**3.A. RESPONSES TO CRITICAL QUESTIONS FOR MODFLOW**

**(Answers to Task D.2 Questions #1A-D, #2A-F, and #3A-J:)**

**1. Model Documentation Provided by WMD’s:**

**A. Does the documentation provide a clear and appropriate description of the NFSEG groundwater flow model and supporting HSPF surface-water models?**

**Yes**, the MODFLOW documentation is quite extensive and well written. There are some additional items discussed in the chapter-by-chapter review that need clarification and a number of editorial comments and suggestions that are included in this report. However, this should not take away from the overall assessment of the peer review panel that this documentation provides a clear and appropriate description of the NFSEG groundwater flow model and supporting HSPF surface-water models**.**

**B. Are the purposes and scope of the documentation clearly stated and sufficient to document the models? Is the content of the documentation consistent with the stated purpose and scope of the document?**

**Yes,** the purposes and scope of the NFSEG MODFLOW model are clearly stated in the report, and the documentation provides analyses and results consistent with the stated purpose. However, the Purpose and Scope section contains additional information that is background material. It would be clearer if the background information were placed into a Background section immediately prior to the Purpose and Scope section.

**C. Is the documentation readable? Are the figures clear? Does the format of the documentation need to be modified or expanded?**

**Yes,** overall, the MODFLOW documentation is quite readable, the figures reflect what they are intended to show, and the format is consistent with that of a well written modeling report. However, there are some specific issues that need to be addressed. Some figures need additional technical information added (the specific items are listed in the chapter-by-chapter review), and some geographic features and places that are named in the text do not appear on any figure (a list of these is included in the editorial corrections and suggestions section of this report).

**D. After reading the documentation, are the purposes, scope, strengths/weaknesses, intended use, and limitations of the NFSEG model understandable?**

**Yes,** the purposes and scope of the MODFLOW model are well described and understandable in the report. The strengths and weaknesses of the model and its intended use and limitations are discussed in Section 8 Model Limitations. The report is very well done, and it should be easily understood by other groundwater modelers and stakeholders.

**2. Model Implementation:**

**A. Is the conceptual model appropriate for the intended use of the model? For example,**

**are critical physical and hydrologic processes represented appropriately?**

**Yes,** the conceptual model for MODFLOW, which is described by Durden et al. (2013) in a separate report, does a good job of describing the physical structure of the aquifers. However, neither that report, nor this report, sufficiently discusses the springs and the baseflows in the rivers. The baseflow discussion is too short, and for the intended use of this model, a thorough documentation and understanding of the baseflows is very important. In addition, ASTM (2018) (also see response to Question 3.J.5) recommends that the error range associated with each calibration target be identified, in addition to the value to be used for calibration. This was not done for the baseflows. Overall, the conceptual model is appropriate and consistent with other models of the Floridan Aquifer System such as the USGS East Central Florida groundwater model (Sepúlveda et al. 2012) and SWFWMD’S District Wide Regulation Model (DWRM) version 3 and Northern District Model (NDM) version 5. The most significant physical process not simulated is flow through conduit systems, but this is addressed in Section 8 Model Limitations.

**B. Is the [MODFLOW] model code appropriate, given the intended use of the model?**

**Yes,** MODFLOW-NWT is a recent version of MODFLOW from the USGS and is appropriate given the stated objectives of the model.

**C. Was the numerical [MODFLOW] model constructed in a manner that is consistent with the underlying conceptual model, using appropriate data and methods of analysis?**

**Yes,** layered model construction where layers represent aquifer and aquitard units and with a rectangular uniform grid is a standard method of simulating the UFA. In addition, the underlying data analysis methods are appropriate. Calibration with PEST and pilot points is quite sophisticated and appropriate given the complex nature of the aquifer system. However, there are some major items that need further attention. The description of baseflows requires further discussion in this report. Also, it appears that spring flows were given much larger weights than river baseflows in the calibration, causing PEST to produce closer matches to the springs and poorer matches to the rivers; this point needs to be discussed in this report as well. Not having recharge or evapotranspiration as PEST parameters requires further discussion in this report and further consideration as possible calibration parameters in any future revision of version 1.1 of the NFSEG model. Further discussion in this report should include an estimate of the accuracy of the recharge and evapotranspiration values calculated in HSPF, an explanation of why springs were simulated in layer 3 and rivers were simulated in layer 1, and whether manually adjusting recharge and evapotranspiration would result in better matches for the river baseflows. Other lessor items are listed in the chapter-by-chapter discussion in the detailed comments section of this report.

**D. Was the hydrologic model code selected appropriate for its intended use?**

**Yes.** [see answer to question #2B above.]

**E. Question specific to HSPF Models:**

**Was the use of HSPF as a method to develop recharge and maximum saturated ET that is assigned to the MODFLOW groundwater flow model a valid and defensible method?**

**F. Questions specific to HSPF Models:**

**a. The version of HSPF utilized for the hydrologic models is a non-standard version of HSPF that is not publically available. Is the version of HSPF utilized appropriate and defensible?**

**b. Was the best available information utilized to develop the HSPF hydrologic models?**

**c. Unique aspects of these systems were represented with Special Actions or with other features of HSPF and are these conceptually sound and implemented appropriately:**

**1. RCHRES representation of Inactive Groundwater Storage to represent spring discharges?**

**2. Closed basins?**

**3. Drainage wells and swallets?**

**4. Implementation of water use:**

**a. Agricultural irrigation?**

**b. Urban:**

**i. Septic?**

**ii. Irrigation?**

**c. Golf courses?**

**d. Reuse spray fields?**

**3. Model Calibration and Application:**

**A. Is the parameterization scheme used in the PEST calibration appropriate?**

**Yes,** the parameterization scheme used in MODFLOW is quite complex but well thought out and appropriate. One criticism, as stated in previous comments and presentations, is not making the evapotranspiration rate an adjustable parameter. Up to 10,000 cells in layer 1 of the model have heads significantly above the top of the layer (e.g., land surface). The extent of layer 1 “flooding” is up to 359 feet above the top of the layer. Some of these areas were addressed by adding drains to simulate additional surface drainage. However, the number of flooded cells and the maximum extent of flooding increased from run 004b to 007h (current model). The suggestion is repeated that consideration should be given to allowing evapotranspiration to be adjusted during the PEST run, at least in these areas of extreme flooding.

Also, not making recharge a PEST parameter needs an explanation (or inclusion as a parameter). By not making recharge a PEST parameter, the only way PEST can significantly modify groundwater flow is by varying conductivities. This may be a contributing factor to the poor match between river baseflows and simulated baseflows and a contributing factor to the poor match between measured and simulated conductivities.

The justifications for treating evapotranspiration and recharge as constants in the PEST calibration in NFSEG Version 1.1 need to be discussed further in this report. Allowing evapotranspiration and recharge to be adjusted during PEST runs should be evaluated further in any future revision of Version 1.1 of the NFSEG model.

**B. Were the types of observations and their implementation in the PEST calibration**

**appropriate, given the intended use of the model?**

**Generally yes.** The PEST calibration in MODFLOW uses data in many different ways. For example, both head and change in head (vertically and horizontally) make maximum use of existing data in the calibration. A better description of the reasoning for the weights assigned to each observation group should be provided, however. The report does a good job of documenting the weights that were used but does not really get into the logic behind the choice of weights. Also, the river baseflow determination needs more discussion and documentation (as mentioned earlier).

**C. Have the differences between observations and their simulated equivalents (model**

**residuals) been described sufficiently? For example, have an appropriate set of summary statistics, plots, and maps been presented that allow for evaluation of model limitations, (such as model bias and uncertainty) in a manner that meets or exceeds existing professional practices?**

**Mostly yes,** but providing some additional information related to simulated differences (residuals) in the MODFLOW calibration is recommended. First, since the report goes into considerable detail on parameter and observation groups, it would be consistent to add a table of the contributions of each observation group to the objective function. The objective function is described in general in the report, but the actual results from the PEST run are not documented. A table is provided of head statistics but not for spring flows and base flows. Spring data and baseflow pick-up estimates in Appendices E and F should also show the percent error in spring flow and base flow values to give the reader a better indication of the degree of fit with the flow observations. In addition, the match for important springs is provided in table form for the 2010 verification simulation (Table 5-2), but spring flow matches should also be tabulated and evaluated for the 2001 and 2009 calibration periods. Also, in the no-pumping simulation, estimates for historical heads and spring flows were used to evaluate the no-pumping simulation results, but estimates for baseflows were not made. A number of rivers in the model domain have gages that date back to the 1930s; if possible, these data should be used to estimate historical baseflows, which could also be used to evaluate the no-pumping simulation. In addition, However, return flow should not be included in the no-pumping simulation. Conceptually, return flows are how excess water is recharged to the groundwater system from pumping, and, thus, there should be no return flow in the absence of pumping.

**D. Have the values of calibrated parameters been described appropriately, using (for**

**example) maps illustrating the range and spatial distribution of parameter values?**

**In general, yes.** The maps in the MODFLOW report are very useful and can be compared to the actual MODFLOW input files by a knowledgeable reader. The text description is a bit limited; however, most modeling reports tend to give cursory descriptions of complex parameter fields, preferring instead to rely on the figures.

**E. Does the final version of the model appear to be adequately calibrated given the available data for calibration and the state of knowledge (and lack thereof) of the hydrologic system prior to development of the model?**

**Yes,** the degree of calibration of the MODFLOW model is quite good. No model is perfect and there are always outliers and areas that cannot be explained, and this model has a several such areas. However, given the regional nature of the model and grid cell sizes, the calibration compares favorably with results obtained for similar regional models (e.g., SWFWMD’S District Wide Regulation Model (DWRM) version 3 and Northern District Model (NDM) version 5, see Table 3A-1). Also, the NFSEG model will certainly be adequately calibrated if the concerns of the reviewers that recommend additional discussion and explanation are addressed.

Table 3A-1-Summary of Statistics for Heads for NFSEG and Three Comparable Regional Groundwater Flow Models in Florida

|  |  |  |  |
| --- | --- | --- | --- |
| Model | Residual Mean (ft) | Absolute Residual Mean (ft) | RMS Error (ft) |
| NFSEG | 0.17 | 4.45 | 8.02 |
| DWRM3 (1995) | 1.54 | 4.00 | 5.50 |
| DWRM3 (2005) | -1.56 | 5.63 | 8.10 |
| NDMS (2010) | 0.86 | 5.23 | 6.74 |

**F. Is the final version of the model appropriate for the intended planning and regulatory uses in the SRWMD and SJRWMD areas of the model domain? Is the NFSEGv1.1 groundwater flow model a sufficient tool for evaluating individual CUP’s and compliance with individual spring MFL’s?**

**Yes,** the NFSEG model is well suited for its intended planning and regulatory uses. The model will be a sufficient tool for evaluating individual CUPs and compliance with individual spring MFLs if the concerns of the reviewers recommending additional discussion and explanation are addressed. At some point, models need to be used to be effective. Experience with SWFWMD’s District Wide Regulation Model revealed that it was only after version 1 was released that areas were found that needed to be improved. Weaknesses in any model will invariably reveal themselves through application to real world problems; as the NFSEG model evolves through time, it should get better and better.

**G. Has the complete model water balance, accounting for all water sources and sinks,**

**been assessed and found reasonable?**

**Yes,** the water budgets described in Section 6 Water Budget Analysis for the model domain and for seven groundwater basins that make up the model domain have been assessed and appear to be reasonable.

**H.** **Have the uncertainty of key model parameters and predictions been assessed using**

**methods that are appropriate and that meet or exceed typical practice for developing groundwater flow models? Has a detailed statistical assessment of uncertainty in modeled groundwater level and spring flow estimates been provided?**

**Yes,** the uncertainty analysis documented for the NFSEG model in Section 7 Sensitivity and Uncertainty Analysis is very detailed and comprehensive, including evaluating predictive uncertainties at selected locations for heads, baseflows, and spring flows (Table 4-1, Appendix L). The modeling team should be commended for undertaking such a significant effort, particularly since very few models ever undergo such a detailed and complete uncertainty analysis.

**I. Have the limitations of the final version of the NFSEG groundwater flow model been adequately described in the model documentation?**

**Yes,** Section 8 Model Limitations concisely explains the limitations of the model with the following exception: in the calibration section (Section 4 Model Calibration, p. 55), it is stated that structural errors typically are the largest source of errors in a model. This should be repeated in Section 8.

**J. Have the Measures of Success for NFSEG Charter Objectives 2, 5, and 6 been met?**

|  |  |
| --- | --- |
| **Objective** | **Measure of Success** |
| **2. The model output helps to answer all regional-scale model questions in Appendix A of the NFSEG Charter.** | **A reasonable groundwater modeling technical expert would judge the model output useful in answering the questions in Appendix A.** |
| **5. The model is calibrated to industry standards.** | **The model calibration statistics meet industry standards in ASTM Standard Guide for Calibrating a Ground-Water Flow Model Application, Designation D 5981-96 (2008).** |
| **6. The model is accepted as a useful tool.** | **Success would be (1) a reasonable, independent groundwater modeling technical expert judging the model developed by this project to be acceptable by the standards of the profession for helping to answer the modeling questions that have been asked; and (2) a clear understanding by all involved parties of the uncertainties and limitations of the model for answering the modeling questions in Appendix A.** |

**Objective 2. The model output helps to answer all regional-scale model questions in Appendix A of the NFSEG Charter. A reasonable groundwater modeling technical expert would judge the model output useful in answering the questions in Appendix A.**

**Yes,** the model output will be useful in answering the regional-scale model questions in Appendix A if the suggestions made by the peer reviewers recommending additional discussion and explanation are addressed.

**Objective 5. The model is calibrated to industry standards. The model calibration statistics meet industry standards in ASTM Standard Guide for Calibrating a Ground-Water Flow Model Application, Designation D 5981-96 (2008).**

**Mostly** the calibration statistics meet industry (ASTM) standards. The exception is that the range of errors in the river and spring baseflows is not listed. ASTM (2018, updated from 2008) states: for a medium- to high-fidelity model application, calibration targets should be established by first identifying all relevant available data regarding groundwater heads (including measured water levels, bottom elevations of dry wells, and top of casing elevations of flowing wells) and flow rates (including records of pumping well or wellfield discharges, estimates of baseflow to gaining streams or rivers or recharge from losing streams, discharges from flowing wells, spring flow measurements, and/or contaminant plume velocities). For each such datum, error bars associated with the measurement or estimate should be included. In the MODFOW simulation, calibration targets for heads were established prior to the calibration process but not for spring flows and baseflows, which should be established. Based on ASTM (2018), one criterion for accepting a calibration is that the residual for heads should be a small fraction of the difference between the highest and lowest heads across the model area. This criterion should be checked in addition to the calibration results for heads and residuals described in Section 4 Model Calibration of the draft model report. In addition, targets for spring flows and baseflows should be established based on the accuracy of the observed (or estimated) values for these parameters. ASTM (2018) recognizes that errors in the estimates for groundwater flow rates will usually be larger than errors in the estimates of heads and, in particular, that baseflow estimates are generally accurate only to within an order of magnitude. In such cases, the upper and lower bounds on the acceptable modeled value of baseflow can be equal to the upper and lower bounds on the estimate. This limit should be recognized when establishing calibration targets and evaluating the calibration for baseflows in the NFSEG groundwater model.

**Objective 6. The model is accepted as a useful tool. Success would be (1) a reasonable, independent groundwater modeling technical expert judging the model developed by this project to be acceptable by the standards of the profession for helping to answer the modeling questions that have been asked; and (2) a clear understanding by all involved parties of the uncertainties and limitations of the model for answering the modeling questions in Appendix A.**

**Yes,** the model should be able to help answer the modeling questions that are asked in Appendix A if the suggestions made by the peer reviewers recommending additional discussion and explanation are addressed. Also, model limitations are discussed in Section 8 Model Limitations, making it possible for involved parties to understand clearly the uncertainties and limitations of the model.