UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 4, 2014

Mr. Mano Nazar
President and Chief Nuclear Officer
Nuclear Division
NextEra Energy
P.O. Box 14000
Juno Beach, FL 33408-0420

SUBJECT: TURKEY POINT NUCLEAR GENERATING, UNIT NOS. 3 AND 4 - STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST - FLOOD-CAUSING MECHANISM REEVALUATION (TAC NOS. MF1114 AND MF1115)

Dear Mr. Nazar:

By letter dated March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued a request for information pursuant to Title 10 of the *Code of Federal Regulations*, Section 50.54(f) (hereafter referred to as the 50.54(f) letter). The request was issued as part of implementing lessons-learned from the accident at the Fukushima Dai-ichi nuclear power plant. Enclosure 2 to the 50.54(f) letter requested licensees to reevaluate flood-causing mechanisms using present-day methodologies and guidance.

By letter dated March 11, 2013, Florida Power and Light Company responded to this request for Turkey Point Nuclear Generating, Unit Nos. 3 and 4. In response to NRC staff requests for additional information; this response was supplemented by letters dated January 31, 2014, February 26, 2014, April 25, 2014, and August 7, 2014.

The NRC staff has reviewed the information provided and, as documented in the enclosed staff assessment, determined that you provided sufficient information in response to the 50.54(f) letter. Because the reevaluated flood-causing mechanism was not bounded by your current plant-specific design-basis hazard, the NRC staff anticipates submittal of an integrated assessment in accordance with Enclosure 2, Required Response 3, of the 50.54(f). In addition, the staff has identified three issues that resulted in open items. These open items are documented and explained in the attached Staff Assessment and will be addressed as part of the integrated assessment.

If you have any questions, please contact me at (301) 415-3733 or email at Robert.Kuntz@nrc.gov.

Sincerely,

Robert F. Kuntz, Senior Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos. 50-250 and 50-251

Enclosure:
Staff Assessment of Flood Hazard
Reevaluation Report

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STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO FLOODING HAZARD REEVALUATION REPORT

NEAR-TERM TASK FORCE RECOMMENDATION 2.1

RELATED TO THE FUKUSHIMA DAI-ICHI NUCLEAR POWER PLANT ACCIDENT

TURKEY POINT NUCLEAR GENERATING, UNIT NOS. 3 AND 4

DOCKET NOS. 50-250 AND 50-251

1.0 INTRODUCTION

By letter dated March 12, 2012 (NRC, 2012a), the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f) "Conditions of license" (hereafter referred to as the "50.54(f) letter"). The request was issued in connection with implementing lessons-learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant as documented in the "Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident" (NRC, 2011b).[1] Recommendation 2.1 in that document recommended that the staff issue orders to all licensees to reevaluate seismic and flooding for their sites against current NRC requirements and guidance. Subsequent Staff Requirements Memoranda associated with Commission Papers SECY-11-0124 (NRC, 2011c) and SECY-11-0137 (NRC, 2011d), directed the NRC staff to issue requests for information to licensees pursuant to 10 CFR 50.54(f).

Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazard for their respective sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits (ESPs) and combined licenses (COLs). The required response section of Enclosure 2 specified that NRC staff would provide a prioritization plan indicating Flooding Hazard Reevaluation Report (FHRR) deadlines for individual plants. On May 11, 2012, the staff issued its prioritization of the FHRRs (NRC, 2012b).

If the reevaluated hazard for all flood-causing mechanisms is not bounded by the current plant design-basis flood hazard, an integrated assessment will be necessary. The FHRR and the responses to the associated requests for additional information (RAIs) will provide the hazard input necessary to complete the integrated assessment report as requested in Enclosure 2 of the 50.54(f) letter.

By letter dated March 11, 2013 (Kiley, 2013a), Florida Power and Light Company (FPL) provided its FHRR for Turkey Point Nuclear Generating, Unit Nos. 3 and 4 (Turkey Point).

1 Issued as an enclosure to Commission Paper SECY 11-0093 (NRC, 2011a).

The licensee stated in its FHRR Section 4.4 that interim actions and procedures exist, and that these interim actions and procedures will be reevaluated and updated, as determined by the integrated assessment. The licensee provided supplemental information on the interim actions, as well as a proposed completion schedule for the interim actions, particularly with respect to the start of hurricane season (Kiley, 2013b). The licensee responded to the staff RAIs by letters dated January 31, 2014 (Kiley, 2014a), February 26, 2014 (Kiley, 2014b), and April 25, 2014 (Kiley, 2014c).

Because all the reevaluated flood-causing mechanisms are not bounded by the current plant-specific design-basis hazard, the staff anticipates submittal of an integrated assessment. The staff will prepare an additional staff assessment report to document its review.

2.0 REGULATORY BACKGROUND

2.1 Applicable Regulatory Requirements

As stated above, Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazards for their respective sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for ESPs and COLs. This section describes present-day regulatory requirements that are applicable to the FHRR.

Section 50.34(a)(1), (a)(3), (a)(4), (b)(1), (b)(2), and (b)(4), of 10 CFR, describes the required content of the preliminary and final safety analysis reports, including a discussion of the facility site with a particular emphasis on the site evaluation factors identified in 10 CFR Part 100. The licensee should provide any pertinent information identified or developed since the submittal of the preliminary safety analysis report in the final safety analysis report.

Section 50.54(f) of 10 CFR states that a licensee shall at any time before expiration of its license, upon request of the Commission, submit written statements, signed under oath or affirmation, to enable the Commission to determine whether or not the license should be modified, suspended, or revoked. The 50.54(f) letter issued onMarch 12, 2012, requested licensees reevaluate the flood-causing mechanisms for their respective sites using present-day methodologies and regulatory guidance used by the NRC for the ESP and COL reviews.

General Design Criterion 2 in Appendix A of 10 CFR Part 50 states that structures, systems, and components (SSCs) important to safety at nuclear power plants must be designed to withstand the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, tsunamis, and seiches without loss of capability to perform their intended safety functions. The design bases for these SSCs are to reflect appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area. The design bases are also to have sufficient margin to account for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

Section 50.2 of 10 CFR defines the design-basis as the information that identifies the specific functions that an SSC of a facility must perform, and the specific values or ranges of values chosen for controlling parameters as reference bounds for design which each licensee is required to develop and maintain. These values may be (a) restraints derived from generally accepted "state of the art" practices for achieving functional goals, or (b) requirements derived from an analysis (based on calculation or experiments or both) of the effects of a postulated accident for which an SSC must meet its functional goals.

Section 54.3 of 10 CFR defines the "current licensing basis" (CLB) as: "the set of NRC requirements applicable to a specific plant and a licensee's written commitments for ensuring compliance with and operation within applicable NRC requirements and the plant-specific design basis (including all modifications and additions to such commitments over the life of the license) that are docketed and in effect." This includes 10 CFR Parts 2, 19, 20, 21, 26, 30, 40, 50, 51, 52, 54, 55, 70, 72, 73, 100 and appendices thereto; orders; license conditions; exemptions; and technical specifications, as well as the plant-specific design-basis information as documented in the most recent final safety analysis report. The licensee's commitments made in docketed licensing correspondence, which remain in effect, are also considered part of the CLB.

Present-day regulations for reactor site criteria (Subpart B to 10 CFR Part 100 for applications on or after January 10, 1997) state, in part, that the physical characteristics of the site must be evaluated and site parameters established such that potential threats from such physical characteristics will pose no undue risk to the type of facility proposed to be located at the site. Factors to be considered when evaluating sites include the nature and proximity of dams and other man-related hazards (10 CFR 100.20(b)) and the physical characteristics of the site, including the hydrology (10 CFR 100.21(d)).

2.2 Enclosure 2 to the 50.54(f) Letter

The 50.54(f) letter requests all power reactor licensees and construction permit holders reevaluate all external flooding-causing mechanisms at each site. The reevaluation should apply present-day methods and regulatory guidance that are used by the NRC staff to conduct ESP and COL reviews. This includes current techniques, software, and methods used in present-day standard engineering practice. If the reevaluated flood-causing mechanisms are not bounded by the current plant design-basis flood hazard, an integrated assessment will be necessary.

2.2.1 Flood-Causing Mechanisms

Attachment 1 to Recommendation 2.1, Flooding (Enclosure 2 of the 50.54(f) letter) discusses flood-causing mechanisms for the licensee to address in its FHRR. Table 2.2.1-1 lists the flood-causing mechanisms the licensee should consider. Table 2.2.1-1 also lists the corresponding Standard Review Plan (NRC, 2007) sections and applicable interim staff guidance (ISG) documents containing acceptance criteria and review procedures. The licensee should incorporate and report associated effects per NRC Japan Lessons- Learned Project Directorate (JLD) JLD-ISG-2012-05 (NRC, 2012c) in addition to the maximum water level associated with each flood-causing mechanism.

2.2.2 Associated Effects

In reevaluating the flood-causing mechanisms, the "flood height and associated effects" should be considered. JLD-ISG-201-05 (NRC, 2012c) defines "flood height and associated effects" as the maximum stillwater surface elevation plus:

- wind waves and run-up effects
- hydrodynamic loading, including debris
- effects caused by sediment deposition and erosion
- concurrent site conditions, including adverse weather conditions

- groundwater ingress
- other pertinent factors

2.2.3 Combined Effects Flood

The worst flooding at a site that may result from a reasonable combination of individual flooding mechanisms is sometimes referred to as a "Combined Effect Flood." Even if some or all of these individual flood-causing mechanisms are less severe than their worst-case occurrence, their combination may still exceed the most severe flooding effects from the worst-case occurrence of any single mechanism described in the 50.54(f) letter (see SRP Section 2.4.2, Area of Review 9 (NRC, 2007). Attachment 1 of the 50.54(f) letter describes the "Combined Effect Flood" [2], as defined in American National Standards Institute/American Nuclear Society (ANSI/ANS) 2.8-1992 (ANSI/ANS, 1992) as follows:

> For flood hazard associated with combined events American Nuclear Society (ANS) 2.8-1992 provides guidance for combination of flood causing mechanisms for flood hazard at nuclear power reactor sites. In addition to those listed in the ANS guidance, additional plausible combined events should be considered on a site specific basis and should be based on the impacts of other flood causing mechanisms and the location of the site.

If two less severe mechanisms are plausibly combined per ANSI/ANS-2.8-1992 (ANSI/ANS, 1992) and SRP Section 2.4.2, Areas of Review 9 (NRC, 2007), then the staff will document and report the result as part of one of the hazard sections. An example of a situation where this may occur is flooding at a riverine site located where the river enters the ocean. For this site, storm surge and river flooding should be plausibly combined.

2.2.4 Flood Event Duration

Flood event duration was defined in the ISG for the integrated assessment for external flooding, JLD-ISG-2012-05 (NRC, 2012c), as the length of time during which the flood event affects the site. It begins when conditions are met for entry into a flood procedure, or with notification of an impending flood (e.g., a flood forecast or notification of dam failure), and includes preparation for the flood. It continues during the period of inundation, and ends when water recedes from the site and the plant reaches a safe and stable state that can be maintained indefinitely. Figure 2.2.4-1 illustrates flood event duration.

2.2.5 Actions Following the FHRR

For the sites where the reevaluated probable maximum flood elevation is not bounded by the current design-basis flood hazard for all flood-causing mechanisms, the 50.54(f) letter requests licensees and construction permit holders to:

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2 For the purposes of this Staff Assessment, the terms "combined effects" and "combined events" are synonymous.

- Submit an Interim Action Plan with the FHRR documenting actions planned or already taken to address the reevaluated hazard.
- Perform an integrated assessment subsequent to the FHRR to: (a) evaluate the effectiveness of the current licensing basis (i.e., flood protection and mitigation systems); (b) identify plant-specific vulnerabilities; and (c) assess the effectiveness of existing or planned systems and procedures for protecting against and mitigating consequences of flooding for the flood event duration.

If the reevaluated flood hazard is bounded by the current design-basis flood hazard for all flood-causing mechanisms at the site, licensees are not required to perform an integrated assessment at this time.

3.0 TECHNICAL EVALUATION

The NRC staff reviewed the information provided for the flood hazard reevaluation of Turkey Point. The licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance used by the NRC staff in connection with ESP and COL reviews. The staff's review and evaluation is provided below.

To provide additional information in support of the summaries and conclusions in the FHRR, the licensee made calculation packages available to the staff via an electronic reading room. When the staff relied directly on some of these calculation packages in its review; these calculation packages are docketed, and are cited, as appropriate, in the discussion below. Certain other calculation packages were found only to expand upon and clarify the information provided on the docket, so they are not docketed or cited.

By letter dated January 15, 2014, the staff requested additional information from the licensee to supplement its FHRR (NRC, 2014b). The licensee provided this additional information by letters dated January 31, 2014 (Kiley, 2014a), February 26, 2014 (Kiley, 2014b), and April 25, 2014 (Kiley, 2014c). Additionally, by letter dated April 25, 2014 (Kiley, 2014c), the licensee revised the previously submitted information. The licensee's responses are discussed in the appropriate section(s) below.

The site grade elevation at the powerblock is 15.7 feet (ft) (4.8 m)[3] North American Vertical Datum of 1988 (NAVD88). Unless otherwise stated, all elevations in this staff assessment are given with respect to NAVD88. Table 3.0-1 provides the summary of controlling reevaluated flood-causing mechanisms, including associated effects from waves and runup, the licensee computed to be higher than the powerblock elevation.

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3 The licensee's flood hazard reevaluation studies were conducted using customary units of measure. In this report, customary measurements are followed by the equivalent measurement in metric units. Because the conversion to metric units may involve loss of precision, the measurement in customary units is definitive.

3.1 Site Information

The 50.54(f) letter includes the SSCs important to safety, and the Ultimate Heat Sink, in the scope of the hazard reevaluation. Per the 50.54(f) letter, Enclosure 2, Requested Information, Hazard Reevaluation Report, Item a, the licensee included pertinent data concerning these SSCs in its FHRR.

The 50.54(f) letter, Enclosure 2 (Recommendation 2.1: Flooding), Requested Information, Hazard Reevaluation Report, Item a, describes site information to be contained in the FHRR. The staff reviewed and summarized this information as follows.

3.1.1 Detailed Site Information

Turkey Point is part of a larger complex that also includes two gas/oil fired steam electric generating units, a natural-gas combined-cycle plant, an extensive 5900 acre (24 km^2) cooling water canal system, and the site of two additional proposed nuclear reactor units. The site is adjacent to Biscayne Bay and the surrounding land area and has minimal topographic relief with elevations generally ranging from 2 to 5 ft (0.6 to 1.5 m). The plant site is elevated above the surrounding topography. The grade level of the plant structures at the powerblock is at elevation 15.7 ft (4.8 m). This is equivalent to 18 ft (5.5 m) on the Mean Low Water datum (Site Datum, which the licensee also refers to as MLW-Site). There are no natural rivers or streams in the vicinity, but there are several man-made canals in the area. According to FHRR Section 2.3.3, some SSCs are elevated significantly above the site's grade level. These include the direct current power equipment at elevations 27.8 ft (8.5 m) and 39.7 ft (12.1 m), the control room at 39.7 ft (12.1 m), and the control rod system at 27.8 ft (8.5 m). Intake cooling water pump motor bases are at 20.2 ft (6.2 m).

The hurricane readiness procedure provides for external flood protection to 17.7 ft (5.4 m) to the north, south, and west of the facility by a continuous barrier consisting of exterior building walls, flood walls, a flood embankment, and stoplogs at the door openings. To the east of the facility, external flood protection is provided to 19.7 ft (6.0 m) with flood protection stoplogs in place. Facilities and SSCs identified in the FHRR as protected to these elevations by these measures are:

- the Auxiliary Building, which houses the Emergency Core Cooling, Containment Spray, Charging, Component Cooling Water, and Boric Acid Injection Systems and their support systems,
- the Auxiliary Feedwater System and 4160 V switchgear in the Turbine Building Area,
- Unit 3 Emergency Diesel Generators.

Additionally, the FHRR states that the Unit 4 Emergency Diesel Generators are in a building that is protected to a minimum elevation of 20.7 ft (6.3 m) and that the spent fuel cooling equipment housed in the Spent Fuel Building is protected to 19.7 ft (6.0 m).

3.1.2 Design-Basis Flood Hazards

The current design-basis flood levels are summarized by flood-causing mechanism in Table 3.1.2-1. For Turkey Point, these mechanisms are described in the Final Safety Analysis Report (FSAR) (FPL, 2011).

3.1.3 Flood-related Changes to the Licensing Basis

The licensee noted in Section 2.3 of its FHRR that several protective features and procedures have been implemented at Turkey Point.

3.1.4 Changes to the Watershed and Local Area

Since the issuance of the Turkey Point facility license, a number of additional canals and surface water control structures have been built in the surrounding area. Additionally, surface and subsurface reservoirs are being established to capture and store fresh water in support of the Comprehensive Everglades Restoration Project. The licensee noted that these canals and reservoirs are at much lower elevation than the plant grade for Turkey Point and do not have the potential to inundate the site.

3.1.5 Current Licensing Basis Flood Protection and Pertinent Flood Mitigation Features

According to the FHRR, the CLB requires hurricane readiness procedure to be implemented 72 hours before tropical storm force winds (39 mph [17.4 m/s] or greater) are projected to reach the site. These measures are described in FHRR Section 2.3.2 as including installation of portable dewatering pumps, electric generators with fuel supplies, and associated hoses in various plant areas; installation of mechanical and inflatable plugs in plant drainage system drains; installation of stoplogs on plant flood protection walls; and filling sandbags and building sandbag dikes at specified plant doors, drains, and manhole covers. The hurricane readiness procedure provides for external flood protection to 17.7 ft (5.4 m) to the north, south, and west of the facility by a continuous barrier consisting of exterior building walls, flood walls, a flood embankment, and stoplogs at the door openings. To the east of the facility (seaward side), external flood protection is provided to 19.7 ft (6.0 m) with flood protection stoplogs in place to protect against wave runup.

FHRR Section 3.1 states that the CLB prescribes installation of pumps to control water levels resulting from accumulation of local intense precipitation in the Condenser Pits and the Units 3 and 4 Component Cooling Water (CCW) Areas during periods when hurricane readiness procedures for severe hurricanes are implemented. Required pumping capacities specified in the CLB are 4,900 gallons per minute (0.31 m^3/s) for the two Condenser Pits, combined, and 250 gallons per minute (0.0158 m^3/s) for each of the CCW Areas.

3.1.6 Additional Site Details to Assess the Flood Hazard

The licensee provided electronic copies of the input files used for FLO-2D modeling in the local intense precipitation (LIP) flood analysis. In addition, staff reviewed information provided in the electronic reading room set up by the licensee.

3.1.7 Results of Plant Walkdown Activities

Enclosure 4 of the 50.54(f) letter requested that licensees plan and perform plant walkdown activities to verify that current flood protection systems are available, functional, and implementable. Other parts of the 50.54(f) letter (Requested Information Item 1.c, and Step 6 of Attachment 1 to Recommendation 2.1, Flooding (Enclosure 2)) asked the licensee to report any relevant information from the results of the plant walkdown activities.

The licensee responded, by letter dated June 11, 2012 (Kiley, 2012b), that they would perform the plant walkdown activities. By letter dated November 20, 2012, FPL provided the flood walkdown report for Turkey Point (Kiley, 2012a). The walkdown report was supplemented by letter, including RAI responses, dated January 29, 2014 (Kiley, 2014d).

The staff prepared a Staff Assessment report, dated June 11, 2014 (NRC, 2014a), to document its review of the walkdown report and concluded that the licensee met the intent of the walkdown guidance.

3.2 Local Intense Precipitation and Associated Site Drainage

The licensee's FHRR includes a reevaluation of the flood hazard, including associated effects, from LIP. The licensee did not report a single reevaluated flood hazard elevation for LIP. Instead, the licensee's analysis of flood hazard from LIP determined peak water depths and water surface elevations at specific locations under two different LIP scenarios, referred to as Scenario A and Scenario B. Scenario A LIP occurs during normal plant operations when no special flood protection measures required for hurricane readiness are in place. Scenario B LIP occurs when the plant is operating under hurricane readiness procedures. Analysis of Scenario B LIP is focused on the Condenser Pits, Unit 3 Component Cooling Water (CCW3) Area, and Unit 4 Component Cooling Water (CCW4) Area. Under normal conditions, rainwater entering these open-air structures can escape by passive drainage, but when hurricane readiness procedures are in place, rainwater is prevented from draining out of these areas because floor drains are plugged and stoplogs are inserted in doorways. The CLB states that when hurricane readiness procedures are implemented, pumps are placed in these areas to remove rainwater.

The licensee reported in its April 25, 2014, RAI response (Kiley, 2014c), a reevaluated flood elevation for LIP Scenario B of 20.8 ft (6.3 m) in the CCW3 Area. The reevaluated flood elevation for LIP Scenario B in the Condenser Pits is 14.5 ft (4.4 m). For LIP Scenario A, the licensee reported maximum flood water depths and elevations at 33 discrete "points of interest" (POIs) at potentially vulnerable locations in the plant area; the greatest depth of water (above ground surface) at a POI location is reported as 1.7 ft (0.5 m), corresponding to elevation 17.2 ft (5.2 m). Reevaluated maximum water elevations for both scenarios are above the plant grade elevation of 15.7 ft (4.8 m).

This flooding mechanism is considered in the CLB (as discussed above and in Section 3.1.5), but is not evaluated in the current design-basis. Thus there is no previously specified elevation for flooding hazard related to LIP.

The licensee used FLO-2D Pro (referred to hereafter as FLO-2D), a two-dimensional hydrodynamic computer model, to calculate the flooding due to LIP (FLO-2D, 2012). The licensee did not report any site-specific validation of the model. The licensee's reevaluation of flood hazard for LIP is based on the one-square-mile (2.6 km^2) probable maximum precipitation (PMP), which the licensee obtained from the U.S. National Weather Service (NWS) Hydrometeorological Reports (HMR) No. 51 (National Oceanic and Atmospheric Administration (NOAA), 1978) and No. 52 (NOAA, 1982). The one-hour, one-square-mile (2.6 km^2) PMP depth for the Turkey Point site given by HMR 52 is 19.4 inches (493 mm). Table 3.2-1 provides the values of PMP for periods of less than one hour. For its reevaluation of potential flooding from LIP, the licensee used these values to create a synthetic hydrograph for the one-hour PMP event. Table 3.2-2 summarizes the synthetic hydrograph, which places the highest rates of rainfall in the middle of the one-hour PMP event.

The licensee noted (in response to an RAI) that the choice of a center-weighted temporal rainfall distribution for analysis is based on the synthetic rainfall distributions presented in the TR-55 methodology (Soil Conservation Service, 1986), which consistently places the most intense rainfall near the middle of the storm. The licensee also performed a sensitivity study, using FLO-2D, to compare the effects on results of the center-, front-, front-third-, end-third-, and end-loaded rainfall distributions. The licensee's sensitivity analysis found that the center-loaded distribution resulted in bounding flood elevations at all but two POIs that had slightly higher flood elevations from a rainfall distribution with a later peak. To bound its analysis, in its subsequent simulations the licensee considered several temporal rainfall distributions and reported the highest peak water surface elevation predicted at each location.

The licensee modeled the Turkey Point site and its surrounding area using a five-foot (1.5 m) FLO-2D grid with elevations obtained from an October 2012 topographic survey. Elevations for the surrounding area were obtained from a 2008 LiDAR survey of Miami-Dade County. FHRR Section 4.1.2 states that the plant drainage system (including catch basins, floor drains, and associated piping) was conservatively assumed not to be functioning during the modeled LIP event.

The licensee used FLO-2D to simulate the generation and flow of runoff from the one-hour PMP event, represented by applying the rainfall over the model grid at one-minute increments, as indicated in Table 3.2-2. Figures 3.2-1 and 3.2-2 illustrate the results of one model run for Scenario A. Figure 3.2-2 shows the locations of POIs. The licensee did not provide similar figures for Scenario B in its FHRR.

The licensee's initial approach for modeling of runoff from rainfall on building roofs was based on modeling assumptions that included treating roof drains as blocked, assuming no roof storage of rain, and routing all rainfall incidents on a roof to computational cells immediately outside the building perimeter. In its letter dated February 26, 2014 (Kiley, 2014b), the licensee reported that it had found that the FLO-2D model treated building grid elements as having the same elevation as the adjacent ground, which could lead to erroneous results, and that it would revise its approach to modeling roof rainfall as part of its Integrated Assessment. Subsequently, this issue was ultimately resolved by the licensee as a supplemental submission to the hazard report in April 2014, as described below.

By letter dated April 25, 2014 (Kiley, 2014c), the licensee revised its response to report that new analyses resulted in changes to the elevations for both Scenario A and B, with Scenario B having a higher peak LIP flood elevation than previously reported. Additional documentation was included in calculation packages in the licensee's electronic reading room, and in FLO-2D input and output files submitted on the docket. Instead of using FLO-2D's protocol for handling rainfall incident on buildings, the licensee's revised modeling treated building roofs as part of the modeled region and explicitly includes roof elevations and slopes in the topographic data input to the model. Ground elevations near the POIs are adjusted to match actual measured ground elevations at the POIs. The CCW areas, Condenser Pits, and some interior building structures are explicitly represented in the model input. The "Levee" feature of the FLO-2D software is used to represent flood barriers on the site and parapets at the edges of some of the building roofs. Manning's roughness coefficient *n* for the reactor block area was conservatively set at 0.05.

For LIP Scenario A, the licensee reported maximum flood water depths and elevations at 33 POIs; the greatest depth of water (above ground surface) at a POI location is reported as 1.7 ft

(0.5 m), corresponding to elevation 17.2 ft (5.2 m), for a POI in the CCW3 Area. For LIP Scenario B in CCW3, the licensee's letter indicates a peak water depth of 5.0 ft (1.5 m); for CCW4 the peak water depth was 1.3 ft (0.4 m). The corresponding water surface elevation for CCW3 was reported as 20.8 ft (6.3 m). The licensee stated that the revised peak water level in CCW3 exceeded the peak levels previously reported for LIP Scenario B and "was found to challenge SSCs" in that area. The licensee stated that it would implement interim actions to block runoff into the CCW areas before the hurricane season and that it had entered the revised flooding results for the CCW area and the need for interim actions into its corrective action program.

The staff reviewed details of the licensee's FLO-2D model implementation and determined that the approaches and assumptions were conservative. The model output files reviewed by NRC staff did not report any errors related to model stability or mass balance. Additionally, staff performed confirmatory analysis using FLO-2D with one of the licensee's input data sets and confirmed the licensee's results.

The staff identifies the peak water surface elevation of 20.8 ft (6.3 m) determined for CCW3 Area for LIP Scenario B as the reevaluated flood hazard elevation for LIP during periods when hurricane preparedness measures are in place. For other time periods (LIP Scenario A), the staff identifies the peak water surface elevation of 17.2 ft (5.2 m) as the reevaluated flood hazard elevation.

The licensee stated that it plans to use FLO-2D in support of its integrated assessment, to evaluate how various combinations of potential facility modifications and flooding response measures would change the elevation, duration, and velocity of LIP flooding under both Scenario A and Scenario B. The staff will review the basis for the licensee's conclusions regarding facility modifications proposed in the integrated assessment as part of the staff review of the integrated assessment. The staff's assessment documented here is based on staff review of the licensee's evaluation of site flooding under the current facility configuration as described in its FHRR and associated supplemental licensee submittals.

The RAIs issued by the NRC staff dated January 15, 2014 (NRC, 2014b), included several requests for clarification of statements made in the FHRR regarding the locations of safety-related SSCs and the potential impacts of flooding on these safety-related SSCs. In its response dated January 31, 2014 (Kiley, 2014a), the licensee clarified that all safety-related SSCs near the Condenser Pits are at or above the top of the Condenser Pit and the Turbine Building at 18.0 ft (5.4 m) on the site datum (elevation 15.7 ft [4.8 m]). The licensee also provided information on the elevations of safety-related SSCs near the CCWs, the locations of three motor control centers near the Auxiliary Building doors, and its analysis of the potential for flood water entering the Auxiliary Building through those doors. In that same letter (Kiley, 2014a), the licensee also explained that the CCW areas were not treated as having blocked drainage under Scenario A because it is expected that water in those areas could drain out the open doorway into the yard area which slopes away from the CCW area. This is in contrast to Scenario B, in which stoplogs would prevent water from leaving the area. Subsequently, by letter dated February 26, 2014 (Kiley, 2014b), the licensee provided detailed information on the locations and local grade elevations of the 33 POIs considered in the FLO-2D modeling. The licensee also stated that the results of its analysis of the potential impacts of flooding will be included in its integrated assessment. The staff will review the basis for the licensee's conclusions regarding these topics as part of the review of the integrated assessment.

The licensee reported in the FHRR that flow velocities predicted by the FLO-2D modeling of LIP Scenario A reached up to approximately 2.6 ft per second (0.8 m/s). The licensee did not report flow velocities from later revisions of its modeling and did not discuss the potential effects from the water velocities predicted by the model. By a letter dated February 26, 2014 (Kiley, 2014b), the licensee stated that neither of the LIP scenarios generates unique debris, sedimentation, groundwater ingress, or waterborne projectiles because runoff would be across impervious surfaces and velocities would be bounded by the velocity of probable maximum storm surge. Staff notes that peak water velocities from LIP could occur on surfaces not exposed to storm surge, and therefore requests that the licensee's integrated assessment consider the potential effects of LIP water velocity on hydrostatic and hydrodynamic loading and erosion, based on model predictions of water velocity and consistent with Section 4 of this staff assessment. This is **Integrated Assessment Open Item 1.**

The licensee performed a calculation to evaluate the potential buildup of water from the Turbine Building Area to the Condenser Pits during LIP Scenarios A and B. The calculation assumed that all precipitation that falls on a 62,000 square-foot (5,760 m^2) area of the Turbine Building runs off into the Condenser Pits, that there is no lag in the delivery of runoff to the Condenser Pits, and that the runoff is distributed equally between the two 16 ft (4.9 m) deep Condenser Pits, which have identical dimensions and have a combined surface area of 7,740 ft^2 (719 m^2). For Scenario B, the licensee also assumed that all outlets from the Condenser Pits were blocked due to the implementation of hurricane readiness procedures. The licensee calculated the maximum water depth in the Condenser Pits for a one-hour LIP event as 14.8 ft (4.5 m), corresponding to a water surface elevation of 14.5 ft (4.4 m). In its January 31, 2014, response to RAIs (Kiley, 2014a), the licensee identified this elevation as the reevaluated bounding flood level for LIP in the Condenser Pits. The licensee stated that this water level would not affect safety-related SSCs. The NRC staff notes that this elevation is below the 15.7 ft (4.8 m) elevation of SSCs near the Condenser Pits. Additionally, the licensee stated that a reevaluation of the pump capacity required to remove water from this area during hurricane preparedness will be included in the integrated assessment.

The licensee presented a single set of flood event duration parameters for LIP (Kiley, 2014b), with no distinction between Scenarios A and B. However, the licensee's discussion of flood duration notes that LIP events related to tropical cyclones and LIP events related to stand-alone storms have different warning/preparation times. Additionally, the enclosed spaces in which water accumulates under Scenario B can be expected to have a longer duration of both inundation and recession than free-draining areas. In response to an RAI, the licensee indicated that for LIP Scenario B in CCW areas; external flooding from hurricane storm surge could add to the volume of water that would need to be managed by adding small amounts of leakage through exterior wall seals and stoplogs. This would increase the duration of elevated water levels for Scenario B (Kiley, 2014b). Additionally, the staff notes that tropical storm rainfall antecedent to a tropical cyclone-related LIP event could increase the volume of water requiring management in an enclosed space, thus adding to the duration of a Scenario B LIP flood event. These observations indicate that different sets of duration parameters need to be considered when addressing the hazards of these two different LIP scenarios. Therefore, the staff determines that the licensee should provide separate estimates of duration parameters for each of the LIP Scenarios (A and B) for consideration in its integrated assessment. This is **Integrated Assessment Open Item 2**.

In addition, based on the staff's reviews of FHRRs to date, the staff has observed that, when using transient rain-fall runoff models, PMP events having longer than 1-hour durations may result in higher LIP flood elevations and longer periods of inundation than the 1-hour event. The NRC staff has also observed that PMP events having relatively short durations may result in limiting warning time and may likewise result in consequential LIP flood elevation (e.g., flood elevations above the openings to plant structures). Therefore, the staff determined that, as part of the integrated assessment report, the licensee should consider a range of rainfall durations associated with the LIP hazard events (e.g., 1-, 6-, 12-, 24-, 48-, and 72-hour PMPs) to determine the controlling scenario(s) for evaluation as part of the integrated assessment (see NRC, 2012c). This should include a sensitivity analysis to identify potentially limiting scenarios with respect to plant response when considering flood height, relevant associated effects, and flood event duration parameters for LIP events. This is **Integrated Assessment Open Item 3**.

The staff confirmed the licensee's conclusion that the reevaluated flood hazard for LIP and associated site drainage is not bounded by the current design-basis flood hazard; therefore, the licensee should include LIP and associated site drainage within the scope of the integrated assessment. The information on flooding from LIP and associated site drainage that is specific to the data needs of the integrated assessment is described in Section 4 of this staff assessment.

3.3 Streams and Rivers

The licensee reported in its FHRR that the reevaluated hazard, including associated effects, for site flooding from streams and rivers does not inundate the plant site. This flood-causing mechanism is not described in the licensee's current design-basis.

The staff reviewed the flooding hazard from streams and rivers, including associated effects, against the relevant regulatory criteria based on present-day methodologies and regulatory guidance below.

The licensee stated in its FHRR (Kiley, 2013) that its reevaluation for flooding in streams and rivers is based primarily on the methodology used for COL applications. The licensee stated that during a precipitation event with the magnitude of the probable maximum precipitation (PMP), the seawater level in Biscayne Bay would control the floodwater level in the canals near the shoreline. The licensee noted that this event would likely be associated with a tropical storm and accompanied by a strong low-pressure system and a storm surge in Biscayne Bay.

The licensee reviewed the Federal Emergency Management Agency (FEMA) Flood Insurance Study, Dade County, Florida and Incorporated Areas (FEMA, 1994), which provides stillwater elevations in Biscayne Bay at the Turkey Point site and near the mouths for the nearby canals for return periods ranging from 10 to 500 years. The highest stillwater elevation given in the FEMA study report is 12.4 ft (3.8 m) National Geodetic Vertical Datum of 1929 (10.8 ft [3.3 m] NAVD88), for the 500-year return period.

The licensee calculated the storage volume provided by the floodplain of the Florida City Canal north of the site to be approximately 1,030 acre-ft (1,270,000 m^3) for every 1 ft (0.3 m) of vertical rise above elevation 5 ft (1.5 m). Given this estimate and the topographic conditions, the licensee stated that there would be no concentration of flood discharge because runoff and canal overflows would spread out laterally in the floodplain and surrounding low terrain. Additionally, the licensee noted that ANSI/ANS 2.8-1992 (ANSI/ANS, 1992) indicates that nuclear power reactor sites located on shorelines only need to consider flooding from the probable maximum hurricane and, due to the controlling nature of coastal water levels along a shoreline, do not also need to consider flooding on adjacent streams or rivers. Accordingly, the licensee did not analyze the impacts of flooding on streams, rivers, and canals.

The staff agrees with the licensee's determination that flooding in streams and rivers will not inundate the site. Accordingly, the staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from streams and rivers is bounded by the current design-basis flood hazard.

3.4 Failure of Dams and Onsite Water Control/Storage Structures

The licensee reported in its FHRR that the reevaluated hazard, including associated effects, for site flooding due to failure of dams and onsite water control/storage structures does not inundate the plant site. This flood-causing mechanism is not described in the licensee's current design-basis.

The staff reviewed the flooding hazard from failure of dams and onsite water control/storage structures, including associated effects, against the relevant regulatory criteria based on present-day methodologies and regulatory guidance below.

The licensee reported in its FHRR that the nearest man-made structure is the Herbert Hoover Dike that surrounds Lake Okeechobee, which is located more than 90 miles northwest of Turkey Point (USGS, 1989). The licensee also reported that there is no direct canal or stream connection between the lake and Turkey Point. In the event of a dike breach, the flood water from the breach has no effect on flooding at Turkey Point. The licensee stated that there are no water storage reservoirs near Turkey Point apart from the cooling water canals, and the reported water level in the canals is significantly lower than the site grade. Therefore, the licensee concluded that there is no flooding impact at Turkey Point from the potential breach of canals.

The staff reviewed publicly available maps and reports, and found that they confirm the licensee's information about dam and dike locations, and the impacts of a failure of the Herbert Hoover Dike. The staff determined that the licensee's reasoning and supporting analysis is appropriate.

The staff agrees that besides the cooling water canals, there are no water storage reservoirs near Turkey Point. Therefore, the staff confirmed the licensee's conclusion that the reevaluated flood hazard for failure of dams and onsite water control/storage structures is bounded by the current design-basis flood hazard.

3.5 Storm Surge

The licensee reported in its FHRR submittal that the reevaluated hazard, including the associated effect of wave runup, for site flooding due to probable maximum storm surge (PMSS) is 19.1 ft (5.8 m). This evaluation was later revised as discussed further below. This flood-causing mechanism is described in the licensee's current design-basis. The current design-basis hazard for site flooding due to storm surge is a still water elevation of 16 ft (4.8 m).

The staff reviewed the flooding hazard from storm surge, including associated effects, against the relevant regulatory criteria based on present-day methodologies and regulatory guidance below.

The licensee selected the design hurricane in accordance with NUREG/CR-7046, NUREG-0800, and JLD-ISG-2012-06. Using the NWS23 methodology (NOAA, 1979) and analyzing a number of storm radii, headings and forward speeds, the licensee determined the critical probable maximum hurricane (PMH) parameters of storm size, pressure, and wind fields for a storm making landfall near Turkey Point (Table 3.5-1). The licensee provided a region-specific hurricane climatology study to support the selection of the radius of maximum wind parameter in FHRR Section 4.4.9.5.

The staff verified that the licensee's meteorological parameters for the reevaluated storm surge analysis were derived in accordance with NRC guidance and reflect the historical record for the site as well as storms occurring since the CLB. Table 3.5-1 shows the licensee's meteorological parameters for the severe storms (Category 4 to Category 5) that were analyzed.

The licensee performed storm surge analyses using the Delft3D software package. The licensee performed wave transformation using Simulating WAves Nearshore (SWAN), a spectral wave model that evaluates the refracted wave height and wave angle based on a spectrum of waves using linear wave theory. The main inputs to SWAN include the water depth, the wave spectra, and the friction factor. The licensee stated in its FHRR (Kiley, 2013), that the output from the SWAN model includes significant wave height, wave period, wave dissipation, and wave direction at each point within the computational grid (Deltares, 2009).

The licensee created the physical features of the numerical models from regional and local bathymetry and topography and calibrated and validated the model to observed tides and historical Hurricanes Andrew and Donna. The licensee used a triple-nested grid with a coarse regional grid consisting of squares of 6.2 miles by 6.2 miles (10 km by 10 km), a medium-fine grid consisting of 1,706-ft by 1,706-ft (520-m by 520-m) squares, and a fine grid consisting of 492-ft by 492-ft (150-m by 150-m) squares.

The antecedent water level conditions including 10-percent exceedance high tide (1.41 ft (0.43 m)) and potential sea level rise (0.39 ft (0.12 m)) are included in the numerical model with an estimated sea level rise for the remaining 20-year licensed life of Turkey Point.

The licensee followed the guidance provided in ANSI/ANS-2.8-1992 (ANSI/ANS, 1992) for the wave runup evaluations based on methodologies and equations from the U.S. Army Corps of Engineers) (USACE) (USACE, 1984). The licensee evaluated different wave approach directions but noted that the critical direction is east to west, perpendicular to the coast and Turkey Point. The licensee concluded that waves with heights greater than one foot will break at the breakwater. The licensee's PMSS still water level is 17.3 ft (5.3 m) and includes the effects of 10-percent exceedance high tide, probable maximum surge, wave setup, and sea level rise. The licensee calculated wave runup of 1.8 ft (0.55 m) for a vertical wall condition using equations from the USACE (USACE, 1984). The maximum water level calculated by the license by combining the PMSS and coincident windwave runup is 19.1 ft (5.8 m). Table 3.5-1 summarizes the licensee results of the storm surge evaluation at Turkey Point.

The FHRR (Kiley, 2013) only evaluated the wave runup for the east side of the powerblock. However, the licensee later updated this submittal by letter dated August 7, 2014 (Kiley, 2014e) and addressed wave runup around the entire powerblock.

The existing eastern powerblock barrier is flood protected to 19.7 ft (6.0 m). The licensee determined that the reevaluated PMSS (storm surge stillwater level, wave runup and sea level rise) at the existing eastern powerblock flood barriers is 19.1 ft (5.8 m), which the licensee stated provides a margin of 0.6 ft (0.18 m).

The existing northern, southern and western powerblock barriers are flood protected to a storm surge stillwater level of 17.7 ft (5.4 m). By letter dated August 7, 2014 (Kiley, 2014e), for each of these barriers, the licensee provided a specific margin for a reevaluated PMSS. The staff calculated the associated reevaluated PMSS for each of these barriers (north, south, and west walls). On the northern flood protection barrier, the reevaluated PMSS reaches elevation 18.0 ft (5.49 m), which exceeds the barrier by 0.3 ft (0.09 m). The reevaluated PMSS on the west and south flood protection walls reach elevation 17.4 ft (5.3 m) and 17.9 ft (5.46 m), respectively, which gives associated margins of 0.3 ft (0.09 m) and exceeds the barrier by 0.2 ft (0.06 m). These values are summarized in Table 3.5-2.

The staff verified the reevaluated licensee Delft3D PMSS stillwater level. Based on NUREG/CR-7046 and RG 1.59 (1977 Revision), the licensee used site-specific antecedent water levels and wave effects (e.g., wave runup) to calculate the reevaluated PMSS of 19.1 ft (5.8 m). The current standard practice is to run storm surge simulations with the antecedent water conditions to take into account non-linear effects. This was performed in the licensee reevaluated Delft3D storm simulations.

The staff assessed the licensee's results by using a hurricane modeling system that combines various wind models, the WAM offshore and STWAVE nearshore wave models, and the ADCIRC circulation model (Luettich et al., 1992, Westerink et al., 1994, Luettich and Westerink 2004). In parallel with the initial ADCIRC runs, the large-domain, discrete, time-dependent spectral wave model WAM (Komen et al., 1994) is run to calculate directional wave spectra that serves as boundary conditions for the local-domain, near-coast wave model STWAVE (Smith et al., 2001 and Smith, 2007.

The staff's sea level rise (1 ft [0.30 m]), initial rise (0.9 ft [0.27 m]) and the 10-percent exceedance high tide (1.7 ft [0.52 m]) are combined to the ADCIRC antecedent stillwater level calculations which include wind wave and wave setup (STWAVE/WAM). No adjustment was made equal to the difference between the 10-percent exceedance high tide and mean tide level, thus adding additional conservatism.

The staff's ADCIRC simulations are adjusted for Turkey Point site specific storm surge characteristics in accordance with NRC guidance (RG 1.59 and NUREG-0800). The staff's independent calculations are consistent with the licensee's FHRR results. Table 3.5-1 summarizes the licensee and staff's meteorological parameters and storm surge results.

As part of its analysis, the licensee also provided information regarding associated effects such as: (1) increased hydrostatic and hydrodynamic loading, (2) waterborne projectiles and debris loading, and (3) other non-flood related mechanisms, such as currents and marine fouling. The NRC staff is not providing an assessment of these analyses in this staff assessment.

The staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from storm surge is not bounded by the current design-basis flood hazard; therefore, the licensee should include flooding from storm surge within the scope of the integrated assessment. The information on flooding from storm surge that is specific to the data needs of the integrated assessment is described in Section 4 of this staff assessment.

3.6 Seiche

The licensee reported in its FHRR that the reevaluated hazard, including associated effects, for site flooding due to seiche does not inundate the plant site. This flood-causing mechanism is not described in the licensee's current design-basis.

The staff reviewed the flooding hazard from seiche, including associated effects, against the relevant regulatory criteria based on present-day methodologies and regulatory guidance below.

Turkey Point is located adjacent to the west shore of Biscayne Bay and the licensee reported that there are no records of seismic seiches within the bay. However, because the bay is a semi-enclosed body of water, seiche oscillation may occur due to atmospheric forcing. The licensee stated that it is likely that such oscillations would occur along the principal axis of the bay in the north-south direction with a natural period of oscillation estimated to be approximately 36.8 minutes.

The licensee stated that because storm surges during a PMH event would overtop offshore keys and other barrier islands, seiche oscillations within the bay would not be expected to coincide with large storm surge events like the PMSS. In addition, the licensee noted that the natural period of oscillation is much greater than the period of wind-waves and shorter than the period of storm surge waves. The licensee also considered other contributions to seiche, such as sea breeze or seismic or atmospheric forcing but concluded that these phenomena would not produce resonance responses in Biscayne Bay. Therefore, the licensee concluded that natural oscillations within the bay do not result in a resonance, and flooding of the plant area due to a seiche event in Biscayne Bay is precluded.

The staff agrees with the licensee and notes that due to the low elevation of offshore keys and barrier islands the features would no longer function as a physical boundary that could contribute to a within-bay seiche, making it unlikely that such a seiche could add to the elevation of the PMSS from the PMH.

The staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from seiche alone does not inundate the plant site. However, because flooding from seiche is not included within the design-basis, the licensee stated that it will be addressed in the integrated assessment. Information on flooding from seiche that is specific to the data needs of the integrated assessment is described in section 4 of this staff assessment.

3.7 Tsunami

The licensee reported in its FHRR that the reevaluated hazard, including associated effects, for site flooding due to tsunami is 14.8 ft (4.5 m) with coincident wind-wave runup. This flood-causing mechanism is not described in the licensee's current design-basis.

The staff reviewed the flooding hazard from tsunami, including associated effects, against the relevant regulatory criteria based on present-day methodologies and regulatory guidance below.

The licensee obtained records of historical tsunami runup events along the U.S. Atlantic coast from the National Geophysical Data Center (NGDC) tsunami database (NGDC, 2008) and the catalog by Lockridge et al., (2002) for the Delaware-New York coast. For paleotsunami events, the licensee indicated that an extensive literature search and review of borehole logs from the site revealed no evidence for paleotsunami deposits. The licensee used the Atlantic and Gulf of Mexico Tsunami Hazards Assessment Group (AGMTHAG) to evaluate potential tsunamigenic source mechanisms (AGMTHAG, 2008). The licensee stated that the major tsunamigenic sources that may affect the southeastern U.S. coasts include submarine landslides and earthquakes. The licensee identified transoceanic tsunamis as a result of earthquakes in the Azores-Gibraltar (east Atlantic) plate boundary and tsunamis generated in the northeastern

Caribbean region as the primary candidates of the probable maximum tsunami (PMT) generation that could affect Turkey Point.

The licensee simulated tsunami propagation and the effects of near shore bathymetric variation at the Florida Atlantic coast in a two-dimensional computer model. For most cases, the licensee used the Delft3D-FLOW computer program (Deltares, 2009), including the critical case tsunami from the Azores-Gibraltar Boundary source, but used the Boussinesq wave model FUNWAVE-TVD for the Florida Escarpment and Cape Fear tsunami sources.

The licensee obtained a maximum tsunami water level at Turkey Point of 12.1 ft (3.7 m) for the postulated PMT generated by earthquake in the Azores-Gibraltar fracture zone. The reported coincident wind wave runup is 2.7 ft (0.82 m). This wind wave runup is added by the licensee to the tsunami maximum water level of 12.1 ft (3.7 m) with adjusted antecedent water level resulting in a maximum water level of 14.8 ft (4.5 m). This result indicates that the site is not inundated by tsunami hazards. However, the licensee stated that because the CLB does not address tsunamis, this hazard will be addressed in the integrated assessment.

Detailed numerical modeling of likely PMT sources has been performed by the staff to determine their impact on the Turkey Point site. The staff used the Boussinesq-based numerical model COULWAVE (Lynett and Liu, 2002) for three different types of tsunami sources. The sources include a near field landslide source immediately offshore of Biscayne Bay (the Florida Straits source), a number of far field landslide sources with extremely large local waves (the Canary Islands source, the Mid-Atlantic source, and the Puerto Rico Trench source), and a far field earthquake source (the Puerto Rico Subduction Zone source). For all conditions, the most conservative source parameters were employed, even when arguably unphysical, to provide an absolute upper limit on the possible tsunami effects at the Turkey Point site. The staff's independent calculation is consistent with the licensee's FHRR.

The staff confirmed the licensee's conclusion that the reevaluated tsunami hazard does not inundate the plant site. However, because the hazard from tsunami is not included within the design-basis, it will be addressed in the integrated assessment. Information on flooding from tsunami that is specific to the data needs of the Integrated Assessment is described in Section 4 of this staff assessment.

3.8 Ice-Induced Flooding

The licensee reported in its FHRR that the reevaluated hazard, including associated effects, for ice-induced flooding of the site does not inundate the plant site. This flood-causing mechanism is not described in the licensee's current design-basis.

The staff reviewed the flooding hazard from ice-induced flooding, including associated effects, against the relevant regulatory criteria based on present-day methodologies and regulatory guidance below.

The licensee evaluated historical meteorological data obtained from the U.S. Geological Survey (USGS), NOAA, and USACE and determined that the climate near Turkey Point is subtropical marine with occasional freezing temperatures recorded at Miami International Airport Weather Station (Kiley, 2013).

The licensee also analyzed water temperature data obtained from USGS and determined that the minimum water temperature was 54.0° F (12.2° C) recorded on April 3, 1959, at USGS Station

No. 02290610 approximately 20 miles (32 km) northwest of Turkey Point. Based on the air and water temperatures, the licensee precluded the possibility of frazil or anchor ice, ice sheet, and wind-driven ice ridges. The licensee also noted that the USACE Ice Jam Database has no record of an ice jam incident in the area of Turkey Point.

The staff independently verified the results of the licensee's evaluation of the ice hazard. The staff's analysis of historical temperature data in the vicinity of Turkey Point and a search of the USACE Ice Jam Database indicate that ice-induced flooding is not a credible mechanism that results in a flooding hazard at the Turkey Point site.

Because sub-freezing air temperatures have never been sustained for a full day and water temperatures have consistently been well above the freezing point near Turkey Point, the staff concluded that ice formation near the Turkey Point site is an unlikely event.

The staff confirmed the licensee's conclusion that the flood hazard from ice-induced flooding alone would not inundate the site. The staff confirmed the licensee's conclusion that the reevaluated hazard for ice-induced flooding of the site is bounded by the current design-basis flood hazard.

3.9 Channel Migrations or Diversions

The licensee reported in its FHRR that the reevaluated hazard, including associated effects, for site flooding due to channel migrations or diversions does not inundate the plant site. This flood-causing mechanism is not described in the licensee's current design-basis.

The staff reviewed the flooding hazard from channel migrations or diversions, including associated effects, against the relevant regulatory criteria based on present-day methodologies and regulatory guidance below.

Based on seismic, geological, topographical, thermal, and hydrological evidence in the site region, the licensee concluded that the hazard, including associated effects, for site flooding due to channel migrations or diversions will not affect the Turkey Point site.

The licensee indicated that historical evidence suggests that hurricanes, tropical storms, northeasters, and tidal wave actions were the primary causes of shoreline changes, such as erosion of sandy beaches and barrier islands along the Florida coasts (Kiley, 2013). The FHRR also states that the shoreline protection structures amplify shoreline fluctuations by altering the natural long shore sediment transport pattern; however, any changes in shoreline migration are gradual in nature.

Based on a review of the licensee's information in the FHRR, the staff determined that the licensee appropriately considered channel-diverting phenomena and their combinations that are relevant for Turkey Point. The staff concluded that there is no potential for stream channel diversion to affect the Turkey Point site due to the absence of natural streams and the minimal topographic relief in the surrounding landscape.

The staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from channel migrations or diversions is bounded by the current design-basis flood hazard.

4.0 INTEGRATED ASSESSMENT AND ASSOCIATED HAZARD DATA

The staff confirmed that the reevaluated hazard results for multiple mechanisms are not bounded by the current design-basis flood hazard. Therefore, the staff concludes that an integrated assessment is necessary. LIP and storm surge exceed the design-basis, result in floods that exceed site grade, and inundate the site, and thus should be evaluated under the integrated assessment. The reevaluated tsunami and seiche hazards are not included within the design-basis and the licensee stated they would be evaluated under the integrated assessment. However, staff agrees with the licensee's conclusion that tsunami and seiche do not inundate the plant site and the resulting integrated assessment for those mechanisms is expected to be relatively limited in scope. Section 5 of JLD-ISG-2012-05 describes the flood hazard parameters needed to complete an integrated assessment. The staff reviewed the following subset of these flood hazard parameters to conclude that the flood hazard information is appropriate input to the integrated assessment:

- Flood event duration (see Figure 2.2.4-1 and Table 4.0-1), including warning time and intermediate water surface elevations that trigger actions by plant personnel, as defined in JLD-ISG-2012-05.
- Flood height and associated effects, as defined in JLD-ISG-2012-05 (see Tables 4.0-2, 4.0-3, 4.0-4).

The staff requested that the licensee provide a basis for the flood event duration parameters via an RAI (NRC, 2014b). In its response (Kiley, 2014b), the licensee summarized the flood duration parameters for PMSS, LIP and PMT as shown in Table 4.0-1. The staff notes that the bases and justification for flood duration parameters (e.g., warning time based on existing forecasting resources or agreements) may be further evaluated as part of the integrated assessment. In addition, the NRC staff identified Integrated Assessment Open Items in Section 3.2 that are related to or may affect flood event duration parameters.

The staff requested that the licensee provide the flood height and associated effects (as defined in Section 9 of JLD-ISG-2012-05) that are not described in the FHRR for mechanisms that trigger an integrated assessment via an RAI (NRC, 2014b). In addition, the staff identified Integrated Assessment Open Items in Section 3.2 that are related to or may affect associated effects. The licensee's response (Kiley, 2014b) summarizes the relevant values for each associated effect which are shown in Tables 4.0-2 and 4.0-3. Table 4.0-4 provides soil/sediment horizontal and vertical pressure associated with the PMSS.

Based upon the preceding analysis, the NRC staff confirmed that the reevaluated flood hazard information defined in the sections above, with the exception of identified Integrated Assessment Open Items, is appropriate input to the integrated assessment. Table 5.0-1 summarizes all Integrated Assessment Open Items.

As described in the 50.54(f) letter, the licensee must submit an integrated assessment. The staff notes that Integrated Assessment Open Items, as well as the basis for flood event duration parameters, will be further evaluated as part of the integrated assessment.

5.0 CONCLUSION

The NRC staff has reviewed the information provided for the reevaluated flood-causing mechanisms of Turkey Point. Based on its review, the staff concludes that the licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance used by the NRC staff in connection with ESP and COL reviews.

Based upon the preceding analysis, the NRC staff confirmed that the licensee responded appropriately to Enclosure 2, Required Response 2, of the 50.54(f) letter, dated March 12, 2012. In reaching this determination, staff confirmed the licensee's conclusions that (a) the reevaluated flood hazard results for LIP, storm surge, seiche, and tsunami are not bounded by the current design basis flood hazard; (b) an integrated assessment including LIP, storm surge, seiche, and tsunami is expected to be submitted by the licensee, and (c) the reevaluated flood-causing mechanism information is appropriate input to the integrated assessment.

The NRC staff identified three Integrated Assessment Open Items related to flow velocity and duration for LIP events. The Integrated Assessment Open Items are summarized in Table 5.0-1. Therefore, the NRC is not providing finality on the flood parameters related to LIP and associated flow velocity and flood event duration as part of this staff assessment.

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Table 2.2.1-1 Flood-Causing Mechanisms and Corresponding Guidance

Flood-Causing Mechanism	SRP Section(s) and JLD-ISG
Local Intense Precipitation and Associated Drainage	SRP 2.4.2 SRP 2.4.3
Streams and Rivers	SRP 2.4.2 SRP 2.4.3
Failure of Dams and Onsite Water Control/Storage Structures	SRP 2.4.4 JLD-ISG-2013-01
Storm Surge	SRP 2.4.5 JLD-ISG-2012-06
Seiche	SRP 2.4.5 JLD-ISG-2012-06
Tsunami	SRP 2.4.6 JLD-ISG-2012-06
Ice-Induced	SRP 2.4.7
Channel Migrations or Diversions	SRP 2.4.9

1. SRP is the Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition (NRC, 2007)
2. JLD-ISG-2012-06 is the "Guidance for Performing a Tsunami, Surge, or Seiche Hazard Assessment" (NRC, 2013a)
3. JLD-ISFG-2013-01 is the "Guidance for Assessment of Flooding Hazards Due to Dam Failure" (NRC, 2013b)

4.

Table 3.0-1 Summary of Controlling Flood-Causing Mechanisms

Reevaluated Flood-Causing Mechanisms and Associated Effects that May Exceed the Powerblock Elevation[1]	Elevation ft (m) NAVD88
Local Intense Precipitation and Associated Drainage Scenario A During normal operations, without hurricane preparedness measures	17.2 (5.2) in CCW3
Scenario B During hurricane preparedness periods	14.5 (4.4) in Condenser Pits 20.8 (6.3) in CCW3
Storm Surge	19.1 (5.8)

1. Flood Height and Associated Effects as defined in JLD-ISG-2012-05.

Table 3.1.2-1 Current Design-Basis Flood Hazard

Flooding Mechanism	Stillwater Elevation ft (m) NAVD88	Associated Effects ft (m)	Current Design-Basis (CDB) Flood Elevation ft (m) NAVD88	Reference
Local Intense Precipitation and Associated Drainage	Not Discussed in CDB	Not Discussed in CDB	None Specified	FHRR section 3.1
Streams and Rivers	Not Analyzed (not applicable)	Not Discussed in CDB	None Specified	FHRR section 3.2
Failure of Dams and Onsite Water Control/Storage Structures	Not Analyzed (not applicable)	Not Discussed in CDB	None Specified	FHRR section 3.3
Storm Surge	16.0 (4.8)	Note (1)	Note (1)	FHRR sections 3.4 and 3.9
Seiche	Not Discussed in CDB	Not Discussed in CDB	Not Discussed in CDB	FHRR section 3.5
Tsunami	Not Discussed in CDB	Not Discussed in CDB	Not Discussed in CDB	FHRR section 3.6
Ice-Induced	Not applicable due to climate	Not applicable	Not applicable	FHRR section 3.7
Channel Migrations or Diversions	Not Discussed in CDB	Not Discussed in CDB	Not Discussed in CDB	FHRR section 3.8

1. The licensee's walkdown report (Kiley, 2012a) identifies 18.3 ft (5.6 m) MLW (16 ft (4.8 m) NAVD88) as the design-basis. The description of licensing basis protection describes model and analysis on which the flood protection is based. In conjunction with the discussion of licensing basis flood protection, the licensee stated: "Elevation 20 ft [6.1 m; MLW] and 22 ft [6.7 m; MLW] is required to provide protection for maximum wave run-up. The licensing and design-basis documents do not indicate an exact elevation to which waves are expected to reach. These documents imply that the maximum wave run-up is less than the elevation of protection provided." However, it is noted that the FHRR (Kiley, 2013) states: "The CLB determined that PMH-induced waves could induce 2.7 foot runup on vertical structures when the PMSS water level is at Elevation 16.0 ft [4.8 m]-NAVD88."

Table 3.2-1 LIP Values for durations less than 1 hour, as reported in FHRR

Duration	Ratio to 1-hour LIP (from HMR-52)	Calculated LIP
5 minutes	0.32	19.4 x 0.32 = 6.21 in. (158 mm)
15 minutes	0.50	19.4 x 0.50 = 9.70 in. (246 mm)
30 minutes	0.73	19.4 x 0.73 = 14.16 in. (360 mm)

Table 3.2-2 Time distribution of 1-hour PMP event assumed in FHRR analyses of LIP effects

Duration (minutes)	Total Time (minutes)	Intensity in/h (cm/h)	PPT Total in (cm)	Cumulative PPT in (cm)
15	15	0.175 (0.445)	2.625 (6.668)	2.625 (6.668)
10	25	0.297 (0.754)	2.970 (7.544)	5.595 (14.211)
5	30	0.349 (0.886)	1.745 (4.432)	7.340 (18.644)
5	35	1.242 (3.155)	6.210 (15.773)	13.550 (34.417)
5	40	0.349 (0.866)	1.745 (4.432)	15.295 (38.849)
5	45	0.297 (0.754)	1.485 (3.772)	16.780 (42.621)
15	60	0.175 (0.445)	2.625 (6.668)	19.405 (49.289)

Table 3.5-1 Meteorological and Storm Surge Parameters Summary for Turkey Point Operating (Units 3 and 4)

Parameter	DB (Units 3 & 4)	Reevaluation Delft3D (Units 3 & 4)	Staff Review
Peripheral Pressure	----	1020 mb (30.12 in. Hg)	1020 mb (30.12 in. Hg)
Central Pressure	----	884 mb (26.1 in. of Hg)	880 mb (26 in. of Hg)
Central Pressure Deficit	----	136 mb (4 in. Hg)	131 mb (4 in. Hg)
Radius of Maximum Winds	----	20 nm (1)	30 nm
Forward Speed	----	6.9 mph (11 kph)	13 mph (21 kph)
Maximum Wind Speed	----	157 mph (253 kph) (Category 5)	140 mph (225 kph) (Category 4)
10% Astronomical High Tide (from Tide Gauges)	----	1.41 ft (0.43 m) NAVD88	----
10% Astronomical High Tide (from RG 1.59)	----	----	1.7 ft (0.52 m) NAVD88
Initial Rise (from RG 1.59)	----	----	0.9 ft (0.27 m)
Sea Level Rise (SLR)	----	0.4 ft (0.12 m) (20 years)	1 ft (0.30 m) (Per Century)
Antecedent Water Level = SLR + 10% Astronomical High Tide + Initial Rise	----	1.8 ft (0.55 m) NAVD88	3.6 ft (1.1 m) NAVD88
Model Uncertainty	----	----	----
PMSS Stillwater Level	16 ft (4.9 m) NAVD88	17.3 ft (5.3 m) NAVD88	18.1 ft (5.5 m) NAVD88
Wave Runup	See Note (1) Table 3.1.2-1	1.8 ft (0.55 m)	Note 3
PMSS + Wave Runup	18.7 ft (5.7 m) NAVD88(2)	19.1 ft (5.8 m) NAVD88	Note 3

1. The licensee analysis for radius of maximum wind considered values of 4, 12, 20, 25, 30, 40 and 100 nautical miles. 20 nautical miles is the upper end of the range in NWS-23.
2. Based on wave runup of 2.7 ft (0.82 m).
3. Wave runup was not calculated for units 3 and 4 for this scenario. This scenario is staff's independent confirmatory analysis of Stillwater level only. Differences between licensee's reevaluation results and staff results are due to differences in modeling assumptions and methodology.

Table 3.5-2 Barrier Specific Summary of Parameters for Reevaluated PMSS (Kiley, 2014e)

Parameter (Elevation NAVD88)	**East Wall ft (m)**	**West Wall ft (m)**	**North Wall ft (m)**	**South Wall ft (m)**
10% Probability of Exceedance High Tide (HT)	1.4 (0.43)	1.4 (0.43)	1.4 (0.43)	1.4 (0.43)
Sea Level Rise (SLR) (20-yr)	0.39 (0.12)	0.39 (0.12)	0.39 (0.12)	0.39 (0.12)
Wave Runup	1.8 (0.55)	0.1 (0.03)	0.7 (0.21)	0.6 (0.18)
Still Water Level(1)	17.3 (5.3)	17.3 (5.3)	17.3 (5.3)	17.3 (5.3)
PMSS(2)	19.1 (5.8)	17.4 (5.3)	18.0 (5.49)	17.9 (5.46)
Flood Protection	19.7 (6.0)	17.7 (5.4)	17.7 (5.4)	17.7 (5.4)
Margin described by licensee w/ SLR	0.6 (0.18)	0.3 (0.09)	Exceeded by 0.3 (0.09)	Exceeded by 0.2 (0.06)

1. Includes 10 percent HT and SLR
2. Includes wave runup

Table 4.0-1: Flood Event Duration for Flood-Causing Mechanisms to be Examined in the Integrated Assessment

Flood-Causing Mechanism	Time Available for Preparation for Flood Event	Duration of Inundation of Site	Time for Water to Recede from Site
Elevated Winds	72 hours	73 hours	
PMSS	48 hours	2 hours[(1)]	3 hours [(2)]
LIP (Scen. A)	These values will be provided as part of Integrated Assessment Open Item 2		
LIP (Scen. B)[(3)]	48 hours	0.5 hour	0.75 hour
PMT	2 hours	Not Applicable	Not Applicable

1. Stillwater value shown. Add 1 additional hour to include wave runup.
2. Stillwater values shown. Add 2 additional hours to include wave runup.
3. LIP coincident with PMSS; values may change based on Integrated Assessment Open Item results

Table 4.0-2 Reevaluated Flood Hazard for Flood-Causing Mechanisms to be Examined in the Integrated Assessment

Flood-Causing Mechanism	Stillwater Elevation ft (m) NAVD88	Associated Effects ft (m) (wave runup)	Reevaluated Flood Hazard ft (m) NAVD88	Reference
Local Intense Precipitation	Scenario A 17.2 (5.2) Scenario B 20.8 (6.3)	Not Applicable	17.2 (5.2) 20.8 (6.3)	Kiley, 2014c
Storm Surge	17.3 (5.3), including tides	1.8 (0.55)	19.1 (5.8)	FHRR Section 3.5
Seiche	Note 1	Note 1	Note 1	FHRR Section 3.6
Tsunami	12.1 (3.68) including tides	2.7 (0.82)	14.8 (4.51)	FHRR Section 3.7

Note 1 - The reevaluated seiche hazard is not included within the design basis and the licensee stated it would be evaluated under the integrated assessment. However, staff agrees with the licensee's conclusion that seiche does not inundate the plant site and the resulting integrated assessment of this mechanism is expected to be relatively limited in scope.

Table 4.0-3 Integrated Assessment Associated Effects Inputs

Associated Effects Factor	Flooding Mechanism				
	PMP/LIP		PMSS	PMT	Seiche
	Scenario A	Scenario B			
Hydrodynamic loading at plant grade	Licensee to consider potential effects of LIP water velocity as part of integrated assessment open item	Licensee to consider potential effects of LIP water velocity as part of integrated assessment open item	Varies with elevation (Figure 3.5-1)	None	None
Debris loading at plant grade	None	None	Up to 20,000 lbs (9,100 kg) (110 lbs/in^2) (758 kPa)	Up to 65,300 lbs (370 lb/in^2)[(1)]	None
Sediment loading at plant grade	None	None	Horizontal: up to 64 psf (3.1 kPa) Vertical: up to 110 psf (5.3 kPa)	None	None
Sediment deposition and erosion	None	None	Scour up to 2 ft (0.61 m); Deposition bounded by PMSS elevation	Deposition bounded by PMT runup elevation	None
Concurrent conditions, including adverse weather	None[(2)]	High winds (Kiley, 2014b RAI 10 response)	High winds (Kiley, 2014b, RAI 10 response)	None	None
Groundwater ingress	None	None	None	None	None
Other pertinent factors (e.g., waterborne projectiles)	None	None	Up to 556,000 lbs (252,000 kg-force) (FHRR, Sect. 4.11)	None	None

1. PMT debris loading acts at maximum water level elevation, 12.1 ft NAVD88, not plant grade.
2. Applies to the time before the event and not during the event.

3.

Table 4.0-4 Soil/Sediment Horizontal and Vertical Pressure

Base elevation of SS ft (m) NAVD88	Depth of Sediment ft (m)	Horizontal Loading psf (kPa)	Vertical Loading psf (kPa)
17.5 (5.3)	0.0	0	0
17.0 (5.2)	0.5 (0.15)	18 (0.86)	31 (1.5)
16.5 (5.0)	1.0 (0.30)	36 (1.7)	61 (2.9)
16.0 (4.9)	1.5 (0.46)	54 (2.6)	92 (4.4)
15.7 (4.8)[1]	1.8 (0.55)	64 (3.1)	110 (5.3)
15.5 (4.7)	2.0 (0.61)	71 (3.4)	122 (5.8)
15.0 (4.6)	2.5 (0.76)	89 (4.3)	153 (7.3)
14.5 (4.4)	3.0 (0.91)	107 (5.1)	183 (8.8)
14.0 (4.3)	3.5 (1.1)	125 (6.0)	214 (10.2)
13.5 (4.1)[2]	4.0 (1.2)	142 (6.8)	244 (11.7)

1. Plant grade elevation
2. Reference ground elevation

Integrated Assessment Open Items: The Integrated Assessment Open Items set forth in the Staff Assessment and summarized in the table below identify certain matters that will be addressed in the integrated assessment submitted by the licensee. These items constitute information requirements but do not form the only acceptable set of information. A licensee may depart from or omit these items, provided that the departure or omission is identified and justified in the integrated assessment. In addition, these items do not relieve a licensee from any requested information described in Part 2, Integrated Assessment, of the March 12, 2012, 10 CFR 50.54(f) letter, Enclosure 2.

Table 5.0-1: Integrated Assessment Open Items

Open Item No.	SA Section No.	Subject to be Addressed
1	3.2	The licensee is requested to consider the potential effects of LIP water velocity on hydrostatic loading and erosion using model predictions of water velocity.
2	3.2	The licensee is requested to provide separate estimates of flood event duration parameters for LIP Scenarios A and B.
3	3.2	The licensee is requested to consider a range of rainfall durations associated with the local intense precipitation flood hazard (e.g., 1-, 6-, 12-, 24-, 48-, 72-hour PMPs) to determine the controlling scenarios for evaluation as part of the integrated assessment. This evaluation should identify potentially limiting scenarios with respect to plant response when considering warning time, flood height, relevant associated effects, and flood-event duration parameters.

Figure 2.2.4-1 - Flood Event Duration

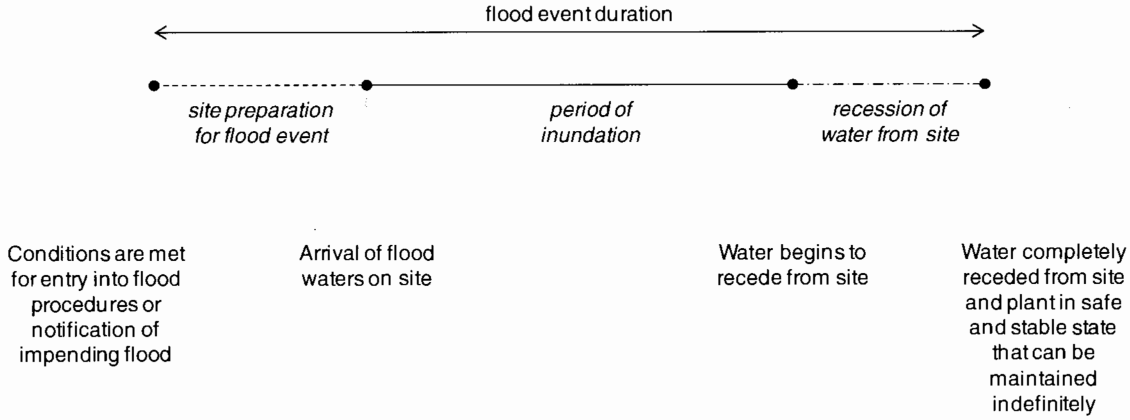


Figure 3.2-1 Example of FLO-2D results, showing maximum water depths predicted in modeling of LIP Scenario A over the entire model domain. (Source: FHRR Figure 4-6)

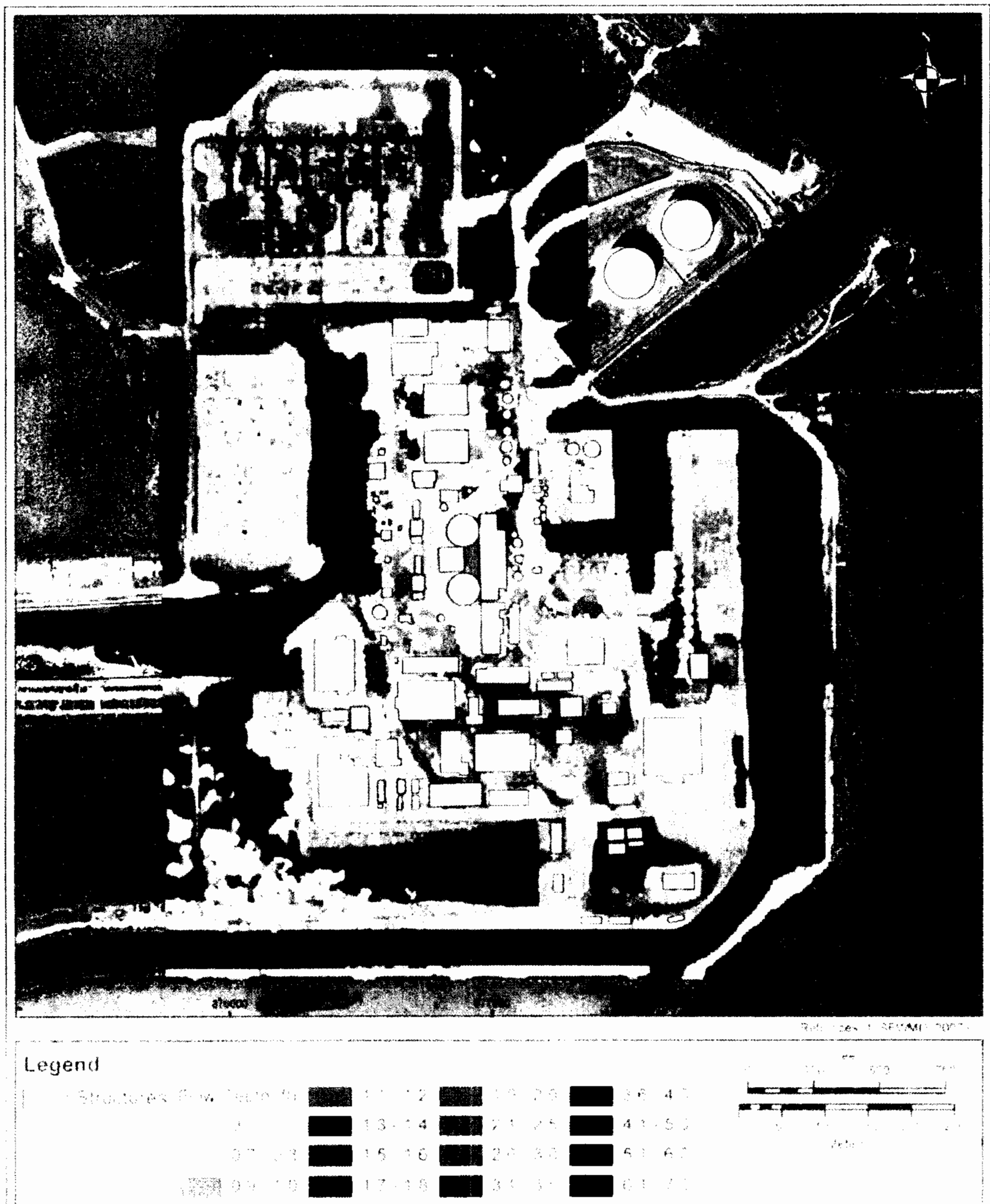
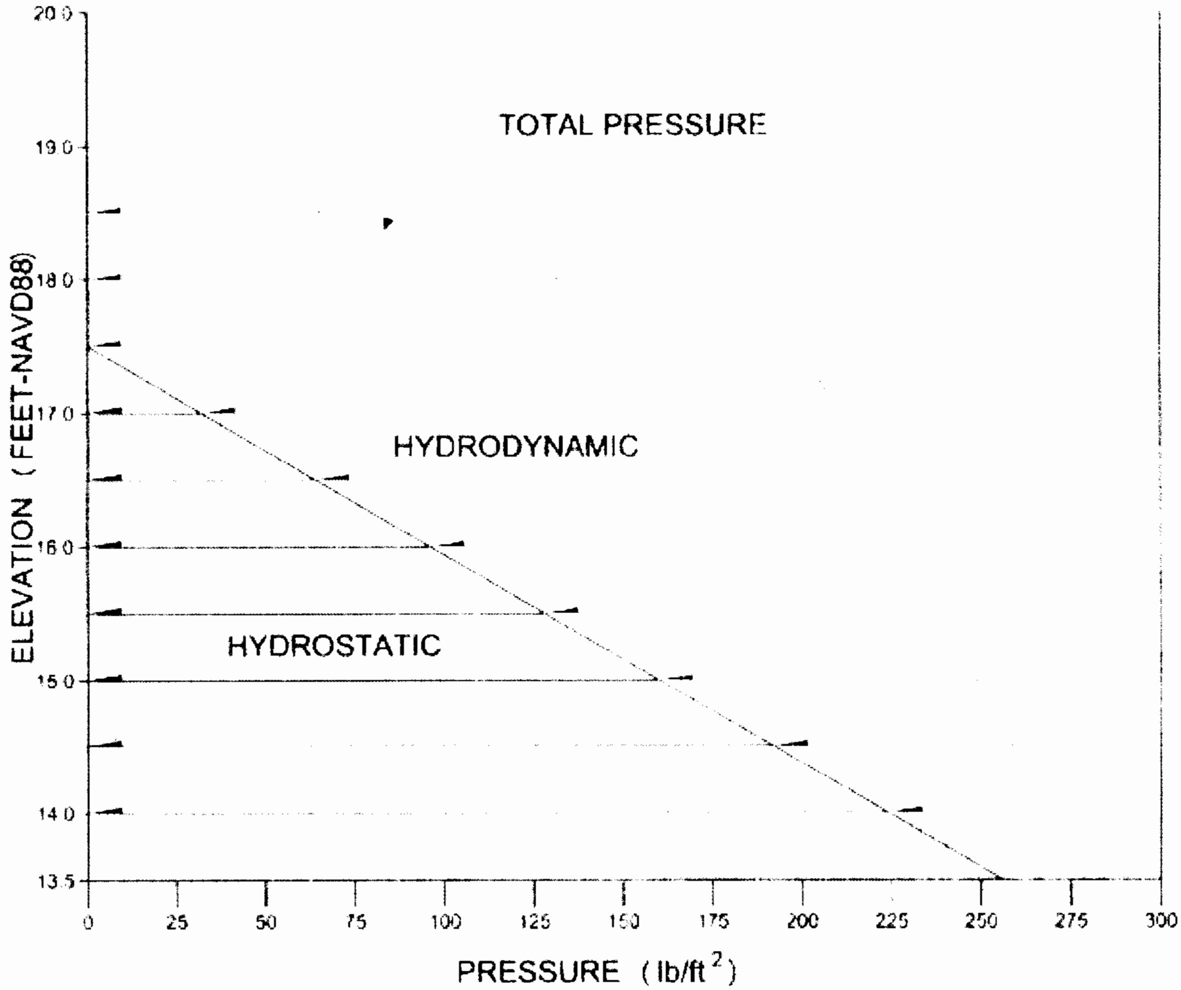


Figure 3.2-2 Locations of numbered points of interest[(1)], with maximum water depths predicted in one FLO-2D model run for LIP Scenario A. (Source: Modified from FHRR Figure 4-7)

1. Points of Interest (POIs) are from Figure 4.8 in the licensee's FHRR submittal (Kiley, 2013a). POIs 17 and 18 are the pits and CCW3 and 4 respectively. Figure 5.1 of (Kiley, 2014a) shows a drawing of the pits and CCW with flo-2d model topography represented.

Figure 3.5-1 Hydrostatic and Hydrodynamic Forces (Source: Modified from FHRR Figure 4-48)



If you have any questions, please contact me at (301) 415-3733 or by email at Robert.Kuntz@nrc.gov.

Sincerely,

/RA/

Robert F. Kuntz, Senior Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos. 50-250 and 50-251

Enclosure:
Staff Assessment of Flood Hazard Reevaluation Report

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