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

November 6, 2014

Mr. C. R. Pierce
Regulatory Affairs Director
Southern Nuclear Operating Company, Inc.
Post Office Box 1295, Bin 038
Birmingham, AL, 35201-1295

SUBJECT: VOGTLE ELECTRIC GENERATING PLANT, UNITS 1 AND 2 – STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST – FLOOD-CAUSING MECHANISM REEVALUATION (TAC NOS. MF1117 AND MF1118)

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 licensees to reevaluate flood-causing mechanisms using present-day methodologies and guidance.

By letters dated March 5, 2013, May 24, 2013, March 6, 2014 and May 28, 2014, Southern Nuclear Operating Company, Inc. responded to this request for Vogtle Electric Generating Plant Units 1 and 2.

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

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

Sincerely,

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

Docket Nos. 50-424 and 50-425

Enclosure:
Staff Assessment of Flood Hazard
Reevaluation Report

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STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO FLOODING HAZARD REEVALUATION REPORT

NEAR-TERM TASK FORCE RECOMMENDATION 2.1

RELATED TO THE FUKUSHIMA DAI-ICHI NUCLEAR POWER PLANT ACCIDENT

VOGTLE ELECTRIC GENERATING PLANT, UNITS 1 AND 2

DOCKET NOS. 50-424 AND 50-425

1.0 INTRODUCTION

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

Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood 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 individual plants. On May 11, 2012, the staff issued its prioritization of the FHRRs (NRC, 2012b).

If the reevaluated hazard for all flood-causing mechanisms is not bounded by the current plant design-basis flood hazard, an integrated assessment will be necessary. The FHRR and the responses to the associated requests for additional information (RAIs) will provide the hazard input necessary to complete the integrated assessment report as described in Japan Lessons-Learned Project Directorate (JLD) interim staff guidance (ISG) JLD-ISG-2012-05, "Guidance for Performing the Integrated Assessment for External Flooding." (NRC, 2012c).

By letter dated March 5, 2013 (Ivey, 2013), Southern Nuclear Operating Company, Inc. (SNOC, the licensee) provided the FHRR for Vogtle Electric Generating Plant (VEGP), Units 1 and 2. By letter dated February 7, 2014 (2014a), the NRC staff issued RAIs to the licensee. The licensee

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

responded to the RAIs by letters dated May 24, 2013 (Pierce, 2013), March 6, 2014 and May 28, 2014 (Pierce, 2014a and 2014b). The licensee did not identify any interim actions.

Because a reevaluated flood-causing mechanism is 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.

2.0 REGULATORY BACKGROUND

2.1 Applicable Regulatory Requirements

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

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

Section 50.54(f) of 10 CFR states that a licensee shall at any time before expiration of its license, upon request of the Commission, submit written statements, signed under oath or affirmation, to enable the Commission to determine whether or not the license should be modified, suspended, or revoked. The 50.54(f) letter issued on March 12, 2012, requested 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.

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-basis 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-basis are also to have sufficient margin to account for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

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

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

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

2.2 Enclosure 2 to the 50.54(f) Letter

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

2.2.1 Flood-Causing Mechanisms

Attachment 1 to Recommendation 2.1, Flooding (Enclosure 2 of the 50.54(f) letter) discusses flood-causing mechanisms for the licensee to address in its FHRR. Table 2.2-1 lists the flood-causing mechanisms the licensee should consider. Table 2.2-1 also lists the corresponding Standard Review Plan (NRC, 2007) sections and applicable interim staff guidance containing acceptance criteria and review procedures. The licensee should incorporate and report associated effects per JLD-ISG-2012-05 (NRC, 2012c) in addition to the maximum water level associated with each flood-causing mechanism.

2.2.2 Associated Effects

In reevaluating the flood-causing mechanisms, the "flood height and associated effects" should be considered. JLD-ISG-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[2]." 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 in the 50.54(f) letter (See Standard Review Plan (SRP) Section 2.4.2, Area of Review 9.(NRC, 2007)). Attachment 1 of the 50.54(f) letter describes the "Combined Effect Flood" as defined in ANSI/ANS 2.8-1992 (ANSI/ANS, 1992) as follows:

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

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

2.2.4 Flood Event Duration

Flood event duration was defined in the ISG for the integrated assessment for external flooding, JLD-ISG-2012-05 (NRC, 2012c), as the length of time during which the flood event affects the site. It begins when conditions are met for entry into a flood procedure, or with notification of an impending flood (e.g., a flood forecast or notification of dam failure), and includes preparation for the flood. It continues during the period of inundation, and ends when water recedes from the site and the plant reaches a safe and stable state that can be maintained indefinitely. Figure 2.2-1 illustrates flood event duration.

2.2.5 Actions Following the FHRR

For the sites where the reevaluated flood hazard is not bounded by the current design-basis flood hazard for all flood-causing mechanisms, the 50.54(f) 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
- Perform an integrated assessment subsequent to the FHRR to (a) evaluate the effectiveness of the current licensing basis (i.e., flood protection and mitigation systems), (b) identify plant-specific vulnerabilities, and (c) assess the effectiveness of existing or planned systems and procedures for protecting against and mitigating consequences of flooding for the flood event duration

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

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

3.0 TECHNICAL EVALUATION

The NRC staff reviewed the information provided for the flood hazard reevaluation of VEGP, Units 1 and 2. The licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance used by the NRC staff in connection with ESP and COL reviews. The staff's review and evaluation is provided below.

The plant grade elevation at the powerblock (e.g., all personnel entrances to Seismic Category I structures) is approximately 220 ft (67 m)[3] mean sea level (MSL)[4]. Table 3.0-1 provides the summary of controlling reevaluated flood-causing mechanisms, including associated effects, the licensee computed to be higher than the corresponding design basis values.

3.1 Site Information

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

To provide additional information in support of the summaries and conclusions in the FHRR, the licensee made several calculation packages available to the staff via an electronic reading room. These calculation packages expand upon and clarify the information provided on the docket.

The staff requested additional information from the licensee to supplement the FHRR. The licensee provided this additional information (Pierce, 2014a and 2014b), which is discussed in the appropriate sections below.

The 50.54(f) letter, Enclosure 2 (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 licensee described the following site information in its FHRR. The VEGP site consists of 3,169 acres (12.8 km^2) located on a coastal plain bluff on the southeast side of the Savannah River in eastern Burke County, Georgia. The VEGP site is directly across the river from the Department of Energy's Savannah River Site. The site is approximately 100 mi (160 km) north-northwest of Savannah, Georgia, approximately 26 mi (42 km) south-southeast of Augusta,

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3 The licensee's flood hazard reevaluation studies were conducted partly using conventional units of measure and partly using metric units. If the primary units (the units in which the measurement was made) were conventional units, a value in conventional units is followed by the equivalent in metric units, in parentheses. Because the units conversion may cause loss of precision, the measurement in primary units is definitive.

4 Unless otherwise stated, all elevations in this staff assessment are given with respect to the MSL datum.

Georgia, and approximately 15 mi (24 km) east-northeast of Waynesboro, Georgia. The site is approximately 150 river miles (240 km) from the mouth of the Savannah River. The contributing drainage area of the Savannah River at the site is 8,304 mi^2 (24,500 km^2).

The licensee stated that the onsite drainage is away from VEGP, Units 1 and 2 to local creeks which run to the Savannah River. VEGP, Units 3 and 4, which are now under construction, are located adjacent to the existing VEGP, Units 1 and 2. The plant grade elevation for all four units is approximately 220 ft (67 m). The Savannah River maintains a normal water elevation of approximately 80 ft (24 m). The VEGP site is not subject to flooding from nearby streams and rivers.

In its FHRR, the licensee provided a site layout map, shown as Figure 3.1-1 in this staff assessment, and described the safety-related structures and ultimate heat sink. The Final Safety Analysis Report (FSAR) for VEGP, Units 1 and 2 (SNOC, 2012a) and FSAR for VEGP, Units 3 and 4 (SNOC, 2011) provide more detailed descriptions of plant facilities. VEGP, Units 1 and 2 are Westinghouse pressurized-water reactors that began commercial operation in May 1987 and May 1989, respectively. VEGP, Units 3 and 4 are Westinghouse AP1000 reactors and are located west of and adjacent to the existing Units 1 and 2. The COL for VEGP, Units 3 and 4 was issued by the NRC on February 10, 2012. The licensee stated in its FHRR that the river flood hazard evaluations used for the VEGP, Units 3 and 4 COL application were used for the VEGP, Units 1 and 2 flood reevaluations except local intense precipitation (LIP) flooding analyses because the sites for existing and new units are adjacent and the data and approaches used to evaluate flood hazards for VEGP, Units 3 and 4 are valid.

The FHRR states that, during the construction of VEGP, Units 1 and 2, the VEGP, Units 3 and 4 site area was included in the grading plan. That is, the VEGP, Units 3 and 4 area was rough-graded to the plan which includes a drainage ditch south-southwest of the VEGP, Units 3 and 4 area to accommodate onsite 100-year storm runoff. This ditch also functions as a LIP drainage path for the VEGP, Units 3 and 4 area.

The licensee stated in its FHRR that the maximum total settlement, which is mainly due to backfill settlement, at the powerblock area for VEGP, Units 1 and 2 measured in 1986 was 3.6 in (9.1 cm). As a result of this settlement, the nominal design elevations (NDEs) are not the actual elevations of the structures. As part of the FHRR preparation, the licensee performed a site survey to confirm the actual elevations of floors at the NDE of 220 ft (67 m). The minimum elevation reported in the survey results was a measured elevation of 219.6 ft (66.9 m). For FHRR purposes , the licensee therefore established elevation 219.6 ft (66.9 m) as the NDE 220 ft for grade level structures.

3.1.2 Design-Basis Flood Hazards

The FHRR describes the current designbasis (DB) flood elevations for various flood causing mechanisms (except the LIP flooding), which are summarized in Table 3.1-1. This information was taken from Section 2.4 of the VEGP, Units 1 and 2 FSAR (SNOC, 2012a). For use in the FHRR, the licensee performed a current design-basis LIP flooding analyses, as summarized below.

To analyze the current design-basis LIP flooding on the VEGP Units 1 and 2 powerblock area, the licensee selected the VEGP Units 3 and 4 construction phase configurations as the worst case scenario among all plausible scenarios. The construction phase configurations include a double-row Vehicle Barrier System (VBS) around the perimeter of the VEGP, Units 1 and 2 powerblock area as an additional row of vehicle barriers was installed after the start of construction for VEGP, Units 3 and 4, and the construction phase drainage features for VEGP, Units 3 and 4, which is more onerous in terms of LIP flooding than that of the VEGP, Units 3 and 4 operation phase. The licensee used the 6-hour centrally distributed probable maximum precipitation (PMP) hyetograph in the VEGP, Units 1 and 2 FSAR (SNOC, 2012a) to determine the peak intensity is 15 in/hr (38 cm/hr). The LIP runoff drains to the surrounding areas by a sloped ground surface.

To simulate VEGP, Units 1 and 2 LIP flooding, the licensee used the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) model (USACE, 2010). The licensee's model has the following three subbasin components:

- the VEGP, Units 1 and 2 powerblock area basin,
- the VEGP, Units 3 and 4 inflow hydrograph, and
- a small watershed discharging into the VEGP, Units 1 and 2 powerblock area.

The HEC-HMS model estimates the runoff hydrographs from the entire VEGP Units 1 and 2 powerblock area which acts as a reservoir since the area is surrounded by VBS walls on all sides. This lumped parameter reservoir is characterized by one stage-volume curve and one stage-discharge curve which are used to estimate subbasin outflows.

The licensee used a 6-hour PMP scenario at 5-minute intervals with the PMP peak placed on the center of the hyetograph. The licensee also conservatively assumed that all catch basins and culverts are clogged by debris or sediment.

The licensee determined the inflow hydrograph from the VEGP Units 3 and 4 basin based on water levels established in a runoff analysis considering the construction phase when the VEGP, Units 3 and 4 powerblock had been backfilled and before the main east-west VEGP, Units 3 and 4 drainage ditch had been improved. During this phase, part of the flows in the main ditch is routed to the VEGP, Units 1 and 2 area through a diversion located adjacent to the main ditch. The licensee simulated the VEGP, Units 3 and 4 runoff using a combination of HEC-HMS (which is different from the VEGP, Units 1 and 2 HEC-HMS model) and an unsteady flow routing option in the Hydrologic Engineering Center's River Analysis System (HEC-RAS) (USACE, 2010). From this simulation, the licensee determined the overflow rates through the VBS.

From the series of modeling, the licensee determined a maximum LIP flood elevation in the VEGP Units 1 and 2 powerblock area of 219.1 ft (66.8 m). The licensee stated in FHRR Section 1.2.1 that this elevation is below the elevation of the safety-related structures and therefore concluded that the safety-related structures for VEGP, Units 1 and 2 are not flooded during the VEGP, Units 3 and 4 construction phase.

3.1.3 Flood-related Changes to the Licensing Basis

The licensee noted in their FHRR that there have been no flood-related changes or changes to flood protection measures beyond the flood protection measures in place for the current design-basis.

3.1.4 Changes to the Watershed and Local Area

The licensee stated in its FHRR that there are no substantial changes in the Savannah River watershed that could potentially affect the flooding in streams and rivers. However, the licensee noted that the changes to the local area resulting from VEGP, Units 3 and 4 construction activities would affect the flooding induced by LIP events at the site of VEGP, Units 1 and 2. The licensee addressed the potential effects of these changes on flooding in FHRR Section 2.1.

3.1.5 Current Licensing Basis Flood Protection and Pertinent Flood Mitigation Features

The licensee stated in its FHRR that the plant site is on a high plateau and is not in the path of adjacent streams or rivers. The licensee further concluded that the safety-related plant structures are not affected by the most severe Savannah River flooding. The licensee stated that LIP could be a potential source of onsite flooding. However, the site grading was planned and constructed so that onsite runoff is directly discharged through culverts and open ditches to the surrounding streams. The licensee's evaluation of the VEGP, Units 1 and 2 design-basis maximum flood level from LIP is lower than the plant grade elevation at the powerblock.

3.1.6 Additional Site Details to Assess the Flood Hazard

Table 2.4.1-2 of the VEGP, Units 1 and 2 FSAR (SNOC, 2012a) summarizes safety-related structures with doors and accesses. The safety-related structures include the Control Building, Auxiliary Building, Containment, Diesel Generator Building, Auxiliary Feedwater Pumphouse, and Nuclear Service Cooling Water Pumphouse. The licensee stated that the Nuclear Service Cooling Water Towers, which are Seismic Category 1 concrete mechanical draft structures, serve as an ultimate heat sink system (SNOC, 2012a). These towers house the equipment required to cool the heated nuclear service water, and the tower basins were designed to store and supply sufficient cooling water.

3.1.7 Plant Walkdown Activities

The 50.54(f) letter, Requested Information Item 1.c and Attachment 1 to Enclosure 2, Step 6, requests the licensee to report any relevant information from the results of the plant walkdown activities associated with Enclosure 4 of the 50.54(f) letter. The licensee submitted the walkdown report by letter dated November 27, 2012 (SNOC, 2012d). In its staff assessment report (NRC, 2014b) the staff concluded that the licensee's implementation of flooding walkdown methodology met the intent of the walkdown guidance.

3.2 Local Intense Precipitation and Associated Drainage

The licensee reported in its FHRR that the reevaluated flood elevations, including plausible associated effects, for LIP is 219.3 ft (66.84 m). This flood-causing mechanism is not described in the licensee's design-basis in the FSAR for VEGP, Units 1 and 2 (SNOC, 2012a), but is described in FHRR Section 1.2.1 as a recalculation. The recalculated design-basis flood elevation for the LIP and associated site drainage hazard reported in the FHRR is 219.1 ft (66.78 m).

The staff requested additional information from the licensee to supplement the FHRR. The licensee (Pierce, 2014a and 2013b) provided the additional information which is discussed below.

The staff reviewed the LIP and associated site drainage, including associated effects, against the relevant regulatory criteria based on present-day methodologies and regulatory guidance.

3.2.1 Local Intense Precipitation

For its reevaluation of LIP flooding, the licensee initially applied a 6-hour PMP scenario with the maximum 1-hour PMP depth of 19.2 in (48.8 cm). The licensee stated that the reevaluated PMP scenario is consistent with the results presented in the VEGP, Units 3 and 4 FSAR (SNOC, 2011) and is also in accordance with NUREG/CR-7046 (NRC, 2011).

In its FHRR, the licensee reported LIP PMP depths for 5-min, 15-min, 1-hour, 2-hour, 3-hour, and 6-hour durations. In its response to RAI No. 5 (Pierce, 2014b), the licensee also considered 12-hour, 24-hour, 48-hour, and 72-hour PMP scenarios for their LIP flood analyses. These PMP values are summarized in Table 3.2-1 of this report. The licensee stated in its RAI response that it did not consider a 72-hour PMP event because it would provide essentially the same outcome. These values were estimated based on Hydrometeorological Report 51 (HMR 51) (NOAA, 1978) and HMR 52 (NOAA, 1982). The licensee used these PMP depths to develop a depth-area-duration curve and generated a 5-min interval hyetograph which represents the distribution of precipitation over time.

The staff confirmed the licensee's maximum 1-hour duration precipitation depth using HMR 52 Figure 24 and the 5-min and 15-min duration precipitation depths using HMR 52 Figure 36 and HMR 52 Figure 37, respectively. The staff also confirmed the PMP durations longer than 6-hour duration from the figures provided in HMR 51. The staff linearly interpolated between the 1-hour and 6- hour duration precipitation depths to obtain 2-hour and 3-hour duration values. As a result, the staff found that the licensee's PMP values are accurate..

3.2.2 Runoff Analyses

In its FHRR, the licensee described the process of LIP runoff reevaluation that involves several separate calculations. The ultimate endpoint of these calculations is to determine the maximum flood elevation in the area containing the safety structures for VEGP, Units 1 and 2. The licensee used the Hydrologic Engineering Center's Hydraulic Modeling System (HEC-HMS) (USACE, 2010a) to simulate a rainfall-runoff scenario.

In simulating the runoff process, the licensee adopted a conceptual level-pool model. The level-pool model is based on a direct, dynamic representation of the conservation of mass which states the change in storage is equal to the inflow less the outflow. In this model, the inflow consists of (1) the LIP runoffs on the area bounded by the VBS around the VEGP, Units 1 and 2 powerblock area, (2) the water estimated to overflow from the adjacent area where new VEGP Units 3 and 4 are being constructed, and (3) runoff from a small watershed. The outflow rates were estimated based on the stage-discharge and storage-elevation relationships for the area encircled by the VEGP, Units 1 and 2 VBS. The licensee constructed the storage-elevation relation based on ground surface elevation data (Pierce, 2014a and 2014b).

3.2.3 Level-Pool Runoff Analysis for the VEGP, Units 1 and 2 Area

FHRR Section 2.1 discusses a HEC-HMS modeling approach to estimate the new design-basis LIP flood hazard within the area encircled by the VEGP, Units 1 and 2 VBS as shown on Figure 3.2-1. The same modeling approach was used for the reevaluation with changing PMP values. The licensee initially used a 6-hour duration PMP scenario as described in the FHRR. The licensee later submitted the result of the maximum LIP flood elevations for three additional PMP durations (e.g., 12-, 24-, and 48-hour) (Pierce, 2014b). This additional information indicates that the predicted maximum water-surface elevations and outflow rates for different PMP durations are nearly identical as they used bounding basin runoffs, but times to peak are different.

VBS is a concrete barrier encircling the VEGP, Units 1 and 2 powerblock area of approximately 66 acres (0.27 km^2). Currently, VBS has a double row of barriers, and the second row of barriers was installed after the construction of Units 3 and 4 was started. The newer VBS row is mostly located outside the older VBS row. The ground elevations on the VBS area are much lower than the plant grade, so that runoff from the powerblock area would drain away. The height of the older VBS is

3.5 ft (1.1 m), and the minimum elevation of the top of VBS is approximately 218.5 ft (66.6 m). The FHRR states that the area within the perimeter of the double row VBS is modeled as a lumped-parameter reservoir. Because the plant grade is sloped from the center of the powerblock to the perimeter near the VBS, runoff will collect in the inside area of VBS. Eventually, water will overflow the top of VBS, and the VBS will act like a broad-crested weir.

The licensee used several conservative assumptions as part of its LIP flooding reevaluation. The key assumptions are that all storm drains beneath the VBS would be completely blocked by debris and sediment, and that no water would flow through or between gaps on the VBS units (e.g., pedestrian openings and vehicle entrance gates). The staff agrees that these assumptions are conservative. The flow over the VBS in the licensee's model is represented by a standard weir equation. Where an outer row of VBS causes the inner row to be submerged, the weir representation is corrected for downstream submergence. The licensee provided additional information on the VBS overflow representation, including the calculations of weir flow and simulations of LIP flood on the site using the HEC-HMS (Pierce, 2014a and 2014b).

The maximum level-pool elevation estimated using the HEC-HMS model applied to the VEGP, Units 1 and 2 area is the basis for the licensee's LIP flooding hazard reevaluation. The licensee's model has the following three subbasin components: (1) a subbasin representing the entire VEGP, Units 1 and 2 powerblock area, (2) the VEGP, Units 3 and 4 area which is treated as an inflow hydrograph in the model, and (3) a small watershed discharging into the VEGP, Units 1 and 2 powerblock area. The staff reviewed each subbasin component to determine whether the conceptual model for LIP runoff described by the licensee was appropriately represented or not.

As a result of the review, the staff found that the entire VEGP, Units 1 and 2 powerblock area is modeled by a single subbasin as a reservoir. An external model was used to determine a state-discharge relation within this subbasin. The licensee assumed that the subbasin is represented by a level-pool conceptual model. The level-pool model is a direct representation of the principle of the conservation of mass which states the change in storage is equal to the inflow less the outflow. One of the major input variables on the model is runoff created by a PMP scenario within the powerblock area. The licensee applied a level-pool assumption for water that flows within the subbasin and collects behind the VBS.

The staff reviewed the licensee-provided onsite topography map (Pierce, 2014a). The staff noted that the some elevations for the VEGP, Units 1 and 2 area, especially in the central powerblock area, are higher than the nominal plant grade. The area near the Reactor Buildings and Turbine Buildings, which are safety-related structures, are well above elevation 220 ft (67 m). The staff noted that this critical building area would be inundated significantly by accumulated runoffs from nearby building roofs and the LIP flood levels on this critical area would be much higher than the licensee's estimated elevation of 219.3 ft (66.8 m), which is lower than the land surface elevations. The staff found that one uniform water-surface level estimated on the top of the VBS system cannot represent the varying flood elevations at all locations within the VEGP, Units 1 and 2 area, especially at the center of the powerblock area which is where many safety-related buildings are located.

The NRC staff recognized that the level-pool model results in underestimating the maximum LIP flood levels on the center of the VEGP, Units 1 and 2 powerblock area. This underestimation is due to the effect of averaging of the spatially-varying LIP floods within the powerblock area using a single subbasin. The staff noted that the licensee's approach used in the reevaluation is quite different from that of the COL approach where the licensee used a HEC-HMS model with over 30 subbasins to simulate LIP floods within the powerblock area (SNOC, 2012c). Since the LIP flooding mechanism is being evaluated as part of an integrated assessment, the staff determined that this numerical modeling issue can be appropriately resolved as part of the integrated assessment. Specifically, the licensee is requested to reevaluate LIP flood parameters, including flood elevations and associated durations, in the center of the VEGP, Units 1 and 2 powerblock area. This is Integrated Assessment Open Item No. 1.

3.2.4 Overflow from the VEGP, Units 3 and 4 Area into the VEGP, Units 1 and 2 Area

The licensee used HEC-HMS (USACE, 2010a) and HEC-RAS (USACE, 2010b) in its reevaluation of the runoff from the VEGP, Units 3 and 4 area. That is, the licensee used HEC-HMS to simulate the runoffs in the Units 3 and 4 caused by a PMP event. The time series of the runoff generated with the HEC-HMS model were input into HEC-RAS to estimate the overflows from the VEGP, Units 3 and 4 domain into the VEGP, Units 1 and 2 domain. The licensee's HEC-RAS analysis is based on a hydraulic routing of the runoff and a lateral weir option to estimate the water-surface elevations and overflow rates over time.

The licensee assumed that a portion of the inflow considered in the level-pool analysis discussed above originates from the VEGP, Units 3 and 4 site area. The water then enters through the west portion of the VEGP, Units 1 and 2 area. The licensee considered both the site grade of VEGP, Units 3 and 4 after construction and the site grade during construction. The licensee determined that the most conservative scenario for overflow would be associated with the site grade during the construction phase of VEGP, Units 3 and 4.

The licensee applied the one-dimensional hydraulic model HEC-RAS to estimate the overflow across a lateral weir. The licensee also used a lateral weir option to represent the flow over the VBS from the VEGP, Units 3 and 4 domain into the level-pool analysis domain. The endpoint of this calculation was the discharge over the VBS from VEGP, Units 3 and 4 into the VEGP Units 1 and 2 VBS domain. The licensee conservatively assumed no potential for flow from the VEGP Units 1 and 2 domain into the VEGP, Units 3 and 4 domain. The model input in this evaluation is the time series of discharges from a hydrologic routing model discussed in the following section. The licensee modeled hydraulic routing along the drainage ditch with an assumption that onsite culverts are totally blocked by debris and sediments. The staff performed a confirmatory analysis with the HEC-RAS model input files provided by the licensee and confirmed that the model was implemented consistently with the approach stated in the FHRR.

3.2.5 Runoff from VEGP Units 3 and 4 Area

The runoff time series used as the input for the hydraulic routing discussed in the prior section is based on hydrologic routing of the LIP runoff from the VEGP, Units 3 and 4 powerblock area. The licensee used the HEC-RAS model to simulate runoffs from 15 subbasins that divide the entire VEGP, Units 3 and 4 powerblock area as described in the FHR Section 1.2.1. The staff performed a confirmatory analysis with the HEC-HMS model input files provided by the licensee and confirmed that the model was implemented consistently with the approach stated in the FHRR.

3.2.6 Summary

The licensee determined that the reevaluated maximum water-surface elevation in the VEGP, Units 1 and 2 powerblock area would be 219.3 ft (66.84 m), which exceeds the design-basis value. Therefore, the licensee stated in its FHRR and RAI response (Pierce, 2014a and 2014b) that an integrated assessment will be prepared for LIP flooding.

The information on flooding from a LIP event and associated site drainage that is specific to the data needs of the integrated assessment is described in Section 4 of this staff assessment.

The NRC staff confirmed the licensee's conclusion that the reevaluated flood hazard for LIP and associated site drainage is not bounded by the current design-basis flood hazard; therefore, the licensee should include LIP and associated site drainage within the scope of the integrated assessment. The staff also determined that the licensee should reevaluate LIP flood parameters, including flood elevations and associated durations, on the center of the VEGP, Units 1 and 2 powerblock area, and include that reevaluation in the integrated assessment. as part of the Integrated Assessment Open Item No. 1.

3.3 Streams and Rivers

The licensee reported in its FHRR that the reevaluated hazard, including associated effects, for site flooding from streams and rivers is 151 ft (46 m). This flood-causing mechanism is described in the licensee's current design-basis. The current design-basis hazard for site flooding from streams and rivers is 165 ft (50.3 m).

The staff requested additional information from the licensee to supplement the FHRR. The licensee provided this additional information by letter dated March 6, 2014 (Pierce, 2014a) and May 28 2014 (Pierce, 2014b).

The staff reviewed the licensee's evaluation of site flooding from streams and rivers, including associated effects, against the relevant regulatory criteria based on present-day methodologies and regulatory guidance below.

The FSARs for both existing and new VEGP units (SNOC, 2012a and 2012c) describes the approach to determine the design-basis probable maximum flood (PMF) on the Savannah River. The licensee ran both the HEC-1 (an earlier version of HEC-HMS) and the NWS DAMBRK (Fread, 1988) numerical models to route the PMF outflows from J. Strom Thurmond Dam past the VEGP site. The licensee obtained the PMF rate of 710,000 cfs (20,100 cms) and corresponding flood elevation of 138 ft (42.1 m). The licensee's results for the flood elevation with wave effects is elevation 165 ft (50.3 m).

For the reevaluation, the licensee estimated the PMF rate of 920,000 cfs (26,000 cms) based on amethod recommended by NRC Regulatory Guide 1.59 (NRC, 1977). This method is based on a relationship for the PMF discharge as a function of watershed area. This method does not require development of a basin-wide PMP value and generally results in conservatively-high discharge values.

To determine flood elevations in the river near the VEGP site, the licensee used the numerical model HEC-RAS (USACE, 2010). The model was originally developed for simulating dam failure flood analyses (SNOC, 2011) on the Savannah River.

Using the HEC-RAS with the PMF rate of 920,000 cfs (26,000 cms) as an upstream inflow, the licensee obtained the maximum stillwater PMF elevation of 139 ft (42.4 m) or the PMF elevation with reevaluated wind effects of 151 ft (46 m), which is lower than the plant grade, as well as the design-basis flood elevation. The licensee submitted the HEC-RAS input and output files used in evaluating river PMF (Pierce, 2014a and 2014b), which were reviewed by the staff.

During the review of the VEGP, Units 3 and 4 ESP and COL applications, the NRC staff reviewed the previous version of the HEC-RAS simulations and concluded that the methodologies and estimations used to determine the river PMF are acceptable (NRC, 2009b and 2012d). This conclusion was based on the result of the staff's bounding PMF analysis. The staff discusses the flood hazards caused by a combination of river PMF and dam failure in the next section.

In summary, the staff confirmed the licensee's conclusion that the PMF from the Savannah River could not inundate the plant site. The staff also confirmed the licensee's conclusion that the reevaluated flood elevation for stream and river flooding is bounded by the current design-basis flood hazard.

3.4 Failure of Dams and Onsite Water Control/Storage Structures

The licensee reported in its FHRR that the reevaluated PMF elevation, including associated effects, for site flooding due to failure of dams and onsite water control/storage structures is 178.1 ft (54.3 m). This flood-causing mechanism is described in the licensee's current design-basis. The current design-basis hazard for dam failure flooding from streams and rivers is 168 ft (51.2 m).

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

The licensee stated in its FHRR that it adopted Section 2.4.4, Dam Failures, of the VEGP, Units 3 and 4 FSAR (SNOC, 2012c) to represent the reevaluation of dam failure flooding for VEGP, Units 1 and 2. The licensee selected 14 major dams in the Savannah River basin. To demonstrate that the site is not inundated by dam failure flooding, the licensee postulated a domino-type failure of two large dams: Russell Dam and J. Strom Thurmond Dam. In addition to the dam failure scenario, the U.S Army Corps of Engineers (USACE) - defined Standard Project Flood (SPF) was simultaneously applied in the HEC-RAS simulation. In order to create a simplified, yet conservative, dam failure flooding scenario, the storage volume of Russell Dam was increased in the model by adding the sum of the storage volumes of the 12 upstream reservoirs, including Jocassee, Keowee, and Hartwell. Russell Dam was assumed to fail by overtopping during an upstream flood. The licensee considered several breach parameter equations and justified the selected conservative breach parameter set. Using the HEC-RAS model with the above combined scenario, the licensee simulated a peak flood rate of 2,233,000 cfs (63,200 cms) and a maximum flood elevation of 166.8 ft (50.8 m) or a flood level with 2-year wind effects of 178.1 ft (54.3 m).

The NRC staff previously reviewed the above dam failure flood analyses for the VEGP, Units 3 and 4 ESP application (NRC, 2009b and 2012d). Based on a sensitivity analysis with conservative upstream inflows, the staff confirmed that the discharge conservatively estimated using the HEC-RAS steady flow analysis was approximately 5.9 million cfs (0.17 million cms) (NRC, 2009b). Using the increased discharge rate and a 50 percent increase in dam breach areas, the staff produced a conservative peak flood stage of 170.1 ft (51.8 m) which is well below the plant grade.

During review of the FHRR, the staff found that the dimensions of dams, including heads and storage volumes on FHRR Table 2.4-215, are slightly different from the latest information on the National Inventory of Dams (NID) database (USACE, 2013). The staff noted that the differences are due to the definitions of storage volume: the FHRR incorporates the USACE data used to establish the SPF on the basin while the NID uses the physical maximum properties. Therefore, the staff performed a bounding confirmatory analysis, as discussed below.

From the NID database, the staff identified a total of 725 dams within the river basin. The total storage volume of these reservoirs is 11.3 million acre-feet (ac-ft) (13.9 cubic kilometers (km^3)). Most of the reservoirs are small in terms of storage volumes, and the ten largest reservoirs by storage volume account for over 97 percent of the total storage volume (see Table 3.4-1). This result indicates that the licensee's selection of 14 major dams is appropriate as they mostly overlap the ten largest dams listed on Table 3.4-1. Using the NID data, the staff calculated the breach peak outflows from each failed reservoir using the peak flow equation by Froehlich (1995) and the United States Bureau of Reclamation (USBR) attenuation equation (1982). Table 3.4-1 lists the estimated peak flows attenuated at the plant site, or a total breach peak flow rate of 1,118,000 cfs (31,600 cms). On this estimation, the staff assumed that the breach outflows are transferred to the plant site instantly and simultaneously without losses. Adding the dam failure peak flow and the PMF discharge of 920,000 cfs (26,000 cms), the staff obtained a combined peak flow rate of 2,038,000 cfs (57,700 cms), and the corresponding stage with 2-year wind effects of 177.3 ft (54 m) (from Figure 3.4-1) which is below the plant grade.

The staff noted that the staff's bounding analysis is conservative because (1) all breach outflows from main river and tributary arrive to the basin outlet instantaneously and simultaneously, and (2) the staff-estimated attenuated peak flows using the USBR attenuation equation are conservative as the equation was developed based on the bounding of historical values (USBR, 1982). As the licensee's dam failure flood elevation is nearly identical to the staff's two bounding analyses discussed above, the staff determined that the licensee's reevaluation of the dam failure flood analysis is acceptable. The staff also determined that other associated effects on the site caused by hydrodynamic loading, debris, sediment, groundwater ingress, or adverse weather conditions are insignificant or not applicable to the dam failure flooding on the Savannah River. The staff notes that there is no onsite water control/storage structures that could cause dam failure related floods.

In summary, the staff confirmed the licensee's conclusion that, the reevaluated hazard for flooding from the failure of upstream dams on the Savannah River is not bounded by the current design basis flood hazard. Therefore, the licensee stated in its response to RAI No. 9 (Pierce, 2014b) that they will include dam failure flood analysis on the Savannah River within the scope of the integrated assessment. The staff expects that the integrated assessment on dam failure flooding will be limited as protection is provided by natural terrain.

3.5 <u>Storm Surge</u>

The licensee reported in its FHRR that the reevaluation of the hazard, including associated effects, for site flooding due to storm surge is not expected to affect the plant site. This flood-causing mechanism is not described in the licensee's current design basis.

The licensee concluded in its FHRR that storm surge would not cause onsite flooding because the VEGP site is 150 river miles (240 river km) inland from the coast and the plant grade elevation of 220 ft (67.1 m) is approximately 150 ft (45.7 m) above the bottom of the Savannah River. Recently, the NRC staff reviewed the potential for flooding due to storm surge associated with the VEGP, Units 3 and 4 ESP and COL application, and concluded that storm surge flooding on the Savannah River will not inundate the plant site (NRC, 2009b and 2012d).

In summary, the staff confirmed the licensee's conclusion that the flooding from storm surge could not inundate the plant site. The staff also confirmed the licensee's conclusion that the flooding from reevaluated hazard for flooding from storm surge is bounded by the current design basis flood hazard.

3.6 Seiche

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

The licensee concluded in its FHRR that seiche would not cause onsite flooding because the VEGP site is 150 river miles (240 river km) inland from the coast and at the plant grade elevation of 220 ft (67.1 m) which is about 150 ft (45.7 m) above the bottom of the Savannah River.

Recently, the NRC staff reviewed the potential for flooding due to seiche associated with the VEGP, Units 3 and 4 ESP and COL application, and concluded that the seiche flooding on the river will not inundated the plant site (NRC, 2009b and 2012d).

In summary, the staff confirmed the licensee's conclusion that the flooding from seiche alone could not inundate the plant site. The staff also confirmed that the reevaluated hazard for flooding from seiche is bounded by the current design-basis flood hazard.

3.7 Tsunami

The licensee reported in its FHRR that the reevaluation of the hazard, including associated effects, for site flooding due to tsunami is not expected to affect the plant site. This flood-causing mechanism is not described in the licensee's current design-basis.

The licensee stated in its FHRR that a tsunami would not cause flooding of the site because the VEGP site is 150 river miles (240 river km) inland from the coast and at the grade elevation of 220 ft (67.1 m) which is about 150 ft (45.7 m) above the bottom of the Savannah River. Recently, the NRC staff reviewed the potential for flooding due to tsunami associated with the VEG,P Units 3 and 4 ESP and COL application, and concluded that the tsunami flooding on the river will not inundated the plant site (NRC, 2009b and 2012d).

In summary, the staff confirmed the licensee's conclusion that the PMF from tsunami alone could not inundate the site. The staff also confirmed that the reevaluated hazard for flooding from tsunami is bounded by the current design-basis flood hazard.

3.8 Ice-Induced Flooding

The licensee reported in its FHRR that the reevaluated PMF, including associated effects, due to ice-induced event is not expected to affect the plant site. This flood-causing mechanism is not described in the licensee's current design-basis.

Based on a search of the Ice Jam Database of USACE (USACE, 2013), the licensee stated in its FHRR that there are no recorded ice jam events in the lower reach of the Savannah River. The licensee also stated that the formation of frazil ice or ice jams would be very unlikely in the vicinity of the plants because the water temperatures in the river remain constantly above freezing.

During the review of VEPG, Units 1 and 2 FSAR Section 2.4.7 the NRC staff confirmed that there is no potential for ice-induced flooding at the plant site (NRC, 2009b and 2012d). As part of the FHRR review, the staff checked the recent Ice Jam Database of USACE (USACE, 2013) and confirmed that there is no recorded ice jams and associated flooding on the Savannah River in the vicinity of site since completion of the ESP and COL reviews. Therefore, the staff determined that the licensee's conclusion on the ice-induced flooding is acceptable.

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

3.9 Channel Migrations or Diversions

The licensee reported in its FHRR that the reevaluated probable maximum flood, including associated effects, due to channel migrations or diversions is not expected to affect the plant site. This flood-causing mechanism is not described in the licensee's current design-basis.

The licensee analyzed in the VEPG, Units 1 and 2 FSAR ,the channel diversion flooding at the site with respect to seismic, topographical, and geological evidence. The licensee found that the surrounding topography in the region consists of gently rolling stable hills with well-developed dendritic creeks so that the river will flow freely without interruptions. The licensee noted that the Savannah River near the site has relatively straight and stable reach and that a comparison of historical topographic maps between 1965 and 1989 shows a nearly unchanged river plan-form within the reach during this period. Moreover, the Savannah River discharge has been regulated by several large multipurpose dams upstream of the VEGP site since 1952, which resulted in reducing the peak flows and thus river morphological activity. Therefore, the licensee concluded that channel diversion and flooding into the Savannah River is highly unlikely.

However, the licensee stated that the diversion of the upstream river course in this region cannot be completely discounted because the river beds are typically underlain by sands, clays, limestones, and gravels, and the course is sinuous on a mild, wide floodplain, potentially impacting the plant water supply but not on flooding. Therefore, the licensee concluded that the channel diversion flooding would not inundate the plant site. The licensee noted that river division or bluff sliding to the river could impact the intake structures which are not safety-related.

In summary, the staff confirmed the licensee's conclusion that the PMF from channel migrations or diversions could not inundate the site. The staff also confirmed that the reevaluated hazard for flooding from channel migrations or diversions is bounded by the current design basis flood hazard.

4.0 INTEGRATED ASSESSMENT AND ASSOCIATED HAZARD DATA

The staff confirmed that the reevaluated hazard results for multiple mechanisms are not bounded by the current design-basis flood hazard. Therefore, the staff concludes that an integrated assessment is necessary, which is consistent with the licensee's statement provided by the response to RAI No. 9 (Pierce, 2014b). That is, LIP flooding exceeds the design basis thus should be evaluated under the integrated assessment. The reevaluated dam failure flooding on the Savannah River is also not bounded by the design basis. The NRC staff agrees with the licensee's conclusion that the dam failure flooding does not inundate the plant site and thus the resulting integrated assessment is expected to be limited in scope.

Section 5 of JLD-ISG-2012-05 (NRC, 2012c) describes the flood hazard parameters needed to complete the integrated assessment. The staff reviewed the following subset of these flood hazard parameters to conclude that the flood hazard information is appropriate input to the integrated assessment:

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

Consistent with the licensee responses to RAIs 8 and 9 (Pierce, 2014a and 2014b), the applicable flood events that trigger an integrated assessment from the FHRR for VEGP, Units 1 and 2 are:

- A maximum LIP level with no associated effects of 219.3 feet (66.8 m), which is 0.2 feet (0.06 m) above the current design-basis LIP level.
- A maximum dam breach flood level with wind effects of 178.1 ft (54.3 m) on the Savannah River, which is 10.1 ft (3.1 m) above the current design-basis dam breach flood level that includes wave effects but are well below the plant grade.

The staff requested, via an RAI (NRC, 2014a), the licensee to provide the applicable flood event duration parameters associated with mechanisms that trigger an integrated assessment. The relevant 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 off the site for the mechanisms that are not bounded by the current design-basis. The licensee's response (Pierce, 2014a and 2014b) to this RAI is summarized below:

- For the LIP flooding, warning time of several hours (usually more than 12) based on local forecasts of storm events with the potential for very large precipitation volumes.
- For the dam breach flooding, warning time of about 12 hours until the initial flood wave begins to arrive at the site location on the Savannah River and about 34 hours until the peak water level arrives at the site location. The times are based on the travel time for the flood wave to travel down the Savannah River after breach of the J. Strom Thurmond Dam
- Flood inundation duration and recession time are zero for dam failure floods because the reevaluated flood elevations are below the plant grade.

The licensee used 6-hour, 12-hour, 24-hour, and 48-hour PMP scenarios for LIP flood analyses (Pierce, 2014a and 2014b). Flood elevation duration parameters are provided in Table 4.0-1. However, the staff determined that the licensee needs to refine the evaluation of the LIP flood parameters (e.g., flood levels and inundation times) near the safety-related facilities in the center of the powerblock area, as discussed in the Integrated Assessment Open Item 1. Therefore, the staff determined that, as part of the integrated assessment, the licensee should refine the total 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. 2.

Based upon the preceding analysis, staff confirmed that the reevaluated flood hazard information defined in the sections above, with the exception of identified open items, is appropriate input to the integrated assessment. The staff notes that the proposed integrated assessment open items as well as the bases for flood duration parameters (e.g., warning time based on existing agreements) may be further evaluated as part of the integrated assessment.

5.0 CONCLUSION

The NRC staff has reviewed the information provided for the reevaluated flood-causing mechanisms for VEGP, Units 1 and 2. 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 on 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, the staff confirmed the licensee's conclusions that (a) the reevaluated flood hazard result for LIP and dam failure are not bounded by the current design-basis flood hazard, (b) an Integrated Assessment including LIP flooding and dam failure flooding is expected to be submitted by the licensee, and (3) the reevaluated flood-causing mechanism information is appropriate input to the integrated assessment as described in JLD-ISG-2012-05 (NRC, 2012c), with the exception of identified open items. The NRC staff identified two integrated assessment open items related to the LIP flooding, which are summarized in Table 5.0-1. Therefore, the NRC is not providing finality on the flood parameters related to the LIP and associate site drainage as part of this staff assessment.

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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

Table 3.0-1: Summary of Controlling Flood-Causing Mechanisms.

Reevaluated Flood-Causing Mechanisms and Associated Effects that May Exceed the Powerblock	ELEVATION (ft (m), MSL)
Local Intense Precipitation and Associated Drainage	219.3 (66.84)

Notes:
(1) Flood Height and Associated Effects as defined in JLD-ISG-2012-05.
(2) The plant nominal design elevation (NDE) for the VEGP Units 1 and 2 site is 220 ft (67 m) msl, while the post-construction settled elevation for this elevation varied. FHRR Section 1.1.1 states the minimum elevation reported by a recent survey was elevation 219.6 ft (66.9 m) msl for the NDE of 220 ft (67m) msl.
(3) The LIP flood estimation is based on the highest water elevation pooling behind the VBS. Maximum water surface elevations in the center of the powerblock will be higher. See the Integrated Assessment Open Items.

Table 3.1-1: Design Basis (DB) Flood Hazard.

Flooding Mechanism	DB Still-Water Level (ft (m) MSL)	DB Associated Effects (ft (m))	Current DB Flood Level (ft (m) MSL)	Reference
Local Intense Precipitation and Associated Drainage	219.1 (66.8)	Not Applicable	219.1 (66.8)	FHRR 1.2
Streams and Rivers/ Savannah River	138 (42.1)	27 (8.2) (Wind Wave)	165 (50.3)	FHRR 1.2, FSAR 2.4.3
Failure of Dams and Onsite Water Control/Storage Structures	141 (43)	27 (8.2) (Wind Wave)	168 (51.2)	FHRR 1.2, FSAR 2.4.4
Storm Surge	No Impact Identified	No Impact Identified	No Impact Identified	FHRR 1.2
Seiche	No Impact Identified	No Impact Identified	No Impact Identified	FHRR 1.2
Tsunami	No Impact Identified	No Impact Identified	No Impact Identified	FHRR 1.2
Ice-Induced	No Impact Identified	No Impact Identified	No Impact Identified	FHRR 1.2
Channel Migrations or Diversions	No Impact Identified	No Impact Identified	No Impact Identified	FHRR 1.2

Note: FSAR indicates Final Safety Analysis Report for VEGP, Units 1 and 2 (SNOC, 2012a).

Table 3.2-1: Probable maximum precipitation depths used as LIP input for the HEC-HMS model (from the response to RAI No. 5 (Pierce, 2014b).

Duration	Precipitation Depths, in (cm)
5-minute	6.20 (15.75)
15-minute	9.80 (24.89)
1-hour	19.20 (48.77)
2-hour	23.52 (59.74)
3-hour	25.95 (65.91)
6-hour	31.00 (78.74)
12-hour	37.0 (93.98)
24-hour	43.6 (110.74)
48-hour	48.0 (121.92)

Table 3.4-1: Major dams in the Savannah River basin used in the staff's confirmatory dam failure flood analyses.

ID	Dam Name	Dam Height (ft(m))	Storage Volume (thousand ac-ft (million km^3))	Attenuated Peak Flow (thousand cfs (cms))
1	J. Strom Thurmond Dam	200 (61)	3,820 (4.71)	491 (13,900)
2	Hartwell Dan	204 (62)	3,439 (4.24)	104 (2,950)
3	Richard B. Russell Dam	195 (59)	1,488 (1.83)	152 (4,300)
4	Jocassee	385 (117)	1,288 (1.59)	36 (1,020)
5	Koewee	170 (52)	956 (1.18)	17 (480)
6	Burton	135 (41)	108 (0.13)	16 (450)
7	Par Pond Lower Dam	66 (20)	86 (0.11)	82 (2,300)
8	Tugalo	155 (47)	43 (0.05)	60 (1,700)
9	Steel Creek Dam	90 (27)	40 (0.05)	116 (3,300)
10	Bad Creek Main Dam	360 (110)	34 (0.04)	44 (1,200)
	Total		11,302 (13.9)	1,118 (31,600)

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

Flood-Causing Mechanism	Site Preparation for Flood Event [Time Unit: hrs]	Period of Site Inundation [Time Unit: hrs]	Recession of Water from Site [Time Unit: hrs]
Local Intense Precipitation and Associated Drainage	Several hours, usually more than 12 hours	The licensee is expected to provide this value as part of the integrated assessment (Refer to Integrated Assessment Open Item Nos. 1 and 2).	
Dam Failure Flooding	12 hours until the initial flood wave begins to arrive	Not applicable because site not inundated by the hazard mechanism	

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

Flood-Causing Mechanism	Stillwater Elevation (ft(m) MSL)	Associated Effects (ft(m))	Reevaluated Flood Hazard (ft(m) MSL)	Reference
Local Intense Precipitation and Associated Drainage	219.3 (66.8)	Assume drain blockages due to sediment, debris, or ice, but no other associate effects including wind, hydrodynamic force, or groundwater effects.	219.3 (66.8)	FHRR Section 2.1
Dam Failure Flooding	166 (50.6)	3.4 (11.3) for wind effects	178.1 (54.3)	FHRR Section 2.3

Table 5.0-1: Integrated Assessment Open Items

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

Open Item No.	SA Section No.	Subject to be Addressed
1	3.2	The licensee is requested to resolve the staff-identified numerical modeling issue associated with the local intense precipitation flood analyses. This issue relates to estimating flood parameters at the center of the VEPG, Units 1 and 2 powerblock area encircled by the vehicle barrier system.
2	4.0	Based on the result of Open Item 1, the licensee is requested to refine the total plant response time for a range of rainfall durations associated with the local intense precipitation hazard events (e.g., 1-, 6-, 12-, 24-, 48-, 72-hour PMPs) to deterimine the controlling scenario(s). 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.

Figure 2.2-1: Flood Event Duration

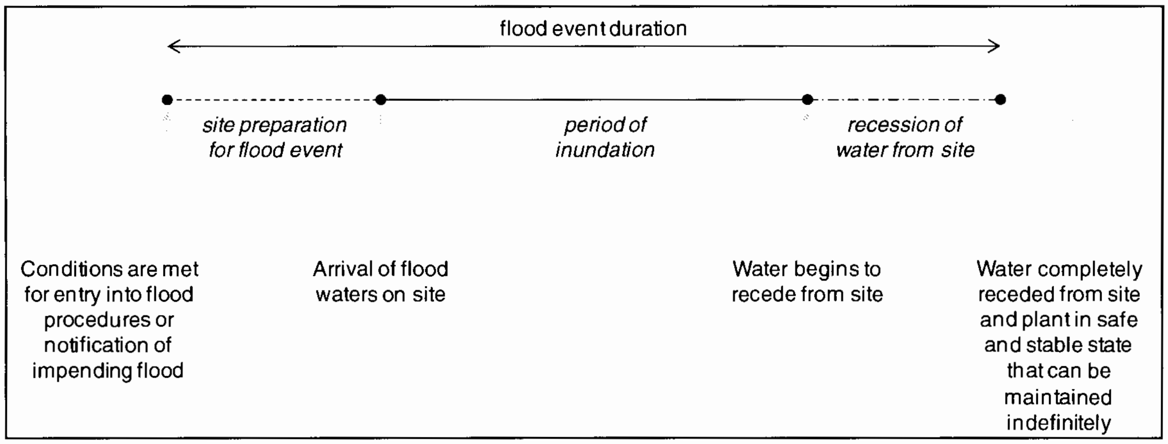


Figure 3.1-1: Site layout for Vogtle Electric Generating Plant Units 1 through 4 (taken from the FHRR Figure1.1-202).

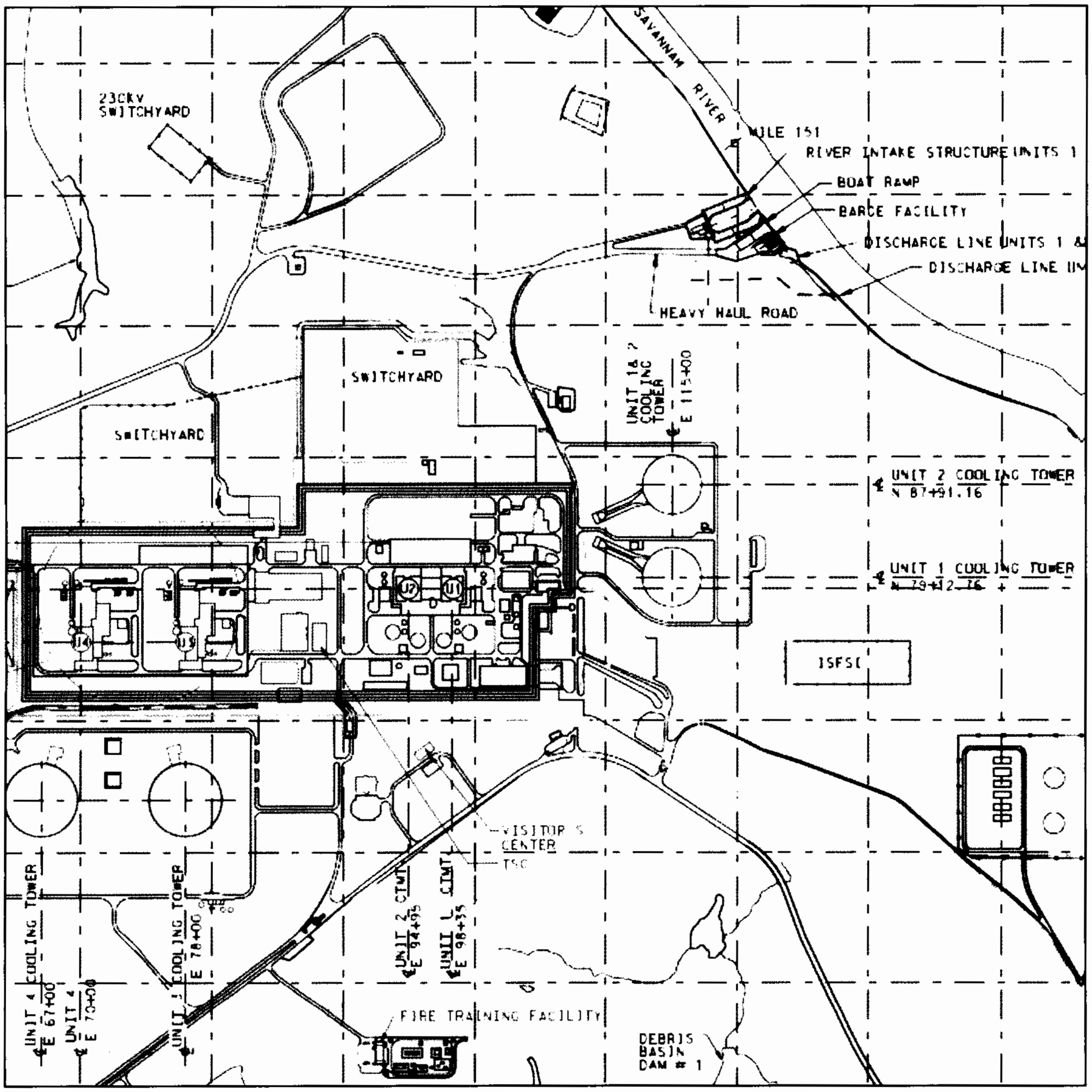


Figure 3.2-1. Drainage of the VEGP Units 1 and 2 powerblock area represented by a level-pool scheme (taken from the RAI response (Pierce, 2014a).

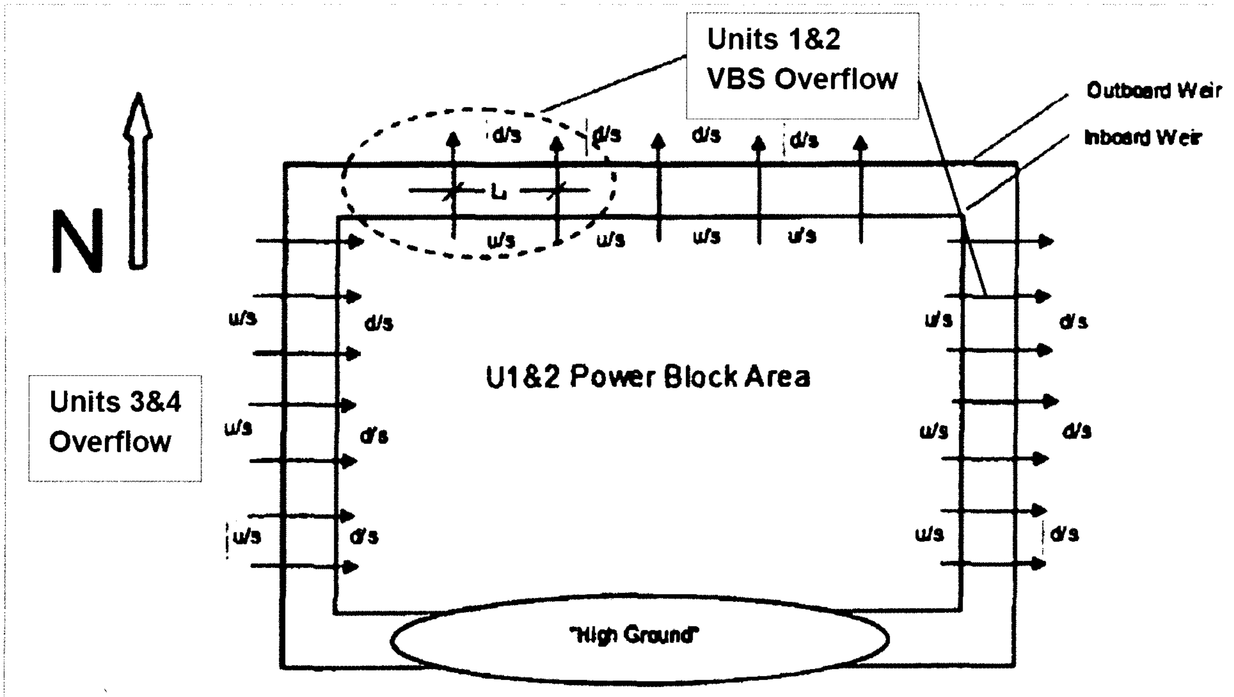
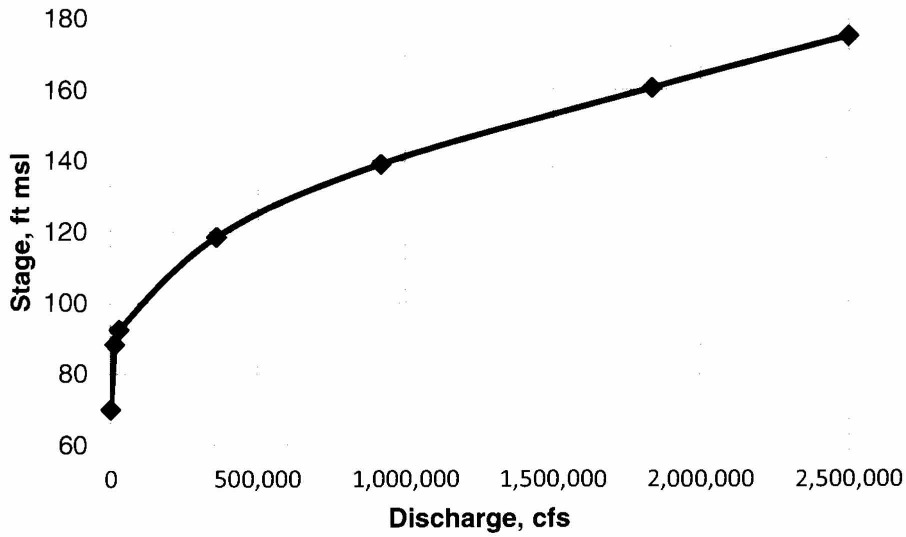


Figure 3.4-1: Stage-discharge rating curve for the Savannah River at the vicinity of the plant site, which was drawn based on the data provided in Table 2.4-223 of the FHRR.



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

Sincerely,

/RA/

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

Docket Nos. 50-424 and 50-425

Enclosure:
Staff Assessment of Flood Hazard
Reevaluation Report

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