St. Johns River Water Management District
Ann B. Shortelle, Ph.D., Executive Director

FINAL TECHNICAL MEMORANDUM

Date: March 2019

By: Chounghyun Seong and Anne Elise Wester
Bureau of Watershed Management and Modeling

Subject: Response to Peer Review Comments in “Review of Wekiva River Hydrology and Hydraulic Modeling“ by Intera

---

This technical memorandum provides responses to peer review comments provided by Intera, Incorporated on 12/31/2018 (Intera, 2018). Peer review comments were based on a review of hydrologic model development for Wekiva River Basin MFLs. The following documentation and files provided by the District were peer reviewed:

- Draft Report, Wekiva River Hydrology and Hydraulic Modeling for Minimum Flow and Level Evaluations (Seong and Wester, 2018), and associated model files.
- A presentation summarizing the model development and calibration (https://www.sjrwmd.com/static/mfls/MFL-Wekiva/ModelPresentation_2018_0926_final.pdf)

It should be noted that, as a result of the peer review, both HSPF and HEC-RAS models were recalibrated and the modeling report was updated. Below are the peer review comments followed by our responses.

Review Questions

(1) Assess adequacy and appropriateness of the data used in model development, calibration, and long-term simulations.

- **Rainfall**

***Comment # 1**. The HSPF .uci files referenced 4 rainfall data sets from DSN 802 (Deland), DSN 3202 (Lisbon), DSN 3902 (Orlando) and DSN 4102 (Sanford). Each timeseries was exported from the RainModel_2017.wdm file and summed by year, as shown below, and compared to Figure 6 of Seong and Wester (2018). The annual totals matched, however Figure 6 of Seong and Wester (2018) should be modified to add the Sanford station to the legend. Examination of the individual hourly timeseries found that the time series between stations matched at times, which was due to gap filling techniques. Additional detail is needed in the document regarding the gap filling techniques used and the performance of the gap-filling techniques. If error statistics are available for gap-filling, they should be presented in the report. If error statistics are not available, they should be calculated by applying the gap-filling technique to a period of the record with observed rainfall and calculating the difference between the observed rainfall and the rainfall simulated with the gap-filling. Overall, the rainfall totals were consistent between gauges and were within reasonable and expected ranges for Florida hydrology.*

Response # 1. The rainfall data from the gauge stations was filled using NexRad data (OneRain inc., 2002) when data was missing. Details of the methodologies were added to the report. The error statistics with regards to the gap-filling process were not calculated since infilled data were minimal.

- **Basin Boundaries**

***Comment # 2.** Watershed boundaries for the HSPF models were determined by the District using elevation and terrain models. Watersheds were grouped into 3 major sub-watersheds: Black Water Creek, Wekiva River, and Little Wekiva River. Although the basin boundaries presented in Figure 2 of Seong and Wester (2018) appear reasonable, additional details on the terrain modeling and a citation for a report could be given, if available. If ground verification of the sub-watershed boundaries was performed, details should also be added to the document. Additional details regarding the closed sub-watersheds (sub-watersheds 39-44) should also be given, including whether the sub-basins are closed 100% of the time or are these basins conditionally isolated.*

Response # 2. The noncontributing sub-basins are closed and do not contribute surface runoff. Outflows from these closed drainage areas provide recharge to the Floridan aquifer. The contributions from these closed sub-watersheds to the Wekiva River were not simulated directly in the HSPF model, but they were included as parts of the spring flows to the Wekiva River System. The watershed boundaries were delineated in GIS by SJRWMD and confirmed in a variety of ways (i.e. ground verification, permit data, and/or contractors).

- **Potential Evapotranspiration (PET) Data**

Comment # 3. *In the external sources block of the model ucis, it was noted that scaling factors were applied to each PET time series, as shown in the table below. The scaling factors are applied by HSPF when the time series is used, making the PET equal to the time series in the RainModel_2017.wdm times the scaling factor. The values presented in the documentation do not include the scaling factors. Documentation should be added to describe the scaling factors and the statistics presented in the documentation should reflect the final PET time series for each station. When scaled, the annual values are slightly low, but not out of the range of what is reasonable for Florida PET rates.*

Response # 3. The scaling factors account for the relative differences in PET developed using the Hargreaves method and the U.S. Geological Survey (USGS) using the Priestly-Taylor method. The scaling factors were used to adjust PET values and ranged from 0.87 to 0.91 for each weather station. Table 3 has been revised to include the scaling factors and now provides a summary (minimum, maximum, and average) of annual PET over the period of 1970-2016 for each of the stations. The revised table is below.

Item	Deland	Lisbon	Orlando	Sanford
Minimum Annual Rainfall	38.48	29.28	30.38	32.83
Maximum Annual Rainfall	76.69	66.88	67.85	71.09
Average Annual Rainfall	56.67	47.99	49.69	52.04
Minimum Annual PET	47.36	48.60	51.50	49.51
Maximum Annual PET	55.66	58.38	56.86	56.32
Average Annual PET	51.79	52.54	53.85	52.63

- **Point Source Discharges**

Comment # 4. *Major point source discharges from 2 wastewater treatment plants (WWTPs) are described in the model documentation. These were included as external sources in the HSPF models. Minor point sources were not discussed in the documentation and were not included in the models. Although minor point sources will likely have a minimal effect on the overall model calibration, the extent to which minor point sources are present should be discussed in the documentation.*

Response # 4. Section 2.6 of the model report was updated to describe why only two particular sites were included in the model. In short, these sites discharge at least 0.1 mgd and are permitted by NPDES to discharge into the Wekiva River.

(2) Assess the validity, defensibility and appropriateness of the model development and calibration.

C) Review model input and output data including but not limited to:

- **Model elevations versus collected data to verify the same datum was used consistently**

Comment # 5. *Water elevations in Table 14 of the documentation were compared to those as recorded in feet-NAVD88 via either the USGS or District website, as shown below. All elevations presented in Table 14 of the documentation matched the corresponding elevation shown below. The model datum was not explicitly stated in the model documentation. It is recommended to add a sentence in the model construction section of the documentation which states the model datum.*

Response # 5. The suggested revision was made. The model datum (NAVD88) was added into the caption of Table 14 and a sentence was added to section 4.1.1. to clarify the model datum used in construction. The text in 4.1.1 now reads, *"The vertical datum used in the model construction is feet-NAVD88."*

- **Flow/stage plots to look for model instabilities;**

Comment # 6. *Flow and stage plots were examined as appropriate in both models to look for modeling instabilities. No model instabilities were noted in the HSPF model. Slight instabilities were noted in the HEC-RAS model as it relates to the simulated stages. As shown, stages are expected to increase as percentile flows increase. There are instances where the flow profiles for various percentile flows intersect each other. Upon further examination of the flow profiles, it was noted that this is due to inconsistencies in the flow profiles based on the observed data. For example, the flow at ROK4 for PF 12 is 72.5 cubic feet per second(cfs), while the flow at ROK4 for PF11 is 79.5 cfs. The corresponding flows downstream at XS2 are 992.4 cfs and 896.8 cfs. While this is to be expected since it is a steady-state model with flow profiles based on observed data, it may be helpful to smooth the flow profiles so that inconsistencies are not simulated (e.g. a higher stage at a lower flow profile)*

Response # 6. Instead of deriving synthetic smooth flow profiles from frequency analysis, we used the observed data to develop flow profiles at Rock Springs, Wekiwa Springs, SR434 and SR46. Because of this, the flow profiles used in the model are more representative of the actual system and reflect natural variation of the flow-stage relationship including the influence of the downstream boundary condition, which is highly affected by the St. Johns River stage. Therefore, it is not unexpected to see a higher stage at a lower flow profile.

- **Output file for model warnings**

Comment # 7. *There were no warning or error messages present in the HSPF model. There were several warnings noted in the HEC-RAS simulation related to the potential need for additional cross sections due to the conveyance ratio being outside of the expected range. Additional cross sections could be added if desired, but this should minimally affect the overall model performance. Several errors were noted for cross sections that needed to be extended for the computed water surface, as shown in the example cross section below. These cross sections should be extended so that the water surface is fully contained within the cross- sectional area. Although this should only minimally affect results, it is good modeling practice.*

Response # 7. Cross sections have been extended for this model and these changes are reflected in the model.

- **Water budget to check for reasonableness;**

Comment # 8. *A water budget was not explicitly provided in the documentation. An independent water budget was developed during the review process using the HSPF binary output file (*.hbn). Those results are presented in a later section of this document. It is highly recommended that, at a minimum, average basin water budgets be added to the documentation for each of the 3 HSPF models (ideally grouped by land cover). The water budgets should express average annual volume in inches over the basin area.*

Response # 8. An average water budget for each of the sub-basin areas is presented below and was inserted in the report. We added all the sub-watershed water balance calculations for each land-use to the report as an appendix.

Watershed	Rainfall (in)	ET (in)	Recharge (in)	Spring (in)	Upstream and PS (in)	Outflow (in)
Black Water Creek	50.6	41.8	1.9	4.6	0.0	12.3
Little Wekiva River	51.4	33.4	8.8	9.8	0.2	20.3
Wekiva River	53.0	40.5	2.2	26.9	39.7	78.0
Total	51.4	39.9	3.2	11.5	0.0	20.6

- **Values assigned to model parameters to check for reasonableness**

Comment # 9. *Parameter values were checked for reasonableness in HSPF and HEC-RAS. In HSPF, initial conditions will impact the simulation for a short period of time, ranging from days to months depending on the model and the initial conditions. There are some inconsistencies with respect to the relative moisture levels at the start of the simulation. Lower zone storage (LZS) is initialized at 6.4-inches for all simulations. Lower zone storage nominal, LZSN, ranges from 0.5 to 7.5 inches, making initial the initial lower zone ratio (LZRAT) vary from almost 13 to just below 1. Additionally, the retention storage capacity, RETSC, is set to 0.1-inches for all impervious land segments. This may be slightly low, which would result in a low impervious ET rate.*

Response # 9. To incorporate peer review comments and improve the HSPF model, we updated and recalibrated the model. Initial parameter values in HSPF were adjusted to match with the calibrated parameter values. In addition, HEC-RAS model inputs were updated with the HSPF model results and Manning’s n values were adjusted. The supplemental parameters for HSPF have been updated and are listed in the report. The model calibration statistics of the previous and updated models are provided below. The calibration statistics of the updated model are similar to or slightly better than previous models. Detailed model performance evaluation is presented in the report.

- **HSPF model performance comparison**
  - **Previous**

Statistics		Black Water Creek		Little Wekiva River		Wekiva River		
		SR44	Near Debary	SR434	SLB	Near Apopka	Old Railroad (RR)	SR46
Daily	RMSE	50.97	73.53	27.01	34.00	29.17	69.63	76.68
	R^2	0.69	0.64	0.69	0.76	0.50	0.73	0.69
	PBIAS %	-1.00	-1.10	-0.40	-6.90	0.00	4.80	-0.30
	high10%	-3.41	1.46	-4.29	-15.02	-6.91	-1.52	-3.99
	low50%	11.76	0.90	-1.26	9.99	0.53	9.28	4.28
	NSE	0.63	0.53	0.67	0.76	0.45	0.71	0.67
	RSR	0.60	0.69	0.57	0.49	0.74	0.54	0.58
Monthly	RMSE	37.24	54.50	15.14	22.50	24.62	47.27	54.36
	R^2	0.75	0.70	0.79	0.82	*0.45**	0.77	0.72
	PBIAS %	-1.30	-1.20	-0.50	-6.60	0.10	4.80	-0.30
	NSE	0.72	0.65	0.79	0.80	*0.34**	0.74	0.70
	RSR	0.53	0.59	0.46	0.44	*0.81**	0.51	0.54

  - **Updated**

Statistics		Black Water Creek		Little Wekiva River		Wekiva River		
		SR44	Near Debary	SR434	SLB	Near Apopka	Old Railroad (RR)	SR46
Daily	RMSE	50.18	68.33	26.76	34.53	27.99	71.61	76.90
	R^2	0.69	0.67	0.69	0.76	0.55	0.73	0.69
	PBIAS %	-2.70	0.80	-3.20	-7.60	-0.10	7.10	1.80
	high10%	-4.09	1.63	-7.88	-16.93	-5.77	-0.53	-2.93
	low50%	3.13	3.43	0.97	10.08	0.74	12.09	6.91
	NSE	0.65	0.59	0.68	0.75	0.49	0.69	0.66
	RSR	0.59	0.64	0.57	0.50	0.71	0.56	0.59
Monthly	RMSE	38.43	53.30	14.88	22.98	22.96	49.79	55.93
	R^2	0.75	0.72	0.80	0.82	0.52	0.77	0.71
	PBIAS %	-2.90	0.70	-3.30	-7.60	-0.10	7.00	1.70
	NSE	0.70	0.66	0.79	0.79	*0.42**	0.71	0.69
	RSR	0.55	0.58	0.45	0.46	*0.76**	0.54	0.56

- **HEC-RAS model performance comparison – steady state**
  - **Previous**

Stream	Station	Profile (ft, NAVD)	PF1	PF2	PF3	PF4	PF5	PF6	PF7	PF8	PF9	PF10	PF11	PF12	PF13
Little Wekiva	SR434	Obs.	21.72	21.68	21.97	22.33	22.71	23.04	23.86	23.60	26.31	26.45	26.67	26.22	28.32
		Sim.	21.95	21.88	22.11	22.27	22.36	22.68	24.07	23.54	26.15	26.23	26.58	26.01	27.67
		Diff.	0.23	0.20	0.14	-0.06	-0.35	-0.36	0.21	-0.06	-0.16	-0.22	-0.09	-0.21	-0.65*
	SLB	Obs.	-	-	-	-	-	-	-	-	-	-	19.66	-	20.64
		Sim.	16.70	16.71	16.88	17.16	17.37	18.20	18.39	18.37	19.54	19.62	19.75	19.54	20.33
		Diff.	-	-	-	-	-	-	-	-	-	-	0.09	-	-0.31
Rock Springs Run	Rock Springs	Obs.	24.81	24.77	24.80	24.82	25.00	25.00	24.92	24.93	25.07	25.09	25.23	25.09	25.95
		Sim.	25.12	25.11	25.14	25.15	25.26	25.18	25.27	25.29	25.30	25.30	25.27	25.30	25.48
		Diff.	0.31	0.34	0.34	0.33	0.26	0.18	0.35	0.36	0.23	0.21	0.04	0.21	-0.47
	ROK2	Obs.	-	-	-	-	17.47	-	-	17.68	17.83	18.01	-	18.19	-
		Sim.	17.56	17.54	17.61	17.63	17.77	17.88	17.91	17.89	17.97	17.98	18.04	17.97	18.84
		Diff.	-	-	-	-	0.30	-	-	0.21	0.14	-0.03	-	-0.22	-
Wekiwa Run	Wekiwa Springs	Obs.	11.90	11.87	12.04	12.07	12.10	12.40	12.34	12.81	12.61	12.72	13.50	12.83	14.52
		Sim.	11.34	11.39	11.46	11.58	11.85	12.52	12.30	12.48	12.73	12.99	13.13	13.18	14.51
		Diff.	-0.56*	-0.48	-0.58*	-0.49	-0.25	0.12	-0.04	-0.33	0.12	0.27	-0.37	0.35	-0.01
Wekiva River	Near Apopka	Obs.	11.41	11.35	-	-	11.51	12.62	-	-	-	-	13.43	-	14.52
		Sim.	11.29	11.33	11.40	11.52	11.80	12.48	12.27	12.45	12.70	12.96	13.10	13.15	14.47
		Diff.	-0.12	-0.02	-	-	0.29	-0.14	-	-	-	-	-0.33	--	-0.05
	Railroad	Obs.	8.38	8.27	8.41	8.53	8.59	9.33	9.45	9.58	10.10	10.44	10.62	10.64	12.18
		Sim.	8.31	8.34	8.38	8.47	8.61	9.30	9.49	9.51	9.95	10.27	10.57	10.57	12.25
		Diff.	-0.07	0.07	-0.03	-0.06	0.02	-0.03	0.04	-0.07	-0.15	-0.17	-0.05	-0.07	0.07
	SR46	Obs.	6.20	6.12	6.24	6.34	6.60	7.23	7.41	7.49	7.91	8.19	8.51	8.46	10.21
		Sim.	6.03	6.05	6.09	6.24	6.41	7.14	7.44	7.50	7.89	8.16	8.42	8.47	9.95
		Diff.	-0.17	-0.07	-0.15	-0.10	-0.19	-0.09	0.03	0.01	-0.02	-0.03	-0.09	0.01	-0.26

* |Values| > 0.5 ft

○ **Updated**

Stream	Station	Profile (ft, NAVD)	PF1	PF2	PF3	PF4	PF5	PF6	PF7	PF8	PF9	PF10	PF11	PF12	PF13
Little Wekiva	SR434	Obs.	21.72	21.68	21.97	22.33	22.71	23.04	23.86	23.60	26.31	26.45	26.67	26.22	28.32
		Sim.	21.95	21.88	22.11	22.27	22.36	22.77	23.68	23.44	26.01	26.13	26.46	25.91	27.66
		Diff.	0.23	0.20	0.14	-0.06	-0.35	-0.27	-0.18	-0.16	-0.30	-0.32	-0.21	-0.31	***-0.66****
	SLB	Obs.	-	-	-	-	-	-	-	-	-	-	19.66	-	20.64
		Sim.	16.68	16.71	16.85	17.14	17.39	18.15	18.91	18.47	19.57	19.62	19.76	19.54	20.26
		Diff.	-	-	-	-	-	-	-	-	-	-	0.10	-	-0.38
Rock Springs Run	Rock Springs	Obs.	24.81	24.77	24.80	24.82	25.00	25.00	24.92	24.93	25.07	25.09	25.23	25.09	25.95
		Sim.	25.03	25.02	25.05	25.06	25.17	25.09	25.18	25.20	25.21	25.21	25.18	25.21	25.39
		Diff.	0.22	0.25	0.25	0.24	0.17	0.09	0.26	0.27	0.14	0.12	-0.05	0.12	***-0.56****
	ROK2	Obs.	-	-	-	-	17.47	-	-	17.68	17.83	18.01	-	18.19	-
		Sim.	17.38	17.35	17.40	17.41	17.48	17.47	17.57	17.49	17.61	17.68	17.75	17.71	18.44
		Diff.	-	-	-	-	0.01	-	-	-0.19	-0.22	-0.33	-	-0.48	-
Wekiwa Run	Wekiwa Springs	Obs.	11.90	11.87	12.04	12.07	12.10	12.40	12.34	12.81	12.61	12.72	13.50	12.83	14.52
		Sim.	11.51	11.53	11.55	11.59	11.73	12.39	12.27	12.38	12.62	12.85	12.97	13.05	14.30
		Diff.	-0.39	-0.34	-0.49	-0.48	-0.37	-0.01	-0.07	-0.43	0.01	0.13	***-0.53****	0.22	-0.22
Wekiva River	Near Apopka	Obs.	11.41	11.35	-	-	11.51	12.62	-	-	-	-	13.43	-	14.52
		Sim.	11.08	11.11	11.14	11.21	11.41	12.24	12.09	12.23	12.50	12.76	12.89	12.97	14.26
		Diff.	-0.33	-0.24	-	-	-0.10	-0.38	-	-	-	-	***-0.54****	-	-0.26
	Railroad	Obs.	8.38	8.27	8.41	8.53	8.59	9.33	9.45	9.58	10.10	10.44	10.62	10.64	12.18
		Sim.	8.32	8.35	8.38	8.47	8.60	9.33	9.47	9.52	9.96	10.28	10.57	10.58	12.22
		Diff.	-0.06	0.08	-0.03	-0.06	0.01	0.00	0.02	-0.06	-0.14	-0.16	-0.05	-0.06	0.04
	SR46	Obs.	6.20	6.12	6.24	6.34	6.60	7.23	7.41	7.49	7.91	8.19	8.51	8.46	10.21
		Sim.	6.04	6.06	6.10	6.25	6.44	7.17	7.36	7.49	7.96	8.15	8.42	8.46	9.86
		Diff.	-0.16	-0.06	-0.14	-0.09	-0.16	-0.06	-0.05	0.00	0.05	-0.04	-0.09	0.00	-0.35

* |Values| > 0.5 ft

- **HEC-RAS model performance comparison – unsteady state**
  - **Previous**

Stream	Station	Statistics (ft, NAVD)	Mean	Max	Min	RMSE	PBIAS	RSR
Little Wekiva River	SR434	Obs.	23.04	26.67	22.21	0.32	0.27	0.32
		Sim.	23.11	26.90	21.75			
		Diff.	0.07	0.23	-0.46			
	SLB	Obs.	17.99	19.66	17.46	0.11	0.14	0.19
		Sim.	18.02	19.81	17.42			
		Diff.	0.03	0.15	-0.04			
Rock Springs Run	Rock Springs	Obs.	25.16	25.35	24.97	0.14	0.53	1.53
		Sim.	25.29	25.37	25.19			
		Diff.	0.13	0.02	0.22			
Wekiwa Run	Wekiwa Springs	Obs.	12.16	13.65	11.80	0.26	1.99	0.80
		Sim.	12.40	13.56	12.03			
		Diff.	0.24	-0.09	0.23			
Wekiva River	Near Apopka	Obs.	11.63	13.56	11.16	0.45	3.57	0.96
		Sim.	12.05	13.47	11.63			
		Diff.	0.42	-0.09	0.47			
	Railroad	Obs.	8.76	10.62	8.33	0.25	2.59	0.62
		Sim.	8.99	10.60	8.58			
		Diff.	0.23	-0.02	0.25			
	SR46	Obs.	6.54	8.51	6.12	0.20	2.32	0.43
		Sim.	6.69	8.64	6.18			
		Diff.	0.15	0.13	0.06			

  - **Updated**

Stream	Station	Statistics (ft, NAVD)	Mean	Max	Min	RMSE	PBIAS	RSR
Little Wekiva River	SR434	Obs.	23.04	26.67	22.21	0.32	0.29	0.33
		Sim.	23.11	26.91	21.75			
		Diff.	0.07	0.24	-0.46			
	SLB	Obs.	17.99	19.66	17.46	0.11	0.13	0.19
		Sim.	18.01	19.71	17.42			
		Diff.	0.02	0.05	-0.04			
Rock Springs Run	Rock Springs	Obs.	25.16	25.35	24.97	0.07	0.16	0.72
		Sim.	25.20	25.27	25.10			
		Diff.	0.04	-0.08	0.13			
Wekiwa Run	Wekiwa Springs	Obs.	12.16	13.65	11.80	0.29	2.13	0.87
		Sim.	12.42	13.40	12.05			
		Diff.	0.26	-0.25	0.25			
Wekiva River	Near Apopka	Obs.	11.63	13.56	11.16	0.22	1.34	0.47
		Sim.	11.79	13.24	11.29			
		Diff.	0.16	-0.32	0.13			
	Railroad	Obs.	8.76	10.62	8.33	0.28	2.63	0.69
		Sim.	8.99	10.38	8.59			
		Diff.	0.23	-0.24	0.26			
	SR46	Obs.	6.54	8.51	6.12	0.25	2.56	0.52
		Sim.	6.71	8.41	6.19			
		Diff.	0.17	-0.10	0.07			

Comment # 10. *Figure 30 in the report shows Manning's n as a function of water level (Figure 30a) and flow (Figure 30b). The physical reasons for Manning's n showing a "more consistent" relationship with flow should be discussed. We hypothesize that stage and flow data from all years were used to make these plots, so the reason the flow produces a cleaner relationship is because the base level changes from the gage are accounted for implicitly. If this is correct, this should be addressed in the report.*

Response # 10. The following updated description was added to the report to clarify this.

"HEC-RAS model provides options for varying Manning's n by flow or depth. A preliminary analysis, based on the period of 2008-2016, was conducted to calculate Manning's n at SR 46; its results showed more consistent relationship between Manning's n and flow (Figure 32). This cleaner relationship is because the base level changes from the gage are accounted for implicitly in the model. Therefore, Manning's n was varied with respect to flow in the HEC-RAS model to simulate low to high flow regimes for both steady and unsteady simulation. In the steady state simulation, the "Vertical Variation in Manning's n Values" option under cross section data editor was used to vary Manning's n, while the "flow roughness factors" option was implemented during the unsteady state simulation."

- **Review of the methodologies used to develop boundary conditions including spring flows and incorporate HSPF output into HEC-RAS models.**

Comment # 11. *Springs were divided into "Step 1, Step 2, and Step 3" springs depending on the amount of data available at the spring and the necessary gap-filling (the term "Step" is a little misleading and should be renamed to "groups" or "category"). More explanation is needed in the Appendix document for the gap-filling of Step 3 springs. For example, according to Table 4, of Appendix A, Messant Springs was filled with Rock Springs. The filled Messant Springs time series was then used to fill Camp La No Che Springs. It is not clear why Rock Springs was not used to fill Camp La No Che Springs, since it is preferable to fill a spring with an observed time series as opposed to a filled time series. Additionally, for all springs, error statistics can be presented for the gap-filling measures since there are at a minimum several observed data points for each of the springs. The quantification of the error associated with the spring flow estimation is imperative since the spring flows serve as model boundary conditions.*

Response # 11. The term "Step" was changed to "Group". The regression error statistics are included below and added to the report. Camp La No Che Spring has only two measurements which were taken in 1954 and 1972, which were very small, 1.1 and 0.66 cfs respectively. Therefore, using Rock or Messant Springs will not make much difference in terms of developing a continuous dataset for this spring. We decided to use Messant springs because it is nearby and groundwater levels at this spring and Camp La No Che springs are similar.

	Group 1 Springs (LOC Analysis)					
Statistics	miami springs	palm springs	rock springs	sanlando springs	starbuck springs	wekiva springs
Mean (Observed)	5.3	5.4	54.8	19.5	12.1	61.4
Mean Error	-0.1	-0.3	0.7	1	-0.2	-0.3
Mean Absolute Error	0.5	0.5	1.5	2.1	1.1	2
Root Mean Squared Error	0.7	0.5	2.1	2.7	1.4	2.7
Standard Deviation of Error	0.7	0.5	1.9	2.5	1.4	2.7

	Group 2 Springs (SLR Analysis)		
Statistics	Helene Springs	Island Springs	Sulphur Springs
Mean (Observed)	1.2	8.4	0.5
Mean Error	0	0	0
Mean Absolute Error	0.1	0.6	0.1
Root Mean Squared Error	0.1	0.8	0.1
Standard Deviation of Error	0.1	0.8	0.1

Comment # 12. *The approach used to incorporate the HSPF output is generally valid. Lateral inflows from sub-watersheds that were adjacent to stream reaches were used as HEC-RAS boundary conditions. Adjustment factors combined with HSPF sub-watershed output were used to estimate flows at flow change locations when observed data was not available at a given flow change location. Although this approach* *is valid, additional details regarding the extent of the use of the HSPF flows and the development of their scaling factors should be added to the documentation.*

Response # 12. We added a table showing details on which HSPF output was used, as well as how it was applied and adjusted for input to HEC-RAS in the report. Scaling factors were derived from the relationship between simulated and observed flows at SR46 to estimate the channel flow profiles at a given flow-change location.

- **Review of PEST Calibration Approach**

Comment # 13. *The weights for the daily, monthly, and total discharge was set to 1.0 while the flow duration data had a weight of 10000. The different weights allow PEST to account for the dramatic change in the range of values and units when aggregated the objective function. The flow data range from 0 to hundreds of cfs while the flow duration ordinates only range from 0 to 1. The total flow data, however, range in the hundreds of thousands. This will put additional emphasis on the matching of the total flow estimates. Descriptions of the weights and relative contribution to the objective function should be documented.*

Response # 13. The objective function typically includes multiple weighted statistical measures, such as mean and percentiles, to evaluate the statistical characteristics of model simulations and observations. The best effort on adjusting these statistical measures and their weights during calibration was made to achieve the best match between model simulations and observed data in terms of low, median, and high flow and its balance. We initially set the weights based on the number of data values of the statistical measures to provide equivalent parameter calibration opportunity between the measures: 1 for daily time-series difference, 30 for monthly time-series difference, and 365 for yearly time-series difference. We assigned more weight on flow duration (or flow exceedance) measures to ensure that high and low flows are equally emphasized. The weights were further adjusted during the process of calibration to better match the observed flows. The weights and relative contribution to the objective function is documented below and included in the report.

Sub models	Series Name	Description	Weight
Black Water Creek	Qmea3, Qmea 7	Sum of differences between simulation and observation in daily flow time-series at SR44 and Near Debary stations	1

	Qmea3_m, Qmea7_m	Sum of differences between simulation and observation in monthly flow time-series at SR44 and Near Debary stations	30
	Qmea3_tot, Qmea7_tot	Difference between simulation and observation in total flow during simulation period at SR44 and Near Debary stations	365
	Qmea3_du, Qmea7_du	Sum of differences between simulation and observation in flow duration curve at SR44 and Near Debary stations	100000
	Qmea3fd, Qmea7fd	Sum of difference between simulation and observation in flow duration curve for 50% low flows at SR44 and Near Debary stations	10000
Little Wekiva River	Qmea1	Sum of differences between simulation and observation in daily flow time-series at SR434 station	1
	Qmea1_m	Sum of differences between simulation and observation in monthly flow time-series at SR434 station	30
	Qmea1_tot	Difference between simulation and observation in total flow during simulation period at SR434 station	3650
	Qmea1_du	Sum of differences between simulation and observation in flow duration curve at SR434 station	1000000
	Qmea1fd	Sum of difference between simulation and observation in flow duration curve for 50% low flows at SR434 station	1000
Wekiva River	Qmea2, Qmea5	Sum of differences between simulation and observation in daily flow time-series at Near Apopka and SR46 stations	1
	Qmea2_m, Qmea5_m	Sum of differences between simulation and observation in monthly flow time-series at Near Apopka and SR46 stations	30
	Qmea2_tot, Qmea5_tot	Difference between simulation and observation in total flow during simulation period at Near Apopka and SR46 stations	3650
	Qmea2_du, Qmea5_du	Sum of differences between simulation and observation in flow duration curve at Near Apopka and SR46 stations	1000000
	Qmea2fd, Qmea5fd	Sum of difference between simulation and observation in flow duration curve for 50% low flows at Near Apopka and SR46 stations	1000; 5000

Editorial Comments

Comment # 14. *It is recommended that the following editorial comments be addressed in the final documentation:*

Response # 14. We updated the report as suggested.

References

Intera, 2018. Re: Review of Wekiva River Hydrology and Hydraulic Modling, Memorandum,

Seong, C., and A. E. Wester, 2018. Wekiva River Hydrology and Hydraulic Modeling for Minimum Flow and Level Evaluations, SJRWMD Draft Report, Palatka, Florida. Available at https://www.sjrwmd.com/static/mfls/MFL-Wekiva/Technical_Report_WekivaMFL_2018_update_0928_Draft.pdf

SJRWMD, 2012. *The St. Johns River Water Supply Impact Study*, Chapter 3: Watershed Hydrology. Appendix 3.B: HSPF Common Logic for the SJRWMD

OneRain Inc., *2002. St. Johns River Water Management District HDSLIB.RADAR_PIXELS*, SJRWMD, vector digital data, Palatka, Florida