FPL

L-2012-296
10 CFR 52.3

August 20, 2012

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-2012-304 to NRC dated July 31, 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 2.3.1-2 and EIS 2.3.1-6 provided in Reference 1. The schedule for this response was provided 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).

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 August 20, 2012.

Sincerely,

William Maher
Senior Licensing Director – New Nuclear Projects

D097
NRO

WDM/RFO

Attachment 1: FPL Response to NRC RAI EIS 2.3.1-2 (eRAI 6354 Rev. 0)
Attachment 2: FPL Response to NRC RAI EIS 2.3.1-6 (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 2.3.1-2 (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 2.3.1-2

Sampling errors result from the inadequate density, frequency, and duration of measurements used to characterize the environment. The density, frequency, and duration of measurements have been provided either indirectly or directly in the applicant's environmental report and security control assessor information. However, the applicant has not discussed the basis for their implicit assumption that potential sampling errors are not a plausible basis that might change the impact determination. The review team requests that the applicant discuss the basis for this assumption.

FPL RESPONSE:

For the purpose of this response, the "security control assessor information" referenced in the RAI is assumed to represent Site Certification Application (SCA) information. The term uncertainty, as used in this response, represents a qualitative assessment of the adequacy of density, frequency, and duration of measurements of hydrogeophysical data and is equivalent to sampling errors. FPL recognizes that all hydrogeophysical data are subject to sampling uncertainty and this uncertainty could change the impact determination if not addressed. The following discussion shows how FPL addressed sampling uncertainty to ensure the numerical model adequately evaluates site impacts. The impact of sampling uncertainty on the numerical modeling results is evaluated through a variety of techniques, including geostatistical data analysis, incorporation of geological interpretation, and sensitivity analyses. The following sections present discussions on how sampling uncertainty was addressed for geological data, boundary condition data, and calibration and validation of data.

Geological Data

The geologic interpretation presented in the groundwater model was developed based on the following:

- The hydrogeologic conceptual model was developed based on historical information at the FPL site and existing literature for southeastern Florida including the area covered by the model domain.
- FPL collected extensive subsurface data from numerous borings in the areas of interest for Units 6 & 7 and the Turkey Point peninsula.
- The FPL groundwater model was qualitatively compared with the recently performed Extended Power Uprate (EPU) borings (JLA Geosciences, Inc., 2010) for assessment of the model hydrostratigraphy.

Site specific and regional geological data and data collected specifically for Units 6 & 7 and the Turkey Point peninsula (proposed location of the Radial Collector Wells (RCWs)) were used to define the hydrostratigraphy, for the groundwater model. Sampling uncertainty associated with model layer definition is primarily related to the density of sample points rather than temporal variability. Density would include the horizontal distribution of boreholes and the vertical resolution in each borehole.

The hydrostratigraphic information was entered into a geostatistical kriging program to prepare elevation of top-of-layer maps for each model layer. These kriged surfaces were then compared to regional and local geologic interpretations to evaluate consistency with the conceptual model with regard to stratum thickness and extent. The areas of greater uncertainty were, in general, beyond the areas of interest at Units 6 & 7 and the Turkey Point peninsula, where a greater density of data were collected.

Model layer definition was based on the hydrostratigraphy developed in the conceptual model and subsequently modified by comments from local and state agencies during the SCA review process. These modifications provided a more robust model by incorporating local knowledge of the Biscayne aquifer from working practitioners. The information used to develop the hydrostratigraphy includes geotechnical, geophysical and geologic logs of onsite and offsite borings, and seagrass studies (FWRI 2010) in Biscayne Bay. Qualitatively, the onsite borings represent higher density (more closely spaced) data whereas the offsite borings represent lower density (more sparse) data. The information sources for these borings are discussed in the response to RAI EIS 2.3.1-1. The seagrass studies were used to determine the type of strata present in model layer 1 at the bottom of Biscayne Bay. Areas designated as continuous seagrass were interpreted to represent sandy bottom conditions, and areas designated as patchy seagrass or hard bottom with seagrass were interpreted to represent areas where the Miami Limestone outcrops. This approach is similar to that used by Langevin et al. (2005) in their modeling of groundwater discharge to Florida Bay. All dry land areas in Biscayne Bay and on the mainland, within the model domain, are interpreted to contain muck in model layer 1.

The EPU borings, as shown in Figure 1 and designated as TPGW wells (JLA Geosciences, Inc., 2010), were utilized for comparison with the model hydrostratigraphy. Stratigraphic data from these wells improved the offsite subsurface dataset and were used in the Turkey Point Units 6 & 7 groundwater flow model to qualitatively assess the thickness and extent of layers used in the model. Specifically, the thickness and extent of the Upper and Lower Higher Flow Zones were identified in these borings and compared to the conceptual model hydrostratigraphy, which was already incorporated into the model. The results of this comparison showed agreement between the conceptual model and the newer boring information. This comparison suggests that the boring density used in the conceptual model was sufficient to adequately characterize the subsurface conditions.

The uncertainty associated with geologic data used in the groundwater flow model was mitigated by:

- Extensive subsurface data from numerous borings in the area of interest for Units 6 & 7 and the Turkey Point peninsula.
- Use of ancillary information such as seagrass studies to supplement borehole information.
- Geostatistical techniques were used to interpolate layer information in areas of sparse information.
- Peer review and adjustment of conceptual model during SCA review by local experts.
- Comparison of conceptual model to recently acquired EPU data to evaluate robustness of conceptual model.

<u>Boundary Condition Data</u>

Boundary condition data used in the model includes surface water and groundwater heads. The sampling uncertainty associated with the surface water and groundwater heads used in the model include the uncertainty components of data density, collection frequency, and measurement duration. The boundary condition heads in the model domain included averaging short-term and long-term variations associated with tidal and seasonal fluctuations. Short-term transient conditions are not well represented in the steady-state groundwater flow model because average values are used. Long-term transient water level variation was evaluated through sensitivity analyses by changing average values specified in the model for the surface water boundary conditions. The sources of information for boundary condition heads are discussed in the response to RAI EIS 2.3.1-1.

Sensitivity cases were analyzed to determine the impact of seasonal high and low water levels in the bay on the operation of the RCWs. The results of the sensitivity analyses, as shown in Table 2CC-211 (FSAR Subsection 2.4.12 Appendix 2CC), indicate less than 1 percent difference in water contribution from landward water sources for the RCWs between the seasonal high and low levels and the average bay level (base case). Another analysis was performed to evaluate the impact of long-term sea level rise on post-construction site groundwater levels. A long-term sea level rise of 1 ft was assumed above the seasonal high bay level of 0.09 ft NAVD 88 (FSAR Subsection 2.4.12 Appendix 2CC Subsection 7.3). The results of the simulation, shown in Table 2CC-213 (FSAR Subsection 2.4.12 Appendix 2CC), indicate an insignificant impact on site groundwater levels as a result of long-term sea level rise.

The surface water system on the landward side of the model domain contains a series of control structures and pumping equipment that maintain water levels in the canals. Canal surface water heads used in the model include the L-31E canal, the interceptor ditch, and the Industrial Wastewater Facility (IWF). Other surface water features in the model include the Mowry Canal (C-103), located to the north of the site, and the Model Land Canal (C-107), located south of the site, which are represented by monitoring stations S20F and S20, respectively. As with the L-31E canal, these canal levels were obtained from the DBHYDRO database (SFWMD 2010) and represent long-term average water levels. For the sensitivity and post-construction sea level rise simulations, these surface water levels were proportionally increased or decreased, as appropriate, to maintain the same relationship to Biscayne Bay level.

Groundwater level information was used to establish the general head boundaries on the landward side of the groundwater model. Sources of groundwater level data are discussed in RAI EIS 2.3.1-1. Data for model domain wells that included groundwater level data in the DBYHDRO database (SFWMD 2010) were extracted from the database. A total of 45 wells distributed across the landward portion of the model domain were identified and used. Measurements from each well over multiple year periods were combined to determine a mean water level at the well. The mean water levels were used to create a potentiometric surface map representative of long-term average groundwater levels for the model domain. Water levels at the landward boundaries of the model were determined from the potentiometric surface and assigned as the head value for the general head boundary.

The uncertainty associated with boundary condition surface water and groundwater levels used in the groundwater flow model was mitigated by:

- The use of a steady-state approximation involving averaging frequently measured surface water and groundwater elevations monitored over multi-year durations to derive a long-term average level. This averaging diminishes the significance of individual measurements and their associated uncertainties.
- The potential for different impacts, other than those represented by the base case model for temporal surface water level variations, was addressed through sensitivity analysis.
- Surface water boundary conditions were linearly interpolated between measuring stations, which is justified because of minimal head losses within the canals due to the relatively flat South Florida topography.

<u>Calibration and Validation of Data</u>

Calibration of the groundwater flow model utilized three site-specific aquifer pumping tests in the area of interest, the IWF water balance, and matching of groundwater flow direction to regional maps using historical groundwater level information. Additional discussion of the calibration data may be found in the response to RAI EIS 2.3.1-5. Validation of the model was performed by comparing the results of a fourth site-specific aquifer pumping test to model output.

The aquifer pumping tests used for model calibration were the PW-7L (Fort Thompson Formation at unit 7), PW-1 (Key Largo Limestone at the proposed location of the RCWs), and PW-7U (Key Largo Limestone at unit 7) tests. The steady-state drawdowns from each test were used as calibration targets to adjust the hydraulic conductivity of model layers and the conductance of general-head boundaries until suitable agreement was obtained. The use of drawdown values as opposed to absolute water levels for the measured data mitigated the impact of individual sampling uncertainty associated with the transducer measurements. The transducers used for the tests are industry standard equipment calibrated by the manufacturer and were field verified against manual water level measurements.

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 test for the RCWs. The data density of observation wells used in the calibration includes the horizontal and vertical distribution of the wells. The PW-1 test has a horizontal well distribution biased toward the landward side of the pumping well to evaluate the affect of pumping on inland groundwater sources. Only one well was seaward of the pumping well to examine the impacts of the bay. The observation wells contain relatively long open intervals indicating low vertical data density; however the hydraulic conductivity contrast between the upper high flow zone and the surrounding materials causes the wells to behave as discrete interval wells as far as the water level response to pumping. Additional information on the test can be found in the HDR, 2009 aquifer performance test report. The PW-7U and PW-7L tests had a closely spaced network of observation wells that monitored discrete intervals within the aquifer. One of the objectives of these tests was to evaluate aquifer parameters for construction dewatering of Units 6 & 7.

The IWF water balance was determined using an analytical surface water model (Golder, 2008). This water balance includes the components of inflow to and outflow from the groundwater system to the IWF. The groundwater flow model can provide the same information. Comparison of the results indicates that the groundwater flow model has higher inflow and outflow rates to the groundwater system. The groundwater flow model results are approximately one-third higher than the analytical surface water model. This is considered an acceptable match since the surface water model is a simple analytical model.

Historical groundwater level information was used to qualitatively assess the model performance. Historical potentiometric surface maps from Dames & Moore (1971) and Langevin (2001) were compared against model-generated potentiometric surface maps. In general, the model captures the overall flow paths and directions shown in the historical data.

The model validation was accomplished using the PW-6U aquifer pumping test data. The steady-state drawdown measured from the test was compared to the model simulation of the test. The results of this comparison are discussed in FSAR 2.4.12 Appendix 2CC. Additional discussion of the model validation may be found in RAI EIS 2.3.1-5.

The uncertainty associated with calibration and validation of data used in the groundwater flow model was mitigated by:

- Calibration was accomplished using drawdown values rather than absolute water level measurements thus eliminating individual reading measurement uncertainty.
- Comparison with the IWF water balance indicates reasonable agreement between the groundwater flow model and the analytical surface water model.
- Comparison of the base case model results to independently developed potentiometric surfaces suggests the model is accurately reproducing the regional flow pattern.
- The validation comparison, suggests that the model is providing reasonable agreement with observed conditions.

Summary

The groundwater flow model was developed to estimate groundwater dewatering flow rates and the feasibility of the RCW system. The dewatering flow rate estimates are unlikely to be affected by sampling uncertainties since the excavation is an engineered system consisting of a diaphragm cut-off wall and a grouted rock bottom. The RCW system will be installed in a leaky aquifer system governed by the horizontal hydraulic conductivity of the aquifer and the vertical hydraulic conductivity of the leaky confining layer. These parameters were found to be sensitive during model calibration and thus are well represented in the model.

A suite of sensitivity analyses was performed on the RCW simulations to address parameter and water level uncertainty. For these simulations the RCW were pumped from the Upper Higher Flow Zone as the base case. Two sensitivity runs were performed to address the uncertainty in Biscayne Bay water levels. One case was run with Biscayne Bay set at the seasonal high water level, and another case was run at the seasonal low level. Two sensitivity runs were performed to assess the impact of the anisotropy ratio in the first three layers of the model, which in general represent the Miami Limestone. The vertical hydraulic conductivity was either doubled or halved from the base case. An additional set of sensitivity runs were performed to evaluate the impact of the hydraulic conductivity of the Key Largo Limestone, which is divided into two zones within the model. The Key Largo Limestone sensitivity runs were intended to determine if the difference in hydraulic conductivity between the zones results in any change in the induced flow to the RCWs. These sensitivity analyses are presented in FSAR Appendix 2CC, Tables 2CC-211 and 2CC-212. Table 2CC-211 presents sensitivity analyses for the origin of water percent contribution to the RCWs. The sensitivity analyses suggested less than a 3 percent change from the base case. Table 2CC-212 presents the approach velocity through the floor of Biscayne Bay with the RCWs operating. The sensitivity analyses suggest less than one-third order of magnitude change in the approach velocity from the base case. The results of these analyses indicate that the model is relatively insensitive to the selected parameters.

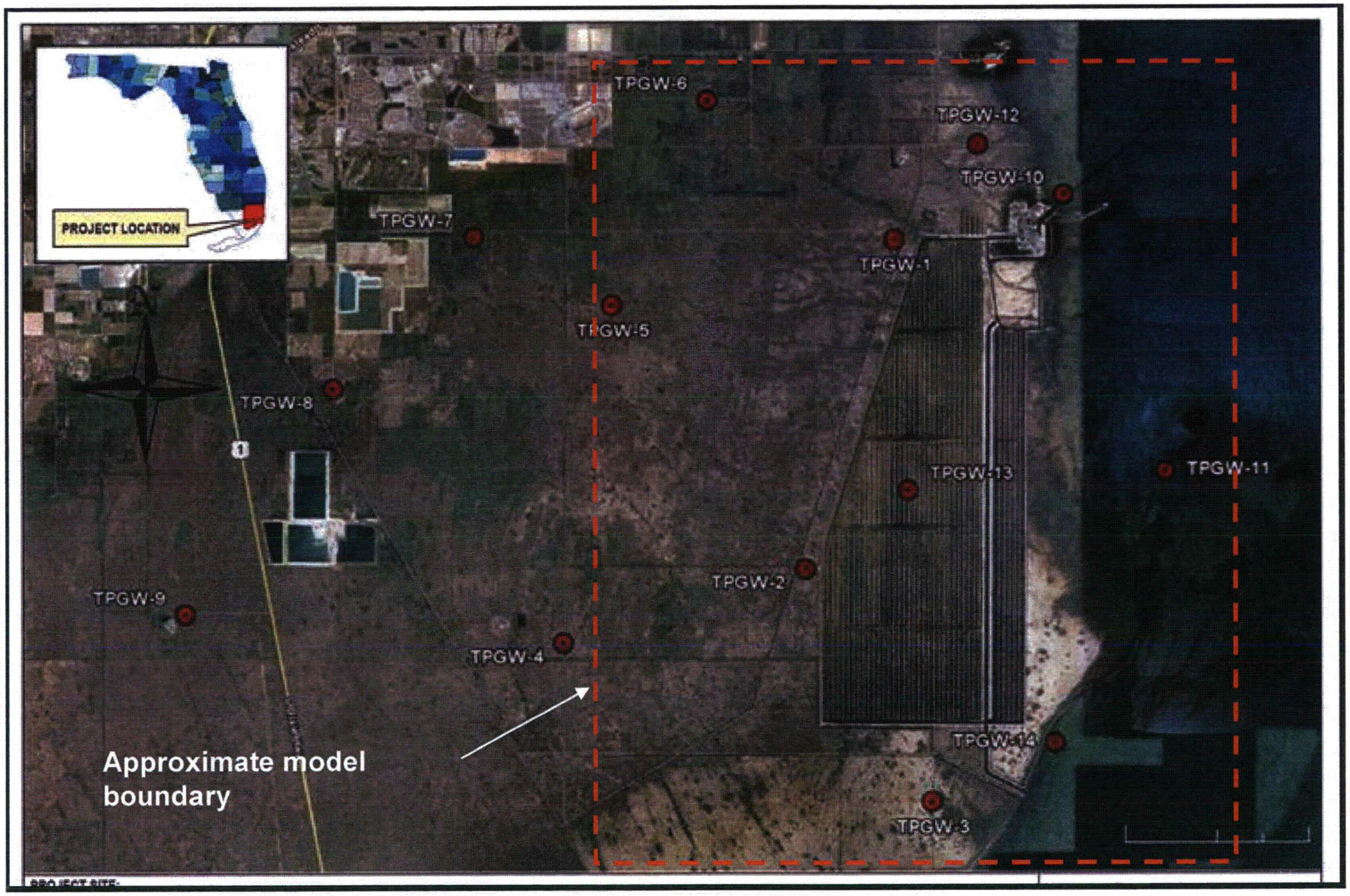
Sampling uncertainty associated with inadequate data density would include inadequate boring coverage for model layer development or inadequate water level coverage within the model domain. The uncertainty associated with inadequate boring coverage was evaluated by comparison of kriged surfaces to the conceptual model and incorporation of regional and local geologic interpretations to develop representative layers within the model. This layering was compared against published hydrostratigraphy and newly acquired subsurface data (TPGW wells) within the model domain. The results of this evaluation indicate that the model layering scheme is consistent with the conceptual model and published information.

Sampling uncertainty associated with the frequency and duration of measurements would primarily be associated with surface water and groundwater level measurements. Since the groundwater flow model is a steady-state model, average surface water and groundwater levels would provide the most representative input information for the model. The datasets represent data collected over multiple years and thus the averages would include effects of long-term fluctuations in levels.

The uncertainty that may arise due to inadequate density, frequency, and duration of measurements is evaluated in the FPL groundwater model through detailed examination of site specific geologic data; interpretation and peer review of the conceptual model by local experts during the SCA process; calibration and validation of the model using site specific pumping test data; and through a series of sensitivity analyses to account for long-term surface water fluctuations at the model boundaries. Based on the above approach it can be shown that the uncertainty associated with density, frequency, and duration of measurements of data used in the groundwater model will not change the impact determination.

This response is PLANT SPECIFIC.

Figure 1
Extended Power Uprate Monitoring Well Locations



Modified from JLA Geosciences Inc., 2010

References:

1. Dames & Moore, 1971. *Geohydrologic Conditions Related to the Construction of Cooling Ponds, Florida Power and Light Company, Steam Generating Station, Turkey Point, Florida*, Prepared for Brown and Root, Inc. 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/Brown%20and%20Root%20Report/, accessed June 4, 2012.

2. FWRI (Fish and Wildlife Research Institute), 2010. *Marine Resources Geographic Information System (MRGIS) GIS Data, Benthic Habitats – South Florida*, Florida Fish and Wildlife Commission (FWC). Available at http://ocean.floridamarine.org/mrgis/Description_Layers_Marine.htm, accessed June 4, 2012.

3. Golder Associates Inc. (Golder), 2008. *Cooling Canal System Modeling Report*, in Turkey Point Uprate Project Site Certification Application, Appendix 10.6, January 13, 2008. Available at http://publicfiles.dep.state.fl.us/Siting/Outgoing/FPL_Turkey_Point/Units%203_4/Application/FPL%20Turkey%20Point%20Uprate%20SCA.pdf, accessed June 8, 2012.

4. JLA Geosciences, Inc., 2010. *Geology & Hydrogeology Report For FPL Turkey Point Plant Groundwater, Surface Water, & Ecological Monitoring Plan*, prepared for Florida Power and Light Company. Available at http://my.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/fpl_tp_geo_and_h2ogeo_rept.pdf, accessed June 4, 2012.

5. Langevin, C., 2001. *Simulation of Groundwater Discharge to the Biscayne Bay, Southeastern Florida*, US Geological Survey Water-Resources Investigations Report 4251.

6. Langevin, C., Swain, E., and Wolfert, E., 2005. Simulation of integrated surface-water/ground-water flow and salinity for a coastal wetland and adjacent estuary, *Journal of Hydrology*, Vol. 314, pp. 212-234, doi:10.1016/j.jhydrol.2005.04.015.

7. SFWMD (South Florida Water Management District), 2010. *DBHYDRO Browser.* Available at http://my.sfwmd.gov/dbhydroplsql/show_dbkey_info.main_menu, accessed June 6, 2011.

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 2.3.1-6 (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 2.3.1-6

Describe how the conductance values and corresponding hydraulic conductivity values (and sediment thickness values where appropriate) were determined for:

a. the perimeter boundaries defined as "general head boundaries"

b. the "river package" boundary between Plant Discharge Canal and the Upper High Flow Zone (Model Layer 4)

c. the "river package" boundary representing the regional canals and the Interceptor Ditch

d. the general head boundary at the bottom of Biscayne Bay for each of the materials defined at this boundary (i.e., sandy sediment and rock)

FPL RESPONSE:

The response is provided in five parts beginning with a general description of how conductances are determined for general-head boundaries and river boundaries, followed by detailed descriptions of these boundary conductances:

- General-head boundary conductances for model perimeter
- River boundary conductances for Plant Discharge Canal and Upper Higher Flow Zone
- River boundary conductances for regional canals and the Interceptor Ditch
- General-head boundary conductances at the bottom of Biscayne Bay

General Description of How Conductances are Determined

For general-head boundaries, the general-head boundary conductance (C) is given by the following equation:

C = (L x W) x K / D (Schlumberger 2009, p. 257)

where the following parameters are used to calculate cell-by-cell conductances:

- Length (L) and width (W) of the model grid cell face (cell face that exchanges flow with a location external to the model)
- Hydraulic conductivity (K) of the material between the external boundary location and the model grid
- Distance (D) from external boundary location to model grid

For river boundaries, the boundary conductance (C) is given by the following equation:

C = (K x L x W) / M (Schlumberger 2009, p. 247)

where the following parameters are used to calculate cell-by-cell conductances:

- Vertical hydraulic conductivity (K) of riverbed material
- Length of river reach (L) through grid cell
- Width of river (W) in the grid cell
- Thickness of the riverbed (M)

Regarding river cell boundary conductances and the flow between surface water and groundwater, the MODFLOW-88 manual (McDonald and Harbaugh 1988) includes these comments:

> *This flow is in general a three-dimensional process, and its representation through a single conductance term can never be more than approximate. If reliable field measurements of stream seepage and associated head differences are available, they may be used to calculate an effective conductance. Otherwise, a conductance value must be chosen more or less arbitrarily and adjusted during model calibration... In general, however, it should be recognized that formulation of a single conductance term to account for a three-dimensional flow process is inherently an empirical exercise, and that adjustment during calibration is almost always required.*

For the FPL model, river cell conductances were adjusted during model calibration to match the cooling canal system water balance.

The groundwater model was developed in two phases: Phase 1 evaluated groundwater control options for construction and simulated the operation of a radial collector well (RCW) system, and Phase 2 included additional post-construction features. Phase 1 and Phase 2 models are described in FSAR Appendix 2CC. Revisions for the Phase 2 model include splitting the top model layer from Phase 1 into two layers, whereas the Phase 2 model has 15 layers and the

Phase 1 model has 14 layers. Cell parameter values used to calculate conductances in the examples below are from the numerical files for the Phase 2 model. Images shown in figures attached to this response are from the Phase 2 model.

General-Head Boundary Conductances for Model Perimeter

Model perimeter boundaries are shown in Figure 1. The cell width along the model perimeter is small relative to the model area, so the boundary cells appear as a narrow green-shaded band in Figure 1 around the model perimeter. The general-head boundary (GHB) package was used to simulate groundwater flow into and out of all sides of the model domain and for all model layers. The rationale for using this boundary package is that with the exception of Biscayne Bay, no water bodies representing fixed-water elevations exist. The benefit of using the GHB package for perimeter boundaries is that it permits extending boundary conditions outside of the numerical grid rather than expanding the numerical grid to coincide with natural boundaries.

To determine the general-head boundary conductance, the inland boundary distances were selected to coincide with the limit of available data for constructing the long-term groundwater level map. Boundary head values were selected using available data from observation wells in the Biscayne aquifer that were maintained by the U.S. Geological Survey and the South Florida Water Management District for the period between February 1 and May 31, 2009. Boundary head values applied to the general-head boundaries for calibration simulations (Phase 1 model) are as follows:

- Western boundary: varies linearly from +0.85 ft NAVD88 at north to -0.20 ft NAVD88 at south
- Eastern boundary: constant -1.05 ft NAVD88 at Biscayne Bay
- Northern boundary: varies linearly from +0.65 ft NAVD88 at west to -1.05 ft NAVD88 at Biscayne Bay
- Southern boundary: varies linearly from -0.95 ft NAVD88 at west to -1.05 ft NAVD88 at Biscayne Bay

The perimeter boundary distances (D) are assigned as follows (see Figure 1):

- Western boundary: D = 52,766 ft (western extent of available water level data)
- Eastern boundary: D = 2500 ft (along Biscayne Bay)
- Northern boundary: The Biscayne Bay coastline along this boundary is located at model grid x-coordinate of 21,500 ft. For cells inland of Biscayne Bay, D = 18,948 ft - X_i, x [(18,948 ft - 2500 ft) / 21,500 ft], where X_i is cell center coordinate in x-direction. For Biscayne Bay cells, D = 2500 ft.
- Southern boundary: The Biscayne Bay coastline along this boundary is located at model grid x-coordinate of 20,320 ft. For cells inland of Biscayne Bay, D = 12,512 ft - X_i x [(12,512 ft - 2500 ft) / 20,320 ft], where X_i is cell center coordinate in x-direction. For Biscayne Bay cells, D = 2500 ft.

To examine whether the selected boundary distances are either excessive or insufficient, simulation of regional flow direction and patterns is compared to potentiometric surface maps, as described in FSAR Appendix 2CC:

> *For matching of regional flow direction and patterns, simulated groundwater contours and levels were compared to potentiometric surface maps for the Biscayne Aquifer from May and November 1993 (Figure 2.4.12-219 and Figure 2.4.12-220). The intention of this is to qualitatively capture the overall flow paths and direction. Figure 2CC-226 through Figure 2CC-233 show the simulated heads for each of the hydrostratigraphic units, indicating a predominant flow direction from west to east, which is in agreement with Figure 2.4.12-219 and Figure 2.4.12-220.*

Based on that comparison, the boundary distances are considered acceptable.
For the general-head boundary along the western and eastern perimeters of the model, the east-west cell face is used for flow, while the north-south face is used for the general-head boundaries assigned to the northern and southern model perimeters. The cell face length (L) corresponds to the cell length along the model perimeter. The cell face width (W) corresponds to the cell height (model layer thickness) at the model perimeter. The horizontal hydraulic conductivity (K_h) of each perimeter cell is used for the boundary hydraulic conductivity (K) parameter.

As an example, the northern perimeter boundary cell in Model Layer 5 at Row 1 and Column 182 is in the Upper Higher Flow Zone, with x-coordinate for the cell center at 18,023 ft. The boundary distance is determined by linear interpolation:

$$D = 18{,}948 \text{ ft} - 18{,}023 \text{ ft} \times [(18{,}948 \text{ ft} - 2500 \text{ ft}) / 21{,}500 \text{ ft}] = 5160 \text{ ft}$$

Then, the calculated conductance is:

$$\begin{aligned} C &= (L \times W) \times K_h / D \\ &= [(100 \text{ ft} \times 1 \text{ ft}) \times 29.6712 \text{ cm/s} \times (2835 \text{ ft/day} / 1 \text{ cm/s})] / 5160 \text{ ft} \\ &= 1630 \text{ ft}^2\text{/day} \end{aligned}$$

<u>River Boundary Conductances for Plant Discharge Canal Boundary and Upper Higher Flow Zone</u>

The extent of the Plant Discharge Canal is identified in Figure 2A. River boundary cell locations in Model Layer 1 and Model Layer 5 (Upper Higher Flow Zone) are shown in Figures 2B and 2C, respectively, for the Plant Discharge Canal. Additional river boundary cells are located in Model Layers 1 through 6 of the Phase 2 model (and Model Layers 1 through 5 of the Phase 1 model). Figure 2D shows river boundary cells in Model Layer 5 (Upper Higher Flow Zone) for the cooling canal system.

The vertical hydraulic conductivity (K_v) of material accumulated in the bottom of the Plant Discharge Canal (and all other canals) was initially assumed to be 1E-05 cm/s in the Phase 1 model. For the Phase 2 revisions, the top model layer from Phase 1 was split into two layers, and the K_v for river boundary cells in Model Layers 1 and 2 was adjusted during calibration and reduced to 3.57E-06 cm/s to better match the cooling canal system water budget.

The horizontal length and width of model cells within the canal are used for the river reach (L) and river width (W) for the river boundary.

A riverbed thickness (M) of 0.1 ft of sediment is assumed to have accumulated in the Plant Discharge Canal (and all other canals).

For example, the calculated conductance for the river boundary cell in Model Layer 5 (Upper Higher Flow Zone) at Row 163 and Column 203 is:

$$C = (K_v \times L \times W) / M$$
$$= [1.0\text{E-05 cm/s} \times (2835 \text{ ft/day} / 1 \text{ cm/s}) \times 100 \text{ ft} \times 97.94 \text{ ft}] / 0.1 \text{ ft}$$
$$= 2777 \text{ ft}^2\text{/day}$$

For river cell conductances at a given model row and model column, the same values for river reach (L), river width (W), and riverbed thickness (M) were applied for each Model Layer intercepted by a given canal. Only the vertical hydraulic conductivity was varied between layers, as mentioned above.

River Boundary Conductances for Regional Canals and the Interceptor Ditch

The locations of regional canals and the Interceptor Ditch are shown in Figure 3. The approach to estimating the river cell boundary conductances for these features is the same as that described in Part (3).

The vertical hydraulic conductivity (K_v) of material accumulated in the bottom of the regional canals and the Interceptor Ditch was initially assumed to be 1E-05 cm/s in the Phase 1 model. For the Phase 2 revisions, the top model layer from Phase 1 was split into two layers, and the K_v for river boundary cells in Model Layers 1 and 2 was adjusted during calibration and reduced to 3.57E-06 cm/s to better match the cooling canal system water budget.

The horizontal length and horizontal width of model cells within the regional canals and Interceptor Ditch are used for the river reach and river width for the river boundary.

A riverbed thickness (M) of 0.1 ft of sediment is assumed to have accumulated in the regional canals and Interceptor Ditch.

For example, the calculated conductance for the river boundary cell along the Interceptor Ditch in Model Layer 6 at Row 302 and Column 149 is:

$$C = (K_v \times L \times W) / M$$
$$= [1.0\text{E-5 cm/s} \times (2835 \text{ ft/day} / 1 \text{ cm/s}) \times 97.94 \text{ ft} \times 100 \text{ ft}] / 0.1 \text{ ft}$$
$$= 2777 \text{ ft}^2\text{/day}$$

For river cell conductances at a given model row and model column, the same values for river reach (L), river width (W), and riverbed thickness (M) were applied for each model layer intercepted by a given canal. Only the vertical hydraulic conductivity was varied, as mentioned above.

General-Head Boundary Conductances at the Bottom of Biscayne Bay

Biscayne Bay is conceptualized as a general-head boundary at the top of Model Layer 1 to represent the exchange of water between the bay and the underlying hydrogeologic unit (see Figure 4). The model underwent a peer review by various state and local agencies for the Site Certification Application, and boundary conditions were revised based on some of the agencies' suggestions for the final calibrated model.

For general-head cells in Biscayne Bay, the top/bottom face is used, so the L and W correspond to the model cell horizontal length and horizontal width.

The vertical hydraulic conductivity (K_v) for each cell in Model Layer 1 beneath Biscayne Bay is used for the boundary hydraulic conductivity parameter. The materials beneath Biscayne Bay in Model Layer 1 are either the Miami Limestone with vertical hydraulic conductivity (K_v) of approximately 0.0059 cm/s or the Offshore Sediment with K_v of approximately 0.0024 cm/s (FSAR Appendix 2CC, Table 2CC-206).

The boundary distance (D) is determined as one-half of the model layer thickness at each cell (corresponding to the vertical distance from the bottom of Biscayne Bay to the cell center). For example, the Biscayne Bay boundary cell in Model Layer 1 at Row 192 and Column 356 is in Offshore Sediment with a cell thickness of 1.75 ft, and the calculated conductance is:

$$\begin{aligned} C &= (L \times W) \times K_v / D \\ &= [(97.94 \text{ ft} \times 50 \text{ ft}) \times 0.00235185 \text{ cm/s} \times (2835 \text{ ft/day} / 1 \text{ cm/s})] / (1.75 \text{ ft} / 2) \\ &= 37{,}315 \text{ ft}^2\text{/day} \end{aligned}$$

This response is PLANT SPECIFIC.

References:

1. McDonald, Michael G., and Arlen W. Harbaugh, 1988. *Chapter A1 – A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model*, Techniques of Water-Resources Investigations of the U.S. Geological Survey, Book 6, Modeling Techniques. Available at http://pubs.usgs.gov/twri/twri6a1/pdf/TWRI_6-A1.pdf, accessed June 13, 2012.

2. Schlumberger Water Services, 2009. *Visual MODFLOW Professional v.2009*, User's Manual.

3. Chiang, Wen-Hsiang, 2005. *3D-Groundwater Modeling with PMWIN: A Simulation System for Modeling Groundwater Flow and Transport Processes*. Springer-Verlag, Berlin.

Figure 1. General-Head Boundaries along Model Perimeter

Note: D = boundary distance and x = model grid x-coordinate.

Figure 2A. Extent of Plant Discharge Canal

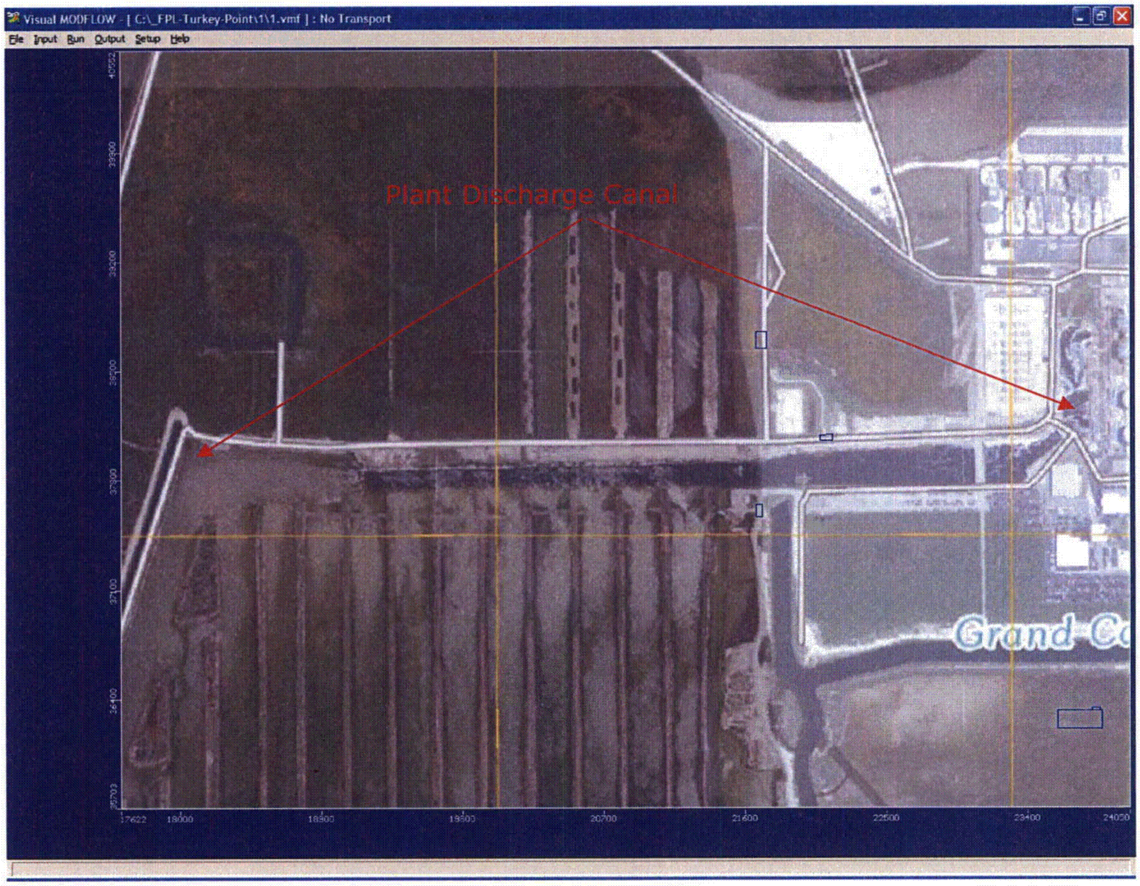


Figure 2B. River Boundary Cells in Model Layer 1

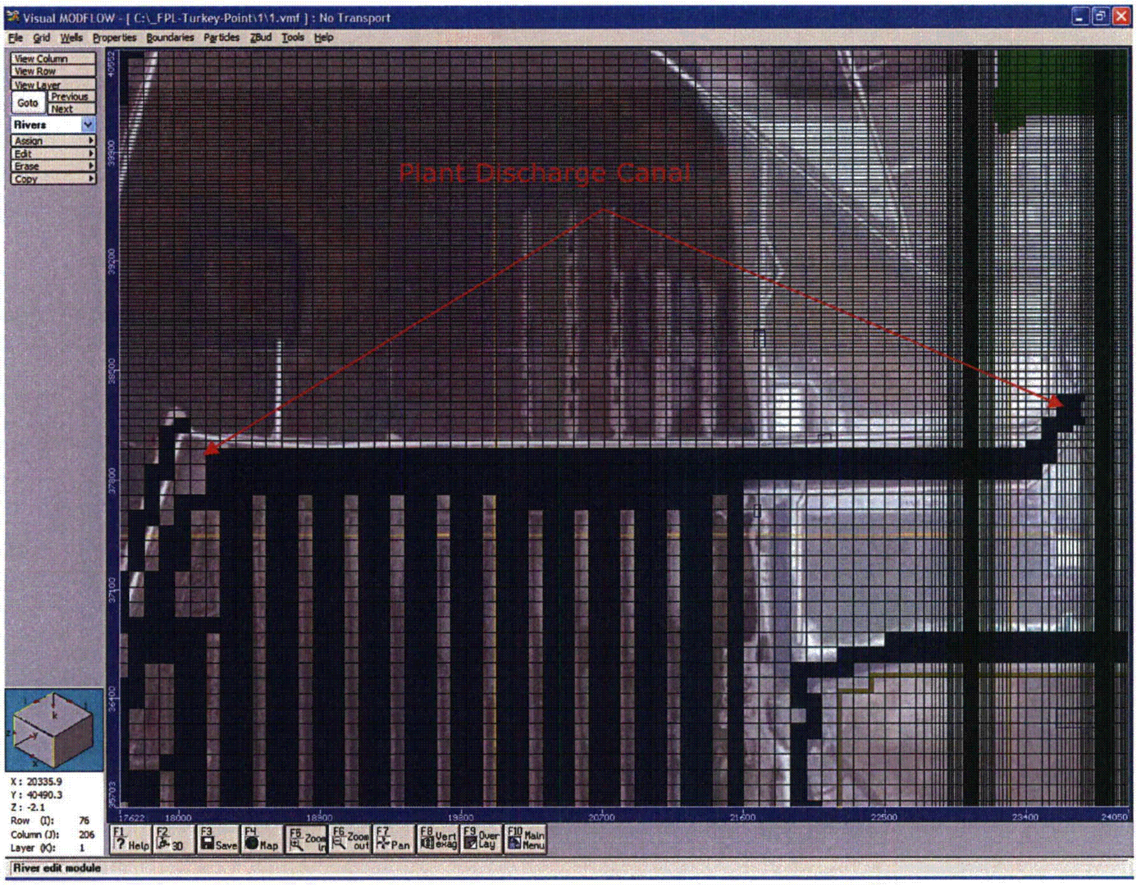


Figure 2C. River Boundary Cells in Model Layer 5 (Upper Higher Flow Zone)
(Plant Discharge Canal)

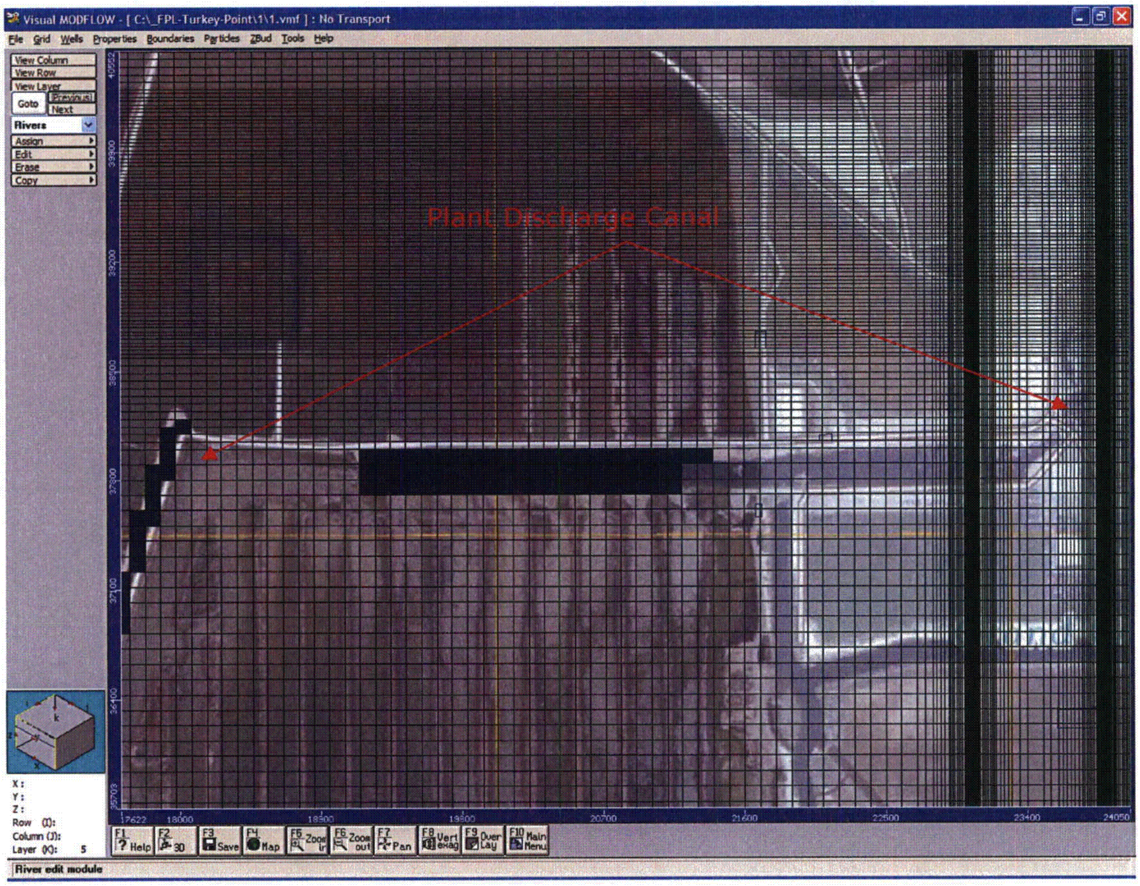
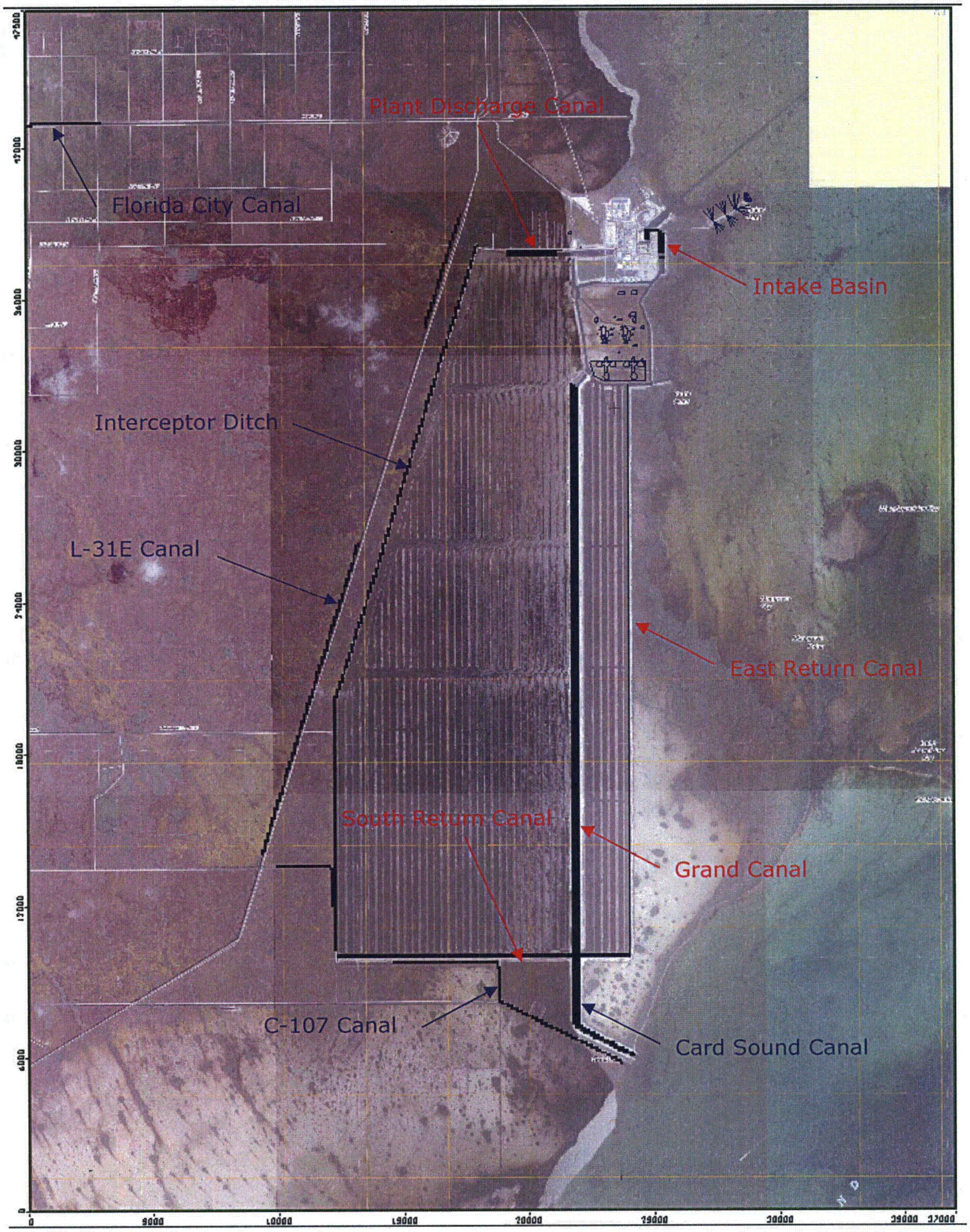


Figure 2D. River Boundary Cells in Model Layer 5 (Upper Higher Flow Zone)



Note: Cooling canal system is labeled in red font.

Figure 3. River Boundary Cells in Model Layer 3
(Regional Canals and Interceptor Ditch)

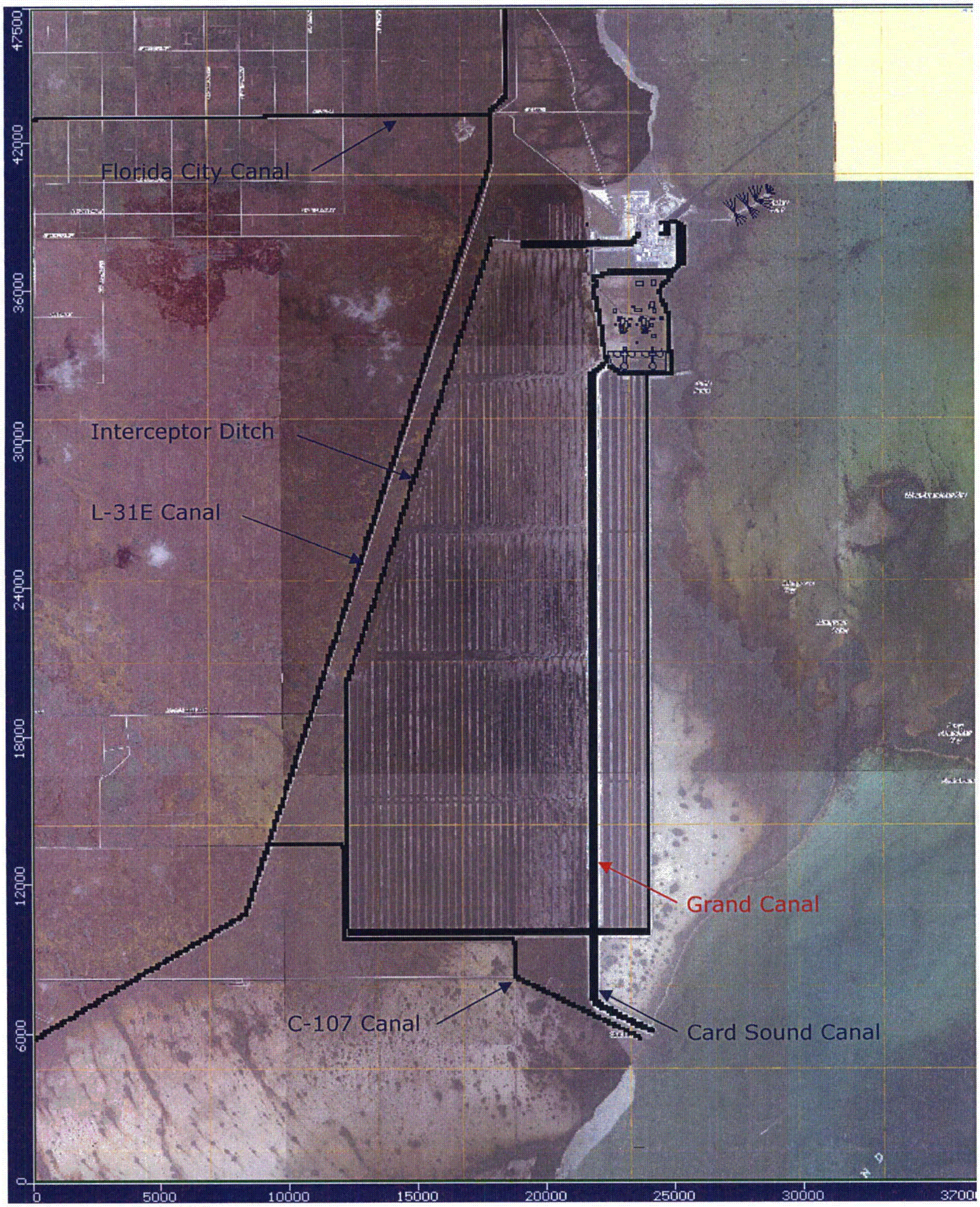
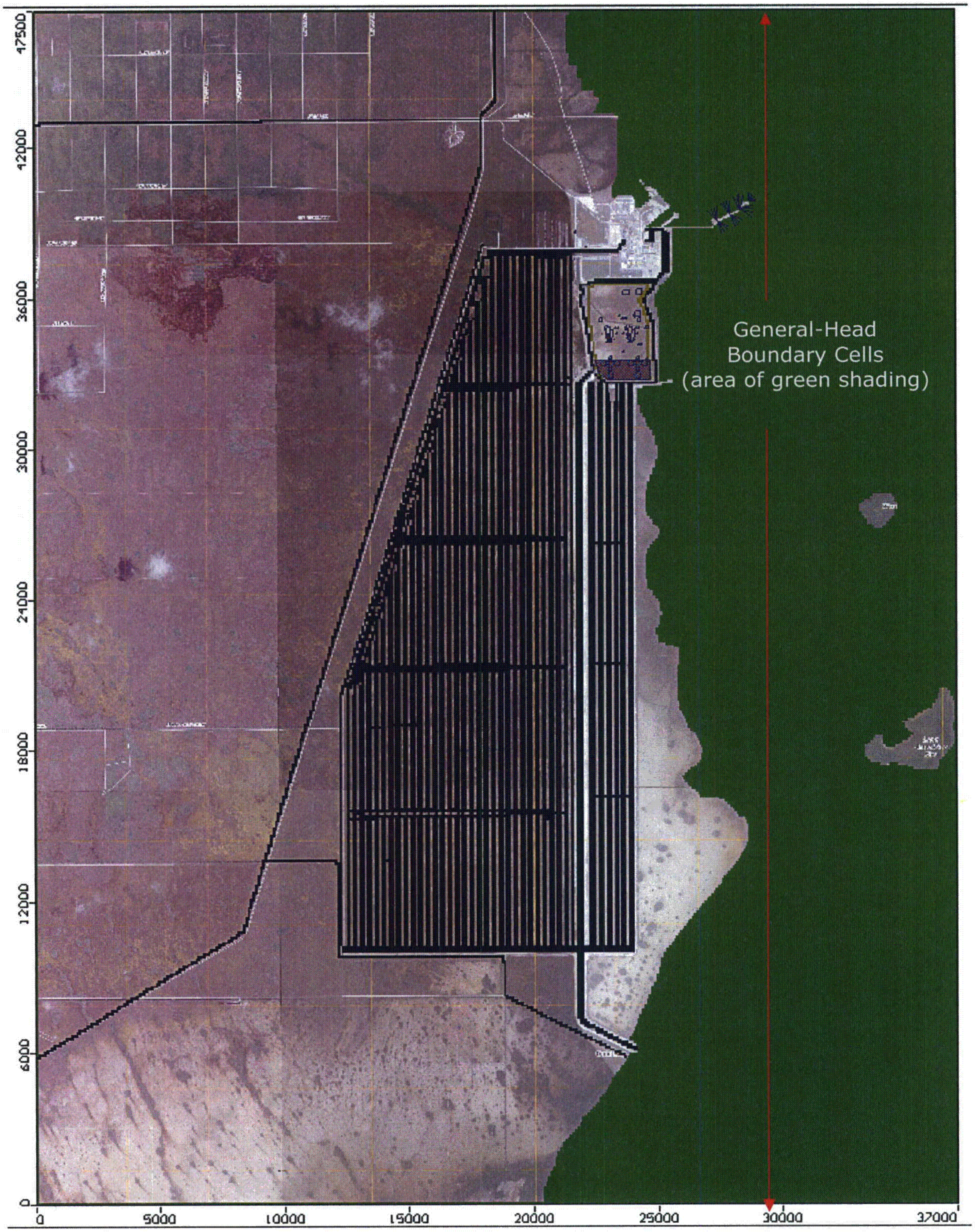


Figure 4. General-Head Boundary in Model Layer 1 at Biscayne Bay



ASSOCIATED COLA REVISIONS:

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

ASSOCIATED ENCLOSURES:

None