Surface Water Quantity Models

Progress Meeting Notes

September 6, 2016

Attendees: **CDM Smith**: John Boyer, Kirk Westphal, Nina Caraway
SCDNR: Joe Gellici, Scott Harder, Andy Wachob, Alex Pellet, Bill Clendenin
DHEC: Rob Devlin
Technical Advisory Committee: Ed Bruce, Heather Nix, Eddie Twilley, Mike Harrelson, William Gaither, Eric Schmidt

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1. **Broad Basin Model**
    a. DNR review of revised model
    - Scott Harder noted that DNR would be forwarding to CDM Smith, several final recommendations for model calibration, focusing on the Tyger and Enoree sub-basins. DNR would also provide a list of potential future "calibration considerations". These would include calibration tests performed by DNR staff, but which were still in an exploratory phase. DNR will take responsibility for incorporating any calibration adjustments that results from these tests, in the next 6-12 months.
    - Joe Gellici noted that DNR would document all changes, and include an addendum to the modeling report, if calibration adjustments are made.
    - John Boyer indicated that CDM Smith is agreeable with this approach, as it allows them to focus on completion of the remaining models.

2. **SWAM Water Use Conservation Enhancements** (see attached slides)
    - John Boyer reviewed new enhancements made to SWAM that provide additional flexibility for including and evaluating water conservation practices. The enhancements will be especially useful in basins like the Catawba-Wateree, which has water conservation measures as actions of the Low Inflow Protocol (LIP). John noted that the enhancements were included using a very similar format to the

reservoir rules, and includes much of the same functionality with regard to composite metrics.

3. **Catawba-Wateree Basin Draft Calibration Model Results** (see attached slides)
   - Nina Caraway reviewed the calibration approach used for the Catawba-Wateree model, and the draft calibration results for several locations. It was noted that calculated releases from Lake Wylie, as provided by HDR Engineering Inc., appear to better batch downstream flow, and thus provide better calibration results, than the CHEOPs output from Lake Wylie. As a result, the calculated releases were used for calibration. The CHEOPS outflows from Lake Wylie will still be used for the baseline model. Nina noted that comparisons of modeled to gaged flow on the mainstem, both above and below Lake Wateree shows less than 5% difference, over the 2006-2010 period selected for calibration.

4. **Savannah Basin UIF Methodology** (see attached memo)
   - John Boyer summarized the Savannah UIF methodology memo, noting that CDM Smith was proposing not to calculate UIFs at most of the inactive gages at the Savannah River site, with short periods of record. All other active or inactive gages on South Carolina tributaries to the Savannah River, except for a single, inactive gage with only 1.5 years of record in the upper portion of the basin, would be included.

5. **Upcoming Stakeholder Meetings**
   a. Catawba-Wateree 2nd Meeting, early October
      - John Boyer indicated that CDM Smith should be ready as early as the week of October 3rd, to hold the 2nd stakeholder meeting in the Catawba-Wateree Basin. John noted he would check with Clemson to determine if that week might work, or if they would prefer to schedule it after the South Carolina Water Resources Conference, which is the week of October 10th.
   b. Santee 2nd Meeting, mid/late-October (after SCWRC)
      - John Boyer indicated that CDM Smith should be ready for the 2nd stakeholder meeting in the Santee Basin during the last week of October or first week of November. John will check with Clemson on potential dates and locations.

Progress Meeting Slides

September 6, 2016

- SWAM Water User Conservation Enhancements
- Catawba-Wateree Basin Model Draft Calibration Results

SWAM Water User Conservation Enhancements

Objectives

- Provide greater flexibility with respect to simulating water user conservation
- Allow for the following types of simulations:
  - *Hindcasting of past conservation actions (calibration/verification)*
  - *Predicting the impacts of future or alternate conservation programs on water availability and basin hydrology*
  - *Predicting the future occurrence of mandatory conservation as a function of basin hydrology and operations (e.g. as impacted by increasing demands, changing climate, etc.).*

Overview

- Enhancements are particularly focused on Low Inflow Protocol (LIP) rules dictating municipal reservoir water use
- Accessed via the water user object input form and specific to that water user
- User-defined rule sets that are date-specific and fully analogous to reservoir operating rules
- As with res ops rules, considered an “advanced user” feature in SWAM.

Overview

- Conditional or unconditional conservation requirements (% reduction in usage)
- Conditions based on (<, >, =):
  - Flows at flow gage
  - Reservoir storage
  - Specific water user account storage
  - Combinations of above (AND / OR).
- Multiple and flexible date ranges
- User defined % consumptive use proportions of water use reductions
- Easily turned on or off to allow for quick “what if” scenario analyses.

Overview

- Additional layers of sophistication for defining conditions of conservation:
  - Moving average metrics
  - “Composite” flow gage or reservoir storage metrics
  - “Ramping” periods for conditions
  - “Moving Trigger” conditions based on relative comparison of flow or storage metrics

Overview

- Note: hydrologic conditions for conservation triggers are assessed at the start of each timestep (daily or monthly)
- Conditions are *forecast* for that timestep based on a combination of known and unknown variables
  - Forecasting not 100% perfect (similar to reality).

SWAM Enhanced Conservation: WS: Camden (Lake Wateree)

Summary of LIP Trigger Points

Stage	Storage Index [1]		Drought Monitor [2] (3-month average)		Monitored USGS [3] Streamflow Gages
0[4]	90% < SI < 100% TSI		3mo Ave DM ≥ 0		AVG ≤ 85% LT 6mo Ave
1	75% TSI < SI ≤ 90% TSI	and	3mo Ave DM ≥ 1	or	AVG ≤ 78% LT 6mo Ave
2	57% TSI < SI ≤ 75% TSI	and	3mo Ave DM ≥ 2	or	AVG ≤ 65% LT 6mo Ave
3	42% TSI < SI ≤ 57% TSI	and	3mo Ave DM ≥ 3	or	AVG ≤ 55% LT 6mo Ave
4	SI ≤ 42% TSI	and	3mo Ave DM = 4	or	AVG ≤ 40% LT 6mo Ave

[1] The ratio of Remaining Useable Storage to Total Usable Storage at a given point in time.

[2] The three-month numeric average of the published U.S. Drought Monitor.

[3] The sum of the rolling sixth-month average for the Monitored USG Gages as a percentage of the period of record rolling average for th month period for the Monitored USGS Streamflow Gages.

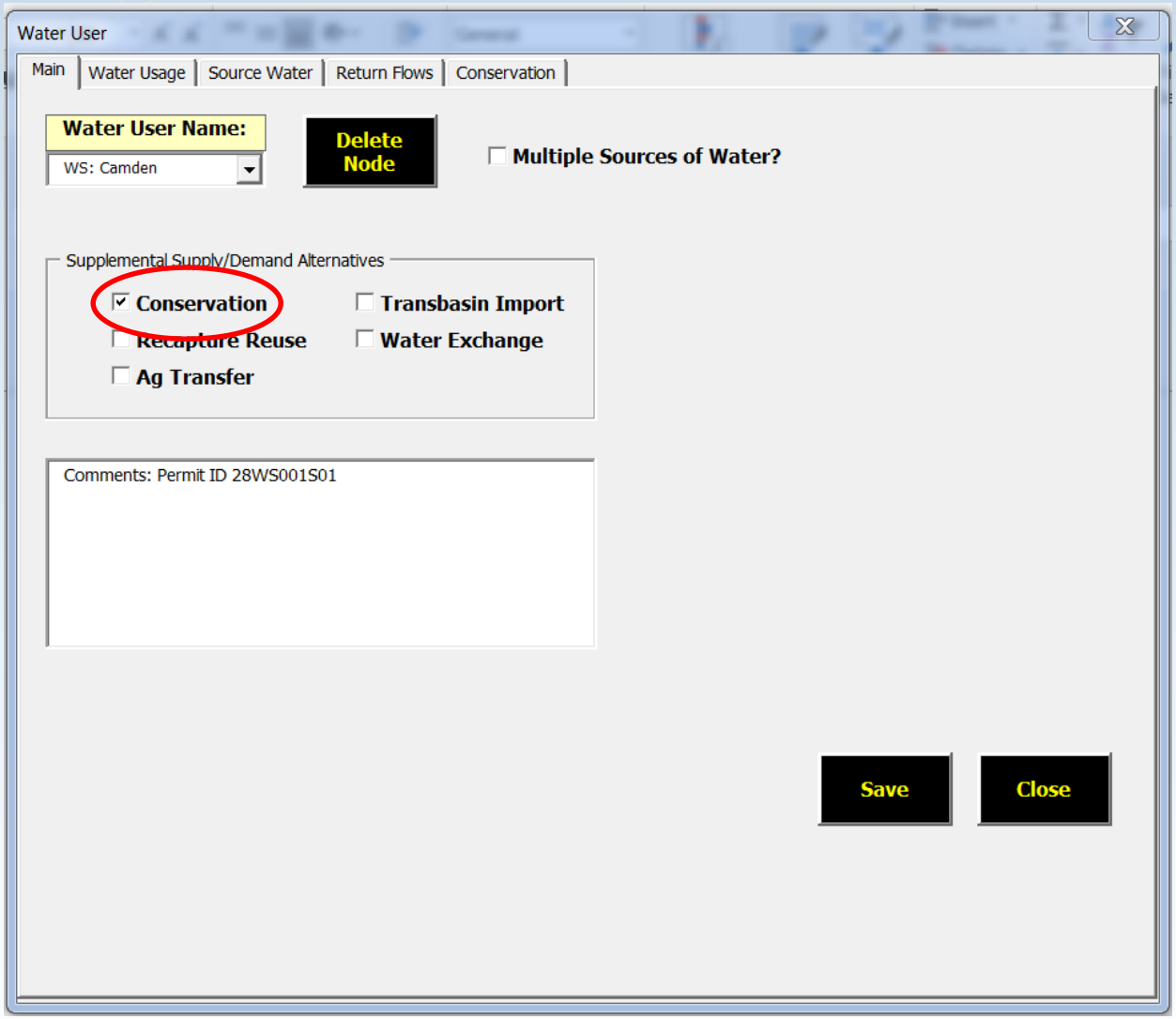
[4] Stage 0 is triggered when any two of the three trigger points are re

(Stages 1 through 4).

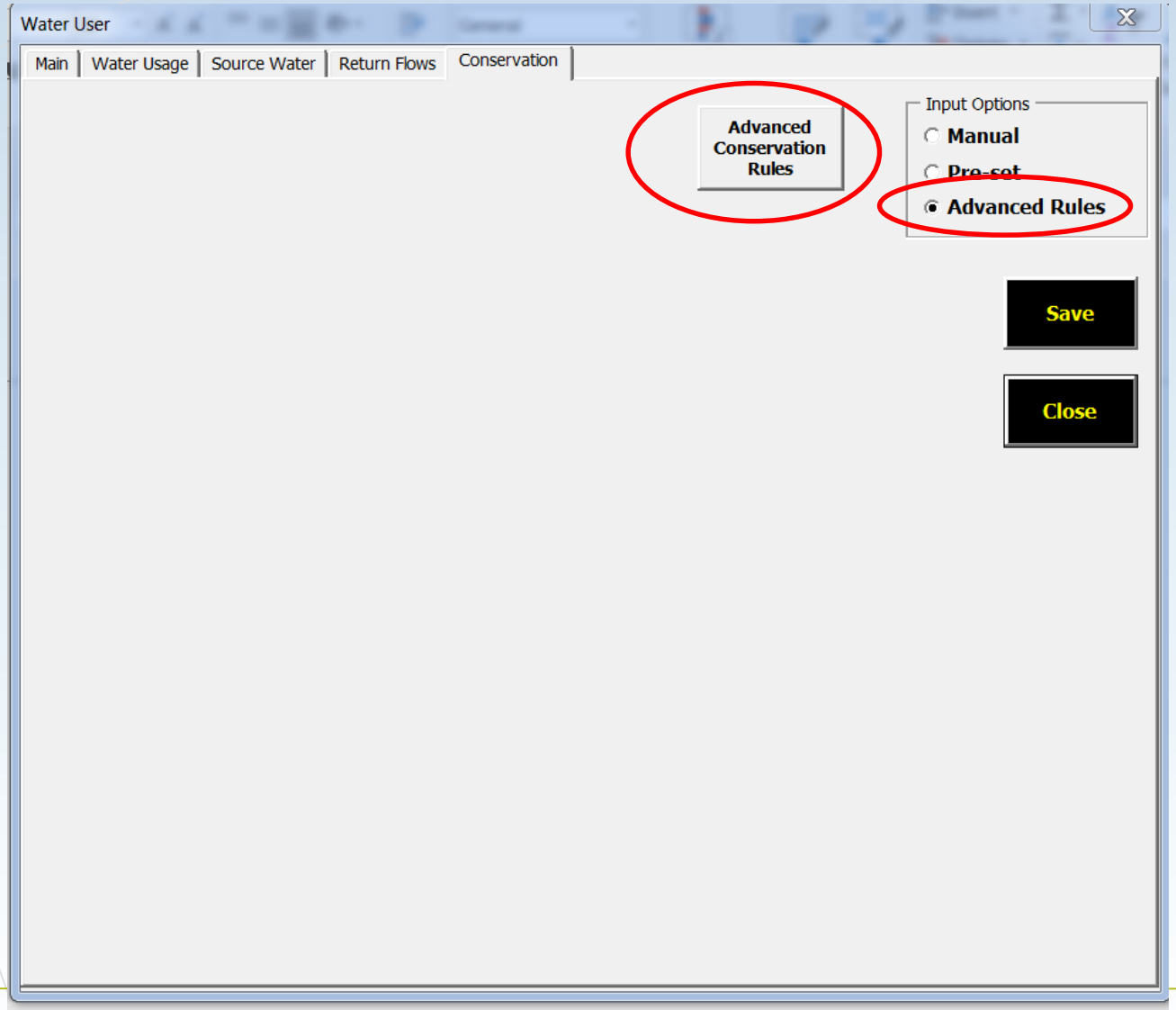
3. Owners of Public Water Supply intakes and owners of intakes used for irrigation with a capacity greater than 100,000 gallons per day will complete the following activities within 14 days after the Stage 1 LIC declaration:
   a. Notify their water customers and employees of the Low Inflow Condition through public outreach and communication efforts.
   b. Request that their water customers and employees implement voluntary water use restrictions, in accordance with their drought response plans, which may include:
      - Reduction of lawn and landscape irrigation to no more than two days per week (i.e. residential, multi-family, parks, streetscapes, schools, etc).
      - Reduction of residential vehicle washing

   At this stage, the goal is to reduce water usage by 3-5% (or more) from the amount that would otherwise be expected. The baseline for this comparison will be generated by each entity and will be based on existing conditions (i.e. drought conditions). For the purposes of determining 'the amount that would

SWAM Enhanced Conservation: WS: Camden (Lake Wateree)



SWAM Enhanced Conservation: WS: Camden (Lake Wateree)



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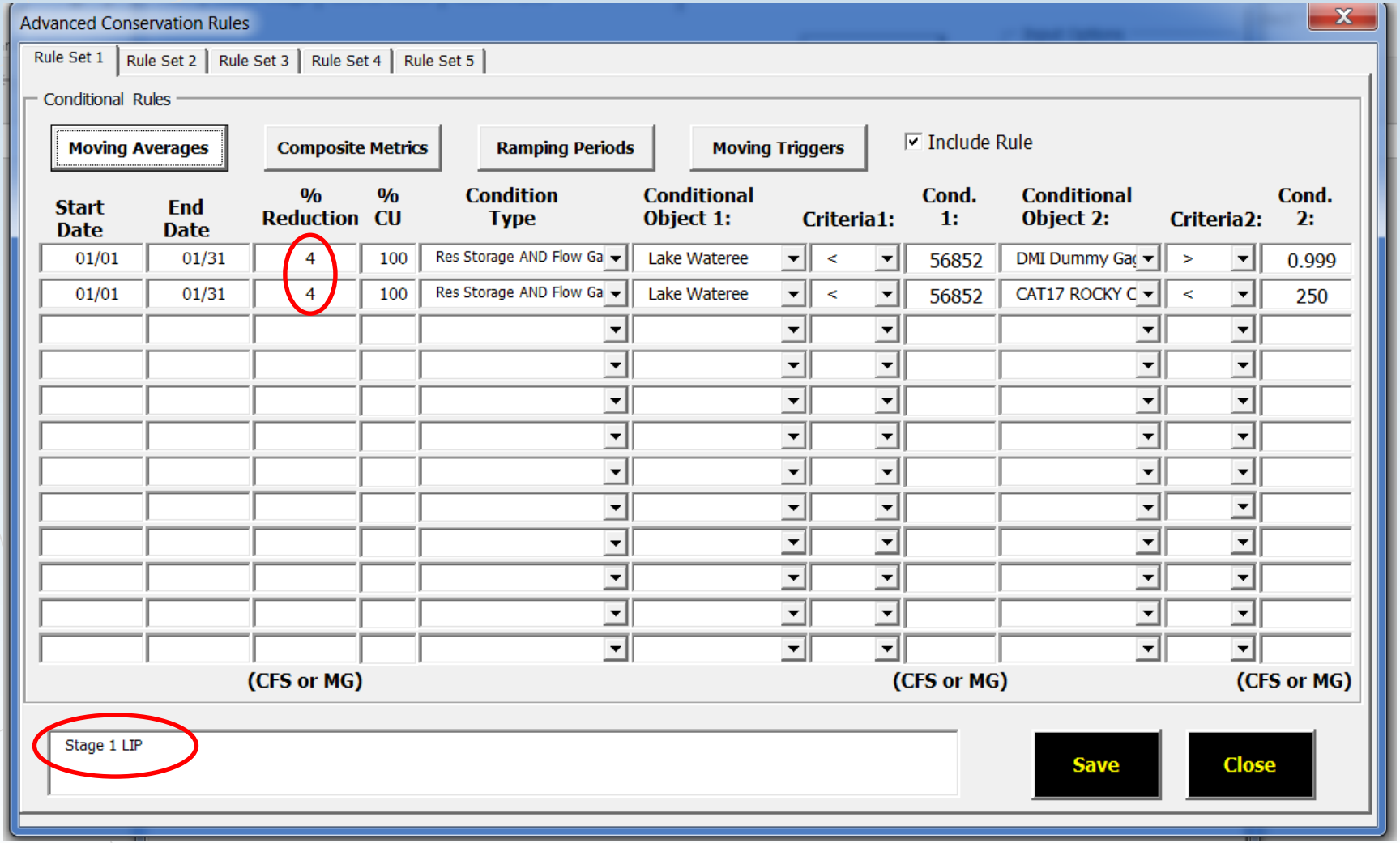

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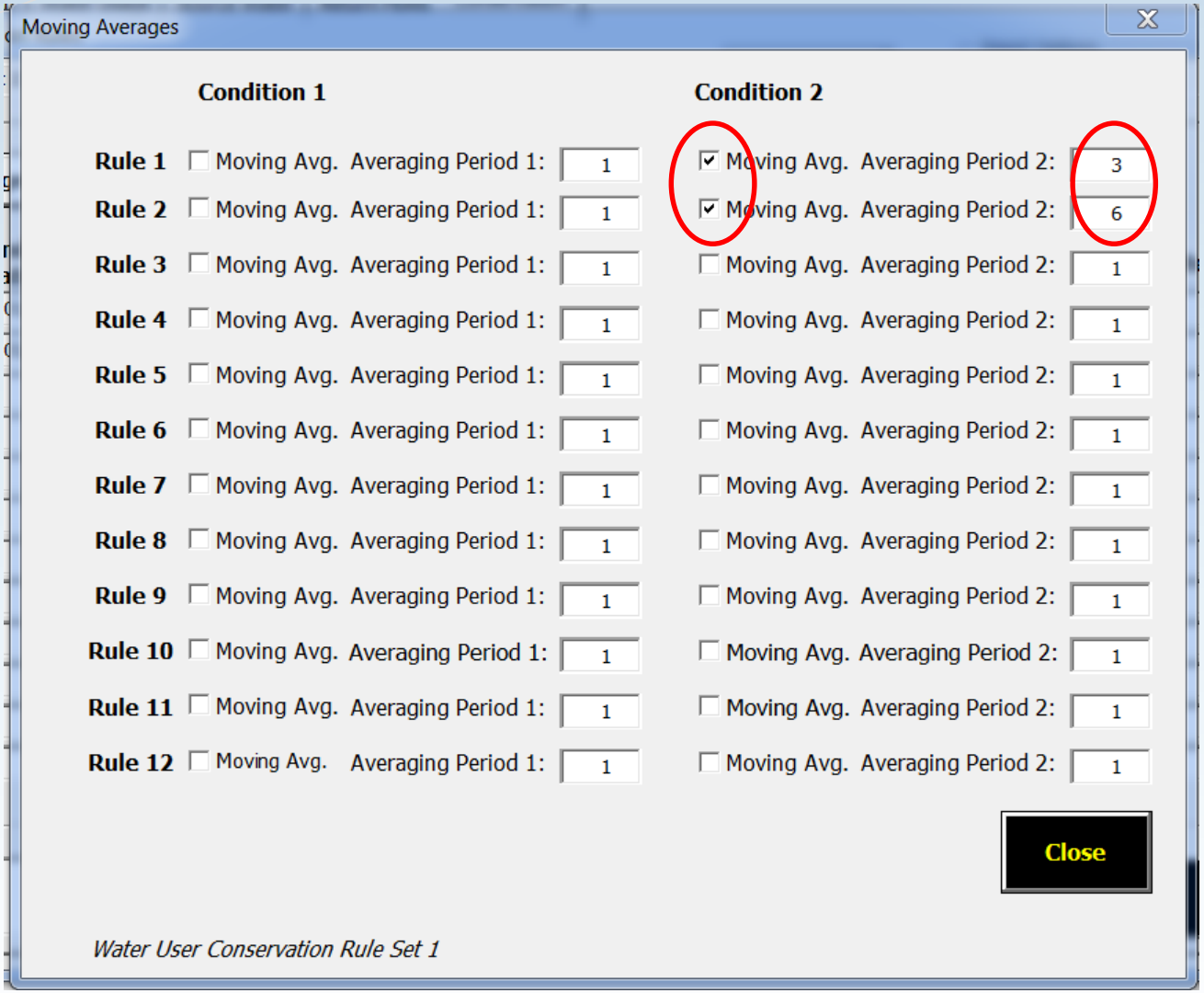
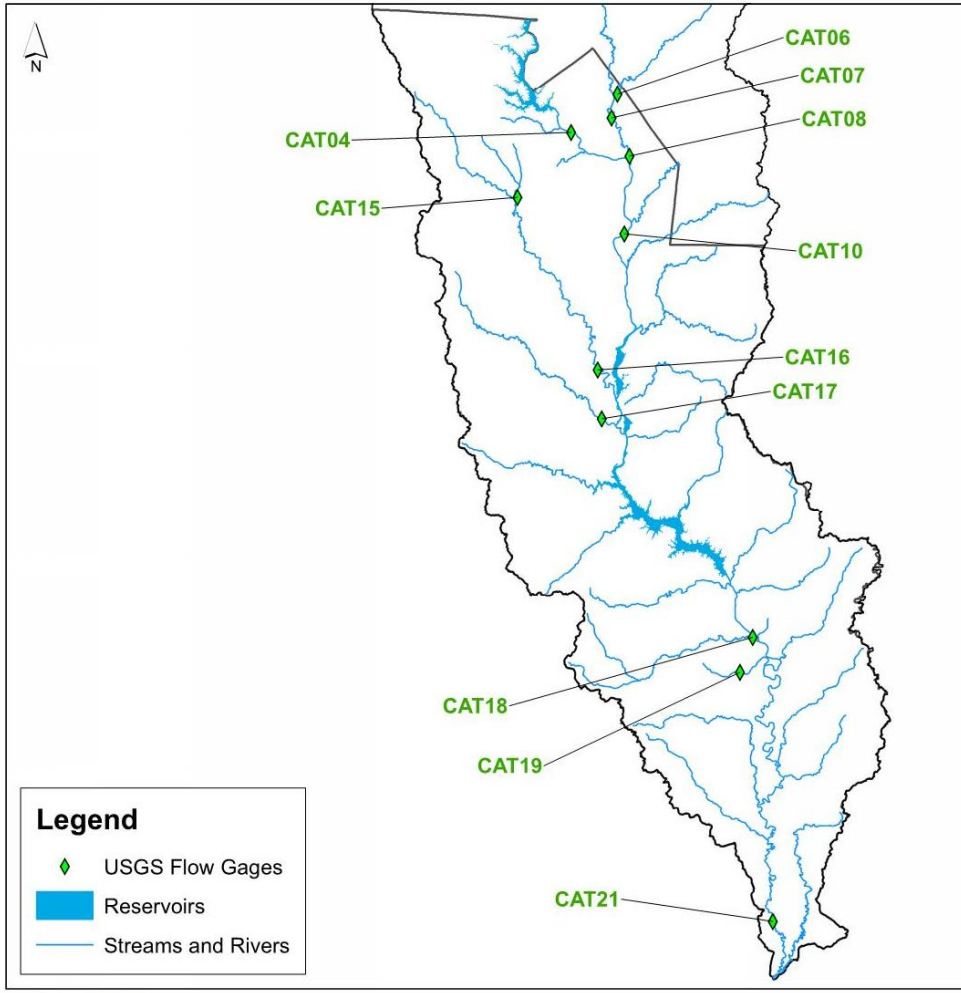


Catawba-Wateree Basin Model Draft Calibration Approach

- Calibration model uses HDR calculated Lake Wylie releases
- Calibration period:
  - June 2006 – 2010 (mainstem)
  - 1983 – 2010 (tributaries)
- Calibration includes comparison to mainstem gages and tribs
  - Two mainstem gages above Fishing Creek Res
  - Two mainstem gages below Lake Wateree
  - Seven tributary gages
- Also received calculated reservoir releases from HDR for comparison to flows just below each reservoir

Catawba-Wateree Basin Model Draft Calibration Results



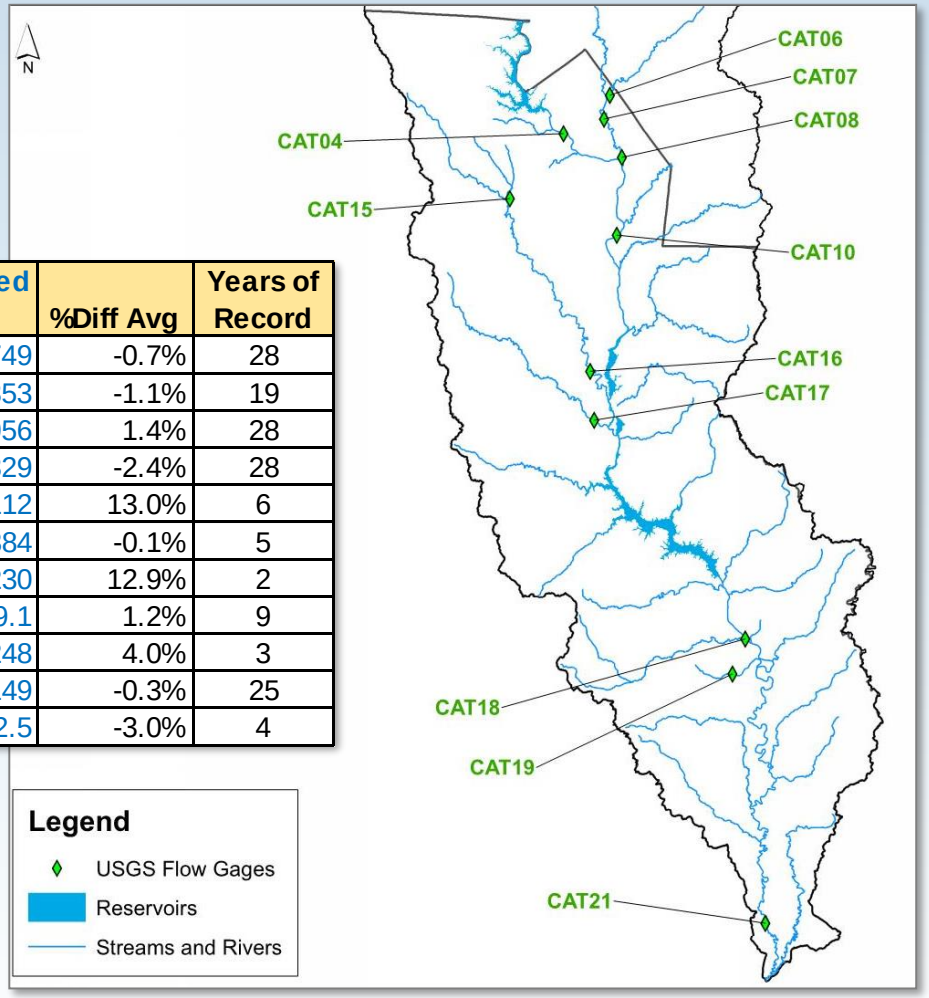
Project Gage ID	USGS Number	Tributary Object	Periods of Record	Basin Area (sq. mi.)	River Mile
CAT04	02146000	Mainstem	4/1942 - 8/1995 10/1995 - 12/2010	3048	4
CAT06	0214676115	McAlpine Creek	10/2005 - 12/2010	95	15
CAT07	02146800	Sugar Creek	4/2006 - 12/2010	263	24
CAT08	02146820	Sugar Creek	5/2001 - 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

Streamflow gages used in calibration

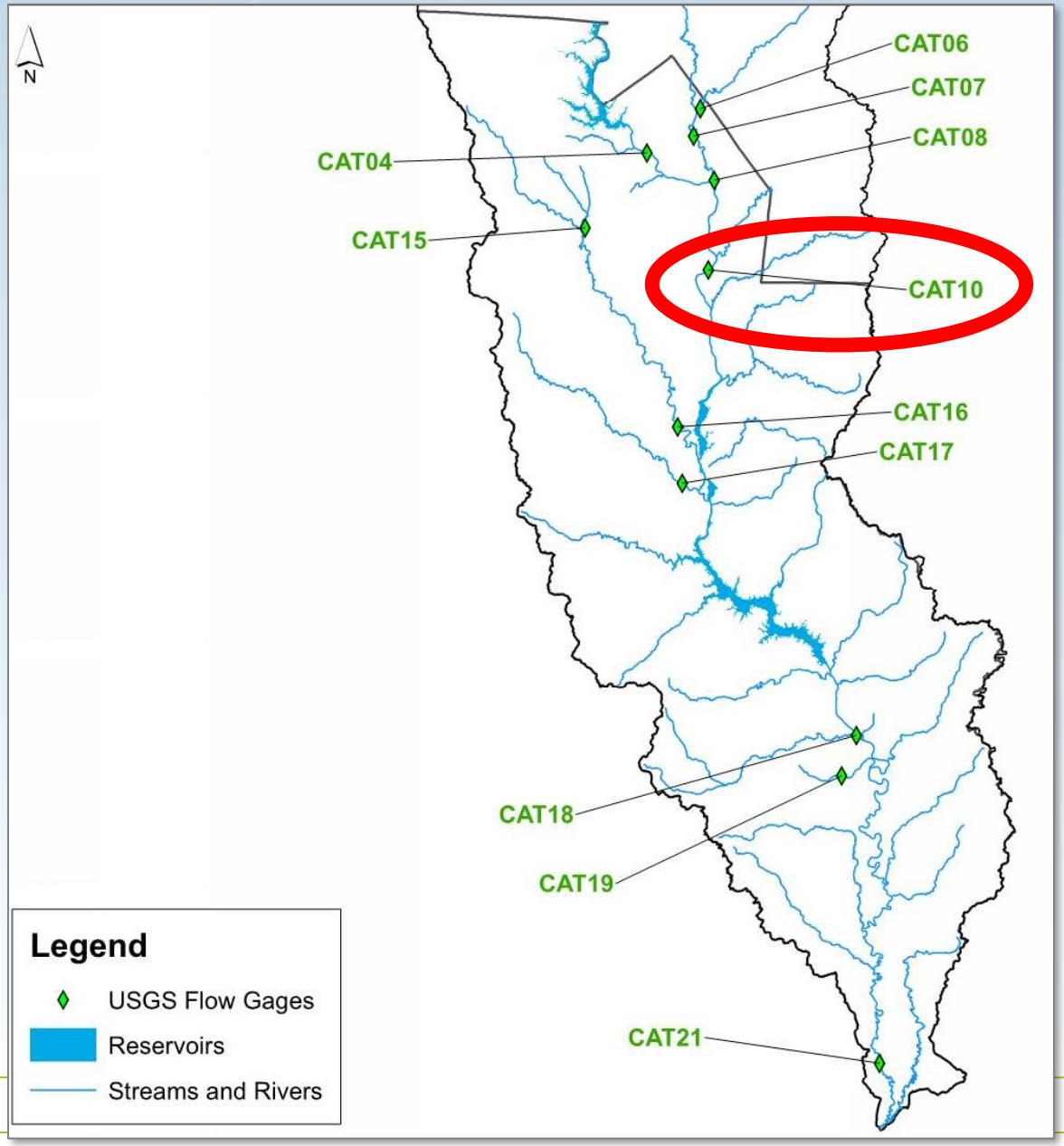
Catawba-Wateree Basin Model Draft Calibration Results

Annual Flow Statistics (CFS) from Monthly Model

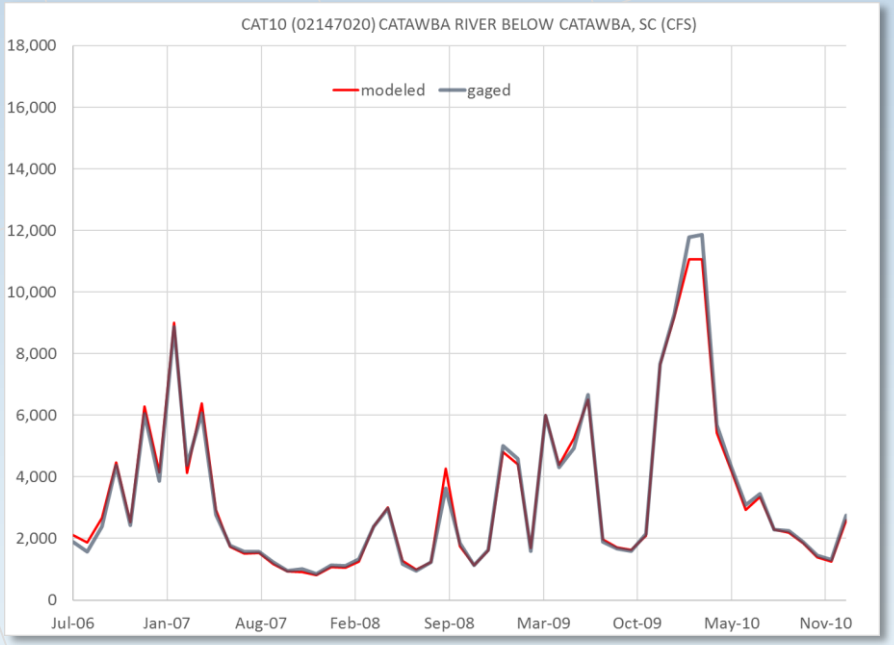
ID	Station	Modeled Avg	Measured Avg	%Diff Avg	Years of Record
CAT04	CATAWBA RIVER NEAR ROCK HILL	2,731	2,749	-0.7%	28
CAT10	CATAWBA RIVER BELOW CATAWBA	3,316	3,353	-1.1%	19
CAT18	WATEREE RIVER NR. CAMDEN	4,011	3,956	1.4%	28
CAT21	WATEREE R. BL EASTOVER	2,760	2,829	-2.4%	28
CAT06	MCALPINE CREEK AT SR2964	126	112	13.0%	6
CAT07	SUGAR CREEK NEAR FORT MILL	384	384	-0.1%	5
CAT08	SUGAR CR. NR FT. MILL	260	230	12.9%	2
CAT15	WILDCAT CREEK BELOW ROCK HILL	19.3	19.1	1.2%	9
CAT16	FISHING CREEK BELOW FORT LAWN	258	248	4.0%	3
CAT17	ROCKY CREEK AT GREAT FALLS	149	149	-0.3%	25
CAT19	GILLIES CREEK NEAR LUGOFF	12.1	12.5	-3.0%	4

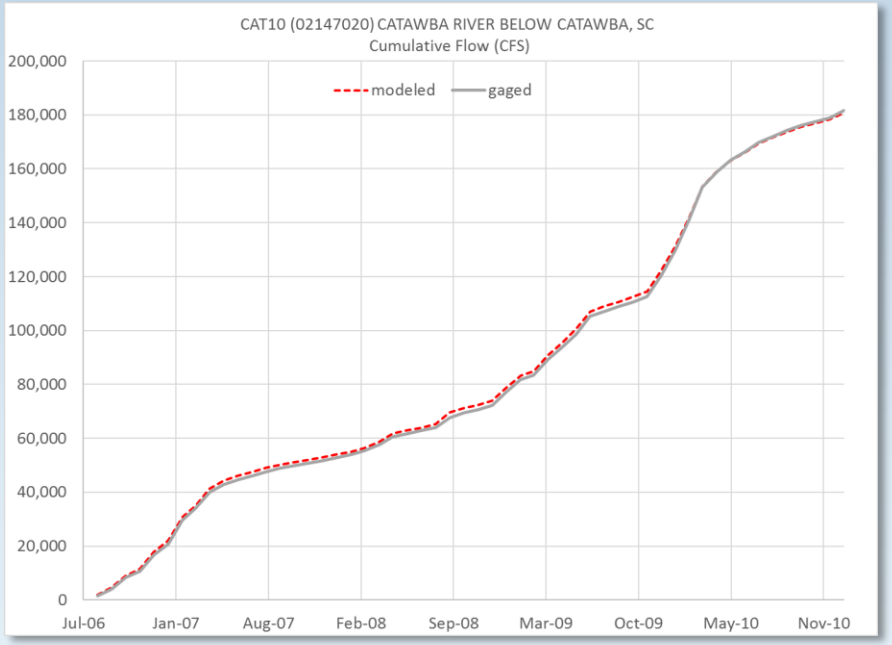


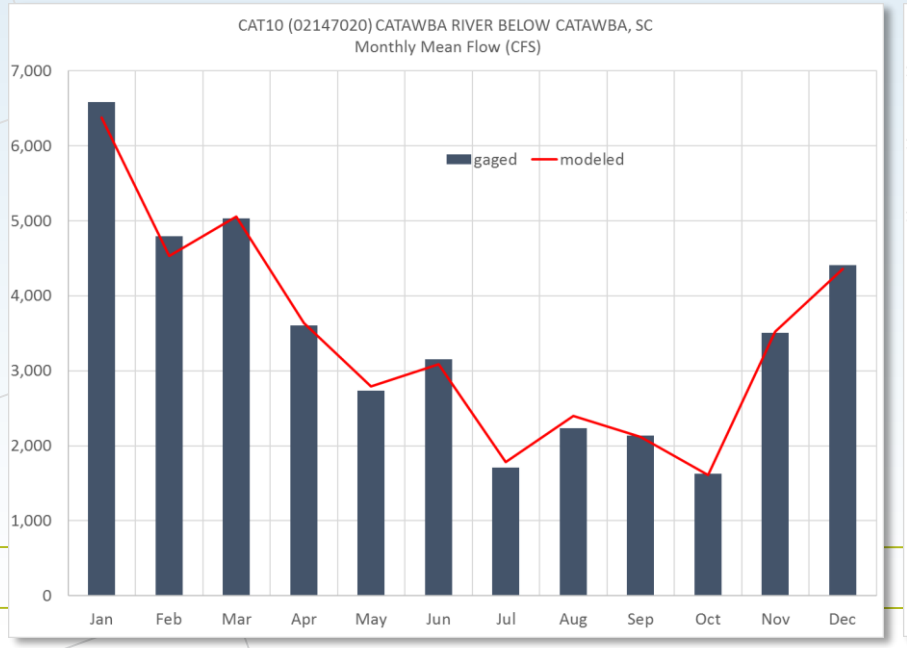
CAT10 Catawba River below Catawba

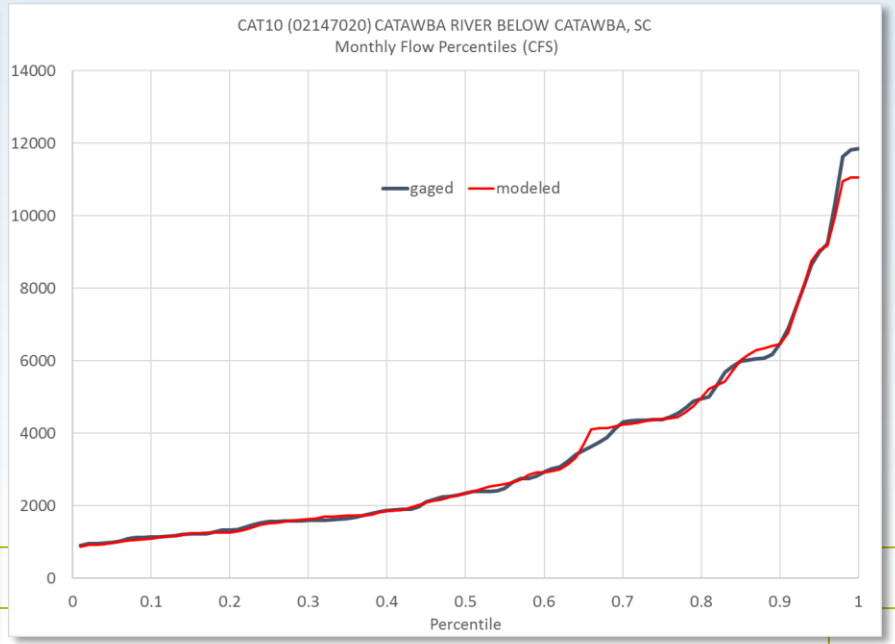


CAT10 Catawba River below Catawba - Monthly

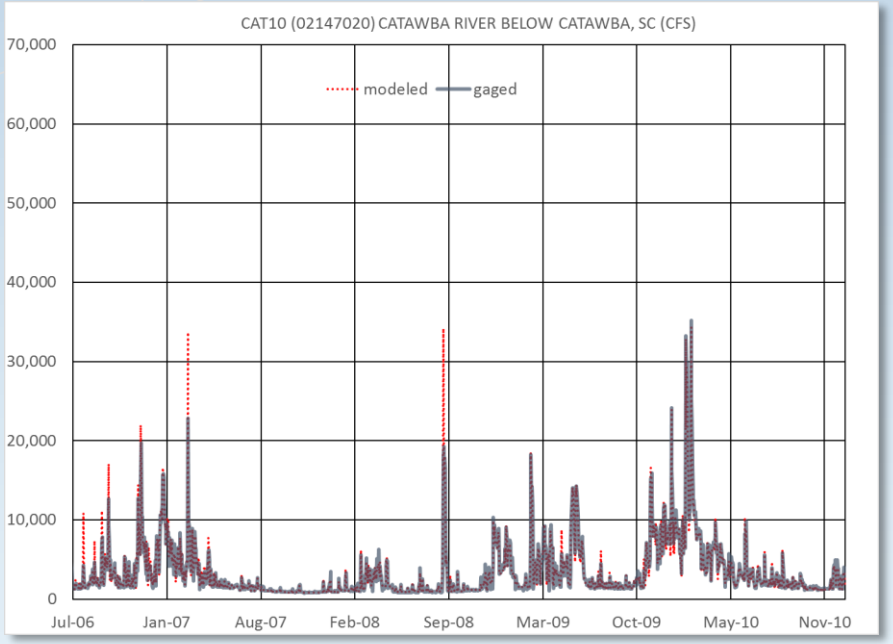


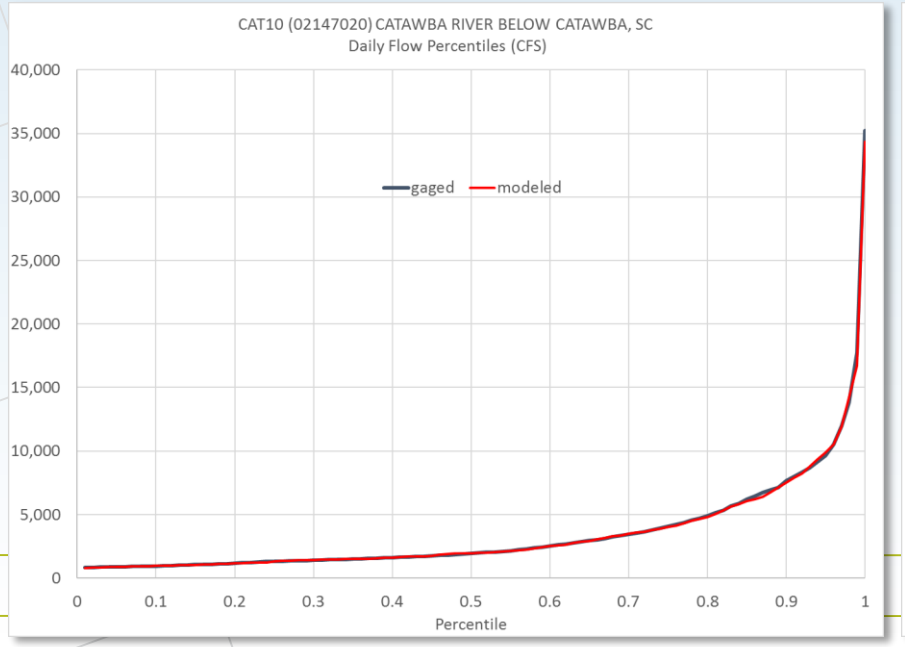


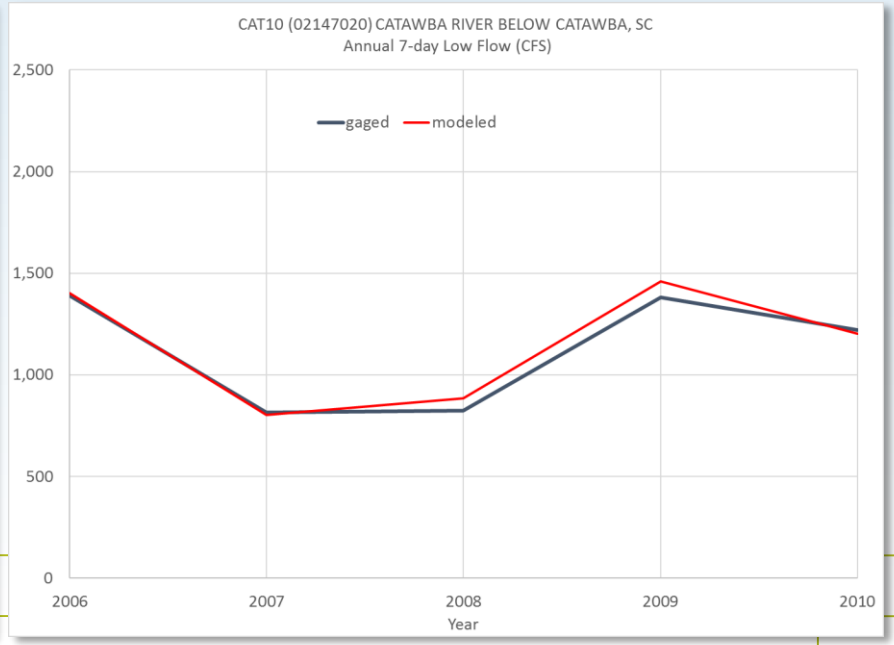




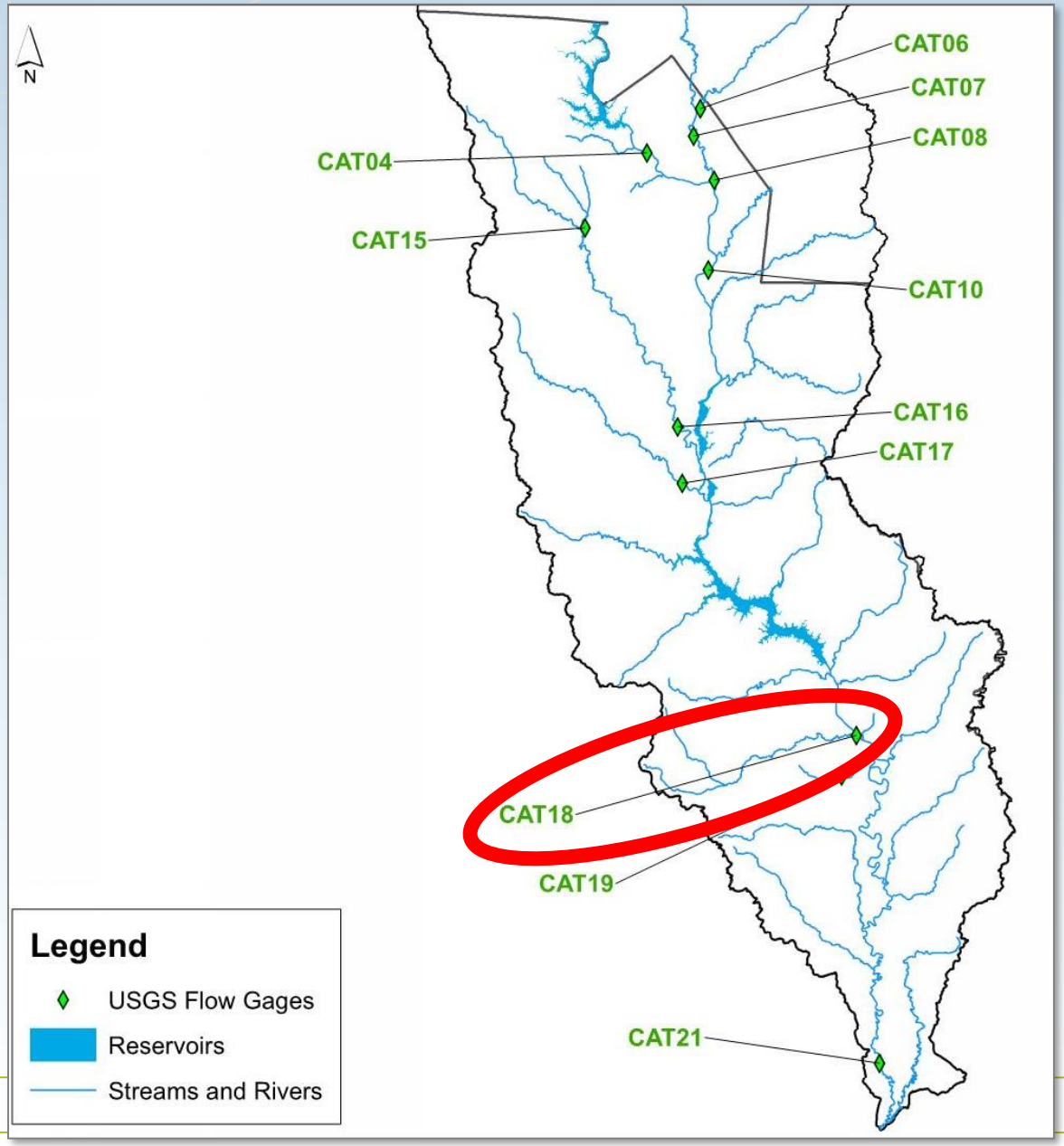
CAT10 Catawba River below Catawba - Daily





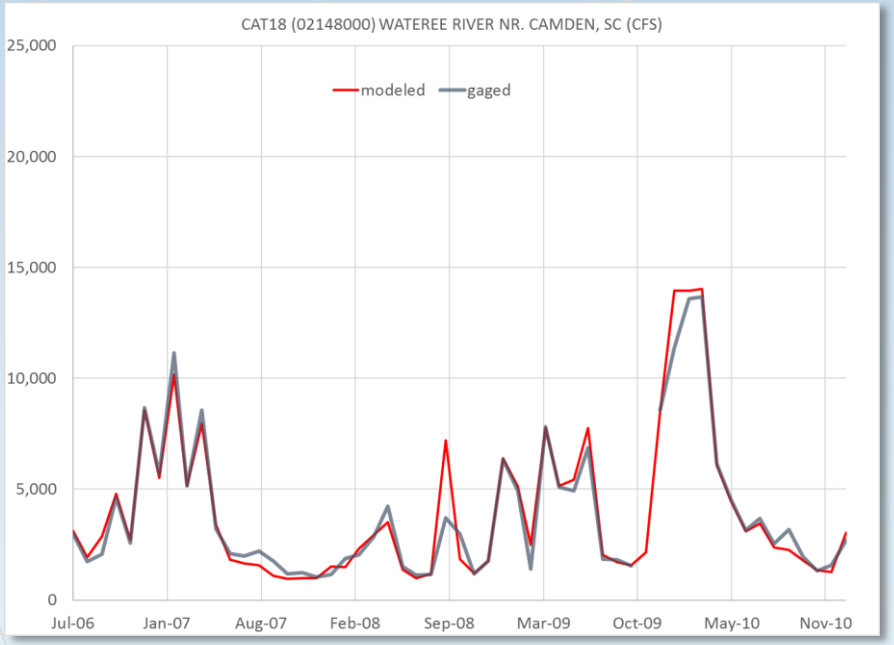


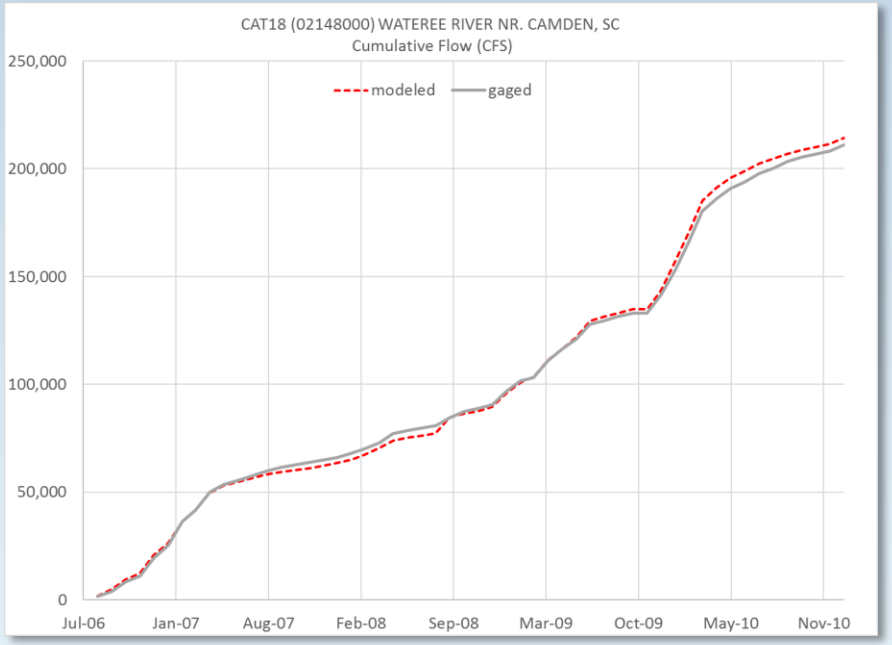
CAT18 Wateree River nr Camden

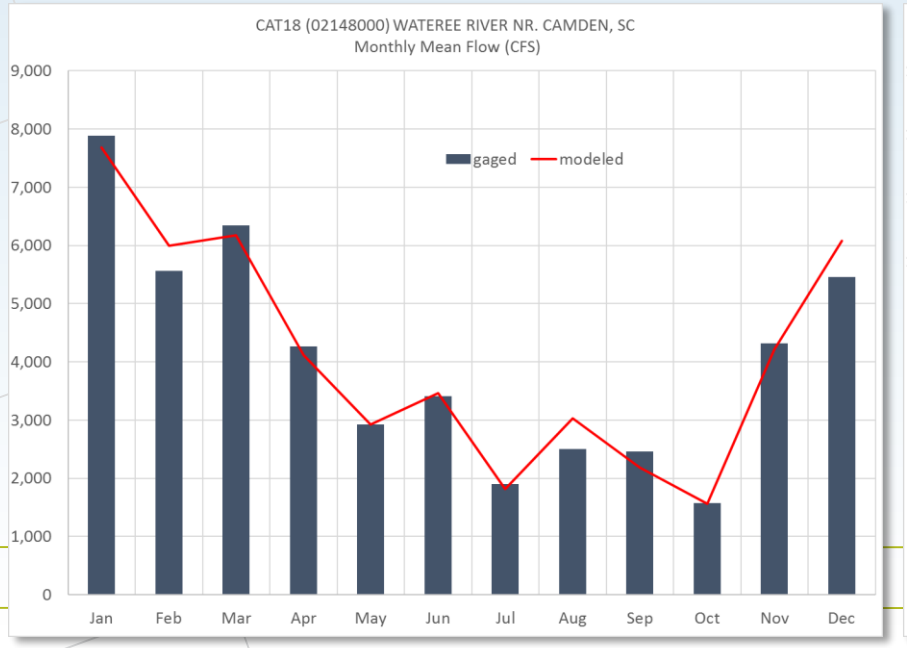


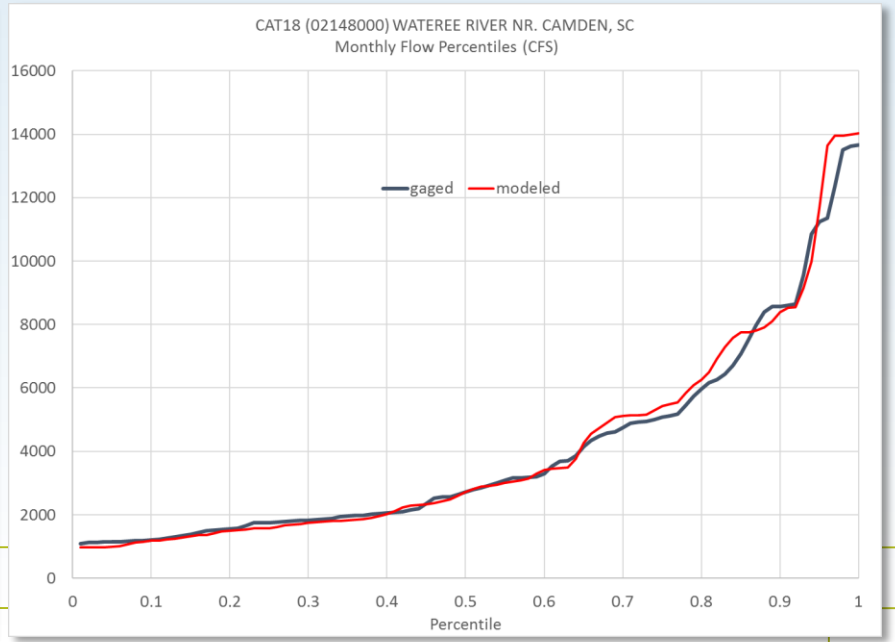
CDM Smith

CAT18 Wateree River nr Camden - Monthly

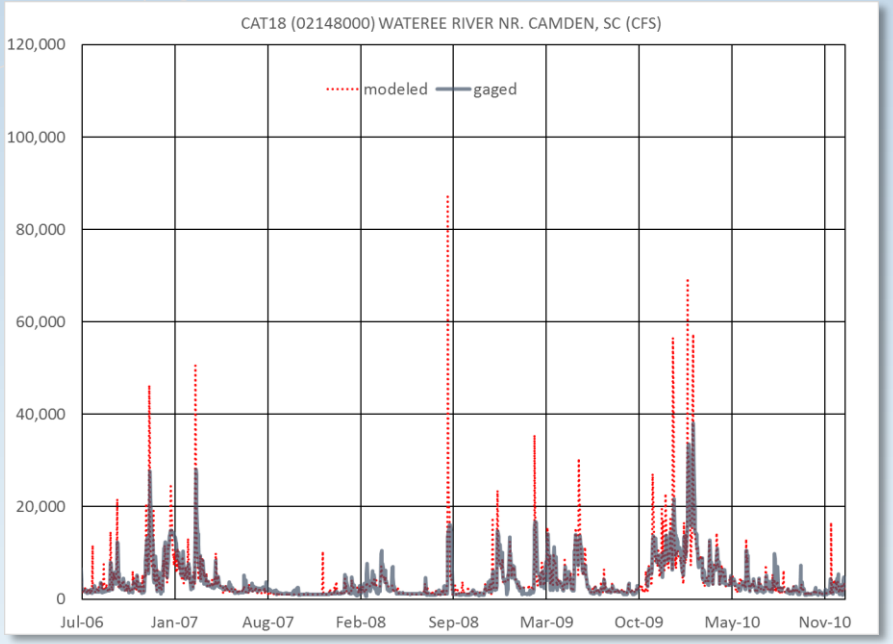


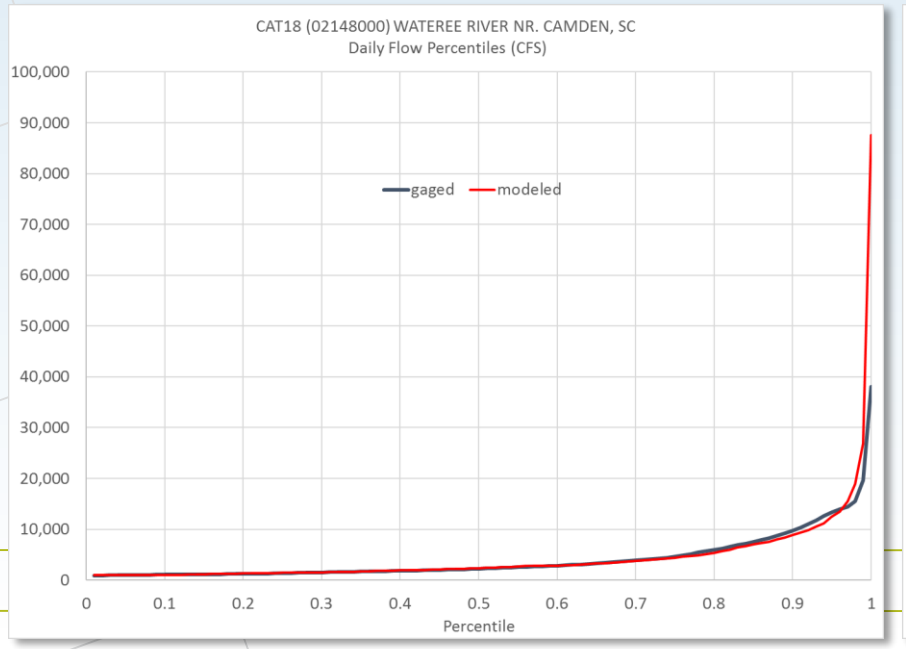


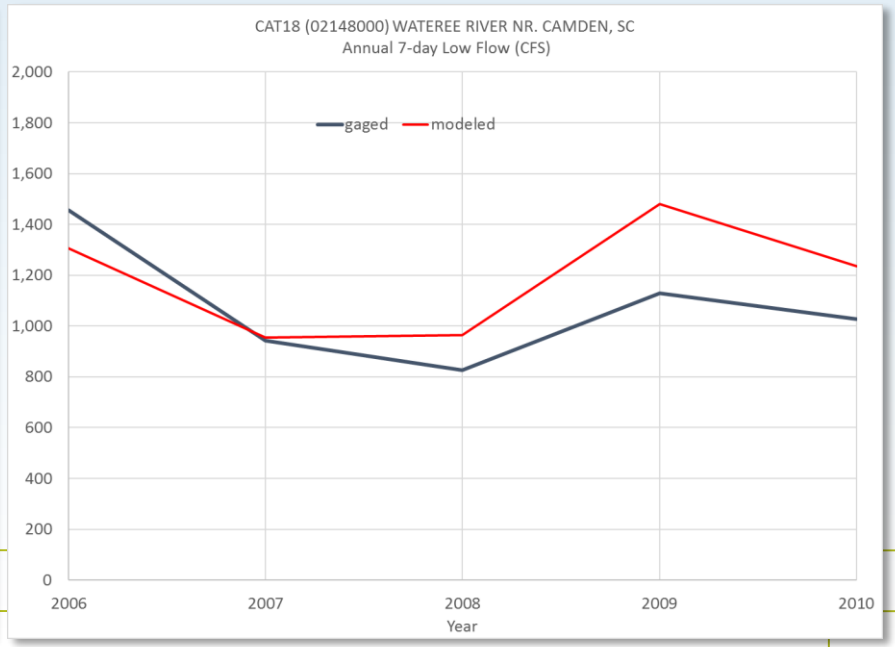




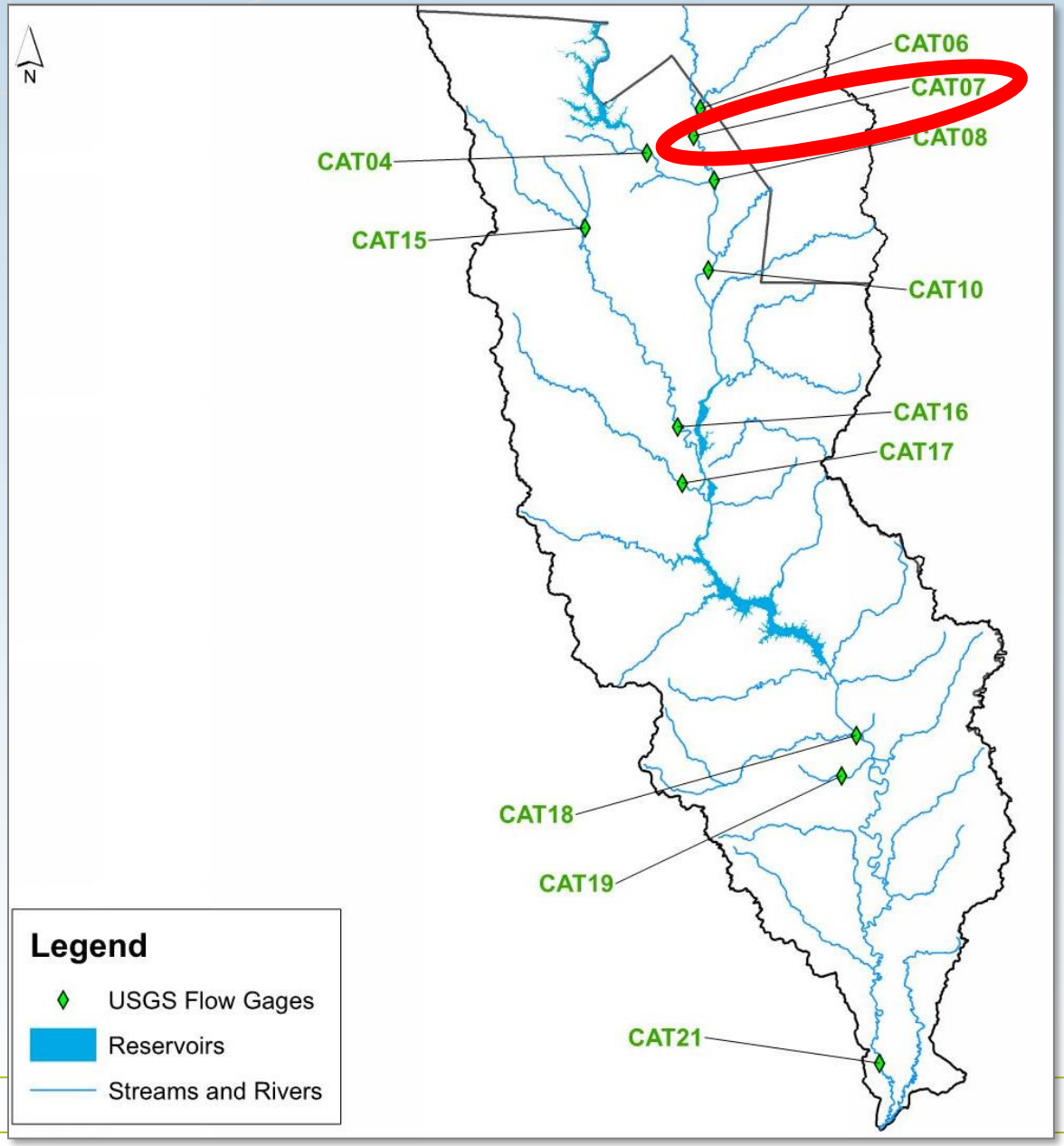
CAT18 Wateree River nr Camden - Daily



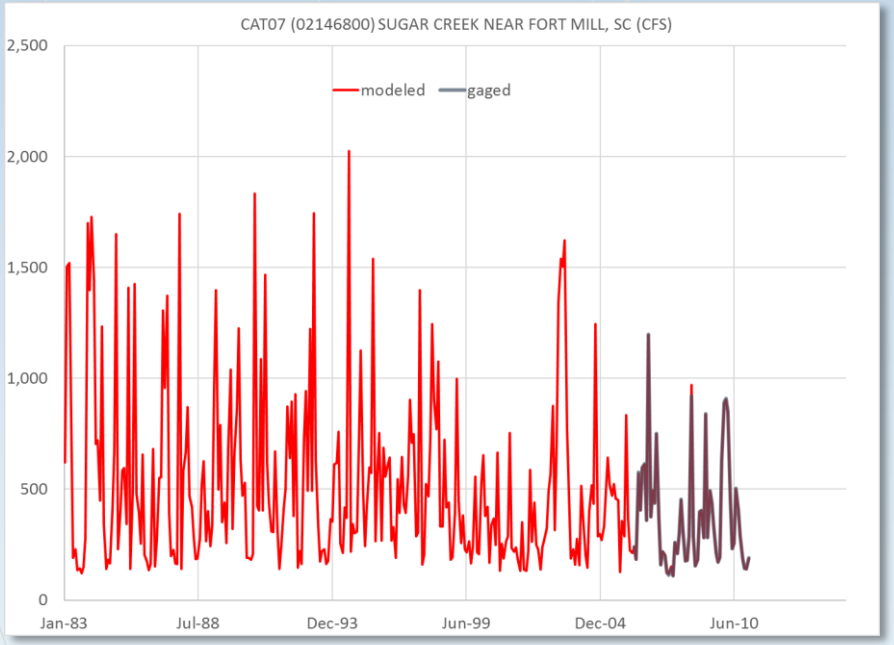


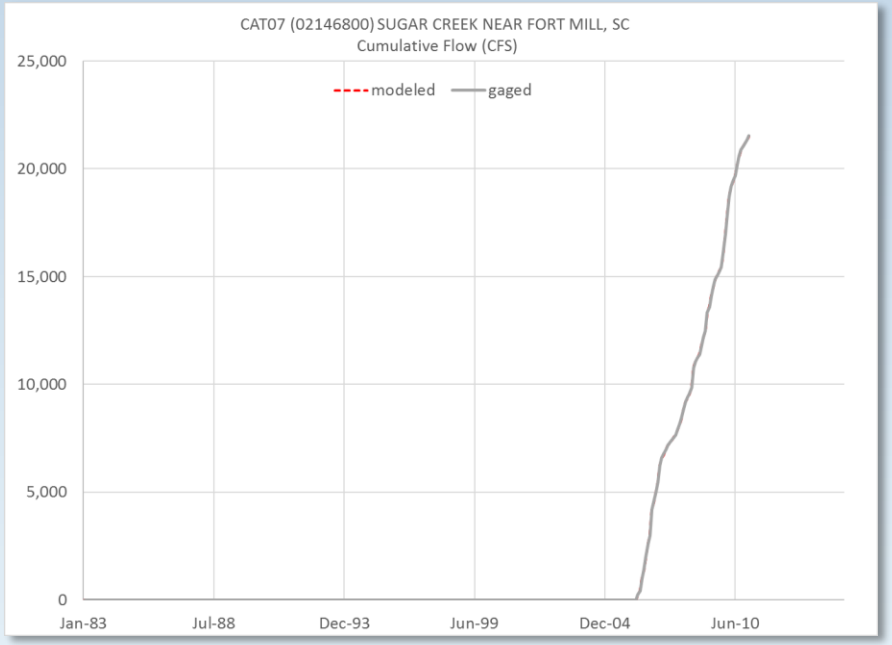


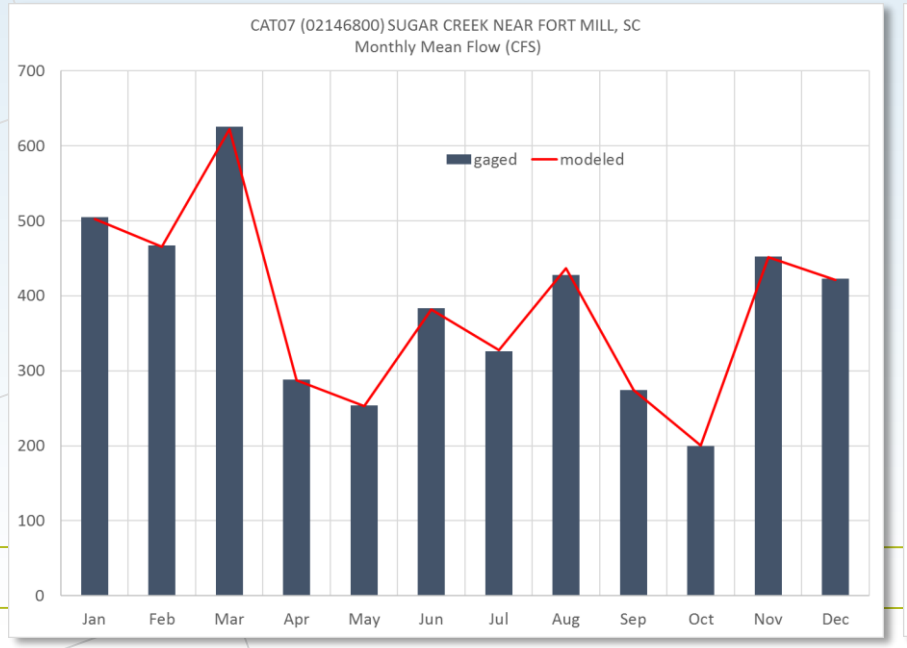
CAT07 Sugar Creek nr Fort Mill

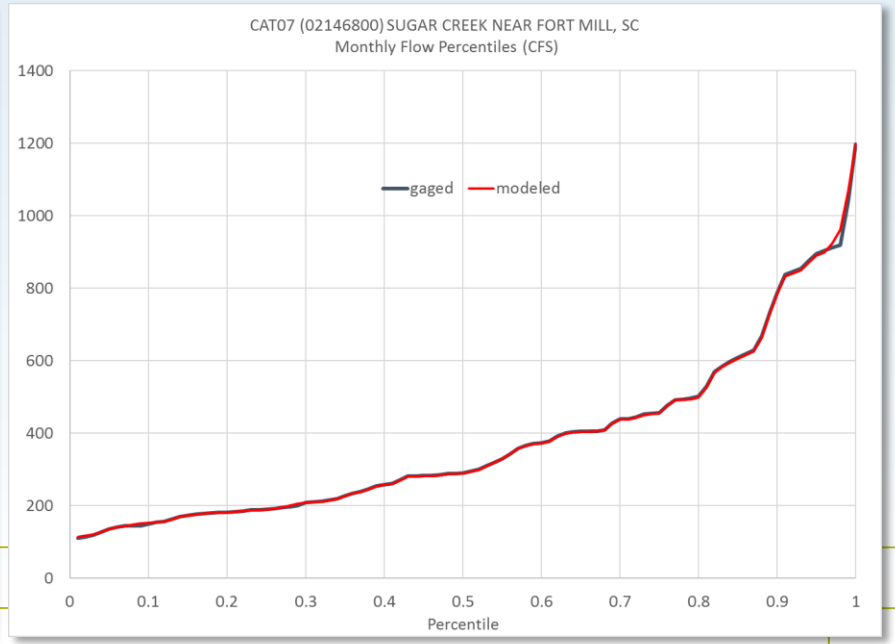


CAT07 Sugar Creek nr Fort Mill - Monthly

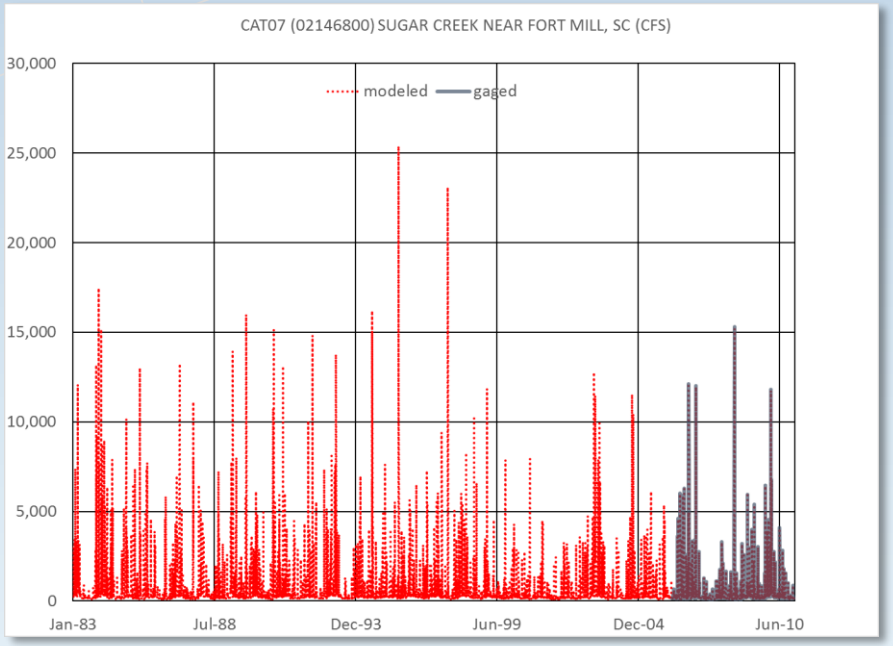


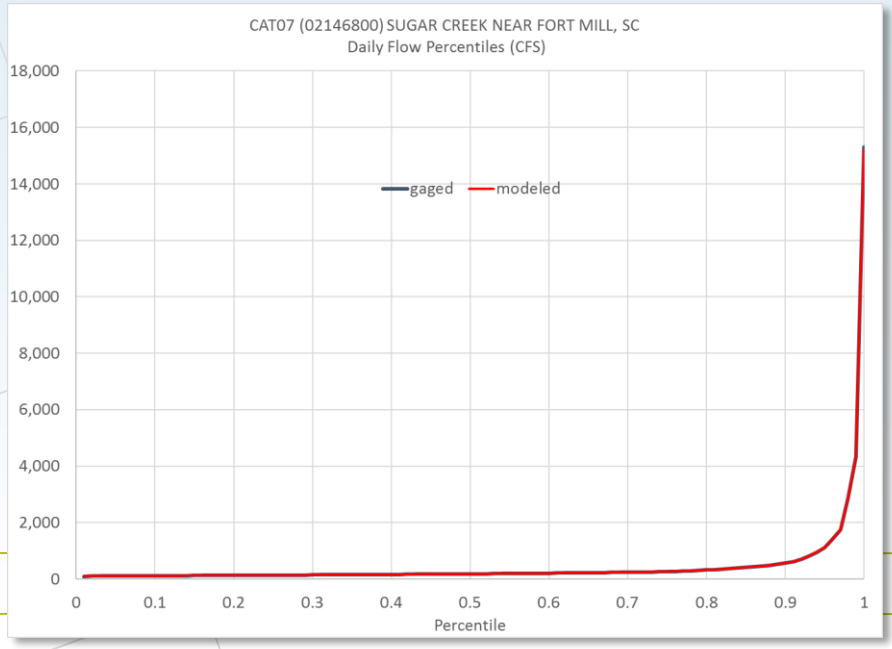


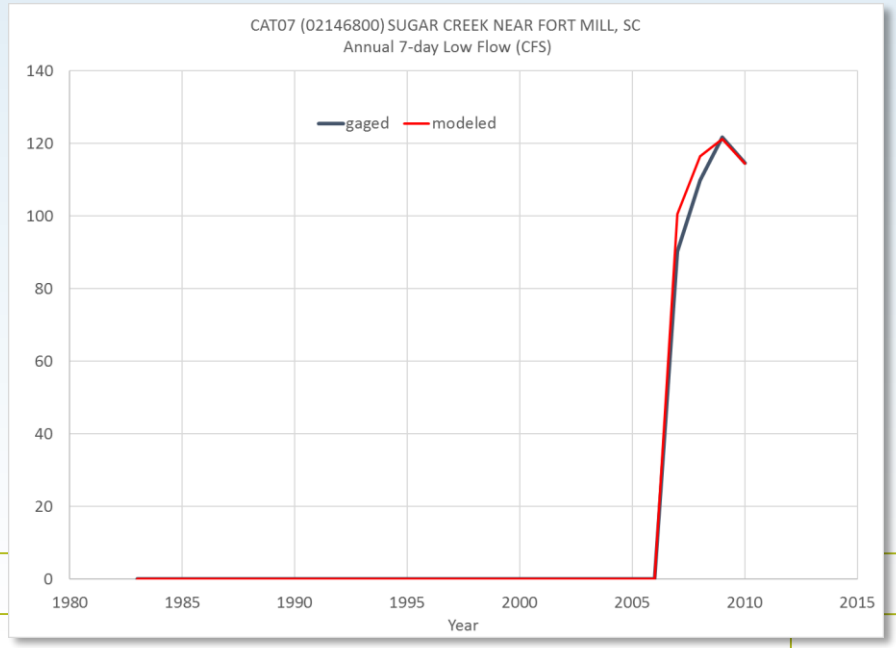




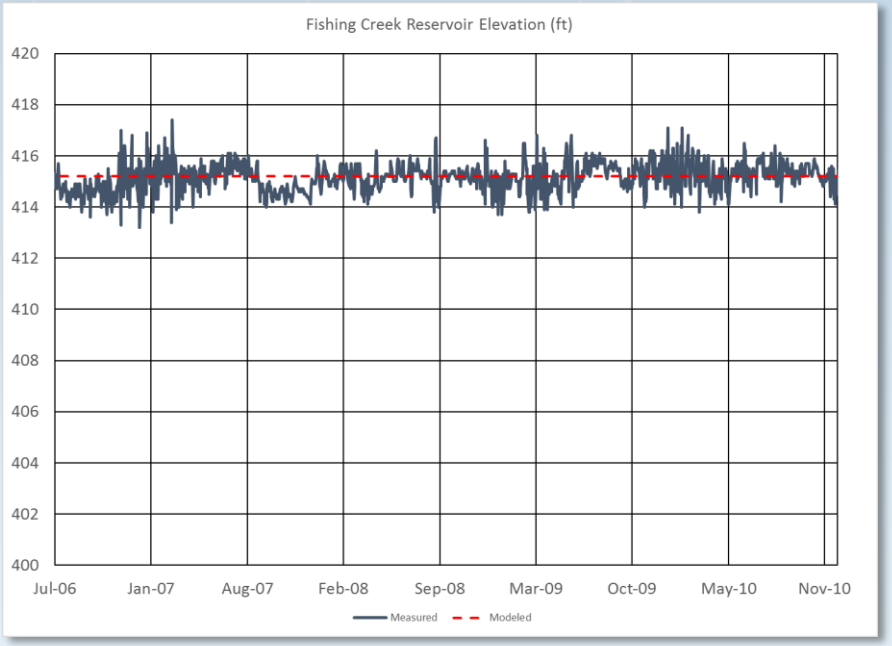
CAT07 Sugar Creek nr Fort Mill - Daily

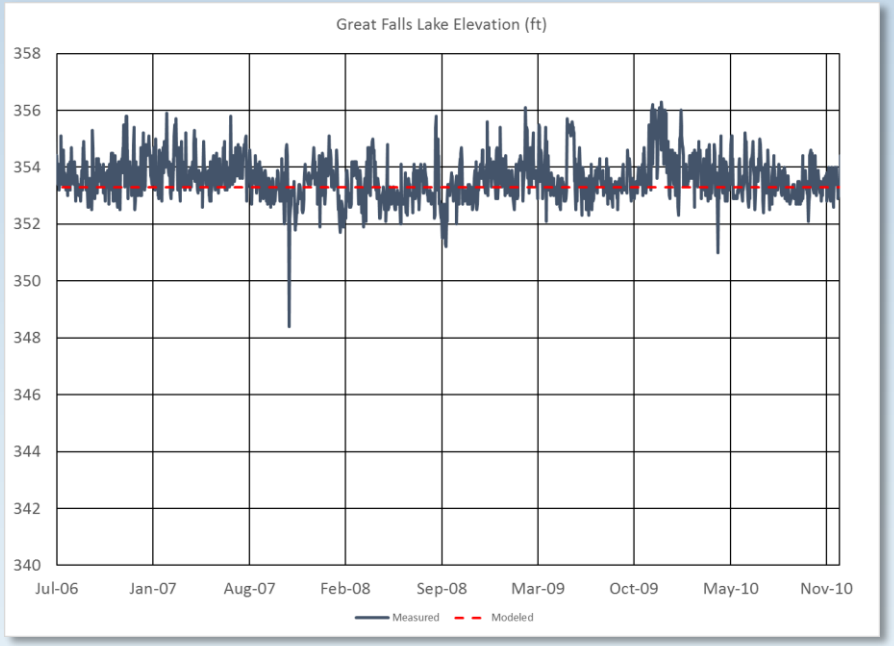


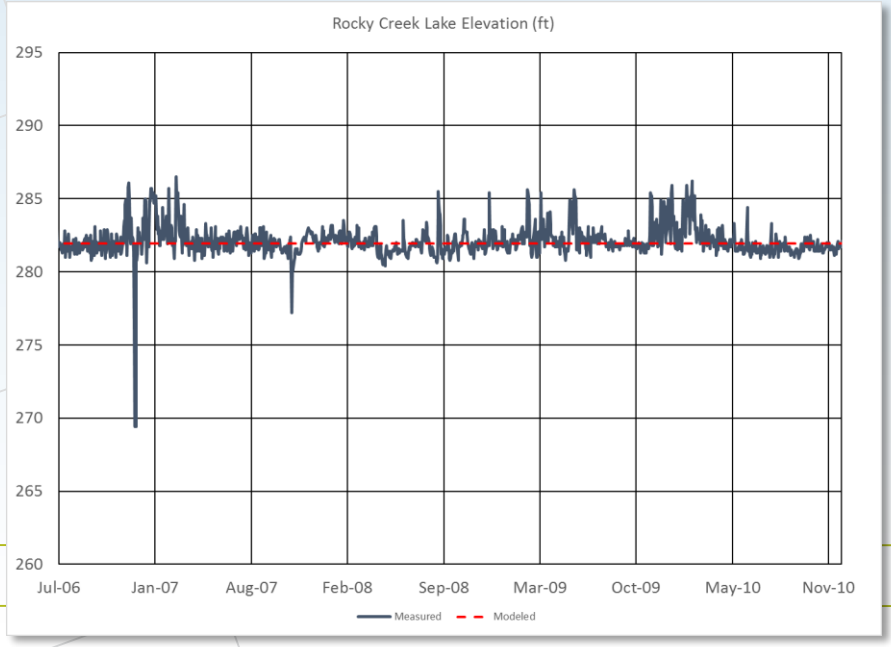


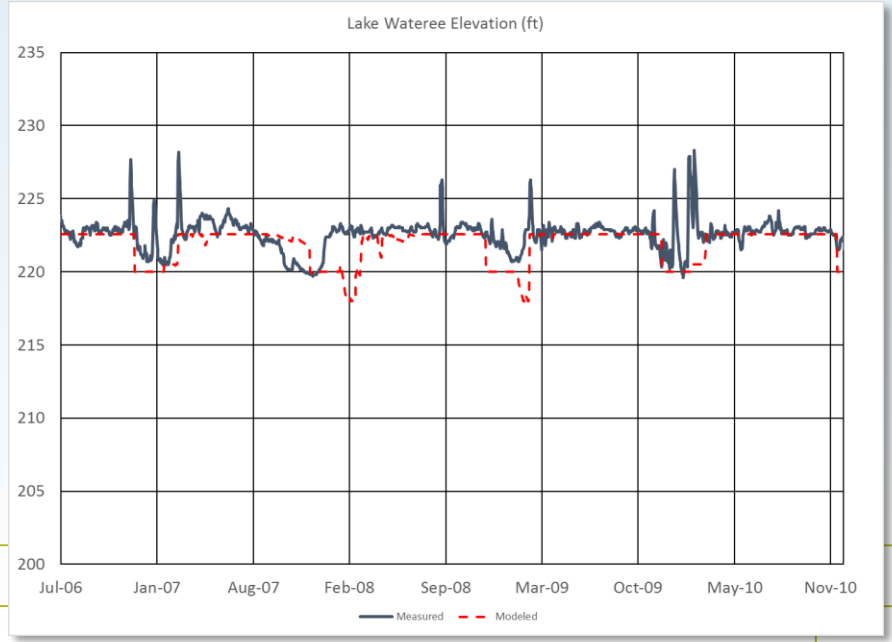


Reservoir Elevations









Technical Memorandum

To: *South Carolina Department of Natural Resources (DNR)*
South Carolina Department of Health and Environmental Control (DHEC)

From: *CDM Smith*

Date: *September 6, 2016*

Subject: *Unimpaired Flow Development*
Savannah River Basin, South Carolina

1.0 Background and Objectives for Unimpaired Flows

Unimpaired flow (UIF) describes the natural hydrology of a river basin. UIFs quantify streamflows throughout a river basin in the absence of human intervention in the river channel, such as storage, withdrawals, discharges, and return flows. From this basis, modeling and decision making can be compared with pristine conditions.

This memorandum identifies the active and inactive flow gages the Savannah River basin and provides recommendations on where UIF development may occur.

2.0 Overview of the Savannah Basin USGS Gages

There are over seventy Unites States Geological Survey (USGS) active or former streamflow gaging stations in the Savannah River Basin within South Carolina or on its border. At eight gaging stations on the Savannah River (mainstem), the Georgia Environmental Protection Division (GA EPD) has calculated UIFs for the period 1939 through 2013 (GA EPD, 2015). Since mainstem UIFs have already been developed, additional UIF development to support the South Carolina Surface Water Availability Assessment is focusing on gage locations at select South Carolina tributaries to the mainstem.

An overview map of the current and former USGS streamflow gages in the Savannah River Basin is shown in **Figure 1**. Proposed (new) UIF locations on South Carolina tributaries to the mainstem are identified by green triangles. The location of previously calculated UIFs are identified by red triangles (GA EPD "Basic" UIF nodes) and red circles with triangles (GA EPD "Planning" UIF nodes). Other mainstem gaging stations, which will be included in the model framework, but will not be subject to UIF development are identified by purple triangles.

Table 1 matches each project ID with its gage number, location, periods of record, activity, and whether it is on a tributary and thus subject to UIF development. **Figure 2** depicts the length and

timing of records for existing and proposed UIFs, and other model framework gages in the Savannah River basin.

3.0 Recommendations for UIF Development

Twenty-one tributary gages are candidates for UIF development. Two situations arose in which a tributary gage was not included:

- USGS gage 02186090 was only active from May 1998 to September 1999. Since no SWAM model objects are upstream of the gage, and given its short period of record, it was excluded.
- A cluster of forty-three gages were installed within the Department of Energy's Savannah River Site (SRS), all of which are currently inactive. A selection of six of these were chosen to represent key tributaries in this region. The remaining inactive gages will be excluded from UIF calculations.

4.0 Summary

Of the almost-eighty USGS gaging stations, twenty-one gages on tributaries have been identified as candidates for UIF development, supplementing the existing eight UIF locations on the mainstem. The two exceptions have either an insufficient period of record or were omitted in order to simplify the SRS site.

5.0 References

GA EPD, 2015. Savannah River Basin Comprehensive Study II: 2009 – 2013 Unimpaired Flow Data Extension (Draft Report).

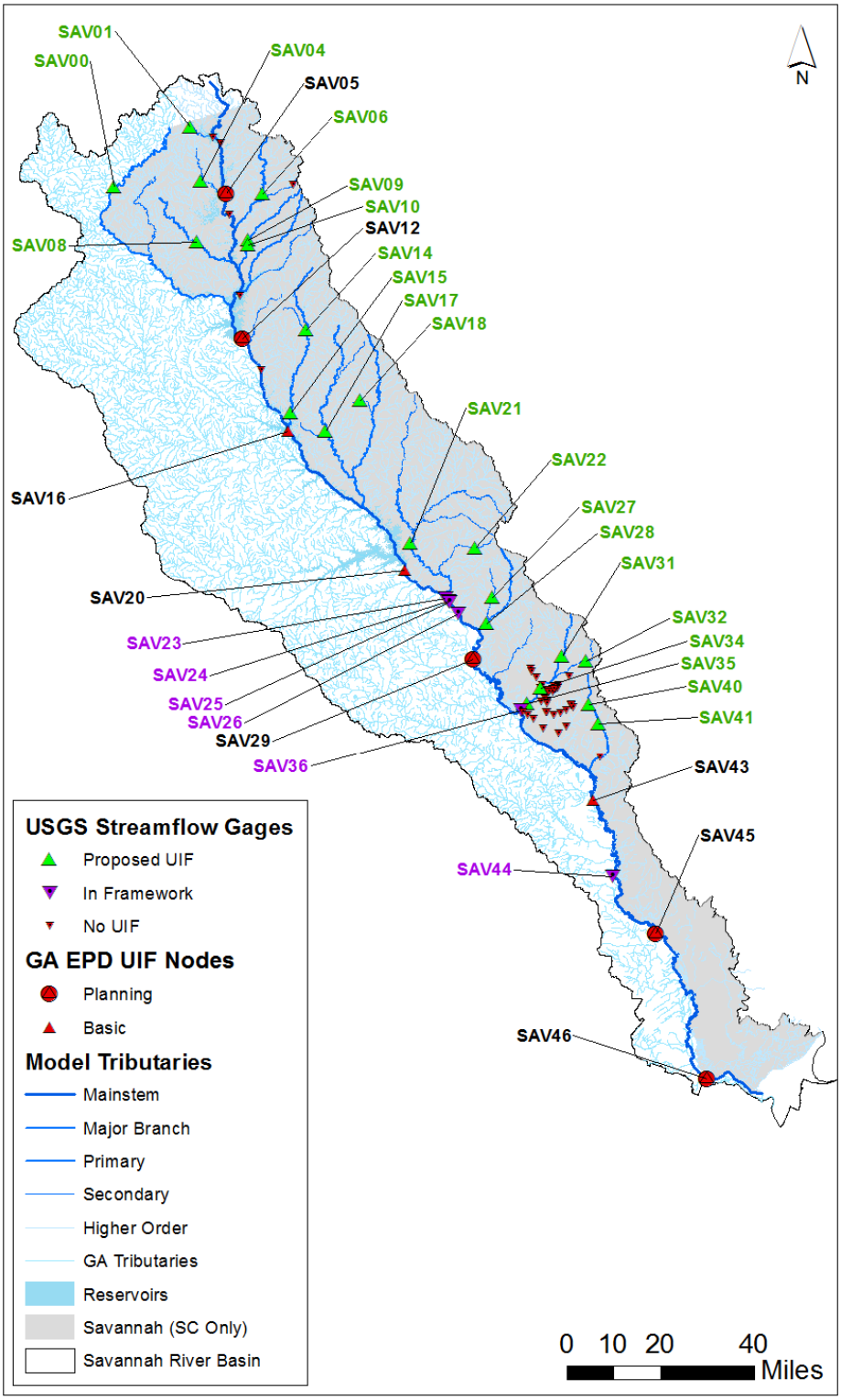


Figure 1: Proposed and Previous UIF Locations

Table 1. Savannah River Basin USGS Streamflow Gages (with project IDs)

Project ID	Tributary UIF	Existing UIF	USGS Number	Description	From:	To:	From:	To:	From:	To:	From:	To:
SAV00	Yes	No	02177000	CHATTOOGA RIVER NEAR CLAYTON, GA	Oct-1939	Dec-2013						
SAV01	Yes	No	02184475	HOWARD CREEK NEAR JOCASSEE, SC	May-1988	Sep-1996						
SAV04	Yes	No	02185200	LITTLE RIVER NEAR WALHALLA, SC	Mar-1967	Sep-2003						
SAV05	No	**Yes**	02185145	LAKE KEOWEE NEAR SIX MILE, SC	Oct-1999	Sep-2000						
SAV06	Yes	No	02186000	TWELVEMILE CREEK NEAR LIBERTY, SC	Aug-1954	Dec-2013						
SAV08	Yes	No	02186645	CONEROSS CK NR SENECA, SC	Apr-1989	Sep-2003						
SAV09	Yes	No	02186699	EIGHTEENMILE CREEK ABOVE PENDLETON, SC	May-1998	Jul-2008						
SAV10	Yes	No	02186702	EIGHTEENMILE CREEK BELOW PENDLETON, SC	Oct-2012	Dec-2013						
SAV12	No	**Yes**	02187252	SAVANNAH RIVER BELOW HARTWELL LK NR HARTWELL, GA	Oct-1984	Sep-1999						
SAV14	Yes	No	02187910	ROCKY RIVER NR STARR, SC	May-1989	Mar-1996	Oct-1996	Oct-2001	Feb-2003	Mar-2004	Oct-2004	Dec-2013
SAV15	Yes	No	02188000	ROCKY RIVER NEAR CALHOUN FALLS, SC	Mar-1950	Sep-1966						
SAV16	No	**Yes**	02189000	SAVANNAH RIVER NEAR CALHOUN FALLS, S. C.	Oct-1896	Sep-1979						
SAV17	Yes	No	02192500	LITTLE RIVER NEAR MT. CARMEL, SC	Jan-1940	Sep-1970	Aug-1986	Oct-2003	Oct-2004	Dec-2013		
SAV18	Yes	No	02192830	BLUE HILL CREEK AT ABBEVILLE, SC	Feb-1998	Aug-2008						
SAV20	No	**Yes**	02195000	SAVANNAH RIVER NEAR CLARKS HILL, S.C.	May-1940	Jun-1954						
SAV21	Yes	No	02196000	STEVENS CREEK NEAR MODOC, SC	Nov-1929	Sep-1931	Feb-1940	Sep-1978	Nov-1983	Dec-2013		
SAV22	Yes	No	02196250	HORN CREEK NR COLLIERS (EDGEFIELD), SC	Oct-1980	Sep-1994						
SAV23	No	No	021964832	SAVANNAH RIVER ABOVE AUGUSTA CANAL NEAR BONAIR,GA	Sep-2011	Dec-2013						
SAV24	No	No	02196484	SAVANNAH RIVER NEAR NORTH AUGUSTA, SC	Oct-1988	Sep-2002						
SAV25	No	No	02196485	AUGUSTA CANAL NR AUGUSTA, GA (UPPER)	Jul-1988	Dec-1992	Oct-1996	Jul-2003	May-2005	Jan-2009	May-2009	Dec-2013
SAV26	No	No	02196500	AUGUSTA CANAL AT AUGUSTA (LOWER)	Nov-1930	Sep-1957	Oct-1988	Sep-1992				
SAV27	Yes	No	02196689	LITTLE HORSE CREEK NEAR GRANITEVILLE, SC	Oct-1989	Dec-1999	Mar-2000	Apr-2001	Feb-2002	Jul-2002		
SAV28	Yes	No	02196690	HORSE CREEK AT CLEARWATER, SC	Apr-2005	Dec-2013						
SAV29	No	**Yes**	02197000	SAVANNAH RIVER AT AUGUSTA, GA	1883-10-01	1891-12-31	1896-01-01	Dec-1906	Jan-1925	Dec-2013		
SAV31	Yes	No	02197300	UPPER THREE RUNS NEAR NEW ELLENTON, SC	Jun-1966	Sep-2002						
SAV32	Yes	No	021973005	TINKER CREEK ON SRS RD 8-11 AT SRS, SC	Oct-1992	Sep-1996	Dec-1998	Sep-2002				
SAV34	Yes	No	02197310	UPPER THREE RUNS ABOVE ROAD C (SRS), SC	Jun-1974	Jan-1998	Dec-1998	Sep-2002				
SAV35	Yes	No	02197315	UPPER THREE RUNS AT ROAD A (SRS), SC	Jun-1974	Jan-1978	Oct-1978	Sep-2002				
SAV36	No	No	02197320	SAVANNAH R. NR JACKSON, SC	Oct-1971	Sep-2002						
SAV40	Yes	No	02197380	LOWER THREE RUNS BELOW PAR POND @ SRS, SC	May-1974	Sep-2002						
SAV41	Yes	No	02197400	LOWER THREE RUNS NEAR SNELLING, SC	Mar-1974	Dec-1996	May-1997	Sep-2002				
SAV43	No	**Yes**	02197500	SAVANNAH R AT BURTONS FERRY BR NR MILLHAVEN, GA	Oct-1939	Sep-1970	Oct-1982	Oct-2003	Oct-2004	Dec-2013		
SAV44	No	No	02198375	SAVANNAH RIVER NEAR ESTILL, SC	Jul-2009	Sep-2014						
SAV45	No	**Yes**	02198500	SAVANNAH RIVER NEAR CLYO, GA	Oct-1929	Sep-1933	Oct-1937	Sep-2014				
SAV46	No	**Yes**	021989773	SAVANNAH RIVER AT USACE DOCK, AT SAVANNAH, GA	Oct-2007	Dec-2013						

*Existing UIFs are in **bold***

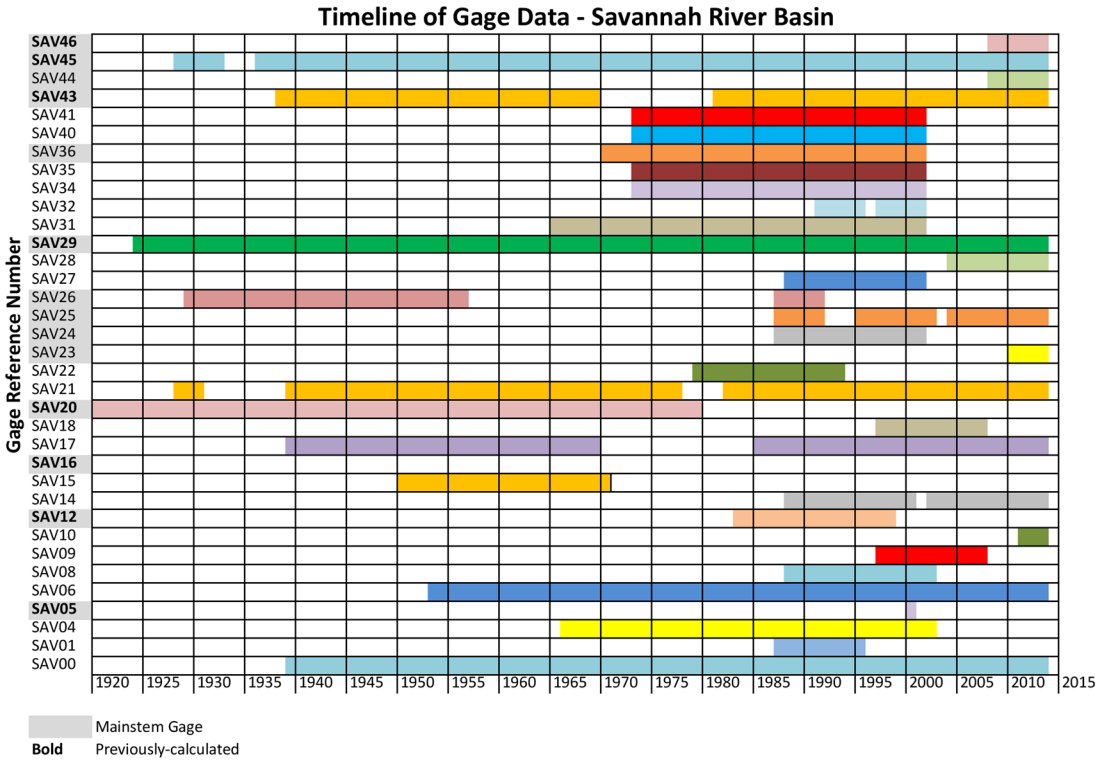


Figure 2. Period of record for proposed UIF USGS gages in the Savannah Basin