UNITED STATES
NUCLEAR REGULATORY COMMISSION
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October 11, 2016

Mr. C.R. Pierce
Regulatory Affairs Director
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P.O. BOX 1295 / BIN B038
Birmingham, AL 35201-1295

SUBJECT: EDWIN I. HATCH NUCLEAR PLANT, UNITS 1 AND 2 – STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST – FLOOD-CAUSING MECHANISM REEVALUATION (CAC NOS. MF3868 AND MF3869)

Dear Mr. Pierce:

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 that licensees reevaluate flood-causing mechanisms using present-day methodologies and guidance. By letter dated March 6, 2014 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14069A054), Southern Nuclear Operating Company, Inc. (the licensee) responded to this request for Edwin I. Hatch Nuclear Plant, Units 1 and 2 (Hatch).

By letter dated December 4, 2015 (ADAMS Accession No. ML15329A135), the NRC staff sent a summary of the staff's review of Hatch's reevaluated flood-causing mechanisms. The enclosed staff assessment provides the documentation supporting the NRC staff's conclusions summarized in the letter. As stated in the letter, the reevaluated flood hazard results for several effects, including local intense precipitation (LIP), were not bounded by the current design basis flood hazard. In order to complete its response to Enclosure 2 to the 50.54(f) letter, the licensee is expected to submit a focused evaluation for LIP and additional assessments for the other effects specified in the letter to address this reevaluated flood hazard, as described in the NRC letter issued September 1, 2015 (ADAMS Accession No. ML15174A257). This closes out the NRC's efforts associated with CAC Nos. MF3868 AND MF3869.

Enclosure 1 transmitted herewith contains security-related information. When separated from Enclosure 1, this document is decontrolled.

If you have any questions, please contact me at (301) 415-1056 or e-mail at Lauren.Gibson@nrc.gov.

Sincerely,

Lauren Kate Gibson

Lauren Gibson, Project Manager
Hazards Management Branch
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Docket Nos. 50-321 and 50-366

Enclosures:
1. Staff Assessment of Flood Hazard Reevaluation Report (non-public, security-related information)
2. Staff Assessment of Flood Hazard Reevaluation Report (public)

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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
EDWIN I. HATCH NUCLEAR PLANT, UNITS 1 AND 2
DOCKET NOS. 50-321 AND 50-366

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) (hereafter referred to as the 50.54(f) letter). The request was made in connection with the implementation of the lessons learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant, as documented in the NRC's Near-Term Task Force (NTTF) Report (NRC, 2011a). Recommendation 2.1 in that document recommended that the staff issue orders to all licensees to reevaluate seismic and flooding hazards for their sites against current NRC requirements and guidance. Subsequent staff requirements memoranda associated with SECY-11-0124 (NRC, 2011b) and SECY-11-0137 (NRC, 2011c) directed the NRC staff to address this recommendation through issuance of a request 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 the 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 the 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 any flood-causing mechanism is not "bounded" by the plant's current design-basis (CDB) flood hazard, an additional assessment of plant response is necessary, as described in the 50.54(f) letter and COMSECY-15-0019, "Mitigating Strategies and Flooding Hazard Reevaluation Action Plan" (NRC, 2015b).

By letter dated March 6, 2014 (SNC, 2014a), Southern Nuclear Operating Company, Inc. (SNC, the licensee) provided its FHRR for Edwin I. Hatch Nuclear Plant (HNP, Hatch), Units 1 and 2. The NRC staff issued two sets of requests for additional information (RAIs) to the licensee by letter dated June 23, 2014 (NRC, 2014a), and by e-mail dated May 4, 2015 (NRC, 2015a), respectively. The licensee responded to the RAIs by letters dated August 6, 2014 (SNC, 2014b), and June 3, 2015 (SNC, 2015), respectively. The NRC staff transmitted information needs to the licensee on October 1, 2015, as documented in the NRC's audit report for Hatch (NRC, 2016b). The licensee's responses to the information needs were provided in the licensee's electronic reading room portal on October 13, 2015. Based on discussions held in February 2016, the NRC staff requested that the responses to Questions 1 and 8 from the October 1, 2015, list of information needs be provided on the docket. The licensee provided the NRC with the responses to Questions 1 and 8 by letter dated March 7, 2016 (SNC, 2016).

The licensee stated in FHRR Section 7 (SNC, 2014a) that interim actions and procedures exist to address flooding as a result of reevaluated LIP hazard elevation. Additionally, the licensee states that interim actions and procedures are planned to address flooding as a result of the

Enclosure

reevaluated probable maximum flood (PMF) hazard; however, further development is necessary.

The reevaluated flood hazard results for local intense precipitation (LIP) and associated drainage, flooding in streams and rivers, and failure of dams and onsite water control/storage structures are not bounded by the CDB hazard. Consistent with the process outlined in COMSECY-15-0019 and Japan Lessons-Learned Division (JLD) Interim Staff Guidance (ISG) JLD-ISG-2016-01, Revision 0 (NRC, 2015c and NRC, 2016c), the staff anticipates that the licensee will perform and document a focused evaluation for LIP and associated site drainage that assesses the impact of the LIP hazard on the site and evaluates and implements any necessary programmatic, procedural, or plant modifications to address this hazard exceedance (NRC, 2015b). Additionally, for the rivers and streams, and the failure of dams and onsite water control/storage structures flood-causing mechanisms, the NRC staff anticipates that the licensee will submit (1) a revised integrated assessment or (2) a focused evaluation consistent with the process outlined in COMSECY-15-0019 (NRC, 2015b) and associated guidance.

On December 4, 2015, the NRC issued an Interim Staff Response (ISR) letter to the licensee (NRC, 2015c). The purpose of the ISR letter was to provide the flood hazard information suitable for the assessment of mitigating strategies developed in response to Order EA-12-049 (NRC, 2012b) and the additional assessments associated with Recommendation 2.1: Flooding. The ISR letter also made reference to this staff assessment, which documents the staff's basis and conclusions. The flood hazard mechanism values presented in the letter's enclosures match the values in this staff assessment without change or alteration.

As mentioned in the ISR letter (NRC, 2015c) and discussed below, for any reevaluated flood hazards that are not bounded by the plant's CDB hazard, the licensee is expected to develop flood event duration (FED) parameters and flood-related associated effects (AE) parameters to conduct the mitigating strategies assessment (MSA) and focused evaluations or revised integrated assessments.

2.0 REGULATORY BACKGROUND

2.1 Applicable Regulatory Requirements

As stated above, Enclosure 2 to the 50.54(f) letter requested that the licensee reevaluate flood hazards at their site(s) 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.

Sections 50.34(a)(1), (a)(3), (a)(4), (b)(1), (b)(2), and (b)(4), of 10 CFR, describe the required content of the preliminary and final safety analysis report, 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.

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 design bases 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 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 updated final safety analysis report (UFSAR). The licensee's commitments made in docketed licensing correspondence that 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 site 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

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 (NRC, 2012a) requested, in part, that 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.

2.2.1 Flood-Causing Mechanisms

Enclosure 2 of the 50.54(f) letter (NRC, 2012a) discusses the flood-causing mechanisms that licensees should address in the 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.

2.2.2 Associated Effects

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

- Wind waves and runup 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 (see SRP Section 2.4.2, "Areas of Review" (NRC, 2007)). 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, 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 site, storm surge and river flooding are plausible combined events and should be considered.

2.2.4 Flood Event Duration

Flood event duration was defined in 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) letter (NRC, 2012a) 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.
- Perform an integrated assessment to: (a) evaluate the effectiveness of the CLB (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 each flood-causing mechanism at the site, licensees are not required to perform an integrated assessment. COMSECY-15-0019 (NRC, 2015b) outlines a revised process for addressing cases in which the reevaluated flood hazard is not bounded by the plant's CDB. The revised process describes an approach in which licensees with a LIP hazard exceeding their CDB flood will not be required to complete an integrated assessment, but would instead perform a focused evaluation. As part of the focused evaluation, licensees will assess the impact of the LIP hazard on their sites and then evaluate and implement any necessary programmatic, procedural, or plant modifications to address the hazard exceedance. For other flood hazard mechanisms that exceed the CDB, licensees can assess the impact of these reevaluated hazards on their site by performing either a focused evaluation or an integrated assessment (NRC, 2015b) consistent with JLD-ISG-2016-01 "Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flooding Hazard Reevaluation" (NRC, 2016c).

3.0 TECHNICAL EVALUATION

The NRC staff reviewed the information provided for the flood hazard reevaluation of HNP. 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 provide additional information in support of the summaries and conclusions in the HNP, Units 1 and 2 FHRR, the licensee made calculation packages available to the staff via an electronic reading room. The calculation packages were found only to expand upon and clarify the information provided on the docket, and so are not docketed or cited. The staff also requested additional information to supplement the information provided by the licensee.

The licensee used both the National Geodetic Vertical Datum of 1929 (NVGD29) and the North American Datum of 1988 (NAVD88). Unless otherwise noted, this staff assessment uses NVGD29 as the primary vertical datum for reported elevations. Table 3.0-1 provides values for conversion between NGVD29 and NAVD88 referenced in this staff assessment.

3.1 Site Information

The 50.54(f) letter (NRC, 2012a) includes the SSCs important to safety (e.g., the ultimate heat sink) in the scope of the hazard reevaluation. The licensee included pertinent data concerning these SSCs in the FHRR (SNC, 2014a). The staff reviewed and summarized this information in the sections below.

3.1.1 Detailed Site Information

The site grade at the powerblock is elevation 129 ft (39.3 m) NGVD29 (SNC, 2014a), with lower adjacent grade elevation at the intake structure of 110 ft (33.5 m) NGVD29. Table 3.1-1 provides the summary of controlling reevaluated flood-causing mechanisms, including associated effects, the licensee computed to be higher than the powerblock elevation.

The location of the site and other pertinent information are described in the FHRR (see Figure 3.1-1) (SCN, 2014a). United States Geological Survey (USGS) stream gauge 02225000 is located approximately 0.5 miles (0.8 km) upstream of the site and is the nearest gauge. Site grade varies from 175 ft (53.3 m) NGVD29 to below 75 ft (22.9 m) NGVD29, with the topography sloping in the north and northeast direction toward the Altamaha River to direct runoff away from the power block via culverts, open ditches, and natural drainage channels. A local topographic divide exists at the reactor building.

As stated in the FHRR (SCN, 2014a),

> The Final Safety Analysis Report (FSAR) identifies three major dams in the Altamaha River Watershed upstream of the site [SNC, 2003]. The three dams are owned and operated by Georgia Power. Sinclair Dam on the Oconee River is the largest of the dams and is located approximately 169 river miles [272.0 river km] upstream of the plant site. Wallace Dam, which is located toward the upper end of Sinclair Reservoir, is the second largest dam, followed by Lloyd Shoals Dam, which is located on the Ocmulgee River approximately 268 river miles [431.3 river km] upstream of the plant site.

Several other smaller dams located upstream of the site were also considered in the FHRR (SNC, 2014a).

Several SSCs important to safety are located below the finished floor elevation of 130 ft (39.6 m) NGVD29, including the low pressure coolant injection, station batteries and inverters, high pressure coolant injection (HPCI)/makeup pumps and valves, plant service water pumps, residual heat removal service water (RHRSW) Pumps, and one 125 volt direct current cabinet.

3.1.2 Design-Basis Flood Hazards

The CDB flood levels are summarized by flood-causing mechanism in Table 3.1-2. The NRC staff reviewed the CDB information provided in the HNP FHRR (SNC, 2014a) and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter (NRC, 2012a).

3.1.3 Flood-Related Changes to the Licensing Basis

The licensee stated that there have been no flood-related changes to the licensing basis since the last license renewal (SNC, 2014a). The NRC staff reviewed the information pertaining to flood-related changes to the licensing basis provided in the HNP FHRR (SNC, 2014a) and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter (NRC, 2012a).

3.1.4 Changes to the Watershed and Local Area

No significant changes have been made to the watershed since the last license renewal. Land use changes have been minimal and limited to the most upstream reaches of the watershed near Atlanta. The NRC staff reviewed the information pertaining to changes to the watershed and local areas provided in the HNP FHRR (SNC, 2014a) and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter (NRC, 2012a).

3.1.5 Current Licensing Basis Flood Protection and Pertinent Flood Mitigation Features

HNP does not rely on flood mitigation features to maintain key safety functions because safety-related structures are located above the maximum CLB flood hazard elevation of 108.3 ft (33.0 m) NGVD29. The site topography and below-grade walls and penetrations function as flood protection features. Water accumulating in the intake structure valve pit as a result of wave runup would be removed using two redundant, submersible sump pumps. Below-grade foundation slabs and exterior walls were designed to resist upward and lateral pressures caused by flooding. The NRC staff reviewed the information pertaining to CLB flood protection and pertinent flood mitigation features provided in the HNP FHRR (SNC, 2014a) and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter (NRC, 2012a).

3.1.6 Additional Site Details to Assess the Flood Hazard

Sediment deposition and aggradation has been documented in the intake structure, even though the Altamaha River has not exhibited meandering indicative of substantial sediment transport. Georgia Power Company conducts routine monitoring of river reaches adjacent to the site using bathymetric surveys in the late spring or early summer to identify instances of sedimentation, which may decrease flood storage capacity. If necessary, dredging is performed to maintain adequate storage capacity. The NRC staff reviewed the information pertaining to additional site details to address the flood hazards provided in the HNP FHRR (SNC, 2014a) and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter (NRC, 2012a).

3.1.7 Results of Plant Walkdown Activities

In response to Enclosure 4 of the 50.54(f) letter (NRC, 2012a), the licensees provided the flood walkdown report for HNP, Units 1 and 2, in letter dated November 27, 2012 (SNC, 2012), as supplemented September 23, 2013 (SNC, 2013). The staff prepared a staff assessment report, dated June 30, 2014 (NRC, 2014b), to document its review of the walkdown report. The NRC staff concluded that the licensee's implementation of flooding walkdown methodology meet the intent of the walkdown guidance.

3.2 <u>Local Intense Precipitation and Associated Site Drainage</u>

The licensee reported in its FHRR that the reevaluated flood hazard, including associated effects, for LIP and associated site drainage varies between 130.1 ft (39.64 m) NGVD29 and 131.2 ft (40.00 m) NGVD29 in the power block and between 110.9 ft (33.81 m) NGVD29 and 111.2 ft (33.89 m) NGVD29 around the intake structure (SNC, 2014a). This flood-causing mechanism is discussed in the licensee's CDB, but no PMF elevation was reported. The FHRR (SNC, 2014a) stated that the CDB maximum flood elevation for LIP is below the finished floor elevation.

In Section 5 of its FHRR, the licensee stated that its LIP reevaluation was conducted in accordance with NUREG/CR-7046 (NRC, 2011e) and the analysis is based on a precipitation input equivalent to the 1-hour, 1-mi^2 (2.6 km^2) probable maximum precipitation (PMP) event at the HNP site, as determined from Hydrometeorological Report (HMR) 52 National Oceanic and Atmospheric Administration (NOAA) (NOAA, 1982). The licensee used the two-dimensional hydrodynamic computer model FLO-2D Build 2009.06 (FLO-2D, 2009) to simulate runoff resulting from this PMP event. As discussed in the audit report (NRC, 2016b), the FLO-2D model simulates the full catchment basin draining to the site and consists of 122,089 grid elements of size 10-ft (3.0 m) by 10-ft (3.0 m), a resolution which the licensee considered adequate for providing appropriate topographic detail of the site. Topographic data were available through a combination of light detection and ranging (LiDAR), survey, and as-built information. LiDAR data, originally provided in the NAVD88 datum, were converted to the NGVD29, using a conversion that NGVD29 elevations are 0.8 ft (0.24 m) higher than NAVD88 elevations (NRC, 2016b). Figure 3.2-1 shows the site layout and topography, as well as the model domain, security barriers, and buildings.

Aerial photography was used to estimate the Manning's roughness coefficients (n-values). Based on the category of land cover developed from aerial photography, Manning's n-values were assigned. The licensee also conducted a sensitivity analysis to assess the impact of Manning's n-values on the maximum water surface elevation (WSE). The analysis compared the effect of Manning's n-values at the high and low ends of the recommended ranges, and found that the differences in WSE were 0.1 ft (0.03 m) or less (NRC, 2016b). The staff found the licensee's range of values reasonable.

The concrete blocks, or vehicle barrier system (VBS), were modeled as 3.5 ft (1.07 m) tall levee features within the model. If water exceeds that elevation, flow will occur over the VBS surface according to the broad crested weir equation with a weir coefficient of 2.85. Buildings, tanks, and cooling towers within the site were modeled as flow obstructions by assigning an approximate top/roof elevation based on LiDAR data. Area reduction factor and width reduction factor values were assigned to accurately model flow conditions around the dry storage casks within the southern independent spent fuel storage installation pad (NRC, 2016b).
The 1-hour, 1-mi^2 (2.6 km^2) PMP event was developed using HMR 52, with sub-hourly rainfall amounts estimated using figures 36 to 38 (NOAA, 1982). The resulting PMP values are provided in Table 3.2-1. The licensee arranged incremental PMP values following a front-loaded temporal distribution, with the most intense rainfall occurring at the beginning of the event. The FLO-2D model used the rainfall distribution input, including these incremental rainfall depths, with a total simulation time of 24 hours and rainfall distributed evenly across the site. NRC staff compared the licensee's PMP values with HMR 52 and confirmed the licensee's reported PMP values. The staff found the licensee's PMP values were reasonable.

In accordance with NUREG/CR-7046 (NRC, 2011e), all active and passive drainage networks were assumed to be non-functional during the LIP event. Rainfall losses were not included in the simulation, with runoff occurring via overland and open channel flow only. The licensee provided clarification stating that its FLO-2D model represents buildings and other obstructions using the approximate roof elevation based on LiDAR data and allowing free flow off of buildings to the site ground (SNC, 2015). Additionally, the licensee conducted the LIP analysis independent of other external high-water events.

The final FLO-2D model simulation produced estimates for maximum flooding depth, water surface elevations, velocities, resultant static loads, and resultant impact loads. Maximum simulated WSEs from the LIP event vary between 130.1 ft (39.64 m) NGVD29 and 131.2 ft (40.00 m) NGVD29 in the power block and between 110.9 ft (33.81 m) NGVD29 and 111.2 ft (33.89 m) NGVD29 near the intake structure. These results indicate flood elevations in excess of the site grade. The licensee has undertaken interim actions to address the concern. Maximum flood elevations and loads are shown in Table 3.2-2.

The staff confirmed through review and sensitivity analysis that the selection of model parameters and representation of site features in the model are reasonable. Additionally, 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 staff expects that the licensee will submit a focused evaluation for LIP and associated site drainage for HNP, Units 1 and 2, consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b).

3.3 Streams and Rivers

In its FHRR, the licensee reported that the reevaluated flood hazard, including associated effects, for streams and rivers is based on a stillwater-surface elevation of 109.6 ft (33.39 m) NGVD29 (SNC, 2014a). Since the maximum stillwater-surface elevation from dam failure exceeds that for stream and river flooding, the wind wave and runup effects are reported in Section 3.4 for dam failure flooding. This flood-causing mechanism is discussed in the licensee's CDB. The CDB PMF elevation for streams and rivers is based on a stillwater-surface elevation of 105.0 ft (32.00 m) NGVD29.

The reevaluated flood elevation resulting from the PMF was evaluated for flooding of the Altamaha River at the HNP site. The methodology used to determine the PMF hazard followed guidance provided in NUREG/CR-7046 (NRC, 2011e), with bounding conditions resulting from the combined effects flood hazard.

A Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) model was constructed by the U.S. Army Corps of Engineers (USACE) (USACE, 2010a) for determining the hydrologic impacts of the watershed PMP event. The resulting peak river flows were input into the HEC-River Analysis System (HEC-RAS) hydraulic model (USACE, 2010b) to compute maximum WSE.

Using a digital elevation model (DEM) of the Altamaha River watershed from USGS, the licensee delineated subbasin boundaries for a total of 76 subbasins, ranging in size from 2 to 717 mi^2 (0.6 to 218.5 km^2). These subbasins were delineated for each USGS stream gauge, tributary confluence, and critical dam within the watershed. Figure 3.3-1 shows the locations of USGS stream gauges and the subbasins.

For the initial estimates of lag times, the Technical Release 55 Soil Conservation Service (SCS) (SCS, 1986) methodology was used for computing segmental velocity. With each reach's flow and cross-sectional area estimated, velocities determined from Manning's equation, using an estimated initial Manning's roughness coefficient, n-value of 0.045, were paired with the respective segment reach distances to obtain an initial estimated travel time. The travel time was refined in the model based on adjustments to the Muskingum routing parameter, K. Due to the assumption that flood routing timing and velocity are correlated with cross-sectional area, the Muskingum K parameter was adjusted with respect to river width. The river-widths were estimated based on orthoimagery. Muskingum storage factors, X, were assigned an initial value of 0.2.

Prior to calibration, the initial constant loss rate was set to 0.05 inch/hr (0.13 cm/hr), consistent with the design basis storm approach in the UFSAR (SNC, 2003). Dam outflow data derived from USGS gauging stations were used for calibration of HEC-HMS, which assumes controlled dam operation procedures provided through spillway curves (NRC, 2016b). The NRC staff finds the licensee's selection of Manning's n-values, Muskingum parameters, and loss rates to be reasonable.

As a part of the modeling process for riverine flooding analyses, dam screening was conducted following the guidance outlined in JLD-ISG-2013-01 (NRC, 2013b). As an initial step in dam screening, 292 dams below 25 ft (7.6 m) in height and 100 ac-ft (123,348.2 m^3) in storage were identified as inconsequential and removed from consideration. In order to further refine the set of dams included in the evaluation, the Volume Method (NRC, 2011e) was used, with only seven dams remaining as potentially critical. The critical dams include Sinclair, Wallace, Lake Juliette, Lloyd Shoals, Lake Tobesofkee, Town Creek Reservoir, and Upper Towaliga Reservoir.

Eight dams and reservoirs were included in the HEC-HMS model calibration, including the seven potentially critical dams mentioned in the previous paragraph and the Barnett Shoals Dam. Stage-area-storage relationships were developed based on information provided in the UFSAR (SNC, 2003) and dam design documents reviewed as part of the NRC audit (NRC, 2016b). Representative data for spillways and top of dams were entered into the model. Using spring 1998 hydrograph data from the Baxley, GA, USGS gauge, baseflow was estimated to be 28,900 ft^3/s (818.4 m^3/s) and used for HEC-HMS model calibration. This March baseflow is 26 percent higher than the March mean determined from 43 years of record (NRC, 2016b). The NRC staff finds the licensee's baseflow assumptions to be reasonable.

In an attempt to improve calibration results, subsurface geologic and aquifer conditions were assessed. Basins overlying the same geologic unit were assigned consistent loss rates and timing/area factors. Calibration was made to a March 1998 storm event which produced a peak discharge of 144,000 ft^3/s (4077.6 m^3/s) at the Baxley, GA, stream gauge. An initial calibration was conducted to increase the model lag time to better match observed conditions. Loss rates were calibrated, with values ranging from 0 in/h to 0.05 in/h (0 cm/h to 0.13 cm/h), which the licensee deemed appropriate. The NRC staff found that the licensee's calibration is reasonable.

In accordance with Appendix H of NUREG/CR-7046 (NRC, 2011e), three different combined effects flood scenarios were evaluated. For Scenario 1, mean monthly baseflow, median soil moisture, 40% PMP, and the full PMP were combined. The 72-h all-season PMP was obtained using information provided in HMR-51 (NOAA, 1978) and HMR-52 (NOAA, 1982). As a part of the input requirements, X and Y coordinates were determined for the Altamaha River

Watershed boundary. The one-hour to six-hour rainfall temporal distribution ratio, preferred storm orientation, and depth-area-duration data were determined from HMR 51 and 52 using the storm center location. The HMR 52 software determined the optimal storm center, orientation, and size combination to maximize watershed rainfall depth and produce the basin-average hydrograph for the probable maximum storm. This approach determined the all-season 72-h PMP value to be 19.20 inches (48.77 cm). To account for long lag times, the 40 percent PMP was added as an antecedent event, followed by a five-day dry period and subsequent full PMP. Six different full PMP temporal rainfall distributions were evaluated to determine the maximum runoff potential, with various combinations of 40 percent PMP distributions also evaluated. The resulting critical storm was a 40 percent PMP preceding a 5-day dry period and full PMP with peak precipitation at 234 hours; the associated peak PMF discharge was found to be 899,636 ft^3/s (25,472.8 m^3/s) at the HNP site. Figure 3.3-2 shows the various temporal distributions that were evaluated for the PMP event.

The licensee selected a 5-day intermediate dry period rather than a shorter period (e.g., three-day) as recommended by NUREG/CR-7046. The licensee provided a sensitivity analysis suggesting fairly low sensitivity to dry period duration (SNC 2015 and 2016). The NRC staff reviewed the sensitivity analysis and determined that the assumption of a 5-day intermediate dry period is reasonable. Additional details regarding this assumption and the sensitivity analyses are provided in the dam failure flood hazard section of this staff assessment (i.e., Section 3.4).

The licensee's Scenario 2 combines mean monthly baseflow with probable maximum snowpack and 100-year snow-season rainfall. Scenario 3 combines mean monthly baseflow with 100-year snowpack and snow-season PMP. As a conservative assumption, the licensee assumed a snow-water equivalency of 50 percent, meaning that the density of the given snowpack was 50% of the density of water. Using HMR 51 and 52, the licensee determined the snow-season PMP to be 60% of the all-season PMP. The probable maximum snowpack depth of 10 inches (25.4 cm) (equivalent to 5 inches (12.7 cm) of water and corresponding to the highest historical daily snow depth for the state of Georgia) is assumed, added to the snow-season PMP of 11.61 inches (29.49 cm), results in a total combined snow-season PMP of 16.61 inches (42.19 cm). Because this value is below the all-season PMP determined in Scenario 1, the all-season PMP was assumed by the licensee to be bounded.

As discussed in the audit report, in order to adequately route riverine flooding as simulated in HEC-HMS, a HEC-RAS model was created to hydraulically simulate the HEC-HMS results. A 277-mile (445.8 km) long reach was created in HEC-RAS to simulate flooding of the Altamaha River at the Hatch site starting at the USGS gauge near Jackson, GA. To account for variation in the Manning's n-values as flood stage and flow change, the model was calibrated using roughness factors and USGS rating curves for each gauge. The only bridge included in the model is the U.S. Route 1 Bridge located 0.64 miles (1.03 km) upstream of the intake structure west of the site. The model representation of the bridge included the number, spacing, and width of 125 piers and used contraction and expansion coefficients of 0.3 and 0.5, respectively. All other cross sections maintained contraction and expansion coefficients of 0.1 and 0.3, respectively (NRC, 2016b). Additional tributaries to the main reach were also modeled in HEC-RAS to provide additional storage, leading to increased flood wave attenuation. In some cases, these tributaries were simulated using lateral weirs, represented as broad crested weirs with weir coefficients of 2.6, connected to storage areas. The NRC staff found that the licensee's model set up was reasonable.

Using the calibrated HEC-HMS model, the all-season hydrologic PMF event was simulated using an unsteady HEC-RAS run, with a maximum WSE of 109.6 ft (33.40 m) NGVD29, which is below the intake structure's finished floor elevation (FFE) of 111.0 ft (33.83 m) NGVD29 and corresponds to a peak flow rate of 726,911 ft^3/s (20,583.8 m^3/s).

The licensee's selection of HEC-HMS and HEC-RAS to simulate PMF flooding at the HNP site is consistent with current regulatory guidance outlined in NUREG/CR-7046 (NRC, 2011e). The NRC staff performed confirmatory analysis to ensure the licensee's results could be replicated, with the results verified. As such, staff considers the licensee's decision to use the USACE's HEC models to be appropriate.

The staff's review found the licensee's methodology for calibrating the model to the 1998 storm event and validating results with USGS rating curves to be appropriate and reasonable. The combined effects flood scenarios constructed in the evaluation are in accordance with current regulatory guidance. The methodologies used to provide mean monthly baseflow, median soil moisture, probable maximum snowpack, and all-season and snow-season PMP values are consistent with current regulatory guidance. The final calibrated stream flow hydrographs appear to closely match the observed flows at various junctions, indicating a high degree of accuracy in the model calibration.

The staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from streams and rivers is not bounded by the CDB flood hazard. Therefore, the NRC staff expects that the licensee will submit a focused evaluation for these hazards or a revised integrated assessment consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b).

3.4 Failure of Dams and Onsite Water Control/Storage Structures

The licensee reported in its FHRR that the reevaluated flood hazard, including associated effects, for failure of dams and onsite water control or storage structures is based on a stillwater-surface elevation [redacted] including wind waves and runup results at or to an elevation of [redacted]. This flood-causing mechanism is discussed in the licensee's CDB. The CDB PMF elevation for failure of dams and onsite water control or storage structures is based on a stillwater-surface elevation of [redacted]

In its FHRR, the licensee evaluated flooding due to dam failure for sunny day, seismic, and overtopping conditions (SNC, 2014a). Overtopping failure was determined to be the bounding dam-failure scenario.

The licensee used the calibrated HEC-HMS model developed for PMF evaluation to simulate the hydrological conditions of the dam failure scenarios. Based on methodology outlined in JLD-ISG-2013-01 (NRC, 2013b), [redacted]. Figure 3.4-1 shows the locations of the critical dams considered in the licensee's evaluation. [redacted]

[redacted]

Under the sunny day breach scenario, the hydrographs produced by the HEC-HMS simulation were used as inputs to the unsteady HEC-RAS model. After performing hydrologic modeling using HEC-HMS and unsteady HEC-RAS modeling, the resulting peak discharge in HEC-RAS was found to be [redacted] which corresponds to a maximum WSE of [redacted]

To evaluate the seismic dam breach hazard, a 50 percent PMP was used as the base precipitation. Simultaneous dam failure was assumed, and a critical failure scenario was found to occur with a breach at [redacted]. After performing hydrologic modeling using HEC-HMS and unsteady HEC-RAS modeling, the resulting peak discharge in HEC-RAS was found to be [redacted] which corresponds to a maximum WSE of [redacted]

The overtopping dam breach scenario included the critical hydrologic PMF event in combination with overtopping and breaching of all upstream critical dams except [redacted] The critical overtopping dam breach scenario, based on sensitivity analysis, excluded hypothetical dams and included dam breach of all other dams. The hypothetical dams were considered as a part of the flooding analysis, but were found to be inconsequential to increasing downstream dam failure flooding and were conservatively excluded from the critical scenario.

Staff finds the licensee's initial dam screening assessment of identifying inconsequential and potentially critical dams to be reasonable.

[redacted] Based on this information the staff concluded that the licensee's selected scenario was reasonable.

After performing hydrologic modeling using HEC-HMS and unsteady HEC-RAS modeling, the resulting peak discharge in HEC-RAS was found to be [redacted] which corresponds to a maximum WSE of [redacted]. This stillwater elevation represents the most significant flooding scenario along the Altamaha River. Under combined effect Scenario 1 an antecedent 40 percent PMP (occurring 5 days prior to the main storm) and 2-year return period wind wave activity were added to this PMF with upstream dam failure scenario. Based on the 2-year recurrence wind speed, critical fetch length, and average depth, the significant wave height was calculated using equations in USACE (2003) and found to be approximately [redacted] A simple adjustment calculation produced a maximum wave height of [redacted]. Additionally, the wind setup was calculated using the same input parameters and found to be [redacted]. These effects, when added to the maximum stillwater elevation, produce a maximum combined effects WSE at the Intake Structure, including maximum wave height and wind setup, of [redacted]. The NRC staff found that the licensee's calculation of wind setup and wave runup reasonable.

Current regulatory guidance recommends using a 3- to 5-day dry period when evaluating combined effect floods. The licensee selected a 5-day dry period to evaluate the combined effects floods. The licensee suggested that the 5-day dry period was selected to prevent the end of the antecedent storm from coinciding with the main storm (SNC, 2015). Additionally, the licensee provided a sensitivity analysis demonstrated that using a shorter dry period of 3-days and a refined model time step of 1-minute resulted in an increase in the maximum stillwater surface elevation to [redacted], which is [redacted] higher than when using a 5-day dry period (SNC, 2016). Although this value is higher than the FHRR-reported value of [redacted] it is still well below the Hatch intake finished floor elevation of 111.0 ft (33.83 m) NGVD29. Among the four different analyses conducted for testing the combined sensitivity of using a 1-hour vs 1-minute model timestep and a 5-day vs 3-day dry period duration, the maximum stillwater surface elevation ranges between [redacted] suggesting fairly low sensitivity to dry period duration (SNC, 2016). Therefore, the NRC staff finds the licensee's use of a 5-day dry period to be reasonable, given a lack of sensitivity to the duration selected and model uncertainties.

The NRC staff confirmed the licensee's conclusion that the reevaluated flood hazard for failure of dams and onsite water control or storage structures is not bounded by the CDB flood hazard. Therefore, the NRC staff expects that the licensee will submit a focused evaluation for these or a revised integrated assessment consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016c).

3.5 Storm Surge

In its FHRR (NRC, 2014a), the licensee reported that the reevaluated hazard, including associated effects, for storm surge does not inundate the plant site, but did not report a PMF elevation. This flood-causing mechanism is not discussed in the licensee's CDB. The staff examined the location, topography, and absence of enclosed or open water body in the vicinity of the site and confirmed the licensee's conclusion that the reevaluated hazard for flooding from storm surge is not a plausible flooding mechanism that would cause flooding hazard at the site.

3.6 Seiche

In its FHRR (NRC, 2014a), the licensee reported that the reevaluated hazard, including associated effects, for seiche does not inundate the plant site, but did not report a PMF elevation. This flood-causing mechanism is not discussed in the licensee's CDB. The staff examined the location, topography, and absence of enclosed or open water body in the vicinity of the site and confirmed the licensee's conclusion that the reevaluated hazard for flooding from seiche is not a plausible flooding mechanism that would cause flooding hazard at the site.

3.7 Tsunami

In its FHRR (NRC, 2014a), the licensee reported that the reevaluated hazard, including associated effects, for tsunami does not inundate the plant site, but did not report a PMF elevation. This flood-causing mechanism is not discussed in the licensee's CDB. The staff examined the location, topography, and absence of enclosed or open water body in the vicinity of the site, and confirmed the licensee's conclusion that the reevaluated hazard for flooding from tsunami is not a plausible flooding mechanism that would cause flooding hazard at the site.

3.8 Ice-Induced Flooding

In its FHRR (NRC, 2014a), the licensee reported that the reevaluated hazard, including associated effects, for ice-induced flooding does not inundate the plant site, but did not report a PMF elevation. This flood-causing mechanism is not discussed in the licensee's CDB.

There is no record indicating freezing in the Altamaha River. River temperature data provided in the Updated Final Safety Analysis Report (UFSAR) (SNC, 2003) indicates that river temperature record at Doctortown, Georgia, has a low value of 37.4 degrees Fahrenheit (°F) (3° Celsius (C)) which is above the freezing temperature. The NRC staff examined the data of USGS stream gauge 02226000 Altamaha River at Doctortown, Georgia, and confirmed the lowest value of record for the daily minimum since 1958 is 37.4°F (3°C). Based on the temperature record, the formation of frazil ice is unlikely and the ice blockage of the intake structure is not considered possible. The staff confirmed the licensee's conclusion that the reevaluated hazard for ice-induced flooding is not a plausible flooding mechanism that would cause flooding hazard at the site.

3.9 Channel Migrations or Diversions

In its FHRR (NRC, 2014a), the licensee reported that the reevaluated hazard, including associated effects, for channel migrations or diversions does not inundate the plant site, but did not report a probable maximum flood elevation. This flood-causing mechanism is not discussed in the licensee's CDB.

As indicated in NUREG/CR-7046 (NRC, 2011e), there are no well-established predictive tools for channel diversion. Accordingly, a qualitative evaluation of Altamaha River diversion potential was performed based on historical data. Historically, there is no indication that the channel alignment from the upstream U.S. Route 1 Bridge to Hatch has any tendency to meander. Diversion away from the site, however, was considered to be a possibility due to potential and observed sedimentation. The licensee concluded that sedimentation appears to occur slowly, and yearly monitoring of the channel bottoms reduces the likelihood of migration away from the site (SNC, 2014a). Additionally, Georgia Power Company conducts monitoring of the Altamaha River reach adjacent to the site, and conducts dredging if necessary. Overall, the licensee does not consider channel migration a flooding hazard at the HNP site.

The staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from channel migrations or diversions is not a plausible flooding mechanism that would cause flooding hazard at the site.

4.0 REEVALUATED FLOOD HEIGHT, EVENT DURATION, AND ASSOCIATED EFFECTS FOR HAZARDS NOT BOUNDED BY THE CDB

4.1 Reevaluated Flood Height for Hazards Not Bounded by the CDB

Section 3 of this staff assessment documents the staff review of the licensee's flood hazard water height results. Table 4.1-1 contains the maximum results, including waves and runup, for flood mechanisms not bounded by the CDB presented in Table 3.1-2. The staff agrees with the licensee's conclusion that LIP, streams and rivers, and failures of dams and onsite water control/storage structures are the only hazard mechanisms not bounded by the CDB.

Consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b), the NRC staff anticipates the licensee will submit a focused evaluation for LIP and associated site drainage. For the rivers and streams and failures of dams and onsite water control/storage structures flood-causing mechanisms, the NRC staff anticipates the licensee will perform additional assessments of plant response, either a focused evaluation or a revised integrated assessment, as discussed in COMSECY-15-0019 (NRC, 2015b).

4.2 Flood Event Duration for Hazards Not Bounded by the CDB

The staff reviewed information provided in SNC's 50.54(f) responses (SNC, 2014a; SNC, 2014b; SNC, 2015; and, SNC, 2016) regarding the flood event duration (FED) parameters needed to perform the additional assessments of plant response for flood hazards not bounded by the CDB. The FED parameters for the flood-causing mechanisms not bounded by the CDB are summarized in Table 4.2-1.

The licensee states in its FHRR (SNC, 2014a) that flooding as a result of the streams and rivers flood-causing mechanism does not inundate the site and therefore flood event durations for this parameter is not required. The NRC staff agree with the licensee's assessment and conclude that FED parameters are not required for this flood-causing mechanism. However, the licensee did not provide all FED parameters for LIP and the failures of dams and onsite water control/storage structures.

The licensee is expected to develop FED parameters for LIP and the failures of dams and onsite water control/storage structures to conduct the MSA and focused evaluations or revised integrated assessments.

4.3 Associated Effects for Hazards Not Bounded by the CDB

The staff reviewed information provided in SNC's 50.54(f) response (SNC, 2014a; SNC, 2014b; SNC, 2015; and, SNC, 2016) regarding AE parameters needed to perform future additional assessments of plant response for flood hazards not bounded by the CDB. The AE parameters directly related to maximum total water height, such as waves and runup, are presented in Table 4.1-1. The AE parameters not directly associated with total water height are listed in Table 4.3-1.

The licensee's AE inputs included hydrodynamic and debris loading at plant grade for the LIP flood causing mechanism.

Sediment deposition and aggradation have been documented at the HNP intake structure; however, the licensee reports that Georgia Power Company conducts continuous monitoring of the Altamaha River adjacent to the site to ensure minimum water depth requirements. This practice eliminates any negative effects from sediment deposition.

Additional associated effects listed as not provided are considered by the licensee as not applicable for the LIP flood hazard.

The licensee did not provide AEs for the failures of dams and onsite water control/storage structures.

The licensee is expected to develop AE parameters for LIP and the failures of dams and onsite water control/storage structures to conduct the MSA and focused evaluations or revised integrated assessments.

4.4 Conclusion

Based upon the preceding analysis, NRC staff confirms that the reevaluated flood hazard information discussed in Section 4 is appropriate input to the additional assessments of plant response as described in the 50.54(f) letter (NRC, 2012a), COMSECY-15-0019 (NRC, 2015b), and the associated guidance.

The licensee is expected to develop missing FED and AE parameters to conduct the MSA and the focused evaluations or revised integrated assessments. The NRC staff will evaluate the missing FED parameters (i.e. warning time, period of inundation, and recession time) and associated effects marked as "not provided" in Tables 4.2-1 and 4.3-1 during its review of the MSA and focused evaluations or revised integrated assessments.

5.0 CONCLUSION

The NRC staff has reviewed the information provided for the reevaluated flood-causing mechanisms of HNP, Units 1 and 2. Based on its review of available information provided by SNC's 50.54(f) response (SNC, 2014a; SNC, 2014b; SNC, 2015; and, SNC, 2016), 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 confirms 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, the staff confirms the licensee's conclusions that (a) the reevaluated flood hazard results for LIP, rivers and streams, and failures of dams and onsite water control/storage structures flood-causing mechanisms are not bounded by the current design basis flood hazard, (b) additional assessments of plant response will be performed for the LIP, rivers and streams, and failures of dams and onsite water control/storage structures flood-causing mechanisms and are expected to be submitted by the licensee, and (c) the reevaluated flood-causing mechanism information is appropriate input to additional assessments of plant response, as described in the 50.54(f) letter and COMSECY-15-0019 (NRC, 2015b), and associated guidance. The NRC staff has no additional information needs at this time with respect to SNC's 50.54(f) response.

6.0 REFERENCES

Notes: ADAMS Accession Nos. refers to documents available through NRC's Agencywide Documents Access and Management System (ADAMS). Publicly-available ADAMS documents may be accessed through http://www.nrc.gov/reading-rm/adams.html.

U.S. Nuclear Regulatory Commission Documents and Publications

NRC (U.S. Nuclear Regulatory Commission), 2007, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition", NUREG-0800, 2007. ADAMS stores the Standard Review Plan as multiple ADAMS documents, which are most easily accessed through NRC's public web site at http://www.nrc.gov/reading-rm/basic-ref/srp-review-standards.html.

NRC, 2011a, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," Commission Paper SECY-11-0093, July 12, 2011, ADAMS Accession No. ML11186A950.

NRC, 2011b, "Recommended Actions to be Taken without Delay from the Near-Term Task Force Report," Commission Paper SECY-11-0124, September 9, 2011, ADAMS Accession No. ML11245A158.

NRC, 2011c, "Prioritization of Recommended Actions to be Taken in Response to Fukushima Lessons Learned," Commission Paper SECY-11-0137, October 3, 2011, ADAMS Accession No. ML11272A111.

NRC, 2011d, "Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United State of America," NUREG/CR-7046, November 2011, ADAMS Accession No. ML11321A195.

NRC, 2012a, letter from Eric J. Leeds, Director, Office of Nuclear Reactor Regulation and Michael R. Johnson, Director, Office of New reactors, "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding the Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident", March 12, 2012, ADAMS Accession No. ML12053A340.

NRC, 2012b, letter from Eric J. Leeds, Director, Office of Nuclear Reactor Regulation, "Prioritization of Response Due Dates for Request for Information Pursuant to Title 10 of the Code of Federal Regulations 40.54(f) Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," May 11, 2012, ADAMS Accession No. ML12097A509.

NRC, 2012c, "Guidance for Performing the Integrated Assessment for External Flooding," Japan Lessons-Learned Project Directorate, Interim Staff Guidance JLD-ISG-2012-05, Revision 0, November 30, 2012, ADAMS Accession No. ML12311A214.

NRC, 2013a, "Guidance for Performing a Tsunami, Surge, or Seiche Hazard Assessment," Japan Lessons-Learned Project Directorate, Interim Staff Guidance JLD-ISG-2012-06, Revision 0, January 4, 2013, ADAMS Accession No. ML12314A412.

NRC, 2013b, "Guidance For Assessment of Flooding Hazards Due to Dam Failure," Japan Lessons-Learned Project Directorate, Interim Staff Guidance JLD-ISG-2013-01, Revision 0, July 29, 2013, ADAMS Accession No. ML13151A153.

NRC, 2014a, "Edwin I. Hatch Nuclear Plant, Units 1 and 2 (HNP)—Request for Additional Information (TAC NOS. MF3868 and MF3869)," dated June 23, 2014, ADAMS Accession No. ML14163A613.

NRC, 2014b, "Edwin I. Hatch Nuclear Plant, Units 1 And 2, Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related To The Fukushima Dai-Ichi Nuclear Power Plant Accident (TAC MD0234-35, ," June 30, 2014, ADAMS Accession No. ML14155A405.

NRC, 2015a, E-mail, "Hatch Nuclear Plant – Fukushima 2.1 Flooding-FHRR Review RAIs," sent May 4, 2015, ADAMS Accession No. ML15124A832.

NRC, 2015b, "Mitigating Strategies and Flooding Hazard Reevaluation Action Plan," Commission Paper COMSECY-15-0019, June 30, 2015, ADAMS Accession No. ML15153A104.

NRC, 2015c, "Edwin I. Hatch Nuclear Plant, Unit 1 and 2 – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 50.54(f) Information Request – Flood-Causing Mechanism Reevaluation," dated December 4, 2015, ADAMS Accession Nos. ML15321A156 (cover letter and redacted tables) and ML15327A249 (non-public tables).

NRC, 2016a, "Compliance with Order EA-12-049 Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events", Interim Staff Guidance JLD-ISG-2012-01, Revision 1 and Comment Resolution, January 22, 2016, ADAMS Accession No. ML15357A142.

NRC, 2016b, "Nuclear Regulatory Commission Report the Audit of Southern Nuclear Operating Company's Flood Hazard Reevaluation Report Submittals Relating to the Near-Term Task Force Recommendation 2.1 Flooding for the Edwin I. Hatch Nuclear Plant, Units 1 and 2," dated May 17, 2016, ADAMS Accession No. ML16032A013.

NRC, 2016c, "Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flooding Hazard Reevaluation; Focused Evaluation and Integrated Assessment, "Interim Staff Guidance JLD-ISG-2016-01, Revision 0, July 11, 2016, ADAMS Accession No. ML16162A301.

<u>Codes and Standards</u>

ANSI/ANS (American National Standards Institute/American Nuclear Society), 1992, ANSI/ANS-2.8-1992, "Determining Design Basis Flooding at Power reactor Sites," American Nuclear Society, LaGrange Park, IL, July 1992.

<u>Other References</u>

FLO-2D, 2009. FL0-2D Reference Manual, Version 2009. FLO-2D Software, Inc., Nutrioso, Arizona.

Froehlich, D. C., 2008, "Embankment Dam Breach Parameters and Their Uncertainties," Journal of Hydraulic Engineering, Vol. 134, No. 12, May, pgs. 1708–1720.

NEI (Nuclear Energy Institute), 2015, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide", NEI 12-06 Revision 2, December 2015, ADAMS Accession No. ML16005A625.

NOAA (National Oceanic and Atmospheric Administration), 1978, "Probable Maximum Precipitation Estimates, United States, East of the 105th Meridian," NOAA Hydrometeorological Report No. 51, June 1978.

NOAA, 1982, "Application of Probable Maximum Precipitation Estimates, United States, East of the 105th Meridian," NOAA Hydrometeorological Report No. 52, August 1982.

SCS, 1986, "Urban Hydrology for Small Watersheds," Technical Release 55, Soil Conservation Service, U.S. Department of Agriculture, June 1986.

SNC (Southern Nuclear Operating Company, Inc.), 2003, "Hatch, Units 1 and 2, Updated Final Safety Analysis Report Updated FSAR (Revision 21)," ADAMS Accession No. ML031960404.

SNC, 2012, "Edwin I. Hatch Nuclear Plant – Units 1 and 2 Flooding Recommendation 2.3 Walkdown Report Requested by NRC Letter, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Daiichi Accident, dated March 12, 2012," dated November 27, 2012, ADAMS Accession No. ML12333A148.

SNC, 2013, " Edwin I. Hatch Plant, Units 1 and 2 Southern Nuclear Operating Company's Supplemental Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendations 2.3 of the Near-Term Task Force Review...," September 23, 2013, ADAMS Accession No. ML13266A367.

SNC, 2014a Edwin I. Hatch Nuclear Plant—Units 1 and 2, "Recommendation 2.1 Flood Hazard Reevaluation Report Requested by NRC Letter dated March 12, 2012," ADAMS Accession No. ML14069A054.

SNC, 2014b, "Edwin I. Hatch Nuclear Plant—Unit 1 & 2, Response to Request for Additional Information," dated August 6, 2014, ADAMS Accession No. ML14219A570.

SNC, 2015, "Edwin I. Hatch Nuclear Plant—Units 1 and 2, Response to Supplemental Request for Additional Information, Recommendation 2.1 Flood Hazard Reevaluation Report," dated June 3, 2015, ADAMS Accession No. ML15154B601.

SNC, 2016, "Edwin I. Hatch Nuclear Plant—Units 1 and 2, Response to Request for Docketing Information Need 1 and 8, Recommendation 2.1 Flood Hazard Reevaluation Report," dated March 7, 2016, ADAMS Accession Nos. ML16069A087 (public cover letter) and ML16069A088 (non-public enclosure)

USBR (U.S. Bureau of Reclamation), 2014, "Evaluation of Erodibility-Based Embankment Dam Breach Equations," Hydraulic Laboratory Report HL-2014-02, Interagency Agreement NRC-HQ-60-12-I-0013, June.

USACE (U.S. Army Corps of Engineers), 2003, "Coastal Engineering Manual," Engineer Manual EM 1110-2-1100, Revision 1, U.S. Army Corps of Engineers.

USACE, 2010a, "HEC-HMS 3.5 Computer Program Build 1417," United States Army Corps of Engineers Hydrologic Engineering Center (HEC), release date: August 2010.

USACE, 2010b, "HEC-RAS Version 4.1.0 Computer Program," United States Army Corps of Engineers Hydrologic Engineering Center (HEC), release date: January 2010.

Xu, Y. and Zhang, L. M., 2009, "Breaching Parameters for Earth and Rockfill Dams," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 135, No. 12, December, pgs. 1957–1970

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

Table 3.0-1. Summary of Datum Conversions for Edwin I. Hatch Nuclear Plant (all values in ft)

	To	
From	**NAVD88**	**NGVD29**
NAVD88	0	+0.8
NGVD29	-0.8	0

Table 3.1-1. Summary of Controlling Flood-Causing Mechanisms

Reevaluated Flood-Causing Mechanisms and Associated Effects that May Exceed the Powerblock Elevation[(1),(2)]	**ELEVATION (NGVD29)**
Local Intense Precipitation and Associated Drainage	
Power Block area	130.1 to 131.2 ft
Intake Structure	110.9 to 111.2 ft
Failure of Dams and Onsite Water Control/Storage Structures	[redacted]

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

(2) The powerblock elevation is 129 ft NGVD29. The intake structure adjacent grade elevation is 110 ft NGVD29.

(3) [redacted]

Table 3.1-2. Current Design-Basis Flood Hazards

Mechanism	Stillwater Elevation	Waves/ Runup	Design Basis Hazard Elevation	Reference
Local Intense Precipitation	Not included in DB	Not included in DB	Not included in DB	FHRR Section 4.b.1 and Table 13
Streams and Rivers				
Flooding of the Altamaha River at atch	105.0 ft NGVD29	Not Applicable	105.0 ft NGVD29	FHRR Section 4.b.2 and Table 13
Failure of Dams and Onsite Water Control/Storage Structures				
Dam Breaches and Failures - Overtopping Failure	[redacted]	[redacted]	[redacted]	FHRR Section 4.b.3 and Table 13
Combined Effect Flood (PMF with overtopping dam failure and wind-induced waves)	[redacted]	[redacted]	[redacted]	FHRR Section 4.b.9 and Table 13
Dam Breaches and Failures - Seismic Failure	[redacted]	[redacted]	[redacted]	FHRR Table 13
Storm Surge	No Impact on the Site Identified	No Impact on the Site Identified	No Impact on the Site Identified	FHRR Section 4.b.4 and Table 13
Seiche	No Impact on the Site Identified	No Impact on the Site Identified	No Impact on the Site Identified	FHRR Section 4.b.5 and Table 13
Tsunami	No Impact on the Site Identified	No Impact on the Site Identified	No Impact on the Site Identified	FHRR Section 4.b.6 and Table 13
Ice-Induced Flooding	No Impact on the Site Identified	No Impact on the Site Identified	No Impact on the Site Identified	FHRR Section 4.b.7 and Table 13
Channel Migrations or Diversions	No Impact on the Site Identified	No Impact on the Site Identified	No Impact on the Site Identified	FHRR Section 4.b.8 and Table 13

Note 1: Reported values are rounded to the nearest one-tenth of a foot

Table 3.2-1: 1-mi²/1-h PMP Distribution (adapted from FHRR Table 2)

Time (minutes)	Cumulative Rainfall Depth (inches)
5	6.17
15	9.68
30	14.13
60	19.26

Table 3.2-2: LIP Predicted Flooding Results at the Main Doors and Bays.
Note: FFE = Finished Floor Elevation (adapted from FHRR Table 3)

Building	Door ID	Max. Water Surface Elevation	Max. Flooding Depth above Surveyed FFE	Flooding Duration above Surveyed FFE	Max. Velocity	Max. Resultant Impact Load	Max. Resultant Static Load
		ft	ft	hr	ft/sec	lb/ft	lb/ft
Intake Structure	Door D-130	110.9	< 0.1	< 0.1	0.91	0.72	3.96
	Door D-131	111.2	0.2	1.0	0.42	0.10	1.82
	Door D-132	111.1	0.2	0.2	0.37	0.40	53.08
Diesel Generator Building	Door D-166	130.2	0.3	1.1	0.35	0.11	4.25
	Door D-167	128.8	0.0	0.0	0.14	0.01	5.75
Turbine and Reactor Building (Units 1 & 2)	Door R-30A	130.1	0.4	1.3	0.91	0.55	6.62
	Door R-23A	130.2	0.4	1.3	0.56	0.28	4.91
	Door T-15	130.1	0.1	1.3	1.61	1.28	1.32
	Door T-16	130.2	0.2	1.4	1.17	0.91	2.27
	Door 2T-17	130.3	0.4	1.3	0.71	0.46	6.02
	Door 2T-18	130.3	0.4	1.2	0.48	0.19	6.72
	Truck Bay Door	130.4	0.9	6.0	0.82	1.55	28.36
Control Building	Freight Elevator	131.2	1.4	1.3	3.06	35.10	78.02

Table 4.1-1: Reevaluated Flood Hazards for Flood-Causing Mechanisms

Mechanism	Stillwater Elevation	Waves/ Runup	Reevaluated Hazard Elevation	Reference
Local Intense Precipitation				
Control Building 1-hr 1 sq. mi. PMP	131.2 ft NGVD29	Minimal	131.2 ft NGVD29	FHRR Table 3
Intake Structure 1-hr 1 sq. mi. PMP	111.2 ft NGVD29	Minimal	111.2 ft NGVD29	FHRR Table 3
Diesel Generator Building 1-hr 1 sq. mi. PMP	130.2 ft NGVD29	Minimal	130.2 ft NGVD29	FHRR Table 3
Turbine and reactor Building (Unit 1 and 2) 1-hr 1 sq. mi. PMP	130.4 ft NGVD29	Minimal	130.4 ft NGVD29	FHRR Table 3
Streams and Rivers	109.6 ft NGVD29	Not applicable	109.6 ft NGVD29	FHRR Section 5.b and Table 13
Failure of Dams and Onsite Water Control/Storage Structures				
Dam Breach and Failures - Overtopping Failure	[redacted]	[redacted]	[redacted]	FHRR Section 5.c and Table 13
Dam Breach and Failures - Seismic Failure	[redacted]	[redacted]	[redacted]	FHRR Section 5.c and Table 13
Combined Effect (PMF with overtopping dam failure and wind-induced waves)	[redacted]	[redacted]	[redacted]	FHRR Section 5.i and Table 13

Note 1: The licensee is expected to develop flood event duration parameters and applicable flood associated effects to conduct the MSA. The staff will evaluate the flood event duration parameters (including warning time and period of inundation) and flood associated effects during its review of the MSA.
Note 2: Reevaluated hazard mechanisms bounded by the current design basis (see Table 3.1-1) are not included in this table.
Note 3: Reported.values are rounded to the nearest one-tenth of a foot.

Table 4.2-1: Flood Event Duration for Flood-Causing Mechanisms

Flood-Causing Mechanism	Time Available for Preparation for Flood Event	Duration of Inundation of Site[1]	Time for Water to Recede from Site	Reference
Local Intense Precipitation and Associated Drainage	Not provided	1.0 h (Intake Structure) 1.1 h (Diesel Generator Building) 6.0 h (Turbine and Reactor Building) 1.3 h (Control Building)	Not provided	FHRR Table 3
Streams and Rivers	Site not inundated	Site not inundated	Site not inundated	FHRR Table 13
Failure of Dams and Onsite Water Control/Storage Structures	Not provided	Not provided	Not provided	FHRR Table 13

[1] The duration of inundation of site values represent the overall maximum flooding duration above surveyed finished floor elevation at the main doors and bays listed in FHRR Table 3.

Table 4.3-1 Integrated Assessment Associated Effects Inputs[(1),(2)]

	Flooding Mechanism		
Associated Effects Factor	**Local Intense Precipitation**	**Failure of Dams and Onsite Water Control/Storage Structures**	**Reference**
Hydrodynamic loading at plant grade (maximum resultant static load)	53.08 lb/ft (Intake Structure) 78.02 lb/ft (Powerblock)	Not Provided	FHRR Table 3
Debris loading at plant grade (maximum resultant impact load)	0.72 lb/ft (Intake Structure) 35.10 lb/ft (Powerblock)	Not Provided	FHRR Table 3
Sediment loading at plant grade	Not Applicable	Not Provided	Not Provided
Sediment deposition and erosion	Sediment deposition and aggradation has been documented at the Intake Structure. Georgia Power Company conducts continuous monitoring of the Altamaha River adjacent to the site to ensure minimum water depth requirements.	Not Provided	FHRR Section 4f, Additional Site Details
Concurrent conditions, including adverse weather	Not Provided	Not Provided	Not Provided
Other pertinent factors (e.g., waterborne projectiles)	Not Provided	Not Provided	Not Provided

(1) The Hydrodynamic and debris loading values represent the overall maximum load at the main doors and bays listed in FHRR Table 3.

(2) [redacted]

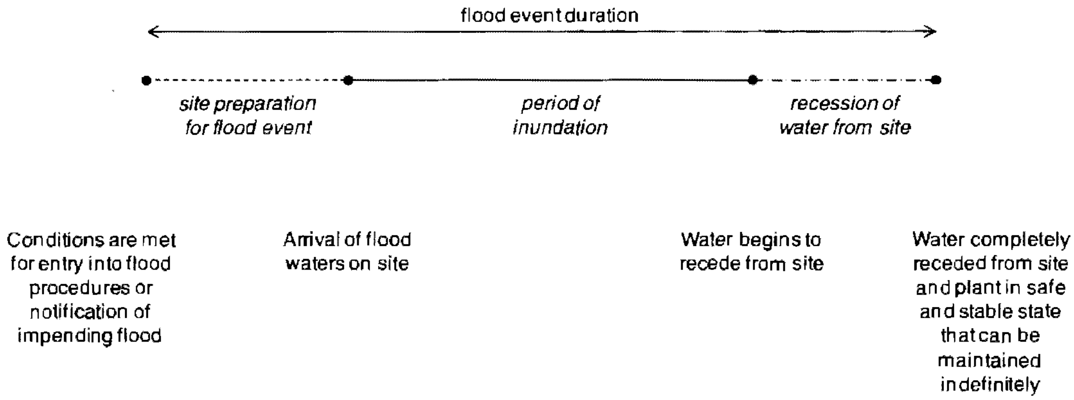

Figure 2.2-1. Flood Event Duration (NRC, 2012c)

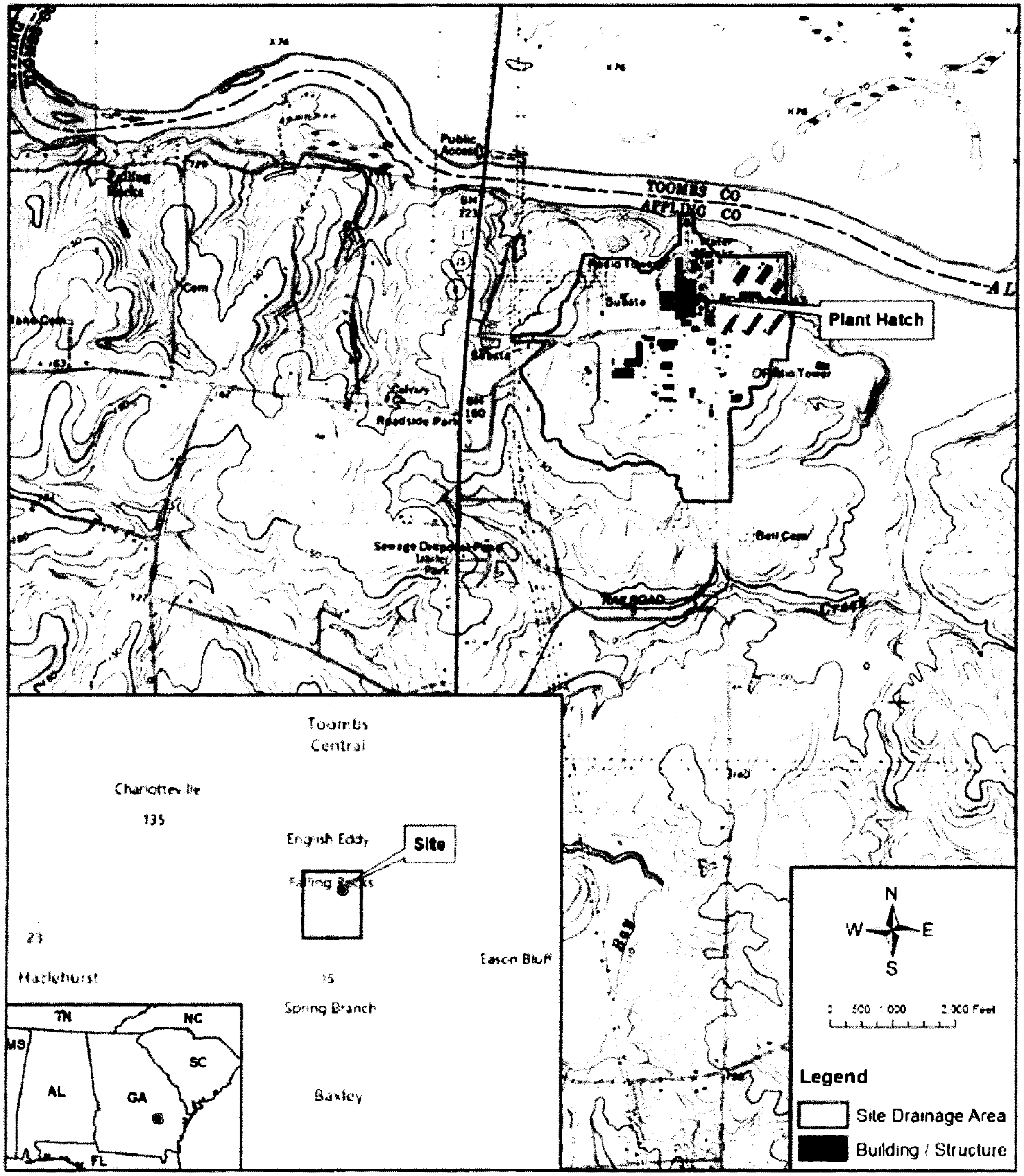

Figure 3.1.1-1: Map of Hatch location (from FHRR, SNC 2014a)

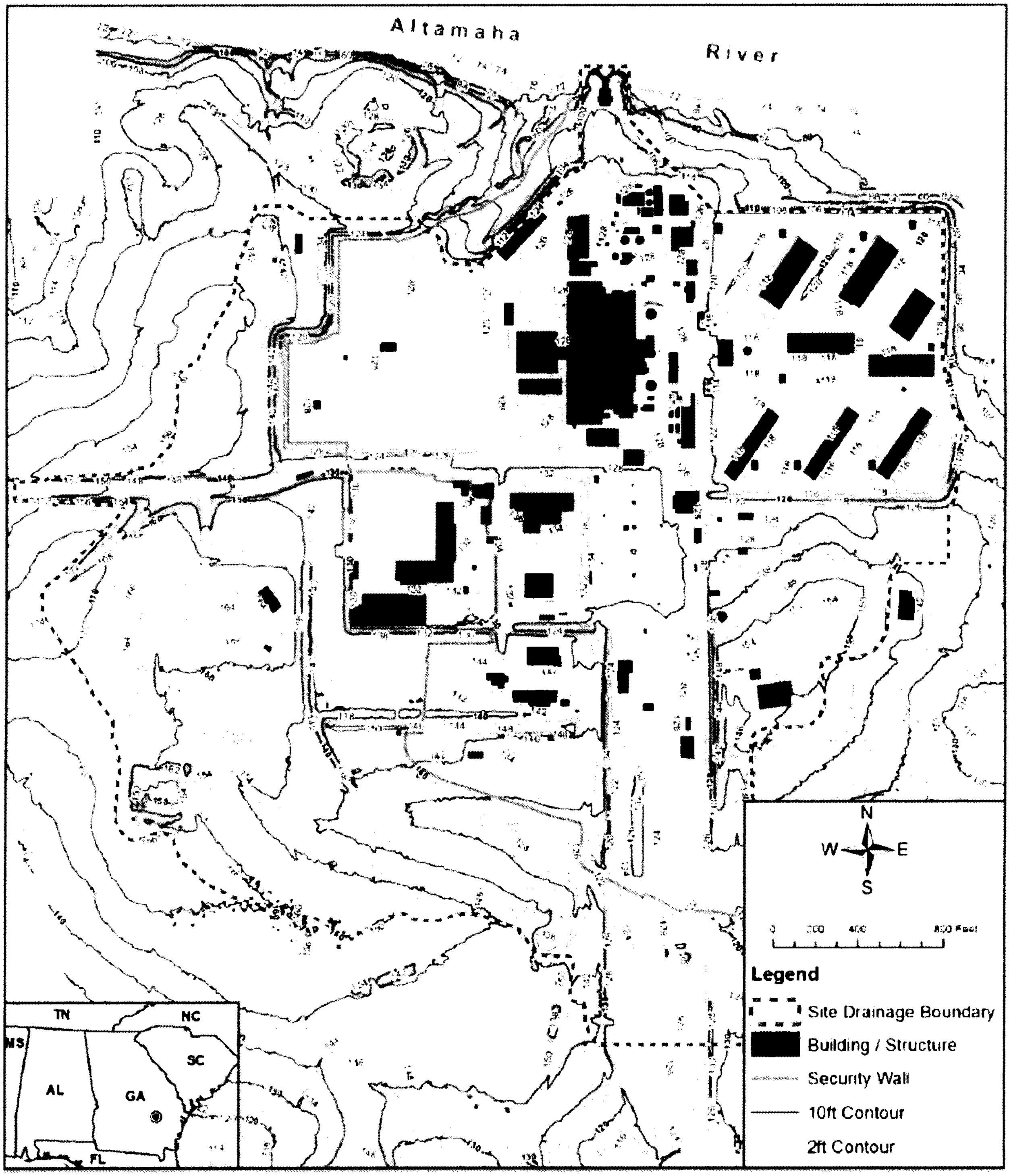

Figure 3.2-1: Site layout and topography (from FHRR, SNC 2014a)

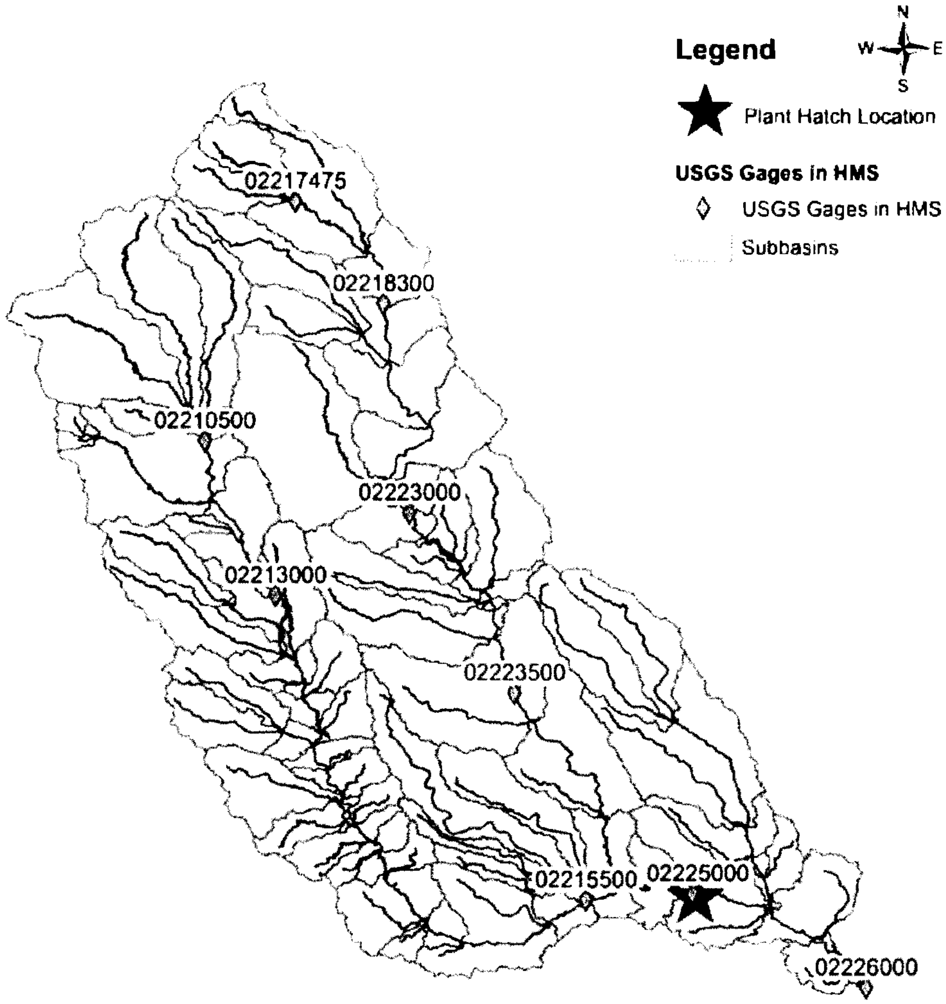

Figure 3.3-1: Streamflow and watershed locations (from FHRR, SNC 2014a)

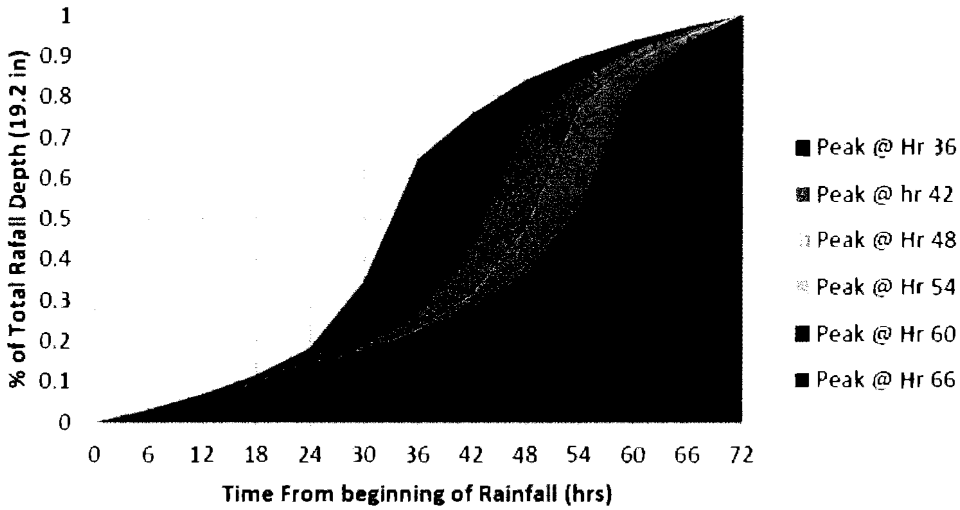

Figure 3.3-2: Temporal distributions of the critical PMP event (from FHRR, SNC 2014a)

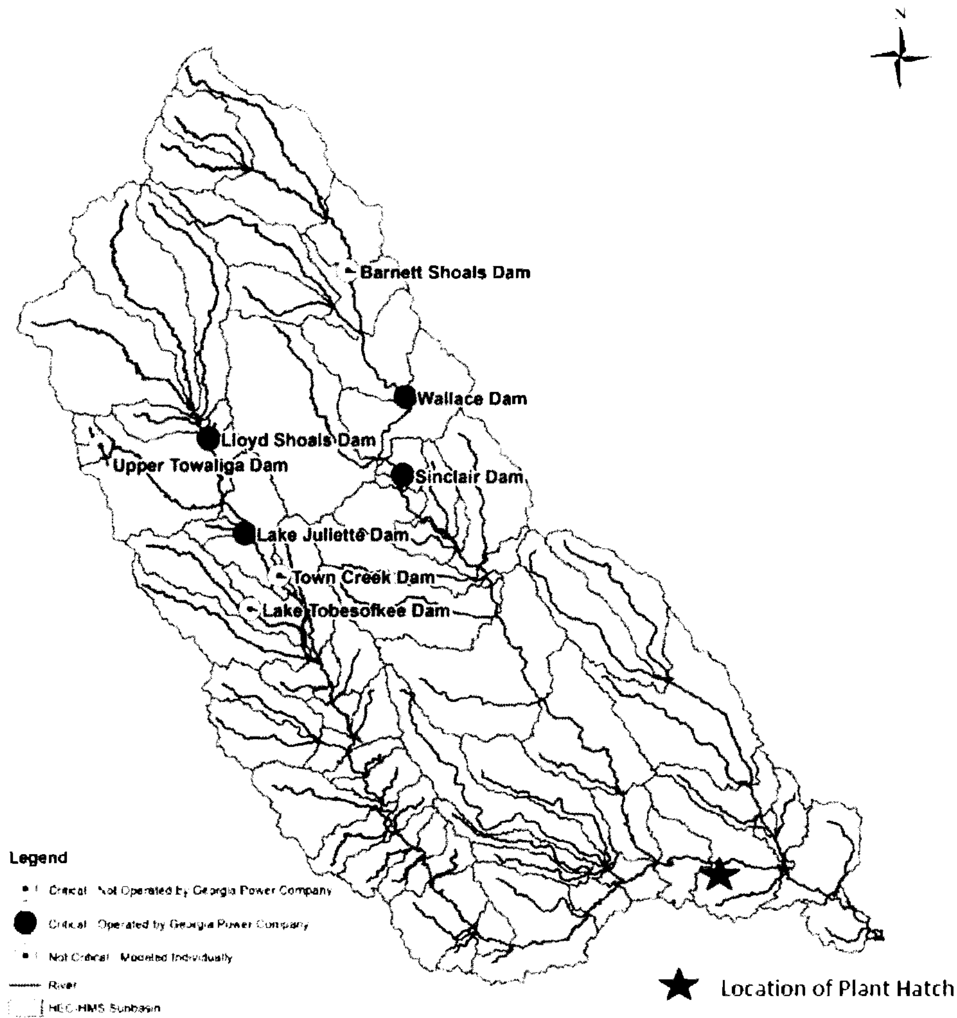

Figure 3.4-1: Hatch watershed and location of major dams (from FHRR, SNC 2014a)

If you have any questions, please contact me at (301) 415-1056 or e-mail at Lauren.Gibson@nrc.gov.

Sincerely,

/RA/

Lauren Gibson, Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear reactor Regulation

Docket Nos. 50-321 and 50-366

Enclosures:
1. Staff Assessment of Flood Hazard Reevaluation Report (non-public, security-related information)
2. Staff Assessment of Flood Hazard Reevaluation Report (public)

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