Note to requester: Portions of this record are redacted under FOIA Exemption B5, Deliberative Process Privilege.

From: Ford, William
To: Martinez, Nancy
Subject: RE: TURKEY POINT: Draft Collective Response to Flooding Questions
Date: Thursday, July 18, 2019 5:52:11 PM

Great. No worries.

From: Martinez, Nancy
Sent: Thursday, July 18, 2019 5:21 PM
To: Ford, William <William.Ford@nrc.gov>
Subject: RE: TURKEY POINT: Draft Collective Response to Flooding Questions

Hi Bill,
Sorry, I should have mentioned the reason I had bolded the text. That was essentially a reminder for myself to double-check that the changes or updates to the SEIS mentioned in the response have actually been made. I will go ahead and remove that.
Thanks,
Nancy

From: Ford, William
Sent: Thursday, July 18, 2019 4:19 PM
To: Martinez, Nancy <Nancy.Martinez@nrc.gov>
Cc: TurkeyPoint34SLR Resource <TurkeyPoint34SLR.Resource@nrc.gov>
Subject: RE: TURKEY POINT: Draft Collective Response to Flooding Questions

Hi Nancy,
I did not see any problems with the content of the response.
However, the response contains 4 different fonts including bolded text (using bolded text is like shouting at the reader).
I recommend that the fonts should be fixed to be all the same.
The system does not let me make changes, but I think it gives you the authority to make changes.
Bill Ford
301-415-1263

From: Martinez, Nancy
Sent: Thursday, July 18, 2019 12:26 PM
To: Ford, William <William.Ford@nrc.gov>
Subject: RE: TURKEY POINT: Draft Collective Response to Flooding Questions

Bill,
I have completed drafting the response to 154R in the CRD. As I mention below, I would appreciate it if you could take a look at the response in case there is anything you recommend that I should add prior to marking the response "reviewed." Once you have taken a look, please let me know. Also, if it is easier for me to send you the response as an attachment in an email, just let me know as well.
Thanks,
Nancy

From: Martinez, Nancy
Sent: Monday, July 15, 2019 11:11 AM
To: Ford, William <William.Ford@nrc.gov>
Subject: RE: TURKEY POINT: Draft Collective Response to Flooding Questions

Thanks Bill. I will incorporate what I can from what you have provided into response 154R.

[redacted] (b)(5)

From: Ford, William
Sent: Monday, July 15, 2019 9:30 AM
To: Martinez, Nancy <Nancy.Martinez@nrc.gov>
Subject: FW: TURKEY POINT: Draft Collective Response to Flooding Questions

Hi Nancy,

(b)(5) [redacted]

Bill Ford
415-1263

From: Ford, William
Sent: Tuesday, July 02, 2019 1:30 PM
To: Prasad, Rajiv <Rajiv.Prasad@pnnl.gov>
Cc: Folk, Kevin <Kevin.Folk@nrc.gov>; TurkeyPoint34SLR Resource <TurkeyPoint34SLR.Resource@nrc.gov>
Subject: TURKEY POINT: Draft Collective Response to Flooding Questions

Hi Rajiv,

[redacted] (b)(5)

Thanks,
Bill Ford
301-415-1263

Note to requester: Portions of this record are redacted under FOIA Exemption B5, Deliberative Process Privilege.

From: Folk, Kevin
To: Martinez, Nancy
Subject: FW: PTN SLR: flooding/climate change response 146R
Date: Thursday, July 11, 2019 7:03:06 PM

[redacted] (b)(5)

From: Prasad, Rajiv <Rajiv.Prasad@pnnl.gov>
Sent: Wednesday, July 10, 2019 6:48 PM
To: Folk, Kevin <Kevin.Folk@nrc.gov>; Ford, William <William.Ford@nrc.gov>
Subject: [External_Sender] PTN SLR: flooding/climate change response 146R

(b)(5) [redacted]

(b)(5)

Rajiv

Rajiv Prasad, Ph.D.
Scientist, Energy and Environment Directorate
Pacific Northwest National Laboratory
902 Battelle Boulevard
P.O. Box 999, MSIN K7-68
Richland, WA 99352 USA
Tel: 509-375-2096, Fax: 509 371-7083
rajiv.prasad@pnnl.gov, www.pnnl.gov

Note to requester: Portions of this email are redacted under FOIA Exemption B5, Deliberative Process Privilege. The attachment, which is immediately following this email, is withheld in full under FOIA Exemption B5, Deliberative Process Privilege.

From: Ford, William
To: Folk, Kevin
Cc: TurkeyPoint34SLR Resource
Subject: FW: Turkey Point Flood Analysis
Date: Thursday, August 01, 2019 12:12:23 PM
Attachments: [redacted] (b)(5)
Importance: High

Hi Kevin,

(b)(5) [redacted]

Bill Ford

From: Giacinto, Joseph
Sent: Thursday, June 27, 2019 12:31 PM
To: Ford, William <William.Ford@nrc.gov>
Subject: Turkey Point

(b)(5) Bill, [redacted]

Joe

(b)(5)

(b)(5)

(b)(5)

(b)(5)

(b)(5)

(b)(5)

Note to requester: This email, with the same attachments, was forwarded from Kevin Folk to Manny Comar on March 26, 2019 as released in full in the final response to FOIA NRC-2020-000123. The attachments are immediately following this email record.

From: Folk, Kevin
To: Prasad, Rajiv (Rajiv.Prasad@pnnl.gov); Meyer, Philip D
Cc: Saulsbury, James W; Ford, William
Subject: RE: List of Documents for PNNL
Date: Wednesday, June 06, 2018 4:27:00 PM
Attachments: 2017-01-27 FPL Attachment 1 GW Flow and Transport Model.pdf
2017-01-27 FPL Phase One Remediation Plan.pdf

Gentlemen:

In the interest of efficiency, I am attaching two documents for your information (with another in a separate email) and that are germane to our audit needs request to FPL (which is duplicated below). In short, Bill Ford and I want you to be aware of our line of inquiry on these matters and relevant new information so that you can better support us in our interactions with FPL and its contractor staff. Likewise, some of this information may well be referenced during the interagency meeting.

As for the audit itself, we do not yet have a detailed audit agenda in place, so we do not yet know what FPL is planning to present to us. Hoping to have it soon!

Please advise if any of the PDFs did not come through directly and I will upload them to EARRTH directly Bo set up for us.

Bill, please elaborate as appropriate.

Rajiv and Phil, please reach back to us with any immediate questions.

Finally, I plan to set up a conference call among us the middle of next week so that we can coordinate. Let me know if there are any days that are problematic.

Thanks.

Kevin

Audit Request for a Groundwater and Surface-Water Modeling Presentation

In 2016, TETRA TECH finished for FPL, "A Groundwater Flow and Salt Transport Model of the Biscayne Aquifer". One of the purposes of this model is to assess the efficacy of the recovery well system to retract the hypersaline plume in the Biscayne Aquifer west and north of FPL's property.

> (Note this report can be found at the end of the September 25, 2017 testimony of Peter Andersen before the Florida 1 Public Service Commission located at: http://www.psc.state.fl.us/library/filings/2017/07901-2017/07901-2017.pdf)

In 2014 TETRA TECH completed an "Evaluation of Drawdown in the Upper Floridan Aquifer Due to Proposed Salinity Reduction-based Withdrawals". To reduce the salinity within the cooling canal system, water from the Upper Floridan Aquifer will be discharged into the cooling canal system. This model was used to determine potential impacts to other users of Floridan Aquifer water from the withdrawal of Floridan Aquifer groundwater.

Also in 2014, TETRA TECH also completed an "Evaluation of Required Floridan Water for Salinity Reduction in the Cooling Canal System". Water and salt balance modeling of the cooling canal system was performed to assess the volume of water from the Floridan Aquifer required to reduce the salinity of cooling canal system water to seawater concentrations. Reducing the salinity in the cooling canal system is predicted to reduce the contribution from the CCS to the hypersaline plume in the Biscayne Aquifer.

> (Note: These 2014 reports can be found in document filed in ADAMS accession number ML14279A555.)

These complex models are important to the prediction to future impacts by the hypersaline groundwater over the period of subsequent license of license renewal.

We would like to better understand these modeling studies and attendant projections. At the audit, we would like an on-site presentation by knowledgeable staff on these models; including any recent updates. We are interested in understanding the projections of cooling canal salinities, of impacts on Floridan Aquifer groundwater users, and of the efficacy of the planned recovery well system operation in retracting the hypersaline plume. Please allow time for questions from NRC staff and contractors.

Additional Related Documents

Turkey Point Plant Annual Monitoring Report September 2017.
(This report may have to be sent to PNNL as it was obtained from a search of the State of Florida Department of Environmental Protection Information Portal located at http://prodenv.dep.state.fl.us/DepNexus/public/searchPortal)

Review of Groundwater Flow and Transport Model of the Biscayne Aquifer Prepared by Tetra Tech for Evaluation of Remedial Measures to Address the Hypersaline Plume Created by the Cooling Canal System at the FPL Turkey Point Power Facility
(This report may have to be sent to PNNL as it was obtained from a search of the Miami-Dade County DERM electronic document data base, which can be accessed at https://www.miamidade.gov/environment/public-records.asp#0

2017 TETRA Tech model changes made in response to the comments made by the Miami-Dade County Consultant.
(This report may have to be sent to PNNL as it was obtained from a search of the Miami-Dade County DERM electronic document data base, which can be accessed at https://www.miamidade.gov/environment/public-records.asp#0)

2016-01-29 Freshening Effectiveness Report
This report may give insight into the accuracy of the predictive models of CCS salinity reduction.
(This report may have to be sent to PNNL as it was obtained from a search of the Miami-Dade County DERM electronic document data base, which can be accessed at https://www.miamidade.gov/environment/public-records.asp#0)

The following document was reviewed as part of the Final Environmental Impact Statement for Turkey Point. The impact statement said it did not change our understanding of how the cooling canal operates.

However, as it focuses on the power uprate and the cause of increased salinities in the cooling canal system, it may come up again during license renewal

Final Report, The Cooling Canal System at the FPL Turkey Point Power Station, May 2016, which can be accessed at http://www.miamidade.gov/mayor/library/memos-and-reports/2016/05/05.12.16-Final-Report-on-the-Cooling-Canal-Study-at-the-Florida-Power-and-Light-Turkey-Point-Power-Plant-Directive-151025.pdf

Attachment 1

Biscayne Aquifer Groundwater Flow and Transport Model: Heterogeneous Hydraulic Conductivity Analyses, January 2017

(Figures)

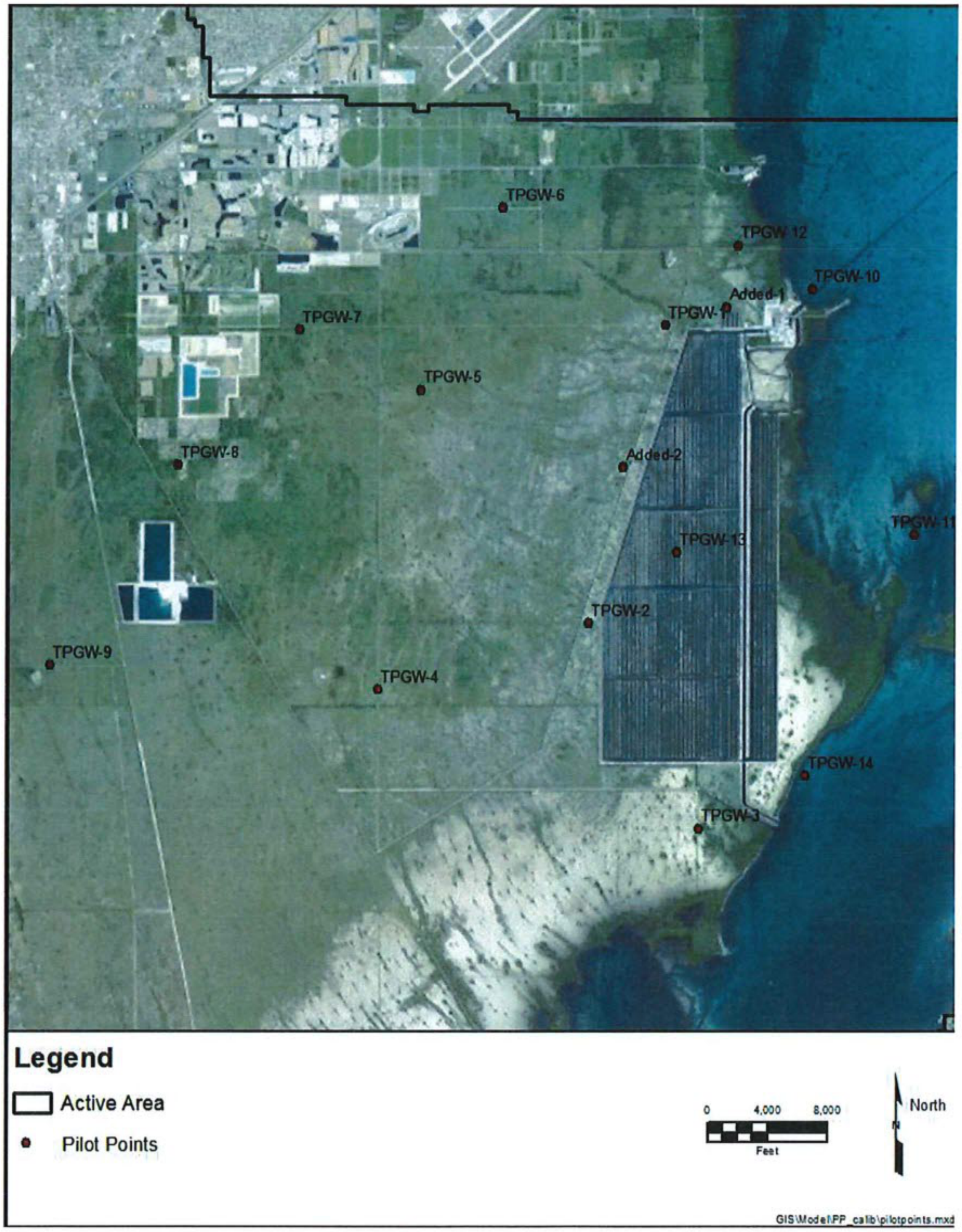


Figure 1. Hydraulic conductivity pilot point locations and the TPGW well name associated with the pilot point locations (where relevant)

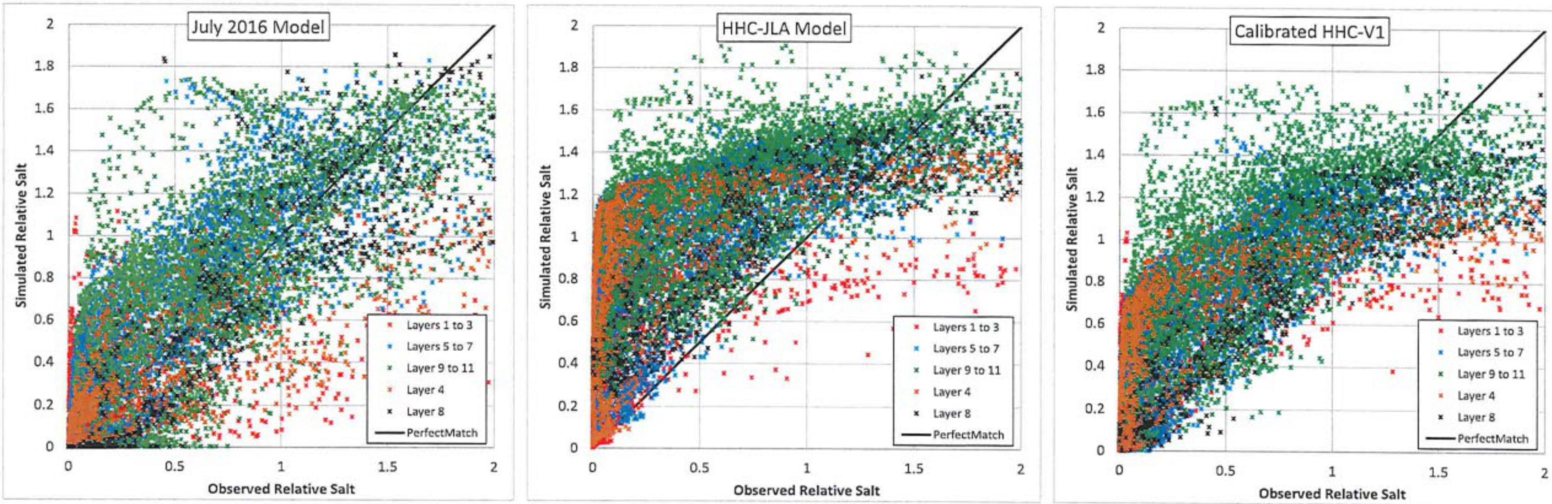


Figure 2. Observed versus simulated CSEM survey salt concentrations for the July 2016, HHC-JLA, and calibrated HHC-V1 models

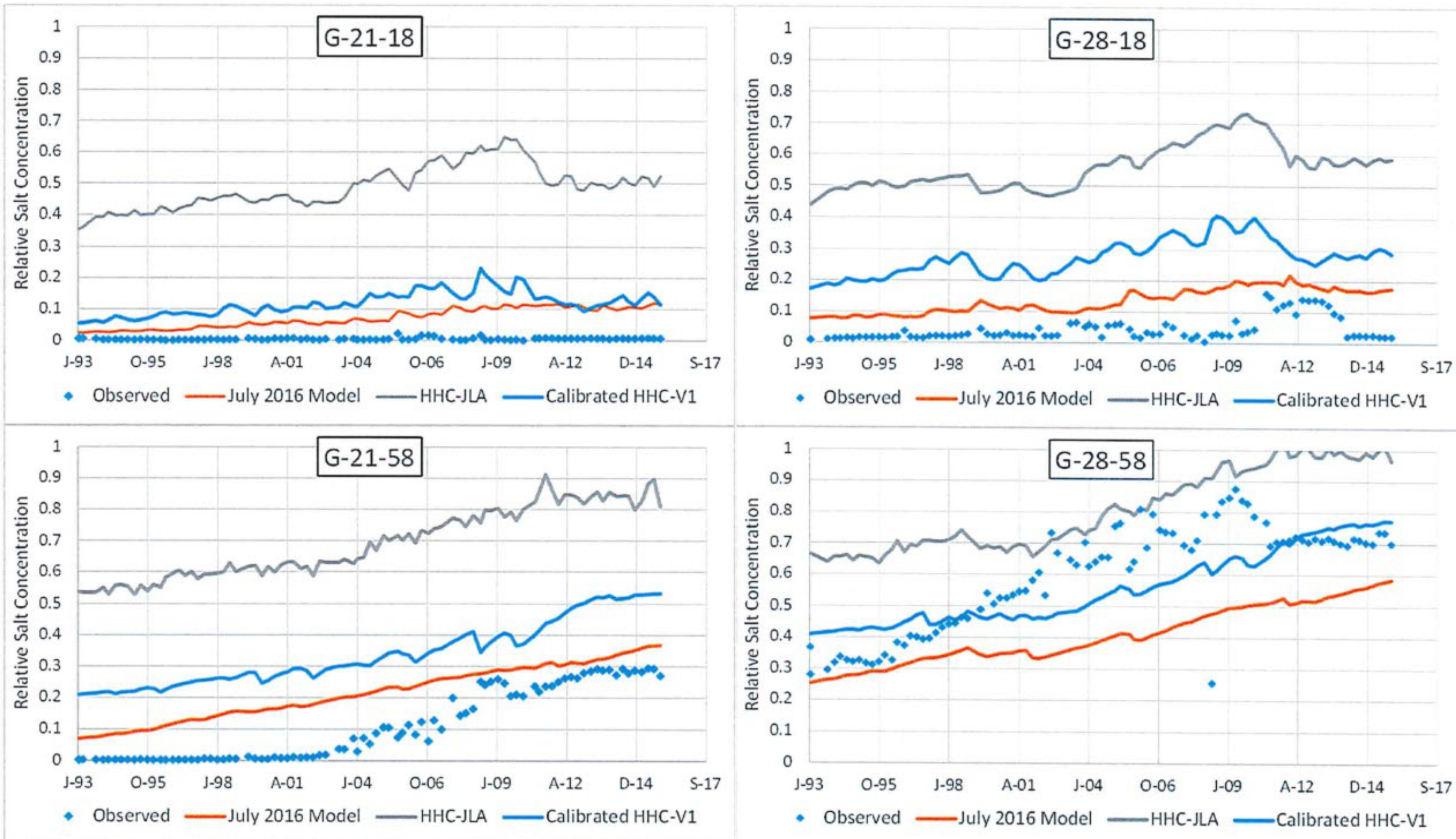


Figure 3. Observed and simulated saltwater wedge breakthroughs for the July 2016, HHC-JLA, and calibrated HHC-V1 models

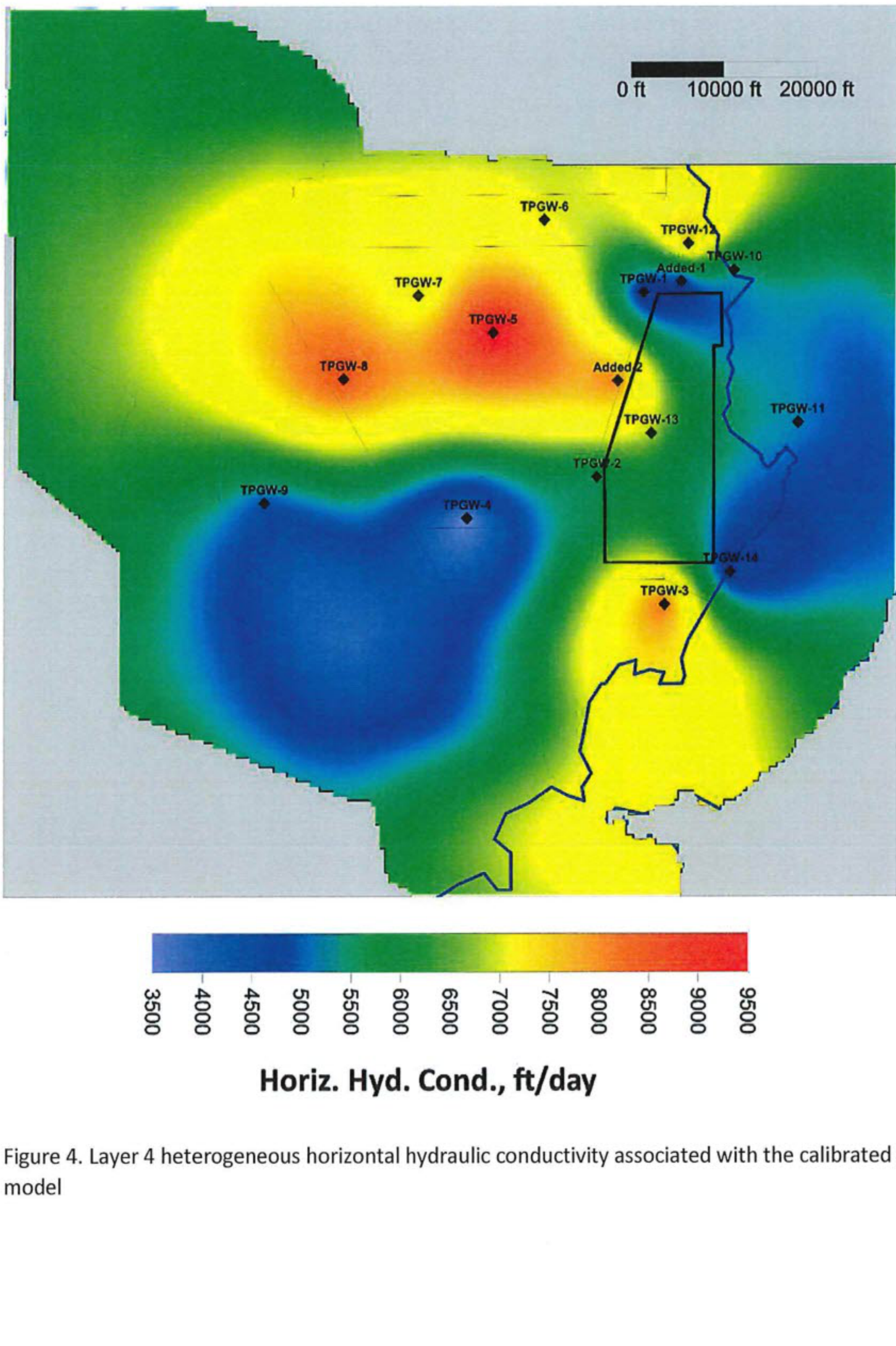


Figure 4. Layer 4 heterogeneous horizontal hydraulic conductivity associated with the calibrated HHC-V2 model

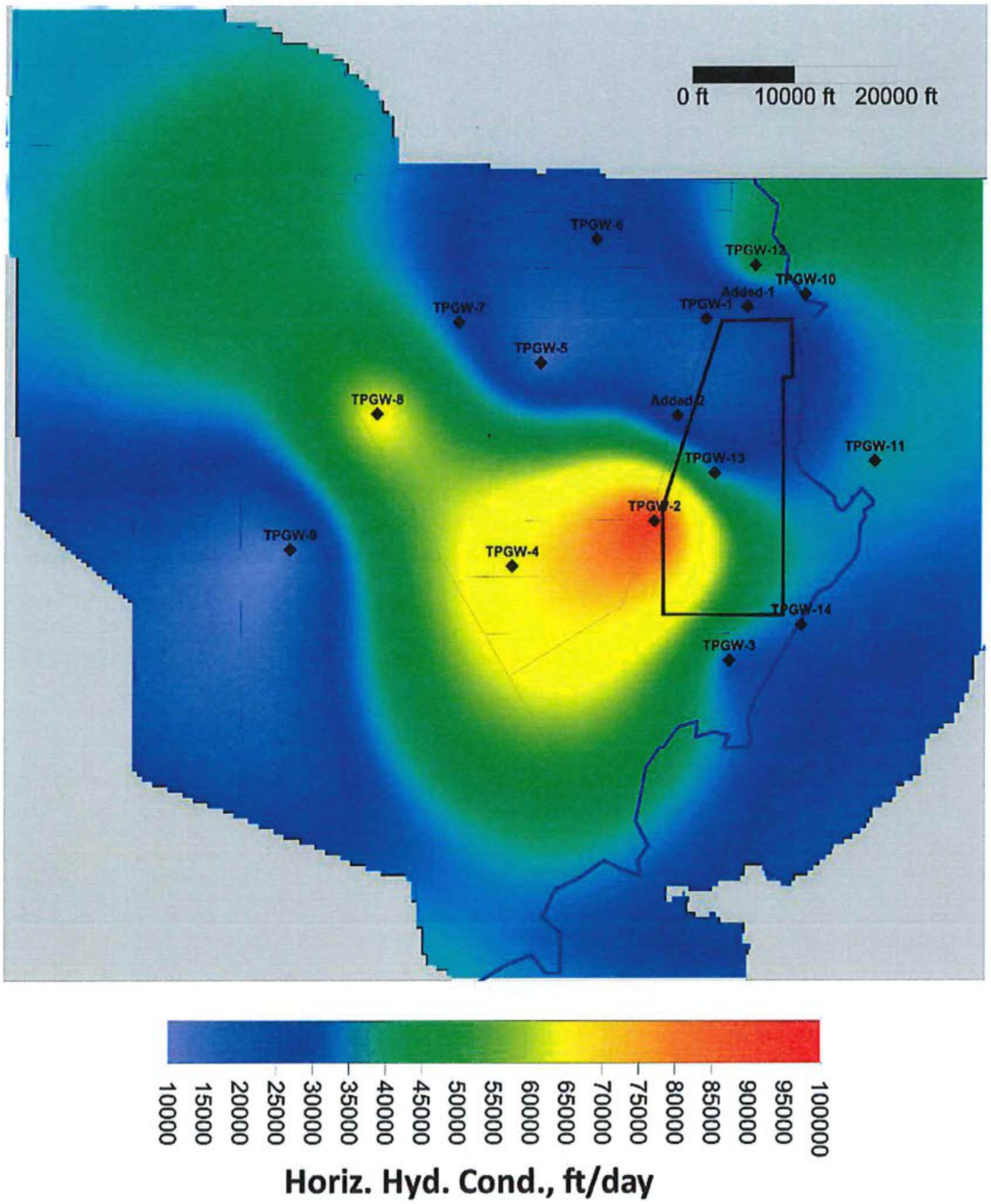


Figure 5. Layer 8 heterogeneous horizontal hydraulic conductivity associated with the calibrated HHC-V2 model

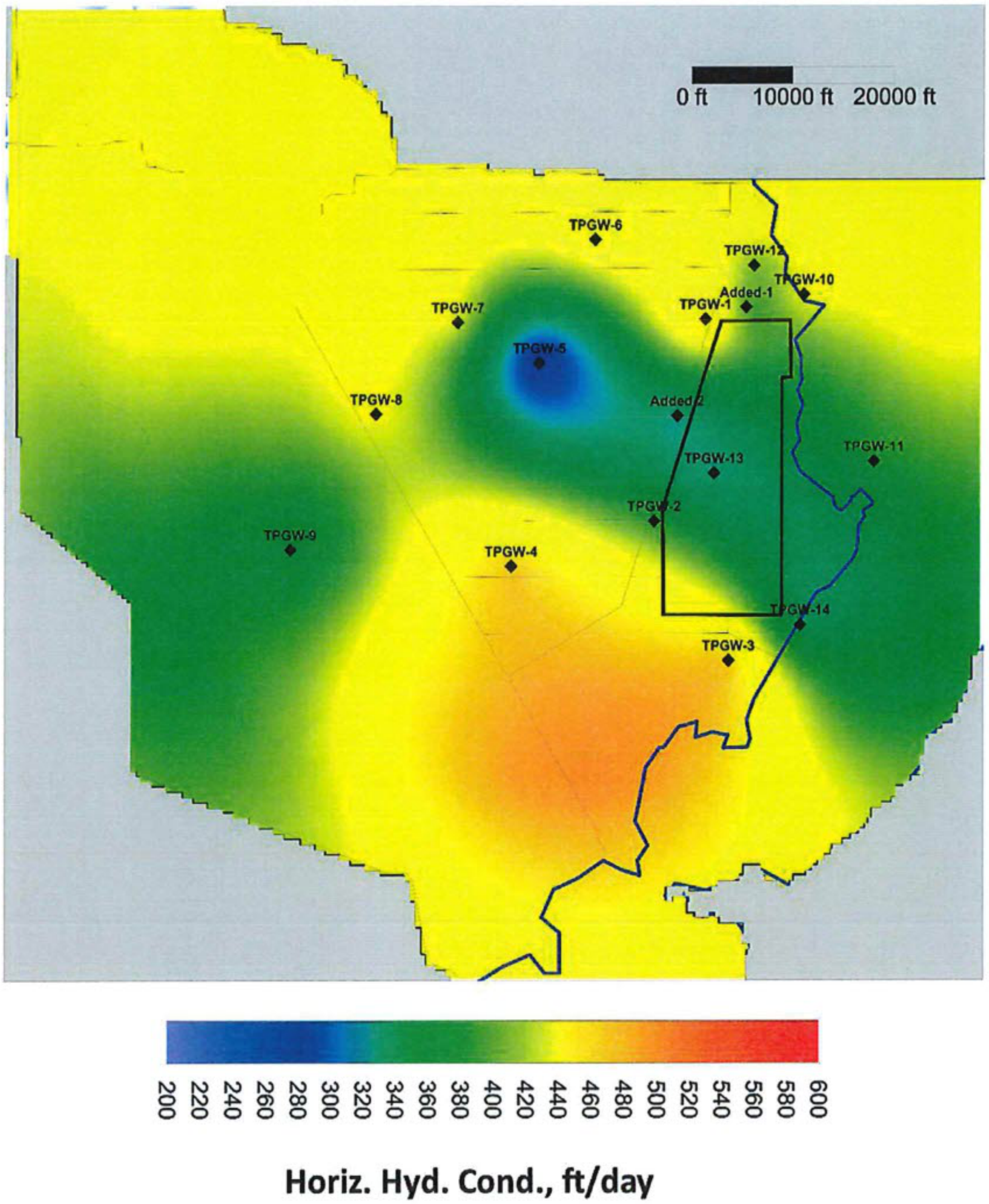


Figure 6. Layer 9 heterogeneous horizontal hydraulic conductivity associated with the calibrated HHC-V2 model

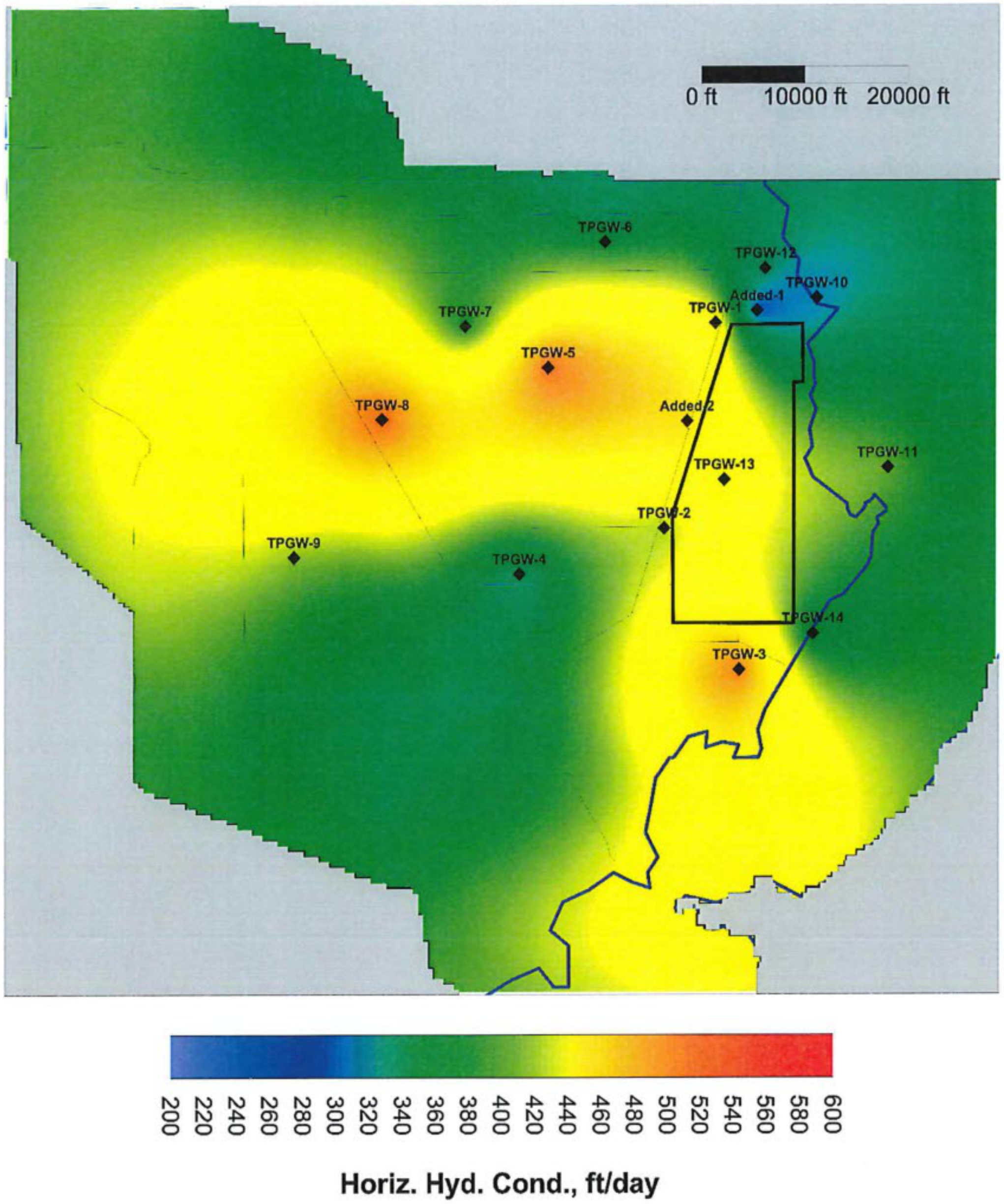


Figure 7. Layer 10 heterogeneous horizontal hydraulic conductivity associated with the calibrated HHC-V2 model

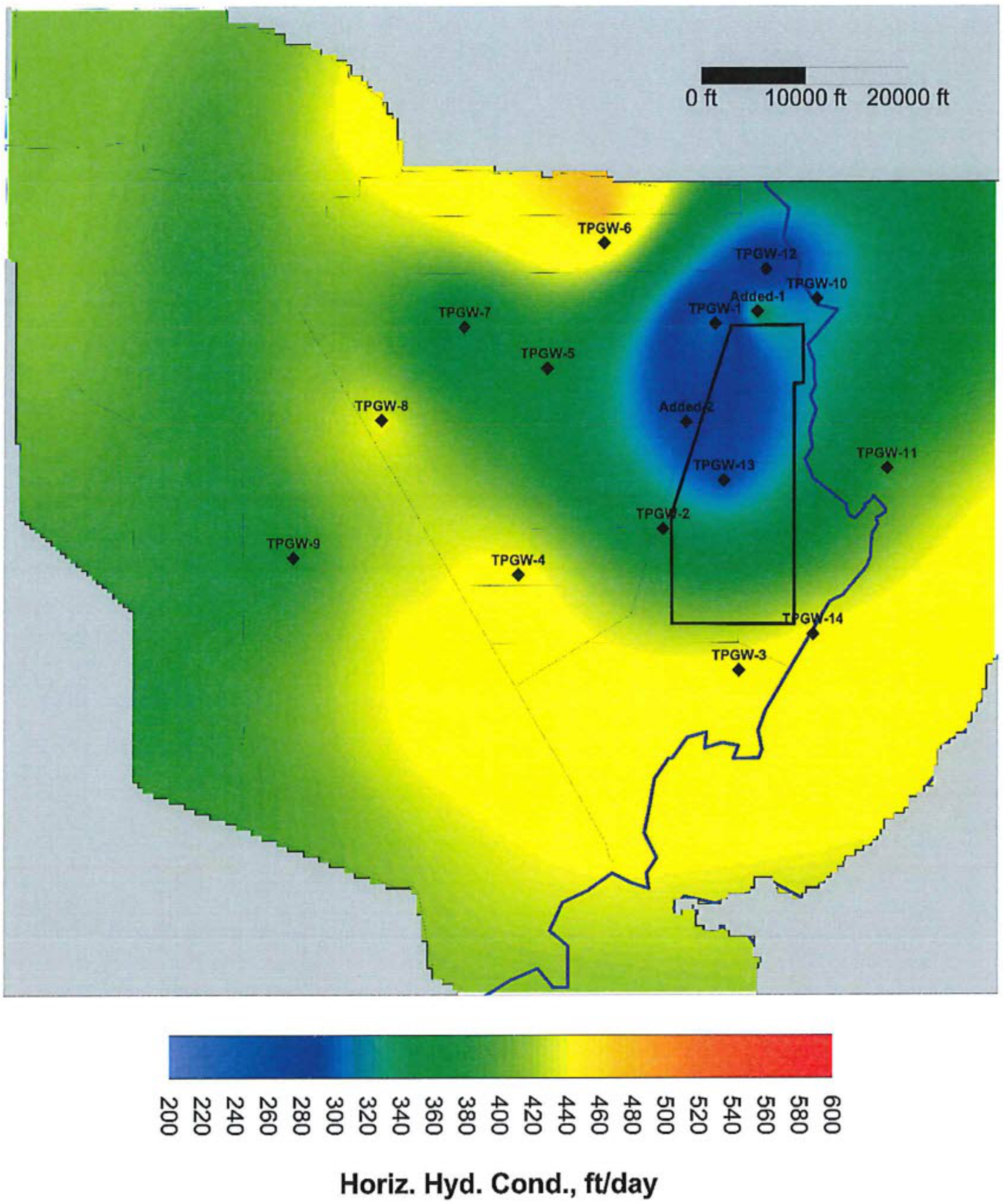


Figure 8. Layer 11 heterogeneous horizontal hydraulic conductivity associated with the calibrated HHC-V2 model

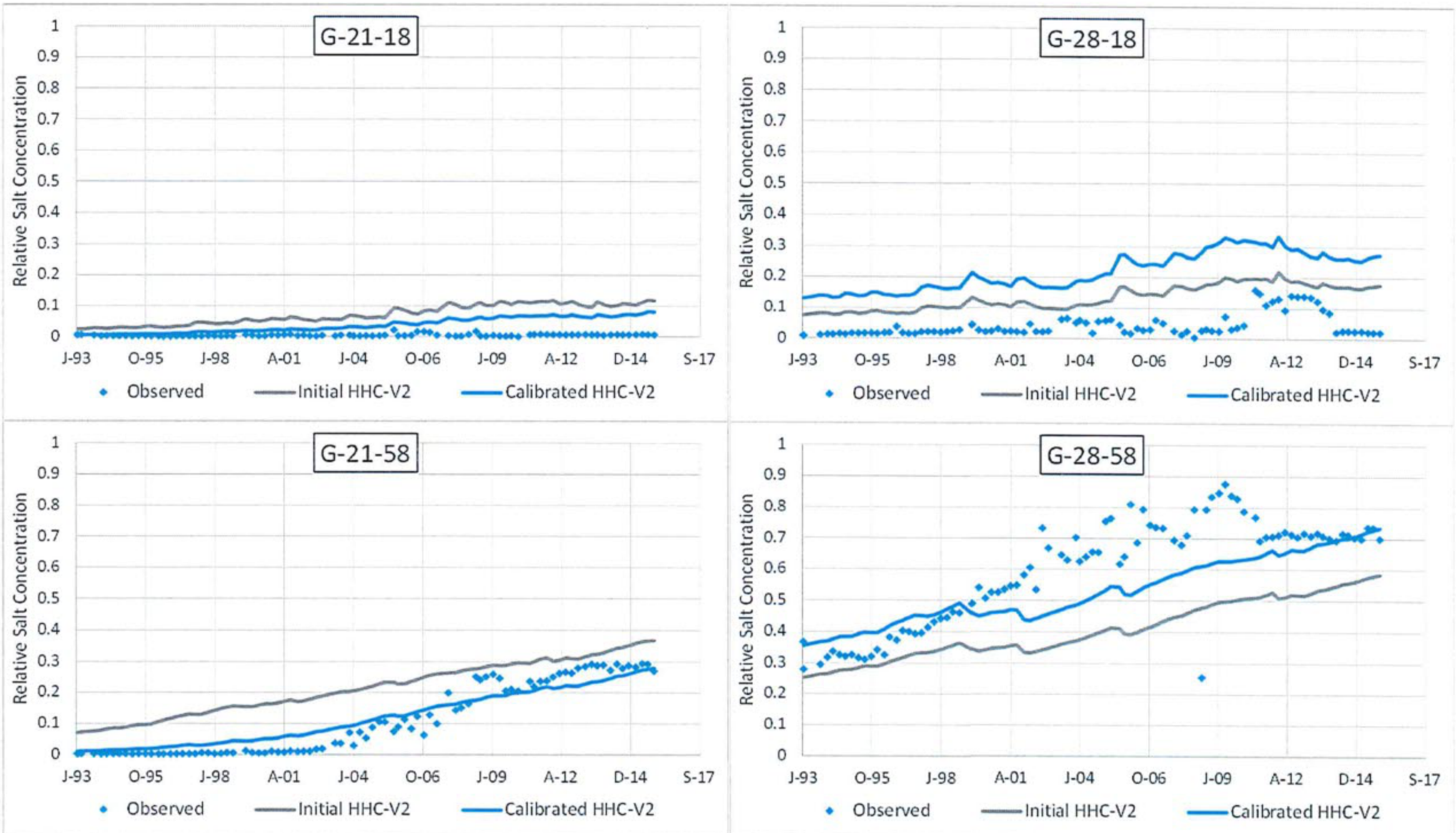


Figure 9. Observed and simulated saltwater wedge breakthroughs for the initial (July 2016) and calibrated HHC-V2 models

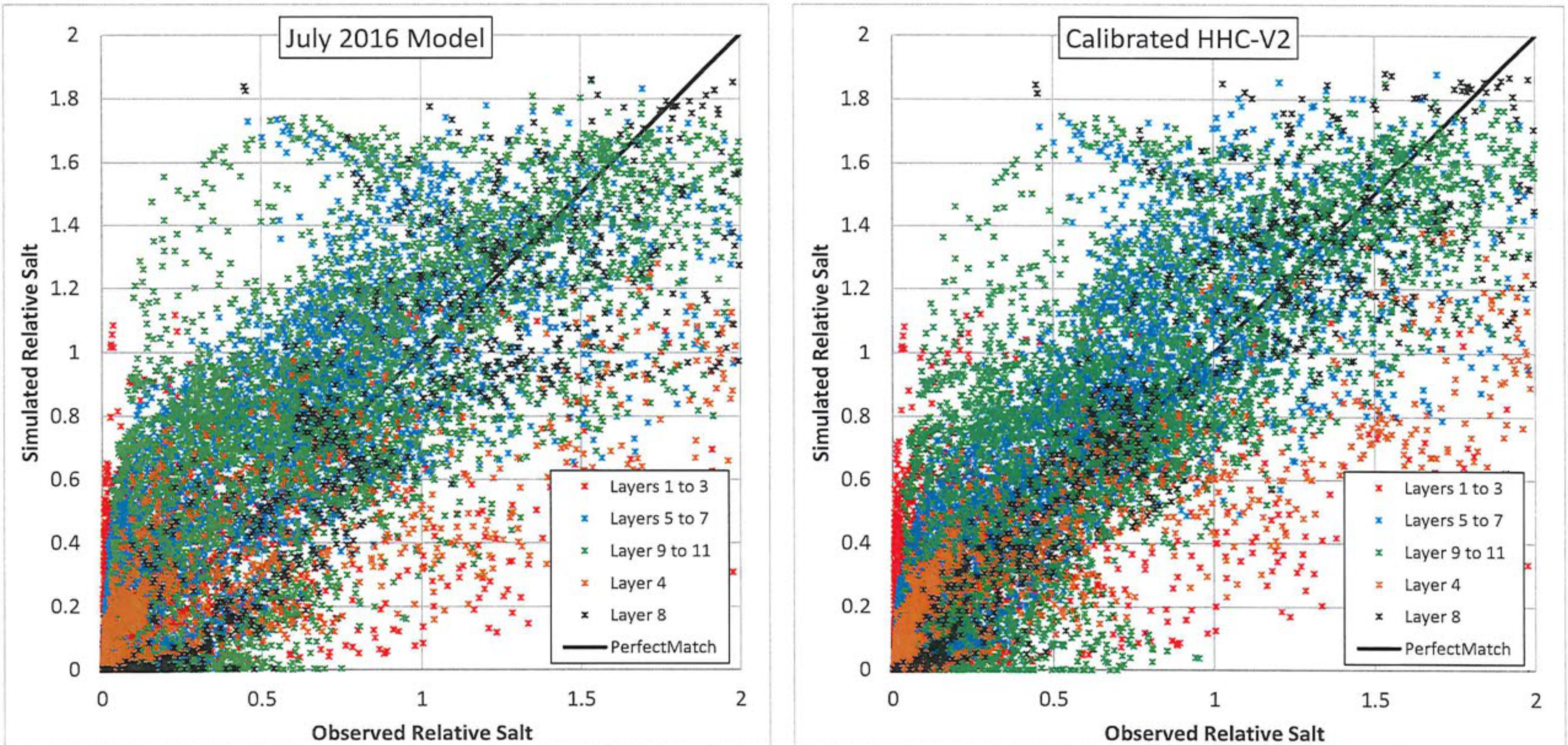


Figure 10. Observed versus simulated CSEM survey salt concentrations for the initial (July 2016) and calibrated HHC-V2 models

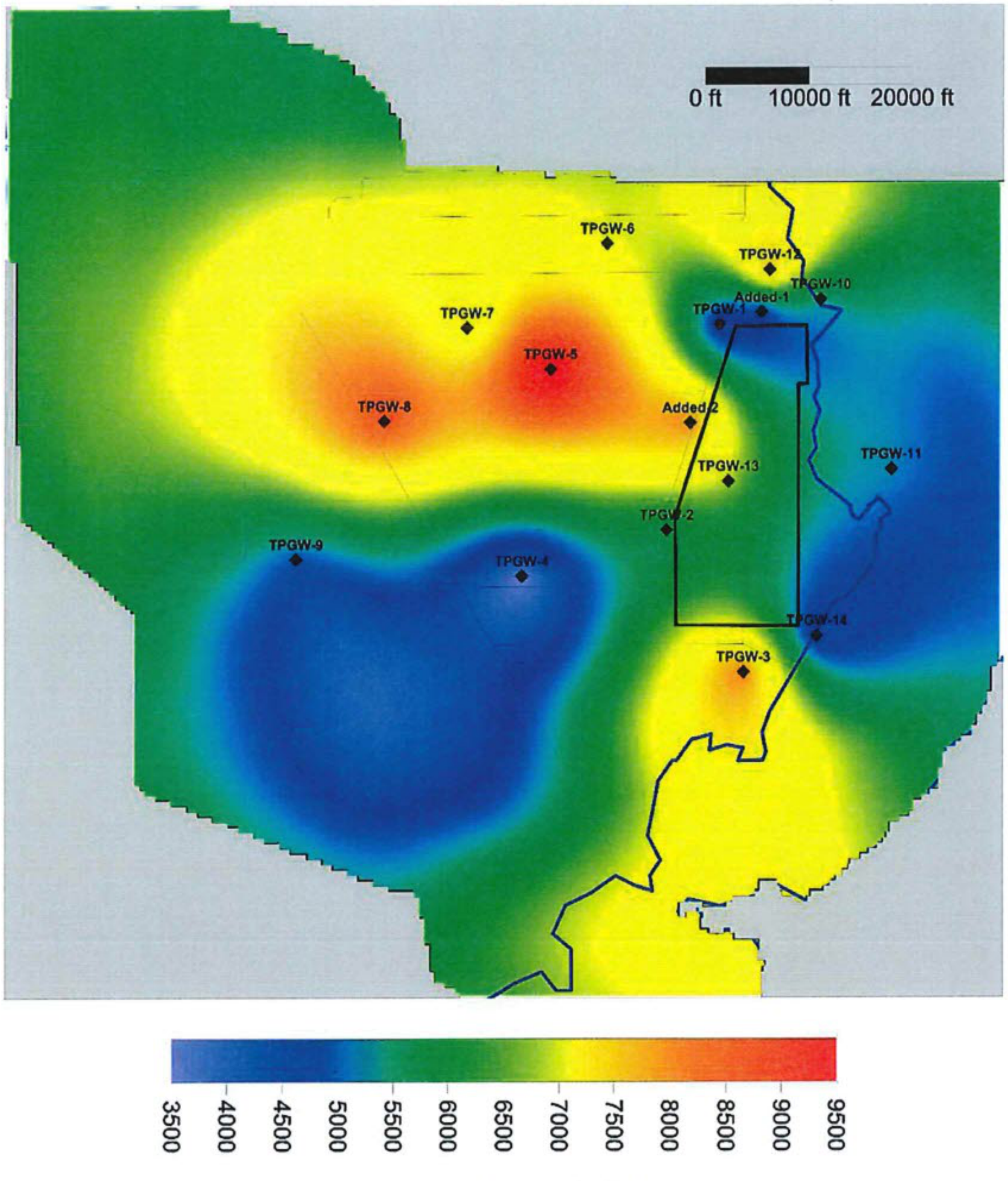


Figure 11. Layer 4 heterogeneous horizontal hydraulic conductivity associated with the calibrated HHC-V3 model

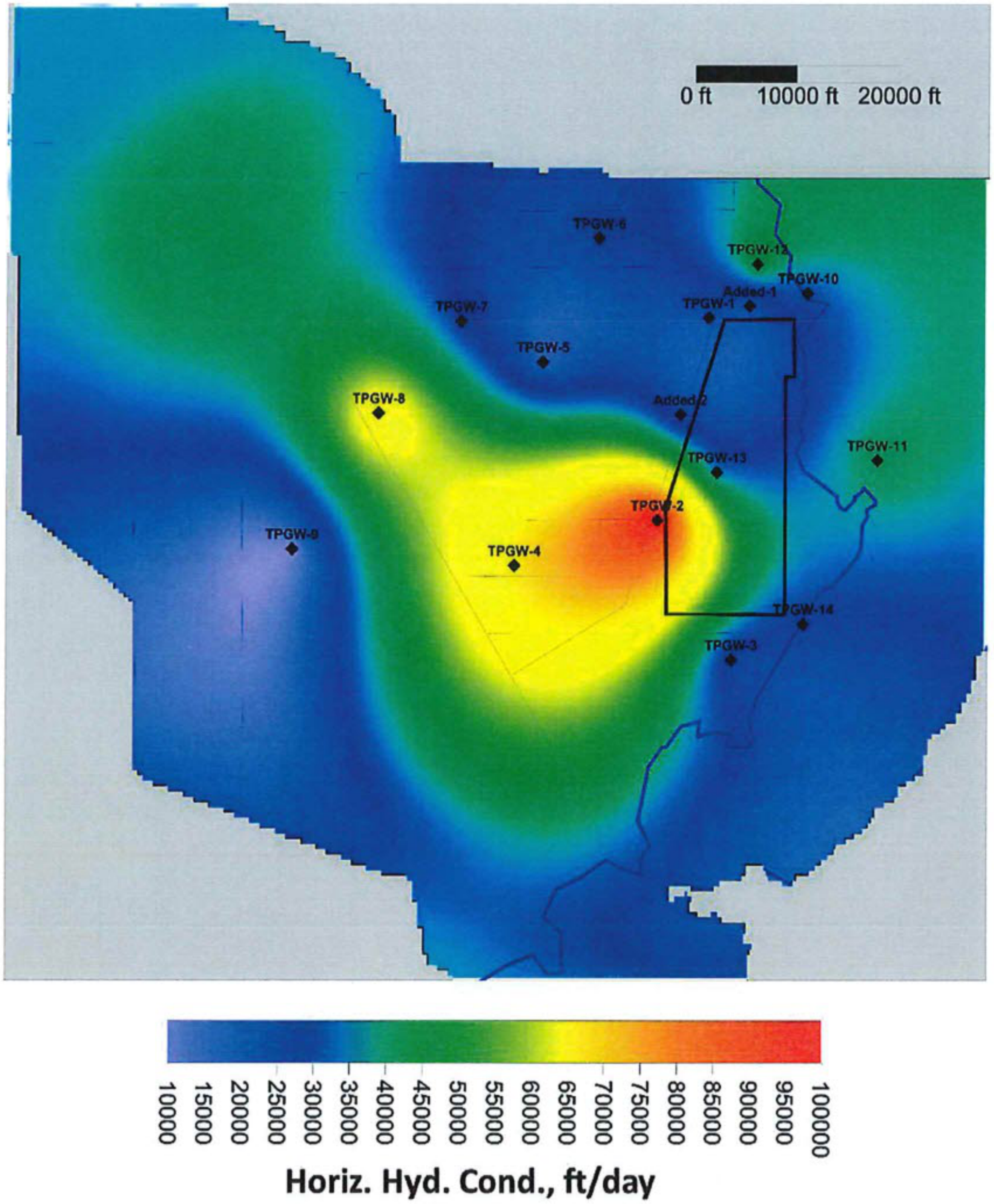


Figure 12. Layer 8 heterogeneous horizontal hydraulic conductivity associated with the calibrated HHC-V3 model

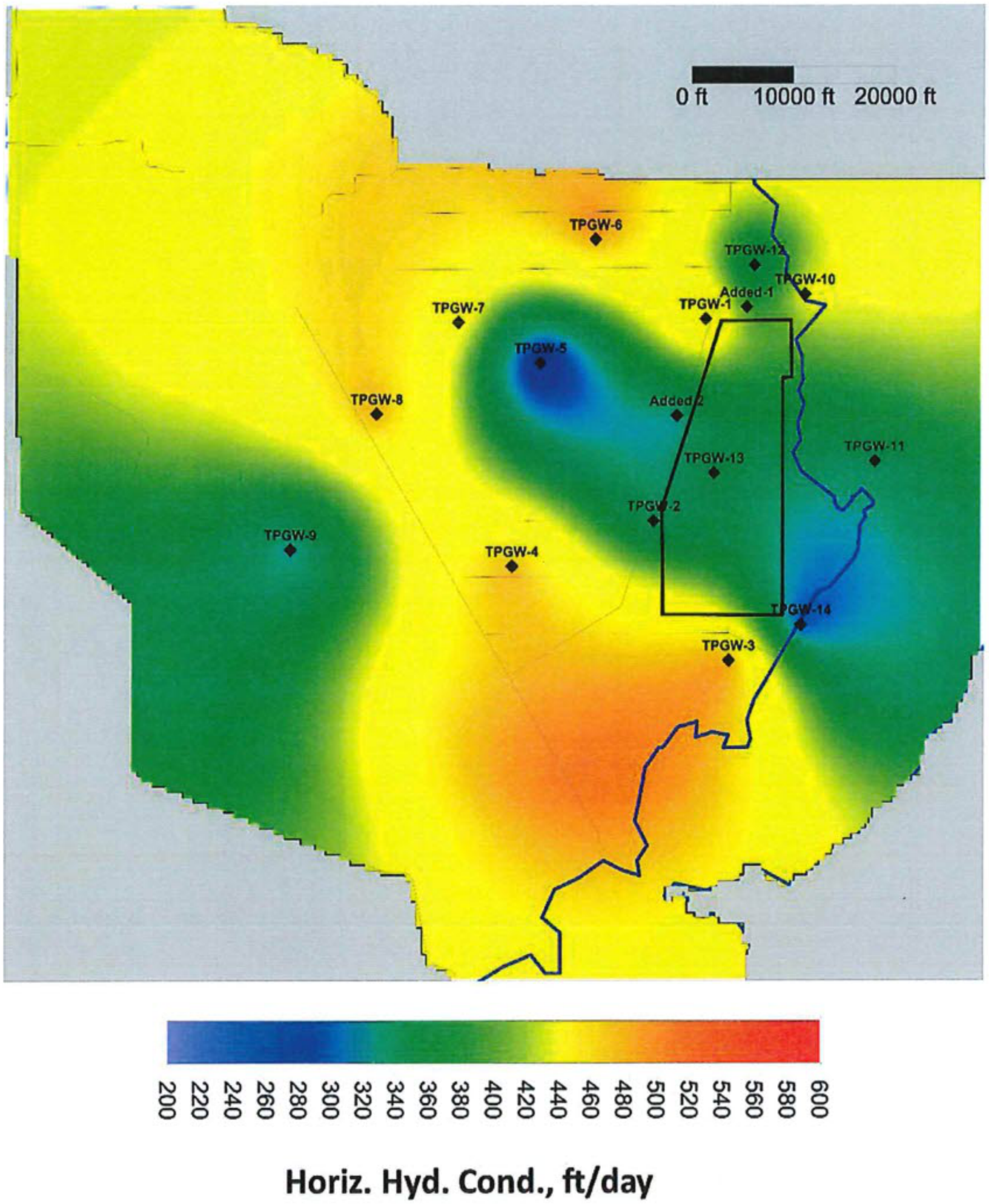


Figure 13. Layer 9 heterogeneous horizontal hydraulic conductivity associated with the calibrated HHC-V3 model

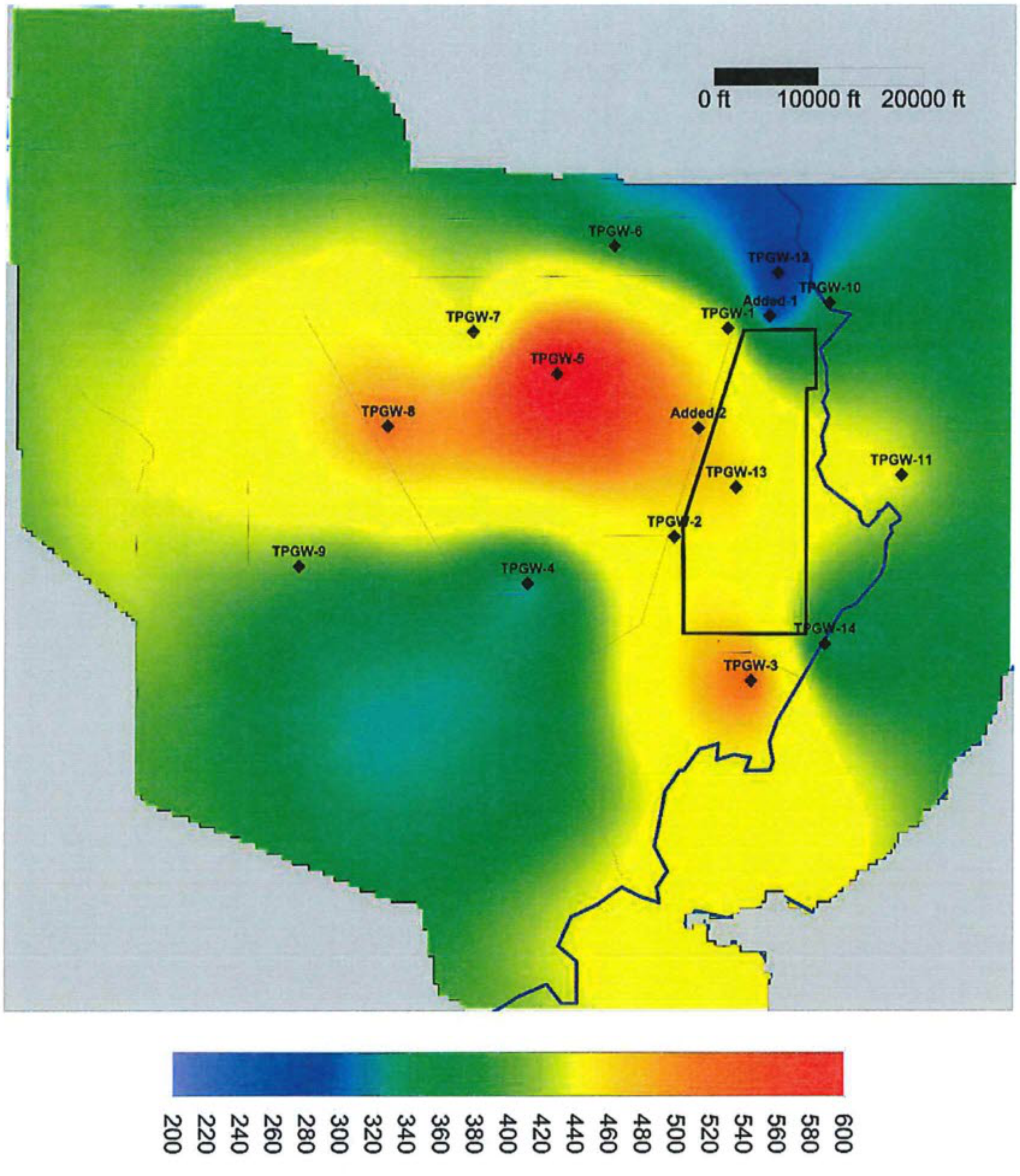


Figure 14. Layer 10 heterogeneous horizontal hydraulic conductivity associated with the calibrated HHC-V3 model

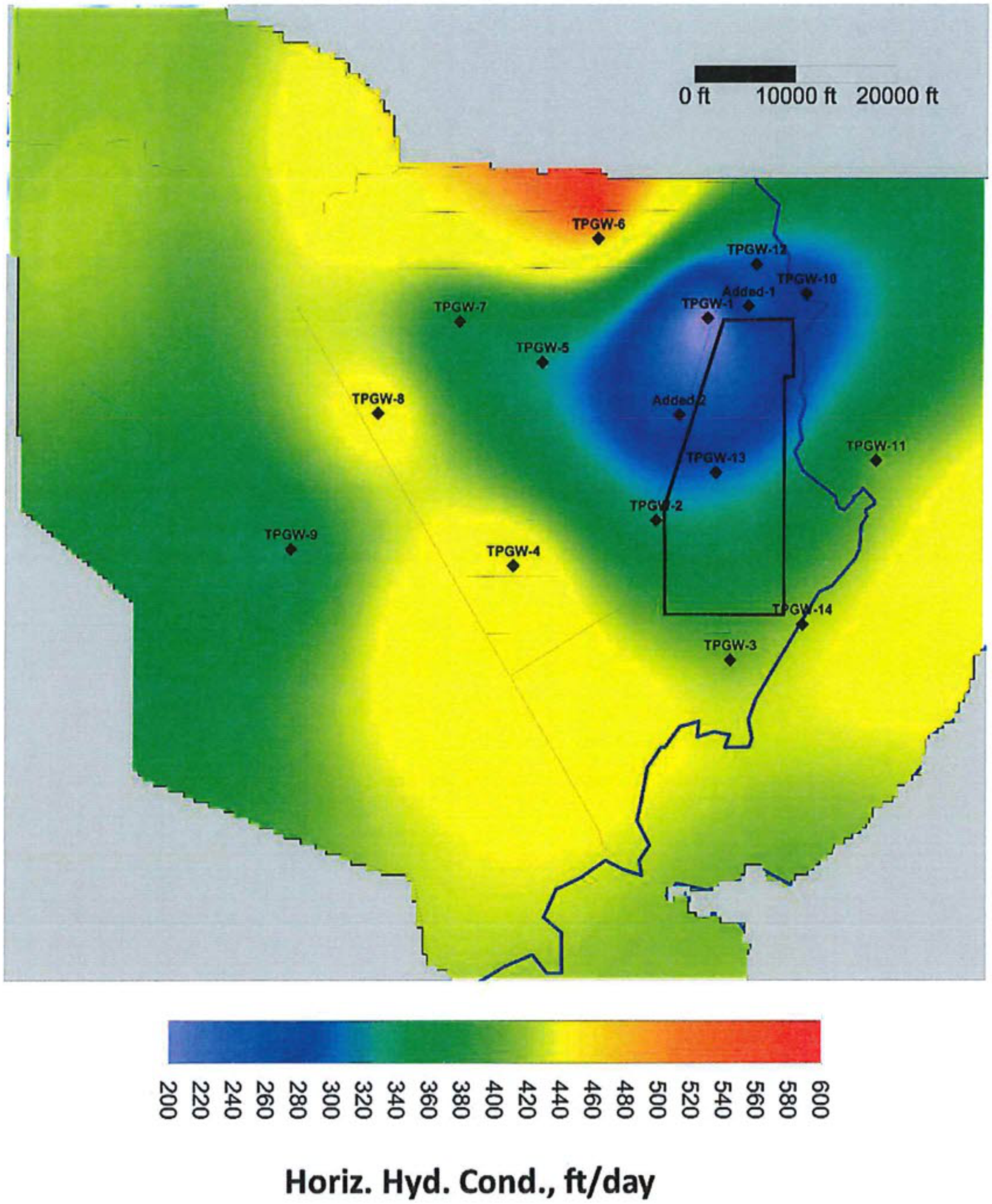


Figure 15. Layer 11 heterogeneous horizontal hydraulic conductivity associated with the calibrated HHC-V3 model

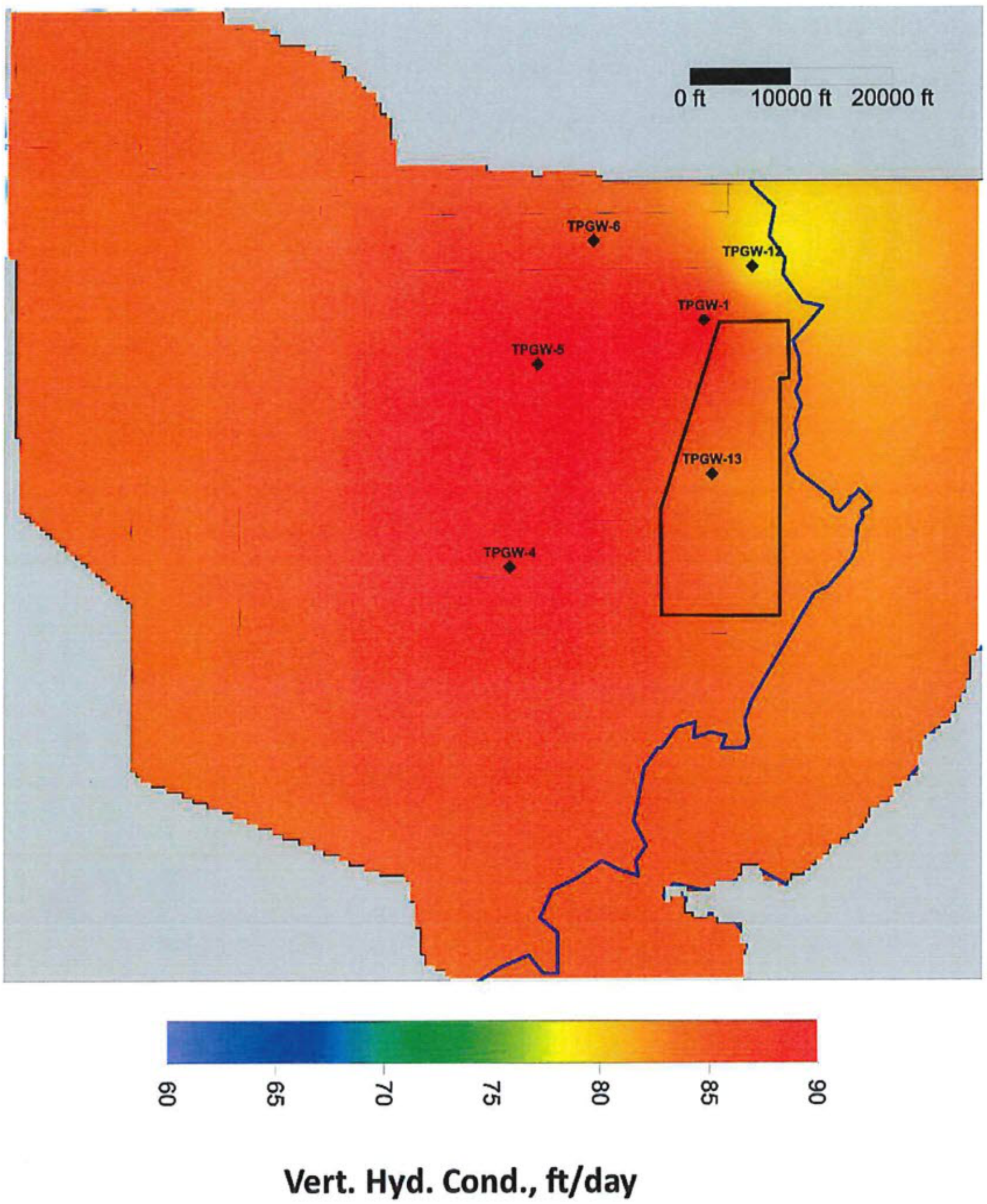


Figure 16. Layer 9 heterogeneous vertical hydraulic conductivity associated with the calibrated HHC-V3 model

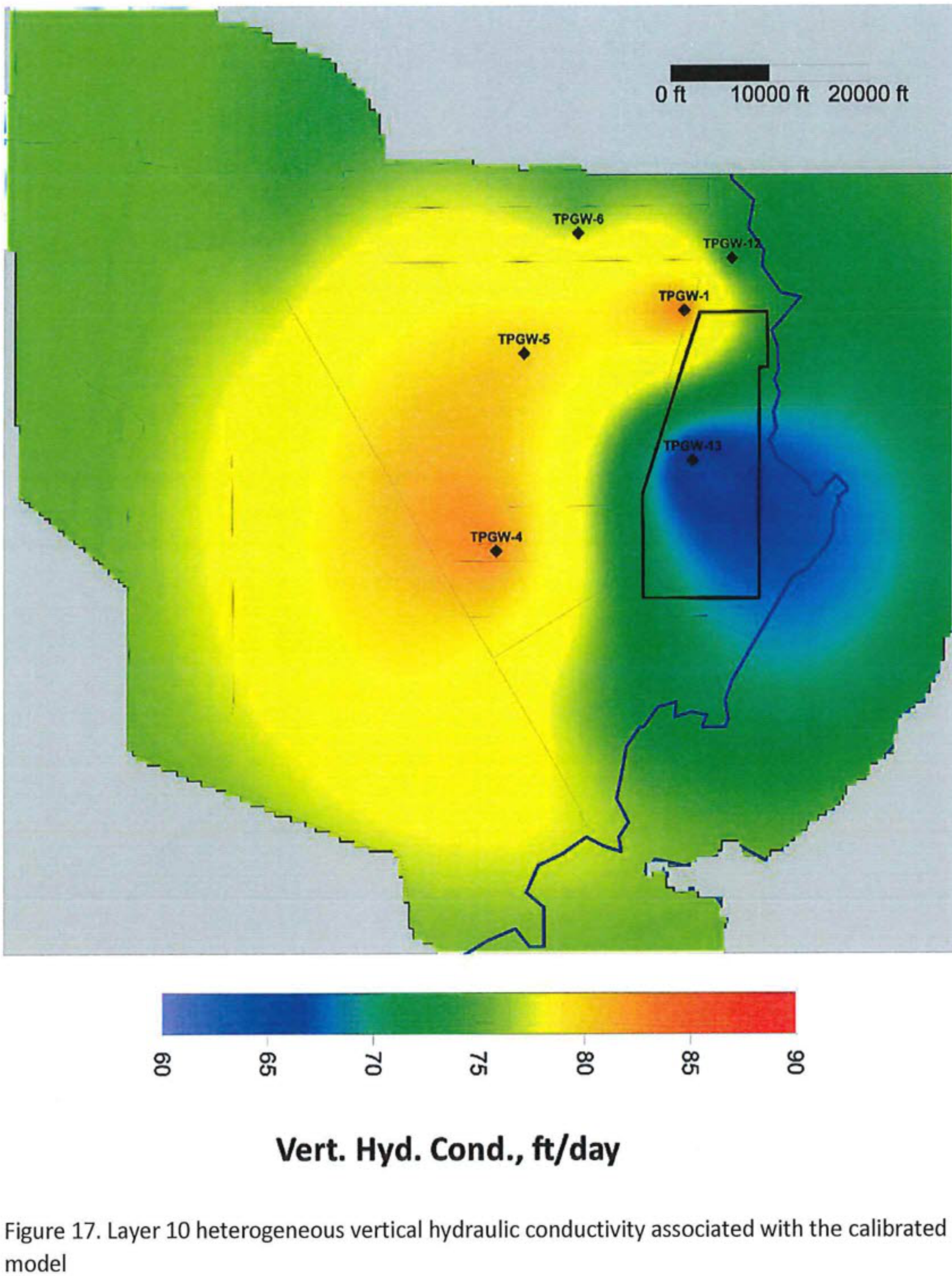


Figure 17. Layer 10 heterogeneous vertical hydraulic conductivity associated with the calibrated HHC-V3 model

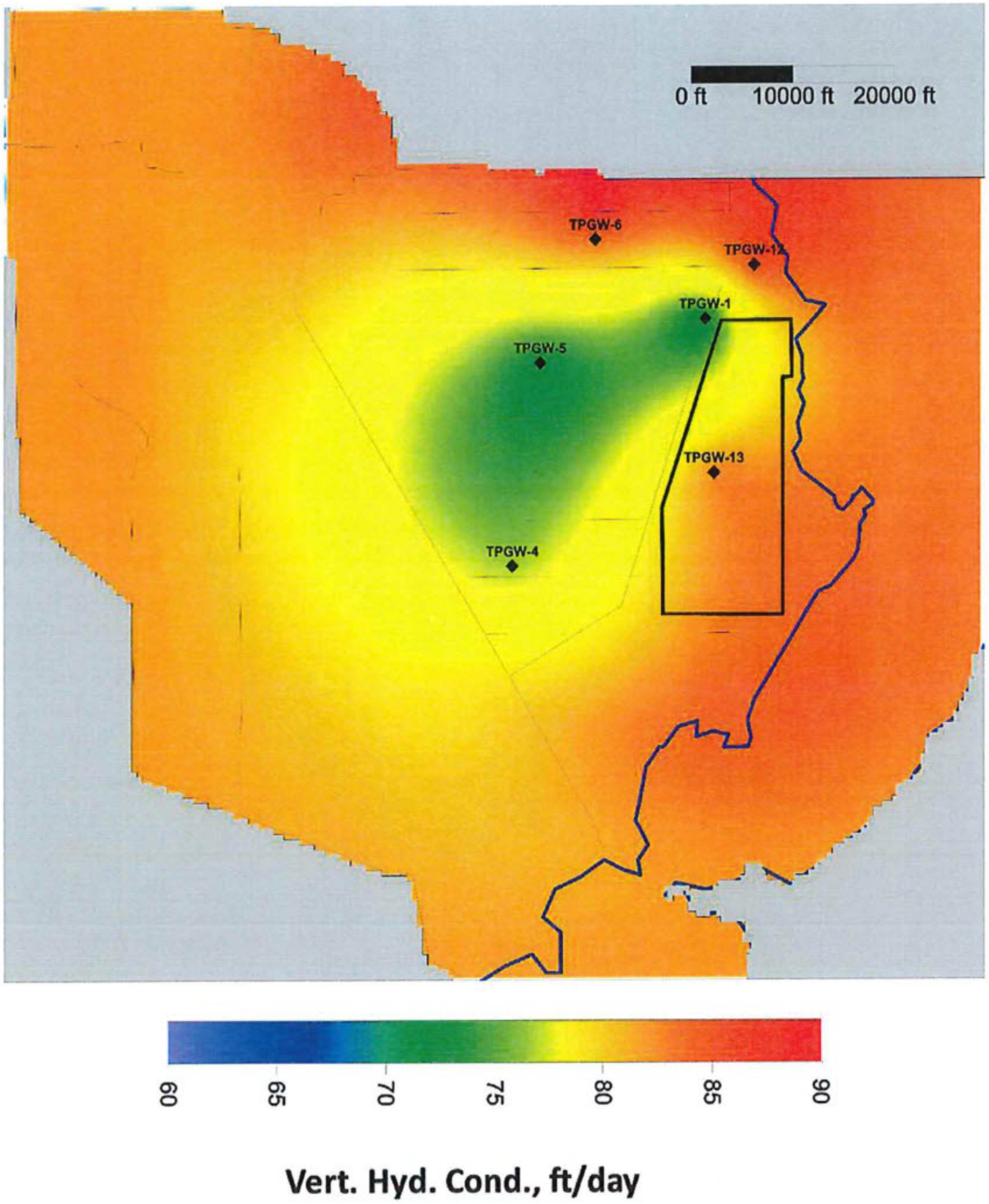


Figure 18. Layer 11 heterogeneous vertical hydraulic conductivity associated with the calibrated HHC-V3 model

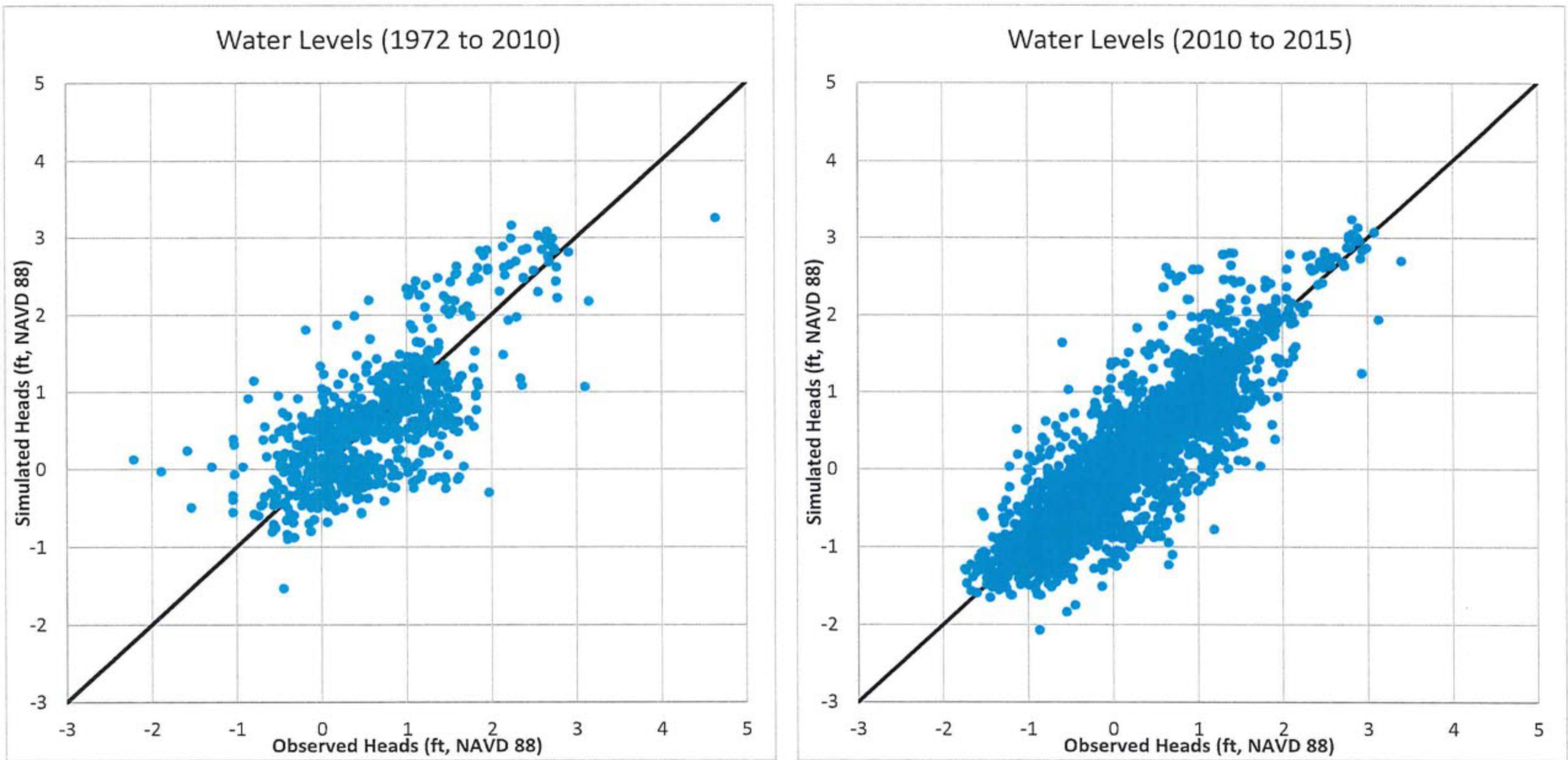


Figure 19. Observed and simulated water levels between 1972 and 2010 (left) and between 2010 and 2015 (right) for the calibrated HHC-V3 model

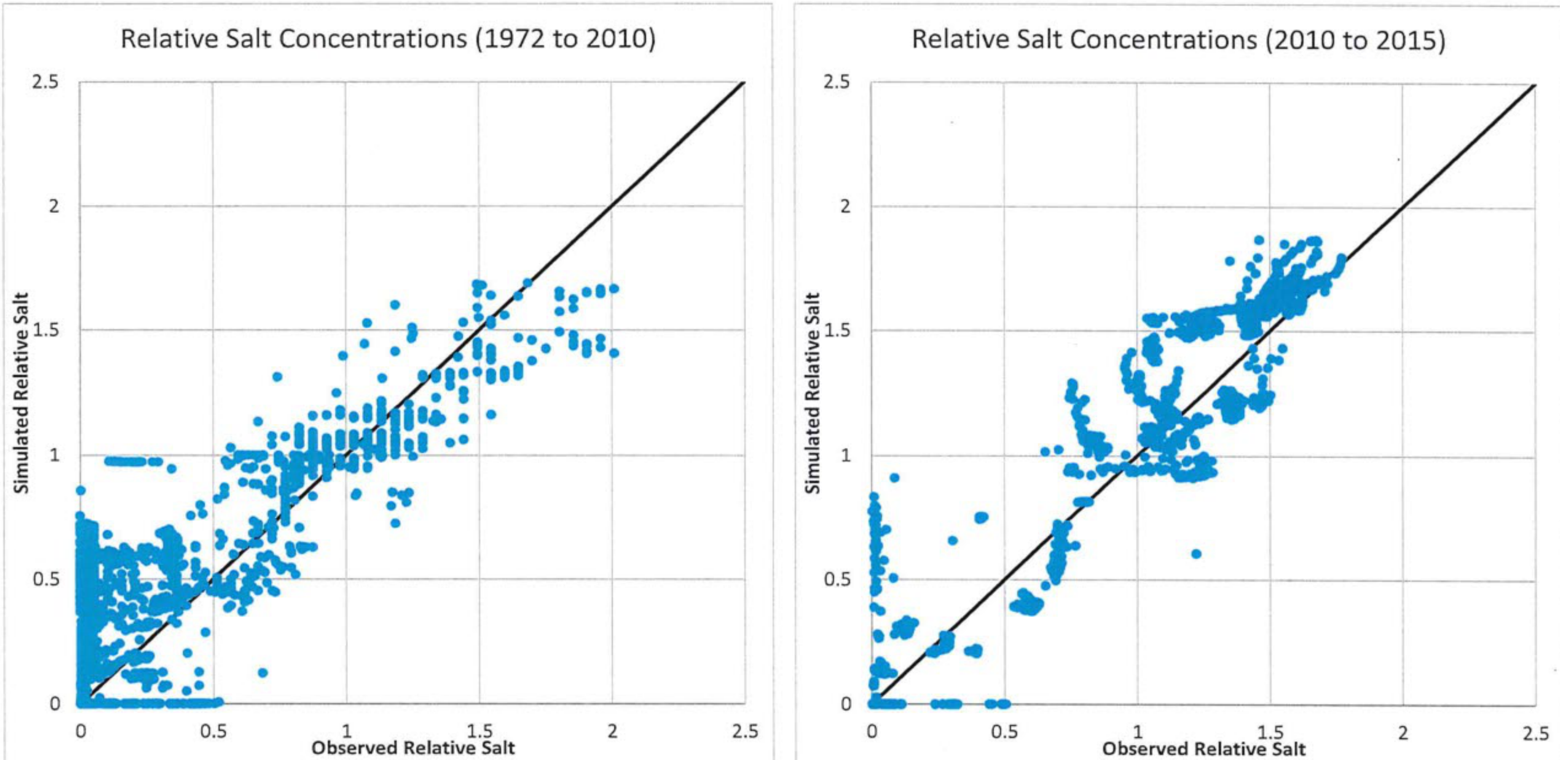


Figure 20. Observed and simulated relative salt concentrations between 1972 and 2010 (left) and between 2010 and 2015 (right) for the calibrated HHC-V3 model

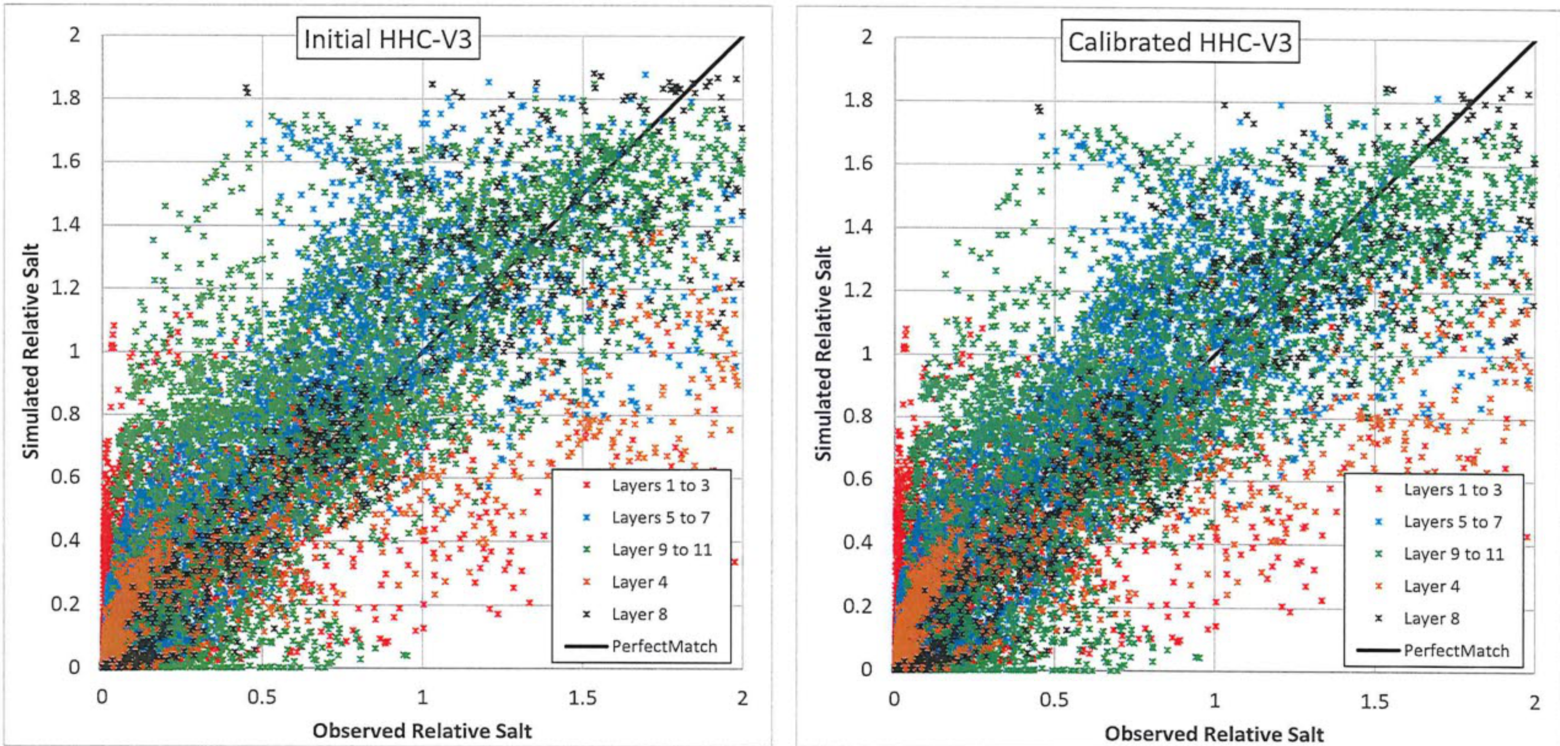


Figure 21. Observed versus simulated CSEM survey salt concentrations for the initial and calibrated HHC-V3 models

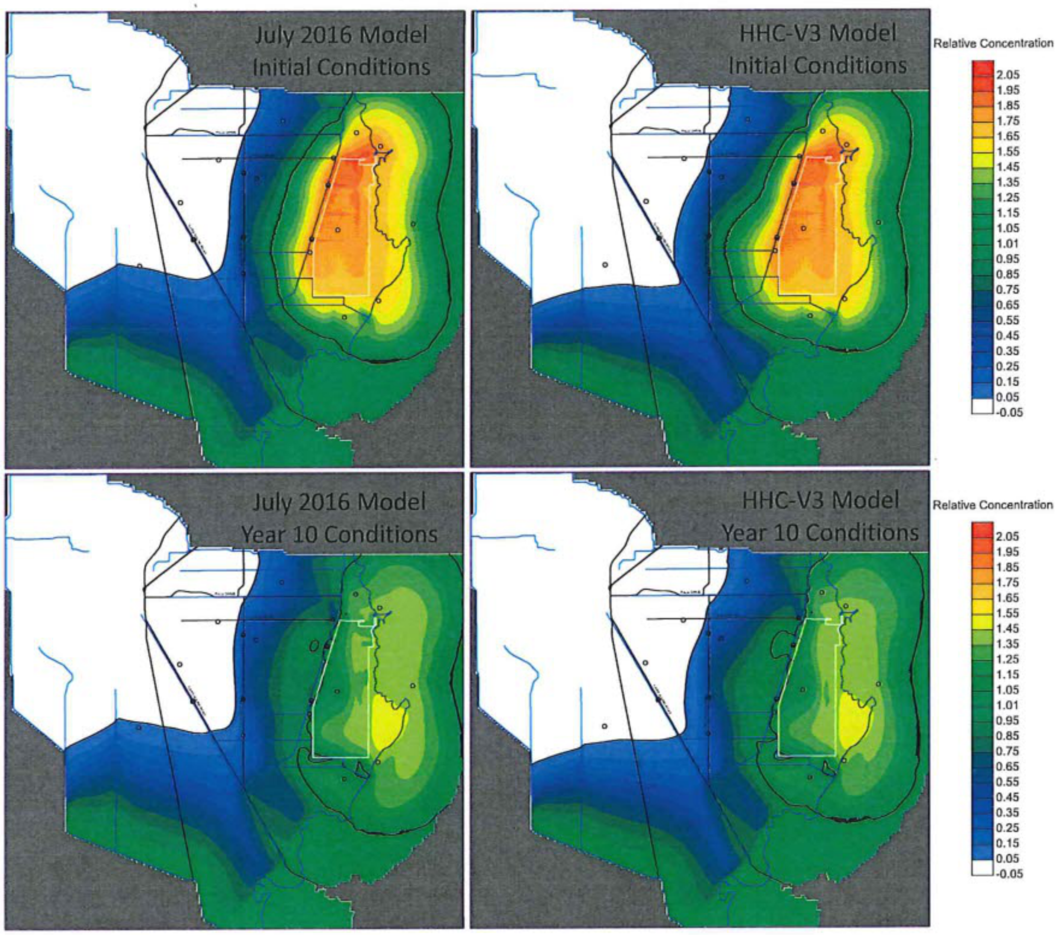


Figure 22. Initial and 10 year relative salt concentrations under RWS alternative 3D in model layer 8 for the July 2016 model (left) and calibrated HHC-V3 model (right)

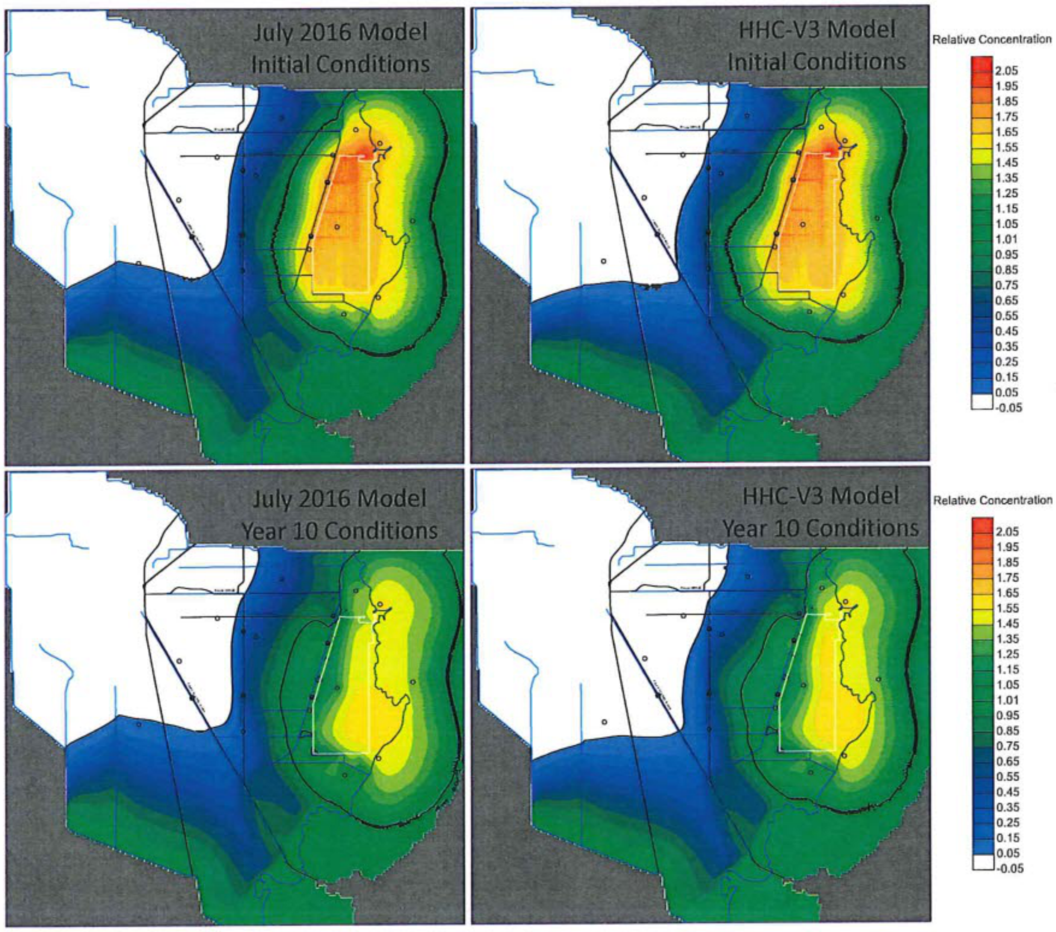


Figure 23. Initial and 10 year relative salt concentrations under RWS alternative 3D in model layer 9 for the July 2016 model (left) and calibrated HHC-V3 model (right)

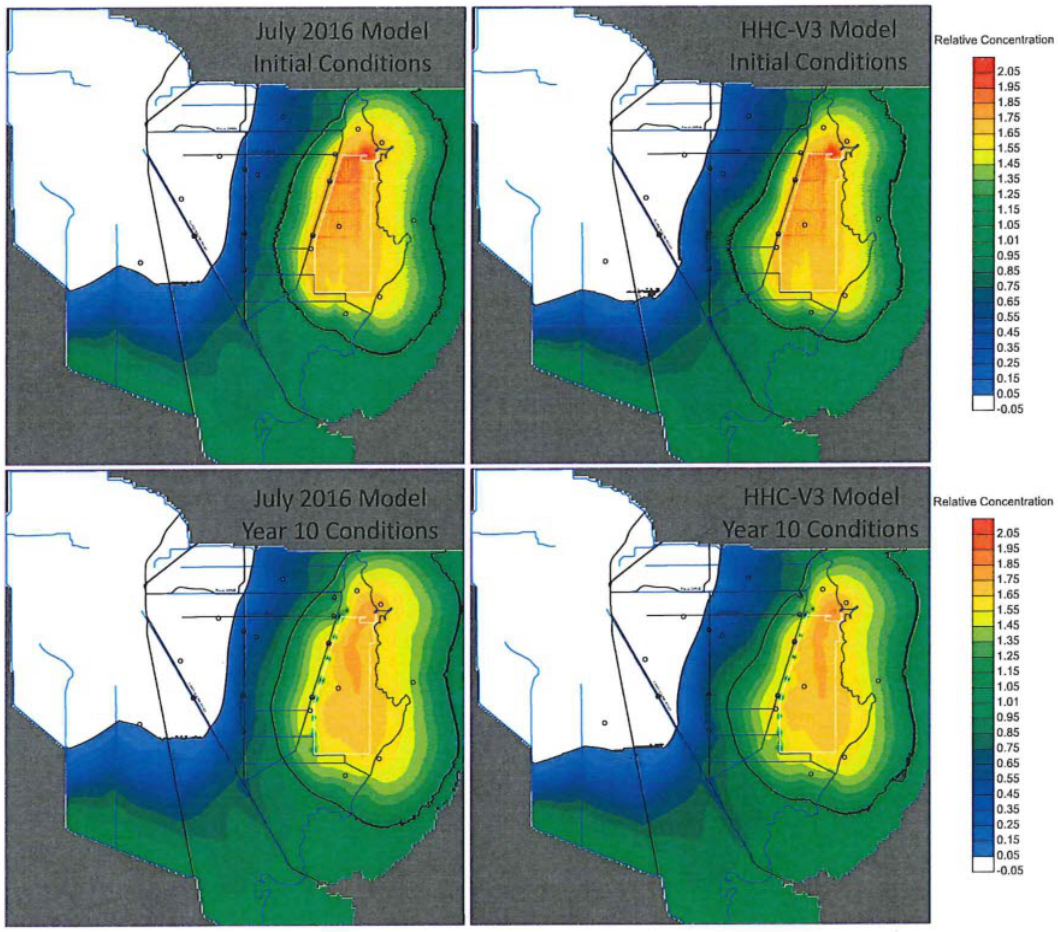


Figure 24. Initial and 10 year relative salt concentrations under RWS alternative 3D in model layer 10 for the July 2016 model (left) and calibrated HHC-V3 model (right)

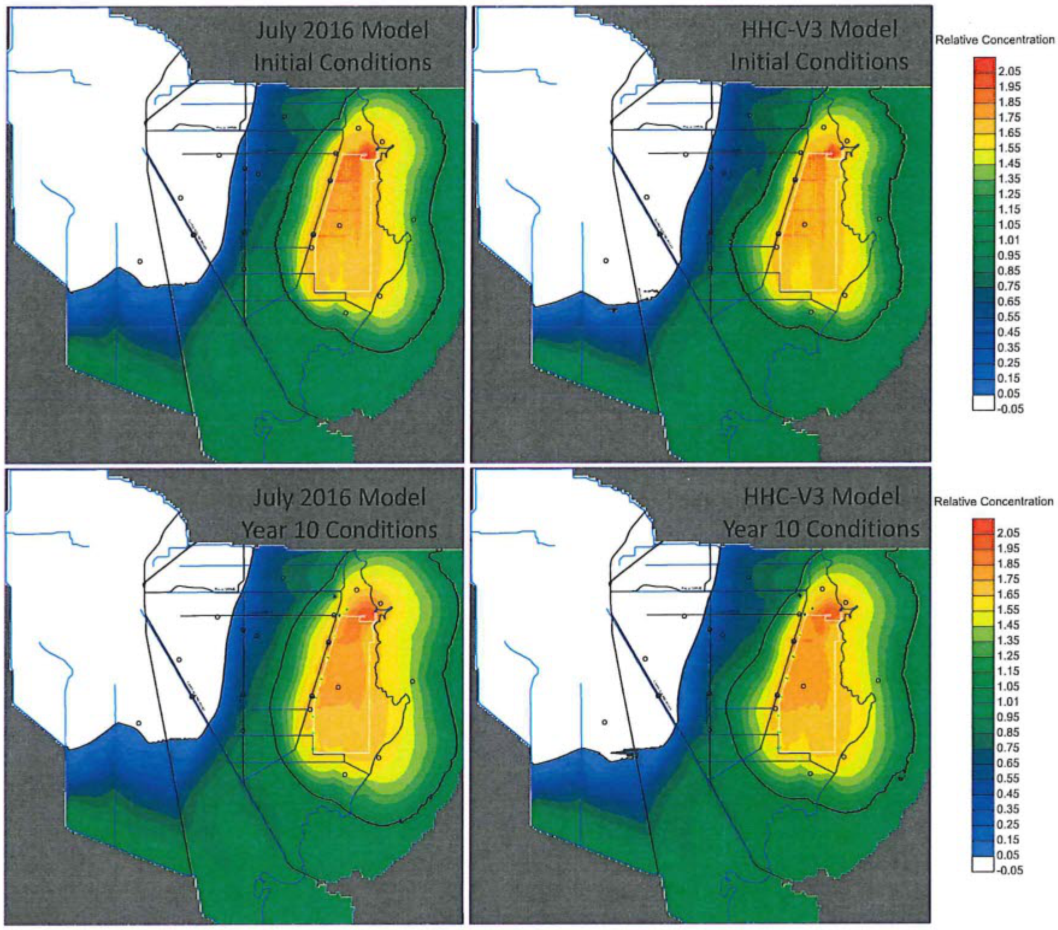


Figure 25. Initial and 10 year relative salt concentrations under RWS alternative 3D in model layer 11 for the July 2016 model (left) and calibrated HHC-V3 model (right)

Attachment 2

Addendum to Regional Biscayne Aquifer Groundwater Model Report Incorporating Comments from SFWMD

Addendum to Regional Biscayne Aquifer Groundwater Model Report Incorporating Comments from SFWMD

Introduction

This Addendum to the July 2016 Biscayne Aquifer model report (Tetra Tech, 2016) describes revisions made to the Variable Density Regional Biscayne Aquifer Groundwater Flow and Transport Model subsequent to both the distribution of the memorandum to regulatory agencies and an external model review meeting held at Miami Dade County Department of Environmental Resource Management (MDC DERM) on July 21, 2016. The motivation for, execution of, and changes to model results as a result of revisions to model boundary conditions are elaborated upon below.

Regional Model Summary

A transient variable density groundwater flow and transport model of the Biscayne Aquifer was developed to assess the impacts of the proposed remediation well extraction on local water resources (Tetra Tech, 2016). The model domain covers an area of approximately 276 square miles and consists of 11 layers. The 11 model layers represent the Miami Oolite, Fort Thompson Formation and two distinct high hydraulic conductivity layers (high flow zones) which represent preferential flowpaths detected in lithologic logs. The model simulates interactions between the Biscayne Aquifer, Biscayne Bay and surface water canals, including the CCS. Net recharge (i.e. recharge minus evapotranspiration) and groundwater withdrawals for both municipal and agricultural uses are also simulated using the best available information. The model is executed using the latest version of the SEAWAT code (Version 4). Water density is assumed to vary as a function of both temperature and salinity.

The regional groundwater model was calibrated to match measured water levels and groundwater salinities over a 47-year period (1968-2015). The first 42 years of the simulation period are simulated seasonally (two seasons per year), whereas the final five years and three months of the calibration period are simulated monthly due to greater data availability during this period. Hydrogeologic properties in the regional model were informed by a local-scale model which was calibrated separately to match drawdowns observed during an aquifer performance test conducted near the site of the proposed UIC wells. Automated calibration was performed on the local-scale and regional models using parameter estimation software ("PEST"). Acceptable statistical measures of calibration quality were achieved for salinities and water levels during calibration of the regional model.

Revisions to the Model

During a model review meeting on July 21, 2016, South Florida Water Management District (SFWMD) technical staff recommended revising how two surface water boundary conditions were simulated. The models used in the simulations presented in this application incorporated both of these suggested revisions, which are described in detail below. The final simulated groundwater heads, salinities and

temperatures from the end of the revised calibration model were used to initialize predictive simulations.

Card Sound Canal

The first suggested revision pertained to the portion of Card Sound Canal (sometimes referred to as "Card Sound Road Canal") south of where the canal nearly intersects the L-31E canal. The models submitted to Miami-Dade County, SFWMD and EPA prior to the review meeting treated Card Sound Canal as a drain boundary condition. Modeling this canal as a drain allowed the Biscayne Aquifer to discharge to the canal, but did not allow the canal to possibly serve as a source of water to the surrounding aquifer. The suggestion made by SFWMD was to model this section of Card Sound Canal as a saline river boundary condition instead of a drain to allow inland saltwater intrusion to occur through the canal. This revision was made, and relative salinity values of one (i.e. 35 practical salinity units, PSU) were assigned to the river boundaries in this section of Card Sound Canal throughout the calibration (1968-2015) and predictive simulations.

L-31E Canal

The second revision suggested by SFWMD was related to the southern section of the L-31E canal. The L-31E canal was treated as a river boundary condition with a relative salinity of zero in the models submitted for review. SFWMD recommended revising the southern portion of this canal (i.e. the section south of control structure S-20) from a river to a drain boundary condition. This revision was also made to the calibration and predictive simulations.

Layer 1 Rewetting

Subsequent to these boundary condition revisions, the model files were imported into the model pre-processor Groundwater Vistas (GWV) to facilitate external model review. Whereas the model was successfully executed from the DOS command prompt, stable and successful model execution within GWV required that layer 1 model cells in the western areas of the model domain be specified as not rewettable. As explained below, this did not affect calibration quality of the model, and was only necessary to be able to execute the model within GWV.

Model Results

Calibration Model

In order to assess the impact of the boundary condition revisions upon the calibrated model quality, simulated results for both models (pre- and post-revised boundary conditions) were compared to each other. First, a comparison of the relative salt concentration versus time at a monitoring well near to the revised boundary conditions simulated by both models provides a visual assessment of the local changes to simulated conditions attributable to the boundary condition revision. The simulated relative salt concentration versus time at monitoring well G-28 (18 ft and 58 ft screens) is provided in Figure 1. At the shallow (18 ft) screen, the impact to simulated salt concentrations due to the revision is negligible. At the deeper (58 ft) screen, the model revision produces slightly greater concentrations at the monitoring well. This result should be expected, as both boundary condition changes would likely produce greater salt concentrations at nearby monitoring wells.

Results at G-28 illustrate impacts to simulated salt concentrations near to the boundary conditions. In order to confirm that these changes are relatively localized, summary statistics for flow and transport model residuals were tabulated for targets throughout the entire model domain prior to and after the boundary conditions revision. The mean absolute error (MAE) was calculated for water level observation calibration targets and observed salt concentration calibration targets at monitoring wells, as well as CSEM survey-based salt concentrations. The MAE for the target categories were compared between the pre- and post-revision models to assess the degree to which the boundary conditions impacted model quality. This comparison is provided in Table 1, below. Inspection of this table reveals that the MAEs for both models are very similar for all calibration target types, which confirms that the boundary condition revision did not significantly affect model results. This is not surprising given the disparate locations of the revised boundary conditions that were revised relative to calibration target data. In fact, for most of the calibration target types where a change to the residuals occurred, the model improved (MAE reduced) as a result of the boundary condition revision.

Prediction Model

Simulation of Recovery Well Systems (RWS) Alternative 3D with the revised boundary condition model yielded similar, yet slightly different results in terms wetland drawdown. Inspection of Figure 2 reveals that the revised model simulates a slightly greater extent of drawdown in wetlands. The slight increase in the extent of wetland impacts simulated by the revised model is consistent with the conversion of L-31E (south of S-20) from a RIV boundary condition (potential source of water to the model) to a DRN boundary condition (not a source of water to the model).

Figure 2 shows the average simulated salt concentration of the water extracted by the five sourthernmost extraction wells that operate as a part of RWS Alternative 3D. These wells were selected because they are nearest to the revised boundary conditions. Note that the simulated average salt concentration of the extracted water is nearly equal in the two versions of the RWS model.

Conclusions

Based on the recommendations provided by SFWMD, revisions to portions of the L-31E and Card Sound Canal boundary conditions were made to the calibrated Biscayne Aquifer groundwater flow model presented to MDC DERM in July 2016. As a result of these recommendations, the representation of these boundary conditions in the revised model is likely improved over the prior model. Based on an evaluation of calibration and prediction models' results, the revisions have an overall minor impact to the historical and future simulated hydrologic and water quality conditions. As of this model improvement and minimal change to model results, these revisions will be preserved in future versions of the calibration and predictions models.

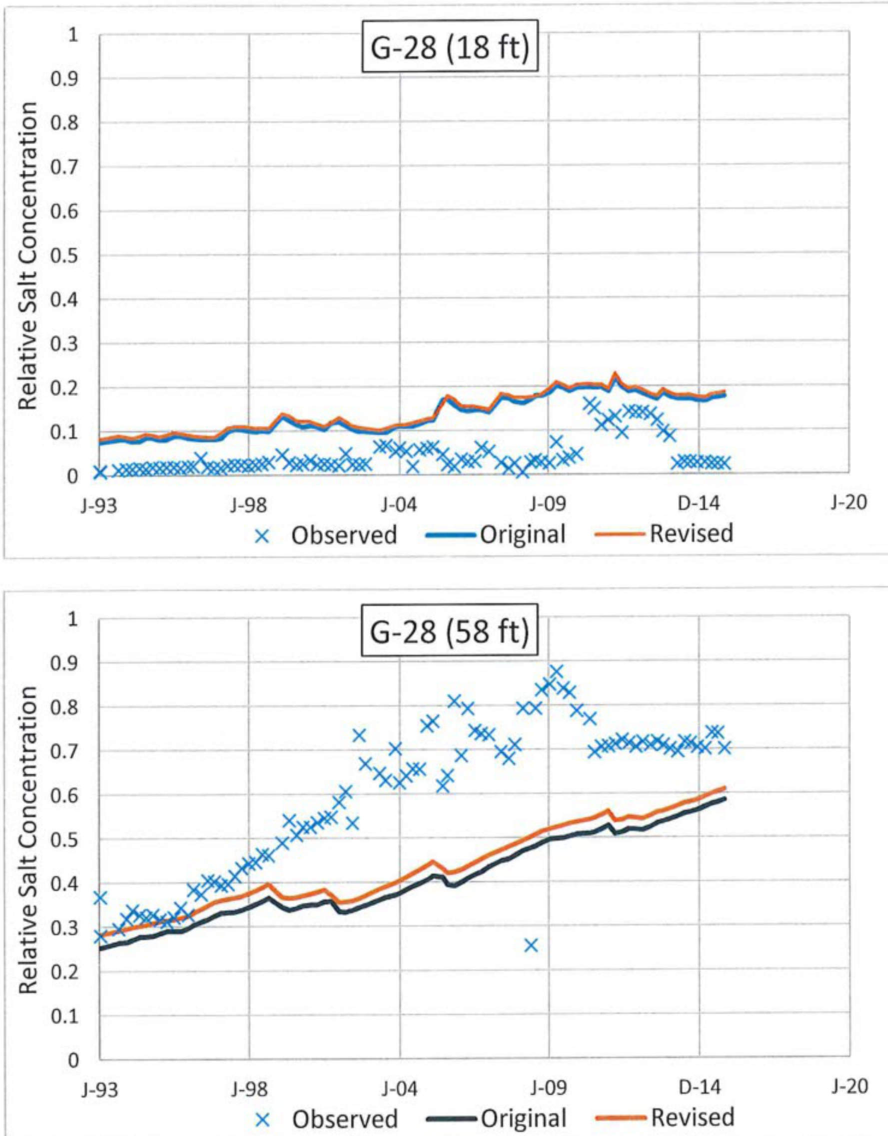


Figure 1. Observed and simulated relative salt concentrations at monitoring well G-28 (shallow and deep screens) for the original calibrated model and calibrated model with the revise boundary conditions

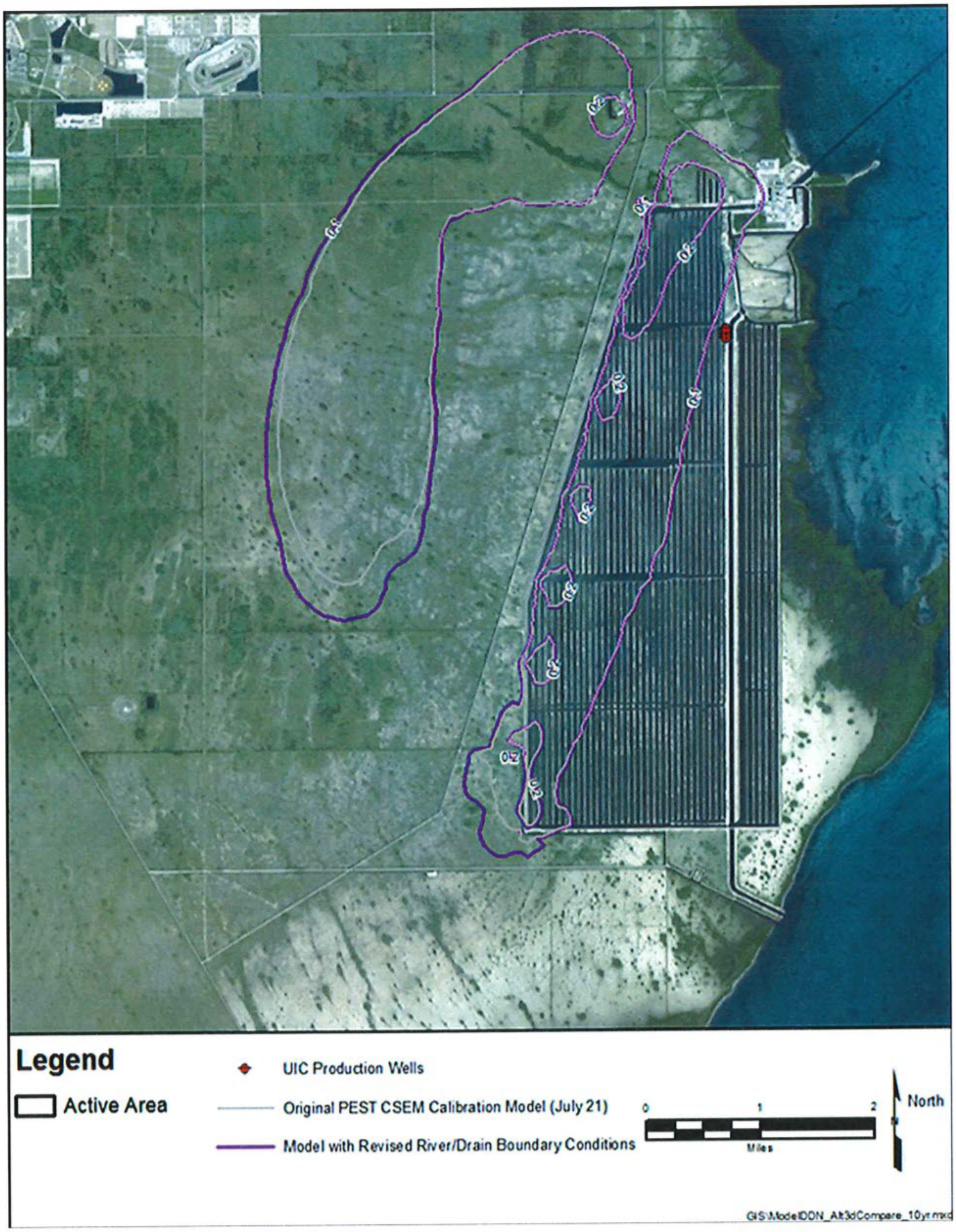


Figure 2. Simulated wetland (Model Layer 1) drawdown after 9 years of Alternative 3D extraction well operation using the original (pre-revision) models and revised boundary condition models

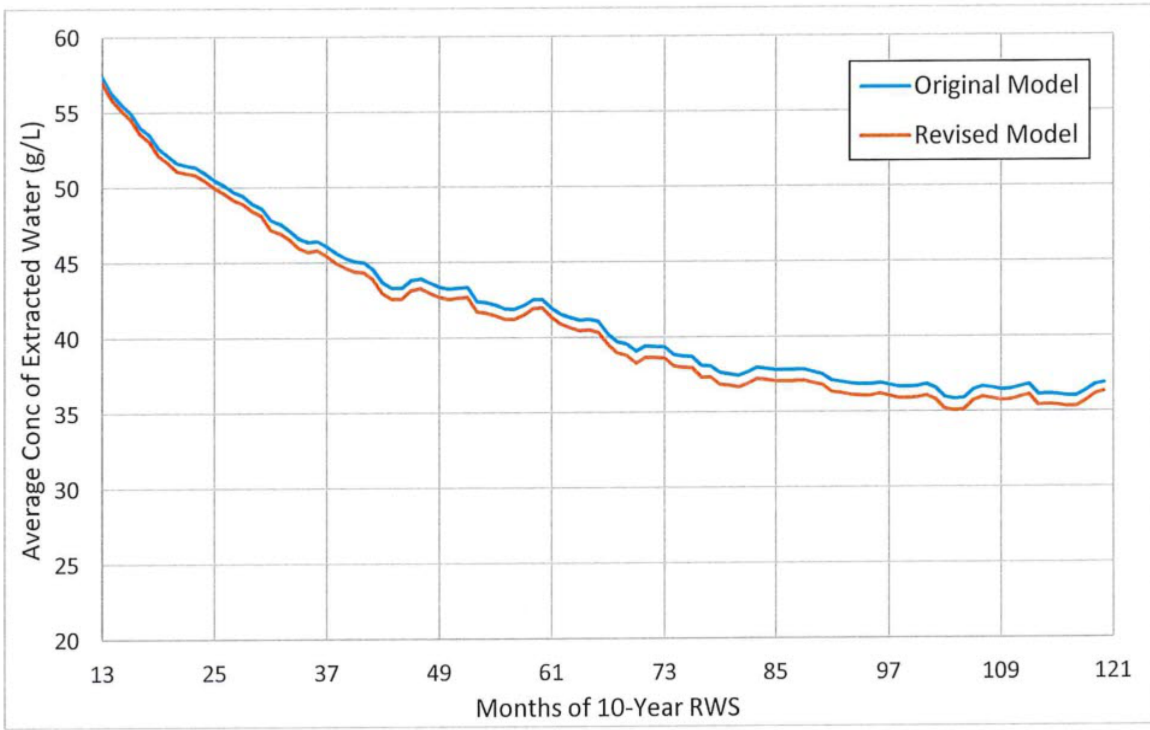


Figure 3. Average simulated (original and revised models) concentration of water extracted by the five southernmost extraction wells that comprise RWS Alternative 3D

Table 1. MAE for the pre- and post-boundary condition revision models for all calibration target types

Target Type	Pre-Revision MAE	Post-Revision MAE	% Difference
Seasonal Water Levels (ft)	0.459	0.459	0.00%
Seasonal Relative Salt Concs	0.198	0.191	-3.54%
Monthly Water Levels (ft)	0.329	0.329	0.00%
Monthly Relative Salt Concs	0.145	0.145	0.00%
CSEM Relative Salt (Layers 1 to 3)	0.116	0.111	-4.31%
CSEM Relative Salt (Layer 4)	0.227	0.225	-0.88%
CSEM Relative Salt (Layers 5 to 7)	0.216	0.213	-1.39%
CSEM Relative Salt (Layer 8)	0.267	0.259	-3.00%
CSEM Relative Salt (Layers 9 to 11)	0.284	0.287	1.06%

Attachment 3

FPL Responses to FKAA Model Review Comments

Response to FKAA Groundwater Model Review

Introduction

Florida Power & Light (FPL) appreciates the review of the Regional Biscayne Aquifer model provided by Florida Keys Aqueduct Authority (FKAA) and its consultant, Water Science Association. With its consultant, Tetra Tech, FPL has evaluated FKAA's comments and concerns associated with the groundwater model. Overall, while FPL believes that incorporating some of FKAA's suggested model revisions will generally improve the caliber of the model, FPL finds that none of these revisions will significantly impact the results of predictive modeling nor will they likely change the optimality of the selected remedial alternative (Alternative 3D).

It is worth noting that the Consent Agreement (CA) between FPL and Miami Dade County (MDC) Department of Environmental Resource Management (DERM) required FPL to develop the variable density groundwater flow and transport model referenced herein within a 180 day timeframe. Given this relatively short timeframe, the model will evolve over time with the introduction of additional data and improved understanding of regional hydrology, hydrogeology, and geology. As such, it is possible that some of the suggested revisions and recommendations proffered by FKAA may be incorporated in the course of the model's evolutionary development

In the Conclusions and Recommendations of the review memorandum, FKAA's consultant elucidated concerns that need to be addressed prior to additional modeling. Responses to these concerns are provided below. Additional and relatively minor concerns, discussed elsewhere in the review memorandum, are addressed at the conclusion of this document

FKAA Concerns Requiring Resolution

FKAA Comment: Assigning spatially variable hydraulic parameters to model layers should be considered since it could affect the flow and transport significantly.

FPL Response: FPL agrees that adding additional and appropriate complexity to the groundwater model has the potential to improve the calibration of the model and perhaps its predictive capability. Uniform hydraulic conductivities were informed by a local aquifer performance test (APT) (Enercon, 2016); and, due to the relatively short period of time allotted for model construction and calibration, the incorporation of greater complexity in the form of heterogeneous hydrologic properties was not possible. Through the course of continued model improvement, Tetra Tech is currently conducting a calibration of the groundwater model wherein the definition of heterogeneous hydraulic conductivities is being evaluated.

FKAA Comment: The varying rates of net recharge part way through the calibration period are not clearly tied to calibration efforts. Some explanation for these changes is required.

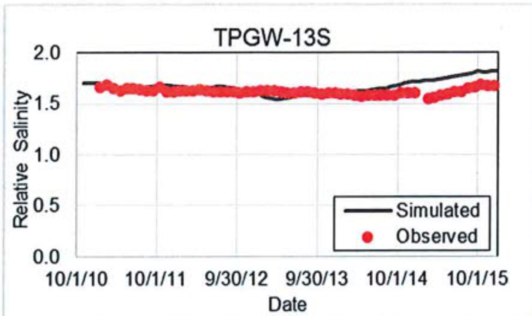
FPL Response: Starting in 1996, NEXRAD-based estimates of precipitation and potential evapotranspiration provided a relatively detailed assessment of precipitation, and were employed to define seasonal recharge for the latter part of the seasonal model (1996 to 2010). Prior to 1996 in the seasonal model, wet and dry seasonal recharge was based on average seasonal precipitation and evapotranspiration, as calculated from available NEXRAD data. A more detailed discussion of precipitation data and the associated estimates of recharge is provided in the modeling documentation (Tetra Tech, June, 2016).

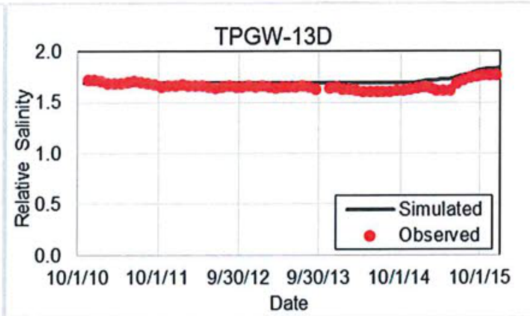
FKAA Comment: The occurrence of "dry cells" and "flooded cells" over large portions of the model domain raise concerns about the appropriateness of model assumptions and/or inputs and could be an issues for overall model accuracy and reliability for predictive application.

FPL Response: Layer 1 of the model represents surficial sediment and muck, which constitute a relatively thin hydrogeologic formation. As such, it is reasonable for this layer to be desaturated in western areas of the model domain. During the continued evolution of the groundwater model the occurrence of dry and flooded cells will be evaluated by the modeling team in order to bolster numerical stability in the model's solution. In the course of this evaluation, modelers will investigate reasonable model revisions that minimize the occurrence of dry cells (e.g. revisions to the representation of layer 1) and flooded cells (e.g. increasing the storage or hydraulic conductivity of shallow model layers).

FKAA Comment: The change of river conductance at the CCS is a major concern. The changes are significant, late in the simulation period. The issues is identified at locations most critical for the performance evaluation of the various remedial alternatives. The change of river conductance may require the model to be recalibrated or the proposed remediation scenarios be reevaluated if the change is not supported by actual field data.

FPL Response: The reduction of CCS RIVER cell conductance late in the monthly simulation is consistent with the siltation that occurred in the CCS during this timeframe. This siltation is believed to have decreased the conductance of the CCS canal beds and the thermal efficiency of the CCS. Several cores collected in the CCS bottom sediments are evidence of such siltation. Additionally, the reduction in conductance due to siltation is apparent in the observed salinities directly below the CCS (TPGW-13S and TPGW-13D; Figure 18 of review memorandum and figures copied below). Despite the significant reduction in conductance, the model still over-predicts the groundwater response to the increase in CCS salinity that occurred in late 2013. This modeled response suggests that, rather than being too large, the reduction in bottom conductance possibly may not be large enough. Discussion of this model characteristic was inadvertently omitted from the model documentation (Tetra Tech, June, 2016).





As the reviewers point out, riverbed conductance is rarely measured in the field, and, as such, is often a calibration parameter. During a calibration analysis conducted in June 2016, the conductance of the CCS (pre- and post-siltation) was adjusted to improve the calibration quality of the model. These adjustments were relatively minor and the post-calibration conductances were on the same order of magnitude at those in the model reviewed.

The decision to include the reduced CCS conductance during model predictions was twofold. First, Model predictions focused on identifying impacts to remediation-based changes. Maintaining the conductance obtained from the calibration ensures that simulated changes are due solely to the simulated remedial alternatives. Second, reduced CCS conductance reflects a conservative model characteristic insofar as the benefits of CCS salinity abatement (Alternatives 2 through 8) would be less pronounced than those resulting from a higher CCS conductance.

FKAA Comment: It is recommended to consider practical well capacities for the proposed extraction wells in the remediation scenarios. To optimize the remediation designs, the performance of individual extraction wells may be assessed by checking the mass removal rates of particle tracking methods.

FPL Response: FPL assumes that this first part of this comment refers to the single extraction well that is assumed to extract 15 MGD from the Biscayne Aquifer beneath the CCS. This single extraction well has since been revised to four extraction wells (each pumping at a rate of 3.75 MGD), located within the vicinity of the Underground Injection Control (UIC). The reduced extraction rates (15 MGD distributed across four wells) are lower than the rate of pumping during the near-CCS aquifer performance test, early in 2016.

FPL concurs that the continued analysis of mass removal is warranted as the model evolves and extracted salt mass will be monitored and reported as described in the agreements and orders with the agencies.

FKAA Comment: Using the MODFLOW Drain package to simulate Card Sound canal should be reconsidered.

FPL Response: This boundary condition has been revised to reflect its potential to contribute saline water to the aquifer. This revision did not have notable impacts on model calibration statistics (less

than 1% change in mean absolute error for heads and salinity in both the seasonal and monthly models) or predictive simulation results.

Other Review Findings

Comments to the groundwater model were discussed elsewhere in the review document. These comments were not identified as requiring resolution prior to additional modeling. Nevertheless, they are addressed below.

CCS Salinities – The review document notes that the simulated CCS salinity does not match the maximum CCS salinity observed during the simulated timeframe. This is due to the fact that simulated conditions at boundary conditions (e.g. the CCS) for each model stress period reflect the *average condition* that occurred during that stress period. Peak salinities in the CCS have been relatively brief, and the timescale of the model simulation is more consistent with capturing long term trends in such variables as salinity, rather than short term changes.

Flow from GHB Cells – FPL and its consultant concur that the flow through GHB cells should be evaluated to confirm the amount of water entering the model through this boundary condition is realistic.

Net Recharge Approach – As the review notes, the net recharge approach is generally used when evapotranspiration parameters and/or surface runoff are difficult to quantify. As this is the case for the modeled area, the net recharge approach was employed in the groundwater model.

FPL.

January 27, 2017

Mr. Wilbur Mayorga, P.E.
Chief, Environmental Monitoring and Restoration Division
Miami-Dade County Department of Regulatory and Economic Resources,
Division of Environmental Resources Management
701 NW 1st Court, 4th Floor
Miami, FL 33136-3912

RE: Florida Power & Light Company Phase I Remediation Action Plan Submittal

Dear Mr. Mayorga:

Florida Power & Light Company (FPL) hereby provides you a copy of the Phase I Remediation Action Plan prepared as requested in Paragraph 4 B., of your letter dated September 29, 2016. In addition, attached to this letter please find design drawings and the FDEP UIC injection well permit modification (Permit No. 293962-003-UC/MM) requested under Paragraph 4 A., of your September letter. FPL acknowledges the two groundwater monitoring well clusters and the surface water gauges identified in Paragraph 3a. and d., of the letter in addition to the three additional monitoring well clusters identified in Paragraph 17 d. iv., of the Consent Agreement and would like to discuss these during our meeting on February 8, 2017. Also, during our November 22, 2016 meeting you requested information pertaining to our water use permit application (Application No. 160916-12). All FPL submittals and SFWMD correspondence are available on the District's e-permitting public access website at: http://my.sfwmd.gov/ePermitting/PopulateLOVs.do?flag=1, (enter the application number only and hit the search records prompt).

FPL looks forward to moving forward with the construction and operation of the DERM approved groundwater remediation system as soon as the requisite project permits are issued. Should you have any questions or request additional information, please contact Steve Scroggs at (561) 694-4496 or me at (561) 691-2808 at your convenience.

Sincerely,

Matthew J. Raffenberg
Sr. Director of Environmental Licensing and Permitting

CC: Lee Hefty, MDC DERM
Barbara Brown, MDC DERM
John Truitt, FDEP
Steve Scroggs, FPL
Alan Katz, FPL

Attachments:

- Turkey Point Cooling Canal System Phase I Remediation Action Plan
- UIC extended testing FDEP permits and drawings

Turkey Point Cooling Canal System
Phase I Remediation Action Plan

Turkey Point Cooling Canal System
Phase I Remediation Action Plan

January 27, 2017

1. Introduction

On May 16, 2016, FPL submitted a three-dimensional, variable density dependent transient groundwater flow and transport model (Model) to DERM along with the design and supporting information of a groundwater recovery well system (RWS) in fulfillment of paragraph 17.b. of the October 7, 2015 Consent Agreement (CA) between Miami-Dade County and FPL. On May 23, 2016, June 10, 2016, and July 14, 2016, FPL submitted supplemental information at the request of MDC DERM about the Model and the RWS. On September 29, 2016, MDC DERM provided conditional approval of FPL's groundwater Recovery Well System (RWS). A component of this approval required FPL to submit a Phase I Remedial Action Plan as described in Paragraph 4.B., of the letter.

FPL's responses to the specific elements contained in paragraph 4.B., of the September 29, 2016 letter comprise this Phase I Remedial Action Plan. Since presenting the Model and the proposed groundwater recovery well system in May 2016, FPL has implemented several actions, including construction and operation of the Upper Floridan Aquifer Cooling Canal System (CCS) freshening well system, commencement of the CCS Biscayne aquifer Underground Injection Control extended injection testing program, and filing permit applications for the construction and operation of the RWS and associated monitoring sites. Documentation of FPL's actions in implementing the provisions of the CA is included in the "*Turkey Point Power Plant Consent Agreement 2016 Annual Report*", November, 10, 2016.

As stated in paragraph 1.A., of the September 29, 2016 letter, the MDC technical team identified several areas associated with development of the Model. To date FPL has made several revisions to the Model identified by the MDC technical team. These revisions include 1) implementing a parameter estimation optimization methodology recommended by Miami-Dade County (PEST) to recalibrate the Model, 2) revising the boundary characterization of the Card Sound Canal south of the CCS, 3) revise the L-31E southern boundary characterization, and 4) adding heterogeneous hydraulic parameter layering across the Model domain and re-calibrating the Model again using PEST. These revisions resulted in no substantive changes to the original Model calibration statistics, location and orientation of the hypersaline plume, or predicted plume response to the RWS alternatives. It is FPL's evaluation that the revisions have offered no significant improvement to the Model's predictive responses because they add no new information. This restructuring of existing assumptions in the absence of providing new actual data has not reduced Model uncertainty in the vicinity of the hyper-saline plume. While two site-specific APT and existing lithologic and geophysical data were used in the Model development, in comparison to the size of the model domain there remains a limited amount of site-specific hydrogeologic data along the central and southern portion of the CCS and eastern Model Lands Basin. Improved understanding of the hydrogeology of the plume will be accomplished during the construction and testing of the alternative 3D RWS extraction wells and the three monitor well sites within the Model Lands Basin later this year.

Responses to specific elements in paragraph 4.B. of the September 29, 2016 letter are provided. It is FPL's evaluation that the revisions to the Model have had no significant changes to the Model's predictive responses. Although the revisions may have resulted in a more complex representation of the hydrogeology, the original model was a suitable tool that contributed to the design of the RWS. Consistent with the CA, FPL will improve upon the model as relevant information becomes available.

Improved understanding of the hydrogeology of the plume will be accomplished by the production of new hydrogeologic data resulting from the construction and testing of the alternative 3D RWS extraction wells and the three new monitor well sites within the Model Lands Basin later this year. Construction and operation of the RWS alternative 3D project and associated monitoring wells is necessary for providing new hydrogeologic information capable of reducing the uncertainties inherent in the current version of the Model.

2. Responses to Paragraph 4B. Phase I Remedial Action Plan

4B.(i);1A. (ii): The model design shall incorporate significant water features such as quarries as well as significant recreational (e.g. golf courses) and other water users located within the model domain.

FPL Response: The existing Model addresses land use coverages and consumptive use withdrawals that exist in the area through the calibration period as described in June, 2016 model documentation by TetraTech (provided to MDC RER on June 10, 2016). Agricultural water use and public water supply represent the most significant consumptive uses within the Model domain. There is a single golf course located within the Model domain. Quarries are not explicitly represented in the existing model as they are located several miles west and north of the hypersaline plume (although water use from wells described in the Earthfx Inc., 2012 model are included). As required under the FDEP Consent Order (OGC File No. 16-0241), FPL shall be conducting an evaluation of causal influences on the position and orientation of the saltwater interface in 2018 using the variable density three dimensional groundwater model developed under the MDC CA. In order to complete this evaluation, FPL will be making some revisions to the model to better assess additional factors that could influence the position and orientation of the saltwater interface including impacts of quarries, land use changes, water management/drainage actions, water use withdrawals, sea level rise, and the CCS operations. Explicit representation of quarries and the golf course withdrawals/recharge will be added to the model under this effort.

4B.(i);1A. (iii): Given the aquifer heterogeneity described in various local and regional studies relating to the Biscayne aquifer in Miami-Dade County, the assumption of aquifer homogeneity with respect to hydraulic parameters across the model domain shall be reevaluated. Available data (e.g. data from the WASD's Newton and Everglades Labor Camp wellfields (copies attached) and the Florida Keys Aqueduct Authority's wellfield) shall be utilized to evaluate and refine assumptions regarding hydraulic parameters within the Model domain.

FPL Response: FPL conducted an evaluation of lithologic and geophysical data from the deep pilot core bore collected at each of the 14 original 2009 Uprate Monitoring well network sites in order to provide estimates of hydraulic conductivity values and ranges for each of the 11 model layers. These estimated values were regionalized within each model layer via a kriging algorithm and then the model was calibrated using the PEST parameter optimization method as described in Attachment 1. Available data from the Newton and the Everglades Labor Camp (ELC) wellfields were considered however, the values reported for the ELC and FKAA wellfields were composite transmissivity values (11,600,000 and 14,900,000 gpd/ft respectively). Assuming the aquifer is approximately 60 feet thick in the region and not accounting for partial penetration issues, estimated composite hydraulic conductivity values of 26,000 and 33,000 ft/day are calculated. The average horizontal hydraulic conductivity values for model layer 4 (6,398 ft/day) and layer 8 (37,435 ft/day) from the regionalized variable K model calibrated model compare favorably with the reported values for the ELC/FKAA wellfields. As described above, additional model revisions associated with the evaluation of causal influences on the position and orientation of the saltwater interface may further refine the hydraulic conductivity values in the western region of the model domain.

4B.(i);1A. (iv): Until the SWR package referenced in item 1A above is incorporated into the model, the model simulations using the river package shall properly account for the construction of the L-31E Canal specifically the discontinuity between the northern and southern portions of the canal at the canal's intersection with the Florida City Canal.

FPL Response: The Model is configured to reflect the L-31E Canal is discontinuous at Palm Drive.

4B.(i);1A. (v): Re-evaluate the model representation of net recharge, especially during the dry seasons, to properly account for evaporative losses.

FPL Response: It is recognized that there are a variety of non-unique methods that can be used to estimate recharge and evaporation in the Model, the approached used by FPL is one such accepted method. No information was provided that the approach used by FPL to represent recharge and evaporation was inconsistent with accepted modeling methods or is otherwise incorrect. Compelling technical data is needed in order to support further investment into alternative recharge and evaporation changes and associated model recalibration.

4B.(i);1A. (vi): Until the SWR package is incorporated into the model, given that the Card Sound Canal is simulated as a drain, address how the model accounts for the canals contribution to the movement of the saltwater interface.

FPL Response: Revisions to the boundary conditions representing the L-31E Canal south of the S-20 structure and the Card Sound Canal have been completed and are described in Attachment 2. While changes to the boundary conditions in these areas from drains to rivers were made (such that these boundaries can discharge to the aquifer), comparison of Model results show no significant differences in the calibration statistics, location and orientation of the hypersaline plume, or response of the RWS alternative 3D in retracting the plume.

4B.(i);1B.: In addition to the above the model reevaluation shall incorporate the applicable comments provided by the South Florida Water Management District (SFWMD) during the groundwater modeling review meeting held at the DERM office on July 21, 2016, along with the comments provided by the Florida Keys Aqueduct Authority, included as an attachment to this correspondence.

FPL Response: Comments provided by the South Florida Water Management District during the groundwater modeling review meeting held at the DERM office on July 21, 2016 have been addressed and documented in a technical memorandum included as Attachment 2. This technical memorandum along with the revised model data sets were provided to the South Florida Water Management District on September 9, 2016 as part of the FPL RWS consumptive use permit application process. While changes to the boundary conditions in these areas were made as recommended, comparison of Model results show no significant differences in the calibration statistics, location and orientation of the hypersaline plume, or response of the RWS alternative 3D in retracting the plume. FPL has also reviewed the comments provided by the Florida Keys Aqueduct Authority and has responded to their comments which is included as Attachment 3 of this report.

4B.(i) last sentence: In addition, the model shall demonstrate that pursuant to Section 28-48 and Section 24-48.3 of the Code of Miami-Dade County, Florida and paragraph 17.b.i of the CA, that the proposed groundwater recovery system will not create potential adverse environmental impacts on the surrounding wetland areas (hydroperiod or water stage).

FPL Response: Drawdowns associated with recovery well system Alternative 3D in layer one (wetlands) of the PEST calibrated model with the SFWMD recommended boundary changes are shown on Figure 2 of the TetraTech technical memorandum entitled *"Addendum to Regional Biscayne Aquifer Groundwater Model Report Incorporating Comments from SFWMD"* (Attachment 2). Drawdowns beneath wetlands are less than 0.3 feet. The Model Lands wetlands within the drawdown influence of Alt 3D are predominantly seasonally inundated emergent marshes which are categorized as Category 2 wetlands in the *"Applicants Handbook for Water Use Permit Applications (09/07/2015)"* by the SFWMD. Numeric criteria for Category 2 wetlands in SFWMD water use permit rules state that drawdowns less than one foot beneath wetlands are not considered harmful. Drawdowns resulting from withdrawals associated with Alt 3D are much less than one foot and are therefore considered not to create potential adverse environmental impacts to surrounding wetlands.

4B.(ii): Copies of any permit, approval, or letter of no objection from SFWMD, Florida Department of Environmental Protection (FDEP) or any other regulatory agency with jurisdiction over the activities related to the design, construction, or operation of any component of the groundwater recovery system.

FPL Response: On September 15, 2016 FPL filed applications with the USACOE, FDEP, and MDC for impacts to wetlands associated with the RWS extraction well pads, piping lay down, and monitoring well pads. On November 9, 2016 these applications were modified by FPL as a result of RWS well and piping design changes which eliminated impacts to wetlands. Minor impacts associated with two monitoring site well clusters required by Miami-Dade County located within the Model Lands Basin (amounting to 0.006 acres of impact) were unavoidable. On December 19, 2016 FDEP issued Environmental Resource Permit No. 13-0127512-014-EI for wetland impacts associated with the monitor websites TPGW-18 and 19 (copy attached). Applications with the USACOE and MDC DERM remain currently under review.

FPL also filed applications for consumptive use and right-of-way permits with the SFWMD. The right-of-way permit application was modified by FPL on November 9, 2016 to realign the piping route along Palm Drive instead of the originally proposed L-31E Levee route which significantly reduced the impacts to the L-31 levee right-of-way and wetlands. The revised piping crossing of the L-31E levee and the associated USACOE 408 authorization are currently under review. The consumptive use application has been deemed complete and the proposed agency action is due by February 15, 2017. Copies of applications and associated data submittals are included in Attachment 5

4B. (iii): Design details and construction plans of the proposed groundwater recovery system which incorporates the revised groundwater model required in 4B.(i) above and which includes:

a. recovery well construction details
b. recovery well spacing and location was supporting justification
c. flow rate per recovery well
d. pump specifications and supporting calculations, ancillary equipment, etc.
e. piping specifications and layout

FPL Response: As stated above, revisions to the Model resulted in little appreciable changes to the original calibration statistics, location and orientation of the hypersaline plume, or predicted plume response to the RWS alternatives. Accordingly, there are no significant changes to the July 2016 Alternative 3D design (summarized below). Final detailed designs and construction plans of the proposed groundwater recovery system and the associated monitoring wells will be informed by the issuance of all permits, completion of the analysis of pilot wells bores and engineering design and analysis. Based on our current best available information, the following project design details are provided:

Recovery well construction details:

- **Well depth; base of the Biscayne aquifer (approximately -90 feet to - 120 feet NAVD),**
- **Casing depth; open to lower high flow zone of the Biscayne aquifer (approximately -70 to - 90 feet NAVD)**
- **Well diameter; 24 inches ID**
- **Well completion; open hole**
- **Casing material; PVC**
- **Flow rate; ~ 1,040 GPM per well, 15 MGD total wellfield extraction rate**
- **Pump and piping specifications to be determined by engineering after permits and site data collection are completed.**

Recovery well location and spacing:

RWS Well #1
TPGW-19 S,M,D
RWS Well #3
RWS Well #2
RWS Well #4
TPGW-18 S,M,D
Deep Injection Well
RWS Well #5
RWS Well #6
RWS Well #7
TPGW-22M
RWS Well #8
TPGW-17 S,M,D
RWS Well #9
RWS Well #10
Google earth

	RWS-1	RWS-2	RWS-3	RWS-4	RWS-5
Latitude	25.445980°	25.438010°	25.434370°	25.422930°	25.410480°
Longitude	-80.352370°	-80.345650°	-80.351340°	-80.354040°	-80.358470°
Spacing to next RWS well	3,650 feet	2,300 feet	4,230 feet	4,740 feet	4,590 feet

	RWS-6	RWS-7	RWS-8	RWS-9	RWS-10
Latitude	25.398460°	25.387920°	25.377250°	25.368390°	25.359392°
Longitude	-80.362770°	-80.366530°	-80.367530°	-80.367540°	-80.367600°
Spacing	4,580 feet	4,020 feet	3,890 feet	3,200 feet	3,275 feet

The locations of the RWS extraction wells were determined based on consideration of several factors including the authorized capacity of the existing underground injection well DW-1 (UIC permit number), minimizing the potential for adverse impacts to wetlands, and the ability of the extraction wells to collectively intercept, capture contain and retract hypersaline groundwater within the Biscayne aquifer west and north of the CCS as demonstrated by the MDC approved (September 29, 2016 letter from Wilbur Mayorga) variable density dependent groundwater model.

Attachment 1

Biscayne Aquifer Groundwater Flow and Transport Model: Heterogeneous Hydraulic Conductivity Analyses, January 2017

(Text and Tables)

Biscayne Aquifer Groundwater Flow and Transport Model: Heterogeneous Hydraulic Conductivity Analyses

Introduction

Florida Power & Light (FPL) and its consultant, Tetra Tech, conceptualized, constructed, and calibrated a variable density groundwater flow and salt transport model of the Biscayne Aquifer in the vicinity of the Turkey Point Power Plant and its Cooling Canal System (CCS). The purpose of this model, presented to Miami Dade County (MDC) Department of Environmental Resource Management (DERM), South Florida Water Management District (SFWMD), and Florida Department of Environmental Protection in May 2016 (Tetra Tech, 2016a), and July 2016 (Tetra Tech, 2016b), is to support the design of the RWS to intercept, capture, and contain the hypersaline plume north and west of the CCS; support authorization through the appropriate regulatory processes; and demonstrate that the RWS will not create adverse impacts to groundwater, wetlands or other environmental resources.

Upon review of the groundwater flow and transport model, MDC and SFWMD recommended certain revisions to the model, including changes to the representation of the L-31E and Card Sound Canal boundary conditions and the representation of variable hydraulic conductivities in key hydrogeologic formations (in lieu of uniform hydraulic conductivity). FPL revised the boundary conditions, with no marked impact on the quality of the model calibration or the simulated effectiveness of selected RWS Alternative 3D, as documented in an attached addendum to the July 2016 technical memorandum (Tetra Tech, 2016b). These boundary revisions are employed herein along with more recent revisions to the model's hydraulic conductivity distributions.

Paragraph 17.b.i. of the October 7, 2015 Consent Agreement (CA) between MDC DERM and FPL required FPL to develop a variable density dependent groundwater model, which was to be informed by an Aquifer Performance Test (APT) conducted at the site (Enercon, 2016) within 180 days of execution of the CA. In developing the model, FPL utilized uniform hydraulic parameters for each model layer which were derived from parameters derived by the APT. The assumption of uniform hydraulic conductivities was later questioned by the MDC, and FPL was required to re-calibrate the model using heterogeneous hydraulic conductivities. This memorandum describes FPL's efforts to address MDC's comments regarding heterogeneous hydraulic conductivity and the associated PEST-based calibration of the model with heterogeneity reflected in key hydrogeologic formations. Multiple calibration efforts were made and are summarized herein, along with assessments of calibration quality and predictive simulation results.

Calibration Overview

Heterogeneous Hydraulic Conductivity Definition

In order to establish smoothly varying heterogeneous hydraulic conductivities in individual layers of the numerical flow model, values of this flow parameter are defined at a number of discrete locations (called pilot points) throughout the model layer. Then, based on an estimate of spatial continuity of hydraulic conductivity values, as defined by a semivariogram, the hydraulic conductivities at these discrete locations are spatially interpolated throughout the model layer via kriging, a geostatistical tool.

Heterogeneous hydraulic conductivities were defined in the shallow (model layer 4) and deep (model layer 8) high flow zones, as well as the deepest portion of the model beneath the lower high flow zone (layers 9, 10, 11), for a total of 5 layers with heterogeneous hydraulic conductivities. The high flow zones were selected for the definition of heterogeneity due to the perceived spatial discontinuities in high permeability materials north and west of the CCS. Heterogeneous hydraulic conductivities were defined in the deepest model layers in an effort to improve the match to CSEM survey-based groundwater salt concentrations.

Pilot points are predominantly coincident with the locations of TPGW monitoring wells (TPGW-1 through TPGW-14) that were installed as a part of the Extended Power Uprate monitoring program. As **Figure 1** illustrates, this monitoring network provides a good spatial distribution of locations to represent heterogeneity in hydraulic conductivity throughout the Biscayne Aquifer where hypersaline groundwater is primarily located. Two additional pilot point locations ("Added-1" and "Added-2") were specified immediately west and north of the CCS (**Figure 1**) in order to provide better opportunity to vary hydraulic conductivity, were it necessary for improved calibration quality. Initially, the values at pilot point locations were defined based on interpretation of TPGW well cores by JLA Geosciences (JLA Geosciences, 2016). The hydraulic conductivity values at the two added locations were initially estimated by averaging the hydraulic conductivity estimates from the two closest TPGW monitoring wells. Throughout the course of calibration, the hydraulic conductivity values at the 16 discrete locations were iteratively adjusted and re-interpolated in an effort to reduce model error with respect to groundwater levels and salt concentrations. A model was constructed and simulated using the original estimated hydraulic conductivities provided by JLA Geosciences. The results of this model (referred to as HHC-JLA) are discussed in the following section of this memorandum.

The initial (pre-calibration) hydraulic conductivities at the 14 TPGW well locations were provided by JLA Geosciences after an evaluation of core photographs, lithologic logs, and supporting data (e.g. digital borehole images and acoustic borehole images) collected during the installation of the TPGW wells (JLA Geosciences, 2010). For each layer of the numerical model at a TPGW well location, JLA Geosciences first interpreted the geologic material identified in the core within the layer's vertical thickness. Then, using professional judgment, a geologist estimated the hydraulic conductivities of those materials, and calculated a weighted average hydraulic conductivity based on the thicknesses of the materials within the model layer's vertical profile. This was repeated for each model layer at each TPGW well location. No aquifer testing test was available or developed as a part of this task.

It is important to note that, while more pilot points could have been specified, the configuration discussed above (16 pilot points defined in each of five layers) introduced 80 new adjustable model

parameters into the calibration, more than quadrupling the number of parameters in the July 2016 calibration. With model run times varying between 6 and 10 hours, the inclusion of these parameters extends the duration of a single PEST-based calibration (throughout which significant reductions in overall model error are achieved) to between two and three weeks.

Three separate PEST-based calibration efforts were conducted. In each of these calibrations, the pilot point horizontal hydraulic conductivities (in high flow zones and deep model layers), the uniform hydraulic conductivities of other layers, vertical hydraulic conductivities, and the CCS canal boundary condition conductance were iteratively adjusted. Additionally, layer-wide porosities and dispersivity were adjusted. Note that the CCS conductance decreases late in the calibration model's simulation timeframe in order to reflect siltation that is believed to have decreased both the conductance of the CCS canal beds and the thermal efficiency of the CCS. Several cores collected in the CCS bottom sediments are evidence of such siltation. Additionally, the reduction in conductance due to siltation is apparent in the observed salinities directly below the CCS (TPGW-13S and TPGW-13D. The factor by which the conductance decreases late in the simulated timeframe is an adjustable parameter in these analyses; the conductance reduction factor was adjusted from 21 down to approximately 16 in the course of this calibration analysis.

Each of the three calibration analyses was designed using insight gained from earlier calibration exercises, such that refinements were made to adjustable model parameters, initial model parameter values, and calibration target weights from one calibration exercise to the next. For example, horizontal-to-vertical hydraulic conductivity ratios (not vertical hydraulic conductivity) for all model layers (uniform in each layer) were adjusted in the first two calibrations. This meant that in model layers with heterogeneous horizontal hydraulic conductivities, the vertical hydraulic conductivity would also be heterogenous, since vertical hydraulic conductivity is the product of the horizontal hydraulic conductivity and the anisotropy factor. However, based on insight gained during the second calibration analysis, the third calibration analysis, vertical hydraulic conductivity was adjusted independent from the horizontal hydraulic conductivity. This is discussed later in this technical memorandum.

The three separate calibration analyses conducted as a part of this effort, along with associated relevant results, are discussed below.

Model Calibration Analyses

First Calibration (HHC-V1 Model)

First Calibration Setup

As mentioned above, the first set of pre-calibration horizontal hydraulic conductivities were provided by JLA Geosciences, based on a review of geologic and geophysical data from the construction of the TPGW monitoring wells. Inspection of **Table 1** reveals that in nearly all of the key model layers these values of horizontal hydraulic conductivity at TPGW well locations were considerably greater than the existing calibrated values presented to MDC and SFWMD in July 2016 (Tetra Tech, 2016b). This is particularly evident in layers 9 through 11, where the uniform calibrated value of hydraulic conductivity (389 ft/day) is less than nearly all of the core-based estimated hydraulic conductivities by at least an order of magnitude. The relatively low calibrated horizontal hydraulic conductivity in the July 2016 model was necessary in order to limit the westward extent of hypersaline water in the deepest model layers. Nevertheless, the July 2016 calibrated flow and transport model still over-simulated the westward

extent of hypersaline water in the deepest model layers. This over-simulation was one of the motivations the calibration analyses described in this memorandum.

The first heterogeneous hydraulic conductivity PEST-based calibration (denoted herein as HHC-V1) began with a simulation of a model using the JLA estimates of hydraulic conductivity (HHC-JLA), results of which are discussed below. The calibration required over 500 model runs and 5 iterations, during which the model error reduced. By the fifth iteration, reductions in model error had begun to plateau and continued calibration beyond the fifth iteration was believed to produce diminishing returns in terms of calibration quality.

First Calibration Results

Table 2 summarizes the normalized mean absolute errors for the different categories of calibration targets for the initial model (JLA-estimated hydraulic conductivities, HHC-JLA), HHC-V1, and the July 2016 calibrated model. Note that a target normalized mean absolute error of less than 10% is often used as a criteria for a calibrated model. In this memorandum, the July 2016 calibrated model refers to that which includes the revisions to certain boundary conditions as documented in the addendum to the July 2016 memorandum (Tetra Tech, 2016c). The statistics summarized in **Table 2** illustrate that, though the significant errors associated with the pre-calibration model (HHC-JLA) were reduced in the HHC-V1 model, the July 2016 calibrated model is a generally better calibrated model, particularly with respect to the match to CSEM survey-based data (salt concentrations measured via a CSEM survey in January 2016). Reductions in model error were achieved by generally reducing the magnitude of horizontal hydraulic conductivities. However, the extent of these reductions was not sufficient to eliminate the model's over-simulation of saline and hypersaline conditions in the Biscayne Aquifer. The variably accurate match to CSEM survey salt concentrations for the July 2016, HHC-JLA, and HHC-V1 models are shown in **Figure 2**. Comparison of the July 2016 model results to the models associated with HHC-V1 elucidates the general over-simulation in both the HHC-JLA and HHC-V1 models. The simulated breakthrough of the saltwater wedge at the shallow and deep depths of wells G-21 and G-28 (**Figure 3**) also illustrate the general over-simulation of groundwater salt concentrations in HHC-V1. Essentially, the HHC-V1 model-simulated saltwater and hypersaline water moving westward at a significantly greater-than-observed rate.

Upon conclusion of the fifth iteration, the PEST-based calibration was terminated, and a new approach to calibration with heterogeneous hydraulic conductivities was designed, set up, and conducted. This second calibration analysis, described below, endeavored to initialize the PEST-based calibration procedure with better calibrated model parameter values than those with which the first calibration analysis was initialized. The purpose of better initializing the second calibration was to start the calibration with a more accurate simulated representation of the saline and hypersaline salt concentrations in the Biscayne Aquifer in an effort to focus the calibration process on refining these already-reasonable model results.

Second Calibration (HHC-V2 Model)

Second Calibration Setup

As described in the July 2016 modeling memorandum, automated calibration with PEST is an optimization-based procedure wherein reductions in model error are iteratively reduced by adjusting the values of sensitive model parameters. This process can be viewed as a multi-dimensional solution

surface defined by the independent variables (adjustable model parameters) and the dependent variable (model error). The optimization-based calibration process endeavors to locate the area of the solution surface where the model error is the lowest (the globally minimum error); the associated set of model parameter values constitutes the best calibrated model. In calibrations where the initial (pre-calibration) model result is located on the solution surface significantly distant from the globally minimum error, it can be very difficult and/or time-consuming for the optimization to identify the globally minimum error.

Based on a review of the error statistics in **Table 2** and simulation results in **Figures 2 and 3**, FPL and Tetra Tech believed that:

1) The first heterogeneous hydraulic conductivity calibration, described above, would not improve upon the July 2016 model without significant time and effort;
2) The difficulty in achieving an improved model was likely attributable to the values of the pilot point hydraulic conductivities (core-based estimates) in the HHC-JLA model. It is recognized that the pilot point values were estimates from visual inspections of cores and geophysical logs and accordingly are subject to a degree of uncertainty; and
3) Calibration targets associated with the salt breakthrough at wells G-21 and G-28, as well as the CSEM survey-based salt concentration targets (particularly in deeper portions of the aquifer) should be emphasized by attributing those targets greater weight in the calculation of overall model error.

In order to improve upon the first calibration effort, FPL and Tetra Tech recognized that a more efficient calibration, that would potentially improve upon the July 2016 model, should initialize pre-calibration pilot point hydraulic conductivities for model layers 4, 8, and 9 to 11 to the calibrated values in the July 2016 model (Tetra Tech, 2016b).

Hence, this second calibration attempt was initialized to aquifer properties consistent with the July 2016 calibrated model and also employed the pilot point methodology to facilitate the definition of heterogeneous hydraulic conductivity in model layers 4, 8, and 9 to 11. In addition, calibration target weights were revised from the first calibration attempt, described above, in order to elevate the importance of matching 1) the saltwater breakthrough at wells G-21 and G-28, and 2) the orientation of saline and hypersaline water in deep model layers (as define by the CSEM survey). The changes to the weights attributed to these calibration targets from the first calibration attempt to the second calibration attempt are summarized in **Table 3**.

The second heterogeneous hydraulic conductivity calibration analysis (HHC-V2) was terminated after three iterations and over 300 model simulations due to diminishing reductions in overall model error by the last iteration. The same parameters that were adjusted in the first calibration attempt (above) were adjusted in this calibration analysis (uniform hydraulic conductivities, pilot point hydraulic conductivities, vertical hydraulic conductivity anisotropies, CCS canal bed conductance, dispersivity, and aquifer porosities).

Second Calibration Results

The adjustments made to the horizontal hydraulic conductivities (both uniform values and pilot point values) to produce the HHC-V2 calibrated model are summarized in **Table 4**. On average, the pilot point

hydraulic conductivity values did not vary significantly from the uniform pre-calibration values in the five model layers that were now represented as having heterogeneous hydraulic conductivity distributions:

- Upper High Flow Zone (Layer 4) – Average pilot point horizontal hydraulic conductivity value calibrated from 6030 ft/day to 6398 ft/day
- Lower High Flow Zone (Layer 8) – Average pilot point horizontal hydraulic conductivity value calibrated from 35980 ft/day to 37435 ft/day
- Deeper Model Layers (Layer 9) – Average pilot point horizontal hydraulic conductivity value calibrated from 389 ft/day to 397 ft/day
- Deeper Model Layers (Layer 10) – Average pilot point horizontal hydraulic conductivity value calibrated from 389 ft/day to 410 ft/day
- Deeper Model Layers (Layer 11) – Average pilot point horizontal hydraulic conductivity value calibrated from 389 ft/day to 362 ft/day

However, inspection of **Table 4** shows that, while the *average* pilot point values did not change significantly (which gives credence to the July 2016 calibrated hydraulic conductivities), there is notable variability in hydraulic conductivity value across the pilot points in each layer. This is particularly true in the high flow zones. For instance, hydraulic conductivity varies from approximately 14,000 ft/day to 100,000 ft/d in the lower high flow zone. This variability in hydraulic conductivity values is illustrated in **Figures 4 through 8** for layers 4, 8, and 9 to 11. Whereas layer 4 is relatively conductive, the greatest horizontal hydraulic conductivities are located west of the CCS, with lower hydraulic conductivities north and southwest of the CCS. Likewise, layer 8 is highly conductive, and most conductive west of the CCS. While layers 9 through 11 are less conductive than other layers, relatively low hydraulic conductivities north of the CCS are evident in the calibration model and imply an effort to curb the model's over-simulation of salt concentrations north and northwest of the CCS in the deeper portions of the groundwater flow model.

Table 5 summarizes the normalized mean absolute errors for the different categories of calibration targets for the initial model and calibrated HHC-V2 model. Note that since the initial model is the same as the July 2016 model (with uniformly valued pilot point hydraulic conductivities), its error statistics are the same as those presented in **Table 2** for the July 2016 model. Errors associated with water level targets were only marginally improved over the course of this second calibration analysis, whereas errors in the simulation of salt concentrations improved. This is most evident in the match to CSEM targets, which improved in all individual CSEM categories (e.g. Layers 5 to 7) and the overall match to CSEM data. Improvement in the match to salt concentration targets is further elucidated in the simulated match to the saltwater breakthrough at wells G-21 and G-28 (**Figure 9**), where the HHC-V2 model better matches the observed saltwater breakthrough at most of the well screens. Additionally, comparison of the observed versus simulated CSEM survey salt concentration data for the initial and HHC-V2 models (**Figure 10**) shows that for most of the model layers, the density of the data clusters moves closer to the 45° line of perfect match. This is particularly evident for layers 4 to 8 and, to a lesser degree, layers 9 to 11.

While this second calibration analysis improved the calibration quality of the model, there appeared some clear areas that warranted improvement, namely the match to deeper model layers' salt concentration data. In an effort to reconcile this match, FPL and Tetra Tech configured and conducted a

third calibration analysis that revised 1) the manner in which vertical hydraulic conductivity was conceptualized and calibrated, and 2) the weighting of calibration targets to add greater import to salt concentration targets in the bottommost portions of the Biscayne Aquifer.

Third Calibration (HHC-V3 Model)

Third Calibration Setup

The third and final calibration analysis with heterogeneous hydraulic conductivities refined the second calibration analysis in three key ways:

1) CSEM survey-based salt concentrations target weights in the deeper model layers were increased relative to the second calibration (**Table 3**);
2) Vertical hydraulic conductivities were decoupled from horizontal hydraulic conductivities by eliminating the anisotropy factor and adjusting vertical conductivities for all layers independent from the horizontal conductivities;
3) A pilot point-based methodology to vertical hydraulic conductivity calibration in model layers 9 through 11 was employed, using a subset of pilot point locations (TPGW-1, -4, -5, -6, -12, -13); modelers determined that simulated results would be insensitive to heterogeneity in the high flow zones (layers 4 and 8).

Vertical hydraulic conductivity was adjusted independent from the horizontal hydraulic conductivity in the following manner:

- Uniform (layer-wide) vertical hydraulic conductivities were calibrated in layers with uniform (layer-wide) horizontal hydraulic conductivities (i.e. model layers 1 to 3 and 5 to 7);
- Heterogeneous, pilot point-based vertical hydraulic conductivities were adjusted independent from the heterogeneous horizontal hydraulic conductivities in the deep model layers (i.e. model layers 9 to 11) using vertical hydraulic conductivity pilot points located coincident with a subset of the TPGW monitoring wells (i.e. TPGW-1, -4, -5, -6, -12, -13); and
- Uniform vertical hydraulic conductivities were defined for the high flow zones (i.e. model layers 4 and 8).

The latter revision introduced a total of 18 additional adjustable parameters to the calibration, which would notably increase calibration timeframes. However, based on calibration results to date, and in an effort to mitigate the added calibration times, the pilot point horizontal hydraulic conductivities in layer 4 were fixed at their second calibration values and unchanged during the third calibration. Thus, a net of two model parameters were added to the calibration analysis. As in the case of the prior calibration, the HHC-V3 calibration analysis was terminated after three iterations and over 300 model simulations due to diminishing reductions in overall model error by the last iteration.

Third Calibration Results

The calibrated horizontal hydraulic conductivities (uniform layer values and pilot points) for the pre-calibration and HHC-V3 models are provided in **Table 6**, where it is evident that values were not significantly adjusted during the third calibration. The heterogeneous hydraulic conductivity fields for Layers 4, 8, and 9 to 11 are illustrated in **Figures 11 to 15**. The heterogeneities illustrated in these figures are slightly different than those shown for the HHC-V2 model (**Figures 4 to 8**), though the general model-wide variability is consistent between both calibrated models. As in the case of horizontal

hydraulic conductivities, the values of vertical hydraulic conductivity varied only slightly over the course of the calibration (**Table 7**); the heterogeneous vertical hydraulic conductivity for layers 9, 10, and 11 are illustrated in **Figures 16 through 18**.

Over the course of the three iterations of this calibration, the overall model error decreased, such that the overall HHC-V3 model error is lower than that of the July 2016 model. During this third calibration the normalized absolute mean error decreased for both the water level and salt concentration targets between 1972 and 2015 (**Table 8**). Plots of observed versus simulated water levels and relative salt concentrations in **Figures 19 and 20**, respectively, illustrate the overall good match to those observed conditions. The simulated breakthrough of saltwater at wells G-21 and G-28 was not impacted by this third calibration effort, and is nearly identical to those shown for the HHC-V2 model.

Overall, the match to the CSEM survey-based concentrations degraded slightly (**Table 8**), due to slight increases in error associated with salt concentrations in layers 1 to 4, 8, and 9. However, reductions in error associated with CSEM survey-based salt concentration targets in Layers 5 to 7 and, most notably, Layers 10 and 11, are relatively significant. Inspection of the plots in **Figure 21** illustrates this improvement in the match to the deeper model salt concentrations, as the cloud of green data points becomes more densely located about the line of perfect match over the course of calibration. Though there still remain some key elements of the HHC-V3 that warrant improvement, as a result of the overall and targeted improvements in the model simulation, this is deemed the best calibrated version of the Biscayne Aquifer Groundwater Flow and Transport Model to date.

Model Predictions

Simulations of RWS alternative 3D were made using the HHC-V3 model. The simulated effectiveness of this RWS alternative in retracting hypersaline water from areas west of the CCS in the deepest portions of the groundwater flow model (model layers 8 to 11) are of particular interest and have been a motivation for reducing model errors through continued calibration analyses and model enhancements.

Figures 22 through 25 compare the retraction of saline and hypersaline groundwater in model layers 8 through 11 due to RWS alternative 3D over a 10-year period as simulated by the HHC-V3 model and that simulated by the July 2016 model. In each of these figures, the left panels illustrate the 10-year changes in groundwater salt concentrations simulated by the July 2016 model, and the right panels simulate results for the HHC-V3 model. The color flood represents varying relative saltwater concentrations, and the hypersaline interface is defined by the rounded black contour that surrounds the CCS. In each of the layers, the initial conditions (top row) are generally different between the two models, due to the different calibrated aquifer conditions and representation of hydraulic conductivity. Conversely, the 10-year location of the hypersaline interface is similarly simulated by both models, with one key exception. Both models simulate retraction in layers 8 and 9, and no retraction in layer 11; however, unlike the July 2016 model (which does not simulate retraction of the hypersaline interface in layer 10), the HHC-V3 model simulates slight retraction of the interface northwest of the CCS in layer 10. The relevance of this change is discussed in the Conclusions below.

Conclusions

In response to a request by MDC DERM and SFWMD, FPL and Tetra Tech conducted a rigorous and increasingly informed calibration of the Biscayne Aquifer Groundwater Flow and Transport model, wherein a heterogeneous representation of hydraulic conductivity was incorporated into the model's high flow zones and deepest model layers. The calibration analyses described herein ultimately produced a model that improves upon the July 2016 model in a number of ways:

- The representation of hydraulic conductivity as a spatially varying aquifer parameter is more realistic than uniformly specified layer-wide hydraulic conductivity
- Overall model error statistics are lower;
- The simulation of historical water levels and salt concentrations is more accurate;
- Normalized absolute mean error for water levels and salt concentrations (1972 to 2015) are well below the 10% threshold used to distinguish a calibrated model;
- The match to CSEM survey-based concentrations is notably improved, as the normalized absolute mean errors for seven layers, as well as the aggregate model, now fall at or below the 10% threshold;
- The match to deep aquifer CSEM salt data is significantly improved; and
- The simulation of RWS alternative 3D now shows some retraction in layer 10, whereas the July 2016 model simulation did not.

The final improvement listed above is a small, yet important, revision to the simulation of RWS alternative 3D, as it demonstrates some success in retracting the hypersaline interface in the deep layers of the model. This improvement is likely attributable to the more appropriate heterogeneous representation of hydraulic conductivity in the deep model layers and the better calibration quality of the model.

It is important to note that, while some improvements were made based on estimated values of aquifer characteristics from the 2010 monitoring network pilot wells, these locations are regional and not well aligned with the location of the hypersaline plume in many cases. It is anticipated that further improvements to the model performance in retracting the plume will be informed by the data collection associated with the construction of the RWS extraction wells themselves as wells as the three monitoring well sites in the Model Lands (to be installed per the conditions of the CA).

While this calibrated model marks a step forward in the simulation of Biscayne Aquifer hydrologic and water quality conditions, there remain facets of the model that warrant refinement. Among these include the simulation of the deep aquifer salt concentrations and the simulated location of the hypersaline interface. It is anticipated that the incorporation of additional hydrogeological and observational data in the calibration process and an increased robustness and realistic representation of aquifer parameters throughout the entire model (rather than in a limited number of layers) may be two of the keys to producing a more accurate simulation of aquifer water quality and the effectiveness of RWS alternative 3D.

References

JLA Geosciences, 2010, Geology & Hydrogeology Report for FPL, Turkey Point Plant Groundwater, Surface Water, & Ecological Monitoring Plan, FPL, Turkey Point Plant, Homestead, Florida. Prepared for Florida Power and Light Company, October 2010.

JLA Geosciences, 2016, Summary of Hydraulic Conductivity Estimation, Technical Memorandum provided to Florida Power & Light, August 16, 2016.

Tetra Tech, 2016a, A Groundwater Flow and Salt Transport Model of the Biscayne Aquifer, Technical Memorandum provided to Florida Power & Light, June 10, 2016.

Tetra Tech, 2016b, Application of Parameter Estimation Techniques to Simulation of Remedial Alternatives at the FPL Turkey Point Cooling Canal System, Technical Memorandum provided to Florida Power & Light, July 14, 2016.

Tetra Tech, 2016c, Addendum to Regional Biscayne Aquifer Model Report (Tetra Tech, 2016), Technical Memorandum provided to Florida Power & Light, October 12, 2016.

Table 1. Horizontal hydraulic conductivity values (in feet per day) derived from TPGW well geologic assessment (JLA Geosciences, 2016)

Well Name	Upper High Flow Zone – Layer 4	Lower High Flow Zone – Layer 8	Deep Model Layers – Layer 9	Deep Model Layers – Layer 10	Deep Model Layers – Layer 11
TPGW-1	2500	55000	13240	430	3160
TPGW-2	62160	39520	45860	31770	46500
TPGW-3	45810	480	31270	44130	24020
TPGW-4	4270	78400	12910	4350	2460
TPGW-5	49120	6230	54720	30280	8670
TPGW-6	26800	380	38350	33550	4890
TPGW-7	68280	7230	6130	15900	5000
TPGW-8	14830	340	5090	4440	5570
TPGW-9	16470	660	8430	29570	25650
TPGW-10	6060	9100	7510	7350	2880
TPGW-11	44330	6870	10320	20100	35070
TPGW-12	48420	2510	11150	5290	4120
TPGW-13	8530	10370	16660	12700	19590
TPGW-14	12730	6010	4620	4050	5950
July 2016 Calibrated Value	6030	35980	389	389	389

Table 2. Normalized mean absolute errors (%) for the HHC-JLA model, the calibrated HHC-V1 model, and July 2016 calibrated model

Target Type	HHC-JLA	HHC-V1	July 2016
Water Levels (1972 to 2010)	6.4	6.3	6.8
Salt Concentrations (1972 to 2010)	14.0	10.2	9.9
Water Levels (2010 to 2015)	6.5	6.6	6.4
Salt Concentrations (2010 to 2015)	14.9	8.7	8.2
CSEM Salt Concentrations (Layers 1 to 3)	17.8	10.5	5.4
CSEM Salt Concentrations (Layer 4)	26.7	15.3	10.9
CSEM Salt Concentrations (Layers 5 to 7)	25.5	13.3	10.4
CSEM Salt Concentrations (Layer 8)	15.7	11.7	12.6
CSEM Salt Concentrations (Layers 9 to 11)	24.8	17.0	13.9
CSEM Salt Concentrations (All Layers)	22.7	13.6	10.0

Table 3. Calibration target weights for all calibration target types in the three heterogeneous hydraulic conductivity calibration analyses (HHC-V1, -V2, -V3)

Target Type	HHC-V1	HHC-V2	HHC-V3
Water Levels (1972 to 2010)	2	1.5	1
Salt Concentrations (1972 to 2010)	2	2	2
Water Levels (2010 to 2015)	1.75	1	1.25
Salt Concentrations (2010 to 2015)	3	3	3.5
Salt Concentrations (wells G-21, G-28)	5	10	10
CSEM Salt Concentrations (Layer 1)	1	1	1
CSEM Salt Concentrations (Layer 2)	1	1	1
CSEM Salt Concentrations (Layer 3)	1	1	1
CSEM Salt Concentrations (Layer 4)	1	1.25	1
CSEM Salt Concentrations (Layer 5)	1	1	1
CSEM Salt Concentrations (Layer 6)	1	1	1
CSEM Salt Concentrations (Layer 7)	1	1	1
CSEM Salt Concentrations (Layer 8)	4.25	4.25	4
CSEM Salt Concentrations (Layer 9)	1.25	1.6	3.5
CSEM Salt Concentrations (Layers 10)	1.25	1.6	4
CSEM Salt Concentrations (Layers 11)	1.25	1.6	4

Table 4. Initial (July 2016) model and calibrated HHC-V2 model horizontal hydraulic conductivities (ft/day)

Aquifer Zone	Pilot Point Name (or Uniform Value)	Initial (July 2016) Model	Calibrated HHC-V2 Model
Miami Limestone	Uniform Value	100	121
Upper High Flow Zone	TPGW-1	6030	4478
Upper High Flow Zone	TPGW-2	6030	5635
Upper High Flow Zone	TPGW-3	6030	8413
Upper High Flow Zone	TPGW-4	6030	3613
Upper High Flow Zone	TPGW-5	6030	9795
Upper High Flow Zone	TPGW-6	6030	6858
Upper High Flow Zone	TPGW-7	6030	6945
Upper High Flow Zone	TPGW-8	6030	9003
Upper High Flow Zone	TPGW-9	6030	4942
Upper High Flow Zone	TPGW-10	6030	5407
Upper High Flow Zone	TPGW-11	6030	5224
Upper High Flow Zone	TPGW-12	6030	7913
Upper High Flow Zone	TPGW-13	6030	6656
Upper High Flow Zone	TPGW-14	6030	4407
Upper High Flow Zone	Added-1	6030	4747
Upper High Flow Zone	Added-2	6030	8324
Shallow Ft. Thompson	Uniform Value	3710	3793
Lower High Flow Zone	TPGW-1	35980	21405

Aquifer Zone	Pilot Point Name (or Uniform Value)	Initial (July 2016) Model	Calibrated HHC-V2 Model
Lower High Flow Zone	TPGW-2	35980	100000
Lower High Flow Zone	TPGW-3	35980	31839
Lower High Flow Zone	TPGW-4	35980	69679
Lower High Flow Zone	TPGW-5	35980	14372
Lower High Flow Zone	TPGW-6	35980	25395
Lower High Flow Zone	TPGW-7	35980	30687
Lower High Flow Zone	TPGW-8	35980	63371
Lower High Flow Zone	TPGW-9	35980	14011
Lower High Flow Zone	TPGW-10	35980	33635
Lower High Flow Zone	TPGW-11	35980	37607
Lower High Flow Zone	TPGW-12	35980	43384
Lower High Flow Zone	TPGW-13	35980	34835
Lower High Flow Zone	TPGW-14	35980	32780
Lower High Flow Zone	Added-1	35980	23601
Lower High Flow Zone	Added-2	35980	22354
Deep Model (Layer 9)	TPGW-1	389	474
Deep Model (Layer 9)	TPGW-2	389	384
Deep Model (Layer 9)	TPGW-3	389	494
Deep Model (Layer 9)	TPGW-4	389	492
Deep Model (Layer 9)	TPGW-5	389	261
Deep Model (Layer 9)	TPGW-6	389	459
Deep Model (Layer 9)	TPGW-7	389	420
Deep Model (Layer 9)	TPGW-8	389	427
Deep Model (Layer 9)	TPGW-9	389	353
Deep Model (Layer 9)	TPGW-10	389	424
Deep Model (Layer 9)	TPGW-11	389	378
Deep Model (Layer 9)	TPGW-12	389	403
Deep Model (Layer 9)	TPGW-13	389	330
Deep Model (Layer 9)	TPGW-14	389	334
Deep Model (Layer 9)	Added-1	389	391
Deep Model (Layer 9)	Added-2	389	326
Deep Model (Layer 10)	TPGW-1	389	447
Deep Model (Layer 10)	TPGW-2	389	411
Deep Model (Layer 10)	TPGW-3	389	523
Deep Model (Layer 10)	TPGW-4	389	336
Deep Model (Layer 10)	TPGW-5	389	529
Deep Model (Layer 10)	TPGW-6	389	349
Deep Model (Layer 10)	TPGW-7	389	378
Deep Model (Layer 10)	TPGW-8	389	533
Deep Model (Layer 10)	TPGW-9	389	407
Deep Model (Layer 10)	TPGW-10	389	313
Deep Model (Layer 10)	TPGW-11	389	399
Deep Model (Layer 10)	TPGW-12	389	339

Aquifer Zone	Pilot Point Name (or Uniform Value)	Initial (July 2016) Model	Calibrated HHC-V2 Model
Deep Model (Layer 10)	TPGW-13	389	454
Deep Model (Layer 10)	TPGW-14	389	359
Deep Model (Layer 10)	Added-1	389	301
Deep Model (Layer 10)	Added-2	389	478
Deep Model (Layer 11)	TPGW-1	389	234
Deep Model (Layer 11)	TPGW-2	389	353
Deep Model (Layer 11)	TPGW-3	389	432
Deep Model (Layer 11)	TPGW-4	389	433
Deep Model (Layer 11)	TPGW-5	389	374
Deep Model (Layer 11)	TPGW-6	389	505
Deep Model (Layer 11)	TPGW-7	389	345
Deep Model (Layer 11)	TPGW-8	389	424
Deep Model (Layer 11)	TPGW-9	389	381
Deep Model (Layer 11)	TPGW-10	389	312
Deep Model (Layer 11)	TPGW-11	389	388
Deep Model (Layer 11)	TPGW-12	389	265
Deep Model (Layer 11)	TPGW-13	389	294
Deep Model (Layer 11)	TPGW-14	389	429
Deep Model (Layer 11)	Added-1	389	342
Deep Model (Layer 11)	Added-2	389	285

Table 5. Normalized mean absolute errors (%) for the initial (July 2016) model and calibrated HHC-V2 model

Target Type	Initial (July 2016) Model	Calibrated HHC-V2 Model
Water Levels (1972 to 2010)	6.8	6.7
Salt Concentrations (1972 to 2010)	9.9	8.3
Water Levels (2010 to 2015)	6.4	6.3
Salt Concentrations (2010 to 2015)	8.2	7.7
CSEM Salt Concentrations (Layers 1 to 3)	5.4	5.5
CSEM Salt Concentrations (Layer 4)	10.9	9.6
CSEM Salt Concentrations (Layers 5 to 7)	10.4	9.1
CSEM Salt Concentrations (Layer 8)	12.6	9.7
CSEM Salt Concentrations (Layers 9 to 11)	13.9	12.8
CSEM Salt Concentrations (All Layers)	10.0	9.1

Table 6. Initial and calibrated HHC-V3 model horizontal hydraulic conductivities (ft/day)

Aquifer Zone	Pilot Point Name (or Uniform Value)	Initial HHC-V3 Value	Calibrated HHC-V3 Value
Miami Limestone	Uniform Value	121	128
Upper High Flow Zone	TPGW-1	4478	4478
Upper High Flow Zone	TPGW-2	5635	5635
Upper High Flow Zone	TPGW-3	8413	8413
Upper High Flow Zone	TPGW-4	3613	3613
Upper High Flow Zone	TPGW-5	9795	9795
Upper High Flow Zone	TPGW-6	6858	6858
Upper High Flow Zone	TPGW-7	6945	6945
Upper High Flow Zone	TPGW-8	9003	9003
Upper High Flow Zone	TPGW-9	4942	4942
Upper High Flow Zone	TPGW-10	5407	5407
Upper High Flow Zone	TPGW-11	5224	5224
Upper High Flow Zone	TPGW-12	7913	7913
Upper High Flow Zone	TPGW-13	6656	6656
Upper High Flow Zone	TPGW-14	4407	4407
Upper High Flow Zone	Added-1	4747	4747
Upper High Flow Zone	Added-2	8324	8324
Shallow Ft. Thompson	Uniform Value	3793	4092
Lower High Flow Zone	TPGW-1	21405	20784
Lower High Flow Zone	TPGW-2	100000	102905
Lower High Flow Zone	TPGW-3	31839	25805
Lower High Flow Zone	TPGW-4	69679	72660
Lower High Flow Zone	TPGW-5	14372	15932
Lower High Flow Zone	TPGW-6	25395	24846
Lower High Flow Zone	TPGW-7	30687	28851
Lower High Flow Zone	TPGW-8	63371	67411
Lower High Flow Zone	TPGW-9	14011	10740
Lower High Flow Zone	TPGW-10	33635	30440
Lower High Flow Zone	TPGW-11	37607	42203
Lower High Flow Zone	TPGW-12	43384	44952
Lower High Flow Zone	TPGW-13	34835	34694
Lower High Flow Zone	TPGW-14	32780	27147
Lower High Flow Zone	Added-1	23601	20506
Lower High Flow Zone	Added-2	22354	23230
Deep Model (Layer 9)	TPGW-1	474	479
Deep Model (Layer 9)	TPGW-2	384	336
Deep Model (Layer 9)	TPGW-3	494	507
Deep Model (Layer 9)	TPGW-4	492	499
Deep Model (Layer 9)	TPGW-5	261	256
Deep Model (Layer 9)	TPGW-6	459	517
Deep Model (Layer 9)	TPGW-7	420	439
Deep Model (Layer 9)	TPGW-8	427	503

Aquifer Zone	Pilot Point Name (or Uniform Value)	Initial HHC-V3 Value	Calibrated HHC-V3 Value
Deep Model (Layer 9)	TPGW-9	353	321
Deep Model (Layer 9)	TPGW-10	424	426
Deep Model (Layer 9)	TPGW-11	378	345
Deep Model (Layer 9)	TPGW-12	403	341
Deep Model (Layer 9)	TPGW-13	330	355
Deep Model (Layer 9)	TPGW-14	334	298
Deep Model (Layer 9)	Added-1	391	388
Deep Model (Layer 9)	Added-2	326	323
Deep Model (Layer 10)	TPGW-1	447	434
Deep Model (Layer 10)	TPGW-2	411	460
Deep Model (Layer 10)	TPGW-3	523	548
Deep Model (Layer 10)	TPGW-4	336	322
Deep Model (Layer 10)	TPGW-5	529	650
Deep Model (Layer 10)	TPGW-6	349	340
Deep Model (Layer 10)	TPGW-7	378	420
Deep Model (Layer 10)	TPGW-8	533	533
Deep Model (Layer 10)	TPGW-9	407	394
Deep Model (Layer 10)	TPGW-10	313	353
Deep Model (Layer 10)	TPGW-11	399	424
Deep Model (Layer 10)	TPGW-12	339	274
Deep Model (Layer 10)	TPGW-13	454	486
Deep Model (Layer 10)	TPGW-14	359	338
Deep Model (Layer 10)	Added-1	301	293
Deep Model (Layer 10)	Added-2	478	500
Deep Model (Layer 11)	TPGW-1	234	172
Deep Model (Layer 11)	TPGW-2	353	333
Deep Model (Layer 11)	TPGW-3	432	399
Deep Model (Layer 11)	TPGW-4	433	460
Deep Model (Layer 11)	TPGW-5	374	327
Deep Model (Layer 11)	TPGW-6	505	575
Deep Model (Layer 11)	TPGW-7	345	350
Deep Model (Layer 11)	TPGW-8	424	446
Deep Model (Layer 11)	TPGW-9	381	345
Deep Model (Layer 11)	TPGW-10	312	274
Deep Model (Layer 11)	TPGW-11	388	397
Deep Model (Layer 11)	TPGW-12	265	297
Deep Model (Layer 11)	TPGW-13	294	305
Deep Model (Layer 11)	TPGW-14	429	410
Deep Model (Layer 11)	Added-1	342	310
Deep Model (Layer 11)	Added-2	285	250

Table 7. Vertical hydraulic conductivities (ft/day) for the HHC-V2 and HHC-V3

Aquifer Zone	Pilot Point Name (or Uniform Value)	HHC-V2 Value	HHC-V3 Value
Miami Limestone	Uniform Value	20.1	19.6
Upper High Flow Zone	Uniform Value	504	570
Shallow Ft. Thompson	Uniform Value	1710	1908
Lower High Flow Zone	Uniform Value	2015	2264
Deep Model (Layer 9)	TPGW-1	84.2	89.7
Deep Model (Layer 9)	TPGW-4	84.2	91.8
Deep Model (Layer 9)	TPGW-5	84.2	90.3
Deep Model (Layer 9)	TPGW-6	84.2	85.9
Deep Model (Layer 9)	TPGW-12	84.2	80.6
Deep Model (Layer 9)	TPGW-13	84.2	84.4
Deep Model (Layer 10)	TPGW-1	82.2	84.3
Deep Model (Layer 10)	TPGW-4	82.2	84.1
Deep Model (Layer 10)	TPGW-5	82.2	81.8
Deep Model (Layer 10)	TPGW-6	82.2	74.8
Deep Model (Layer 10)	TPGW-12	82.2	73.2
Deep Model (Layer 10)	TPGW-13	82.2	64.3
Deep Model (Layer 11)	TPGW-1	78.7	72.1
Deep Model (Layer 11)	TPGW-4	78.7	75.7
Deep Model (Layer 11)	TPGW-5	78.7	72.8
Deep Model (Layer 11)	TPGW-6	78.7	89.0
Deep Model (Layer 11)	TPGW-12	78.7	86.2
Deep Model (Layer 11)	TPGW-13	78.7	83.9

Table 8. Normalized mean absolute errors (%) for the initial and calibrated HHC-V3

Target Type	Initial (July 2016) Model	HHC-V3
Water Levels (1972 to 2010)	6.8	6.6
Salt Concentrations (1972 to 2010)	9.9	8.0
Water Levels (2010 to 2015)	6.4	6.1
Salt Concentrations (2010 to 2015)	8.2	7.6
CSEM Salt Concentrations (Layers 1 to 3)	5.5	6.1
CSEM Salt Concentrations (Layer 4)	9.7	9.8
CSEM Salt Concentrations (Layers 5 to 7)	9.1	8.9
CSEM Salt Concentrations (Layer 8)	9.7	10.0
CSEM Salt Concentrations (Layer 9)	11.0	11.5
CSEM Salt Concentrations (Layer 10)	10.7	10.2
CSEM Salt Concentrations (Layer 11)	17.7	16.5
CSEM Salt Concentrations (All Layers)	9.1	9.2

Note to requester: The attachment, which is immediately following this email, is also publicly available at http://www.cleanenergy.org/wp-content/uploads/WSA_FKAA_Remedial-Model-Review-Tech-Memo_08122016.pdf

From:	Folk, Kevin
To:	Prasad, Rajiv (Rajiv.Prasad@pnnl.gov); Meyer, Philip D
Cc:	Saulsbury, James W; Ford, William
Subject:	RE: List of Documents for PNNL
Date:	Wednesday, June 06, 2018 4:28:00 PM
Attachments:	2016-08-12 MD DERM Contractor Review of FPL GW Cleanup Model.pdf

Third document

From: Folk, Kevin
Sent: Wednesday, June 06, 2018 4:20 PM
To: Prasad, Rajiv (Rajiv.Prasad@pnnl.gov) <Rajiv.Prasad@pnnl.gov>; Meyer, Philip D <Philip.Meyer@pnnl.gov>
Cc: Saulsbury, James W <james.saulsbury@pnnl.gov>; Ford, William <William.Ford@nrc.gov>
Subject: FW: List of Documents for PNNL

Gentlemen:

In the interest of efficiency, I am attaching three documents for your information and that are germane to our audit needs request to FPL (which is duplicated below). In short, Bill Ford and I want you to be aware of our line of inquiry on these matters and relevant new information so that you can better support us in our interactions with FPL and its contractor staff. Likewise, some of this information may well be referenced during the interagency meeting.

As for the audit itself, we do not yet have a detailed audit agenda in place, so we do not yet know what FPL is planning to present to us. Hoping to have it soon!

Please advise if any of the PDFs did not come through directly and I will upload them to EARRTH directly Bo set up for us.

Bill, please elaborate as appropriate.

Rajiv and Phil, please reach back to us with any immediate questions.

Finally, I plan to set up a conference call among us the middle of next week so that we can coordinate. Let me know if there are any days that are problematic.

Thanks.

Kevin

Audit Request for a Groundwater and Surface-Water Modeling Presentation

In 2016, TETRA TECH finished for FPL, "A Groundwater Flow and Salt Transport Model of the Biscayne Aquifer". One of the purposes of this model is to assess the efficacy of the recovery well system to retract the hypersaline plume in the Biscayne Aquifer west and north of FPL's property.

(Note this report can be found at the end of the September 25, 2017 testimony of Peter

Andersen before the Florida 1 Public Service Commission located at: http://www.psc.state.fl.us/library/filings/2017/07901-2017/07901-2017.pdf)

In 2014 TETRA TECH completed an "Evaluation of Drawdown in the Upper Floridan Aquifer Due to Proposed Salinity Reduction-based Withdrawals". To reduce the salinity within the cooling canal system, water from the Upper Floridan Aquifer will be discharged into the cooling canal system. This model was used to determine potential impacts to other users of Floridan Aquifer water from the withdrawal of Floridan Aquifer groundwater.

Also in 2014, TETRA TECH also completed an "Evaluation of Required Floridan Water for Salinity Reduction in the Cooling Canal System". Water and salt balance modeling of the cooling canal system was performed to assess the volume of water from the Floridan Aquifer required to reduce the salinity of cooling canal system water to seawater concentrations. Reducing the salinity in the cooling canal system is predicted to reduce the contribution from the CCS to the hypersaline plume in the Biscayne Aquifer.

(Note: These 2014 reports can be found in document filed in ADAMS accession number ML14279A555.)

These complex models are important to the prediction to future impacts by the hypersaline groundwater over the period of subsequent license of license renewal.

We would like to better understand these modeling studies and attendant projections. At the audit, we would like an on-site presentation by knowledgeable staff on these models; including any recent updates. We are interested in understanding the projections of cooling canal salinities, of impacts on Floridan Aquifer groundwater users, and of the efficacy of the planned recovery well system operation in retracting the hypersaline plume. Please allow time for questions from NRC staff and contractors.

Additional Related Documents

Turkey Point Plant Annual Monitoring Report September 2017.
(This report may have to be sent to PNNL as it was obtained from a search of the State of Florida Department of Environmental Protection Information Portal located at http://prodenv.dep.state.fl.us/DepNexus/public/searchPortal)

Review of Groundwater Flow and Transport Model of the Biscayne Aquifer Prepared by Tetra Tech for Evaluation of Remedial Measures to Address the Hypersaline Plume Created by the Cooling Canal System at the FPL Turkey Point Power Facility
(This report may have to be sent to PNNL as it was obtained from a search of the Miami-Dade County DERM electronic document data base, which can be accessed at https://www.miamidade.gov/environment/public-records.asp#0

2017 TETRA Tech model changes made in response to the comments made by the Miami-Dade County Consultant.

(This report may have to be sent to PNNL as it was obtained from a search of the Miami-Dade County DERM electronic document data base, which can be accessed at https://www.miamidade.gov/environment/public-records.asp#0)

2016-01-29 Freshening Effectiveness Report
This report may give insight into the accuracy of the predictive models of CCS salinity reduction. (This report may have to be sent to PNNL as it was obtained from a search of the Miami-Dade County DERM electronic document data base, which can be accessed at https://www.miamidade.gov/environment/public-records.asp#0)

The following document was reviewed as part of the Final Environmental Impact Statement for Turkey Point. The impact statement said it did not change our understanding of how the cooling canal operates.

However, as it focuses on the power uprate and the cause of increased salinities in the cooling canal system, it may come up again during license renewal

Final Report, The Cooling Canal System at the FPL Turkey Point Power Station, May 2016, which can be accessed at http://www.miamidade.gov/mayor/library/memos-and-reports/2016/05/05.12.16-Final-Report-on-the-Cooling-Canal-Study-at-the-Florida-Power-and-Light-Turkey-Point-Power-Plant-Directive-151025.pdf

Water Science Associates

Technical Memorandum

To: Mr. Thomas Walker, FKAA Director of Operations
From: W. Kirk Martin, P.G., Water Science Associates
Date August 12, 2016
Re: Review of Groundwater Flow and Transport Model of the Biscayne Aquifer
Prepared by Tetra Tech for Evaluation of Remedial Measures to Address the Hypersaline Plume Created by the Cooling Canal System at the FPL Turkey Point Power Facility

1. INTRODUCTION

Florida Power and Light Company (FPL) maintains a cooling canal system (CCS) for operation of power generation units at their Turkey Point Power Generation Facility in southeast Miami-Dade County. The CCS consists of some 6000 acres of canals through which water is circulated for dissipation of heat created by the power generation units. The CCS is characterized as a "closed-loop" cooling system in that the same water is circulated through the extensive canal network without direct input of new water to the system. However, the CCS does not function as a closed loop system hydrologically in that as the warmed water is circulated, evaporation losses to the atmosphere remove freshwater from the canal system causing a concentration of salinity that exceeds typical ocean salinities by a factor of two or more. This increased salinity is accompanied by a corresponding increase in water density that causes hypersaline water to migrate downward into the underlying groundwater system and radially outward from beneath the CCS. Operation of the CCS includes manipulation of water levels in an "interceptor ditch" running along the west side of the CCS with the intent that control of water levels in the ditch would prevent CCS water from migrating west of the L-31E Canal. However, groundwater monitoring data shows that hypersaline water emanating from the CCS has moved westward of the L-31E Canal a distance of more than two miles and is influencing movement of the saline water interface within the Biscayne Aquifer more than four miles inland.

The Florida Department of Environmental Protection (FDEP) issued a Consent Order in June of 2016 outlining a number of remedial requirements to address the impacts of the CCS on the surrounding groundwater system. These included implementation of a remediation project using a recovery well system that will halt the westward migration of hypersaline water from the CCS within 3 years and reduce the westward extent of the hypersaline plume to the L-31E Canal within 10 years without adverse environmental impacts. The Consent Order further requires FPL submit detailed plans for the remediation project including supporting data.

A groundwater flow and solute transport variable density model was developed by Tetra Tech (Tetra Tech, 2016) on behalf of FPL to evaluate proposed remediation options. The USGS computer code SEAWAT (Guo and Langevin 2002) was the code selected for modeling purposes. The model went through several stages of calibrations and a number of remedial scenarios (predictions) were simulated. The calibration included a pre-development steady-state model (prior to 1940), a steady-state calibration model (1940 - 1968), a seasonal calibration model (1968 - 2010) and a monthly calibration model (2010 - 2015). Seven remediation scenarios were evaluated with the calibrated SEAWAT model.

Water Science Associates was contracted by the Florida Keys Aqueduct Authority (FKAA) to conduct a review of the Tetra Tech models. Water Science Associates used the services of Dr. Weixing Guo, coauthor of the SEAWAT modeling code to conduct the internal model analysis. The objectives of this model review were to evaluate the major assumptions and

approaches; review the model construction, model calibration and model predictions to see if the assumptions were reasonable; and determine if the model was constructed correctly, the model calibration was acceptable and predictions were sound.

The model review was focused on the materials listed below:

- A technical memorandum, *A Groundwater Flow and Solute Transport Model of the Biscayne Aquifer*, from Tetra Tech dated June, 2016
- A PowerPoint presentation, *Variable Density Groundwater Model Analysis and Results – Model Use, Design, Calibration and Description of Alternatives* (Andersen and Ross of Tetra Tech dated May 16, 2016)
- A PowerPoint presentation, *Variable Density Groundwater Model Analysis and Results – Remedial Alternatives Modeling Evaluations and Selected Alternative* (Ross and Andersen of Tetra Tech dated May 16, 2016)
- The SEAWAT model input and output files provided by FPL

The technical memorandum indicates that the models were developed with Groundwater Vistas as the graphical user interface (GUI). However, the Groundwater Vistas files were not available for the model review effort. The Groundwater Vistas files would have helped facilitate visualization of the model input data greatly. However, Dr. Guo was able to directly access the model input files for the technical review.

2. GENERAL MODEL DESCRIPTION

The model has 295 rows and 274 columns with a variable grid spacing, ranging from 200 feet to 500 feet. The model has 11 layers with variable thicknesses to represent the Biscayne Aquifer. The uppermost layer consists of unconsolidated surficial sediments. Layers 2 to 4 represent the Miami Oolite limestone, and Layers 5 through 11 represent the Fort Thompson Formation. Layer 4 and Layer 8 were assigned with high permeability values, based on available well logs.

3. REVIEW OF MODELS

3.1 Steady-State Model

The steady-state model calibration has seven steady-state stress periods for the period from 1940 to 1968. The initial conditions of the steady-state model were derived from the model of pre- development conditions. The sea level for Biscayne Bay was set to -0.71 feet NAVD. The results from the steady-state models, including simulated heads, salinity, and temperature, were used as the initial conditions for the seasonal calibration model.

3.2 Seasonal Transient Calibration Model

The model simulated a 42-year period from 1968 to 2010. The seasonal calibration model has 84 stress periods. Each stress period represents one season, wet (May to October) or dry (November to April). The CCS was added in the model in stress period 10 representing May 1973.

Figure 1 shows the net recharge applied in each stress period or season in the model at a selected location (R255 C21). It indicates that the most recharge occurs during the wet seasons as expected. A recharge of 10 inches per year in the wet season is applied uniformly from 1968 to 1995 whereas variable recharge rates are applied from 1996 through 2010 including net recharge being applied during the dry season in certain years. The technical memorandum does not indicate why the recharge rates were varied. Presumably, the change could be part of the calibration process. However, it is not clear why the recharge from 1968 to 1995 are uniform or why the change was made for years after 1995.

The net recharge in some years appears to be very high. For example, the net recharge was almost 20 inches in the wet season in 2005, which is about one third of annual precipitation. It should be noted that since the following figure only shows the recharge at one arbitrarily selected location, it might not necessarily represent the entire model area.

The results of seasonal calibration model were used as the initial conditions for the monthly calibration model.

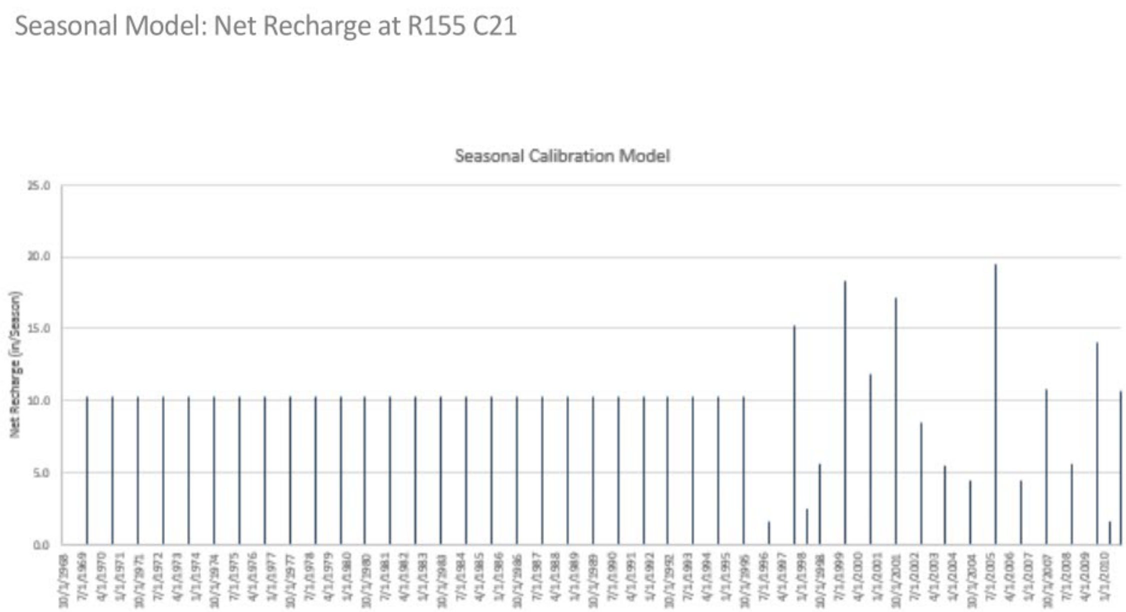


Figure 1. Net recharge (inches/season) applied in the seasonal calibration model.

3.3 Monthly Calibration Model

The monthly calibration model covers the period from October 1, 2010 to December 31, 2015. It has 63 monthly stress periods for a total simulation time of 5 years and 3 months.

A large area of dry cells appears at the west side of the model with some dry cells appearing just after the first stress period in the monthly calibration model (Figure 2).

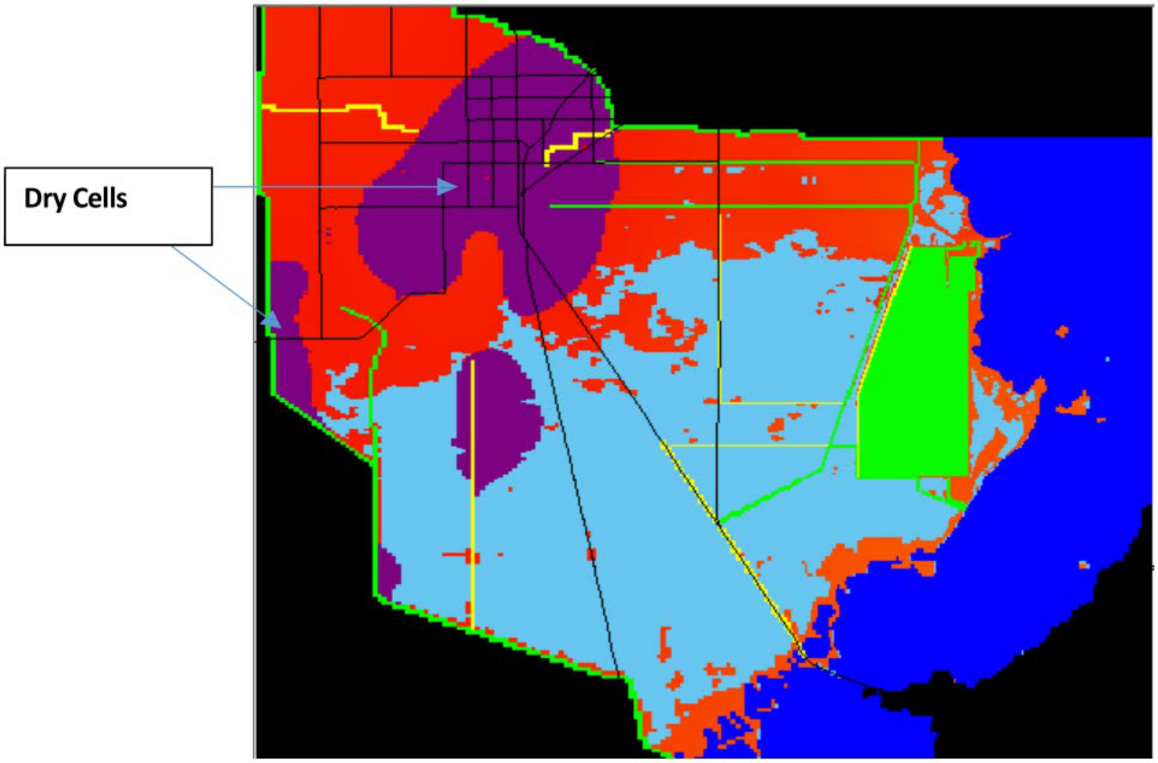


Figure 2. Dry cells in model Layer 1 at the end of stress period 1 in the monthly calibration model.

Table 1 shows the heads and bottom elevations at two cells located at the active-dry cell border at the end of stress period 1 in the monthly calibration model. In MODFLOW, a cell becomes dry when the simulated water level in the cell is below the layer bottom elevation. Simulated water levels drop from 0.929 feet at cell R55 C22 to a value below -0.758 foot at the adjacent cell (R55 C23) compared to the head change (0.05 feet) in underlying Layer 2.

Table 1. Water levels and bottom elevations at selected cells at the active-dry cell area border

	Cell (55, 22)	Cell (55, 23)
Head in Layer 1 (ft)	0.929	Dry
Bottom Elevation (ft)	-0.735	-0.758
Head in Layer 2 (ft)	0.893	0.846

Observation of the dry cells indicates that the river conductance along the C-111 canal, where dry cells are present, may be too low. The larger dry cell areas, appearing only in Layer 1 may not affect the simulation results but the model developers should investigate the reason for the dry cells.

In addition to the dry cells, the model results also showed large areas where the cells were "flooded" when calculated water levels were above the land surface. The flooded cells may be caused by inadequately accounting for evapotranspiration in the model's "net recharge" approach or by using non-representative hydraulic parameters in the shallow layers. Monthly net recharge rates at a selected location (R155 C21) are presented on Figure 4.

The model results also show a large area of drawdown due to withdrawals from the FKAA wellfield (Figure 3). Such a large extent of cone of depression is not consistent with field measurements and likely represents an inaccurate simulation of the wellfield influence in an area of extremely high transmissivity. The effect of model boundary interference with wellfield drawdown may also be indicated.

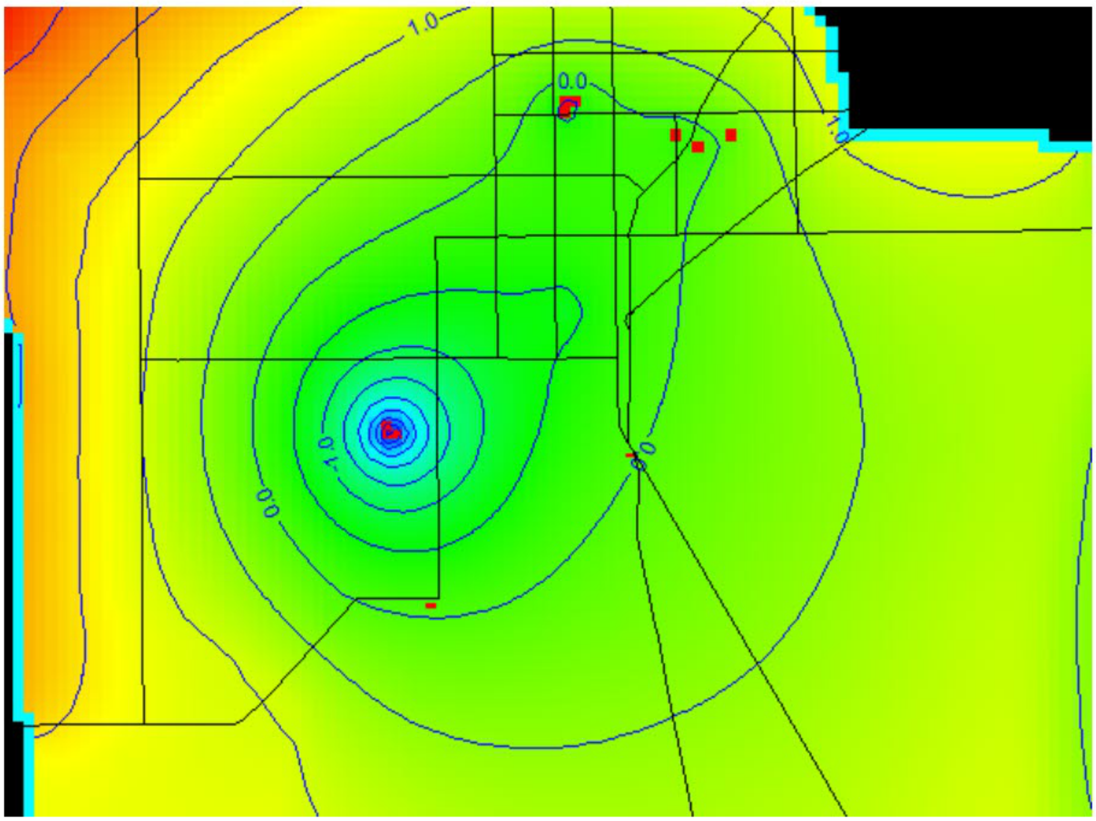


Figure 3. Simulated water levels (ft, NGVD) for December 2015, in Layer 8.

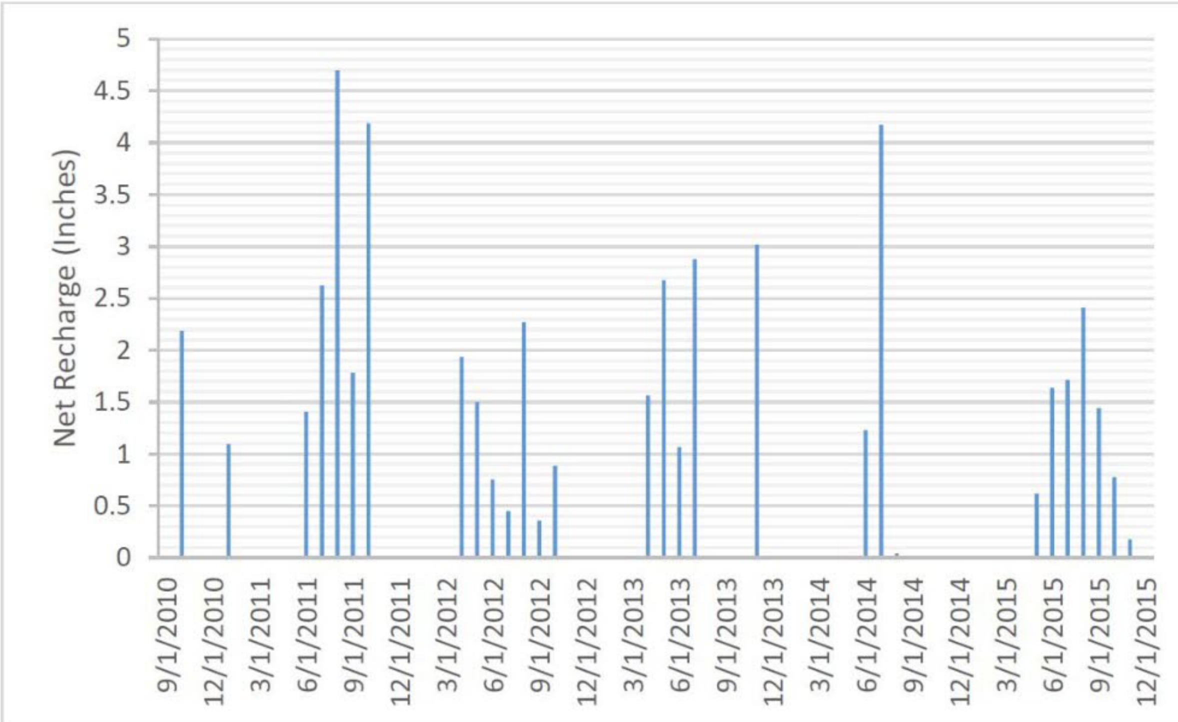


Figure 4. Net recharge (inches/season) applied in monthly calibration model.

3.4 Prediction Models

The calibrated SEAWAT model was used to assess 18 remediation scenarios. Seven general scenarios were evaluated and within some of the general scenarios, a number of different configurations were simulated. Each scenario is a 10-year simulation. The hydrologic stresses and boundary conditions of each scenario were derived from the period of 2011 to 2015, simulated in the monthly SEAWAT model and repeated one time. The 2011-2015 timeframe experienced reasonably wide-ranges of environmental conditions (dry and wet conditions) for model evaluation purposes.

Four remediation scenarios were selected for evaluation as part of this review. The selection of these four scenarios was based on the highest total "Rank Matrix" scores shown in the Power-Point presentation (Rose and Andersen, 2016). Among all of the scenarios, Alternative 3 (configurations ALT3B, ALT3C and ALT3D) were identified by Tetra Tech as the "superior alternatives." Alternative 3 involved one year of extraction at 15 MGD from the base of the Biscayne Aquifer adjacent to the Underground Injection Control (UIC) well followed by 9 years of pumping at a combined rate of 15 MGD from a number of extraction wells spaced approximately 2000 feet apart along the western edge of the CCS.

Scenario ALT3B

Proposed extraction wells were open to model Layers 10 and 11. The locations of these wells are shown on Figure 5.

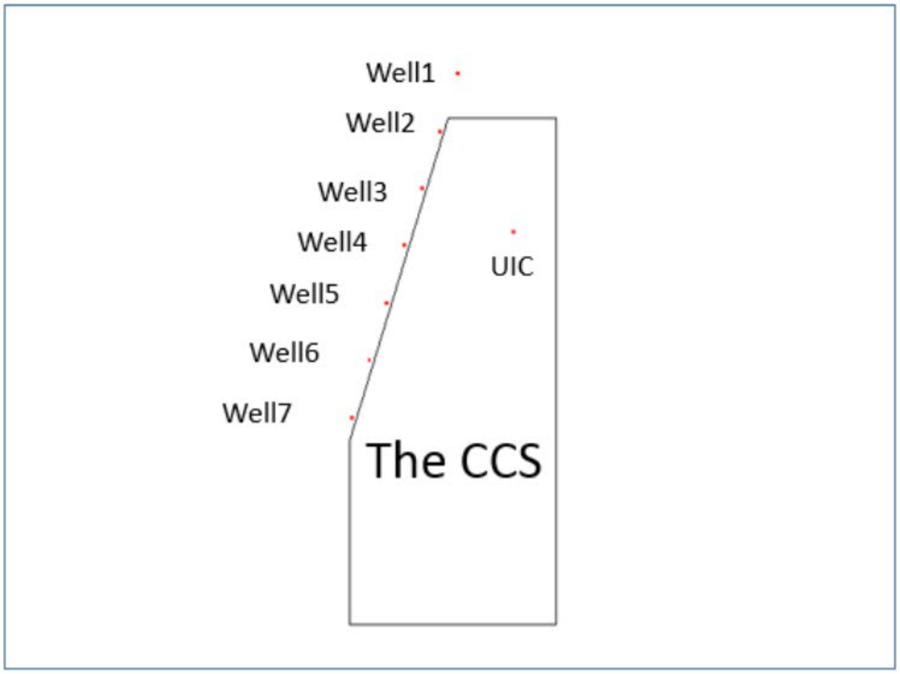


Figure 5. Location of proposed extraction wells in ALT3B.

The extraction rates for each of these wells are shown in the table below. A total extraction rate of 15 MGD is applied. In the first year, 15 MGD is to be extracted from the base of Biscayne Aquifer (Layers 10 and 11) from a single well located near the UIC disposal well. Then, all the pumping is shifted to the 7 extraction wells located along the western edge of the CSS. The pumping rates assigned to the extraction wells are summarized in Table 2.

Table 2. Proposed extraction rates (ALT3B)

ID	Row	Column	Layer 10	Layer 11	Sum (ft3/day)	Sum (MGD)	Active
Well1	66	179	-107565.1	-178893.22	-286458.32	2.1427	Years 2-10
Well2	82	174	-103984.37	-182473.95	-286458.32	2.1427	Years 2-10
Well3	98	169	-120169.26	-166289.05	-286458.31	2.1427	Years 2-10
Well4	114	164	-116588.53	-169869.78	-286458.31	2.1427	Years 2-10
Well5	130	159	-90377.598	-196080.72	-286458.318	2.1427	Years 2-10
Well6	146	154	-74622.391	-211835.92	-286458.311	2.1427	Years 2-10
Well7	162	149	-75052.078	-211406.24	-286458.318	2.1427	Years 2-10
Total					***-2005208.21***	***14.9990***	
Near UIC	110	195	-504309	-1500898.3	-2005207.3	14.9990	Year 1

Scenario ALT3C

Scenario ALT3C has a similar overall design to Scenario ALT3B but with a slightly revised configuration. The well locations for ALT3C are shown in the Figure 6 and extraction rates are tabulated in Table 3. The extraction has one well pumping in the first year at a rate of 15 MGD at the UIC well location and 7 wells along the west side of the CCS pumping at a total 15 MGD in simulation years 2 through 9.

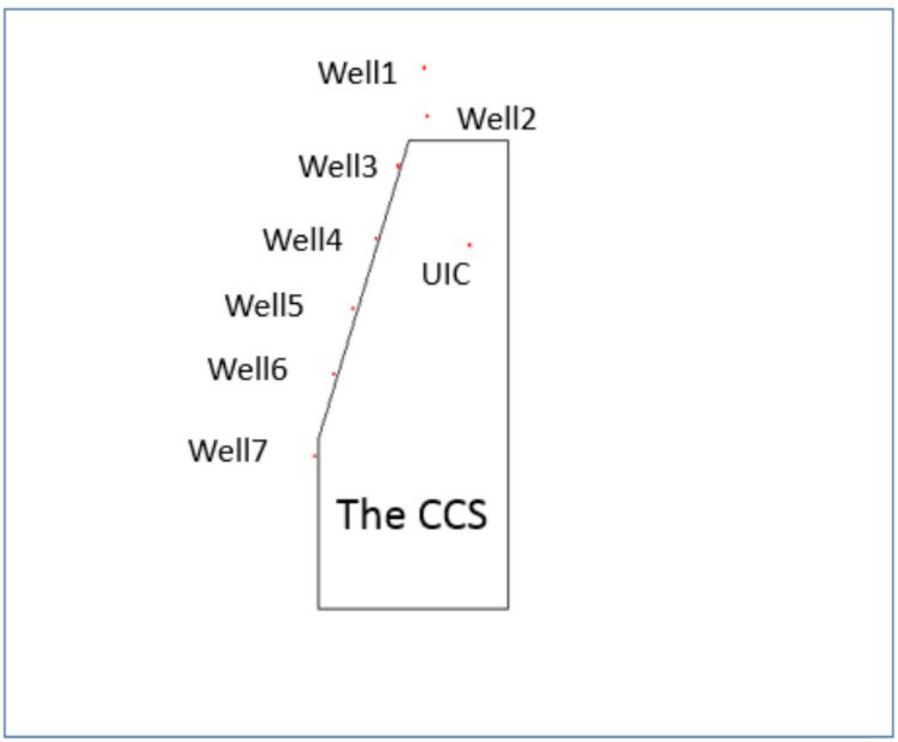


Figure 6. Location of proposed extraction wells in ALT3C.

Table 3. Proposed extraction rates (ALT3C)

ID	Row	Column	Layer 10	Layer 11	Sum (ft3/day)	Sum (MGD)	Active
Well1	57	181	-115872.39	-170585.93	-286458.32	2.1427	Years 2-10
Well2	71	182	-102981.76	-183476.55	-286458.31	2.1427	Years 2-10
Well3	86	173	-106922.18	-179466.13	-286388.31	2.1422	Years 2-10
Well4	108	166	-126757.8	-159700.51	-286458.31	2.1427	Years 2-10
Well5	129	159	-92096.348	-194361.97	-286458.318	2.1427	Years 2-10
Well6	149	153	-73763.016	-212695.30	-286458.316	2.1427	Years 2-10
Well7	174	147	-77343.745	-209114.57	-286458.315	2.1427	Years 2-10
Total					-2005138.2	14.9984	
Near UIC	110	195	-504309	-1500898.3	-2005207.3	14.9990	Year 1

Scenario ALT3D

Figure 7 shows the well configuration of ALT3D. Although the total extraction rate of 15 MGD remains the same as in ALT3B and ALT3C, 11 extraction wells were proposed: one near the UIC well and 10 extraction wells along the western edge of the CCS area. According to the performance "Ranking Matrix" (Tetra Tech, 2016), ALT3D has the highest performance score among 15 simulated remediation scenarios.

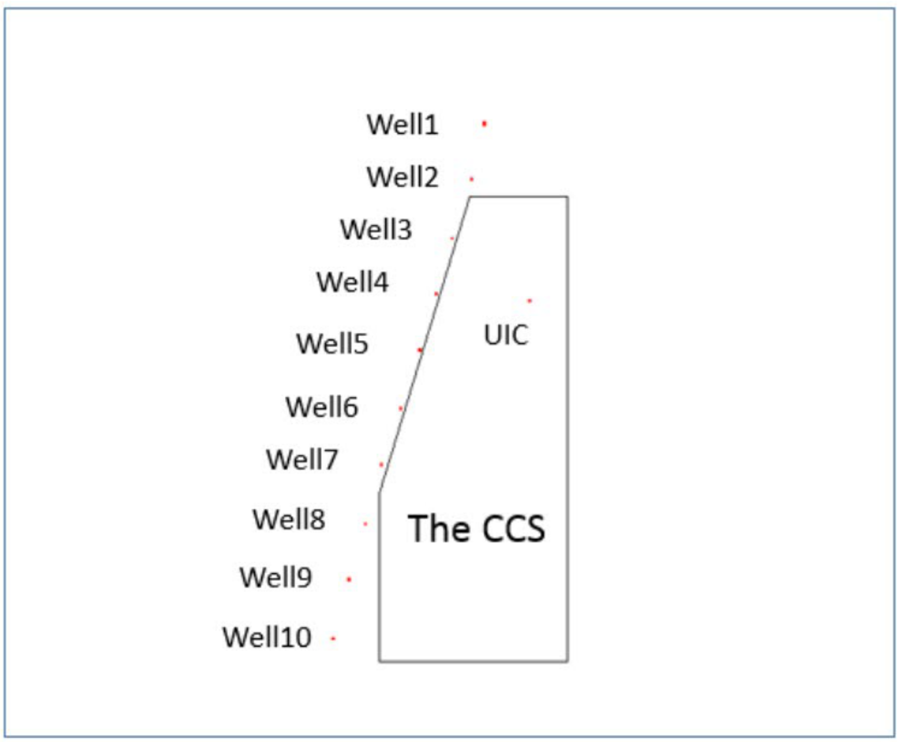


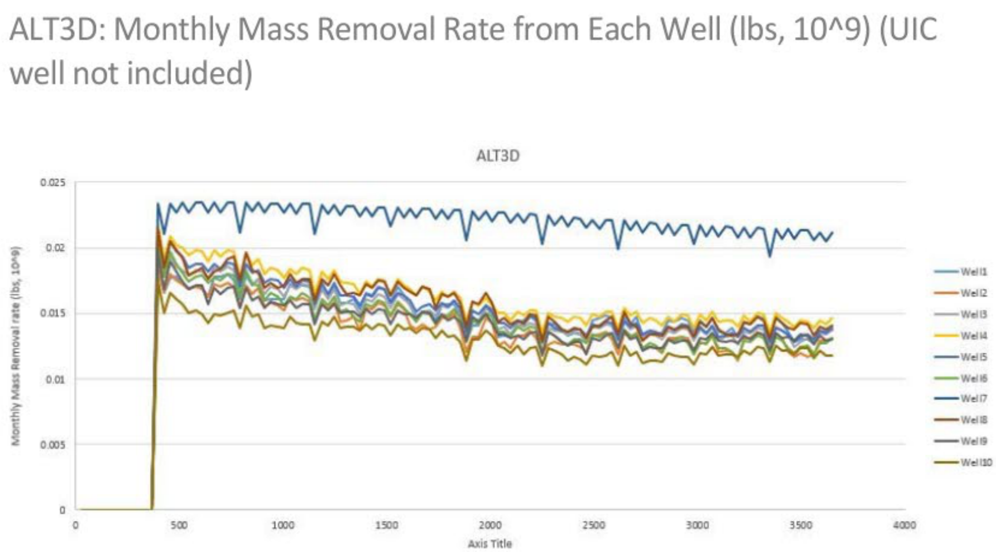
Figure 7. Location of proposed extraction wells in ALT3D.

The performance of individual extractions (except the near UIC well), at the monthly mass removal rate, is shown on Figure 8. The proposed extraction rates for ALT3D scenario is provided in Table 4. It seems most of these proposed extraction wells behave similarly except for Well 7. The reason for better performance at Well 7 should be investigated. It follows that optimal location of proposed extraction wells may be determined by looking into the performance of each well.

Table 4. Proposed extraction rates (ALT3D)

ID	Row	Column	Layer 10	Layer 11	Sum (ft3/day)	Sum (MGD)	Active
Well1	57	181	-81110.672	-119410.15	-200520.822	1.4999	Years 2-10
Well2	73	177	-72388.016	-128132.8	-200520.816	1.4999	Years 2-10
Well3	91	171	-78604.161	-121916.66	-200520.821	1.4999	Years 2-10
Well4	108	166	-88730.463	-111790.36	-200520.823	1.4999	Years 2-10
Well5	125	161	-68177.079	-132343.74	-200520.819	1.4999	Years 2-10
Well6	143	155	-53238.278	-147282.54	-200520.818	1.4999	Years 2-10
Well7	169	149	-52837.236	-147683.58	-200520.816	1.4999	Years 2-10
Well8	178	144	-56145.829	-144374.99	-200520.819	1.4999	Years 2-10
Well9	195	139	-55243.486	-145277.33	-200520.816	1.4999	Years 2-10
Well10	213	134	-54341.142	-146179.68	-200520.822	1.4999	Years 2-10
Total					-2005208.19	14.9990	
Near UIC	110	195	-504309	-1500898.3	-2005207.3	14.9990	Year 1

Figure 8. Performance of individual extraction wells in ALT3D (near UIC well is not shown).



Scenario ALT4

In Scenario ALT4, six horizontal wells are proposed, in addition to the deep Biscayne Aquifer well near the UIC well. Total extraction rate is just under 15 MGD. The location of these wells are shown in Figure 9. Each of the horizontal wells were modeled as wells in three consecutive model cells. A horizontal well is typically modeled in MODFLOW as a series of cells with a high value of hydraulic conductivity. Since the horizontal wells were modeled as "wells," pumping rates were specified for each well cell as shown in Table 5. In reality, however, the flow to a horizontal well depends on a number of factors: aquifer permeability, head gradient, well size, skin effects, etc. that are typically unknown before some form of field-testing is conducted as part of the horizontal well construction process.

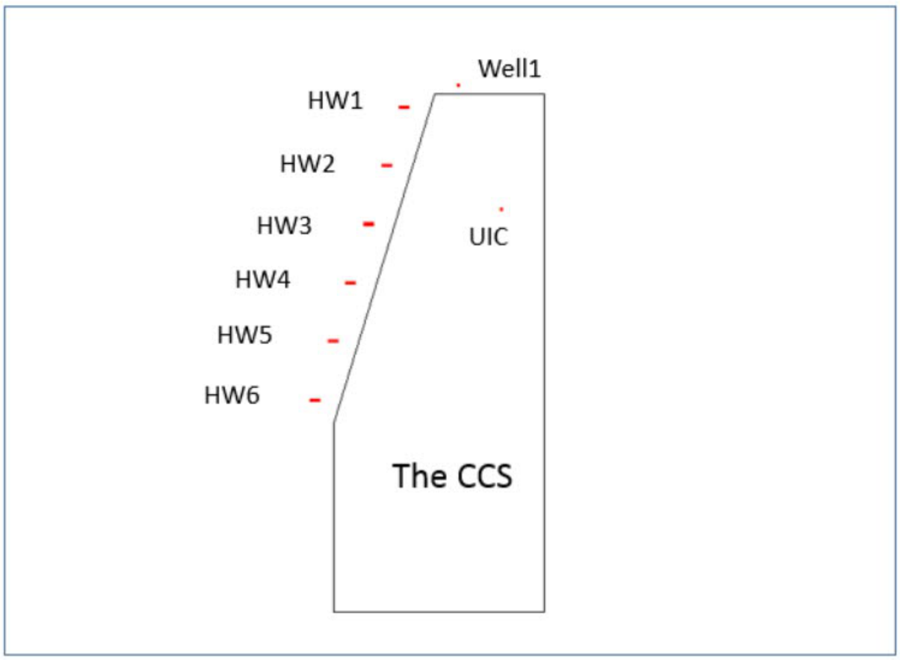


Figure 9. Location of proposed extraction wells in ALT4.

Table 5. Proposed extraction rates (ALT4)

ID	Row	Columns	Segment1	Segment2	Segment3	Sum (ft3/day)	Sum (MGD)	Active
Well1	76	183	-186785.14	n/a	n/a	-186785.14	1.3972	years 210
HW1	82	167-169	-57291.663	-114583.33	-114583.33	-286458.323	2.1427	years 2-10
HW2	98	162-164	-57291.663	-114583.33	-114583.33	-286458.323	2.1427	years 210
HW3	114	157-159	-57291.663	-114583.33	-114583.33	-286458.323	2.1427	years 2-10
HW4	130	152-154	-57291.663	-114583.33	-114583.33	-286458.323	2.1427	years 2-10
HW5	146	147-149	-57291.663	-114583.33	-114583.33	-286458.323	2.1427	years 2-10
HW6	162	142-144	-57291.663	-114583.33	-114583.33	-286458.323	2.1427	years 2-10
Total						-1905535.078	14.2534	
			Layer 10	Layer 11				
Near UIC	110	195	-504309.86	-1500898.3		-2005208.16	14.9990	Year 1

4. DISCUSSION

Several issues were identified during this model review. Some of the issues may affect the validity or usability of the prediction models.

A. River Conductance

The CCS is modeled using the MODFLOW RIVER package. This package allows water exchange between surface water and groundwater. Three input parameters (river stage, riverbed conductance and river bottom elevation) are used to define a river cell. The flow between a river cell and the underlying aquifer is calculated using the following equation:

$$Q=C \times (DH)$$

Where, DH (L) is the head difference between the river cell and underlying aquifer, Q (L^3/T) is the flow, and C is the riverbed conductance (L^2/T), which is a lumped parameter of riverbed hydraulic conductivity and riverbed geometry. In SEAWAT, the salinity and temperature can be specified for the water within the river.

In MODFLOW, a river cell is also treated as an unlimited sink or source of water. MODFLOW does not track how much water is in a river cell. Therefore, a river cell could provide an unrealistic amount water to the aquifer and vice versa. Since the flow is proportional to the difference in head, the use of appropriate conductance values is critical. Rarely measured in the field, river conductance is typically a model parameter that may be adjusted during the model calibration process.
The CCS simulation was activated in the 10th stress period of the Seasonal Calibration model (which corresponds to late 1972). From that time, the river cells representing the CCS are active throughout the rest of the transient model calibration period (1968-2016) and remain active in all of the prediction models (10 years). During most of the transient model calibration period, relatively high values of river conductance values were assigned to the river cells representing the CCS. According to the model technical memorandum, the heads, salinity and temperature assigned to each river cell in the CCS were based on field-measured data.

For illustration purposes, a randomly selected location within the CCS (Row 154, Column 180) is shown in Figure 10. Simulated water levels changes and concentration changes in the canal and Layers 1 through 11 are shown on Figures 11 through 15.

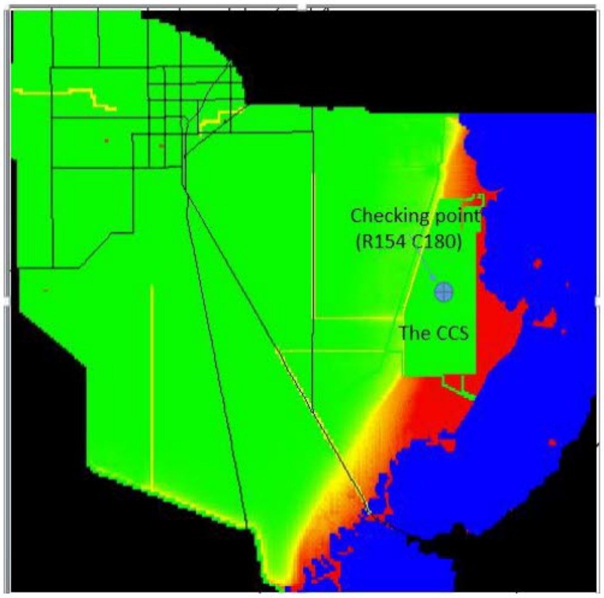


Figure 10. Location of checking point.

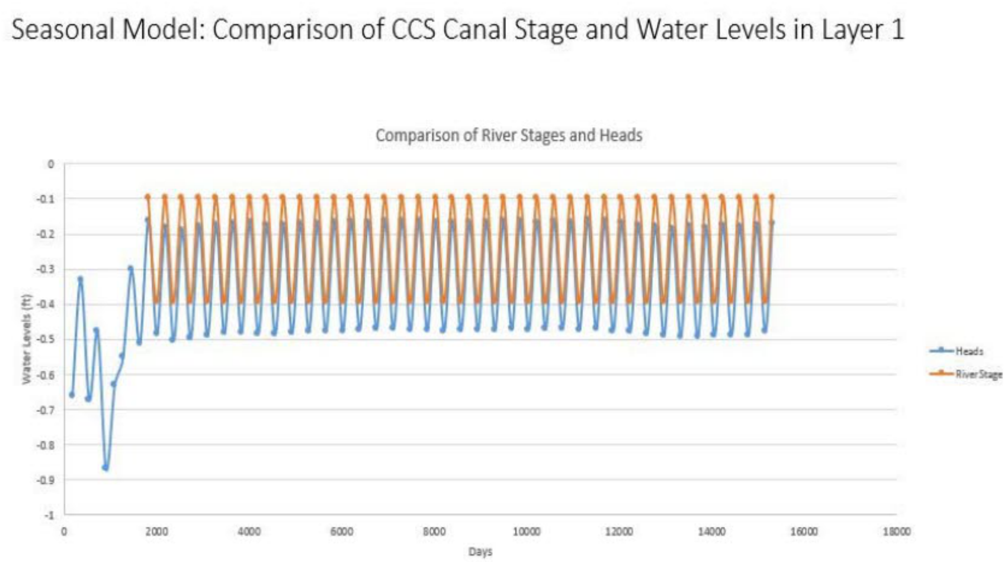


Figure 11. Simulated head changes in model Layers 1-4 in seasonal calibration model.

For most of the calibration period, the river conductance at the selected location is 16,667 ft^2/day and the water levels in the aquifer below the CCS show a close synchronized pattern with the stages assigned for the CCS. It is noted that

Layers 1 through 11 are hydraulically well connected and water levels in these layers fluctuate in a similar fashion. As indicated on Figure 11, a slight offset of about 0.05 feet is noted between the simulated water level in Layer 1 and stage values in the canal. The salinity in the aquifer is also very similar to the salinity specified in the CCS at the selected location as indicated on Figures 14 and 15.

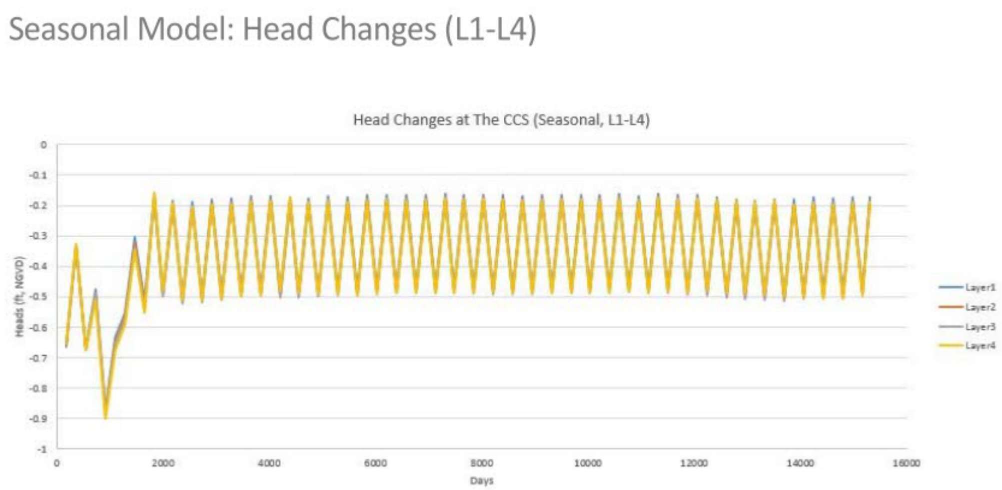


Figure 12. Simulated head changes in model Layers 1-4 in seasonal calibration model.

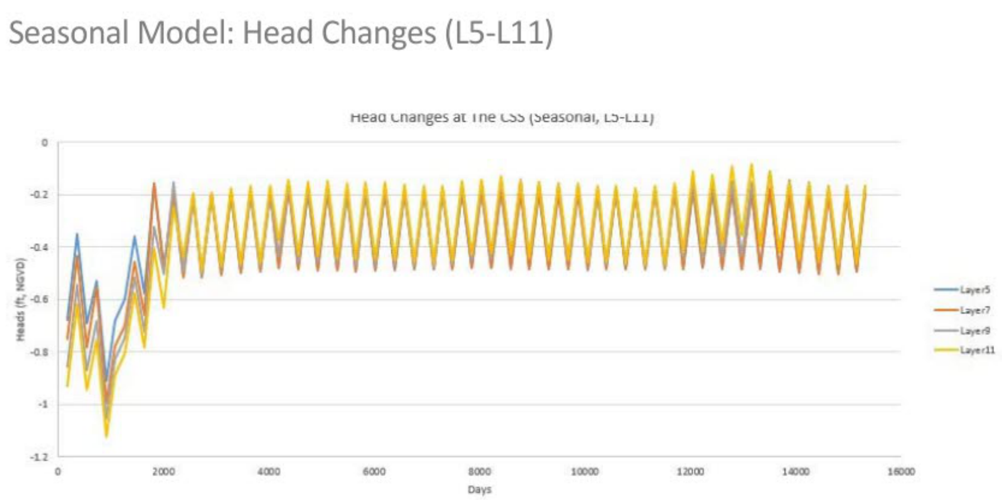


Figure 13. Simulated head changes in model Layers 5-11 in seasonal calibration model

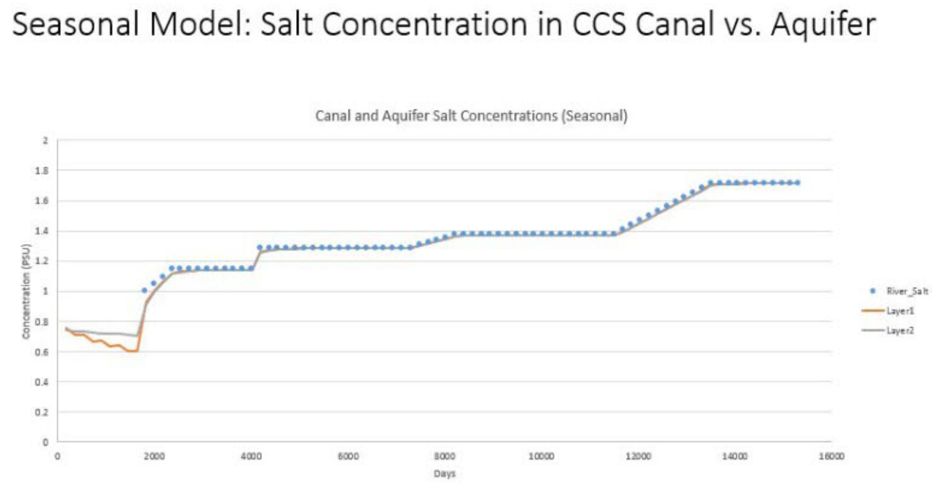


Figure 14. Simulated salt concentration changes in the CCS and model Layers 1 and 2 in seasonal calibration model.

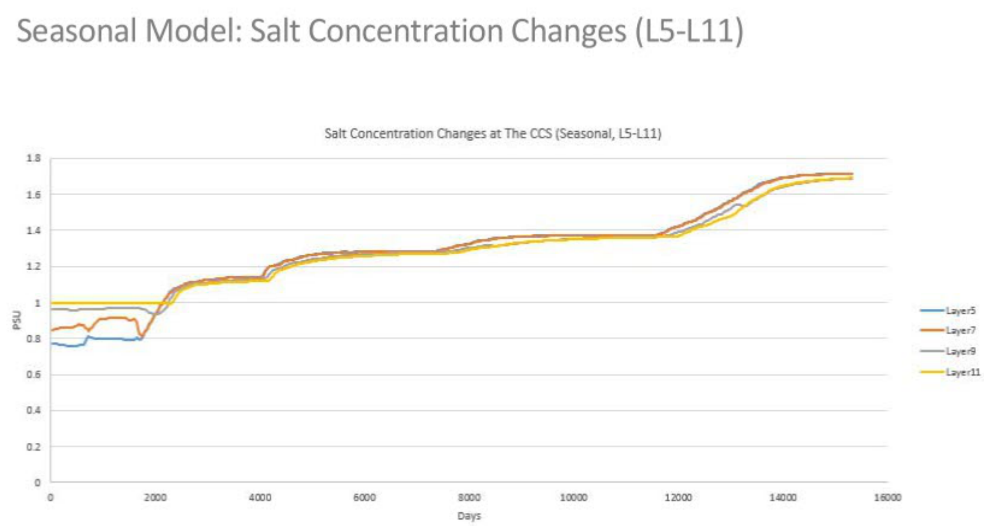


Figure 15. Simulated salt concentration changes in model Layers 5, 7, 9, and 11 in the seasonal calibration model.

According to the technical memorandum, the river conductance in the CCS were "calculated using the appropriate layer hydraulic conductivities and either the GIS-based surface area of the surface water feature (for the canal bottoms) or the lateral exposed area (for the vertical canal-aquifer interfaces)." Review of the CCS river cells, shows that the river

conductance values specified for the CCS are, in general, quite high, on the order of 1X10^{-3} to 1X10^{-4} ft^2/day. However, for reasons not indicated in the report, the river conductance values for the CCS were reduced significantly toward the end of the monthly calibration period during Stress Period 38, corresponding to November, 2013. The sudden change in river conductance value, at the randomly selected check point (R154, C180) is shown in Table 6.

Table 6. River conductance for the CCS canal at R154 C180

Stress Period	Row	Col	Stage (ft)	Conductance (ft2/d)	Bottom Elev. (ft)
31	154	180	-0.26876	**16667**	-3.77
32	154	180	-0.13292	**16667**	-3.77
33	154	180	-0.15232	**16667**	-3.77
34	154	180	-0.19454	**16667**	-3.77
35	154	180	-0.28552	**16667**	-3.77
36	154	180	-0.27359	**16667**	-3.77
37	154	180	-0.2862	**16667**	-3.77
38	154	180	-0.27312	667	-3.77
39	154	180	-0.27745	667	-3.77
40	154	180	-0.49713	667	-3.77
41	154	180	-0.64699	667	-3.77
42	154	180	-0.81633	667	-3.77
43	154	180	-0.94633	667	-3.77
44	154	180	-0.70736	667	-3.77
45	154	180	-0.69858	667	-3.77
46	154	180	-0.49237	667	-3.77

The river conductance at this location was reduced by approximately 96%. The change from 16,667 ft^2/day to 667 ft^2/day may suggest a possible data processing error or change in model assumptions for the remediation simulations. The conductance for most of the river cells representing the CCS, if not all, seem to have a similar reduction. The large change in river conductance for the CCS may not have significantly affected the overall model calibration statistics since the change

was made towards the end of the calibration period, and it seems to have occurred only at the CCS area. However, the change indicates a very different set of conditions for the remediation simulations as compared to the model calibration efforts. The impact of this change may also significantly affect the simulation results as shown in Figures 16 and 17.

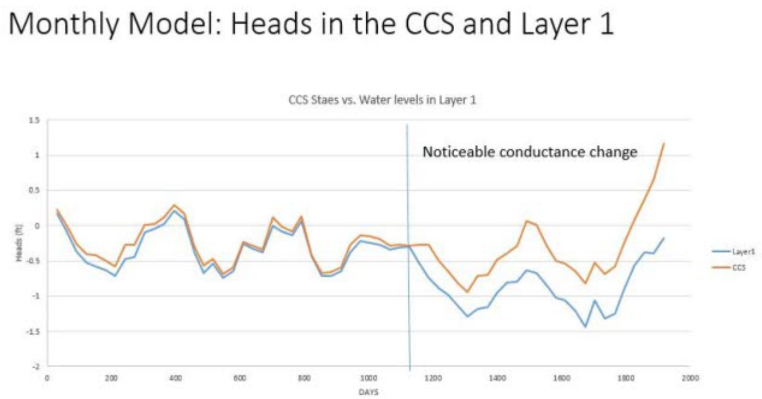


Figure 16. Simulated water levels in the CCS canal and model Layer 1 in monthly calibration model.

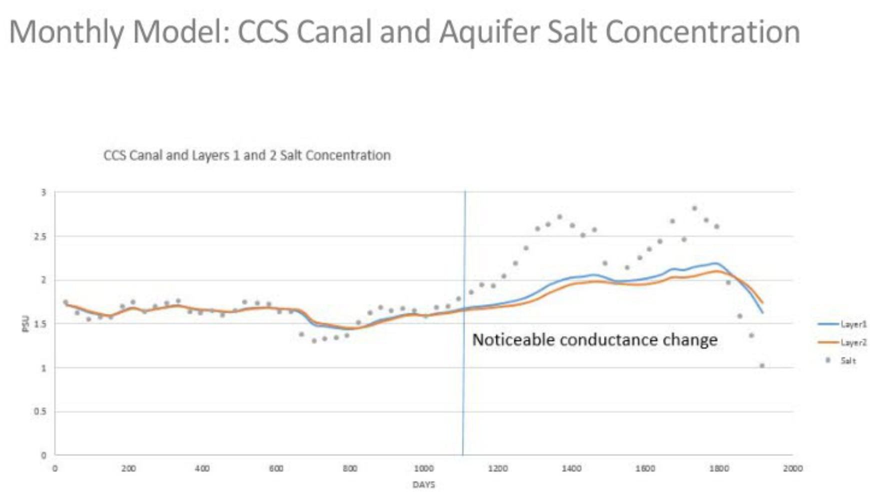


Figure 17. Simulated salt concentration changes in the CCS canal and model Layers 1 and 2 in the monthly calibration model.

Review of the figures indicates that the simulated heads and salinity start to deviate from the values specified in the CCS after the river conductance values are reduced. This impact is also observed in the model calibration time series (from the Tetra Tech PowerPoint presentation presented as Figure 18).

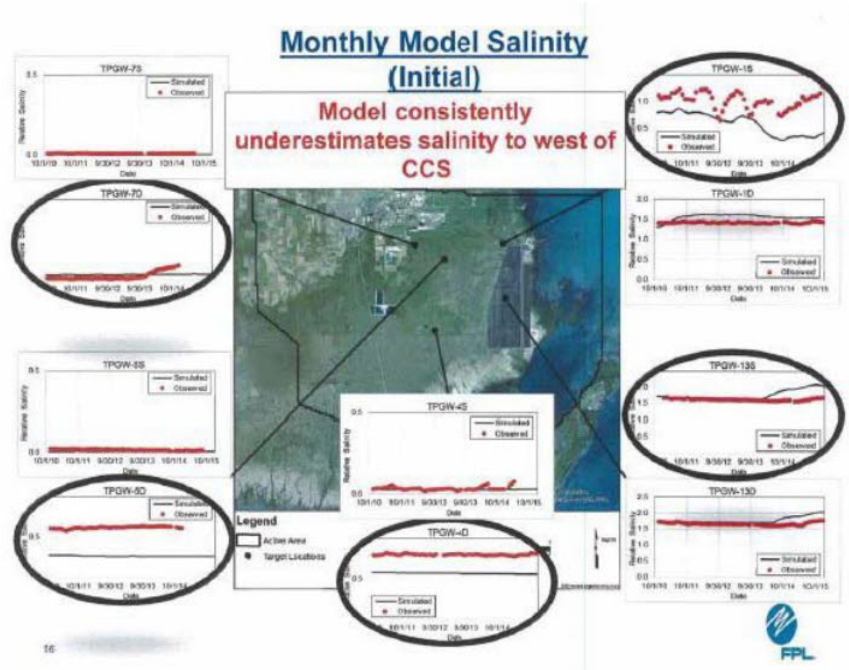


Figure 18. Salinity calibration results of the monthly model (Tetra Tech, 2016).

As shown above, simulated salinity values in the calibration target monitor wells, TPGW-13S and TPGW-13D, started moving away from observed values at approximately the end of 2013. Another monitoring well, TPGW-7D, located a significant distance away from the CCS, also showed a similar pattern change. The revised river conductance values for the CCS were used in all of the predictive models. This is a concern. The change of the river conductance beneath the CCS was significant and made at a very late stage of the model calibration period. The reduced river conductance may not be representative of actual field conditions and was not considered during most of the model calibration period. The validity of the prediction scenarios are therefore placed in question because of the significance of the change and the late stage of the change in the area most critical for performance evaluation of the proposed remediation measures.

B. Constant Hydraulic Properties

Vertically, the model has 11 layers to represent the Biscayne Aquifer. Constant values of hydraulic parameters (horizontal and vertical hydraulic conductivity and specific yield/storativity) were used for each of the model layers. However, much data has been collected within the Biscayne Aquifer showing high degrees of variability across Miami-Dade County. It is not clear why the spatial variations of hydraulic parameters were not represented in this model considering aquifer heterogeneity could significantly affect the groundwater flow and solute transport processes especially in local scales.

C. Inactive Areas, Dry cells and Flooded Cells

A large area of dry cells is present at the west side of the model. When the cells become dry, no flow or solute transport will be simulated in the cells for subsequent time steps. In addition, a large portion of model area is flooded. These dry cells or flooded cells may not be critical for the purpose of this modeling study, but they may indicate more serious issues, such as issues with the net recharge approach and/or poorly calibrated hydraulic parameters.

D. Pumping Rate and Locations

In all of the alternatives reviewed, an extraction rate of 15 MGD was proposed from one well completed near the UIC well within the base of the Biscayne Aquifer for the first year of remediation. Although it is simple to have a well with such a pumping rate built into a numerical model, it may not be practical to install a well with such a capacity. Fish and Stewart (1991) showed the highest pumping rate reported for wells tapping the Biscayne Aquifer is approximately 10 MGD, and in practice, individual well withdrawal rates are typically limited to 5 MGD from the Biscayne Aquifer. In addition, the groundwater under the CCS has a much higher salinity (about 1.8 PSU or 63,000 mg/l) thus a higher fluid density (1045 kg/m3) than freshwater, so it would be more difficult to pump the saline water at this rate from one well.

Additionally, all of the extraction scenarios had an approximate total pumping rate of 15 MGD, which correlates to the permitted capacity of the existing injection well at the facility. While a limitation of 15 MGD has practical value in utilizing existing infrastructure for disposal of the extracted hypersaline fluids, it would be of interest to see if other extraction rates not restricted to existing disposal limitations yield better remedial results.

It would be of interest to see if a higher efficiency of extraction of the hypersaline plume and seaward movement of the saline water interface could be achieved with the location of the extraction wells more towards the middle of the hypersaline plume. It would also be beneficial to look at the mass removal rate of each extraction well, as shown in Figure 8 for ALT3D, to optimize the remediation system design.

E. Salinity in CCS

As shown on Figure 15, the maximum salinity in the CCS simulated in the seasonal model is about 1.8 PSU. It is relevant to note that salinity as high as 3.0 PSU has been reported for CCS (Chin, 2015). Higher salinity, up to about 2.7 PSU as shown in Figure 17, was applied to the CCS in the monthly model. However, due to change in canal conductance at that time, the salinity in deeper layers appears to not be impacted by the salinity in the CCS. It needs to be understood why the simulated salinity does not match the observed peak salinity values in the canal and how the low conductance in canal post 2013 is affecting the salinity in lower model layers.

F. Flow from GHB Cells

General head boundary (GHB) was applied along the model active area in most model layers to represent the hydraulic connection between the model domain and its surrounding hydrogeological units. The flow in and out these GHB cells should be checked as part of mass balance analysis to ensure the amount of water entering into the model is realistic.

G. Canal Representation using Drain Package

The Card Sound Canal was represented in the model using the Drain package. Drain cells allow water to move from aquifer to the drain cells but not vice versa. Use of the Drain cell approach does not allow the model to simulate saltwater intrusion that may occur in the area surrounding the Card Sound Canal.

H. Net recharge Approach

A net recharge approach was carried out for representation of the major water balance elements of rainfall, runoff, evaporation, and transpiration. A positive recharge means the recharge reaches the water table and a "negative recharge" indicates the aquifer is losing water (ET is greater than the natural recharge). Negative recharge rates were "ignored" by assigning the recharge rate as zero with the assumption that under a negative recharge scenario, "the maximum ET rates would not be realized due to insufficient rainfall." The approach is generally used when the parameters for MODFLOW EVT (evapotranspiration) package and or the surface runoff are difficult to quantify. However, the approach may underestimate water losses due to ET in the dry season.

5. CONCLUSIONS AND RECOMMENDATIONS

Overall, it appears that a significant amount of work was conducted to develop these data-intensive, variable-density models. Most assumptions and approaches used during model development seem to be reasonable and the model development followed the general standard procedures. The model calibration seems reasonable. The calibration results indicate that the model-calculated water levels and salinity are in general agreement with the field data.

However, the following concerns need to be addressed or resolved before the model can be used for remedial design purposes.

- Assigning spatially varying hydraulic parameters to model layers should be considered since it could affect the flow and transport significantly.

- The varying rates of net recharge part way through the calibration period is not clearly tied to calibration efforts. Some explanation for these changes are required.

- The occurrence of "dry cells" and "flooded cells" over large portions of the model domain raise concerns about the appropriateness of model assumptions and/or inputs and could be an issue for overall model accuracy and reliability for predictive application.

- The change of river conductance at the CCS is a major concern. The changes are significant, late in the simulation period. The issue is identified at locations most critical for the performance evaluation of the various remedial alternatives. The change of river conductance may require the model to be recalibrated or the proposed remediation scenarios be reevaluated if the change is not supported by actual field data.

- It is recommended to consider practical well capacities for the proposed extraction wells in the remediation scenarios. To optimize the remediation designs, the performance of individual extraction wells may be assessed by checking the mass removal rates or particle tracking methods.

- Using the MODFLOW Drain package to simulate Card Sound canal should be reconsidered.

One of the objectives for the model development was to "ameliorate the westward movement of the saltwater and hypersaline water interface in the Biscayne aquifer." Proposed extraction wells in the scenarios reviewed indicated removal of salt from the aquifer and some mitigation of the westward extent of the hypersaline plume. However, none of the analyses indicated if these proposed remediation systems would sufficiently prevent the further westward migration of the saltwater interface west of the hypersaline water plume.

6. REFERENCES

Fish, J.E. and M. Stewart, 1991. Hydrogeology of the surficial aquifer system, Dade County, Florida, US Geological Survey, Water-Resources Investigations Report, 90-4108.

FPL, May 2016. Variable Density Groundwater Flow Model Analysis and Results: Model Use, Design, Calibration, and Description of Alternatives, PowerPoint Presentation.

FPL, May 2016. Variable Density Groundwater Flow Model Analysis and Results: Remedial Alternatives Modeling Evaluations and Selected Alternatives, PowerPoint Presentation.

Guo, W. and C. Langevin, 2002. User's Guide to SEAWAT: A computer Program for Simulation of Three- dimensional Variable-Density Ground-Water Flow, USGS Techniques of Water Resources Investigations, Book6, Chapter A7.

Tetra Tech, June 2016. A Groundwater Flow and Salt Transport Model of the Biscayne Aquifer, Consultant's Report to FPL.
Chin, David, 2015. The cooling-canal system at the FPL Turkey Point Power Station: http://www.miamidade.gov/environment/cooling-canal-study-and-feedback.asp

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From: Folk, Kevin
To: "Prasad, Rajiv"
Cc: Ford, William; TurkeyPoint34SLR Resource
Subject: RE: PTN SLR: decommissioning-related comments
Date: Wednesday, July 03, 2019 9:57:24 AM
Importance: High

Rajiv:

(b)(5)

From: Prasad, Rajiv <Rajiv.Prasad@pnnl.gov>
Sent: Sunday, June 30, 2019 1:30 AM
To: Folk, Kevin <Kevin.Folk@nrc.gov>
Cc: Saulsbury, James W <james.saulsbury@pnnl.gov>
Subject: [External_Sender] PTN SLR: decommissioning-related comments

[redacted] (b)(5)

Thanks!

Rajiv

Rajiv Prasad, Ph.D.
Scientist, Energy and Environment Directorate
Pacific Northwest National Laboratory
902 Battelle Boulevard
P.O. Box 999, MSIN K7-68
Richland, WA 99352 USA
Tel: 509-375-2096, Fax: 509 371-7083
rajiv.prasad@pnnl.gov, www.pnnl.gov

Note to requester: Portions of this record are redacted under both FOIA Exemption B5, Deliberative Process Privilege and B5, Attorney-Client Privilege.

From: Folk, Kevin
To: Burton, William; Ford, William; Grange, Briana; Hoffman, Robert; Martinez, Nancy; Clark, Phyllis; Rautzen, William; Rikhoff, Jeffrey
Cc: Beasley, Benjamin; Oesterle, Eric; Schaaf, Robert
Subject: RE: RE: Turkey Point Annual Monitoring Report
Date: Wednesday, September 04, 2019 12:15:00 PM
Importance: High

Butch:

(b)(5)

Kevin

From: Burton, William
Sent: Wednesday, September 04, 2019 11:44 AM
To: Folk, Kevin <Kevin.Folk@nrc.gov>; Ford, William <William.Ford@nrc.gov>; Grange, Briana <Briana.Grange@nrc.gov>; Hoffman, Robert <Robert.Hoffman@nrc.gov>; Martinez, Nancy <Nancy.Martinez@nrc.gov>; Clark, Phyllis <Phyllis.Clark@nrc.gov>; Rautzen, William <William.Rautzen@nrc.gov>; Rikhoff, Jeffrey <Jeffrey.Rikhoff@nrc.gov>
Cc: Beasley, Benjamin <Benjamin.Beasley@nrc.gov>; Oesterle, Eric <Eric.Oesterle@nrc.gov>; Schaaf, Robert <Robert.Schaaf@nrc.gov>
Subject: RE: RE: Turkey Point Annual Monitoring Report

(b)(5)

From: Burton, William
Sent: Wednesday, September 04, 2019 11:42 AM
To: Folk, Kevin <Kevin.Folk@nrc.gov>; Ford, William <William.Ford@nrc.gov>; Grange, Briana <Briana.Grange@nrc.gov>; Hoffman, Robert <Robert.Hoffman@nrc.gov>; Martinez, Nancy <Nancy.Martinez@nrc.gov>; Clark, Phyllis <Phyllis.Clark@nrc.gov>; Rautzen, William <William.Rautzen@nrc.gov>; Rikhoff, Jeffrey <Jeffrey.Rikhoff@nrc.gov>
Cc: Beasley, Benjamin <Benjamin.Beasley@nrc.gov>; Oesterle, Eric <Eric.Oesterle@nrc.gov>; Schaaf, Robert <Robert.Schaaf@nrc.gov>
Subject: FW: RE: Turkey Point Annual Monitoring Report

Hi Folks,

(b)(5)

Butch

From: Turk, Sherwin
Sent: Wednesday, September 04, 2019 11:34 AM
To: Folk, Kevin <Kevin.Folk@nrc.gov>; Ford, William <William.Ford@nrc.gov>; Beasley, Benjamin <Benjamin.Beasley@nrc.gov>; Burton, William <William.Burton@nrc.gov>
Cc: Campbell, Tison <Tison.Campbell@nrc.gov>; Roth (OGC), David <David.Roth@nrc.gov>
Subject: FW: RE: Turkey Point Annual Monitoring Report

(b)(5)

[redacted]

Shep

Sherwin E. Turk
Special Counsel for Litigation
Office of the General Counsel
U.S. Nuclear Regulatory Commission
Mail Stop O14-A44
Washington, D.C. 20555

Sherwin.Turk@nrc.gov
(301) 287-9194

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From: Folk, Kevin
To: "Prasad, Rajiv"
Cc: Ford, William; TurkeyPoint34SLR Resource
Subject: RE: RE: TURK-SLR3&4-DR-00031 (16)
Date: Monday, July 22, 2019 9:43:09 AM

Rajiv:

(b)(5)

[redacted]

From: Prasad, Rajiv <Rajiv.Prasad@pnnl.gov>
Sent: Friday, July 19, 2019 6:21 PM
To: Folk, Kevin <Kevin.Folk@nrc.gov>
Subject: [External_Sender] RE: TURK-SLR3&4-DR-00031 (16)

(b)(5) Kevin, [redacted]

(b)(5) [redacted]

[redacted] (b)(5)

Thanks!

Rajiv

Rajiv Prasad, Ph.D.
Scientist, Energy and Environment Directorate
Tel: 509-375-2096, Fax: 509 371-7083

From: Prasad, Rajiv
Sent: Friday, July 19, 2019 11:32 AM
To: Folk, Kevin <Kevin.Folk@nrc.gov>
Subject: RE: TURK-SLR3&4-DR-00031 (16)

Kevin, I just did – please check if you can access the comment/response now – the draft response is 172R.

Rajiv

Rajiv Prasad, Ph.D.
Scientist, Energy and Environment Directorate
Tel: 509-375-2096, Fax: 509 371-7083

From: Folk, Kevin <Kevin.Folk@nrc.gov>
Sent: Friday, July 19, 2019 11:26 AM
To: Prasad, Rajiv <Rajiv.Prasad@pnnl.gov>
Subject: TURK-SLR3&4-DR-00031 (16)

Hi, Rajiv:

For the subject comment, looks like you need to mark as draft and mark me as the secondary reviewer. As it is, I only have read-only access. I will then knock this one out quickly. Thanks.

Kevin

Note to requester: Portions of this record are redacted under FOIA Exemption B5, Deliberative Process Privilege.

From: Folk, Kevin
To: Ford, William
Cc: TurkeyPoint34SLR Resource
Subject: RE: TURKEY POINT: Revised Text Section 4.5.1.1 Water Quality Impacts on Adjacent Water Bodies
Date: Tuesday, September 10, 2019 1:54:00 PM

Bill:

(b)(5) [redacted]

From: Ford, William
Sent: Tuesday, September 10, 2019 10:42 AM
To: Folk, Kevin <Kevin.Folk@nrc.gov>
Cc: TurkeyPoint34SLR Resource <TurkeyPoint34SLR.Resource@nrc.gov>
Subject: TURKEY POINT: Revised Text Section 4.5.1.1 Water Quality Impacts on Adjacent Water Bodies
Importance: High

Hi Kevin,

(b)(5) [redacted]

Thanks,

Bill Ford
301-415-1263

Note to requester: The attachments are immediately following this email record. The first attachment is also publicly available in ADAMS at ML17339A789. The second attachment is also publicly available, as part of a larger document in ADAMS, at ML17347A086.

From: Ford, William
To: Dozier, Jerry
Cc: Beasley, Benjamin; Burton, William; Folk, Kevin; Martinez, Nancy; James, Lois; Moser, Michelle; Grange, Briana
Subject: Slides of Sea Level Rise Projections at Turkey Point
Date: Friday, March 30, 2018 11:11:32 AM
Attachments: fpl-safety-presentation.pdf
staff-safety-panel-slides-turkeypt-6-and-7.pdf

Hi Jerry,

Per your request, I have attached slides from Florida Power and Light and another set of slides from the NRC staff. These slides were part of the mandatory Commission Hearing on the proposed new reactors at Turkey Point that was held in December, 2017.

These slides include summary information on future sea levels, storm surge, and flooding potential at the Turkey Point site.

Please note that in these slide, while the new reactor sites remain above water, for some projections, storm surge will over top the cooling canals (Florida Power and Light slide 2)

With respect to sea level rise, NRC staff slides (6 and 7) have used a 1 foot increase in sea level.

However, Butch Burton pointed out to me the following paragraph in the NRO response to public comments on the FEIS for the proposed new reactors at Turkey Point (NUREG-2176, page E-144).

"The review team is aware that the sea-level rise of 1–4 ft by 2100 is not bounding. It is not implausible that sea level rise significantly in excess of 4 ft could occur by 2100. Such extreme sea-level rises would inundate much of South Florida making it uninhabitable. However, NEPA requires consideration of likely future scenarios not extreme future scenarios. However, the gradual increase in sea level and NRC's safety process protects the public health and safety."

Thanks,

Bill Ford
301-415-1263

Turkey Point Nuclear Power Plant

Units 6 & 7

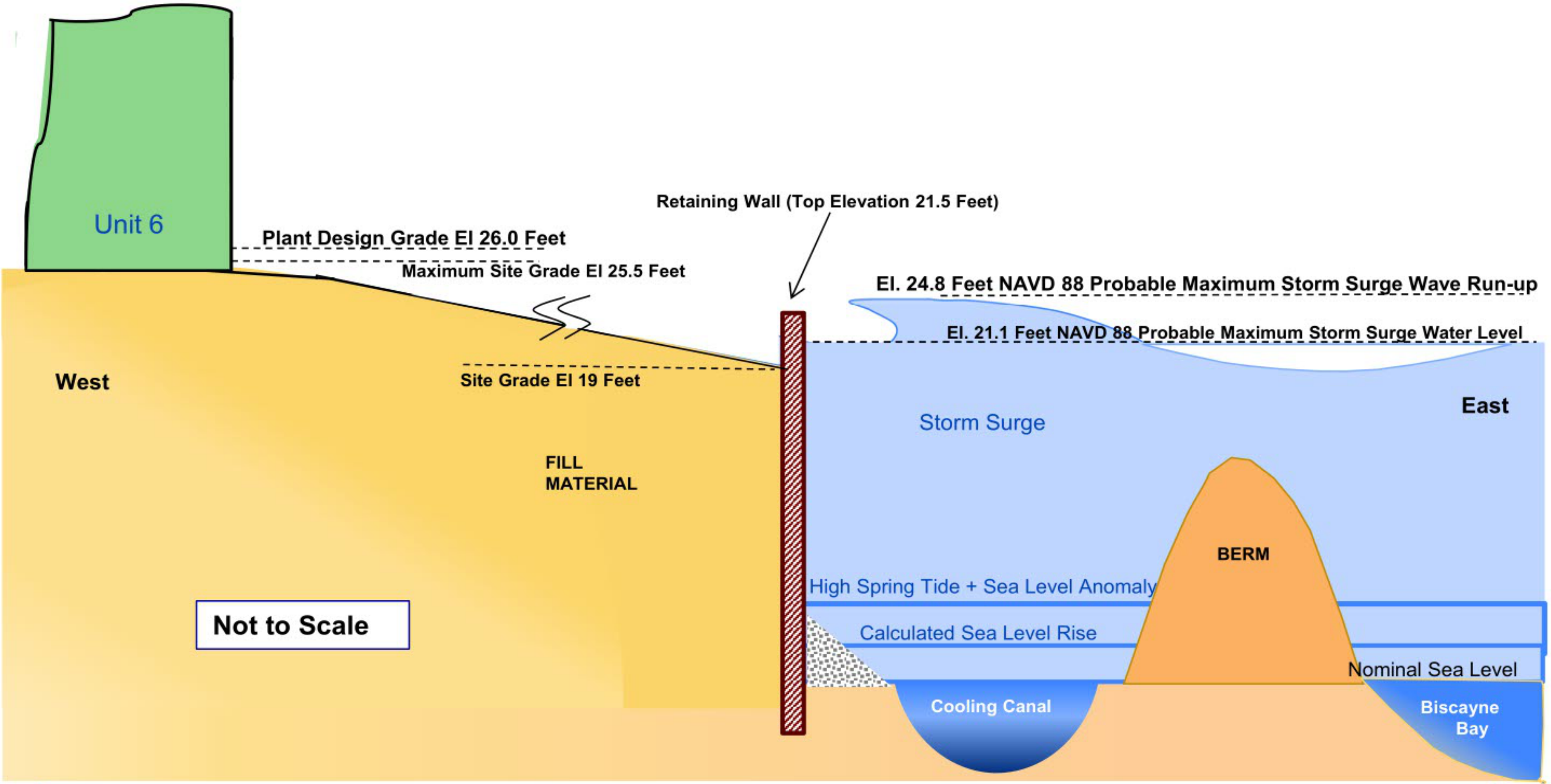
Safety Panel

Steve Franzone
Licensing Manager

Paul Jacobs
Engineering Supervisor

Rick Orthen
Licensing Engineer

Conservative Probable Maximum Storm Surge Analysis accounts for sea level rise



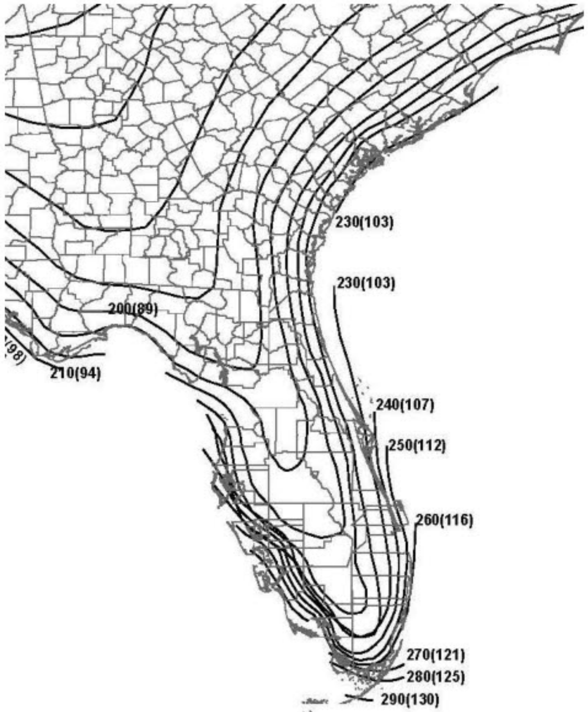
The analysis is performed using worst case parameters to calculate storm surge and wave run-up

FPL

Highest estimated historical 3-second wind gust speed was 204 mph during Hurricane Andrew in 1992 & is bounded by the 300 mph AP1000 DCD Tornado Wind Speed

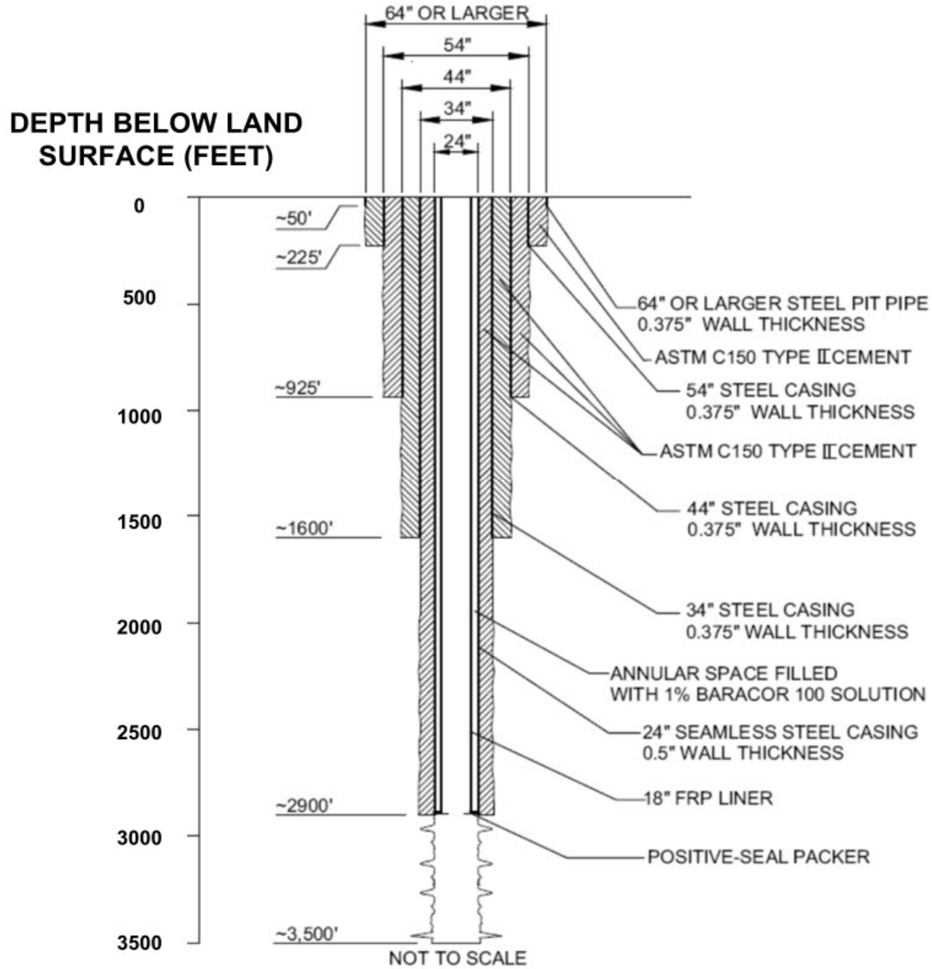
Wind Speeds Associated with PTN 6&7

- AP1000 DCD Tier 2 Operating Basis wind speed is 145 mph, 3 second gust, 50-year return interval
- Turkey Point "Operating Basis " wind speed is 150 mph, 3 second gust, 50-year return interval
- The wind load does not control the design for the Nuclear Island structures, therefore, a small increase is acceptable



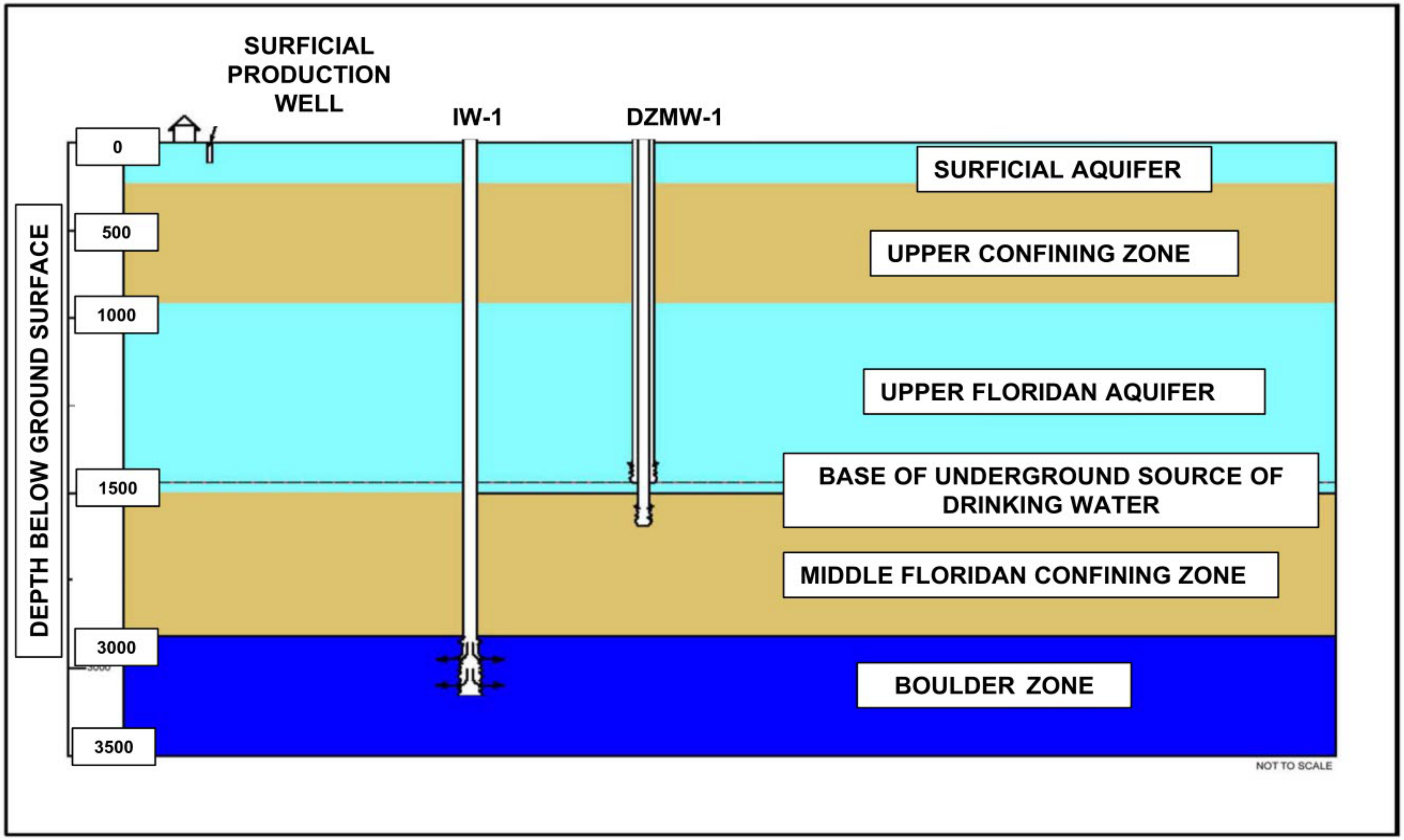
Turkey Point Units 6 & 7

Underground Injection Control Well Design

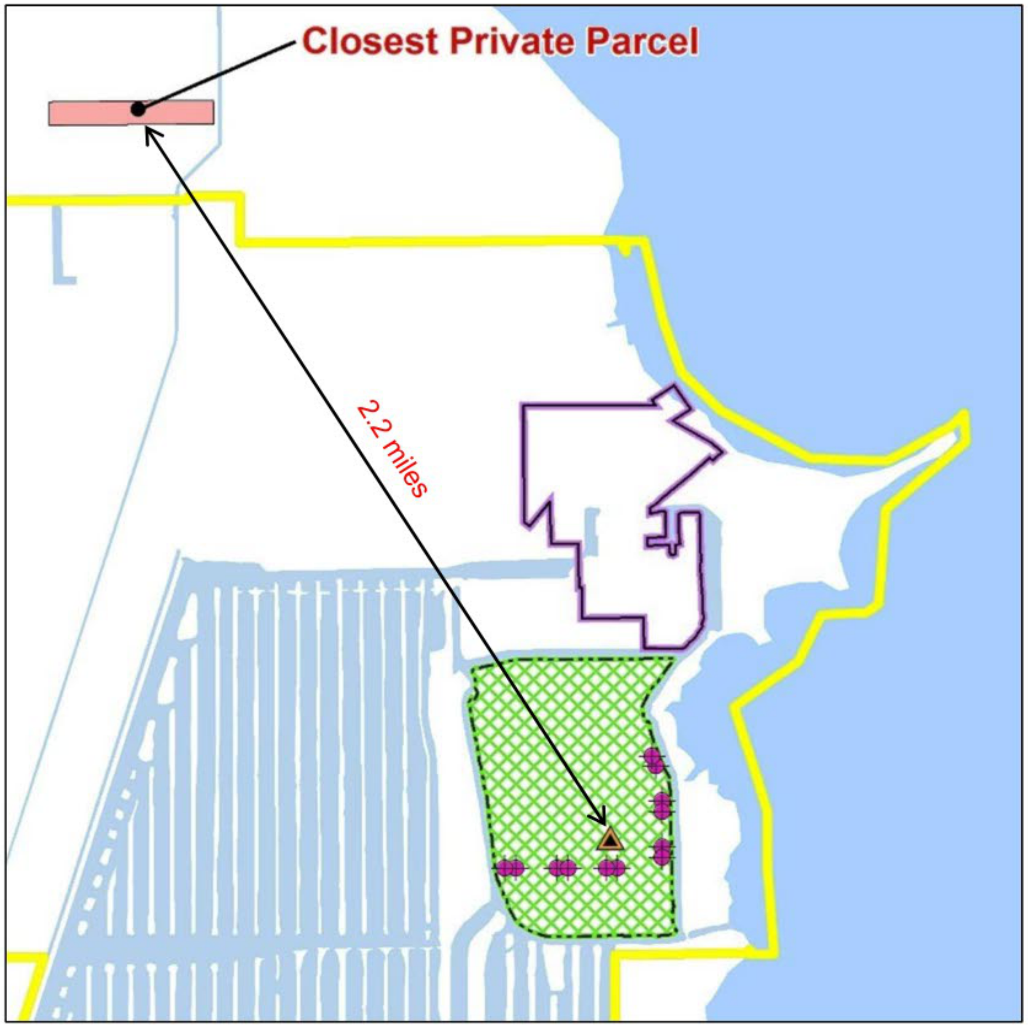


Members of the public are geologically isolated from liquid effluents

Deep Well Injection System



Geologic confinement of liquid effluent minimizes exposure



U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Combined License Application Mandatory Hearing Florida Power & Light Company Turkey Point Units 6 and 7

- Safety Panel
- December 12, 2017

Panelists

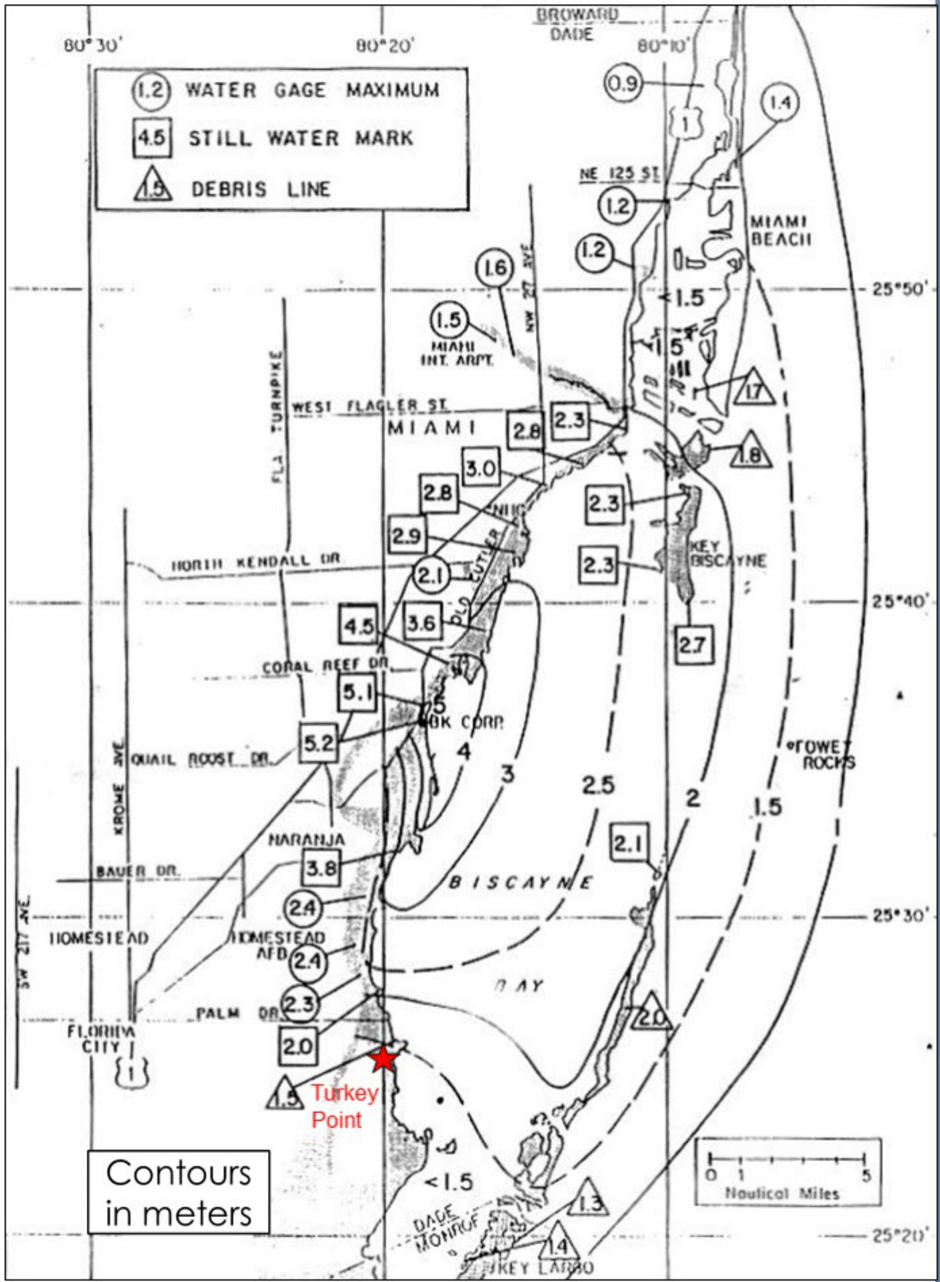
- Manny Comar – Senior Project Manager, NRC
- Joseph Giacinto – Lead Hydrologist, NRC
- Zachary Gran – Health Physicist, NRC
- Ellen Smith – Hydrologist, ORNL

Safety Panel Topics

- Storm Surge and Sea Level Rise
- Deep Well Injection for Liquid Radioactive Waste Disposal

Historical Storm Surge

- Hurricane Andrew made landfall 8 miles north of site in 1992.
- Category 5 storm
- Remains highest Florida storm surge on record:
  - 15.4 ft 8 miles north of site
  - 3-4 ft at the site



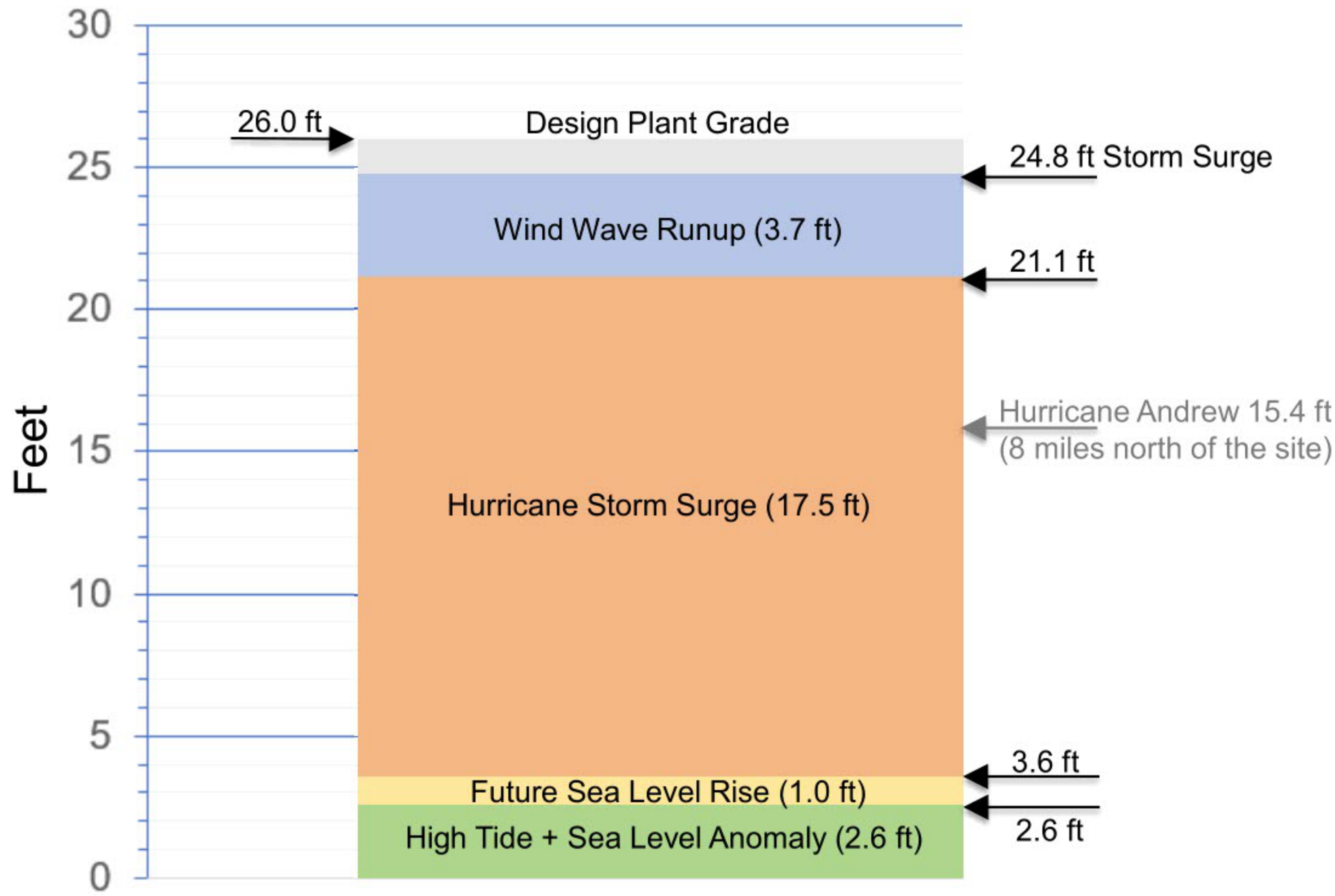
Storm Surge Components

- Used combination of Probable Maximum Hurricane parameters that results in highest storm surge
- Added 20 percent to predicted surge
- Additional conservative assumptions
  - Extreme high tide, sea level rise, wind and waves
- Estimated storm surge of 24.8 ft
- Design plant grade of 26.0 ft

Sea Level Rise in the Storm Surge Analysis

- NRC guidance was followed.
- NOAA-derived linear trend for Miami Beach data: 0.78 ft rise in 100 years
- Miami Beach gauge taken out of service in 1981—Key West gauge data from 1913 until 2016 show a consistent trend
- Analysis includes 1.0 ft rise to year 2100
- Sea level rise is observable and gradual.

Storm Surge Components



Staff Storm Surge Conclusions

- Estimated storm surge is beyond historical extremes.
- Multiple conservatisms appropriately account for uncertainty.
- The design basis flood level from storm surge is appropriately conservative.
- The design-basis flood level does not reach the design plant grade.

Deep Well Injection

- FPL is proposing to use Deep Well Injection to dispose of liquid effluent releases.
- First use of such disposal by a nuclear power plant in the USA
- 10 CFR 20.2002 describes the methods for obtaining approval of proposed disposal procedures.

Background – Deep Well Injection

- Injection into the Boulder Zone of the Lower Floridan aquifer (approximately 3000 feet deep)
- The Boulder Zone of the Lower Floridan aquifer is separated from the Upper Floridan Aquifer by the approximately 1500 ft thick Middle Confining Unit (MCU) which will prevent upward migration.

Background – Deep Well Injection

- Approximately 180 FDEP Class I Underground Injection Control (UIC) wells from various industries permitted in Florida

- FPL proposes 12 Class I UIC wells and 6 dual-zone monitoring wells for Turkey Point Units 6 and 7.

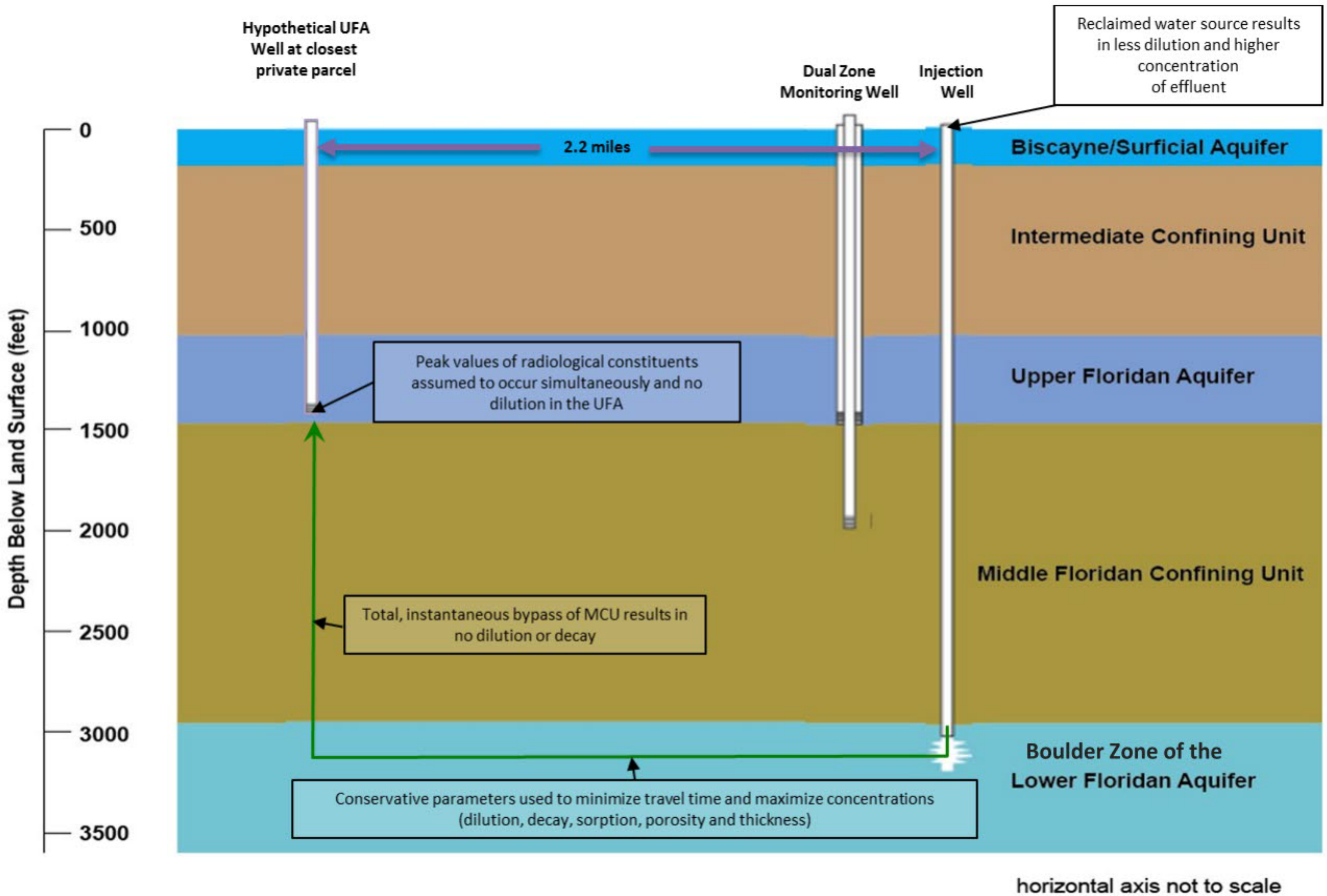
Staff Analysis

- Staff typically approves 10 CFR 20.2002 requests that will result in a dose to a member of the public (including all exposure groups) that is no more than “a few millirem/year”.
  - SECY-07-0060 and NUREG-1757, “Decommissioning Process for Materials Licensees”
  - Criteria in 10 CFR Part 50, App. I, used for suitable criteria for evaluating dose

Staff Analysis

- Independent dose analysis using the concentrations described by FPL. Staff Analysis considered:
  - H-3, Cs-134, Cs-137, and Sr-90
  - Nearest hypothetical receptor at 2.2 miles NW
  - Irrigated food pathways of vegetables, milk, meat, and drinking water as potential pathways for dose
  - Assumed full breach of the MCU

Injection Scenario



Staff's Conclusions

- Based on the conservative assumptions stated by staff, the releases were determined to be in compliance with:
  - 10 CFR Part 20 Appendix B
  - 10 CFR Part 50 Appendix I
  - 10 CFR 20.2002

Acronyms

- CFR – Code of Federal Regulations
- Cs – Cesium
- FDEP – Florida Department of Environmental Protection
- FPL – Florida Power & Light Company
- GDC – General Design Criterion
- H-3 – Tritium
- MCU – Middle Confining Unit

Acronyms

- NOAA – National Oceanographic and Atmospheric Administration
- ORNL – Oak Ridge National Laboratory
- PMH – Probable Maximum Hurricane
- Sr – Strontium
- UFA – Upper Floridan Aquifer
- UIC – Underground Injection Control