St. Johns River
Water Management District
Michael A. Register, P.E., Executive Director
4049 Reid Street • P.O. Box 1429 • Palatka, FL 32178-1429 • 386-329-4500 • www.sjrwmd.com

TECHNICAL MEMORANDUM

DATE: September 14, 2022

FROM: Olkeba T. Leta, Ph.D.
Bureau of Watershed Management and Modeling

SUBJECT: Responses to Peer Review Comments – Johns Lake Hydrologic Model

---

This technical memorandum provides responses to peer review comments on the Interconnected Channel and Pond Routing version 4 (ICPR4) model of Johns Lake provided by the Applied Technology and Management (ATM) on 5/29/2022 (ATM, 2022). The model was developed to assess Johns Lake minimum levels. The following documentations provided by SJRWMD were also peer reviewed during the model review process:

- Hydrologic modeling for minimum flows and levels support – Johns Lake, November 2021, by Leta and others.
- ICPR4 hydrologic modeling support for Johns and Avalon Lakes, March 2021, by Streamline Technologies (SLT).
- Minimum flows and levels program hydrologic modeling services for Lakes Johns and Avalon in Orange County, July 2019, by Collective Water Resources (CWR).

Figure 1 shows location of Johns Lake watershed along with the model schematic representations. The figure will also be referred for clarity while addressing some of the peer review comments.

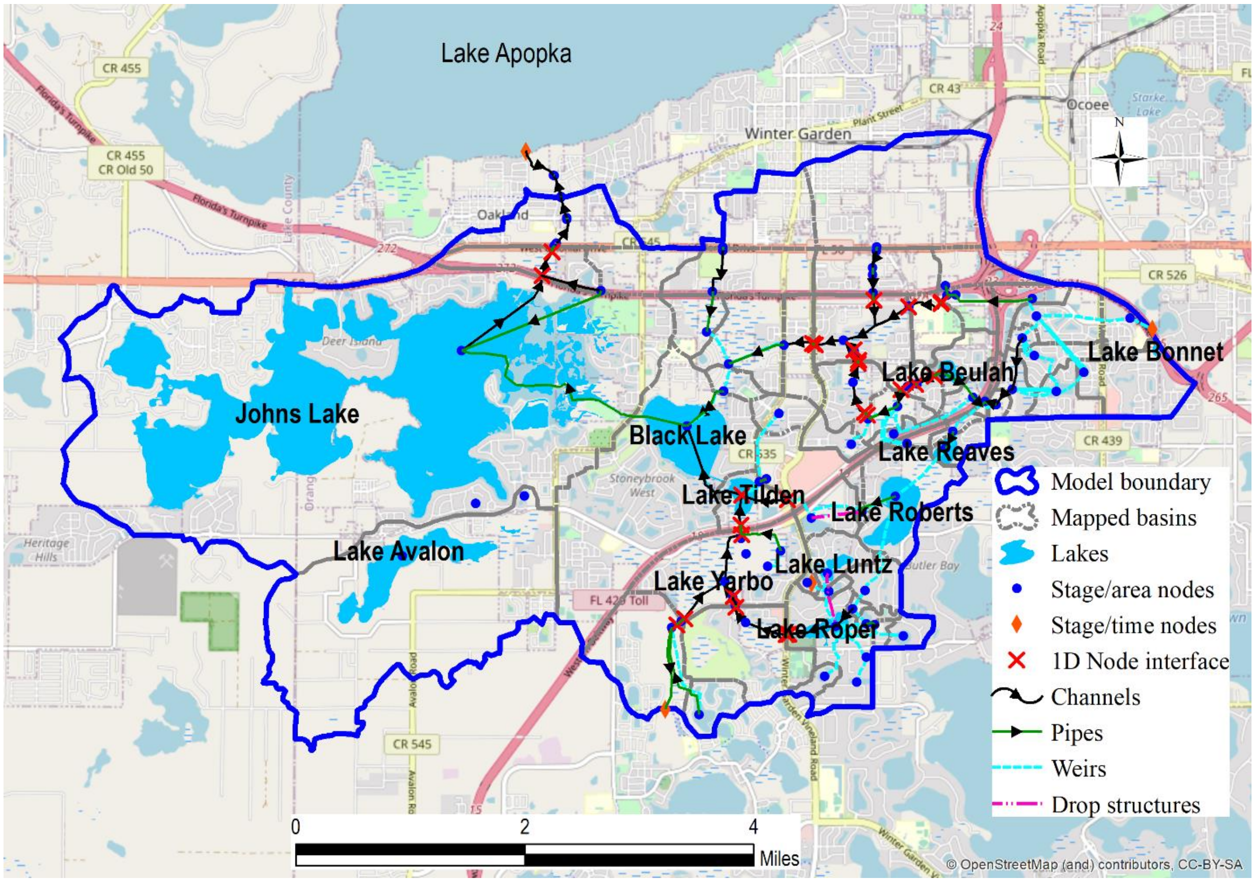

Figure 1. Model boundary, major lakes, and model schematic representation

While below are the peer-review comments provided by ATM (2022) (in italic), the responses to the comments by the SJRWMD are followed (in blue).

Comment #1. *SJRWMD used best available lake level measurements in Johns Lake and Lake Avalon to calibrate and verify the simulation; however, SJRWMD possesses additional lake level measurements that, if used for calibration or verification, may improve predictions of future lake levels forced by Floridan aquifer system pumping scenarios and forced by global or regional climate change. SJRWMD may wish to revise the simulation to use additional lake level measurements for calibration or verification*

Response #1: As documented in the model summary report (see Appendix – 2, Calibration and Validation section), we utilized the sporadically available observed water levels data for all lakes located upstream of Johns Lake, visually compared the data with the corresponding simulated lake levels, and consistently checked the reasonable simulations of water levels time series during model calibration, verification, and long-term simulation steps. For example, Figure 2 and Figure 3 present sporadically observed lake levels data along with daily simulated water levels (without further calibration) for both Black and Tilden Lakes, which are just upstream of Johns Lake. The figures clearly indicate that ICPR4 adequately reproduced the temporal variations and magnitudes of observed data that confirms the suitability of the model for simulating the hydrologic processes of the system. Like Johns Lake, the model overestimated observed water levels before 1993, but as compared to Johns – those differences are relatively small for both Black and Tilden Lakes. This is also reflected with acceptable goodness-of-fit statistical values for both lakes as summarized in Table 1. Furthermore, in order to assess the sensitivity of Johns Lake for inflows from the upstream southeast lakes such as Lake Yarbo, Luntz, Roberts, and Reaves (see Figure 1), we also performed sensitivity analysis (SA). We performed SA by turning off links that carry flows from these lakes to Lake Tilden and Black Lake. Johns Lake did not show high sensitivity to inflows from Lake Reaves, Luntz, and Roberts as the simulated water levels of the lake were minimally changed when the links that carry flows from these lakes were turned off (Figure 4). This is mainly due to the relatively high inflows to Black Lake coming from the north and northeast part of the watershed, including the farther upstream Lake Beulah (see Figure 1). Due to numerical instability issues, we were not able to successfully run SA by turning off the links from north/northeast (Lake Beulah) and south (Lake Yarbo) to Black and Tilden Lakes, respectively. However, the model already showed reasonable results for both Lake Beulah and Yarbo (see Response #10). Given limited data for the farther upstream lakes, Johns Lake showed low sensitivity to flows coming from the southeast lakes, and the model generally matched the temporal evolutions and magnitudes of observed water levels for most of the lakes, it is believed that further calibration for the upstream lakes would not be expected to substantially improve the mismatch between observed and simulated water levels of Johns Lake before 1993.

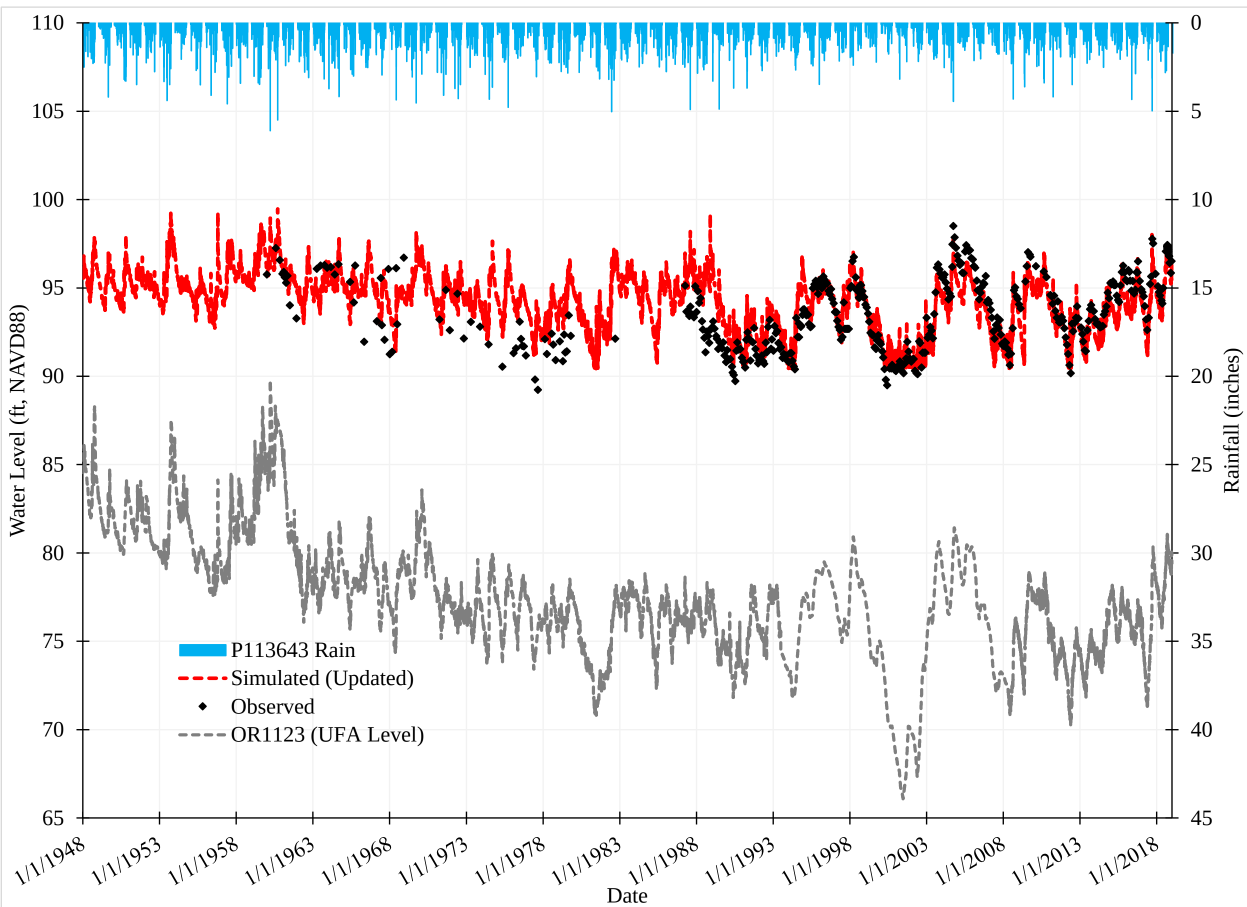

Figure 2. Observed and simulated lake levels for Black Lake (after model update). P113643 represents rainfall pixel ID.

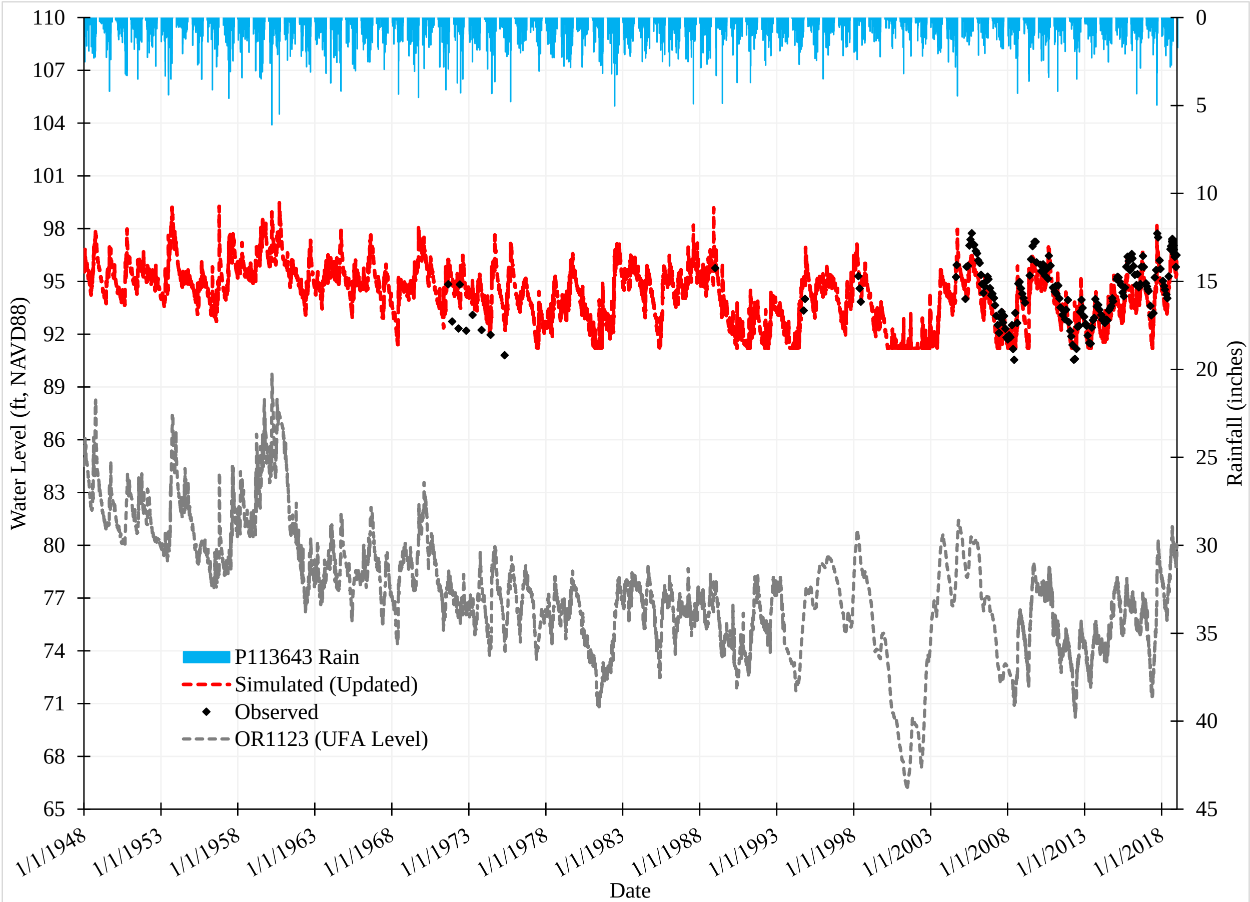

Figure 3. Observed and simulated water levels for Lake Tilden (after model update). P113643 represents rainfall pixel ID

Table 1. Goodness-of-fit statistics for Black and Tilden Lakes calibration/validation and long-term simulation periods

Statistics	**Symbol**	**Black Lake**		**Lake Tilden**	
		Calibration/validation (1995-2018)	**Long-term (1948-2018)**	**Calibration/validation (1995-2018)**	**Long-term (1948-2018)**
Nash-Sutcliffe Efficiency	NSE	0.83	0.61	0.74	0.72
Root mean squared error	RMSE	0.87	1.29	0.91	0.96
Mean error	ME	-0.45	0.11	-0.69	-0.58
Absolute mean error	AME	0.72	1.00	0.77	0.80
Percent bias	PBIAS	-1.00	0.12	-0.85	-0.61
Pearson correlation coefficient	R	0.93	0.79	0.94	0.91
Percent of observation bracketed with ± 1 foot	±1ft (%)	71.79	60.13	71.89	70.05

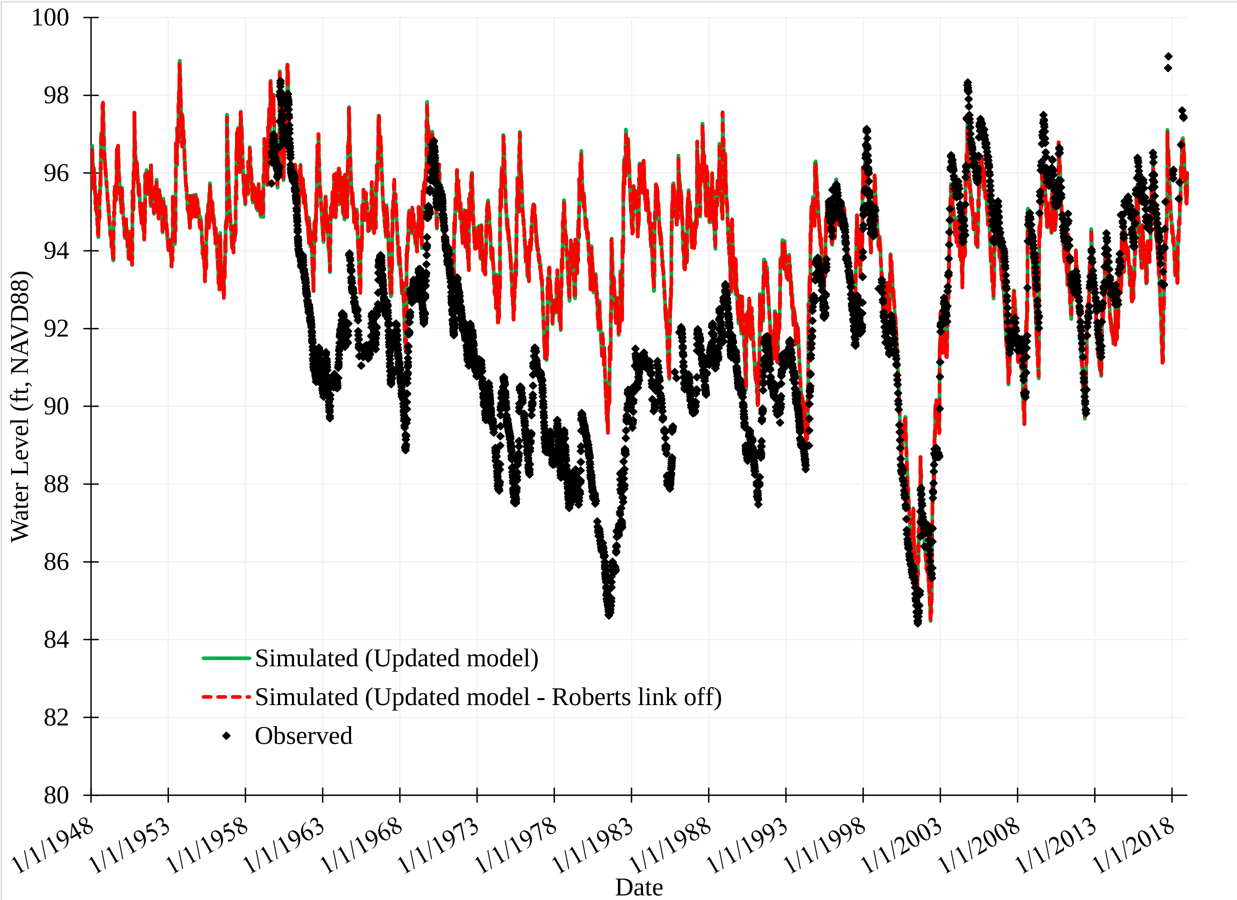

Figure 4. Simulated water levels of Johns Lake with and without link inflows from Lake Roberts (after model update)

Comment #2*. SJRWMD built the numerical simulation from geospatial data, hydro-meteorological data, and a U.S. Environmental Protection Agency Stormwater Management Model (SWMM) by Collective Water Resources (2019). SJRWMD worked with Streamline Technologies (2021) to refine the Collective simulation. SJRWMD broadly adopted the Streamline refinement of the Collective simulation. SJRWMD may wish to document the primary source of information used to populate structural dimensions and elevations in the Collective simulation. For example, if Collective relied on a specific survey of structural elevations to populate SWMM, SJRWMD may wish to review the primary survey documents and explicitly reference these documents in the report that describes the SJRWMD ICPR4 simulation.*

Response #2: although the primary sources of the data have been already well-documented in CWR (2019) report, the model summary report is updated accordingly, and relevant references are included.

Comment #3*. In February 2021, Orange County Stormwater Management Division published a study by CDM Smith of the Johns Lake outfall and a conceptual design for the outfall. The study included new data, a permit review, new survey, and an ICPR4 simulation of extreme flood events. CDM (2021) assessed flood hazards by simulating the Johns Lake hydrologic system, forced by specific episodic events, such as a precipitation event with a one-percent chance of being exceeded in any given year (the so-called 100-year storm). The study also updates and references several* *previous studies and simulations of Johns Lake. SJRWMD may wish to itemize water-control structures, such as culverts, that exist in the CDM simulation, the Collective Water Resources (2019) simulation, and the SJRWMD ICPR4 simulation. SJRWMD may wish to include structural dimensions and elevations in this itemization, to ensure that SJRWMD details all relevant structures and that control elevations and dimensions in the SJRWMD simulation conform to elevations from other simulations. Where differences exist between control elevations and dimensions in the SJRWMD simulation and other simulations, SJRWMD may wish to document and justify these differences.*

Response #3: we compared water structural data from different sources and noticed some differences in structures' invert elevations and dimensions as shown Table 2, but the data from the CDM (2021) are believed to be more up to date. Therefore, we updated the water structural data from CWR (2019) with data from CDM (2021). However, these updates showed minor impacts on the simulated water levels of Johns Lake (Figure 5 and Table 3).

Table 2. Comparison of water control structures from Black Lake to West Orange Trail

Source	Name	Upstream invert (ft, NAVD88)	Downstream invert (ft, NAVD88)	Depth (ft)	Width (ft)	Geometry	Remark
CWR (2019)	Dual box culverts at Avalon Drive	89.10	89.00	5	9	Rectangular	
	Box-culvert at Florida's Turnpike	88.36	88.26	10	10	Rectangular	
	Dual RCP Pipe at south of SR50	91.75	91.89	6	6	Circular	
	Dual box culverts under SR50	84.78	84.75	11	8	Rectangular	
	CMP Pipe with slide gate at north of SR50	93.33	93.23	6	6	Circular	
	CMP Pipe at north of SR50	94.50	94.40	3.5	3.5	Arch	
	Culvert 1 at East Oakland Avenue	92.18	92.65	3.5	3.5	Horizontal Ellipse	
	Culvert 2 at East Oakland Avenue	92.93	93.05	3	3	Circular	
	Dual pipe at West Orange Trail	90.14	89.63	4	4	Circular	
SJRWMD (2021)	Dual box culverts at Avalon Drive	89.10	89.00	5	9	Rectangular	
	Box-culvert at Florida's Turnpike	NA	NA	10	10	Rectangular	Not modeled
	Dual RCP Pipe at south of SR50	91.75	91.89	6	6	Circular	
	Dual box culverts under SR50	NA	NA	11	8	Rectangular	Not modeled
	CMP Pipe with slide gate at north of SR50	93.33	93.23	6	6	Circular	
	CMP Pipe at north of SR50	94.50	94.40	3.5	3.5	Arch	
	Culvert 1 at East Oakland Avenue	92.18	92.65	3.5	3.5	Horizontal Ellipse	
	Culvert 2 at East Oakland Avenue	92.93	93.05	3	3	Circular	
	Dual pipe at West Orange Trail	90.14	89.63	4	4	Circular	
CDM (2021)	Dual box culverts at Avalon Drive	89.15/89.2*	89.73/89.7*	5	9	Rectangular	Slightly different elevation used
	Box-culvert at Florida's Turnpike	88.30	88.47	10	11	Rectangular	
	Dual RCP Pipe at south of SR50	91.75/91.79*	92.07/92.1*	5	5	Circular	Slightly different elevation used
	Dual box culverts under SR50	85.04/85.05*	85.18/85.2*	10.9167/10.833*	9	Rectangular	Slightly different elevation/diameter used
	CMP Pipe with slide gate at north of SR50	93.41	93.55	5.75/5.5833*	5.75/5.5833*	Circular	Slightly different diameter used
	CMP Pipe at north of SR50	94.71	95.00	3.3333	3.3333	Horizontal Ellipse	
	Culvert 1 at East Oakland Avenue	92.54	92.24	4.75	4.75	Horizontal Ellipse	
	Culvert 2 at East Oakland Avenue	NA	NA	NA	NA	NA	Not modeled
	Dual pipe at West Orange Trail	89.89/90.08	89.32/90.16*	4	4	Circular	Slightly different elevation used

*Upstream/downstream values correspondingly used for the upstream and downstream part of the structures.

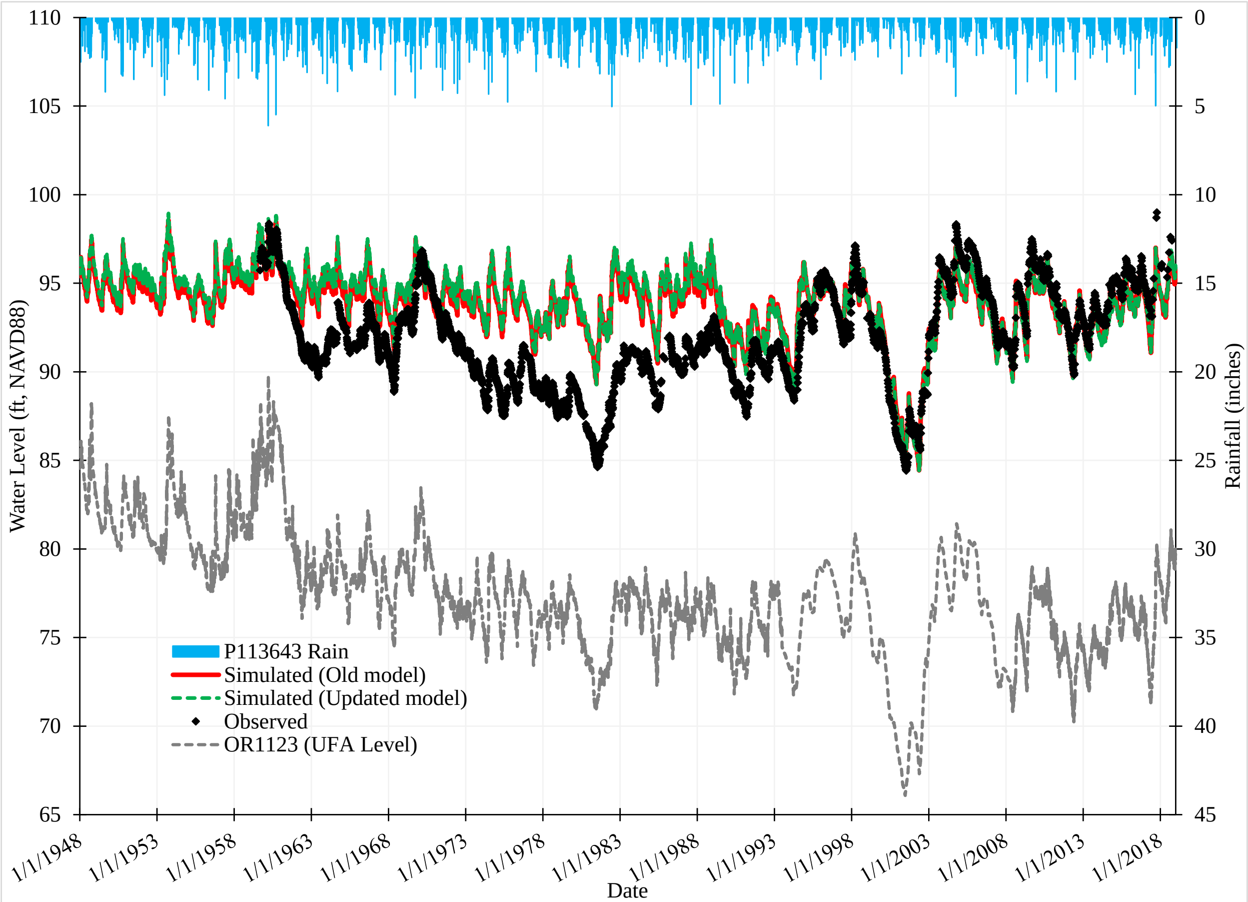

Figure 5. Observed and simulated water levels for Johns Lake before and after updating the model. P113643 represents pixel ID

Table 3. Goodness-of-fit statistics for Johns Lake calibration/validation and long-term simulation periods

Statistics	Symbol	Old model		Updated model	
		Calibration/validation (1995-2018)	Long-term (1948-2018)	Calibration/validation (1995-2018)	Long-term (1948-2018)
Nash-Sutcliffe Efficiency	NSE	0.92	-0.25	0.92	-0.39
Root mean squared error	RMSE	0.96	3.04	0.92	3.19
Mean error	ME	-0.23	2.14	-0.18	2.30
Absolute mean error	AME	0.79	2.47	0.76	2.60
Percent bias	PBIAS	-0.25	2.33	-0.50	2.52
Pearson correlation coefficient	R	0.95	0.61	0.95	0.59
Percent of observation bracketed within ± 1 foot	±1ft (%)	67.91	25.89	69.31	25.66

***Comment #4**. Streamline Technologies (2021) refined a preliminary SJRWMD ICPR4 simulation to generalize several water-control structures, for use in continuous simulation of the hydrologic cycle in Johns Lake. Itemization of water-control structures in the CDM, Collective, Streamline,* *and SJRWMD simulations will also appropriately document and relate generalized dimensions and elevations with the relevant structure, in the actual physical system.*

Response #4: Please see Table 2 of Response #3. This table summarizes the existing water structures from Black Lake to Johns Lake outfall until West Orange Trail and corresponding data. The table is included in the revised version of the model summary report. It should be noted that SLT and SJRWMD basically used the same data, except the large box culverts at Florida's Turnpike and SR50, which were eliminated from the model by SLT (2021) as these structures experience insignificant losses due to other constrictions in the system and to speed up the computation time.

Comment #5. *CDM (2021) included a permit review. SJRWMD may wish to ensure that the simulation details changes to the hydrologic and overland flow system that may have occurred since the Collective Water Resources (2019) simulation. For example, a residential development is presently being constructed near West Orange Trail (appendix photograph17). New water control structures (photograph14, photograph 15, and photograph16) may have been constructed, to drain storm water from this new development into the Johns Lake overland flow domain. SJRWMD may wish to review CDM (2021) and other documents to ensure that new water control structures are incorporated, as appropriate, into the SJRWMD ICPR4 simulation. If new water control structures do not appreciably affect Johns Lake levels, SJRWMD may wish to justify this in a report that describes the simulation.*

Response #5: CDM (2021) intensively reviewed SJRWMD's land use/land cover (LULC) 2014 data and compared with the 2019 aerial imagery. Although CDM (2021) reported some new developments were not reflected in the SJRWMD's LULC 2014 map, their report documented that the LULC 2014 data is generally appropriate for hydrologic modeling purpose of Johns watershed system. In addition, CWR (2019) updated the 2014 LULC map of SJRWMD based on the 2017 aerial imagery, especially for new developments covering ≥ 10 acres. Given CDM (2021) concluded the general appropriateness of the SJRWMD's LULC2014 data and CWR (2019) already updated the 2014 LULC data of SJRWMD, we believe that utilizing the updated LULC of 2014 data based on the 2019 aerial imagery would not expect to appreciably affect the simulated water levels of Johns Lake. Furthermore, we updated the Johns outfall structures until West Orange Trail and matched the structural properties based on the ICPR4 model of CDM (2021). Regarding the new water control structures, Johns Lake water level was not sensitive to the control structure located just downstream of the West Colonial Drive (WCD). The lake was rather sensitive to the weir link representing a paved channel between the WCD and water control structure (Figure 6). For example, changing the assumed weir opening position from two-third to full of the pipe dimension had no effects on the simulated water levels of Johns Lake while lowering the weir link invert elevation by 0.5 feet would generally cause decrease in simulated water levels of Johns Lake. Given this situation and the new water control structures are far downstream of the WCD structure, we believe that further updating the model with those recently constructed downstream water control structures would not affect the current and long-term simulated water levels of Johns. We added this discussion to the updated model summary report.

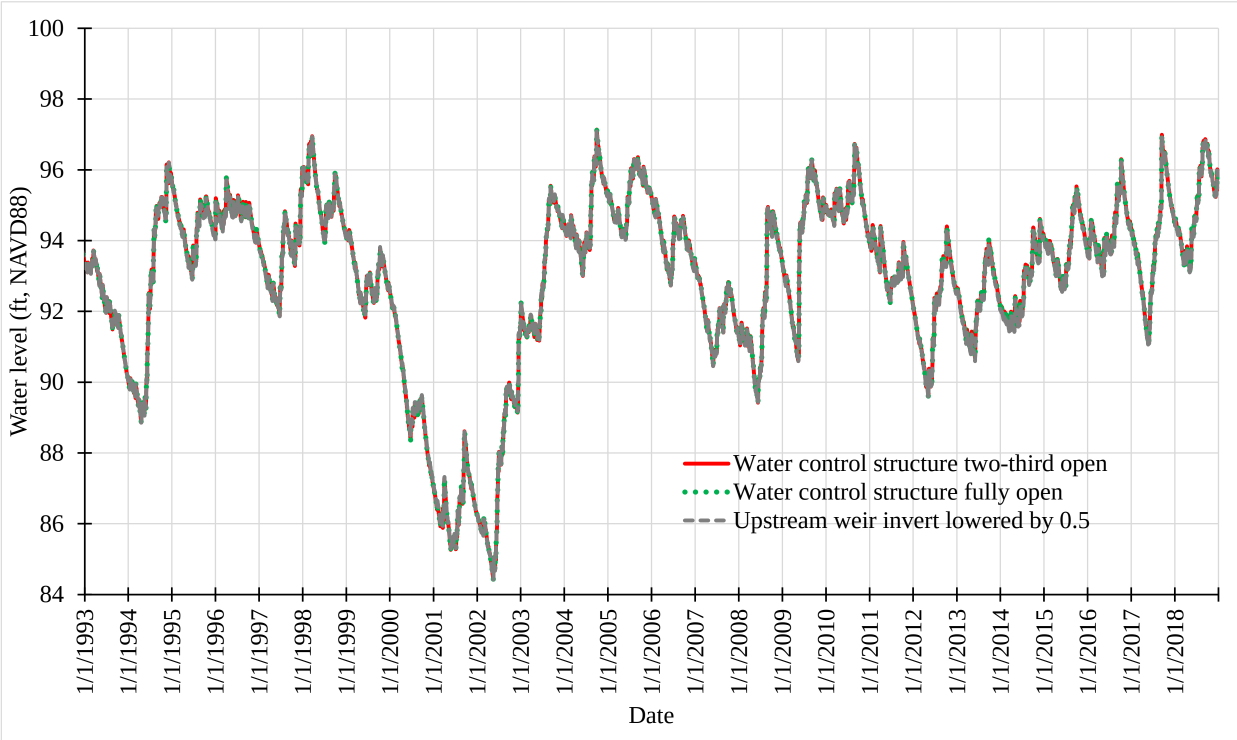

Figure 6. Effect of water control structure and weir link invert elevation on simulated water levels of Johns Lake

***Comment #6**. SJRWMD used available bathymetric lake-bed elevations for Johns Lake and Lake Avalon. SJRWMD did not use bathymetric lake-bed elevations for other lakes, perhaps because these elevations are not available.*

SJRWMD used bathymetric elevations of the Johns Lake bed to best represent the relationship between level and volume in Johns Lake. The major objective of this ICPR4 simulation is to quantify the elevation of a minimum lake level in Johns Lake, necessary to satisfy rule 62.40. Accurate lake-bed elevations in Johns Lake are necessary to best simulate the role of hydrologic, hydrogeologic, and atmospheric forcing on lake level. SJRWMD's use of bathymetric elevations for the Johns Lake bed is critical to this simulation of a minimum Johns Lake levels. This understanding of the change in lake volume as a function of lake level is critical, particularly at relatively low lake levels above, near, and below a proposed minimum lake level.

SJRWMD used bathymetric elevations of the Lake Avalon bed to best represent the stage-volume relationship in Lake Avalon. Although the major objective of this ICPR4 simulation is to quantify a minimum Johns Lake level, necessary to satisfy rule 62.40, the importance of benthic discharge flux to Johns Lake and benthic recharge flux from Johns Lake on lake level requires accurate representation of the hydraulic gradient from Johns Lake to the surficial aquifer, the Floridan aquifer system, and to adjacent lakes. Accurate lake-bed elevation in Lake Avalon is necessary to best simulate the role of hydrologic, hydrogeologic, and atmospheric forcing on lake level in Lake Avalon, and the role of Lake Avalon level on the hydraulic gradient between Johns Lake and Lake Avalon. SJRWMD's use of bathymetric elevations of the Lake Avalon bed is critical to this simulation of a minimum Johns Lake level. This understanding of the change in Lake Avalon volume as a function of lake levels also critical.

Response #6-1: Lake Avalon is a closed system (see Figure 1) and thus expected to have no effect on Johns Lake. The lake was included in the ICPR4 model only for comparison purpose with the SWMM model of CWR (2019). In addition, this lake is not on the priority list of SJRWMD MFLs program. Consequently, this resolution document has not addressed any comments related to Lake Avalon.

SJRWMD did not use bathymetric elevations for Beulah Lake, Black Lake, Luntz Lake, Roberts Lake, Tilden Lake, and Yarbo Lake. Although the major objective of this ICPR4 simulation is to quantify a minimum Johns Lake level, necessary to satisfy rule 62.40, the importance of benthic discharge flux to Johns Lake and benthic recharge flux from Johns Lake on lake level requires accurate representation of the hydraulic gradient from Johns Lake to these other lakes. Lake level in Lake Luntz (fig.8), Lake Roberts (fig.9), and Lake Tilden (fig.10) is not simulated below a minimum elevation for each lake, which is greater than measured lake levels on these lakes. This failure to simulate minimum levels in these lakes is likely due to an absence of stage-volume information below a lake level in the digital elevation model.

SJRWMD may wish to revise the simulation to incorporate lake-bed elevations for other lakes. SJRWMD may choose to measure lake-bed elevation; or SJRWMD may make reasonable assumptions about lake-bed elevations from an assumed maximum lake depth and an assumed lake bed geometry, and to document these reasonable assumptions in the report that describes the simulation. Simulations are abstract representations of more complex systems. Although crude, some hydrologists will accept an assumed maximum lake depth and assumed lake bed geometry as an acceptable, abstract representation.

Response #6-2: since the groundwater generally flows from southwest to northeast direction (e.g., see Appendix – 1, Figure B-11 and Appendix – 2, Figure C-2 of the report), the upstream lakes are assumed to have minimal groundwater flow/baseflow contributions to Johns Lake during the dry season. Estimated average depths by CWR (2019) were also already used and included in the stage-area curve relationship of those far upstream lakes. In addition, simulated water levels for Black Lake, Lake Tilden, and Lake Beulah showed reasonable agreement with observations (see Figure 2, Figure 3, and Response #10, Figure 7, respectively), and Johns Lake levels were not sensitive to inflows from the southeast lakes such as Lake Luntz, Reaves, and Roberts (see Figure 4). Therefore, updating bathymetric data for those upstream lakes was not considered.

***Comment #7**. John Schmidt, President, Johns Lake Association, asked in the April 6 teleconference whether SJRWMD simulated the water control structure near West Colonial Drive (photograph 7, photograph 8, photograph 9), and the influence of this water-control structure on flow from the Johns Lake watershed to Lake Apopka. Leta and others (2021) state that "larger discrepancy between the long-term observed and simulated stages is noticed before 1993, a period when significant urbanization had not occurred or considered as a pre-development period. The decrease in model performance during this period could be due to additional uncertainties attributed by … significant land use/land cover developments of the watershed." SJRWMD simulated contemporary land use. SJRWMD also simulated structure elevations and structure geometry for a water control structure near West Colonial Drive (photograph 7, photograph 8, photograph 9), which controls the flow of water from Johns Lake to Lake Apopka; and channel roughness near this water control structure (photograph 8, photograph 12, and photograph 19).*

SJRWMD may choose to revise the simulation to incorporate transient land use based on available historical aerial photographs. The University of Florida manages an archive of aerial photographs that detail Johns Lake and surrounding areas, with photographic mosaics from 1941, 1947, 1954, 1958, and 1974. SJRWMD maintain GIS shapefiles for land use in 1973, 1984, 1990, 1994, 1999, 2004, 2009, and 2014.

To improve the match between measured and simulated lake level by simulating transient hydraulic conditions, SJRWMD may also choose to perform additional research into changes in elevations and geometry for the West Colonial Drive water control structure, changes in channel roughness, and changes in water control structure operation.

Response #7: The current ICPR4 model version does not have the capability to simultaneously use transient LULC maps unless several models are constructed and individually calibrated and validated to different LULC maps. More importantly, we will use the model for calculating changes in lake levels due to pumping and apply those values to the long-term observed water levels for MFLs assessment. Thus, the use of transient LULC data was not considered. Regarding water control structure, as mentioned in Response #5, we found that Johns Lake was not sensitive to the water control structures downstream of WCD, indicating changing the operation and geometry of the weir would most likely not have significant effect on the simulated lake levels of Johns (see Figure 6). Scenario analyses on water control structure's operation, geometry, and downstream channel roughness values are also beyond the scope of this project.

Comment #8. *Assumptions: A simulation is an abstract representation of a more complex system. Simulations typically require assumptions that result in tractable solutions, but introduce abstractions. To simulate Johns Lake levels, SJRWMD made several assumptions. For example, SJRWMD assumed piecewise homogeneity in a groundwater simulation that defines the Floridan aquifer system boundary condition. Leta and others (2021) did not systematically identify or justify assumptions. Because assumptions are not systematically identified and justified, reviewers of this simulation and the supporting document are challenged to methodically consider each assumption. SJRWMD may wish to revise the document that describes the simulation to systematically identify each assumption, and to explicitly justify each assumption.*

Response #8: we created spatially varied average offset values map from May and September potentiometric maps of 1978 to 2017 and then added those values to observed time series well data to move up and down the locally observed well data and consider spatial variability. Although the method did not consider temporal offset values due to limited data, such approach gives more weight to the observed well data over the spatially interpolated May/September potentiometric maps from sparsely scattered well data, and thus reduces uncertainty introduced from the spatially interpolated potentiometric maps. Additionally, while using the temporally varied spatial maps (if monthly maps available) is possible, that would also significantly increase the memory usage of the model and computational demand, especially for the long-term MFLs simulations. For example, based on our experience with the ICPR4 model of Clermont Chain of Lakes developed by Jones and Edmunds Associates (JEA) (2020), using the spatially interpolated May/September potentiometric maps, and superimposing with bi-weekly offset values doubled the computation demands and memory usage. The simple and robust approach used in the ICPR4 model of Johns Lake produced comparable results and simultaneously reduced the computation time/memory uses. Therefore, we believe that our approach used for Johns Lake works well and saves reasonable amount of computation time. We revised the report document and clarified this, including the other assumptions.

Comments #9. *John Schmidt, President, Johns Lake Association, asked in the April 6 teleconference whether SJRWMD considered changes in benthic sediments in Johns Lake and Lake Avalon. Leta and others (2021) stated that "the relationship between [Johns Lake]and [groundwater]stages might have changed overtime." Leta and others (2021) also stated that "sediment and nutrients loadings to the lake might have increased and caused [bed]compaction during the post-development period. This could have altered the leakance value of the lake between the pre-and post-development conditions. Since we assumed constant leakance value, which we derived based on the post-development conditions, it is possible that the pre-development leakance value would be higher than the calibrated leakance value." Leta and others (2021) evaluated a relatively greater leakance for the pre-development period prior to about 1993. Specifically, Leta and others (2021) stated "we further increased the calibrated leakance value of Johns Lake by 50%, a value proposed by [Streamline Technologies] (2021), and evaluated its effects on simulated stages of Johns [Lake]. We found that the effect of increased leakance values on pre-development simulated stages is relatively low as compared to the effects of land use and land cover change and adjusted groundwater stages." Leta and others (2021) acknowledge transience in land use and leakance, between the period before about 1993 and the period after 1993. If SJRWMD choose to simulate the physical system that existed prior to 1993, SJRWMD may wish to simulate transient leakance and transient land use (as suggested in comment7). Note that this recommendation and the recommendation in comment26 are mutually exclusive, such that SJRWMD may choose to follow either this recommendation or the recommendation in comment26, recognizing that it will not be possible to conform to both recommendations.*

Response #9: please see Response #7. As stated there, although not impossible, the use of transient LULC and parameter values is practically very difficult to be implemented in the current version of ICPR4 model. Most importantly, as discussed in Leta and others (2021) (see "LONG-TERM SIMULATION" section), instead of directly using the simulated lake levels – the MFLs analysis may use the long-term observed lake levels adjusted with time series differences (delta values). The latter values can be easily derived from time series simulated historical and MFLs scenarios lake levels. This method would reduce uncertainty introduced from lack of incorporating pre-development LULC data and related parameter values information into the model, including rainfall uncertainty.

Comment #10. *SJRWMD include measured lake levels in the ICPR4 simulation as time-stage nodes for the following lakes (fig.3): Lake Avalon (fig.4), Lake Beulah (fig.5), Black Lake (fig.6), Johns Lake (fig.7), Lake Luntz (fig.8), Lake Roberts (fig.9), and Lake Tilden (fig.10). SJRWMD used measured lake levels in Johns Lake for calibration and validation, and described this calibration in the associated report (Leta and others, 2021). SJRWMD also used measured lake levels in Lake Avalon (appendix 2 of Leta and others, 2021). Leta and others (2021) calculate calibration statistics for both Johns Lake and Lake Avalon (Leta and others, 2021 and appendix 2 of Leta and others, 2021). Leta and others (2021) did not describe calibration using measured lake levels for Lake Beulah, Black Lake, Lake Luntz, Lake Roberts, or Lake Tilden. Leta and others (2021) did not calculate calibration statistics for these other lakes. SJRWMD may wish to describe calibration or validation of the simulation to these other measured lake levels, including calculation of calibration statistics. Although calibration and validation of the simulation to these* *other lake levels may not ultimately result in significant changes to the probability distribution of simulated Johns Lake levels, the only genuine method to prove this may be to calibrate the simulation to measured levels in these other lakes and calculate calibration statistics for these other lakes.*

Response #10: please see Response #1 regarding the model goodness-of-fit statistics. Since the model already adequately matched the observed levels of Black Lake except for the observed outlier of 7/7/2000 (Figure 8) and Lake Tilden (Figure 3), we did not make further improvements for these two lakes. It should be noted that in the Figure 5 of ATM (2022), observed water levels of Lake Tilden were compared to simulated values from a node called "N-Tilden_100" in the model. This node represents an upland wetland area in the northeast of Lake Tilden (Figure 1). Instead, the observed data should have been compared with simulated water levels from the 1D node interface named "N-Tilden_000" in the model. If node N-Tilden_000 outputs were used, the model adequately reproduced the observed water levels of Lake Tilden (see Figure 3 and Figure 12). We improved the observed and simulated water levels match for the Lake Beulah, which contributes to the major inflows to the Black Lake, by increasing the leakance value of the lake (Figure 7). Overall, the statistical values for Lake Beulah improved after model update (Table 4), but Nash-Sutcliffe Efficiency (NSE) values are still negative due to its sensitivity to measured water levels that seem to be outliers. For Lake Luntz, it looks like there is an upward shift in elevation datum of the gauge especially after 1984 that seems difficult to match for the entire period of record (POR). However, the simulated water levels of Lake Yarbo, which accounts for the majority of total inflows (when combined with inflows from Lake Roberts & Luntz) to Lake Tilden, reasonably matched the observed data for that period (Figure 10). Regarding Lake Roberts, a wrong conversion value was inadvertently used while converting the depth values populated in the SWMM model of CWR (2019) to water level values included in the ICPR4 model. Addressing that issue resulted in reasonable match of simulated water levels with observed water levels especially since 2002 (Figure 11). Like Lake Luntz, the model overestimated the observed low water levels of Lake Roberts. For this lake, the quality of observed data is questionable as it shows a mix of shift in elevation datum and outliers for example in 1995 and 2004 (Figure 11). In general, due to reasonable agreements of simulated and observed water levels temporal variations and acceptable statistical values at Johns, Black, Tilden, and Beulah Lakes, we conclude that performing additional calibration and/or validation process for the upstream southeast lakes would not significantly improve the simulated water levels of Johns and thus provide more fruitful results.

Table 4. Goodness-of-fit statistics for the old and updated models of Lake Beulah

Statistics	Symbol	Old model		Updated model	
		Calibration/validation (1995-2018)	Long-term (1948-2018)	Calibration/validation (1995-2018)	Long-term (1948-2018)
Nash-Sutcliffe Efficiency	NSE	-2.13	-2.67	-1.65	-1.63
Root mean squared error	RMSE	1.15	1.20	1.00	1.07
Mean error	ME	0.98	1.04	0.68	0.76
Absolute mean error	AME	1.02	1.08	0.83	0.90
Percent bias	PBIAS	1.22	0.97	0.88	0.71
Pearson correlation coefficient	R	0.57	0.55	0.56	0.54
Percent of observation bracketed within ± 1 foot	±1ft (%)	44.74	40.00	61.80	58.47

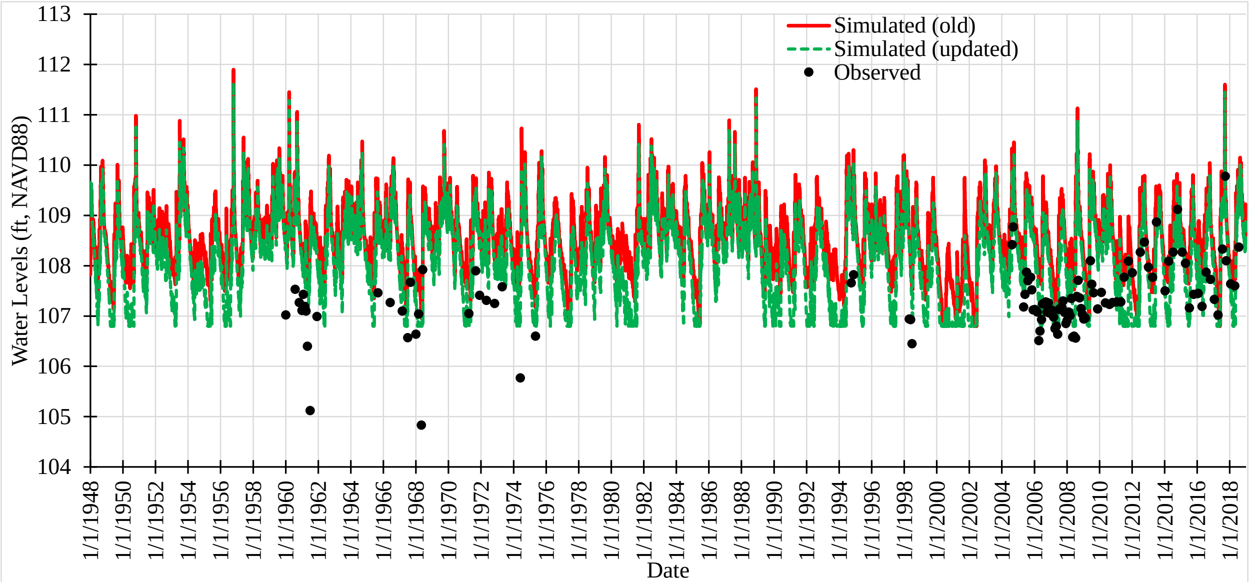

Figure 7. Observed and simulated daily water levels for Lake Beulah

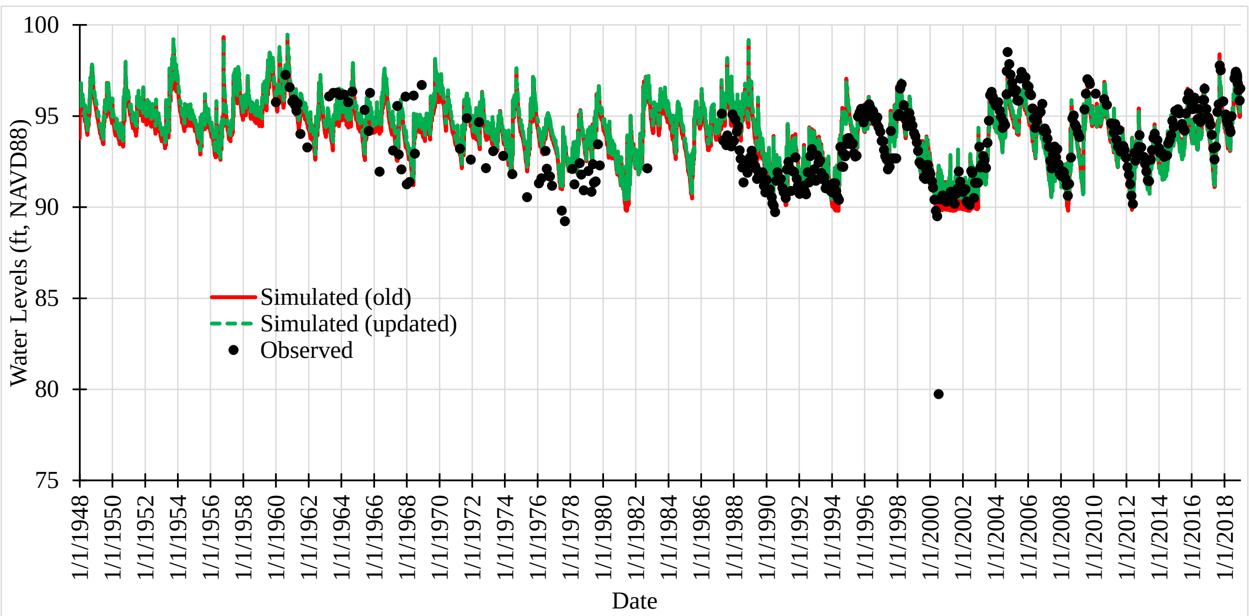

Figure 8. Observed and simulated daily water levels for Black Lake

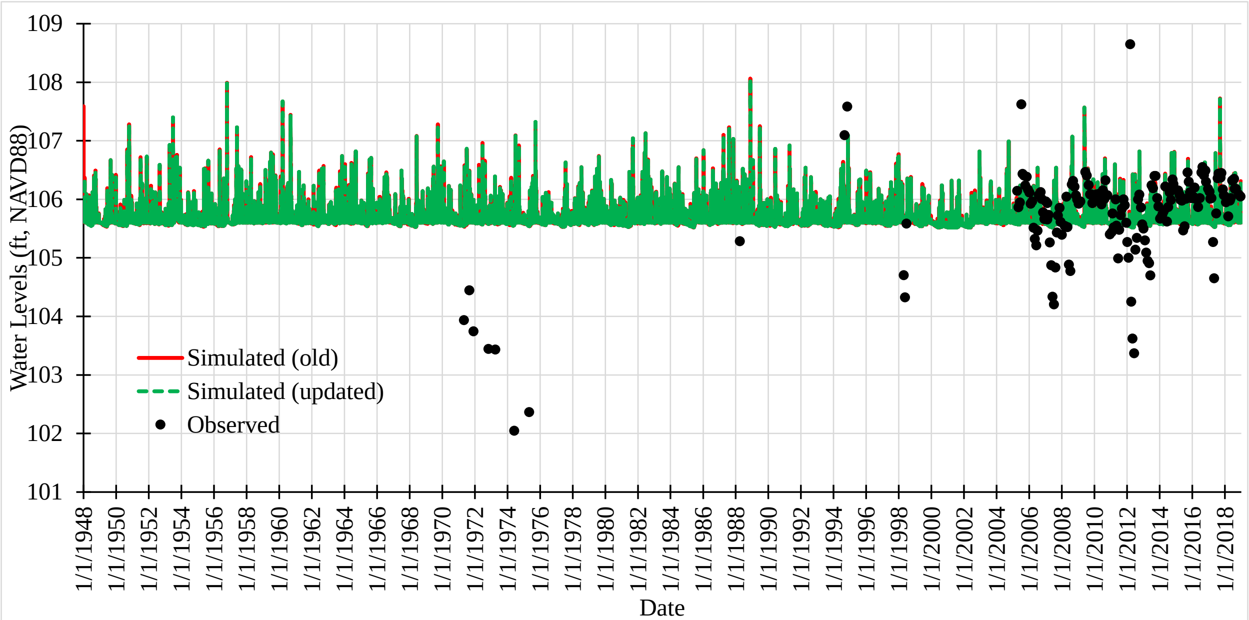

Figure 9. Observed and simulated daily water levels for Lake Luntz

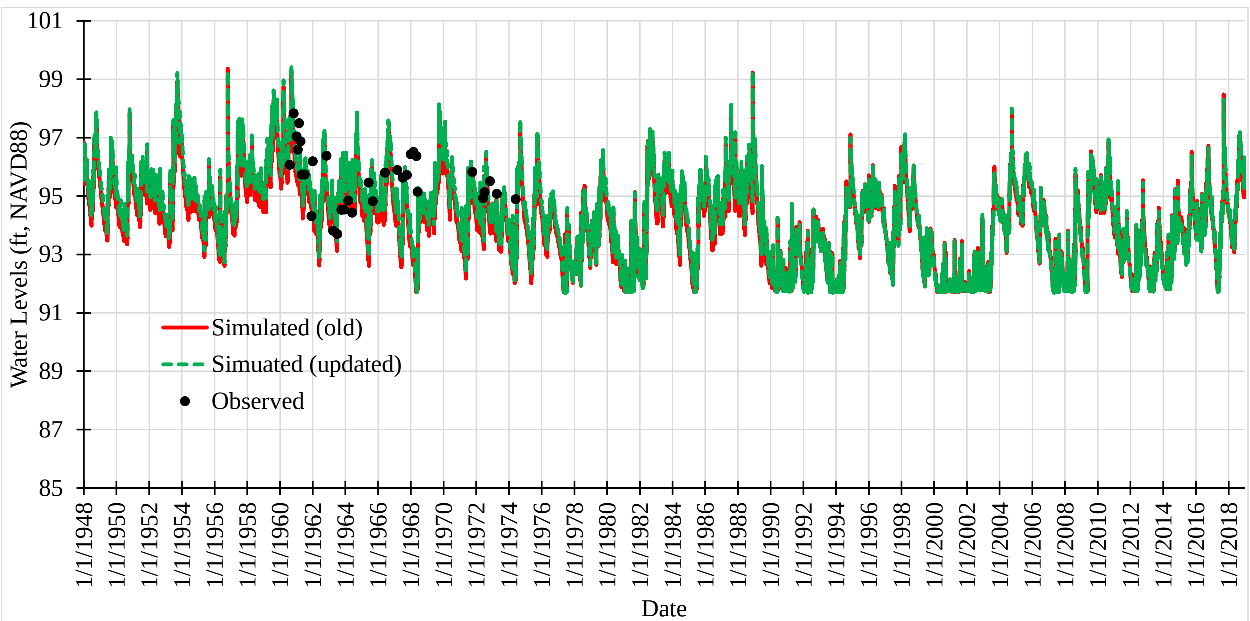

Figure 10. Observed and simulated daily water levels for Lake Yarbo

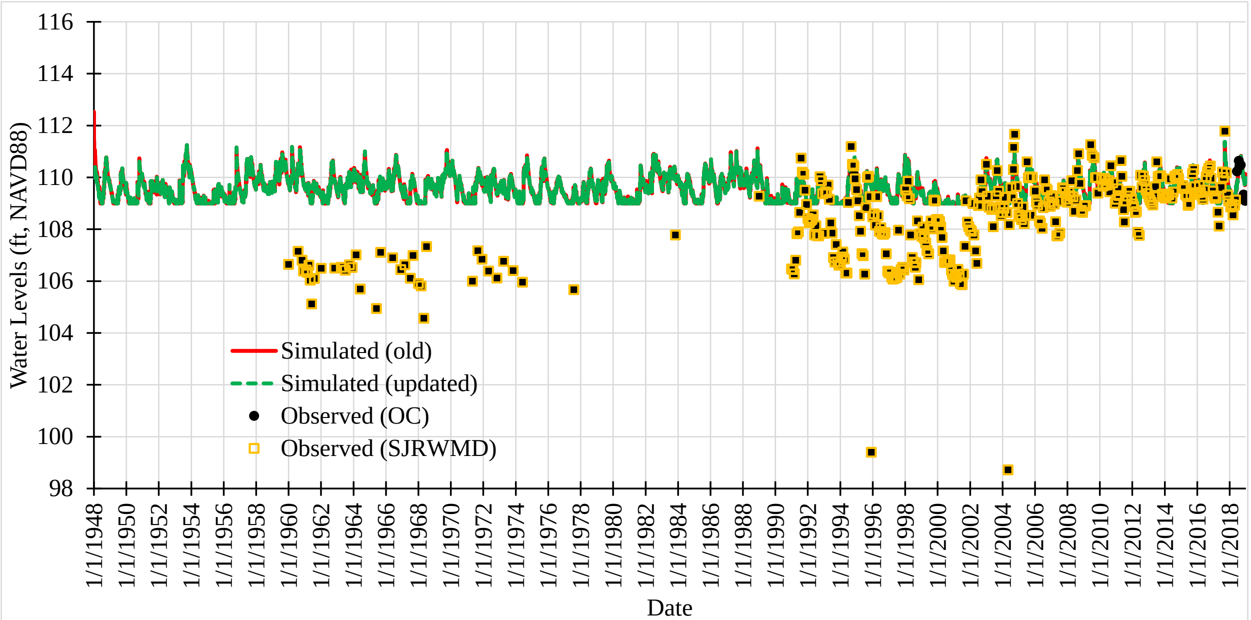

Figure 11. Observed and simulated daily water levels for Lake Roberts. OC: Orange County

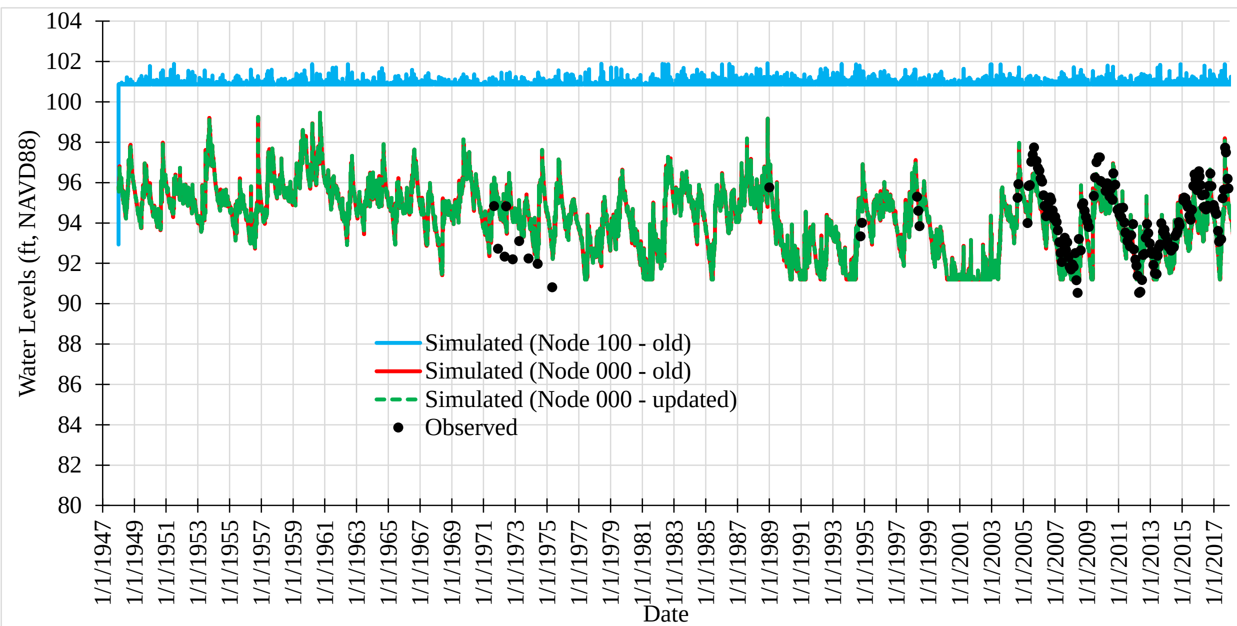

Figure 12. Observed and simulated daily water levels for Lake Tilden (Node 000)

***Comment #11**. SJRWMD included measured lake levels in the ICPR4 simulation as time-stage nodes (plotted on Figure 4 through Figure 10 as blue polylines). Liquid Solutions Group—as consultants to Orange County Stormwater Management Division—provided SJRWMD with measured lake levels following the April 6, 2022, public teleconference (also plotted on Figure 4 through Figure 10, as orange points). SJRWMD time-stage lake levels appear to match Liquid Solutions Group lake levels for all lakes, except Lake Roberts. SJRWMD may wish to determine which set of Lake Roberts levels are correct.*

Response #11: as mentioned in Response #10, we inadvertently used a wrong conversion factor to change observed water depth time series (used in the SWMM model) to water level time series that used in the ICPR4 model. The corrected data from SJRWMD also appeared to match the data from Orange County (see Figure 11).

Comment #12. *When calculating calibration statistics, SJRWMD should include differences between simulated lake level and measured lake level at coincident times. SJRWMD should either not include differences between simulated lake level and interpolated lake level at intermediate times between measured lake levels; or SJRWMD should discuss and explicitly justify use of differences between simulated lake level and interpolated lake level at intermediate times between measured lake levels, in calibration statistics.*

Response #12: it should be noted that we populated the non-continuous (sporadic) observed water levels data into the ICPR4 model only for visualization and comparison purposes, performed during model calibration, validation, and long-term simulation processes. ICPR4 internally interpolates missing values between two observed points and plots the interpolated time series values, but we did not use the interpolated values while calculating the model goodness-of-fit statistics. We externally calculated the differences between observed and simulated lake levels only for the coincident times. Therefore, all the reported statistical values in Leta and others (2021) report are only for the coinciding dates.

Comment #13. *Calibration and validation of the simulation to measured lake levels on Lake Avalon, Lake Beulah, Black Lake, Lake Luntz, Lake Roberts, and Lake Tilden (comment 10) will improve the reliability of the simulation. Simulated lake levels do not match measured lake levels on Lake Beulah (fig. 5), Lake Luntz (fig. 8), Lake Roberts (fig. 9), or Lake Tilden (fig. 10). The simulation will be more reliable if simulated lake levels match measured lake levels on these lakes. The simulation will also be a more reliable predictor of the effect of Floridan aquifer system pumping and climate change on lake level if the simulation is capable of matching measured lake levels on these lakes. Although calibration and validation of the simulation to these other lake levels may not ultimately result in significant changes to the probability distribution of simulated Johns Lake levels, the only genuine method to prove this may be to calibrate the simulation to measured levels in these other lakes and calculate calibration statistics for these other lakes.*

Response #13: please see Responses #1 and 10.

Comment #14. *Leakance is the quotient of hydraulic conductivity and hydrogeologic unit thickness. Leakance parameterizes the flow of water between a lake and an underlying hydrogeologic unit or aquifer system. More water flows through a hydrogeologic unit with a relatively greater leakance than through a unit with a relatively lesser leakance, forced by the same hydraulic gradient. Leta and others (2021) assert that Johns Lake level is most sensitive to leakance between Johns Lake and the Floridan aquifer system than other parameters: Leta and others (2021) stated that leakance is the "most important parameter" in the simulation. Leta and others (2021) also assert that Johns Lake level is sensitive to hydraulic conductivity of the surficial aquifer system. Hydraulic conductivity is the ratio of groundwater flow to the hydraulic gradient that forces the flow. The hydraulic gradient between Johns Lake and surrounding lakes forces groundwater flow to or from Johns Lake. Given the sensitivity of Johns Lake level to groundwater flow to and from the lake, SJRWMD may wish to accurately simulate hydraulic gradients to and from Johns Lake (comment 10 and comment 11), which are both a function of Floridan aquifer* *system potentiometric-surface elevation and lake level in lakes near Johns Lake. SJRWMD may wish to improve the accuracy of hydraulic gradient simulation by refining the simulation to decrease the difference between simulated and measured lake level in Lake Beulah, Lake Luntz, Lake Roberts, and Lake Tilden. Although calibration and validation of the simulation to these other lake levels may not ultimately result in significant changes to the probability distribution of simulated Johns Lake levels, the only genuine method to prove this may be to calibrate the simulation to measured levels in these other lakes and calculate calibration statistics for these other lakes.*

Response #14: please see Responses #1, 10, & 11.

Comment #15. *Datum: Leta and others (2021) reference the North American Vertical Datum of 1988 (NAVD88) eight times. Although all elevations input into the simulation appear to be relative to NAVD88, SJRWMD does not explicitly state a datum reference for all elevation citations. SJRWMD may improve simulation input files and simulation documents by explicitly citing NAVD88 throughout input files and documents; or by explicitly citing a different datum, if relevant.*

Response #15: as the reviewer noted, we used the North American Vertical Datum of 1988 (NAVD88) reference. This was further clarified in the updated model summary report.

Comment #16. *SRWMD may wish to document surveyor, survey dates, publication dates, survey methods, survey owner, resolution, and other relevant metadata for specific, important simulation inputs, including but not limited to the NRCS soils survey, the digital elevation model, bathymetric elevations, and structural dimensions and elevations of water control structures, such as culverts and drop structures.*

Response #16: We updated the model summary report with relevant information.

Comment #17. *Simulation parameters: SJRWMD used ICPR4 weir cross sections to define weir length and weir geometry by extracting weir station and weir elevation from a digital elevation model, along a defined cross section. The following weir cross sections may not be extended a sufficient width to fully enclose the water surface: C-Black_800, C-Black_510B, C-Yarbo_020B, C-Clarice_000, and C-Luntz-000C. This list of weirs is not an exhaustive list of all the weirs where this may occur. This list details a few examples where this may occur. SJRWMD may wish to ensure that all weir cross sections fully enclose the water surface during weir flow. SJRWMD may wish to extend cross sections that do not fully enclose weir flow. This comment relates to weir geometry. I did not determine whether these weirs flow or do not flow, or whether correction of weir length will change simulation results.*

A simulation is an abstract representation of a more complex system. Streamline Technologies (2021) abstractly represented some pipes as weirs, to accelerate run time during the continuous simulation of the hydrologic cycle. This is a useful strategy. In the present comment, I refer to traditional, broad-crested weirs, in which water flows over a landform defined by a topographic ridge, where incipient weir flow occurs at the minimum topographic elevation across the ridge. In the present comment, I do not refer the abstract representation of water control structures—such as culverts—as weirs, in which the weir geometry does not conform to a landform defined by a topographic ridge, but conforms to a structural geometry, such as a circular cross-section, through which water begins to flow at some governing, invert elevation.

Response #17: We double checked, updated (when necessary), and ensured the full enclosure of all weirs cross-sections implemented in the model. These updates showed minor impacts on simulated water levels of Johns Lake (see Response #3).

***Comment #18**. Simulation parameters: SRWMD used ICPR4 weir cross sections to define weir length and weir geometry. Weir elevations along the defined weir alignment may have been automatically sampled from the DEM by ICPR4. If the weir alignment is not along the crest of the weir, but along an offset alignment parallel to the crest, weir elevations and weir geometry may not accurately reflect the crest, and the weir may transmit water at an incorrect, lower elevation. Mis-aligned weir cross sections may exist at the following weir cross sections: C-Black_800, C-Black_1130E, C-Yarboi_020B, C-Black_140B, C-Clarice_000, C-Luntz_000C. This list of weirs is not an exhaustive list of all the weirs where this may occur. This list details a few examples where this may occur. This comment relates to weir geometry. I did not determine whether these weirs transmit flow or whether correction of possible alignment deficiencies will change simulation results; SJRWMD may wish to systematically make this determination with respect to all weir cross sections.*

For example, the western side of weir C-Black_800 may sample a raster cell along the basin boundary that is lower than the physical weir divide. The governing weir section may conform to a ridge that is a few feet southeast of the basin boundary. Mis-aligned weir cross sections that sample lower elevations can result in simulated weir flow when weir flow will not occur in the physical system, because the DEM is not sampled along the true ridge. SJRWMD may wish to re-orient weir cross-section geometry to conform to the ridge, paying attention to relatively small spatial scales that may exist between two pixels, or at a near-pixel scale. Conformance of basin boundary delineation to weir-cross section delineation is not generally necessary, because simulation components that rely on basin boundaries may not be critically sensitive to near-pixel-scale alignment.

Streamline Technologies (2021) abstractly represented some pipes as weirs, to accelerate run time during the continuous simulation of the hydrologic cycle. In the present comment, I refer to traditional, broad-crested weirs, in which water flows over a landform defined by a topographic ridge, where incipient weir flow occurs at the minimum topographic elevation across the ridge. In the present comment, I do not refer the abstract representation of water control structures—such as culverts—as weirs, in which the weir geometry does not conform to a landform defined by a topographic ridge, but conforms to a structural geometry, such as a circular cross-section, through which water begins to flow at some governing, invert elevation.

Response #18: while we made some alignments and extensions to the following weirs mentioned in the above comment, we did not make any changes to the above-mentioned C-Black_1130E & C-Black_140B weirs because both weirs had zero flows for the period 1948 to 2018 as well as very close to the watershed boundary in the east.

- Weir C-Black_800: extended to the left side but has minor impact on weir flows.
- Weir C-Black_510B: extended to the right but did not have any weir flows.
- Weir C-Yarbo_020B: extended but barely flows (only once in 1988).
- Weir C-Clarice_000: extended but did have small flows that happened three times between 1948 and 2018.

- Weir C-Luntz_000C: extended but did have once small flow in 1988 (< 5 cfs) between 1948 and 2018.
- We also checked other weirs and updated as needed.

Overall, updating weirs alignments and cross-sections only had minor impacts on the simulated lake levels (see Figure 5 of Response #3), indicating the model was not sensitive to these alignments.

Comment #19*. Simulation parameters: SJRWMD used a uniform Manning's n friction parameter for channel cross section C-Johns_Out_210. Typically, Manning's n friction parameter is less in the channel than in the overbank. SJRWMD may wish to justify a uniform Manning's n friction parameter for channel cross section C-Johns_Out_210 and for other channel cross sections where friction is simulated as uniform; or simulate channel friction with zones that reflect non-uniform frictional resistance across each channel, based on field measurements and observation.*

Response #19: we addressed this comment by utilizing different Manning's values for overbanks and channels for the above-mentioned channel, and consistently checked the remaining channels used in the model. We assigned Manning's values for C-Johns_Out_210 and others based on the values used in the SWMM model of CWR (2019).

Comment #20. Simulation parameters: SJRWMD used a uniform channel cross section for channels C-Black_920 and C-Black_930, such that the upstream channel cross section is identical to the downstream channel cross section. Inspection of the DEM shows that these channel cross sections may not be uniform, along the channel. SJRWMD may wish to revise channel cross section designations throughout the simulation domain to ensure that channels C-Black_920 and C-Black_930, and other channels that exhibit variation in cross section, along the channel, are not simulated by a uniform cross section, along the channel.

Response #20: we revised all channels and used two cross-sections for the upstream and downstream sections of the channels when needed – depending on the length of the channel and topographic variations. For example, we changed from one cross-section to two cross-sections for the channels C-Black_920, C-Black_930, C-Johns_Out_050, C-Johns_Out_090, and C-Black_220. We also changed the geometry of C-Black_220, C-Roper_100 and C-Yarbo_120 channels from trapezoidal to irregular. However, such changes only had negligible impacts on the simulated water levels of Johns (see Figure 5).

Comment #21*. Simulation parameters: SJRWMD do not use exit loss or entrance loss coefficients for some channels. SJRWMD may wish to use exit loss and entrance loss coefficients for channels, where appropriate. For example, where a channel discharges into a lake, exit head loss may occur as flow in the channel decelerates into the lake.*

Response #21: we updated the links contraction, expansion, and exit loss coefficients. For example, we updated the exit loss value for channel C-Johns_Out_010, based on the value used in the ICPR4 model of CDM (2021). We also changed the exit loss coefficients for pipes C-Johns_Out_060A, C-Johns_Out_110A, and C-Johns_Out_110B_110C from 0 to 1.

Comment #22*. Simulation parameters: Collective Water Resources (2019) parameterized water as 100% impervious. SJRWMD changed land cover impervious designations for water from 100% impervious to 0% impervious. SJRWMD may wish to explain whether land cover* *impervious designations should be 100% impervious or 0% impervious, whether land cover imperviousness can be 100% impervious at some locations and 0% impervious at other locations, and to document the consequences of this change.*

Response #22: we are not sure why CWR (2019) used 100% imperviousness value for water to simulate long-term lake levels using the SWMM model. We believe that assigning 100% imperviousness value for water plays a significant role during stormwater (short-term event) modeling. In addition, the imperviousness value of water might not be such important for the SWMM model since area weighted imperviousness values were estimated per sub-basin that included other LULC's imperviousness values. However, individual imperviousness value is very critical for the ICPR4 model as it requires individual values for each LULC types. Most importantly, since ICPR4 physically represents water bodies as pond control volume (PCV) and directly communicates with overland flow and groundwater flow systems, we believe that the use of 100% imperviousness value for water is not appropriate for long-term groundwater-surface water interaction and MFLs modeling.

Comment #23*. Leta and others (2021) stated that "the ICPR4 model showed reasonable simulations of surface water – groundwater interaction processes and stages of Johns Lake, indicating the model can be used for MFLs modeling and scenarios analysis." Leta and others (2021) did not discuss specific scenarios. Florida's water management districts may wish to simulate future conditions precipitation, evaporation, evapotranspiration, potentiometric-surface elevation in the Floridan aquifer system, and other hydrologic fluxes and processes in the development of MFLs, particularly with respect to changes that are occurring in global and regional climate systems, and the influence of these changes on the development of MFLs.*

Response #23: the scenarios mentioned in Leta and others (2021) refer to utilizing the model for simulating lake levels time series under the no-pumping, current-pumping, and historical Upper Floridian Aquifers (UFA) conditions, including deficit/freeboard conditions. This was clarified in the updated model summary report. Regarding the climate change scenario, there are significant uncertainties associated with climate change projections generated from global and regional climate models and propagates into hydrologic models (e.g., see Evin et al, 2021; Senatore, et. al, 2022). Because of this, SJRWMD commonly implement adaptive management strategies including regularly monitoring the MFLs status and conducting additional studies as needed.

Comment #24*. ICPR4 is a closed source model. The source code for ICPR4 is not available for inspection by the general public. The publishers of ICPR4 require that users pay a fee to use ICPR4. Florida's water management districts may wish to consider whether MFLs should be developed with open-source models, to improve transparency and accessibility for the general public.*

Response #24: CWR (2019) originally developed the freely available SWMM model for Johns Lake, but the model has not well performed in simulating the water levels of Johns especially during the validation period. This is most likely due to a simplified representation of groundwater-surface water (GW-SW) interaction by the SWMM model. Johns Lake and wetland areas generally experience strong GW-SW interaction that need to be better represented, which is beyond the capability of the SWMM model. Consequently, we developed ICPR4 that relatively better represents the GW-SW interaction of the system and improved simulated water levels of Johns Lake, especially the low to medium lake levels that are critical for MFLs assessment.

***Comment #25**. Leta and others (2021) stated that "larger discrepancy between the long-term observed and simulated stages is noticed before 1993 … The decrease in model performance during this period could be due to additional uncertainties attributed by lack of long-term observed groundwater and rainfall data within the watershed …" Leta and others (2021) explicitly acknowledge that long-term measured groundwater levels and rainfall depths in the overland flow simulation domain are deficient. SJRWMD attempted to mitigate deficient groundwater levels near Johns Lake by correlating a time series for groundwater level near the lake with a longer-duration time series for groundwater level about ten miles east of the lake; and using this correlation to extend the duration of the groundwater time series near Johns Lake. However, Leta and others (2021) also stated that "additional bias was introduced into the extended data before 1993". SJRWMD may wish to identify the Johns Lake system prior to 1993 as sufficiently different than the contemporary Johns Lake system, such that simulated lake levels prior to 1993 are characterized as not informative of a contemporary water resource valuation. SJRWMD may wish to consider characterizing the Johns Lake simulation, from 1993 to 2018, as sufficient to inform contemporary MFL development, and to justify exclusion of simulation prior to 1993 as not informative of contemporary MFL development. This characterization may require additional analysis, investigation, and justification, beyond the argument that I present here.*

Response #25: please see Responses #7 and 9 for details. Additionally, the long-term historical run using current conditions should not be expected to match observed data under very different historical conditions.

***Comment #26**. SJRWMD may wish to use the 1993 to 2018 simulation of the contemporary Johns Lake hydrologic and hydrogeologic system, to develop a longer-term simulation of the contemporary system, forced by historic precipitation, evapotranspiration, and potentiometric-surface elevations prior to 1993. This simulation of the contemporary system should be parameterized to reflect the contemporary system. SJRWMD may wish to characterize a longer-term simulation as hypothetical, and to use this hypothetical simulation as a representative long-term, contemporary-system simulation for developing a contemporary MFL. SJRWMD may wish to avoid comparing this hypothetical simulation to measured lake levels prior to 1993, since the simulated hydrologic and hydrogeologic system does not represent the system that may have existed over this longer term, prior to 1993.*

Response #26: please see Responses #7, 9, and 25.

***Comment #27**. Long-term simulation results: Leta and others (2021) compared measured and simulated Johns Lake level from 1948 to 2018. Leta and others (2021) calculated simulation statistics that compare the fit between measured and simulated Johns Lake levels and compare the fit between measured and simulated Lake Avalon levels. Leta and others (2021) also possessed lake levels for the following lakes: Lake Beulah, Black Lake, Lake Luntz, Lake Roberts, and Lake Tilden. SJRWMD may wish to compare measured and simulated lake level for these other lakes with plots and calibration statistics.*

Response #27: please see Responses #1 and 10 for details. Overall, the model reasonably represented the observed water levels of Lake Beulah, Black Lake, Lake Tilden, and Lake Yarbo (see Figure 7, Figure 8, Figure 10, and Figure 12, respectively). For Lake Luntz and Roberts, while ICPR4 reasonably matched the observed and simulated water levels for the post-development period, the model consistently overestimated observed water levels of the pre-development period – where vertical datum seems shifted and data quality is questionable. However, the outflows from these lakes showed minimal effect on the simulated water levels of Johns Lake. Therefore, addressing the mismatch for the pre-development period and assessing the calibration statistics of Lake Luntz and Roberts is not necessary to improve the simulated water levels of Johns.

Comment #28. *Long-term lake levels: Measured and simulated Johns Lake levels deviate over the 70-year record, such that differences between measured and simulated levels during a contemporary period—from the late 1990s to 2018—are generally less than differences between measured and simulated levels during an historical period—from 1948 to the late 1990s. SJRWMD provide reasonable explanations as to why the contemporary match is better than the historical match, including transient land use, transient leakance, transient channel conditions, changes in the geometry and operation of the control structure near West Colonial Drive, and poor measurements.*

A plot of simulated levels versus annual exceedance probability does not compare well with a plot of measured levels versus annual exceedance probability, over an undisclosed period of record. The slope is positive of a linear regression of measured Johns Lake levels from 1980 to 2018. The slope is zero of both a linear regression of simulated Johns Lake levels from 1980 to 2018 and a linear regression of measured Upper Floridan aquifer potentiometric-surface elevations from 1980 to 2018. Does this failure to match slopes of regressions of simulated and measured lake level, together with the match between the slopes of simulated lake level and measured Floridan aquifer system potentiometric-surface elevation, suggest that the SJRWMD ICPR4 simulation is not sufficient to investigate lake level change forced by groundwater pumping? Will incorporation of additional lake level measurements from lakes in the southeastern part of the Johns Lake overland flow simulation domain improve matches between measured and simulated lake level, and improve the ability of the simulation to predict lake level changes forced by groundwater pumping?

Response #28: first, as already pointed out in the report of Leta and others (2021), due to lack of long-term observed UFA levels at well OR1123 (located within the watershed and used in the model), we estimated OR1123 UFA levels before 1993 from observed water levels at well OR0047 (located outside the watershed approximately at 8 miles from well OR1123). This was completed by using regression model developed based on the observed well data at OR1123 and OR0047 for the overlapping POR (2010 to 2018). However, the entire POR data of well OR0047 showed weak correlation with the entire POR data of Johns Lake. And the correlation was significantly increased if the datasets were split into pre- and post-1993, highlighting the relationship between the OR0047 and Johns Lake might have been changed over time (see "Groundwater Stages" section of Appendix – 2, for detail). Due to this uncertainty, the estimated data before 1993 should be excluded that also resulted in positive slopes for both simulated and observed lake levels (Figure 13). Consequently, the UFA data before 1993 should not be used in such analysis since that period data likely bears uncertainty and leads to weak interpretation. Second, stable (zero) slopes for both long-term simulated lake and observed UFA levels evidently indicate that the model is sufficiently responding to the forcing boundary of UFA data. Not incorporating pre-development LULC information into the model partly explains the weak relationship and discrepancy between observed and simulated lake levels of pre-1993. This is clearly seen in Figure 13 as the long-term simulated lake levels generally show decreasing trend, whereas the long-term observed lake levels show increasing trends, which probably highlights more urbanization and runoff during the post-development period. As intensively discussed in Responses #1, 10, and 27, improving the match between the observed and simulated lake levels in the southeast part of the watershed would not be expected to potentially improve the larger discrepancy between observed and simulated water levels of Johns Lake for the pre-development conditions. This is because the major inflows to the lake come from the northeast of the watershed, and the model reasonably simulates high-water levels when the upstream lakes primarily contribute inflows to downstream lakes. Therefore, we believe that the model is expected to be reasonably responding to the UFA forced by groundwater pumping. Please also note that the simulated lake levels will not be used in MFL analysis. Instead, changes in lake levels due to groundwater pumping will be calculated using the model simulations and later be used for MFL analysis.

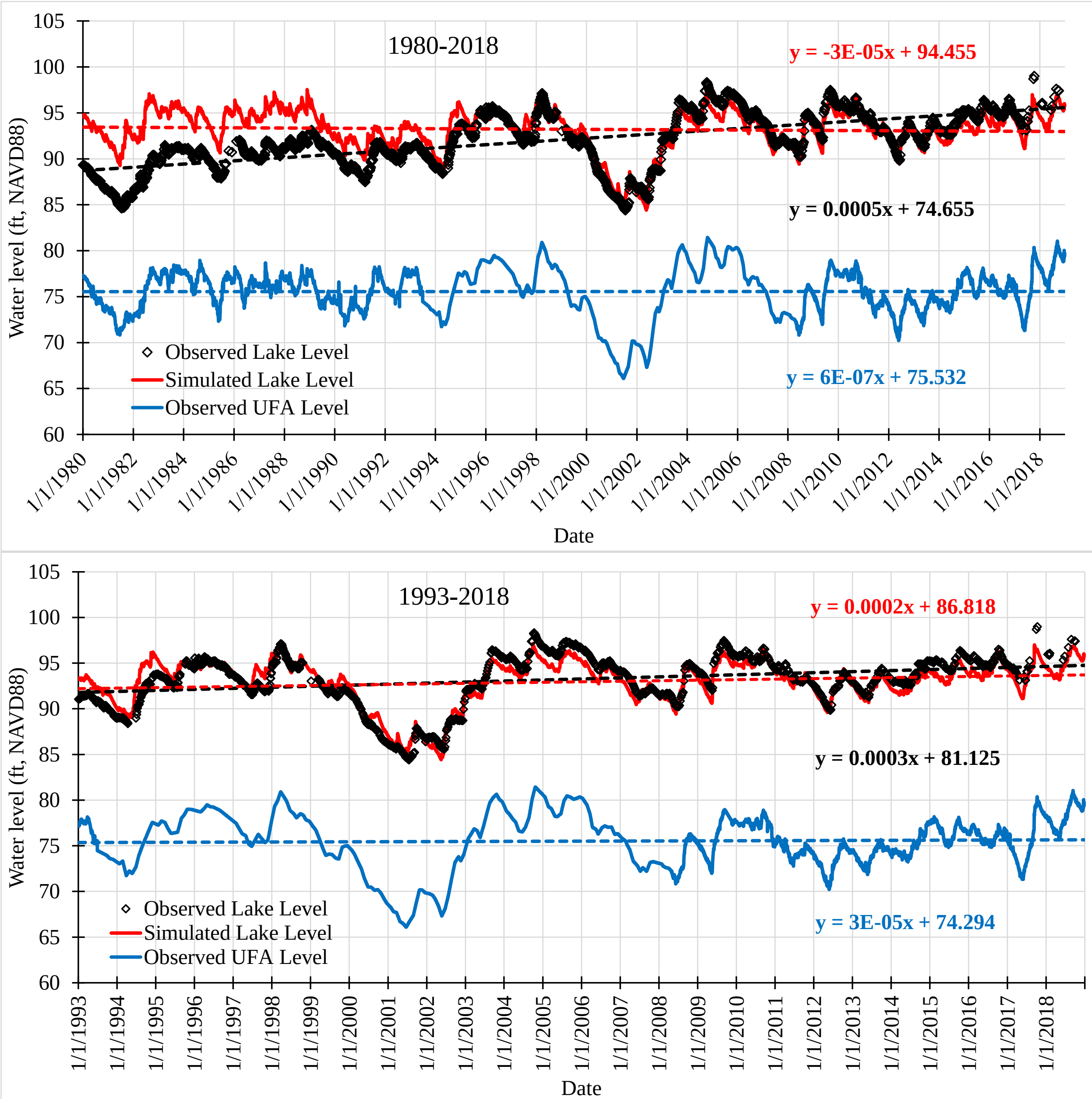

Figure 13. Observed and simulated water levels for Johns Lake along with observed UFA level used as boundary condition. Dash lines represent the corresponding color linear regressions.

Comment #29*. Instabilities: The initial condition in the following links results in relatively greater rates of change for flow than during other periods of the flow time series: C_Johns_000C, C-Black_600, C-Reaves_000 (fig. 11B), C-Johns_Out_140, and C-Johns_Out_170A (fig. 11A). SJRWMD may wish to build a hot start initial condition that does not result in relatively greater rates of change for flow than during other periods of the flow time series, for all links in the simulation. Ideally, a time series for flow should change gradually from an initial condition, for all links in the simulation. SJRWMD may wish to avoid abrupt changes in flow immediately after the simulation commences, throughout the simulation.*

Response #29: to address this issue, we ran the model for the period 2003 to 2018 and then selected date and corresponding simulated results, which are close to the average observed water levels of the system. This approach resolved the initial conditions issue throughout the system (e.g., see Figure 14).

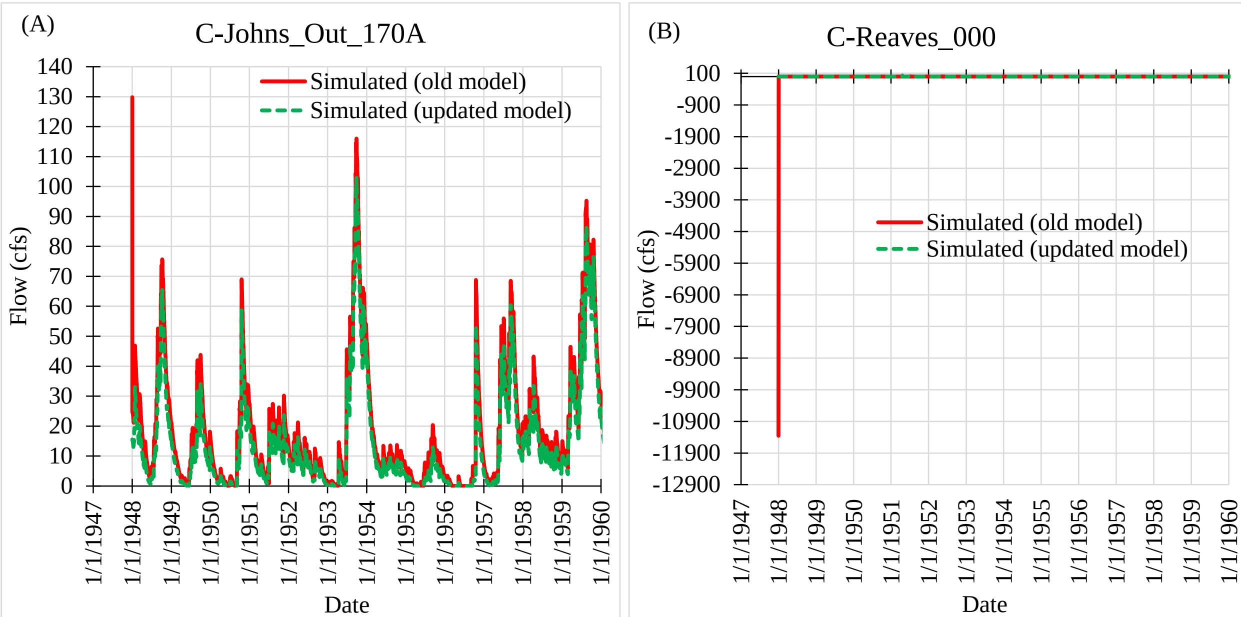

Figure 14. Example of simulated daily flows for (A) link C-Johns_Out_170A and (B) link C-Reaves_000

Comment #30. *Instabilities: The initial conditions for stage at the following nodes results in a relatively greater of water-surface elevation change than during other periods of the stage time series. N-Johns_000_A, N-Tilden_100 (fig. 12). SJRWMD may wish to build a hot start initial condition that does not result in relatively greater rates of water-surface elevation change than during other periods of the flow time series, for all nodes in the simulation. Ideally, the time series for water-surface elevation should change gradually from an initial condition, at all nodes in the simulation. SJRWMD may wish to avoid abrupt changes in water-surface elevation immediately after the simulation commences, throughout the simulation.*

Response #30: please see Response #29 and Figure 15

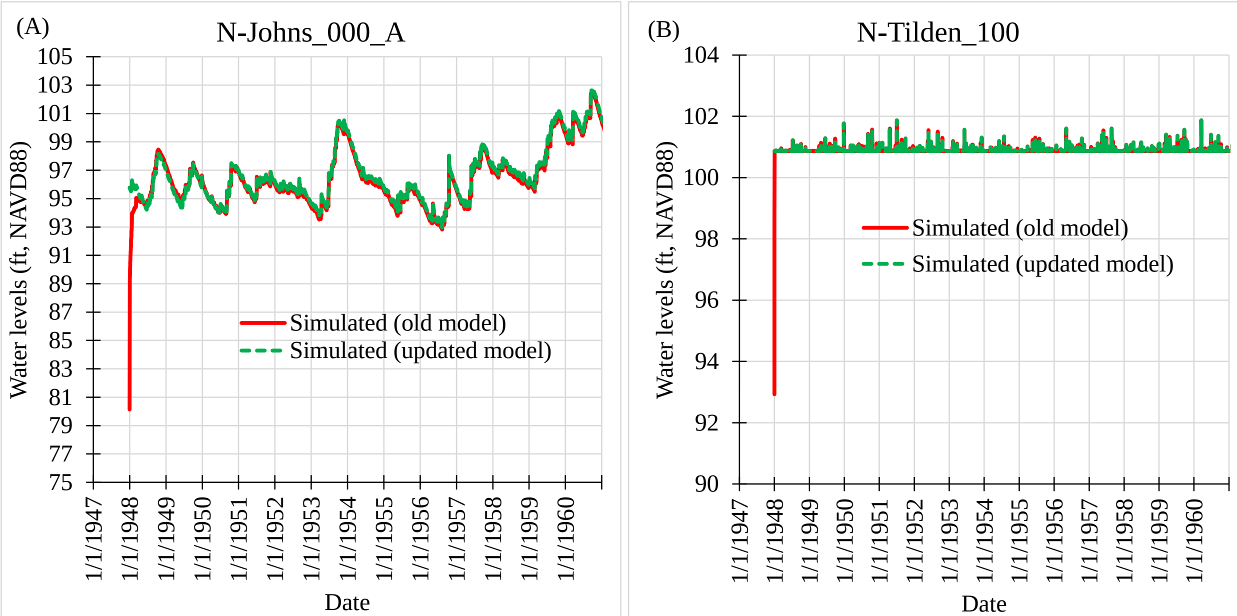

Figure 15. Simulated daily water levels for (A) node N-Johns_000_A and (B) node N-Tilden_100

***Comment #31**. Instabilities: The following links exhibit relatively greater rates of change for flow than during other periods of flow time series; or possibly oscillation, in which flow rate changes rapidly and repeatedly from positive to negative over a relatively short duration: C_Black_020B_C, C_Black_120C (fig. 13), C_Black_710B, C-Black_600, and C-Black_200. SJRWMD may wish to physically justify these changes in flow or oscillatory behavior, or use simulation strategies, such as damping, to diminish these rates of flow change.*

Response #31: Whereas using hot start generally resolved the abruptly changing flows and instability issues especially after simulation commences (e.g., see Figure 14 of Response #29), the kind of changes reported in the above comment normally occur during flashy storms particularly for links used to represent over-topping flows along the roads and mapped-basins' edges. Therefore, adapting simulation strategies such as flow damping threshold would not help. For example, increasing the flow damping threshold from 0.005 to 0.01 had minimal to no effect on the simulated time series flow rates of link C-Black_020B_C, which was used to model over-topping along the road (Figure 16). Such links typically experience sudden jump in flows due to flashy rainfall occurrence (≥ 5 inches per day) as shown in Figure 16.

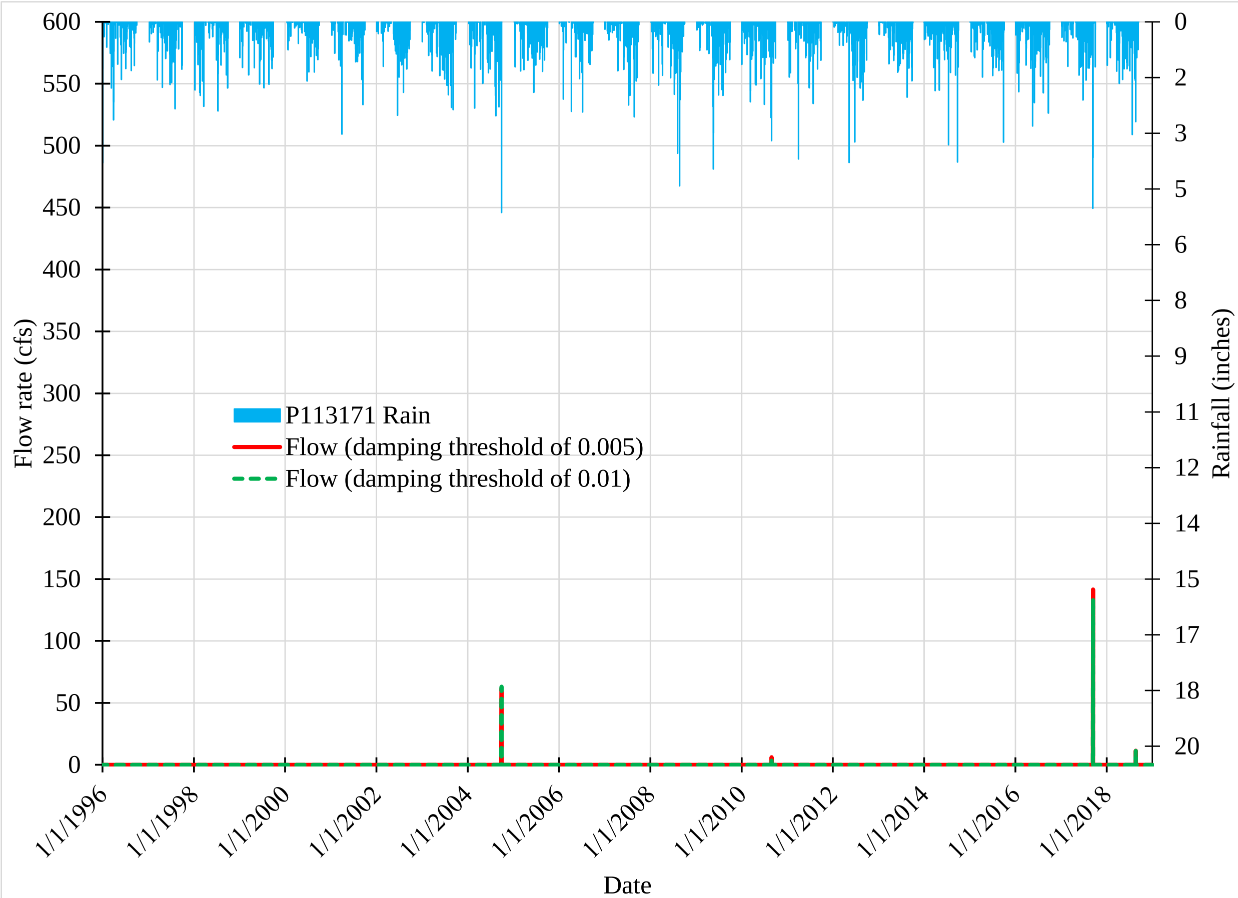

Figure 16. Simulated flow for link C-Black_020B_C with flow damping threshold of 0.005 and 0.01 (both after model update).

Comment #32. *Assumptions and Sensitivity: SJRWMD parameterized several processes that govern the hydrologic cycle. SJRWMD systematically analyzed the sensitivity of the following five key parameters: initial abstraction, crop coefficient, vertical saturated hydraulic conductivity, horizontal saturated hydraulic conductivity, and leakance. SJRWMD assumed parameters, based on standards of practice, literature, other simulations, and similar applications in Florida. SJRWMD systematically investigated the reasonableness of the parameter assumptions by analyzing parameter sensitivity. SJRWMD's sensitivity analyses are generally reasonable. SJRWMD tested sensitivity of selected parameters by increasing or decreasing each parameter with a pre-determined coefficient (table 1). SJRWMD determined that leakance is the most sensitive parameter; however, SJRWMD's determination was not based on a uniform sensitivity change coefficient, for all tested parameters. SJRWMD multiplied leakance by 3, but only increased initial abstraction by 20 percent (equivalent of multiplying initial abstraction by 1.2). does a sensitivity change coefficient of 3 for leakance perturb the simulation in a manner that is equivalent to a sensitivity change coefficient of 1.2 for initial abstraction? SJRWMD's sensitivity analyses may not be as determinative of relative sensitivity function with respect to the change in estimable parameters (Doherty, 2020). SJRWMD may wish to revise the report that describes to acknowledge limitations in sensitivity analyses and limitations in statements related to relative sensitivity of individual parameters.*

Response #32: we did not intend to perform relative sensitivity analysis (SA) to identify/screen the most sensitive parameters for calibration process, but the purpose of running SA was to evaluate if the calibrated values are well identified during the model calibration process and inform the end users where to focus more if further analysis and additional data collections are performed in the future. We set different parameter perturbation values/coefficients depending on available information, knowledge, and possible ranges for each parameter. For example, due to lack of information and limited knowledge on the leakance parameter values of the study area, we applied high perturbation values for this parameter.

References

Applied Technology and Management (ATM) (2022). Johns Lake Minimum Flows and Levels Peer Review Task B4: Final Peer-review Technical Memorandum.

CDM Smith (2021). Phase 1: Johns Lake outfall study and conceptual design: CDM Smith report to the Orange County Public Works Department, Stormwater Management Division, archived at Orange County, Orlando, Florida.

Collective Water Resources (2019). Hydrologic Modeling Services for Lakes Johns and Avalon: Collective Water Resources report.

Doherty, J. (2010). PEST: Model independent parameter estimation user manual (5th ed., with slight additions): Brisbane, Australia, Watermark Numerical Computing, 336 p., accessed July 28, 2015, at http://www.pesthomepage.org/getfiles.php?file=pestman.pdf.

Evin G., Somot S., and Hingray B. (2021). Balanced estimate and uncertainty assessment of European climate change using the large EURO-CORDEX regional climate model ensemble. *Earth Syst. Dynam*., 12, 1543–1569, https://doi.org/10.5194/esd-12-1543-2021.

Jones & Edmunds Associates (2020). Minimum Flows and Levels Program Hydrologic Modeling Services – Clermont Chain of Lakes.

Leta, O.T., Jia. Y., and Jobes. T. (2021). Hydrologic modeling for minimum flows and levels support—Johns Lake. St. Johns River Water Management District report, 104 p., archived at the St. Johns River Water Management District, Palatka, Florida.

Senatore A., Fuoco D., Maiolo M., Mendicino G., Smiatek G., and Kunstmann H. (2022). Evaluating the uncertainty of climate model structure and bias correction on the hydrological impact of projected climate change in a Mediterranean catchment. *Journal of Hydrology: Regional Studies*, 42(2022) 101120, https://doi.org/10.1016/j.ejrh.2022.101120.

Streamline Technologies (2021). ICPR4 Hydrologic Modeling Support for Johns and Avalon Lakes: Streamline Technologies report to the St. Johns River Water Management District, archived at the St. Johns River Water Management District, Palatka, Florida.