PMTurkeyCOLPEm Resource

From: Orthen, Richard [Richard.Orthen@fpl.com]
Sent: Wednesday, October 17, 2012 1:42 PM
To: Williamson, Alicia; Matthews, David; Maher, William; Comar, Manny; Stewart, Scott; McCree, Victor
Subject: FPL Letter L-2012-337 Dated 17OCT12: Response to NRC RAI Letter 120329 (eRAI 6354 Rev. 0) ESRP 2.3.1 - Hydrology
Attachments: L-2012-337 Dated 17OCT12 RAI Ltr 120329 eRAI 6354 2.3.1-1 -3 -4 -5 -7 -9 -10 Response_reduced.pdf

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555-0001

Re: Florida Power & Light Company
Proposed Turkey Point Units 6 and 7
Docket Nos. 52-040 and 52-041
Response to NRC Request for Additional Information Letter 120329
(eRAI 6354 Rev. 0) Related to ESRP Section 2.3.1 - Hydrology

References:

1. NRC Letter to FPL dated April 3, 2012, Environmental Request for Additional Information Letter 120329 Related to ESRP Section 2.3.1, Hydrology, for the Combined License Application Review for Turkey Point Units 6 and 7

2. FPL Letter L-2012-317 to NRC dated August 20, 2012, Revised Schedule for Response to NRC Request for Additional Information Letter 120329 (eRAI 6354 Rev. 0) Related to ESRP Section 2.3.1 – Hydrology

Florida Power & Light Company (FPL) provides, as an attachment to this letter, its response to the Nuclear Regulatory Commission's (NRC) Request for Additional Information (RAI) EIS 2..3.1-1, EIS 2.3.1-3, EIS 2.3.1-4, EIS 2.3.1-5, EIS 2.3.1-7, EIS 2.3.1-9 and EIS 2.3.1-10 provided in Reference 1. The revised schedule for this response was provided by FPL in Reference 2. The attachment identifies changes that will be made in a future revision of the Turkey Point Units 6 and 7 Combined License Application (if applicable).

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If you have any questions, or need additional information, please contact me at 561-691-7490.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on October 17, 2012.

Sincerely,

William Maher
Senior Licensing Director – New Nuclear Projects

WDM/RFO

Attachment 1: FPL Response to NRC RAI EIS 2.3.1-1 (eRAI 6354 Rev. 0)
Attachment 2: FPL Response to NRC RAI EIS 2.3.1-3 (eRAI 6354 Rev. 0)
Attachment 3: FPL Response to NRC RAI EIS 2.3.1-4 (eRAI 6354 Rev. 0)
Attachment 4: FPL Response to NRC RAI EIS 2.3.1-5 (eRAI 6354 Rev. 0)
Attachment 5: FPL Response to NRC RAI EIS 2.3.1-7 (eRAI 6354 Rev. 0)
Attachment 6: FPL Response to NRC RAI EIS 2.3.1-9 (eRAI 6354 Rev. 0)
Attachment 7: FPL Response to NRC RAI EIS 2.3.1-10 (eRAI 6354 Rev. 0)

cc:
PTN 6 & 7 Project Manager, AP1000 Projects Branch 1, USNRC DNRL/NRO
Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, Turkey Point Plant Units 3 & 4

NRC RAI Letter No. 120329 Dated April 3, 2012

SRP Section: EIS 2.3.1 – Hydrology

Question from Environmental Project Branch 1 (RAP1)

NRC RAI Number: EIS 2.3.1-1 (eRAI 6354 Rev. 0)

Preface: The review team acknowledges the value of numerical models in hydrological analyses; however a single model scenario does not generally address all aspects of a hydrological impact assessment. Therefore, the review team considers all available models and performs an independent analysis in order to understand the patterns in the predictions that may be similar and those that might be dissimilar and to determine if such difference would result in a change in the impact assessment. Because of the inherent uncertainty in hydrologic models due to: measurement errors, sampling errors, conceptual model errors, non-uniqueness and the potential misapplication of the numerical model the review team does not make a determination based solely on results of a numerical model. Items 1 through 3 are to ensure that the review team understands how the applicant addressed the three classes of uncertainty mentioned above. Items 4 through 10 are to ensure that the review team understands that the three-dimensional finite-difference groundwater flow model (MODFLOW) was appropriately applied by the applicant.

EIS 2.3.1-1

Measurement uncertainties are addressed in the applicant's Quality Assurance program. However, where the applicant relies on data from sources not subject to the applicant's QA protocol, the review team requests the applicant describe the pedigree of the data and the applicant's assessment of how measurement uncertainties associated with such data effect the outcome of the analysis.

FPL RESPONSE:

The response to the question posed in ER RAI 2.3.1-1 is addressed in two parts: Data Pedigree and Assessment of Measurement Uncertainty.

Part A: Data Pedigree

The Turkey Point Units 6 & 7 numerical groundwater flow model used a variety of input information. Table 1 summarizes the model input components and sources and also indicates the entity providing control of the information quality. The model input components shown are stratigraphic data for model layers, surface water levels, groundwater levels, evapotranspiration, recharge, hydraulic conductivity values, Biscayne Bay bathymetry and surface topography, cooling canal water balance, and water salinity to correct head levels for density. The data sources listed on the table can be subdivided into three categories:

1. COLA Data Sources: Data collected specifically to support characterization and investigation of the Turkey Point Units 6 & 7 site; includes information collected by MACTEC Engineering and Consulting (MACTEC) for Bechtel Power Corporation (Bechtel) to support the Turkey Point Units 6 & 7 Combined Operating License Application (COLA) and a preliminary feasibility study for the Units 6 & 7 site by Enercon Services, Inc. (Enercon)/William Lettis and Associates, Inc. (WLA) for Florida Power & Light Company (FPL). These sources were subject to the applicant's Quality Assurance (QA) protocol as appropriate to the nature and scope of the work being performed.
2. Non-COLA Turkey Point Data Sources: Data collected to support Turkey Point site activities not directly related to nuclear plant licensing, such as water supply development and environmental monitoring; includes the Dames & Moore studies, Golder Associates, Inc., (Golder) investigations, and the HDR Engineering, Inc., (HDR) Turkey Point Aquifer Performance Test. These sources were not subject to the applicant's nuclear quality protocol for Turkey Point Units 6 & 7.
3. External Agency Data: Regional data collected by federal, state, and local agencies such as the U.S. Geological Survey (USGS), National Oceanic and Atmospheric Association (NOAA), Florida Geological Survey (FGS), Florida Fish and Wildlife Commission (FWC), and South Florida Water Management District (SFWMD). These sources are publicly available data, not associated with the applicant's nuclear quality protocol.

1) COLA Data Sources

The first category of data sources includes data collected by MACTEC under their 10 CFR 50 Appendix B-compliant QA/quality control (QC) program. The work performed at the Turkey Point Units 6 & 7 site was specific to the COLA and was subject to the applicant's nuclear quality protocol. MACTEC has extensive experience collecting data associated with nuclear quality data objectives.

This category also includes data collected by Enercon/WLA for the Feasibility Geologic Investigation (FGI), which at the direction of the applicant and in accordance with the applicant's QA protocol as appropriate to the nature and scope of this work, was performed under a commercial QA work plan that was developed to comply with geologic and seismic elements in NRC Regulatory Guide 1.165 and Standard Review Plan sections 2.5.1 to 2.5.3 and geotechnical elements in Regulatory Guide 1.132 and Standard Review Plan section 2.5.4. While these data were collected under a commercial QA plan, Enercon/WLA also have extensive experience collecting data associated with nuclear quality objectives, and the elements of the commercial QA program implemented for the purposes of the FGI were in general accordance with those of the 10 CFR 50 Appendix B-compliant programs and procedures implemented for their COLA-related investigations of other sites.

2) Non-COLA Turkey Point Data Sources

The second category of data includes information collected under the Dames & Moore, HDR, or Golder QA/QC programs, as discussed below.

Dames & Moore

The Dames & Moore data used in the groundwater model are historical data collected in the 1970s for a geohydrologic evaluation related to the construction of site cooling ponds and a Floridan aquifer water supply investigation at the Turkey Point site. These investigations were performed in support of construction of the original site facilities. Dames & Moore was a geosciences and engineering company with extensive experience supporting the design and construction of nuclear power plants. Data collected by Dames & Moore represent historical data associated with the existing, permitted units, including nuclear units 3 and 4, and were covered under the QA/QC programs applicable to these units.

HDR

HDR performed aquifer performance tests at the planned location of the radial collector well (RCW) system at the Turkey Point peninsula. The RCW system is a backup cooling water system for the proposed Turkey Point Units 6 & 7.

The HDR investigation for the *Turkey Point Exploratory Drilling and Aquifer Performance Test Program* (HDR 2009) data collection, evaluation, and report preparation was conducted under HDR's internal QA/QC Program. The HDR QA/QC Program documents establish procedures to perform work. One component of the program requires that all documents, data, and calculations be reviewed by a qualified person prior to submitting the document or calculations to the client as a draft. The reviewer is a qualified person other than the principal author of the document or the principal designer. A draft document is then submitted to the client and the client's designated reviewers, prior to the issuance of the final document.

Prior to performing the aquifer performance test (APT), HDR prepared an APT performance plan. The plan was reviewed internally using HDR's subconsultant ASRUS, LLC, per HDR's QA/QC program and then provided to FPL and other reviewers designated by FPL. The test plan was approved for implementation by FPL and was carried out per the approved plan

The following methods and standards were used in the data collection process:

Survey

The locations of monitoring wells, the pumped well, surface water measurement stand pipes, and top-of-casing elevations for the Turkey Point Exploratory Drilling and Aquifer Performance Test Program were provided by the well drilling contractor, performed by a professional land surveyor licensed in the state of Florida. Elevations are referenced to North American Vertical datum of 1988 (NAVD 88). The surveyor certified that the survey work met the minimum technical standards in Chapter 61G17-6 of the Florida Administrative Code, pursuant to Section 472.027 Florida Statutes, including a horizontal accuracy of this survey work that was performed as a Commercial/High Risk Linear: 1 foot in 10,000 feet closure, and the vertical accuracy of this survey work was performed to closure requirement of 0.05 feet times the square root of the distance in miles. The monitoring wells and the pumping well are between 1100 and 4300 feet from the benchmarks used for the survey. Thus, the horizontal accuracy is between ±0.11 and ±0.43 feet, and the vertical accuracy is between ± 0.02 and ± 0.05 feet.

Sample Collection and Handling

Sample collection and handling followed the Florida Department of Environmental Protection (FDEP) standard operating procedures (SOPs) for field procedures, which are included in DEP-SOP-001/01 (February 1, 2004). The FDEP SOPs comprise minimum requirements under the FDEP Quality Assurance Rule, 62-160, F.A.C. Field procedures for groundwater sampling are included in SOP FS2200. Sample collection, handling, and preservation were in accordance with FDEP SOPs.

Water Level Monitoring

The water level data collected at monitor wells during the test program was collected using In-Situ, Inc., Aqua TROLL 200 and Level TROLL 700 instruments. Each well was equipped with both sensors. The Aqua Troll 200 and Level Troll 700 instruments are factory-calibrated for pressure and temperature. Although the Level Troll 700 instruments were programmed to record water level data on a more frequent basis than the 200 series instruments, the use of two instruments provided the opportunity to compare data from two separate sources. The surface water data were collected at two locations using only the Aqua Troll 200. The accuracy of the Aqua Troll 200 and Level Troll 700 instruments for the pressure sensor is ± 0.1 percent of full scale. For a 15 psig transducer, this would equate to a ± 0.03 foot measurement uncertainty, and for a 30 psig transducer, the uncertainty would be ± 0.07 feet.

Flow Measurement

The water flow measurements collected during the Turkey Point APT were collected using a McCrometer, Inc., Ultra Mag flow meter. This meter has an accuracy of ± 0.5

percent over a flow range of 0 to 15,233 gallons per minute. The well drilling contractor was required to provide a meter with a current calibration verification before the test.

Golder Associates

The Golder Quality Management Plan in force during the preparation of the Golder reports used in model development consists of two documents: a quality assurance manual for Florida operations and a project management implementation guide. The QA manual provides details on how Golder collects, generates, and validates data. This document describes the framework of directives and procedures used to assure that work is performed by trained and qualified personnel and that all technical and client QA requirements are met. The project management implementation guide specifies the detailed procedures for the preparation and review of deliverables and that all investigations, calculations, and other project inputs are documented and expressed in terms that can be verified. All data input and reporting is checked for completeness and accuracy by suitably qualified personnel, and evidence of such checks are documented in the file with signatures or initials and dates. The guide also sets standards for the use of commercially available software and Golder-developed software used to make technical calculations and to conduct numerical modeling.

One of the Golder documents used to develop the model includes a report regarding the existing cooling canals and is a summary of monitoring data collected in 2006 and 2007 and 1991 and 1992 as part of an agreement between FPL and the SFWMD. This agreement contains monitoring procedures and data verification methods required for the data that were presented and summarized in the Golder report. The groundwater data presented in the Golder report were validated against the monitoring plan and the raw data analyses provided by FPL to Golder. The data for 1991 and 1992 and the monitoring procedures and data verification are presented in a Dames & Moore report provided to Golder. These data were validated against the monitoring plan. See Table 1 for the groundwater flow model input parameters and sources.

The second report, Cooling Canal System Modeling Report (Golder 2008), in the *Site Certification Application Turkey Point Uprate Project*, Appendix 10.6, is a modeling analysis of cooling canal system before and after the extended power uprate (EPU) project for Turkey Point Units 3 & 4. The data used in this report were generated under monitoring procedures and data verification under reporting programs to the SFWMD and FDEP as summarized below. In addition, a review of data inputs and outputs and calculations was performed. The reporting program, data, and QA information are summarized below.

The discharge monitoring data used in the model are presented in an official report to the FDEP under its federally approved NPDES program and follows specific QA/QC protocols conducted by FPL. The groundwater quality data used for the report included the QC information for the groundwater data used in the modeling. Golder reviewed this information to validate the quality of the data. Meteorological data used in this report (e.g., precipitation, dew point, wind speed) came from the National Climatic Center and is publically available via NOAA. Salinity data for Biscayne Bay was obtained from the SFWMD DBHYDRO Web site. The QA programs of the SFWMD are publicly available.

The calculations in the report were generated in a spreadsheet and reviewed according to Golder's procedures. The calculation for the pre- and post-EPU project water use diagram were generated in a spreadsheet and reviewed according to Golder's procedures. See Table 1 for the use of this report within the FPL groundwater flow model.

Relevant data from the Dames & Moore, HDR, and Golder reports were reviewed and evaluated for use within the FPL groundwater flow model. Based on a comparison with other data used in the model and engineering judgment, it was determined to include the data in the model.

3) External Agency Data

The data from the third category were from publicly available sources. These regional data were collected by federal, state, and local agencies. The locations of information quality guidelines for NOAA (NOAA 2012b), the USGS (USGS 2012a, Brunett et al. 1997), and the SFWMD (SFWMD 2008) are presented in the references section. Information on the accuracy of the National Elevation Dataset surface topography is provided by the USGS (2012b). The bathymetric dataset accuracy is provided by the NOAA (2012a). The FWRI reference (FWRI 2010) is a seagrass study in Biscayne Bay that represents a qualitative evaluation of bay bottom conditions, consisting of areas designated as continuous seagrass, patchy seagrass, or hard bottom with seagrass. This information is used to interpret bay bottom conditions (sand deposits or limestone).

The data retrieved from internet websites that supports information in the FPL COLA has been utilized to support development of site characteristics that may be used as design inputs. As such, these activities related to data retrieval are not safety-related design, construction, or operation activities and thus, specific QA measures are not required by regulation. Nevertheless, FPL employed quality measures sufficient for the use of this information in the FPL COLA. The measures utilized to authenticate data retrieved from internet websites include formally documenting the website used, review of the resulting application information, and independent examination of the source. The review determines that the data and conclusions reached were accurately represented and supported within the context of the data used.

Part B: Assessment of Measurement Uncertainties

The assessment of measurement uncertainties and their impact on the numerical model includes the following considerations:

Average Conditions

The numerical model is a steady-state model using input for heads, recharge, evaporation, and density correction based on average values of data collected over multiple years rather than discrete measurements. If a dataset was averaged with multiple data points, the impact of a questionable value associated with an individual measurement would be minimized. Thus, individual measurement uncertainties in the source data for large datasets would be minimized and have a negligible influence on model input or output.

Model Development

Hydrostratigraphic layer elevations were developed from geotechnical and geophysical logs from Units 6 & 7, pumping test well clusters in the Turkey Point Unit 6 & 7 plant areas and Turkey Point peninsula, pumping wells from the 1975 Turkey Point plant property Upper Floridan aquifer study, from historical boring and well logs from the Turkey Point plant property, and from well logs in the FGS lithologic database. The model hydrostratigraphic layers were developed by the applicant's hydrogeologists based on review of site-specific hydrogeologic literature and interpretation of the available boring logs. Spreadsheets were developed identifying distinguishable hydrogeologic material intervals. Model layers were then developed from the boring log information and extrapolated into those areas of the model domain with limited subsurface information. Industry standard model QA protocol (such as ASTM 2010) includes evaluation of the model layers to identify any significant deviations or anomalies in layer thicknesses, which may indicate measurement uncertainties in the stratigraphic data. Where this condition is identified, interpolation from neighboring data points and professional judgment is used to adjust the input data accordingly. Identification and incorporation of zones of higher hydraulic conductivity were incorporated into a later revision of the model. These zones of higher hydraulic conductivity are associated with secondary porosity; one zone was placed at the top of the Key Largo Limestone and a second zone was placed within the Fort Thompson Formation. The locations of these zones of higher hydraulic conductivity were reviewed and confirmed with data from more recent EPU project boring logs and other associated information. This process, coupled with the fact that grid-based, numerical flow models are simplified approximations of a natural system to begin with, suggests that the effect on model outcome of measurement uncertainties associated with stratigraphic data are minimal.

Model Calibration

The process of model calibration is one in which model parameters are varied until a reasonable fit of observed conditions is achieved. The primary calibration parameters, hydraulic conductivity distribution and various head-dependent conductance values, used in the model were based on site-specific information as well as appropriate literature values; these parameters were adjusted during model calibration. Calibration involved the matching of modeled heads to observed heads during aquifer pumping tests. These tests included both the Turkey Point Units 6 & 7 tests and the PW-1 area test for the RCWs. Data from the Units 6 & 7 and the PW-1 pumping tests were reviewed, and outliers were removed from the dataset (Final Safety Analysis Report [FSAR] Appendix 2BB and HDR 2009). These water level response measurement outliers were removed based on an evaluation of erroneous values or anomalous trends and were not used in the analysis to determine APT aquifer properties and therefore were not carried through into model development. (Inclusion of the questionable data in the analysis or in development of the FPL groundwater flow model could yield incorrect results or cause instability during model calibration and thus was excluded.) The model calibration process was also used to identify and evaluate data outliers.

Parameter estimation was performed using manual optimization, whereby the parameters were iteratively varied until a satisfactory agreement between three sets of simulated and observed on-site pumping test drawdowns, regional flow directions, and flow magnitudes was achieved. The hydraulic conductivity of all layers was varied within a predefined range that was determined based on a literature evaluation and previously-defined site hydrogeologic parameters. The regional flow direction and pattern determined from historical potentiometric surface maps for the Biscayne aquifer were compared with the simulated groundwater level contours from the model and were found to be in general agreement. The interaction of groundwater with the surface water comprising the cooling canal system was assessed by comparing model results against estimates obtained from an independent water balance model on a steady-state basis. Furthermore, a validation of the model was performed by simulating a fourth onsite pumping test that indicated a good match between observed and modeled drawdown values. Thus, the impact of uncertainty in initial hydraulic conductivities and conductance values has been mitigated by model calibration.

Sensitivity Analyses

Sensitivity analyses were also simulated to determine bounding cases for various parameters. Sensitivity analyses were performed to evaluate the impact of uncertainty in the anisotropy ratio in the top three layers of the model beneath Biscayne Bay. The results of these sensitivity cases are shown in Table 2CC-211 and Figure 2CC-253 (FSAR Appendix 2CC). For the sensitivity cases for the anisotropy ratio, Table 2CC-211 and Figure 2CC-253 show the most variation from the base case as compared to the other sensitivity simulations (Figures 2CC-252 and -254). The variation between the percentage of water from Biscayne Bay for the base case and anisotropy ratio sensitivity simulations, however, is less than 5 percent (FSAR Table 2CC-211). Based on these results, the model appears to show little sensitivity to changes in the anisotropy ratio.

Sensitivity analyses were performed to evaluate the impact of uncertainty in the horizontal hydraulic conductivity of the Key Largo Limestone. The sensitivity cases for changing the hydraulic conductivity in the Key Largo Limestone indicate that the model is relatively insensitive to this change (Table 2CC-211 and Figure 2CC-254 [FSAR Appendix 2CC]).

The impact of variability of surface water levels was examined by performing sensitivity analyses on water levels in Biscayne Bay and the canals. The sensitivity cases were for the seasonal high and low levels in Biscayne Bay. Water levels in the cooling canals, L-31E Canal, Card Sound Canal, and Model Land Canal were adjusted based on the water level in Biscayne Bay. The sensitivity analyses were performed to assess changes in RCW water capture in response to higher- or lower-than-average surface water levels. The results of the sensitivity analyses indicate that RCW capture is relatively insensitive to changes in surface water levels.

Additional analyses were performed to evaluate uncertainties in post-construction conditions at the Turkey Point Units 6 & 7 site. These analyses include variation of recharge rates in the plant area, simulation of Makeup Water Reservoir north wall failure, and simulation of the impact of long-term sea level rise (FSAR Appendix 2CC, Section 6.0). Simulating bounding conditions for these parameters mitigates the impact of their related uncertainties.

The results of the sensitivity analyses described above show that while there is slight uncertainty related to anisotropy ratio, Key Largo Limestone horizontal hydraulic conductivity, surface water levels, and post-construction conditions, the impacts of these uncertainties on the model results are insignificant.

Transducer Uncertainty

An example of the impact of level measurement uncertainty on the model results can be seen by comparing the calibration statistics from the PW-1 aquifer pumping test (FSAR Appendix 2CC, Table 2CC-208) with the accuracy of the transducers used to measure the actual head. As stated previously, the transducers have a ± 0.1 percent accuracy of full scale. For a 15 psig transducer, this would equate to a ± 0.03 foot measurement uncertainty. An additional source of measurement uncertainty associated with the pumping test water level data is the correction for tidal influences. This component of uncertainty is minimized by using a local tidal reference to correct the data and using appropriate industry standard methods for correction of the data (FSAR Appendix 2BB and HDR 2009).

Comparison with the head residuals (Ri) shown in Table 2CC-208 indicates that the model head residual is generally greater than or equal to the measurement uncertainty, thus mitigating the impact of the uncertainty. The groundwater flow model is calibrated to drawdown. Thus, if an initial head reading has an uncertainty of ± 0.1 percent, all subsequent measurements have the same uncertainty, and therefore the drawdown measurement remains unchanged. Because the FPL groundwater flow model is calibrated to drawdown rather than measured head, associated measurement uncertainties are expected to have no impact on the model outcome.

Summary

All data were collected under QA/QC programs administered by the respective controlling entity, as summarized in Table 1 and discussed in this RAI response. The impacts of measurement uncertainties were mitigated by using average values in the steady-state model, adjusting uncertain values during calibration, and performing sensitivity analyses. Based on this assessment, measurement uncertainties are expected to have minimal impact on the results of the numerical model.

Table 1
Groundwater Flow Model Input Parameters and Sources

Model Component	Source (Type)	Information Quality Entity	Use
Stratigraphic data for model Layering	Site Geotechnical Investigation Report (C) (FPL 2011b)	MACTEC	Turkey Point Units 6 & 7 stratigraphy, Location of Higher Flow Zones
	Final Data Report, Aquifer Pumping Test (C) (MACTEC 2009)	MACTEC	Turkey Point Units 6 & 7 Location of Higher Flow Zones
	Geohydrologic Conditions Related to the Construction of Cooling Ponds (NC) (Dames & Moore 1971)	Dames & Moore	Turkey Point Plant site stratigraphy, Location of Higher Flow Zones
	Floridan Aquifer Water Supply Investigation (NC) (Dames & Moore 1975)	Dames & Moore	Turkey Point Plant site stratigraphy, Location of Higher Flow Zones
	Technical Report NPS/NRWRD/NRTR-2006/356 (EA) (Reich et al. 2006)	USGS	Biscayne Bay stratigraphy
	FGSLOGS FGS Lithological Database (EA) (Florida Geological Survey 2008)	FGS	Off site stratigraphy
	Feasibility Geological Investigation (C) (Enercon Services, Inc., and WLA 2006) (Non-public)	Enercon/WLA	Turkey Point Units 6 & 7 stratigraphy, Location of Higher Flow Zones
	Turkey Point Aquifer Pumping Test (NC) (HDR 2009)	HDR	Stratigraphy at Turkey Point peninsula, Location of Higher Flow Zones
	Marine Resources Geographic Information System (EA) (FWRI 2010)	FWC	Biscayne Bay sandy and hard bottom areas
Surface Water Levels	Virginia Key - Station 8723214 (EA) (NOAA 2010a)	NOAA	Biscayne Bay Water Level
	Cooling Canal Data Analysis Report (NC) (Golder Associates, Inc., 2008)	Golder Associates	Interceptor Ditch Levels
	Turkey Point Aquifer Pumping Test (NC) (HDR 2009)	HDR	Head drop across Cooling Canal System

Table 1
Groundwater Flow Model Input Parameters and Sources

Model Component	Source (Type)	Information Quality Entity	Use
Surface Water Levels	S20_H, S20_T, S20F_H, S20F_T - DBHYDRO database data (EA) (SFWMD 2010a)	SFWMD	External canal L-31E Levels
Groundwater Levels	Geohydrologic Conditions Related to the Construction of Cooling Ponds (NC) (Dames & Moore 1971)	Dames & Moore	Biscayne Aquifer Water Level Maps for calibration soft targets
	Water-Resources Investigation Report 4251 (EA) (Langevin 2001)	USGS	Biscayne Aquifer Water Level Maps for calibration soft targets
	Aquifer Pumping Test Results (C) (FPL 2011a)	MACTEC	Powerblock Aquifer Pumping Test - for calibration targets/validation water levels
	Long-Term Groundwater Data Collection Program (C) (MACTEC 2009) (Non-public)	MACTEC	Turkey Point Units 6 & 7 groundwater level measurements
	Turkey Point Aquifer Pumping Test (NC) (HDR 2009)	HDR	Pumping test at Turkey Point peninsula for calibration targets
	Groundwater level measurements - DBHYDRO database (EA) (SFWMD 2010b and 2010c)	SFWMD	General Head and River boundaries
Evapotranspiration	Water-Resources Investigation Report 4251 (EA) (Langevin 2001)	USGS	Maximum evapotranspiration rate and extinction depth
Recharge	S20F precipitation data - DBHYDRO database (EA) (SFWMD 2010d)	SFWMD	Annual rainfall data
Hydraulic Conductivity Values*	Aquifer Pumping Test Results and Interpretation (C) (FPL 2011a)	MACTEC	Onshore Muck, Miami Limestone, Key Largo Limestone, Freshwater Limestone, Fort Thompson, Tamiami Formation
	Turkey Point Aquifer Pumping Test (NC) (HDR 2009)	HDR	Miami Limestone, Key Largo Limestone

Table 1
Groundwater Flow Model Input Parameters and Sources

Model Component	Source (Type)	Information Quality Entity	Use
Hydraulic Conductivity Values*	SFWMD Technical Publication HESM-1 (EA) (Krupa and Mullen 2005)	SFWMD	Onshore Muck, Miami Limestone, Freshwater Limestone
	Water-Resources Investigations Report 01-4074 (EA) (Sonenshein 2001)	USGS	Onshore Muck, Miami Limestone, Key Largo Limestone, Freshwater Limestone, Tamiami Formation
	Water-Resources Investigations Report 4251 (EA) (Langevin 2001)	USGS	Muck
	Water-Supply Paper 2458 (EA) (Merritt 1996)	USGS	Miami Limestone, Fort Thompson Formation
	Water-Resources Investigations Report 96-4118 (EA) (Swain et al. 1996)	USGS	Miami Limestone, Fort Thompson Formation, Tamiami Formation
	Water-Resources Investigations Report 90-1408 (EA) (Fish and Stewart 1991)	USGS	Key Largo Limestone, Tamiami Formation
	Geohydrologic Conditions Related to the Construction of Cooling Ponds (NC) (Dames & Moore 1971)	Dames & Moore	Onshore Muck
	Water-Resources Investigations Report 03-4208 Scientific Investigations Report 2005-5235 (EA) (Cunningham et al. 2004 and Cunningham et al. 2006)	USGS	Range for anisotropy ratio
Biscayne Bay Bathymetry and Surface Topography	Office of Coast Survey (OCS) - Harbor Sounding (EA) (NOAA 2010b)	NOAA	Bathymetry of Biscayne Bay
	National Elevation Dataset (NED) (EA) (USGS 2010)	USGS	Surface topography

Table 1
Groundwater Flow Model Input Parameters and Sources

Model Component	Source (Type)	Information Quality Entity	Use
Cooling Canal Water Balance	Cooling Canal System Modeling Report (NC) (Golder Associates, Inc., 2008)	Golder Associates	Model calibration soft target
Water Salinity to correct head levels for density	Cooling Canal Data Analysis Report (NC) (Golder Associates, Inc., 2008) (Non-public)	Golder Associates	Groundwater salinity in vicinity of cooling canals
	Cooling Canal System Modeling Report (NC) (Golder Associates, Inc., 2008)	Golder Associates	Cooling Canal Salinity
	Water-Resources Investigations Report 4251 (EA) (Langevin 2001)	USGS	Groundwater salinity west and north of the site, Extent of saltwater intrusion
	Coastal Water Quality Network (EA) (Boyer and Briceno 2008)	SFWMD	Biscayne Bay salinity
	Station 123 in Biscayne Bay (EA) (Southeast Environmental Research Center 2008)	SFWMD	Biscayne Bay Salinity

* Starting values, adjusted during calibration.
COLA = Combined Operating License Application; USGS = U.S. Geological Survey; FGS = Florida Geological Survey; WLA = William Lettis and Associates, Inc.;
NOAA = National Oceanic and Atmospheric Administration; SFWMD = South Florida Water Management District
Source Type: (C) Units 6 & 7 COLA Data Source; (NC) Non Units 6 & 7 COLA Turkey Point Data Source; (EA) External Agency Data

This response is PLANT SPECIFIC.

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ASSOCIATED COLA REVISIONS:

No COLA changes have been identified as a result of this response.

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. 120329 Dated April 3, 2012

SRP Section: EIS 2.3.1 – Hydrology

Question from Environmental Project Branch 1 (RAP1)

NRC RAI Number: EIS 2.3.1-3 (eRAI 6354 Rev. 0)

Preface: The review team acknowledges the value of numerical models in hydrological analyses; however a single model scenario does not generally address all aspects of a hydrological impact assessment. Therefore, the review team considers all available models and performs an independent analysis in order to understand the patterns in the predictions that may be similar and those that might be dissimilar and to determine if such difference would result in a change in the impact assessment. Because of the inherent uncertainty in hydrologic models due to: measurement errors, sampling errors, conceptual model errors, non-uniqueness and the potential misapplication of the numerical model the review team does not make a determination based solely on results of a numerical model. Items 1 through 3 are to ensure that the review team understands how the applicant addressed the three classes of uncertainty mentioned above. Items 4 through 10 are to ensure that the review team understands that the three-dimensional finite-difference groundwater flow model (MODFLOW) was appropriately applied by the applicant.

EIS 2.3.1-3

Conceptual model errors are associated with the assumptions of the model. Conceptual model errors are the most difficult to address. For instance, models considering variable density fluid flow versus homogeneous fluid flow, homogeneity of aquifer media, grid resolution, boundary conditions, etc. The applicant has elected to provide model results for a single realization of a single conceptual model. Therefore, the review team requests that the applicant discuss how conceptual model errors are addressed with a single realization, and how conclusions of the analysis might vary under alternative conceptual model conditions. The applicant may want to discuss other models for the site developed by other agencies and how their results support the applicant's assessment.

FPL RESPONSE:

The model presented in FSAR Appendix 2CC represents the results of an iterative process of conceptual and numerical model development wherein the model has evolved based on the collection and interpretation of new data and review of the model by subject matter experts during the Site Certification Application (SCA) process. Thus, while a single conceptual model and a single realization are presented in the FSAR, it should be recognized that other conceptual models have been considered during model development. Evidence that supports the use of the current conceptual model is provided below. The evidence includes a description of how the conceptual model has evolved over time and a comparison to existing groundwater models that have been developed for the region.

<u>Conceptual Model Development</u>

The FPL groundwater model was developed based on the conceptual knowledge obtained from site-specific tests (FSAR Appendix 2CC, Subsection 3.0) and also knowledge obtained from published regional and subregional groundwater modeling studies by the U.S. Geological Survey (USGS) and the South Florida Water Management District (SFWMD). The model was calibrated and validated to steady-state pumping drawdown tests, and subjected to sensitivity analyses.

The FPL groundwater model underwent multiple conceptual model revisions as the model evolved from that presented in Rev. 0 (Bechtel Power Corporation 2009) to that presented in Rev. 1 (Bechtel Power Corporation 2011). These revisions were prompted by the SCA completeness review as well as the applicant's ongoing review and interpretation of site data. A summary of the conceptual changes to the models is provided below.

Conceptual Model Element	Rev. 0 Groundwater Model Report	Rev. 1 Groundwater Model Report
Hydrostratigraphy	Key Largo Limestone and Fort Thompson Formation vertically homogeneous across the model domain.	Key Largo Limestone and Fort Thompson Formation vertically heterogeneous. Incorporation of two zones of higher hydraulic conductivity to represent secondary porosity; one at the top of the Key Largo Formation and one within the Fort Thompson Formation.
Hydrostratigraphy	Muck layer continuous over inland and offshore portions of the model and horizontally homogeneous.	Muck layer present over inland portion of the model. Offshore portion of the model revised to include sediment and rock present on the floor of Biscayne Bay, spatially distributed based on presence or absence of seagrass.
Hydrostratigraphy	Key Largo Limestone horizontally homogeneous.	Key Largo Limestone horizontally heterogeneous. Incorporation of two different zones of horizontal hydraulic conductivity based on evaluation of pumping tests performed at Units 6 & 7 and at Turkey Point peninsula.
Boundary Conditions	Zero recharge over gross plant area.	Recharge spatially distributed over Units 6 & 7 plant area based on detailed plant layout (post-construction distribution based on locations of buildings, roads, and ground cover).
Boundary Conditions	Biscayne Bay represented as constant head boundary condition.	Biscayne Bay represented as general head boundary condition to more accurately account for interaction between groundwater and surface water.
Boundary Conditions	Flow to radial collector well laterals distributed uniformly over their length.	Flow to radial collector well laterals distributed non-uniformly over their length to account for non-uniform flow resistance.

The FPL groundwater flow model was recently revised (Rev. 2 groundwater model report) (Bechtel Power Corporation 2012) as the result of minor adjustments to the model input and output files. The Rev. 2 groundwater model report presents the same conceptual model as that presented in the Rev. 1 groundwater model report and the updated model retains the calibration and validation results presented in the Rev. 1 groundwater model report. Numerical comparisons of the affected Rev. 1 and Rev. 2 groundwater model report results indicate that the differences are minor as discussed in Section 3.1.1.2 of the Rev. 2 groundwater model report (Bechtel Power Corporation 2012), and the Rev. 1 groundwater model report conclusions are unchanged.

The significant differences of the conceptual models between the Rev. 0 and Rev. 2 groundwater model reports are the incorporation of the two higher flow zones, representation of the Key Largo Limestone as two different zones of horizontal hydraulic conductivity, and changes to the representation of the Biscayne Bay bottom sediments. In addition to the conceptual model changes, other changes and updates were performed in both the Rev. 1 and Rev. 2 groundwater model reports to improve the reliability of the numerical groundwater flow model.

The comparisons of the groundwater budget between that presented in the Rev. 0 and Rev. 2 groundwater model reports did not show any appreciable differences in the origin of water supplying the radial collector wells. The Rev. 0 groundwater model report predicts that approximately 97 percent of the flow to be originating from Biscayne Bay and approximately 3 percent originating from inland. Comparable values for the Rev. 2 groundwater model report are approximately 98 percent of the source water to be originating from Biscayne Bay and approximately 2 percent of the water originating from inland for the base case model simulation. As can be seen from these results, the differences in the underlying conceptual models lead to very small differences in the relative amounts of water supplied from Biscayne Bay versus that supplied from inland sources.

It should be noted that the method for calculating the origin of flow to the RCW differed between the Rev. 0 groundwater model report and that used for both the Rev. 1 and Rev. 2 groundwater model reports. For the Rev. 0 groundwater model report, a control volume was defined around the RCW that was bounded to the north and east by the model perimeter with Biscayne Bay, to the west by the shoreline, and the south by a surface water divide for the RCW. The surface water divide was determined by particle tracking and was used to identify the location within Biscayne Bay where water would ultimately discharge to the RCW. The water supplying the RCWs was then determined from the mass balance for the control volume. For the Rev. 1 and Rev. 2 groundwater model reports, forward particle tracking was used in which particles were placed in each boundary condition cell and the operation of the RCW then simulated. The starting locations for those particles that ultimately discharge to the RCW and their associated boundary fluxes were summed to determine the relative contributions to the RCW. The different methods used to determine the origin of water to the RCW are considered to have negligible impact on determining the source of water percentages.

Sensitivity Analysis

To quantify the uncertainty associated with the origin of the source water for the RCW pumping in the Upper Higher Flow Zone, a series of sensitivity analyses with alternative model configurations were undertaken. The sensitivity analyses are discussed in FSAR Appendix 2CC, Subsection 5.2.3, and are as follows:

- Seasonal high water of Biscayne Bay of 0.09 feet NAVD 88
- Seasonal low water of Biscayne Bay of –1.40 feet NAVD 88
- Offshore (i.e., in Biscayne Bay) vertical hydraulic conductivity of the first three layers of the model *doubled* from the base case (the calibrated model)
- Offshore vertical hydraulic conductivity of the first three layers of the model *halved* from the base case (the calibrated model)
- Key Largo Limestone horizontal hydraulic conductivity is set at 5.9 centimeters per second (cm/sec) across the model
- Key Largo Limestone horizontal hydraulic conductivity is set at 10 cm/sec across the model
- RCW pumping from the Key Largo Limestone

The results of the sensitivity analyses are presented in FSAR Appendix 2CC, Table 2CC-211, and depict that even with alternative model configurations, the predicted source of the water for the RCW from Biscayne Bay ranges between approximately 95 percent and 99 percent, with the remaining source of water from inland areas. Similarly, when comparing the sensitivity of drawdown due to RCW pumping for different model configurations, the 0.1 foot drawdown contour (the farthest drawdown contour) in the top layer for most of the alternative model configurations was east of the CCS as shown in Figures 2CC-246, 2CC-247, 2CC-252, 2CC-253, and 2CC-254 of FSAR Appendix 2CC.

The RCW water percentage origins as shown in Table 11 of Bechtel Power Corporation (2012) are slightly different than that shown in FSAR Appendix 2CC, Table 2CC-211, Revision 3 and are based on updated groundwater modeling results to be presented in a future COLA revision.

Comparison to Existing Groundwater Models

The FPL groundwater model was compared against existing models published by Langevin (2001), Giddings et al. (2006), and Hughes et al. (2010), which are within the vicinity of Units 6 & 7 and Turkey Point peninsula. The purpose of the comparison of the models is to provide a measure of confidence as to how the FPL groundwater model conceptually compares to the other three models. Although all the models differ from one another due to the individual models' objectives and numerical structure, a comparison to the FPL groundwater model is provided.

The following model attributes were considered in this comparison: 1) model objective; 2) model domain and resolution; 3) density dependence; 4) hydrostratigraphy; 5) boundary conditions; 6) calibration and validation; and 7) flow patterns. This comparison was performed based on published descriptions and not on the quantitative evaluation of the electronic files of these models and, thus the comparisons in this response are qualitative in nature. Table 1 summarizes the results. Additional discussion is provided below.

1) *Model objective*

The objective of the Langevin (2001) model is to estimate subregional groundwater discharge to the Biscayne Bay. As a result, this model does not simulate the Cooling Canal System (CCS). The model developed by Hughes et al. (2010) simulates the CCS; however, it does not represent the spatial heterogeneity in three dimensions, as it is a two-dimensional cross-section model. The model developed by Giddings et al. (2006), referred to as the LECsR model, does not simulate the CCS. The main objective of this model is to evaluate general water management issues of the Biscayne aquifer in the subregional scale. The objectives of the FPL groundwater model are to estimate water quantities for excavation dewatering and to evaluate the influence of the radial collector wells; the CCS is represented in detail.

2) *Model domain and resolution*

The size of the model domain and resolution of the computational grid is determined by the modeling objectives. Because the objectives of the four models discussed here differ, the model domains and resolution of the computational grid differ as well. The Langevin (2001) model encompasses an area of approximately 2440 square miles and has the coarsest grid, with horizontal grid dimensions of 3280 ft by 3280 ft. The Giddings et al. (2006) model encompasses an area of approximately 7500 square miles with horizontal grid dimensions of 704 ft by 704 ft. The Hughes et al. (2010) model is a two-dimensional cross-sectional model and therefore cannot be compared directly with the other three-dimensional models. The cross-section represented in the model is approximately 28.6 miles in length with column widths varying from 32.8 ft in the CCS area to 656 ft in the western portion of the cross section. The FPL groundwater model encompasses an area of approximately 63 square miles; in order to represent Unit 6 & 7 site features, the horizontal grid is highly resolved (3 ft by 3 ft at the plant area and 25 ft by 25 ft at Turkey Point).

3) *Density dependence*

The Giddings et al. (2006) model and the FPL groundwater model assume constant density, whereas the Langevin (2001) and Hughes et al. (2010) models assume variable density.

4) *Hydrostratigraphy*

Each of the four models represents the hydrostratigraphic units that comprise the surficial aquifer. The Langevin (2001), Giddings et al. (2006), and FPL groundwater models represent the formations as identified in the literature (e.g., Miami limestone, Key Largo limestone, Fort Thompson formation, and Tamiami formation). The Hughes et al. (2010) model does not represent these formations explicitly, but instead generically represents the hydrostratigraphy as an upper permeable unit, low permeable unit, and lower permeable unit.

5) *Boundary conditions*

To simulate groundwater/surface water interactions between major canals and the Biscayne aquifer, the Langevin (2001), Giddings et al. (2006), and FPL groundwater models assigned the cells representing canals as river boundaries, whereas the Hughes et al. (2010) model assigned these cells as general head boundaries. Biscayne Bay was simulated as a constant head boundary in the Langevin (2001) and Hughes et al. (2010) models. In the Giddings et al. (2006) model, Biscayne Bay was not represented explicitly; however, the cells representing the perimeter of the coast were assigned as general head boundaries. In the FPL groundwater model, the cells underlying Biscayne Bay were simulated as general head boundaries. Both recharge and evapotranspiration was represented in the Langevin (2001), Giddings et al. (2006), and FPL groundwater models; whereas in Hughes et al. (2010), no recharge and evapotranspiration was represented. In general, the overall boundary conditions for the Langevin (2001), Giddings et al. (2006), and FPL groundwater models were similar; however, the boundary conditions used in Hughes et al. (2010) were in most cases different from the other three models.

6) *Calibration and validation*

The Langevin (2001) model was calibrated using head and canal baseflow data, and the general position of the saltwater interface on a monthly average basis for the period 1989-1998; however, no validation was conducted. The Giddings et al. (2006) model was calibrated using daily head data for the January 1986 through September of 1999 period, and validated against head data for the September 1999 through December 2000 period. The Hughes et al. (2010) model was not calibrated and validated. The FPL groundwater model was calibrated against steady-state drawdown data from three pumping tests and validated against one pumping test.

7) *Flow patterns*

Because the modeling objectives and grid resolutions of each groundwater model differ, only a qualitative comparison of groundwater flow patterns is possible. A comparison of the results produced by the FPL, Langevin (2001), and Giddings et al. (2006) models indicates that they are consistent in terms of the overall regional flow patterns. The local flow patterns in the vicinity of the CCS, due to the exchange of water between the canals and the groundwater, are represented in the FPL groundwater model, whereas the less-resolved, regional and subregional models described by Giddings et al. (2006) and Langevin (2001) do not represent this detail. Direct comparison of model results to the Hughes et al. (2010) model is not possible, as it is a two-dimensional cross-section model; however, the flow patterns inferred from the solute transport simulations indicate consistency with the FPL groundwater model.

<u>Agency Models Developed for the Site</u>

As part of the coordinated state and Federal permitting and licensing process for the Units 6 & 7 project, FPL works closely with agencies to share project information. Specifically, six agencies have participated in discussions related to groundwater models for the site. These agencies are: National Park Service (NPS), SFWMD, USGS, Miami Dade County (MDC), US Army Corps of Engineers (ACOE), and Florida Department of Environmental Protection

(FDEP). FPL recently requested these agencies to identify to FPL new or emerging groundwater and surface water models pertinent to the Units 6 & 7 site. FPL is reviewing responses received to identify any actions FPL believes would be relevant to FPL's assessment of impacts to the site. A summary of the agency responses received and relevant actions will be provided to the NRC in a supplement to this RAI response. As expressed in FPL letter L-2012-256 dated June 25, 2012, FPL remains interested in examining the results of any independent groundwater or surface water model(s) that the NRC or its contractors have developed related to the Units 6 & 7 site.

Summary

The groundwater model represents FPL's current conceptual understanding of the groundwater system at the Turkey Point Units 6 & 7 site. This understanding has evolved over time. Numerical results generated with different conceptual models yield very similar results in terms of the origins of the water supplying the radial collector wells, and the conclusions of the analysis are seen to be similar under alternative conceptual model conditions. In addition, a comparison of the current conceptual model to existing models developed by the USGS (Langevin 2001 and Hughes et al. 2010) and SFWMD (Giddings et al. 2006) indicates that the models are similar in terms of hydrostratigraphy and boundary conditions, and that the flow patterns produced by the models are generally similar. These similarities serve as additional evidence that the conceptual model is appropriate for the site.

This response is PLANT SPECIFIC.

References:

1. Bechtel Power Corporation, 2009. *Groundwater Model Development and Analysis: Units 6 & 7 Dewatering and Radial Collector Well Simulations*, Rev. 0. http://publicfiles.dep.state.fl.us/Siting/Outgoing/FPL_Turkey_Point/Units_6_7/Completeness/Plant_Associated_Facilities/2nd_round_Completeness/FPL_Response_Part_A_Information/Attached%20Reports/Bechtel%20Groundwater%20Report/Groundwater%20Modeling%20Report.pdf (Access date: 6/12/2012)

2. Bechtel Power Corporation, 2011. *Groundwater Model Development and Analysis: Units 6 & 7 Dewatering and Radial Collector Well Simulations*, Rev. 1. http://publicfiles.dep.state.fl.us/Siting/Outgoing/FPL_Turkey_Point/Units_6_7/Completeness/Plant_Associated_Facilities/4th_Round_Completeness/FPL%20Response_4thCompleteness/Groundwater%20Modeling%20Report,%20Rev.%201,%202011/Groundwater_Model_Report-Revision_1_022311_Final.pdf (Access date: 6/12/2012)

3. Bechtel Power Corporation, 2012. *Groundwater Model Development and Analysis: Units 6 & 7 Dewatering and Radial Collector Well Simulations*, Rev. 2.

4. Florida Power and Light Company (FPL), 2009. Turkey Point Exploratory Drilling and Aquifer Performance Test Program. August 19, 2009. http://publicfiles.dep.state.fl.us/Siting/Outgoing/FPL_Turkey_Point/Units_6_7/Completeness/Plant_Associated_Facilities/1st_round_Completeness/FPL_Response_1st_Incompleteness/Attached%20Reports/HDR/Aquifer%20Performance%20Test_August-2009/Report_HDR%20APT_FPL_081909.pdf (Access date: 6/20/2012)

5. Giddings, Jefferson, Kuebler, Laura, Restrepo, Jorge, Rodberg, Kevin, Montoya, Angela, and Radin, Hope, 2006. *Lower East Coast subRegional (LECsR) MODFLOW Model Documentation* (DRAFT), South Florida Water Management District, West Palm Beach, Florida. http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/lec_sr_draft_documentation.pdf (Access date: 6/12/2012)

6. Hughes, Joseph, Langevin, Christian, and Brakefield-Goswami, Linzy, 2010. Effect of Hypersaline Cooling Canals on Aquifer Salinization, *Hydrogeology Journal*, Vol. 18:25–38.

7. Langevin, Christian, 2001. *Simulation of Ground-Water Discharge to Biscayne Bay, Southeastern Florida*. U.S. Geological Survey, Water Resources Investigations Report 00-4251. http://fl.water.usgs.gov/PDF_files/wri00_4251_langevin.pdf (Access date: 6/12/2012)

Table 1: Comparison of FPL Model With Other Agencies Models

Groundwater Model	Objective(s)	Agency or Organization	Density Dependence	Grid size and Model Domain Area (Horizontal Direction) 1 m = 3.28 ft	Hydrostratigraphy	Boundary Conditions	Calibration and Validation
Langevin (2001)[1] (Three-dimensional subregional model)	Quantify the rates and patterns of submarine groundwater discharge to Biscayne Bay.	USGS	Variable Density	Grid Size = 3280 ft x 3280 ft Model Domain Area = Approximately 6.8E+10 square feet or 2439.2 square miles The model domain area was not discretely reported in the report; however, it was calculated based on 89 rows and 71 columns with uniform grid size of 3280 ft.	Total of 11 layers: • Layer 1: inactive • Layer 2: peat and marl layer in the northeastern and southern parts of the model designated as Zone 2; in the central part of the model, it was designated as Zone 3 and the rest of the model domain was designated as Zone 1 • Layers 3 to 11: Miami Limestone, Fort Thompson Formation, and the permeable zones of the Tamiami Formation	Groundwater/surface-water interactions between major canals and the Biscayne aquifer were simulated using the River package of MODFLOW for the major canals of South Florida. However, the CCSs were not simulated discretely. Biscayne Bay was simulated with constant head boundary conditions along with the perimeter of the model domain offshore for all layers. Hydrologic effects of surface water in the Everglades National Park and costal lowlands were simulated using the General Head Boundary (GHB) package of MODFLOW. The Recharge and Evapotranspiration package of MODFLOW was applied to determine the net recharge to the model.	Calibration Yes Validation No
LECsR, Giddings et al. (2006)[2] (Three-dimensional model)	Simulate groundwater flow of the Surficial Aquifer System (SAS), wetland hydroperiods, water deliveries,	SFWMD	Constant Density	Grid Size = 704 ft x 704 ft Model Domain Area = Approximately 7500 square miles	Total of 3 layers: • Layer 1: Holocene + Q5+Q4 • Layer 2: Q3 + Q2 + Q1 • Layer 3: T2 + T1 Holocene = Lake Flirt Marl, undifferentiated soil and sand Q5 = Pamlico Sand Q4 = Miami Limestone Q3 = Fort Thompson Formation	The LECsR model used several MODFLOW packages; some standard and some nonstandard (i.e., developed by the SFWMD). The major canals were simulated using the River package. In situations where only the canals are draining the aquifer, the Drain	Calibration Yes Validation Yes

Table 1: Comparison of FPL Model With Other Agencies Models

Groundwater Model	Objective(s)	Agency or Organization	Density Dependence	Grid size and Model Domain Area (Horizontal Direction) 1 m = 3.28 ft	Hydrostratigraphy	Boundary Conditions	Calibration and Validation
	canal-aquifer interaction, and general management of the water resources for the lower east coast of Florida.				Q2 = Anastasia Formation Q1 = Key Largo Limestone T2 = Pinecrest Sand Member T2 = Ochopee Limestone Member Layer 1 includes the Holocene and Pleistocene series of marl, undifferentiated soil and sand, Pamlico sand, and Miami limestone. Layer 2 includes the lower permeable sediments within the upper SAS and the higher permeable limestone of the Biscayne aquifer. This includes the Fort Thompson, Anastasia, and the Key Largo formation. Layer 3 includes the Gray Limestone/Lower Tamiami Formation	package was also used. The CCSs were not discretely simulated, except for the perimeter canals. The GHB package was used to simulate the perimeter of the model cells and also to depict equivalent freshwater heads at the coast to determine interactions of the inland aquifer with the Biscayne Bay. The Biscayne Bay was not discretely simulated. The Recharge and Evapotranspiration package was used to simulate recharge to the aquifer.	
Hughes et al. (2010)[3] (Two-dimensional cross-section model)	Determine the sensitivity of hydraulic conductivity on the combined effect of salinity and temperature on density-driven convection for the CCS.	USGS	Variable Density	Grid Size = Discretized into 718 columns horizontally and 30 layers vertically. Column widths varied from 32.8 ft in the CCS area to 656 ft in the western portion. Model Domain = a cross-section model approximately 46 km or 150880 ft or 28.6 miles in length.	Total of 30 layers, each layer is 3.28 ft thick : • Layers 1 to 8: Upper permeable unit • Layers 9 to 11: Low permeability unit • Layers 12 to 19: Lower permeable unit • Layers 20 to 22: Low permeability unit • Layers 23 to 30: Lower permeable unit	A freshwater constant head boundary was assigned to the westernmost column. A head-dependent flux boundary condition (GHB) was assigned for the L31-E canal, interceptor canal, and the CCSs. The Biscayne Bay was simulated as a constant head seawater boundary condition. No recharge or evapotranspiration packages were used to simulate surface recharge or discharge; instead, only regional flow from	Calibration No Validation No

Table 1: Comparison of FPL Model With Other Agencies Models

Groundwater Model	Objective(s)	Agency or Organization	Density Dependence	Grid size and Model Domain Area (Horizontal Direction) 1 m = 3.28 ft	Hydrostratigraphy	Boundary Conditions	Calibration and Validation
						the western boundary was used to simulate flow in the aquifer.	
(FSAR Appendix 2CC, Subsection 3.3) [4] (Three-dimensional model)	Simulate groundwater flow in the Biscayne aquifer to evaluate construction and post-construction activities related to the operation of two new nuclear reactors.	FPL	Constant Density	Grid Size = Varied from 3 ft x 3 ft within the plant area for Units 6 & 7 to 100 ft x 100 ft at the model perimeter. At Turkey Point, the grid spacing was 25 ft x 25 ft. Model Domain Area = Approximately 1.76E+09 square feet or 63 square miles	Total of 14 layers. • Layer 1: onshore organic soils (muck and marl), offshore sand/sediment and Miami Limestone. • Layers 2 to 3: Miami Limestone • Layer 4: Upper Higher Flow Zone • Layers 5 to 6: Key Largo Limestone • Layer 7: Freshwater Limestone • Layers 8 to 9: Fort Thompson Formation • Layer 10: Lower Higher Flow Zone • Layers 11 to 13: Fort Thompson Formation Layer 14: Tamiami Formation	For the calibrated groundwater model, several types of boundary conditions were applied to the model. River package boundary conditions were applied to determine the groundwater/surface water interactions for the CCSs, L-31E canal, Card Sound canal, C-107 canal, and the Florida City canal. The GHB package was assigned to the perimeter of all the model layers and model layer 1 of the Biscayne Bay. Recharge and Evapotranspiration was applied as a flux boundary to model layer 1. No flow boundary was assigned to the bottom layer (to depict no vertical groundwater movement from the Lower Tamiami Formation into the overlying Biscayne aquifer).	Calibration Yes Validation Yes

Note: Both USGS models measured length in meters; however, to compare with the other models, the grid dimensions and hydraulic conductivity values were converted to imperial units of ft. Similarly, the hydraulic conductivities of the FPL model were in cm/sec and were converted here to ft/day for consistent comparison with the other models.

[1] Langevin, Christian, 2001. *Simulation of Ground-Water Discharge to Biscayne Bay, Southeastern Florida*, U.S. Geological Survey, Water-Resources Investigations Report 00-4251.

[2] Giddings, Jefferson, Kuebler, Laura, Restrepo, Jorge, Rodberg, Kevin, Montoya, Angela, and Radin, Hope, 2006. *Lower East Coast subRegional (LECsR) MODFLOW Model Documentation* (DRAFT), South Florida Water Management District, West Palm Beach, Florida.

[3] Hughes, Joseph, Langevin, Christian, and Brakefield-Goswami, Linzy, 2010. Effect of hypersaline cooling canals on aquifer salinization, *Hydrogeology Journal*, Vol. 18:25–38.

[4] Groundwater model development and analysis, *Turkey Point Units 6 & 7 COL Application, Part 2 – FSAR,* Appendix 2CC, Rev. 03.

ASSOCIATED COLA REVISIONS:

There are no changes to the COLA as the result of this response. Changes as the result of the revised groundwater model will be reflected in a future COLA revision.

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. 120329 Dated April 3, 2012

SRP Section: EIS 2.3.1 – Hydrology

Question from Environmental Project Branch 1 (RAP1)

NRC RAI Number: EIS 2.3.1-4 (eRAI 6354 Rev. 0)

Preface: The review team acknowledges the value of numerical models in hydrological analyses; however a single model scenario does not generally address all aspects of a hydrological impact assessment. Therefore, the review team considers all available models and performs an independent analysis in order to understand the patterns in the predictions that may be similar and those that might be dissimilar and to determine if such difference would result in a change in the impact assessment. Because of the inherent uncertainty in hydrologic models due to: measurement errors, sampling errors, conceptual model errors, non-uniqueness and the potential misapplication of the numerical model the review team does not make a determination based solely on results of a numerical model. Items 1 through 3 are to ensure that the review team understands how the applicant addressed the three classes of uncertainty mentioned above. Items 4 through 10 are to ensure that the review team understands that the three-dimensional finite-difference groundwater flow model (MODFLOW) was appropriately applied by the applicant.

EIS 2.3.1-4

In performing model calibration, it was necessary to divide the Key Largo Limestone into two different hydraulic conductivity zones in order to adequately match pumping tests performed in two wells, one in each of the defined zones. This highlights the difficulty in developing an accurate predictive model for a large and complex system consisting of many model parameters using relatively little calibration data from limited areas of the model. Describe and quantify the uncertainty in the model prediction of the relative volume of water that will be extracted from the inland Biscayne aquifer compared to the volume extracted from the bay that results from the potential alternative model configurations that would fit the available data due to the limited calibration data.

FPL RESPONSE:

Extensive hydrologic, geologic, and hydrogeologic data, test results, and evaluations were available for the areas of the model considered critical to calibrate and to perform predictive simulations. These areas included the location of the radial collector well system (RCW) at Turkey Point peninsula and Units 6 & 7.

The rationale for splitting the Key Largo Limestone was based on 1) obtaining two different, independent hydraulic conductivity values when analyzing the pumping test data at Units 6 & 7 and at Turkey Point peninsula; and 2) borehole drilling programs suggest the Key Largo Limestone exhibited heterogeneity across the modeling domain. The Key Largo Limestone was separated into two zones to match the pumping test at PW-1, with a hydraulic conductivity of 10 cm/sec, which is approximately 1.7 times greater than the hydraulic conductivity of the Key Largo Limestone at the proposed Units 6 & 7 power block area (FSAR Appendix 2CC, Subsection 4.4.1). The splitting of the Key Largo Limestone into two different hydraulic conductivity zones is further validated by the PW-6U pumping test, which was conducted within the footprint of proposed Unit 6. The test was performed to evaluate the hydrogeologic properties of the Key Largo Limestone at this location. Based on the calibration and validation of the model to the pumping tests performed in the Key Largo Limestone, it can be inferred that the hydraulic conductivity of the Key Largo Limestone is different at Units 6 & 7 than that at the Turkey Point peninsula.

The model was calibrated by adjusting the hydraulic conductivity values and the conductance for head-dependent boundary conditions (cooling canal system [CCS], regional canals, Biscayne Bay, and model domain boundaries) through a manual approach. These parameters were varied to achieve satisfactory agreement between simulated and observed pumping test drawdowns, regional flow directions, and flow magnitudes for the CCS. The FPL groundwater flow model was calibrated to steady-state drawdown values at observation wells from three different pumping tests: PW-7U, PW-7L, and PW-1. PW-7U and PW-7L pumping tests were undertaken within the footprint of proposed Unit 7. The target zone of the PW-7U pumping test is in the Key Largo Limestone, and for PW-7L, it is in the Fort Thompson Formation. The PW-1 pumping test was conducted at Turkey Point peninsula, with the well open zone across the Key Largo Limestone.

The FPL groundwater model underwent two different conceptual model calibrations, one presented in the Rev. 0 groundwater model report (Bechtel Power Corporation 2009) and another presented in the Rev. 1 groundwater model report (Bechtel Power Corporation 2011). The significant differences of the conceptual models between the Rev. 0 and Rev. 1 groundwater model reports are the incorporation of the two higher flow zones (upper and lower higher flow zones) and changes to the conceptualization of the Biscayne Bay bottom sediments. The upper and lower higher flow zones are assumed to be a one foot thick laterally continuous and aerially extensive zone of higher hydraulic conductivity in the model domain. The upper higher flow zone is assumed to be present on top of the Key Largo Limestone over the model domain, whereas the lower higher flow zone is assumed to be present approximately 15 feet below the top of the Fort Thompson Formation over the model domain. The model configuration presented in the Rev. 1 groundwater model report is the basis for the model results currently presented in FSAR Appendix 2CC.

The FPL groundwater flow model was recently revised (Rev. 2) (Bechtel Power Corporation 2012) to update perimeter general-head boundary conductance values in the model input files. The Rev. 2 groundwater model report presents the same conceptual model as that presented in the Rev. 1 groundwater model report and the updated model retains the calibration and validation results as those presented in the Rev. 1 groundwater model report. Numerical comparisons of the affected Rev. 1 and Rev. 2 results indicate that the differences are minor, and the Rev. 1 groundwater model report conclusions are unchanged.

<u>Uncertainty in the Model Prediction</u>

To quantify the uncertainty in the model prediction of the relative volume of water extracted by the RCW from the inland Biscayne aquifer compared to the volume extracted from the bay resulting from potential alternative model configurations, a series of sensitivity analyses for the RCW was conducted. The base case run included RCW pumping from the upper higher flow zone. The sensitivity analyses were based on those parameters determined to be most sensitive, as identified during model calibration (i.e., fitting the steady-state drawdown of the PW-1 pumping test data) and for seasonal high and low water levels. During the calibration phase it was expected that perturbing the vertical hydraulic conductivity of the sediments at the bottom of Biscayne Bay and the horizontal hydraulic conductivity of the Key Largo Limestone would result in the greatest difference between the observed and the simulated heads. Because calibration included fitting the PW-1 pumping test data, which were collected in the area of the RCW, the calibration provides more certainty of the model hydrogeologic parameters at the RCW location, indicating that the RCW sensitivity results are reasonable. The sensitivity analyses performed with alternative model configurations, which are discussed in the Rev. 2 groundwater model report (Bechtel Power Corporation 2012) and summarized in FSAR Appendix 2CC, Subsection 5.2.3, are as follows:

- RCW pumping from the Key Largo Limestone
- Base case run, with seasonal high water of Biscayne Bay of 0.09 feet NAVD 88
- Base case run with seasonal low water of Biscayne Bay of -1.40 feet NAVD 88
- Base case run with offshore (i.e., in Biscayne Bay) vertical hydraulic conductivity of the first three layers of the model *doubled* from the base case (the calibrated model)
- Base case run with offshore (i.e., in Biscayne Bay) vertical hydraulic conductivity of the first three layers of the model *halved* from the base case (the calibrated model)
- Base case run with Key Largo Limestone horizontal hydraulic conductivity set at 5.9 cm/s across the model
- Base case run with Key Largo Limestone horizontal hydraulic conductivity set at 10 cm/s across the model

The results of these sensitivity analyses (i.e., origin of water collected by the RCW) are shown in Table 11 of Bechtel Power Corporation (2012). The table depicts that even with alternative model configurations, the predicted percentage of RCW source water that originates from Biscayne Bay ranges between approximately 95% and 99%, and the percentage of water from inland areas ranges from 0.9% to 4.6%. However, most of the inland water originates from the CCS, and only 0.1% to 1.4% of the water collected by the RCW is predicted to originate from the regional eastward flow. In seven of the eight sensitivity simulations, the percent of water captured by the RCW from regional eastward flow is less than or equal to 0.3%. The half vertical hydraulic conductivity sensitivity simulation results in the largest percent of regional eastward flow captured by the RCW, with a value of 1.4%. The RCW pumping from the Key Largo Limestone showed virtually no difference in the percentage of water origination when compared to the base case run. The RCW origins of water percentages as shown above are slightly different than that shown in FSAR Appendix 2CC, Table 2CC-211, Revision 3 and are based on updated groundwater modeling results (Bechtel Power Corporation, 2012) to be presented in a future COLA revision.

Similarly, when comparing the sensitivity of drawdown due to RCW pumping for different model configurations, the 0.1 foot drawdown contour (the farthest drawdown contour) in the top layer for most of the alternative model configurations was east of the CCS as shown in Figures 2CC-246, 2CC-247, 2CC-252, 2CC-253, and 2CC-254 of FSAR Appendix 2CC. The maximum extent of the 0.1 foot drawdown contour was for the model configuration where the vertical hydraulic conductivity of the first three layers in Biscayne Bay was half that of the base case as shown in Figure 2CC-253 of FSAR Appendix 2CC.

The comparisons of the groundwater budget between the Rev. 0 and Rev. 2 groundwater model reports (Bechtel Power Corporation, 2009 and Bechtel Power Corporation, 2012) did not show any appreciable differences in the origin of water supplying the radial collector wells. The Rev. 0 groundwater model report predicts that approximately 97 percent of the flow to be originating from Biscayne Bay and approximately 3 percent originating from inland. Comparable values from the Rev. 2 groundwater model report are approximately 98 percent of the source water originating from Biscayne Bay and approximately 2 percent of the water originating from inland areas for the base case model simulation. As can be seen from these results, the differences in the underlying conceptual models lead to very small differences in the relative amounts of water supplied from Biscayne Bay versus that supplied from inland areas.

In addition to the changes to the conceptual model between the Rev. 0 and Rev. 1 groundwater model reports, other changes and updates were performed to improve the reliability of the numerical groundwater flow model (Rev. 2 groundwater model report, Section 3.1.1, Bechtel Power Corporation 2012).

<u>Summary</u>

To quantify the uncertainty associated with the origin of the source water for RCW pumping, a series of sensitivity analyses with alternative model configurations were undertaken. The most sensitive parameters included the vertical hydraulic conductivity of the material beneath Biscayne Bay and above the location of the RCW, and additionally, the horizontal hydraulic conductivity of the Key Largo Limestone. Both the Rev. 0 and Rev. 2 groundwater model reports, which present two distinctly different conceptual models that are calibrated to the same set of pumping test data, showed very little difference in the percentage of water originating from Biscayne Bay due to RCW pumping.

Thus, the uncertainty is quantified based on the results from potential alternative model configurations and sensitivity analyses which indicate that approximately 95% to 99% of the water supplying the RCW originates from Biscayne Bay, while 0.9% to 4.6% of the water originates from the inland portion (includes both the CCS and regional eastward flow) of the Biscayne aquifer.

This response is PLANT SPECIFIC.

References:

Bechtel Power Corporation, 2009. *Groundwater Model Development and Analysis: Units 6 & 7 Dewatering and Radial Collector Well Simulations*, Rev. 0. Available at: http://publicfiles.dep.state.fl.us/Siting/Outgoing/FPL_Turkey_Point/Units_6_7/Completeness/Plant_Associated_Facilities/2nd_round_Completeness/FPL_Response_Part_A_Information/Attached%20Reports/Bechtel%20Groundwater%20Report/Groundwater%20Modeling%20Report.pdf, accessed on June 12, 2012.

Bechtel Power Corporation, 2011. *Groundwater Model Development and Analysis: Units 6 & 7 Dewatering and Radial Collector Well Simulations*, Rev. 1. Available at: http://publicfiles.dep.state.fl.us/Siting/Outgoing/FPL_Turkey_Point/Units_6_7/Completeness/Plant_Associated_Facilities/4th_Round_Completeness/FPL%20Response_4thCompleteness/Groundwater%20Modeling%20Report,%20Rev.%201,%202011/Groundwater_Model_Report-Revision_1_022311_Final.pdf, accessed on June 12, 2012.

Bechtel Power Corporation, 2012. *Groundwater Model Development and Analysis: Units 6 & 7 Dewatering and Radial Collector Well Simulations*, Rev. 2.

ASSOCIATED COLA REVISIONS:

There are no changes to the COLA as the result of this response. Changes as the result of the revised groundwater model will be reflected in a future COLA revision.

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. 120329 Dated April 3, 2012

SRP Section: EIS 2.3.1 – Hydrology

Question from Environmental Project Branch 1 (RAP1)

NRC RAI Number: EIS 2.3.1-5 (eRAI 6354 Rev. 0)

Preface: The review team acknowledges the value of numerical models in hydrological analyses; however a single model scenario does not generally address all aspects of a hydrological impact assessment. Therefore, the review team considers all available models and performs an independent analysis in order to understand the patterns in the predictions that may be similar and those that might be dissimilar and to determine if such difference would result in a change in the impact assessment. Because of the inherent uncertainty in hydrologic models due to: measurement errors, sampling errors, conceptual model errors, non-uniqueness and the potential misapplication of the numerical model the review team does not make a determination based solely on results of a numerical model. Items 1 through 3 are to ensure that the review team understands how the applicant addressed the three classes of uncertainty mentioned above. Items 4 through 10 are to ensure that the review team understands that the three-dimensional finite-difference groundwater flow model (MODFLOW) was appropriately applied by the applicant.

EIS 2.3.1-5

Model simulated drawdowns compared to measured drawdowns at wells PW-7U and PW-6U resulted in normalized root mean square error (NRMS) of 11.3% and 11.4%, respectively. These values were outside of the specified NRMS criterion of 10%. Describe possible implications of the relatively poor fit of the drawdown at these wells on the ability of the model to predict the relative volume of water that will be extracted from the inland Biscayne aquifer compared to the volume extracted from the bay.

FPL RESPONSE:

The response to Question 02.03.01-5 is addressed in two parts: (1) evaluation of the fit of the drawdown data from PW-7U and PW-6U in the groundwater model, and (2) the model's ability to predict relative volume extracted from inland aquifer by radial collector wells (RCWs).

<u>Part 1</u>

Based on the following discussion of best practices and the full compliment of model calibration and validation statistics, FPL believes an acceptable fit has been demonstrated. The model calibration is considered a relatively good fit based on the following considerations:

- Model calibration and validation considers data other than NRMS for pumping tests at wells PW-7U and PW-6U, including graphs of observed and calculated drawdown, absolute residual mean (ARM), root mean square (RMS), cooling canal system water balance, as well as pumping tests at wells PW-1 and PW-7L.

- The calibration simulation for pumping test PW-7U with NRMS of 11.3% includes one observation well that accounts for 0.33 ft^2 of the total squared residual of 0.60 ft^2 for 16 observation wells, and therefore, the one well could be considered an outlier.

- The validation simulation for pumping test PW-6U with NRMS of 11.4% is not used to develop the calibrated model and therefore is not subject to modification of parameter values to minimize the residual statistics.

- There are no industry or agency standards that specify numerical criteria for acceptable groundwater model calibration.

- Selection of normalized root-mean-square (NRMS) criterion of 10% is subjective.

Determining whether a groundwater flow model is acceptably calibrated involves evaluation and review of all calibration data. In the case of the FPL Turkey Point Units 6 & 7 groundwater flow model (referred to as the FPL model), calibration involved matching three pumping tests (PW-1, PW-7L, and PW-7U) and the cooling canal system water balance. Following calibration, the model was validated using a fourth pumping test (PW-6U) and results were evaluated using the same parameters as the calibration simulations.

The FPL model adopted the absolute residual mean (ARM) and root-mean-square (RMS) of residuals as calibration measures, with the residual defined as the difference between the computed and observed drawdown at a particular location. The ratio of the RMS value to the difference in the maximum and minimum drawdown defines the NRMS value for this model. An NRMS value of 10% based on drawdown values is an internally established calibration criterion and is recognized as a target rather than a requirement.

Calibration of the FPL groundwater model is not based solely on minimizing the NRMS as established from the pumping test simulations. The criteria included ARM and RMS, as noted above. The graphs of calculated and observed drawdown in Final Safety Analysis Report (FSAR) Appendix 2CC, Figures 2CC-220, 2CC-223, 2CC-225, and 2CC-236, along with the ARM and RMS values, demonstrate that the model is able to accurately replicate three pumping tests for calibration and a fourth pumping test for validation:

- PW-1 test for calibration – ARM of 0.03 ft and RMS of 0.04 ft

- PW-7L test for calibration – ARM of 0.69 ft and RMS of 0.97 ft

- PW-7U test for calibration – ARM of 0.15 ft and RMS of 0.19 ft

- PW-6U test for validation – ARM of 0.12 ft and RMS of 0.18 ft

The graph of calculated and observed drawdown for pumping test PW-7U shown in FSAR Appendix 2CC, Figure 2CC-225, indicates one well to be a possible outlier. This one observation well accounts for 0.33 ft^2 of the total squared residual of 0.60 ft^2 (and NRMS of 11.3%) for 16 observation wells. The squared residual for the other 15 observation wells ranges from 0.00 ft^2 to 0.07 ft^2. The one observation well with a squared residual of 0.33 ft^2 could be considered an outlier, although removing this well from the calibration statistics does not improve the NRMS.

For pumping test PW-6U, which was simulated during the validation phase, the results for the residual statistics are considered good, even with an NRMS of 11.4%. This is because these test data were not used to guide the development of the model but rather to test the validity of the model following its construction. This validation simulation is not part of the calibration process and therefore was not subject to modification of parameter values to minimize the residual statistics. FSAR Appendix 2CC, Table 2CC-210 is mistakenly titled “Model Calibration PW-6U” and should be “Model Validation PW-6U”.

There are no industry-standard criteria that quantitatively define what constitutes an acceptable calibration of a groundwater numerical model. No such criteria are given in the primary industry standard (ASTM International 2008), Nuclear Regulatory Commission guide on hydrogeologic modeling studies (U.S. Nuclear Regulatory Commission 2003), or in one of the standard textbooks on groundwater modeling (Anderson and Woessner 2002). What these documents indicate is that model calibration is the process of estimating the true hydrogeologic parameters without bias and as closely as possible. This typically is achieved by defining appropriate calibration criteria in terms of the residuals and optimizing the parameters in a way that comes closest to satisfying these criteria. With regard to matching water level measurements, these guidance documents use the term “small” when referring to head residuals or the NRMS but do not define “small” in a quantitative sense. Specifically, ASTM International (2008) “Standard Guide for Calibrating a Ground-Water Flow Model Application” (Section 6.4.1) indicates the following:

> *Due to the many approximations employed in modeling and errors associated therewith (see Guide D5447), it is usually impossible to make a model reproduce all heads measurements within the errors of measurement. Therefore, the modeler must increase the range of acceptable computed heads beyond the range of the error in measurement. Judgment must be employed in setting these new acceptable residuals. In general, however, the acceptable residual should be a small fraction of the difference between the highest and lowest heads across the site.*

The FPL model also incorporated the results of an analytical water balance performed on the cooling canal system, but no quantitative industry criteria have been established for what is an acceptable match between modeled and calculated/observed flows. Recognizing the greater uncertainty associated with measuring or estimating observed flows, ASTM International (2008) Section 6.4.2 provides the following guidance:

> *Errors in the estimates of groundwater flow rates will usually be larger than those in heads. For example, baseflow estimates are generally accurate only to within an order of magnitude. In such cases, the upper and lower bounds on the acceptable modeled value of baseflow can be equal to the upper and lower bounds on the estimate.*

The intent of describing these additional calibration parameters is to show that leeway exists in the determination of what is considered an acceptably calibrated model and that multiple criteria (different parameters for residual statistics and water balance) preclude reliance on a single calibration parameter. With this discussion in mind, it should be recognized that establishing a value for the NRMS is a subjective matter and that an NRMS marginally greater than 10% can still be considered an acceptable value for a calibrated model.

<u>Part 2</u>

With regard to "ability of the model to predict the relative volume of water that will be extracted from the inland Biscayne aquifer compared to the volume extracted from the bay," this is addressed by the following points:

- The PW-1 pumping test was conducted at the planned location of the RCWs and had the lowest ARM (0.03 ft), lowest RMS (0.04 ft), and lowest NRMS (5.3%) of the four pumping test simulations.
- Sensitivity analyses of the calibrated model demonstrate that the portion of well flow from the inland area ranged from 0.9% to 4.6%, with 2.2% for the base case (calibrated model).

For the evaluation of volume of water extracted by the RCWs from the inland areas and the bay, the model calibration is considered a good fit for the PW-1 pumping test that was conducted at the planned location of the RCWs, with ARM of 0.03 ft, RMS of 0.04 ft, and NRMS of 5.3%. The graph of calculated and observed drawdown provided in FSAR Appendix 2CC, Figure 2CC-223 also supports the position that the model is able to accurately replicate the PW-1 test. Because other pumping tests at PW-6U, PW-7U, and PW-7L were conducted within the planned power block for FPL Units 6 & 7, the pumping test at PW-1 is the most important pumping test of the four for evaluating the volume of water extracted from the inland areas and the bay.

Following standard groundwater modeling practice (Anderson and Woessner 1992), a sensitivity analysis was conducted to quantify the uncertainty in the calibrated model caused by uncertainty in the estimates of aquifer parameters and boundary conditions. The primary calibration parameter that affected the NRMS was the hydraulic conductivity of the Key Largo Limestone, and because of this, hydraulic conductivity was selected as one of the parameters to be adjusted during the sensitivity analyses. Several other parameters were also independently adjusted during sensitivity analyses with the intention of evaluating the relative volume of water that will be extracted from the inland Biscayne aquifer compared to the volume extracted from the bay.

The base case for steady-state operation of the RCWs indicates that 97.8% of the groundwater recharge originated from Biscayne Bay and 2.2% originated from inland areas. The 2.2% from inland areas includes 2.0% from the cooling canals and 0.2% from other inland areas west of the wells.

In the sensitivity analyses, flow from inland areas ranged from 0.9% to 4.6% for the seven cases simulated as shown in FSAR Appendix 2CC. The vertical hydraulic conductivity is the most important parameter affecting the percent of flow originating from inland areas and from Biscayne Bay, accounting for the range of 0.9% to 4.6% in the sensitivity cases. Excluding the sensitivity simulations for vertical hydraulic conductivity, the portion of flow from inland areas has a narrower range of just 1.5% to 2.4%. Nevertheless, with significant changes in important model parameters, including vertical hydraulic conductivity, the contribution from inland areas to the RCWs remains as a small percentage of RCW flow.

The RCW's origin of water percentages as shown above are minor changes from FSAR Appendix 2CC, Table 2CC-211 (Revision 3) and are based on updated groundwater modeling results to be presented in a future COLA revision.

Summary

Model calibration and validation considers data other than the NRMS for pumping tests at wells PW-7U and PW-6U, including graphs of observed and calculated drawdown, ARM, RMS, and cooling canal system water balance, as well as pumping tests at wells PW-1 and PW-7L. An NRMS marginally above 10% is considered an acceptable fit, particularly given the results for these other parameters. Therefore, based on consideration of graphs of observed and calculated drawdown, multiple parameters for residual statistics, and the canal cooling system water balance, the model is able to accurately replicate the four pumping tests, including PW-7U and PW-6U pumping tests with NRMS values of 11.3% and 11.4%, respectively.
For determining the contribution of flow to the RCWs from inland areas, the model calibration for pumping test PW-1 is far more significant than pumping tests PW-7U and PW-6U. Furthermore, based on the good fit for the PW-1 pumping test at the RCW location and the sensitivity analyses, the model is able to predict, within a relatively narrow range, the volume of water that will be extracted from the inland Biscayne aquifer compared to the volume extracted from the bay, regardless of NRMS values marginally above 10% for PW-7U and PW-6U.

This response is PLANT SPECIFIC.

References:

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2. ASTM International, 2008. *Standard Guide for Calibrating a Groundwater Flow Model Application*, Designation D5981-96 (Reapproved 2008).

3. ASTM International, 2010. *Standard Guide for Application of a Groundwater Flow Model to a Site-Specific Problem*, Designation D5447-04 (Reapproved 2010).

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ASSOCIATED COLA REVISIONS:

The title name for FSAR Appendix 2CC, Table 2CC-210 will be changed in a future COLA revision as shown below:

Model ~~Calibration~~**Validation** PW-6U – Measured Versus Simulated Drawdowns (at end of test)

This change also affects the Table of Contents:

Changes as a result of the revised groundwater flow model will be reflected in a future COLA revision.

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. 120329 Dated April 3, 2012

SRP Section: EIS 2.3.1 – Hydrology

Question from Environmental Project Branch 1 (RAP1)

NRC RAI Number: EIS 2.3.1-7 (eRAI 6354 Rev. 0)

Preface: The review team acknowledges the value of numerical models in hydrological analyses; however a single model scenario does not generally address all aspects of a hydrological impact assessment. Therefore, the review team considers all available models and performs an independent analysis in order to understand the patterns in the predictions that may be similar and those that might be dissimilar and to determine if such difference would result in a change in the impact assessment. Because of the inherent uncertainty in hydrologic models due to: measurement errors, sampling errors, conceptual model errors, non-uniqueness and the potential misapplication of the numerical model the review team does not make a determination based solely on results of a numerical model. Items 1 through 3 are to ensure that the review team understands how the applicant addressed the three classes of uncertainty mentioned above. Items 4 through 10 are to ensure that the review team understands that the three-dimensional finite-difference groundwater flow model (MODFLOW) was appropriately applied by the applicant.

EIS 2.3.1-7

Provide any available information on how measurements of the hydraulic conductivity of the sediment found at the bottom of Biscayne Bay were determined.

FPL RESPONSE:

Hydraulic conductivity measurements of the sediment at the bottom of Biscayne Bay are not available. However, information used to estimate Bay sediment distribution and hydraulic conductivity values is provided in this response in two parts: (1) description of how the hydraulic conductivity and extent of sediment on the Bay floor were developed for the Florida Power & Light (FPL) groundwater flow numerical model, and (2) summary of additional literature regarding Bay floor information that was not directly used in development of the FPL groundwater model, but which further supports the FPL modeling approach.

<u>Part 1</u>

The hydraulic conductivity and extent of sediment on the Bay floor for the numerical model were based on the following information:

- Literature review
- Benthic seagrass data
- Extent of sediment materials beneath the Bay
- Estimates of hydraulic conductivity values
- Model calibration and sensitivity simulations
- Regional flow models comparison

Literature Review

Literature sources that were examined for evaluation of the hydraulic conductivity and extent of Bay floor sediments include the following, which are cited in Environmental Report (ER) Section 2.3 and/or Final Safety Analysis Report (FSAR) Subsection 2.4.12:

- Fish and Wildlife Research Institute (FWRI 2010) – benthic seagrass data and sediment extent
- Geology and Hydrogeology Report (JLA 2010) prepared for FPL – borehole logs for FPL monitoring well locations
- U.S. Geological Survey (USGS) reports by Ishman (1997), Langevin (2001), USGS (2006), and Wingard et al. (2004) – borehole logs for Biscayne Bay, and groundwater modeling study\

Benthic Seagrass Data

As stated in ER Subsection 2.3.1.2.3, regarding the uppermost layer in the numerical model:

> Model Layer 1 — This layer consists of muck onshore and rock and sandy material on the floor of Biscayne Bay. The location of these layers is based on the results of investigations performed in 1971 (Dames & Moore 1971) and 2008 (MACTEC 2008). Specifically, muck is known to be present on land; however, this unit does not extend into Biscayne Bay, where exposed rock and sandy material are present in its place. The Model Layer 1 hydrostratigraphic units in Biscayne Bay were assigned using the Marine Resources Geographic Information System (MRGIS) "Benthic Habitats — South Florida" file (FWRI 2010). Benthic zones designated as "Continuous Seagrass" were designated as sandy material in Layer 1, as loose material is necessary to support seagrass. "Patchy (Discontinuous) Seagrass" and "Hardbottom with Seagrass" benthic zones were designated as rock in Model Layer 1."

The extent of the above benthic zones within the model domain is shown on two figures provided with this response:

- Figure 1 – Extent of "Continuous Seagrass" and "Patchy (Discontinuous) Seagrass" (FWRI 2012)
- Figure 2 – Extent of "Hardbottom with Seagrass" and "Mangroves" (FWRI 2012)

Extent of Sediment Materials Beneath the Bay

During model development, muck initially was assumed present throughout Biscayne Bay. However, as stated in FSAR Appendix 2CC:

> "The muck layer in Biscayne Bay has been revised based on a literature review of sediment/rock type on the floor of Biscayne Bay. This review identified sandy soils and bare rock (Miami Limestone) that had previously been represented as muck."

FSAR Appendix 2CC, Figure 2CC-215 shows the distribution of materials in Biscayne Bay that were applied to the FPL groundwater model. Figure 3 shows the material zones in Model Layer 1, corresponding to Miami Limestone, Offshore Sediment, and Muck. Two small areas of Muck are shown east of the coastline, which correspond to small islands comprising part of the Florida Keys. The coastline in the FPL groundwater model, between Offshore Sediment and inland Muck, was adjusted slightly west of the boundary between the “Continuous Seagrass” (Figure 1) and “Mangroves” (Figure 2), so that some shoreline mangroves are included within the general-head boundary for Biscayne Bay and within the Offshore Sediment in Model Layer 1. However, most of the mangroves are located within the inland Muck in Model Layer 1.

The materials assigned for offshore areas in Model Layer 1, based on the benthic zone mapping previously described, are as follows:

- Offshore Sediment – “Continuous Seagrass”
- Miami Limestone – “Hardbottom with Seagrass” and “Patchy (Discontinuous) Seagrass”

Several borehole drilling investigations have been completed in Biscayne Bay, and these studies provide additional information on the Bay floor materials, as summarized below:

- JLA (2010) – Drilling within Biscayne Bay was performed at three locations to install groundwater monitoring wells. The well locations are shown in Figure 4, and are within the FPL model domain. No sediment was recovered in coring. Based on visual observations of the Bay bottom, sediment is absent at TPGW-10 (although a couple of inches or less of sediment is visible nearby), approximately eight inches of sandy sediment is at TPGW-11, and approximately six inches of sandy sediment is at TPGW-14.

- Ishman (1997) – Sediment cores were collected at six locations beyond the model domain. Figure 5 shows three core locations nearest to the FPL model domain. The sediments primarily include mud at CB-1, shelly sandy mud at PB-1, and shelly medium sand and peat at BP-1, with thicknesses of 85 to 146 cm (33 to 57 inches).

- USGS (2006) – Drilling was performed at three locations to install wells along a transect from northwest to southeast across Biscayne Bay, although this transect lies north of the FPL model domain. The results indicate that “in this part of the Bay, the limestone is typically overlain by less than 6 in. of modern carbonate sediment (Wanless, 1967).”

- Wingard et al. (2004) – Sediment cores were also collected at three locations near the shoreline in Biscayne Bay, but these are also beyond the FPL model domain. The sediments include fine sand and mud, with thicknesses of 77.5 to 92 cm (31 to 36 inches).

The presence of sediment at the core locations described above is consistent with the extent of sediment and rock based on MRGIS benthic zones, as applied in the FPL groundwater model.

Estimates of Hydraulic Conductivity Values

FSAR Appendix 2CC, Table 2CC-204 summarizes hydraulic conductivity values from “FPL onsite tests” and “literature review” for hydrogeologic units in the numerical model. No values are indicated for Offshore Sediment because measurements were not available.
During development of the FPL groundwater model, the vertical hydraulic conductivity for the Offshore Sediment was expected to be greater than the value for Muck (K_v = 0.00044 cm/s) and less than the value for Miami Limestone (K_v = 0.00588 cm/s). The final value used in the FPL groundwater model for Offshore Sediment (K_v = 0.00235 cm/s) is between the values for these other materials and was determined by model calibration as described below.

Model Calibration and Sensitivity Simulations

The FPL groundwater model used the following values for hydraulic conductivity of Bay floor materials (as listed in Table 1):

- Offshore Sediments – horizontal hydraulic conductivity (K_h) = 0.0353 cm/s (100 ft/day), and vertical hydraulic conductivity (K_v) = 0.00235 cm/s (6.7 ft/day)

- Miami Limestone – horizontal hydraulic conductivity (K_h) = 0.0882 cm/s (250 ft/day), and vertical hydraulic conductivity (K_v) = 0.00588 cm/s (16.7 ft/day)

The hydraulic conductivity of the Offshore Sediment was estimated during the calibration phase and primarily determined from simulations of the pumping test PW-1 at Turkey Point peninsula. During calibration simulations, the vertical hydraulic conductivity was reduced, with a change in the anisotropy ratio (K_h/K_v) from an initial value of 10:1 to a final value of 15:1, and thereby improving the model fit to the calibration criteria.

As stated in FSAR Appendix 2CC, sensitivity of the numerical model to vertical hydraulic conductivity was evaluated as follows:

> “Two additional sensitivity runs were performed to assess the impact of the anisotropy ratio in Biscayne Bay on the radial collector well simulations. In the base model, an anisotropy ratio of 15:1 (Kh:Kv) is used. In the sensitivity runs, the vertical hydraulic conductivity (Kv) is either doubled or halved, producing anisotropy ratios of 7.5:1 and 30:1, respectively. This change is only made offshore to the first three layers of the model, which represent the Miami Limestone (and a small area of sediment in layer 1).”

As determined from FSAR Appendix 2CC, Table 2CC-211, doubling the K_v slightly increases the contribution to the radial collector wells (RCWs) from Biscayne Bay, while halving the K_v slightly decreases the contribution to the RCWs:

- Inflow to RCWs from Biscayne Bay for base case = 84,922 gpm (97.8% of 86,832 gpm)

- Inflow to RCWs from Biscayne Bay with doubled K_v = 86,051 gpm (99.1% of 86,832 gpm)

- Inflow to RCWs from Biscayne Bay with halved K_v = 82,838 gpm (95.4% of 86,832 gpm)

The RCW origin of water percentages as shown above are minor changes from FSAR Appendix 2CC, Table 2CC-211 (Revision 3) and are based on updated groundwater modeling results to be presented in a future COLA revision.

Regional Flow Models Comparison

The vertical hydraulic conductivities of 6.7 ft/day (Offshore Sediments) and 16.7 ft/day (Miami Limestone) in the FPL groundwater model, and an anisotropy ratio (K_h/K_v) of 15:1, are within the range of values applied in a USGS study (Langevin 2001) to evaluate groundwater discharge into Biscayne Bay. The USGS study used vertical hydraulic conductivity values of 0.1 to 328 ft/day, and anisotropy ratios of 10:1 to 100:1, as described below.

The USGS modeling study included two cross-sectional models and a three-dimensional model, with the modeling domains extending into Biscayne Bay. Within the offshore area, the modeling study applied vertical hydraulic conductivity values of 9 m/day (30 ft/day) and 100 m/day (328 ft/day) for the cross-sectional models, and zones of 0.03, 15, and 90 m/day (0.1, 49, and 295 ft/day) in the three-dimensional model. Sediment in Biscayne Bay was not explicitly included in the cross-sectional models. However, the three-dimensional model included an onshore/offshore zone of sediment with a vertical hydraulic conductivity of 0.03 m/day (0.1 ft/day). The anisotropy ratio was 100:1 in the three-dimensional model, and 10:1 to 1000:1 in the cross-sectional models.

<u>Part 2</u>

This part of the response summarizes supplemental information that was not directly used in development of the FPL groundwater model, but which further supports the FPL modeling approach in determining the Biscayne Bay sediment extent and hydraulic conductivity.

Additional literature regarding Bay floor information includes the following references not cited in ER Section 2.3 or FSAR Appendix 2CC:

- Study by EAI (2009) prepared for FPL – seagrass survey at Turkey Point
- National Parks Conservation Association report (Robles et al. 2005) – sediment thickness and seagrass density in Biscayne Bay
- Technical journal articles by Hughes et al. (2010), Langevin et al. (2005), and Lirman et al. (2003) – cross-sectional groundwater model extending into Biscayne Bay, Everglades-Florida Bay coupled surface water-groundwater model, and sediment thickness in Biscayne Bay
- USGS reports by Prager and Halley (1997), Langevin et al. (2004), Wingard et al. (2003), and Wingard et al. (2007) – Florida Bay bottom types, Everglades-Florida Bay coupled surface water-groundwater model, and sediment characterization in Biscayne Bay

Benthic Seagrass

The bottom descriptions and photographs from Biscayne Bay and Florida Bay appear to indicate similar conditions. The locations of Florida Bay and Biscayne Bay are shown in Figure 6. In a study of Florida Bay bottom types (Prager and Halley 1997), the majority of Florida Bay floor consists of the following:

- Hardbottom – “Little to no seagrass cover and only up to 5 cm of sediment overlying the Pleistocene limestone bedrock.”

- Sparse seagrass – “Greater than 50% of bottom is exposed… Sediments are predominantly slightly muddy carbonate sand, sandy mud, or sand and vary from approximately 3 cm to over 2 m in thickness.”

- Intermediate seagrass – “Greater than 50% seagrass cover with open areas of exposed sediment… Sediments are dominated by sandy and shelly (gravely) carbonate mud. Sediment thickness tends to be greater than 0.33 m and may reach up to over 2 m.”

- Dense seagrass – “Considered dense where the bottom is completely obscured from view by grass growth… Carbonate sediments, generally greater than 0.33 m… These sediments are muddy sand.”

Photographs from Florida Bay of these examples are shown in Figure 7, and photographs of Biscayne Bay floor are shown in Figure 8. As previously discussed for the FPL groundwater model, areas identified in Biscayne Bay as “Hardbottom with Seagrass” and “Patchy (Discontinuous) Seagrass” are designated as Miami Limestone, and areas identified as “Continuous Seagrass” are designated as Offshore Sediment.

A seagrass survey was conducted in 2009 along 26 transects surrounding the Turkey Point peninsula (EAI 2009). The transects extended to approximately 300 m from the shoreline. The seagrass in this area includes turtle grass (*Thalassia testudinum*) and, to a lesser extent, shoal grass (*Halodule wrightii*). Thalassia seagrass coverage ranged from 0% (not present) to >90%, with highest coverage immediately surrounding the peninsula (Figure 2 in EAI 2009). The area with greater than 50% seagrass coverage is consistent with the extent of the MRGIS zone around Turkey Point of “Continuous Seagrass” shown in Figure 1 of this response.

Sediment Thickness

Additional studies show a correspondence between sediment thickness and seagrass density. As noted in a report on Biscayne Bay National Park (Robles et al. 2005), “Christian et al. (2004) found that as sediment depth decreased in the southern Biscayne Bay, seagrass densities also decreased” and that “over 50% of the benthos is seagrass habitat, while coral and hardbottom account for 35% of the Bay bottom in this region.”

A study of coral communities in Biscayne Bay (Lirman et al. 2003) determined “sediment thickness measurements by pushing a marked metal pole into the sediments until the carbonate platform was reached.” Figure 9 shows sediment thickness within Biscayne Bay. The study results indicated that “wherever mean sediment depth exceeds 10-15 cm, seagrasses are the dominant benthic organisms” and “the inverse relationship between coral density and sediment depth suggests a threshold value of 5 cm in sediment depth for dense coral communities to develop."

Additional sediment cores were collected by the USGS at three mud banks in Biscayne Bay (Wingard et al. 2003), although the locations are beyond the FPL model domain. The sediments were greater than one meter in thickness, and generally were mud with shells and plant material. As noted in the report, "modern bottom sediments *[in Biscayne Bay]* consist of quartz sand, carbonate sand, and mud (especially in southern Card and Barnes Sounds) with large areas of little or no Holocene sediment accumulation." Similarly, the FPL groundwater model includes areas of offshore sediment and areas of little or no sediment (hardbottom). Sediment cores from various sampling programs by the USGS in Biscayne Bay between 1996 and 2003 (Ishman 1997, Wingard et al. 2003, Wingard et al. 2004) are summarized in a study on age dating of sediments (Wingard et al. 2007).

Hydraulic Conductivity Values for Sediment

In a modeling study by the USGS (Langevin et al. 2004, Langevin et al. 2005) to evaluate surface water and groundwater flow for a coastal wetland (southern Florida Everglades) and adjacent estuary (Florida Bay), a "thin, hydraulically resistive layer" was explicitly included in the model. Within Florida Bay, "leakage coefficients were assigned based on mapped bottom types (Prager and Halley 1997)." A vertical hydraulic conductivity of 0.75 m/day (2.5 ft/day) was assigned to "hard-bottom areas" in Florida Bay. "All other bottom types in Florida Bay were assumed to have 1 m thick sediment layer" with a vertical hydraulic conductivity value of 0.1 m/day (0.3 ft/day). The vertical hydraulic conductivity values of 0.3 to 2.5 ft/day for Florida Bay floor are less than the values of 6.7 to 16.7 ft/day applied in the FPL groundwater model for the Biscayne Bay floor.

In another modeling study by the USGS (Hughes et al. 2010) to evaluate the Cooling Canal System (CCS) at Turkey Point, a cross-sectional model was created that extended into Biscayne Bay. The total model length was approximately 46 km, with 1-m thick model layers. The uppermost material in the model consisted of an "upper permeable unit" with a thickness of 8 m. Offshore sediment was not explicitly included. Model simulations used several different hydraulic conductivity configurations, with vertical hydraulic conductivity of 0.1, 10 or 1000 m/day (0.3, 33 or 328 ft/day) for the uppermost model material, with identical values applied onshore and offshore, and anisotropy ratios of 10:1 to 100:1.

The values of 6.7 to 16.7 ft/day in the FPL groundwater model for the Biscayne Bay floor are within the range used in the USGS cross-sectional model. The anisotropy ratio of 15:1 in the FPL groundwater model is also within the range used in the USGS model.

<u>Summary</u>

The Model Layer 1 hydrostratigraphic units in Biscayne Bay were assigned using the Marine Resources Geographic Information System (MRGIS) "Benthic Habitats — South Florida" bottom mapping zones (FWRI 2010). Benthic zones designated as "Continuous Seagrass" were assigned as Offshore Sediment. "Patchy (Discontinuous) Seagrass" and "Hardbottom with Seagrass" benthic zones were assigned as Miami Limestone. As noted by various studies, seagrass extent corresponds with sufficiently thick sediment to sustain plant growth, but large areas of Biscayne Bay, and a large portion of the offshore area of the FPL model domain, consist of little or no sediment accumulation.

Measurements of sediment hydraulic conductivity for Biscayne Bay were not available for model development. During calibration of the FPL groundwater model, the vertical hydraulic conductivities for Bay floor materials were reduced to improve the model fit to the calibration criteria. The final values for vertical hydraulic conductivity are within the range applied in other Biscayne Bay models (Hughes et al. 2010, Langevin et al. 2001, and Langevin et al. 2004). Table 1 provides a summary comparison of model hydraulic conductivities for Bay floor materials. Furthermore, the hydraulic conductivity for the Offshore Sediment (K_v = 6.7 ft/day) was expected to be between the values for Muck (K_v = 1.2 ft/day) and Miami Limestone (K_v = 16.7 ft/day), and the FPL groundwater model does meet this expectation.

This response is PLANT SPECIFIC.

References:

Previously Cited in the COLA ER and/or FSAR

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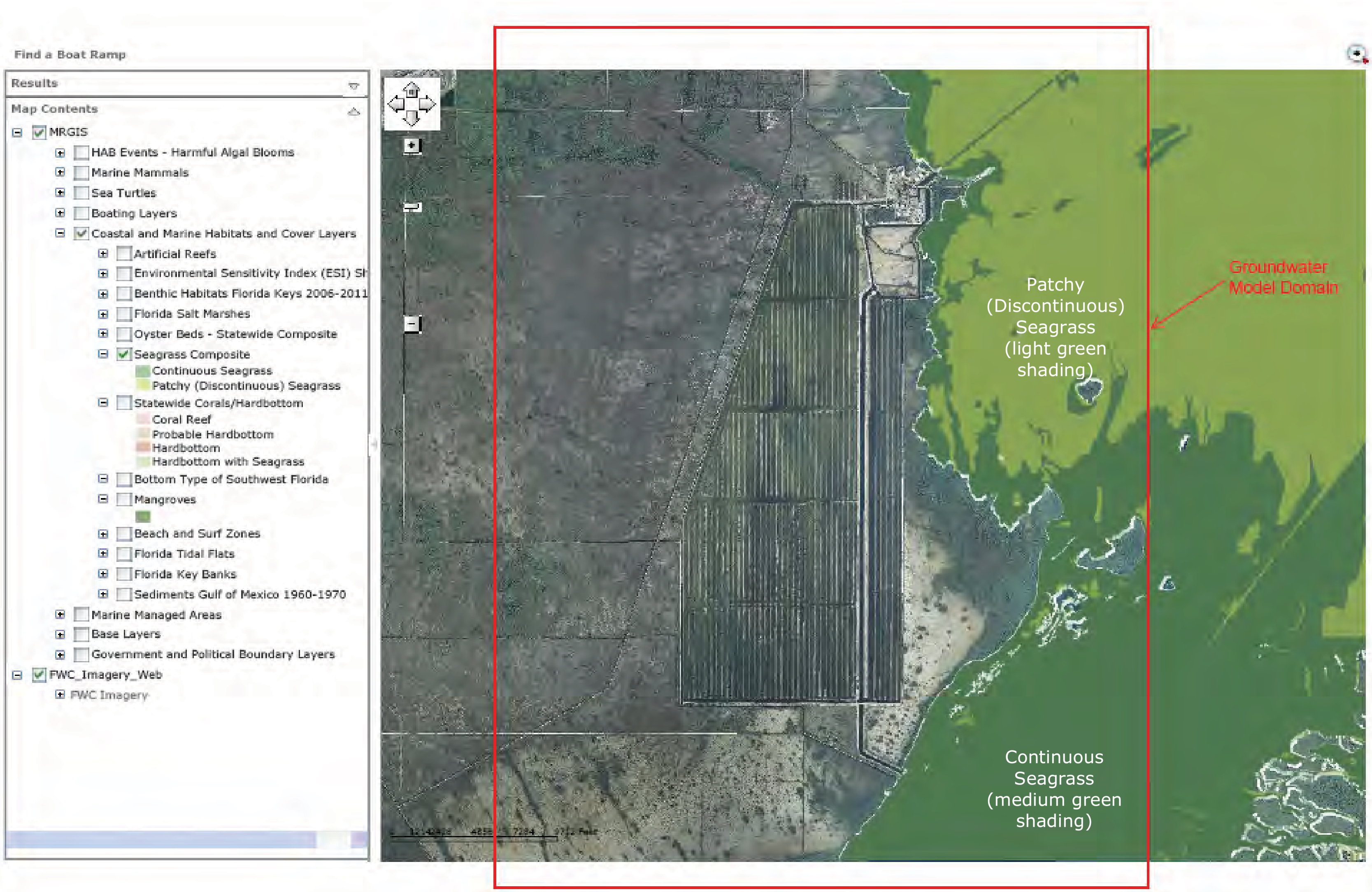
Table 1. Hydraulic Conductivity of Bay Floor Materials

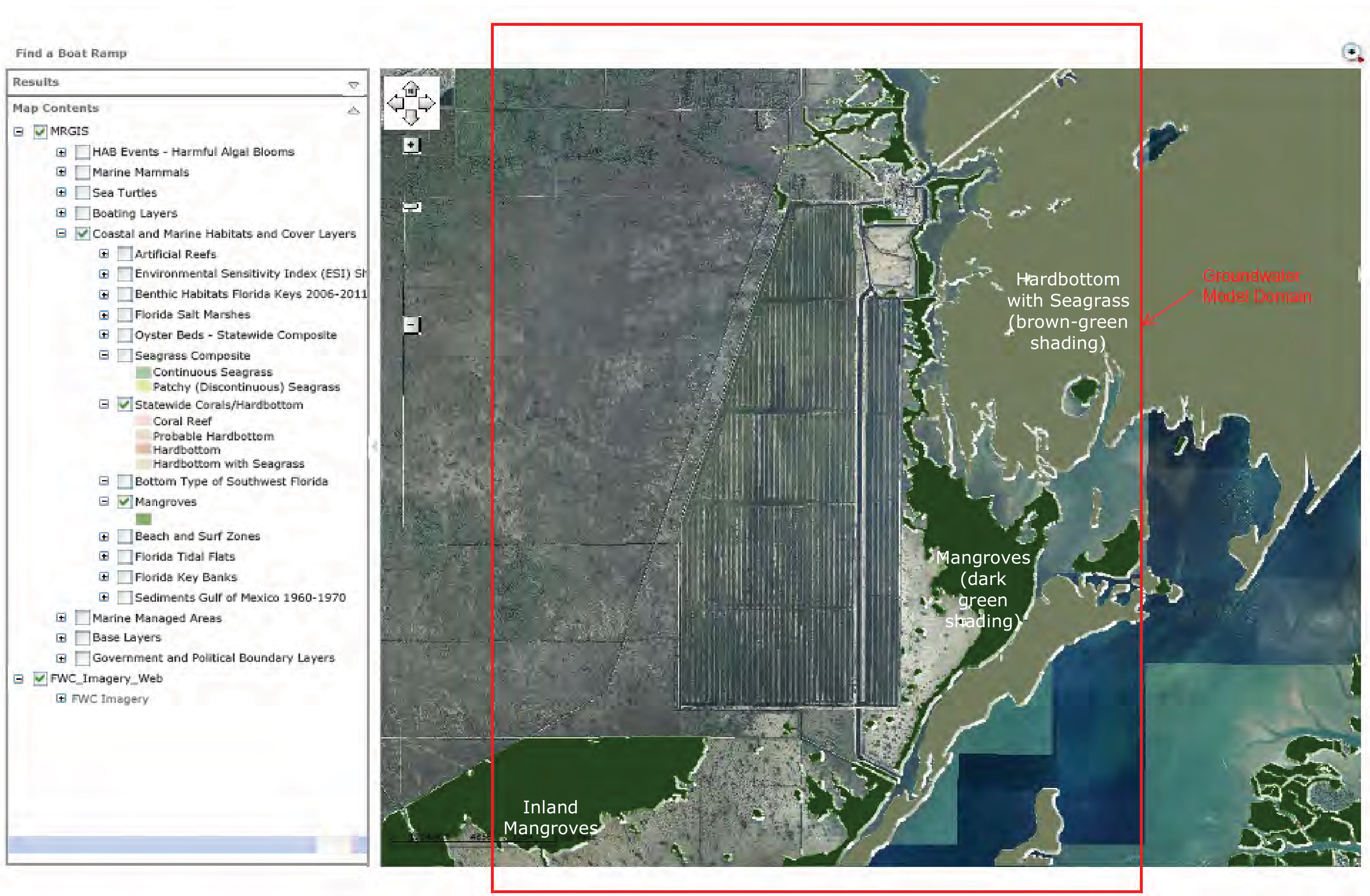
	Hydraulic Conductivity						Anisotropy
	(cm/s)		(m/day)		(ft/day)		Ratio
	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	(K_h/K_v)
FPL Groundwater Model							
Offshore Sediment	0.0353	0.00235	30	2	100	6.7	15
Miami Limestone	0.0882	0.00588	76	5	250	16.7	15
Langevin (2001) Biscayne Bay models							
Deering Estate cross-sectional model	1.2	0.12	1000	100	3281	328	10
Coconut Grove cross-sectional model	10	0.010	9000	9	29,527	30	1000
3-D model - peat & marl (south & northwest)	0.0035	0.000035	3	0.03	9.8	0.1	100
3-D model - central coast (center of model)	1.7	0.017	1500	15	4921	49	100
3-D model - majority of model	10	0.10	9000	90	29,527	295	100
Langevin et al. (2004) Everglades-Florida Bay model							
Florida Bay "hard-bottom areas"	--	0.00087	--	0.75	--	2.5	--
Florida Bay "sediment"	--	0.00012	--	0.1	--	0.3	--
Biscayne aquifer	5.8	0.00087	5000	0.75	16,404	2.5	6667
Hughes et al. (2010) Biscayne Bay model							
Case A "upper permeable unit"	12	0.12	10,000	100	32,808	328	100
Cases B and C "upper permeable unit"	1.2	0.012	1000	10	3281	33	100
Case D "upper permeable unit"	0.0012	0.00012	1	0.1	3.3	0.3	10

Figure 1. Extent of "Continuous Seagrass" and "Patchy (Discontinuous) Seagrass"



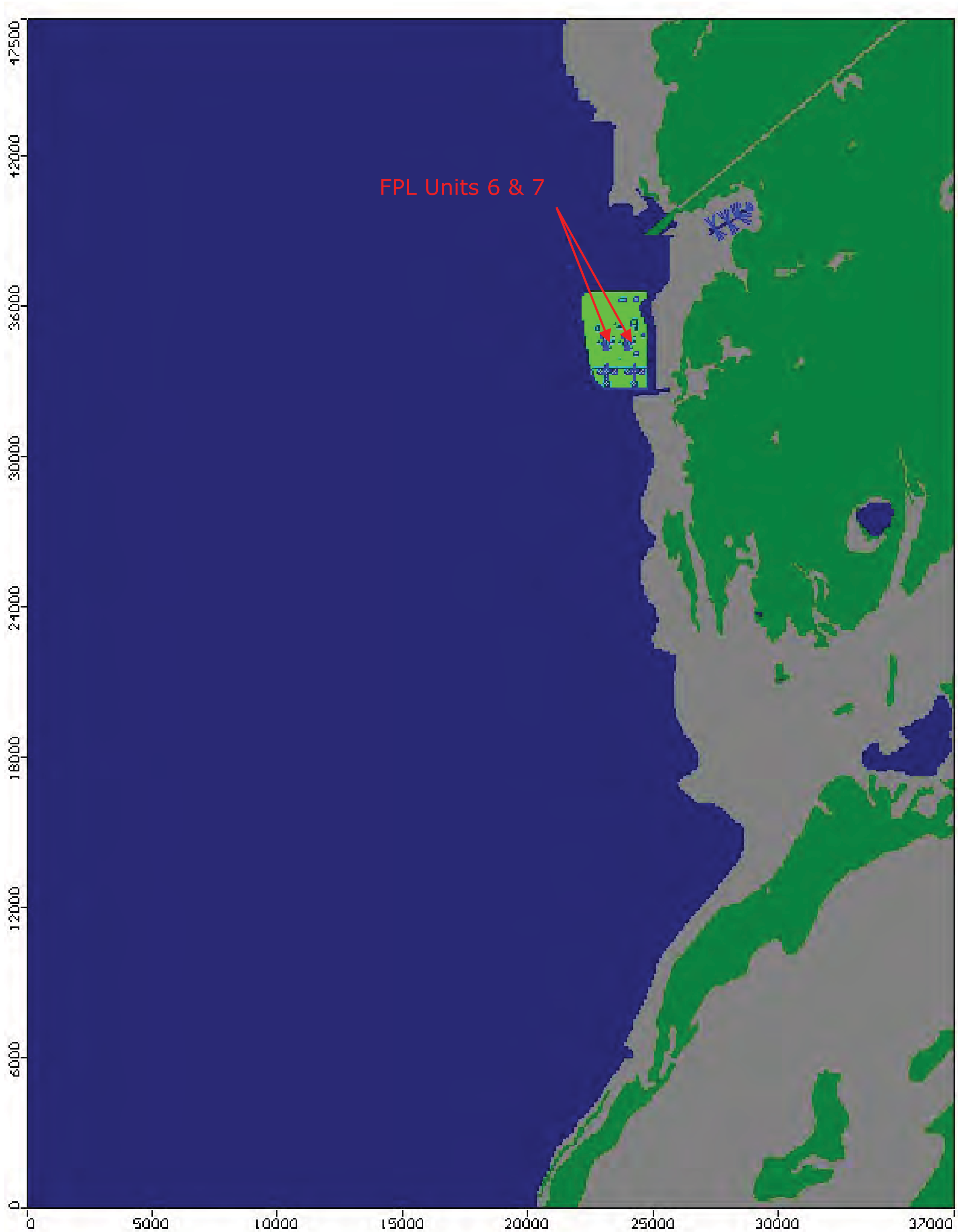
Source: Image is best available screen capture from FWRI (2012).

Figure 2. Extent of "Hardbottom with Seagrass" and "Mangroves"



Source: Image is best available screen capture from FWRI (2012).

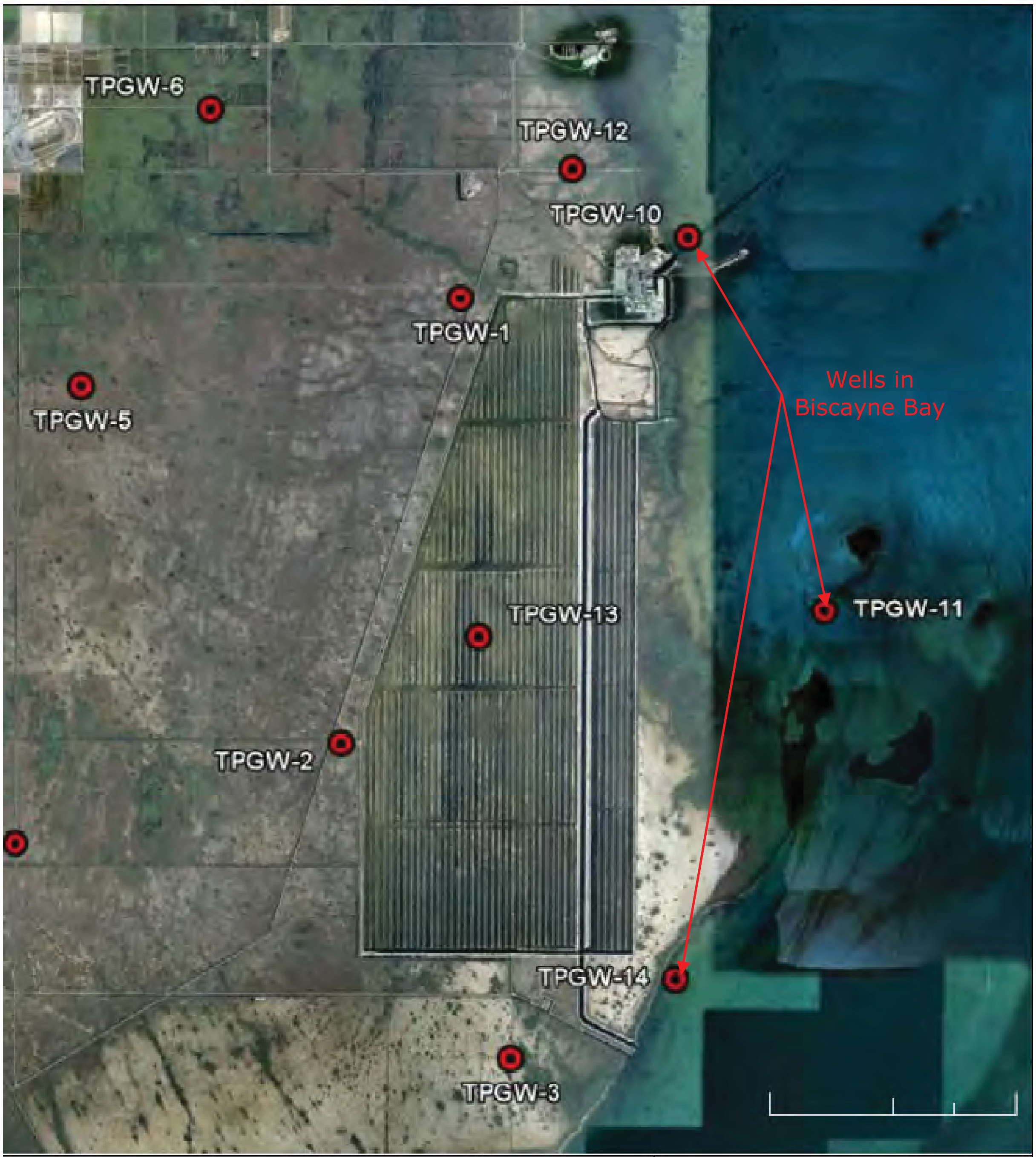
Figure 3. FPL Groundwater Model Layer 1 Material Zones



Notes: Blue = Muck. Green = Miami Limestone. Gray = Offshore Sediment. Area of image corresponds with the groundwater model domain.

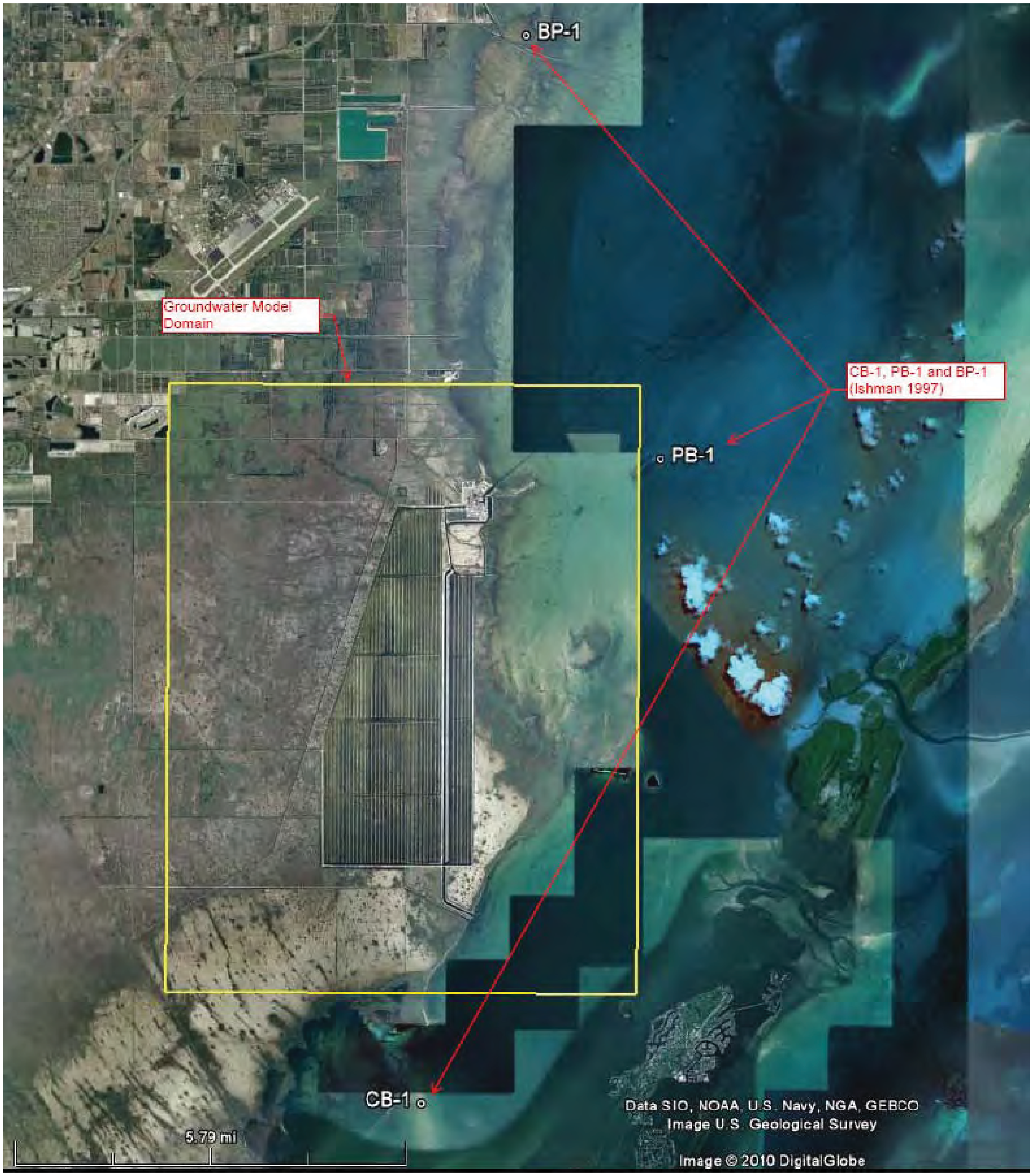
Source: Modified from FSAR Appendix 2CC, Figure 2CC-215.

Figure 4. Turkey Point Groundwater Monitoring Wells



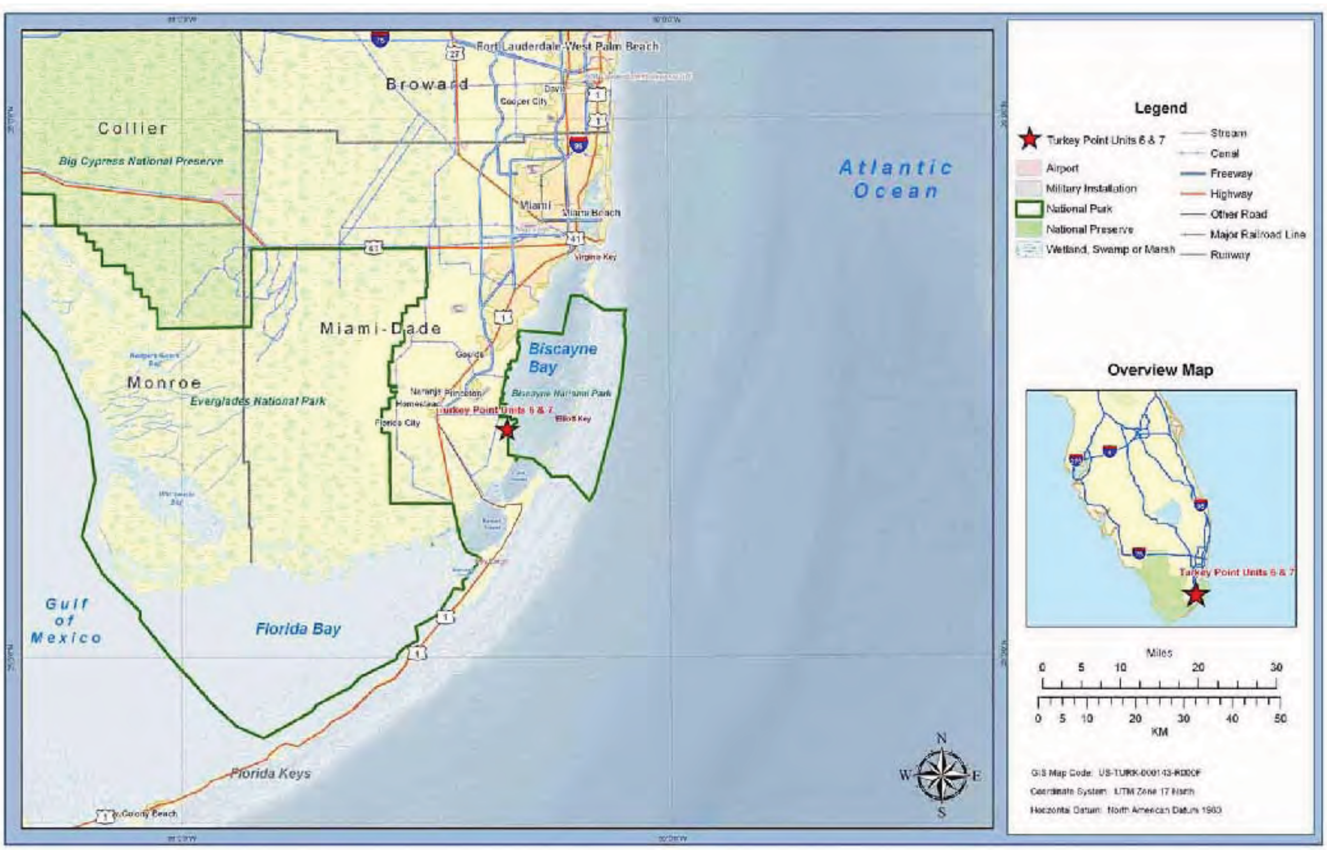
Source: Image cropped from Figure 1 in JLA (2010).

Figure 5. Biscayne Bay Core Locations BP-1, PB-1 and CB-1



Source: Core locations based on Table 1 in Ishman (1997).

Figure 6. Locations of Florida Bay and Biscayne Bay



Source: ER Figure 2.3-1.

Figure 7. Florida Bay Floor Photographs

Figure 7A. Hardbottom (Prager and Halley 1997)

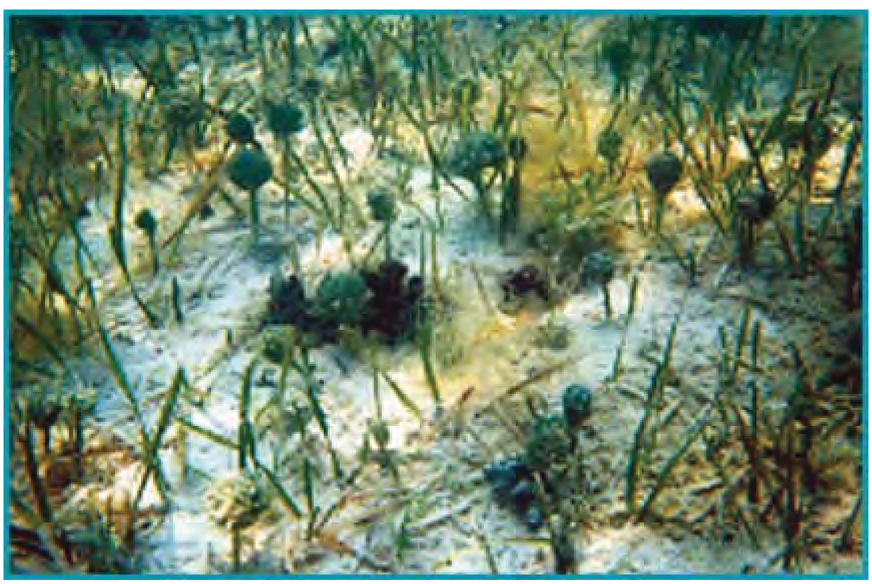


Figure 7B. Sparse Seagrass Cover (Prager and Halley 1997)

Figure 7. Florida Bay Floor Photographs

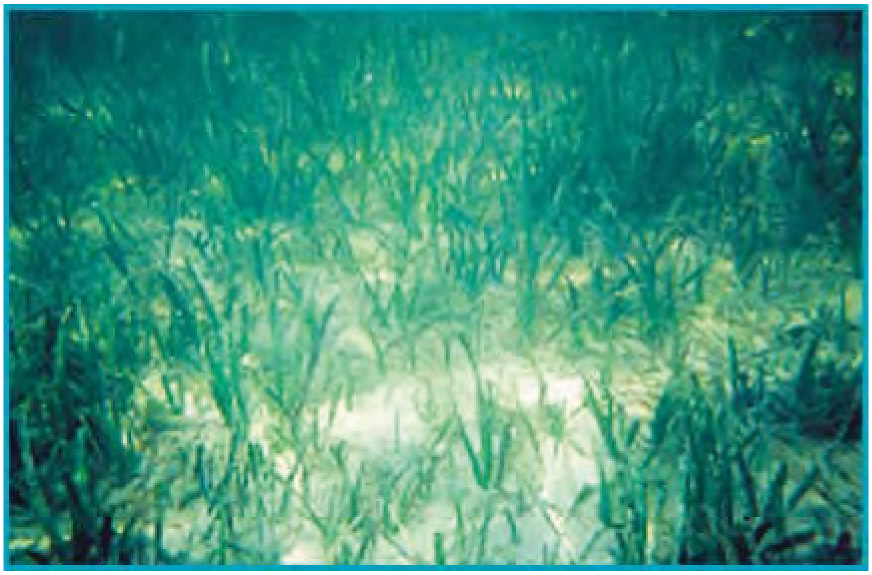


Figure 7C. Intermediate Seagrass Cover (Prager and Halley 1997)

Figure 7D. Dense Seagrass Cover (Prager and Halley 1997)

Figure 8. Biscayne Bay Floor Photographs

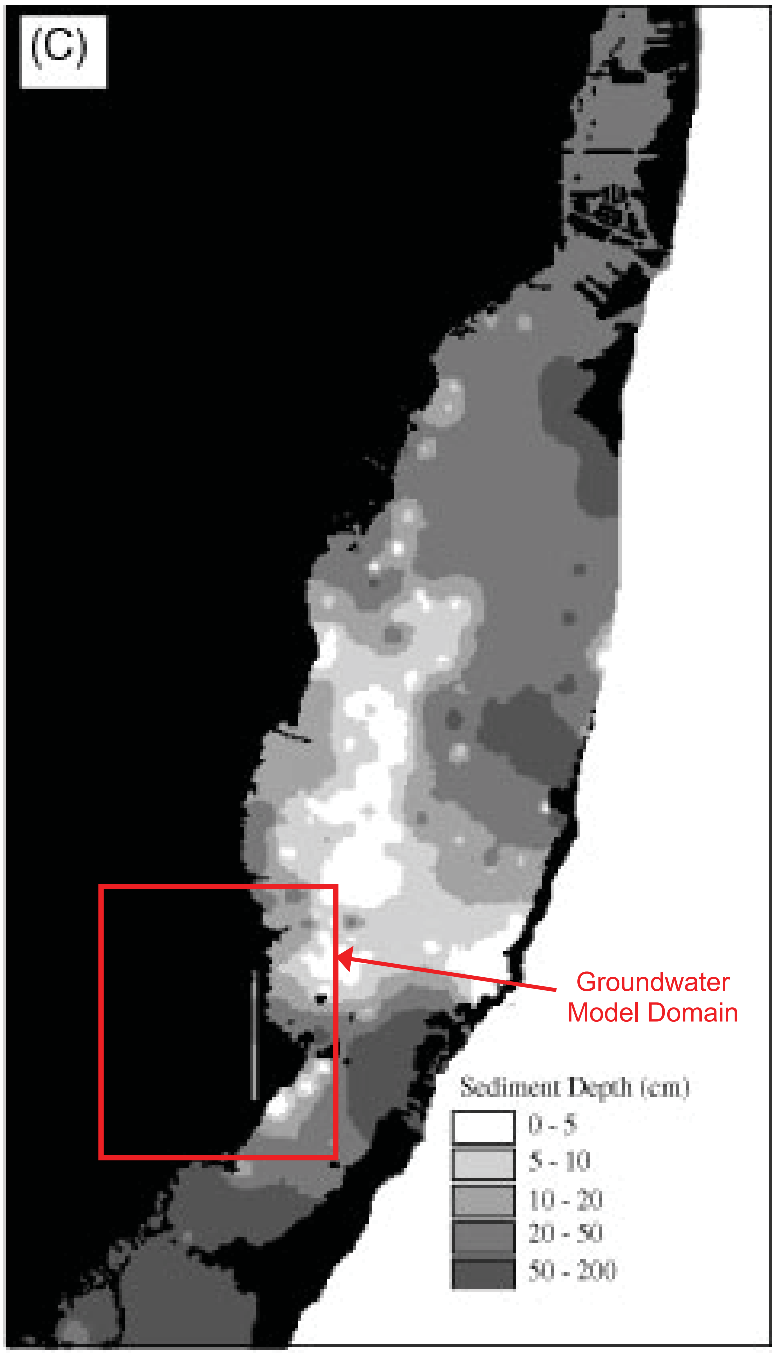
Figure 8A. Hard bottom (NPS 2012)

Figure 8B. Thalassia bed (Robles et al. 2005)

Figure 8. Biscayne Bay Floor Photographs

Figure 8C. Halodule bed (Robles et al. 2005)

Figure 9. Sediment Thickness



Note: “Sediment Depth” actually is sediment thickness.

Source: Image cropped from Figure 4 in Lirman et al. (2003).

ASSOCIATED COLA REVISIONS:

The text for FSAR Appendix 2CC, Subsection 5.2.3 will be changed in a future COLA revision as shown below:

> Two additional sensitivity runs were performed to assess the impact of the anisotropy ratio in Biscayne Bay on the radial collector well simulations. In the base model, an anisotropy ratio of 15:1 (Kh:Kv) is used. In the sensitivity runs, the vertical hydraulic conductivity (Kv) is either doubled or halved, producing anisotropy ratios of **7.5:1 and** 30:1~~ and 7.5:1~~, respectively. This change is only made offshore to the first three layers of the model, which represent the Miami Limestone (and a small area of sediment in layer 1).

The title name for FSAR Appendix 2CC, Table 2CC-206 will be changed in a future COLA revision as shown below:

> Model Calibration ~~PW-7L~~ – ~~Horizontal~~ Hydraulic Conductivity

This change also affects the Table of Contents:

> Table 2CC-206 Model Calibration ~~PW-7L~~ – ~~Horizontal~~ Hydraulic Conductivity

Reference 8 in FSAR Appendix 2CC will be changed in a future COLA revision as shown below:

> ~~U.S. Geological Survey (USGS), 2006. *Groundwater Characterization and Assessment of Contaminants in Marine Areas of Biscayne National Park.*~~**Reich, C., Halley, R.B., Hickey, T., and Swarzenski, P., 2006. Groundwater Characterization and Assessment of Contaminants in Marine Areas of Biscayne National Park, Technical Report/NPS/NRWRD/NRTR-2006/356. Available at: http://sofia.usgs.gov/publications/reports/bisc_gw_char/Bisc_gw_char.pdf, accessed May 17, 2012.**

Changes as a result of the revised groundwater flow model will be reflected in a future COLA revision.

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. 120329 Dated April 3, 2012

SRP Section: EIS 2.3.1 – Hydrology

Question from Environmental Project Branch 1 (RAP1)

NRC RAI Number: EIS 2.3.1-9 (eRAI 6354 Rev. 0)

Preface: The review team acknowledges the value of numerical models in hydrological analyses; however a single model scenario does not generally address all aspects of a hydrological impact assessment. Therefore, the review team considers all available models and performs an independent analysis in order to understand the patterns in the predictions that may be similar and those that might be dissimilar and to determine if such difference would result in a change in the impact assessment. Because of the inherent uncertainty in hydrologic models due to: measurement errors, sampling errors, conceptual model errors, non-uniqueness and the potential misapplication of the numerical model the review team does not make a determination based solely on results of a numerical model. Items 1 through 3 are to ensure that the review team understands how the applicant addressed the three classes of uncertainty mentioned above. Items 4 through 10 are to ensure that the review team understands that the three-dimensional finite-difference groundwater flow model (MODFLOW) was appropriately applied by the applicant.

EIS 2.3.1-9

Modeling of the radial collector well (RCW) system predicts approximately 2.2% (base case) of the 120 MGD produced by the RCW, or 2.64 MGD, will come from the Biscayne aquifer west of the RCW location. Describe how this flow rate compares to available estimates of wet season groundwater inflow to Biscayne Bay over the portion of the Biscayne Bay shoreline that will be influenced by drawdown from the RCW system.

FPL RESPONSE:

The following is addressed to compare wet season groundwater inflow to Biscayne Bay over the portion of Biscayne Bay shoreline that will be influenced by drawdown by the proposed radial collector wells (RCW) and the percentage of water collected by the RCWs that will originate from inland sources:

1. Shoreline influenced by the RCWs
2. Estimated groundwater discharge along shoreline influenced by the RCWs
3. Comparison of groundwater discharge to inland groundwater collected by the RCWs
4. Comparison as related to the local hydrologic conditions at Turkey Point Units 6 & 7

Shoreline Influenced by the RCWs

In this response, the length of shoreline influenced by the RCW system is defined by a significant change in estimated groundwater discharge into Biscayne Bay between conditions without RCW operation and with RCW operation. This distance can be estimated using the three-dimensional numerical groundwater flow model that was developed for the Florida Power & Light (FPL) Units 6 & 7 as described in the FSAR Appendix 2CC (Appendix 2CC). Current model results from the seasonal high water level simulation (which approximates wet season water levels in the aquifer, industrial wastewater facility [IWWF] or cooling canal system, regional canals, and bay) are available in the form of flux between layers, which represents Darcy flux (i.e., the rate at which groundwater moves vertically from one layer to another adjacent layer) in feet per day (ft/d). Figure 1 presents a side-by-side comparison for the flux of groundwater between model layers 1 and 2 for a case without RCW operation and a case with RCW pumping. Negative flux values signify an upward flux of groundwater (i.e., from model layer 2 to 1), which indicates groundwater flow towards surface water; positive flux values represent a downward flux.

Based on Figure 1, groundwater flux varies along the Biscayne Bay shoreline. Starting at the northern model perimeter and moving toward the south, Figure 1 indicates the following for the case without RCW operation:

- At the northern perimeter of the model domain, groundwater moves upward into Biscayne Bay.

- At a point along the shoreline a small distance north of the Turkey Point peninsula, the figure indicates a reversal in flux direction.

- South of the Turkey Point peninsula, along the shoreline adjacent to the IWF, groundwater continues to flow inland until a point at the southern end of the IWF where there is another reversal in flow direction. At the southern end of the IWF, near Card Sound Canal, groundwater, although at small flux rates, begins to flow again toward Biscayne Bay.

With the exception of an area localized around the Turkey Point peninsula, the conditions described above are generally equivalent for the case considering RCW pumping (see Figure 1).

As mentioned, the portion of shoreline influenced by RCW operation is defined as the length of shoreline along which there is a significant change in estimated groundwater discharge into Biscayne Bay between conditions without RCW operation and with RCW operation. Under conditions without the RCW system operating, the influenced shoreline north of the Turkey Point peninsula begins where groundwater flux values turn from positive to negative (i.e., where there is a reversal in flux direction). Thus, this length of shoreline begins at the point north of Turkey Point peninsula that corresponds to the intersection of the shoreline and the line of zero flux (see Figure 1) and extends north to a point where there is no significant change in groundwater flux to Biscayne Bay. The point at which the change in groundwater flux becomes insignificant can be determined by comparing the flux between layers in the area north of the Turkey Point peninsula for the case including RCW operation and the case excluding RCW operation. Figure 2 shows a side-by-side comparison of the flux between layers 1 and 2, both with and without RCW pumping, from the Turkey Point peninsula to the northern model perimeter.

For a comparison between the case with the RCWs operating and the case without the RCWs, several transects have been overlain on Figure 2. Each transect begins at the shoreline and runs approximately perpendicular to the flux contours. In some cases, the transects extend from the shore and terminate at the line of –0.01 flux (ft/d), rather than the line of zero flux. In these cases the line of zero flux is located a considerable distance from the –0.01 contour, does not accurately represent the band of groundwater discharge adjacent to the shoreline, and any groundwater discharge within this area is expected to be negligible. Using the flux contours and transect distances scaled from Figure 2, groundwater flux in cubic feet per day (ft^3/d) per foot of shoreline can be estimated for each transect; Table 1 presents these estimates. Because the transects for each case were placed in approximately the same locations, transects from the case without RCW pumping can be compared to the case with RCW pumping (e.g., transect 1 can be compared to transect 7) to determine the portions of shoreline along which groundwater flux significantly changes. The percent difference between comparable transects is shown in Table 1. Based on Table 1 estimates, there is significant change in groundwater flux to Biscayne Bay at the comparisons of transects 3 through 6 (RCWs off) with transects 9 through 12 (RCWs on), respectively. North of transect 3 (and transect 9), there is no significant change in groundwater flux. Therefore, the northern extent of the shoreline influenced by the RCWs is the point at which transect 3 intersects the shoreline.

Based on the above analysis, the length of RCW-influenced shoreline extends from the line of zero flux (under conditions without RCW operation) to the intersection of transect 3 with the shoreline. This section of shoreline is overlain on Figure 2 as dashed lines. Scaling the distance of shoreline that runs approximately perpendicular to the transects provides an estimate of length of influenced shoreline of approximately 4500 ft. This method of measuring the influenced shoreline ignores the east-west running shoreline, which is assumed to be perpendicular to groundwater flow.

Note that the area of influence in an unconfined aquifer, according to the South Florida Water Management District (SFWMD), is defined by the 0.1-foot drawdown contour (SFWMD 2010). For reference, the 0.1-foot drawdown contour for the Upper Higher Flow Zone layer (i.e., the layer in which the 0.1-foot contour extends farthest from the RCWs) under seasonal high water level conditions is shown in Figure 1.

Estimated Groundwater Discharge Along Shoreline Influenced by the RCWs

The discussion above describes the portion of shoreline influenced by the RCWs as approximately 4500 ft. Using the transects within this section of shoreline (transects 3 through 6 and 9 through 12), the total groundwater flux to the bay along this portion of shoreline can be determined by averaging the groundwater flux estimates and multiplying the average by the length of influenced shoreline. For the case with the RCWs off, the average groundwater flux is approximately 76 ft^3/d per foot of shoreline. For the case with the RCWs on, the average groundwater flux is approximately 39 ft^3/d per foot of shoreline. Over the 4500 feet of influenced shoreline, the total groundwater flux to Biscayne Bay is approximately 342,000 ft^3/d (2.6 million gallons per day [MGD]) and 174,000 ft^3/d (1.3 MGD) for the cases with the RCWs not operating and operating, respectively.

Several estimates of groundwater discharge to Biscayne Bay have also been reported in available literature. Langevin, in an initial report (Langevin 2001), uses field investigations and a regional-scale, variable-density, groundwater flow model to determine that the average rate of fresh groundwater discharge to Biscayne Bay under base case conditions over a 10-year period is approximately 2.2 x 10^5 cubic meters per day (using fixed initial salt concentrations) for the coastline of Biscayne Bay (i.e., 100 kilometers). In a subsequent journal article, Langevin (2003) reports a slightly higher base case average rate of 3.7 x 10^5 cubic meters per day (using spatially and temporally varying salt concentrations). In both cases, nearly 100 percent of the fresh groundwater discharge is reported to be to the northern half of the bay (north of control structure S-123) (Langevin 2001). Structure S-123 is approximately 13 miles north of the Turkey Point peninsula (as estimated from ER Figure 2.3-10). Additionally, Byrne (Langevin 2001) provides separately determined estimates of groundwater (i.e., including fresh, brackish, and saline groundwater) discharge to Biscayne Bay that range from 10 to 20 cubic meters per day per meter of coastline. These estimates, however, are based on regional hydrologic conditions that are not specific to those at Units 6 & 7. The use of site-specific estimates is therefore more appropriate; the literature estimates are not discussed further. The local hydrologic conditions are discussed later in this response.

Comparison of Groundwater Discharge to Inland Groundwater Collected by the RCWs

The question asks for a comparison of the estimated groundwater discharge over the portion of RCW-influenced shoreline to the amount of flow from the inland Biscayne aquifer that will be collected by the RCW system. The question also states that 2.64 MGD of the water collected by the RCWs will come from groundwater in the Biscayne aquifer west of the RCW location. The simulated total RCW system pumping rate is 86,832 gallons per minute (Appendix 2CC, Section 5.2) or approximately 125 MGD. The base case simulation predicts that approximately 97.8 percent (122.29 MGD) of the water collected by the RCW system will originate from boundaries representing Biscayne Bay. Of the remaining 2.2 percent, approximately 2.0 percent (2.5 MGD) will originate from the IWWF, and 0.2 percent (0.25 MGD) will originate from boundaries representing groundwater derived from recharge by precipitation west of Biscayne Bay. Percentages for the seasonal high water level case are slightly different than those for the base case. For the seasonal high water level simulation, approximately 98.1 percent (122.66 MGD), 1.8 percent (2.25 MGD), and 0.1 percent (0.13 MGD) of the RCW water will originate from Biscayne Bay, the IWWF, and boundaries representing groundwater from recharge by precipitation west of Biscayne Bay, respectively. Note that the RCWs are simulated in the FPL groundwater flow model as operating on a steady-state basis (i.e., 24 hours a day, 365 days a year). In actuality, the RCWs are only expected to be operated as a backup water supply. The percentages of RCW source water presented above are slightly different from Appendix 2CC, Table 2CC-211, and are based on updated modeling results. These changes will be reflected in a future COLA revision.

The groundwater flux to Biscayne Bay along the portion of RCW-influenced shoreline has been discussed above and volumetric estimates for cases without RCW operation and with RCW operation are estimated at 2.6 MGD and 1.3 MGD, respectively. These values are similar to the values presented above for the predicted contribution to the RCW system from inland sources, which are approximately 2.8 MGD for the base case and 2.4 MGD for the seasonal high water level simulation. In addition, the difference between the volumetric groundwater flux between RCWs operating and not operating is approximately 1.3 MGD, which is approximately half of the amount of water collected that will originate from inland sources and be collected by the RCW system.

<u>Comparison as Related to the Local Hydrologic Conditions at Turkey Point Units 6 & 7</u>

The comparison above indicates that the amount of groundwater flux to Biscayne Bay along the portion of RCW-influenced shoreline will be similar to the amount of groundwater that will originate from inland sources and be collected by the RCW system. This comparison considers total groundwater and does not distinguish between types of groundwater (e.g., fresh, saline, brackish). The relative importance of the above comparison is apparent when applied to local fresh groundwater conditions. Fresh groundwater conditions are considered because fresh groundwater is a resource constraint in the area; saline or saltwater resources are virtually unlimited. Fresh groundwater conditions at the Units 6 & 7 site and the effects on these conditions from the RCW system are described here based on the following items: FPL groundwater flow model results, the location of the freshwater-saltwater interface, the influence of the L-31E Canal and other regional canals, and the influence of the IWWF. Additional literature details are also provided.

The FPL groundwater flow model results, as discussed above, indicate that 1.9 percent of the water collected by the RCW system will originate from inland sources (for the seasonal high water level simulation). However, note that a very small percentage, 0.1 percent (0.13 MGD), will originate from freshwater sources, i.e., recharge by precipitation.

Locally, the Biscayne aquifer, which underlies Units 6 & 7, contains saline to saltwater and is not useable as a potable water supply (Environmental Report [ER] Subsection 2.3.1.2.1.2). The approximate location of the freshwater-saltwater interface is shown in ER Figure 2.3-23. The figure indicates that the saltwater interface at the base of the aquifer is approximately 6 to 8 miles inland of Units 6 & 7 (ER Subsection 2.3.1.2.1.3). Because the freshwater-saltwater interface is located several miles inland, and the aquifer at the site contains saline to saltwater, groundwater at the Units 6 & 7 site is predominantly brackish or saltwater.

With regard to regional canals, the L-31E Canal is located approximately 4 miles east of the salinity intrusion line and approximately 2 miles west of the Turkey Point peninsula (as estimated from ER Figure 2.3-23). A 2011 ecological sampling study was conducted for FPL (2011); sampling along transects located east of L-31E (i.e., F1 and F5) show little to no fresh groundwater at the surface compared to transects immediately west of L-31E (i.e., F2, F3, F4, and F6), which mostly show freshwater on the west side of the canal (FPL 2011, Figure 5.1-10; transect locations are shown in Figure 1.3-1). These sampling results indicate that L-31E intercepts a large portion of the eastward-flowing fresh groundwater, further limiting fresh groundwater flow toward Units 6 & 7. Another study using geochemical methods to investigate freshwater sources to Biscayne Bay indicates that a large percentage, approximately 37 percent (plus or minus 4 percent), of the regional canal water comes from groundwater (Stalker 2008), further demonstrating that the regional canals intercept a large portion of eastward-flowing groundwater. Consequently, lateral flow of fresh groundwater through the aquifer underneath Units 6 & 7 is limited.

In terms of the interaction of the RCWs with the freshwater regional canals, drawdown contours from the base case and sensitivity simulations (Appendix 2CC, Figures 2CC-246, 2CC-247, and 2CC-252 through 2CC-254) show that the RCW drawdown contours will not extend beyond the western extent of the IWWF and will not reach the Florida City Canal to the north (the location of the Florida City Canal is shown in ER Figure 2.3-14). The RCWs will thus not induce significant flow from the L-31E Canal, from any of the freshwater canals west of the L-31E Canal, from the Florida City Canal, or from areas north of the Florida City Canal. Freshwater transported to Biscayne Bay by the regional canals will therefore not be impacted by the RCW system.

Furthermore, the IWWF plays a significant role in the local hydrologic conditions at the site. Due to the circulating flow in the IWWF, water levels must be highest in the distribution canals on the west side of the IWWF and lowest in the return canals on the east side of the IWWF. The highest water levels are found in the plant discharge canal, and the lowest water levels are found near the power plant intakes. Water levels in the collection canal, at the south end of the IWWF, are approximately equal to local sea level (Golder 2008). Consequently, average water levels in the return canals must be at or below local sea level, while average water levels in the distribution canals must be at or above local sea level. Because the water levels in the canals nearest to Biscayne Bay are lower than the bay water level, a westward gradient causes seawater to flow from the bay through the surficial aquifer into the IWWF. This westward gradient is confirmed by the simulated potentiometric contours in Appendix 2CC, Figures 2CC-226 through 2CC-233, which show a potentiometric low in the area of the return canals directly south of Units 6 & 7.

On a basis including all of Biscayne Bay, fresh groundwater contributes approximately 2 percent and 1 percent of the total water input during the wet and dry seasons, respectively (Stalker 2008). Locally, at the easternmost extent of the Turkey Point peninsula, groundwater contributes approximately 3 percent of the total water input in the wet season and less than 0.5 percent of the total water input in the dry season (Stalker 2008, Figure 2.14). This study suggests that fresh groundwater plays a minimal freshwater role in the area at Turkey Point peninsula.

Langevin reports that, based on field investigations and a regional-scale groundwater flow model, nearly 100 percent of the fresh groundwater discharge occurs in the area north of structure S-123 (Langevin 2001 and 2003), which is approximately 13 miles north of the Turkey Point peninsula (see ER Figure 2.3-10). Based on Langevin's analysis, there is little to no fresh groundwater discharge to Biscayne Bay near Turkey Point peninsula.

The above discussion can be summarized as follows:

- A very small percentage, 0.1 percent, of the RCW-collected water will originate from groundwater derived from recharge by precipitation.
- The site is located several miles to the east of the freshwater-saltwater interface, indicating that groundwater at Units 6 & 7 is predominantly brackish to saltwater.
- Canal L-31E intercepts eastward-flowing fresh groundwater, which further limits the amount of fresh groundwater at the site.
- The IWWF creates a potentiometric low that induces groundwater flow from Biscayne Bay towards the IWWF.

- Fresh groundwater contributes a small percentage, between approximately 3 percent in the wet season and less than 0.5 percent in the dry season, of the total water input to the bay at the Turkey Point peninsula (Stalker 2008).

- Langevin (2001 and 2003) indicates that nearly 100 percent of the fresh groundwater discharge to Biscayne Bay occurs to the northern portion of the bay (i.e., more than approximately 13 miles north of the Turkey Point peninsula).

<u>Summary</u>

The above response has addressed the question in four separate parts as summarized below.

1. The portion of influenced shoreline can be determined as the length of shoreline along which the RCW system significantly changes the amount of groundwater discharge into Biscayne Bay as estimated using flux between model layers 1 and 2. This portion of shoreline is estimated at approximately 4500 ft and is shown in Figure 2.

2. The groundwater flux along this portion of RCW-influenced shoreline has been estimated using simulated flux between model layers 1 and 2 and is estimated at 2.6 MGD and 1.3 MGD for the cases without RCW operation and with RCW operation, respectively.

3. When the estimated groundwater flux to the Bay (both with and without RCW operation) is compared to the predicted amount of flow collected by the RCW system that will originate from inland sources (i.e., 2.38 MGD for the seasonal high water level case), the values are very similar.

4. The local conditions above describe that there is little to no fresh groundwater inflow to Biscayne Bay near the Turkey Point peninsula, suggesting that while the RCW system does alter the amount of groundwater discharge to Biscayne Bay, the RCW system will have negligible impact on fresh groundwater discharge to Biscayne Bay.

This response is PLANT SPECIFIC.

References:

1. FPL Turkey Point Annual Monitoring Report for Units 3 & 4 Uprate Project, August 2011. Available at http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/fpl_turkey_pt_2011_monitoring_rpt.pdf. Accessed July 23, 2012.

2. Golder Associates, Inc., 2008. *Cooling Canal System Modeling Report.* Available at http://publicfiles.dep.state.fl.us/Siting/Outgoing/FPL_Turkey_Point/Units_6_7/Completeness/Plant_Associated_Facilities/2nd_round_Completeness/FPL_Response_Part_A_Information/Attachments/2nd%20Round%20Attachments/Attachment%202SFWMD-B-40(33)_Cooling%20Canal%20System%20Report.pdf. Accessed May 24, 2012.

3. Langevin, C.D., 2001. *Simulation of Ground-Water Discharge to Biscayne Bay, Southeastern Florida*, U.S. Geological Survey, Water-Resources Investigations Report 00-4251.

4. Langevin, C.D., 2003. Simulation of Submarine Ground Water Discharge to Marine Estuary: Biscayne Bay, Florida, *Ground Water*, Vol. 41, No. 6, pp.758–771.

5. SFWMD, 2010. *Basis of Review for Water Use Permit Applications within the South Florida Water Management District*, March 18, 2010. Available at http://my.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/bor_wu.pdf. Accessed July 19, 2012.

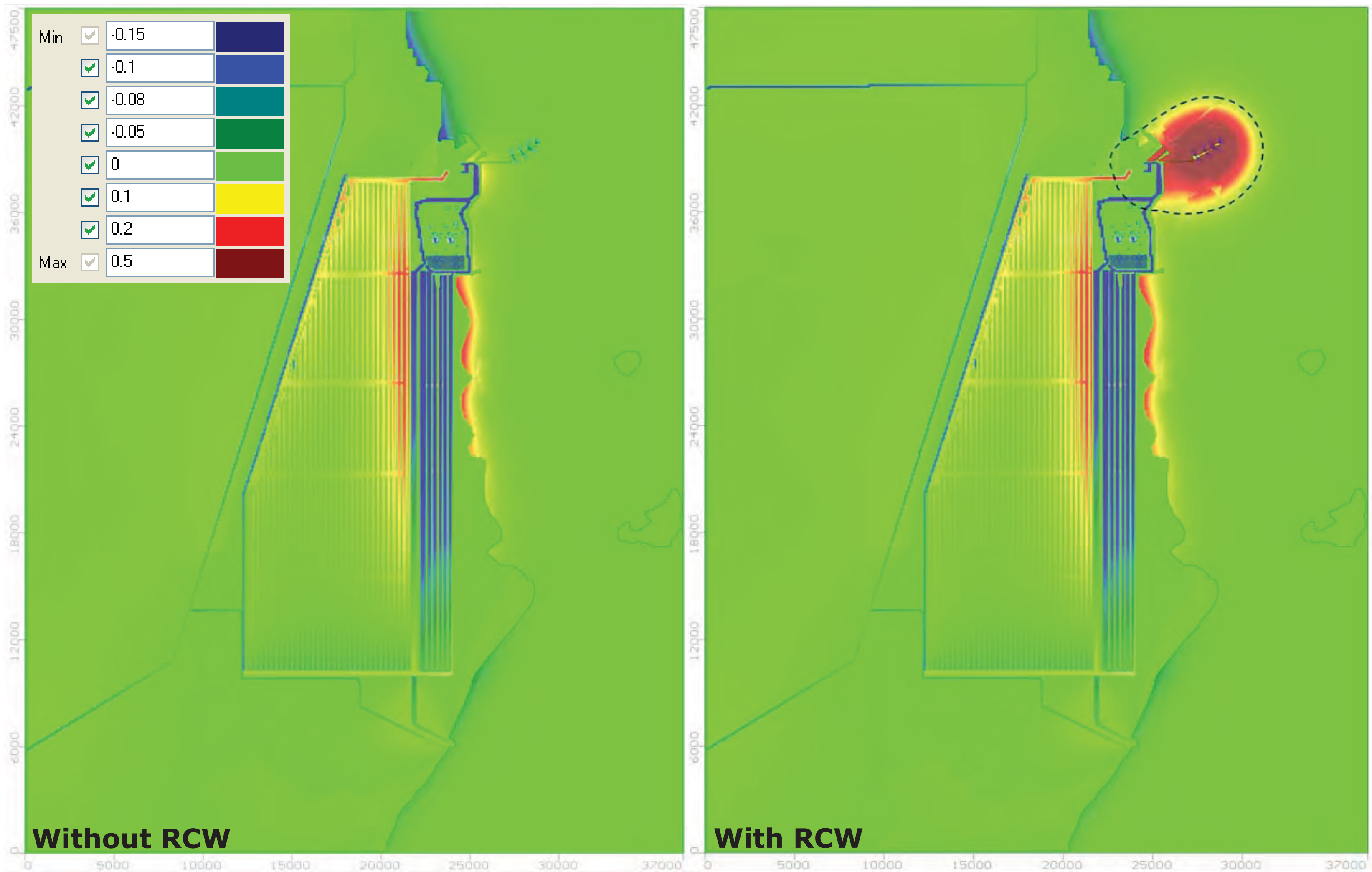
6. Stalker, J.C., 2008. *Hydrological Dynamics between a Coastal Aquifer and the Adjacent Estuarine System, Biscayne Bay, South Florida*. Dissertation, Florida International University.

Table 1. Flow per Unit Width of Shoreline

No RCW Pumping			RCW Pumping			
Transect	**Distance (ft)(1)**	**Flow per shoreline (ft^3/d/ft)**	**Transect**	**Distance (ft)(1)**	**Flow per shoreline (ft^3/d/ft)**	**Percent Difference(2)**
1	1682	63	7	1667	62	1%
2	1850	86	8	1842	86	0%
3*	1873	70	9*	1693	62	11%
4*	1397	41	10*	1468	28	30%
5*	1718	63	11*	1024	29	54%
6*	2392	130	12*	767	35	73%

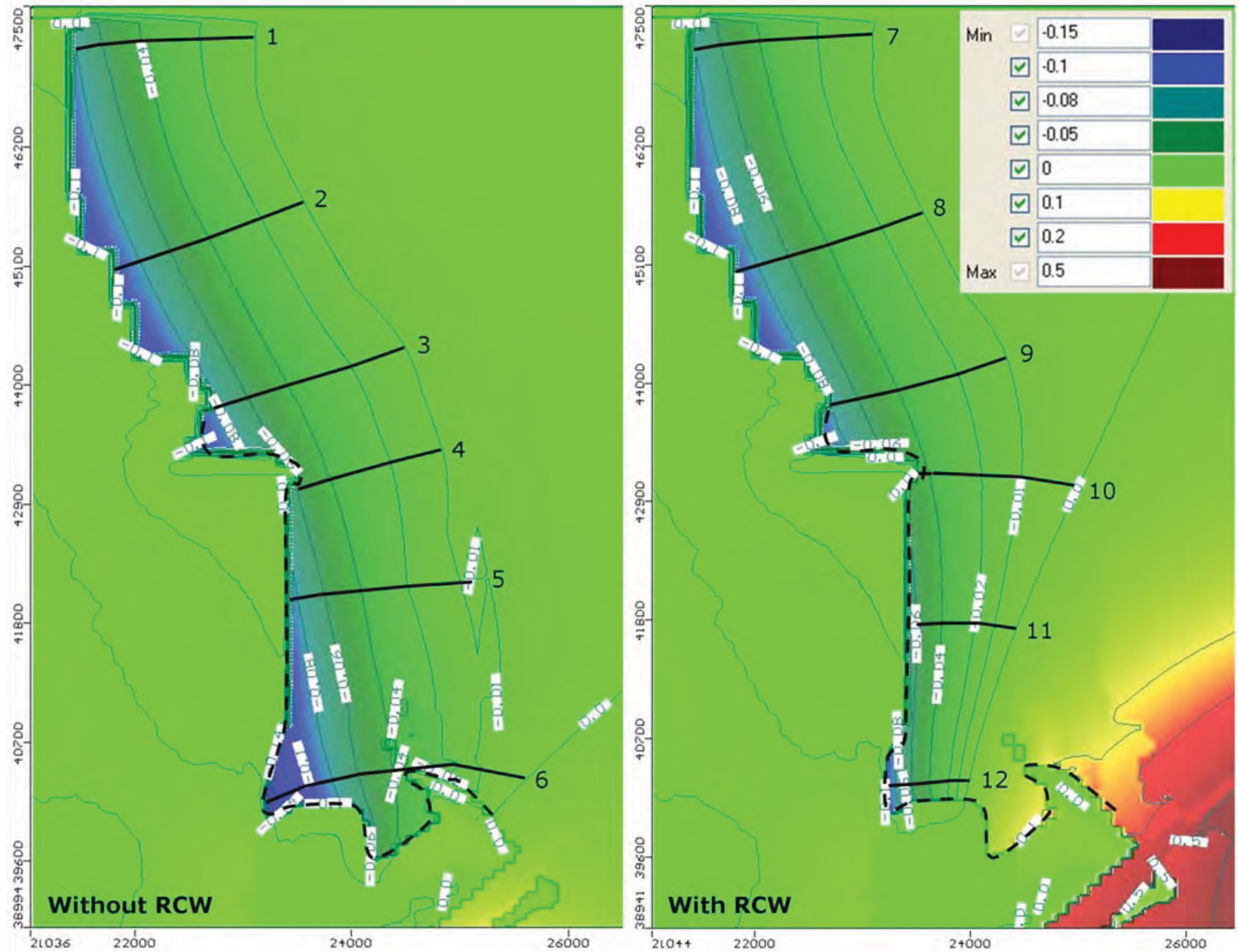
[1]The distances for each transect were scaled from Figure 2.
[2]The percent difference is calculated as:
([Flow per shoreline, No RCW pumping] – [Flow per shoreline, RCW Pumping]) / [Flow per shoreline, No RCW Pumping] * 100
*Transects within the section of shoreline influenced by RCW operation.

Figure 1. Flux Between Model Layers 1 and 2 (ft/day)



Notes: -Flux values are in ft/day.
-The figure displays results using the seasonal high water level conditions with model coordinates on the axes.
-The dashed line in the case with RCWs represents the 0.1-ft drawdown contour for the Upper Higher Flow Zone layer.

Figure 2. Flux Between Model Layers 1 and 2 – Shoreline North of Turkey Point Peninsula (ft/day)



Notes: -Flux values (contours) are in ft/day.
-The figure displays results using the seasonal high water level conditions with model coordinates on the axes.
-Black lines are transects, and the dashed line indicates the portion of influenced shoreline.

ASSOCIATED COLA REVISIONS:

Changes as a result of the revised groundwater flow model will be reflected in a future COLA revision.

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. 120329 Dated April 3, 2012

SRP Section: EIS 2.3.1 – Hydrology

Question from Environmental Project Branch 1 (RAP1)

NRC RAI Number: EIS 2.3.1-10 (eRAI 6354 Rev. 0)

Preface: The review team acknowledges the value of numerical models in hydrological analyses; however a single model scenario does not generally address all aspects of a hydrological impact assessment. Therefore, the review team considers all available models and performs an independent analysis in order to understand the patterns in the predictions that may be similar and those that might be dissimilar and to determine if such difference would result in a change in the impact assessment. Because of the inherent uncertainty in hydrologic models due to: measurement errors, sampling errors, conceptual model errors, non-uniqueness and the potential misapplication of the numerical model the review team does not make a determination based solely on results of a numerical model. Items 1 through 3 are to ensure that the review team understands how the applicant addressed the three classes of uncertainty mentioned above. Items 4 through 10 are to ensure that the review team understands that the three-dimensional finite-difference groundwater flow model (MODFLOW) was appropriately applied by the applicant.

EIS 2.3.1-10

Describe the impact on the existing groundwater users and reasonably foreseeable future groundwater users (at the end of the license period) of continuously removing the model predicted volume of water from the inland portion of the Biscayne aquifer for both the base case (2.64 MGD) and the "half vertical hydraulic conductivity" sensitivity case (5.64 MGD).

FPL RESPONSE:

There will be no significant adverse impact on existing groundwater users or on reasonably foreseeable future groundwater users within the licensing period from operation of the Radial Collector Wells (RCWs). The bases for this conclusion are explained in detail below. The focus of the explanation is on freshwater resources because availability of freshwater is a resource constraint in the area around Biscayne Bay; saline and saltwater resources are virtually unlimited.

1. The current and projected regional groundwater use in the vicinity of Units 6 & 7 is discussed in FSAR Section 2.4.12.2. The primary groundwater use in the county is for public water supply, followed by agricultural irrigation. In Miami-Dade County, fresh (chloride concentration less than or equal to 250 mg/L) groundwater is restricted to the Biscayne aquifer. FSAR Figure 2.4.12-213 shows the location of current fresh groundwater users in Miami-Dade County based on water use well permits filed with the South Florida Water Management District (SFWMD, 2011). The nearest permitted agricultural well is approximately 4 miles northwest and the nearest permitted public supply well is approximately 6 miles west of the Turkey Point peninsula, where the RCWs are located.

2. As discussed in ER Section 2.3 and as shown in ER Figure 2.3-23, the salt water intrusion line in the Biscayne Aquifer (i.e., the freshwater-saltwater interface at the base of the aquifer based on chloride concentration of 1000 mg/L) is located about 5 to 6 miles west of the Turkey Point peninsula. This line represents the practical eastward limit for current and future groundwater users that require fresh to slightly saline groundwater (i.e., public or agricultural supplies) because water treatment costs would be high. Consequently, there is very little likelihood that future groundwater users would construct water supply wells within 4 to 5 miles of the RCWs.

3. The L-31E canal is located approximately 3 to 4 miles east of the salinity intrusion line and approximately 2.0 miles west of the Turkey Point peninsula. Based on monitoring well data (FPL, August 2011), the fresh water layer near the surface becomes progressively thinner between the salinity intrusion line and the L-31E canal. West of the L-31E canal, fresh groundwater flows naturally toward the coast in a thin surface layer. Most of this groundwater is very likely intercepted by the L-31E canal and released to Biscayne Bay through other canals north and south of the Turkey Point peninsula. Based on pore water and ecological sampling data [Figure 5.1-10, transects F1 through F5, (FPL, August 2011)], a few feet of fresh water exists near the surface west of the L-31E canal, but very little or no fresh groundwater is observed near the surface east of the L-31E canal. This difference is also reflected in the wetland vegetation.

4. The RCWs are located seaward of the salinity transition zone. Sherif and Kacimov (June 2008) have demonstrated through numerical simulation using a variable-density finite-element transport model that pumping from the seaward side of the salinity transition zone does not adversely impact salinity intrusion.

5. The calibrated and verified groundwater model (FSAR Appendix 2CC, Rev 3) was used to calculate the drawdown in the aquifer caused by the RCWs. The results for the base case scenario are shown in Figures 2CC-246 and 2CC-247 for the top layer and the pumped layer, respectively. In an unconfined aquifer, the area of influence is typically defined (e.g., SFWMD March 18, 2010) by the 0.1 ft drawdown contour. For the base case scenario, the area of influence in both layers extends west approximately 1.0 mile from the center of the Turkey Point peninsula (i.e., the center of RCW pumping). To account for model uncertainty, a sensitivity analysis was conducted. Figure 2CC-253 (FSAR Appendix 2CC, Rev 3) shows the 0.1 ft drawdown contour in the top layer of the model for the half vertical hydraulic conductivity (½ Kv) scenario. For this scenario, the area of influence extends approximately 1.5 miles west from the center of pumping on the Turkey Point peninsula. In both cases, the area of influence is at least 0.5 mile east of the L-31E canal and at least 0.2 mile south of the Florida City canal that runs along Palm Drive. Therefore, the RCWs are not inducing significant flow from the L-31E canal, from any of the freshwater systems west of the L-31E canal, from the Florida City canal, or from coastal areas north of Palm Drive.

6. The amount of water that will be removed from inland areas is small. As shown in the groundwater modeling report (FSAR Appendix 2CC, Rev 3), for the base case scenario, the model predicted that a total of 2.2 percent of the water pumped by the RCWs would originate from inland areas (i.e., areas west of the Biscayne Bay shoreline). As a result of a revision to the groundwater model, the amount of water from inland sources has been

slightly revised: Of the 2.2 percent from inland areas, 2.0 percent (versus 1.9 percent in the current model) originates from the cooling canal system (CCS) and 0.2 percent (versus 0.3 percent in the current model) originates from inland boundaries other than the CCS (i.e., precipitation recharge boundaries). When the RCW pumping rate is 124.4 MGD, the flow to the RCWs from the CCS would be 2.49 MGD and the flow from other inland boundaries would be 0.249 MGD.

7. To account for model uncertainty, a sensitivity analysis was conducted. The half vertical hydraulic conductivity (½ Kv) scenario produced the greatest predicted flow from inland areas (see Table 2CC-211). Under this scenario, 3.2 percent (3.98 MGD) of the water originates from the CCS and 1.4 percent (1.74 MGD) from other inland areas.

8. FPL has proposed a 90-day restriction on the use of the RCWs (FPL, July 2011). The following paragraph describes the basis for the 90-day use restriction:

    For purposes of the Application, in order to be conservative, FPL modeled and included the results for the radial collector well system operating 24 hours per day, 365 days per year. However, the radial collector wells are in fact proposed solely as a backup water supply that will be used only when the MDC reclaimed water supply is not available in sufficient quantity or quality and for operational testing and periodic maintenance. FPL has proposed the concept of a use restriction consistent with that imposed for the FPL West County Energy Center (up to 90 days during a calendar year). It is anticipated that the final nature and limitations of a use restriction will be established by a condition of certification.

    Therefore, as presently proposed by FPL to the permitting authority, the annual average flow of water from inland areas will be no more than 25 percent of the amount shown in the groundwater modeling report (FSAR Appendix 2CC, Rev 3). Under the proposed restricted limits and based on the updated groundwater modeling results, the annual average flow from the CCS will be 0.62 to 1.00 MGD and the annual average flow from inland areas other than the CCS will be 0.06 to 0.44 MGD, if operated up to the proposed permit limitation mentioned earlier. If the reclaimed water system proves to be reliable, the amount pumped from the RCWs and their associated predicted flows could be significantly less than the proposed limits.

9. As shown above in Item 8, most of the water removed from inland areas originates from the CCS that is not a freshwater resource. Water from the CCS is hypersaline (above the salinity of sea water). CCS water is not a resource that could be used by current or future water users for potable supply, agricultural irrigation or for environmental benefit or restoration.

References:

1. SFWMD 2011, *Water Use Regulation Facility Site*. Available at http://my.sfwmd.gov/gisapps/sfwmdxwebdc/dataview.asp?query=unq_id=1576. Accessed January 12, 2011.

2. FPL Turkey Point Annual Monitoring Report for Units 3 & 4 Uprate Project, August 2011. Available at http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/fpl_turkey_pt_2011_monitoring_rpt.pdf. Accessed July 23, 2012.

3. FPL (July 2011). Responses to 5th Round SCA Completeness – Miami-Dade County, Plant and Associated Non-Transmission Facilities, FPL Turkey Point Units 6 & 7 Site Certification Application, Introduction, p.1, para.3. Available at http://publicfiles.dep.state.fl.us/Siting/Outgoing/FPL_Turkey_Point/Units_6_7/Completeness/Plant_Associated_Facilities/5th_Round_Completeness/. Accessed July 23, 2012.

4. Sherif, M. and Kacimov, A. (2008), "Pumping of Brackish and Saline Water in Coastal Aquifers: An Effective Tool for Alleviation of Seawater Intrusion"; *Proceedings of 20th Salt Water Intrusion Meeting*, *Naples, Florida*. pp. 254-257, June 23-27, 2008. Available at http://conference.ifas.ufl.edu/swim/papers.pdf. Accessed July 23, 2012.

5. SFWMD, March 18, 2010, *"Basis of Review for Water Use Permit Applications within the South Florida Water Management District"*. Available at http://my.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/bor_wu.pdf. Accessed July 23, 2012.

ASSOCIATED COLA REVISIONS:

No COLA changes have been identified as a result of this response.

Changes as a result of the revised groundwater flow model will be reflected in a future COLA revision.

ASSOCIATED ENCLOSURES:

None