Crystal River Energy Complex Discharge Canal Plume Modeling

Prepared for

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Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
BBEST	Basin and Bay Expert Science Team
CFBC	Cross Florida Barge Canal
CREC	Crystal River Energy Complex
DEF	Duke Energy Florida, Inc.
ENC®	Electronic Navigational Chart
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FM	Flexible Mesh
FPC	Florida Power Corporation
ft	feet
ft^2	square feet
ft^3	cubic feet
HCT	helper cooling tower
HD	Hydrodynamics
km	kilometer
LNP	Levy Nuclear Plant
LWL	lower low water
m	meters
m^2	square meters
m^3	cubic meters
mgd	million gallons per day
mi	miles
MLLW	mean lower low water
MLW	mean low water
NAVD88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
psu	practical salinity unit
RMSE	root-mean square error
s	second

SWFWMD	Southwest Florida Water Management District
TMEM	technical memorandum
TR	tidal range

Summary

During development of the Environmental Impact Statement (EIS) for the Levy Nuclear Power Plant (LNP), the U.S. Nuclear Regulatory Commission (NRC) simulated offshore salinity and temperature impacts of the combined Crystal River Energy Complex (CREC) and LNP discharge (NRC, 2012). The simulations were based on the operation of CREC Units 1 through 5. Duke Energy Florida, Inc. (DEF) now plans to decommission CREC Unit 3 as well as CREC Units 1 and 2 at a later time. This technical memorandum (TMEM) provides the results of offshore salinity and temperature modeling considering the proposed operational changes at CREC to evaluate whether the EIS results are bounding (i.e., the proposed changes would not alter the conclusions in the EIS).

Because the NRC conducted the plume modeling internally, their model and approach were approximated using a new model. This new model was calibrated against the EIS results. Scenarios were run using the new model and proposed changed operating conditions at CREC.

The differences in magnitude of salinity and temperature were mapped and compared to the EIS results. The proposed changes to operations will cause the future plume to be altered compared to the scenarios considered in the EIS. The simulated concentrations of salinity were higher than those estimated in the EIS; however, the extent of the plume was smaller. Additional considerations about the real impact of these differences are discussed below.

In general, the elevated salinity, and to a lesser extent, the temperature, may be near the literature's maximum tolerable values for species of concern close to the shoreline, near where CREC discharges. The extent of the elevated values in the plume is only one to two thousand meters from the discharge point and the extent of high values is limited to the embayment between the intake dike and the Cross Florida Barge Canal (CFBC). Because of the limited size, known species of concern in this area, and variable conditions over the seasons, it is unlikely that there will be a significant environmental impact from the future operations as a result of the addition of the LNP discharge.

There will be some permitting and operations challenges that DEF will need to address at the CREC regardless of the addition of the LNP discharge. These include better isolating the intake and discharge points for CREC Units 4 and 5. This was assumed to be addressed in this evaluation. Further issues related to permitting CREC are also possible, but even with the elevated salinity and temperature values near the shore, the difference is not considered significant or warranting further review at this time. The impacts of the dilution on radionuclides are discussed in a separate TMEM.

Introduction

DEF plans to construct a nuclear power plant in southwestern Levy County, Florida, referred to as the LNP. As evaluated and permitted to date, the LNP will discharge cooling tower blowdown to the discharge canal at DEF's CREC, located approximately 9.6 miles south of the LNP site. The CREC site includes three older power units (Units 1, 2, and 3) that use once-through cooling water and two newer units (Units 4 and 5) that use dedicated cooling towers. There are four banks of helper cooling towers (HCTs) aligned along the north shore of the CREC main discharge canal about midway between the power plants and the Gulf of Mexico (Gulf). These HCTs can be used on the combined discharge from CREC Units 1 through 5 (and LNP in the future). These HTCs are normally used only during the summer to meet the National Pollutant Discharge Elimination System (NPDES) permit limit of 96.5 degrees Fahrenheit (°F).

DEF is in the process of decommissioning CREC Unit 3 and is planning to decommission CREC Units 1 and 2 in the future. During permitting and licensing of the LNP, discharge dilution calculations were performed along the CREC discharge canal to assess the impact of the additional LNP discharge on the temperature and salinity of the Gulf (CH2M HILL, 2011). The NRC independently simulated the salinity and temperature distribution in the Gulf from the point of discharge from the CREC canal at the shoreline (NRC, 2012). The NRC EIS analyses assumed CREC Units 1 to 5 would be in operation when LNP Units 1 and 2 became operational. The EIS is the basis for portions of the permitting and licensing documents for LNP.

This TMEM presents the results of revised discharge dilution calculations and numeric modeling considering CREC's announced or planned decommissioning. Scenarios evaluated include the CREC discharge effects by decommissioning CREC Unit 3 only and CREC Units 1, 2, and 3. The results of the revised analyses are compared to the EIS results to evaluate whether the original analyses are bounding when considering the decommissioning of CREC Units 1, 2, and 3. The potential effects of the proposed operational changes on water quality, aquatic ecology, and site selection are discussed in this TMEM. Potential effects of modified dilution on radiological exposure are discussed in a separate TMEM.

Gulf Model Development

Once the discharges from the CREC and LNP power plants are discharged into the main discharge canal and they flow out into the Gulf, the movement of the plume is affected by tidal dynamics, density differences, wind, and other discharges in the area. When the LNP impact was small in comparison to the large once-through cooling water discharge flow rates at CREC with all five units operating, complete mixing was sufficient to describe conditions at the end of the main canal (see Attachment A for updated discharge dilution calculations). With much lower flows, the tidal dynamics are more important at the shoreline and even up into the canal. Numerical modeling that accounts for these different influences is required to assess the impact to the Gulf. This section provides an overview on how the discharge was simulated in the Gulf.

Offshore Model Objective

Specifically, the objective of the model is to assist in assessing the change in the spatial extent and distribution of the thermal and salinity plumes in the nearshore environment of the CREC discharge canal associated with the addition of flow from the LNP, in combination with a parallel foreseeable reduction in the discharge from the CREC units. Numerical modeling is required to account for the dilution, dispersion, and mixing in the ambient water of the Gulf.

The NRC conducted offshore modeling for the LNP EIS (NRC, 2012). NRC's model was developed internally; therefore, the NRC model and all of the underlying assumptions were not available for use or reference. A new model was developed as described in this section and calibrated as described in Attachment B. The results of the new model are presented in Section 2 and are compared to NRC's salinity and temperature results (presented as difference maps in the EIS) to evaluate whether the results presented in the EIS are bounding.

Approach

A new modeling analysis was applied to evaluate whether the EIS results (NRC, 2012) are bounding considering the decommissioning of CREC Units 1, 2, and/or 3. The new model was calibrated to the temperature and salinity results presented in the EIS (NRC, 2012), which assumed the following:

- Bathymetry data used are from the National Oceanic and Atmospheric Administration (NOAA, 2013a and b).
- Ambient salinity was assumed to be 35 practical salinity units (psu). Ambient water temperatures were obtained from the NOAA tide gauge at Cedar Key (stated as 86°F and 58°F for the summer and winter conditions, respectively in NRC, 2012).
- Discharge flows and salinities were included as point discharges from the original dilution computations presented in CH2M HILL (2011) and were specified at the upstream ends of CERC and CFBC.

- Simulations were developed for 1-month tidal conditions.
- Simulations were performed for both winter (October - May) and summer (June - September) conditions using July 2012 flows and January 2013 flows, respectively.

Modeling Software

Historical temperature data at the project site were analyzed to determine variations in water temperature with depth. Data indicate that the water column is generally well mixed; the average temperature difference between the surface and bottom samples was less than 1 degree Celsius (°C). Based on the historical temperature data and shallow conditions in the discharge basin, a two-dimensional vertically averaged hydrodynamic transport model was implemented to simulate the CREC discharge into, and the ensuing salinity and temperature distribution in, the Gulf.

The software package MIKE 21 was used with the Hydrodynamics (HD) Flexible Mesh (FM) module (MIKE 21 by DHI, 2012a). MIKE 21 characterizes the water body with a FM and solves the two-dimensional, depth-integrated shallow water equations of continuity and momentum, and transport equations. The equations are spatially discretized using a cell-centered finite volume approach with triangular elements. The module simulates wind- and tide-induced water levels and currents. The simulated current regime (i.e., the flows) serves as a base for the thermal and salinity recirculation modeling. The FM approach permits the use of varying mesh resolution, with finer resolution assigned to the area of interest to better resolve the bathymetric and flow details. The invocation of the additional temperature and salinity transport sub-modules, as well as accounting for heat flux through the air-water interface and density variation, enables the simulation of thermal and salinity plumes seamlessly.

Model Inputs

Model Domain

The regional model domain is bounded at the landward edge of a broad bay between Clearwater/Tampa Bay to the southeast and Apalachicola to the northwest as shown in Figure 1. Embedded within the regional model is a finer resolution of the local Gulf area near CREC, also shown in Figure 1.

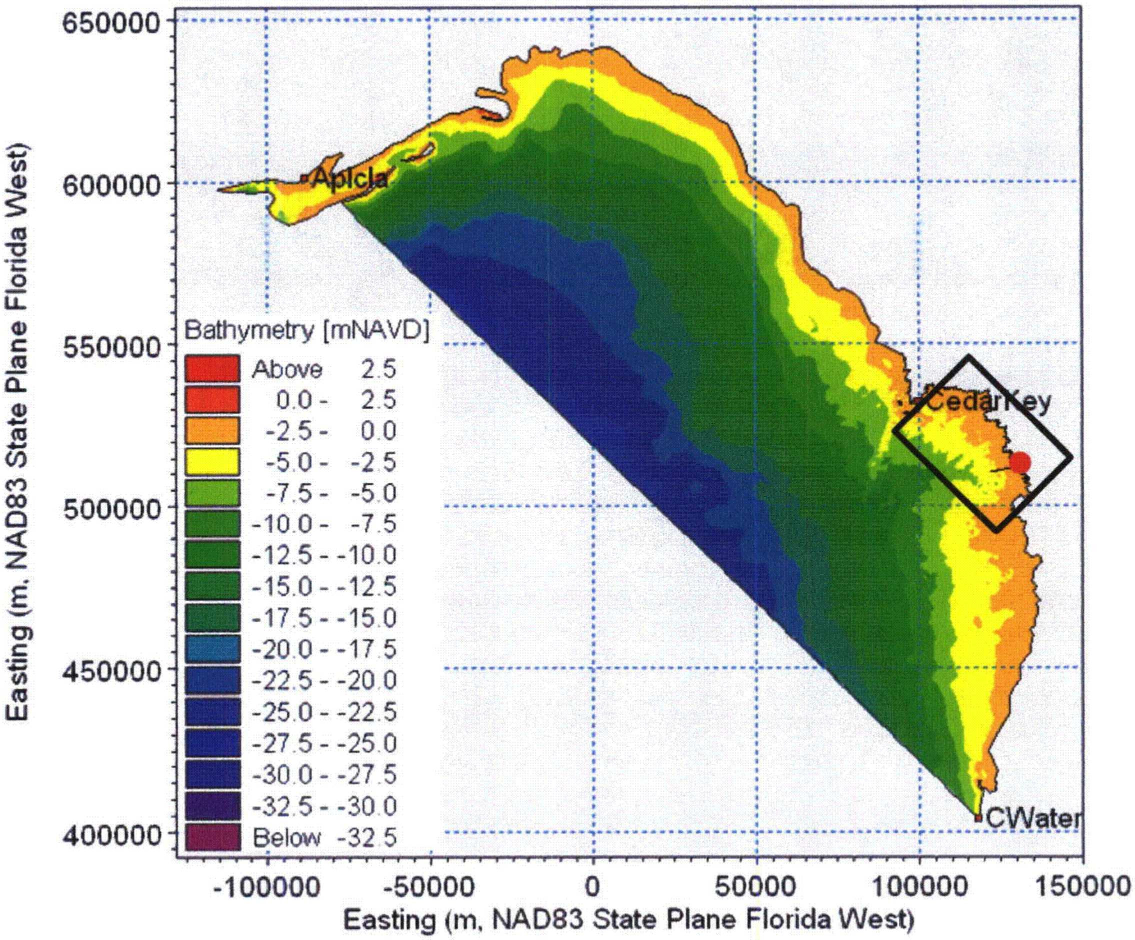

FIGURE 1
Location of the Regional and Local Model Domains

Notes: The black rectangle denotes the local model while the red circle, the project site; CWater = Clearwater; Aplcla = Apalachicola.

The regional model domain has a single open boundary to the southwest that measures approximately 273 kilometers (km) (170 miles [mi]). The side lengths of the triangular elements range from 4 km (2.5 mi) in the offshore region to approximately 600 meters (m) (1969 feet [ft]) in the nearshore, totaling 10,938 nodes and 20,671 elements. The deepest part of the model area is about -30 m (-98.4 ft) North American Vertical Datum of 1988 (NAVD88).

The local model domain shown in Figure 2 measures 34 km (21.1 mi) in the longest offshore direction, and 34 km (21.1 mi) along the offshore boundary and has three open boundaries. The deepest part of the model area is -9.7 m (-31.8 ft) NAVD88. The side lengths of the triangular elements range from 1 km (0.6 mi) in the offshore region to approximately 100 m (326 ft) in the nearshore, totaling 11,863 nodes and 20,703 elements. Quadrilateral elements are used to define the various channels at the following resolutions:

- CFBC: 250 m (820 ft) long (defined as along channel) by approximately 90 m (295 ft) across (transverse direction, one element wide).
- Intake channel: 100 m (328 ft) long by approximately 90 m (295 ft) across (one element wide).
- Discharge channel: 10 m (32.8 ft) long by approximately 17 m (55.8 ft) across (three elements wide) for the first 1,100 m (3,609 ft). Further downstream the element length linearly increases to 25 m (82 ft) at the outlet and thereafter a constant 50 m (164 ft) in the nearshore area while maintaining the same element width throughout.

The much finer resolution used for the discharge channel is meant to reasonably simulate the salinity along the channel, balanced with the computational premium requirement associated with increasing the number of nodes.

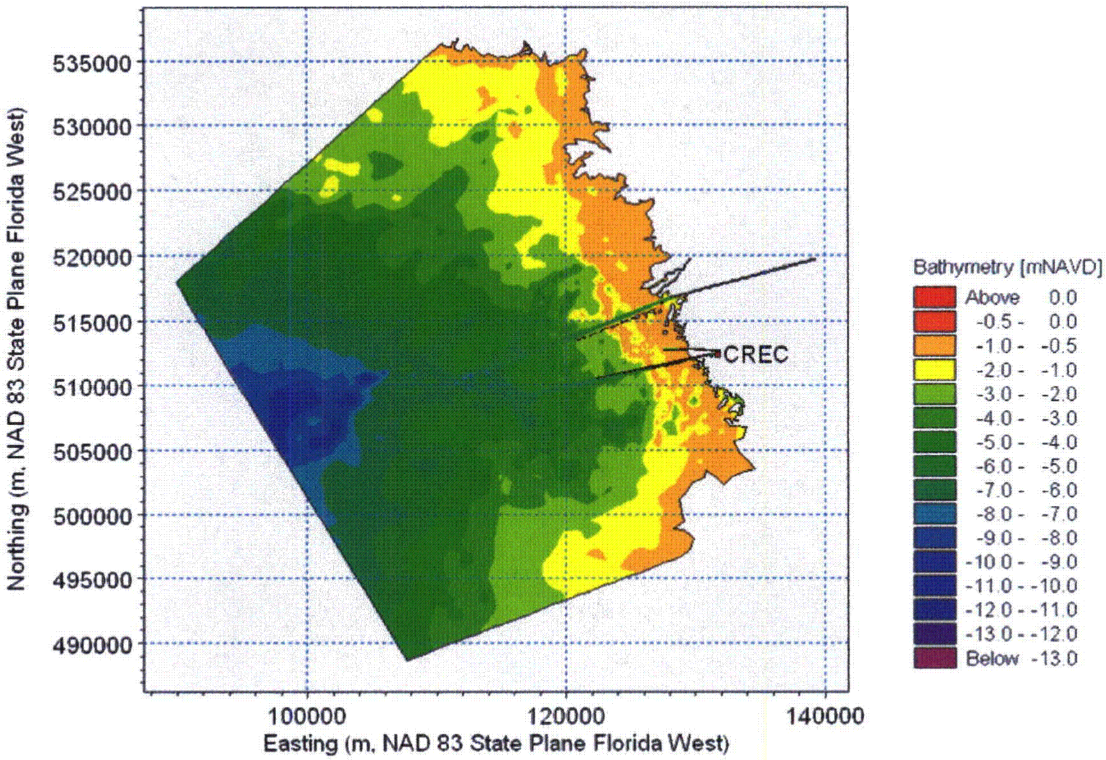

FIGURE 2
Local Model Domain

Figure 2 shows that the large oyster reefs that are linear shallow zones parallel to the shoreline (topping at approximately 0 m [0 ft] mean sea level) are reasonably resolved.

Bathymetry

The bathymetric inputs were obtained from the following two sources ranked in decreasing priority of use:

1. Electronic Navigational Chart® (ENC®) 11409 downloaded from NOAA's ENC direct to the geographic information system web portal (NOAA, 2013a). The data consist of the raw xyz set of varying resolution in geographical coordinates, reduced to meters mean lower low water level (MLLW). The coverage is the nearshore area along the project frontage.
2. U.S. Coastal Relief Model, a gridded bathymetry map downloaded from NOAA's National Geophysical Data Center website (NOAA, 2013b) covering the offshore area. The data have a 90-m (295-ft) grid resolution, are in geographical coordinates, and are reduced to meters NAVD88. While these data are available only in integer units, their use in the deeper offshore region away from the project frontage ensures that the associated uncertainty in the model bathymetry relative to the offshore depths is reduced and deemed acceptable.

The coverage of the two spatial datasets is shown in Figure 3.

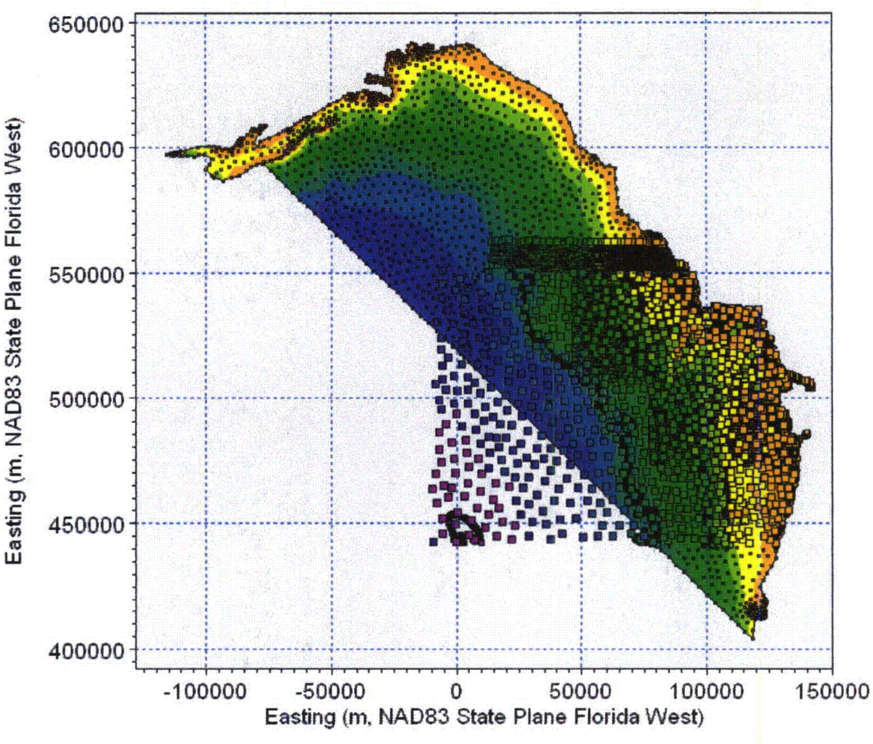

FIGURE 3
Spatial Coverage of the Two Bathymetric Datasets
Notes: Large squares denote ENC; small squares denote U.S. Coastal Relief Model

Channel Geometry

The bathymetry set does not resolve the several channels and rivers (downstream end) adequately to be properly reflected in the local model; therefore, channel dimensions were gleaned from the published reports summarized in Table 1. A depth of 3.1 m (10.2 ft) (referenced to NAVD88) was adopted for the discharge depth to be conservative.

TABLE 1
Summary of Channel Dimensions from Published Reports

Channel	Depth (ft)	Depth (m)	Source	Adopted in Model (m NAVD88)
CREC Intake Canal	-20		FPC, 1985 (ft MLW)	-6.6
CREC Discharge Canal		-3	FPC, 1985	-3.1
CREC Discharge Canal	-11.6		FPC, 1993 (ft MLW*)	-4.0
Cross Florida Barge Canal		-5 to -7	SWFWMD, 2007 (m NAVD88)	-6.0
Withlacoochee River	-4		NOAA, 2013c	-1.9
Crystal River	-6.5		NOAA, 2013c	-2.7

FPC Florida Power Corporation
MLW mean low water (*reported as just low water in the noted reference)
SWFWMD Southwest Florida Water Management District

Calibration

Scenarios were selected for simulation in an effort to evaluate the results of proposed future operations by comparison with scenarios run in the EIS. Therefore, the new model was calibrated to reasonably approximate the EIS results (NRC, 2012). Scenarios were simulated for summer and winter conditions. Scenarios 0 and 0a, as summarized in Table 2, refer to the past operating conditions of CREC Units 1 through 5. Both the results with and without LNP were evaluated to ensure that the new model was reasonably representative of the EIS. For internal consistency purposes, these new calibration results were used as the basis for comparison with the modeled future scenarios. The model calibration is discussed in detail in Attachment B and the results of the calibration are summarized in this section.

The peak temperature and salinity values over the calibrated model domain for the summer and winter simulations were extracted and difference maps (Scenario 0a - Scenario 0) of the temperature and salinity distributions prepared for comparison, as was done in the EIS. The difference maps for salinity for the summer and winter simulations are shown in Figures 4 and 5, respectively. The difference maps for temperature for the summer and winter simulations are shown in Figures 6 and 7, respectively. Contour lines of the salinity difference from the original modeling study (red lines are from NRC, 2012) were overlaid for ease of comparison.

Considering the assumptions upon which the calibration was based (discussed in detail in Attachment B), the comparisons shown in these figures are acceptable and the new model was considered calibrated. Overall, only minor differences in salinity and temperature were noted between Scenarios 0 and 0a. Maximum differences in salinity were 0.75 psu or less and maximum differences in temperature were 0.6 °F or less over comparable areal extents.

TABLE 2
Calibration Scenarios

Basis: Original Dilution Calculations (CH2M HILL, 2011)

Calibration Scenario (Scenario 0) CREC Units 1 - 5 Summer Conditions				Calibration Scenario (Scenario 0) CREC Units 1 - 5 Winter Conditions			
Location	**Flow (mgd)**	**Temperature (°F)**	**Salinity[a] (psu)**	**Location**	**Flow (mgd)**	**Temperature (°F)**	**Salinity[a] (psu)**
Gulf Ambient	-	86	35	Gulf Ambient	-	58	35
Point of Discharge	1,838	96.5	36.3	Point of Discharge	1,595	76.1	35.4
Calibration Scenario (Scenario 0a) LNP Units 1 and 2 and CREC Units 1 - 5 Summer Conditions				**Calibration Scenario (Scenario 0a) LNP Units 1 and 2 and CREC Units 1 - 5 Winter Conditions**			
Location	**Flow (mgd)**	**Temperature (°F)**	**Salinity[a] (psu)**	**Location**	**Flow (mgd)**	**Temperature (°F)**	**Salinity[a] (psu)**
Gulf Ambient	-	86	35	Gulf Ambient	-	58	35
Point of Discharge	1,926	96.5	37.0	Point of Discharge	1,682	77.1	36.3

[a] The ambient temperatures simulated in the numerical modeling are slightly lower than the ambient temperatures used in the discharge dilution calculations presented in Attachment A. Ambient temperatures of 86°F (summer) and 58°F (winter) were used for consistency with the original numerical modeling assumptions (NRC, 2012); mgd = million gallons per day.

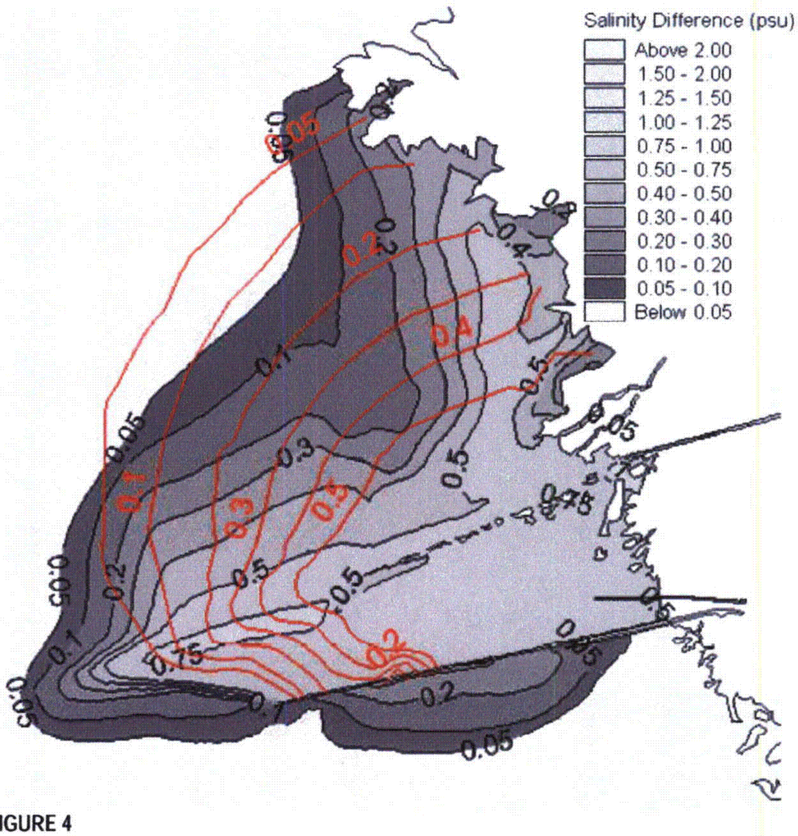

FIGURE 4
Salinity Difference of the Discharge Plume between Scenario 0a and Scenario 0 (Scenario 0a – Scenario 0), Summer Conditions, Ebb Tide

Note: The red contours denote the difference contours from NRC Figure 5-8A (2012).

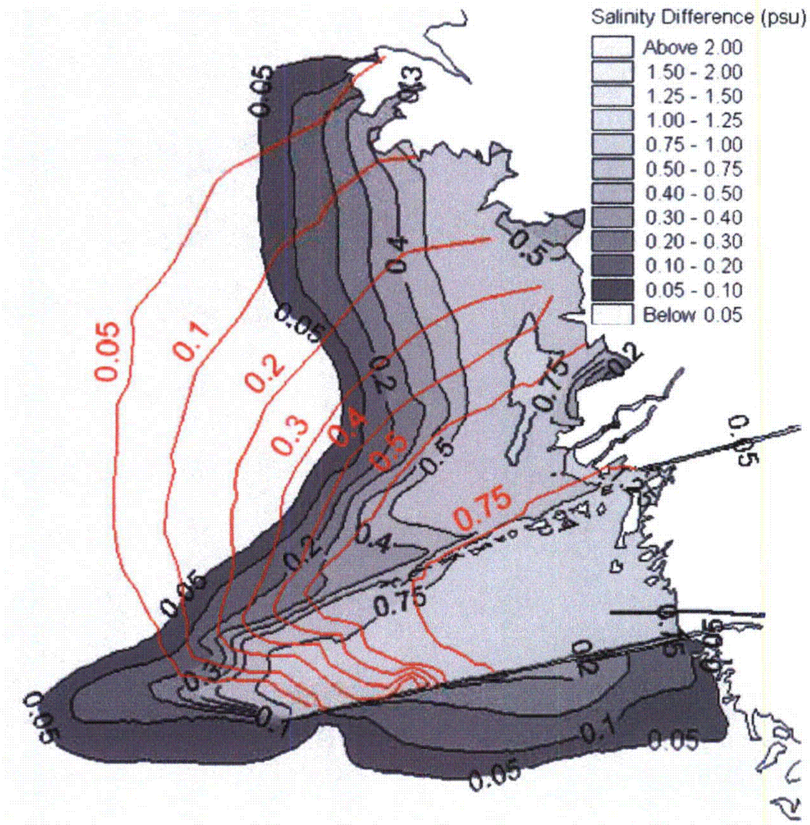

FIGURE 5
Salinity Difference of the Discharge Plume between Scenario 0a and Scenario 0 (Scenario 0a – Scenario 0), Winter Conditions, Ebb Tide

Note: The red contours denote the difference contours from NRC Figure 5-8B (2012).

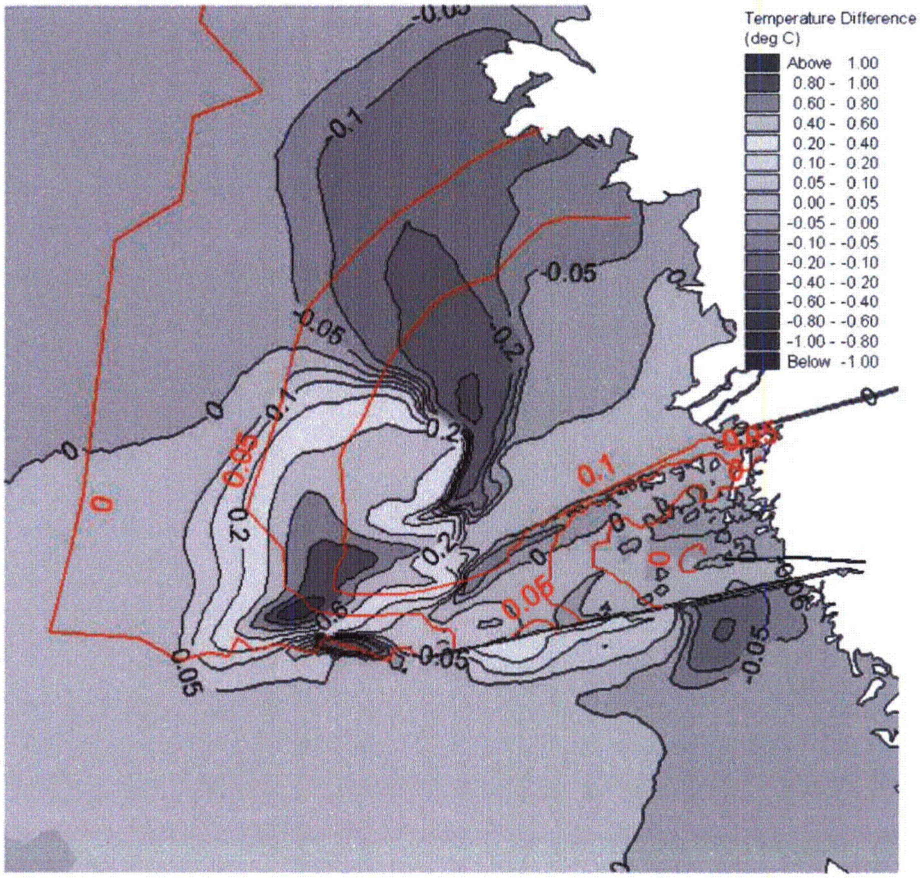

FIGURE 6

Temperature Difference of the Discharge Plume between Scenario 0a and Scenario 0 (Scenario 0a – Scenario 0), Summer Conditions, Ebb Tide

Note: The red contours denote the difference contours from NRC Figure 5-6 (2012).

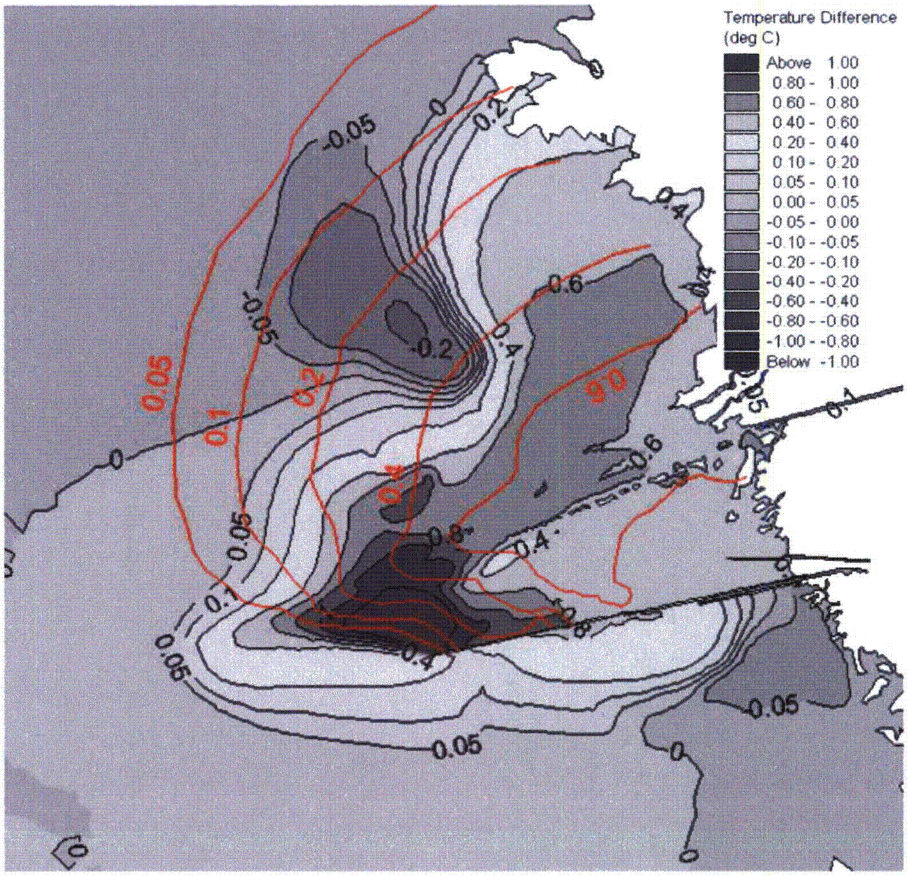

FIGURE 7
Temperature Difference of the Discharge Plume between Scenario 0a and Scenario 0 (Scenario 0a – Scenario 0), Winter Conditions, Ebb Tide

Note: The red contours denote the difference contours from NRC Figure 5-7 (2012).

Proposed Future Scenarios Evaluated

If CREC Units 1, 2, and 3 cease operation and there is no other discharge into the main canal, fresh seawater would not be available to Units 4 and 5. Therefore, a new source of saltwater flow is required within the discharge canal at the Unit 4 and 5 intake. It was assumed that if CREC Units 1, 2, and 3 are decommissioned, ambient seawater will need to be introduced in an amount about equal to the needs of Units 4 and 5.

Predictive scenarios that were evaluated are summarized below and in Table 3. The flow, salinity, and temperature characteristics for each scenario are calculated in Attachment A. The equivalent scenarios in Attachment A are identified in Table 4:

- Scenario 1 - Simulates operation of LNP and decommissioning of CREC Unit 3 (CREC Units 1, 2, 4 and 5, plus LNP).
- Scenario 2a - Simulates operation of LNP and decommissioning of CREC Units 1, 2, and 3 (CREC Units 4 and 5, plus LNP). Because the replacement of ambient seawater is needed

to allow for the operation of the Units 4 and 5 cooling towers, this scenario assumes some intake modification (separation of intake/discharge, relocation of intake, etc.).

- Scenario 2b - Simulates operation of LNP and decommissioning of CREC Units 1, 2, and 3 (CREC Units 4 and 5, plus LNP). This scenario assumes that the existing configuration of the Units 4 and 5 cooling water intake remains unchanged but does not account for the upcycling of salinity in the discharge canal that would occur if the CREC Units 4 and 5 intake were impacted by the salinity/temperature of the discharge. This scenario does not represent a feasible alternative and is provided for information purposes only. The only difference simulated between Scenarios 2a and 2b is the discharge flow.

TABLE 3
Discharge Plume Modeling Scenarios

Basis: Revised Dilution Calculations

Scenario 1: CREC units 1, 2, 4, 5 and LNP Units 1, 2 Summer Conditions				Scenario 1: CREC units, 1,2, 4, 5 and LNP Units 1, 2 Winter Conditions			
Location	Flow (mgd)	Temperature[a] (°F)	Salinity (psu)	Location	Flow (mgd)	Temperature[a] (°F)	Salinity (psu)
Gulf Ambient	-	86	35	Gulf Ambient	-	58	35
Point of Discharge	848	95.1	43.4	Point of Discharge	726	92.7	44.8
Scenario 2a: CREC units 4 and 5 and LNP Units 1 and 2 Summer Conditions				**Scenario 2a: CREC units 4 and 5 and LNP Units 1 and 2 Winter Conditions**			
Location	Flow (mgd)	Temperature[a] (°F)	Salinity (psu)	Location	Flow (mgd)	Temperature[a] (°F)	Salinity (psu)
Gulf Ambient	-	86	35	Gulf Ambient	-	58	35
Point of Discharge	176	93.4	47.9	Point of Discharge	176	93.4	47.9
Scenario 2b: CREC units 4 and 5 and LNP Units 1 and 2 Summer Conditions				**Scenario 2b: CREC units 4 and 5 and LNP Units 1 and 2 Winter Conditions**			
Location	Flow (mgd)	Temperature[a] (°F)	Salinity (psu)	Location	Flow (mgd)	Temperature[a] (°F)	Salinity (psu)
Gulf Ambient	-	86	35	Gulf Ambient	-	58	35
Point of Discharge	67	93.4	47.9	Point of Discharge	67	93.4	47.9

[a] The ambient temperatures simulated in the numerical modeling are slightly lower than the ambient temperatures used in the discharge dilution calculations presented in Attachment A. Ambient temperatures of 86°F (summer) and 58°F (winter) were used for consistency with the original numerical modeling assumptions (NRC, 2012).

TABLE 4
Cross Referenced Scenarios between Numerical Modeling and Discharge Dilution Computations in Attachment A

Modeling Scenario (Table 3)	Calculation Scenario (Attachment A)
Scenario 1	Scenario b
Scenario 2a	Scenario c
Scenario 2b	Modified (flow) Scenario c
Scenario 3 (discussed below)	Scenario d

Gulf Simulation Results

This section provides the modeling results and discussion of the magnitude, shape, and spatial distribution of the modeled plumes. Three conservative assumptions are applied to the input conditions for the predictive simulations as follows, as compared to the calibration assumptions:

i) The CFBC channel dimensions are as reported in NRC (2012). These channel dimensions are 60m (196 ft) wide and -3.7m (12 ft) deep. The quadrilateral elements in the channel are 200 m (6560 ft) long (defined as along channel) by approximately 30 m (98 ft) across (transverse direction, two elements wide).

ii) The CFBC low flow discharge (120 cfs) is as reported in NRC (2012).

iii) The average intake flow of LNP Units 1 and 2 (190 cfs) as reported in NRC (2012) is introduced as a flow sink at the head of CFBC.

The above changes are made to account for the potential influx of Gulf saline water up the CFBC, which is needed to supply the LNP intake flow. Also, the smaller channel section is more conservative with respect to salinity and temperature impacts in the nearshore zone.

The results here are presented in terms of the peak salinity values over a 14-day simulation period to provide an envelope for the likely seaward spread of the plume during a typical seasonal spring-neap tidal cycle. Difference maps, for comparison with EIS results, are presented in Attachment C and are discussed in this section (Table 5).

TABLE 5
Cross Reference of Simulation Results and Figures

Parameter	Season	Scenario	Result Type	Figure
Salinity	Summer	Scenario 0a Scenario 1 Scenario 2a Scenario 2b	Absolute	Figure 8
Salinity	Winter	Scenario 0a Scenario 1 Scenario 2a Scenario 2b	Absolute	Figure 9
Temperature	Summer	Scenario 0a Scenario 1 Scenario 2a Scenario 2b	Absolute	Figure 10
Temperature	Winter	Scenario 0a Scenario 1 Scenario 2a Scenario 2b	Absolute	Figure 11
Salinity	Summer	Scenario 1 – Scenario 0a	Difference	Figure C1
		Scenario 2a – Scenario 0a	Difference	Figure C2
		Scenario 2b – Scenario 0a	Difference	Figure C3
Salinity	Winter	Scenario 1 – Scenario 0a	Difference	Figure C4
		Scenario 2a – Scenario 0a	Difference	Figure C5
		Scenario 2b – Scenario 0a	Difference	Figure C6
Temperature	Summer	Scenario 1 – Scenario 0a	Difference	Figure C7
		Scenario 2a – Scenario 0a	Difference	Figure C8
		Scenario 2b – Scenario 0a	Difference	Figure C9
Temperature	Winter	Scenario 1 – Scenario 0a	Difference	Figure C10
		Scenario 2a – Scenario 0a	Difference	Figure C11
		Scenario 2b – Scenario 0a	Difference	Figure C12

Evaluation Objective

The purpose of the production runs (predictive simulations) was to obtain the salinity and temperature plume characteristics by applying the calibrated flow/temperature/salinity model to the three scenarios listed in Table 3. All the input conditions discussed in Section 1 were retained except for the discharge flow, temperature, and salinity at the head of the discharge channel.

Salinity Plume Results

The extents of the salinity plumes in absolute values for the summer and winter conditions are shown in Figures 8 and 9, respectively. Because of the larger discharge rate associated with Scenario 1, salinity levels as high as the source discharge cover a large portion of the nearshore area between the CREC outlet and the CFBC outlet. For Scenario 2 (a and b), the salinity drops substantially below the source salinity of 47.9 psu with increasing distance.

A sharp salinity front develops on the north edge of the plume as a result of interaction with the net freshwater flow from the Withlacoochee River (Figure 8). For Scenario 1, this front is a little south of the spoil piles near the CFBC. For Scenario 2 (a and b), the front is much closer to the discharge outlet because the discharge rate is much lower without Units 1 and 2. For the winter conditions, the extent of reduced salinity shrinks considerably for Scenario 1 but remains about the same under Scenario 2 (a and b). Overall, winter conditions present the larger increases and wider extent in the salinity levels for Scenario 1.

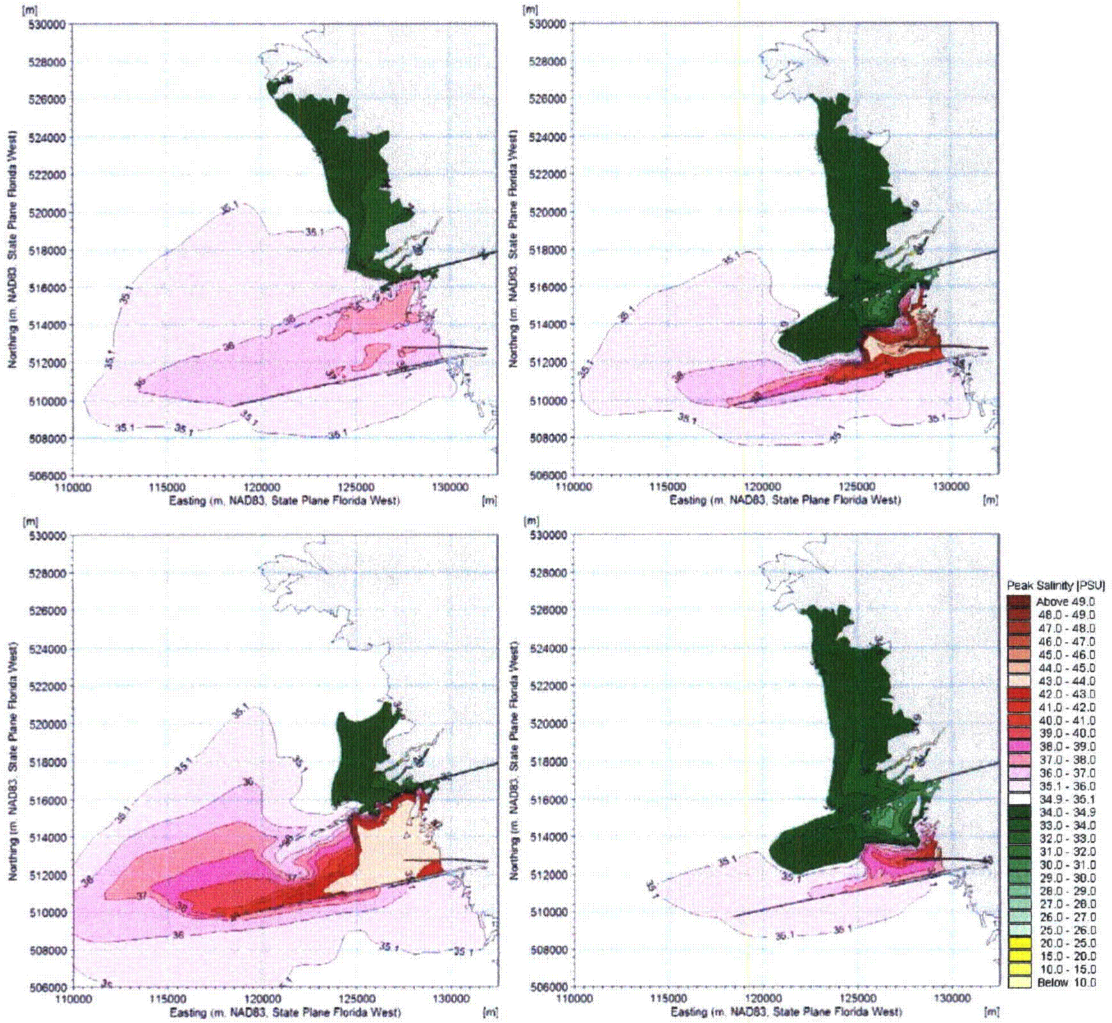

FIGURE 8
Extent of Modeled Salinity Plumes, Summer Conditions

Notes: Top Left Panel: Scenario 0a; Bottom Left Panel: Scenario 1; Top Right Panel: Scenario 2a; Bottom Right Panel: Scenario 2b.

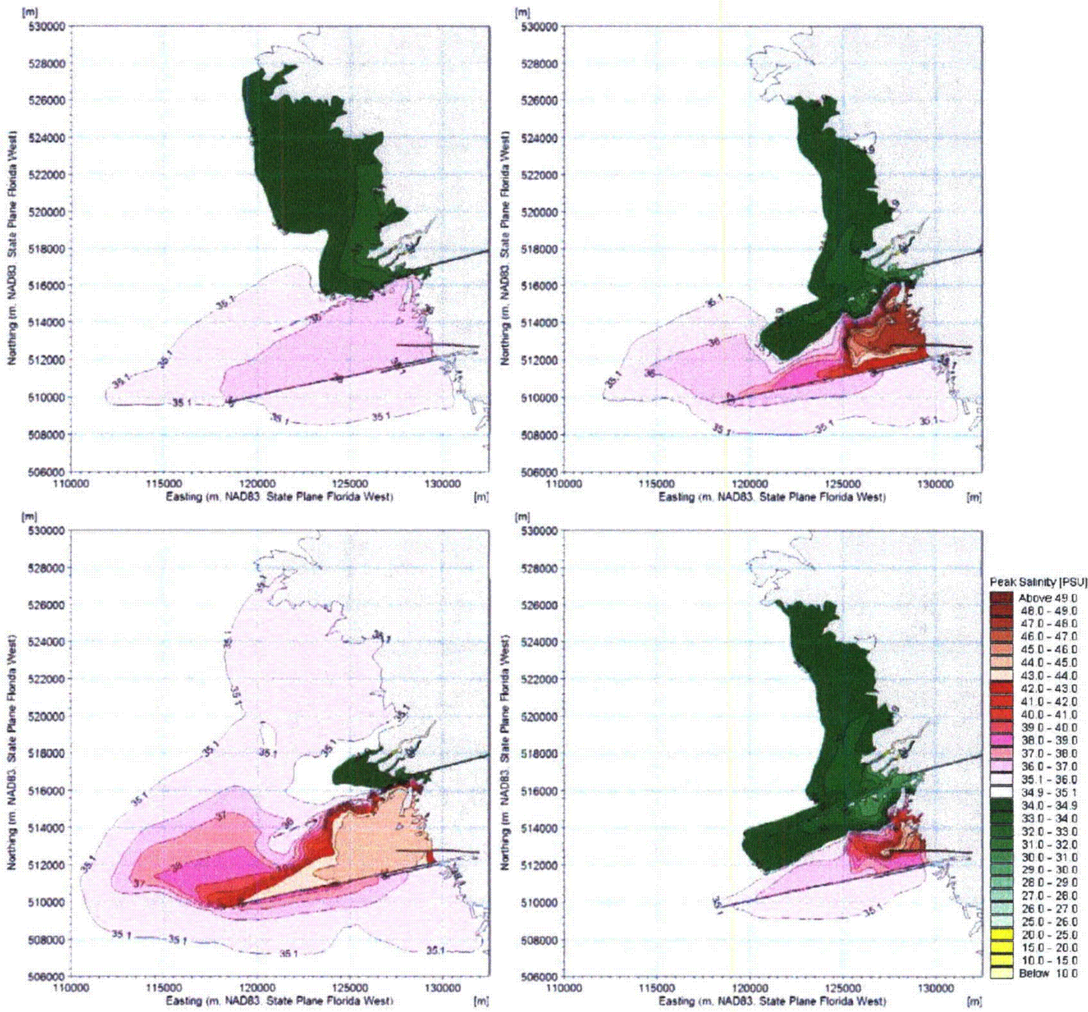

FIGURE 9
Extent of Modeled Salinity Plumes, Winter Conditions

Notes: Top Left Panel: Scenario 0a; Bottom Left Panel: Scenario 1; Top Right Panel: Scenario 2a; Bottom Right Panel: Scenario 2b.

Salinity difference maps relative to the results of Scenario 0a (CREC Units 1 through 5 and LNP Units 1 and 2) are presented on Attachment C Figures C1, C2, and C3 (summer condition) and Figures C4, C5, and C6 (winter condition), for comparison with the salinity difference results of NRC (2012). The increase of the salinity level in the nearshore area between the discharge channel and the spoil islands skirting along the south edge of the CFBC is up to approximately 12 psu, though this area of high salinity increase is much reduced for Scenario 2 (a and b) because of the reduced discharge. This predicted increase is larger than the maximum increase predicted by NRC (2012) of less than 1 psu; therefore, the EIS results are not bounding for salinity. However, for both the summer and winter conditions, the salinity of the water near the outlets of Withlacoochee River and CFBC decreases because the inflow of freshwater (lower salinity) from these surface water features has increased relative to the flow of saline discharge from CREC. Near the Withlacoochee

River and offshore from the CREC discharge, the overall level of salinity is lower than shown in the EIS results. Potential ecological impacts from the predicted increase in salinity are discussed in Section 4.

Temperature Plume Results

The temperature plumes at peak ebb tide conditions are shown in absolute terms in Figures 10 and 11 for the summer and winter conditions, respectively. Similar to the trend observed in the salinity plume pattern, the temperature plume associated with Scenario 2 (a and b) has a smaller footprint and a smaller increase in temperature over the respective ambient temperature (30°C [86°F] for the summer and 14.4°C [58°F] for the winter condition).

A similar trend is observed for the winter conditions comparison in terms of the areal extent and the absolute temperature level reached (approximately 35°C [95°F]). However, the temperature increase is greater for the winter condition because of the lower ambient temperature. The role of the intake barrier in arresting and minimizing the extent of the temperature plume toward the south side of the barrier is also evident. (This happens for the salinity too, although to a slightly lesser extent.)

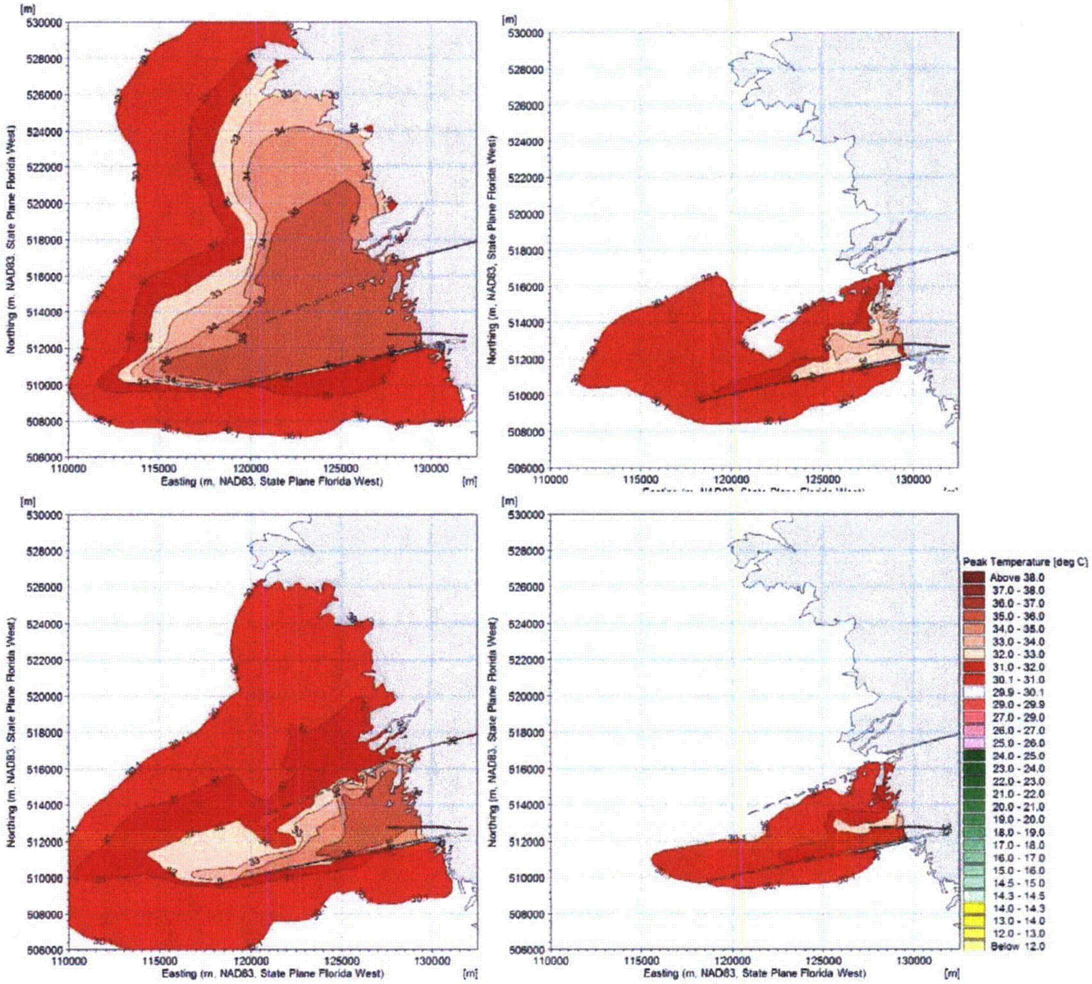

FIGURE 10
Extent of Modeled Temperature Plumes, Summer Conditions

Notes: Top Left Panel: Scenario 0a; Bottom Left Panel: Scenario 1; Top Right Panel: Scenario 2a; Bottom Right Panel: Scenario 2b.

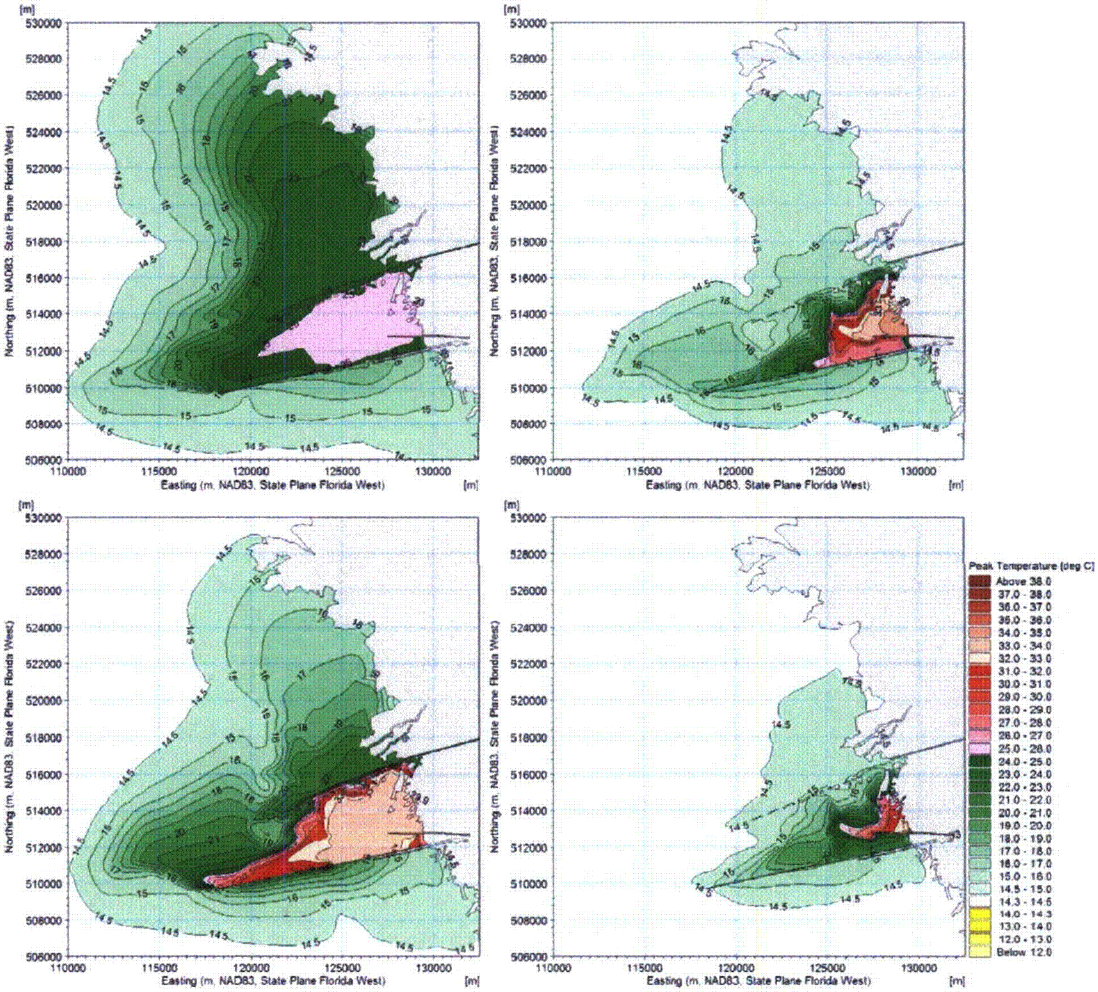

FIGURE 11
Extent of Modeled Temperature Plumes, Winter Conditions

Notes: Top Left Panel: Scenario 0a; Bottom Left Panel: Scenario 1; Top Right Panel: Scenario 2a; Bottom Right Panel: Scenario 2b.

The difference maps of temperature change, relative to Scenario 0a (CREC Units 1 through 5 and LNP 1, 2) are presented on Attachment C Figures C7, C8, and C9 (summer condition) and Figures C10, C11, and C12 (winter condition), for comparison with the temperature difference results of NRC (2012). For the summer conditions, the temperature plumes of both Scenarios 1 and 2 (a and b) remained bounded by the NRC results (2012), both largely registering a lowering of the temperature below that of Scenario 0a except for a zone of small increase (0.1°C) at the seaward end of the intake barrier for Scenario 1.

For the winter conditions, Scenario 1 registers a Gulf temperature difference up to 8°C (46.4°F) in the nearshore area. The significant increase in winter discharge temperatures for Scenario 1 is caused by a change in the input assumptions (as can be seen by comparing Tables 2 and 3 for winter discharge temperatures). The NRC (2012) modeling was

performed with theoretical winter discharge temperatures for CREC Units 1 and 2 ranging from 75.8 to 80°F and a temperature of 70°F for Units 4 and 5. The new modeling was performed with actual discharge temperature data for CREC Units 1 and 2, which ranged from 100.8 to 103°F. For CREC Units 4 and 5, a temperature of 94.6°F (equal to the summer conditions) was selected to be conservative for the purposes of these analyses. Therefore, the increase in temperature observed for the Scenario 1 winter condition is a result of the calculation assumptions. Likewise, for Scenario 2 (a and b), a similar increase in the temperature occurs but is confined to a smaller immediate nearshore area centered at the discharge outlet. Therefore, the NRC results (2012) compared with the predictive analyses are not bounding for the winter condition along the shoreline at the discharge point as a result of the differences in calculation assumptions.

Environmental Impacts of New Modeling Results

A two-dimensional depth-averaged flow model comprising a regional and a local model domain was developed to simulate the tidal flow regime in the nearshore waters fronting the CREC site. The regional flow model was calibrated based on the published predicted tides of NOAA, and the current field from the local model qualitatively compared with published current measurement with reasonable agreement.

New scenarios of proposed future CREC discharge conditions were compared to the results of the EIS scenarios. If the EIS results were higher in magnitude and/or spatial extent, then they would be considered bounding and the proposed changes would not alter the conclusions. The results of predictive numerical modeling indicate that the NRC results (2012) are not bounding for the following temperature and salinity increases:

- Salinity increases under Scenarios 1 and 2 (a and b) for the winter condition
- Salinity increases under Scenarios 1 and 2 (a and b) for the summer condition
- Temperature increases under Scenarios 1 for 2 (a and b) for the winter conditions are not bounded due to the differences in CREC Unit discharge temperatures used in the original analyses and the analyses described in this TMEM

Thus, the NRC results (2012) are bounding for the temperature increases for the summer condition only. Therefore, this section evaluates the differences in terms of environmental impact. Potential surface water quality impacts of modified discharge flows as considered in this TMEM include thermal, chemical, and physical impacts (such as scouring) that could result from modified effluent discharges.

Water Quality

Potential thermal and salinity impacts have been addressed by the dilution calculations (Attachment A) and numerical modeling (Sections 2 and 3) discussed previously. Compliance with the NPDES permit for releases of cooling water and other liquid effluents will ensure compliance with the Federal Water Pollution Control Act (Clean Water Act) and Florida water quality standards. It is beyond the scope of this TMEM to conduct a detailed analysis, but there could be compliance issues for the CREC related to the proposed changes.

The existing NPDES permit limit for the CREC is monitored at the end of the discharge canal and is limited to 96.5°F during summer months. This limit was established because of a grandfathering clause in the rules for existing discharges. It is assumed that this provision would continue.

The salinity changes may affect compliance with two other parameters, chlorides and specific conductivity. Florida standards (Florida Administrative Code [FAC]) limit changes to chlorides as follows (FAC 62-530(18)):

> *Not increased more than 10% above normal back-ground. Normal daily and seasonal fluctuations shall be maintained.*

Specific conductance also has a similar type of limit (FAC 62-530(23)):

> *Not increased more than 50% above normal back-ground or to 1275, whichever is greater.*

DEF submitted a water quality sampling plan to the Florida Department of Environmental Protection (FDEP) to include monthly water quality sampling for 5 years prior to operations at stations to the north and south of the CFBC and CREC, including stations in the Big Bend Seagrasses Aquatic Preserve and St. Martins Marsh Aquatic Preserve to measure characteristics such as dissolved oxygen, temperature, and salinity (CH2M HILL, 2011). These additional data may be required by FDEP to demonstrate background concentrations. Higher salinity in the CREC discharge may need to be dealt with during the permitting of LNP. A site-specific limit may be possible given the limited extent of the simulated future plume. Compliance with water quality standards is an issue for CREC with or without the LNP inclusion and, within this context, the addition of LNP is not considered a limiting factor on water quality.

Physical Impacts

Scouring is not anticipated to increase with the decommissioning of CREC 1, 2, and/or 3 because the overall discharge flow rate will decrease from a maximum of 1,926 mgd (88 mgd from LNP Units 1 and 2; or 1,838 mgd from CREC 1 - 5) to a maximum of 176 mgd (88 mgd from LNP Units 1 and 2, 88 mgd from CREC 4 and 5) to 848 mgd (88 mgd from LNP Units 1 and 2, 760 mgd from CREC 1, 2, 4 and 5).

Aquatic Resource Impacts

Aquatic resources within the vicinity of the CREC discharge canal are potentially the most impacted from modifications to the discharge plume. These resources include the sessile communities of submerged aquatic vegetation (seagrasses) and oyster reefs. These benthic communities provide habitat for species of fish and invertebrates and are considered essential fish habitat. Impacts could occur if seasonal maximum values of temperature and/or salinity increase above the tolerances of local aquatic communities.

The addition of LNP Units 1 and 2 to the CREC discharge plume was determined to have an insignificant effect on local aquatic resources by the NRC (2012), as discussed in the EIS. The EIS included maps showing the difference between Scenario 0 simulations of CREC Units 1 through 5 and Scenario 0a simulations of CREC Units 1 through 5 with the addition of LNP 1 and 2. The maps of the difference in the two plumes for temperature and salinity illustrated minimal change in value and extent.

To evaluate potential ecological impacts for the new potential future conditions, one additional scenario, Scenario 3, was developed. Scenario 3 is essentially equivalent to Scenario 0 (CREC Units 1 through 5) except Scenario 3 takes into account the revised winter

discharge temperature assumptions (see Attachment A). Comparisons of the modeled Scenarios 1 and 2 (a and b) in relation to Scenario 3, which describe the predicted impact of the addition of LNP and the decommissioning of CREC Units 1, 2, and/or 3, are described below. The results of Scenario 3 are presented in Figures 12 through 15.

Thermal Impacts to Aquatic Resources

Impacts to aquatic communities are not expected from changes to thermal characteristics of the discharge plume under Scenarios 1 and 2 (a and b). The maximum thermal value expected from the addition of LNP Units 1 and 2 did not increase under any modeled scenario or season relative to Scenario 3 (Figures 12 and 13). The Scenario 3 modeled maximum temperature (36°C) was equaled during Scenario 1 (summer) but to a smaller areal extent. In three of the four comparisons (Scenario 1 [winter], Scenario 2a/b [summer], and Scenario 2a/b [winter]), the thermal maximum decreased by several degrees relative to Scenario 3. Overall, the areal extent of the thermal plume was smaller under Scenario 1 and much smaller under Scenario 2 (a and b) than the size predicted by Scenario 3. The range of thermal values resulting from the various modeled scenarios continues to be within the tolerance range of the seagrass and oyster aquatic communities.

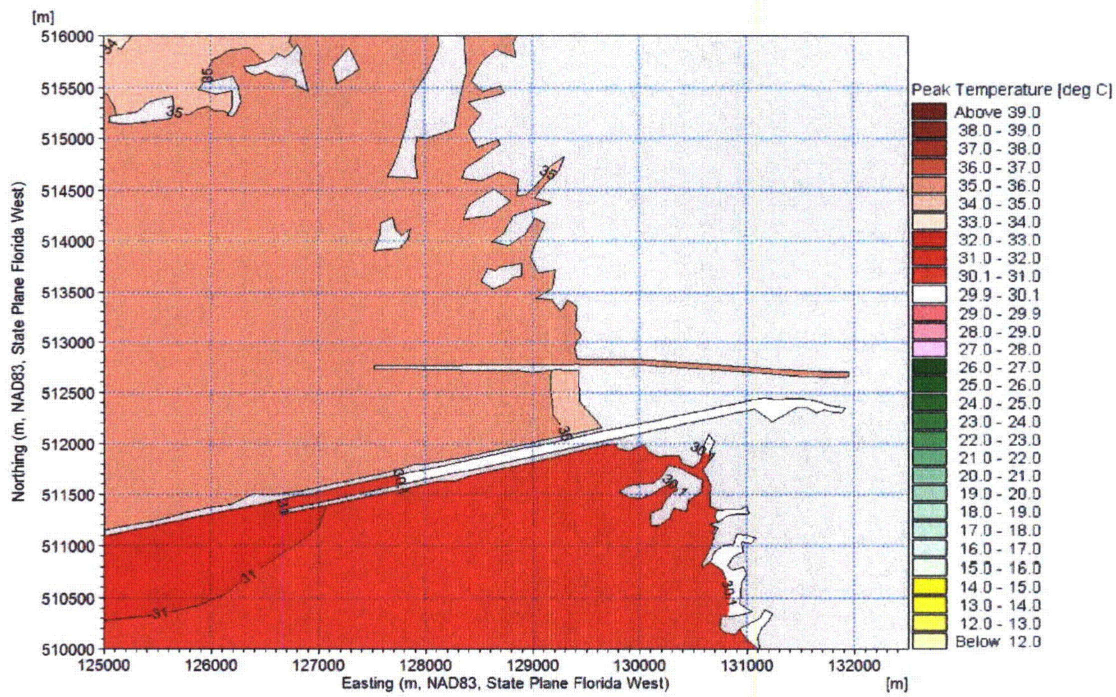

FIGURE 12
Extent of Modeled Temperature Plume, Summer Conditions, Scenario 3

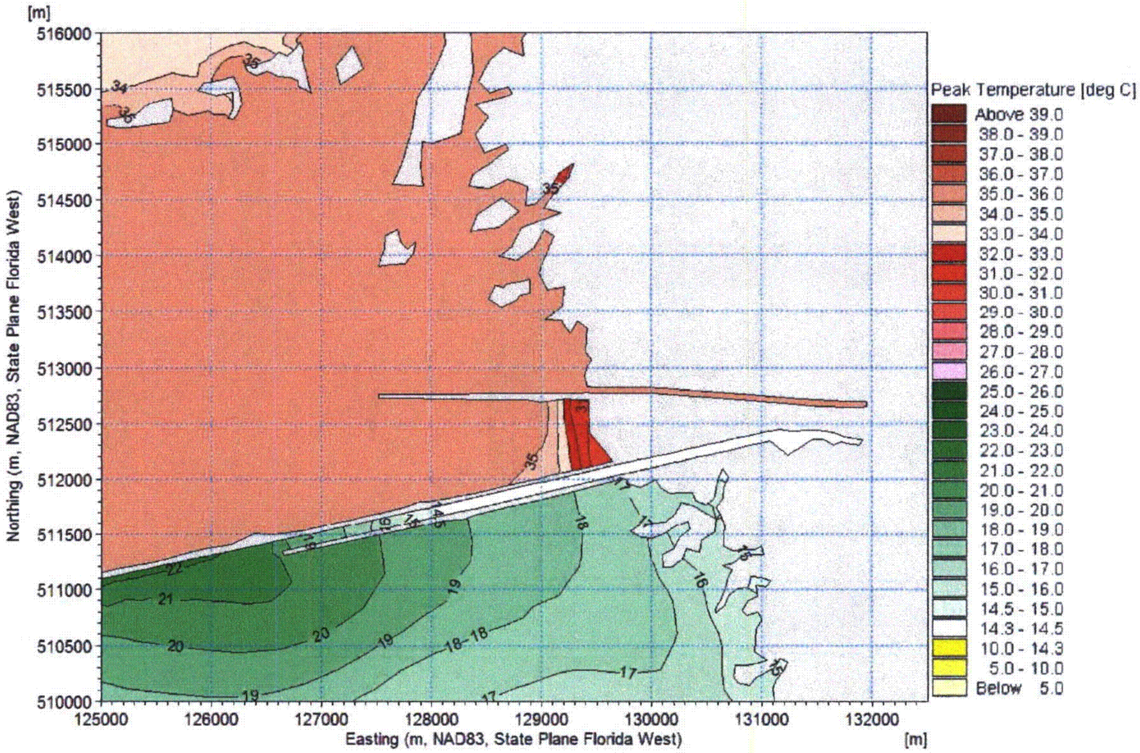

FIGURE 13
Extent of Modeled Temperature Plume, Winter Conditions, Scenario 3

Salinity Impacts to Aquatic Resources

Impacts to aquatic communities from changes to the salinity characteristics of the discharge plume are expected to be minimal under Scenarios 1 and 2 (a and b). The greatest increases to the salinity maximum values occur during the winter for both Scenarios 1 and 2 (a and b). Scenario 1 (winter) depicts salinity values up to 45 psu (+5.0 psu over Scenario 3 [winter] maximum, Figure 15) over an area similar in size to areas previously modeled to be 38 - 40 psu (Scenario 3). Scenario 2 (winter) depicts a greater maximum value increase to 48 psu (+8.0 psu over Scenario 3 [winter] maximum, Figure 15) but in a smaller, localized area immediately adjacent to the discharge canal and the shoreline to the north. The salinity plume under this scenario is smaller in areal extent and the salinity values reduce more quickly with distance from the discharge canal than in the plume footprint presented in Scenario 3. Summer conditions show only slight increases in maximum salinity values for Scenarios 1 and 2 (a and b) and overall the plume areal extent is smaller than in Scenario 3 (Figure 14).

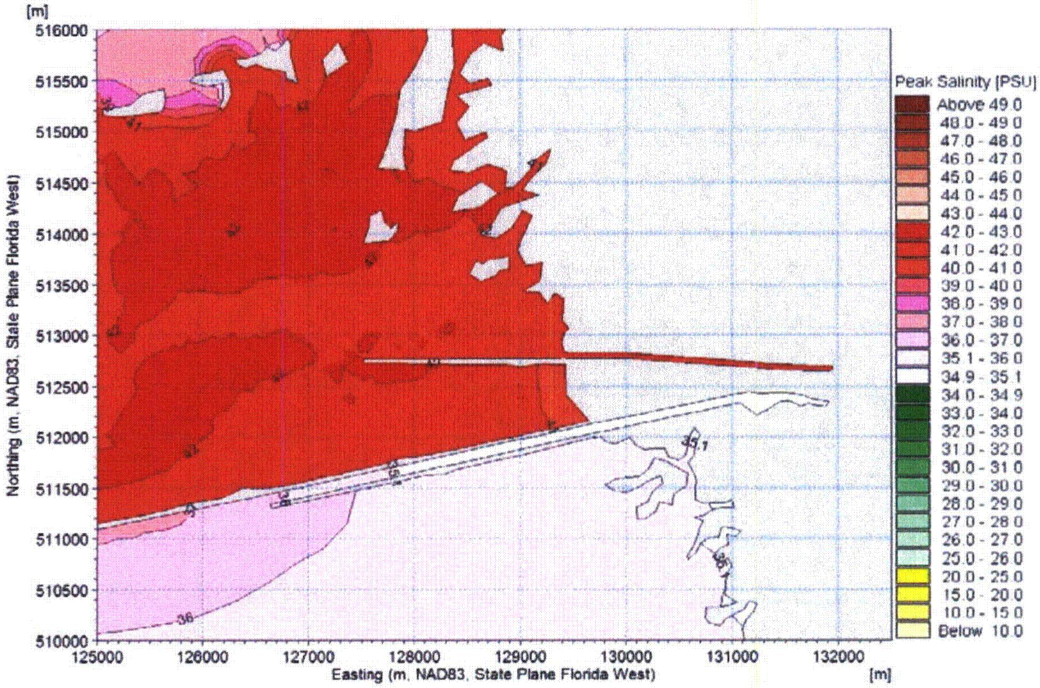

FIGURE 14
Extent of Modeled Salinity Plume, Summer Conditions, Scenario 3

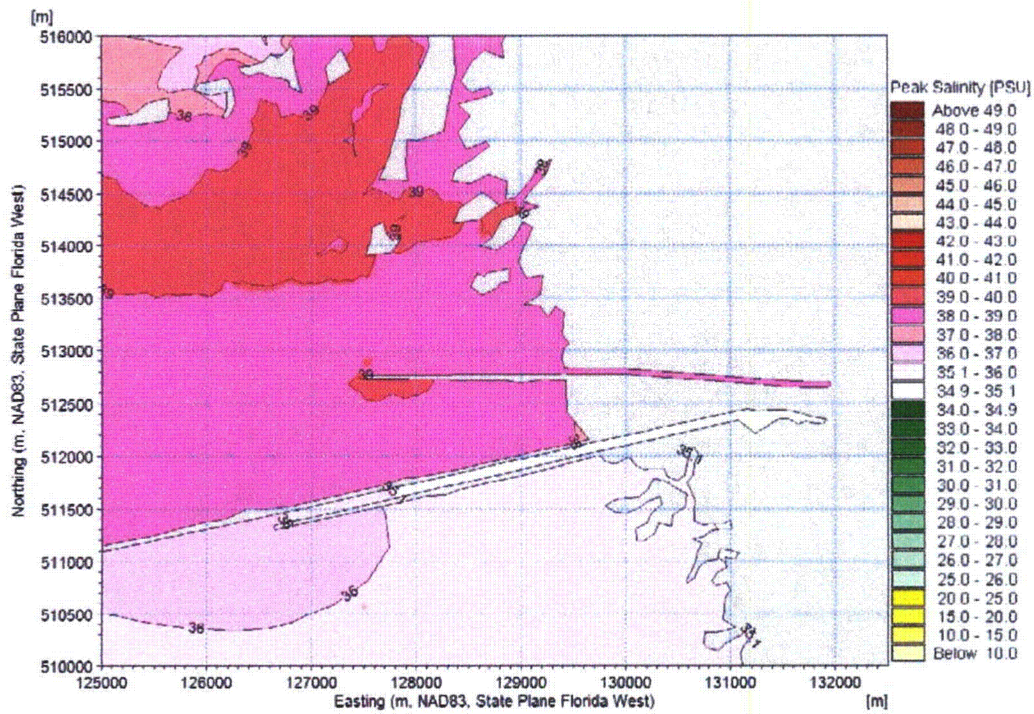

FIGURE 15
Extent of Modeled Salinity Plume, Winter Conditions, Scenario 3

Seagrasses mapped within these areas of increased maximum salinity values are dominated by shoal grass (*Halodule wrightii*) and manatee grass (*Syringodium fillforme*) (Environmental Report Section 2.4.2). Shoal grass has a wide range of salinity tolerance for optimal growth (20 - 44 psu) and has been found to survive hypersaline environments (< 70 psu) (Basin and Bay Expert Science Team [BBEST], 2012). Manatee grass has a lesser range for optimal growth (24 - 38 psu) (BBEST, 2012) and has a maximum tolerance of around 45 psu (McMillan and Moseley, 1967). Other less commonly occurring seagrasses include turtle grass (*Thalasia testudinum*) and star grass (*Halophila engelmannii*). These have been reported to have optimal salinity ranges of 20 - 40 psu (BBEST, 2012; Day et al., 1989). Maximum salinity tolerances for turtle grass and star grass have been reported as high as 60 psu (Koch et al., 2007) and 75 psu (Fourqurean et al., 2002).

Under the Scenario 2a/b (winter) conditions, there exists some potential for impacts to seagrasses from the increases in maximum salinity values. These impacts may include a loss of coverage of manatee grass, which would be near its salinity maximum. The impacts would be confined to a relatively small area along the shoreline just to the north of the discharge canal. Manatee grass losses would likely be replaced by shoal grass, which already dominates in these areas.

Oysters (*Crassostrea virginica*) are a common benthic invertebrate found in the vicinity of the discharge canal. Oysters have a wide range of salinity tolerance (10 - 28 psu) for optimal growth (Wilson et al., 2005). They have been found to occur within salinities ranging from 4 - 45 psu) (Day et al., 1989). Reported maximum salinity tolerances vary widely due to the broad geographic range oysters inhabit. The upper range of their occurrence (45 psu) generally represents their maximum tolerance. There is a small potential for impact to oysters from the elevated maximum salinity values under Scenario 2a/b (winter). Any impacts would be confined to the limited area, with modeled peak salinities ranging from 45 to 48 psu. The elevated winter salinities under Scenario 2a/b, however, would occur outside of the oyster spawning and recruitment season (spring and summer), further minimizing impacts to oysters.

Overall impacts of salinity changes due to decommissioning on aquatic communities are expected to be minor and very localized. In general, communities in the limited area where salinity increases may occur are adapted to, and tolerant of, high salinities and the fluctuations common to nearshore areas. Based on this assessment, impacts are not considered significant or warranting further review.

Site Selection Criteria

The LNP site was selected as the site for DEF's new nuclear power plant after a thorough site selection process. Twelve site selection criteria categories including 41 criteria were applied during the process. Four of these site selection criteria are potentially related to the plan to discharge LNP blowdown to the CREC discharge canal (Table 6).

Thermal discharge effects were discussed above. As stated previously, the combined thermal discharge will meet current NPDES requirements at the end of the canal (current compliance point and criterion) and any impacts to aquatic ecology will be minor and very localized. Therefore, revisions to the site selection process are not required based on the thermal discharge effects site selection criteria.

Radionuclide impacts are discussed in a separate TMEM. The dilution estimated by the new model was utilized to assess the environmental exposure.

TABLE 6
Site Selection Criteria

Category	Criteria	Related to CREC Discharge?
Health and Safety Criteria: Accident Cause-Related Criteria	Geology and Seismology Cooling System Requirements: Cooling Water Supply Cooling Water System: Ambient Temperature Requirements Flooding Nearby Hazardous Land Uses	No
Health and Safety Criteria: Accident Effects-Related Criteria	Extreme Weather Conditions Population Emergency Planning Atmospheric Dispersion	No
Health and Safety Criteria: Operational Effects-Related Criteria	Surface Water – Radionuclide Pathway	Yes
	Groundwater Radionuclide Pathway	No
	Air Radionuclide Pathway	No
	Air-Food Ingestion Pathway	No
	Surface Water – food radionuclide pathway	Yes
	Transportation Safety	No
Environmental Criteria: Operational-Related Effects on Aquatic Ecology	Thermal Discharge Effects	Yes
	Entrainment/Impingement effects	No
	Dredging/Disposal Effects	No
Environmental Criteria: Operational-Related Effects on Terrestrial Ecology	Drift Effects on Surrounding Areas	No
Socioeconomic Criteria	Socioeconomic – Construction Related Effects Socioeconomics – Operation Environmental Justice Land Use	No
Engineering and Cost-Related Criteria: Health and Safety Related Criteria	Water Supply Pumping Distance Flooding Civil Works Brownfield Site Remediation (if applicable) Water Supply	No
Environmental Criteria: Construction-Related Effects on Aquatic Ecology	Disruption of Important Species/Habitats Bottom Sediment Disruption Effects	No
Environmental Criteria: Construction-Related Effects on Terrestrial Ecology	Disruption of Important Species/Habitats and Wetlands Dewatering Effects on Adjacent Wetlands	No

TABLE 6
Site Selection Criteria

Category	Criteria	Related to CREC Discharge?
Environmental Criteria: Operational-Related Effects on Aquatic Ecology	Thermal Discharge Effects	Yes
Engineering and Cost: Transportation- or Transmission-Related Criteria	Railroad Access Highway Access Barge Access Transmission Cost and Market Price Differentials	No
Engineering and Cost-Related Criteria: Related to Socioeconomic & Land Use	Topography Land Rights Labor Rates	No

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Attachment A
Initial Dilution Calculations

A. Discharge Dilution Calculations

Duke Energy Florida, Inc. (DEF) provided the U.S. Nuclear Regulatory Commission (NRC) with discharge dilution estimates to demonstrate that the Levy Nuclear Plant (LNP) additional discharge did not substantially change the characteristics of the overall discharge from CREC. The NRC used these discharge dilution results to conduct offshore modeling internally. This attachment updates the original discharge dilution estimates. The scenarios developed in this attachment were utilized in this technical memorandum (TMEM) for evaluating offshore impacts.

A.1 Discharge Dilution Calculation Assumptions

The revised discharge dilution calculations are based on the data and assumptions from the original discharge dilution calculations (CH2M HILL, 2011) summarized in this section with the following associated revisions and updates:

- Scenarios - Three scenarios were considered:
  a. Current operations (operating Crystal River Energy Complex [CREC] Units 1, 2, 4, and 5)
  b. Current operations with LNP operating (operating CREC Units 1, 2, 4, and 5 and LNP Units 1 and 2)
  c. Decommissioning of CREC Units 1, 2, and 3 with LNP operating (operating CREC Units 4 and 5 and LNP Units 1 and 2)
  d. Past operations (operating CREC Units 1 through 5)
- Current temperature data (2009 through 2012 [DEF, 2013a]) were available for CREC Units 1 and 2. Calculations used the 99th percentile cooling water flow rate and outlet temperature for summer (June - September) and winter (October - May) conditions. Winter cooling water temperatures were assumed to be the same as summer cooling water temperatures for CREC Unit 4 because current temperature data were not available. Temperature data for the other discharge streams were retained from the original analysis (CH2M HILL, 2011).
- One to four banks of helper cooling towers (HCTs) were used in the calculation to meet the end-of-canal temperature permit limit of 96.5 degrees Fahrenheit (°F). HCTs cool discharge canal water to 89.5°F (Black & Veatch, 1992). Calculations assume a maximum change (input to output) of 13.5°F or a minimum of 89.5°F, whichever is higher.
- No mixing is assumed with the ambient water in the discharge canal and heat dissipation within the canal is assumed negligible to determine the characteristics of the point source. Full mixing is assumed among the discharge streams.
- Salinity changes for the HCTs and CREC 4 and 5 were based on cycles of concentration. Salinity concentrations for the other discharge streams were retained from the original analysis (CH2M HILL, 2011).

- The Units 4 and 5 primary cooling system withdraws and discharges at locations close together in the main discharge canal. If all once-through cooling water from Units 1, 2, and 3 were to cease, then Units 4 and 5 cooling system would not function. It was assumed that the intake cooling water for Units 4 and 5 would be replaced by a new source of ambient seawater.
- LNP discharge is assumed to be the worst-case scenario with the maximum flow rate of 87.9 million gallons per day (mgd).
- Ambient temperature and salinity concentrations were retained from the original analysis, i.e., ambient temperatures of 86°F (summer) and 58°F (winter) and ambient salinity of 35 psu for both seasons (CH2M HILL, 2011).

Assumptions are conservative to assess whether the original analysis was bounding. As the flow rates are reduced in the future, the heat dissipation and dispersion within the canal will become relatively more important factors than under the high discharge flow rates when all five CREC units were operating (in 2008).

A.2 Results of Discharge Dilution Calculations

The results of the discharge dilution calculations are summarized in Table A1, and the calculations are presented in Table A2.

TABLE A1
Summary of Original and Revised Discharge Dilution Calculations

		Properties of Outflow from CREC Discharge Canal					
		Discharge (mgd)		Temperature (°F)		Salinity (psu)	
Scenario	Description	Summer	Winter	Summer	Winter	Summer	Winter
Scenario a	CREC Units 1, 2, 4, 5	760	638	94.9	92.0	42.3	43.7
Scenario b	CREC Units 1, 2, 4, 5 and LNP Units 1, 2	848	726	95.1	92.7	43.4	44.8
Scenario c	CREC Units 4, 5 and LNP Units 1, 2	67	67	93.4	93.4	47.9	47.9
Scenario d	CREC Units 1 - 5	1,602	1,617	96.5	96.5	41.8	38.6
Original Analysis	CREC Units 1 - 5	1,838	1,595	96.5	76.1	36.3	35.4
Original Analysis	CREC Units 1 - 5 and LNP Units 1, 2	1,926	1,682	96.5	77.1	37.0	36.3

The results indicate that current operating conditions (no Unit 3, Scenario a) require the use of two HCTs to meet the permit limit of 96.5°F in the discharge canal during summer conditions. A discussion with DEF personnel verified that this is how the facility is being operated to meet permit conditions (DEF, 2013b). Although a similar need for more cooling was indicated for winter conditions (two HCTs), actual operating conditions do not require the use of the HCTs because of mixing of colder ambient water and greater heat loss to air, which are not considered in these discharge dilution calculations.

The addition of the LNP discharge to the existing discharges at CREC (no Unit 3, Scenario b) results in small increases to projected temperature and salinity in the discharge canal (0.2°F and 1.1 psu, respectively, for summer conditions and 0.7°F and 1.1 psu, respectively, for winter conditions). The original dilution calculations identified no significant increase in temperature with the addition of the LNP discharge; however, the original dilution calculations used four HCTs and heat management at CREC Units 1 and 2 (reduced heat load) to reduce the overall temperature in the discharge canal to meet the permit limit. The revised dilution calculations indicate that reducing heat loads from Units 1 and 2 will not be necessary, and that only two of the four HCTs are needed to maintain temperatures in the discharge canal below the permit limit of 96.5°F. The small projected increase of 0.2 to 0.7°F in the discharge canal is therefore considered insignificant and bounded by the original analysis because heat management and additional HCTs can be implemented if required.

The LNP discharge after future decommissioning of CREC Units 1 and 2 (no Units 1, 2, or 3, Scenario c) results in small changes to projected temperature compared to Scenario a (-1.5°F and +1.4°F for summer and winter conditions, respectively) and compared to Scenario b (-1.7°F and +0.7°F for summer and winter conditions, respectively).

Overall, projected temperatures are similar to those projected for current operating conditions (Scenario a). Larger increases in salinity are projected, however, between Scenarios a and c: increases up to 5.6 and 4.2 psu for summer and winter conditions, respectively, compared to those observed for the original analysis. Again, this is a conservative assessment because mixing and dispersion are not included in the mass and heat balance approach used herein.

A.3 Conclusions

A two-dimensional numerical model was developed to further refine the projected temperature and salinity concentrations in the CREC discharge canal and the nearby Gulf of Mexico. This model was run to assess whether the original analysis is bounding for salinity. These revised discharge dilution calculations indicate that the results of the original calculations bound potential impacts to temperatures in the CREC discharge canal related to decommissioning of CREC Units 1, 2, and/or 3 because the permit limits will not be exceeded at the point of compliance at the end of the main discharge canal.

Table A2
Revised Discharge Dilution Calculations

Estimated Temperature and Salinity Changes Along the CREC Discharge Canal

Summer Conditions Assumptions:

Typical High August Gulf Water Temperature =	80 °F
99th Percentile August Gulf Water Temperature =	91 °F
Typical Gulf Salinity in vicinity of CREC =	27 psu
High Gulf Salinity =	35 psu
Number of HCT pumps in service =	2

Winter Conditions Assumptions:

Typical High January Gulf Water Temperature =	60 °F
99th Percentile January Gulf Water Temperature =	NA °F
Typical Gulf Salinity in vicinity of CREC =	27 psu
High Gulf Salinity =	35 psu
Number of HCT pumps in service =	2

Scenario a

Summer Conditions - Current Operations, No CR3

	Flow (gpm)		Temperature (F)		Salinity (psu)	
Location on CREC	Unit	CREC Canal	Discharge	CREC Canal	Discharge	CREC Canal
LVW CR3	0	0	–	–	–	–
Unit 3	0	0	–	–	–	–
Unit 1	310,000	310,000	106.0	106.0	35.0	35.0
Unit 2	327,986	637,986	103.0	104.5	35.0	35.0
4+5 intake	-75,778	562,208	104.5	104.5	35.0	35.0
4+5 discharge	61,111	623,319	94.7	103.5	43.4	35.8
LNP	0	623,319	92.0	103.5	52.5	35.8
HCT Intake	-433,000	190,319	103.5	103.5	35.8	35.8
CT 1 - 2 discharge	168,745	359,064	90.0	97.2	46.0	40.6
TWR A, B discharge	0	359,064	0.0	97.2	0.0	40.6
CT 3 - 4 discharge	168,745	527,808	90.0	94.9	46.0	42.3
TWR C, D discharge	0	527,808	0.0	94.9	0.0	42.3

Summary	
Gulf Ambient	
Temperature:	91.0 °F
Salinity:	35.0 psu
Point of Discharge	
Flow:	760 mgd
Temperature:	94.9 °F
Salinity:	42.3 psu

Permit limit is 96.5 DegF 3-hr avg, Cooling flow from CREC 1,2 is based on 99 percentile flow from January 2009 through December 2012. Cooling water flow from CREC 4,5 is 88 mgd. Helper Cooling Tower (HCT) on north side of discharge canal consists of four units (CT 1-4).

Winter Conditions - Current Operations, No CR3

	Flow (gpm)		Temperature (F)		Salinity (psu)	
Location on CREC	Unit	CREC Canal	Discharge	CREC Canal	Discharge	CREC Canal
LVW CR3	0	0	–	–	–	–
Unit 3	0	0	–	–	–	–
Unit 1	249,000	249,000	103.0	103.0	35.0	35.0
Unit 2	304,000	553,000	99.0	100.8	35.0	35.0
4+5 intake	-75,778	477,222	100.8	100.8	35.0	35.0
4+5 discharge	61,111	538,333	94.7	100.1	43.4	36.0
LNP	0	538,333	92.0	100.1	52.5	36.0
HCT Intake	-433,000	105,333	100.1	100.1	36.0	36.0
CT 1 - 2 discharge	168,745	274,078	89.5	93.6	46.1	42.2
TWR A, B discharge	0	274,078	0.0	93.6	0.0	42.2
CT 3 - 4 discharge	168,745	442,822	89.5	92.0	46.1	43.7
TWR C, D discharge	0	442,822	0.0	92.0	0.0	43.7

Summary	
Gulf Ambient	
Temperature:	60.0 °F
Salinity:	35.0 psu
Point of Discharge	
Flow:	638 mgd
Temperature:	92.0 °F
Salinity:	43.7 psu

Scenario b

Summer Conditions - No CR3, with LNP

	Flow (gpm)		Temperature (F)		Salinity (psu)	
Location on CREC	Unit	CREC Canal	Discharge	CREC Canal	Discharge	CREC Canal
LVW CR3	0	0	–	–	–	–
Unit 3	0	0	–	–	–	–
Unit 1	310,000	310,000	106.0	106.0	35.0	35.0
Unit 2	327,986	637,986	103.0	104.5	35.0	35.0
4+5 intake	-75,778	562,208	104.5	104.5	35.0	35.0
4+5 discharge	61,111	623,319	94.7	103.5	43.4	35.8
LNP	61,042	684,361	92.0	102.5	52.5	37.3
HCT Intake	-433,000	251,361	102.5	102.5	37.3	37.3
CT 1 - 2 discharge	168,745	420,106	89.5	97.3	47.9	41.6
TWR A, B discharge	0	420,106	0.0	97.3	0.0	41.6
CT 3 - 4 discharge	168,745	588,850	89.5	95.0	47.9	43.4
TWR C, D discharge	0	588,850	0.0	95.0	0.0	43.4

Summary	
Gulf Ambient	
Temperature:	91.0 °F
Salinity:	35.0 psu
Point of Discharge	
Flow:	848 mgd
Temperature*:	95.1 °F
Salinity:	43.4 psu

Assumes 1.5 cycles of concentration (COC) at LNP using maximum potential LNP intake salinity is same as CREC

Winter Conditions - No CR3, with LNP

	Flow (gpm)		Temperature (F)		Salinity (psu)	
Location on CREC	Unit	CREC Canal	Discharge	CREC Canal	Discharge	CREC Canal
LVW CR3	0	0	–	–	–	–
Unit 3	0	0	–	–	–	–
Unit 1	249,000	249,000	103.0	103.0	35.0	35.0
Unit 2	304,000	553,000	99.0	100.8	35.0	35.0
4+5 intake	-75,778	477,222	100.8	100.8	35.0	35.0
4+5 discharge	61,111	538,333	94.7	100.1	43.4	36.0
LNP	61,042	599,375	92.0	99.3	52.5	37.6
HCT Intake	-433,000	166,375	99.3	99.3	37.6	37.6
CT 1 - 2 discharge	168,745	335,120	89.5	94.4	48.3	43.0
TWR A, B discharge	0	335,120	0.0	94.4	0.0	43.0
CT 3 - 4 discharge	168,745	503,864	89.5	92.7	48.3	44.8
TWR C, D discharge	0	503,864	0.0	92.7	0.0	44.8

Summary	
Gulf Ambient	
Temperature:	60.0 °F
Salinity:	35.0 psu
Point of Discharge	
Flow:	726 mgd
Temperature:	92.7 °F
Salinity:	44.8 psu

Estimated Temperature and Salinity Changes Along the CREC Discharge Canal

Summer Conditions Assumptions:

Typical High August Gulf Water Temperature =	80	°F
99th Percentile August Gulf Water Temperature =	91	°F
Typical Gulf Salinity in vicinity of CREC =	27	psu
High Gulf Salinity =	35	psu
Number of HCT pumps in service =	2	

Winter Conditions Assumptions:

Typical High January Gulf Water Temperature =	60	°F
99th Percentile January Gulf Water Temperature =	NA	°F
Typical Gulf Salinity in vicinity of CREC =	27	psu
High Gulf Salinity =	35	psu
Number of HCT pumps in service =	2	

Scenario c

Summer Conditions - No CR1, 2, 3, with LNP

Location on CREC	Flow (gpm) Unit	Flow (gpm) CREC Canal	Temperature (F) Discharge	Temperature (F) CREC Canal	Salinity (psu) Discharge	Salinity (psu) CREC Canal
LVW CR3	0	0	–	–	–	–
Unit 3	0	0	–	–	–	–
Unit 1	0	0	0.0	0.0	0.0	0.0
Unit 2	0	0	0.0	0.0	0.0	0.0
4+5 intake	-75,778	-75,778	0.0	0.0	0.0	0.0
4+5 discharge	61,111	-14,667	94.7	94.7	43.4	43.4
LNP	61,042	46,375	92.0	93.4	52.5	47.9
HCT Intake	0	46,375	0.0	93.4	0.0	47.9
CT 1 - 2 discharge	0	46,375	0.0	93.4	0.0	47.9
TWR A, B discharge	0	46,375	0.0	93.4	0.0	47.9
CT 3 - 4 discharge	0	46,375	0.0	93.4	0.0	47.9
TWR C, D discharge	0	46,375	0.0	93.4	0.0	47.9

Summary	
Gulf Ambient	
Temperature:	91.0 °F
Salinity:	35.0 psu
Point of Discharge	
Flow:	67 mgd
Temperature:	93.4 °F
Salinity:	47.9 psu

Assumes 1.5 cycles of concentration (COC) at LNP using maximum potential LNP intake salinity is same as CREC

Winter Conditions - No CR1, 2, 3, with LNP

Location on CREC	Flow (gpm) Unit	Flow (gpm) CREC Canal	Temperature (F) Discharge	Temperature (F) CREC Canal	Salinity (psu) Discharge	Salinity (psu) CREC Canal
LVW CR3	0	0	–	–	–	–
Unit 3	0	0	–	–	–	–
Unit 1	0	0	0.0	0.0	0.0	0.0
Unit 2	0	0	0.0	0.0	0.0	0.0
4+5 intake	-75,778	-75,778	0.0	0.0	0.0	0.0
4+5 discharge	61,111	-14,667	94.7	94.7	43.4	43.4
LNP	61,042	46,375	92.0	93.4	52.5	47.9
HCT Intake	0	46,375	0.0	93.4	0.0	47.9
CT 1 - 2 discharge	0	46,375	0.0	93.4	0.0	47.9
TWR A, B discharge	0	46,375	0.0	93.4	0.0	47.9
CT 3 - 4 discharge	0	46,375	0.0	93.4	0.0	47.9
TWR C, D discharge	0	46,375	0.0	93.4	0.0	47.9

Summary	
Gulf Ambient	
Temperature:	60.0 °F
Salinity:	35.0 psu
Point of Discharge	
Flow:	67 mgd
Temperature:	93.4 °F
Salinity:	47.9 psu

Scenario d

Summer Conditions Assumptions:

Typical High August Gulf Water Temperature =	80	°F
99th Percentile August Gulf Water Temperature =	91	°F
Typical Gulf Salinity in vicinity of CREC =	27	psu
High Gulf Salinity =	35	psu
Number of HCT pumps in service =	4	

Winter Conditions Assumptions:

Typical High January Gulf Water Temperature =	60	°F
99th Percentile January Gulf Water Temperature =	NA	°F
Typical Gulf Salinity in vicinity of CREC =	27	psu
High Gulf Salinity =	35	psu
Number of HCT pumps in service =	2	

Summer Conditions - Past Operations with heat management, With LNP

Location on CREC	Flow (gpm) Unit	Flow (gpm) CREC Canal	Temperature (F) Discharge	Temperature (F) CREC Canal	Salinity (psu) Discharge	Salinity (psu) CREC Canal
LVW CR3	0	0	–	–	–	–
Unit 3	680,000	680,000	108.4	109.0	35.0	–
Unit 1	310,000	990,000	101.1	106.5	35.0	35.0
Unit 2	327,986	1,317,986	101.1	105.2	35.0	35.0
4+5 intake	-75,778	1,242,208	105.2	105.2	35.0	35.0
4+5 discharge	61,111	1,303,319	94.7	104.7	43.4	35.4
LNP	0	1,303,319	92.0	104.7	52.5	35.4
HCT Intake	-866,000	437,319	104.7	104.7	35.4	35.4
CT 1 - 2 discharge	337,489	774,808	91.2	98.8	46.0	40.0
TWR A, B discharge	0	774,808	0.0	98.8	0.0	40.0
CT 3 - 4 discharge	337,489	1,112,297	91.2	96.5	46.0	41.8
TWR C, D discharge	0	1,112,297	0.0	96.5	0.0	41.8

Summary	
Gulf Ambient	
Temperature:	91.0 °F
Salinity:	35.0 psu
Point of Discharge	
Flow:	1,602 mgd
Temperature:	96.5 °F
Salinity:	41.8 psu

Permit limit is 96.5 DegF 3-hr avg, Cooling flow from CREC 1,2 is based on 99 percentile flow from January 2009 through December 2012, Cooling water flow from CREC 4,5 is 88 mgd. Helper Cooling Tower (HCT) on north side of discharge canal consists of four units (CT 1-4).

Winter Conditions - Past Operations with heat management, With LNP

Location on CREC	Flow (gpm) Unit	Flow (gpm) CREC Canal	Temperature (F) Discharge	Temperature (F) CREC Canal	Salinity (psu) Discharge	Salinity (psu) CREC Canal
LVW CR3	0	0	–	–	–	–
Unit 3	680,000	680,000	98.8	98.8	35.0	35.0
Unit 1	249,000	929,000	103.0	99.9	35.0	35.0
Unit 2	304,000	1,233,000	99.0	99.7	35.0	35.0
4+5 intake	-75,778	1,157,222	99.7	99.7	35.0	35.0
4+5 discharge	61,111	1,218,333	94.7	99.4	43.4	35.4
LNP	0	1,218,333	92.0	99.4	52.5	35.4
HCT Intake	-433,000	785,333	99.4	99.4	35.4	35.4
CT 1 - 2 discharge	168,745	954,078	89.5	97.7	46.1	37.3
TWR A, B discharge	0	954,078	0.0	97.7	0.0	37.3
CT 3 - 4 discharge	168,745	1,122,822	89.5	96.5	46.1	38.6
TWR C, D discharge	0	1,122,822	0.0	96.5	0.0	38.6

Summary	
Gulf Ambient	
Temperature:	60.0 °F
Salinity:	35.0 psu
Point of Discharge	
Flow:	1,617 mgd
Temperature:	96.5 °F
Salinity:	38.6 psu

Attachment B
Offshore Model Calibration

B. Offshore Model Calibration

B1. Calibration Scenarios

Scenarios 0 and 0a, as summarized in Table B1, refer to the past operating conditions of Crystal River Energy Complex (CREC) Units 1 through 5. These scenarios were used as the basis for comparing the calibration of the new model to the modeling performed by the U.S. Nuclear Regulatory Commission (NRC) (2012).

TABLE B1
Discharge Plume Modeling Scenarios

Basis: Original Dilution Calculations (CH2M HILL, 2011)							
Calibration Scenario (Scenario 0) CREC Units 1 - 5 Summer Conditions				Calibration Scenario (Scenario 0) CREC Units 1 - 5 Winter Conditions			
Location	Flow (mgd)	Temperature (°F)	Salinity[a] (psu)	Location	Flow (mgd)	Temperature (°F)	Salinity[a] (psu)
Gulf Ambient	-	86	35	Gulf Ambient	-	58	35
Point of Discharge	1,838	96.5	36.3	Point of Discharge	1,595	76.1	35.4
Calibration Scenario (Scenario 0a) LNP and CREC Units 1 - 5 Summer Conditions				Calibration Scenario (Scenario 0a) LNP and CREC Units 1 - 5 Winter Conditions			
Location	Flow (mgd)	Temperature (°F)	Salinity[a] (psu)	Location	Flow (mgd)	Temperature (°F)	Salinity[a] (psu)
Gulf Ambient	-	86	35	Gulf Ambient	-	58	35
Point of Discharge	1,926	96.5	37.0	Point of Discharge	1,682	77.1	36.3

[a] The ambient temperatures simulated in the numerical modeling are slightly lower than the ambient temperatures used in the discharge dilution calculations presented in Attachment A. Ambient temperatures of 86°F (summer) and 58°F (winter) were used for consistency with the original numerical modeling assumptions. mgd = million gallons per day; °F = degrees Fahrenheit; psu = practical salinity unit

B2. Calibration of the Flow Model

The regional flow model was driven by predicted tides generated from the Global Tide Model in the MIKE 21 Toolbox (DHI, 2012) based on the pre-packaged tidal constituents in 0.25° grids. Model calibration was conducted using the predicted tides published by the National Oceanic and Atmospheric Administration (NOAA) (NOAA, 2013d) at the Cedar Key tide station (Station ID: 8727250).

August 2012, which is representative of the summer condition, was selected for model calibration. Wind and river discharges were not included because they would not influence the predicted tides at Cedar Key. The resulting comparison between predicted and modeled tides is shown in Figure B1, which indicates good agreement in terms of tidal range and also

tidal phases. The associated error statistics for the 1-month model calibration are summarized in Table B2, which indicates a slight tendency toward under-estimation as seen from the negative bias (less than 1-inch average bias). The primary calibration parameter used is the bottom roughness, which is parameterized using the inverse of the Manning "n" designated as "M;" the calibrated M value is 40 $m^{1/3}$/second (s) (or n = 0.025).

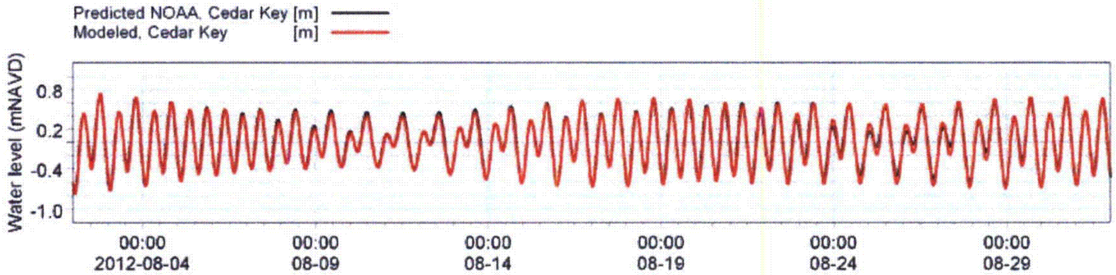

FIGURE B1
Comparison of Modeled Tides and NOAA's Predicted Tides at Cedar Key, Model Calibration

TABLE B2
Summary of Error Statistics - Model Calibration Period

RMSE		Average Bias (modeled – NOAA predicted)		
(m)	Normalized by mean TR[a] (%)	(m)	Normalized by mean TR[a] (%)	Correlation Coefficient
0.05	6.3	-0.02	-2.4	0.99

[a] The mean tidal range at Cedar Key by NOAA is 0.86 m.
RMSE root-mean square error
TR tidal range

The calibrated model was then applied to December 2012 (verification), which is representative of the winter condition. The comparison plot is shown in Figure B2, and the error statistics are summarized in Table B3.

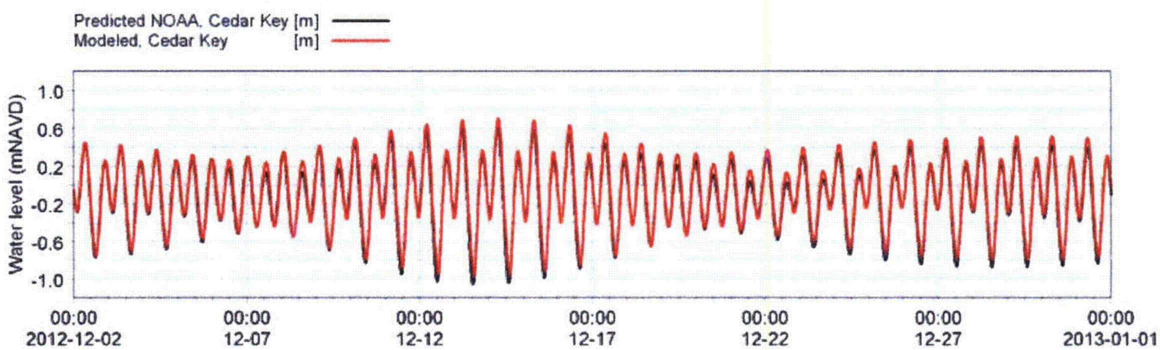

FIGURE B2
Comparison of Modeled Tides and NOAA's Predicted Tides at Cedar Key, Model Verification

TABLE B3
Summary of Error Statistics - Model Verification Period

RMSE		Average Bias (modeled – NOAA predicted)		
(m)	Normalized by mean TR[a] (%)	(m)	Normalized by mean TR[a] (%)	Correlation Coefficient
0.07	8.5	0.05	5.5	0.99

[a] The mean tidal range at Cedar Key by NOAA is 0.86 m.
RMSE root-mean square error
TR tidal range

Figure B2 indicates a similar degree of agreement, while Table B3 indicates a tendency toward over-estimation and also slightly higher error statistics (average bias of about 2 inches). However, the overall deviation is less than 10 percent in both periods.

Additional comparison was made between published and modeled current data (Florida Power Corporation [FPC], 1985) using the modeled currents from the local model. The comparison is approximate and based on seasonal fluctuations because the published data were from a different year. Published data include water level measurements for a 1-month duration for August 1983 and January 1984 at several locations; however, only data for the locations shown in Figure B3 were available as time series plots. Note that the locations of the stations on Figure B3 are approximate. The published current plots are for a 5-day period each (August 8-12, 1983, and January 5-9, 1984) and show peak current speed ranging from 0.22 - 0.45 m/s (0.7 - 1.5 ft/s) at the stations, with the nearshore stations (S1) generally registering weaker currents compared to those offshore.

Comparison with the modeled currents for the months of August 2012 and January 2013 indicate reasonable agreement where the modeled nearshore peak current (S1) is on the order of 0.3 m/s (1 ft/s), while those in the offshore (S5 and S7) are 0.4 m/s (1.3 ft/s). To the extent that the current magnitude is sensitive to the water depths, the uncertainty in the locations of the stations renders the comparison at best approximate.

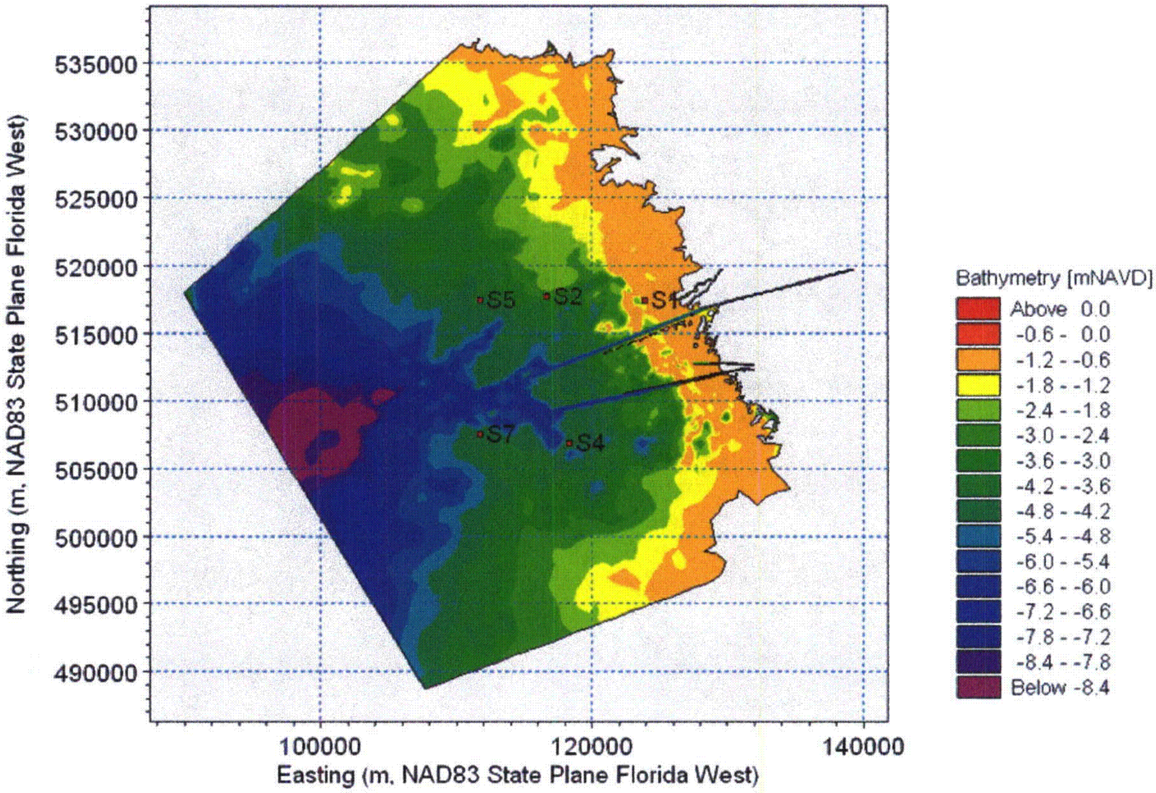

FIGURE B3
Approximate Location of Current Measurements from FPC (1985) Used in Comparison

Based on the good agreement achieved in the water level-based calibration and verification and the approximate comparison with measured currents in terms of peak current speed for each season, it is considered that the flow model is reasonably validated and can produce a realistic current field to drive the temperature and salinity sub-modules.

B.2 Calibration of the Temperature/Salinity Sub-Modules

The primary calibration parameter for the temperature and salinity sub-modules is the dispersion coefficient. In two-dimensional, depth-averaged models, the dispersion usually describes the transport caused by non-resolved processes. In coastal areas, the dispersion also accounts for the transport caused by non-resolved turbulence or eddies. The effects of these non-resolved processes can be significant in the horizontal direction, in which case the dispersion coefficient then becomes a function of the mesh resolution as well.

In the MIKE 21 FM flow model, the horizontal dispersion can be formulated in the following ways:

- Scaled eddy viscosity formulation
- User-specified dispersion coefficient formulation

Using the scaled eddy viscosity formulation, the dispersion coefficient is calculated as the product of the eddy viscosity, calculated in the solution of the flow equations, and a scaling factor.

In the absence of site tracer studies to provide the dispersion characteristic, the MIKE 21 Manual (DHI, 2012) recommends that the scaled eddy formulation with a default scaling factor of 1 be used to calculate the dispersion coefficient. The MIKE 21 Manual (DHI, 2012) acknowledges that it is difficult to assign generally applicable values for the dispersion coefficient; however, using the Reynolds analogy, the dispersion coefficient can be written as the product of a length scale and a velocity scale. In shallow waters, the length scale can often be taken as the water depth, while the velocity scale is the typical current speed.

For the nearshore area, Figure B3 indicates that the nearshore water depth is on the order of 1 to 2 m. Furthermore, the preceding section suggests that the nearshore current velocity is on the order of 0.1 - 0.2 m/s (0.3 - 0.7 ft/s). Thus, a first-order estimate of the dispersion coefficient could be in the range of 0.1 - 0.4 square meter (m^2)/s (1.1 - 4.3 square feet [ft^2]/s). Preliminary simulations using the model mesh (nearshore element size of 100 m [328 ft]) and applying a scaling factor of 1 indicate that the modeled nearshore dispersion coefficient is in the range of 0.1 - 0.6 m^2/s (1.1 - 6.5 ft^2/s). Thus, the scaled eddy formulation with a scaling factor of 1 was used in generating the temperature and salinity plumes for comparison with the results of the NRC modeling (NRC, 2012) described in the following section.

a. Comparison with Published NRC Temperature and Salinity Difference Plots

In the Environmental Impact Statement (EIS) report (NRC, 2012), the difference plot was calculated between the existing scenario (Scenario 0 of Table B1) and the proposed scenario with the addition of the two new LNP flows (Scenario 0a). These scenarios are summarized in Table B4, and are used herein for consistency.

TABLE B4
Thermal/Salinity Plume Scenarios Simulated by NRC (2012)

	Discharge (mgd)		Salinity (psu)		Discharge Temperature (Ambient Temperature)	
Configuration	Summer	Winter	Summer	Winter	Summer	Winter
CREC Units 1-5 (Scenario 0)	1838	1595	36.3	35.4	96.5°F (86°F)	76.1°F (58°F)
CREC Units 1-5 and LNP Units 1 and 2 (Scenario 0a)	1926	1682	37	36.3	96.5°F (86°F)	77.1°F (58°F)

The set-up of the two scenarios for comparison requires the specification of the parameters described in the following subsections.

i. Surface Water Flows

Based on available flow data, a flow discharge of 3 cubic meters (m^3)/sec (106 [ft^3]/sec) was adopted for both the Withlacoochee River and the Cross Florida Barge Canal (CFBC) (NRC, 2012). These values generally correspond to low flow conditions. Because these freshwater flows (salinity = 0 psu) work to reduce the ambient salinity, it is conservative to assume low flow conditions. The ambient temperature of the river flow is taken to be the ambient temperature shown in Table B4 (the same as that in the Gulf).

ii. Initial and Boundary Temperature and Salinity Conditions

The initial and boundary (at the three open boundaries) values of temperature and salinity are set to the respective ambient values in Table B1.

iii. Intake and Discharge Flow/Temperature/Salinity Conditions

No flow was assumed in the intake channel, which is separated from the discharge channel by a continuous barrier for a distance of approximately 11.8 kilometers (km) (7.3 miles [mi]) from the shoreline. The CREC discharge flow, temperature, and salinity values are as specified in Table B1 (point of discharge).

iv. Simulation Period

Two 1-month period simulations were conducted: August 2012 for the summer condition and January 2013 for the winter condition. The regional model was first run as a flow simulation using only predicted tides generated from the Global Tide Model (DHI, 2012) as boundary conditions, and without considering the surface flows from the various channels. The flows (water level and velocities) at the open boundaries of the local model were then extracted from the regional model output to drive the local model. The temperature/salinity sub-module was invoked in the local model simulation, which included all the surface flows.

Both the regional and local model simulations commenced from a steady-state condition (cold start). To allow for model spin-up time (starting from a quiescent condition as opposed to applying the previous run results), only the last two weeks of the simulation results were used for the comparison.

v. Modeled Outputs

Both the summer and winter simulations end with a spring tide phase (period of larger tides of a spring-neap cycle). The flow conditions selected to provide the temperature and salinity outputs for comparison therefore correspond to the spring tide: specifically, the two ebb/flood tides occurring on August 29-30, 2012, and January 29-30, 2013. These conditions are indicative of the larger plume extent and temperature/salinity over a typical neap-spring cycle, as borne out by the comparison between neap and spring tide conditions.

The peak temperature and salinity values over the model domain for the two spring tide simulations were then extracted and difference maps of the temperature and salinity distribution were prepared for comparison.

vi. Comparison of Salinity Distribution

The difference map for salinity for the summer condition is shown in Figure B4. Contour lines of the salinity difference from the original modeling study (NRC, 2012) were overlaid for ease of comparison (red lines are from EIS). Broadly, the seaward extents of insignificant increase in salinity are similar, even though the shapes of the contours vary. In addition, the occurrences of a zone of salinity increase between 0.5 and 0.75 psu covering the nearshore area near the discharge outlet are also similar; however, the following differences are noted:

- Two tongues of higher-salinity increase are apparent from the present results compared to the semicircular shape of the contours from the NRC study (2012). The larger of the two is in the offshore direction where the highest band of salinity increase occurs along the seaward extension of the CFBC dredge islands. The smaller tongue tends to move northward parallel to the shoreline.
- A small area of salinity increase peaking at approximately 0.2 psu occurs on the south side of the intake barrier, emanating from the Fisherman Pass.

Considering the possible variation in the range of ebb tide from the neap phase to the spring phase used as the flow condition and also the schematization of the various channel dimensions, it was concluded that the differences are acceptable and that the use of the scaled viscosity formulation for the dispersion coefficient was reasonable.

The same comparison for the winter condition is shown in Figure B5. The similarity in the broad extent and the pattern of differences as noted for the summer condition are also applicable here. A salinity increase between 0.75 psu and 1.0 psu appears to occur in the nearshore area fronting the discharge outlet.

vii. Comparison of Temperature Distribution

The comparison of peak temperature during ebb tide is similarly shown in Figures B6 and B7 in the form of difference maps for the summer and winter conditions, respectively. Generally, the temperature difference in the nearshore area fronting the discharge outlet and extending to more than half the length of the intake barrier is similar to the results found by NRC (2012). The difference in temperature was less than 0.1 degrees Celsius (°C) for the summer condition and between 0.5°C and 0.6°C for the winter condition.

While there are spatial differences from the results of NRC (2012) in isolated areas, these differences likely arise from the uncertainty associated with the specific flow condition considered in the NRC's results, including the schematization of channel dimensions, and inherent differences with NRC's model engine and set-up. There was insufficient documentation in the EIS to determine the specific differences.

The temperature/salinity sub-module is deemed reasonably validated by using the scaled eddy viscosity formulation that renders the dispersion coefficient a function of the velocity gradient and mesh resolution.

viii. Sensitivity Tests

Sensitivity tests of the envelope of plume excursion and elevation in temperature/salinity were conducted by:

- Increasing the river discharges (to 20 m^3/s [706 ft^3/s])
- Increasing the depth of the discharge channel to 4.0 m (131 ft) (Table 1 in text)
- Increasing the mesh resolution of the discharge channel and the nearshore area in the vicinity of the discharge outlet by 3 to 4 times
- Including ambient wind and waves
- Including heat exchange processes based on ambient air temperature and synoptic relative humidity
- Increasing the dispersion coefficient (as a spatially constant value) up to 2 m^2/s (21.5 ft^2/s).

The results indicated that the plume extent and level either remain similar or are bounded by the previous results. Therefore, the local area model was judged to be calibrated and not overly sensitive to other factors that could influence the results in a less conservative manner.

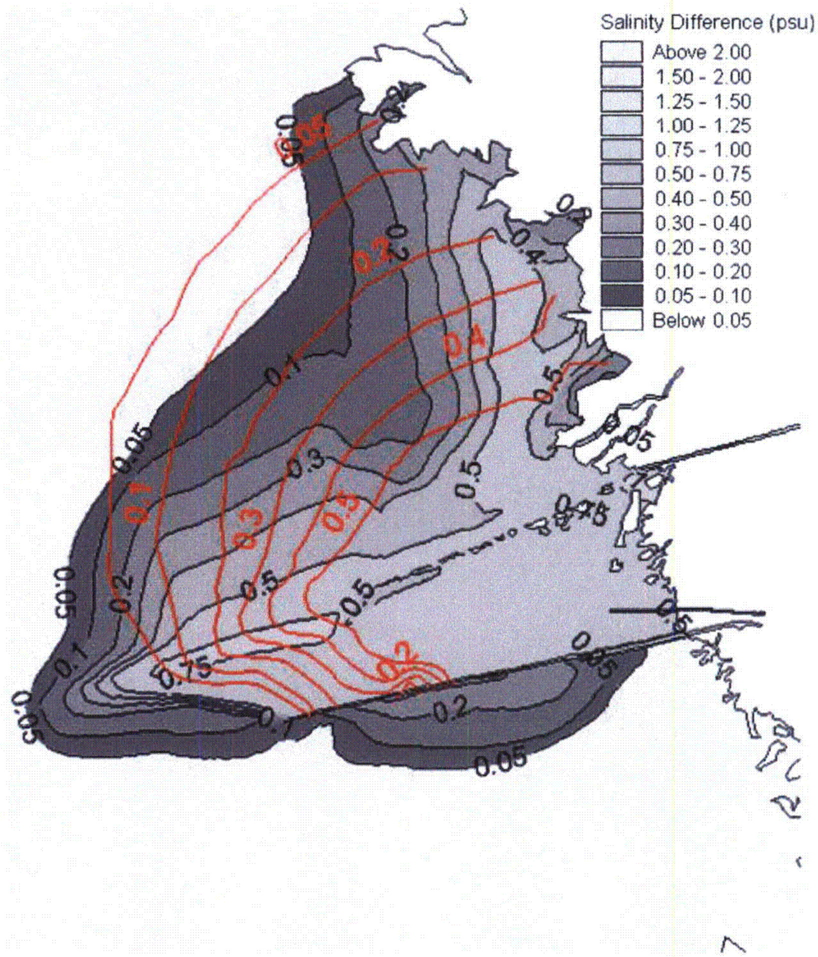

FIGURE B4
Salinity Difference of the Discharge Plume between Scenario 0a and Scenario 0 (Scenario 0a – Scenario 0), Summer Conditions, Ebb Tide

Note: The red contours denote the difference contours from NRC Figure 5-8A (2012).

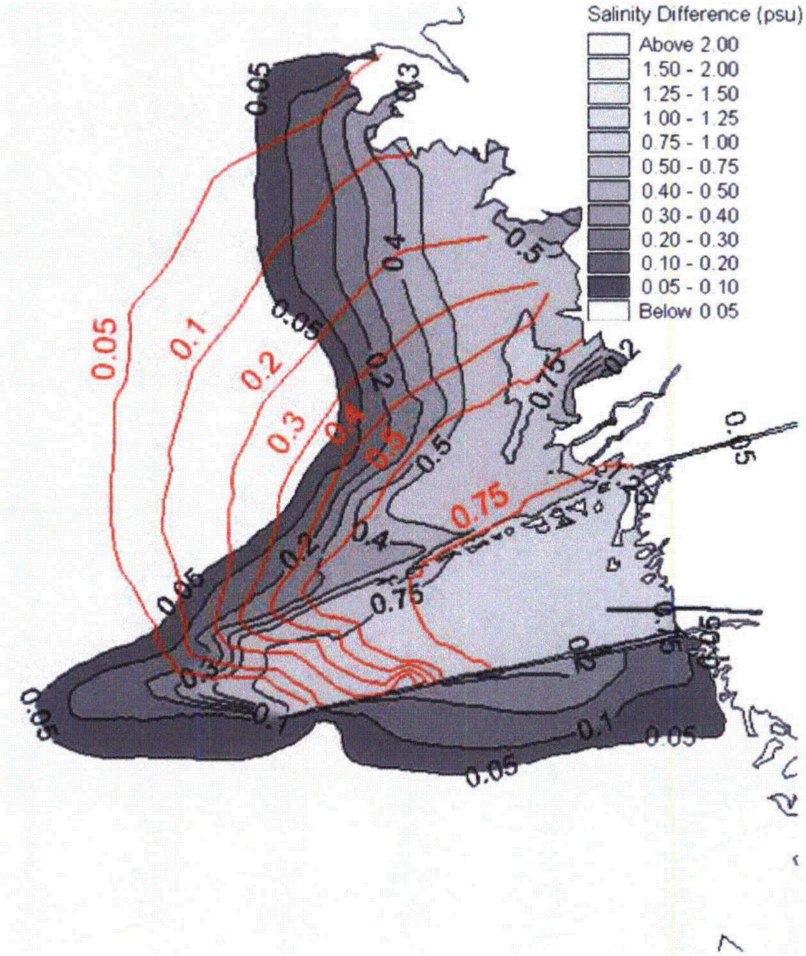

FIGURE B5
Salinity Difference of the Discharge Plume between Scenario 0a and Scenario 0 (Scenario 0a – Scenario 0), Winter Conditions, Ebb Tide

Note: The red contours denote the difference contours from NRC Figure 5-8B (2012).

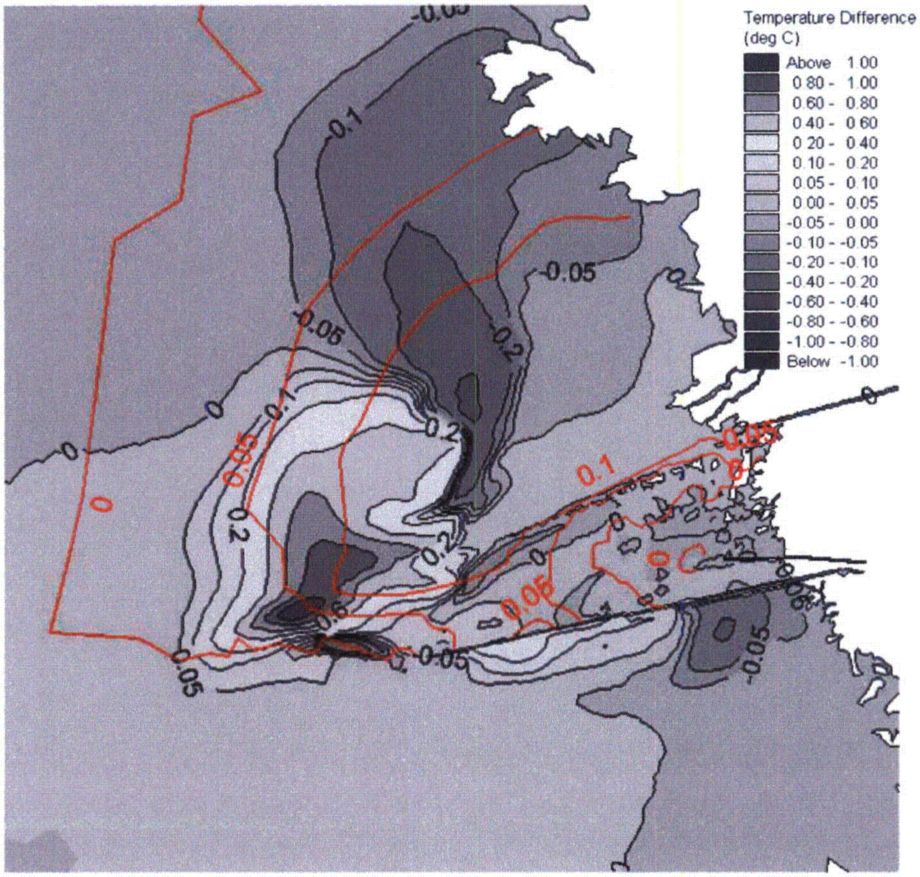

FIGURE B6

Temperature Difference of the Discharge Plume between Scenario 0a and Scenario 0 (Scenario 0a – Scenario 0), Summer Conditions, Ebb Tide

Note: The red contours denote the difference contours from NRC Figure 5-6 (2012).

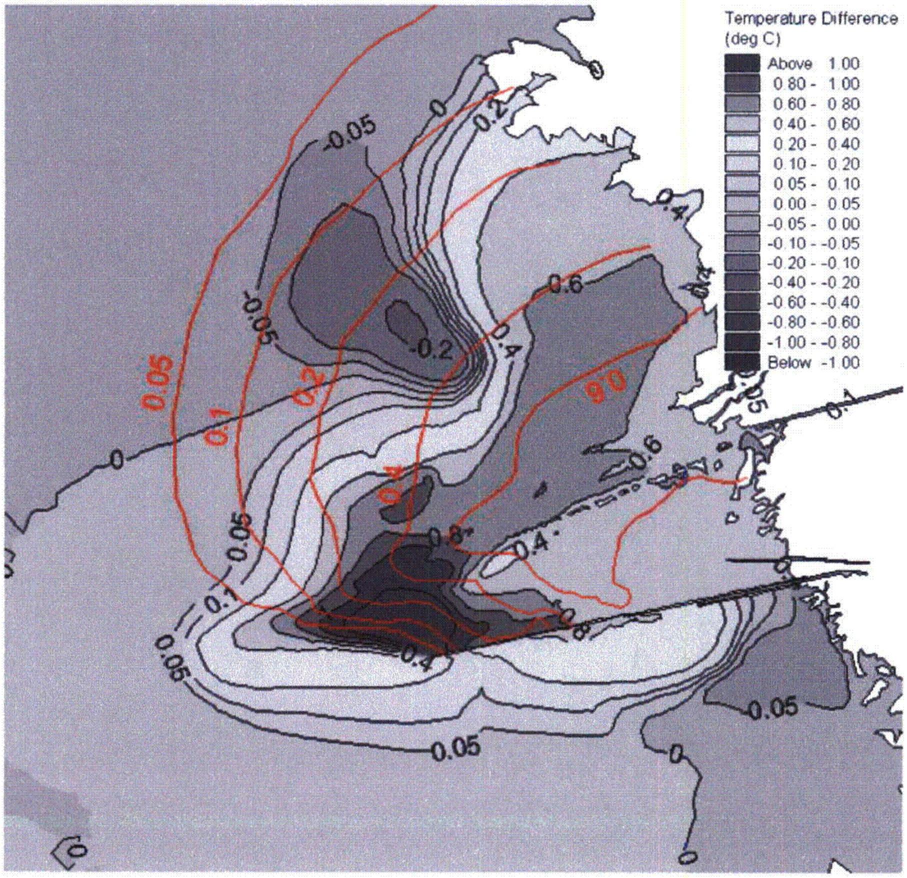

FIGURE B7
Temperature Difference of the Discharge Plume between Scenario 0a and Scenario 0 (Scenario 0a – Scenario 0), Winter Conditions, Ebb Tide

Note: The red contours denote the difference contours from NRC Figure 5-7 (2012).

Attachment C
Simulated Salinity and Temperature Differences

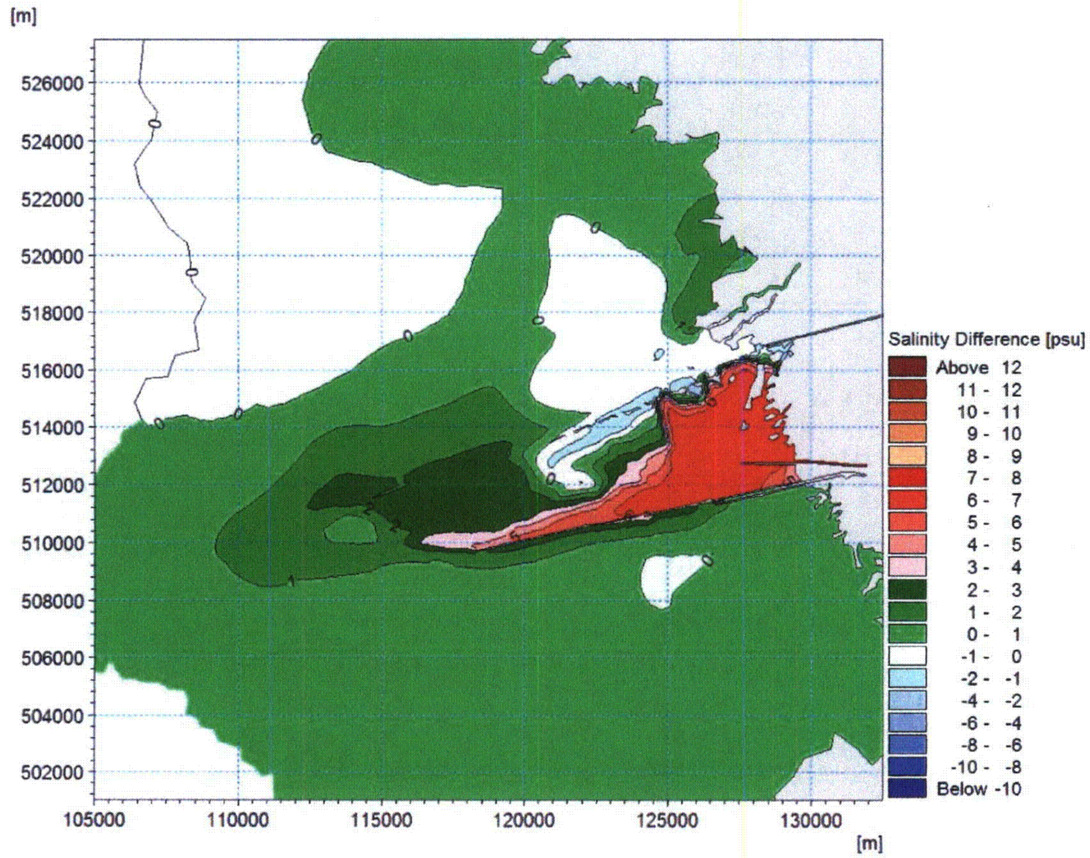

FIGURE C1
Salinity Difference between Scenario 1 and Scenario 0a (Scenario 1 – Scenario 0a), Summer Conditions

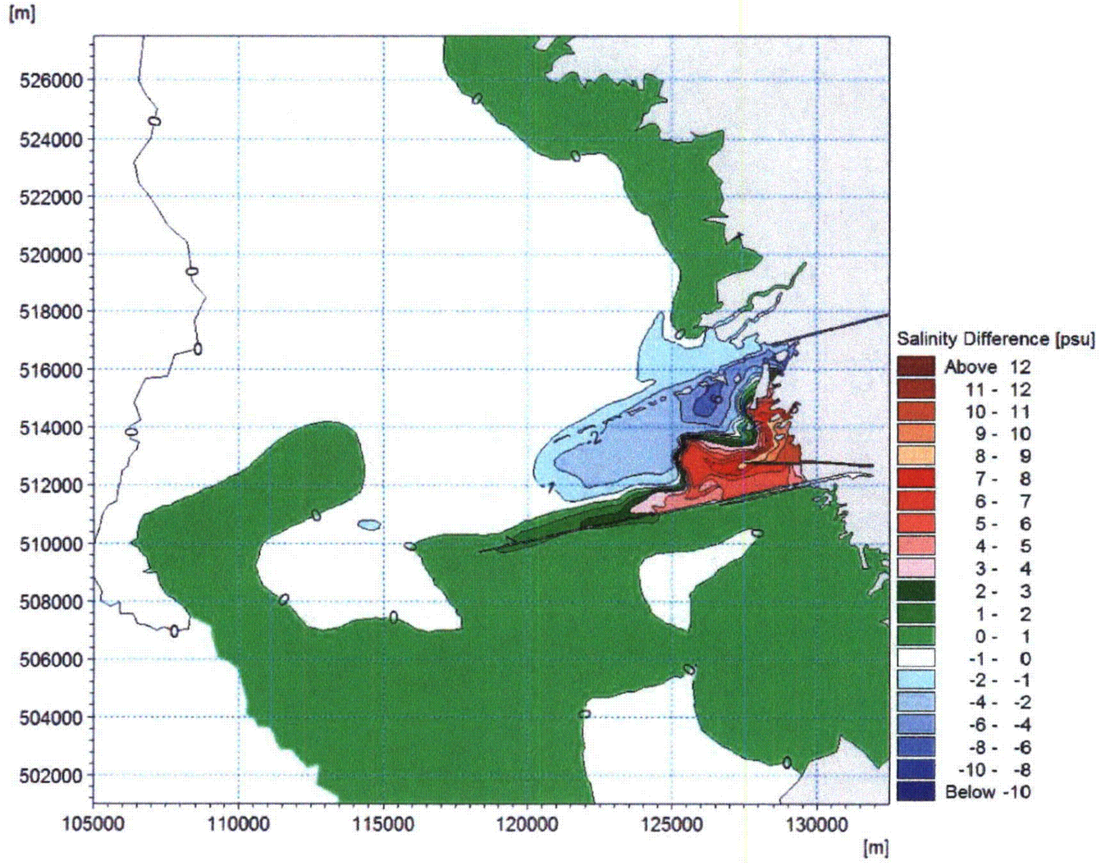

FIGURE C2
Salinity Difference between Scenario 2a and Scenario 0a (Scenario 2a – Scenario 0a), Summer Conditions

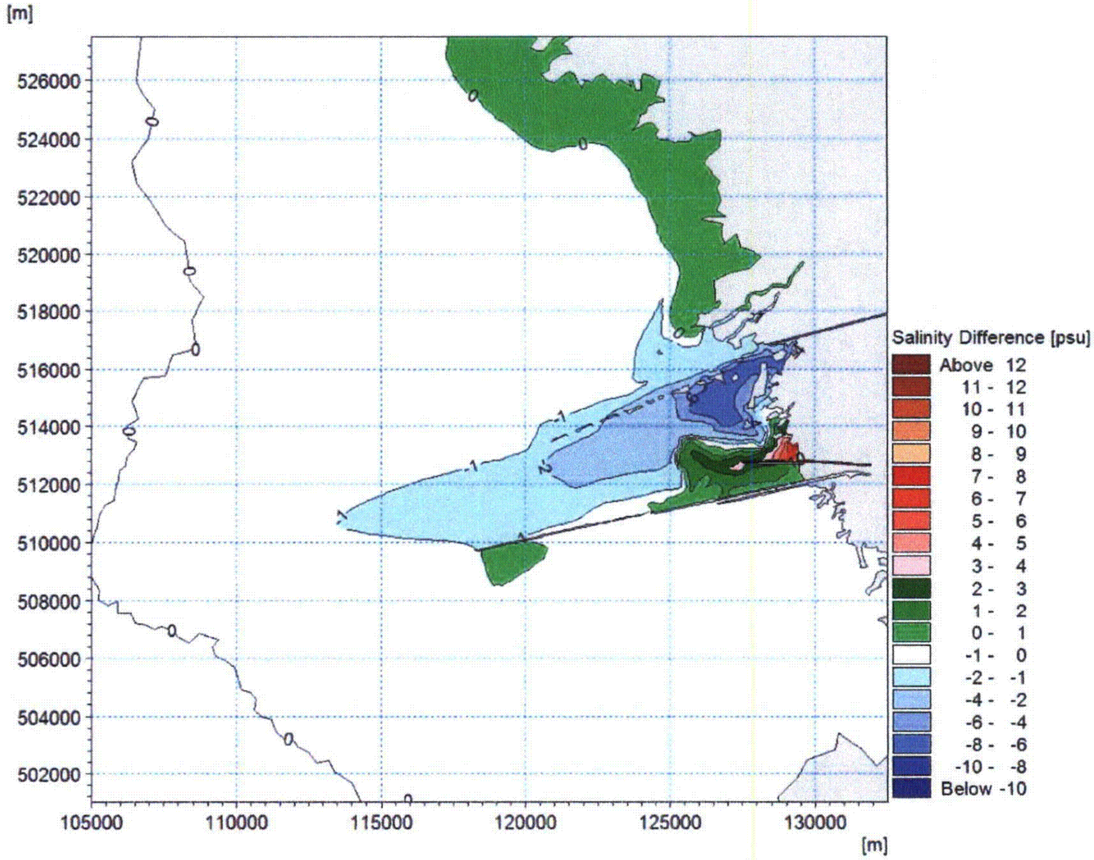

FIGURE C3
Salinity Difference between Scenario 2b and Scenario 0a (Scenario 2b – Scenario 0a), Summer Conditions

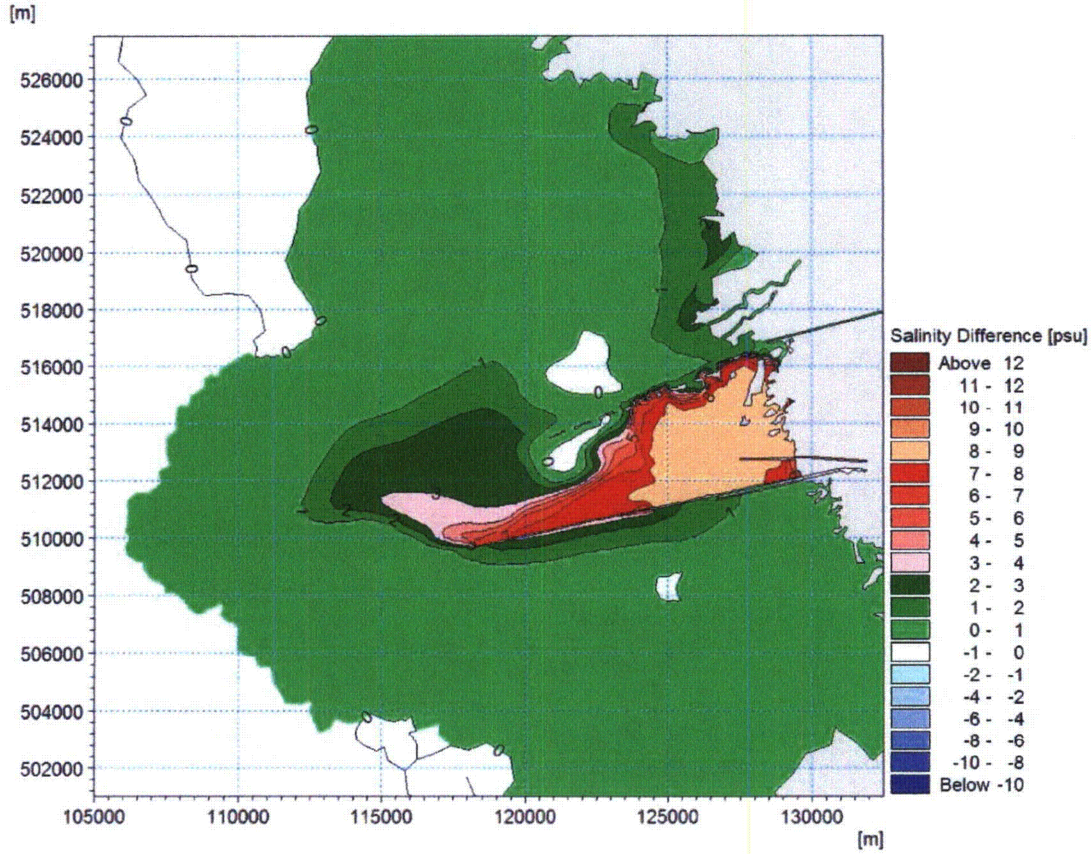

FIGURE C4
Salinity Difference between Scenario 1 and Scenario 0a (Scenario 1 – Scenario 0a), Winter Conditions

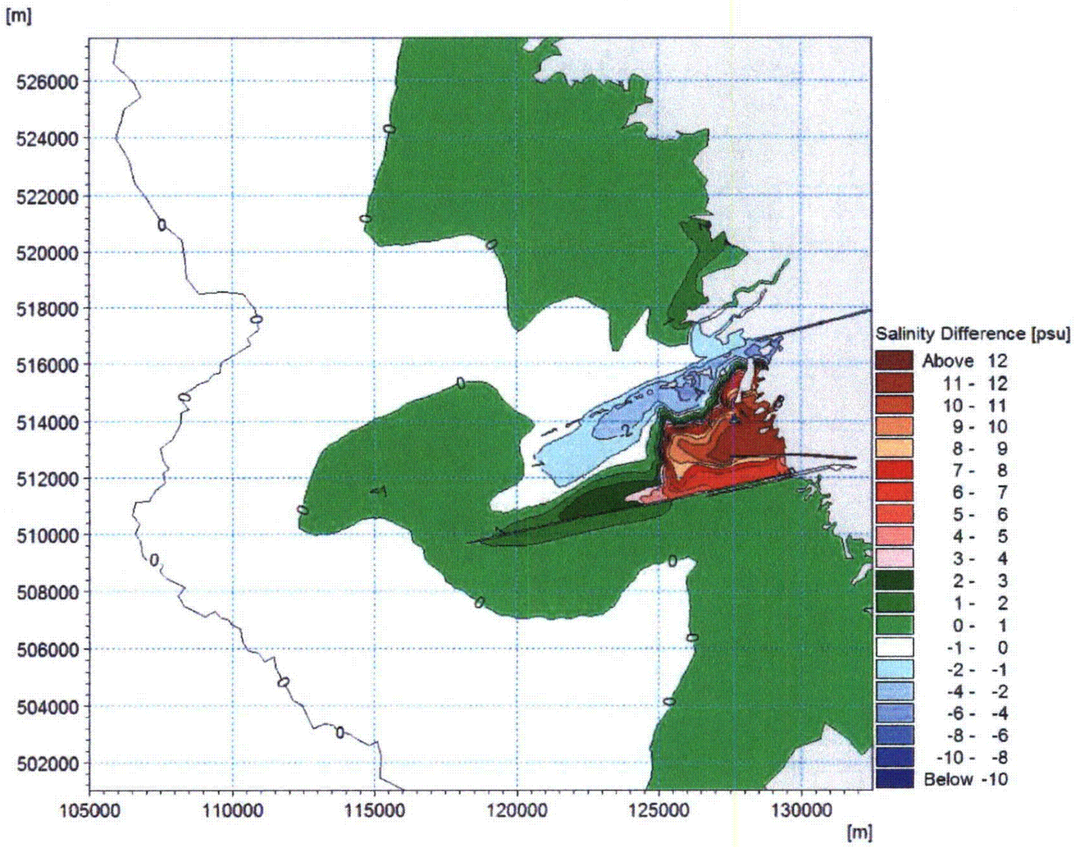

FIGURE C5
Salinity Difference between Scenario 2a and Scenario 0a (Scenario 2a – Scenario 0a), Winter Conditions

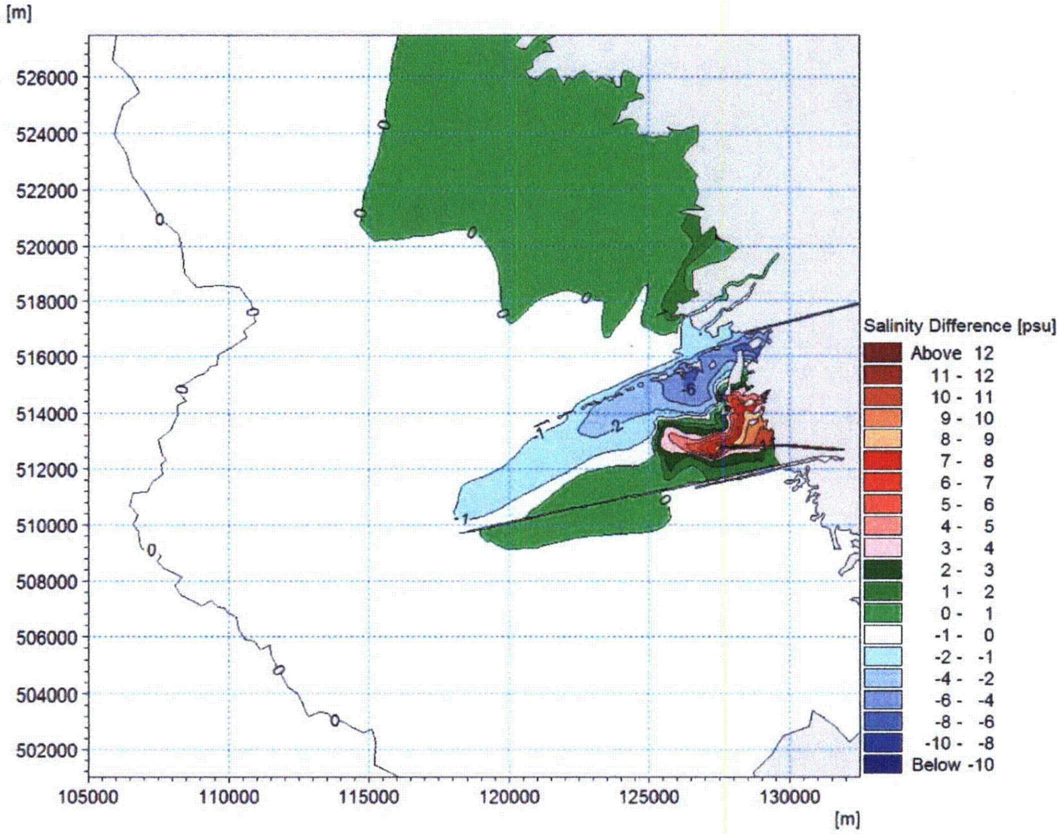

FIGURE C6
Salinity Difference between Scenario 2b and Scenario 0a (Scenario 2b – Scenario 0a), Winter Conditions

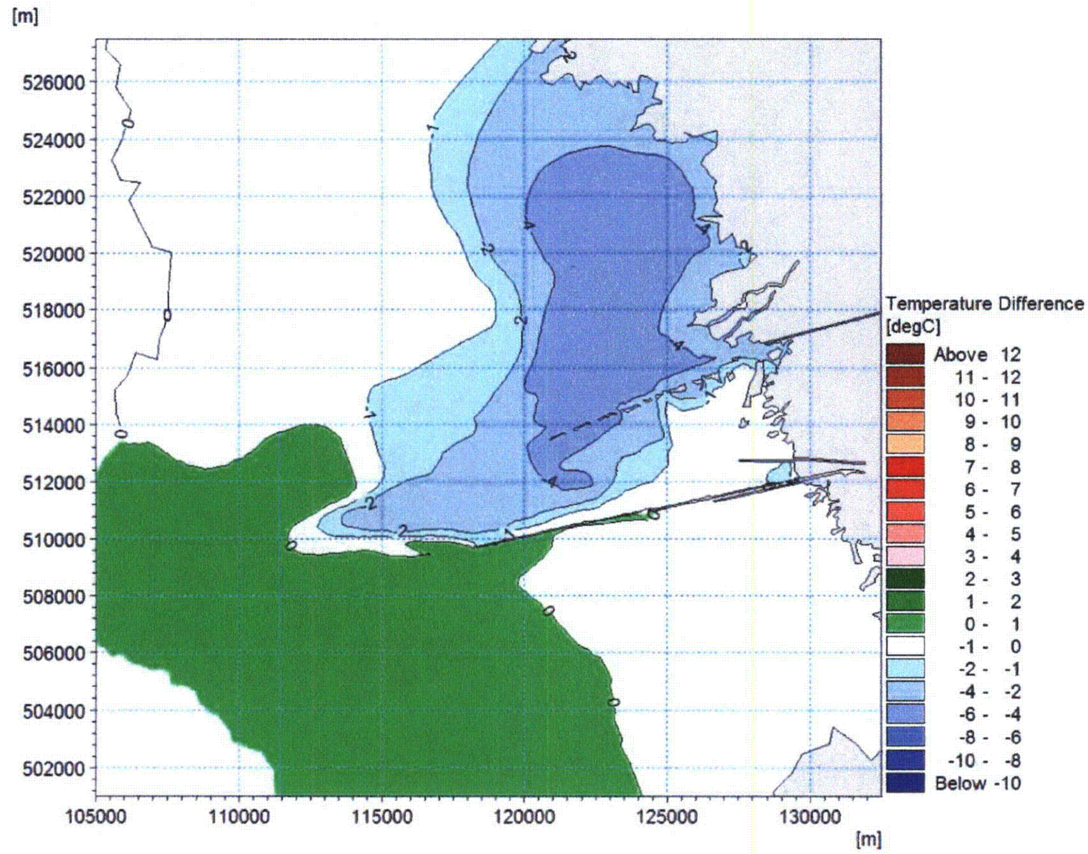

FIGURE C7
Temperature Difference between Scenario 1 and Scenario 0a (Scenario 1 – Scenario 0a), Summer Conditions

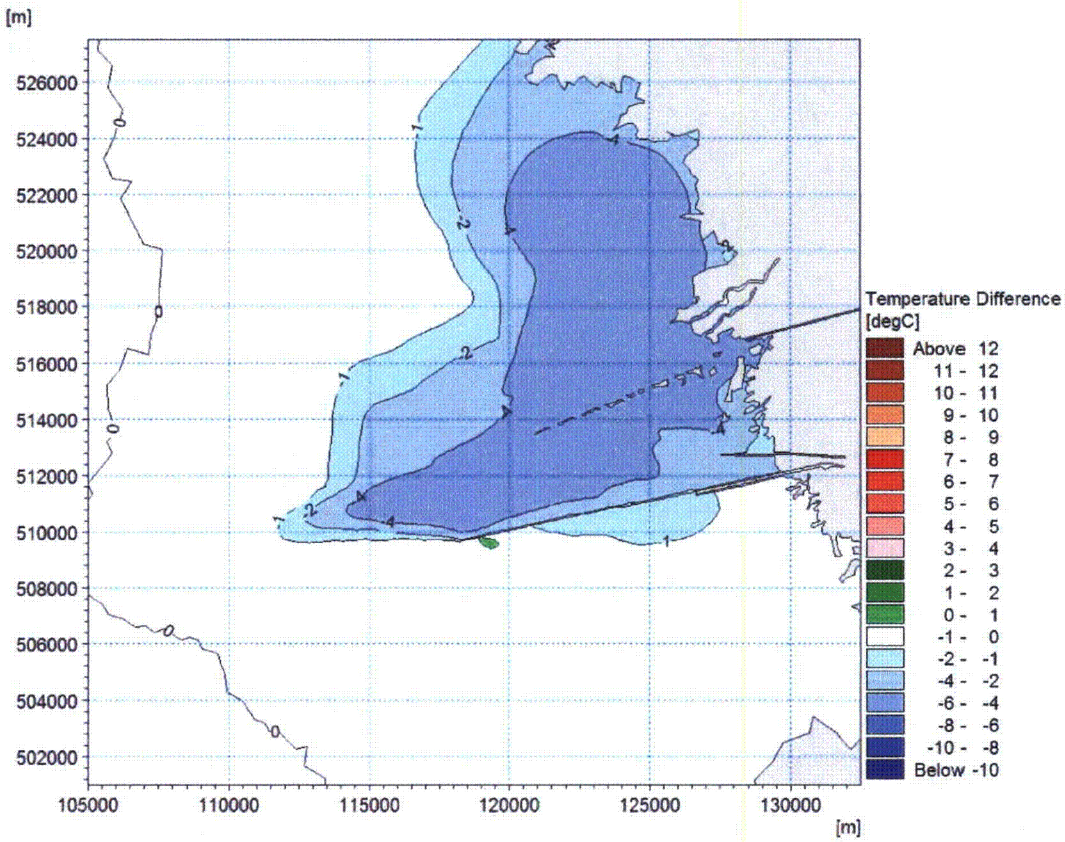

FIGURE C8
Temperature Difference between Scenario 2a and Scenario 0a (Scenario 2a – Scenario 0a), Summer Conditions

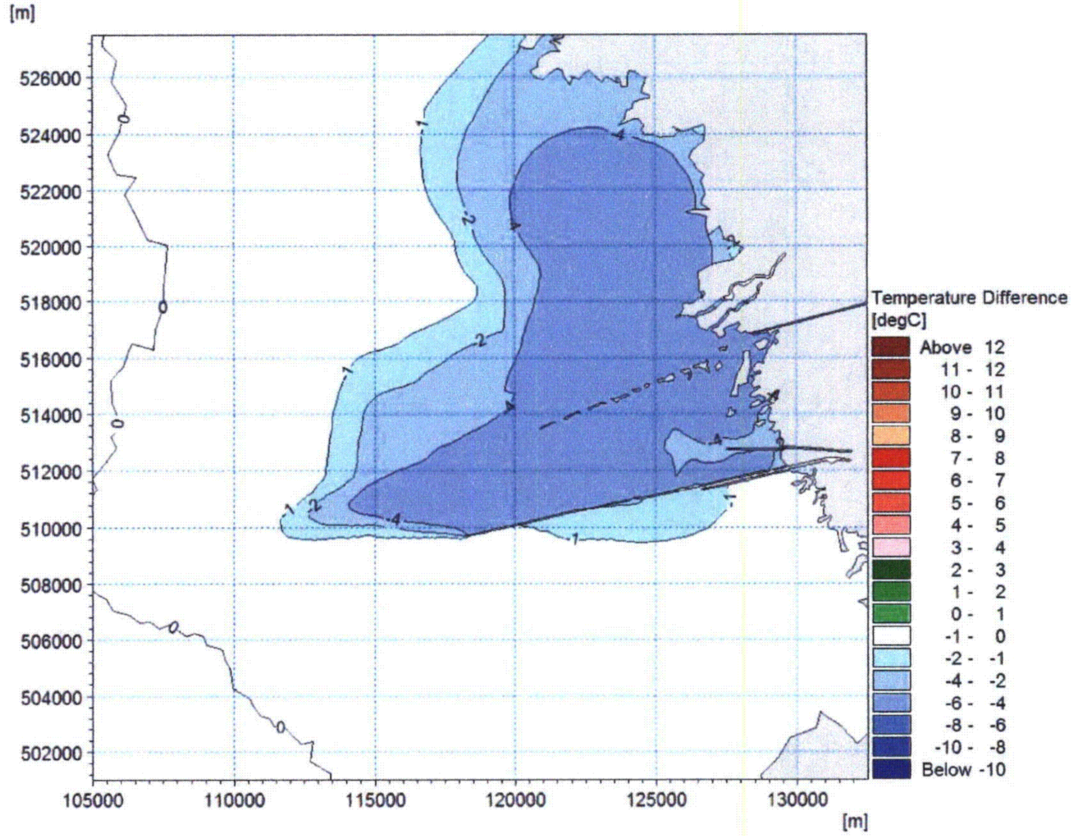

FIGURE C9
Temperature Difference between Scenario 2b and Scenario 0a (Scenario 2b – Scenario 0a), Summer Conditions

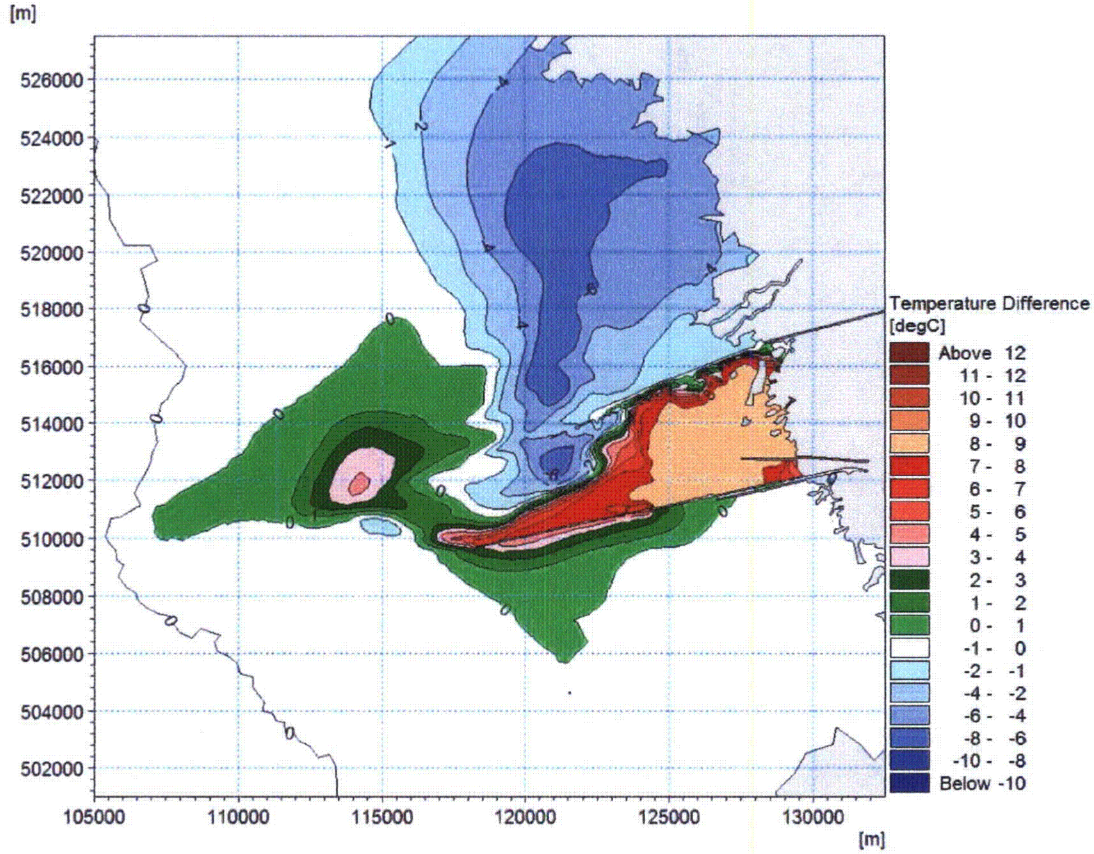

FIGURE C10
Temperature Difference between Scenario 1 and Scenario 0a (Scenario 1 – Scenario 0a), Winter Conditions

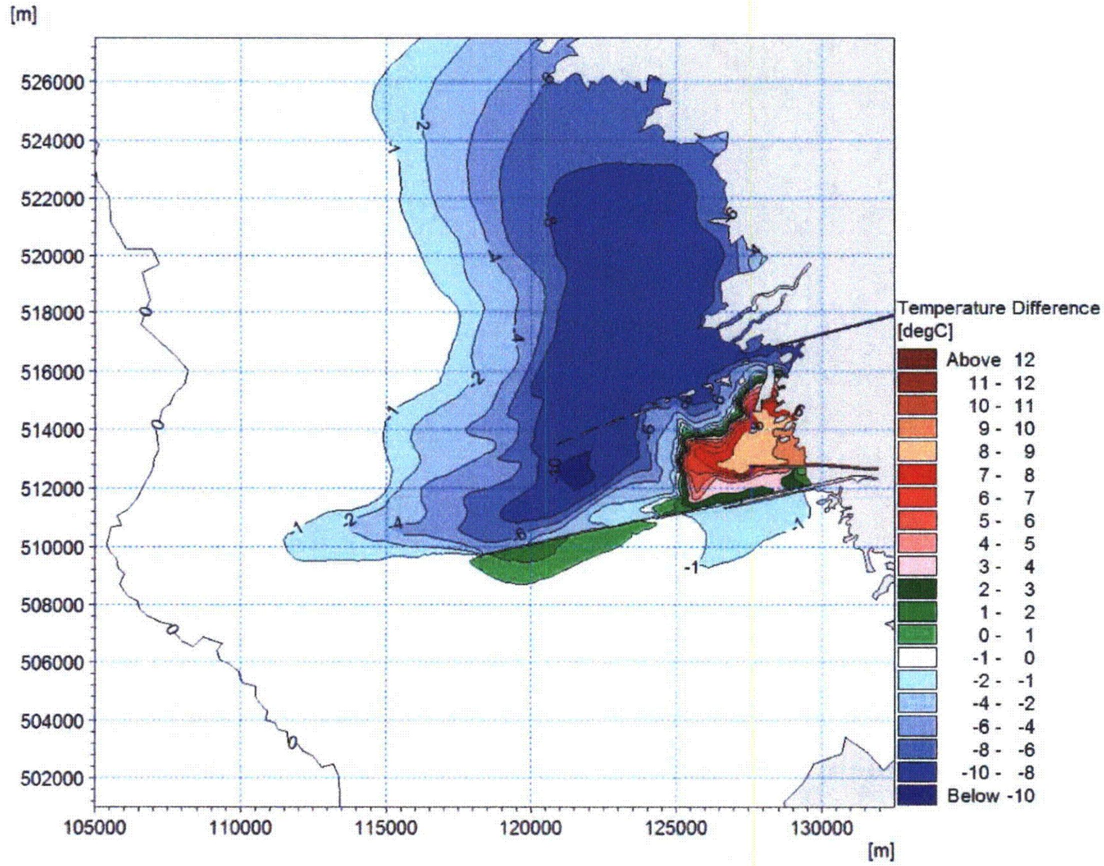

FIGURE C11
Temperature Difference between Scenario 2a and Scenario 0a (Scenario 2a – Scenario 0a), Winter Conditions

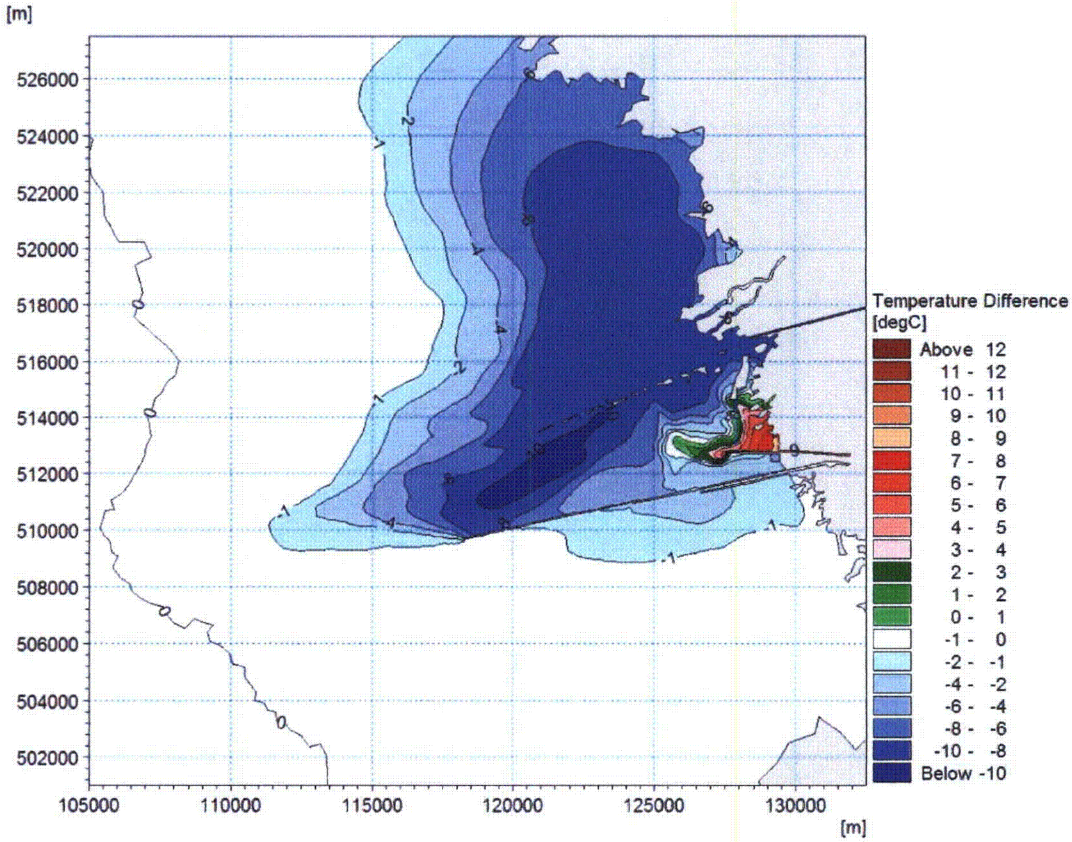

FIGURE C12
Temperature Difference between Scenario 2b and Scenario 0a (Scenario 2b – Scenario 0a), Winter Conditions

PECOLA-2-LI-022-0004-R0
Phase 1 Assessment Report: Impact of Decrease in Dilution Factor
(36 pages attached)

Phase 1 Assessment Report:

Impact of Decrease in Dilution Factor

PECOLA-2-LI-022-0004-R0

Project: LNP COLA Phase III Support
Contractor: JVT
Contract WA #: 255934-09
Task #s: 09 & 10

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Table of Contents

Table of Contents - continued

1.0 Summary

As a result of Duke Energy Florida's decision to decommission Crystal River Units 1, 2, and 3, the current licensing bases documents that utilize a dilution factor (DF) of 21 to calculate the radiological impacts due to radioactive liquid waste pathway releases during normal operations are no longer correct. This change in DF increases the potential doses to the maximum exposed individual (MEI), population within a 50 mile radius of the Levy nuclear power plant (NPP), and terrestrial and aquatic biota but does not exceed the regulatory dose design objectives or increase the cancer risk. This Phase 1 Assessment Report is based on an evaluation of the relevant Levy COLA application documents impacted as a result of this dilution change. The evaluation was performed in accordance with 10 CFR. 51.92 and the ISG-11 evaluation processes to arrive at the following basic conclusions. This change does not correct any significant errors in an application, is not needed to ensure compliance with NRC regulations, and does not support other licensing basis documents (e.g., conforming changes to information in the FSAR supporting technical specifications). This change does not involve any significant technical correction associated with the design or programs described in the LNP FSAR or the AP1000 Design Control Document. The change is not needed to resolve any significant vulnerability identified by the probabilistic risk assessments (PRAs) or other studies.

A supplement to the FEIS is not required per 10 CFR 51.92 because the change in DF results in no substantial changes in the proposed action that are relevant to environmental concerns, There are no new and significant circumstances or information relevant to environmental concerns and bearing on the proposed actions or its impacts.

The liquid waste management system augments provided in Regulatory Guide 1.110 were reviewed and found not to be cost beneficial in reducing the population dose. The costs per person-rem reduction associated with these augments exceed the $1,000 person-rem criteria prescribed in Appendix I to 10 CFR Part 50 and are therefore not cost beneficial.

2.0 Introduction

2.1 Problem Identification

As a result of Duke Energy Florida's decision to decommission CR3, current licensing bases documents utilizing a DF of 21 to calculate the radiological impacts due to radioactive liquid waste pathway releases during normal operations are no longer correct. The doses to the MEI, members of the public, and biota need to be revised as a result of the change in the DF in the COLA's supporting documents.

In addition, a cost – benefit analysis determined that no augments to the liquid waste management system, per USNRC Regulatory Guide 1.110, were required. As a result of the change in DF, the cost – benefit analysis must also be revised to demonstrate compliance with 10 CFR 50, Appendix I Section II.D.

2.2 Importance

The DF utilized in current licensing bases documents is a combination of Levy and Crystal River Units 1, 2, 3, 4, an 5 liquid effluent releases to a common discharge canal. The change in the DF eliminates the dilution flows associated with Crystal River Units 1, 2 and 3. Offsite release of liquid effluents from the liquid waste management system during normal operations must meet certain regulatory requirements; specifically 10 CFR 50 Appendix I and 40 CFR 190. In addition a cost - benefit analysis concerning liquid waste management system augments must meet the requirements of Regulatory Guide 1.110 (Reference 7.3) and demonstrate compliance with 10 CFR 50, Appendix I Section II.D. Due to the change to the DF, the current licensing bases documents do not reflect actual plant performance and there is no updated supporting documentation to support compliance with the regulatory requirements mentioned above.

2.3 Objectives

The objective of this Report is to perform a qualitative review of the Levy affected documents listed in Section 4.1 and determine the regulatory impact of the decrease in the DF and recommend which documents should be revised.

3.0 Discussion

3.1 Assumptions

a. As a result of the decommissioning of CR, the DF used to assess the doses to the MEI, members of the public, and biota, and the cost – benefit analysis will change.
b. The estimated change in the DF is from a factor of 21 to 3 (Reference 7.1). The impact on the doses is an increase of a factor of 7. [Note: A Nuclear Safety Related Process using independent validation process was implemented by WorleyParsons. It is noted that the "flow dilution factors" provided by CH2MHill's RFI-417 were not provided as an input that was independently verified, but was provided as a reviewed design input developed in accordance with CH2MHill's procedures].

c. Text with a red font indicates a proposed revision as a result of the change in DF. Values in red font in the Tables have not been updated to reflect the change in DF. These FSAR Tables will need to be revised at a future date as a result of the change in the dilution factor.

3.2 Method of Assessment

Each of the documents in Section 4.1 is evaluated to determine the impact of the change in the DF. The applicable sections of the document that are impacted are identified, and an analysis of the impact of these changes is presented.

4.0 Results

4.1 List of Documents that are Affected

a. NUREG-1941, Final Environmental Impact Statement (FEIS) Section 5.9, "Radiological Impacts of Normal Operations", Table 9-6, and Appendix. J (Reference 7.4).
b. Final Safety Analysis Report (FSAR) Section 11.2, "Liquid Waste Management Systems", (Reference 7.5).
c. Calculation LNG-0000-N5C-001, "Dose to Important Biota," (Reference 7.6).
d. Calculation LNG-0000-N5C-003, "Liquid Effluent Doses & Concentrations – Levy Site", (Reference 7.7).
e. LNP Cost – Benefit Analysis (included in Reference 7.7).

4.2 Description of Affected Document Changes

a. FEIS Section 5.9
FEIS Section 5.9 describes the radiological impacts of normal operation for the liquid effluent pathway, including annual doses to the MEI, population doses within a 50 mile radius of the Levy NPP site, and dose to biota based on a dilution factor of 21. The impact on doses due to the change in DF is evaluated in Section 4.3.a.

b. FSAR Section 11.2
FSAR Section 11.2 describes the radiological impacts of normal operation for the liquid effluent pathway, including annual doses to the MEI, population doses within a 50 mile radius of the Levy NPP site, and a liquid radwaste system cost benefit analysis based on a dilution factor of 21. The impact on doses and the cost benefit analysis due to the change in DF is evaluated in Section 4.3.b.

c. Calculation LNG-0000-N5C-001
Calculation LNG-0000-N5C-001 determines the potential dose to biota from the normal liquid effluent releases from the site and demonstrates compliance with 40 CFR 190, International Atomic Energy Agency IAEA Report 332 (Reference 7.2), and National Council on Radiation Protection and Measurements, NCRP 109 (Reference 7.9). The impact on dose to biota and compliance with 40 CFR 190, IAEA Report 332, and NCRP 109 requirements due to the change in DF is evaluated in Section 4.3.c.

d. Calculation LNG-0000-N5C-003
Calculation LNG-0000-N5C-003 estimates annual radiation doses to the MEI and population within a 50 mile radius of the Levy NPP site resulting from the release of liquid radioactive effluents to demonstrate compliance with 10 CFR 50, Appendix I requirements. The impact on doses and compliance with 10 CFR 50 Appendix I (including cost benefit analysis) requirements due to the change in DF is evaluated in Section 4.3.d.

e. LNP Cost – Benefit Analysis
The LNP Cost – Benefit Analysis is evaluated in Calculation LNG-0000-N5C-003 and FSAR Section 11.2. The impact on the cost benefit analysis due to the change in DF is evaluated in Sections 4.3.d and 4.3.e.

4.3 Affected Document Information Changed

a. FEIS Section 5.9

The following Sections and Tables are no longer correct as a result of the change in the DF:

The following text is excerpted directly from FEIS Section 5.9.3.2, "Population Dose".

PEF estimated the collective total body dose within a 50-mi radius of the proposed LNP site for gaseous and liquid pathways to be 5.74 and 1.13 person-rem/yr per unit, respectively (PEF 2009a). Collective population doses from the gaseous and liquid effluent pathways were estimated by PEF using the GASPAR II and LADTAP II computer codes, respectively. The NRC staff performed an independent evaluation of population doses and obtained similar results (see Appendix J).

*As a result of the change in the DF, the dose due to the liquid pathway will increase from 1.13 to 1.13 * 7 or 7.91 person-rem/yr per unit. Per Section J.2.6 and Table J-7 (Reference 7.4), the resultant dose is much less than the background radiation dose (4.5E+05 person-rem/yr – staff estimate) to the population living within a 50 mile radius of the proposed Levy nuclear power plant. Therefore the increase in dose remains insignificant when compared to the background dose.*

The following text is excerpted directly from FEIS Section 5.9.3.2, "Population Dose".

Radiation protection experts assume that any amount of radiation may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response relationship is used to describe the relationship between radiation dose and detriments such as cancer induction. A recent report by the National Research Council (2006), the Biological Effects of Ionizing Radiation (BEIR) VII report, uses the linear, no-threshold model as a basis for estimating the risks from low doses. This approach is accepted by the NRC as a conservative method for estimating health risks from radiation exposure, recognizing that the model may overestimate those risks. Based on this method, the NRC staff estimated the risk to the public from radiation exposure using the nominal probability coefficient for total detriment. This coefficient has the value of 570 fatal cancers, nonfatal cancers, and severe hereditary effects per 1,000,000 person-rem (10,000 person-Sv), equal to 0.00057 effects per person-rem. The coefficient is taken from International Commission on Radiation Protection (ICRP) Publication 103 (ICRP 2007).

The estimated collective total body dose to the population living within 50 mi of the proposed LNP site is 6.9 person-rem/yr per unit, which is less than the 1754 person-rem/yr value that ICRP and NCRP suggest would most likely result in zero excess health effects (ICRP 2007; NCRP 1995).

*As a result of the change in the DF, the dose due to the liquid pathway will increase from 1.13 to 1.13 * 7 or 7.91 person-rem/yr per unit. The dose of 6.9 above includes the contribution from the gaseous pathway which stated above is 5.74. Thus the total dose from both pathways increases from 6.9 to 5.74 + 7.91 or 13.65 person-rem/yr per unit. This dose is still significantly below the ICRP and NCRP (References 7.10 and 7.11 respectively) limit of 1754 person-rem/yr per unit, thus no additional cancers should occur as a result of this change.*

The following text is excerpted directly from FEIS Section 5.9.5.3, "Impact of Estimated Biota Doses".

Table 5-14 compares estimated total body dose rates to surrogate biota species produced by releases from LNP Units 1 and 2 to the IAEA/NCRP biota dose guidelines (IAEA 1992; NCRP 1991). The maximum total dose from liquid and gaseous pathways from the bounding calculation is about 0.5 mrad/d. Thus, the doses to biota calculated by PEF are far below the 100-mrad/d IAEA guideline (IAEA 1992) for terrestrial biota and the 1000-mrad/d guideline for aquatic biota. Based on the information provided by PEF and the NRC staff's independent evaluation, the NRC staff concludes that the radiological impact on biota from the routine operation of the proposed LNP Units 1 and 2 would be SMALL, and additional mitigation would not be warranted.

*As a result of the change in the DF, the maximum total dose from liquid and gaseous pathways will increase from 0.5 mrad/d to 0.5 * 7 or 3.5 mrad/d even assuming that the liquid pathway is the only pathway that contributes to the dose. The dose of 3.5 mrad/d is still significantly below the IAEA and NCRP Guidelines (References 7.2 and 7.9 respectively) of 100-mrad/d for terrestrial biota and 1000-mrad/d for aquatic biota.*

The following Table is excerpted directly from the FEIS: Table 5-9, "Annual Dose to the Maximally Exposed Individual for Liquid Effluent Releases for a New Unit."

Table 5-9: Annual Doses to the Maximally Exposed Individual for Liquid Effluent Releases from a New Unit

Pathway	Age Group/ MEI	Total Body (mrem/yr)	Maximum Organ (GI-LLI) (mrem/yr)	Thyroid
Fish	Adult	0.0027	0.0089	0.0056
	Teen	0.0018	0.0064	0.0051
	Child	0.0012	0.0026	0.0052
Invertebrate	Adult	0.0013	0.062	0.0058
	Teen	0.0012	0.049	0.0054
	Child	0.0012	0.021	0.0058
Shoreline	Adult	0.00039	0.00039	0.00039
	Teen	0.0022	0.0022	0.0022
	Child	0.00045	0.00045	0.00045
Swimming	Adult	0.0000019	0.0000019	0.0000019
	Teen	0.000010	0.000010	0.000010
	Child	0.0000022	0.0000022	0.0000022
Boating	Adult	0.0000079	0.0000079	0.0000079
	Teen	0.0000053	0.0000053	0.0000053
	Child	0.0000011	0.0000011	0.0000011

As a result of the change in the DF, each of the total body, maximum organ (GI-LLI), and thyroid dose in Table 5-9 would increase by a factor of 7. Even with the increase, the 10 CFR 50, Appendix I requirements of 3 mrem/year whole body and 10 mrem/year maximum exposed organ would not be exceeded (see Table 5-11 below).

The following Table is excerpted directly from the FEIS: Table 5-11, "Comparisons of MEI Dose Estimates from Liquid and Gaseous Effluent for a Single New Nuclear Unit to 10 CFR Part 50, Appendix I Design Dose Objectives."

Table 5-11: Comparisons of MEI Dose Estimates from Liquid and Gaseous Effluent for a Single New Nuclear Unit to 10 CFR Part 50, Appendix I Dose Design Objectives

Pathway/Type of Dose	PEF (2009a)	Appendix I Design Objectives
Liquid Effluents		
Total Body	0.0052 mrem (Teen – all pathways)	3 mrem
Maximum Organ Dose	0.071 mrem (Adult – GI-LLI)	10 mrem
Gaseous Effluent (Noble Gases Only)		
Gamma Air Dose	1.7 mrad	10 mrem
Beta Air Dose	9.4 mrad	20 mrem
Total Body Dose	3.1 mrem	5 mrem
Skin Dose	6.3 mrem	15 mrem
Gaseous Effluents (Radioiodines and Particulates)		
Maximum Organ Dose	9.7 mrem (Child – bone)	15 mrem

*As a result of the change in the DF, for the liquid effluents pathway, the total body and maximum organ doses in Table 5-11 would increase by a factor of 7. Even with the increase, the 10 CFR 50, Appendix I requirements of 3 mrem/year whole body (0.0052 * 7 = 0.0.0364) and 10 mrem/year maximum exposed organ (0.071 * 7 = 0.497) would not be exceeded.*

The following Table is excerpted directly from the FEIS: Table 5-12, "Comparisons of Maximally Exposed Individual Dose Rates with 40 CFR Part 190 Criteria (mrem/yr)."

Table 5-12: Comparison of Maximally Exposed Individual Dose Rates with 40 CFR Part 190 Criteria (mrem/yr)

		LNP Units 1 and 2			
	CREC Total Liquid and Gaseous Dose	Liquid	Gaseous	Total	40 CFR 190 Dose Standards
Total Body	0.00008	0.021	5.5	5.5	25
Thyroid	0.002	0.025	12.8	12.9	75
Other Organ – Bone	0.002	0.14	19.4	19.5	25

*As a result of the change in the DF, the dose due to the liquid pathway will increase by a factor of 7 for the total body (0.021 * 7 = 0.147), thyroid (0.025 * 7 = 0.175), and other organ – bone (0.14 * 7 = 0.98). The total dose increases from 5.5 to 5.6 (0.00008 + 0.147 + 5.5), the thyroid dose increases from 12.8 to 13.0 (0.002 + 0.175 + 12.8) and the other organ – bone increases from 19.5 to 20.4 (0.002 + 0.98 + 19.4) mrem/yr. These doses are still below the 40 CFR 190 dose limits provided in Table 5-12. The Crystal River Unit 3 contribution should be removed, although it is a small fraction of the total dose.*

The following Table is excerpted directly from the FEIS: Table 5-13, "Biota Doses for Proposed Units 1 and 2."

Table 5-13: Biota Doses for Proposed Units 1 and 2

	Doses from Liquid Effluents in Discharge Canal		Doses from Gaseous Effluents	
	LNP 1 and 2		LNP 1 and 2	
	Internal Dose (mrad/yr)	External Dose (mrad/yr)	Internal Dose (mrad/yr)	External Dose (mrad/yr)
Saltwater Fish	0.11	0.57	0.0	0.0
Invertebrate	3.90	1.10	0.0	0.0
Algae	8.80	0.00	0.0	0.0
Muskrat	0.88	0.38	0.0	2.00
Raccoon	0.14	0.28	0.0	2.00
Heron	0.62	0.38	0.0	1.40
Duck	0.83	0.57	0.0	2.00
Manatee	1.3	0.57	0.0	0.0
Northern Bobwhite	0.00	0.00	0.014	18.0

As a result of the change in the DF, the internal and external doses from liquid effluents in the discharge canal will increase by a factor of 7.

The following Table is excerpted directly from the FEIS: Table 5-14, "Comparison of Biota Doses from the Proposed LNP Units 1 and 2 to IAEA Guidelines for Biotic Protection."

Table 5-14: Comparison of Biota Doses from the Proposed LNP Units 1 and 2 to IAEA Guidelines for Biota Protection

Biota	PEF Estimate of Dose to Biota (mrad/d)	IAEA/NCRP Guidelines for Protection of Biota Populations (mrad/d)
Fish	0.01	1000
Invertebrate	0.02	1000
Algae	0.03	1000
Muskrat	0.02	100
Manatee	0.02	100
Raccoon	0.01	100
Heron	0.01	100
Duck	0.02	100
Northern bobwhite	0.5	100

As a result of the change in the DF, the PEF estimate of doses from liquid effluents will increase by a factor of 7. The resulting doses (assuming the gaseous component is also increased by a factor of 7) are still significantly below the IAEA and NCRP Guidelines (References 7.2 and 7.9 respectively) provided in Table 5-14 of 100-mrad/d for terrestrial biota and 1000-mrad/d for aquatic biota.

Note FEIS Appendix J (Reference 7.4), the NRC independent dose assessment of the radiological impacts resulting from the radioactive liquid effluent pathway releases during normal operations for the proposed new Levy nuclear Units 1 and 2 is also impacted as a result in the change in the DF. As seen by the discussion above, the change in the DF will not impact any of their conclusions.

FEIS Table 9-6, "Past, Present, and Reasonable Foreseeable Projects and Other Actions Considered In the Cumulative Analysis of the Crystal River Alternative Site", provides a summary of the CR3 state of operation, license renewal, and uprate. Due to the decision by Duke Energy Florida to decommission CR3, Table 9-6 no longer applies to the current situation at CR3. Revising Table 9-6 would have no impact on the NRC conclusions or results.

b. FSAR Section 11.2

The following Sections and Tables are no longer correct as a result of the change in DF:

The following paragraphs in Section 11.2.3.5.1, "Estimated Individual Dose rates", need to be revised due to an increase in individual dose rates (summarized in Table 11.2-203) which must also be revised to reflect increased dose rates.

The following paragraphs are excerpted directly from the FSAR.

Fish and invertebrate consumption assumes they are caught at the plant discharge. LADTAP II default consumption values are used in lieu of site-specific consumption data. The estimated maximum dose rates to a single organ are 0.009 mrem/yr from fish and 0.062 mrem/yr from invertebrates to an adult GI-LLI. The maximum total body dose rates are calculated to be 0.0027 mrem/yr from fish and 0.0013 mrem/yr from invertebrates to an adult.

*As a result of the change in the DF, the maximum dose rates due to the liquid pathway will increase from estimated maximum dose rate to a single organ from 0.009 to 0.009 * 7 or 0.063 mrem/yr from fish and from 0.062 to 0.062 * 7 or 0.434 mrem/yr from invertebrates to an adult GI-LLI. The maximum total body dose rates increase from 0.0027 to 0.0027 * 7 or 0.0189 mrem/yr from fish and from 0.0013 to 0.0013 * 7 or 0.0091 mrem/yr from invertebrates to an adult (see Table 11.2-203 below for regulatory impact).*

Shoreline, swimming, and boating recreation results in a maximum dose rate to a single organ of 0.0025 mrem/yr to a teenager's skin. The maximum total body dose rate is calculated to be 0.0022 mrem/yr to a teenager.

*As a result of the change in the DF, the maximum dose rate due to the liquid pathway will increase for shoreline, swimming, and boating recreation to a maximum dose rate to a single organ from 0.0025 to 0.0025 *7 or 0.0175 mrem/yr to a teenager's skin. The maximum total body dose rate is calculated to increase from 0.0022 to 0.0022 * 7 or 0.0154 mrem/yr to a teenager (see Table 11.2-203 below for regulatory impact).*

The maximum dose rate to any organ considering all pathways was calculated to be 0.071 mrem/yr to an adult's GI-LLI. The maximum total body dose rate is calculated to be 0.0052 mrem/yr to a teenager.

*As a result of the change in the DF, the maximum dose rates due to the liquid pathway will increase from 0.071 to 0.071 * 7 or 0.497 mrem/yr to an adult's GI-LLI and from 0.0052 to 0.0052 * 7 or 0.0364 mrem/yr to a teenager total body (see Table 11.2-203 below for regulatory impact).*

A portion of the following paragraph that discusses the total public dose contribution due to the common location of the liquid effluent releases from Levy and Crystal River Unit 3 may be deleted.

~~**In addition to the exposures from Levy, the liquid doses from Crystal River Unit 3 contribute to the total public dose due to the common location of the liquid effluent releases from Levy and Crystal River via the Crystal River discharge canal. Crystal River Unit 3 doses, based on actual plant effluent radioactive releases for the calendar years 2003 to 2006, are: 0.00008 mrem/yr (whole body), 0.002 mrem/yr (thyroid) and 0.002 mrem/yr (maximum organ).**~~ Direct radiation exposure from containment and other plant buildings is negligible based on information documented in AP1000 DCD, Tier 2, Chapter 12, Section 12.4.2.1.

The following paragraph in Section 11.2.3.5.2, Estimated Population Dose", needs to be revised due to an increase in the estimated population dose (summarized in Table 11.2-204) which must also be revised to reflect increased dose rates.

The following paragraphs are excerpted directly from the FSAR.

The estimated population dose within 81 km (50 miles) is calculated as 1.13 person-rem total body and 1.21 person-rem thyroid. Table 11.2-204 provides population doses by pathway and organ.

*As a result of the change in the DF, the estimated population dose within 81 km (50 miles) increases from 1.13 to 1.13 * 7 or 7.91 person-rem total body and from 1.21 to 1.21 *7 or 8.47 person-rem thyroid (see Table 11.2-204 below for regulatory impact).*

The following paragraph in Section 11.2.3.5.4, "Liquid Radwaste Cost Benefit Analysis", needs to be revised due to an increase in the estimated population dose (summarized in Table 11.2-204) which must also be revised to reflect increased dose rates. *As a result of the increase in population dose, the conclusions of the cost benefit analysis remain valid. The costs per person-rem reduction exceed the minimal threshold value of $1000 per person-rem criteria prescribed in Appendix I to 10 CFR Part 50 or RG 1.110.*

The following paragraph is excerpted directly from the FSAR.

The LNP population doses are given in Section 11.2.3.5.2. As discussed above, the lowest cost liquid radwaste system augment is $11,140. Assuming 100% efficiency of this augment, the minimum possible cost per person-rem is determined by dividing the cost of the augment by the population dose. This is $9,858 per person-rem total body ($11,140/1.13 person-rem) and $9,207 per person-rem thyroid. These costs per person-rem

reduction exceed the $1,000 per person-rem criteria prescribed in Appendix I to 10 CFR Part 50 and are therefore not cost beneficial.

As a result of the change in the DF, the cost – benefit analysis needs to be revised because of the following change to the text above:

*This is $1408 per person-rem total body ($11,140/(1.13 * 7 or 7.91) person-rem) and $1315 per person-rem thyroid ($11,140/(1.21 * 7 or 8.47). These costs per person-rem reduction exceed the $1,000 per person-rem criteria prescribed in Appendix I to 10 CFR Part 50 and no further action is required.*

The following Table is excerpted directly from the FSAR: Table 11.2-201, "Dilution Factors."

Table 11.2-201
Dilution Factors

Input Parameter	Value
Dilution Factor for all Pathways	21(a)

a) The dilution factor of 21 is conservatively based on the following:

1. LNP Cooling Tower Blowdown
   Rate 56,520 gpm (gallons per minute) 81.4 Mgd (million gallons per day)
2. Crystal River Plant Discharge Canal Actual Flow Rates
   1568.2 Mgd Average 2/1/03-2/28/07
   44.4 Mgd Average 11/1/05-2/28/07
   39.2 Mgd Average 11/1/05-2/28/07
   1651.8 Mgd Total Average Existing Canal Flow Rate
3. Dilution Factor in Crystal River Discharge
   Canal = (Flow rate in canal (#2) + LNP Blowdown (#1)) /
   LNP Blowdown (#1)
   = (1651.8 Mgd + 81.4 Mgd) / 81.4 Mgd = **21**

As a result of the change in the DF, the dilution factor and Note "a", Items 1, 2 and 3 in Table 11.2-201 must be revised per the information received from CH2M Hill.

The following Table is excerpted directly from the FSAR: Table 11.2-203, "Individual Dose Rates."

Table 11.2-203: Individual Dose Rates

Dose (mrem/yr)								
Adult								
Pathway	**Skin**	**Bone**	**Liver**	**Total Body**	**Thyroid**	**Kidney**	**Lung**	**GI-LLI**
Fish		1.51 E-03	3.57E-03	2.71 E-03	5.66E-03	1 .90E-03	1 .28E-03	8.96E-03
Invertebrate		1 .83E-03	2.26E-03	1 .33E-03	5.82E-03	2.94E-03	4.09E-04	6.20E-02
Shoreline	4.53E-04	3.87E-04	3.87E-04	3.87E-04	3.87E-04	3.87E-04	3.87E-04	3.87E-04
Swimming		1 .89E-06	1 .89E-06	1 .89E-06	1 .89E-06	1 .89E-06	1 .89E-06	1 .89E-06
Boating		7.87E-06	7.87E-06	7.87E-06	7.87E-06	7.87E-06	7.87E-06	7.87E-06
Total	4.53E-04	3.74E-03	6.23E-03	4.44E-03	1.19E-02	5.23E-03	2.09E-03	7.14E-02
Teenager								
Pathway	**Skin**	**Bone**	**Liver**	**Total Body**	**Thyroid**	**Kidney**	**Lung**	**GI-LLI**
Fish		1.58E-03	3.41 E-03	1.83E-03	5.14E-03	1.68E-03	1.12E-03	6.42E-03
Invertebrate		1 .89E-03	2.21 E-03	1 .20E-03	5.40E-03	2.97E-03	3.87E-04	4.95E-02
Shoreline	2.53E-03	2.16E-03	2.16E-03	2.16E-03	2.16E-03	2.16E-03	2.16E-03	2.16E-03
Swimming		1 .05E-05	1 .05E-05	1 .05E-05	1 .05E-05	1 .05E-05	1 .05E-05	1 .05E-05
Boating		5.27E-06	5.27E-06	5.27E-06	5.27E-06	5.27E-06	5.27E-06	5.27E-06
Total	2.53E-03	5.65E-03	7.80E-03	5.20E-03	1 .27E-02	6.83E-03	3.68E-03	5.81 E-02
Child								
Pathway	**Skin**	**Bone**	**Liver**	**Total Body**	**Thyroid**	**Kidney**	**Lung**	**GI-LLI**
Fish		1.96E-03	2.93E-03	1.18E-03	5.19E-03	1.40E-03	9.16E-04	2.66E-03
Invertebrate		2.41E-03	1.89E-03	1.22E-03	5.79E-03	2.64E-03	3.33E-04	2.14E-02
Shoreline	5.28E-04	4.51 E-04	4.51 E-04	4.51 E-04	4.51 E-04	4.51 E-04	4.51 E-04	4.51 E-04
Swimming		2.20E-06	2.20E-06	2.20E-06	2.20E-06	2.20E-06	2.20E-06	2.20E-06
Boating		1.10E-06	1.10E-06	1.10E-06	1.10E-06	1.10E-06	1.10E-06	1.10E-06
Total	5.28E-04	4.82E-03	5.27E-03	2.85E-03	1.14E-02	4.49E-03	1.70E-03	2.45E-02

*As a result of the change in the DF, all the individual dose rates in Table 11.2-203 must be increased by a factor of 7. Even with the increase, the 10 CFR 50, Appendix I requirements of 3 mrem/year whole body (0.0052 * 7 = 0.0364 - teenager) and 10 mrem/year maximum exposed organ (0.071 * 7 = 0.497 – GI-LII adult) would not be exceeded.*

The following Table is excerpted directly from the FSAR: Table 11.2-204, "Population Doses from Liquid Effluents."

Table 11.2-204: Population Doses from Liquid Effluents

Dose (person rem/yr)								
Pathway	**Skin**	**Bone**	**Liver**	**Total Body**	**Thyroid**	**Kidney**	**Lung**	**GI-LLI**
Sport Fish		1.85E-02	3.99E-02	2.72E-02	4.12E-02	2.06E-02	1.40E-02	8.28E-02
Commercial Fish		8.24E-04	1 .78E-03	1 .22E-03	1 .53E-03	9.22E-04	6.27E-04	3.63E-03
Sport Invertebrate		6.29E-02	7.10E-02	4.22E-02	1.12E-01	9.43E-02	1.29E-02	1.70E+00
Commercial Invertebrate		1.86E-03	2.10E-03	1.25E-03	2.64E-03	2.80E-03	3.84E-04	5.05E-02
Shoreline	1.23E+00			1.05E+00	1.05E+00			
Swimming				5.12E-03	5.12E-03			
Boating				2.52E-03	2.52E-03			
Total	1.23E+00	8.41E-02	1.15E-01	1.13E+00	1.21E+00	1.19E-01	2.79E-02	1.84E+00

All the doses in Table 11.2-204 will increase by a factor of 7. Even accounting for the contribution from the gaseous effluent pathway, the population dose increases to the whole body and critical organs is much less than the background radiation dose (4.5E+05 person-rem/yr – staff estimate – see Section J.2-6 and table J-7 of the FEIS, Reference 7.4) to the population living within a 50 mile radius of the proposed Levy nuclear power plant.

The following Table is excerpted directly from the FSAR: Table 11.2-205,"Comparison of Maximum Exposed Individual Doses from the LNP Site with the 40 CFR 190 Criteria (mrem/yr)."

Table 11.2-205: Comparison of Maximum Exposed Individual Doses from the LNP Site with the 40 CFR 190 Criteria (mrem/yr)

Type of Dose	Design Objective (40 CFR 190)	Crystal River Unit 3 Liquid Dose based on Operating Data	LNP Calculated Liquid Dose (two units)	LNP Calculated Gaseous Dose (two units)	Total Site Dose
Whole Body Dose Equivalent	25	0.00008	0.021	5.5	5.52
Dose to Thyroid	75	0.002	0.025	12.8	12.87
Dose to another organ	25	0.002	0.14	19.4	19.54

*As a result of the change in the DF, the MEI dose due to the liquid pathway will increase by 7 for the total body (0.021 * 7 = 0.147), thyroid (0.025 * 7 = 0.175), and other organ – bone (0.14 * 7 =0.98). The total dose increases from 5.5 to 5.6, the thyroid dose increases from 12.8 to 13.0 and the other organ – bone increases from 19.54 to 20.3 mrem/yr. These doses are still below the 40 CFR 190 dose limits provided in Table 11.2-205. The Crystal River Unit 3 contribution should be removed, although it is a small fraction of the total dose.*

c. Calculation LNG-0000-N5C-001

The following Sections and Tables are no longer correct as a result of the change in DF:

Section 3.0 “Input and Assumptions”, Subheading “Effluent Discharges”, Item 1.

The following text is excerpted directly from the calculation.

LNP liquid effluent discharges are expected to be through the CR discharge canal or alternately a Gulf discharge location. Dilution factors for the discharge canal and Gulf discharge location are 21 and 55, respectively [Subacz]. The lower dilution associated with the CR discharge canal is used in this analysis. The LNP blowdown rate to either discharge location is 63 cfs per unit [Toll].

As a result of the change in the DF, the dilution factor must be revised.

Section 5.0 “Calculation”, Subheading “Liquid Effluent Dose to Surrogate Biota”.

The following paragraphs are excerpted directly from the calculation.

The calculations of biota doses are performed using LADTAP II for AP1000 and CR-3 liquid effluents. The dilution factor and diluting flows are identified in Section 3. The remaining input to LADTAP II is shown in Tables 4 and 5.

As a result of the decommissioning of CR3, there is no CR3 liquid radioactive effluent.

The calculated doses from liquid effluents are shown in Table 12 for the surrogate biota. The external doses include the contribution from sediment and shoreline exposure durations in Table 2. The computer output is in Attachments 1 and 3 for LNP and CR-3, respectively.

As a result of the decommissioning of CR3, there is no CR3 liquid radioactive effluent. Consequently, Attachment 3 computer output is no longer required.

Section 5.0 “Calculation”, Subheading “Effective Energy Absorption Dose”.

The following text is excerpted directly from the calculation.

Table 8 gives the effective energy absorptions by radionuclide used in LADTAP. LADTAP output in Attachments 1 and 2 give the relative contributions for each nuclide as a percent of the surrogate biota internal doses. These percentages are stripped from the output and posted to Table 9 for LNP and CR-3. Table 10 identifies the food pathways and effective radii for the important biota and gives the calculated effective energy absorption ratios using the above summation.

As a result of the decommissioning of CR3, there is no CR3 liquid radioactive effluent. Consequently, the doses attributed to the liquid effluent discharge from CR3 are no longer required.

Section 5.0 “Calculation”, Subheading “Calculated Doses to Biota from Liquid and Gaseous Pathways”.

The following paragraphs are excerpted directly from the calculation.

Table 12 shows the dose contributions from the various pathways. LNP and CR-3 liquid effluent doses are calculated for surrogate biota using LADTAP. The computer output is in Attachments 1 and 3. The results are listed in Table 12 under the heading “Surrogate Biota”. Observe that liquid effluents result in internal (ingested food) and external (swimming and shoreline) doses contributions.

As a result of the decommissioning of CR3, there is no CR3 liquid radioactive effluent. Consequently, Attachment 3 computer output is no longer required.

Internal annual doses from liquid effluents to important biota are calculated and shown in Table 12 under the “Important Aquatic Biota” and “Important Terrestrial Biota” headings. Doses are determined for LNP and CR-3 liquid effluent contributions. Internal doses are determined from the similarity of the important and surrogate biota food pathways. Table 7 identifies the similar pathways used to establish doses. The internal doses (D_c' applicable to important fish and D_{cp}' applicable to certain important terrestrial biota) are scaled using Eq-1 or Eq-2 and the appropriate surrogate dose. Food ingestion rates and body masses are shown in Table 2; Table 10 gives the dose weighted effective energy absorption factor which are dependent on species effective radii.

As a result of the decommissioning of CR3, there is no CR3 liquid radioactive effluent. Consequently, the doses attributed to the liquid effluent discharge from CR3 are no longer required.

Section 6.0 "Results".

The following text is excerpted directly from the calculation.

Table 12 gives the calculated doses to important biota. The doses include contributions from liquid effluents from the proposed LNP AP1000 units and CR-3 since the release location via the CR discharge canal is the same.

As a result of the decommissioning of CR3, there is no CR3 liquid radioactive effluent. Consequently, the doses attributed to the liquid radioactive effluent discharge from CR3 are no longer required.

The following Table is excerpted directly from the calculation: Table 12, "Dose Contributions to Important and Surrogate Biota Other Than Man."

Table 12: Dose Contributions to Important and Surrogate Biota Other Than Man

Biota	LNP Liquid Effluents		CR 3 Liquid Effluents		Gaseous Effluents	
	Internal Dose, mrad/yr	External Dose, mrad/yr	Internal Dose, mrad/yr	External Dose, mrad/yr	Internal Dose, mrad/yr	External Dose, mrad/yr
Surrogate Biota						
Saltwater Fish	1.1E-01	5.7E-01	6.8E-02	5.5E-01	0	0
Invertebrate	3.9E+00	1.1E+00	2.0E-01	1.1E+00	0	0
Algae	8.8E+00	3.0E-03	3.0E-01	1.6E-03	0	0
Muskrat	8.8E-01	3.8E-01	2.9E-01	3.7E-01	0	2.0E+00
Raccoon	1.4E-01	2.8E-01	4.3E-02	2.7E-01	0	2.0E+00
Heron	6.2E-01	3.8E-01	1.8E-01	3.7E-01	0	1.4E+00
Duck	8.3E-01	5.7E-01	2.5E-01	5.5E-01	0	2.0E+00
Important Aquatic Biota						
American Alligator	6.0E-02	5.7E-01	2.1E-02	5.5E-01	0	1.0E+00
Gulf Sturgeon	3.4E-01	5.7E-01	3.1E-01	5.5E-01	0	0
Manatee	1.3E+00	5.7E-01	6.1E-01	5.5E-01	0	0
Sea turtles	4.8E-01	5.7E-01	2.3E-01	5.5E-01	0	0
Smalltooth Sawfish	4.2E-01	5.7E-01	4.0E-01	5.5E-01	0	0
Suwannee Cooter	0	0	0	0	2.5E-01	1.0E+00
Blue hard crab, oysters and stone crab	3.9E+00	1.1E+00	2.0E-01	1.1E+00	0	0
Red drum, flounder, and spotted sea trout	1.9E-01	5.7E-01	1.5E-01	5.5E-01	0	0
Red grouper, black grouper, gag grouper, spotted sea trout and flounder	2.7E-01	5.7E-01	2.4E-01	5.5E-01	0	0
Important Terrestrial Biota						
Bald Eagle	5.7E-01	0	1.6E-01	0	1.2E-01	8.6E-01
Eastern Indigo Snake	8.1E-02	1.3E-01	2.0E-02	1.3E-01	6.5E-01	1.0E+00
Florida Black Bear	0	0	0	0	1.7E+00	1.7E+00
Gopher Tortoise	0	0	0	0	1.7E+00	2.3E+00
Northern Bobwhite	0	0	0	0	1.4E+02	1.8E+01
Red-cockaded Woodpecker	0	0	0	0	2.2E+01	2.0E+00
Whitetail Deer	0	0	0	0	1.5E+00	2.0E+00
Wild turkey	0	0	0	0	1.0E+00	2.0E+00
Wood Stork	8.4E-01	3.8E-01	2.4E-01	3.7E-01	4.0E-01	1.4E+00

As a result of the change in the DF, the internal and external doses from the Levy liquid effluents will increase by a factor of 7. The doses from the CR3 liquid effluents can be deleted. The regulatory impact is evaluated in Table 13 below.

The following Table is excerpted directly from the calculation: Table 13, "Dose Contributions to Important and Surrogate Biota Other Than Man."

Table 13: Comparison of Doses to Surrogate and Important Biota from Facility Effluents to ORNL 1995 Evaluated Daily Limits

Species	Total Dose, mrad/yr	Total Dose, mrad/day
Aquatic Biota - 1000 mrad/day		
Saltwater Fish	2	0.01
Saltwater Invertebrate	7	0.02
Algae	10	0.03
American Alligator	3	0.01
Gulf Sturgeon	2	0.01
Manatee	4	0.02
Sea turtles	2	0.01
Smalltooth Sawfish	2	0.01
Suwannee Cooter	2	0.01
Blue hard crab, oysters, etc.	7	0.02
Red drum, flounder, and spotted sea trout	2	0.01
Red grouper, black grouper, gag grouper, spotted sea trout and flounder	2	0.01
Terrestrial Biota - 100 mrad/day		
Muskrat	4	0.02
Raccoon	3	0.01
Heron	3	0.01
Duck	5	0.02
Bald Eagle	2	0.01
Eastern Indigo Snake	3	0.01
Florida Black Bear	4	0.02
Gopher Tortoise	5	0.02
Northern Bobwhite	163	0.45
Red-cockaded Woodpecker	25	0.07
Whitetail Deer	4	0.02
Wild Turkey	4	0.02
Wood Stork	4	0.02
Total doses are compiled from Table 12.		

As a result of the change in the DF, the internal and external doses from the Levy liquid effluents will increase by a factor of 7. The doses contributed from the CR3 liquid effluents can be deleted. Even if the total doses in Table 13 are increased by a factor of 7 (includes CR3 liquid effluent pathway contribution and Levy gaseous effluent contribution), the resulting doses are still significantly below the IAEA and NCRP Guidelines (References 7.2 and 7.9 respectively) of 100-mrad/d for terrestrial biota and 1000-mrad/d for aquatic biota.

Attachment 1: *LNP LADTAP Output needs to be replaced based on a rerun of the associated input file to correct the change in the dilution factor.*

Attachment 3: *CR3 LADTAP Output can be deleted from the calculation because CR3 is no longer operational and will not contribute to the radioactive liquid effluent dose.*

d. Calculation LNG-0000-N5C-003

The following Sections and Tables are no longer correct as a result of the change in DF:

Section 5.0 "Input", Item 4.

The following text is excerpted directly from the calculation.

The dilution factors for the liquid effluents are 21 for the Crystal River Unit 3 discharge point and 55 for the Gulf discharge point per Reference 6.

As a result of the change in the DF, the dilution factor must be revised and a new reference must be utilized.

Section 6.2 "Doses", Cards 9 – 12 & 14 - 16, 21 (dilution)

As a result of the change in the DF, the dilution factor must be revised.

The following Tables and text are excerpted directly from Section 7.2, "Maximum Individual Doses – Crystal River 3 Discharge" of the calculation.

Maximum Individual Dose Summary (Activity Discharge per Unit) (Per Attachment 1)			
	Organ Receiving Maximum Dose		
Age Group	**Dose Organ**	**Dose (mrem/yr)**	**Total Body Dose (mrem/yr)**
Adult	**GI-LLI**	**0.071**	0.0044
Teen	GI-LLI	0.058	**0.0052**
Child	GI-LLI	0.025	0.0029
Infant	NA	NA	NA

As a result of the change in the DF, the organ and total body doses from the Levy liquid effluents will increase by a factor of 7.

Calculation of TEDE (mrem/yr)								
Organ	Total Body	GI Tract	Bone	Liver	Kidney	Thyroid	Lung	TEDE
Adult organ dose (mrem/yr)	4.44E-03	7.14E-02	3.74E-03	6.23E-03	5.23E-03	1.19E-02	2.09E-03	
WF per Reference 2	1	0.06	0.12	0.06	0.06	0.03	0.12	
WF * organ dose (mrem/yr)	4.44E-03	4.28E-03	4.49E-04	3.74E-04	3.14E-04	3.57E-04	2.51E-04	1.05E-02

As a result of the change in the DF, the TEDE dose and supporting total body and organ doses from the Levy liquid effluents will increase by a factor of 7 (see below).

The values for the GI tract, liver and kidney are taken as 0.06, each based on the value of 0.30 for the five "remainder" organs not specifically listed as specified in 10 CFR 20.1003. The TEDE from the liquid pathways is 1.05E-02 mrem/yr or 1.05E-05 rem/yr.

*As a result of the change in the DF, the TEDE dose from the Levy liquid effluents will increase by a factor of 7. The TEDE from the liquid pathways increases from 1.05E-02 to 1.05E-02 *7 or 7.35E-02 mrem/yr or from 1.05E-05 to 1.05E-05 *7 to 7.35-05 rem/yr.*

The following text is excerpted directly from Section 7.4, "Population Doses – Crystal River Discharge" of the calculation.

Total Body person-Rem	1.13
Thyroid person-Rem	1.21

*As a result of the change in the DF, the doses from the Levy liquid effluents will increase by a factor of 7. Total body dose in person-rem increases from 1.13 to 1.13 * 7 or 7.91 and thyroid dose in person-rem increases from 1.21 to 1.21 * 7 or 8.47.*

The augments provided in R.G. 1.110 were reviewed and were found not to be cost beneficial in reducing the population dose of 1.13 person-rem whole body and 1.21 person-rem thyroid. The lowest cost liquid radwaste system augment is $11,140, which would be $11,140/ 1.13 person-rem or $9,858 per person-rem whole body and $9207 per person-rem thyroid. These costs per person-rem reduction exceed the $1,000 per person-rem criteria prescribed in Appendix I to 10 CFR Part 50 and are therefore not cost beneficial.

As a result of the change in the DF, the cost – benefit analysis needs to be revised because of the following change to the text above:

*This is $1408 per person-rem total body ($11,140/(1.13 * 7 or 7.91) person-rem) and $1315 per person-rem thyroid ($11,140/(1.21 * 7 or 8.47). These costs per person-rem reduction exceed the $1,000 per person-rem criteria prescribed in Appendix I to 10 CFR Part 50 and no further action is required.*

Section 8.0, "References", *a new reference for the revised dilution factor will need to be added.*

Attachment 1: *"LADTAP Output: LNP 2 LIQ INP SLF=1 1 Unit blowdown Dil=21" will need to be rerun with the corrected dilution factor.*

Attachment 3: *"RG 1.110 EXCEL File", the cost benefit analysis will need to be revised to account for the change in dose due to the decrease in the dilution factor.*

e. LNP Cost – Benefit Analysis

The LNP cost – benefit analysis is performed in calculation LNG-0000-N5C-003, Section 7.4, "Population Doses – Crystal River Discharge" and is described in Levy FSAR Section 11.2.3.5.4. Both documents concluded the following:

- The augments provided in R.G. 1.110 (Reference 7.3) were reviewed and were found not to be cost beneficial in reducing the population dose of 1.13 person-rem whole body and 1.21 person-rem thyroid.
- The lowest cost liquid radwaste system augment is $11,140, which would be $11,140/ 1.13 person-rem or $9,858 per person-rem whole body and $9207 per person-rem thyroid.
- These costs per person-rem reduction exceed the $1,000 per person-rem criteria prescribed in Appendix I to 10 CFR Part 50 and are therefore not cost beneficial.

As a result of the increase in whole body and thyroid doses due to the decrease in the dilution factor, the above statements must be revised and an analysis must be performed to re-evaluate the cost benefit of augmenting the liquid waste management system.

For AP1000 sites with population dose estimates less than 11.14 person-rem whole body or thyroid dose from liquid effluents, no further cost-benefit analysis is needed to demonstrate compliance with 10 CFR 50, Appendix I Section II.D.

In the current version of Levy FSAR Chapter 11.2 the conclusion of the cost – benefit analysis (CBA) evaluation is that no augments are cost beneficial since all satisfy the RG 1.110 threshold (cost per person-rem total body or thyroid does not exceed $1000 per person-rem). For liquid and gaseous radwaste systems for light-water-cooled nuclear power reactors augments are defined as all items of reasonably demonstrated technology that, when added to the system sequentially and in order of diminishing cost-benefit return, can, for a favorable cost-benefit ratio, effect reductions in dose to the population reasonably expected to be within 50 miles of the reactor.

As a result of the LNP dilution flow change, the revised population doses for Levy without dilution from the fossil units and CR3 are estimated as 7.91 person-rem total body and 8.47 person-rem thyroid

The lowest cost liquid radwaste system augment is $11,140. Assuming 100 percent efficiency of this augment, the minimum possible cost per person-rem is determined by dividing the cost of the augment by the population dose. This is $11,140/7.91 person-rem total body or $1408 per person-rem total body, and $11,140/8.47 person-rem thyroid or $1315 per person-rem thyroid. Because the cost per person-rem total body/thyroid exceeds the $1000 per person-rem criterion provided in Regulatory Guide 1.110, no further action is required.

4.4 Evaluation of Changes and Regulatory Questions

4.4.1 Does the Change Involve the Correction of Significant Errors in the Application?

As a result of Duke Energy Florida's decision to decommission Crystal River Units 1, 2, and 3, current licensing bases documents utilized a DF of 21 to calculate the radiological impacts due to radioactive liquid effluent pathway releases during normal operations are no longer valid. This change increases the doses by a factor of 7 to the MEI, population within a 50 mile radius of the Levy NPP, and terrestrial and aquatic biota but does not exceed the regulatory dose design objectives or increase the cancer risk. The change is not the result of an error in the application but rather the shutdown of Crystal River Units 1, 2, and 3.

Therefore the change does not involve the correction of significant errors in the application.

4.4.2 Is the Change Needed to Ensure Compliance with NRC Regulations?

As a result of Duke Energy Florida's decision to decommission Crystal River Units 1, 2, and 3, current licensing bases documents utilized a DF of 21 to calculate the radiological impacts due to radioactive liquid effluent pathway releases during normal operations are no longer valid. Although this change increases the doses by a factor of 7 to the MEI, population within a 50 mile radius of the Levy NPP, and terrestrial and aquatic biota, the doses do not exceed the regulatory dose design objectives (10 CFR 50 Appendix I and 40 CFR 190). In addition, the conclusions of the cost-benefit analysis performed per Regulatory Guide 1.110 and required per 10 CFR 50 Appendix I do not change.

Consequently no change is needed to ensure compliance with NRC regulations.

4.4.3 Is the Change Needed to Support Other Licensing-Basis Documents (e.g., Conforming Changes to Information in the DCD Supporting Technical Specifications)?

As a result of Duke Energy Florida's decision to decommission Crystal River Units 1, 2, and 3, current licensing bases documents utilized a DF of 21 to calculate the radiological impacts due to radioactive liquid effluent pathway releases during normal operations are no longer valid. This change increases the doses by a factor of 7 to the MEI, population within a 50 mile radius of the Levy NPP, and terrestrial and aquatic biota but does not exceed the regulatory dose design objectives or increase the cancer risk. In addition, the conclusions of the cost-benefit analysis performed per Regulatory Guide 1.110 and required per 10 CFR 50 Appendix I do not change. This change is not considered

significant and may be captured in Chapter 11.2 of the Levy FSAR as a routine FSAR revision.
Therefore no change is needed to support other licensing-basis documents such as the DCD or DCD supporting Technical Specifications.

4.4.4 Does the Change Involve a Significant Technical Correction Associated with the Design or Program described in the Licensing Document (i.e., if not changed, would preclude operation within the bounds of the licensing basis, as opposed to proposed alternatives to the described design or program)?

As a result of Duke Energy Florida's decision to decommission Crystal River Units 1, 2, and 3, current licensing bases documents utilized a DF of 21 to calculate the radiological impacts due to radioactive liquid effluent pathway releases during normal operations are no longer valid. This change increases the doses by a factor of 7 to the MEI, population within a 50 mile radius of the Levy NPP, and terrestrial and aquatic biota but does not exceed the regulatory dose design objectives or increase the cancer risk. In addition, the conclusions of the cost-benefit analysis performed per Regulatory Guide 1.110 and required per 10 CFR 50 Appendix I do not change. Therefore the change is not considered significant and the change may be captured in Chapter 11.2 of the Levy FSAR as a routine FSAR revision.

Consequently, the change does not involve a significant technical correction associated with the design or program described in the licensing document.

4.4.5 Is the Change Needed to Address a Significant Vulnerability Identified by Probabilistic Risk Assessments (PRAs) or Other Studies (e.g., a Change in PRA Insight)?

As a result of Duke Energy Florida's decision to decommission Crystal River Units 1, 2, and 3, current licensing bases documents utilizing a DF of 21 to calculate the radiological impacts due to radioactive liquid effluent pathway releases during normal operations are no longer valid. Although this change increases the doses by a factor of 7 to the MEI, population within a 50 mile radius of the Levy NPP, and terrestrial and aquatic biota, the doses do not exceed the regulatory (10 CFR 50 Appendix I) dose design objectives or increase the cancer risk. In addition, the conclusions of the cost-benefit analysis performed per Regulatory Guide 1.110 and required per 10 CFR 50 Appendix I do not change.

Therefore, this change is not needed to address a significant vulnerability identified by probabilistic risk assessments (PRAs) or other studies (e.g., a change in PRA insight.

4.4.6 Is a Supplement to the Final EIS Required?

The determination to prepare a supplement to the Final EIS is governed by 10 CFR 51.92, "Supplement to the Environmental Impact Statement", (Reference 7.8). The need to prepare a supplement is based on the response to the two key questions discussed below.

4.4.6.1 Are there substantial changes in the proposed action that are relevant to environmental concerns?

The changes to Section 5.9 of the FEIS as a result of revising the dilution factor is discuss in Section 4.3.a of this Report. The changes in the proposed action that are relevant to environmental concerns are: (1) does the increase in doses to the MEI, population within a 50 mile radius of the Levy NPP, and terrestrial and aquatic biota exceed the regulatory dose design objectives, and (2) is there an increase in cancer risk?

The increase in dose does not exceed any regulatory dose design objectives as discussed above.

Per Section 4.3.a, the dose due to the liquid pathway will increase from 1.13 to 7.91 person-rem/yr per unit. The resultant dose is much less than the background radiation dose 4.5E+05 person-rem/yr to the population living within a 50 mile radius of the proposed Levy nuclear power plant.

The total dose from both the liquid and gaseous pathways increases from 6.9 to 13.65 person-rem/yr per unit. This dose is still significantly below the limit of 1754 person-rem/yr per unit that ICRP and NCRP suggest would most likely result in zero excess health effects,

The maximum total dose from liquid and gaseous pathways will increase from 0.5 mrad/d to 10.5 mrad/d even assuming that the liquid pathway is the only pathway that contributes to the dose. This dose is significantly below the IAEA and NCRP Guidelines of 100-mrad/d for terrestrial biota and 1000-mrad/d for aquatic biota.

The MEI total body, maximum organ, and thyroid dose would increase by a factor of 7 due to the liquid effluent pathway, however, even with the increase, the 10 CFR 50, Appendix I requirements of 3 mrem/year whole body and 10 mrem/year maximum exposed organ would not be exceeded.

The MEI liquid plus gaseous effluent pathway whole body dose increases from 5.5 to 5.6, the thyroid dose increases from 12.8 to 13.0 and the maximum organ increases from 19.5 to 20.4 mrem/yr. These doses are still below the 40 CFR 190 dose limits of 25 mrem/yr whole body and other organ and 75 mrem/yr thyroid.

Consequently, there are no substantial changes in the proposed action that are relevant to environmental concerns.

4.4.6.2 Are there new and significant circumstances or information relevant to environmental concerns and bearing on the proposed actions or its impacts?

The new circumstance is the decision by Duke Energy Florida to decommission Crystal River Units 1, 2, and 3. Since Levy and CR share a portion of the liquid effluent discharge canal, with the permanent shutdown of CR, the dilution factor is reduced. The only environmental impact is whether the increase in doses to the MEI, population within a 50 mile radius of the Levy NPP, and terrestrial and aquatic biota exceed the regulatory dose design objectives or there is an increase in cancer risk? Based on the analysis above, the reduction in the DF and the increase in dose will not exceed any regulatory dose design objectives or result in an increase in cancer risk.

Therefore, there are no new and significant circumstances or information relevant to environmental concerns and bearing on the proposed actions or its impacts.

Based on the response to questions 4.4.6.1 and 4.4.6.2, a supplement to the FEIS is not required.

5.0 Conclusions

As a result of Duke Energy Florida's decision to decommission Crystal River Units 1, 2, and 3, current licensing bases documents utilizing a dilution factor (DF) of 21 to calculate the radiological impacts due to radioactive liquid effluent pathway releases during normal operations are no longer correct. This change in DF increases the doses by a factor of 7 to the MEI, population within a 50 mile radius of the Levy NPP, and terrestrial and aquatic biota but does not exceed the regulatory dose design objectives or increase the cancer risk. In addition, the conclusions of the cost-benefit analysis performed per Regulatory Guide 1.110 and required per 10 CFR 50 Appendix I do not change. The change in DF does not correct any significant errors in an application, is not needed to ensure compliance with NRC regulations, and does not support other licensing basis documents (e.g., conforming changes to information in the FSAR supporting technical specifications). This change does not involve any significant technical correction associated with the design or program described in the LNP FSAR or the AP1000 DCD. The change is not needed to resolve any significant vulnerability identified by the probabilistic risk assessments (PRAs) or other studies.

A supplement to the FEIS is not required per 10 CFR 51.92 because the change in DF results in no substantial changes in the proposed action that are relevant to environmental concerns and there are no new and significant circumstances or information relevant to environmental concerns and bearing on the proposed actions or its impacts.

6.0 Recommendations

As a result of the findings of this Report, the following activities are recommended for Phase II:

1. Revise the cost – benefit analysis
2. Revise calculation LNG-0000-N5C-001, "Dose to Important Biota."
3. Revise calculation LNG-0000-N5C-003, "Liquid Effluent Doses & Concentrations – Levy Site."
4. Update the Final Safety Analysis Report (FSAR) Section 11.2, "Liquid Waste Management Systems" to reflect the changes above.
5. Duke Energy should finalize the WorleyParsons' developed draft ISG-11 Evaluation of Changes for the assessment of the dilution factor change licensing impact.

7.0 References

7.1 JVT-Request for Information, RFI #417, "Offshore Dilution Factor for LNP Discharge Plume into the Gulf of Mexico", 6/26/2013.

7.2 International Atomic Energy Agency (IAEA), "Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards", Report Series No. 332, 1992.

7.3 USNRC Regulatory Guide 1.110, "Cost – Benefit Analysis for Radwaste Systems for Light-Water Cooled Nuclear Power Reactors", March 1976, (for comment).

7.4 USNRC NUREG-1941, "Environmental Impact Statement for Combined Licenses (COLs) for Levy Nuclear Plant Units 1 and 2", April 2012.

7.5 Levy Nuclear Plant Units 1 and 2 COL Application Part 2, Final Safety Analysis Report, Chapter 11, "Radioactive Waste Management", Section 11.2, "Liquid Waste Management Systems", Revision 5.

7.6 Progress Energy COLA AP-1000 Levy calculation LNG-0000-N5C-001, "Dose to Important Biota", Revision 1.

7.7 Progress Energy COLA AP-1000 Levy calculation LNG-0000-N5C-003, "Liquid Effluent Doses & Concentrations – Levy Site", Revision 2.

7.8 USNRC Code of Federal Regulations, Title 10 Part 51.92, "Supplement to the Environmental Impact Statement."

7.9 National Council on Radiation Protection and Measurements "Effects of Ionizing Radiation on Aquatic Organisms", NCRP Report No. 109, Bethesda, Maryland, 1991.

7.10 International Commission on Radiological Protection (ICRP), Recommendations of the ICRP, ICRP Publication No. 103, "Annals of the ICRP 37 (2-4)", Ottawa, Ontario, Canada, 2007.

7.11 National Council on Radiation Protection and Measurements (NCRP), "Principles and Application of Collective Dose in Radiation Protection", NCRP Report No. 121, Bethesda, Maryland, 1995.