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

April 29, 2015

Mr. Benjamin C. Waldrep, Vice President
Shearon Harris Nuclear Power Plant
5413 Shearon Harris Rd
New Hill, NC 27562-0165

SUBJECT: SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1 – STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST FLOOD CAUSING MECHANISM REEVALUATION (TAC NO. MF1103)

Dear Mr. Waldrep:

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 in Japan. 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 12, 2013, Duke Energy Progress, Inc. responded to this request for Shearon Harris Nuclear Power Plant, Unit 1. This response was supplemented by letters dated March 24, 2014, and April 1, 2015.

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 some reevaluated flood-causing mechanisms were not bounded by your current plant 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) letter.

In addition, the staff has identified one issue that resulted in an open item. This open item is 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) 415-3809 or email at Juan.Uribe@nrc.gov.

Sincerely,

Juan F. Uribe, Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket No. 50-400

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
SHEARON HARRIS NUCLEAR POWER PLANT, UNIT NO. 1
DOCKET NO. 50-400

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 (NRC, 2012a) 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 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 each plant. 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 plant's current design-basis (CDB) 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 described in Enclosure 2 of the 50.54(f) letter. By letter dated March 12, 2013 (Duke, 2013), Duke Energy Progress, Inc. (the licensee, Duke) provided the FHRR for Shearon Harris Nuclear Power Plant (HNP), Unit 1. The licensee did not identify any interim actions. The NRC staff issued an RAI to the licensee (NRC, 2014a). By letter dated March 24, 2014 (Duke, 2014b)the licensee responded to the RAI. The licensee submitted a revised version of the FHRR by letter dated April 1, 2015 (Duke, 2015) in order to rectify a number of administrative errors which required clarification Specifically, the phrases "licensing basis" and "Current Licensing Basis" were used interchangeably with the phrase "design-basis."

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

Because some of 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 of the integrated assessment.

The licensee submitted a separate flooding walkdown report associated with Near-Term Task Force (NTTF) Recommendation 2.3 (Duke, 2012). The staff prepared a separate staff assessment report to document its review of the licensee's flooding walkdown report (NRC, 2014b).

2.0 REGULATORY BACKGROUND

2.1 Applicable Regulatory Requirements

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 (FSARs), 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 FSAR.

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.

General Design Criterion 2 in Appendix A of 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, 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 FSAR. 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 that all power reactor licensees and construction permit holders reevaluate all external flood-causing mechanisms at each site. This includes current techniques, software, and methods used in present-day standard engineering practice.

2.2.1 Flood-Causing Mechanisms

Attachment 1 to Recommendation 2.1, Flooding (Enclosure 2 of the 50.54(f) letter) (NRC, 2012a) discusses flood-causing mechanisms for the licensee to address in its FHRR. Table 2.2-1 lists the flood-causing mechanisms that the licensee should consider. Table 2.2-1 also lists the corresponding Standard Review Plan (SRP) (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 Japan Lessons-Learned (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. The ISG for performing the Integrated Assessment for external flooding, JLD-ISG-2012-05 (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 Effect 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 Attachment 1 of the 50.54(f) letter describes the "Combined Effect Flood" 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[2], 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) 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 example 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 2.2-1 illustrates flood event duration.

2.2.5 Actions Following the FHRR

For the sites where the reevaluated flood hazard is not bounded by the CDB flood hazard for all flood-causing mechanisms, the 50.54(f) (NRC, 2012a) letter requests licensees and construction permit holders to:

- Submit an interim action plan with the FHRR documenting actions planned or already taken to address the reevaluated hazard(s)

- Perform an integrated assessment subsequent to the FHRR to: (a) evaluate the

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

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 CDB 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 has reviewed the information provided for the flood hazard re-evaluation of HNP, Unit 1. 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 are provided below.

To support the summaries and conclusions in the HNP, Unit 1 FHRR (Duke, 2013), the licensee made calculation packages available to the staff via an electronic reading room. When the staff relied directly on any of these calculation packages in its review, they or portions thereof were docketed, and are cited, as appropriate, in the discussion below.

The staff requested additional information from the licensee to supplement the FHRR by letter dated February 10, 2014 (NRC, 2014a). The licensee provided this additional information by letter dated March 24, 2014 (Duke, 2014b), which is discussed in the appropriate sections below. In addition, the licensee submitted a revised version of its FHRR (Revision 1) by letter dated April 1, 2015 (Duke, 2015), in order to clarify the use of the phrases "licensing basis" and "Current Licensing Basis", since they were used interchangeably with the phrase "design basis" in the March 12, 2013, FHRR. The licensee stated that all changes made were to correct administrative errors.

3.1 Site Information

The 50.54(f) letter includes the SSCs important to safety, and the Ultimate Heat Sink (UHS), 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 the HNP, Unit 1 FHRR (Duke, 2013). The 50.54(f) letter (NRC, 2012a), Enclosure 2 (NTTF Recommendation 2.1: Flooding), Requested Information, 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

The HNP, Unit 1 site is located within Wake and Chatham Counties in central North Carolina. The site grade at the power block is elevation 260 ft (79.2 m) NGVD29 (Duke, 2014b). Table 3.0-1 provides the summary of controlling reevaluated flood-causing mechanisms, including associated effects, which the licensee computed to be higher than the powerblock elevation. Associated and nearby water storage impoundments include the Main Reservoir and the Auxiliary Reservoir. These two reservoirs are collectively referred to as Harris Lake and are

owned and operated by Carolina Power and Light Company. The Auxiliary Reservoir is formed by the Auxiliary Dam which impounds the Tom Jack Branch,[3] a tributary of Buckhorn Creek. The Auxiliary Dam has a crest elevation of 260.0 ft (79.25 m).

The Main Reservoir is located adjacent to the HNP, Unit 1 site, and is formed by the Main Dam which is located approximately 4.5 miles (7.2 km) south of the HNP, Unit 1 site. The Main Dam and Reservoir impound Buckhorn Creek. An arm of the Main Reservoir, the Thomas Branch, is adjacent to and east of the HNP, Unit 1 site. The Main Dam has a crest elevation of 260.0 ft (79.25 m). The Main Reservoir provides water to the plant through the Cooling Tower Makeup Water Intake Structure that adjoins the plant. The HNP, Unit 1 site, adjacent reservoirs and associated watersheds are shown in Figure 3.1-1.

3.1.2 Design-Basis Flood Hazards

The CDB[4] flood levels for HNP, Unit 1 are described in Section 2.1 of the HNP, Unit 1 FHRR (Duke, 2013). Subsequently, the licensee submitted a revised FHRR (Duke, 2015) in order to clarify the use of the phrases "licensing basis" and "Current Licensing Basis", since they were used interchangeably with the phrase "design-basis" in the March 12, 2013, FHRR. The CDB flood levels are summarized by flood-causing mechanisms in Table 3.1-1.

3.1.3 Flood Related Changes to the Licensing Basis

The FHRR stated that there have been no flood-related changes or changes to flood-protection measures beyond the flood-protection measures in place for the CDB.

3.1.4 Changes to the Watershed and Local Area

The FHRR stated that the site runoff and flowpaths have changed due to uneven settlement across the site. Additionally, various structures such as temporary and permanent buildings and parking areas have been constructed on site.

The FHRR indicated that there have been no substantial changes to the Main and Auxiliary Dams and their associated watersheds (Duke, 2013). The staff independently inspected recent U.S. Department of Agriculture (USDA), National Agriculture Imagery Program (NAIP) aerial photography[5] (USDA, 2012) and confirmed that the only apparent changes within the watershed and local area were those associated with the plant site itself, and some municipal growth within

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[3] Also known as Tom Jack Creek.

[4] In the March 2013, FHRR, the licensee often used the terms “design basis” and “licensing basis,” or “CLB,” interchangeably. Because many references to CLB were to various elevations that were specific to each flood hazard, the staff assumes in those instances in this document that the licensee intended the term CLB in the FHRR to refer to the current design basis (CDB). The staff will thus use the term “CDB” as appropriate throughout this document. The staff also confirmed that the changes in the revised FHRR were administrative in nature and did not have an inpact on the technical information provided in the March 2013 submittal.

[5] One-meter resolution aerial photography was inspected.

watershed headwaters areas in the vicinity of Apex, North Carolina, a suburb of Raleigh, North Carolina. Lands within the watershed otherwise consist primarily of forest and fields.

3.1.5 Current Licensing Basis Flood Protection and Pertinent Flood Mitigation Features

Section 2.2 of the FHRR provides a description of the CLB (Duke, 2013). The licensee stated that the Auxiliary Separating Dike, with a crest elevation of 255 ft (77.7 m), has the potential to be overtopped as a result of waves generated by either the Probable Maximum Hurricane (PMH) wind action on the normal reservoir level, or the Probable Maximum Flood (PMF) with associated winds. The dike is protected on both the upstream and downstream slopes by riprap.

The site is protected from the Main Reservoir by a 300-ft (91.4-m) wide spoil material embankment. The licensee designed the embankment such that half of the embankment width could erode during the design storm event and still protect the site.

The site is capable of draining away, via overland flow, runoff caused by the probable maximum precipitation (PMP). All safety-related structures that have external entrances at or above elevation 261 ft (79.6 m), with the exception of the Waste Processing Building (WPB), are protected to elevation 262.0 ft (79.86 m) by the use of watertight or airtight doors, or other barriers. The WPB is not protected above 261.1 ft (79.6 m). However, there is no access to safety-related equipment through the WPB entrances.

The PMP storm water, which flows between the retaining wall and the Fuel Handling Building (FHB) is collected into sumps and then pumped out through the storm drainage system. Additionally, this system processes storm water overflow from the WPB and the FHB when drains are assumed to be plugged during the PMP event. In the event that the pumps and sumps are inoperable, the licensee stated that all openings below 236 ft (71.9 m) would be closed and penetrations would be sealed.

The storm water coming from the HNP, Unit 1 Containment Building (CB) and from the cancelled HNP, Unit 2 area of the original site drain to a common sump (Duke, 2013). This sump is designed to accommodate the PMP flood hazard assuming failure of the sump pump. Additionally, the licensee indicated that the HNP, Unit 1 wall heights are adequate to accommodate the PMP; and, HNP, Unit 1 openings below 243.0 ft (74.1 m) subject to flooding from the cancelled HNP, Unit 2 area have been closed and waterproofed.

3.1.6 Additional Site Details to Assess the Flood Hazard

The FHRR stated that it had developed and used a Digital Elevation Model (DEM) of the site (Duke, 2013). The FHRR also stated that DEM data for the site were derived from photogrammetric data which included 2 ft (0.6 m) contours and elevation points with an estimated Root Mean Square Error (RMSE) of 0.61 ft (0.19 m) for the 2 ft (0.6 m) contour.

3.1.7 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. Step 6 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.

By letter dated November 27, 2012, Duke provided the flood walkdown report for HNP, Unit 1 (Duke, 2012). The NRC staff prepared a staff assessment report, dated June 27, 2014, to document its review of the walkdown report (NRC, 2014b). The NRC staff concluded that the licensee's implementation of the flooding walkdown methodology met the intent of the walkdown guidance.

3.2 Local Intense Precipitation and Associated Site Drainage

The FHRR reported that the reevaluated flood hazard, including associated effects, for LIP is elevation 261.4 ft (79.7 m) (Duke, 2013). This flood-causing mechanism is described in the licensee's CDB.

3.2.1 Site Drainage

The FHRR stated that runoff will occur as overland flow on roads and ground surfaces that enter the Main Reservoir located east of the site and the Auxiliary Reservoir located west of the site. Using the topographic information discussed in Section 3.1.6, above, the licensee defined the subbasin boundaries and their flowpaths.

The staff reviewed the drainage flowpaths and the subbasins delineated by the licensee, as well as the Vehicle Barrier System (VBS) for use in the LIP flooding analysis. The staff examined the delineated subbasin boundaries and noted that several subbasin boundaries follow the route of the VBS.The staff reviewed the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center-River Analysis System (HEC-RAS) (USACE, 2010) output provided by the licensee.

3.2.2 Local Intense Precipitation

The FHRR stated that the LIP analysis used the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) Hydrometeorological Report HMR 52 (NOAA, 1982) to estimate the 1-hr, 30-min, 15-min, and 5-min PMP depths for a 1-mi^2 (3-km^2) drainage area. The results were analyzed and presented as an intensity-duration-frequency (IDF) curve. The 1-hr PMP depth is 18.9 in (48.0 cm) for a 1-mi^2 (2.6-km^2) drainage area. The staff confirmed that the licensee's LIP depth values for the HNP Unit 1 site were consistent with PMP values reported in HMR 52.

3.2.3 Runoff Analyses

The FHRR stated that the LIP analysis used the rational method to transform precipitation intensity to runoff. The licensee computed the peak discharge in the FHRR using the subbasin areas, precipitation intensity, and assumed a runoff coefficient of 1 (which is equivalent to the assumption that no precipitation losses would occur during the LIP event). The staff noted the assumption of no losses is conservative. The rainfall intensity used in the rational method was derived from a rainfall IDF curve using the data provided in Table 3.2-1. The staff reviewed the layout of the HEC-RAS cross sections and concluded that the locations of cross sections in subbasins around the nuclear island are appropriate.

The licensee estimated in the FHRR the times of concentration for each subbasin and estimated the rainfall intensity for the LIP event using the IDF curve. The licensee stated (Duke, 2014b) that the total time of concentration ranged from 7.2 minutes to 52.0 minutes with precipitation intensities ranging from19.97 in/hr (50.72 cm/hr) to 60.12 in/hr (152.7 cm/hr).

As discussed in the FHRR and the additional information provided by the licensee (Duke, 2014b), the time-of-concentration calculation was partially based on the slope along the flowpath. As part of the sensitivity analyses in Section 3.2.6, below, the staff discussed the sensitivity of the time-of-concentrations, precipitation, and discharge to varying the topography based on the RMSE.

3.2.4 Sumps and Containment Areas

The FHRR described four areas (i.e., subbasins 5, 6, 8, and 16; Figure 3.2-1) with sumps and containment areas that would retain all runoff and excluded the runoff contribution from these subbasins in its LIP flood analysis. The four areas described by the licensee (Duke, 2013 and Duke, 2014b) are expected to retain the building runoff from the LIP event in sumps, or in containment areas located between retaining walls.

For the storage areas with sumps (subbasins 5, 6, and 16; Figure 3.2-1), the licensee stated that when the storage volume of each sump is filled to an elevation of 261 ft (79.6 m), any additional runoff will spill onto the site. For the containment volume in the Tank Building (subbasin 8; Figure 3.2-1), which is between the Tank Building and the walls that enclose the building area, the licensee states that the storage volume will contain all of the LIP runoff from the building (Duke, 2014b). The top of the wall is 286 ft (87.2 m) and the invert between the walls is 261 ft (79.6 m) (Duke, 2014b). According to the licensee (Duke, 2014b), the LIP will fill the Tank Building storage to an elevation of 276.1 ft (84.16 m), which the staff estimated is only 60 percent of the total storage capacity. The staff considered the possibility that storm events with longer durations and hence, larger accumulated depths, could also occur, which is the case for the basin-wide PMP examined in Section 3.3.

3.2.5 Hydraulic Model

The FHRR stated that a HEC-RAS hydraulic model of the site was developed for the LIP analysis and was applied to route the runoff from the subbasins along the estimated flow paths. As discussed below, the staff reviewed the cross-section information contained in the model's input file. The locations of the model's cross-sections are shown in Figure 3.2-1.

The FHRR stated that approximately half of the HNP, Unit 1 site is covered by gravel and the remainder by asphalt, concrete, and roofs. In response to a staff RAI, the licensee provided additional information (Duke, 2014b) that describes the flowpath reaches used in the HEC-RAS model simulations and identifies the type of groundcover at each cross-section (e.g., asphalt, concrete, gravel, or mixed). The licensee stated that the Manning's roughness coefficient for gravel and concrete or asphalt are 0.025 and 0.013, respectively. For the HNP, Unit 1 site hydraulic model, the FHRR stated that an average Manning's roughness coefficient value of 0.02 was used.

Typical values of Manning's roughness coefficient values range from 0.017 to 0.025 for gravel and 0.011 to 0.015 for concrete with trowel finish, while smooth asphalt is 0.013 (see Chow, 1959). Therefore, the staff concluded that the licensee selected appropriate values for Manning's roughness coefficient in the HEC-RAS model consistent with published values.

3.2.6 Sensitivity Analyses

The staff evaluated the sensitivity of the HEC-RAS LIP flood water-surface elevation predictions to several input parameters. The staff analyzed the sensitivity of results to the following three changes: (1) varying topographic elevations (based on reported RMSE), (2) alternating flowpaths if the assumption of VBS blocking is not applied, and (3) varying values of Manning's roughness coefficient. Each of these three analyses is discussed below.

First, the staff considered the effects of spot elevation error in the HEC-RAS model, and concluded that the flood analysis is insensitive to spot elevation error for these reasons: (a) because the contours are derived from the spot elevations such that the spot elevation error is typically smaller than the contour error that was applied to the dataset in the sensitivity analysis; and, (b) because the error does not actually appear in the dataset as bias in the conservative manner that the sensitivity analysis was applied; and, (c) because additional resulting site impact was minimal from this conservative treatment of error in the sensitivity analysis. Also, the staff considered the effect of topographic errors on subbasin slope and estimated times of concentration by systematically applying the error to the elevation dataset and concluded the flood analysis is insensitive to errors in estimated times of concentration using site topography data.

Second, the licensee stated that the Jersey barriers that form the VBS have slots under the barriers that could become clogged during the LIP event; hence, the licensee assumed complete blockage of the VBS. Because the licensee assumed the VBS was completely blocked, it is possible that the potential exchange of flows between subbasins is being prevented. The staff considered alternative flowpaths if the assumption of total blockage at the VBS is not applied, and found, through sensitivity analysis performed by staff, no significant change in the water surface elevation. The staff considers the licensee's modeling of the VBS to be appropriate.

Finally, the staff considered the effect of a higher Manning's roughness coefficient on flood water-surface elevations. The staff concluded that the flood analysis is insensitive to a widened range of Manning's roughness coefficient values.

3.2.7 Flood Event Duration

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. The staff requested additional information from the licensee (NRC, 2014a) to supplement the HNP, Unit 1 FHRR. The licensee's response (Duke, 2014b, RAI No. 18 response) is discussed in Section 3 of this staff assessment. The staff notes that longer duration PMP events, such as the 72-hr PMP, generate greater volumes of runoff; and, the shorter duration PMP events, such as the 1-hour PMP, result in (potentially significantly) shorter warning time with greater peak event magnitude, and likewise may result in flooding above the elevation of openings to plant structures. Therefore, the staff determined that, as part of the Integrated Assessment Report, the licensee should evaluate the plant response for a range of rainfall durations associated with the LIP hazard events
(e.g., 1-, 6-, 12-, 24-, 48-, 72-hour PMPs) to determine the controlling scenario(s) (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. **This is Integrated Assessment Open Item No. 1**.

3.2.8 Conclusion

The staff confirmed the licensee's conclusion that the reevaluated flood hazard for LIP and associated site drainage is not bounded by the CDB 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 FHRR stated that the reevaluated flood hazard, including associated effects, for streams and rivers is based on a stillwater-surface elevation of 256.5 ft (78.18 m) at the Plant Island, 243.8 ft (74.31 m) at the Main Dam, and 259.3 ft (79.03 m) at the Auxiliary Dam. Inclusion of the effects from wind setup and wave runup results in an elevation of 256.5 ft (78.18 m) at the Plant Island, 249.8 ft (76.14 m) at the Main Dam, and 259.3 ft (79.03 m) at the Auxiliary Dam. This flood-causing mechanism is described in the licensee's CDB.

The FHRR identified the Buckhorn Creek watershed, with an area of 70.3 mi^2 (182.1 km^2), as the primary drainage upstream of the Main Dam, as shown on Figure 3.1-1. Figure 3.1-1 also shows the Auxiliary Dam, which discharges to the Main Reservoir upstream of the Main Dam, and has a watershed of 3 mi^2 (8 km^2).

3.3.1 Probable Maximum Precipitation

The licensee stated that HMR 51 (NOAA, 1978) and HMR 52 (NOAA, 1982) and ANSI/ANS-2.8 (ANS, 1992) were used in the development of the PMP (Duke, 2013). The licensee used HMR 51 to compute precipitation depths at 6-hr intervals for a range of isohyetal areas. The staff examined the reported 6-hr incremental precipitation developed by the licensee in the FSAR (PEC, 2012) that was used in the FHRR, and found the 6-hr incremental duration

appropriate for the Buckhorn Creek watershed and the calculated PMP depths reasonable and consistent with HMR 51. The staff examined methods used to develop the PMP storm and the antecedent storm and found them complete and consistent with HMR-52, ANSI/ANS-2.8 and NUREG/CR–7046.

3.3.2 Precipitation Losses

To determine precipitation losses, the FHRR referenced U.S. Department of Agriculture soils characteristics and land-use types to estimate infiltration rates in a range of 0.05 in/hr to 0.15 in/hr (0.1 cm/hr to 0.38 cm/hr) within the watersheds upstream of the Main and Auxiliary Dams. Additionally, the licensee (Duke, 2014b) provided the potential and actual infiltration rates for the antecedent storm, dry period, and the PMP.

The FHRR assumed that the potential precipitation loss due to infiltration linearly decreased to zero within 72 hours and remained at zero through the duration of the full PMP period. The actual infiltration rate will always be less than or equal to the potential infiltration rate, and the licensee modeled both infiltration rates as going to zero then remaining at zero following the antecedent period. The staff concluded that the approach used by the licensee is conservative and appropriate.

3.3.3 Snyder Coefficients

In its FHRR, the licensee computed the transformation of precipitation to runoff using Snyder's synthetic hydrograph method (Snyder, 1938) for the subbasins upstream of the Main and Auxiliary Dams, using values of 3.91 and 0.75, respectively, for Snyder's equation peaking and basin time lag coefficients. The licensee provided a conservative time lag estimate of 1.7 hr (Duke, 2014b, RAI No. 11 response) that was used in the FHRR. The staff reviewed and determined that the coefficients provided are reasonable and appropriate.

3.3.4 Unit Hydrographs

In its FHRR, the licensee used the USACE Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) (USACE, 2010) to compute the runoff hydrographs from the PMP to generate 1-hr unit hydrographs. The unit hydrographs were peaked by 25 percent and the time lag decreased by 20 percent to account for potential nonlinearities of runoff during the PMP. The staff reviewed the licensee unit hydrograph development methods and found them to be conservative and appropriate.

3.3.5 Spillway Rating Curves

The FHRR stated that with the current configuration the spillway crests of the Main and Auxiliary Dams are 220 ft and 252 ft (67.1 m and 76.8 m), respectively, and the crests of both dams are 260 ft (79.2 m). The spillway crest widths of the Main and Auxiliary Dams are 50 ft and 170 ft (15.2 m and 51.8 m), respectively. The FHRR bases the discharge rating curves for the Main and Auxiliary Dams on rating curves from HNP Unit 1 FSAR (PEC, 2009). The licensee provided additional information (Duke, 2014b) stating that from the flooding reanalysis, no tailwater effects on spillway discharge rate would occur during the PMF.

The Main Dam rating curve (PEC, 2009), has an upper limit of 239.5 ft (73.00 m). To accommodate the possibility of flood elevations exceeding this upper limit in the flooding reanalysis, the FHRR extended the Main Dam rating curve to 260 ft (79.2 m). This is shown in Figure 3.3-1.

Typically, the value of a spillway discharge coefficient (C) increases with the water surface elevation (Duke, 2014b, RAI No. 13 response; Roberson, et al, 1988). However, for the Main Dam the FHRR used a C equal to 3.5 for all water-surface elevations greater than 239.5 ft (73.0 m). The staff agrees that the smaller spillway coefficient results in smaller computed discharges, leading to a higher and therefore conservative water surface elevation in the Main Reservoir. The staff finds the methods and analysis appropriate.

The staff reviewed the licensee's explanation and conclusions (Duke, 2014b, RAI No. 12 response) relative to tailwater potential at the Auxiliary Dam spillway as induced by the Main Reservoir downstream and agrees with the licensee that, since the spillway would not be submerged, no backwater effects are anticipated. The staff reviewed the HNP, Unit 1 flooding reanalysis and, considering the conservatism of the use of a fixed spillway coefficient, agrees with the licensee's approach to estimate and extend the Main Dam spillway rating curve (Figure 3.3-1) for the current configuration.

3.3.6 Runoff and Probable Maximum Flood Elevations

In its FHRR, the licensee used HEC-HMS to compute runoff from the watersheds upstream of the Main and Auxiliary Dams and PMF water-surface elevations in the Main and Auxiliary Reservoirs using level-pool routing of runoff along with the reservoir stage-storage and storage-discharge curves. The licensee (Duke, 2014b) provided updated stage-storage information for the Main Reservoir and compared the suitability of using HEC-HMS for level-pool routing in the reanalysis with hydraulic routing. With the current Main Dam configuration, the computed stillwater PMF elevation using the level-pool routing of HEC-HMS is 243.8 ft (74.31 m). Using HEC HMS, the licensee determined in its FHRR that the maximum PMF elevation was 243.8 ft (74.32 m) in the Main Reservoir and 256.5 ft (78.18 m) in the Auxiliary Reservoir. Thus, the maximum PMF elevations are below the HNP Unit 1 site grade elevation of 260 ft (79.2 m).

By using the extended rating curve for the current configuration of the Main Dam spillway, the staff found that the reported outflow discharge was consistent with the Main Dam spillway rating curve. The staff also found that the reported outflow discharge was consistent with the Auxiliary Dam from the Auxiliary Dam spillway rating curve.

3.3.7 Coincident Wind and Wave Activity

In its FHRR, the licensee used methods from the Coastal Engineering Manual (Burcharth and Hughes, 2011), and ANSI/ANS-2.8 (ANS, 1992) guidance to calculate wind-wave effects. The FHRR referenced a two-year wind with duration of 1 hr and a speed of 50 mph (22 m/s). The FHRR reported that the fetch directions were based on distances at the Main Reservoir water level elevation of 240 ft (73.2 m) and considered the headlands at this lower elevation which reduces the fetch. The FHRR concluded that the fetch data developed at the higher water level are conservative.

The FHRR reported that the PMF elevations, including wind-wave activity, at HNP, Unit 1 was 246.9 ft (75.26 m) on the side adjacent to the Main Reservoir and 257.6 ft (78.52 m) on the side adjacent to the Auxiliary Reservoir. Hence the maximum PMF elevations with wind-wave activity are below the HNP, Unit 1 site grade elevation of 260 ft (79.2 m).

The staff agrees with the FHRR's use of the Coastal Engineering Manual (Burcharth and Hughes, 2011), and ANSI/ANS-2.8 (ANS, 1992) guidance to calculate wind-wave effects, and with parameter quantification by the licensee. The staff reviewed and agrees that fetch directions and distances at the higher water level are conservative and appropriate.

3.3.8 Conclusion

The staff confirmed the licensee's conclusion that the reevaluated flood hazard for site flooding from streams and rivers is not bounded by the current design-basis flood hazard; therefore, the licensee should include site flooding from streams and rivers within the scope of the Integrated Assessment, including combined effects such as wind setup and wave runup. Because this flooding mechanism does not inundate the site, the staff expects that the resulting scope of the integrated assessment addressing this mechanism will be limited. The information on flooding from streams and rivers that is specific to the data needs of the Integrated Assessment is described in Section 4 of this staff assessment.

3.4 Failure of Dams and Onsite Water Control/Storage Structures

The licensee stated in FHRR Section 3.9 that there are no dams upstream or downstream of Harris Reservoir that pose a flooding hazard at the HNP, Unit 1 site (Duke, 2013). This flood-causing mechanism is described in the licensee's CDB. The FHRR reported that the CDB hazard for site flooding due to failure of dams and onsite water control/storage structures is bounded by the streams and rivers flood-causing mechanism at the Auxiliary Dam.

The FHRR discussed the review of the National Hydrography Database, and found that all impoundments, except the Main and Auxiliary Reservoirs, within the Buckhorn Creek basin provide impoundment of lakes less than 10 acres (0.04 km^2) in size. The FHRR considered smaller impoundments not to be a hazard to the site.

The staff determined that the impoundment size screening performed by the licensee is consistent with the intent of JLD-ISG-2013-01 (NRC, 2013); and, the staff independently examined the USACE National Inventory of Dams (NID) database for dams that could potentially inundate the site. The result of staff's review is that no significant dams exist upstream of the site. Therefore, based on its review of the NID, the staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from failure of dams and onsite water control/storage structures remains bounded by the streams and rivers flood-causing mechanism at the Auxiliary Dam, and does not inundate the site.

3.5 Storm Surge

The licensee stated in its FHRR that the reevaluated hazard, including associated effects, for site flooding due to storm surge near HNP, Unit 1 is 254.5 ft (77.57 m). This flood-causing mechanism is described in the licensee's CDB. The CDB hazard for site flooding due to storm

surge at the HNP, Unit 1 site is 254.9 ft (77.69 m). At the Auxiliary Dam, the reevaluated hazard elevation of 257.9 ft (78.61 m) is not bounded by the design basis of 256.2 ft (78.09 m). No design-basis was evaluated at the Main Dam, where the reevaluated hazard elevation is 233.4 ft (71.14 m).

To estimate the effects from storm surge, the FHRR referenced current methods supplemented with guidance from NUREG/CR-7046 (NRC, 2011e). Additionally, the licensee used NOAA Technical Report NWS 23 in the FHRR to determine parameter values used in the PMH calculation.

The meteorological characteristics used by the licensee to calculate the PMH were obtained from National Oceanic and Atmospheric Administration (NOAA) Technical Report NWS 23 (NOAA, 1979) for Milepost 2200 and 35.6 degrees latitude. The licensee computed wave runup using the methods in USACE (2008) and wind setup using the methods in USACE (1997).

To determine the fetch, the licensee used five straight line fetch distances in the PMH-induced wave runup and wave setup calculations. Since several headlands interrupt the fetches when the Main Reservoir level is at the present lower level of 220 ft (67.1 m), the licensee stated that the calculated fetches were conservative for present conditions.

The licensee determined the PMH-induced wave runup and wind setup at the Main and Auxiliary Reservoirs assuming normal operating water levels in the Auxiliary and Main Dams, and by following the procedure given in the USACE Coastal Engineering Manual, Engineer Manual 1110-2-1100 (USACE, 2008). The licensee calculated the average water depth of the reservoirs by taking the storage volume at the stillwater elevation divided by the surface area but used the higher value from the HAR,[6] Units 2 and 3 COLA FSAR (Revision 3) (PEC, 2011) in subsequent calculations. The licensee did not evaluate the CDB flood hazard level for PMH-induced storm surge for the Main Dam, but noted that both the Main and Auxiliary Dams and HNP, Unit 1 are protected up to elevation 260 ft (79.2 m).

The licensee noted that the reevaluated PMH-induced storm surge flood level for the Auxiliary Dam exceeds the CDB flood level by 1.65 ft (0.50 m) but remains below the Auxiliary Dam flood protection level by 2.15 ft (0.66 m). In addition, water wave phase speed and water velocity would produce significantly smaller dynamic forces with floating debris compared to dynamic forces produced by hurricane/tornado wind projectiles.

The licensee stated the embankment of the plant island along the Main Reservoir is protected by 300 ft (91.4 m) of sacrificial spoil fill at elevation 245 ft (74.7 m). The extent of erosion due to the two worst fetches is estimated by the licensee to be 150 ft (45.7 m) resulting from a PMH duration of 48 hours. Therefore, the licensee stated that the sacrificial spoil fill provides a conservative design.

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[6] Harris Advanced Reactor (HAR) is a proposed addition of new Units 2 and 3 to the HNP, Unit 1 site, and is located adjacent to HNP Unit 1.

The staff agrees with the licensee that dynamic forces from floating debris are minimal compared to those resulting from hurricane/tornado wind projectiles and concludes that the CDB is bounding for hydrodynamic loading on the safety-related structures, except for the Auxiliary Dam, which is not bounded by the CDB. The staff further concludes that the loading from waterborne projectiles and debris are bounded by loading from other hazards such as tornado wind and tornado missiles. The staff confirmed the fetch lengths, straight-line fetches, wind speed, and calculation of wind-wave runup and setup associated with the HNP, Unit 1 and Auxiliary/Main dams. The staff agrees with the licensee's use of the USACE (2008) as the source of applicable methodology for the performing relevant wave action calculations. The staff also agrees that the sacrificial spoil fill erosion of 50 percent provides a conservative design.

The staff confirmed the licensee's conclusion that the reevaluated hazard at the Auxiliary Dam for flooding from storm surge is not bounded by the CDB flood hazard; therefore, the licensee should include flooding from storm surge within the scope of the Integrated Assessment. Because this flooding mechanism does not inundate the site, the staff expects that the resulting scope of the integrated assessment addressing this mechanism will be limited. 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 seiche does not inundate the plant site, and did not report a PMF elevation. This flood-causing mechanism is not described in the licensee's CDB. In the HNP, Unit 1 FHRR, the licensee demonstrated mathematically that "the magnitude of resonance wave for all fetch lengths is zero" (Duke, 2013). The licensee also explained that "because the wind fetch is approximately 100 times longer than the significant wave length, [...] wave amplification due to resonance will not occur on the Auxiliary or Main Reservoirs at the HNP Unit 1 site" (Duke, 2013). The staff reviewed the licensee's analyses and conclusions and agrees that seiche flooding would not inundate the HNP, Unit 1 site. The staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from seiche is bounded by the CDBflood hazard.

3.7 Tsunami

The licensee reported in its FHRR that the reevaluated hazard, including associated effects, for tsunami does not inundate the plant site, and did not report a probable maximum flood elevation. This flood-causing mechanism is not described in the licensee's CDB. The licensee reported in the FHRR that tsunami effects are not a safety-related consideration due to the site's inland location 140 mi (225 km) from the Atlantic Ocean.

The licensee also considered the possibility of tsunami-like effects in the Main and Auxiliary Reservoirs as induced by slope failure. The licensee considered topography, geology, seismicity and groundwater and determined that the potential for such effects is negligible. The licensee further noted that no such events have occurred at the site since the reservoirs were filled.

The staff reviewed the location of the site and the distance from the Atlantic Coast, as well as the licensee's findings and agrees that tsunami related flooding would not inundate the HNP, Unit 1 site. The staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from tsunami is bounded by the CDBflood hazard.

3.8 Ice-Induced Flooding

The licensee reported in its FHRR that the reevaluated hazard, including associated effects, for ice-induced flooding does not inundate the plant site, but did not report a PMFelevation. This flood-causing mechanism is not described in the licensee's CDB. The licensee provided a review of historical temperature records from the NWS Cooperative Observer Station No. 317069 in Raleigh, North Carolina, for the period 1971 to 2000. The licensee concluded that ice formation in the site vicinity is limited to minor freezing along shorelines of large bodies of water.

The staff independently reviewed daily temperature data for the Raleigh-Durham area from National Climate Data Center (NCDC) gage ID GSOD 72306013722, covering the time period from 1946 to 2013. The data indicated that the longest period of sustained sub-freezing temperatures was four days, which was expected to be an insufficient amount of time for any significant ice jam to form. To confirm this, the staff independently searched the U.SACE Cold Regions Research and Engineering Laboratory (CRREL) Ice Jam Database for current and historical ice jams near the HNP, Unit 1 site and found no current or historical ice jams in the vicinity.

The staff reviewed the licensee's FHRR and agrees that ice–induced flooding is not a flooding mechanism of concern for HNP, Unit 1. The staff confirmed the licensee's conclusion that the reevaluated hazard for ice-induced flooding of the site is bounded by the CDB flood hazard.

3.9 Channel Migrations or Diversions

The licensee reported in its FHRR that the reevaluated hazard, including associated effects, for channel migrations and diversions does not inundate the plant site, and did not report a PMF elevation. This flood-causing mechanism is not described in the licensee's CDB. The licensee reported in the HNP, Unit 1 FHRR that there is no historical evidence of natural channel diversions in tributaries upstream of the main dam. The licensee also considered and screened out the possibility of channel migration or diversions as induced by either topographic characteristics or geographic features such as landslides.

The staff reviewed basin topography and topology and noted there was no evidence of channel migration or diversion along nearby streams or tributaries that could threaten the site. Accordingly, the staff agrees that channel diversions or migrations is not a flood causing mechanism of concern for the HNP Unit 1 site. The staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from channel migrations or diversions is bounded by the CDB flood hazard.

4.0 INTEGRATED ASSESSMENT AND ASSOCIATED HAZARD DATA

The staff confirmed that, for certain flooding mechanisms, the reevaluated hazard is not bounded by the CDB flood hazard. Therefore, the staff concludes that an Integrated Assessment is necessary and should consider the following flood-causing mechanisms, including associated effects: (a) local intense precipitation, (b) streams and rivers, and (c) storm surge.

Section 5 of JLD-ISG-2012-05 (NRC, 2012c) describes the flood hazard parameters needed to complete the Integrated Assessment. The staff reviewed these parameters, and concluded that the following parameters from this Staff Assessment are appropriate as input to the Integrated Assessment:

- Flood event duration, including warning time and intermediate water surface elevations that trigger actions by plant personnel, as defined in JLD-ISG-2012-05. Flood event durations for the flood-causing mechanisms identified above are shown in Table 4.0-1.

- Flood height and associated effects, as defined in JLD-ISG-2012-05. Flood height and associated effects for the flood-causing mechanisms identified above are shown in Table 4.0-2.

4.1 Flood Event Duration

The staff requested the licensee to provide the applicable flood event duration parameters associated with mechanisms that trigger an Integrated Assessment. The applicable flood duration parameters include the warning time the site will have to prepare for the event, the period of time the site is inundated, and the period of time necessary for water to recede from the site for the mechanisms that are not bounded by the CDB. The staff also requested the licensee to provide the flood height and associated effects for these same mechanisms:

(a) Local Intense Precipitation (LIP) - The warning time stated by the licensee for an inundation of the site as a consequence of a LIP event is zero, since it may occur without warning from localized storms (Duke, 2014b). The site is assumed by the licensee to be inundated for a period of one hour (Duke, 2014b). The water level is then expected by the licensee to recede below site grade within one hour (Duke, 2014b). The licensee in the FHRR identified the flood height as 0.4 ft (0.12 m) at the Waste Process Building and 0.4 ft (0.12 m) at the Diesel Fuel Oil Storage Tank Building. The hydrodynamic loadings at these locations are minimal when compared to the strength of the buildings;

(b) Streams and rivers including wind and wave - The warning time for flooding from rivers and streams is 36 hours (Duke, 2014b) based on information from the National Weather Service; the site is not inundated from this flood mechanism;

(c) Storm surge - The warning time for flooding from storm surge is 36 hours (Duke, 2014b) based on information from the National Weather Service; the site is not inundated from this flood mechanism.

The staff expects that the scope of the integrated assessment addressing mechanisms that do not inundate the site, including storm surge and flooding from streams and rivers, will be minimal.

Section 3.2.7 of this Staff Assessment discusses flood event duration associated with local intense precipitation. As noted in that section, the licensee is requested to evaluate the plant response time considering a range of rainfall durations associated with the local intense precipitation flood hazard (e.g., 1-, 6-, 12-, 24-, 48-, 72-hour PMPs). 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. **This is Integrated Assessment Open Item No. 1.**

4.2 Conclusion

Based upon the preceding analysis, NRC staff confirmed that the reevaluated flood hazard information defined in the sections above, with the exception of the identified Integrated Assessment Open Item, is appropriate input to the integrated assessment. As described in the 50.54(f) letter, the licensee should submit the Integrated Assessment Report no later than two years from the date of the HNP, Unit 1 FHRR. However, subsequent to the issuance of the 50.54(f) letter the NRC issued a letter (NRC, 2014c) revising the requirement to submit an integrated assessment for FHRRs submitted before June 2013, which includes the HNP, Unit 1. As a result, the revised requirement extended the due date for an integrated assessment by 6 months.

5.0 CONCLUSION

The NRC staff has reviewed the information provided for the reevaluated flood-causing mechanisms of Shearon Harris Nuclear Power Plant, Unit 1. 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 local intense precipitation, flooding from streams and rivers, and storm surge flooding mechanisms are not bounded by the current design basis flood hazard, (b) an integrated assessment including local intense precipitation, streams and rivers, and storm surge floods is expected to be submitted by the licensee, and (c) the reevaluated flood-causing mechanism information is appropriate input to the Integrated Assessment as described in JLD-ISG-2012-05 (NRC, 2012c).

The NRC staff identified one Integrated Assessment Open Item related to the assumptions for establishing local intense precipitation durations and related flood warning times. The Integrated Assessment Open Item is summarized in Table 5.0-1. Therefore, the NRC is not providing finality on the flood parameters related to the local intense precipitation and associated site drainage as part of this staff assessment.

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Notes: (1) ADAMS Accession Nos. refers to documents available through NRC's Agencywide Document Access and Management System (ADAMS). Publicly-available ADAMS documents may be accessed through http://www.nrc.gov/reading-rm/adams.html. (2) "n.d." indicates no date is available or relevant, for example for sources that are updated by parts; "n.d.-a", "n.d.-b" indicate multiple undated references from the same source.

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Table 2.2-1: 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

SRP is the Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition (NRC, 2007)

JLD-ISG-2012-06 is the "Guidance for Performing a Tsunami, Surge, or Seiche Hazard Assessment" (NRC, 2013a)

JLD-ISFG-2013-01 is the "Guidance for Assessment of Flooding Hazards Due to Dam Failure" (NRC, 2013b)

Table 3.0-1: Summary of Controlling Flood-Causing Mechanisms at HNP

Reevaluated Flood-Causing Mechanisms and Associated Effects that May Exceed the Powerblock Elevation[1] (260 ft (79.2 m) NGVD29)	ELEVATION ft (m) NGVD29
Local Intense Precipitation and Associated Drainage	261.4 (79.67)

[1]Flood Height and Associated Effects as defined in JLD-ISG-2012-05 (NRC, 2012c)

Table 3.1-1. Current Design Basis Flood Hazards at HNP

Flooding Mechanism	Stillwater Level ft (m) NGVD29	Associated Effects	Flood Level[1] ft (m) NGVD29	Section in FHRR (Duke, 2013)
Local Intense Precipitation and Associated Drainage (based on 1-hr PMP)	261.27 (79.64)	Negligible	261.27 (79.64) at powerblock buildings	2.1.1, 4.1 and Table 6
Streams and Rivers (using PMF resulting from 36-hr PMP) combined with wind setup and wave runup	256.0 (78.03) at Plant Island 238.9 (72.82) at Main Dam 256.0 (78.03) at Auxiliary Dam	1.7 ft (0.52 m) at Plant Island, wind setup and wave runup 4.2 ft (1.28 m) at Main Dam, wind setup and wave runup 2.0 ft (0.61 m) at Auxiliary Dam, wind setup and wave runup	257.7 (78.55) at Plant Island 243.1 (74.10) at Main Dam 258.0 (78.64) at Auxiliary Dam	2.1.2, 2.1.3, 2.1.8, 4.2, and Table 6
Failure of Dams and Onsite Water Control/Storage Structures	Bounded by Streams and Rivers at Auxiliary Dam	None (below site grade)	Bounded by Streams and Rivers at Auxiliary Dam	2.1.9 and 4.9
Storm Surge (based on PMH)	252.0 (76.81) at Plant Island No analysis at Main Dam 252.0 (76.81) at Auxiliary Dam	2.9 ft (0.88) at Plant Island, wind setup and wave runup No analysis at Main Dam 4.2 ft (1.28 m) at Auxiliary Dam, wind setup and wave runup	254.9 (77.69) at Plant Island No CDB at Main Dam 256.2 (78.09) at Auxiliary Dam	2.1.8 and Table 6
Seiche	N/A	N/A	Not discussed in current design basis	2.1.4 and 4.4
Tsunami	N/A	N/A	Not discussed in current design basis	2.1.5 and 4.5
Ice-Induced	N/A	N/A	Not discussed in current design basis	2.1.6 and 4.6

Flooding Mechanism	Stillwater Level ft (m) NGVD29	Associated Effects	Flood Level[1] ft (m) NGVD29	Section in FHRR (Duke, 2013)
Channel Migrations or Diversions	N/A	N/A	Not discussed in current design basis	2.1.7 and 4.7

N/A = Not Applicable

[1] Site grade at elevation 260.0 ft (79.25 m) NGVD29.

Table 3.2-1. Local Intense Precipitation Depths for the HNP Site

Duration	Area, mi^2 (km^2)	Multiplier	Applied to	Precipitation Depth, in (cm)
1 hr	1.0 (2.6)	Not applicable	Not applicable	18.9 (48.0) (HMR-52, Fig. 24)
30 min	1.0 (2.6)	0.741 (HMR 52, Fig. 38)	1-hr, 2.6 km^2 (1-hr, 1 mi^2) PMP	13.9 (35.3)
15 min	1.0 (2.6)	0.514 (HMR 52, Fig. 37)	1-hr, 2.6 km^2 (1-hr, 1 mi^2) PMP	9.7 (24.6)
5 min	1.0 (2.6)	0.327 (HMR 52, Fig. 36)	1-hr, 2.6 km^2 (1-hr, 1 mi^2) PMP	6.18 (15.7)

Source: Duke, 2013 (FHRR, Table 2)
HMR 52 is Hansen, Schreiner, and Miller (1982)

Table 4.0-1. Flood Event Duration for Reevaluated Hazards to be Examined in the Integrated Assessment

Flood-Causing Mechanism	Time for Site Preparation for Flood Event	Period of Site Inundation	Time for Recession of Water from Site
Local Intense Precipitation and Associated Drainage	0 hours	1 hour[1]	1 hour[1]
Storm Surge	36 hours	Site not inundated	Site not inundated
Flooding in Streams and Rivers	36 hours	Site not inundated	Site not inundated

[1]These values are estimates by licensee, as analysis was limited to steady-state one-dimensional modeling.

Table 4.0-2. Reevaluated Flood-Causing Mechanisms and Associated Effects to be Examined in the Integrated Assessment

Flood-Causing Mechanism	Stillwater Elevation[1] NGVD29	Associated Effects	Flood Hazard[1,2] NGVD29	Reference
Local Intense Precipitation and Associated Drainage (based on 1-hr PMP)	Varies with maximum of 261.4 ft (79.7 m) at the Diesel Fuel Oil Storage Tank and Waste Processing Buildings	Assumed drain blockages due to sediment, debris, or ice. Other associated effects: wind (N/A), hydrodynamic force (minimal), and groundwater effects (none).	261.41 ft (79.68 m) at Diesel Fuel Oil Storage Tank Building (protected to 262.0 ft (79.86 m)); not bounded by CDB of 261.27 ft (79.64 m) 261.36 ft (79.66 m) at Waste Processing Building (protected to 261.06 ft (79.57 m); not bounded by CDB of 261.27 ft (79.64 m)	FHRR, Table 3 and Table 6
Streams and Rivers (based on PMF resulting from design storm consisting of antecedent storm at 0.4 x 72-hr PMP followed by 72-hr dry period followed by 72-hr PMP, combined with wind setup and wave runup)	256.50 ft (78.18 m) at Plant Island; not bounded by CDB of 256.0 ft (78.03 m) 243.84 ft (74.32 m) at Main Dam; not bounded by CDB of 238.9 ft (72.82 m) 256.50 ft (78.18 m) at Auxiliary Dam; not bounded by CDB of 256.0 ft (78.03 m)	1.14 ft (0.35 m)[3] at Plant Island, wind setup and wave runup 5.96 ft (1.82 m)[3] at Main Dam, wind setup and wave runup 2.84 ft (0.87 m)[3] at Auxiliary Dam Upstream, wind setup and wave runup	257.64 ft (78.53 m) at Plant Island; bounded by CDB of 257.7 ft (78.55 m) 249.80 ft (76.14 m) at Main Dam; not bounded by CDB of 243.1 ft (74.10 m) 259.34 ft (79.05 m) at Auxiliary Dam; not bounded by CDB of 258.0 ft (78.64 m)	FHRR, Section 3.2.1.5 and Table 6
Storm Surge (based on PMH, combined with wind setup and wave runup)	252.0 ft (76.81 m) at Plant Island 220.0 ft (67.06 m) at Main Dam 252.0 ft (76.81 m) at Auxiliary Dam	2.47 ft (0.75 m) at Plant Island, wind setup and wave runup 13.43 ft (4.09 m) at Main Dam, wind setup and wave runup 5.85 ft (1.78 m) at Auxiliary Dam Upstream, wind setup and wave runup	254.47 ft (77.56 m) at Plant Island; bounded by CDB of 254.9 ft (77.69 m) 233.43 ft (71.15 m) at Main Dam; no CDB 257.85 ft (78.59 m) at Auxiliary Dam; not bounded by CDB of 256.2 ft (78.09 m)	FHRR, Table 4 and Table 6

N/A = Not Applicable
[1] Numbers of significant figures in elevation and flood hazard values reflect those presented by the licensee in the FHRR
[2] Protected to 260.0 ft (79.25 m) NGVD29 unless otherwise noted.

[3] Deduced from hazard elevation and stillwater elevation.

Table 5.0-1: Integrated Assessment Open Items

Integrated Assessment Open Item(s): The Integrated Assessment Open Item set forth in the Staff Assessment and summarized in the table below identifies certain matters that will be addressed in the Integrated Assessment submitted by the Licensee. This item constitutes information requirements but does not form the only acceptable set of information. A licensee may depart from or omit this item, provided that the departure or omission is identified and justified in the Integrated Assessment. In addition, this item does 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.

Open Item No.	SA Section No.	Subject to be Addressed
1	4.0	The licensee is requested to evaluate the plant response time considering a range of rainfall durations associated with the local intense precipitation flood hazard (e.g., 1-, 6-, 12-, 24-, 48-, 72-hour PMPs). 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.

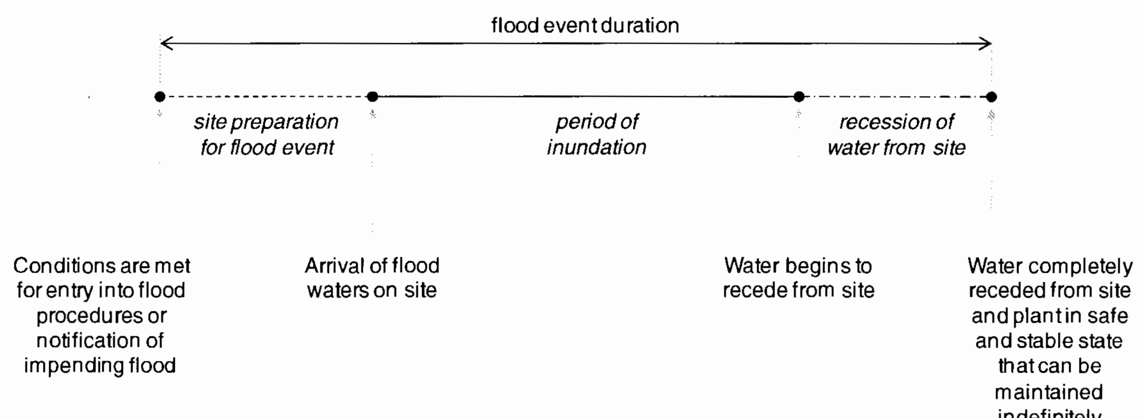
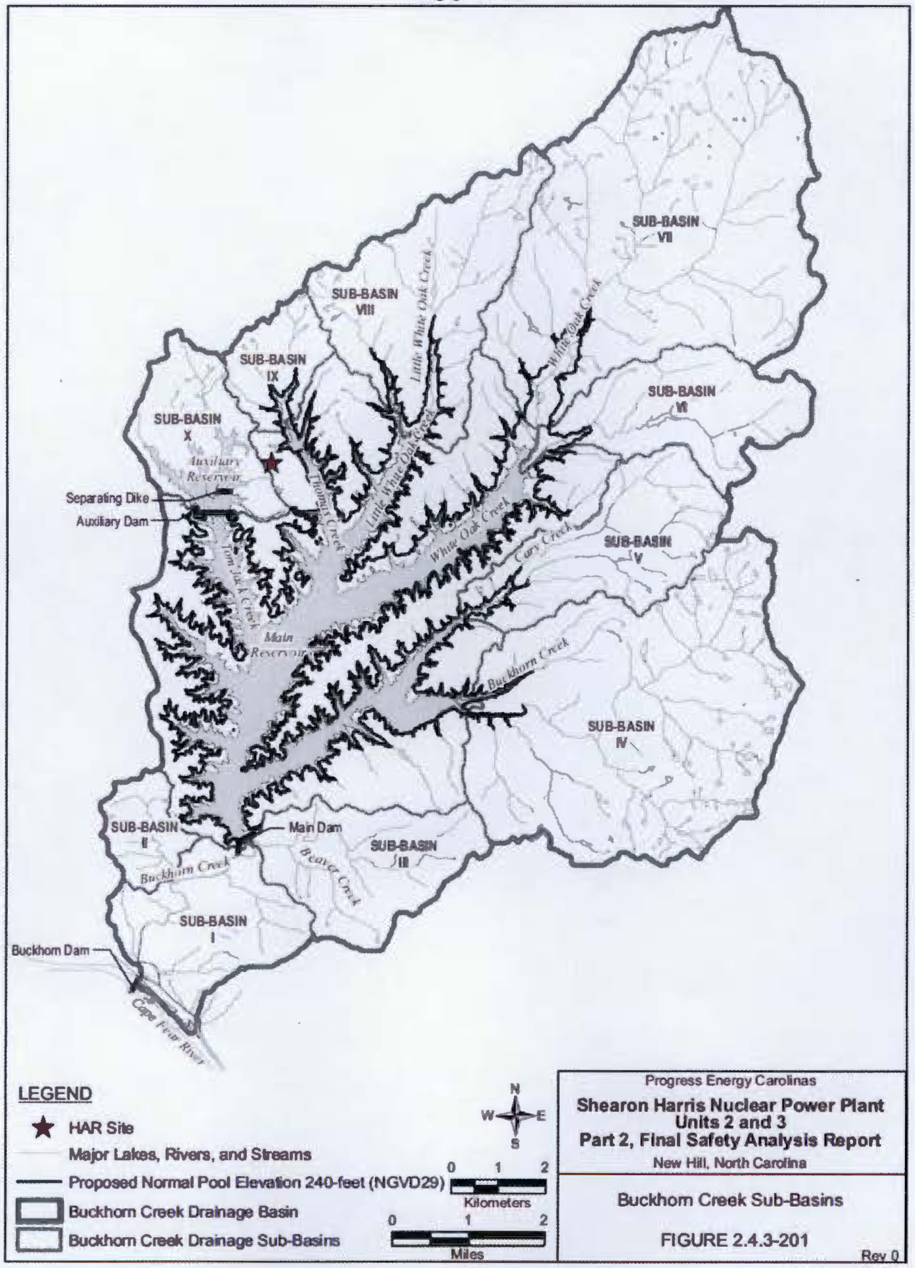


Figure 2.2-1 Flood Event Duration

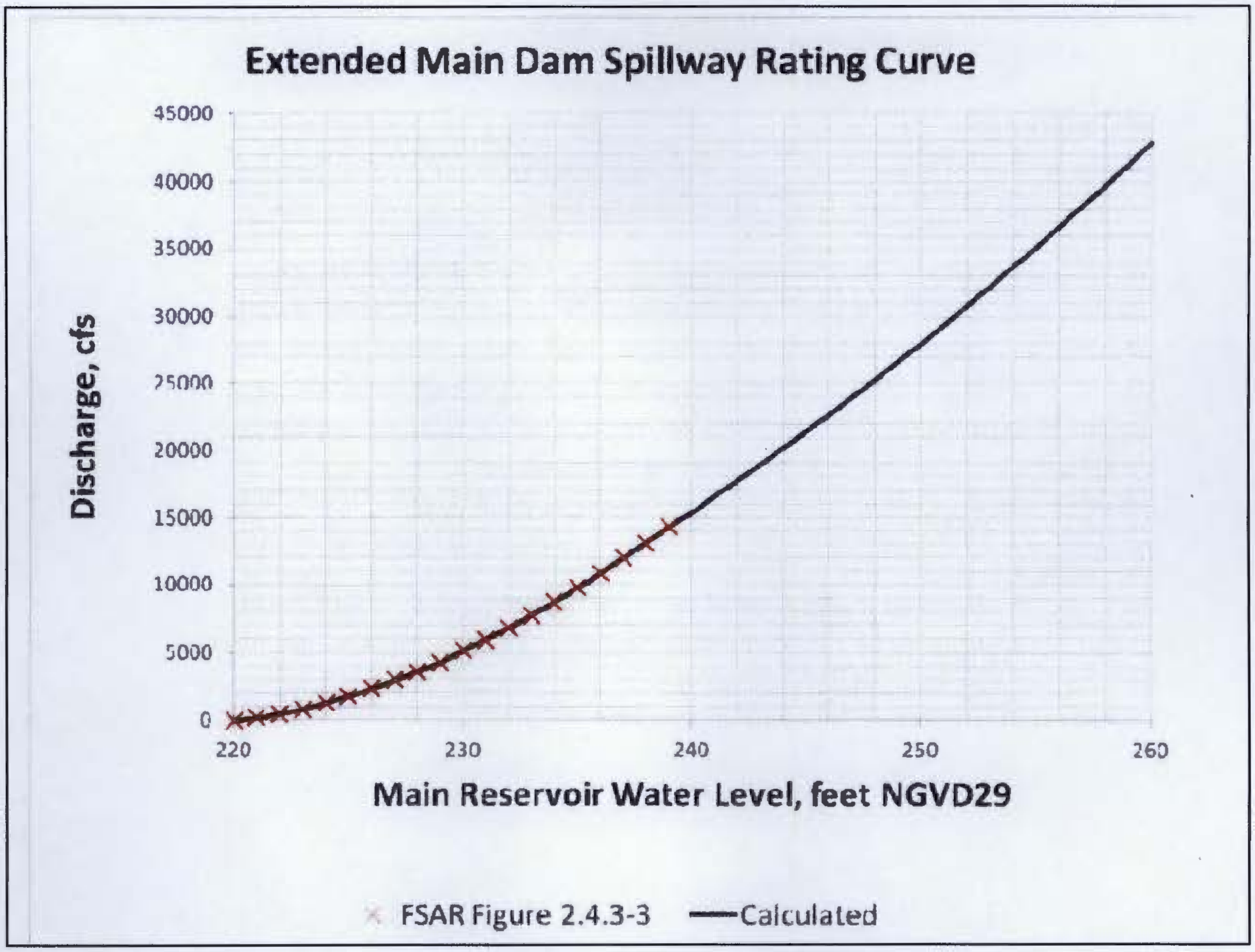


Source: PEC. 2012. Figure 2.4.3-201

Figure 3.1-1. Locations of Main and Auxiliary Dams and Reservoirs in the Buckhorn Creek Drainage, and Sub-basins Used for the Flooding Analyses from Stream and Rivers.

(Modified from Duke, 213, FHRR Figure 3)

Figure 3.2-1. Locations of Buildings, Subbasins, and Cross Sections in the HNP Unit 1 Site Hydraulic Model



The licensee extended the rating curve beyond the water level of 239.5 ft (73.0 m) assuming that the discharge coefficient did not increase above 239.5 ft (73.00 m), but remained constant at a value of 3.5. Source: Duke, 2014b

Figure 3.3-1. Calculated Rating Curve for the Main Dam Spillway

If you have any questions, please contact me at (301) 415-3809 or email at Juan.Uribe@nrc.gov.

Sincerely,

/RA/

Juan F. Uribe, Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket No. 50-400

Enclosure:
Staff Assessment of Flood Hazard
Reevaluation Report

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