August 22, 2016

Response to NFSEG Technical Team Review HSPF Questions and Comments from July 1, 2016: Liquid Solutions Group, LLC

We believe that the recharge and maximum saturated evapotranspiration (MSET) estimates produced by the HSPF models are reasonable considering the intended use of the HSPF models, which is to develop the initial estimates of recharge and MSET for the groundwater model.

The following objective of the HSPF models was highlighted in the NFSEG model conceptualization report, which was approved by the technical team:

"An important objective of the HSPF models is that they be used to narrow and help quantify the expected range of plausible recharge rates over the model domain"

The primary objective of the HSPF models was to minimize the uncertainty in the initial estimates of recharge and MSET and overcome the shortcomings of the previous methods used for developing the initial estimates of recharge and MSET for regional groundwater models.

Recharge and evapotranspiration (ET) account for 70-80% of the water budget in groundwater models. Therefore, they need to be given a special attention to minimize the uncertainty in model predictions. In previous regional groundwater models, recharge was estimated using a simplified approach, which was based on the SCS curve method. Significant concerns about recharge estimates were raised by the stakeholders during the review of Northeast Florida regional groundwater model. Because of this, a more robust method that included the use of HSPF model was proposed and approved by the technical team in the early stage of NFSEG model development. The following major improvements resulted from using HSPF models:

- The estimated recharge from the previous method required significant adjustment during the calibration process. The HSPF-derived recharge minimized the need for adjusting the recharge during the groundwater model calibration. In fact, the NFSEG v1.0 model met calibration criteria approved by the technical team for both 2001 and 2009 hydrologic conditions without adjusting the HSPF-derived recharge estimates.

- The previous method did not include above or underground evapotranspiration processes. Thus, it could not produce MSET estimates. As a result, the MSET dataset was developed using a simple assumption of minimum ET in the previous groundwater models. HSPF is capable of simulating both above and underground ET processes. This capability allowed us to generate MSET estimates using HSPF which did not have to be adjusted during the calibration of NFSEG v1.0.

- The previous method did not have the capability of maintaining a mass balance of surface water processes. Because of this, no calibration was conducted to match the observed river flows. Because HSPF has the ability to fully simulate surface water hydrologic processes, the HSPF models were calibrated to match simulated flows with observed river flows, within the limitations of the available data and HSPF program.

It should also be noted that the NFSEG model is not a coupled surface-groundwater model. There will always be uncertainties associated with recharge and MSET estimates no matter what method is used since no measured data is available for recharge and MSET, especially on a large scale. The primary goal of using HSPF was to reduce those uncertainties in recharge and MSET estimates and minimize the need to adjust the recharge and MSET during the calibration process. We believe the current HSPF models achieved this goal because they produced recharge and MSET estimates within a reasonable range of expected values, and the NFSEG v1.0 met the calibration criteria set by the technical team for both 2001 and 2009 hydrologic conditions without adjusting the recharge and MSET values derived from HSPF models.

We maintain that the quality of recharge and MSET estimates derived from HSPF models should be judged by their performance during groundwater model calibration. NFSEG v1.0 performed very well despite the very ambitious set of calibration targets that were more stringent than previous regional models. The model met the target calibration criteria set by the technical team, and the first and second magnitude springs flows were matched closely. The model performed very well in the critical areas of concern, including the lower Santa Fe river and Keystone Heights, by matching water levels, spring flows and baseflows closely. Overall, the model performed significantly better in the North Florida water supply planning area than previous models.

Below are our responses to specific comments and concerns submitted by LSG as part of the technical team review process.

Response to Summary of Key Concerns

1. The HSPF surface water models produce unrealistic recharge and evapotranspiration (ET) estimates in some areas due to:
a. Anomalies in rainfall input data
b. Unsuitable calibration for 2001 and 2009 conditions in some basins
c. Adjacent HSPF models producing incompatible results due to an inconsistent model development process

Response:

a. We appreciate the thorough review of HSPF model output by LSG and have corrected the few errors found by LSG related to rainfall input and recharge discontinuities. Some of the recharge discontinuities could be explained by real features (e.g., a subwatershed dominated by a discharging lake) and needed no correction.

b. The HSPF models were calibrated using best available data from 1992 to 2014. Forcing the model to match the flows in only one or two years versus the full period of record would not have been appropriate. This would result in unrealistic model parameters which may subsequently affect the model's ability to estimate the recharge and MSET. The models should be judged by their ability to match the total flows for the entire calibration period. A model's poor performance in a single year could be the result of a lack of local rainfall and evapotranspiration data and/or a physical alteration of the system. We understand the importance of achieving good calibrations for 2001 and 2009. However, as previously stated, the purpose of HSPF models was to provide the initial estimates for the groundwater model and to minimize the need to adjust these parameters during the calibration. No matter what method is used, there will always be uncertainties in recharge and MSET estimates. Because of this, the groundwater calibration process was set up so that these initial estimates could be changed within an acceptable range as needed.

c. We respectfully disagree that models are producing incompatible results due to an inconsistent model development process. Initially, multiple staff were needed to build the HPSF models. However, all models used the same hydrology (USGS) and meteorology data source (NLDAS), and all subsequent calibrations were performed simultaneously by one staff member. The same calibration criteria were used for each model.

3. The coupling of the surface water and groundwater models requires improvement due to:
a. Concerning closed basin and springflow assumptions utilized for the coupled model approach

b. Incompatible results from individual HSPF models provided directly to MODFLOW
c. Inability of third parties to execute and evaluate the model coupling algorithms

<u>Response:</u>

It is important to remember that the surface water and ground water models <u>do not comprise a coupled model</u>. The model results from HSPF do not necessarily represent the final recharge estimates for the MODFLOW model. As stated above, the HSPF models provide initial recharge estimates for the MODFLOW model.

a. As discussed in the response to consolidated review comments below, we feel that the representation of closed basins and assumptions for spring flow estimates are adequate for the intended model purposes. We have added more detail in our model report that we hope will provide more clarity on these two conceptual issues.

b. We appreciate the review of LSG and their help in finding errors. We have diligently worked to correct errors where differences in recharge cannot be easily explained abrupt changes in geology, soil type, or land use.

c. As outlined in the response to consolidated review comments below, we are providing software to assist the technical team in evaluating HSPF model output. The ability to simultaneously run and post-process all of the HPSF models efficiently and consistently required an approach with extensive scripting by our staff. We feel it is important for the review process that the technical team be able to run these same scripts. However, because of the original intended use of the HSPF models to provide initial estimates, we do not intend for the HSPF models to be run to evaluate permits.

We believe that in its current state the NFSEG Model will not yet provide reliable predictions. Therefore, we suggest the following steps be completed and fully documented, with enough time in the model development schedule to allow stakeholders to meaningfully review all revisions:
1. Update and recalibrate the 72 HSPF models to address issues and to ensure consistency among the models and technical accuracy of all models
2. Implement a process to address potentially inconsistent output at the interfaces between HSPF models
3. Undertake a review of the HSPF output/MODFLOW input and assess suitability of the model coupling

<u>Response:</u>

1. As explained in the beginning of this document, we believe the NFSEG model in its current state can provide reliable regional-scale predictions. Please note that there are a total of

46 models that contribute to recharge in the NFSEG active model domain, and an additional 9 necessary contributing models outside of the active model domain (55 total models). We do not believe there is a need to recalibrate all of the models. Several HSPF models within the North Florida water supply planning area have been recalibrated after incorporating updates from the technical team comments. As stated above, all models were calibrated simultaneously by one staff member to ensure consistency among the models.

2. We do not think there are output inconsistencies between HSPF models because the output of all of the HSPF models are processed at the same time by one staff member using the same procedure. After updating and recalibrating several models, the recharge discontinuities, which were limited to certain areas, have been minimized. It should be noted that the recharge discontinues cannot be totally eliminated due to differences in rainfall, soil and land use types.

3. As stated above, the NFSEG model is not a coupled surface-ground water model. The methods used to develop initial recharge and MSET estimates were discussed in detail and approved by the technical team at the early stage of the model development. In addition, the methods worked very well for calibrating NFSEG v1.0 model. Therefore, we do not believe there is a need to reassess the methods.

Response to Consolidated Review Comments

1. Comment A1:

   On December 16, 2015, we submitted two questions regarding the golf course irrigation included in the NFSEG Model. The Districts responses do not appear to have addressed these questions. The original questions are provided below for convenience.

   a. **What is the source(s) of water for the golf course irrigation provided by the Districts?**
   b. **Why is there such a significant annual average variation in the quantities of golf course irrigation the Districts are proposing to include in the model? For example, the quantity of golf course irrigation proposed for Duval County reduces from 9.86 MGD to 2.41 MGD from 2001 to 2009, and then stays relatively constant from 2009 to 2010. The change in magnitude in golf course irrigation in Duval County from 2001 to 2009 is greater than would be anticipated from climatic variations in irrigation demand and implies a significant reduction in the number of golf courses within Duval County. In addition, the District's data implies that no golf courses within St. Johns County were irrigated in 2001.**

Response:

a. The source for LRA water use in SJRWMD was reported EN-50 data. This data is by station and has source identifiers. The source for LRA water use in SRWMD was published USGS data. USGS data is only published every five years. Interim years LRA water use was linearly interpolated. GW/SW splits were based on a weighted average from published USGS data, and the split between surface and groundwater sources was approximately 50/50.

b. Because the Upper Floridan Aquifer is well-confined in Duval and most of St. Johns counties, the effect of any discrepancy in golf course irrigation would not make much difference in the 2009 model calibration. Therefore, we do not think this would affect the capability of NFSEG v1.0 to predict the future regional impacts for water supply planning. However, we will revisit this issue before completion of NFSEG v1.1, which will be used for regulatory decisions.

2. Comment A2:

The comment responses from the Districts appear to indicate they have made specific changes to the Keystone Heights area as a result of preliminary review comments from the Technical Team. Please provide a detailed explanation of those changes.

Response:

We only made changes to the drain elevations in Keystone height area. The drain elevations were updated based on available information on surface water structures, Alligator creek stages and lake levels.

3. Comment A3:

As part of the comments submitted in support of the preliminary review of the NFSEG Model, the following question was asked, “Are calibration parameters varied by subwatershed and then indexed to a single land use, or are specific calibration parameters across the entire model domain set at same value and then indexed?” The Districts response indicated that the model was developed with the ability to vary subwatershed parameters by zone. Was this done, or was the model just set up with the ability to do this? We would request a review the input parameter indexing method at the next Technical Team meeting.

Response:

We have included a description of this parameter indexing in our model report. Our approach was similar to the peer-reviewed Water Supply Impact Study conducted by SJRWMD.

4. Comment A4:

There are several comment responses from the Districts that indicate they are revising or reviewing certain aspects of, or data used in, the NFSEG models as a result of the preliminary comments received from the Technical Team. What is the Districts' timeline for completing these evaluations and any associated changes? A brief list of the items the Districts indicated they are currently re-evaluated is provided below:

- **Overlapping hydrologic boundary conditions in MODFLOW (e.g., overlapping drain and river nodes).**
- **Reclaimed water land application including irrigation, RIBs, sprayfields, etc.**
- **Non-agricultural irrigation.**

Changes made to recharge as a result of the Districts re-evaluation of these items should be incorporated into both the HSPF Models and MODFLOW Model, as appropriate.

Response:

For HSPF, we have updated and incorporated our reuse data into the models to ensure that the most complete dataset is being utilized. Please see the responses to the groundwater model comments for overlapping hydrologic boundary conditions in MODFLOW.

5. Comment A5:

As discussed during the May 11, 2016 Technical Team meeting, please provide a detailed summary of the calibration statistics for the HSPF Models for the modeled period of record at the simulated gages. We would also specifically like to see the calibration for 2001 and 2009 since these are the years used for the MODFLOW Model.

Response:

We have incorporated the statistics requested by LSG in Appendix S1 (items 1-4,6,7,8). Item 5 in Appendix S1 will be reported in the MODFLOW section. Nash-Sutcliffe values and mean daily flow comparisons are presented in the model report. Daily calibration plots, daily frequency distribution plots, and annual statistics are included as an electronic appendix to the model report due to the large number of plots requested. (See also response to comment 2).

6. Comment A6:

From review of the HSPF Models and as we discussed, it appears the simulated streamflows from the calibration simulations and the "No Water Use" simulations, are exactly the same for each model provided to the Technical Team. Please confirm that the correct model simulations were provided to the Technical Team.

Response:

This problem has now been fixed. The calibrated models were mistakenly put in a different folder than what was described in the README file.

7. Comment A7:

Rainfall used as input to the HSPF Models was reviewed. The year 2001 is generally considered a "dry" year. However, based on the information provided to us, in 2001 the annual rainfall used in the HSPF sub-basin (Sub-basin 37 of Model 03080103) that includes Lake Brooklyn and Lake Geneva in the Keystone Heights area was considerably higher than expected (>57 inches). The rainfall used for this HSPF sub-basin in 2009 is also different, though to a lesser degree, than the surrounding sub-basins. Figures depicting 2001 and 2009 rainfall used in the referenced area are attached. Please confirm the accuracy of the rainfall data used in these HSPF sub-basins.

Response:

There was an incorrect assignment of rain and potential evaporation data to this sub-watershed. This was corrected, and all the models were reviewed to make sure that the proper rain and potential evaporation data was assigned to each sub-watershed. (See also response to comments 1 and 4)

8. Comment A8:

We do not note any gage data utilized in the Keystone Heights area. Please describe how the Keystone Heights area was calibrated in the HSPF model.

Response:

The calibrated parameters from nearby subwatersheds that had flow data to calibrate against were used for these closed basins. Please refer to the model report for more detail on the methods used to calibrate closed basins.

9. <u>Comment A9:</u>

   The HSPF Models used to develop recharge and maximum saturated ET for the MODFLOW Model were calibrated to observed daily data from 1991 through 2014. However, only annual average data from 2001 and 2009 are currently being used to develop a steady-state version of the NFSEG Groundwater Model. As such, the calibration of the HSPF Models for 2001 and 2009 conditions is critical to the HSPF-calculated recharge being used to calibrate the MODFLOW Model. Attached are figures depicting HSPF model calibration results for 2001 and 2009 for two streamflow gages in the NFRWSP area; the Santa Fe River at Worthington Springs and South Fork Black Creek near Penny Farms. In 2001, the flow in the Santa Fe River at Worthington Springs was over-predicted by 163 percent by the HSPF Model. In 2009, flows at the same gage were under-predicted by 29 percent. In 2001 and 2009, the flows in the South Fork Black Creek were over-predicted by 49 percent and under-predicted by 34 percent, respectively. Please review the calibrations for the years 2001 and 2009 for the HSPF Models assure they are calibrated to acceptable levels for the intended purpose of the HSPF Models at this time.

   <u>Response:</u>

   The HSPF models were calibrated using the best available data from 1992 to 2014. Forcing the model to match the flows in only one or two years among 12 years would not be appropriate. This may result in unrealistic model parameters which may subsequently affect the model's ability to estimate recharge and MSET. The models should be judged by their ability to match the total flows for the entire calibration period. A model's poor performance in matching flows in certain years at certain gauges could be a result of the lack of local rainfall and evapotranspiration data and/or some physical alterations in the system. We understand the importance of achieving a good calibration for 2001 and 2009. However, as previously stated, the purpose of HSPF models was to provide initial estimates for the groundwater model and to minimize the need to adjust these parameters during the calibration. Given that the MODFLOW calibration criteria have been met, we feel that further calibration of the HSPF models for water supply planning is unwarranted. However, we will continue improving the HSPF models as needed until NFSEG v1.1 is completed.

10. Comment A10:

We have previously noted the importance of having a NFSEG Model which can be fully utilized by third parties. We appreciate the Districts' work to develop a version of the MODFLOW model that can be used on standard PC computers. The HSPF Models are complex, and we appreciate the Districts' assistance to date to allow us to run the HSPF Models. However, at this time, we have been unable to fully utilize the HSPF Models, specifically to derive the net recharge and maximum ET estimates used as input to the MODFLOW Model. We request the Districts develop versions of all HSPF pre-processors and HSPF post-processors that can be readily run by a stakeholder or permittee on standard PC computers. Again, while we appreciate the assistance provided to date, we would appreciate detailed documentation of the HSPF Models and a user's manual so third parties can utilize the tools developed by the Districts.

Response:

The ability to perform multiple calibrations on so many HPSF models while ensuring input and output consistency between models required the use of customized scripting. This was done in a Linux environment, which facilitated data transfer between PEST and other critical software. For model review purposes, we are assembling a Linux virtual machine that can run on standard PC computers, as well as providing documentation on how to execute the scripts. This was done as a convenience for the reviewers. It should be noted that all of the software used to run and postprocess the HSPF models (with the possible exception of ArcGIS, which is widely used on personal computers running standard Windows operating systems) is open-source software that is frequently used for large-scale, numerically intensive modeling projects.

11. Comment A11:

Due to the importance of the output and the varying calibration results, a robust sensitivity analysis of the HSPF models should be performed to assess the effects of changing various parameters on the model output. Recharge and ET are by far the largest inflow and outflow water budget parameters in the MODFLOW model.

Response:

A sensitivity/uncertainty analysis was performed using the groundwater model. As part of sensitivity/uncertainty analysis, recharge and MSET parameters were varied to assess their effect on model predictions. Please see the details in the uncertainty analysis report attached to the model documentation.

12. Comment 1:

In previous comments, LSG identified an issue with incorrect rainfall input to one HSPF model. Because of this issue, LSG broadened its review of the rainfall input to the HSPF models. Figure 1 and Figure 2 depict 2001 and 2009 rainfall used in the HSPF Models. Based on this review, some areas appear to have higher or lower rainfall than anticipated Please describe the source of rainfall data that was used in the HSPF models. Please provide a comprehensive analysis of how the data used for the HSPF models compares to other available sources of rainfall data, such as gage observations, for the area of the NFSEG Model? Please review and confirm the accuracy of the rainfall data used in the HSPF models.

Response:

We corrected the gauge assignment issue with the specific model and have reviewed the rainfall input for all of the other models (See also comment A7 from May 27, 2016). In the early stages of this project, we conducted a review of NLDAS datasets for meteorology inputs versus traditional rain gauge data. This review has been provided as an Appendix to the model report. (See also response to comments A7 and 4)

13. Comment 2:

On June 17, 2016, the Districts provided an ftp link to revised NFSEG HSPF Models. One of the changes made to the revised HSPF models was to provide model output for 2001 and 2009 including daily and monthly flow hydrographs and cumulative frequency distributions for simulated and observed flows. We appreciate the Districts providing these additional output data as was previously discussed at the Technical Team meeting on June 1, 2016. However, based on the Districts' response to a previous comment, the Districts indicated the following broader group of metrics and aspects of model performance were considered during calibration:

Average daily flow;
Average monthly flow;
Average yearly flow;
Average period of record flow;
Frequency distribution curve;
Literature estimates of evapotranspiration from different land uses; and
Hydrologic indices:
Mean of daily flow;
Mean monthly flow of all Januaries, Februaries, etc.;
Ratio of total flow to base flow;
Mean of rise rate (calculated from when flow is increasing); and

Mean of fall rate (calculated from when flow is decreasing).

Therefore, we request that the Districts provide additional detailed calibration statistics for the HSPF models for both the entire simulation period and specific years of 2001 and 2009. Namely, please provide calculated statistics for the metrics used to calibrate the HSPF models.

Response:

Please see also response to comment A5. We have provided the requested statistics and plots specified in Appendix S1 (items 1-4) of this document. Appendix S1 is from an email exchange with LSG, and it clarifies the statistics requested in this comment.

Daily plots and statistics, as well as monthly and annual flows, are provided as an electronic appendix to the model report.

Closed Basin Recharge: Below are simulated average yearly recharge to the Upper Floridan aquifer associated with known sinks for 2001, 2009, and 2010. Data for calibration targets were only available for Alachua Sink (references provided below table).

Closed Basin Recharge, Sink or Injection ID and/or Name	Reported Values (cfs)	2001 HSPF Simulated Recharge (cfs)	2009 HSPF Simulated Recharge (cfs)	2010 HSPF Simulated Recharge (cfs)
Alachua Sink	8.95 – 25.67*	53.4	41.98	81.15
	20.77 – 88.89**			
Orange Lake Sink	40*	49.56	55.14	55.14

*Values from previous studies:

Ritter, M. 1991. A hydrologic study of Alachua sink, Alachua County, Florida (8.95 cfs average)

Gao X., Gilbert, D. and Magley, W. 2006. TMDL Report Nutrient TMDL for Alachua Sink (21.57 cfs – simulated)

Phelps, G.G. 1987. Effects of Surface Runoff and Treated Wastewater Recharge on Quality of water in the Floridan Aquifer System, Gainesville Area, Alachua County, Florida (25.67 cfs)

Motz, L.H., Spangler, D.P. An Impact Analysis of the Ground Water and Geological Effects of Potential Control of the Sinkhole Discharge at Heagy-Burry Park, Orange Lake, Florida. SJRWMD Special Publication SJ98-SP3.

** Annual average from 2007 to 2015 (2011 was not considered because it has a short period of record) at SJRWMD station 27274763 Paynes Prairie at Culvert Upstream at Gainesville Discharge

The following table provides annual average recharge values for all closed basins:

Closed Basin ID	2001 HSPF Simulated Recharge (cfs)	2009 HSPF Simulated Recharge (cfs)	2010 HSPF Simulated Recharge (cfs)
HUC 3110203 Reach 25	0.03	0.00	0.00
HUC 3080101 Reach 7	12.12	11.91	4.50
HUC 3100208 Reach 45	37.19	39.97	39.97
HUC 3100208 Reach 46	19.99	19.99	19.99
HUC 3110202 Reach 40	11.79	9.10	9.78
HUC 3080102 Reach 16	1.51	1.09	1.47
HUC 3080102 Reach 17	1.94	4.84	2.21
HUC 3080102 Reach 18	53.04	41.98	81.15
HUC 3080102 Reach 19	6.06	6.22	10.00
HUC 3080102 Reach 20	10.00	10.00	10.00
HUC 3080102 Reach 21	5.01	5.01	5.01
HUC 3080102 Reach 22	5.01	5.01	5.01
HUC 3080102 Reach 23	12.88	12.08	15.12
HUC 3080102 Reach 24	18.60	14.22	23.35
HUC 3080102 Reach 31	7.40	7.40	7.40
HUC 3080102 Reach 34	49.56	55.14	55.14
HUC 3110203 Reach 26	7.23	6.78	6.64
HUC 3110203 Reach 27	0.61	0.82	0.48
HUC 3110203 Reach 28	0.43	0.72	0.39
HUC 3120001 Reach 17	0.00	0.00	0.01
HUC 3120001 Reach 18	0.00	0.00	0.00
HUC 3120001 Reach 19	0.00	0.00	0.00
HUC 3120001 Reach 20	0.00	0.00	0.00
HUC 3120001 Reach 21	0.00	0.00	0.00
HUC 3120001 Reach 22	0.00	0.00	0.00

Closed Basin ID	2001 HSPF Simulated Recharge (cfs)	2009 HSPF Simulated Recharge (cfs)	2010 HSPF Simulated Recharge (cfs)
HUC 3120001 Reach 23	0.00	0.00	0.00
HUC 3110101 Reach 27	0.01	0.01	0.01
HUC 3110201 Reach 37	9.04	13.23	9.61
HUC 3110201 Reach 38	23.07	32.32	31.83
HUC 3110201 Reach 39	19.41	24.11	18.99
HUC 3090101 Reach 27	13.08	11.40	17.34
HUC 3110205 Reach 31	0.75	2.22	3.25
HUC 3110205 Reach 33	13.25	13.58	13.50
HUC 3110205 Reach 34	18.44	18.44	18.44
HUC 3110205 Reach 35	9.17	6.75	6.38
HUC 3110206 Reach 23	49.18	65.45	83.34
HUC 3110206 Reach 24	7.68	10.20	12.91
HUC 3110206 Reach 25	18.55	15.48	21.98
HUC 3110206 Reach 26	8.68	7.22	10.46
HUC 3100101 Reach 27	33.42	34.59	47.32
HUC 3100101 Reach 43	9.83	8.67	13.56
HUC 3100205 Reach 29	3.98	7.08	7.24
HUC 3100207 Reach 37	1.16	1.42	1.73

The following table contains simulated Upper Floridan aquifer discharge to surface waters being represented as HSPF Inactive Groundwater Outflow (IGWO) from a virtual HSPF underground reservoir for the 2001, 2009, and 2010:

Contributing Groundwater Capture Zone	2001 Simulated Discharge (cfs)	2009 Simulated Discharge (cfs)	2010 Simulated Discharge (cfs)
HUC 03110201 Reach 36	68.48	61.52	55.85

Contributing Groundwater Capture Zone	2001 Simulated Discharge (cfs)	2009 Simulated Discharge (cfs)	2010 Simulated Discharge (cfs)
HUC 03110201 Reach 34	0.38	0.59	0.17
HUC 03110201 Reach 35	17.47	21.86	7.39
HUC 03110203 Reach 23	67.26	132.42	50.35
HUC 03110205 Reach 1	178.91	172.24	154.80
HUC 03110205 Reach 16	108.13	104.25	102.18
HUC 03110205 Reach 21	367.10	369.27	361.28
HUC 03110205 Reach 22	112.79	111.87	115.15
HUC 03110205 Reach 26	176.29	207.40	245.87
HUC 03110205 Reach 29	216.73	227.02	279.79
HUC 03110206 Reach 5	185.52	213.15	204.58
HUC 03110206 Reach 17	122.42	140.77	141.35
HUC 03110206 Reach 18	387.66	445.78	447.60
HUC 03110206 Reach 21	29.39	32.42	32.46
HUC 03110206 Reach 22	1.55	1.71	1.71

14. Comment 3:

Though calibration statistics for 2001 and 2009 HSPF predicted flows have not been received from the Districts, LSG has reviewed HSPF predicted average flows for 2001 and 2009 for several observation gages being used by the Districts in the calibration of the HSPF models. The difference between observed flow and predicted flow (e.g., error) for the observation gages reviewed are presented in Table 1.

We are concerned about the accuracy of HSPF predicted average flows for 2001 and 2009 at some locations. Errors in surface water flows indicate errors in predicted runoff and baseflow, which could be resulting in errors in the predicted recharge and maximum saturated ET values being assigned from the HSPF models to the groundwater flow model. The magnitude of some of the predicted errors in Table 1 are several inches per year and

could be resulting in significant errors (on the order of inches per year) in recharge to the surficial aquifer system in the groundwater flow model. Also, for the selected watersheds within the North Florida Regional Water Supply Planning area listed in Table 1, the models all underpredict streamflow for 2009. Please address the accuracy of 2001 and 2009 recharge rates being predicted by HSPF and assigned to the groundwater flow model given the significant inaccuracies in runoff in several basins. Please consider the use of alternative HSPF model calibration techniques that would result in an improved calibration for the periods for which the HSPF models are coupled to MODFLOW.

Response:

Please see response to comment A9.

15. Comment 4:

As previously noted, the 2001 annual rainfall used as input to HSPF model for sub-basin (Sub-basin 37 of Model 03080103) in the Keystone Heights area was considerably higher than expected (>57 inches). On June 17, 2016, LSG received an ftp link from the Districts providing updated HSPF models indicating that the rainfall in the subject sub-basin had been changed. However, we have the following questions on these revision(s):

- **What was the error or issue with the original rainfall data assigned to the model?**
- **If a new source of data was used for the revised HSPF model, then what was the source?**
- **Since rainfall is a primary component of the water budget of the model, do the Districts plan to recalibrate the HSPF model for sub-basin 37?**
- **Do the Districts plan to recalibrate all or a portion of the MODFLOW groundwater flow model based on any changes in recharge and maximum saturated ET calculated in the revised HSPF model?**

Response:

There was an error in assignment of rainfall input data to the basin. We have corrected the error and reviewed all basins for similar errors. No new source of rainfall data was used for the model. All of the HSPF models went through a final calibration after all corrections were made. The MODFLOW model uses the most recent calibrated HSPF recharge and maximum saturated ET, which includes all of the corrections made during the review process. (See also response to comments A7 and 1)

16. Comment 5:

LSG previously noted that significant discontinuities in HSPF-derived recharge estimates occur in the vicinity of Union County, Bradford County, and Clay County along HSPF model boundaries. Because of this issue, LSG broadened its review of recharge being calculated by HSPF and assigned as MODFLOW input. Four figures have been included as follows:

- **Figure 3: 2001 HSPF calculated recharge by watershed and subwatershed**
- **Figure 4: 2001 recharge assigned to the MODFLOW groundwater flow model**
- **Figure 5: 2009 HSPF calculated recharge by watershed and subwatershed**
- **Figure 6: 2009 recharge assigned to the MODFLOW groundwater flow model**

From these figures, discontinuities in recharge along HSPF model boundaries can be observed in other areas of the model. This result of HSPF means that two adjacent areas with similar land use, soil type, elevation, etc. on either side of an HSPF model boundary have been assigned notably different recharge values. This does not appear to be a reasonable representation of the physical system. We recommend a thorough evaluation of the model conceptualizations causing this issue and the development of a revised methodology to address this issue.

Response:

After reviewing the models, we do not feel that model conceptualizations were causing these errors. We have reviewed all models and corrected the few errors related to rainfall input and recharge discontinuities. Some of the recharge discontinuities could be explained by real geographical features and needed no correction. Please see our previous responses to the similar comments above.

17. Comment 6:

HSPF was also used to calculate the maximum saturated evapotranspiration (ET) assigned to the ET Package in MODFLOW. Similar to HSPF-calculated recharge, discontinuities in HSPF calculated maximum saturated ET along HSPF model boundaries can be observed in Figure 7, Figure 8, Figure 9, and Figure 10. Again, this result of HSPF means that two adjacent areas with similar land use, soil type, elevation, etc. on either side of an HSPF model boundary have been assigned notably different maximum ET values. This does not appear to be a reasonable representation of the physical system. We recommend a thorough evaluation of the model conceptualizations causing this issue and the development of a revised methodology to address this issue.

Response:

As stated in response to comment 5, we do not feel that model conceptualizations were causing these errors. The corrections made in response to comment 5 were also made to maximum saturated ET. Please see our previous responses to the similar comments above.

18. Comment 7:

The HSPF models developed in support of the North Florida Southeast Georgia (NFSEG) groundwater flow model were based on United States Geologic Survey (USGS) 8-digit hydrologic unit code (HUC8) watershed boundaries. It is our understanding that USGS 12-digit hydrologic unit code (HUC12) subwatershed boundaries were used as a guide to subdivide HUC8 watersheds, but in the case of sub-watersheds 36, 37, and 38 of HSPF Model 03080103 the HUC12 basin boundaries were modified to represent that these are isolated or "closed" basins. Figure 11 presents USGS HUC8 watersheds, USGS HUC12 sub-watersheds, and the sub-watersheds used to develop the NFSEG HSPF models. In many cases, the HSPF sub-watersheds appear to align with USGS HUC 12 sub-watersheds. However, in many other cases, the HSPF sub-watersheds do not appear to align with USGS HUC 12 sub-watersheds. Please provide a detailed description of the methodology used to subdivide HUC8-level watersheds for the development of HSPF sub-watershed models?

Response:

We have provided a more detailed description of the delineation approach in the model report. In short, HUC 12 boundaries were used in closed basins, flat basins, and frontal (coastal) basins where our delineation software did not work well.

19. Comment 8:

The HSPF-calculated parameters "Active Groundwater Inflow" (AGWI) and "Inactive Groundwater Inflow" (IGWI) are summed to derive recharge input to the NFSEG groundwater flow model. It is also our understanding that HSPF-calculated parameters "Direct Surface Runoff" (SURO), "Interflow Zone Outflow" (IFWO), and "Active Groundwater Outflow" (AGWO) are the components that comprise total surface water flow out of a watershed, which is the parameter used to calibrate the HSPF models.

In a closed watershed (e.g., a watershed with no surface water outflow), surface water runoff (SURO), surficial aquifer system groundwater lateral seepage to surface water bodies (IFWO), and baseflow (AGWO) stay within the watershed and ultimately become recharge to the surficial aquifer system (and ultimately available as recharge to the Upper Floridan aquifer [UFA]) through stormwater retention systems, low-lying areas, lakes and wetlands.

As an example, the results for 2009 for the HSPF sub-basin 37 of Model 03080103 in the Keystone Heights area are summarized in Table 2. For this sub-basin, HSPF calculates 13.11 inches per year (in/yr) of recharge and 15.10 in/yr of streamflow. However, there is no discharge from this sub-basin so based on the HSPF model results, 28.21 in/yr (15.10 in/yr + 13.11 in/yr) remains in the watershed and could become recharge the surficial aquifer system.

As previously described by the Districts, the HSPF models were calibrated to streamflow gages. However, in closed watersheds, there is no streamflow gage to use for calibration of this subwatershed and these subwatersheds do not contribute flow to any gage. Therefore, we request additional details on how closed basins were calibrated. Specifically, for this sub-basin, how was the distribution between recharge (13.11 in/yr) and streamflow (15.1 in/yr) determined?

Response:

Please refer to the model report for detailed documentation of calibration of closed basins. Closed basins had to be calibrated using parameters from nearby watersheds. SURO, IFWO, and AGWO are delivered to the reach (stream or lake), where evaporation can still occur. Thus, the 15.1 in/yr of streamflow for model 03080103 does not all recharge. The model for 03080103 is different from other closed basins, in that SURO and AGWO are not delivered to groundwater recharge subsequent to being delivered to the reach. The reason for this is explained in the response to comment 10.

20. Comment 9:

In a closed watershed (e.g., a watershed with no surface water outflow), surface water runoff, surficial aquifer system groundwater lateral seepage to surface water bodies, and baseflow stay within the watershed and ultimately become recharge to the surficial aquifer system (and ultimately available as recharge to the Upper Floridan aquifer [UFA]) through stormwater retention systems, low-lying areas, lakes and wetlands. To account for this the Districts previously indicated that each closed basin has assigned to it a conceptual concentrated discharge mechanism to the UFA estimated from the stage in the HSPF closed basin reach (through the programming of an HSPF Special Action). However, a Special Action to represent the closed basins in Model 03080103 could not be located. Without these discharge mechanisms in the NFSEG Model, the calculated recharge will be significantly underpredicted. Please update the HSPF Models as required to accurately simulate these closed basins.

Response:

In the Keystone Heights area (03080103), all the concentrated flows reach the UFA through lakes. Because the leakage through lakes were simulated directly in the MODFLOW model, the “concentrated discharge mechanism” used in other closed basins was not applied to this model. Otherwise, the concentrated recharge would be double counted.

21. Comment 10:

The designation of closed watersheds in the NFSEG Model area was reviewed in more detail. Figure 12 presents sub-watersheds designated as “closed” by the USGS at a HUC12 level. The Florida Geological Survey’s sinkhole GIS coverage have been included on the Figure 12 to demonstrate other potential subwatersheds that may effectively be considered closed.

As previously noted by the Districts, each closed basin has assigned to it a conceptual concentrated discharge mechanism to the Upper Floridan aquifer estimated from the stage in the HSPF closed basin reach (through the programming of an HSPF Special Action). In Figure 12, drainage wells and sinks included in the NFSEG groundwater flow model are included and show that many closed basins have a modeled drainage well or sink. However, please confirm that the Special Action to represent recharge to the UFA was applied in all closed basins and that all drainage wells and sinks as included in the NFSEG groundwater flow model were included in the corresponding NFSEG HSPF model. Please indicate which HSPF model sub-basins included the closed basin Special Action programming (and corresponding injection well in the groundwater flow model). If there are closed basins that do not include this Special Action and injection well, please indicate which ones and explain why. Lastly, please explain how calculated streamflow within closed basins was accounted for when assigning recharge results from HSPF to MODFLOW.

Response:

All of the closed basins except 03080103 have a special action that represents recharge to the UFA. The table provided in response to item 6 in Appendix S1 includes all of the closed basins with special actions to represent recharge. Concentrated flows from HSPF were used to develop injection wells dataset for MODFLOW model.

22. Comment 11:

In certain areas, the HSPF models developed include a simulated “underground reservoir” of groundwater by summing model-calculated groundwater inflow to the inactive groundwater zone (IGWI). This “underground reservoir”, was used to simulate river baseflow (via concentrated discharge from the UFA to springs and rivers) in areas where the Suwannee River and its tributaries are springfed or are incised into the UFA. We have the following questions regarding the use of this method for estimating UFA discharge to surface waters in the HSPF models:

- **Please provide a detailed description of this process.**

- **Springshed and watershed boundaries do not often coincide and can be quite different. What is the rationale for using HSPF watershed boundaries in the development of springflow estimates?**
- **IGWI is being used to calculate springflows based on an HSPF watershed, but AGWI plus IGWI are being use to drive MODFLOW estimates of springflow based on simulated groundwater levels. Please explain the reasonableness of this difference in conceptualization. Has HSPF been used in this way before?**
- **Are there any other studies or models that utilize HSPF to represent the magnitude and timing of springflows in a coupled model in this manner? If so, please provide citations. Based on those studies or models, is the use of HSPF in this way reasonable for use in the NFSEG model?**
- **Do the estimates of IGWI include simulated discharges to the aquifer via sinks and drainage wells as noted in the Districts responses?**
- **If yes, then please explain how UFA discharge to river systems and recharge to the UFA from sinks and recharge wells were separately aggregated into the IGWI term in select basins and how these terms were calibrated.**
- **Furthermore, given that recharge from sinks and drainage wells are handled as injection wells into the UFA in MODFLOW, are these flows also included in the IGWI term that is mapped as surficial aquifer recharge in MODFLOW for these basins?**
- **How were springs represented as IGWI in HSPF calibrated?**
- **Please provide the calibration statistics for springs or spring baseflow represented as IGWI in the HSPF models.**

<u>Response:</u>

Please refer to the model report for details of the method used to represent springflow in the HSPF models. By incorporating the IGWO parameter, calibrations (and water balances) in the Suwannee area were significantly improved, and thus recharge estimates have been improved. Gauges that are dominated by springflow are the only sites where IGWO (not IGWI) will represent the dominant flow. Please see the response to Comment 2 for gauges where discharge to surface water was represented by IGWO.

23. <u>Comment 12</u>

The results for AGWI and IGWI from HSPF were evaluated in more detail for several basins. Table 3 presents a summary of the disaggregation of these two parameters for several example HSPF models:

Based on the results presented in Table 2, it appears that essentially all recharge in the Lower St. Johns River Basin is calculated in the HSPF Model as AGWI. It also appears that all recharge in the Lower Suwannee River Basin is calculated in the HSPF Model as IGWI. Recharge within the Santa Fe River Basin is calculated as both AGWI and IGWI.

Considering these example watersheds, please explain how the conceptualization and representation of springs in the HSPF models is affecting the specific recharge components calculated by HSPF (AGWI and IGWI). Specifically, please provide further explanation of the following:

- **In a basin such as the Lower Suwannee River Basin, where IGWI dominates, is basically all HSPF-simulated groundwater recharge being represented as discharge from the UFA to the river system as IGWI? Does this model conceptualization mean that effectively all rainfall that recharges the surficial aquifer system in this surface water basin is assumed to be discharged to the river system as spring-derived baseflow?**
- **For basins with both AGWI and IGWI such as the Santa Fe River Basin, how was the disaggregation between AGWI and IGWI determined and calibrated?**
- **Would the assumptions made regarding model input and calibration that resulted in the disaggregation of the components of recharge have a significant effect on other HSPF computed results (e.g., maximum saturated ET)? Please elaborate.**

Response:

For the lower Suwannee, the model represents almost all recharge as being discharged to the river system. Based on knowledge of the hydrogeology of the area, there is no separate surficial aquifer system.

For basins like the Santa Fe, calibration was performed in a similar manner to other basins. Calibration was performed for the entire regime of gauging stations. This system has a confined and unconfined portion (because of the Cody Scarp), and thus AGWI and IGWI are important.

Assumptions made regarding model input and calibration affect all computed results. However, we feel that the calibration results for the aforementioned basins have a physical basis.

24. Comment 13:

As previously noted, total streamflow was calculated as the sum of HSPF parameters SURO, IFWO, and AGWO. It was noted from review of HSPF results that IFWO is frequently calculated as 0 in/yr (or effectively 0 in/yr). This appears to have occurred in 55 of the 72 HSPF models. However, in the remaining 17 HSPF models, this parameter was calculated to be as high as 11.2 in/yr. How was this parameter determined/calibrated and why does there appear to be such as wide range of results for this parameter? How was the disaggregation between SURO, IFWO, and AGWO determined/calibrated? Would the assumptions made regarding model input and calibration of the components of total streamflow have a significant effect on other HSPF computed results (please elaborate)?

Could the difference in these parameters between HSPF models lead to issues at the boundaries between HSPF models?

Response:

Based on prior modeling in Florida, we feel that 0 in/yr for IFWO is reasonable for many areas, for the physical reason that the topography is flat and the water table is generally high. The wide range is due to some model basins in Georgia having much more relief, where more interflow would be expected. We do not anticipate that 0 in/yr for IFWO will lead to significant effects on other HSPF compute results.

25. Comment 14:

HSPF Model 03110205 representing the Lower Suwannee River Basin has the following calculated values for the components of streamflow:

- **SURO: 1.35 in/yr**
- **IFWO: 0 in/yr**
- **AGWO: 0.0002 in/yr**

Of the 72 HSPF models, this is the only model that has a calculated baseflow (AGWO) that is effectively 0 in/yr. We recognize that much if not all of the baseflow for this system may be comprised of spring discharge represented in the inactive groundwater zone for this watershed; however, please confirm that this watershed does not effectively have any contributing surficial aquifer system baseflow.

Response:

Given that much of this area is unconfined, there is generally no surficial aquifer present.

26. Comment 15:

We have reviewed the Ichetucknee River basin in the HSPF model and the groundwater flow model. In HSPF Model 03110206, the Ichetucknee River appears to be represented by sub-basins 5, 9, 23, 24, and 51, where 51 is a "virtual" reservoir representing springflow (as previously discussed). The HSPF model appears to route sub-basins 23 and 24 to virtual sub-basin 51, which is routed to sub-basin 5 (location of Ichetucknee River gage), which is then routed to sub-basin 9 as it discharges to the Santa Fe River. We have the following questions regarding the representation of the Ichetucknee River in HSPF:

- **Please explain where the individual components of the HSPF water budget for sub-basins 23 and 24 are routed. Specifically, are AGWI and IGWI from sub-basins 23 and**

24 routed to sub-basin 51 and are AGWO, SURO, and IFWO from sub-basins 23 and 24 routed to sub-basin 5?

- **Is the water routed from sub-basins 23 and 24 to sub-basin 51 converted to IGWO (which represents springflow in virtual sub-basins) in sub-basin 51?**
- **Is IGWO (springflow) from sub-basin 51 routed as streamflow to sub-basin 5?**
- **The streamflow gage for the Ichetucknee River is at the discharge of sub-basin 5. What terms (e.g., AGWO, SURO, IFWO, AGWI, IGWI, and IGWO) from which sub-basins (5, 23, 24, and 51) are summed to calculate total streamflow in the Ichetucknee River for calibration to gage data?**

Table 4 presents the output for the various HSPF terms discussed above. We have the following questions regarding these HSPF model outputs.

- **In sub-basins 5 and 9, AWGI and IGWI are the same value. In sub-basins 23 and 24, AGWI and IGW are not the same value. How was the disaggregation between AGWI and IGWI conceptualized? For these basins, how was the disaggregation of AGWI and IGWI calibrated?**
- **The sum is AGWI and IGWI represents recharge that is ultimately mapped to the groundwater flow model. The term "AGWI + IGWI" in Table 4 is a calculation made by LSG based on the results of the individual HSPF components AGWI and IGWI provided by the Districts. In Table 4, the term "RCH" is also from an output file provided by the Districts. For the Ichetucknee River, LSG's calculation using District information and the District's calculation of recharge do not match. Please review and explain this discrepancy.**
- **The HSPF results for the Ichetucknee River basin show significant surface water runoff and baseflow components being calculated by HSPF. However, in the MODFLOW calibration, the Ichetucknee River was conceptualized as being exclusively composed of spring baseflows (no contributing surface runoff or surficial baseflow). It appears that the hydrologic conceptualization for the Ichetucknee River is inconsistent between HSPF and MODFLOW. We are concerned that this inconsistency will lead to unreliable conclusions in the application of the model in this critical area.**
- **What is the source of the data used to perform the MODFLOW calibration of the Ichetucknee River in 2001?**

Average recharge input assigned to the groundwater flow model for each of the sub-basins presented in Table 4 are presented in Table 5.

We understand that the Districts developed a process for mapping transient HSPF recharge output to MODFLOW as steady-state input for 2001 and 2009. We also understand that this process can result in differences between the HSPF recharge output and MODLFOW recharge input. However, in this instance, some sub-basins have MODFLOW input recharge higher than HSPF and others the opposite situation occurs. We do not understand how this occurs. Please

confirm the accuracy of the recharge mapped from HSPF to MODFLOW. Also, as noted elsewhere, the process whereby HSPF output is coupled to MODLFOW as input is a vital component of the NFSEG model. We request a detailed description of how recharge is mapped from HSPF to MODFLOW and the opportunity to thoroughly review and apply the algorithms utilized in this process.

Response:

Reach 51 represents a storage reach, which was added to the HSPF model to simulate the water that is part of the springshed contributing to sub-basin 5. This includes sub-basins 5, 23, 24, sub-basin 1 and external sub-basins in model 03110201 that are part of the springshed. Sub-basin 5 drains downstream into sub-basin 9. Sub-basin 1 is part of the Olustee Creek sub-basin, which drains into Santa Fe River. IGWI from this sub-basin was conceptualized draining into Reach 51, since it is within the springshed that contributes to sub-basin 5. Sub-basin 1 has a surface connection to the Olustee Creek and drains downstream to Santa Fe River, the stream flow from sub-basin 1 is draining to sub-basin 12, which is part of the creek sub-basin.

- Sub-basins 23 and 24 are closed sub-basins, they do not have a surface connection to the drainage network of the Ichetucknee River basin. Subbasin 23 does have a channelized drainage network, although flow is typically ephemeral, and the direct runoff that they convey is generally completely captured by swallets. Surface water in these sub-basins infiltrates and contribute to the springflow at sub-basin 5. Sub-basins 23 and 24 are within the springshed boundary, which drains into Ichetucknee River, then IGWI from these sub-basins was assumed to be contributing to the springflow at sub-basin 5.

  IGWI from sub-basins 23 and 24 was routed to Reach 51, which was conceptualized to store the water and release it as springflow downstream at reach 5.

  AGWI from sub-basins 23 and 24 becomes part of the Active Ground Water Storage, which is released as AGWO.

  SURO, IFWO and AGWO components are sent to the local reach, but since sub-basins 23 and 24 are not connected to the river drainage surface network, to keep the local reach from increasing in depth indefinitely, a closed basin sink was created using Special Actions that sends excess water from the local surface reach to Reach 51. In effect, through the closed basin sink Special Action, HSPF is "routing" SURO, IFWO and AGWO from these sub-basins to Reach 51. It was assumed that the stream flow from sub-basins 23 and 24 become part of the water contributing to the springflow at Reach 5.

- Water from sub-basins 23 and 24 is routed to Reach 51, which releases water into sub-basin 5 as springflow.

- Water from Reach 51 was conceptualized to drain into reach 5 as springflow.

- HSPF streamflow is composed of SURO, IFWO and AGWO. Total streamflow at Reach 5, includes streamflow from Reach 5 and flow from Reach 51. As explained above, Reach 51 is a storage reach that receive SURO, IFWO, AGWO (through HSPF closed basin sink Special Action) and IGWI from sub-basins 23 and 24, sub-basin 1 and other external sub-basins and it releases the water into Reach 5.

- Disaggregation between AGWI and IGWI is performed by HSPF using the parameter DEEPFR. This parameter determines the distribution to active and inactive groundwater. DEEPFR was part of the calibration process, and according to Technical Note 6[1] that defines HSPF parameters, ranges between 0.2 and 0.5. For sub-basins 5 and 9, a calibrated value of 0.5 was calculated. It means that half of the water from infiltration and percolation goes to AGWI and the other half become IGWI.

- The table below shows the updated recharge values from the current model for the Ichetucknee River:

Table 4: Summary of HSPF Results for the Ichetucknee River Basin (2001)

Basin	AGWI (in/yr)	IGWI (in/yr)	AGWI + IGWI (in/yr)	AGWO (in/yr)	SURO (in/yr)	IFWO (in/yr)	Runoff (in/yr)
5	4.65	4.65	9.3	4.60	0.00	0	4.6
9	4.59	4.59	9.18	4.44	2.25	0	6.69
23	4.29	3.77	8.06	4.18	3.34	0	7.52
24	4.46	3.92	8.38	4.39	1.44	0	5.83
1	7.03	1.76	8.79	3.85	1.72	0	5.57

Also, we noticed that in Table 4 from the comments, the AGWI + IGWI values are exactly the same values in the RCH column, but they are in different rows (see figure below).

Table 4: Summary of HSPF Results for the Ichetucknee River Basin (2001)

Basin	AGWI (in/yr)	IGWI (in/yr)	AGWI+ IGWI (in/yr)	RCH (in/yr)	AGWO (in/yr)	SURO (in/yr)	IFWO (in/yr)	Surface Water Runoff and Baseflow (in/yr)
5	3.91	3.91	7.82	7.63	0.65	1.26	0	1.91
9	4.51	4.51	9.02	7.95	0.92	2.25	0	3.17
23	6.1	1.53	7.63	7.82	5.95	2.84	0	8.79
24	6.36	1.59	7.95	9.02	6.26	1.41	0	7.67

[1] EPA. BASINS Technical Note 6: Estimating Hydrology and Hydraulic Parameters for HSPF. EPA, July 2000

- The SURO component for sub-basin 5 (Ichetucknee River) is 0.00, which indicates that the streamflow is exclusively baseflow and springflow.
- For the Ichetucknee River MODFLOW calibration for 2001, the HSPF-derived baseflow was used for river gage 2322700, which included the collective spring flows + diffuse (River Package) gw-river exchanges. There is also another flow target including only the collective spring flows used in model calibration. The collective spring flows were estimated by SRWMD using the available historical data.

27. <u>Comment 16:</u>

The Districts indicated both the 2001 and 2009 calibration simulations are based on 2001 land use. Has the effect and sensitivity of using 2001 land use in the 2009 calibration simulation been evaluated?

<u>Response:</u>
We do not believe there is a need to evaluate the sensitivity of using different land use. First of all, we do not expect a dramatic change in land use from 2001 to 2009. Second, as stated previously, the purpose of the HSPF models was to provide the initial estimates of recharge and MSET. A sensitivity/uncertainty analysis was conducted using the groundwater model by varying different parameters including recharge and MSET. Please see the documentation for details of the analysis.

Appendix S1: Requested Statistics and Plots from Liquid Solutions Group

From: Brian J. Megic <bmegic@liquidsolutionsgroup.com>
Sent: Friday, July 15, 2016 3:13 PM
To: Fatih Gordu; Joanne Chamberlain; Heather Barnes; 'Angel Martin'; 'Bob Knight'; 'Brent Goodman'; 'Brown, Amy'; 'Camilo Gaitan'; 'Carlos Herd'; 'Cliff Lewis'; 'Darrin Herbst'; 'Davis, Valerie'; 'Del Bottcher'; Douglas Durden; Douglas Hearn; 'Douglas P. Dufresne'; George Robinson; James Walters; 'Jeff Lehnen'; 'Jill McGuire'; 'Jim Gross'; 'Jim Kennedy'; John Fitzgerald; 'John Sloane'; klvanzant@gmail.com; Kraig McLane; Mike Register; 'OAWPCalendar'; parks.small@dep.state.fl.us; 'Paul Still'; 'Richard H. Hutton'; 'Rob Denis'; 'Ron Basso'; 'Ron Stewart'; Scott Laidlaw; Sherry Brandt-Williams; steipk@jea.com; Tammy Bader; Tim Cera; Tim Desmarais; 'Todd Kincaid'; 'Tom Bartol'; 'Tony Cunningham'; 'Trey Grubbs'; 'Ty Edwards'; ulan@umces.edu; 'Vivian Katz'; 'Webb Farber'; Wei Jin; 'Williams, Curt'; Yanbing Jia; Alisha B. Gipe; Gus@alachuacounty.us; 'Kennedy, Jim'
Subject: Request for NFSEG Model Calibration Statistics

Sherry/Tim/Fatih,

At the July 6, 2016 North Florida Southeast Georgia (NFSEG) Technical Team meeting, the Districts indicated they would like to have further discussions regarding the model calibration statistics LSG requested as part of May 27, 2016 and July 1, 2016 NFSEG Model review comments. To facilitate the production of this important model information, LSG has developed a streamlined list of requested calibration results and data.

We understand the Districts are currently making modifications to the MODFLOW and HSPF models based on internal and external comments received. Therefore, we propose that the information/data below only be produced for the next version of the NFSEG Model released to the Technical Team, and not the versions that have been published to date.

1) **Nash-Sutcliffe Coefficients**: Summary table of the Nash-Sutcliffe coefficients for stream gages used for the calibrations of the HSPF models.
2) **Average Daily Flows**: Simulated and observed average daily flow for the stream gages used for calibration of the HSPF models (tabular and graphical) for the period-of-record, 2001, 2009, and 2010.
3) **Average Yearly Flows**: Simulated and observed average yearly flow (including percent difference for each year) for the stream gages used for calibration of the HSPF models (tabular and graphical) for each year in the period-of-record.
4) **Daily Cumulative Frequency Distributions**: Simulated and observed daily cumulative frequency distributions for the stream gages used for calibration of the HSPF models (tabular and graphical).
5) **River Baseflows**: A summary of the average yearly modeled baseflows for 2001 and 2009 for all stream gages used for calibration of the river baseflows in the MODFLOW model. An example table is provided below.

Stream Gage Number and Name	2001 Observed/ Calculated Baseflow (MGD)	2001 Simulated HSPF Baseflow (MGD)	2001 Simulated MODFLOW Baseflow (MGD)	2009 Observed/ Calculated Baseflow (MGD)	2009 Simulated HSPF Baseflow (MGD)	2009 Simulated MODFLOW Baseflow (MGD)
Gage 1						
Gage 2						
Etc.						

6) **Closed Basin Recharge**: A summary of simulated and observed (or estimated target) average yearly recharge to the Upper Floridan aquifer associated with closed basin recharge, sinks, or injection wells represented with a Special Action in HSPF for the period of record, 2001, 2009, and 2010 as summarized in the example table below. Where a calibration target (qualitative or quantitative) was available for this parameter (e.g., Orange Lake sink), please provide the data used to develop the calibration target.

Closed Basin Recharge, Sink or Injection ID and/or Name	POR Historical Recharge (MGD)	POR Simulated Recharge (MGD)	2001 Historical Recharge (MGD)	2001 HSPF Simulated Recharge (MGD)	2009 Historical Recharge (MGD)	2009 HSPF Simulated Recharge (MGD)	2010 Historical Recharge (MGD)	2010 HSPF Simulated Recharge (MGD)
Orange Lake Sink								
Sink 2								
Etc.								

7) **Upper Floridan Aquifer Discharge Flows**: A summary of simulated Upper Floridan aquifer discharge to surface waters being represented as HSPF Inactive Groundwater Outflow (IGWO) from a virtual HSPF underground reservoir for the period-of-record, 2001, 2009, and 2010 as shown in the example table below.

Contributing Groundwater Capture Zone	POR Simulated Discharge (MGD)	2001 Simulated Discharge (MGD)	2009 Simulated Discharge (MGD)	2010 Simulated Discharge (MGD)
Ichetucknee River				
IGWO 2				
Etc.				

8) **Water Budget Parameters**: Consistent with the HSPF model results provided by District staff on May 19, 2016, simulated monthly and average yearly water budget terms for all HSPF model parameters (e.g., SUPY, PET, AGWO, AGWI, IGWI, etc.) for the period of record, 2001, 2009, and 2010.

If you have any questions, please let me know. We are happy to meet at your convenience to discuss the above.

Regards,

Brian

____
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