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

July 13, 2017

Mr. Peter P. Sena, III
President and Chief
Nuclear Officer
PSEG Nuclear LLC - N09
P.O. Box 236
Hancocks Bridge, NJ 08038

SUBJECT: SALEM NUCLEAR GENERATING STATION, UNITS 1 AND 2 – FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT (CAC NOS. MF7972 AND MF7973)

Dear Mr. Sena:

By letter dated March 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340), 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 Licenses" (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 NRC's Near-Term Task Force (NTTF) report (ADAMS Accession No. ML111861807).

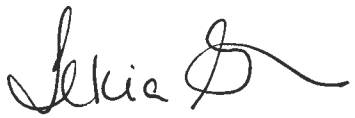
Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazards for their sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses (ADAMS Accession No. ML12056A046). Concurrent with the reevaluation of flood hazards, licensees were required to develop and implement mitigating strategies in accordance with NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML12054A735). In order to proceed with implementation of Order EA-12-049, licensees used the current licensing basis flood hazard or the most recent flood hazard information, which may not be based on present-day methodologies and guidance, in the development of their mitigating strategies.

By letter dated December 30, 2016 (ADAMS Accession No. ML16365A151), PSEG Nuclear LLC (the licensee) submitted the mitigation strategies assessment (MSA) for Salem Nuclear Generating Station, Units 1 and 2 (Salem). The MSAs are intended to confirm that licensees have adequately addressed the reevaluated flooding hazards within their mitigating strategies for beyond-design-basis external events. The purpose of this letter is to provide the NRC's assessment of the Salem MSA.

The NRC staff has concluded that the Salem MSA was performed consistent with the guidance described in Appendix G of Nuclear Energy Institute 12-06, Revision 2, as endorsed by Japan Lessons-Learned Division (JLD) interim staff guidance (ISG) JLD-ISG-2012-01, Revision 1, and that the licensee has demonstrated that the mitigation strategies are reasonably protected from reevaluated flood hazards conditions for beyond-design-basis external events. This closes out the NRC's efforts associated with CAC Nos. MF7972 and MF7973.

If you have any questions, please contact me at 301-415-6197 or at Tekia.Govan@nrc.gov.

Sincerely,



Tekia Govan, Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Enclosure:
Staff Assessment Related to the
Mitigating Strategies for Salem

Docket Nos. 50-272 and 50-311

cc w/encl: Distribution via Listserv

STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO MITIGATION STRATEGIES FOR

SALEM NUCLEAR GENERATING STATION, UNITS 1 AND 2

AS A RESULT OF THE REEVALUATED FLOODING HAZARD NEAR-TERM TASK FORCE

RECOMMENDATION 2.1- FLOODING CAC NOS. MF7972 AND MF7973

1.0 INTRODUCTION

By letter dated March 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340), 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 Licenses" (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 NRC's Near-Term Task Force (NTTF) report (ADAMS Accession No. ML111861807).

Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazards for their sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses (ADAMS Accession No. ML12056A046). Concurrent with the reevaluation of flood hazards, licensees were required to develop and implement mitigating strategies in accordance with NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML12054A735). That order requires holders of operating reactor licenses and construction permits issued under 10 CFR Part 50 to modify the plants to provide additional capabilities and defense-in-depth for responding to beyond-design-basis external events, and to submit to the NRC for review a final integrated plan (FIP) that describes how compliance with the requirements of Attachment 2 of the order was achieved. In order to proceed with implementation of Order EA-12-049, licensees used the current licensing basis flood hazard or the most recent flood hazard information, which may not be based on present-day methodologies and guidance, in the development of their mitigating strategies.

The NRC staff and industry recognized the difficulty in developing and implementing mitigating strategies before completing the reevaluation of flood hazards. The NRC staff described this issue and provided recommendations to the Commission on integrating these related activities in COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flood Hazards," dated November 21, 2014 (ADAMS Accession No. ML14309A256). The Commission issued a staff requirements memorandum on March 30, 2015 (ADAMS Accession No. ML15089A236), affirming that the Commission expects licensees for operating nuclear power plants to address the reevaluated flood hazards, which are considered beyond-design-basis external events, within their mitigating strategies.

Nuclear Energy Institute (NEI) 12-06, Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide" (ADAMS Accession No. ML16005A625), has been endorsed by the NRC as an appropriate methodology for licensees to perform assessments of the mitigating strategies against the reevaluated flood hazards developed in response to the March 12, 2012, 50.54(f) letter. The guidance in NEI 12-06, Revision 2, and Appendix G in particular, supports the proposed Mitigation of Beyond-Design-Basis Events rulemaking. The NRC's endorsement of NEI 12-06, including exceptions, clarifications, and additions, is described in NRC Japan Lessons-Learned Division (JLD) interim staff guidance (ISG) JLD-ISG-2012-01, Revision 1, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML15357A163). Therefore, Appendix G of NEI 12-06, Revision 2, describes acceptable methods for demonstrating that the reevaluated flooding hazard is addressed within the Salem Nuclear Generating Station, Units 1 and 2 (Salem) mitigating strategies for beyond-design-basis external events.

2.0 BACKGROUND

By letter dated March 11, 2014 (ADAMS Accession No. ML14071A401), PSEG Nuclear LLC (PSEG, the licensee) submitted its flood hazard reevaluation report (FHRR) for Salem. By letter dated September 10, 2015 (ADAMS Accession No. ML15238B704), the NRC issued an interim staff response (ISR) letter for Salem. The ISR letter provided the reevaluated flood hazard mechanisms that exceeded the current design basis (CDB) for Salem and parameters that are a suitable input for the mitigating strategies assessment (MSA), as described in NEI 12-06. For Salem, the mechanism listed as not bounded by the CDB in the ISR letter is the local intense precipitation (LIP). By letter dated December 30, 2016 (ADAMS Accession No. ML16365A151), PSEG submitted the Salem MSA for review by the NRC staff.

3.0 TECHNICAL EVALUATION

3.1 Mitigating Strategies under Order EA-12-049

By letter dated February 28, 2013 (ADAMS Accession No. ML13059A296), the licensee submitted the Overall Integrated Plan (OIP) for Salem in response to Order EA-12-049. At 6 month intervals following the submittal of its OIP, the licensee submitted reports on its progress in complying with Order EA-12-049. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated January 24, 2014 (ADAMS Accession No. ML13339A667), and October 10, 2014 (ADAMS Accession No. ML14258A308), the NRC staff issued an Interim Staff Evaluation and audit report, respectively, on the licensee's progress. By letter dated September 28, 2016 (ADAMS Accession No. ML16273A349), the licensee submitted its compliance letter and the FIP in response to Order EA-12-049. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-049.

By letter dated January 19, 2017 (ADAMS Accession No. ML16351A182), the NRC staff issued a safety evaluation documenting the results of the NRC staff's review of the FLEX strategies for

Salem. The safety evaluation concluded that the integrated plans, if implemented as described, should adequately address the requirements of Order EA-12-049.

A brief summary of Salem's FLEX strategies are listed below:

- Operators will take prompt actions to minimize reactor coolant system (RCS) inventory losses by isolating potential letdown paths. Decay heat is removed by steaming to the atmosphere from the steam generators (SGs) through the SG power-operated relief valves (PORVs) or main steam safety valves, and makeup to the SGs is initially provided by the turbine-driven auxiliary feedwater (TDAFW) from the auxiliary feedwater storage tank (AFST). The operators will perform direct current (dc) bus load stripping within 2.5 hours following event initiation to ensure that safety-related battery life is extended up to 6 hours.

- Following dc load stripping and prior to battery depletion, 480-volt alternating current (Vac) FLEX diesel generators (DGs) will be started. Salem has four 480 Vac FLEX diesel generators. Three DGs are required to supply power to the units. These FLEX DGs will be used to repower essential battery chargers on both units within 6 hours of the extended loss of ac [alternating current] power (ELAP) initiation, and to repower additional equipment as needed.

- RCS makeup and boration will be initiated within 8 hours of the ELAP to ensure natural circulation, reactivity control and boron mixing is maintained in the RCS. Operators will provide reactor coolant makeup using FLEX high-pressure charging pumps, one per unit, to deliver borated water drawn from a FLEX connection on a boric acid storage tank (BAST). There are two BASTs per unit, but only one is assumed to be available per unit.

- The water supply for the TDAFW pump is initially from the AFST, if available. The AFST will provide a minimum of 9 hours of RCS decay heat removal, in addition to absorbing the latent heat associated with the planned RCS cooldown. Prior to emptying the AFST the operators will align another water source to the TDAFW pump suction.

- The operators will provide long-term containment cooling and depressurization by operating one containment fan cooling unit, with service water for cooling supplied by a FLEX pump. These components will be powered using the 4160 Vac diesel generator equipment provided by the National Strategic Alliance for FLEX Emergency Response (SAFER) Response Center (NSRC).

3.2 Evaluation of Current FLEX Strategies Against Reevaluated Hazard(s)

The LIP event is the only flood hazard for which the reevaluated maximum water surface elevation (WSE) exceeds its CDB WSE. The licensee explained that the reevaluated LIP event produces a maximum flood level at critical door locations of 102 ft Public Service Datum (PSD); however, the plant's minimum flood-protected elevation is 115 ft PSD. Nevertheless, the licensee compared the CDB, FLEX design-basis (DB), and ISR letter for the LIP event.

Based on this comparison, the licensee confirmed that the FLEX DB stillwater elevation bounds the ISR letter and that the LIP maximum stillwater elevation was considered when determining the outdoor FLEX storage areas and FLEX DG location. The licensee explained that the hydrodynamic and hydrostatic loads during a LIP event are considered negligible when compared to the loads on systems, structures, and components (SSCs) analyzed in the DB due to the storm surge event. Furthermore, the licensee determined that the debris load is negligible based on the low flow velocity and water depths produced by the LIP event. Based on the licensee's comparison and assessment of its FLEX DB and ISR letter for the LIP event, the NRC staff finds it reasonable that the reevaluated flood levels, including associated effects, from the LIP event will not impact the licensee's ability to implement its FLEX strategies.

The licensee also assessed the reevaluated LIP flood event duration (i.e., period of inundation and period of recession) and its impact on the FLEX strategies. The licensee stated that the period of inundation during the reevaluated LIP event is 1 hour and is bounded by the FLEX DB (duration). The NRC staff noted that if an ELAP event occurs as a result of the reevaluated LIP event, the period of inundation would not impact the FLEX strategies because permanent installed safety-related plant equipment would be relied upon early in the ELAP event (i.e., FLEX Phase 1) and is protected by permanent plant features. The licensee stated that the period of recession during the reevaluated LIP event is less than eleven hours and is bounded by the FLEX DB flood. The licensee explained that following a 1-hour LIP event, waters recede from critical door locations in less than 2 hours. The licensee indicated that minor standing water remains around the site 11 hours following the conclusion of the LIP event; however, the outdoor FLEX storage areas are accessible and critical FLEX deployment routes are passable. Based on the low levels of standing water around the site and the FLEX DB bounding the information in the ISR letter, the NRC staff finds it reasonable the licensee can successfully access and deploy its FLEX equipment during an ELAP event.

The licensee explained that following the submittal of its Salem FHRR, it revised its operating procedure that directs operators to close all watertight doors. Specifically, this procedure was revised to include actions to close watertight doors if the National Weather Service (NWS) predicts LIP to exceed 6 inches over the next 24 hours; thus, ensuring that safety-related SSCs are protected from floodwaters. The NRC staff finds this procedural revision to be a precaution that further ensures that permanent safety-related plant equipment is protected from floodwaters.

3.3 Evaluation of Associated Effects

The NRC staff reviewed the information provided by the licensee in the Salem MSA regarding associated effects parameters for flood hazards not bounded by the CDB. Associated effects parameters related to WSE (i.e., stillwater elevation with wind waves and runup effects) were previously reviewed by the NRC staff, and were transmitted to the licensee via an ISR letter. Associated effects parameters not directly associated with WSE are discussed below and are summarized in Table 3.3-1 of this staff assessment.

For the LIP flood-causing mechanism, the licensee stated that the associated effects of LIP-related flooding, including hydrodynamic and debris loads, erosion and sedimentation, groundwater, concurrent site conditions, and other effects, are minimal due to the relatively slow water velocities and low water depths for a LIP event and limited sources of debris and

sediment within the power block area. The NRC staff confirmed this statement by reviewing the licensee-provided LIP model input and output files. The NRC staff found that the estimated inundation depths and water velocities presented in the Salem FHRR are acceptable and that the modeling is reasonable for use in the Salem MSA. The NRC staff reviewed the potential for debris load at the Salem site and concluded that there are no significant sources of material (trees, vegetation, etc.) that would contribute to debris loads at the site. The NRC staff agrees with the licensee's conclusion that the associated effects parameters for the LIP flood-causing mechanism are either minimal or will have no impact on the safety-related plant facilities.

3.4 Evaluation of Flood Event Duration

The NRC staff reviewed information provided by the licensee in the Salem MSA regarding the flood event duration (FED) parameters needed to perform the MSA 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 3.4-1 of this staff assessment.

The licensee states in the MSA that warning time is not credited (not applicable) in the flood protection strategy for LIP flood since only permanent/passive flood protection measures are relied on, and therefore, was not considered as part of the Salem MSA. In addition, the licensee states in the Salem MSA that SSCs important to safety are currently protected by means of permanent passive measures and permanent active features (i.e., watertight doors). The watertight door closure can be performed well within the LIP warning time provided by the 24-hour NWS's Probabilistic Quantitative Precipitation Forecast (NWS PQPF). The Salem flooding walkdown report documents actual closure in approximately 1 hour of exceeding a high river water level trigger, based on operating experience. Therefore, they determined that the period of site preparation for an anticipated LIP event based on the current watertight door closure procedure with 24-hour NWS PQPF is adequate. The NRC staff notes that the approach to determine LIP warning time and site preparation time is consistent with guidance provided by Appendix G of NEI 12-06, Revision 2. The NRC staff notes the licensee also has the option to use NEI 15-05 to estimate warning time (as needed) for further analyses.

The licensee calculated maximum WSEs for the LIP flood-causing mechanism at multiple locations within the Salem powerblock; those locations and their corresponding WSEs are described in Table 6.1-2 of the Salem ISR letter. In the Salem MSA letter, the licensee reported that the period of inundation is about 1 hour. The time necessary for LIP-related flood waters to recede from the Salem site is less than 11 hours. The NRC staff confirmed these FED parameters by reviewing the licensee-provided LIP model input and output files. Based on this review, the NRC staff determined that the licensee's FED parameters for the LIP flood-causing mechanism are reasonable and acceptable for use in the Salem MSA.

4.0 CONCLUSION

The NRC staff has reviewed the information provided in the Salem MSA related to the original FLEX strategies, as evaluated against the reevaluated hazard(s) described in Section 2 of this staff assessment, and found that:

- The FLEX strategies are not affected by the impacts of the ISR flood levels (including impacts due to the environmental conditions created by the ISR flood levels);

- The deployment of the FLEX strategies is not affected by the impacts of the ISR flood levels; and

- Associated effects and FED are reasonable and acceptable for use in the Salem MSA, and have been appropriately considered in the Salem MSA.

Therefore, the NRC staff concludes that the licensee has followed the guidance in NEI 12-06, Revision 2, and demonstrated the capability to deploy the original FLEX strategies, as designed, against a postulated beyond-design-basis event for the LIP flood-causing mechanisms, including associated effects and flood event duration.

Table 3.3-1. Associated Effects Parameters not Directly Associated with Total Water Height for Flood-Causing Mechanisms not Bounded by the CDB

	FLOOD-CAUSING MECHANISM
Associated Effects Parameter	**LOCAL INTENSE PRECIPITATION**
Hydrodynamic loading at plant grade	Minimal
Debris loading at plant grade	Minimal
Sediment loading at plant grade	Minimal
Sediment deposition and erosion	Minimal
Concurrent conditions, including adverse weather	Minimal
Groundwater ingress	Minimal
Other pertinent factors (e.g., waterborne projectiles)	Minimal

Source: Salem FHRR and Salem MSA

Table 3.4-1. Flood Event Durations for Flood-Causing Mechanisms Not Bounded by the CDB

FLOOD-CAUSING MECHANISM	TIME AVAILABLE FOR PREPARATION FOR FLOOD EVENT	DURATION OF INUNDATION OF SITE	TIME FOR WATER TO RECEDE FROM SITE
Local Intense Precipitation and Associated Drainage	Not Applicable (or use NEI 15-05 as needed)	1 hr (1)	< 11 hrs (1)
(1) Salem MSA Letter			

SALEM NUCLEAR GENERATING STATION, UNITS 1 AND 2– FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT DATED July 13, 2017

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