The Emergence of South Carolina's New Tools for Surface Water Availability Assessment

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WATER + ENVIRONMENT + TRANSPORTATION + ENERGY + FACILITIES

South Carolina Environmental Conference SCEC

Myrtle Beach, SC

Presentation Outline

- Project purpose and status
- Surface Water Allocation Model (SWAM) overview
- Project highlights…
  - Comparison of managed and unimpaired flows
  - Aspects of model development, calibration, and verification
- SWAM Demonstration



What is the South Carolina Surface Water Availability Assessment?

DNR

CDM Smith

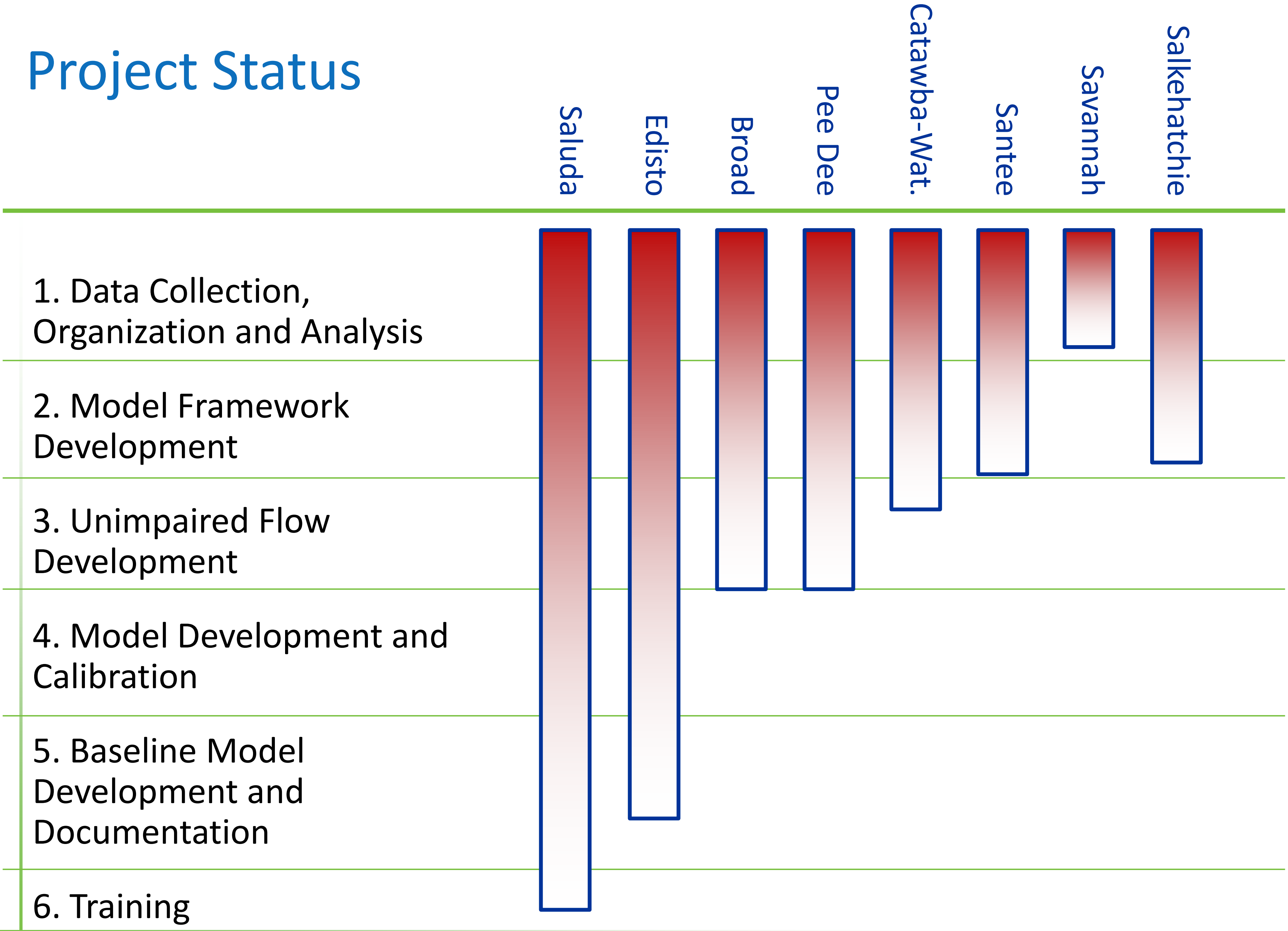
CLEMSON UNIVERSITY

DHEC PROMOTE PROTECT PROSPER South Carolina Department of Health and Environmental Control

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.

Project Status

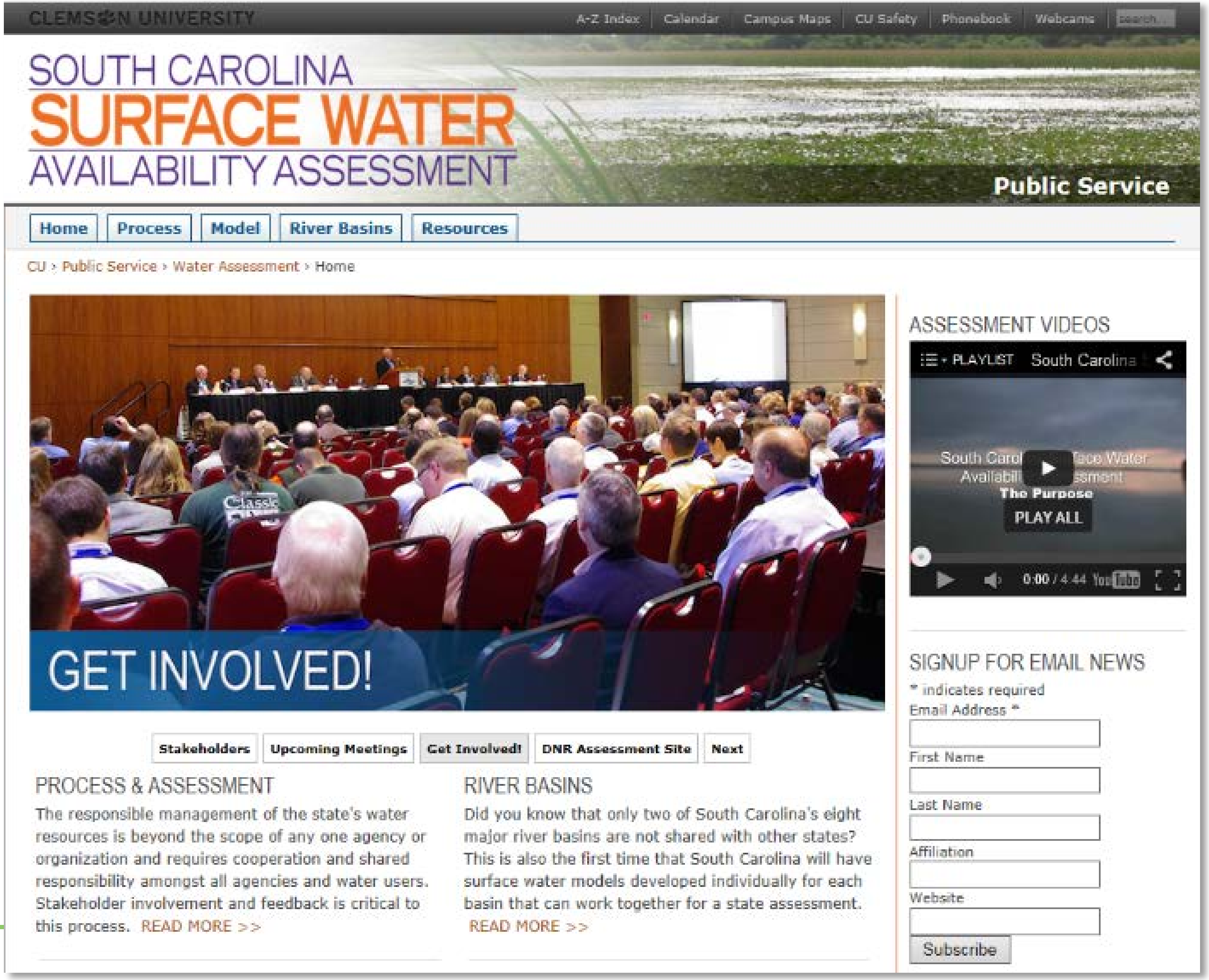


Technical Advisory Committee

- Advisory group consisting of representatives from:
  - Municipalities & industry
  - Non-governmental organizations
  - Energy
  - Agriculture
  - Consultants
- Engage in project meetings and model training
- Provide valuable technical feedback, insight, data analysis, and direction

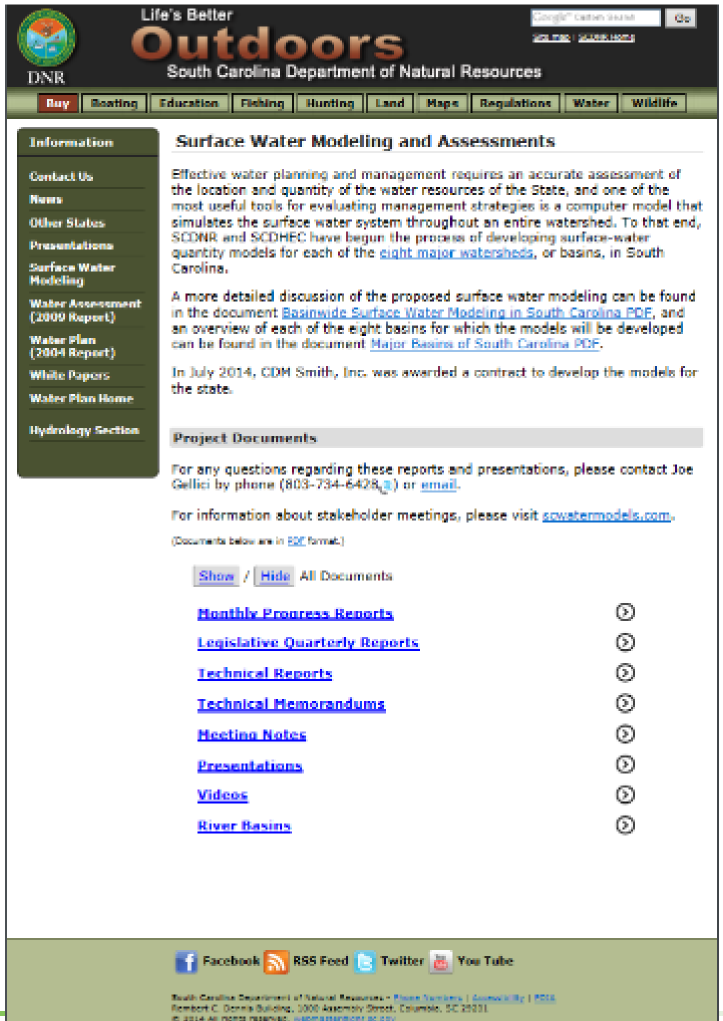
Clemson's Stakeholder Outreach Site

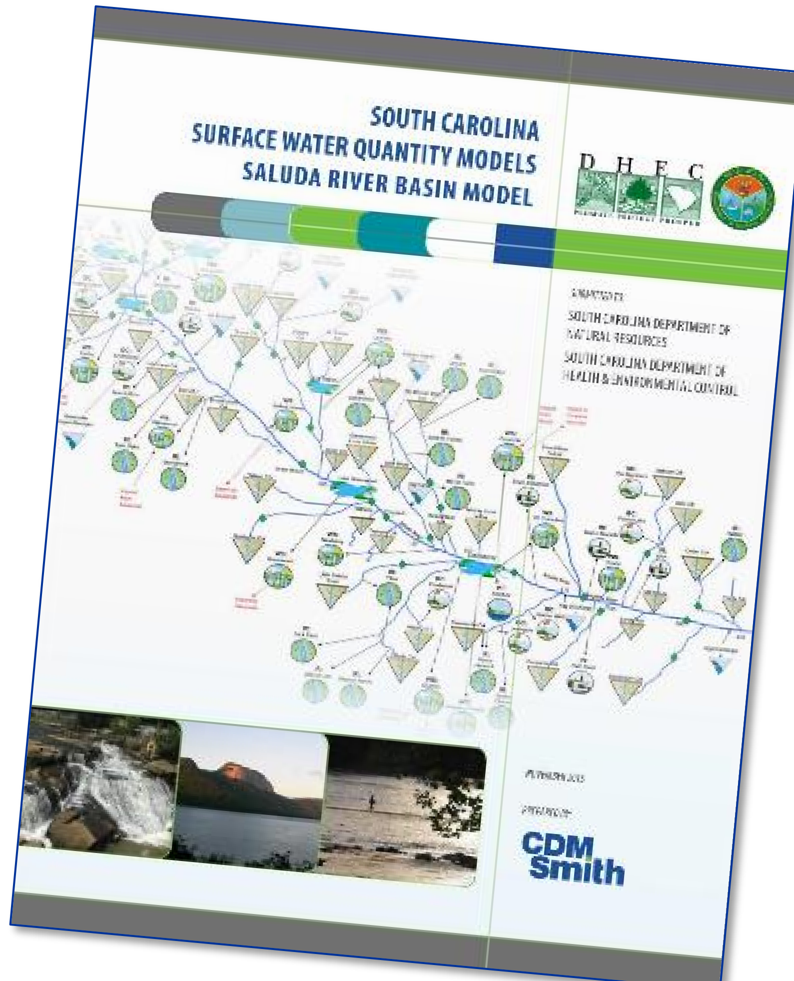
- http://www.scwatermodels.com



Modeling Report and Other Documents

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

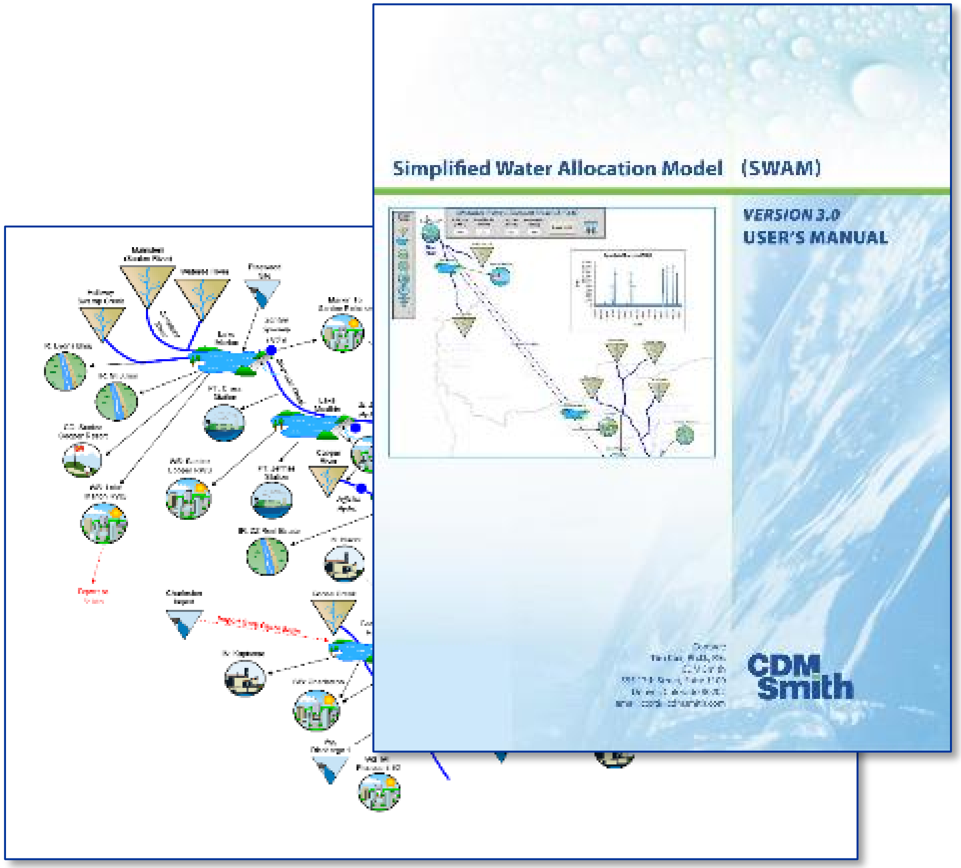




Simplified Water Allocation Model (SWAM)

Simplified Water Allocation Model (SWAM)

- Developed in response to an increasing need for a desktop tool to facilitate regional and statewide water allocation analysis
- Calculates physically and legally available water, diversions, storage, consumption and return flows at user-defined nodes
- Used to support large-scale planning studies in Colorado, Oklahoma, Arkansas, and Texas



The Simplified Water Allocation Model is…

- A water accounting tool
- A WHAT-IF simulation model
- A network flow model that 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)

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
- Consolidate hydrologic data
- 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
- Evaluate and test complex reservoir operating rules

Unimpaired Flows and Model Development

UIF Definition and Uses

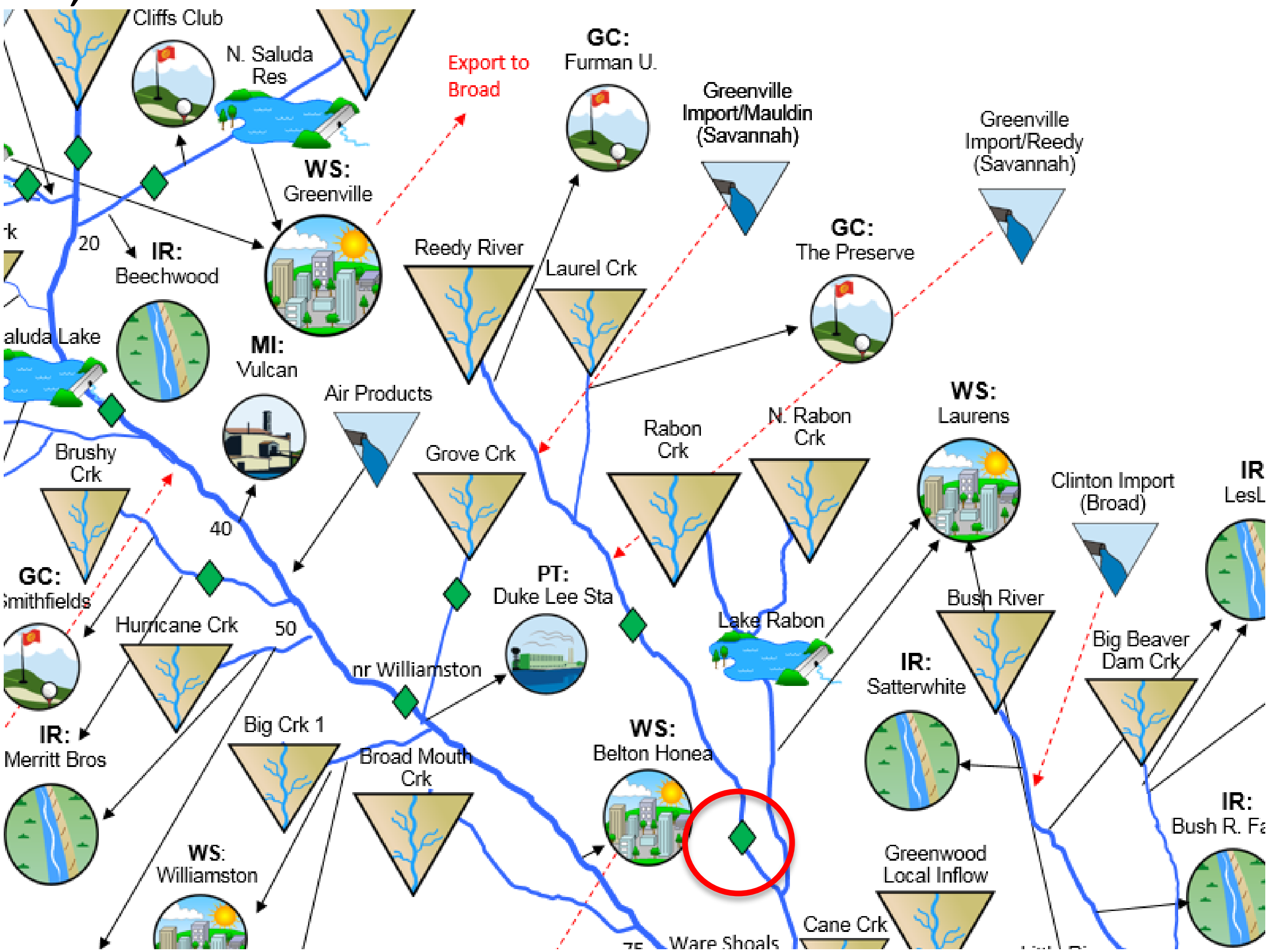
- Definition: Estimate of natural historic streamflow in the absence of human intervention
- Unimpaired Flow =

  Measured Gage Flow + River Withdrawals + Reservoir Withdrawals –Discharge to Reservoirs – Return Flow + Reservoir Surface Evaporation – Reservoir Surface Precipitation + Upstream change in Reservoir Storage + Runoff from Previously Unsubmerged Area

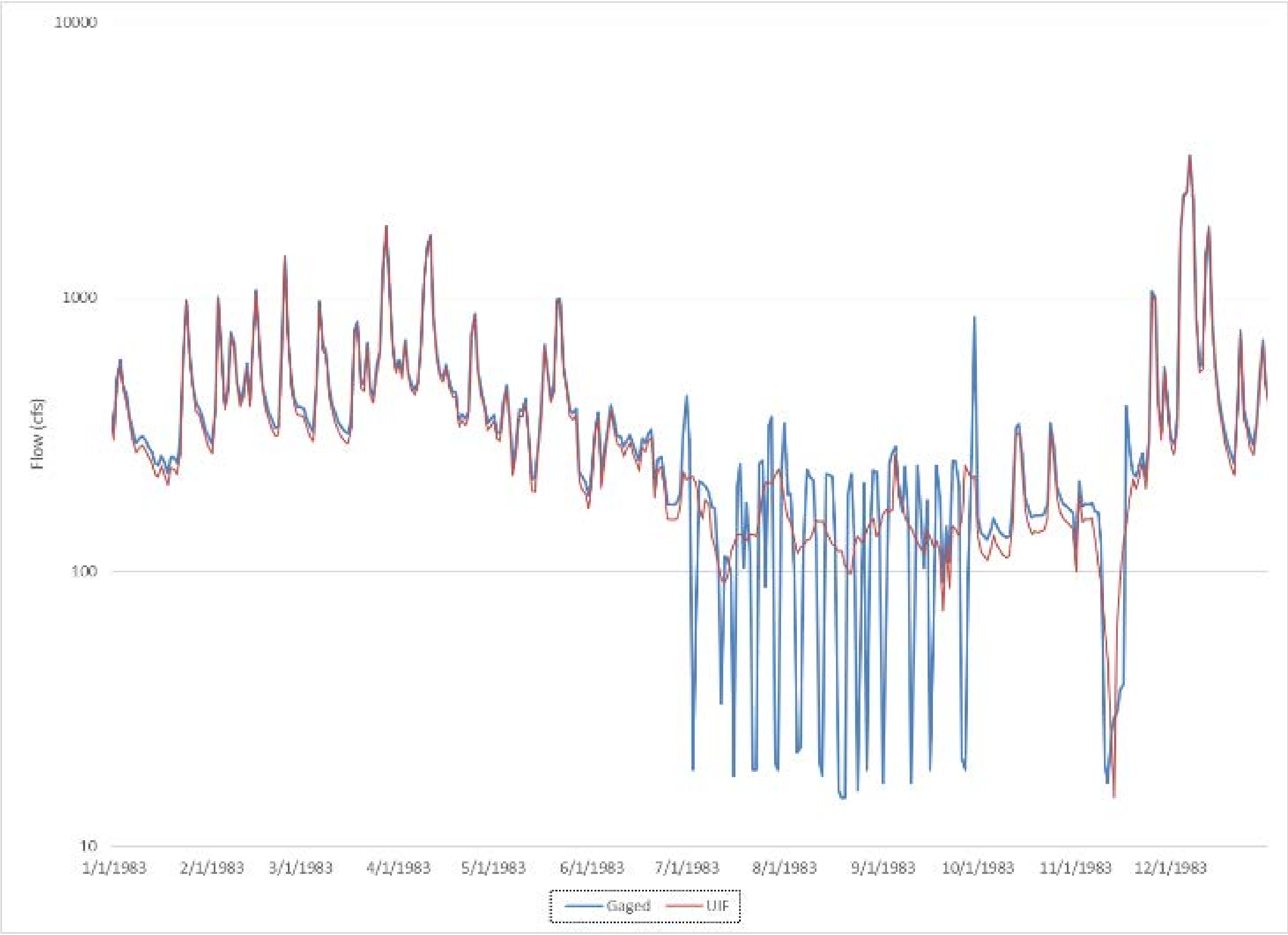
- Fundamental input to the model at headwater nodes and tributary nodes
- Comparative basis for model results

Saluda UIF Example

- USGS streamflow gage 02165000 on Reedy River near Ware Shoals, SC

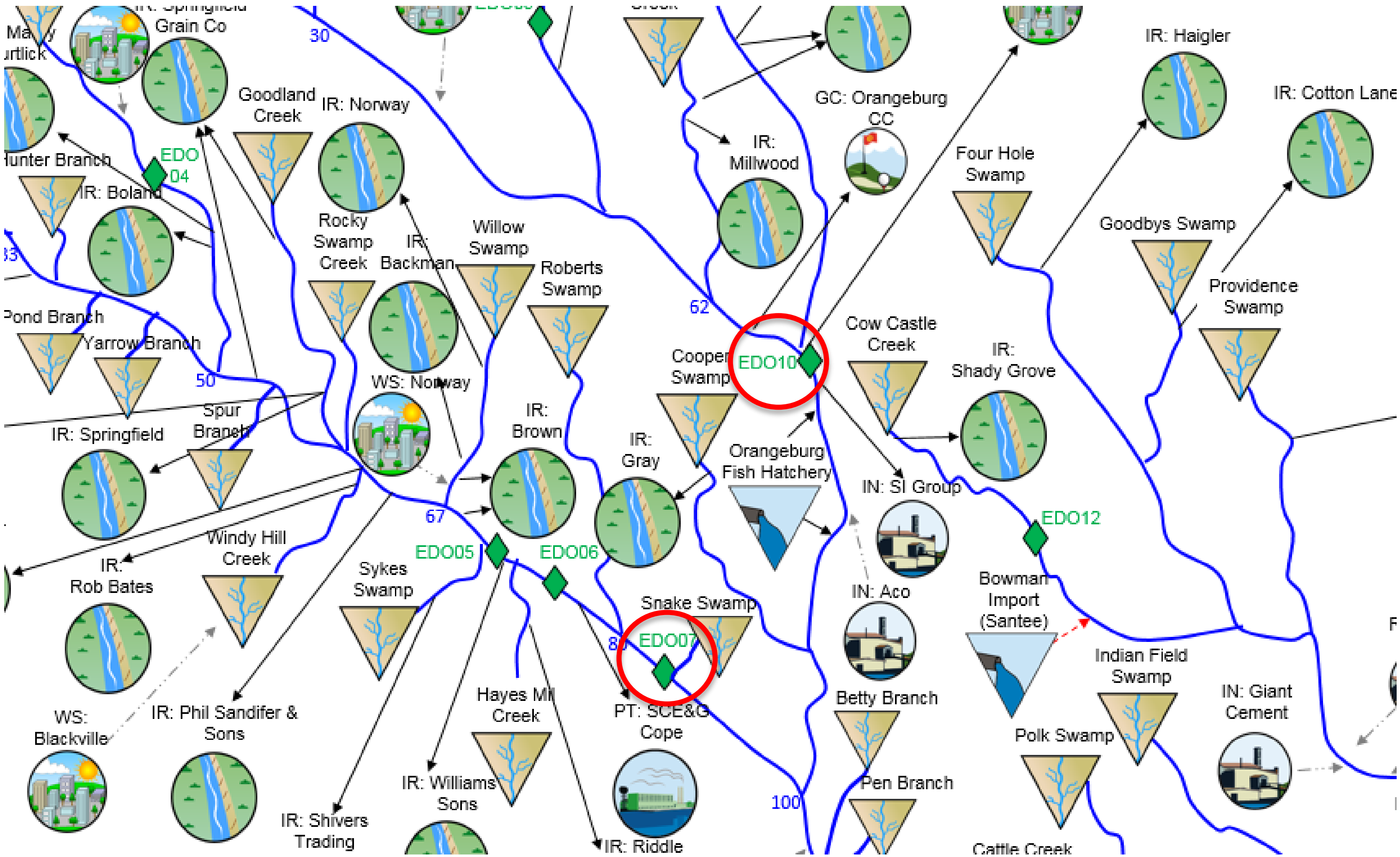


Saluda UIF Example

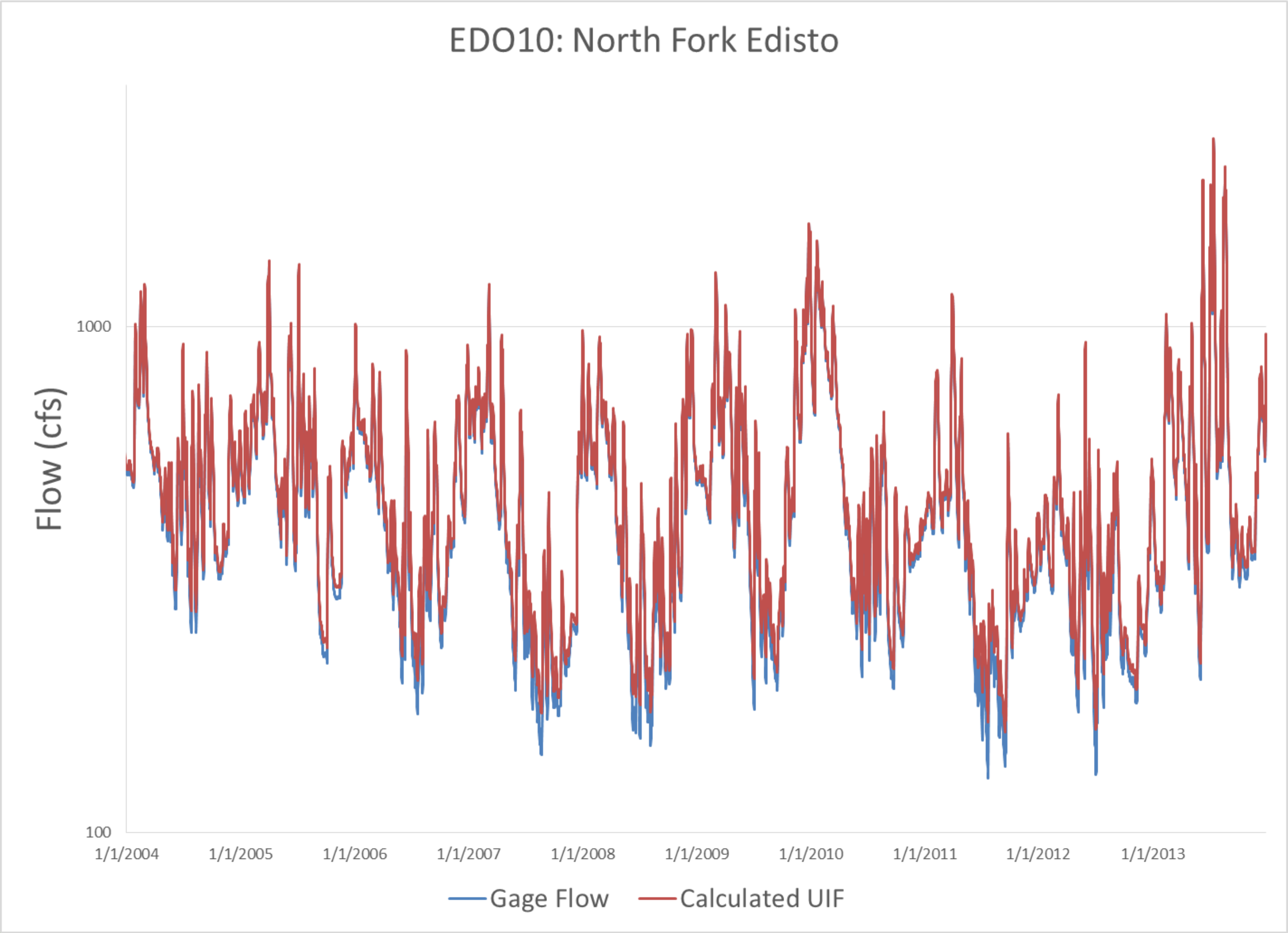


Edisto UIF Examples

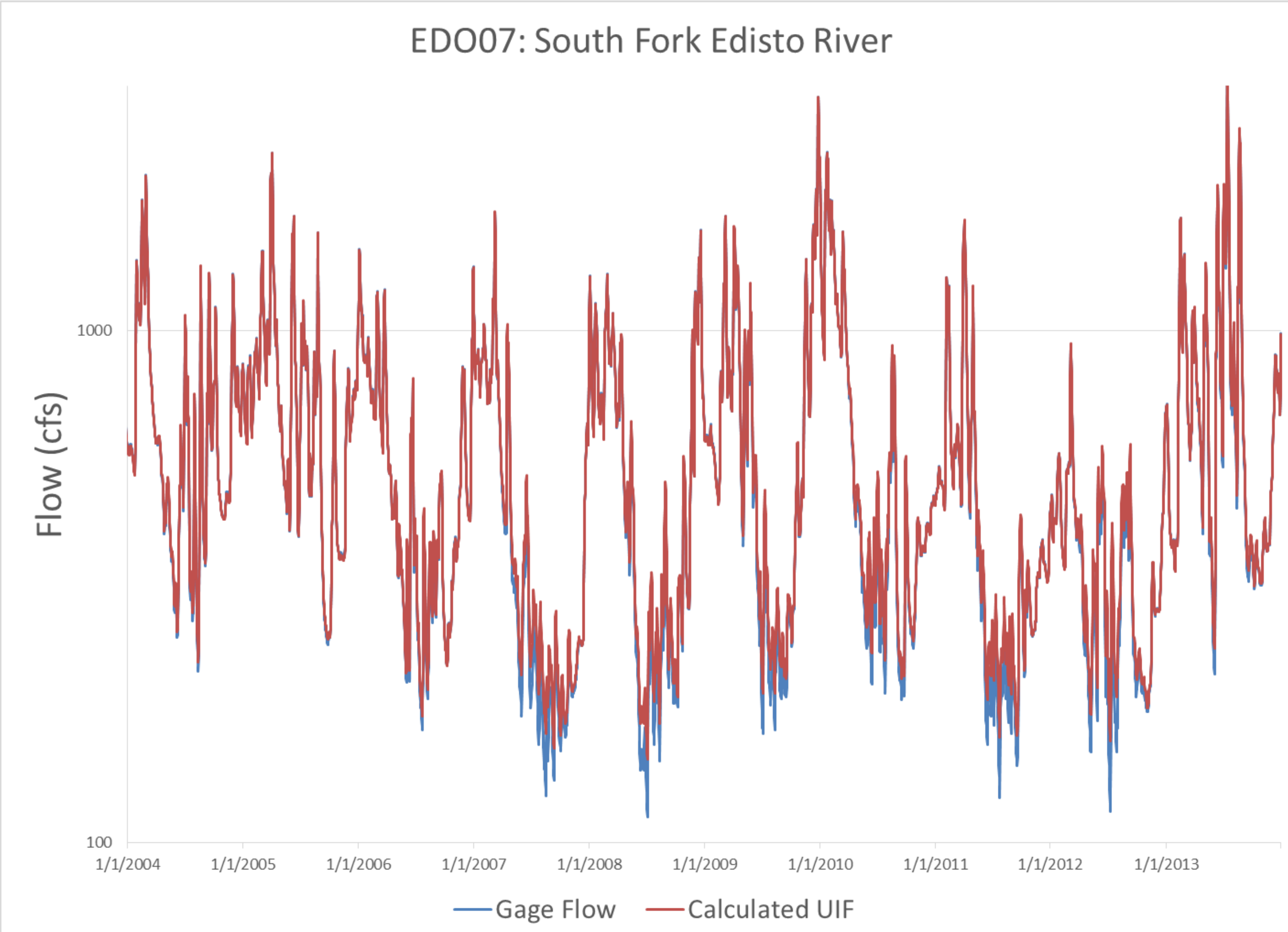
- USGS gages on North Fork (02173500) and South Fork (02173051) Edisto Rivers



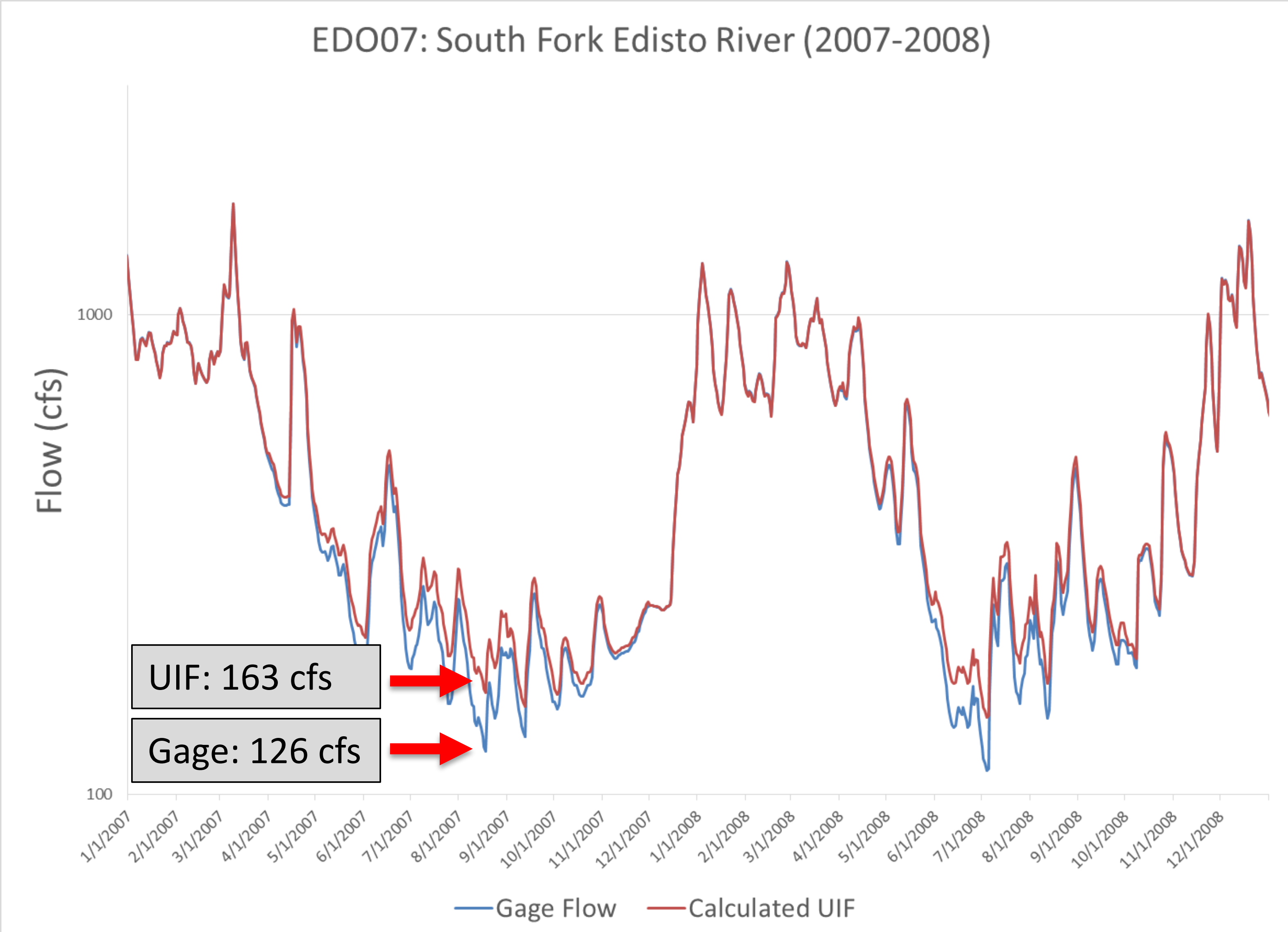
Edisto UIF Examples



Edisto UIF Examples



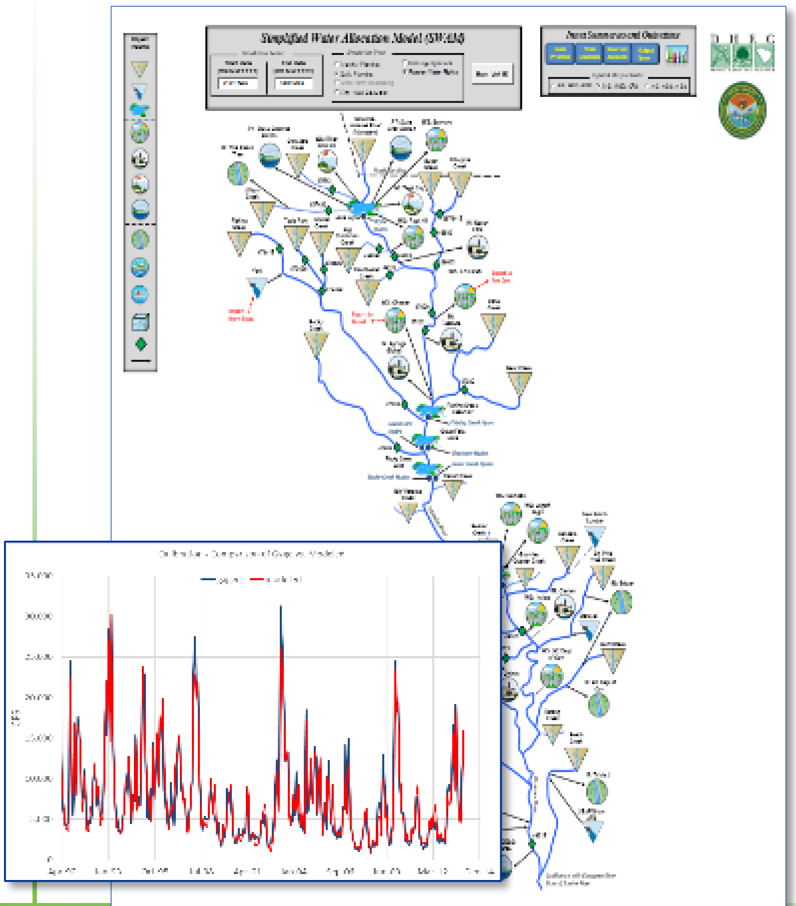
Edisto UIF Examples

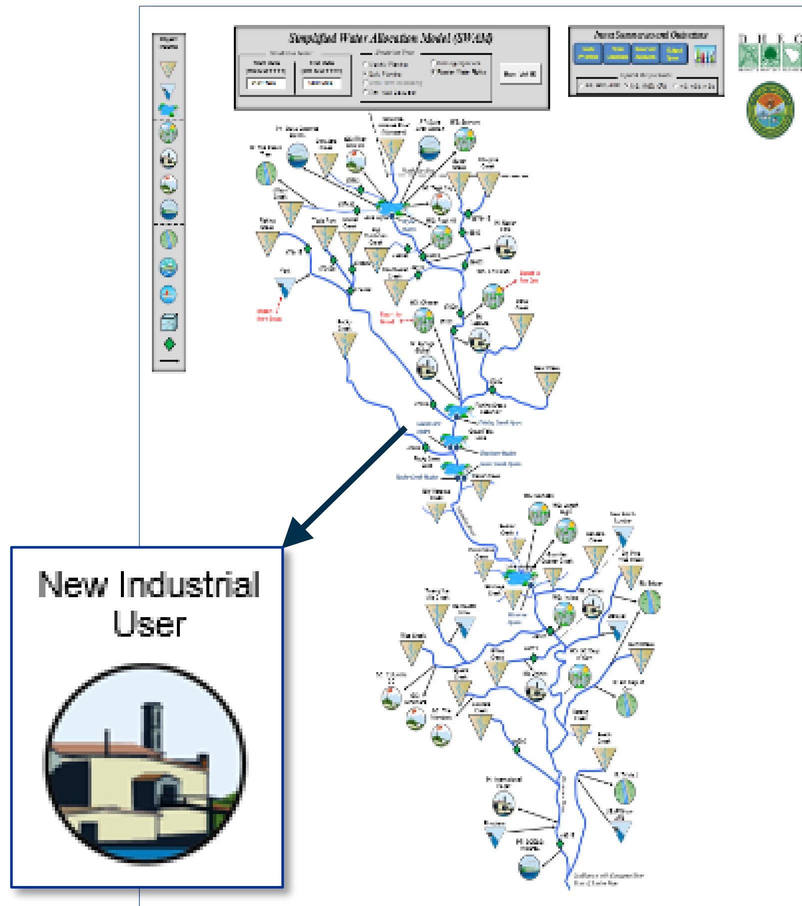


Model Development, Calibration, and Verification

Two Versions of Every Model

- Calibration with UIFs and historic use records
- Baseline: planning with UIFs, current uses, and user-defined future uses





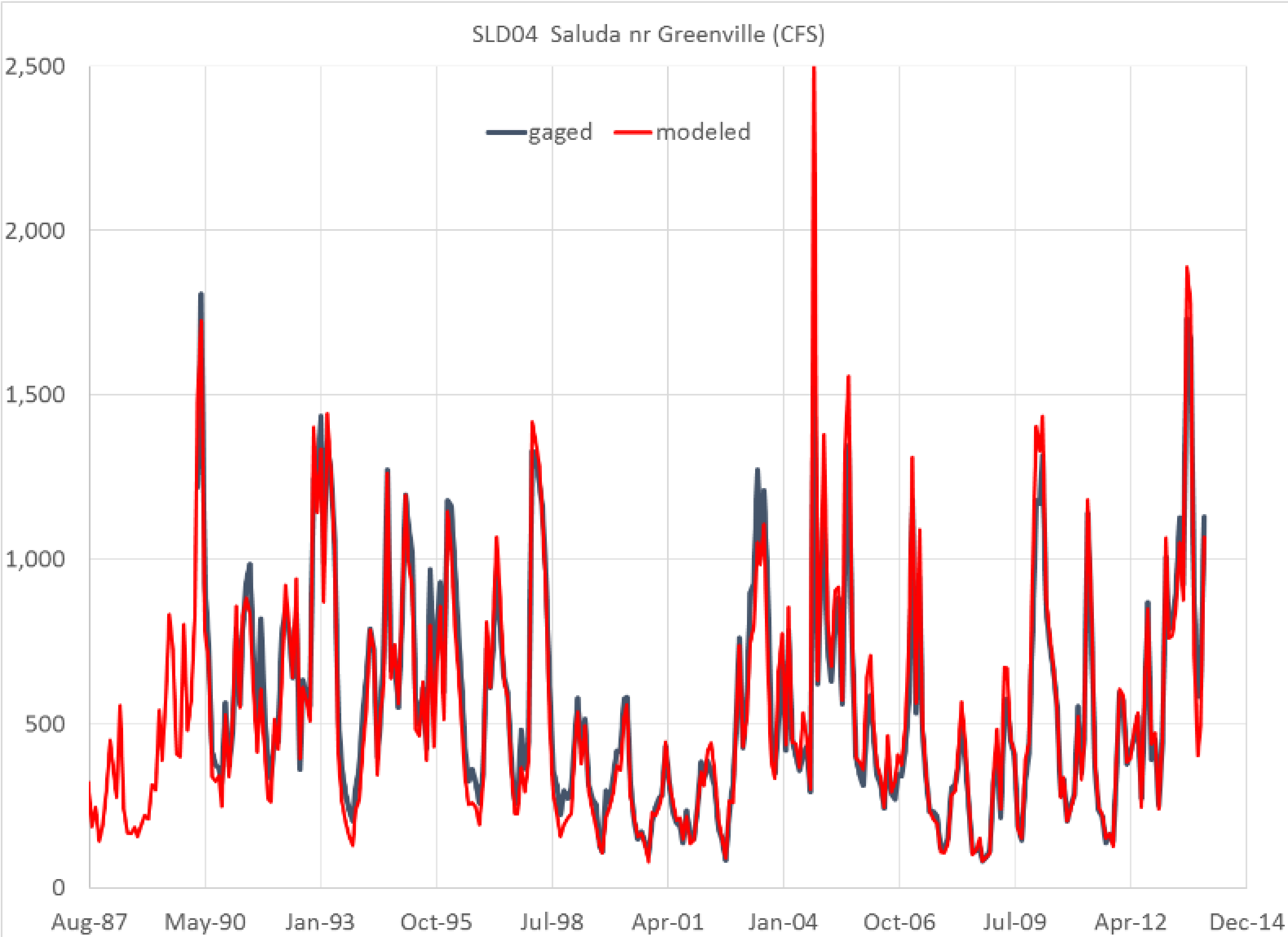
Calibration/Validation General Approach

- 1983 – 2013 hindcast period; monthly timestep first
  - Includes droughts in both early and late 2000's
- Comparison to gaged (measured) flow data
  - Operations and impairments are implicit in that data
- Assess performance at (subject to gage data availability):
  - Multiple mainstem locations
  - 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)

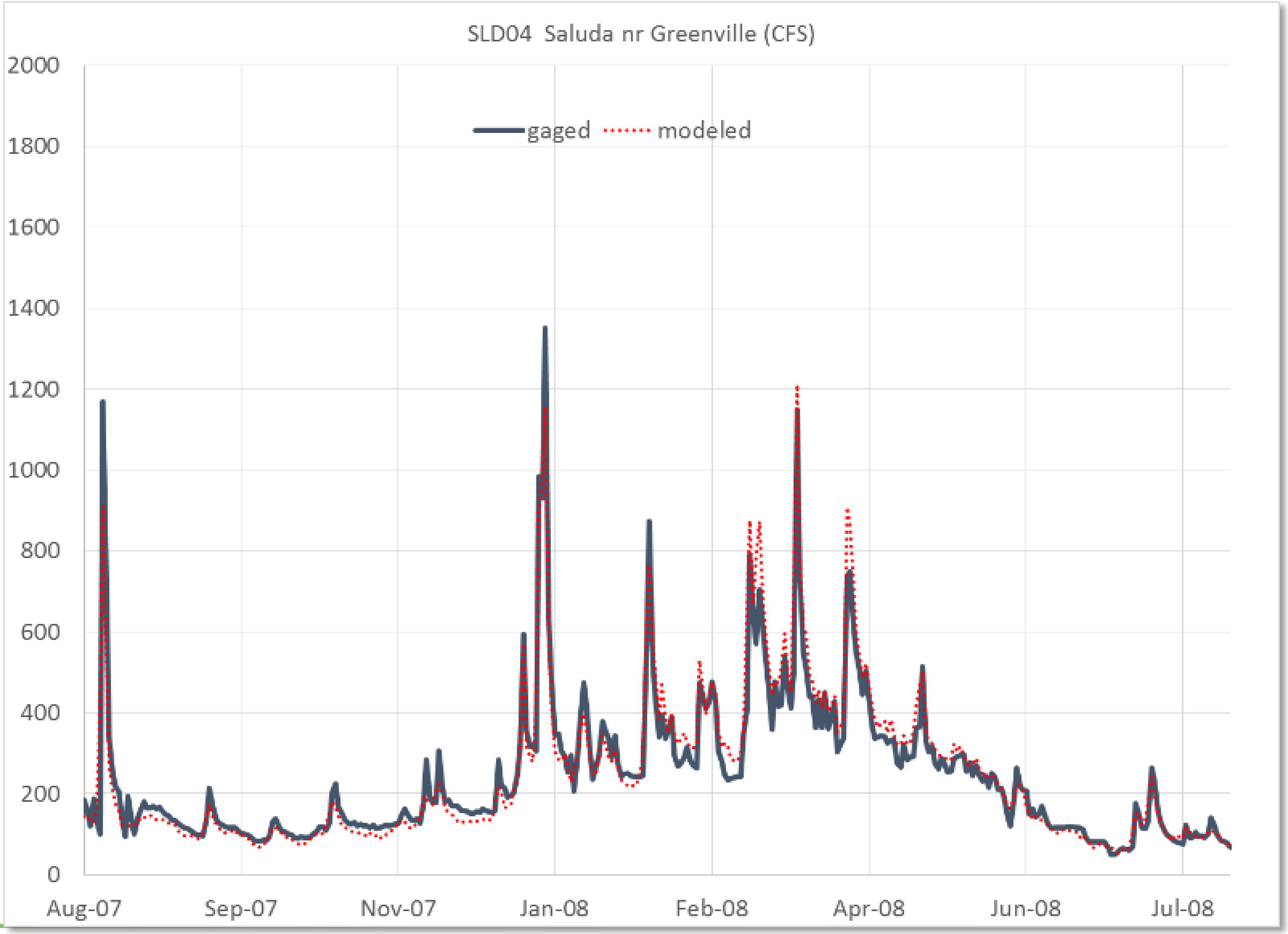
Potential Sources of Model Error & Uncertainty

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

Monthly Flow Comparison

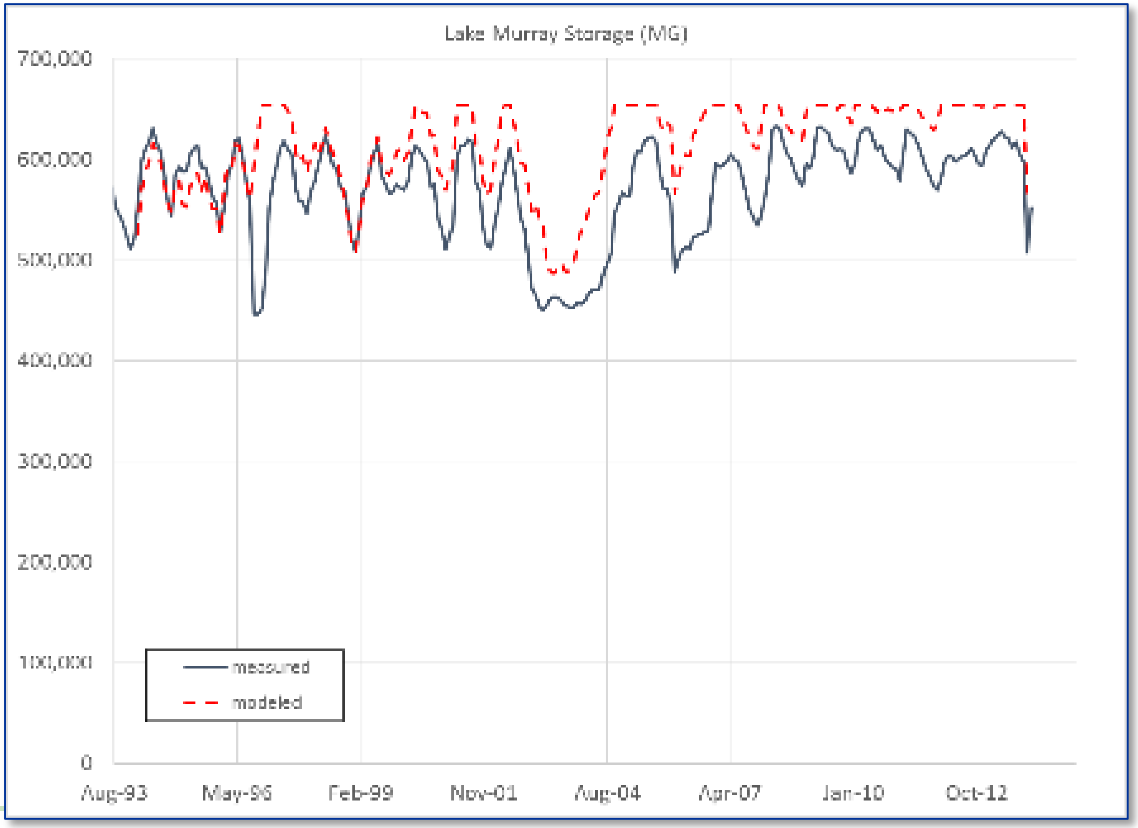


Daily Flow Comparison – Drought Period



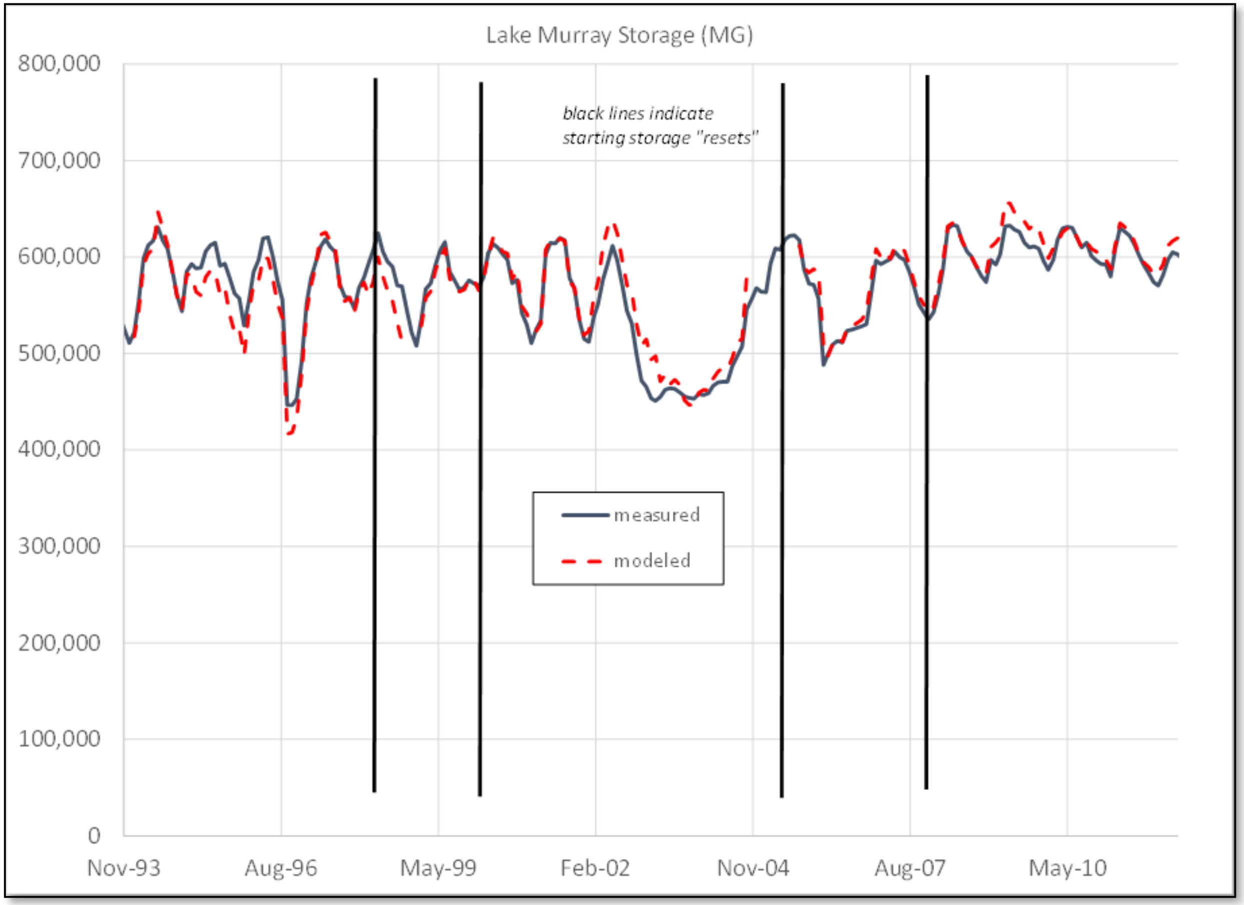
Lake Murray Verification Exercise

- **Approach:** Set the Lake Murray release equal to the historical release, then run the model to check that the combination of inflow, evaporation, and withdrawals/discharges result in a reasonable match of historical lake levels/storage.
- **Observations:** Modeled lake storage was higher than observed storage for certain years



Lake Murray Verification Exercise

- **Adjustments**: Adjust inflow by selecting alternative reference gages for headwater inputs at select, ungaged tributaries
- **Results**: Better match of modeled and measured Lake Murray storage



Baseline Model

- Represents current demands and operations combined with an extended period of estimated hydrology
  - Most demands reflect 2005-2013 averages
  - Estimated hydrology from 1920's-30's to 2013
  - Current reservoir rules, guide curves, minimum releases
  - Rules can be adjusted
  - Inactive users are not included
- The baseline model serves as the starting point for future predictive simulations

Example Use
Assessing a New M&I User – Edisto Example

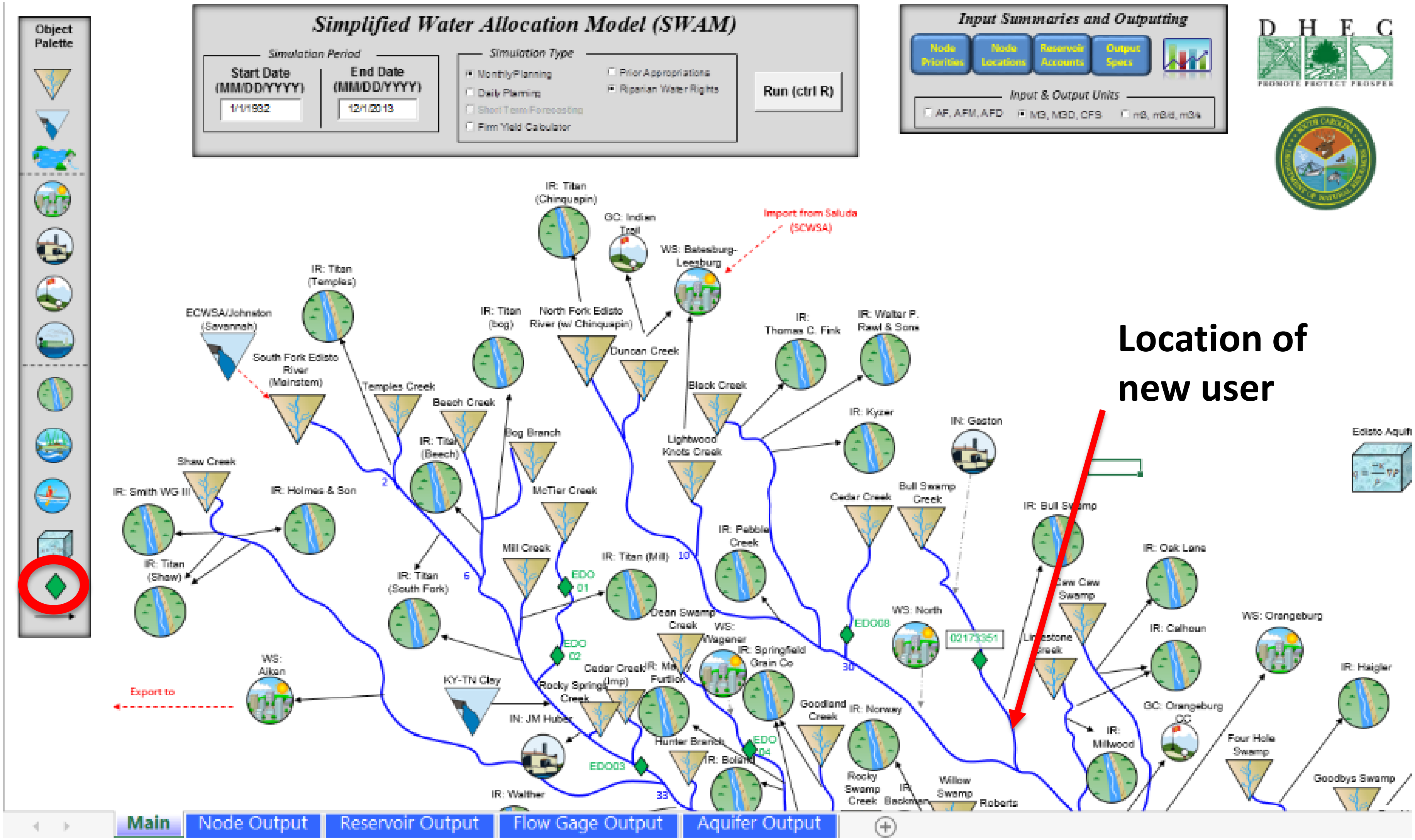
- Add model flow gage at proposed withdrawal location
  - Calculate minimum instream flows (20/30/40 Rule)

- Add a new M&I permittee
  - Demand = 500 MGY (0.6-2.6 MGD)
  - *Can the river sustain the new user?*

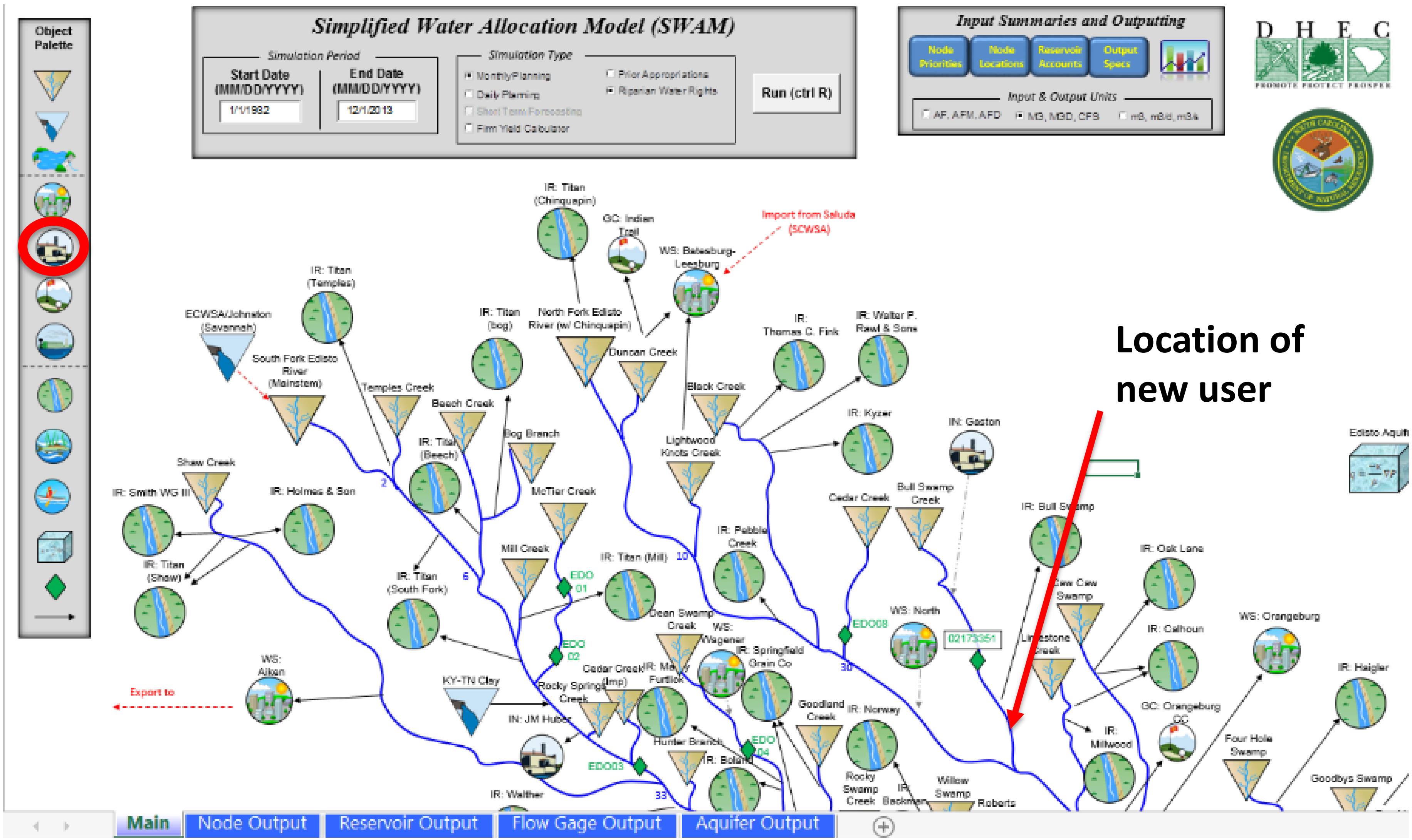
- Enter minimum instream flows in user object
  - *Are there shortages, i.e. does the withdrawal cause streamflow to drop below the minimum instream flow?*

Note that this example does not necessarily represent how DHEC will use the model to evaluate a proposed withdrawal

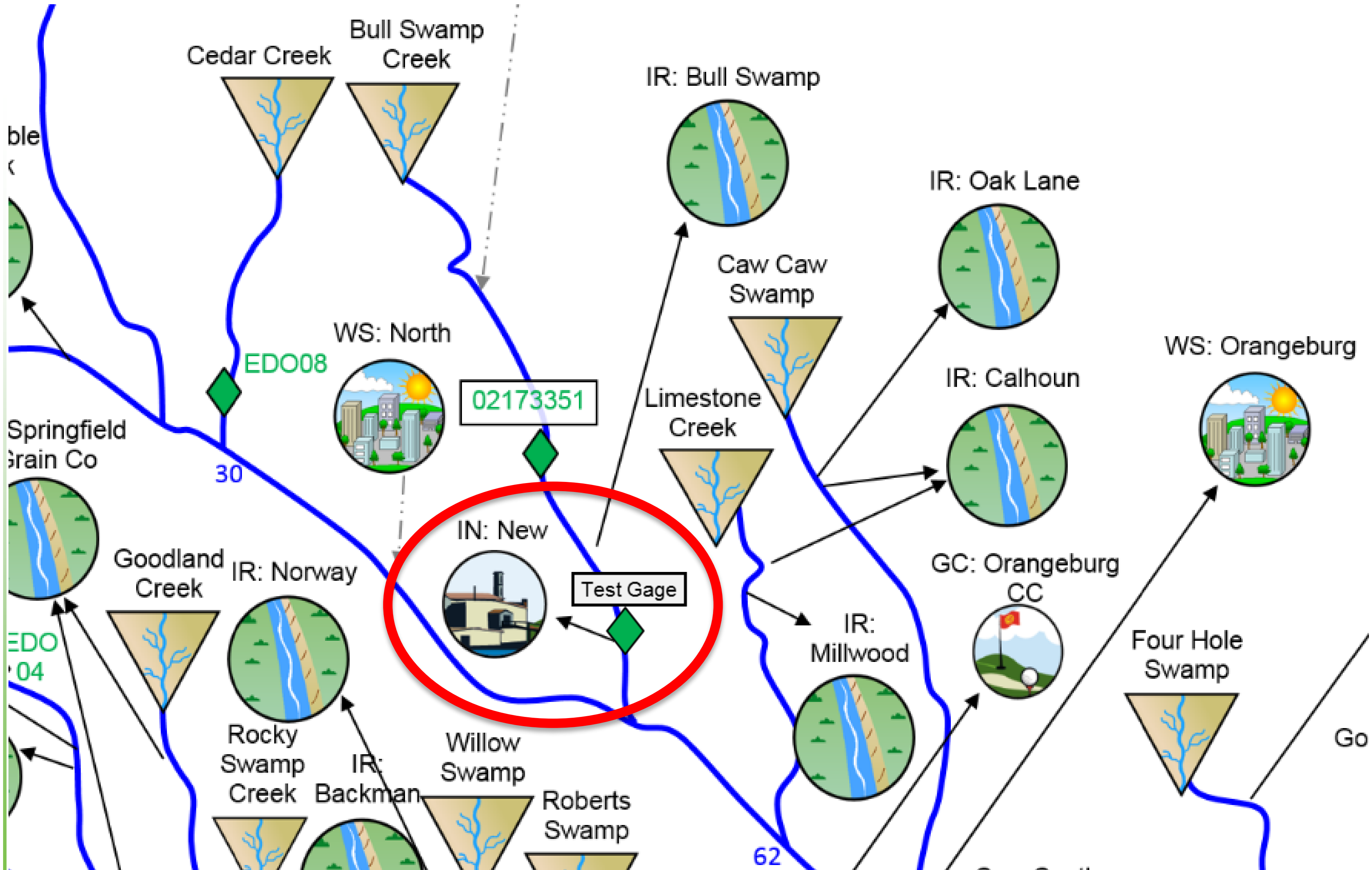
Add Flow Gage from Palette



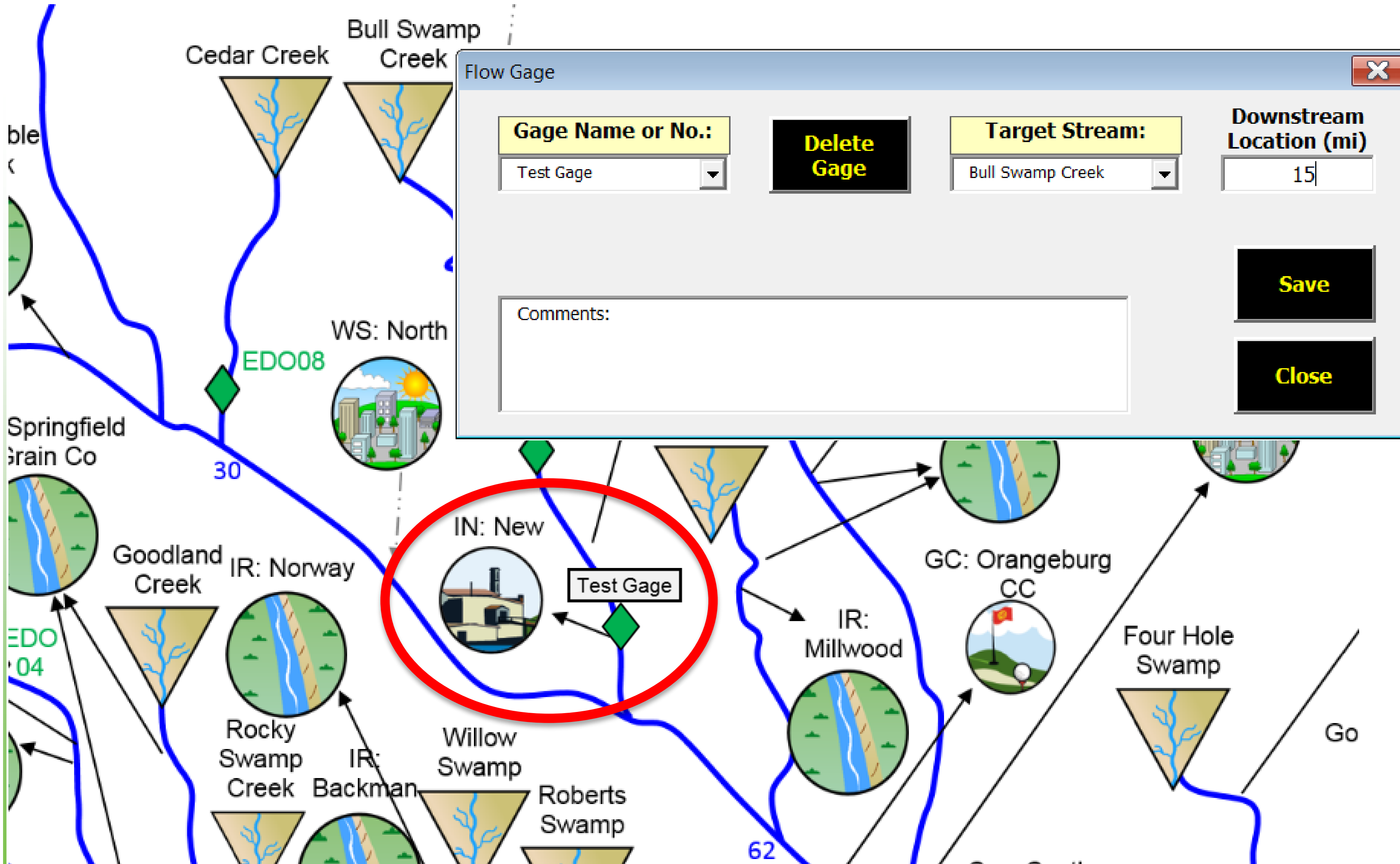
Add Industrial Water User Object from Palette



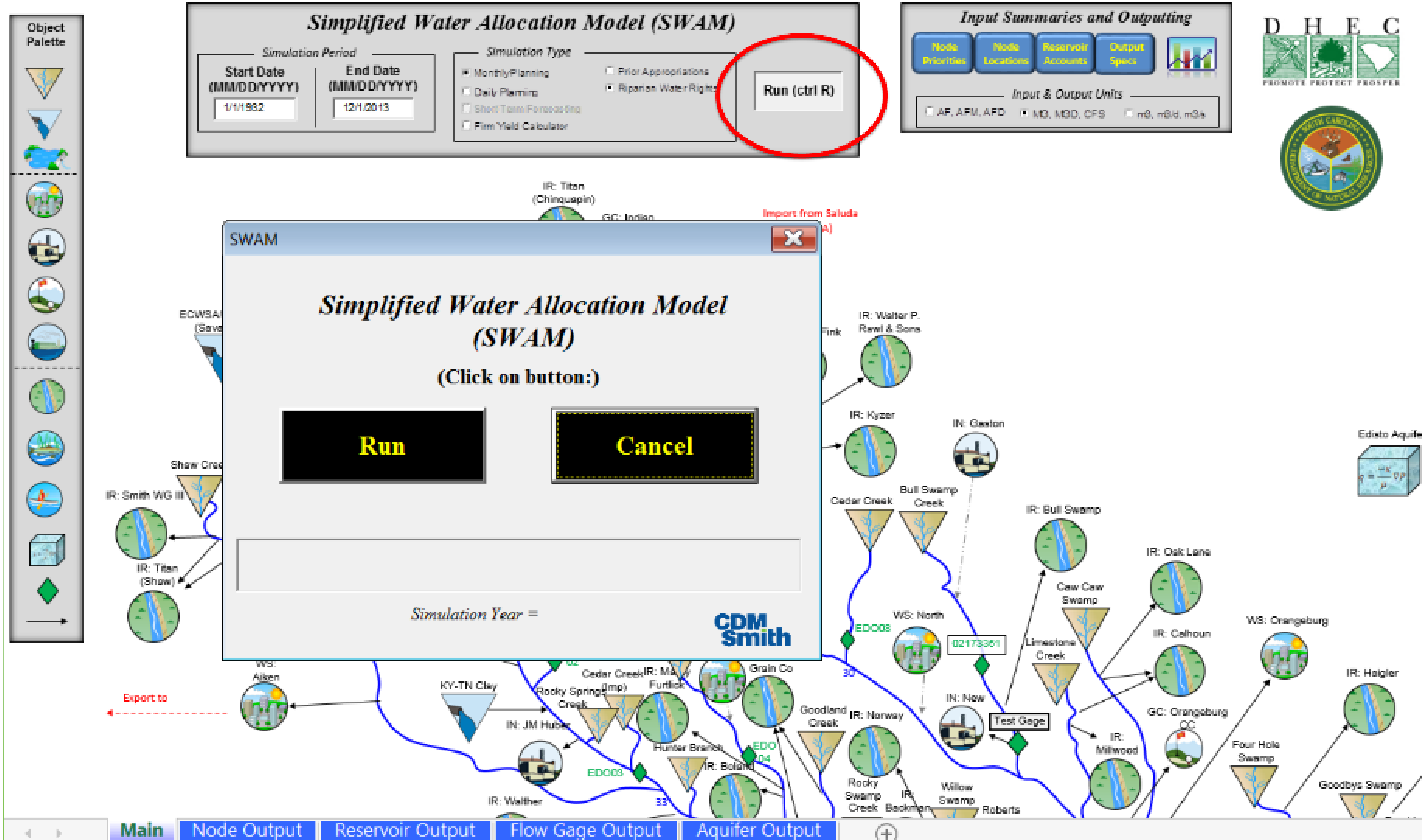
Add Flow Gage & Industrial Water User Objects



Specify Flow Gage Location



Run the Model over the Entire Period of Record



Calculate the Minimum Instream Flows

Model Output:

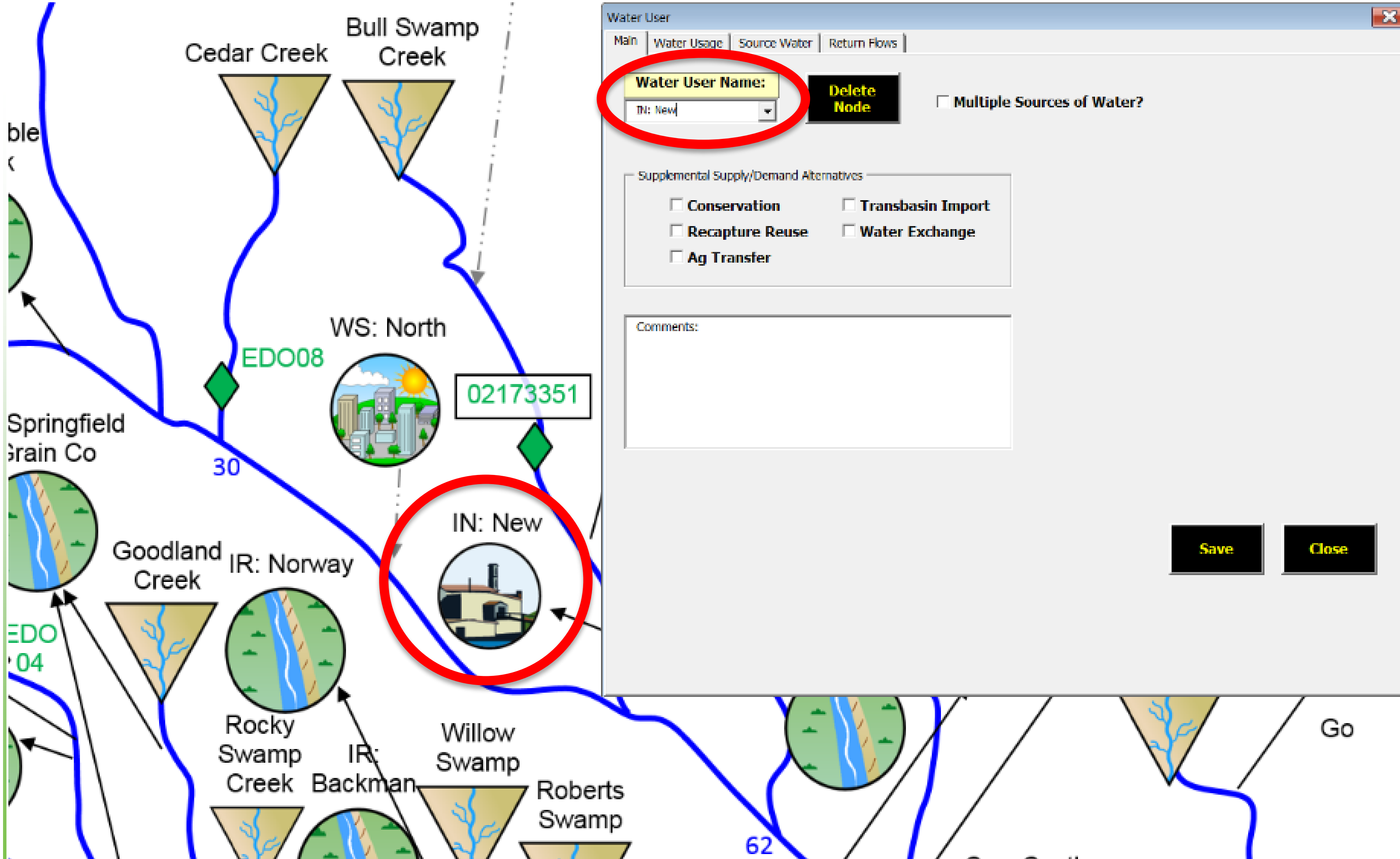
	Reach / mi
	Bull Swamp Creek / 15
Date	**Test Gage Flow (CFS)**
Min	**5**
Max	**96**
Avg	**25**
1/1/32	34.7
1/2/32	34.7
1/3/32	34.7
1/4/32	37.8
1/5/32	34.7
1/6/32	34.7
1/7/32	37.8
1/8/32	43.7
1/9/32	50.3
1/10/32	53.4
1/11/32	50.3
1/12/32	50.3
1/13/32	50.3
1/14/32	53.4
1/15/32	50.3
1/16/32	46.9
1/17/32	40.6
1/18/32	37.8
1/19/32	34.7

Minimum Flow Calculations:

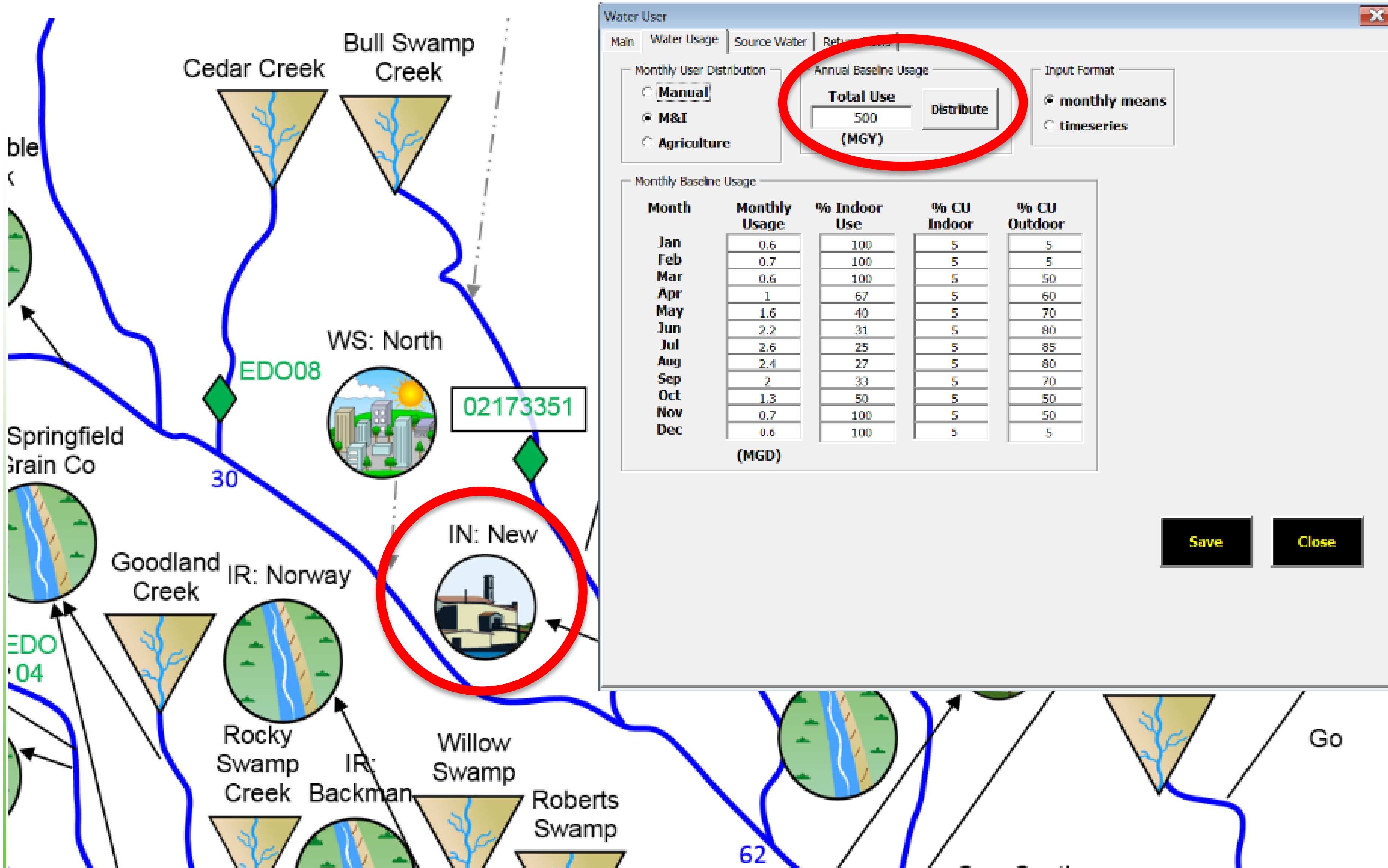
	: 40%
	: 30%
	: 20%

Month	Instream Flow (cfs)
Jan	10.3
Feb	10.3
Mar	10.3
Apr	10.3
May	7.7
Jun	7.7
Jul	5.2
Aug	5.2
Sep	5.2
Oct	5.2
Nov	5.2
Dec	7.7

Add the New User in the Water User Dialogue

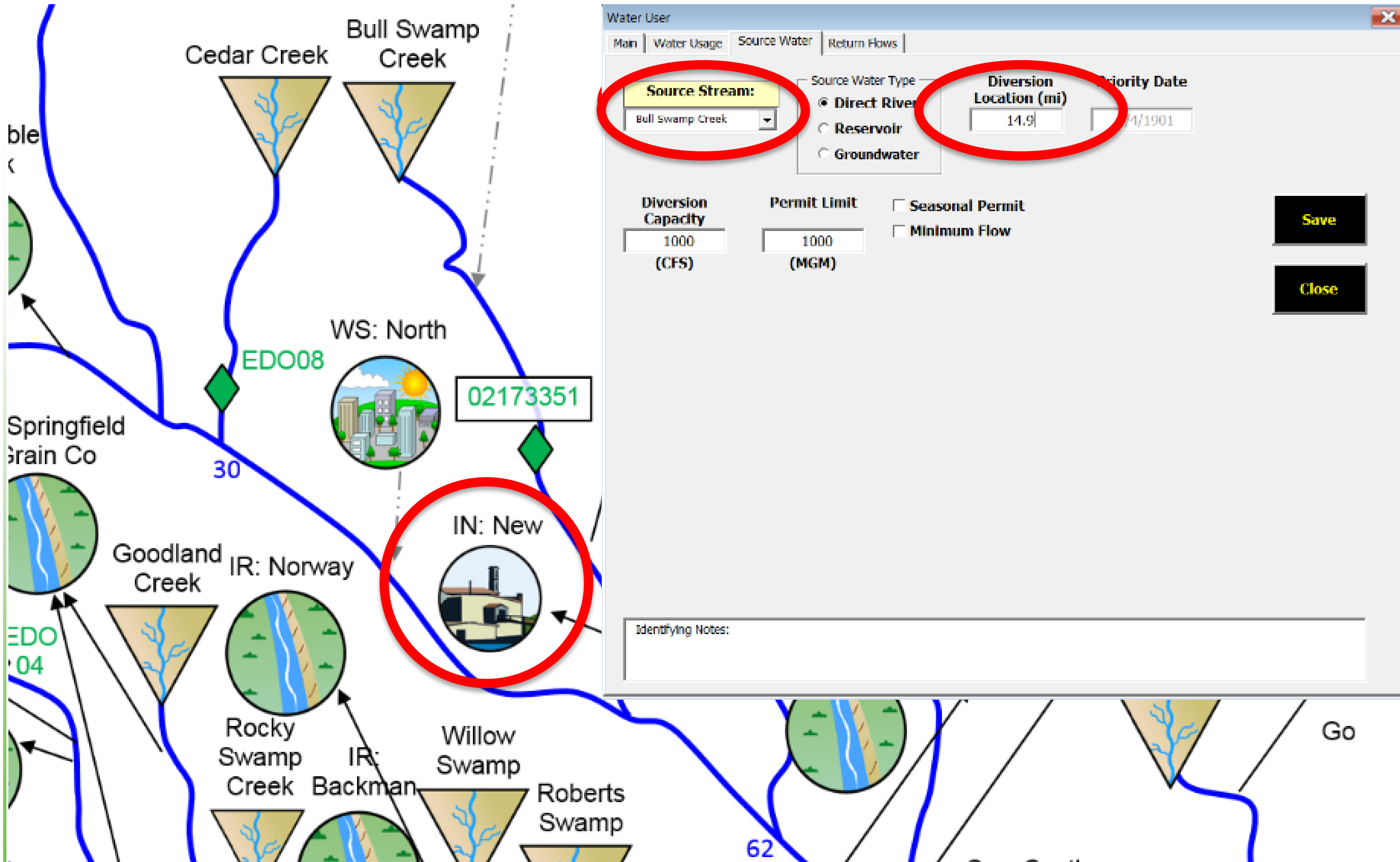


Specify Water Use

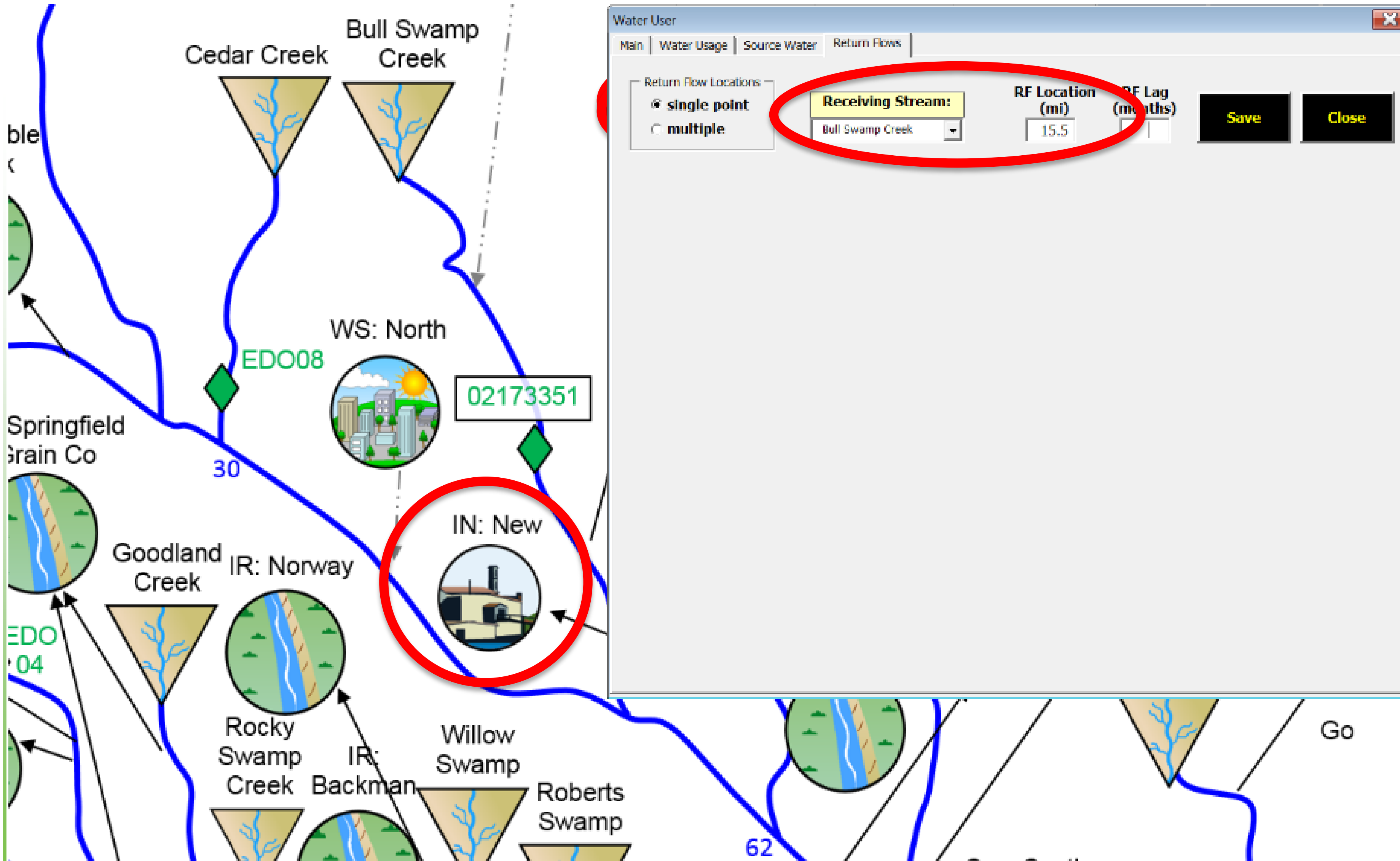


Month	Monthly Usage	% Indoor Use	% CU Indoor	% CU Outdoor
Jan	0.6	100	5	5
Feb	0.7	100	5	5
Mar	0.6	100	5	50
Apr	1	67	5	60
May	1.6	40	5	70
Jun	2.2	31	5	80
Jul	2.6	25	5	85
Aug	2.4	27	5	80
Sep	2	33	5	70
Oct	1.3	50	5	50
Nov	0.7	100	5	50
Dec	0.6	100	5	5

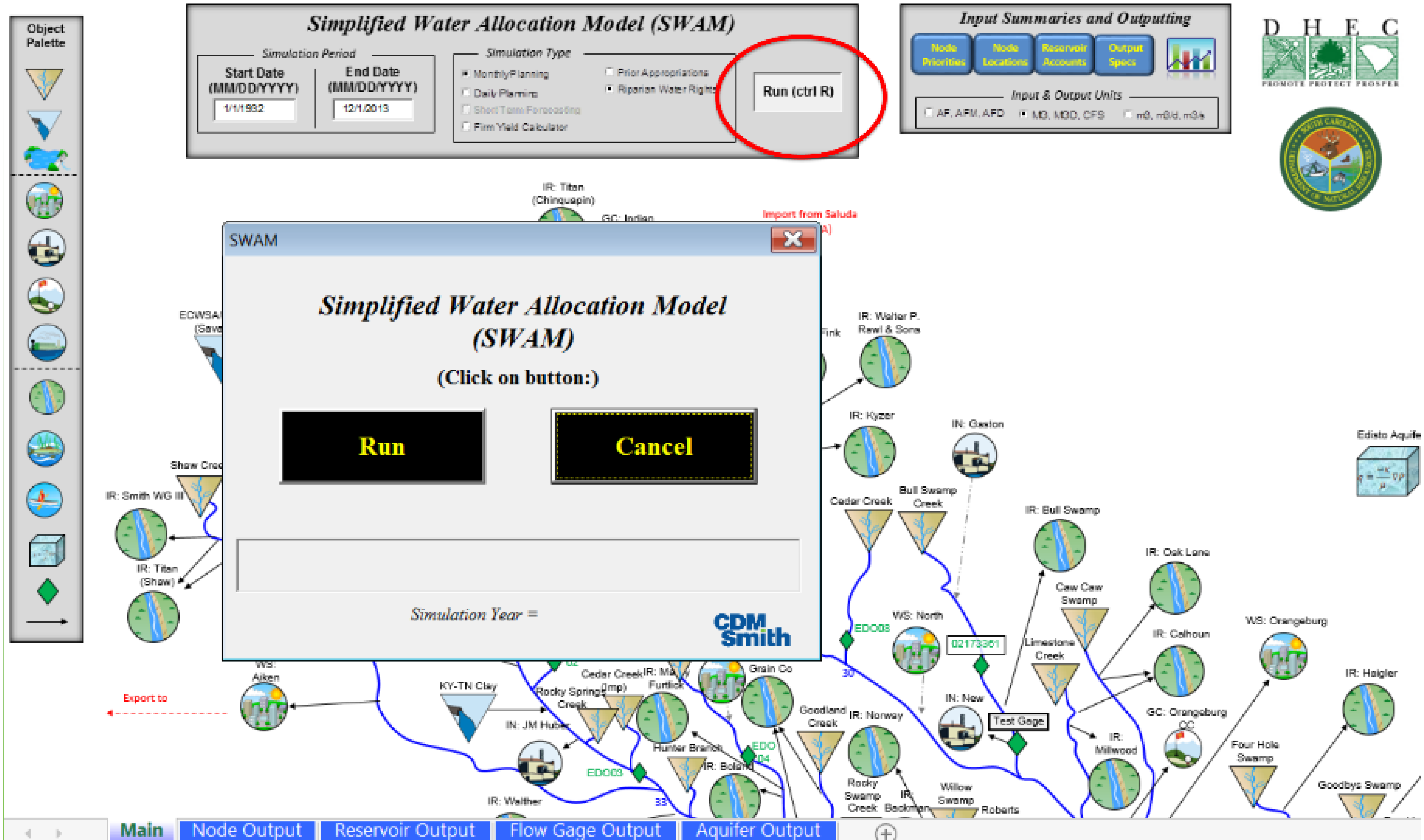
Specify the Source and Diversion Location



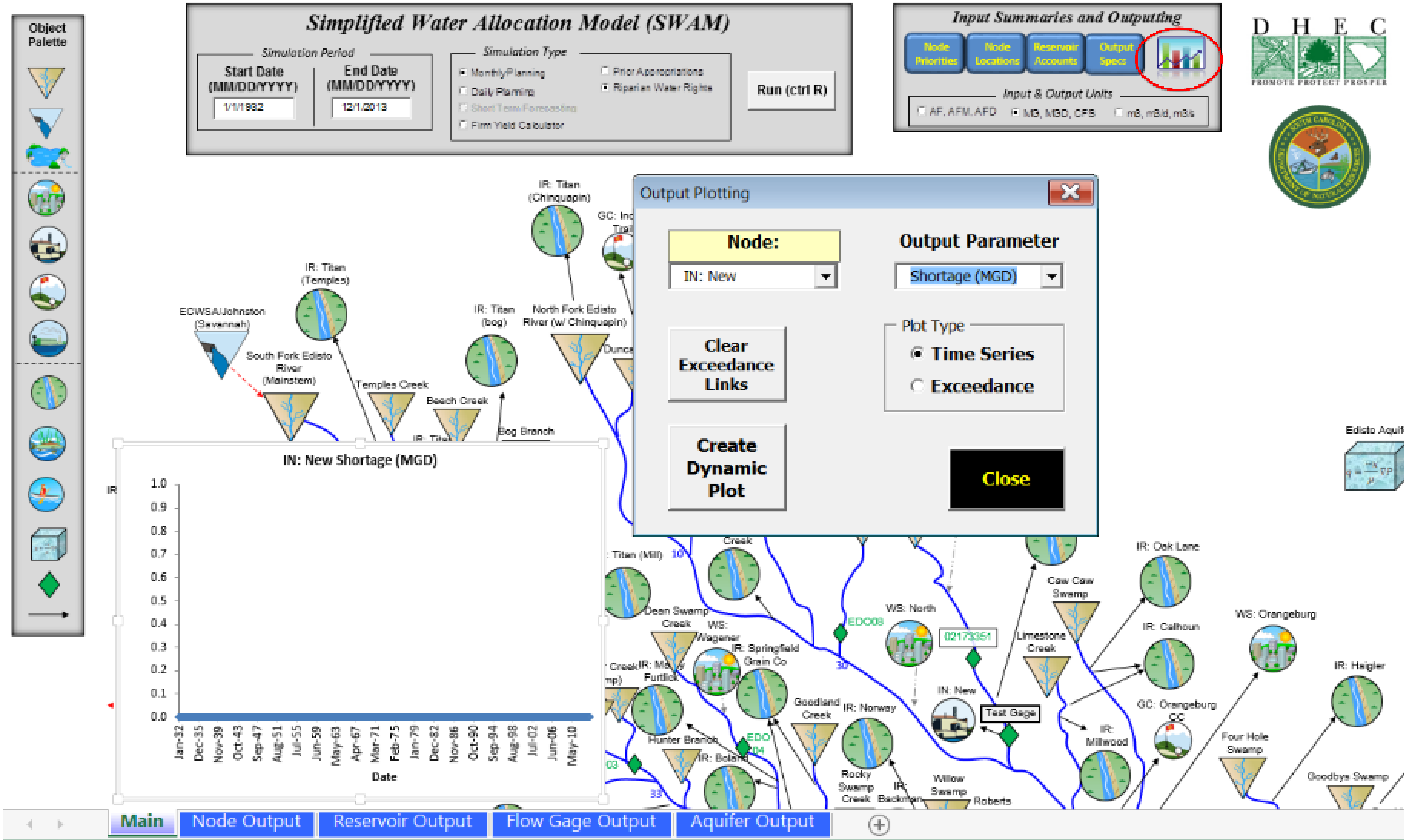
Designate the Return Location



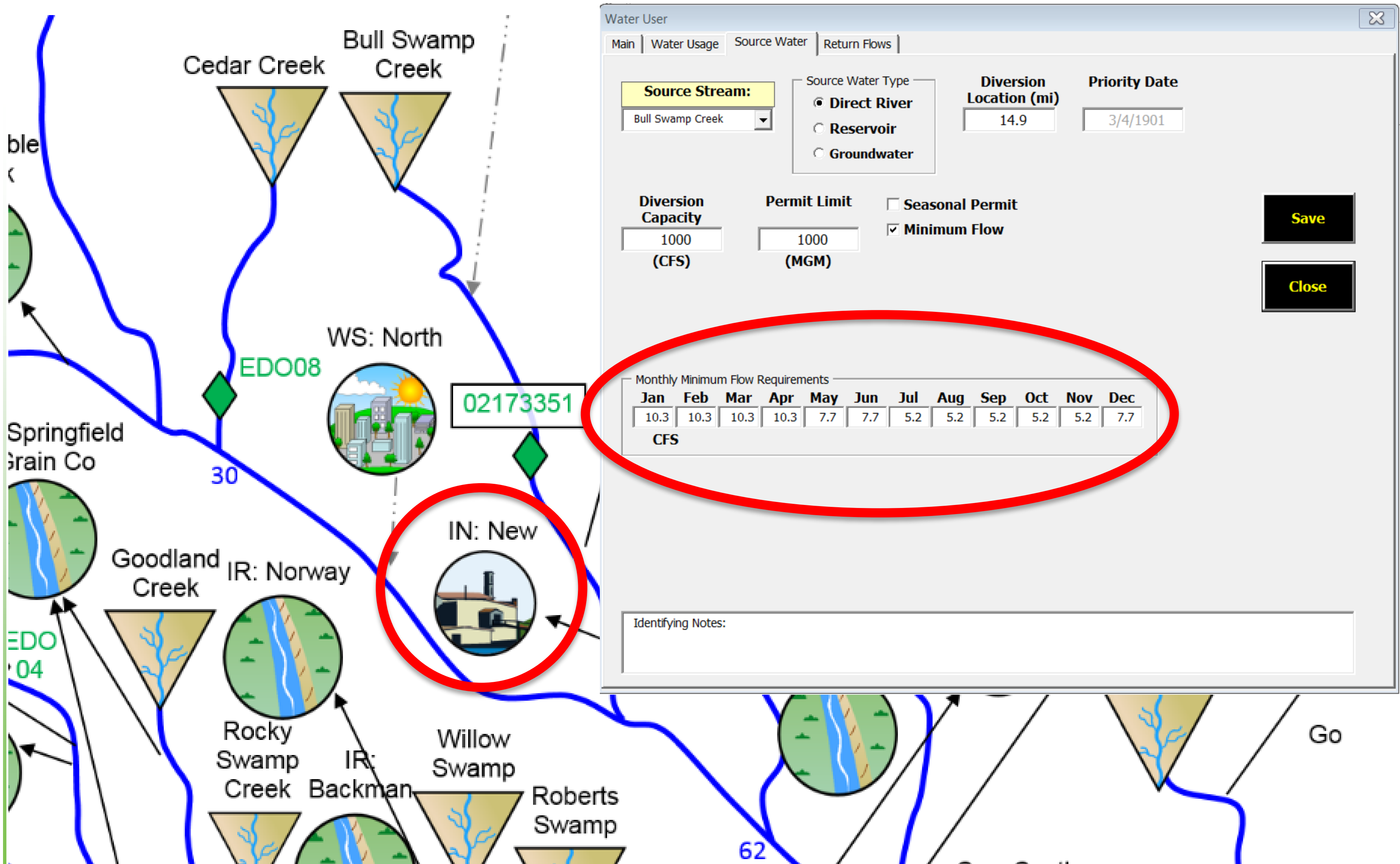
Run the Model over the Entire Period of Record



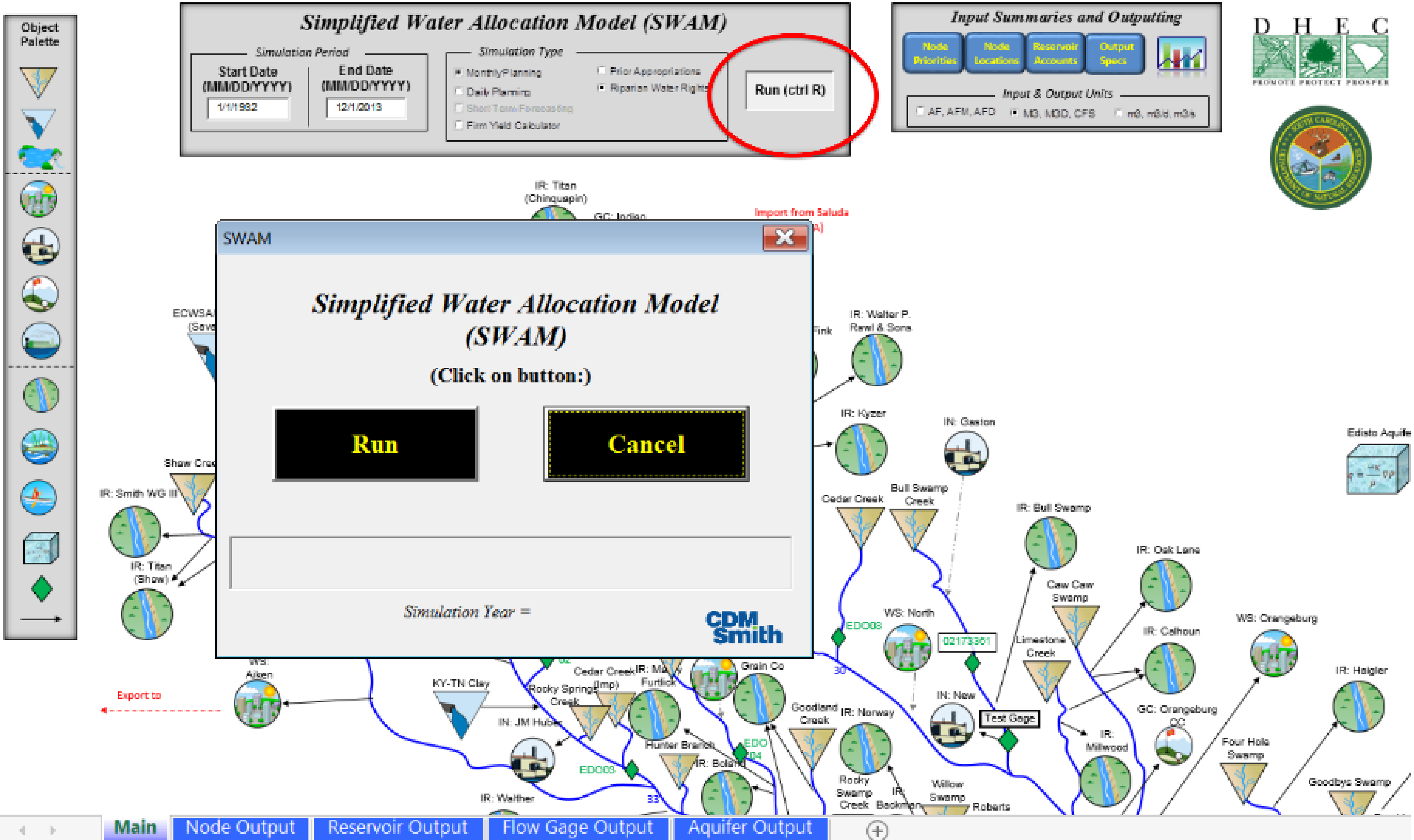
Build a Shortage Plot for the New User



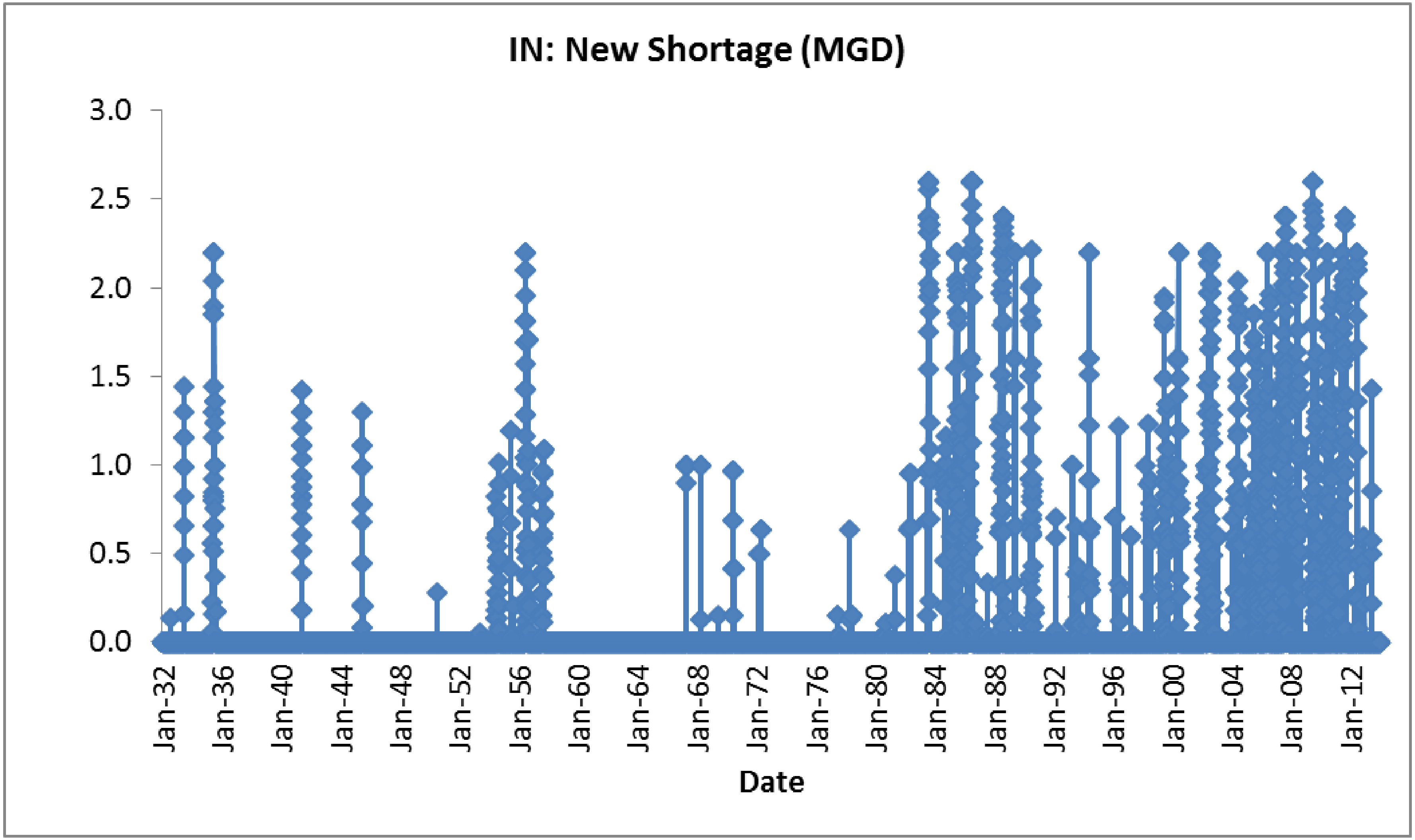
Add Minimum Flows



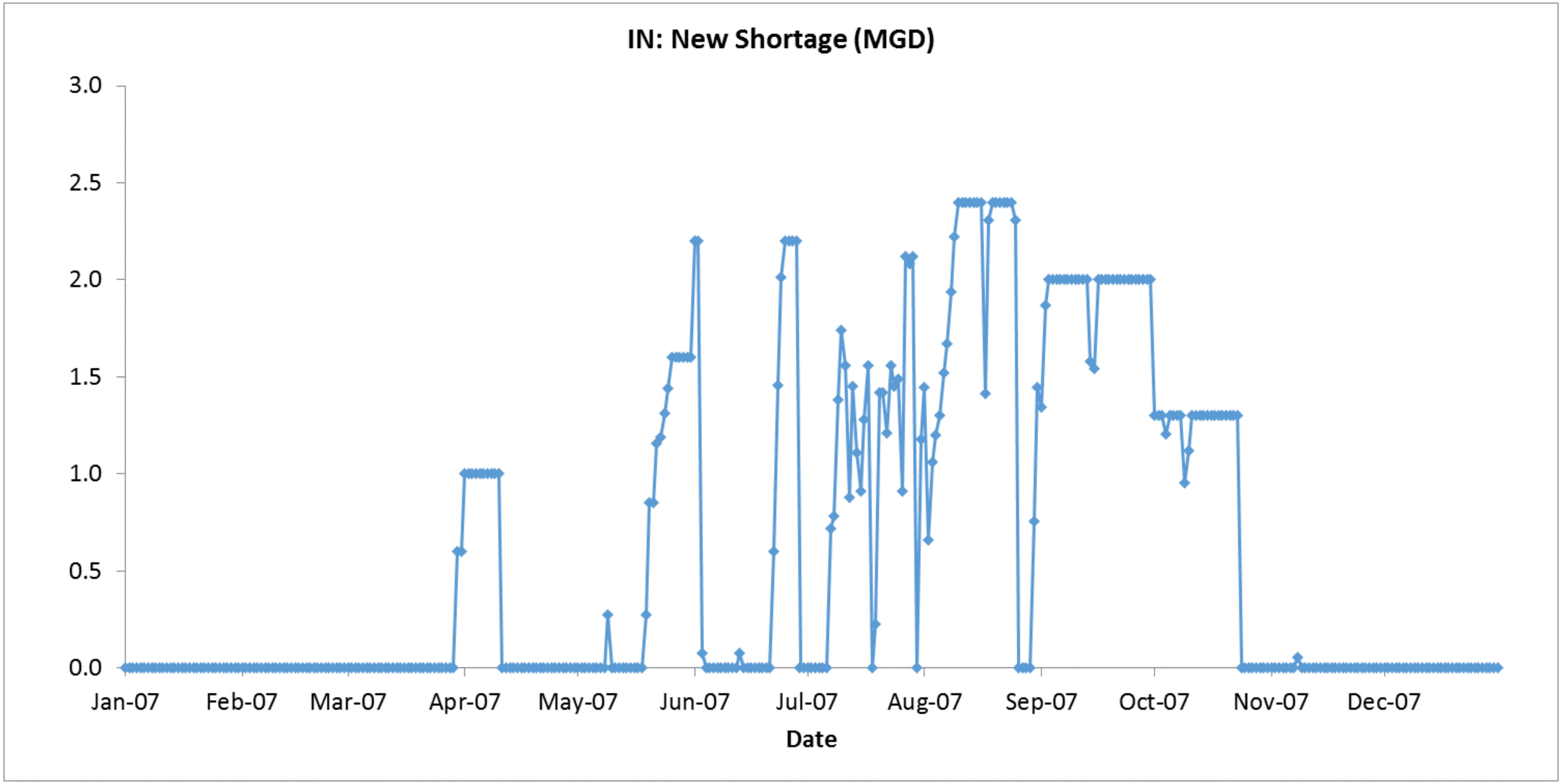
Re-Run the Model



Shortages with Min. Instream Flows Enforced



Shortages with Min. Instream Flows Enforced: 2007



Shortages also Available in Node Output Table

		Priority Rank	Reach	Location	Permit Limit (MGM)	Ditch Capacity (CFS)	Storage Capacity (MG)	Storage Withdrawal Permit (MGM)		
	IN: New	*49*	*Bull Swamp Creek*	*15*	*1000*	*1000*	*0*	*325829*		
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)**
Min	**2**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**
Max	**67**	**36**	**3**	**0**	**0**	**3**	**2**	**1**	**0**	**0**
Avg	**17**	**11**	**1**	**0**	**0**	**1**	**0**	**1**	**0**	**0**
1/31/06	17	8	1	0	0	1	0	1	0	0
2/28/06	15	5	1	0	0	1	0	1	0	0
3/31/06	10	0	0	0	0	1	1	0	0	0
4/30/06	8	0	0	0	0	1	1	0	0	0
5/31/06	5	1	1	0	0	2	1	0	0	0
6/30/06	17	13	2	0	0	2	0	1	0	0
7/31/06	7	4	3	0	0	3	0	1	0	0
8/31/06	11	9	2	0	0	2	0	1	0	0
9/30/06	11	8	2	0	0	2	0	1	0	0
10/31/06	9	6	1	0	0	1	0	1	0	0
11/30/06	17	14	1	0	0	1	0	1	0	0
12/31/06	16	10	1	0	0	1	0	1	0	0
1/31/07	20	11	1	0	0	1	0	1	0	0
2/28/07	18	8	1	0	0	1	0	1	0	0
3/31/07	17	6	1	0	0	1	0	1	0	0
4/30/07	10	0	0	0	0	1	1	0	0	0
5/31/07	7	2	2	0	0	2	0	1	0	0
6/30/07	11	7	2	0	0	2	0	1	0	0
7/31/07	6	4	3	0	0	3	0	1	0	0
8/31/07	5	3	2	0	0	2	0	1	0	0
9/30/07	2	0	0	0	0	2	2	0	0	0
10/31/07	5	2	1	0	0	1	0	1	0	0
11/30/07	6	3	1	0	0	1	0	1	0	0
12/31/07	17	11	1	0	0	1	0	1	0	0

Main | Node Output | Reservoir Output | Flow Gage Output | Aquifer Output

Other Example Uses

- 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
- Consolidate hydrologic data

Questions?

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