Memorandum

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

From: *CDM Smith*

Date: *June 29, 2018*

Subject: *Edisto River Basin Baseline Model Update*

The purpose of this memorandum is to document the updates made to the Edisto Baseline Model, based on the 2018 Edisto recalibration exercise, the addition of 2014-2016 water use and discharge data, and the extension of hydrology inputs through year 2016. The calibration model and other updates were previously documented in the following:

1. DNR's *Technical Memorandum (TM) E1;*
2. DNR's update of the unimpaired flow (UIF) dataset, as documented in *TM-E2*;
3. DNR's extension of water withdrawals and returns for all active users and the addition of new irrigation water use objects, as documented in *TM-E3*;
4. CDM Smith's May 2, 2018 memorandum *Edisto River Basin Model Review of Updates and Recalibration*; and
5. E-mail correspondence (included here as **Attachment A**) between John Boyer/CDM Smith and Scott Harder/DNR documenting final adjustments to the Edisto Calibration and Baseline Models.

Baseline Model Updates

Updates to the Edisto Baseline are summarized in items 1 – 10 below.

1. The following three Water User objects were removed from the Baseline Model, as they are no longer active, or in the case of IR: Calhoun, have surface water intakes in ponds that are filled by groundwater wells:

   IN: ACO
   IN: Roseburg
   IR: Calhoun

2. Existing Agriculture (Ag) Water User objects were modified as follows:

    - Baseline demands for existing Ag Water User objects were updated after incorporating 2014-2016 reported water usage. As previously done, the last 10 years of available data were typically used to calculate the average withdrawal. There was no reported 2014-2016 water use for the following Ag Water User Objects: IR: Maury Furtick, IR: River Bluff Sod, IR: Boland Farm, IR: Brown Farms and IR: Kyzer.

    - Non-zero demands were incorporated for IR: William & Sons, IR: Turf Connections, and IR: Walthers, based on reported data from 2014-2016. Previously, no reported data was available.

    - A fourth intake was included for IR: Cotton Lane Farms with a 6.481 MGM limit.

    - A new intake (S04) was included for IR: Haigler with a 28.35 MGM limit.

3. New Ag Water User objects were added, including:

    - IR: Double B Farms (with a 33.7 MGM limit);

    - IR: RRR Farms (with a 134 MGM limit); and

    - IR: Inabinet Farms (with a 34 MGM limit).

4. Several farms received updated river miles since headwater areas were adjusted slightly during recalibration. These include: IR: Oak Lane, IR: Riddle Dairy, IR: Haigler, IR: Willshire, IR: Millwood, IR: Titan – Temples Creek, IR: Titan – Bog Branch, IR: Gray and IR: Cotton Lane.

5. Tributary and Discharge objects were updated to include daily and monthly flows for calendar years 2014, 2015 and 2016.

6. Gain/Loss and Sub-basin Flow Factors were updated based on the recalibration exercise and DNR's suggested addition adjustments, as documented in Attachment A.]

7. The new USGS gage South Fork Edisto River above Springfield (02172558) was added to the interface. On the model interface, it the gage is labelled EDO14.

8. The PT: SCE&G Cope Water User object was modified. Two return flow locations were added – one on Roberts Swamp and one on the Mainstem (South Fork Edisto River). The Consumptive Use factors were corrected, and the water use was updated.

9. The WS: Aiken Water User object source water accounts and water use were modified to reflect the fact that groundwater withdrawals are preference No. 1 and the remainder of demand is satisfied by withdrawals from Shaw Creek. Return flow was modified such that 98.5% of return flow is to river mile 1001 on the mainstem, representing discharge to the Savannah basin, and the remaining return flow is to Shaw Creek.

10. All other non-Ag Water User objects were updated to incorporate new 10-year average withdrawals (2007-2016). In limited cases when the last three years of withdrawals were reported as zero, the water use was set at zero, instead of the 10-year average. IN: Gaston, WS: Norway and GC: Orangeburg CC fall into this category. All three are groundwater users; however, GC: Orangeburg previously withdrew from surface water.

Attachment A

Boyer, John

From: Boyer, John
Sent: Monday, June 04, 2018 11:32 AM
To: Scott Harder
Cc: Butler, Alexander P.; Devlin, Rob (DEVLINRJ@dhec.sc.gov); Joe Gellici; Bill Clendenin; Cox, Timothy J. (CoxTJ@cdmsmith.com); Caraway, Nina M.
Subject: RE: Edisto Recalibration and Updated SWAM Models

Scott –

Regarding No. 2, below (Item 7) – you were correct that in the original *EdistoCUandDemand* workbook, pipe -001 was being double counted. The latest version of the calibration model has the correct return values. We'll make sure the baseline model has the correct return amounts. As suggested, we'd like to keep it as a water user object with two return flow locations: Pipe -001 returning to the South Fork Edisto River and the remaining pipes returning to Roberts Swamp (where the calibration model has the returns).

John

From: Boyer, John
Sent: Friday, June 01, 2018 3:27 PM
To: 'Scott Harder' <HarderS@dnr.sc.gov>
Cc: Butler, Alexander P. <butlerap@dhec.sc.gov>; Devlin, Rob (DEVLINRJ@dhec.sc.gov) <DEVLINRJ@dhec.sc.gov>; Joe Gellici <GelliciJ@dnr.sc.gov>; Bill Clendenin <ClendeninB@dnr.sc.gov>; Cox, Timothy J. (CoxTJ@cdmsmith.com) <CoxTJ@cdmsmith.com>; Caraway, Nina M. <carawaynm@cdmsmith.com>
Subject: RE: Edisto Recalibration and Updated SWAM Models

Scott –

See responses below for Edisto comments. We will proceed with finalizing the Edisto, per the comments and responses below; however, let me know if there is anything additional you would like to discuss.

Thanks,
John

From: Scott Harder <HarderS@dnr.sc.gov>
Sent: Tuesday, May 08, 2018 3:46 PM
To: Boyer, John <BoyerJD@cdmsmith.com>
Cc: Butler, Alexander P. <butlerap@dhec.sc.gov>; Devlin, Rob (DEVLINRJ@dhec.sc.gov) <DEVLINRJ@dhec.sc.gov>; Joe Gellici <GelliciJ@dnr.sc.gov>; Bill Clendenin <ClendeninB@dnr.sc.gov>
Subject: RE: Edisto Recalibration and Updated SWAM Models

Hi, I have reviewed the new calibration model and results along the mainstem are greatly improved. The varying GLFs based on percentile make a large difference. Here are a few comments and recommendations that I strongly encourage you to implement:

1. Under item 1b. Extension of Water Withdrawal and Return Data (from the memorandum), there is reference to several industries that have no reported data or stopped reporting recently – Gaston, ACO, and Roseburg. Gaston appears to still have an active discharge, but our records show that ACO and Roseburg are no longer active. It would be helpful if SCDHEC could verify this. Pending verification, we would recommend ACO and Roseburg being removed from the baseline model.

Response: I've also asked DHEC to confirm they are no longer active. Assuming yes, we'll remove both water user objects.

2. Item 7. Replacement of PT: SCE&G Cope Water User Object: One of our original comments on this object was that it appeared that discharge data was accidentally being double counted. This concern does not appear to be addressed in CDM's response.
   Response: I'll review this again with Nina early next week. The original SCE&G discharge data was suspect, and I need to get with her to understand the adjustments we made in our EdistoCUandDemand workbook.

3. I have gone through an exercise to use EDO03 and the 1940-1966 period to calibrate the upper part of the south fork Edisto down to EDO14 at MM 40.7 (the end mile is listed as 40.2 in the model we received and this needs reconciled as well). I started by tweaking the GLFs at MM40.7 to improve the calibration at EDO03 for the 1940-1966 period. I then used the GLFs at MM 40.2 and tested the results at EDO14 for the years 2014-2016 – these results looked reasonable though, of course there are only a few years of data to look at. The whole point of this exercise was to remove a model bias that underestimated seasonal low flows/droughts in the upper part of the basin (in other words, the model was showing there to be less water during low flow seasons than there really was). This calibration exercise removes this bias.
   Response: Agree with your adjustments. EDO14 is at MM 40.7. This will be updated in the model.

4. I also made some tweaks to the GLFs at MM69.2 for EDO05 based on the 1983-2016 period. Once a better calibration was achieved at EDO05 and new GLFs were determined for MM69.2, I went back to the 1940-1966 period to do a validation check on how well the new GLFs for MM69.2 worked for the 1940-1966 period. This is a little tricky since the GLFs are based on percentiles that are computed for the period of record being analyzed. However, the results for the 1940-1966 period looked very reasonable using the factors developed from 1983-2016 period, which gives confidence that the GLFs determined will likely work well for the whole period of record (1931-2016). A table of new GLFs are shown below.
   Response: Except for at EDO6, your modifications to the GLFs produce reasonable results. We understand you ignored EDO6 due to potential gage issue (gage/data quality was rated "fair" when other gages in area were typically rated "good"). Looking at the EDO6 gage data compared to the model results, it seems plausible that the gage/data may be somewhat suspect for a portion of the calibration period. We will incorporate the GLFs as adjusted.

5. Item 6. Tributary and Mainstem Adjustments Between ED05 and ED07: I am still uncomfortable with the large increase in the SBFF for Roberts Swamp. I have tested using the default DA ratio SBFF for the tributary and adjusting the GLFs between ED05 and ED07. Similar results can be attained at ED07 in terms of calibration using either SBFFs adjustments at Roberts Swamp or by only adjusting the GLFs; however you need to use some widely varying GLFs to achieve a good calibration. I would rather depend on GLFs here, but either way, we have to recognize there is some uncertainty in the model results for this stretch – perhaps related to higher than normal gage errors.
   Response: Agree that this remains an area of relatively high uncertainty. Luckily it is a very short reach (13 miles). It is a little surprising that the same level of calibration can be achieved at ED07 using either approach. Either approach seems acceptable. We will include your adjustments in the final.

6. I made some tweaks to GLFs at MM218 as well, which I think improve the calibration. I have left GLFs at MM 114.2 as is.
   Response: OK

7. Though the GLF enhancement has led to notably better results, it would be nice to tie GLFs to some physical reality or characteristic in the basin. I am not sure I can completely explain why the all factors should work like they do and as a result they feel like "fudge factors". Any additional feedback on how to best use this GLF enhancement might be helpful.

Response: Time variable GLFs (or SBFFs) capture differences in river hydraulics and hydrology during different times of year and under different flow conditions. Rainfall--runoff dynamics are known to vary as a function of things like: relative stage/groundwater table levels, antecedent soil moisture conditions, storm hyetograph patterns, etc.. The time-variable parameters in SWAM implicitly capture some of these dynamics. While they can't be tied directly to specific physical processes, they are quantified using measured flow data and the variability is implied by these flow data. They are calibration parameters, but certainly can be justified based on known general hydrologic and hydraulic dynamics.

I have uploaded my version of the model along with results workbooks into a folder SCDNR-Edisto-Calibration. The files have an extension _N6. Feel free to contact me if you need any clarification regarding what is in the uploaded files. Here are my calibrated GLFs:

Gain/Loss Factors (per unit length)

Flow Percentiles: OR Calendar Months ("Jan" – "Dec"):	End Miles: 40.20	69.30	82.00	114.20	218.10	
0.01	6.50	-0.50	-5.00	-2.00	-12.00	
0.10	6.50	0.50	-3.00	-2.00	-12.00	
0.20	6.00	1.50	-1.00	-3.00	-8.00	
0.30	6.00	2.00	4.50	-3.00	-7.00	
0.40	6.00	2.50	8.00	-3.00	-7.00	
0.50	6.00	2.50	15.00	-5.00	-7.00	
0.60	6.00	3.00	17.00	-5.00	3.00	
0.70	6.00	3.50	17.00	10.00	3.00	
0.80	5.00	5.00	25.00	12.00	5.00	
0.85	5.00	6.00	25.00	12.00	5.00	
0.95	3.50	7.00	30.00	12.00	16.00	
1.00	3.00	7.00	42.00	12.00	18.00	

Thanks,
Scott