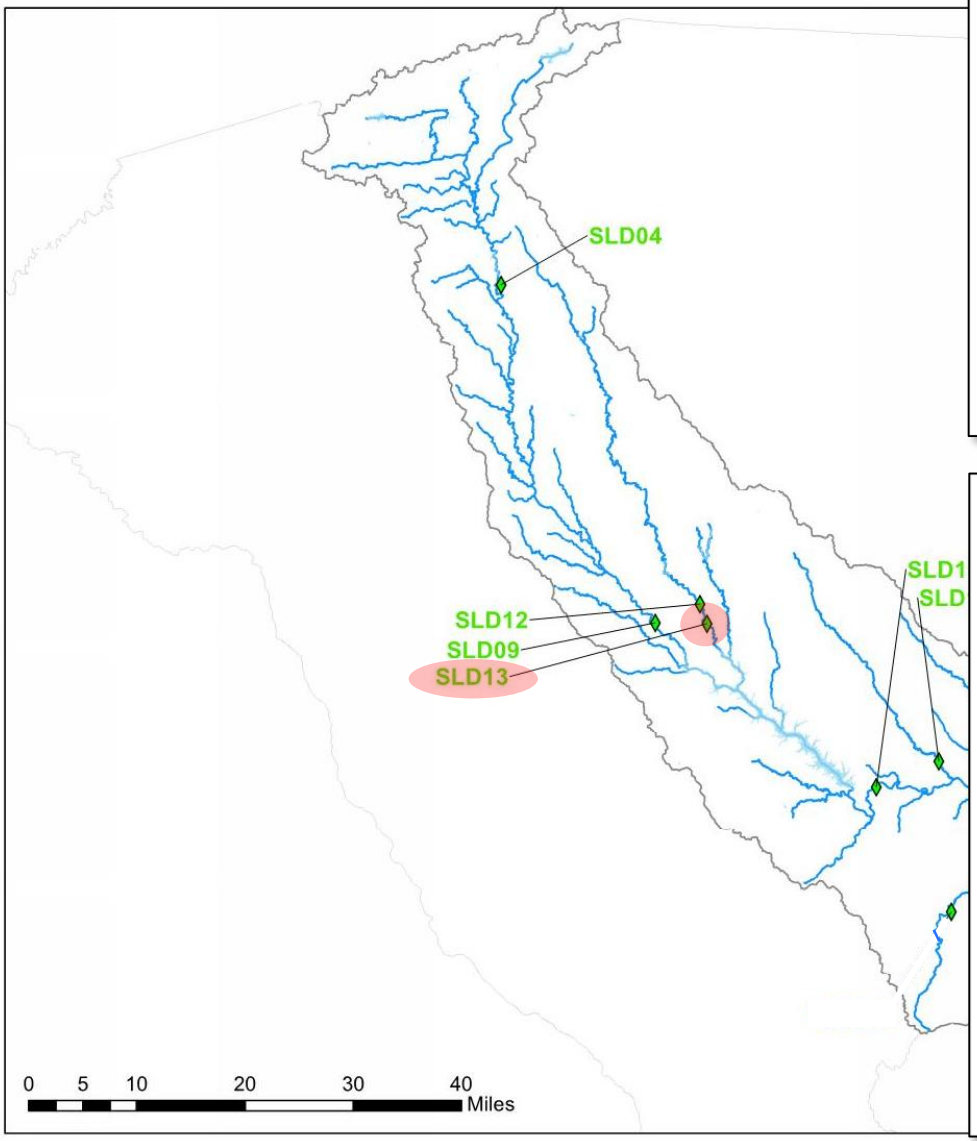
7/01–8/02

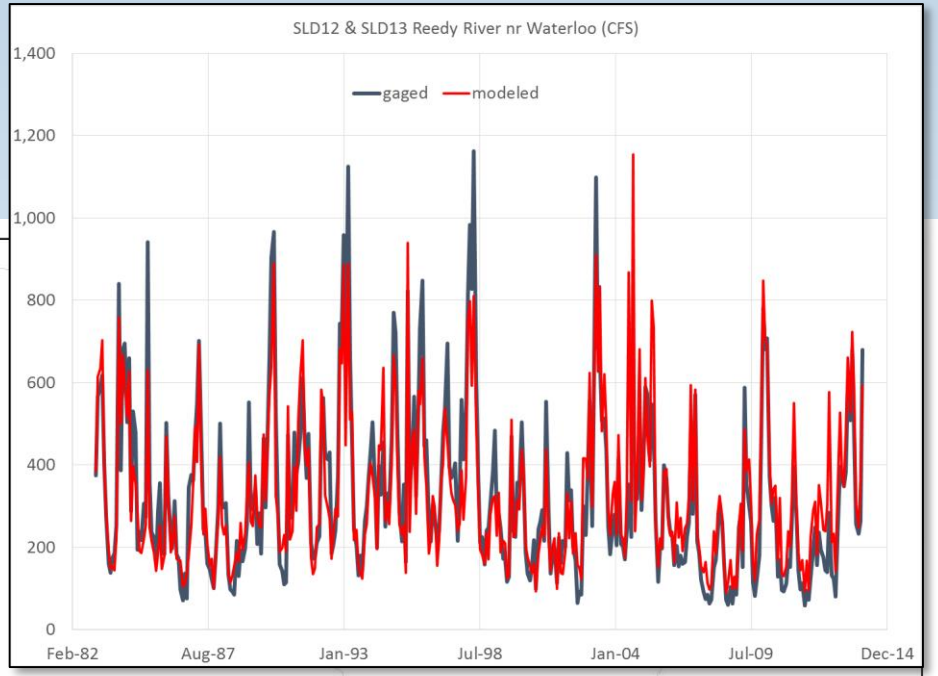


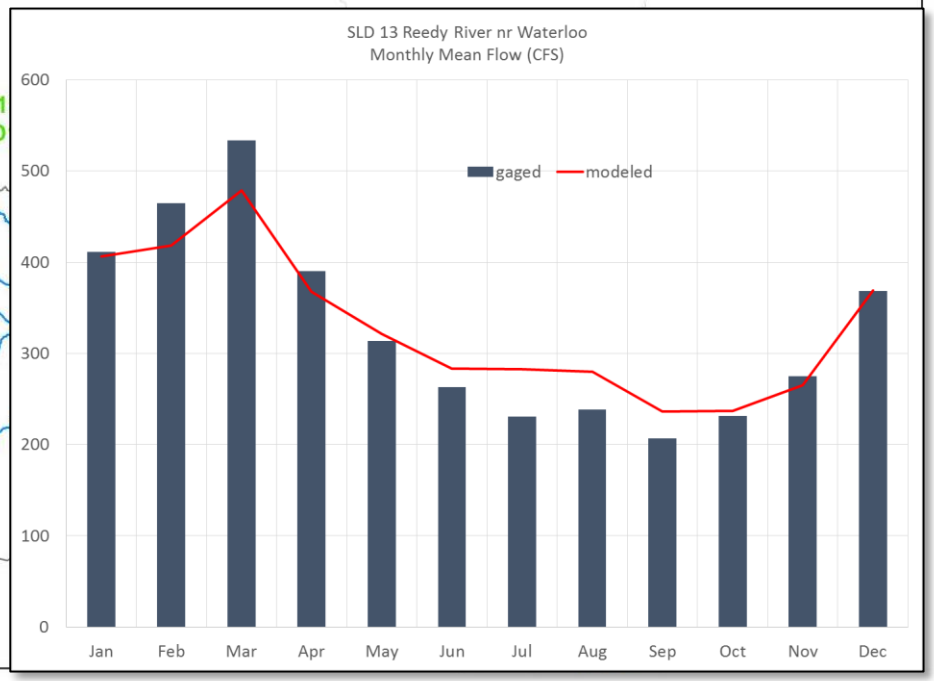




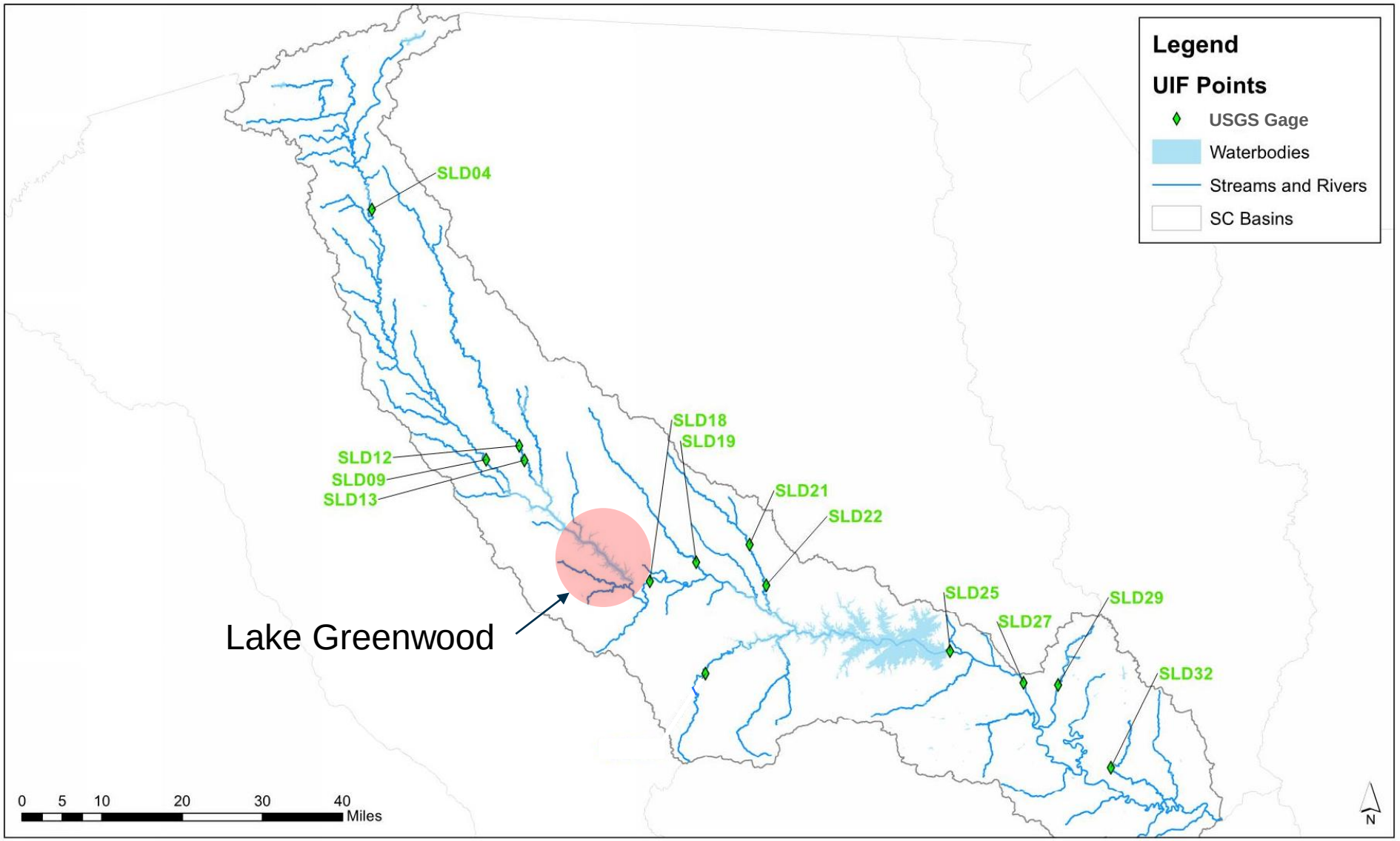
Reedy River Near Waterloo



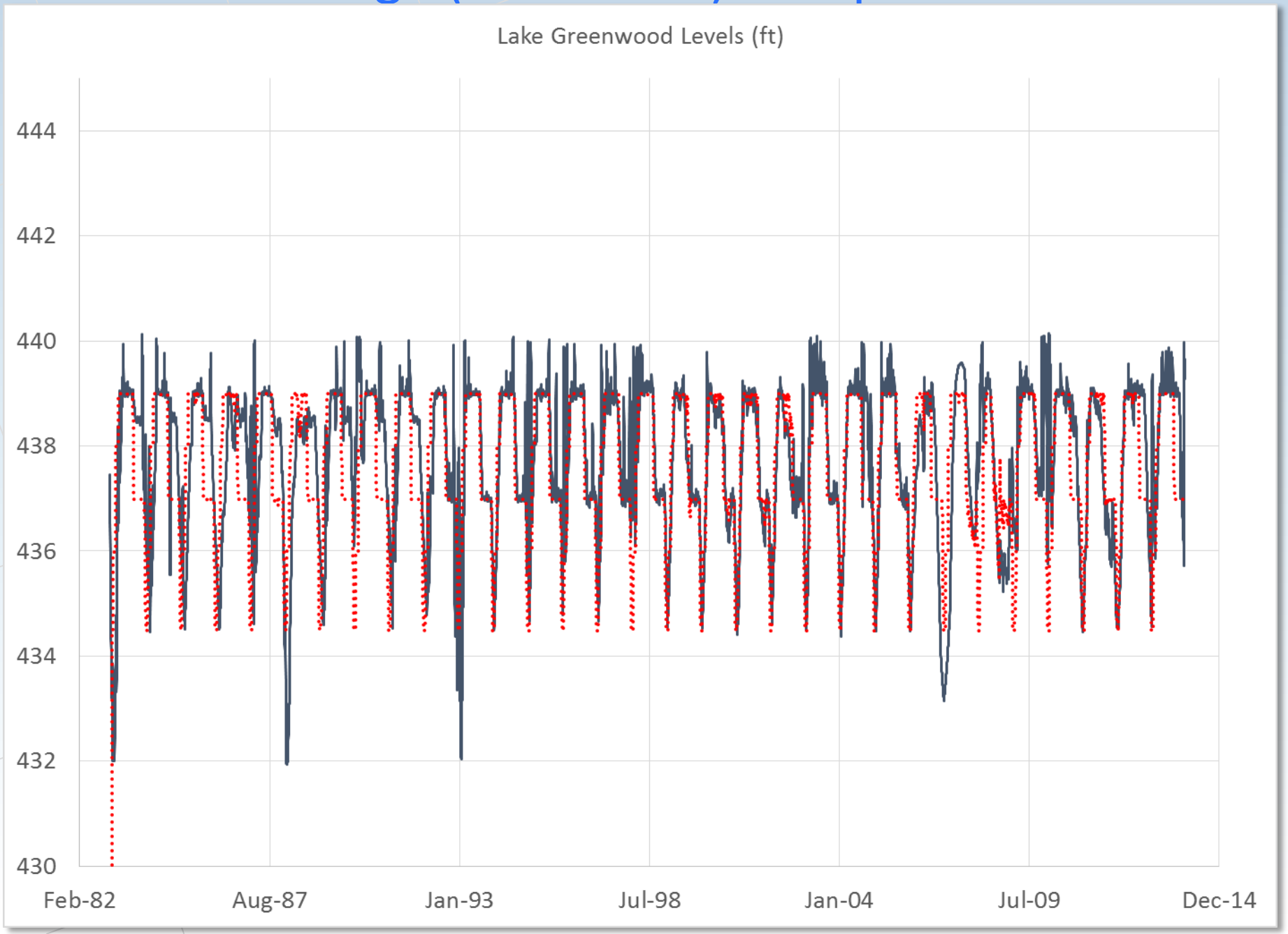




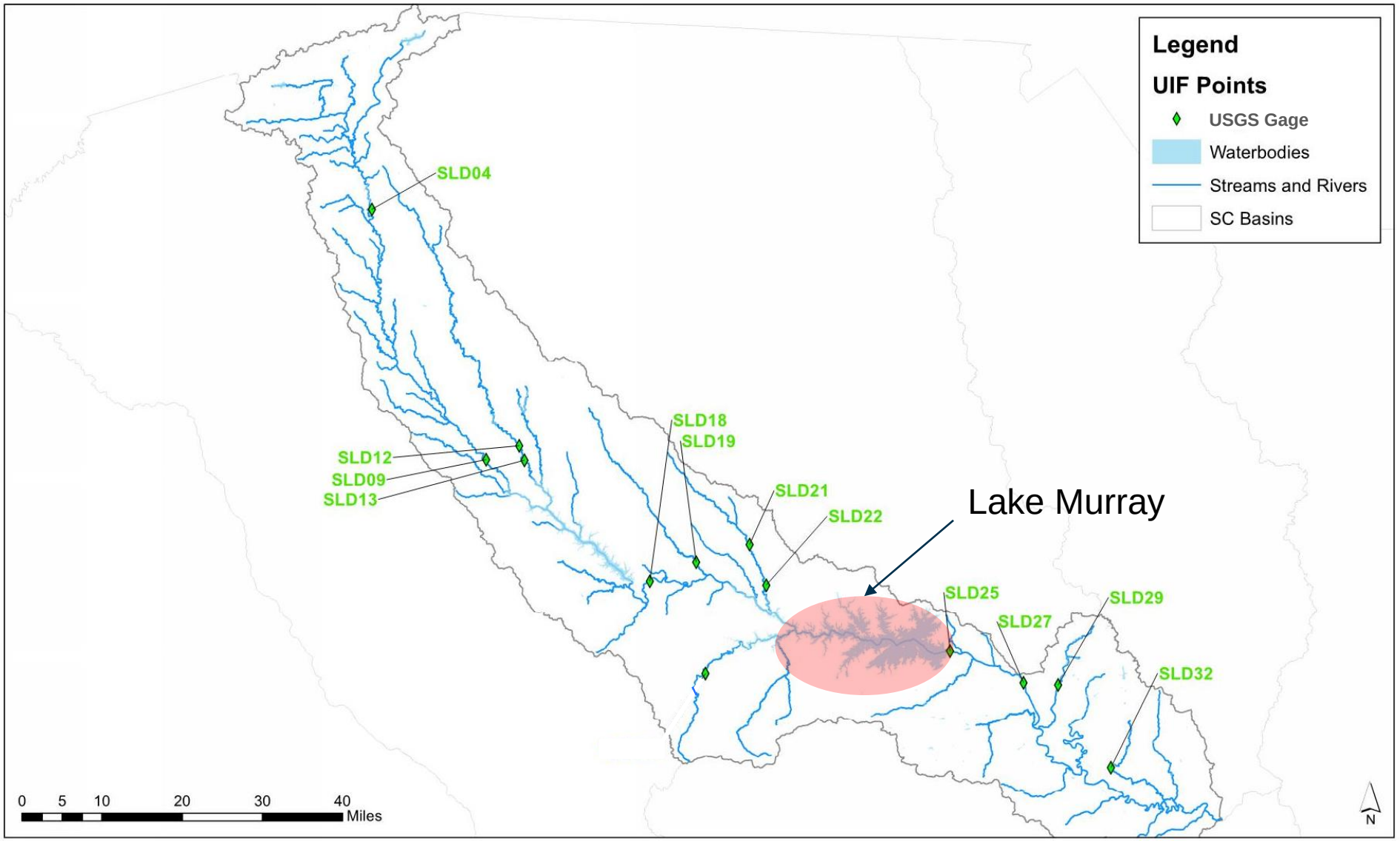
Lake Greenwood



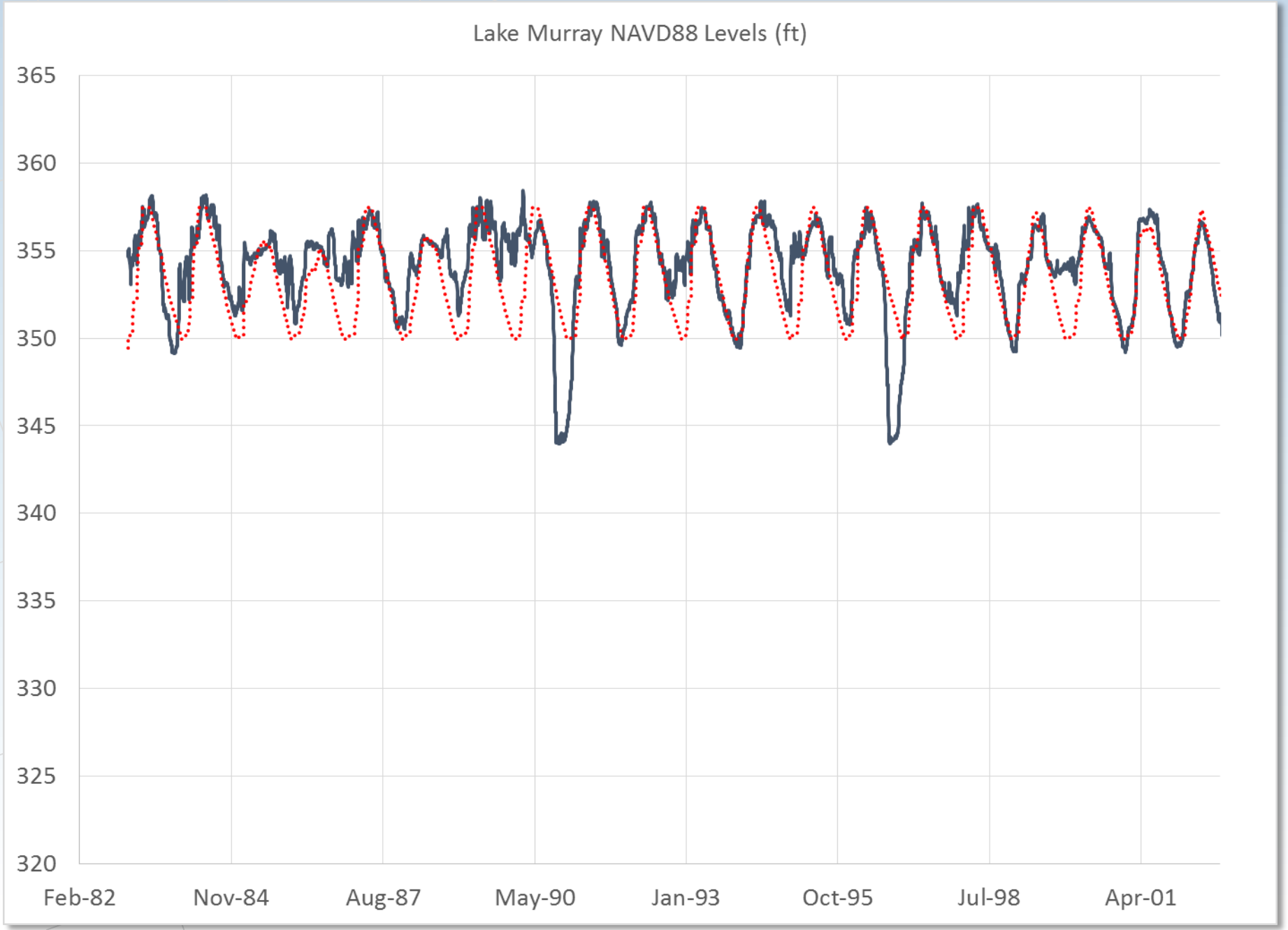
Storage (Lake Level) Comparison



Lake Murray


Legend
UIF Points
USGS Gage
Waterbodies
Streams and Rivers
SC Basins
SLD04
SLD12
SLD09
SLD13
SLD18
SLD19
SLD21
SLD22
Lake Murray
SLD25
SLD27
SLD29
SLD32
0 5 10 20 30 40
Miles
N

Storage (Lake Level) Comparison



SWAM Calibration/Validation Summary

- For all sites, modeled mean flow values, averaged over the full period of record, are within 1% of measured mean flows
- Monthly mean flows percentile deviations are all generally within 10-20% with no clear bias
- Modeled low flow values (as represented by 7Q10 flows) are within 2% of measured values at mainstem gages SLD04, SLD18, and SLD25, and 35% at SLD09 and SLD27.
- The model adequately hindcasts delivered water supply for each water user in the model (no significant shortfalls).

Saluda River Basin

BASELINE MODEL

Baseline Model

- Represents current demands and operations combined with an extended period of estimated hydrology
  - Most demands reflect 2005-2014 averages
  - Estimated hydrology from 1925 to 2014
  - Current reservoir rules, guide curves, minimum releases
  - Future rules (e.g., Lake Murray Striped Bass) can be toggled on/off
  - Inactive users are not included
- The baseline model serves as the starting point for future predictive simulations

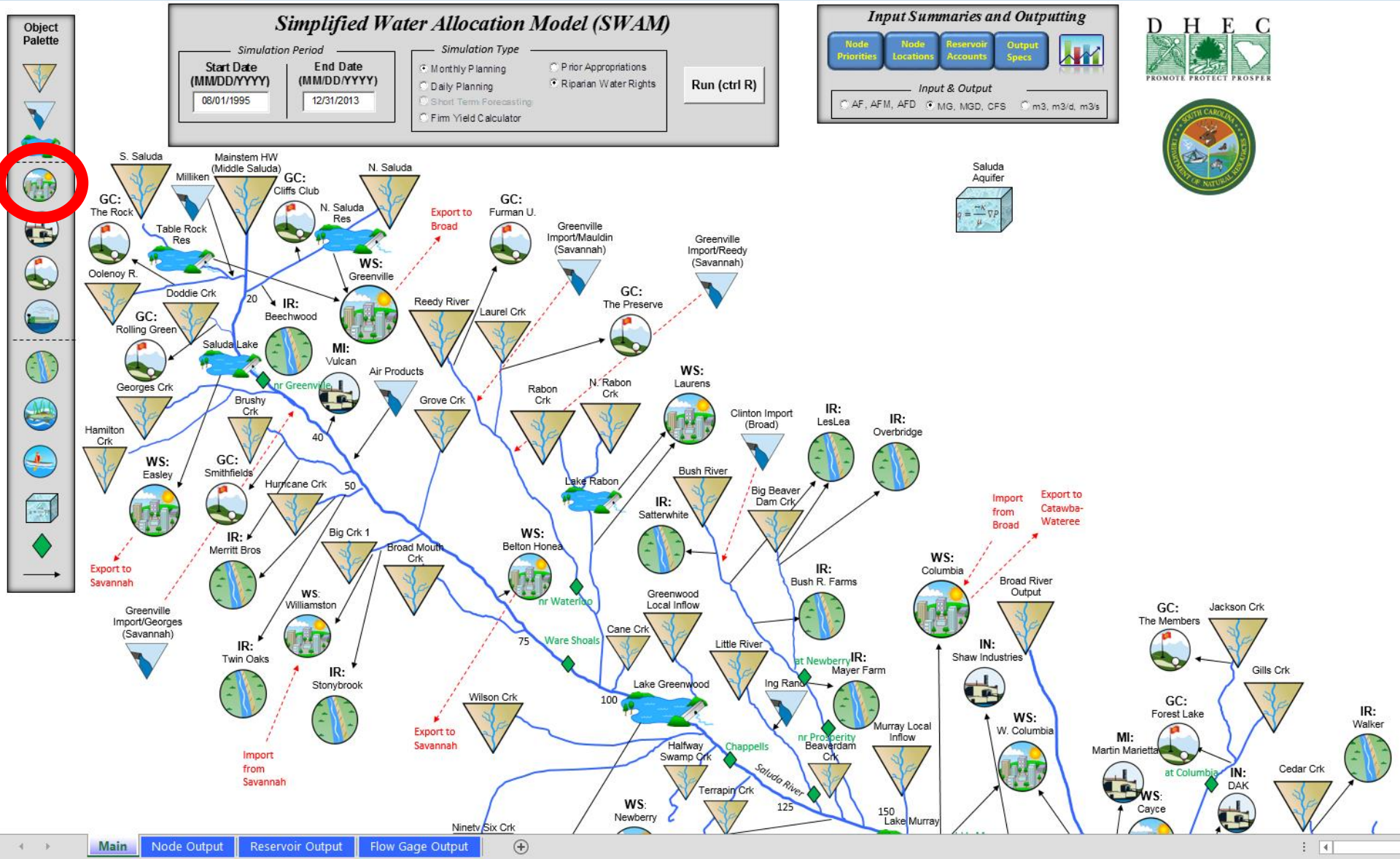
The Models Can Be Used To…

- Determine surface water availability
- Predict where and when future water shortages would occur
- Test alternative water management strategies, new operating rules, and “what-if” scenarios
- Evaluate the impacts of future withdrawals on instream flow needs
- Evaluate interbasin transfers
- Support development of Drought Management Plans
- Compare managed flows to natural flows
- Consolidate hydrologic data

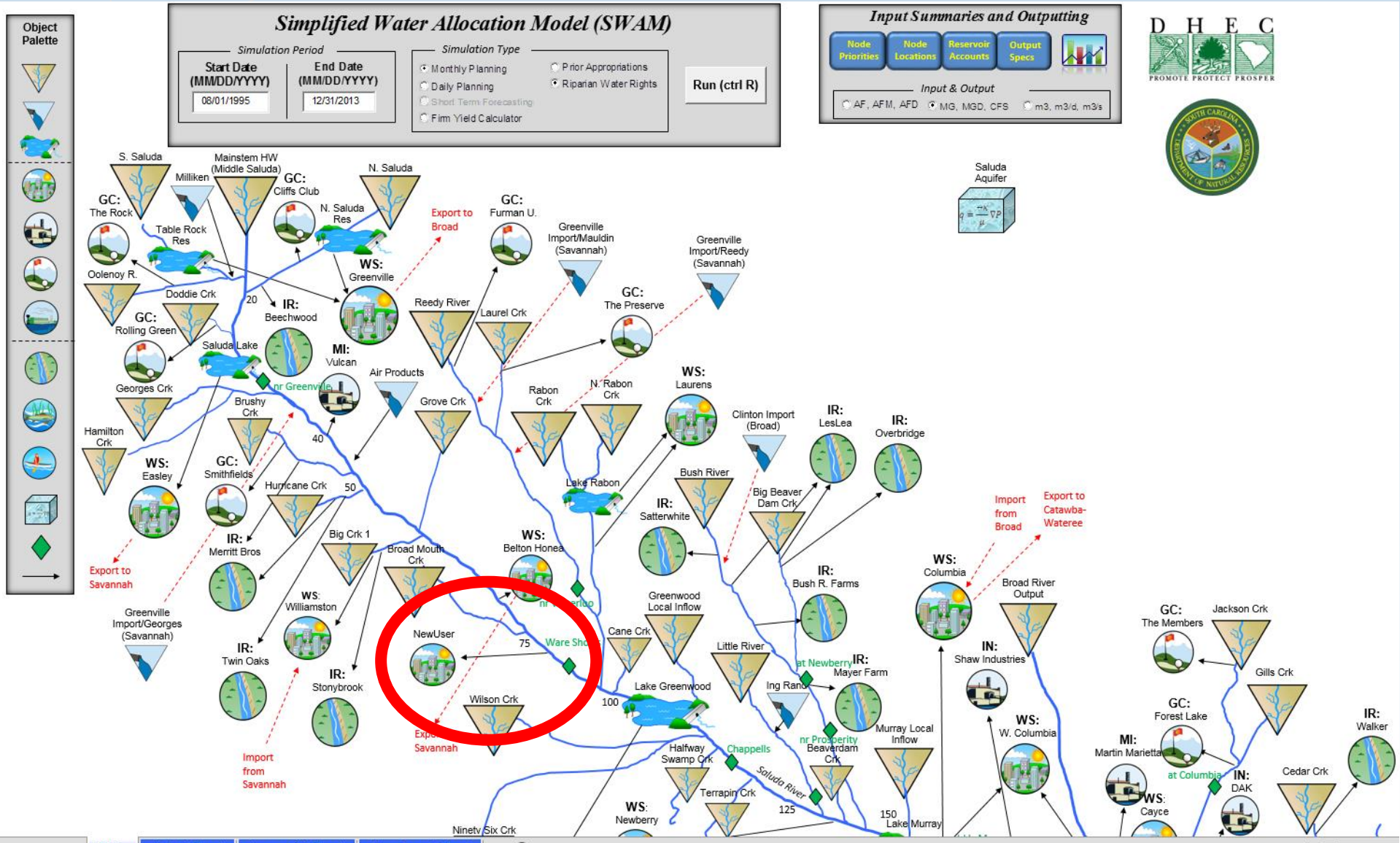
Example Use
Adding a New User

- Add a new M&I permittee near Ware Shoals
  - Demand = 20,000 MGY (55 mgd)
  - *Can the river sustain the new permit, without impacting downstream users?*
- Add a new Instream Flow Object downstream
  - Instream Flow Target = 100 cfs
  - *Are their shortages?*

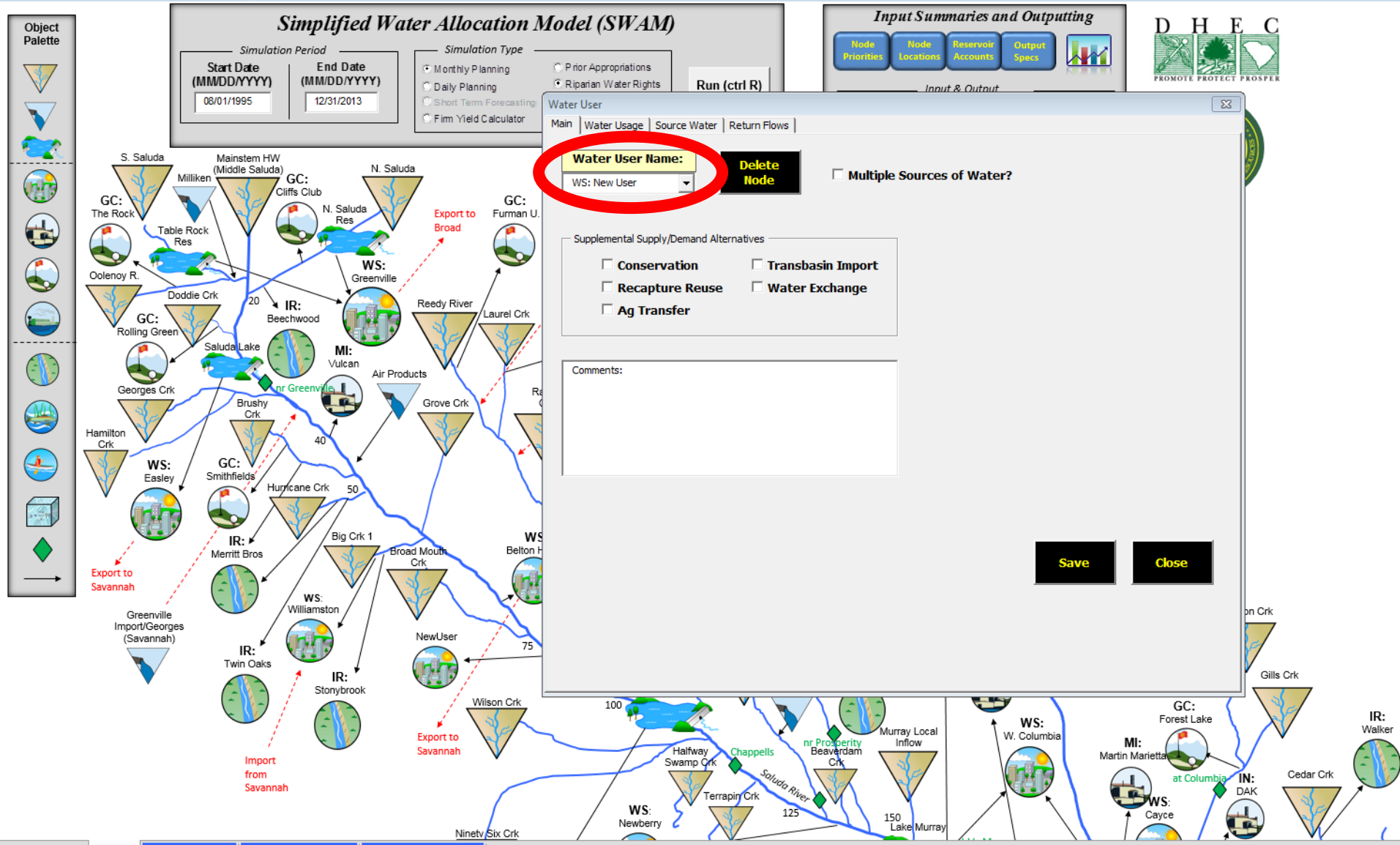
Add a Municipal Water User Object from the Palette



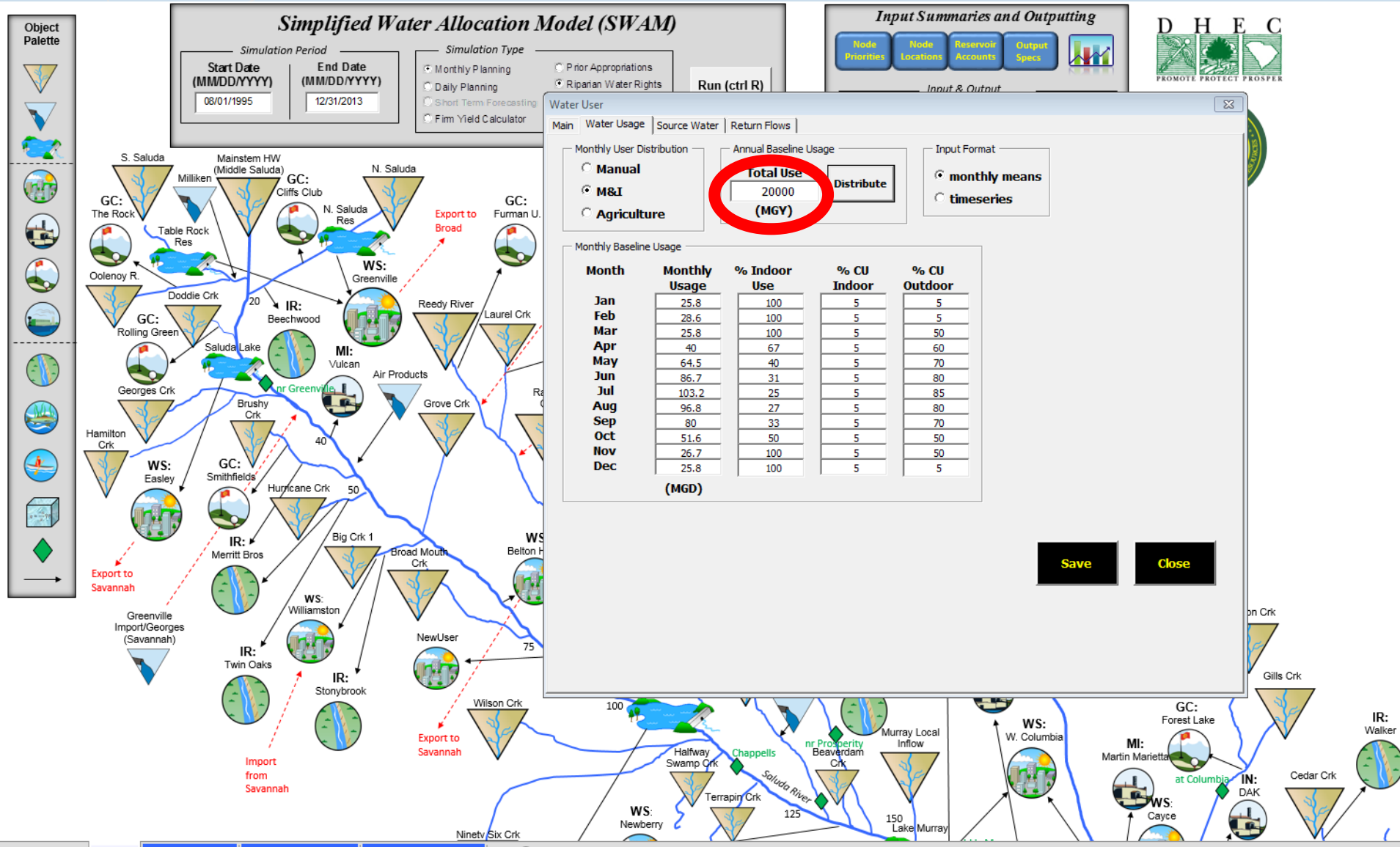
Add a Municipal Water User Object from the Palette



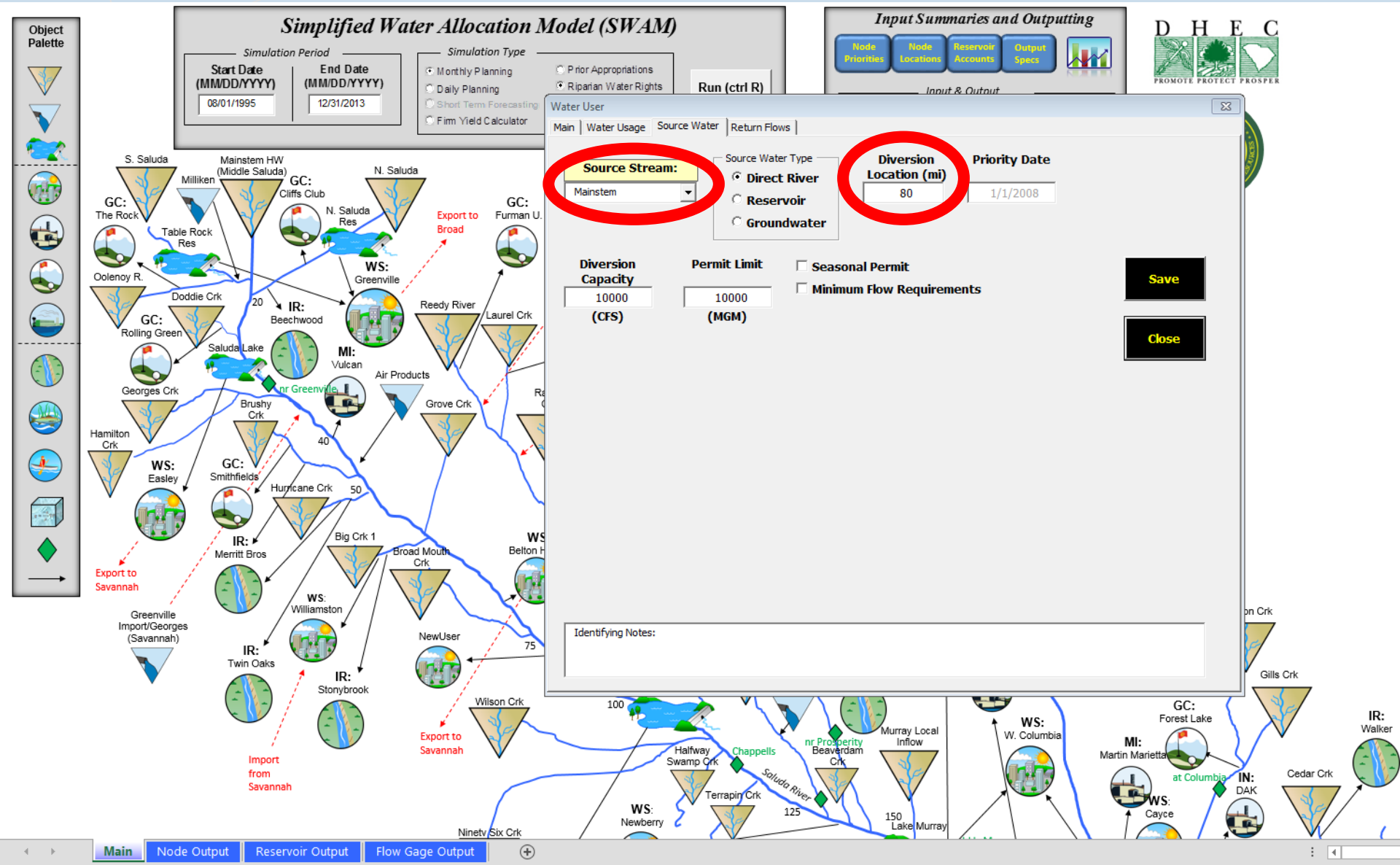
Add the New User in the Water User Dialogue



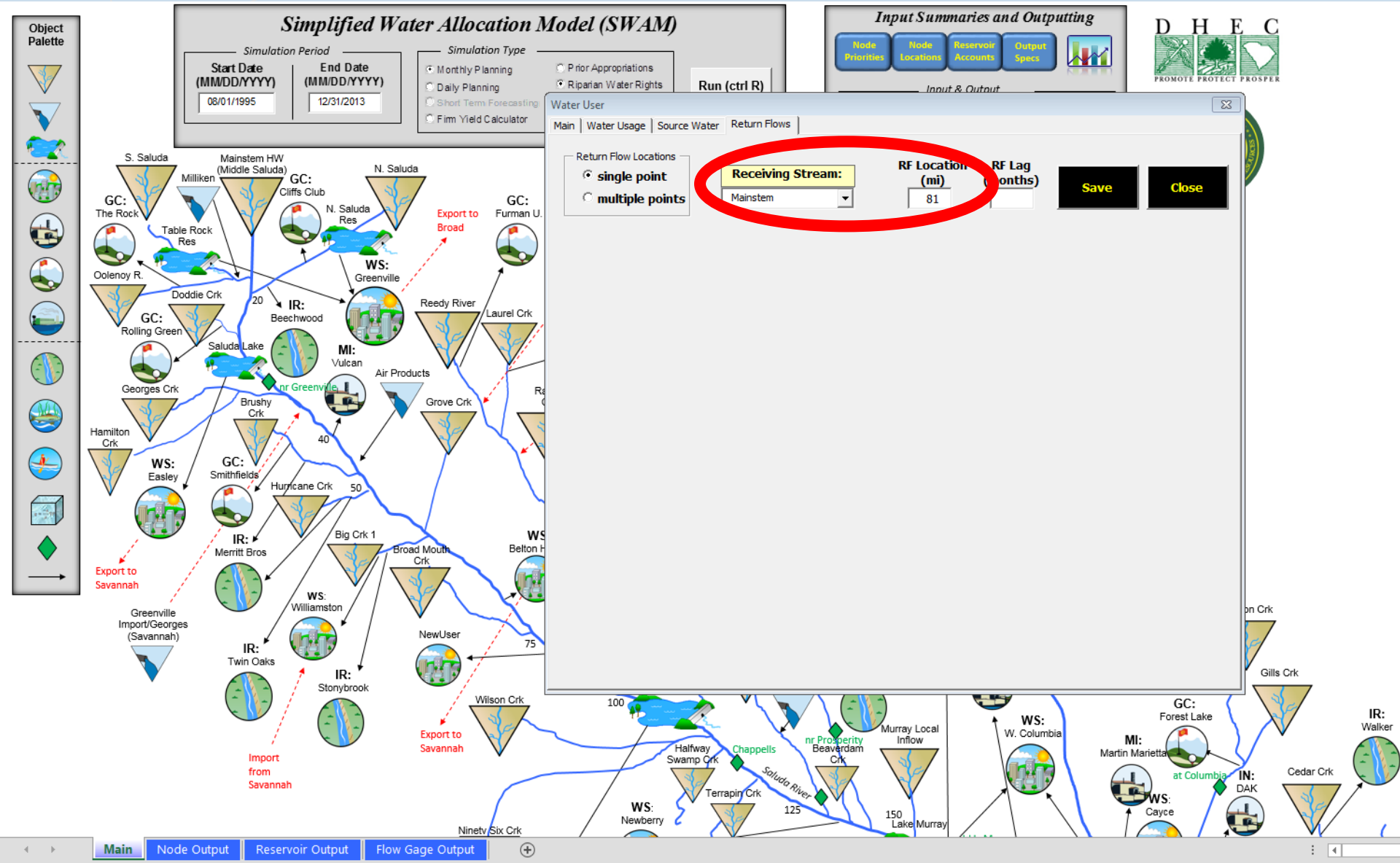
Specify Water Use



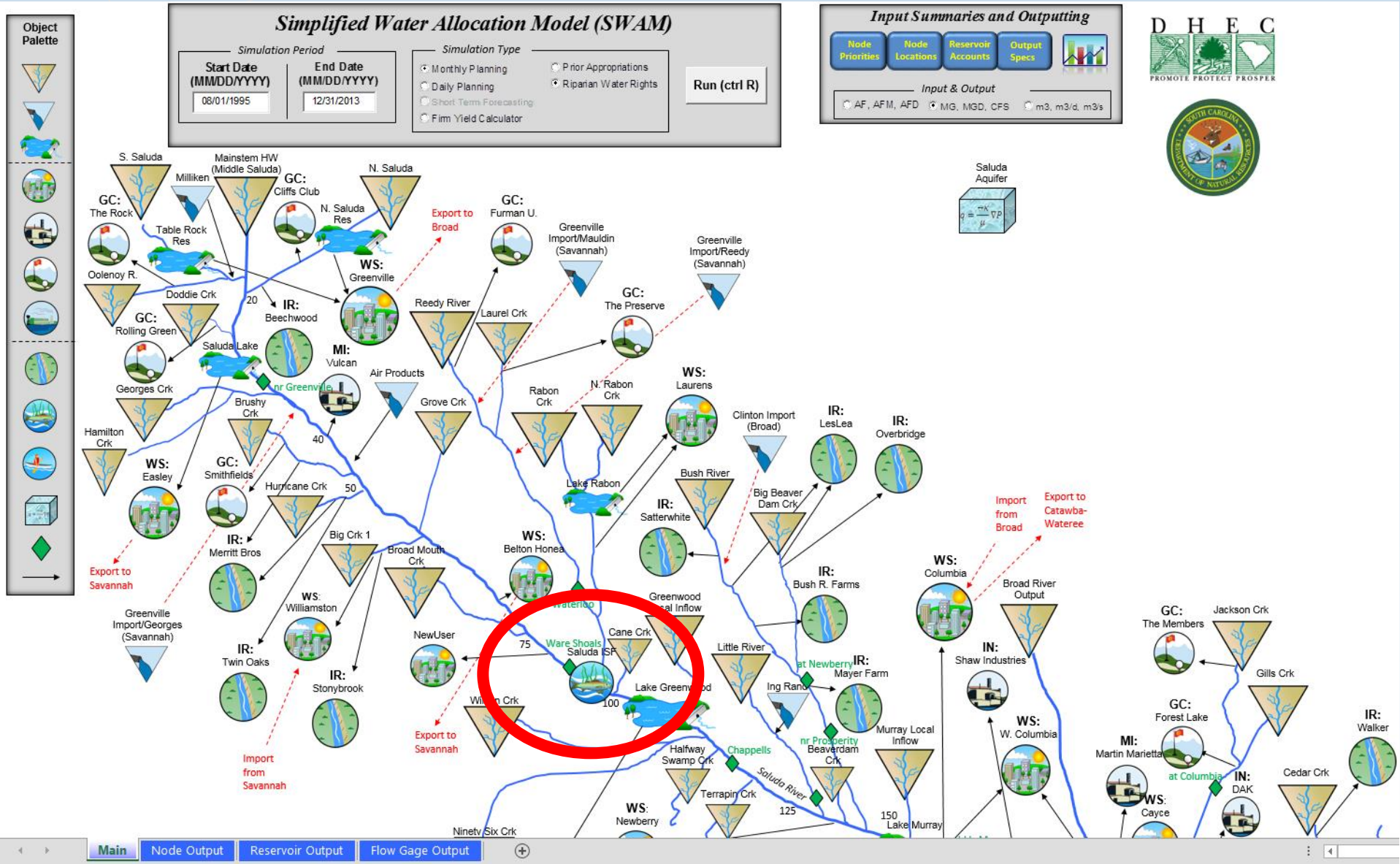
Specify the Source and Diversion Location



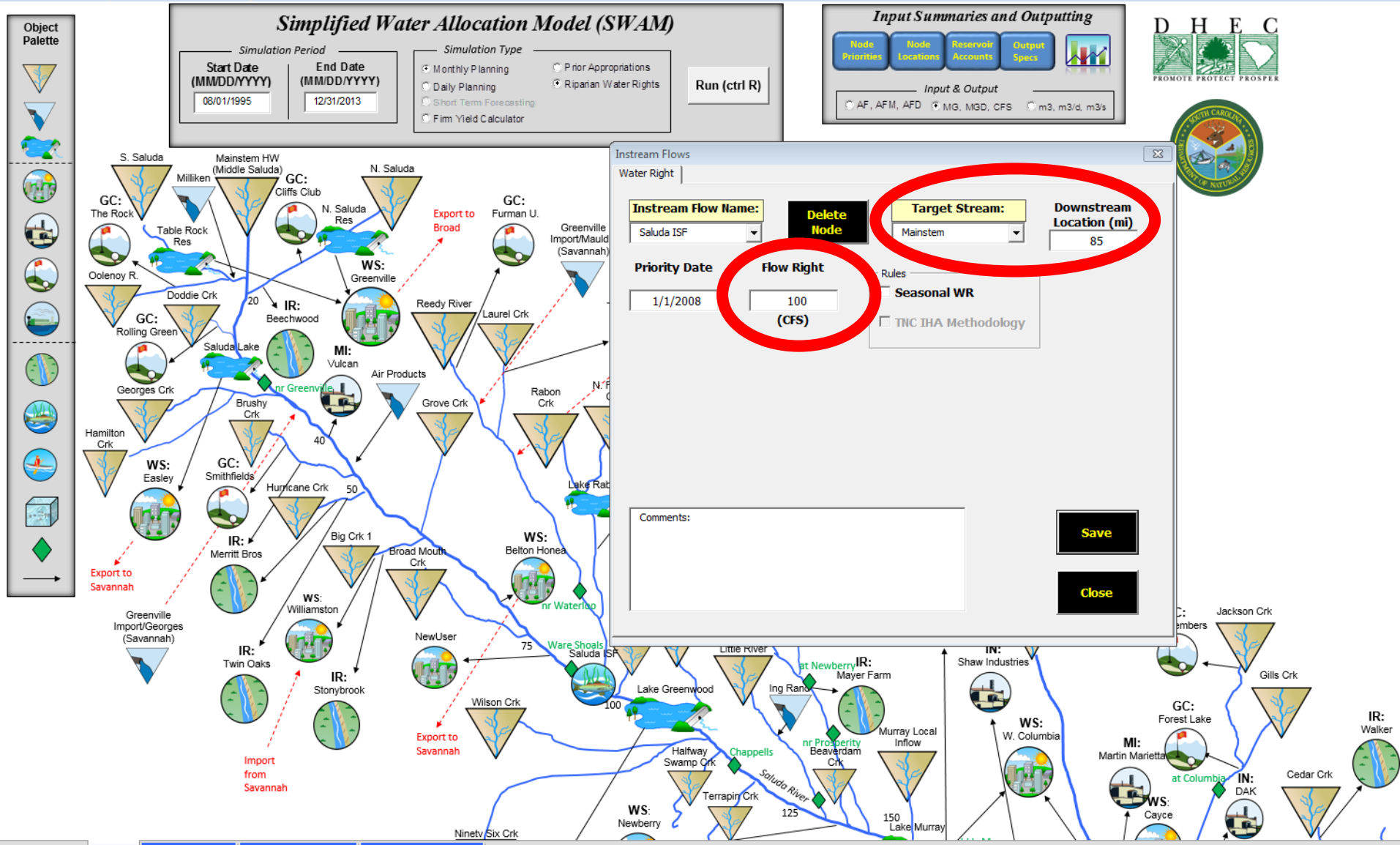
Specify the Return Location



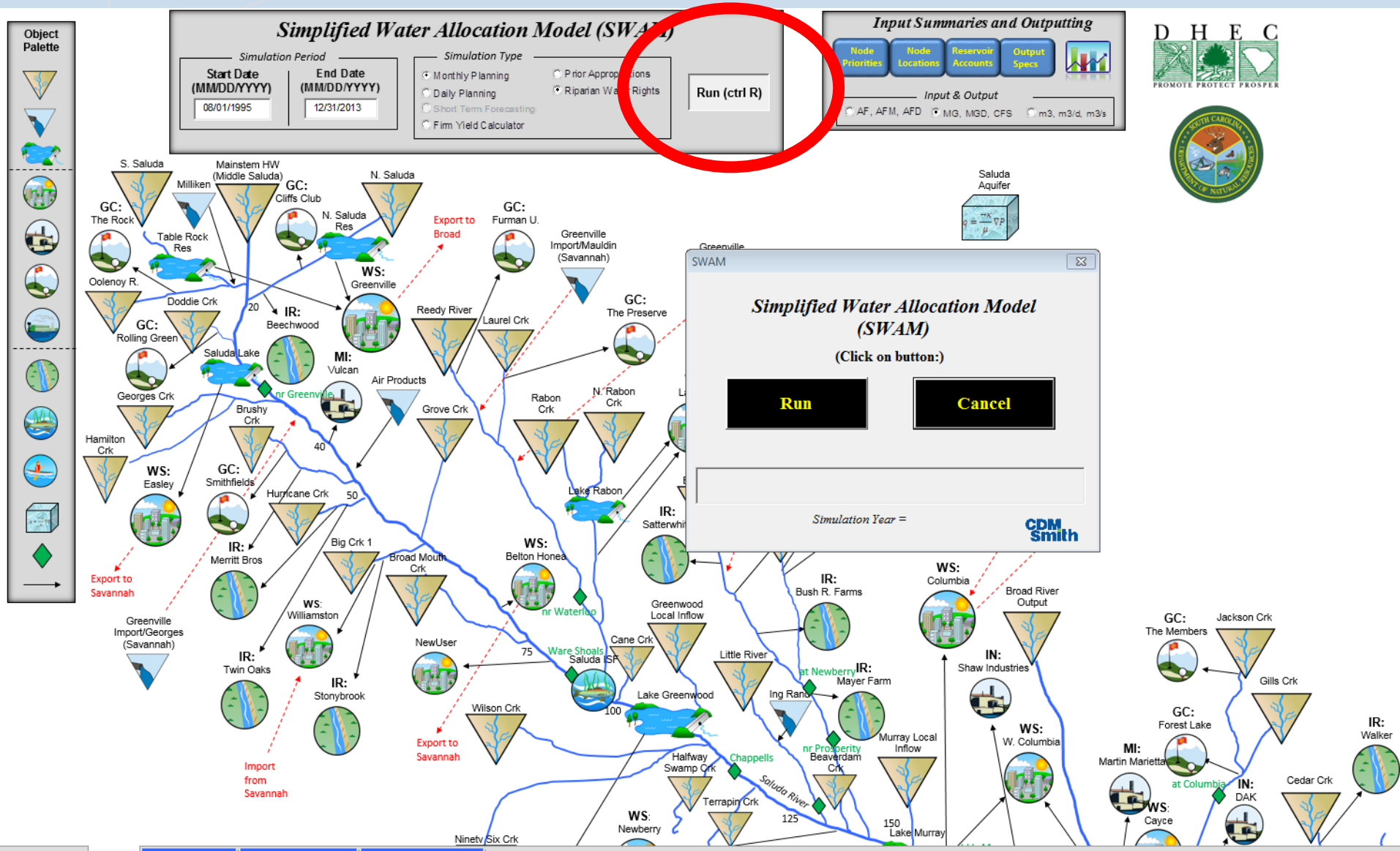
Add an Instream Flow Object from the Palette



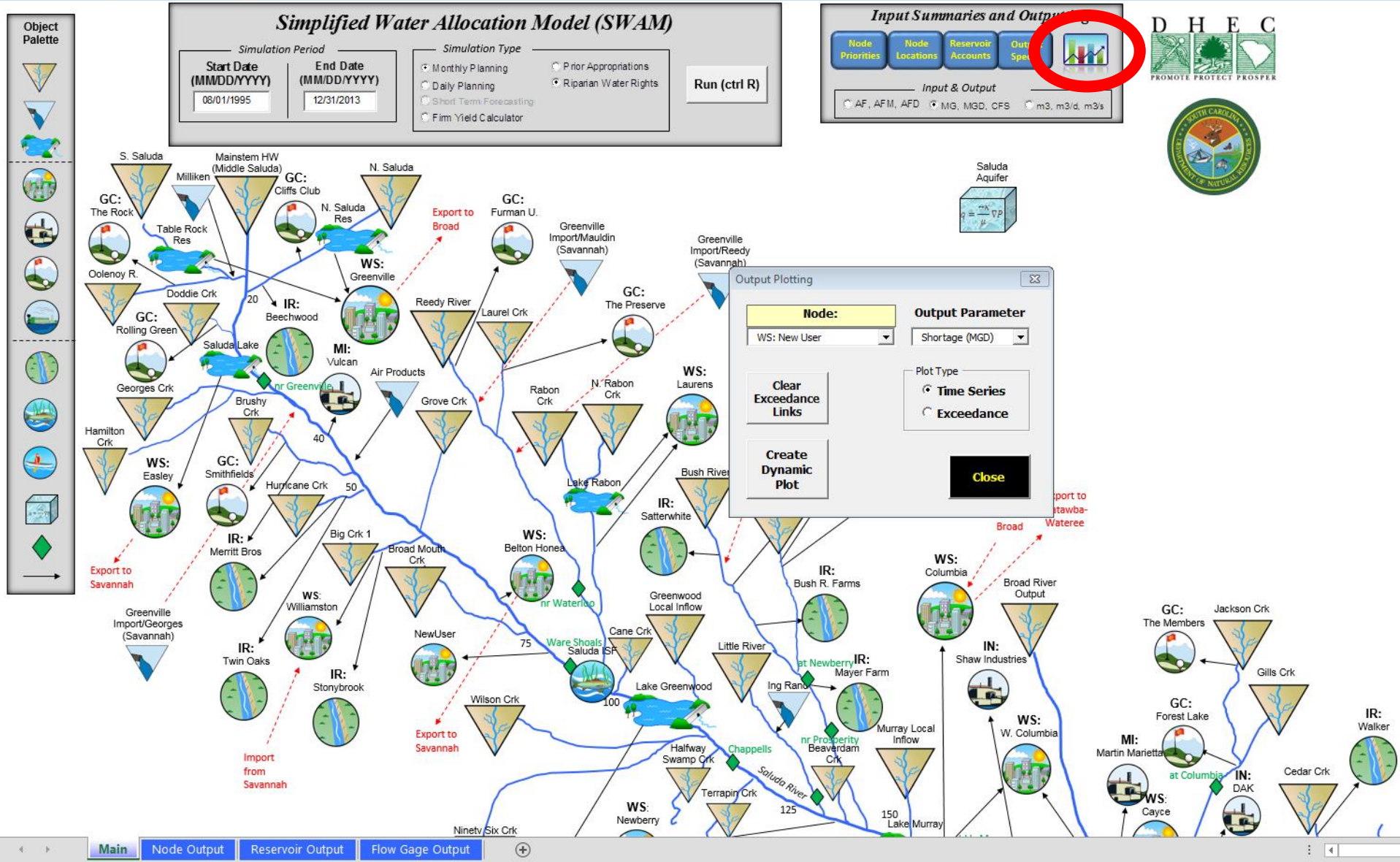
Specify the Instream Flow Amount and Target Stream



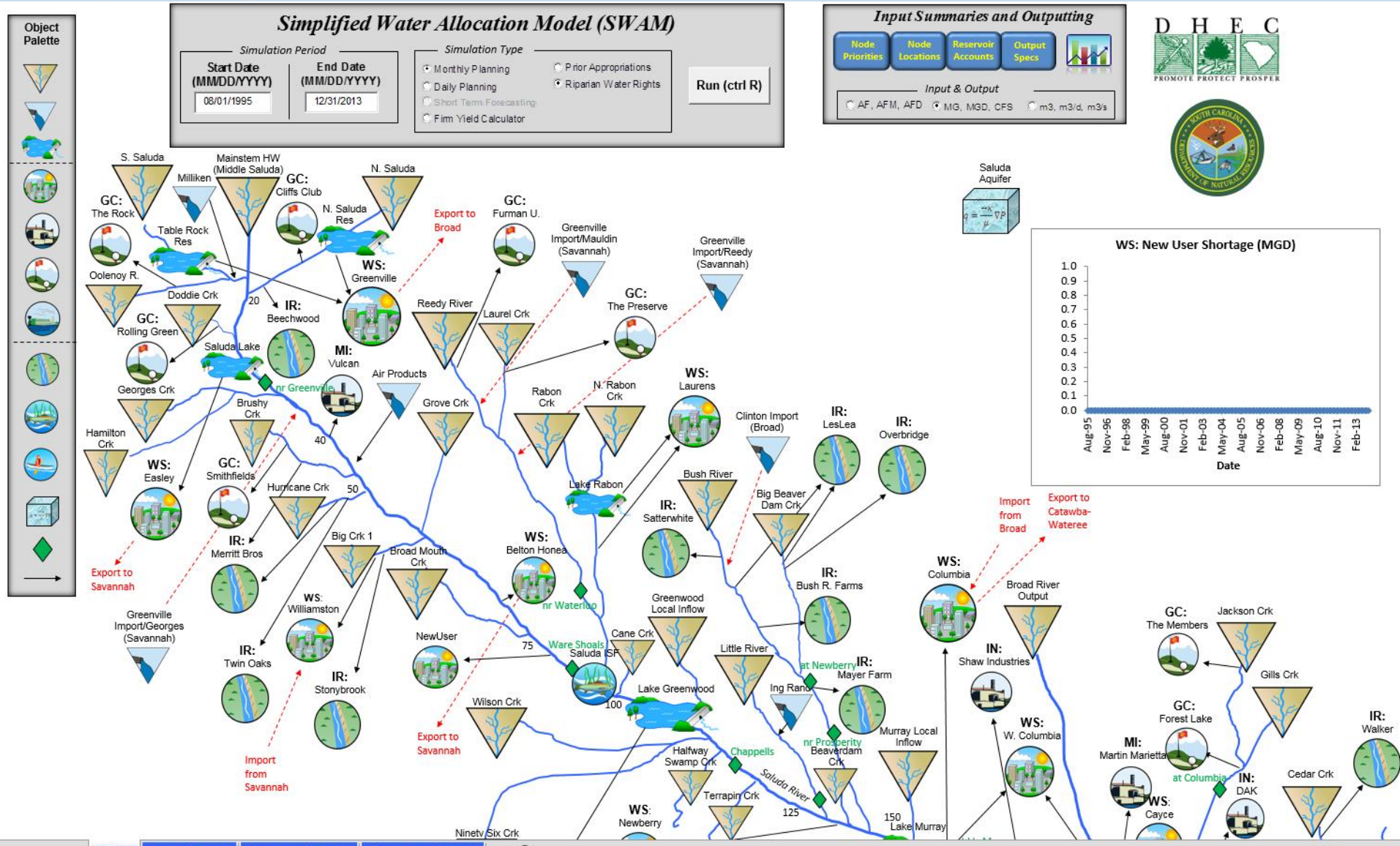
Run the Model Scenario



Build a Shortage Plot for the New User



Build a Shortage Plot

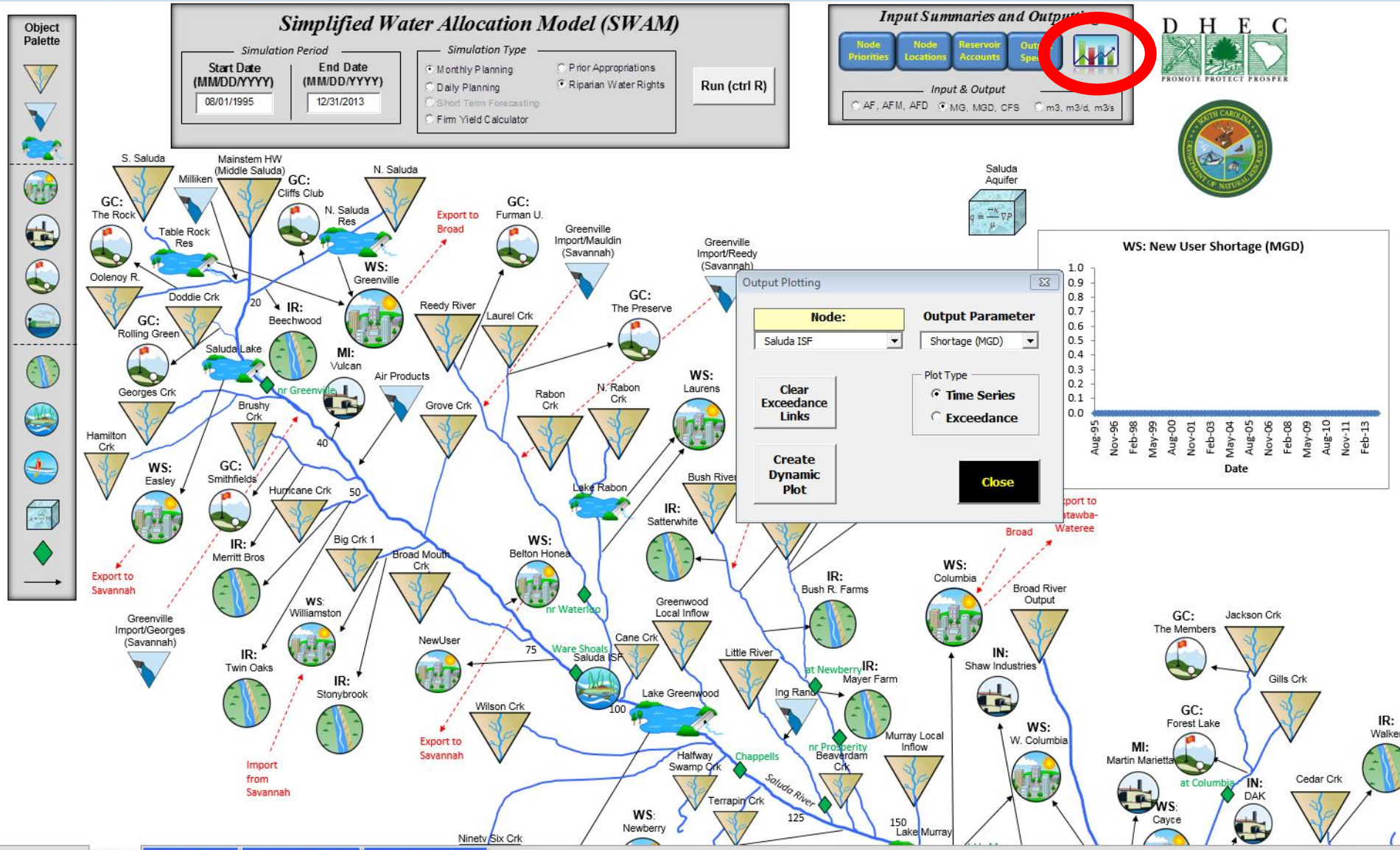


Shortages are Also Listed in the Node Output Table

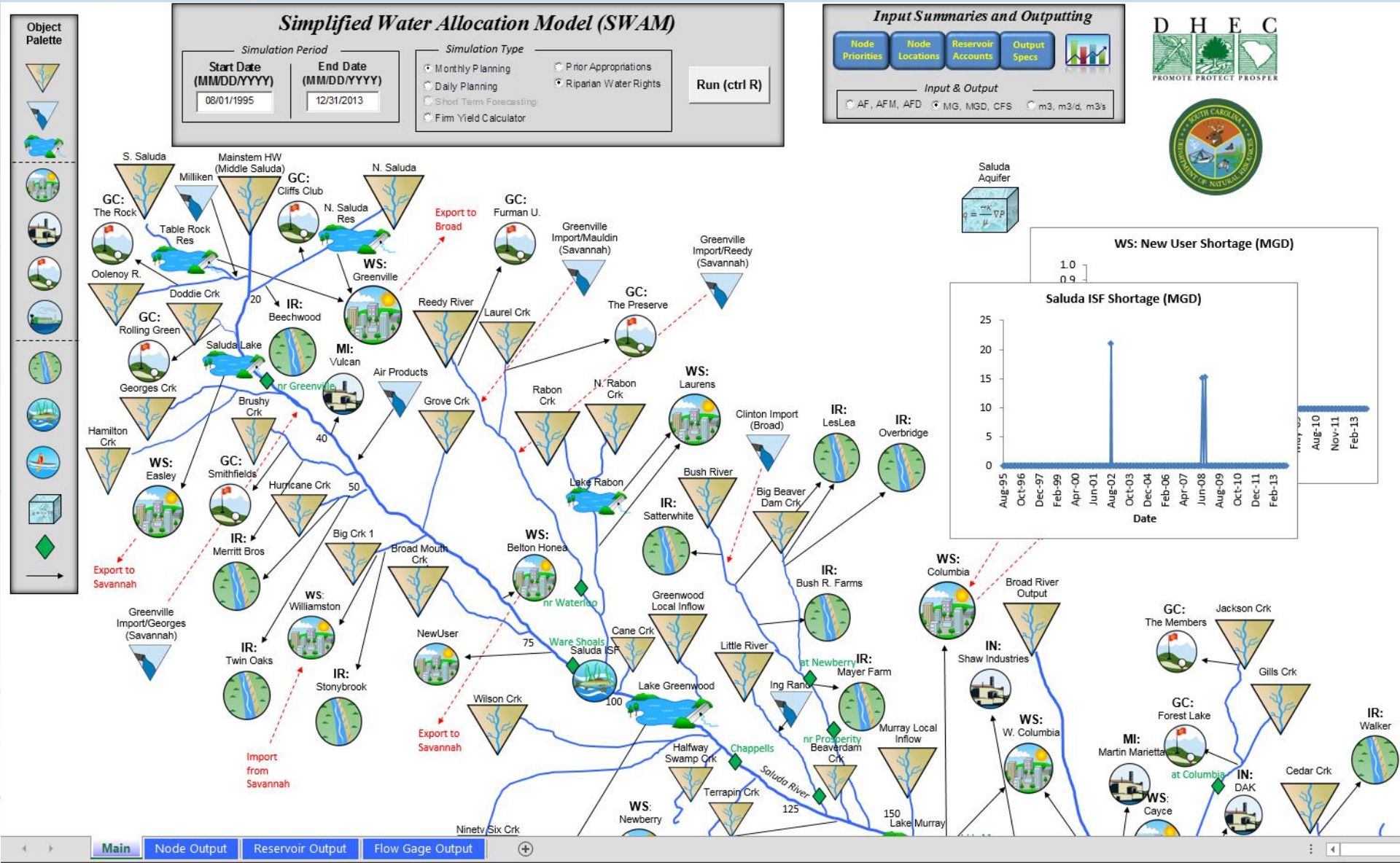
	A	B	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK
1	Output			Priority Rank	Reach	Location	Permit Limit (MGM)	Ditch Capacity (CFS)	Storage Capacity (MG)	Storage Withdrawal Permit (MGM)					Priority Rank	Reach	Location	Permit Limit (MGM)
2			*WS: New User*	*49*	*Mainstem*	*80*	*10000*	*10000*	*0*	*325829*				*Saluda ISF*	*51*	*Mainstem*	*85*	*2003*
3		Date	Physically Avail. (MGD)	Legally Avail. (MGD)	Diverted (MGD)	Storage (MG)	GW Pumping (MGD)	Demand (MGD)	Shortage (MGD)	Return Flow (MGD)	Release (MGD)	Evap Losses (MGD)		Physically Avail. (MGD)	Legally Avail. (MGD)	Diverted (MGD)	Storage (MG)	GW Pumping (MGD)
4		Min	87	87	26	0	0	26	0	25	0	0		44	44	44	0	0
5		Max	2368	357	103	0	0	103	0	41	0	0		2338	65	65	0	0
6		Avg	543	298	55	0	0	55	0	32	0	0		523	64	64	0	0
7		8/31/95	904	323	97	0	0	97	0	39	0	0		850	65	65	0	0
8		9/30/95	442	333	80	0	0	80	0	41	0	0		405	65	65	0	0
9		10/31/95	630	323	52	0	0	52	0	37	0	0		619	65	65	0	0
10		11/30/95	850	333	27	0	0	27	0	25	0	0		852	65	65	0	0
11		12/31/95	530	323	26	0	0	26	0	25	0	0		531	65	65	0	0
12		1/31/96	1141	323	26	0	0	26	0	25	0	0		1144	65	65	0	0
13		2/28/96	1103	357	29	0	0	29	0	27	0	0		1106	65	65	0	0
14		3/31/96	948	323	26	0	0	26	0	25	0	0		951	65	65	0	0
15		4/30/96	710	333	40	0	0	40	0	31	0	0		704	65	65	0	0
16		5/31/96	573	323	65	0	0	65	0	36	0	0		547	65	65	0	0
17		6/30/96	404	333	87	0	0	87	0	37	0	0		357	65	65	0	0
18		7/31/96	309	309	103	0	0	103	0	36	0	0		244	65	65	0	0
19		8/31/96	326	323	97	0	0	97	0	39	0	0		270	65	65	0	0
20		9/30/96	311	311	80	0	0	80	0	41	0	0		274	65	65	0	0
21		10/31/96	241	241	52	0	0	52	0	37	0	0		228	65	65	0	0
22		11/30/96	376	333	27	0	0	27	0	25	0	0		377	65	65	0	0
23		12/31/96	797	323	26	0	0	26	0	25	0	0		800	65	65	0	0
24		1/31/97	654	323	26	0	0	26	0	25	0	0		656	65	65	0	0
25		2/28/97	845	357	29	0	0	29	0	27	0	0		847	65	65	0	0
26		3/31/97	1081	323	26	0	0	26	0	25	0	0		1084	65	65	0	0
27		4/30/97	867	333	40	0	0	40	0	31	0	0		862	65	65	0	0
28		5/31/97	664	323	65	0	0	65	0	36	0	0		638	65	65	0	0
29		6/30/97	616	333	87	0	0	87	0	37	0	0		569	65	65	0	0
30		7/31/97	427	323	103	0	0	103	0	36	0	0		362	65	65	0	0
31		8/31/97	266	266	97	0	0	97	0	39	0	0		211	65	65	0	0
32		9/30/97	268	268	80	0	0	80	0	41	0	0		231	65	65	0	0
33		10/31/97	461	323	52	0	0	52	0	37	0	0		449	65	65	0	0
34		11/30/97	390	333	27	0	0	27	0	25	0	0		391	65	65	0	0
35		12/31/97	490	323	26	0	0	26	0	25	0	0		491	65	65	0	0
36		1/31/98	1461	323	26	0	0	26	0	25	0	0		1465	65	65	0	0
37		2/28/98	1413	357	29	0	0	29	0	27	0	0		1416	65	65	0	0
38		3/31/98	1306	323	26	0	0	26	0	25	0	0		1309	65	65	0	0
39		4/30/98	1277	333	40	0	0	40	0	31	0	0		1272	65	65	0	0
40		5/31/98	945	323	65	0	0	65	0	36	0	0		921	65	65	0	0
41		6/30/98	575	333	87	0	0	87	0	37	0	0		529	65	65	0	0
42		7/31/98	338	323	103	0	0	103	0	36	0	0		273	65	65	0	0
43		8/31/98	281	281	97	0	0	97	0	39	0	0		225	65	65	0	0
44		9/30/98	214	214	80	0	0	80	0	41	0	0		176	65	65	0	0
45		10/31/98	258	258	52	0	0	52	0	37	0	0		245	65	65	0	0
46		11/30/98	270	270	27	0	0	27	0	25	0	0		270	65	65	0	0

Main | Node Output | Reservoir Output | Flow Gage Output

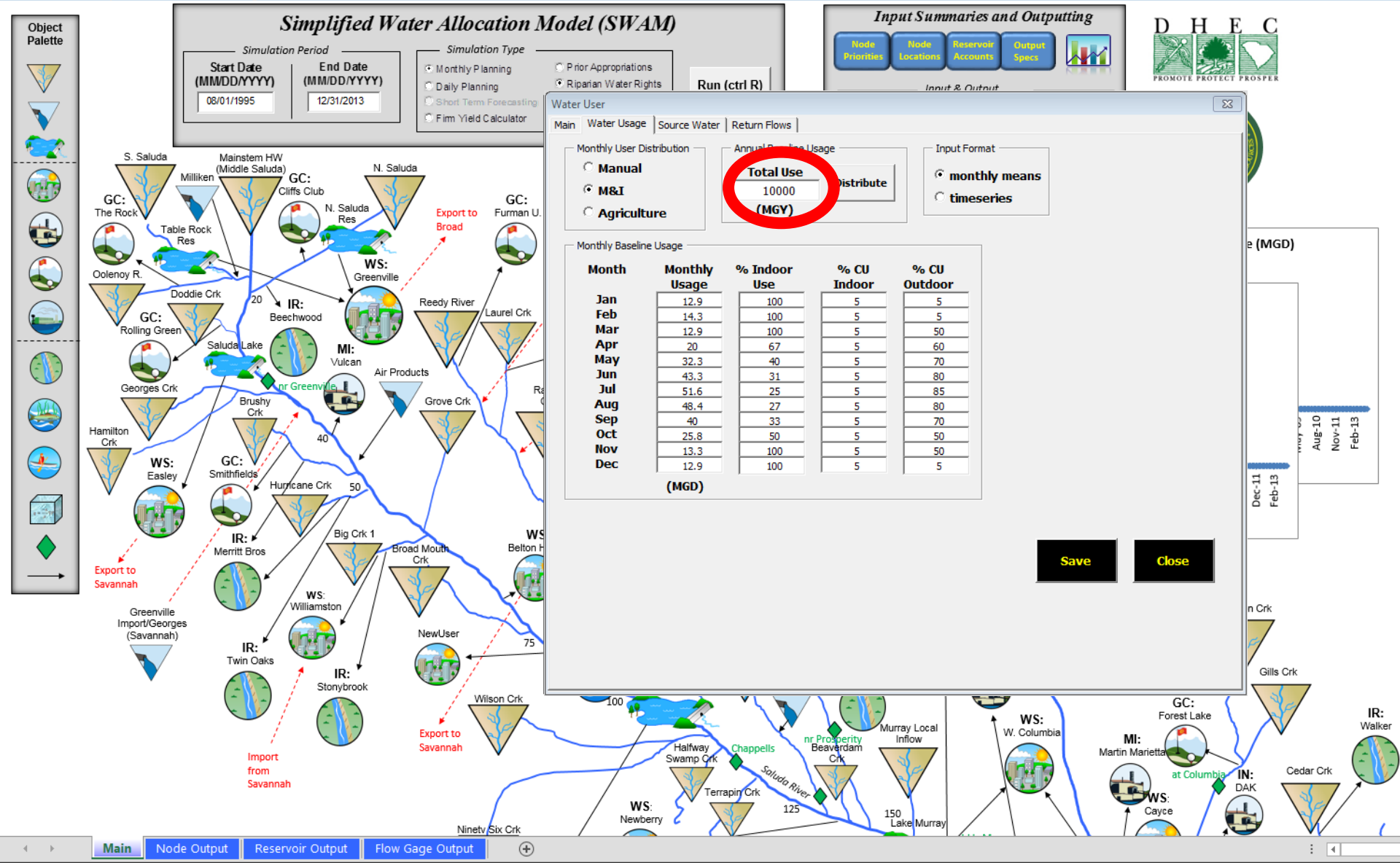
Build a Shortage Plot for the Instream Flow Object



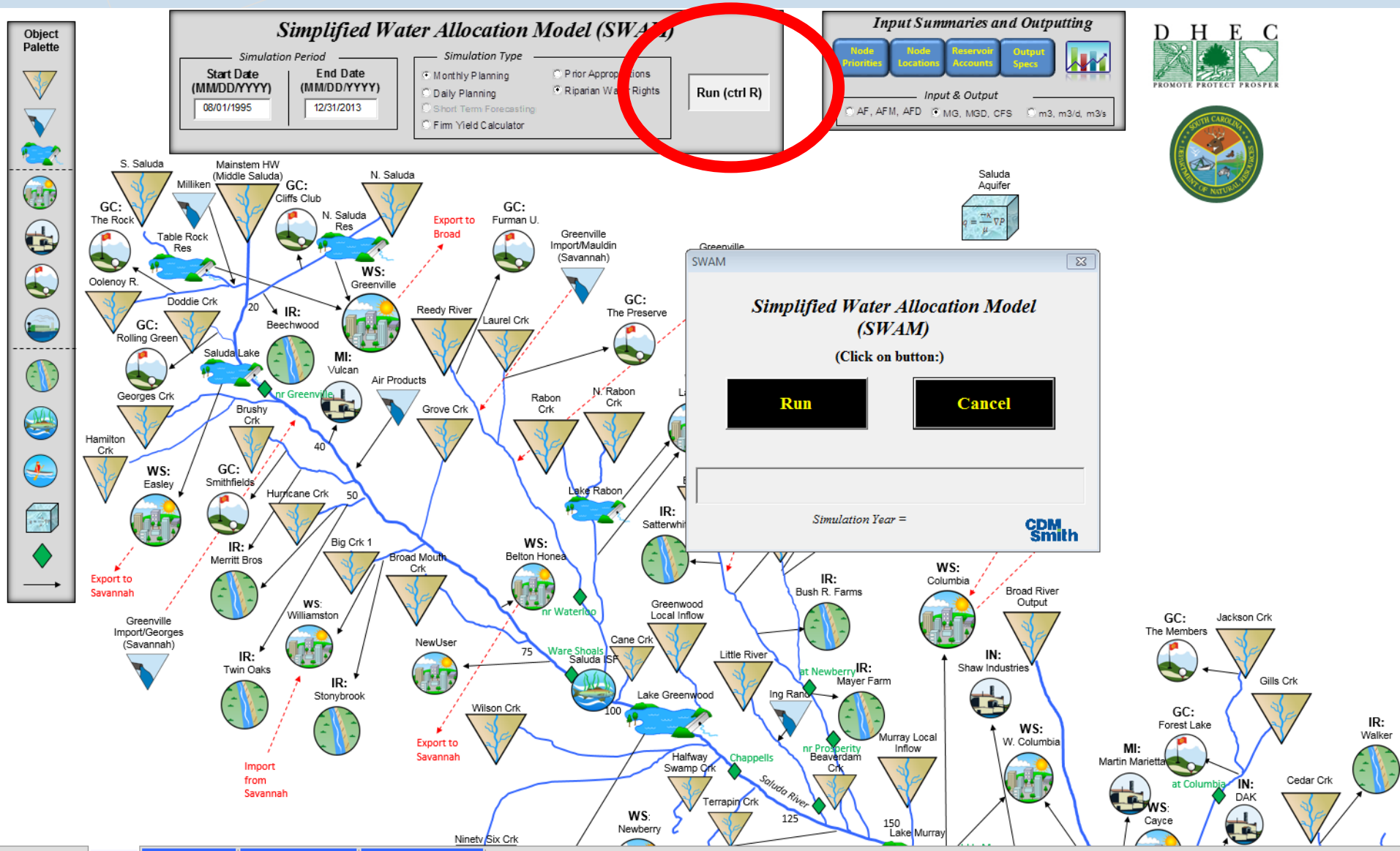
Build a Shortage Plot for the Instream Flow Object



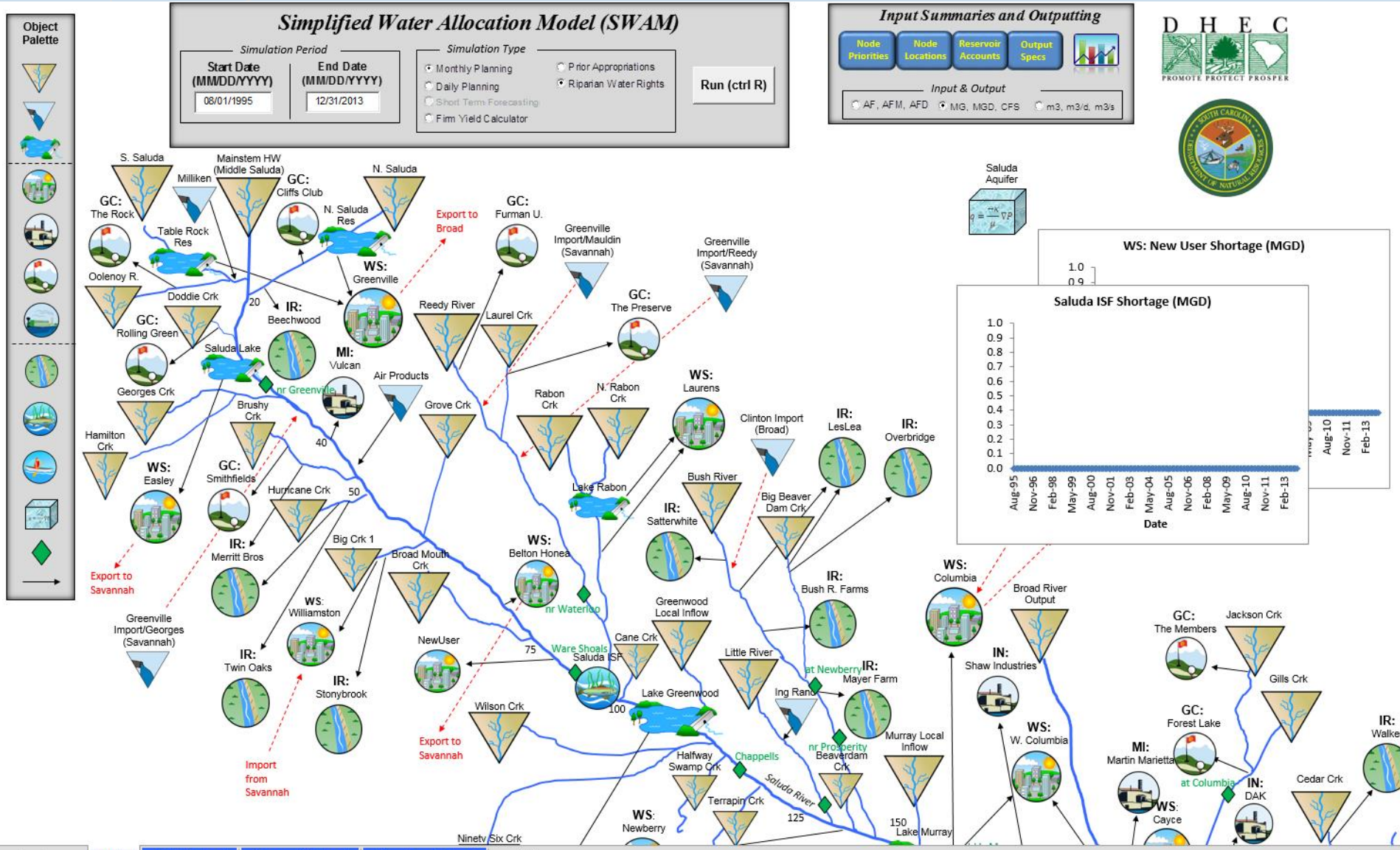
Reduce the New Users Total Water User



Rerun the Model Scenario



Dynamic Shortage Plots Update Automatically



Demonstrations and Q&A

- Station 1 (Tim)

  Evaluating an increase in WS User demands

- Station 2 (John)

  Evaluating a withdrawal with a minimum instream flow constraint

- Station 3 (Kirk)

  Adding new M&I user and an instream flow object

Saluda River Basin

THANK YOU