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TECHNICAL MEMORANDUM: PEER REVIEW OF UPPER OCKLAWAHA RIVER BASIN HSPF MODEL AND DOCUMENTATION REPORT

Prepared for:

St. Johns River Water Management District

Prepared by:

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Jan. 5, 2016

INTRODUCTION

Janicki Environmental has been tasked by the St. Johns River Water Management District (the District) to provide an independent scientific peer review of scientific and technical data, methodologies, and assumptions related to the development of hydrologic models and any statistical relationships used for the determination and implementation of MFLs in the Upper Ocklawaha River Basin (UORB) Lakes in Marion, Lake, and Orange counties.

The review is directed to include the hydrologic model and the model documentation report developed for the UORB Lakes, to assess the following:

- Adequacy of hydro-meteorological records in terms of quality, spatial coverage, and length of record,
- Methods and procedures for data analysis,
- Appropriateness, defensibility, and validity of hydrologic models/relationships,
- Validity and appropriateness of all assumptions used in the development of the models/relationships, and
- Deficiencies, errors, or sources of uncertainty in model/relationship development, calibration, and application

The model documentation report being reviewed, as provided by the District, is:

> Huang, X., and D.R. Smith. 2015. DRAFT Lake Apopka and the Upper Ocklawaha River Minimum Flows and Levels Hydrologic Assessment Method Report. (July 16, 2015).

The model documentation report describes the model as applied to Lake Apopka and the Upper Ocklawaha River Basin (LAUORB). The report documents the LAUORB MFLs hydrologic assessment method including the HSPF model setup, model calibration, and long-term simulation of LAUORB baseline hydrologic conditions.

Specific items/questions were provided by the District to be addressed via this review. These items/questions are provided in numbered sections below in bold font, with comments/ responses following as appropriate.

REVIEW

1) **Assess adequacy of hydro-meteorological records in terms of quality, spatial coverage, and length of record.**

a) Was "best information available" utilized to develop the hydrologic model?

Response:

Data used for hydrologic model development are described in Section 3.4, and include:

1) District's 1995 land use classified into HSPF hydrologic modeling land use groups,

2) NOAA daily rainfall records from three sites disaggregated to hourly rainfall using WDMUtil, and assigned to basins by the Thiessen polygon method,

3) Potential evaporation estimated using Hargreaves method scaled to USGS GOES evaporation estimates, and assigned to basins by the Thiessen polygon method,

4) Bathymetry data collected in 1991 by ECT augmented with results from VanSickle and Pachhai et al (2013), and

5) Spring flow data measured monthly.

These data are the "best information available" for model development.

b) Are there any deficiencies regarding data availability?

Response:

No.

c) Was relevant information available that was discarded without appropriate justification? Would use of discarded information significantly affect results?

Response:

The description of how the potential evaporation was estimated is provided on pp. 48-49. What is the rationale for selecting this method? Observed daily ET data are available at IFAS FAWN site at Apopka since 1998, and other nearby sites (Okahumpka and Umatilla). Why use the Hargreaves method instead? It may be worthwhile to compare the estimates used in the model to those from the IFAS FAWN sites to provide further support for the method used.

2) Assess methods and procedures for data analysis.

a) Are the analytical methods and procedures appropriate?

Response:

The methods and procedures are appropriate. To support the methodology for developing rainfall for each basin (description of how the rainfall data were assigned to basins is provided on p. 48), please provide rationale for selecting the Thiessen polygon method, instead of some other method, such as inverse distance weighting, for assigning rainfall. Similarly for potential evaporation development use of Thiessen polygon method, provide rationale.

b) Are there any deficiencies and/or errors in analytical methods?

Response:

1) For clarification, please provide some discussion of how the Hargreaves evaporation scaling factors were developed (p. 49).

2) On p. 17 in discussion of Palatlakaha River modeling results providing poor results, the authors state that the river has a relatively small contributing flow. It would be helpful to provide a graphical comparison of the Palatlakaha flows and the total inflows to the lake system here in support of this statement.

3) On p. 18, there is a statement that the "..increase between the 1995 and 2009 land use scenarios can be shown to have a minimal effect on the flow estimates..." This is the first mention of utilizing the 1995 and/or 2009 land use datasets. There should be some discussion as to why comparisons are being provided between 1995 and 2009 land use (in Tables 4-7).

4) In Section 4.1.2 on p 53, the authors note that if K, A, and ΔL are constant then the three parameters can be lumped into K'. ΔL is defined as the distance between the lake bottom and the Upper Floridan Aquifer, and the assumption that this is constant over time for a given lake should have some supportive evidence. Please provide further discussion to support this assumption.

3) Assess hydrological model/relationships.

a) Determine if the model is appropriate, defensible, and valid, given the District's MFLs approach.

Response:

The model is appropriate, defensible, and valid, although some additional calibration of water levels and flows between lakes may be warranted (see below).

b) Was there adequate data to develop, calibrate, and apply the model/relationship?

Response:

Yes, the data were adequate.

c) Given the available data and the District's MFLs approach, are there more appropriate models/relationships for assessing the water body?

Response:

The hydrologic model approach appears to be most appropriate for the District's efforts.

d) Evaluate the validity and appropriateness of all assumptions used in the development of the hydrologic model/relationship.

Response:

Assumptions used in the development of the hydrologic model as identified by the reviewer are as follows:

1) The 1995 land use is appropriate for the calibration period of 1995-2006.

2) The Palatlakaha River Planning Unit flows are not conducive to simulation, so that flows from this unit are as measured.

3) The LAUORB HSPF model as calibrated with the CFWI ECFT groundwater model is the appropriate model to start with for this model development effort.

4) The Thiessen polygon method is appropriate for developing rainfall and potential evaporation estimates.

5) The Hargreaves method provides the best methodology for developing potential evaporation.

6) In Section 4.1.2 on p 53 and following, the authors note that if K, A, and ΔL are constant then the three parameters can be lumped into K'. ΔL is defined as the distance between the lake bottom and the Upper Florida Aquifer, and the assumption is that this is constant over time for a given lake.

7) In Section 4.1.5, assumptions regarding the time needed to equalize head differences between lakes connected by open channels are provided.

- **Are the assumptions reasonable and consistent given the "best information available"?**

Response:

1) Assumption that the 1995 land use is appropriate for the 1995-2006 calibration period is reasonable, given the comparison of 1995 and 2009 land use provided in the document.

2) Assumption that the Palatlakaha River Planning Unit flows should be measured flows is reasonable. As mentioned above, it would be useful to quantify the relative flows from this unit with respect to all flows to the system.

3) Assumption that the LAUORB HSPF model as calibrated with the CFWI ECFT groundwater model is the appropriate starting point for this model calibration effort is reasonable.

4) The assumption that the Thiessen polygon method is appropriate for assignment of rainfall and potential evaporation is reasonable, although some additional discussion of other methods is warranted along with the reasoning for selecting the Thiessen polygon method.

5) The assumption that the Hargreaves method provides the best methodology for developing potential evaporation is reasonable, although support could be provided for this method via comparison with observed data at nearby IFAS FAWN sites.

6) The assumption is made that if the terms in Darcy's Equation (Section 4.1.2, p 53 and following), K, A, and ΔL, are constant, then the three parameters can be lumped into K'. The assumption that ΔL can be assumed constant over time for a given lake should have some supportive evidence.

7) The assumptions provided in Section 4.1.5 regarding the time needed to equalize head differences between lakes connected by open channels is reasonable.

- **Is there information available that could have been used to eliminate any of the assumptions? Would the use of this additional information substantially change the model results?**

Response:
The only additional information available for use that this reviewer is aware of are the IFAS FAWN evaporation data from nearby sites. It is unlikely that this information would substantially change the model results.

- **Are the assumptions stated clearly?**

Response:

No, it would be nice to see a list of assumptions related to development of the hydrologic model provided by the authors, with discussion of each including potential impact on model results. A subsection at the end of Section 4 might be the best place for this to be included.

- **What, if any, additional assumptions are implied or inherent in the development of the model/relationship?**

Response:

This reviewer has listed assumptions, both actual and implied/inherent, above in 3d.

- **Are other methodologies (modeling or non-modeling) available that would require fewer assumptions but could provide comparable or better results? Are adequate data available to support using these alternative methodologies?**

Response:

The hydrologic model is the most appropriate tool for addressing the MFL issues.

e) Are there deficiencies and/or errors in model/relationship development, calibration, or applications?

- **If so, describe each deficiency and/or error and enumerate and describe the necessary remedies, and provide an estimate of the time and effort required to develop and implement each remedy.**

Response:

1) The explanation in Section 4.1.3 (pp. 54-55) on the development of the UFA levels could benefit from some clarification. Perhaps a simple1-2 sentence summary would work, following the first paragraph of the section that outlines the process which is provided in detail in the next three paragraphs. Time/effort estimate: 10 minutes.

2) In Figs 27 & 28 (p 73), it appears the model typically under-predicts elevations in Lake Apopka below ~64 feet, and typically over-predicts elevations above 64 feet. Please provide some discussion as to the possible reason(s) for this, the implications for interpretation and use of the model output, and provide rationale for decision as to whether or not this should be addressed. Time/effort estimate: If the decision is to address this via additional calibration efforts, perhaps 5 days' worth of work may be necessary to fine tune the calibration, inclusive of the additional efforts to address the comments below (3e3-3e7).

3) In Figs 31 & 32 (p 75), it appears the model typically over-predicts elevations in Lake Eustis. Please provide some discussion as to the possible reason(s) for this, the implications for interpretation and use of the model output, and provide rationale for decision as to whether or not this should be addressed. Time/effort estimate: If the decision is to address this via additional calibration efforts, perhaps 5 days' worth of work may be necessary to fine tune the calibration, inclusive of the additional efforts to address the comments above (3e2) and below (3e4-3e7).

4) In Figs 33 & 34 (p 76), it appears the model typically over-predicts elevations in Lake Harris. Please provide some discussion as to the possible reason(s) for this, the implications for interpretation and use of the model output, and provide rationale for decision as to whether or not this should be addressed. Time/effort estimate: If the decision is to address this via additional calibration efforts, perhaps 5 days' worth of work may be necessary to fine tune the calibration, inclusive of the additional efforts to address the comments above (3e2-3e3) and below (3e5-3e7).

5) In Figs 35 & 36 (p 77), it appears the model typically over-predicts elevations in Lake Yale prior to the end of 2002, and under-predicts afterwards. Please provide some discussion as to the possible reason(s) for this, the implications for interpretation and use of the model output, and provide rationale for decision as to whether or not this should be addressed. Time/effort estimate: If the decision is to address this via additional calibration efforts, perhaps 5 days' worth of work may be necessary to fine tune the calibration, inclusive of the additional efforts to address the comments above (3e2-3e4) and below (3e6-3e7).

6) In Figs 37 & 38 (p 78), it appears the model typically over-predicts elevations in Lake Griffin prior to the end of 2002, and then simulates the observed elevations very accurately. Please provide some discussion as to the possible reason(s) for this, the implications for interpretation and use of the model output, and provide rationale for decision as to whether or not this should be addressed. Time/effort estimate: If the decision is to address this via additional calibration efforts, perhaps 5 days' worth of work may be necessary to fine tune the calibration, inclusive of the additional efforts to address the comments above (3e2-3e5) and below (3e7).

7) In Figs 39 & 40 (p 79) and 43 & 44 (p 81), it appears the model typically over-predicts flows in Apopka-Beauclair Canal and at Moss Bluff Lock and Dam. Please provide some discussion as to the possible reason(s) for this, the implications for interpretation and use of the model output, and provide rationale for decision as to

whether or not this should be addressed. Time/effort estimate: If the decision is to address this via additional calibration efforts, perhaps 5 days' worth of work may be necessary to fine tune the calibration, inclusive of the additional efforts to address the comments above (3e2-3e6).

- **If the identified deficiencies cannot be remedied, then identify and describe one or more alternative methodologies (modeling or non-modeling) that are scientifically defensible given the available data. Provide an estimate of the time and effort required to develop and implement them.**

Response:
It is expected that the deficiencies can be remedied via additional calibration efforts and text clarifications.

f) **Identify all sources of model uncertainty and assess their impact on applying the model to assess whether an MFL will be achieved.**

Response:
Sources of uncertainty include uncertainty associated with all measured data utilized directly as input to the model (land use classification and areas, rainfall, measured flows from the Palatlakaha River, potentiometric surfaces, bathymetry, spring flows), uncertainty associated with relationships developed using measured data (potential evaporation from Hargreaves method, rate of groundwater recharge/discharge, rating curves for lake discharges), and uncertainty associated with the set of calibration parameters. For a quantified assessment of the impacts of the sources of uncertainty on model results, methods exist for performing an uncertainty analysis. However, this is seldom done for modeling evaluations, as it is intensive to complete and care must be taken in the interpretation of results. For application of the model to assess impacts of potential flow reductions (MFLs), it is important to be assured that the model responds as it should to external forcings (the model behaves as expected - calibration effort) over a wide range of conditions (from very dry to very wet periods, included in the calibration period). When the model meets expectations for calibration, then application of the model with varying flow conditions (scenarios) can be performed with the assurance that the model results in reasonable responses to the scenario conditions. Evaluation of the scenario output to the baseline output provides at least a sense of the relative differences expected, with the degree of assurance that the results are reasonable and accurate directly related to the goodness-of-fit determined for the calibration.

Monitoring programs associated with MFLs provide data for evaluation of potential effects upon MFL implementation, and serve to provide real-world responses to flow conditions. Any deleterious effects noted in the empirical data as a result of changes in flows may be addressed by resource managers, whether these effects were predicted by the modeling effort or not, and the data collected may be used to refine the model for future use.

g) Are the conclusions in the model report supported by the modeling results?

Response:

Yes, the model is ready for use in MFL evaluations, although additional fine-tuning of the calibration would serve to improve the model's use as a scenario testing tool.

Additional Comments

1) Second sentence on p. 9 references Fig. 2, should reference Fig. 3.

2) Consider adding location of M1 structure where Palatlakaha River enters Lake Harris in Fig. 2.

3) Second sentence on p. 14, please add reference to Fig. 5.

4) Last sentence of first paragraph on p. 14, shouldn't the Lake Griffin planning unit also include Lake Ella/Holly? Since Lake Ella is identified in Fig. 2, it should be mentioned in text as well.

5) Please provide the source of the land use information (District) displayed in Fig. 5, Fig. 7, and Tables 4-7.

6) Text at bottom of p. 23 needs to be adjusted.

7) Figs. 16 and 17 are provided in Section 3.3 on pp. 42 and 43, respectively, but are not referred to in the text until Section 4.1.3. It would be beneficial to have the text describing the figures preceding the figures themselves.

8) In Table 12 (p. 58), the selected base well for Lake Apopka shows a correlation for concurrent data between ECFT simulated UFA head and observed well data of 0.77. This seems very low, especially in comparison to all the other lake correlations. Why? Is this the best correlation?

9) Please provide more description of the information shown in Figs. 23-26 to clarify what's being shown.

10) Last sentence of Section 8.2 (p. 89), the MOVE-3 method was described in Section 4.1.3, not the previous section.

11) On p. 90 is reference to the stage-area-storage relation for the NSRA, with the relationship provided in Table 19 (p. 92). Please explain more fully the relationship between the three columns of the table.

12) On p. 94 is a discussion of the lake stage duration curves for the 48-year baseline conditions. Please provide a sentence describing an example of the conclusions that can be drawn from the information presented in Figs. 57-59. For example: Levels in Lake Apopka are greater than 65.8 feet 50% of the time.