RESPONSES TO NFUCG COMMENTS AS LISTED IN THEIR "SUMMARY OF KEY CONCERNS" OF JULY 1, 2016

<u>The following comments were submitted initially on May 27, 2016, and attached to the comments submitted on July 1, 2016, as "Appendix A"</u>:

1. <u>Comment A12:</u>

   The NFSEG model is a large, complex model that is intended to improve upon and overcome limitations of previous models of the area. We think that a comparison of the NFSEG Model calibration to the calibration of other available models would be helpful for the Technical Team and other stakeholders to better understand the potential performance of the NFSEG Model. Therefore, we request the following:

- **An analysis comparing on an apples-to-apples basis (e.g., same area, same layer, etc) the calibration of the NFSEG Model to other available models used for the area (e.g., NEF Model, NF Model, MegaModel).**
- **Please provide and analysis comparing (apples-to-apples) the water budget of the NFSEG Model to other**

<u>Response</u>:

The NFSEG groundwater model was designed and constructed under the supervision of the NFSEG Technical Team. Important design features of the NFSEG groundwater model were enunciated in various documents presented to and approved by the NFSEG Technical Team, including:

1. The Goals and Objectives Technical Memo;
2. The Data Review and Analysis Report; and the
3. NFSEG Model Conceptualization Report

These reports are available on the NFSEG website. Taken as a whole, these reports provide a detailed description of the project objectives, the proposed model design, and model-development process.

The design of the NFSEG groundwater model was intended to address deficiencies in existing groundwater models. The following improvements, relative to existing models, have been built into the NFSEG model, in accordance with the project objectives:

A. Ability to evaluate inter-district and inter-state groundwater pumping impacts by positioning model lateral boundaries at great distances from the NFRWSP planning area, in many instances at the approximate physical limits of the system;

B. Improved methodology for determining rates of recharge and maximum saturated ET through the use of HSPF surface-water modeling;
C. Improved calibration process through use of PEST;
D. Enhanced calibration rigor obtained by matching water levels and flows to two calibration periods (calendar years 2001 and 2009) that represent significantly different hydrologic conditions;
E. Improved representation of aquifer-system hydrostratigraphy relative to that of Miller (1986);
F. Improved estimates of agricultural water use and domestic-self-supply water use;
G. Improved rigor in representation of dual-zone pumping wells through representation with the USGS MNW2 Package;
H. Expanded availability of water-level data in areas of limited data availability through implementation of sophisticated statistical techniques;
I. Improved representation of ET extinction depth that takes account of soil type and land cover;
J. Inclusion of additional calibration constraints not used in development of previous models, including: vertical head differences between adjacent aquifers, and horizontal-head differences between corresponding adjacent points in the same aquifer.
K. Collaboration with stakeholders by way of the NFSEG Technical Team throughout the development process.

Most of these improvements involve data, techniques, and computing power that were unavailable to builders of existing models. They have come at great cost to the Districts in terms of staff time, and in some cases, contractual dollars.

In summary, we believe that direct comparisons with other models are inappropriate due to (1) differences in the objectives and approaches of the NFSEG project as specified by the NFSEG Technical Team, (2) enhancements in the design and conceptualization of the NFSEG model, as noted above, and (3) enhancements in the availability of data used in the construction of the NFSEG model, also as noted above.

We believe that a better approach is to judge the NFSEG groundwater model by its ability to satisfy the project objectives using the procedures and approaches outlined and approved by the NFSEG Technical Teamincluding the ability of the NFSEG model to meet the calibration goals as specified by the NFSEG Technical Team. The objectives and approaches specified by the NFSEG Technical Team are consistent with industry-wide standards and practices. We view adherence to them as internally sufficient for assuring appropriate development of the NFSEG groundwater model.

2. Comment A13:

The NFSEG MODFLOW model has several areas in the NFRWSP region that appear to uniformly (or almost uniformly) overpredict or underpredict the UFA potentiometric surface by more than average. As shown in Figure A7, we note areas in Union, Bradford, Baker, Columbia and Clay Counties, and Putnam and Volusia Counties as having underpredicted potentiometric levels. While an area in Alachua County has overpredicted potentiometric levels. We would request that the Districts further evaluate these areas to improve the calibration.

Response:

The relatively large aquifer-layer-3 water-level residuals in areas of the model domain that correspond to Union and Alachua counties have been reduced to within an acceptable range (Figure ***1***). We achieved this by increasing the weights of these observations, and/or by adjusting the bounds of hydraulic conductivity of nearby pilot points in the PEST-calibration process.

Modification of the calibration process to address isolated instances of water-level residuals in excess of 5 feet, such as those corresponding to parts of Putnam and Volusia counties, may result in 'over-fitting', which can have a negative effect on the predictive capabilities of the model. Therefore, we did not attempt to address residuals in the parts of the model domain corresponding to areas outside of Alachua and Union counties, as the referenced residuals corresponding to those areas appear to be isolated in nature and therefore are not indicative of widespread problems.

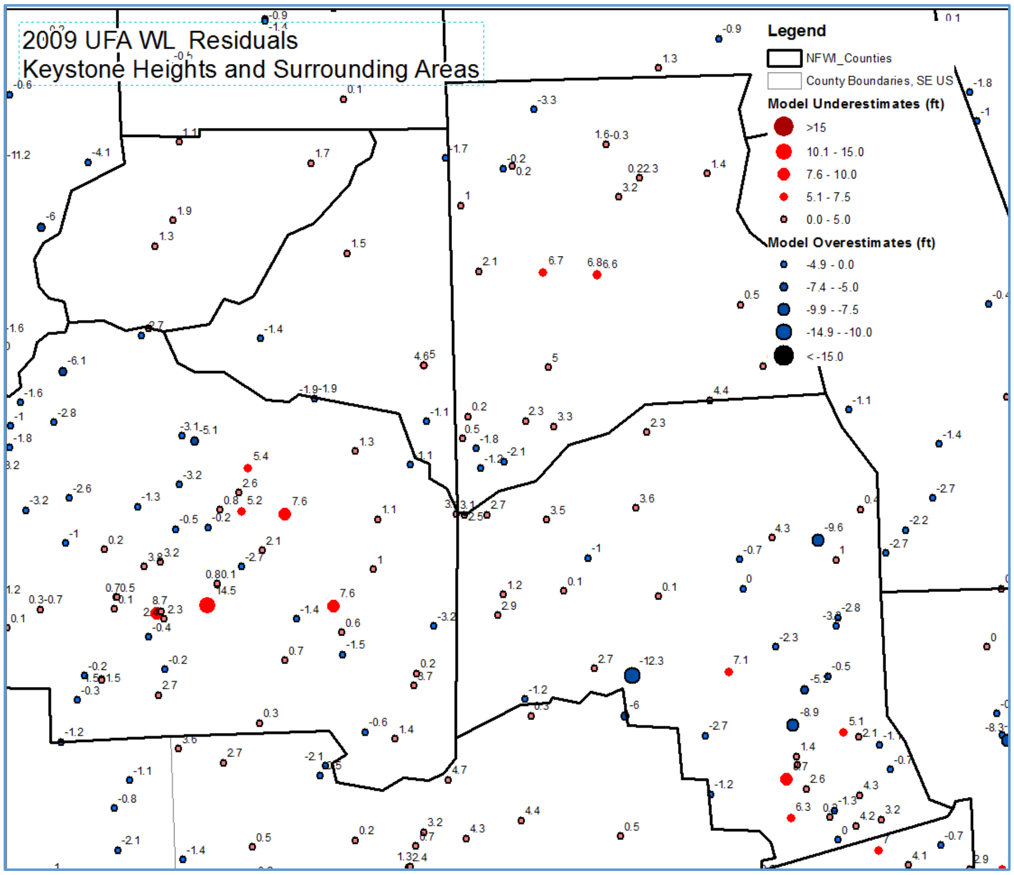

Figure 1. Current 2009 UFA Residuals, Keystone Heights and Surrounding Areas

3. <u>Comment A14:</u>

We request that the Districts provide more information on how the PEST calibration parameters for pilot points were developed. Specifically, we would like to understand how the geospatial distribution of pilot points (e.g., for UFA hydraulic conductivity) was determined and how the range of values was derived for each pilot point. We note that in some areas of the MODFLOW model, that there are significant differences in a small area in the PEST pilot point range used. For example, in Figure A8, in southeast Putnam County, there is a wide range in PEST pilot points for UFA hydraulic conductivity, which are driving the model hydraulic conductivity. For this area, please confirm that this pilot point arrangement is appropriate.

Response:

Using Groundwater Vistas, we first created a triangular mesh of pilot points based on observation-well locations. Gaps in the resulting mesh were filled at regular intervals of 25,000 or 125,000 feet, forming local grid patterns. Later, additional pilot points were added in areas of steep gradients in the potentiometric surface of the Upper Floridan aquifer, at APT locations, near springs, and at other locations where prior system knowledge appeared to warrant additional pilot points.

Assigned hydraulic-conductivity ranges are based on prior system knowledge. In some cases, APT results warrant smaller ranges. Where knowledge is lacking, however, wider ranges are applied. This process involves hydrological judgement and is therefore semi-qualitative in nature. It should be noted also that significant differences in the transmissivity of the Floridan aquifer system can occur over short distances because of its karstic nature and inherent heterogeneity.

In summary, the locations and upper and lower bounds of pilot points were set based on our best understanding of the groundwater system. However, these features are subject to change depending on the consensus of the NFSEG Technical Team.

4. Comment A15:

We request that the Districts provide additional information on how PEST was used to calibrate baseflows and springflows in the MODFLOW model. We appreciate the information provided to date on this; however, we require additional information to better understand how this information was utilized in the PEST calibration. For example, were spring (GHB) and river cell conductances individually calibrated, or were rivers and springs grouped with conductances adjusted by some relative method? In addition for "spring groups" were the individual springs also used for the calibration? Lastly, as shown in Figure B9, we are unable to reproduce the "observed" values provided for the LSFR spring group. Additional information to reconcile the difference noted would be appreciated.

Response:

Springs were calibrated individually, which is to say that each spring in the model had a corresponding target flow in the model calibration, and individual conductance values were determined for each spring. In regards to matching the discharge rates of spring groups, however, the simulated flux rates of individual spring vents were totaled for comparison to the observed total. These spring groups were added to the set of flow targets in key areas to emphasize the importance of the collective spring flows in these areas, and because reliable individual spring-discharge rates may not be available for individual springs.

In the case of river-package boundary conditions used to represent stream reaches, conductance was estimated initially based on the hydraulic conductivity of the surrounding aquifer. During the PEST calibration process, initial conductance values were subjected to adjustment by PEST through application of conductance multipliers. Conductance multipliers were developed on a sub-watershed basis, with all river-boundary segments within a given sub-watershed being subject to a common conductance multiplier.

Regarding the Lower Santa Fe spring group, we determined that some of the individual springs in the observation group should not have been present in the model, as these were 'resurgence' features, in which the dominant source of discharge is from swallets capturing upstream river flow. The PEST control file was updated to assign zero-valued weights to the individual targets for these resurgences, and zero-valued (fixed) GHB conductances to these features.

5. Comment A16:

Please explain how the Keystone Heights region was calibrated in the MODFLOW model. Specifically, how were lake levels (or levels/conductances/fluxes at lake boundary conditions), creek flows, and the surficial aquifer calibrated (e.g., what parameters were varied, what data were used, etc.)?

Response:

Lake levels, which are represented with river-package boundary conditions, are fixed, not simulated. No base-flow estimate was available for Alligator Creek, so no matching of simulated to estimated base flow was performed. The primary observation group for this area is aquifer water level, both surficial and Upper Floridan, and lake leakage rates. Leakage rates between the major lakes in this area and the groundwater system were estimated using data obtained from numerous past studies, and the simulated rates determined using river-package boundary conditions were extracted and compared with these estimates. We were able to match observed groundwater levels very well. Simulated lake leakage rates fall within the expected range of estimated lake leakage rates (Figure ***1*** and Table 1).

Lake	Leakage to the UFA	
	Simulated	Literature
Lake Magnolia	33 - 43 in/yr	16 - 113 in/yr
Lake Lowry	34 - 35 in/yr	28 - 89 in/yr
Lake Geneva	4 - 14 in/yr	7 - 13 in/yr
Lake Brooklyn	60 - 90 in/yr	36 - 100 in/yr

Table 1. Simulated and Estimated Leakage Rates of Selected Lakes (inches/year)

6. Comment A17:

   Recharge to MODFLOW is derived as an output from the HSPF models. In our review of MODFLOW recharge input, significant discontinuities in recharge occur in some locations along HSPF model boundaries. As shown in Figure A10 and Figure A11, one such area is in Union and Bradford Counties where the Lower St. Johns River, St. Mary's River and Santa Fe River HSPF models converge. Please explain the differences in MODFLOW recharge in this area.

   Response:

   The problems with the HSPF models that you are referring to were corrected. Noticeable discontinuities in the recharge distributions have now been minimized or eliminated (Figure 2 and Figure 3). Please review the responses to the HSPF comments for details.

Recharge 01

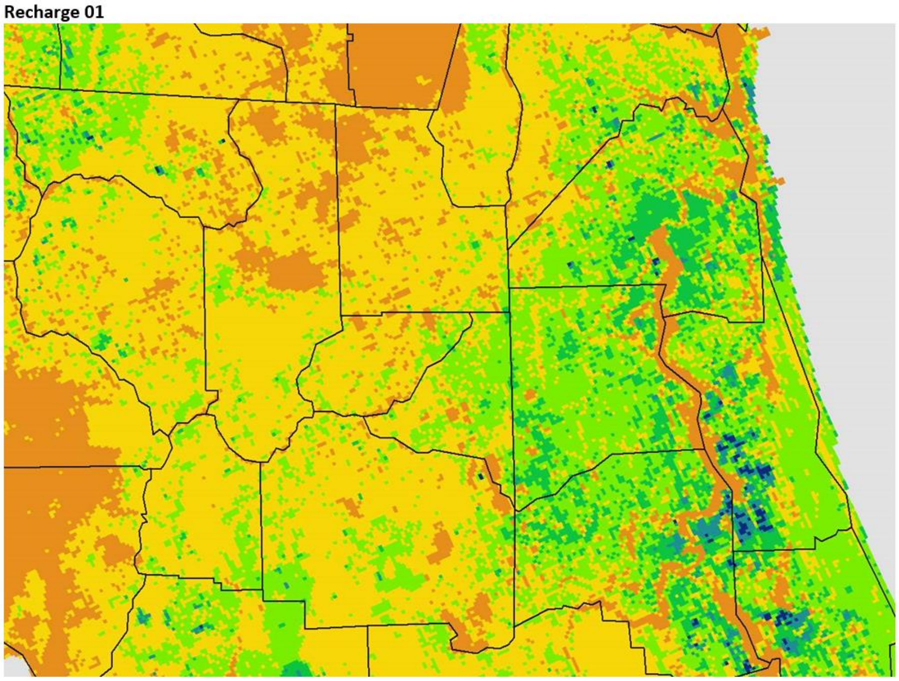

Figure 2. HSPF-Derived NFSEG Recharge Distribution, 2001

Recharge 09

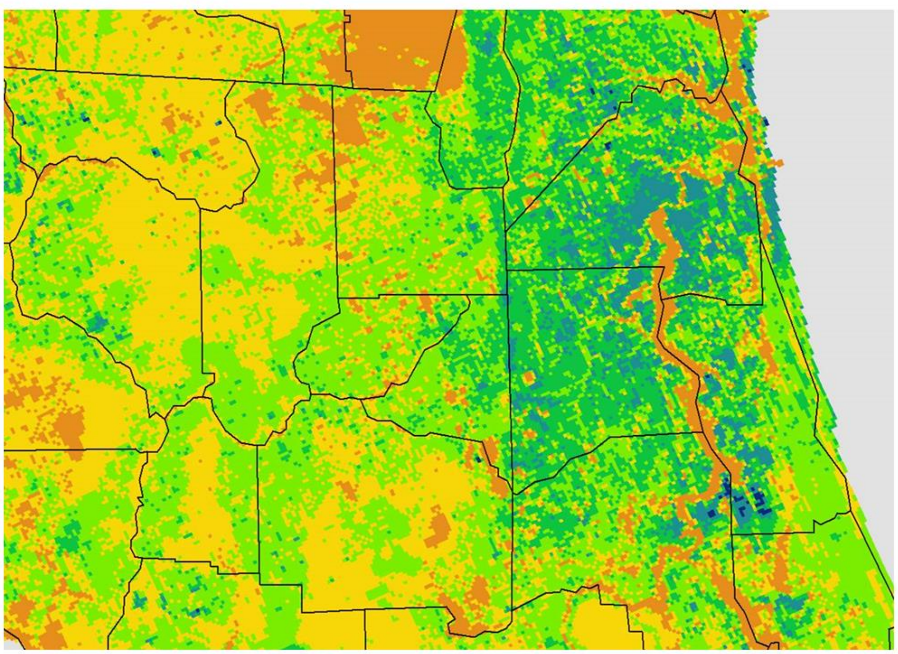

Figure 3. HSPF-Derived NFSEG Recharge Distribution, 2009

7. Comment A18:

The HSPF Models developed by the Districts were used to calculate the recharge and maximum saturated ET to use in the MODFLOW Model. However, the HSPF Models were also used to estimate baseflow targets for rivers and streams represented in the MODFLOW Model. Approximately 328 streamflow gages appeared to have been used to generate results from the HSPF Models. It also appears that 166 of the 328 gages were used in the PEST calibration process; however, many of these 166 PEST gages are noted as not being used. Ultimately, from the information provided, it appears that less than ten gages may have been used as baseflow targets in MODFLOW. Please provide a detailed listing of which gages were used to calibrate baseflows from the MODFLOW Model (for each year).

Response:

Two base-flow observation groups are employed in the NFSEG calibration process: (1) the pick-up group, which represents either the change in the baseflow between adjacent stream gages, or the baseflow at the downstream end of reaches that have a downstream gage but lack an upstream gage; and (2) the cumulative group, which represents the total baseflow at a given stream gage that occurs along a reach that has multiple upstream gages. . Cumulative estimates (targets) were used in basins for which calibration to base flow was considered to be more critical, or to provide a cumulative baseflow target for a larger area of the model domain. Examples include the Suwannee and Santa Fe River basins. The number of pick-up estimates for 2001 was 85, and the number for 2009 was 92. In many cases, baseflows from more than one station (often several) were needed to define an observation in the 'pickup' group. This results in having fewer pickup observations than gaging stations. The number of (non-zero weighted) cumulative targets for 2001 was 10, and number for 2009 was 6.

Estimation of reliable base-flow rates proved difficult in many cases. Less reliable base-flow estimates were de-emphasized in, or eliminated from the calibration process. The NFSEG model calibration process still includes a large number of baseflow estimates, as well as a robust set of other observation groups, however; so the having fewer baseflow estimates than theoretically possible (given the number of available gages) did not necessarily prevent adequate model calibration in critical areas of the model domain. The other observation groups include groundwater levels, spatial water-level differences, and spring discharge rates. Please also read the response to comment A19 in this regard.

8. Comment A19:

It is our understanding that the Districts' original intent was to use river and stream baseflows calculated from the HSPF Models as targets in MODFLOW. However, as presented to the Technical Team, issues were identified by the District with some of the HSPF baseflow estimates. As such, alternative methods to estimate baseflow were utilized for many streams and rivers. Based on the information provided by the District, it appears three methods may have been used to estimate baseflow, including "HSPF," "observed," and "PART." At the next Technical Team meeting, please review the methods used to develop baseflow and the reasons why the alternative methods were developed.

<u>Response</u>:

Three different approaches were used to estimate base-flow rates. They are listed here in order of the relative reliability of the resulting estimates. For cases in which stream flow (or change in stream flow along a given reach) was dominated by groundwater discharge, we used the observed streamflow (or change in streamflow) as the estimate of the base-flow rate. For cases in which stream-flow observations were available but were not dominated by groundwater discharge, we used the HSPF modeling results or USGS baseflow-separation program, PART, to estimate baseflow. In these cases, baseflow was estimated as the product of (gaged) streamflow and the ratio of HSPF-simulated baseflows to HSPF-simulated streamflow if the HSPF results were considered to be suitable for this purpose; otherwise the estimates from PART were used, if deemed acceptable. Finally, if the above criteria were not met, we used HSPF-simulated baseflows as our targets, but assigned them a, lower weight. Zero or low weights were also assigned to baseflow estimates derived from gages located on stream reaches that appear to be tidally affected, as determined by review of streamflow hydrographs. A zero weight was also assigned to base-flow estimates derived for gages with watersheds not fully encompassed by the NFSEG active model domain.

9. <u>Comment A20:</u>

On several occasions, the Districts have indicated that the current version of the NFSEG Model should be considered a "regional planning" model. However, the Districts have not provided detailed information on how the NFSEG Model will be used in the planning process (e.g., specific simulation information, etc.) We understand that the District is in the process of developing these simulations and defining necessary model outputs. As part of the Technical Team's review of the NFSEG Model, it would be useful to have more detail on how the model will be used as soon as possible. Since the NFSEG Model is an evaluation tool, this information is critical to better understand if the model tool is suitable for the intended use.

<u>Response</u>:

As discussed in past Technical Team meetings, the version of the NFSEG groundwater model being reviewed by the Technical Team currently will be used for planning purposes only. Information on planning simulations were presented at the February 3, 2016 Tech Team Meeting.

10. Comment A21:

As discussed during the May 11, 2016 Technical Team meeting, please provide a summary of how future increased recharge (e.g., irrigation, RIBs, Sprayfields, etc.) will be developed and represented in the model for planning simulations.

Response:

The proposed methodology and initial results for estimating future return flow was presented and discussed at the NFSEG Technical Team meeting on August 3, 2016.

11. Comment A22:

Are the Districts developing tools and procedures to evaluate specific water resource constraints (e.g., the Lower Santa Fe River and the Ichetucknee River). When will they be available for review?

Response:

With regard to evaluating flows, the referenced tools are Python programs developed by SRWMD for extraction of base-flow rates at gage sites in the NFSEG model domain, including those on the lower Santa Fe and Ichetucknee rivers. We have since provided these tools for your use in response to the present inquiry.

12. Comment A23:

When will the Districts review the simulations being performed in support of the NFRWSP with the Technical Team?

Response:

We presented simulation plans at previous NFSEG Technical Team meetings. We will provide additional details as they develop.

The following comments were submitted on July 1, 2016:

13. Comment 17:

In previous comments, it was noted that in some areas of the MODFLOW model there are significant differences in the PEST pilot point range used across small areas. The example area provided was in southeast Putnam County where there is a wide range in PEST pilot points for UFA hydraulic conductivity that appear to be driving the model calibrated hydraulic conductivity. This PEST setup led to maximum UFA hydraulic conductivities of 5,000 ft/day in an area where APTs have measured hydraulic conductivities on the order of 10s and 100s of ft/day.

LSG has broadened the review of the pilot point ranges being used to calibrate the MODFLOW model. Figure 13 presents the calibrated hydraulic conductivity of the UFA and a summary of the calibrated hydraulic conductivities compare to the pilot point ranges assigned to the model.

As can be seen, most of the areas of the groundwater model with highest UFA hydraulic conductivity coincide with areas where the PEST calibration process utilized the highest hydraulic conductivity allowed. As such, the calibration is being influenced by the pilot points ranges assumed for calibration. Because the pilot point assumptions appear to be critical to the calibration, please confirm the appropriateness of the assumed pilot point ranges in these areas.

<u>Response</u>:

The specified upper and lower bounds of hydraulic conductivity are based on prior system knowledge (e.g., numerous prior studies, APT results, etc.). Hitting upper bounds is not necessarily undesirable, as upper bounds are still within what is considered a reasonable range based on available information. Allowing PEST to go beyond specified bounds would of course result in a different set of hydraulic conductivities within the areas of influence of the pilot points in question and maybe a closer fit to observed data. However, obtaining a better fit is not a fair trade-off for allowing PEST to introduce unreasonable calibration-parameter values into the model. (Please also see our response to Comment A14 above).

If you have information indicating that the currently specified bounds are not reasonable in specific instances, please provide this information for discussion and resolution. To the extent that hitting the upper bounds is indicative of parameter uncertainty or might imply that other unknown factors are influencing results, uncertainty analysis is currently being performed to address such concerns.

14. <u>Comment 18:</u>

To what degree was manual calibration performed before the PEST calibration was implemented? Was manual calibration limited to specific geographical areas, aquifer systems, or hydrogeologic parameters? Please provide a description of any manual

calibration performed. Also, to the extent manual calibration was performed, please provide the manually calibrated model input and output files.

Response:

Prior to PEST calibration, a process of extensive testing was undertaken to gage the sensitivity of the NFSEG groundwater model to changes in hydraulic conductivity and other model parameters and to aid in the determination of reasonable ranges for these parameters. This process was used as well to assess the workability of the various lateral and internal boundary conditions and other model features and to affect necessary improvements or corrections. The following benefits were derived from the preliminary testing and sensitivity analysis:

1. Improved understanding of the hydrological system;
2. Improved knowledge of model sensitivity to changes in hydraulic conductivity and other parameters;
3. Improved understanding of potential ranges of horizontal and vertical hydraulic conductivity within model layers;
4. Improved understanding of model numerical requirements, resulting in improved numerical stability and performance through implementation of MODFLOW-NWT;
5. Corrections of and/or improvements in model features.

The analysis involved matching model-simulated water levels and spring discharges to corresponding observed or estimated values throughout the model domain. The groundwater flow system was approximated as steady-state in this analysis, and matching was carried out to 2001 and 2009 median observed conditions. The analysis culminated in a high level of consistency between simulated and observed water levels and spring discharges throughout the model domain for both 2001 and 2009information.

It should be noted that a number of outstanding issues remained after this initial testing effort (it was not intended to be a final product from the NFSEG project), and this process did not include matching to the following observation groups, which were introduced later in the PEST-calibration phase of model development:

1. Vertical head differences;
2. Horizontal head differences;
3. Base flows;
4. Numerous spring-flow observations that were unavailable in the early phase of model development. The spring flows in question were primarily of small-magnitude springs.
5. Lake leakages

15. <u>Comment 19:</u>

On June 15, 2016 the Districts provided the computer program and associated configuration files that the Districts are using to extract simulated river and springflows from the NFSEG groundwater flow model for calibration and output processing. For the Santa Fe River at the Ft. White gage, the program extracts predicted flows from the River Nodes (representing river baseflow from the surficial aquifer) and General Head Boundary (GHB) Nodes (representing springs) used to represent the Santa Fe River upstream of Ft. White in the NFSEG groundwater flow model. Upon review of the results, the program does not appear to be accurately calculating Santa Fe River flows from MODFLOW. The program also appears to be inaccurately compiling MODFLOW results for other river systems, but specific issues for the Santa Fe River are described below.

Figure 14 attached presents the River Nodes and GHB Nodes in the NFSEG groundwater flow model and the River Nodes and GHB Nodes the program provided by the District designates as being associated with the Santa Fe River upstream of Ft. White. From review of the attached figure, there appears to be River Nodes that are not in the Santa Fe River system that the program provided by the Districts appears to be associating with this system. Conversely, there are River Nodes and GHB Nodes that are on the Santa Fe River system that the program does not appear to be associating with this system. It was also noted that the program appears to only be extracting predicted flows from River Nodes in Layer 1 of the model, though several river systems represented in the NFSEG groundwater flow model also have River Nodes in Layer 2 of the model. Please confirm that the output compiling program is extracting the correct flow information for each river system and that the correct predicted flows for specific river and spring systems were used in the calibration process.

<u>Response</u>:

This issue was investigated by spot checking some of the features that you identified in figure 14 of your review comments. For example, in that figure, the River Package feature in cell (1,620,364) was identified as being incorrectly assigned to the Lower Santa Fe River, instead of near a small tributary to the St. Johns River. This inference appears to be based on the (understandable) confusion of the ‘Reach number’ in the Groundwater Vistas (GWV) file (which was 3088 in this case) with the third column in the gaged-reach definition file, which is an input file to one of the postprocessing programs used to extract simulated fluxes from the MODFLOW output. It appears that the Reach number value in the GWV file is the unique, ‘3-dimensional’ identifier for this River Package boundary condition feature. This is different than the identifier in the input file to the postprocessing program (which is a ‘2-dimensional’, ‘map-view’ identifier). When the location of 2-dimensional River Package feature 3088 was manually checked, it was located in cell (1, 563, 243) which occurs in the reach of the Santa Fe River upstream of the Fort White gage (as it should be). It was also cross-referenced correctly to record 3120 of the River Package input file (through another another input file to this postprocessing program). One of the GHB features that was shown in figure 14 was also examined. This feature had a GWV reach number of 351, which (for GHB features) is the same as the identifier used in the gaged-reach definitions file. When the assignment of this feature in the gaged-reach definition file was checked, it was found to be correctly assigned to the individual spring with id, s141707001, and also correctly assigned to gaging station, 2313700 Waccasassa River near Gulf Hammock (not gaging station 2322500 Santa Fe River near Fort White). It was also cross-referenced correctly to record, 2690, in the River Package input file and MODFLOW listing file. Therefore, this does not appear to be a problem with the postprocessing of fluxes to river reaches. Please also refer to response number 4 above (response to your comment A15).

16. Comment 20:

As part of previously submitted comments it was noted that approximately 328 streamflow gages appeared to have been used to generate results from the HSPF Models, 166 of the 328 gages were used in the PEST calibration process, but that less than 10 gages may have been given full weight in the calibration of river baseflows in MODFLOW. To the extent that changes in MODFLOW predicted river baseflows will be a key output from the NFSEG Model, we suggest that a more robust calibration of the rivers represented in the groundwater flow model is required to ensure that it produces reliable results.

Response:

Please review response number 7 above (response to your comment number A18). We would add that we have reviewed our treatment of base flows and that we feel that it is generally as good as can be expected in view of uncertainties associated with the baseflow estimates. If you have suggestions for improvements in regards to specific instances, please provide that information to the Technical Team for discussion and resolution.

17. Comment 21:

Along the Suwannee River and Santa Fe River, overlapping boundary conditions and other potential issues with the hydrologic boundary conditions have been identified. Several figures are provided to illustrate the concerns, but the issues extend beyond the specific areas provided.

Figure 15 attached presents a segment of the Santa Fe River basin that demonstrates some of the potential issues that have been identified. Using this figure as an example, LSG has the following questions regarding the hydrologic boundary conditions used in the model:

Along the Santa Fe River, there are often overlapping boundary conditions that appear to be conflicting with one another. Figure 15 presents three examples. The northernmost example has four River Nodes in one cell; one in Layer 1 and three in Layer 2. The stages set in the River Nodes vary from 47.04 feet to 52.11 feet. The river bottom elevations set in these River Nodes vary from 31.66 feet to 45.71 feet. Riverbed conductance values set in these River Nodes range from 0 feet/day to 1.64 feet/day. Based on this information, we have the following questions:
How were River Node stages and bottom elevations set? If overlapping boundary conditions are going to be maintained, we believe the river stages should be set at the same elevation in these River Nodes. In this particular example, the river stage predicted by the model is 53.6 feet. Based on this result, it appears the calculated stage in this cell is being driven by the River Node stage assignment of 52.11 feet. This is creating a "hump" in the calculated river gradient as the calculated river stage upstream and downstream of this cell are lower than 53.6 feet. Why are conductance values of 0 feet/day being used? This occurs in several river cells.

The next example has three River Nodes and one Drain Node in one cell; all located in Layer 1. The stage set in the River Nodes is consistently 37.99 feet, which appears conceptually appropriate. However, the river bottom elevations set in the River Nodes range from 36.91 feet to 37.69 feet. This indicates the river depth in this location is as low as 0.3 feet. Please confirm the river bottom elevations being used in this location. The riverbed conductance values set for in these three River Nodes ranges from 37.55 feet/day to 28,828 feet/day. Why is there such a broad range of conductance values set in the River Nodes in this location? The Drain elevation in this location is set at 46.16 feet with a conductance of 100,000 feet/day. In this case, the Drain Node does not appear to be interfering with the River Nodes.

The third example has four River Nodes located in Layer 1. The river stages set in these River Nodes vary from 38.94 feet to 50.55 feet. The bottom elevations set in these River Nodes vary from 37.21 to 49.98 feet. Why do these values vary by over 10 feet, and why is the river bottom elevation set in some River Nodes higher than the river stage set in other River Nodes? The conductance values set in these River Nodes vary from 3,141 feet/day to 12,540 feet/day. Why is there such a broad range of conductance values set in the River Nodes in this location?

Figure 16 presents a segment of the Upper Suwannee River as represented in the NFSEG groundwater flow model. Using this figure as a second example, LSG has the

following questions and comments regarding the hydrologic boundary conditions used in the model:

There are segments of the Suwannee River with Layer 2 River Nodes, but no Layer 1 River Nodes. Why are the Layer 1 River Nodes discontinuous in this (and other) locations? What does this conceptualization represent? What process was used to define the assignment of rivers to the hydrostratigraphic layers represented in the groundwater flow model?
In Figure 16, the assigned Layer 1 River Node stage and simulated Layer 1 heads have been added in red and black text, respectively.

"Humps" in the assigned stages can be observed along the Suwannee River.
There are Layer 1 River Node stages set to 0 feet. There are multiple cells with overlapping hydrologic boundary conditions.

Figure 17 presents a segment of the Upper Suwannee River, just downstream of the segment presented in Figure 16, as represented in the NFSEG groundwater flow model. Using this figure as an example, LSG has the following questions and comments regarding the hydrologic boundary conditions used in the model. There are Layer 1 River Node stages (presented in red text) that are set to 0 feet.

Though we understand the groundwater head in Layer 1 (presented in black text) is not necessarily going to converge to the assigned stage of the Layer 1 River Node, we would expect the calibrated heads and assigned stages to be reasonably close, particularly if the assigned stages were based on historical data. There are cells presented in Figure 17 where the calculated head in Layer 1 is over 20 feet different than the assigned stage of the Layer 1 River Node. Please explain why the Layer 1 calculated heads are sometimes notably different than the assigned stages of the Layer 1 River Nodes. There are multiple cells with overlapping hydrologic boundary conditions.

The above represent just several examples of potential issues associated with hydrologic boundary conditions set in some areas of the model. In addition to the questions above regarding assigned river stages, river bottom elevations, and riverbed conductance values, the following general questions were also developed based on this review of the hydrologic boundary conditions.

In some model cells, there are GHB Nodes set in Layer 3 to represent springs. These spring GHB Nodes are sometimes located in the same cell as Layer 1 and Layer 2 River Nodes. Have the spring pool elevations set in the GHB Nodes been compared to the stages set in overlapping River Nodes and evaluated to determine how any potential differences in these set stages are influencing the results?

A segment of the Santa Fe River from Oleno State Park to just upstream of the City of High Springs is underground. In the NFSEG groundwater flow model, this segment of the River is represented with River Nodes in Layer 1. We understand the inherent complexity of representing this system in the model; however, can the Districts please provide additional information on the conceptualization of this segment of the river and the sensitivity of the results to this conceptualization?

Response**:**

The general approach for representing streams in the model involves the following concepts:

1. NHD flowlines were used to represent the paths of streams;
2. NHD flowlines have associated Strahler-Order numbers. Flowlines with Strahler Order of 2 or greater were represented with the river package, as these are assumed to correspond to perennial stream reaches. Flowlines with Strahler Order of 1 were represented with the drain package, as these are assumed to correspond to ephemeral stream reaches.
3. As it is possible to have of NHD flowlines of Strahler Order 1 and 2 and above in the same MODFLOW grid cell, both river-package and drain-package boundaries can be assigned to the same grid cell in this approach.
4. In the present version of the model, some aspects of the river-package and drain-package representations of the NHD flowlines are handled differently, although the processing for both features is conceptually consistent.
5. In the case of the river package, the NHD flowlines are intersected with the MODFLOW grid to form flowline sub-segments. Within grid cells, the resulting sub-segments are further sub-divided at stream confluences.
6. An elevation for each of the resulting sub-segments is computed by averaging all of the 3DEP DEM (http://nationalmap.gov/3DEP/index.html) elevation values in 3DEP DEM grid cells that intersect each flowline subsegment. Mathematical functions from the EPA Basins watershed analysis tool (https://www.epa.gov/exposure-assessment-models/basins) were then used to translate these elevation values into estimates of stream water-surface bottom elevations.
7. After determining the stream water surface-surface and bottom elevations, the model layer(s) occupied vertically by a given stream sub-segment are determined by comparing the stream surface and bottom elevations to the top and bottom elevations of model layers 1 through 3 of the grid cell in which the sub-segment is located.
8. In most cases, the top and bottom of the sub-segment fall within a single model layer. In such cases, a single line of input in the river-package input file is used to represent the sub-segment in each stress period.
9. In some cases, the sub-segment surface and bottom elevations straddle more than one model layer (e.g., the surface is in layer 1 while the bottom is in layer 2). In such

cases, two separate river-package inputs must be created for the sub-segment in question.

10. In some cases, the surface of the stream is determined to be below the bottom of model layer 1, so the river-package representation of the sub-segment is assigned to model layer 2 or 3, as the case may be. In such cases, no representation is assigned to model-layer 1.
11. Given this approach, it becomes apparent that multiple river-package boundaries can be assigned to the same grid cell.

12. The approach used for Strahler-Order 1 NHD flowline sub-segments (which are represented using the drain package) is identical to that described above for the River Package (Strahler-order 2 or greater) features, except that typically one drain boundary condition feature is created in a give MODFLOW grid cell. The elevations of these features were computed as the length-weighted average elevation of the Strahler order 1 flowline subsegments occurring within a given MODFLOW cell.

As stated previously, it is possible for Strahler-Order 1 and Strahler-Order 2 and above flowlines to be located within the same grid cell. Hence, it is possible to have both river-package and drain-package boundaries (as well as GHB, Well, and other boundary-condition features) in the same grid cell. The presence of multiple boundary-condition features of the same or different types in a given MODFLOW grid cell reflects the fact that multiple hydrologic features (corresponding to these boundary-condition features) occur in the real world, and these features will often have different stage, thalweg, conductance, or other values.

Regarding conductance values, the initial conductance value for each river-package boundary within a PEST iteration is based on the horizontal and vertical hydraulic conductivity of the grid cell to which the river-package boundary is assigned. These values are subject to modification in the PEST calibration process through use of conductance multipliers, as discussed in response number 4 above.

We have updated the river stages and bottom elevations after model layer 1 top elevation was updated to incorporate the latest USGS 10-meter elevation data set. Each river and drain boundary is assigned a unique reach ID in the present approach. To prevent updated entries from delaying the PEST-calibration process, we assigned values of zero conductance to river-package boundaries that are no longer active. This is why input lines with zero conductance are present currently in the river-package input file. In the next version of the NFSEG model, these river boundaries will be removed.

18. <u>Comment 22:</u>

Riverbed conductance in MODFLOW is intended to simulate the hydraulic conductivity of the soil material present at the bed of a river, which could be different than the hydraulic conductivity of the soil material in the aquifer system beneath or adjacent to

the river. Figure 18 presents riverbed conductance values set in River Nodes representing the Santa Fe River and Ichetucknee River systems. It was noted that the riverbed conductance values set in some River Nodes can be on the order of millions of feet per day and in excess of 70,000,000 feet per day in some cells along the Santa Fe River. These riverbed conductance values appear unrealistically high and will significantly affect the change in flow predicted in these River Nodes.
Please review the riverbed conductance values assigned to the MODFLOW groundwater flow model and confirm the reasonableness of these values. Please provide the limits being assigned to riverbed conductance values being assigned to the PEST calibration process. Please note that the legend for Figure 18 presents riverbed conductance values in excess of 1 billion feet/day that are not shown on the figure. These values are located elsewhere within the model domain and generally appear to be located in areas where the Hawthorn Formation is not present.

Response:

The conductance of the River Package is a function of the effective conductance along a flowpath that connects the river bottom and the centroid of a given MODFLOW grid cell. In the NFSEG model, River Package conductance is computed initially using the hydraulic conductivities of surrounding aquifer. River Package conductance values are then updated during the calibration by multiplying the intial conductance values by river conductance multipliers (assigned to each sub-watershed) that are adjusted by PEST. In other words, we let the calibration determine whether the conductance of river bed is different than the hydraulic conductivities of the surrounding aquifer. It should be noted that conductance is not only a function of hydraulic conductivity but also a function of river channel geometry and the length of the river segment. Because of this, its unit is square feet per day (which is not the same as hydraulic conductivity). Therefore, it should not be compared directly with the hydraulic conductivities since it can easily be 10 or 100 times (or more) higher than the hydraulic conductivities of surrounding aquifer depending on the channel geometry and length. In addition, in some river systems such as Santa Fe river, the river system is dominated by springs and other karst features (for example,a portion of the river goes underground and essentially becomes part of the aquifer system). In such systems, it is not uncommon to see high river-boundary conductance values. Some conductance values greater than 1 billion of the model were present in the westernmost area of the draft version of the model. The largest conductance values in the most recent version of the model are on the order of half a billion, and many of the features that had conductances greater than 1 billion are now much lower (on the order of 10,000 to 1,000,000 square feet per day) after making some corrections in the western area of the model.

19. Comment 23:

The flows for Gainesville Regional Utilities' (GRU's) recharge wells at the Kanapaha Water Reclamation Facility are not correct in the latest version of the model.

Response:

These well recharge well flows have been corrected.

20. Comment 24:

It was generally noted that the injection well flows associated with sink features represented in the NFSEG groundwater flow model (e.g., the sink at Orange Lake) appeared to have notably changed between the preliminary version of the model released in October 2015 and the current version of the model release in May 2016. How are these flows being calculated and why did they change between the two versions of the model?

Response:

A number of HSPF calibrations have been performed since October 2015. Estimated flows to sinks have changed as a result.

21. Comment 25:

Appendix A and Appendix B provide comments previously submitted by LSG during of review of the NFSEG Model. We look forward to resolving all outstanding comments previously provided with the Districts.

Response:

Appendix B comments were addressed prior to the most recent NFSEG Technical Team meeting (July 6, 2016). As for Appendix A comments pertaining to the MODFLOW model, see responses 1 through 12 above.

22. Comment 26:

As noted in an email to District staff on June 1, 2016, we found a few potential minor issues with the NFSEG groundwater model as follows:

- **Cell R368 C153 in Layer 5 is inactive**
- **Extinction depth is different in 2001 and 2009 in Cell R635, C405.**

The following are noted as RIBs (recharge) but they are negative flows (withdrawals) in the WEL file:

- **Sunny Hill Plantation Well Number 001**
- **Camp Kulaqua, RIB**

Response:

These problems have been corrected.

23. Comment 27:

We have previously noted the importance of having a model which can be fully utilized and reviewed by third parties. In previous comments during the review period, we noted that a key component(s) of the NFSEG Model used to couple the HSPF models with the MODFLOW model could not be readily run by stakeholders. At that time, we requested that the Districts' provide this component to the Technical Team in a form that could be more readily utilized.

As of the date of these comments, the component(s) have not been provided to the Technical Team. As a result, we have been unable to review the execution of the process used to couple the models via the transformation of HSPF model output for use as MODFLOW input. We also have no written documentation on this process so we have been unable to evaluate it at a conceptual level. Therefore, we are unable to render an opinion on the suitability of this coupling process.
We believe that this coupling process is a key component of the NFSEG Model. As a result, a thorough review of this process must be a part of the review process.

Response:

Although the recharge and maximum saturated ET did not need to be adjusted during the calibration of NFSEG v1.0, the intent of HSPF models was to develop the initial recharge and maximum saturated ET estimates for the groundwater model. Therefore, we do not consider the NFSEG model to be a coupled surface/groundwater model because these models were calibrated separately and were never executed simultaneously as part of a given model run. A Groundwater Vistas file and MODFLOW model files (which can easily be run and reviewed by any third party who has MODFLOW modeling experience) was provided to the Technical team to facilitate the model review. HSPF models were provided to the Technical Team on May 2, 2016, for review as well. HSPF models can also be run and reviewed by any third party who has HSPF modeling and Linux experience, and both sets of software are available in the public domain). However, we understand that stakeholders may not have much experience with running the programs in Linux environment. Therefore, a virtual desktop was created to address this issue. The files and the instructions to install and run the files are included in the model delivery package

24. Comment 28:

What is the schedule for the completion of the 2010 verification simulation? When will the results of the verification simulation be provided to the Technical Team for review? 14

Performance of a verification simulation is included in the NFSEG Model Work Plan as a task to be completed before use of the model for predictive simulations.

Response:

We expect to perform the 2010 'verification simulation' before the completion of the next version of NFSEG (NFSEG v1.1) which will be used for MFL and regulatory evaluations. It should be noted that conducting such a simulation is not essential for completing the development of version 1.0 of the NFSEG model.

25. Comment 29:

As documented in the approved NFSEG Work Plan and due to the importance of the NFSEG Model, a robust parameter sensitivity analysis was identified as a key analysis to be performed during the development of the NFSEG Model. What is the schedule for the completion of the parameter sensitivity analysis? When will the results be provided to the Technical Team for review?

Response:

A sensitivity and predictive uncertainty analysis was conducted. Please see the groundwater modeling document for details of the analysis.