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

March 20, 2020

Mr. Ernest J. Kapopoulos, Jr.
Site Vice President
H. B. Robinson Steam Electric Plant
Duke Energy Progress, LLC
3581 West Entrance Road, RNPA01
Hartsville, SC 29550

SUBJECT: H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2 – STAFF ASSESSMENT OF FLOOD HAZARD FOCUSED EVALUATION AND INTEGRATED ASSESSMENT (EPID NO. L-2018-JLD-0172)

Dear Mr. Kapopoulos:

The purpose of this letter is to document the staff's evaluation of the H. B. Robinson Steam Electric Plant, Unit No. 2 (Robinson) flooding integrated assessment (IA) which was submitted in response to Near-Term Task Force (NTTF) Recommendation 2.1, "Flooding." The U.S. Nuclear Regulatory Commission (NRC) has concluded that that the results and risk insights described in the Robinson flooding IA and the staff's independent assessment support the NRC's determination that no further response or regulatory actions are required. The staff notes that the Robinson seismic probability risk assessment (SPRA) was recently submitted to the NRC in response to NTTF Recommendation 2.1, "Seismic." As a result, the staff has not yet completed its review and is not making a determination with respect to potential flooding risks that may be altered, heightened, or proceed differently under the recently evaluated seismic hazard. The staff's evaluation of the Robinson's SPRA is expected to be completed before the end of calendar year 2020.

By letter dated March 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340), the NRC issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, under Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f), hereafter referred to as the "50.54(f) letter." The request was 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 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). By letters dated March 12, 2014, and August 29, 2015 (ADAMS Accession Nos. ML14086A384 and ML15243A077 (non-public), respectively), Duke Energy Progress, LLC (Duke, the licensee) submitted its flood hazard reevaluation report (FHRR) for Robinson.

After reviewing the licensee's FHRR, the NRC staff issued by letter dated December 23, 2015 (ADAMS Accession No. ML15357A064), a summary of its review of Robinson reevaluated flood-causing mechanisms. The NRC staff also issued a staff assessment by letter dated January 5, 2017 (ADAMS Accession No. ML16355A381, non-public), which provided the documentation supporting the NRC staff's conclusions summarized in the letter. These letters affirmed that the local intense precipitation (LIP), streams and rivers, failure of dams, storm surge, and seiche flood-causing mechanisms at Robinson are not bounded by the plant's current design basis, and, therefore, additional assessments of the flood hazard mechanisms are necessary.

By letters dated December 19, 2018, and January 23, 2020 (ADAMS Accession Nos. ML18353A435 and ML20027A545, respectively), the licensee submitted its IA and supporting documentation for Robinson. Integrated assessments are intended for the NRC to assess the site's capability to cope with the reevaluated hazard and to determine if additional regulatory actions are necessary under the backfit regulation.

The NRC staff has concluded that the Robinson IA was performed consistent with the guidance described in Nuclear Energy Institute (NEI) 16-05, Revision 1, "External Flooding Assessment Guidelines" (ADAMS Accession No. ML16165A178), and consistent with the NRC staff endorsement of that guidance. Guidance document NEI 16-05, Revision 1, has been endorsed by Japan Lessons-Learned Division (JLD) interim staff guidance (ISG) JLD-ISG-2016-01, "Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flood Hazard Reevaluation" (ADAMS Accession No. ML16162A301).

The NRC staff has also concluded that the licensee has demonstrated that feasible flood protection, if appropriately implemented, exists for the LIP flooding mechanism and that the site is reasonably protected against this flood hazard. In addition, the NRC staff has further concluded that the streams and rivers flood mechanism bounds the upstream dam failures, seiche, and storm surge flood mechanisms. Stillwater levels for these flooding mechanisms are below site grade but the maximum water surface elevation including combined effects are above site grade. The streams and rivers mechanism is above site grade and bounds these flooding mechanisms. The staff has determined that the licensee has adequately evaluated the streams and rivers flood hazard using the guidance in NEI 16-05, Revision 1, as endorsed. This determination is primarily based on the following considerations:

1. The site has adequately characterized the "high" and "low" likelihood flooding scenario thresholds. The Robinson IA provided a high likelihood flood elevation of 221.7 feet (ft.) mean sea level (MSL), which is below the site grade of 225.0 ft. MSL and the consequential flood height level of 226.6 ft. MSL. Above the consequential flood height of 226.6 ft. MSL flood waters impact Robinson structures, systems, and components and may result in an extended loss of alternating current power and a loss of normal access to the ultimate heat sink.

2. For "high" likelihood (more frequent) flooding scenarios, the licensee has demonstrated an effective flood protection strategy that relies on installed plant equipment to maintain core cooling, containment integrity and spent fuel pool cooling.

3. For "low" likelihood (less frequent) flooding scenarios, the licensee has demonstrated a feasible flood mitigation strategy. For this "low" likelihood scenario, the licensee has demonstrated that it can maintain core cooling, containment integrity (as applicable), and spent fuel pool cooling, assuming that site flood levels reach the consequential flood level of 226.6 ft. MSL 59 hours after the beginning of the rain event with a maximum flood level of 228.9 ft. MSL 70 hours after the beginning of the rain event.

4. The staff has inspected, audited, and reviewed, as appropriate, pertinent provisions of the licensee's strategy and found it acceptable.

Based on the above, the NRC staff concludes that no additional regulatory actions are necessary with respect to the reevaluated flooding hazard.

If you have any questions, please contact Juan Uribe at 301-415-3809, or by e-mail at Juan.Uribe@nrc.gov.

Sincerely,

/RA/

Mohamed Shams, Deputy Director
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No: 50-261

Enclosure:
Staff Assessment Related to the
Flooding Focused Evaluation and
Integrated Assessment for Robinson

cc w/encl: Listserv

STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO THE FOCUSED EVALUATION AND INTEGRATED ASSESSMENT

FOR H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2

AS A RESULT OF THE REEVALUATED FLOODING HAZARD

NEAR-TERM TASK FORCE RECOMMENDATION 2.1 - FLOODING

EPID NO. L-2018-JLD-0172

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, under Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f), hereafter referred to as the "50.54(f) letter." The request was 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 of 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 and combined licenses (ADAMS Accession No. ML12056A046). If the reevaluated hazard for any flood-causing mechanism is not bounded by the plant's current design basis (CDB) flood hazard, an additional assessment of plant response would be necessary. Specifically, the 50.54(f) letter states that an integrated assessment (IA) should be submitted, and described the information that the IA should contain. By letter dated November 30, 2012 (ADAMS Accession No. ML12311A214), the NRC staff issued Japan Lessons-Learned Project Directorate (JLD) interim staff guidance (ISG) JLD-ISG-2012-05, "Guidance for Performing the Integrated Assessment for External Flooding."

On June 30, 2015 (ADAMS Accession No. ML15153A104), the NRC staff issued COMSECY-15-0019, describing the closure plan for the reevaluation of flooding hazards for operating nuclear power plants. The Commission approved the closure plan on July 28, 2015 (ADAMS Accession No. ML15209A682). COMSECY-15-0019 outlines a revised process for addressing cases in which the reevaluated flood hazard is not bounded by the plant's CDB. The revised process describes a graded approach in which licensees with hazards exceeding their CDB flood may not be required to complete an IA, but instead may perform a focused evaluation (FE). By letter dated September 1, 2015 (ADAMS Accession No. ML15174A257), the NRC informed all affected licensees of the plan to use a graded approach in addressing the reevaluated flood hazard.

Nuclear Energy Institute (NEI) 16-05, Revision 1, "External Flooding Assessment Guidelines" (ADAMS Accession No. ML16165A178), was issued by NEI to describe a method of applying a graded approach to address the reevaluated flood hazards. It has been endorsed by the NRC as an appropriate methodology for licensees to use in response to the 50.54(f) letter. The NRC's endorsement of NEI 16-05, including exceptions, clarifications, and additions, is described in NRC JLD-ISG-2016-01, "Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flood Hazard Reevaluation" (ADAMS Accession No. ML16162A301). Therefore, NEI 16-05, Revision 1, as endorsed, describes acceptable methods for H. B. Robinson Steam Electric Plant, Unit No. 2 (Robinson) to address their response to the reevaluated flood hazard mechanisms.

The NRC staff described how the licensee's assessment of the reevaluated hazard would be reviewed to determine if further regulatory action should be taken, such as backfitting additional safety enhancements, in an internal memorandum dated September 21, 2016 (ADAMS Accession No. ML16237A103). This memorandum describes the formation of a Senior Management Review Panel (SMRP) from the Office of Nuclear Reactor Regulation that are expected to reach a decision for each plant submitting an integrated assessment. The SMRP is supported by NRC technical staff who are responsible for consolidating relevant information and developing recommendations for the consideration of the panel. In presenting recommendations to the SMRP, the supporting technical staff is expected to recommend placement of each flooding IA plant into one of three groups:

1) **Group 1** will include plants for which available information indicates that further regulatory action is not warranted. For flooding hazards, Group 1 will include plants that have demonstrated (1) effective protection for severe flood hazards, and (2) that consequential flooding is expected to occur only for hazards with a sufficiently small mean annual frequency of exceedance.

2) **Group 2** will include plants for which further regulatory action should be considered under the NRC's backfit provisions. This group may include plants that are unable to protect against relatively frequent flood hazards such that the event frequency in combination with other factors result in a risk to public health and safety for which a regulatory action is expected to provide a substantial safety enhancement.

3) **Group 3** will include plants for which further regulatory action may be needed, but for which more thorough consideration of both qualitative and quantitative risk insights is needed before determining whether a formal backfit analysis is warranted.

The evaluation process that was performed to provide the basis for the staff's grouping recommendation to the SMRP for Robinson is described below. Based on its evaluation, the staff recommended to the SMRP that Robinson be classified as a Group 1 plant and therefore, no further regulatory action was warranted.

2.0 BACKGROUND

This document provides the final NRC staff assessment associated with the information that the licensee provided in response to the reevaluated flooding hazard portion of the 50.54(f) letter. Therefore, this background section includes a summary description of the reevaluated flood information provided by the licensee and the associated assessments performed by the NRC staff. The reevaluated flood information includes: 1) the flood hazard reevaluation report (FHRR); 2) the mitigation strategies assessment (MSA); and 3) the IA.

Flood Hazard Reevaluation Report

By letters dated March 12, 2014, and August 29, 2015 (ADAMS Accession Nos. ML14086A384 and ML15243A077 (non-public), respectively), Duke Energy Progress, LLC (Duke, the licensee) submitted its FHRR) for Robinson. On December 23, 2015 (ADAMS Accession No. ML15357A064), the NRC staff issued an interim staff response (ISR) letter for Robinson. For Robinson, the mechanisms listed as not bounded by the CDB in the ISR letter are local intense precipitation (LIP), streams and rivers, failure of dams, storm surge, and seiche. By letter dated January 5, 2017 (ADAMS Accession No. ML16355A381, non-public), the NRC staff issued an FHRR staff assessment, which provided the documentation supporting the NRC staff's conclusions summarized in the ISR letter.

Mitigation Strategies Assessment (MSA)

By letter dated April 12, 2017 (ADAMS Accession No. ML17107A217), the licensee submitted the flooding MSA for Robinson for review by the NRC staff. The MSAs were intended to confirm that licensees had adequately addressed the reevaluated flooding hazards within their mitigating strategies for beyond-design-basis external events that were put in place to meet NRC Order EA-12-049, “Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events.” By letter dated August 19, 2015 (ADAMS Accession No. ML15232A007), Duke submitted a compliance letter and Final Integrated Plan (FIP) in response to Order EA-12-049. The NRC staff’s safety evaluation for the licensee’s compliance plans for Order EA-12-049 was issued on March 31, 2016 (ADAMS Accession No. ML16075A377). By letter dated May 9, 2018 (ADAMS Accession No. ML17249A730), the NRC staff issued its assessment of the Robinson MSA.

The licensee determined in its April 12, 2017, MSA that the reevaluated LIP event and the reevaluated streams and rivers event bounded all other non-bounded flood mechanisms: failure of dams, storm surge, and seiche. The licensee also stated that in terms of the flood controlling parameters (i.e., flood height, warning time, and inundation time), all applicable flood nonbounded mechanisms were bounded by the LIP event and the streams and rivers event. The licensee determined that the LIP event and the streams and rivers event impacted the FLEX strategies described in the FIP and therefore the licensee developed alternate mitigating strategies (AMS) in order to address the potential impacts to the FLEX strategies. The new AMS include relocating FLEX pumps prior to the flood, revision to plant procedures, validation of new and/or modified actions, and new analyses as described in Sections 7 and 8 of the MSA. The staff found the licensee’s MSA approach acceptable as documented in the May 9, 2018, letter.

In SECY-16-0142, “Draft Final Rule – Mitigation of Beyond-Design-Basis Events [MBDBE] (RIN 3150-AJ49),” (ADAMS Accession No. ML16291A186) provisions were proposed that would have required mitigation strategies to address the reevaluated flood hazard information on a generic basis. As reflected in the Affirmation Notice and Staff Requirements Memorandum (SRM) dated January 24, 2019, the Commission determined that sites addressing the reevaluated hazards on a generic basis was not needed for adequate protection of public health and safety but should instead be assessed on a plant-specific, case-by-case basis under the requirements of 10 CFR § 50.109, “Backfitting,” and § 52.98, “Finality of combined licenses; information requests.”

The Commission directed in the Affirmation Notice and SRM dated January 24, 2019 (ADAMS Accession No. ML19023A038), that the staff use the 50.54(f) process to ensure that the NRC and its licensees will take the needed actions, if any, to ensure there is no undue risk to public health and safety due to the potential effects of the reevaluated flood hazards. The SRM further directs that the staff should continue these efforts, utilizing existing agency processes to determine whether an operating power reactor license should be modified, suspended, or revoked in light of the reevaluated hazard.

In a letter dated August 20, 2019 (ADAMS Accession No. ML19067A247), the NRC staff provided a path forward to treat the reevaluation of flood hazards in light of the Commission's direction in the January 24, 2019, Affirmation Notice and SRM. The staff assessment documented in this letter was performed in accordance with the information in the August 20, 2019, staff letter including a plant-specific determination on whether additional regulatory actions are warranted to address the reevaluated hazard.

The staff's evaluation of the integrated assessment considers, as appropriate, the licensee's intention to use FLEX equipment to address the reevaluated hazards in accordance with the Commission direction.

Integrated Assessment

By letters dated December 19, 2018, and January 23, 2020 (ADAMS Accession Nos. ML18353A435 and ML20027A545, respectively), the licensee submitted its IA and supporting documentation for Robinson. The IAs are intended for the NRC to assess the site's capability to cope with the reevaluated flood hazard and to determine if additional regulatory actions are necessary. These regulatory actions would be taken in accordance with 10 CFR 50.109, "Backfitting." To facilitate its review of the integrated assessment, the NRC staff issued an audit plan by letter dated July 18, 2017 (ADAMS Accession No. ML17192A452), stating its intention to review additional relevant information and supporting documentation, as needed.

The staff notes that the Robinson seismic probability risk assessment (SPRA) was recently submitted to the NRC in response to NTTF Recommendation 2.1, "Seismic." As a result, the staff has not yet completed its review and is not making a determination with respect to potential flooding risks that may be altered, heightened, or proceed differently under the recently evaluated seismic hazard. The staff's evaluation of the Robinson's SPRA is expected to be completed before the end of calendar year 2020.

3.0 TECHNICAL EVALUATION

Robinson is located 3 miles (mi) west-northwest of Hartsville, South Carolina, on the southwest shore of Lake Robinson. The main surface water feature in the site vicinity is Lake Robinson, created by the impoundment of Black Creek at the Lake Robinson Dam for industrial cooling purposes. Lake Robinson's normal pool elevation is 220 feet (ft.) mean sea level (MSL). The elevation of the plant site is 225 ft. MSL. At Robinson, MSL is equivalent to the National Geodetic Vertical Datum of 1929 (NGVD29). The CDB flood elevation at Robinson due to external events is 222 ft. MSL, which is below the site grade. As previously stated, the mechanisms listed as not bounded by the CDB for Robinson are LIP, streams and rivers, failure of dams, storm surge, and seiche.

The guidance described in NEI 16-05, Revision 1, defines consequential flooding conditions as conditions that represent the least severe flood at the site that could adversely affect key structures, systems or components (SSCs) and potentially fail a key safety function (KSF). For Robinson, the consequential flooding condition occurs at an elevation of 226.6 ft. MSL. Above this elevation, flood waters impact Robinson SSCs and may result in an extended loss of alternating current (ac) power (ELAP) and a loss of normal access to the ultimate heat sink (LUHS).

For LIP the reevaluated hazard is 229.1 ft. MSL, which is 4.1 ft. above site grade and 2.5 ft. above the consequential flood elevation. The licensee's IA provided a Path 3 focused evaluation to demonstrate a feasible response to the LIP event. In accordance with NEI 16-05, Revision 1, a Path 3 evaluation is intended to utilize NEI 12-06 Rev. 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," (ADAMS Accession No. ML16005A625) where a process for determining the feasibility of a response strategy has already been implemented. The staff's evaluation of the LIP event is found in Section 3.1 of this document.

In its IA submittal, the licensee stated that the streams and rivers flood mechanism bounds the failure of dams, storm surge, and seiche flood mechanisms. In addition, the licensee re-evaluated several assumptions and conservatisms for the streams and rivers flood mechanism in the IA. The licensee also re-evaluated the Wind-Driven Wave (WDW) component associated with the failure of dams, storm surge, and seiche flood-causing mechanisms. The re-evaluation resulted in the licensee lowering the maximum flood level for the streams and rivers mechanism from the levels previously reviewed by the staff and described in the ISR letter. After the hazard revisions, the licensee stated that flooding from the streams and rivers mechanism continues to bound the failure of dams, storm surge, and seiche flood-causing mechanisms. The licensee chose NEI 16-05 Path 5, "scenario-based approach," to address the streams and rivers flood-causing mechanism. The overall goal of a Path 5 evaluation is to demonstrate that scenarios with consequential flooding and higher frequencies of occurrence have an effective flood strategy. For scenarios with lower frequencies, the goal is to demonstrate that a feasible response strategy is available to mitigate the effects of extreme flood conditions.

The licensee characterized the "high" likelihood streams and rivers flooding scenario threshold as equivalent to an elevation of 221.7 ft. MSL, which is below the site grade of 225.0 ft. MSL and the consequential flood height level of 226.6 ft. MSL. For the "low" likelihood streams and rivers flooding scenario, the licensee provided a strategy to maintain core cooling, containment integrity (as applicable) and spent fuel pool cooling, assuming that site flood levels reach the consequential flood level of 226.6 ft. MSL approximately 59 hours after the beginning of the rain event with a maximum flood level of 228.9 ft. MSL occurring approximately 70 hours after the beginning of the rain event.

The NRC staff's evaluation of the failure of dams, storm surge, and seiche flood-causing mechanisms is found in Section 3.2 of this document. The staff's evaluation of the rivers and streams mechanism is found in Section 3.3 of this document.

3.1 Local Intense Precipitation

The LIP flood elevation used in the IA submittal is consistent with the MSA, and both evaluations used LIP parameters that the staff found acceptable as documented in the ISR letter and FHRR staff assessment issued by the NRC. Furthermore, the staff found the flood event duration (FED) and associated effects (AEs) for the LIP event to be acceptable as documented in the May 9, 2018, MSA staff assessment. The FED and AE parameters in the Path 3 LIP evaluation are the same as those found in the licensee's MSA.

The staff found the licensee's approach for addressing LIP by use of a modified FLEX strategy acceptable as documented in the staff's assessment dated May 9, 2018. The licensee did note several differences in its December 19, 2018, submittal from that found in its April 12, 2017, MSA. Specifically, the licensee stated in its December 19, 2018, submittal that a new concrete pad will elevate the two pre-staged FLEX auxiliary feedwater (AFW) pumps to provide additional margin to the maximum LIP flood level, several trigger conditions were updated/revised, and several site procedures needed to be updated as a result of the changes.

3.1.1 NRC Staff Technical Evaluation for Local Intense Precipitation

For plant operation in Modes 1-4, which covers power operation and shutdown with reactor coolant system (RCS) temperature above 200 degrees Fahrenheit (°F), the licensee stated that the FLEX strategies for LIP would remain mostly unchanged, and that the FLEX equipment would be capable of being aligned in order to perform their respective functions. Reactor decay heat removal would occur via steam release from the steam generator (SG) power-operated relief valves (PORVs) to the atmosphere. The licensee stated in its December 19, 2018, MSA that if the SG PORVs are not available, the main steam isolation valve bypass lines, and steam header vents would be locally opened to release steam since they are accessible even with high water levels. The Class 1E batteries and the pre-staged FLEX diesel generators that energize the battery chargers will not be inundated since they are located on the 242.5 ft. elevation of the reactor auxiliary building (RAB). The SG makeup would remain the same until the steam driven auxiliary feedwater (SDAFW) pump is lost due to inundation from the LIP flood. There are two permanently staged intermediate pressure FLEX pumps on concrete pads near the six AFW tanks, with their suction aligned to the AFW tanks. These concrete pads were installed by the licensee in order to elevate the FLEX AFW pumps from the floodwaters, and provide additional margin. In addition, the pumps are anchored in order to withstand water flow. One of these pumps will then be used to supply the SGs through the FLEX connection located near the SDAFW pump discharge, at elevation 229 ft., which is higher than the LIP flood level of 228.8 ft. in that location.

Equipment deployment activities for makeup to the RCS are planned to commence approximately 16 hours after the beginning of the LIP event when the LIP flood levels in the vicinity of the equipment staging areas and the RAB have receded to approximately 0.8 ft. above site grade. The licensee stated in the IA submittal that the RCS makeup pump suction connection to the RWST or deployment of the portable mixing tank would not be impacted by this flood level. Finally, the spent fuel pool (SFP) makeup strategy would remain the same since it is planned to occur approximately 23 hours after an ELAP is declared, and by that time the water level at the site is expected to be too low to affect this strategy. The licensee stated that hoses will be secured to prevent significant movement during flooding. After depletion of the water in the AFW tanks and the condensate storage tank (CST), the licensee will deploy a portable low-pressure FLEX pump to use Lake Robinson as the long-term source of cooling water and will also use the lake water to refill the AFW tanks and the CST.

For plant operation in Modes 5 and 6, with the RCS less than 200°F, the licensee indicated in its IA submittal that a revised FLEX strategy for core cooling and RCS makeup will be needed for certain plant conditions, such as when the RCS is vented and the reactor cavity is not flooded. Under this scenario, RCS makeup is required within 2 hours after an ELAP is declared, due to the boil-off from the RCS. The current FLEX strategy requires disassembly of valves on the ground floor of the RAB and connection of hoses to those valves. These connections will be just above the water level during the LIP event, but the RAB ground floor will be flooded, thus complicating operator actions to route hoses and establish the connection for RCS makeup.

The licensee also stated in its IA submittal, that the revised action trigger occurring 24 hours prior to the LIP event will be used to establish plant conditions that either support natural circulation with the RCS being cooled using the SGs, or establish plant conditions with the reactor vessel head removed and the refueling cavity flooded. In the second scenario, core cooling will be achieved by boil-off from the flooded refueling cavity. Because of the large volume of the refueling cavity, makeup capability will not be required until after flood waters have decreased below the consequential flood elevation. One of the two pre-staged intermediate pressure FLEX pumps will be used for RCS makeup by providing borated water from either the RWST or from a connection on the SFP cooling system (taking water from the SFP) to one of two safety injection lines to the RCS or directly into the refueling cavity. The licensee also stated that makeup water for the RCS can also be provided from the AFW tanks or the lake, as needed, using a FLEX pump. A borated water supply would not be required as boron does not evaporate during boil-off. During refueling operations, there is the possibility of a full-core offload to the SFP. The licensee stated that analyses have determined that in this case, SFP boil-off to 10 ft. above the fuel racks will take about 23 hours after the ELAP occurs. The licensee's strategy is to deploy a portable FLEX pump to provide SFP makeup from the lake or the discharge canal. The pump discharge hose can be connected to the SFP cooling system, or placed directly into the SFP, or connected to spray monitor nozzles on the SFP operating floor that spray water into the SFP. The NRC staff notes that 10 ft. of water above the fuel assemblies provides sufficient shielding from the fuel assemblies, which will allow operators to access the SFP operating floor.

In its April 12, 2017, MSA, the licensee stated that the trailers available at the site will raise the pumps to a height of 228.8 ft. and that the calculated flood elevation at that location is 228.7 ft. As noted in the staff's evaluation dated May 9, 2018, the NRC staff questioned the small amount of margin. In its December 19, 2018, submittal the licensee stated that a new concrete pad has been installed which further elevates the two pre-staged FLEX auxiliary feedwater (AFW) pumps to provide additional margin to the maximum LIP flood level. The staff finds this approach acceptable.

The staff audited documents related to the site's response to the LIP hazard. Specifically, the staff reviewed Engineering Change (EC) 413616 and the associated plant sketch, and verified with the licensee that installation of the concrete pad at the site had been completed. With regards to the revision of site procedures described in the December 2019 submittal, the licensee stated that the procedure changes are being tracked by NTM 02117149-01, "RNP Flooding IA Procedure Revisions and Validation" and are expected to be completed by December 31, 2020. By letter dated January 23, 2020, the licensee submitted a letter which described the completion of the remaining actions, and the ability of the site to maintain the LIP strategies described above as regulatory commitments. As a result of the actions already completed, and the regulatory commitments described by the licensee, the NRC staff finds this approach consistent with the guidance described in COMSECY-15-0019, and Path 3 of NEI 16-05.

3.1.2 Local Intense Precipitation Conclusion

The NRC staff has evaluated the information provided in the IA submittal related to the revised FLEX strategies, as evaluated against the reevaluated LIP hazard described in Section 3.1.1 of this staff assessment. The NRC staff finds that the equipment and actions in the revised FLEX strategy, if implemented as described, are reasonably protected against the LIP hazard event. Furthermore, the NRC staff has determined that the strategies to maintain core cooling, containment integrity (as appropriate), and spent fuel pool cooling can be appropriately implemented upon revision of plant procedures and FLEX support guidelines (FSGs). The NRC staff made its determination based upon:

- The inclusion of action triggers based upon the 24-hour warning time in the plant procedures for projected rainfalls of 5.75 inches;

- The action to establish plant conditions that either support natural circulation with the RCS being cooled using the SGs, or establish plant conditions with the reactor vessel head removed and the refueling cavity flooded, prior to flood levels exceeding the consequential level; and

- The effectiveness of the licensee's planned actions, including regulatory commitments, for coping with a LIP event.

Therefore, the NRC staff concludes that the licensee has demonstrated the capability, if implemented as described, to deploy strategies against postulated beyond-design-basis events for the LIP event, including associated effects and flood event duration. Furthermore, the licensee has provided a regulatory commitment to complete and maintain the strategies that would address a reevaluated LIP hazard at the site.

3.2 Failure of Dams, Storm Surge, and Seiche

In Enclosure 2 of its IA submittal, the licensee stated that the WDW component for the failure of dams, storm surge, and seiche was reanalyzed from that presented in the FHRR. The reanalysis referenced in the December 19, 2018, submittal is summarized in Table 3.2-1.

Table 3.2-1 Dam Failure, Storm Surge, and Seiche Flood Elevations

Flood-Causing Mechanism	Stillwater Surface Elevation (ft. MSL)	Integrated Assessment Maximum Water Surface Elevation (Including Combined Effects) (ft. MSL)	Flood Hazard Reevaluation Report Maximum Water Surface Elevation (Including Combined Effects) (ft. MSL)
Dam Breach Failure (Upstream)	Refer to IA submittal	Refer to IA submittal	Refer to IA submittal
Probable Maximum Storm Surge	221.5 (224.4 including storm surge)	226.5	231.8
Seiche	221.5	226.2	226.2

The flood level elevations provided in the IA submittal for dam failure, probable maximum storm surge, and seiche are lower than the reanalyzed flood level elevation for the streams and rivers flood-causing mechanism.

3.2.1 Analysis of Failure of Dams, Storm Surge, and Seiche

In its IA submittal, the licensee used the same stillwater elevations that were previously reviewed and approved by the NRC staff for the dam failure and storm surge flood mechanisms. However, the licensee re-evaluated the maximum (dynamic) water surface elevations for these two flood hazard mechanisms based on a modified scenario that accounted for water entering and leaving the site via wave overtopping flowrates. The licensee made no changes to the seiche flood mechanism.

The licensee's previous analysis, while accounting for water entering the site from the Lake Robinson shoreline, did not account for flow accumulating in low areas of the site and flow leaving the site via the discharge channel located north-east of the site. In the re-evaluated scenarios, the licensee accounted for water entering the site from the Lake Robinson shoreline and leaving the site via a discharge channel. Both the Lake Robinson shoreline and the entrance to the discharge channel are protected by a berm-like structure that was assumed to behave hydraulically as a broad crest weir. The licensee stated that the Lake Robinson shoreline is approximately 430 ft. in length and that the entrance to the discharge channel is approximately 350 ft. in length.

For the re-evaluated dam failure scenario, using the maximum water surface elevation including wave height and wind setup at the Lake Robinson shoreline, the licensee used a rating curve to estimate the maximum flowrate entering the site from Lake Robinson to be 34.4 cubic feet per second (cfs). The licensee then stated that this same flowrate would leave the site via the discharge channel after passing over the channel berm. Using the shorter berm length at the entrance to the channel, the licensee estimated the maximum water surface elevation (including combined effects) to be 226.1 ft NGVD29.

Similarly, the licensee used a rating curve to estimate the maximum re-evaluated storm surge flowrate (which includes wave height and wind setup) entering the site from Lake Robinson to be 380.1 cfs. The licensee then stated that this same flowrate would leave the site via the discharge channel after passing over the channel berm. Using the shorter berm length at the entrance to the channel, the licensee estimated the maximum water surface elevation (including combined effects) to be 226.5 ft NGVD29.

The NRC staff reviewed site drawings and maps of the site to assess the credibility of the licensee's proposed scenario, the length of the berms along Lake Robinson, and at the entrance to the discharge channel. Additionally, the NRC staff reviewed the methodology used by the licensee to estimate the maximum wave overtopping flowrates and the maximum water surface elevation. Based on the staff's review of the modified scenario and associated flowrate calculations, the staff found the analysis and results to be reasonable and appropriate.

The stillwater flood level elevations provided in the IA submittal for the dam failure (222.8 ft. MSL), storm surge (224.4 ft. MSL), and seiche (221.5 ft. MSL) are below the site grade of 225 ft. MSL. The combined effects from these flood-causing mechanisms are slightly above grade and may result is some splashing along the shoreline, but it is not expected to impact the power block or key SSCs such that an ELAP or LUHS occurs. Therefore, the staff concludes that the licensee has effective flood protection for the dam failure, storm surge, and seiche flood-causing mechanisms in accordance with the guidance found in NEI 16-05, Revision 1 as endorsed by the NRC.

In addition, the staff notes that the dam failure, storm surge, and seiche flood-causing mechanisms are bounded by the licensee's analysis of the streams and rivers flood-causing mechanism. Therefore, the staff also concludes that the revised FLEX strategies can be implemented against the dam failure, storm surge, and seiche flood-causing mechanisms in the event that they are needed. The NRC staff's conclusions associated with streams and rivers are described in Section 3.3 of this staff assessment. Therefore, the staff reasonably concludes that the revised FLEX strategies provide a defense-in-depth feature for maintaining core cooling, containment integrity, and spent fuel pool cooling should installed plant equipment not be available.

3.2.2 Failure of Dams, Storm Surge, and Seiche Conclusion

Based on the staff's assessment in Section 3.2.1 of this document, the staff concludes that the licensee has effective flood protection by primarily relying on site grade, and using installed plant equipment for the dam failure, storm surge and seiche flood-causing mechanisms in accordance with the guidance found in NEI 16-05, Revision 1 as endorsed by the NRC. Should the need arise, it is also reasonable to assume that FLEX strategies are available, and provide a defense-in-depth feature for maintaining core cooling, containment integrity, and spent fuel pool cooling

3.3 Streams and Rivers (Combined Event with Wind/Wave)

For the streams and rivers flood mechanism, the licensee performed the evaluation consistent with Path 5 of NEI 16-05, whose purpose is to demonstrate an effective response to consequential flooding that has a relatively high likelihood of occurrence, and a feasible response to mitigate the effects of an extreme flood with a low likelihood of occurrence. Guidance document NEI 16-05, Revision 1, as endorsed, states that floods with an annual exceedance probability (AEP) of 10^{-4} (or 10^{-3} with margin), or higher, is the threshold that should be considered for the more frequent, "high" likelihood floods.

In Enclosure 2 of its IA submittal, the licensee described a reevaluated streams and river flood scenario. Consistent with NEI 16-05, Revision 1, the licensee chose a high likelihood flooding scenario elevation of 221.7 ft. MSL, and the low likelihood scenario flood elevation of 228.9 ft. MSL. The low likelihood elevation of 228.9 ft. MSL is less than the previously reviewed FHRR and ISR values of 233.8 ft. MSL for the streams and rivers flood mechanism. Figure 3.3-1 provides the flood levels and timeline associated with the low likelihood scenario provided in the Robinson IA. The licensee stated in the Robinson IA that for the low likelihood scenario wind wave runup is not considered applicable because the security barriers will serve as a wave break.

The NRC staff's assessment of the flood levels associated with the high likelihood streams and rivers flood scenario is found in Section 3.3.1 of this document. The NRC staff's assessment of the flood levels associated with the low likelihood streams and rivers flood scenario is found in Section 3.3.2 of this document. The NRC staff also reviewed the proposed site response to the high likelihood and low likelihood scenarios in Sections 3.3.3 and 3.3.4, respectively.

3.3.1 Review of Streams and Rivers Flood Hazard Revision

The following is a summary of the NRC staff's review of the precipitation frequency analysis, which is a component of the streams and rivers revised hazard submitted as part of the IA. Additional technical details of can be found in the IA submittal.

3.3.1.1 <u>Use of Precipitation Frequency Estimates</u>

The licensee describes a scenario-based approach in the IA used to evaluate the controlling combined effects flooding. Among the two scenarios evaluated, Scenario 1 estimates flood level associated with an AEP of 10^{-4}. To estimate this flood level, the licensee used an estimated basin-average, 72-hour precipitation frequency (PF) depth as input to a flood frequency analysis for the Black Creek Watershed (171 mi^2) upstream of Robinson. As described in the IA, the 72-hour duration was selected to maintain consistency with the duration used in the probable maximum flood assessment. In its IA, the licensee provided basin-average, 72-hour PF estimates for AEPs ranging from 10^{-2} to 10^{-6}, with the 10^{-2} and 10^{-4} estimates used as input for subsequent flood frequency analysis modeling and the AEP 10^{-4} estimate used for Scenario 1. The licensee's PF calculation is summarized below.

3.3.1.2 Meteorological Background

A PF estimate represents a precipitation depth calculated for a given location, specified duration, AEP, and area. Historically, point PF estimates (i.e., PF associated with very small areas) have been developed by the National Oceanic and Atmospheric Administration (NOAA) through its Atlas 14 studies[1] and precursor studies. The Atlas 14 studies have been produced as a series of regional volumes covering different parts of the United States, with the volumes maintaining the same general procedures for point PF estimation at a given location. Nevertheless, since the PF estimates provided by Atlas 14 are available only up to 10-3 AEP (1000-year return period), Atlas 14 cannot provide sufficient PF inputs for some purposes. Hence, the licensee conducted an independent PF evaluation using methods that are largely consistent with Atlas 14.

In certain hydrologic applications (e.g., urban planning, critical infrastructure protection, flood risk mitigation), watershed-wide PF estimates are needed. Since using averaged point PF estimates across a region would overestimate areal PF estimates, areal reduction factors (ARFs) have traditionally been used. Current United States practice for ARF estimation involves using decades-old charts provided in the U.S. Weather Bureau Technical Paper No. 29 (e.g., U.S. Weather Bureau, 1957) or the approach presented in NOAA Technical Report NWS 24 (Meyers and Zehr, 1980), both of which suffer from key limitations. Rather than using ARFs to convert point PF estimates to areal PF estimates, more direct areal PF estimation can be made. The licensee's approach, as documented in calculation RNP-18-001, Rev. 0, "72-hour Precipitation-Frequency Analysis for Controlling Storm Type," follows a more direct areal PF analysis approach in which a stochastic storm generation procedure is used to generate synthetic watershed-specific data. However, the licensee's overall approach follows an independent PF evaluation using methods that are largely consistent with Atlas 14. The licensee's calculation methodology is summarized below.

3.3.1.3 Precipitation Data Collection

The licensee's PF approach involves significant data collection and statistical analysis efforts. The primary data sources used in the analysis are daily, hourly, and ancillary precipitation rain gauge products. Daily and hourly precipitation data were collected from various databases maintained by the National Centers for Environmental Information (NCEI, formerly the National Climatic Data Center). Daily precipitation data were used to support storm analysis and the PF analysis calculation, while hourly data were used to support storm analysis. As described in the IA, additional ancillary data were also collected and used to support storm analysis. The licensee used the NOAA North Atlantic tropical storm-track database from the International Best Track Archive for Climate Stewardship (Knapp et al., 2010) to identify and link historical precipitation data related to tropical storm events. The staff finds the licensee's data collection to be reasonable.

[1] https://hdsc.nws.noaa.gov/hdsc/pfds/ (accessed November 20, 2019)

3.3.1.4 Calculation Approach

The licensee's point PF calculation generally follows the approach used in NOAA Atlas 14. However, unlike Atlas 14, the licensee's point PF approach was (1) performed using storm typing in which the precipitation data included were limited to only tropical storm remnant (TSR) events, and (2) extended to produce watershed PF estimates. As described in the IA, such TSR events are associated with synoptic-scale precipitation from an approaching or departing tropical storm or hurricane. The licensee's use of storm typing and selection of only TSR events was informed by a controlling storm type study, as documented in Appendix B of the IA. The controlling storm type study analyzed TSR and mid-latitude cyclone storm types to assess which type provided the largest 72-hour precipitation amounts (i.e., was controlling) at rare AEPs. The licensee concluded that TSR events were controlling in the Black Creek watershed and used only TSR events in its point and watershed PF analysis. The use of only TSR events should conceptually improve statistical fitting compared to the use of all precipitation events; however, such storm typing has not been used in conventional PF analyses (e.g., Atlas 14) and has not been previously reviewed by staff.

The NRC staff reviewed the storm typing approach and identified some technical concerns with the decision to exclude non-TSR precipitation events. The concerns that the staff had are consistent with those found in a white paper titled "Potential Concerns of the Storm Typing Approach in Estimating Extreme Rainfall Estimates," (ADAMS Accession No. ML19346E657). The staff agreed that the licensee's storm type approach would conceptually produce lower PF estimates than a similar study in which no storm typing was used. Based on this conclusion, staff decided to perform confirmatory and sensitivity analysis of the licensee's results. Overall, staff finds the licensee's storm tying approach yielded smaller PF estimates than the conventional non-storm typing approach used in Atlas 14. The NRC staff eventually derived non-storm typed PF estimates to support subsequent flood level sensitivity analysis.

3.3.1.5 Precipitation Frequency Analysis Results

As described in Table 5 of the IA submittal, the licensee's calculated point PF estimates were found to be approximately 20 percent lower than NOAA Atlas 14 estimates. The licensee described the modified regional frequency analysis (L-Moments approach) as being the primary reason for this difference. The staff found this difference to be considerable and therefore performed confirmatory and sensitivity analysis of the licensee's results. The resulting investigation found the licensee's point PF estimates to be potentially non-conservative (i.e., underestimated). Before engaging the licensee to provide more detailed technical rationale for the selected approach, the NRC staff used alternative (sensitivity-based) non-storm typed PF estimates as input to hydrologic and hydraulic modeling to assess water level impacts in Lake Robinson. The resulting water level assessment yielded no significant increase in the Lake Robinson water level. This results primarily from the additional precipitation-based reservoir inflow being less than the Robinson Dam gates' design flow capacity. As such, the results of the licensee's estimation were deemed to be reasonable as described in the IA. The licensee's calculated watershed PF estimates, including best estimates and 90% confidence bounds for AEP ranging from 10^{-2} through 10^{-6}, are provided in Table 1. The licensee's resulting watershed PF estimates are approximately 8 percent lower than the point PF estimates, equating to an approximate 0.92 ARF. The NRC staff finds this value to be reasonable and within the range expected for the watershed size being considered (171 mi^2).

Table 1. Black Creek Watershed PF estimates. (Table 4.2.1-1 from ML18353A435)

Return Period (yr)	AEP	5th Percentile (inches)	Best Estimate (inches)	95th Percentile (inches)
100*	10^{-2}	7.85	8.55	9.25
1,000	10^{-3}	11.3	12.65	14.2
10,000*	10^{-4}	14.6	17.05	20.05
100,000	10^{-5}	17.65	21.85	27.1
1,000,000	10^{-6}	20.5	27	35.55

*estimates used for flood frequency analysis

3.3.1.6 Refinement to the Licensee's HEC-HMS model

The licensee incorporated several refinements to their hydrologic model to account for additional realisms. A summary of these changes is provided below.

- The number of subbasins was increased from 28 to 38. The licensee stated that this would better account for the upstream dams within the subbasins and better represent the drainage patterns throughout the subbasins.

- The licensee also modified the rainfall loss methodology from the Natural Resource Conservation Service (NRCS) Curve Number (CN) to the initial and constant loss method. The licensee stated that this change would better reflect the infiltration for the type of soils in the subbasins.

- The rainfall-runoff transform methodology was changed by the licensee from a user-specified Unit Hydrograph to the Clark Unit Hydrograph. The licensee stated that this methodology would better account for the travel time and flow attenuation in the subbasins. The licensee also re-calibrated the Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) model by adjusting the Tc (Time of Concentration) and R (Storage Coefficient) for each subbasin.

- The licensee changed the methodology for representing the baseflow within the subbasins. The licensee switched from the Threshold Discharge method to the Ratio to Peak method. The licensee stated that this change would better represent the receding limb of the baseflow hydrograph.

- The licensee also incorporated the latest imagery and topographic data to improve the representation of the rivers and streams within the hydrologic model.

- The storm orientation (pattern) was optimized to better represent the rainfall distribution for the subbasins.

Once the changes to the hydrologic model discussed above were incorporated into the model, the licensee used five tropical storms as input for the re-calibration of the hydrologic model. These storms are listed below.

- Tropical Storm Marco and remains of Klaus (October 1990)
- Hurricane Frances (September 2004)

- Unnamed storm (November 2006)
- Hurricane Joaquin (October 2015)
- Hurricane Matthew (October 2016)

Once the hydrologic model was calibrated based on the five storms, the licensee made adjustment to the subbasin hydrographs to account for non-linearity effects previously discussed in their FHRR.

3.3.1.7 Updates to the HEC-RAS model Information

The licensee stated that no other changes were made to the FHRR HEC-RAS (River Analysis System) model except to include the lateral inflows coming from the additional subbasins in the updated HEC-HMS model.

3.3.1.8 Refinements to Wind Wave Analysis

Using the results from the refined hydrologic model, the licensee modified the wind wave analysis for flooding at the Robinson site and overtopping of Robinson Dam. The licensee updated the parameters such as the fetch lengths in the Lake Robinson. The Robinson site is protected by vehicle barriers. The licensee's new analysis indicates that these barriers will cause wave breaking and prevent wave action from propagating past the vehicle barriers. The new results of wave runup analysis, although lower than the runup in the FHRR, still indicate that the wind wave with runup would overtop the Lake Robinson Dam.

The licensee references the U.S. Army Corps of Engineers (USACE) Greater New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS) to assert that overtopping will not cause a dam breach. According to the licensee, the HSDRRS provides the basis of licensee's assumption that "Lake Robinson Dam … [has]… good vegetative cover that can withstand an overtopping discharge of 1.0 cfs/ft." The licensee further stated that the performance range from the HSDRRS for overtopping of grass embankments is from 0.0 to 1.0 cfs per ft. (cfs/ft.) with a 2.0 safety factor. Additionally, the licensee stated that Bermuda grass with vehicle ruts is able to withstand 4.0 cfs/ft. with only minor erosion, and the calculated overtopping discharge rate of 0.75 cfs/ft. is less than the 1.0 cfs/ft. discharge limit (USACE 2013) for "good vegetative cover." As a result, the overtopping from wave runup "will not cause a breach of the dam."

The NRC staff reviewed several of the modifications made to the HEC-HMS model listed above to determine their effect on the results and to determine if they were reasonable. Specifically, the staff examined the HEC-HMS GIS files provided by licensee and compared them against publicly available GIS data from NRCS. The NRC staff estimated a total subbasin area of 170.85 mi^2 where the licensees subbasin area was 170.86 mi^2. As a result, the NRC staff found that the licensee's subbasins reasonably represent site conditions, and align with the publicly-available information from the NRCS website. The NRC staff also made an additional visual comparison of the layout of tributaries in the NRCS hydrography layer in comparison with the licensee's subbasin layout that shows the subbasin boundaries reasonably enclose these NRCS tributaries. The NRC staff found that the subbasins are adequately represented by the licensee's model.

The NRC staff also reviewed the new rainfall-runoff methodology including the adjustment to the time of concentration (Tc) and storage coefficient (R) for each subbasin. Based on the examination of the model calibration, and the examination of the Tc and R parameters with adjustments for dams, the NRC staff understands the licensee's changes to the Clarks unit hydrograph and find the changes reasonable and appropriate for use in the IA analysis.

As part of its review, the NRC staff reviewed various channel centerlines used in the HEC-HMS model. Although there were some discrepancies in the model, the changes in stream reach length using the publicly available hydrography data reduced the peak discharge slightly and had no effect on the HEC-HMS computed maximum flood. Consequently, the NRC staff conclude that the geographic representation of the stream reaches used by the licensee is reasonable and appropriate.

The NRC staff initially examined variation in licensee's initial and constant infiltration values based on over or under estimation of calibrated peak discharge at a single location. Generally, the over-estimated storms have larger initial infiltration values, which while the input is conservative, the output peak discharge is overestimated. To further evaluate the loss rates developed by the licensee during recalibration of the HEC-HMS, the NRC staff also examined NRCS soils data reports for the Black Creek watershed and used GIS data (general and gridded) downloaded from NRCS for the state of South Carolina. By this method the NRC staff identified approximately 62 different soil types in the watershed. The NRC staff compared the constant loss rates used by the licensee with infiltration capacity from the soils reports and found they are or near the minimums for soils found in the Black Creek watershed. Hence these are conservative estimates of values from the soil types found in the Black Creek watershed.

The licensee's HEC-HMS model uses the storage-discharge and elevation-storage methods for simulation of the Lake Robinson reservoir and dam releases. According to the licensee, the dam rating curves were developed from the HEC-RAS model. The NRC staff notes that the HEC-HMS elevation input is the reservoir water surface elevation, also called the headwater (HW) elevation.

The NRC staff noticed some apparent disagreements between the HEC-HMS and HEC-RAS models. The first disagreement is that during spillway discharge (<40,000 cfs), the HW elevation from the HEC-HMS model increases more than the HW elevation from the HEC-RAS model. This is likely that the HEC-RAS model is capable of dynamically changing the spillway gate opening, while the HEC-HMS model only uses the specified (general) rating curve and is not able to respond dynamically to the change in HW elevation. Hence the HEC-RAS HW elevation-discharge curve should more accurately represent the response to the probable maximum flood (PMF) inflows.

The second apparent disagreement is the discharge at which the transition to overtopping flow (the break in the curve) for the HEC-RAS model is as described by the licensee, which is based on the tainter gates maximum capacity 40,000 cfs. However, the HEC-HMS HW elevation-discharge curve breaks closer to 50,000 cfs. The NRC staff notes that the purpose of the HEC-HMS model is to estimate inflows to Lake Robinson, and the purpose of the HEC-RAS model is to estimate the water surface elevation of Lake Robinson based on the inflows from HEC-HMS and the operation of the Lake Robinson dam. Because the inflows from HEC-HMS to the HEC-RAS hydraulic model of Lake Robinson is the primary connection between the two models, the discrepancies do not affect the outcomes (subbasin hydrographs from HEC-HMS and water surface elevations from HEC-RAS) of the two analyses.

The NRC staff's evaluation of the licensee's information on dam stability indicates that of the vegetation cover on the downstream face of Lake Robinson Dam should provide a reasonable level of erosion protection during wind-induced wave overtopping provided there is a good grass cover of centipede grass (considered to be equivalent to the Bermuda grass study during levee overtopping tests) that has appropriate levels of root density and grass thatching.

3.3.1.9 Conclusion on the Revised Streams and Rivers Flood Hazard Analysis

The NRC staff has reviewed the Robinson IA, supporting electronic files, and supporting calculation packages. The staff have found the methods and results for the hydrologic and hydraulic analyses to be reasonable and appropriate. As a result of the above analysis, the NRC staff concludes that the flood elevation up to 221.7 ft. MSL is appropriate for use at the Robinson site when evaluating effective flood protection (the “high” likelihood event) in accordance with NEI 16-05, Revision 1, as endorsed.

Furthermore, the NRC staff concludes that the flood elevation of up to 228.9 ft. MSL is appropriate for use at the Robinson site when evaluating feasible mitigation strategy (the “low” likelihood event) in accordance with NEI 16-05, Revision 1, as endorsed.

3.3.2 Effective Flood Protection for “High” Likelihood Events up to 221.7 ft. MSL

As stated in Section 3, the Robinson site grade elevation is 225 ft. MSL and the consequential flood height (the flood level at which key SSCs are impacted) is 226.6 ft. MSL. Effective protection is provided by natural topography such that key SSCs that ensure the KSFs of maintaining core cooling, containment integrity, and spent fuel pool cooling are not impacted by the high likelihood flood scenario.

The available physical margin (APM) is approximately 3.3 ft. to site grade and 4.9 ft. to the consequential flood height. The staff finds that the APM is adequate in accordance with the guidance found in NEI 16-05, Revision 1, Appendix B, as endorsed. The NRC staff also agrees that the licensee does not rely on any personnel or time-sensitive actions, or new modifications to the plant in order to respond to the high likelihood rivers and streams flood elevation of 221.7 ft. MSL.

3.3.2.1 Conclusion on Demonstration of Effective Flood Protection

The NRC concludes that based on the information provided by the licensee in the IA, as confirmed by its own independent analysis, Robinson has demonstrated effective flood protection that has APM, is reliable, and does not rely on human actions given that the site grade is a passive flood protection feature. As a result, the flood response to the “high likelihood” streams and river event is considered to be adequate, and provides reasonable assurance that key SSCs that provide KSFs will continue to perform their intended function for the duration of the event.

3.3.3 Feasible Mitigation Response for “Low” Likelihood Events above up to 228.9 ft. MSL

The NRC staff had previously reviewed the mitigating strategies at Robinson and documented its conclusions by letter dated May 9, 2018 (ADAMS Accession No. ML17249A730). Based on the streams and rivers hazard refinement described in Section 3.3.1 of this staff assessment, the licensee made several changes to the alternate mitigating strategy at the site. Most notably:

- The feasible response strategy no longer requires relocation of FLEX equipment during site preparation time, and the site does not lose the UHS which is Lake Robinson,

- Robinson will no longer have two separate meteorological action triggers for LIP and the streams and rivers events, and instead rely on the LIP action trigger (24-hour PQPF of 5.75 in) to address both scenarios,

- The tainter gate action threshold has changed from the Flood MSA to shut down the plant. The new threshold flow rate through the Tainter gates is 25,000 cfs which occurs approximately 5 hours prior to flow reaching the design capacity for the tainter gates.

- An increase in inundation time at the site result in several of the streams and rivers combined event actions from the flood MSA to be re-evaluated.

The NRC staff's review focused on the proposed changes to the strategy by the licensee. The licensee's feasible mitigation strategy in the IA relies on two parallel paths: 1) controlling the level on Lake Robinson, and 2) implementing FLEX strategies at the site to ensure the reactor core heat removal functions can be performed at the onset of the PMF event. In general, the staff sought to understand if the revised streams and rivers hazard impacted any of the FLEX storage location(s), any staging areas, haul paths, connection points, activities, timelines, etc., that had been previously evaluated.

3.3.3.1 Controlling Lake Robinson Levels

Two tainter gates are available at Lake Robinson dam and are used to control lake levels. They serve a dual function at the site: 1) mitigate the probable maximum precipitation event, and a safety function (Technical Specification 3.7.8) to passively support the UHS by maintaining integrity of the boundary they form. The gates are electrically-operated and have a design flow capacity of 40,000 cfs. The licensee has several maintenance procedures to inspect the tainter gates, and their frequency varies from monthly to every 5 years depending on the procedure being performed. The following preventative maintenance applies to the gates:

- PMRQ 45675-01, "Lake Robinson Dam Inspection & Report,"
- Administrative Procedure AD-EG-ALL-1214, "Condition Monitoring of Structures,"
- Maintenance Procedure PM-569, "Dam, Tainter Gate and Spillway Inspection," and
- PMID 81452-01, "Monthly Lubrication of the Auxiliary Gas Engine's Shaft."

In order to maintain control of the lake levels, the licensee established two monitoring triggers:

1. A meteorological forecast 24-hour Probabilistic Quantitative Precipitation Forecast (PQPF), using the 95th percentile, of at least 5.75 inches of rainfall. Using the 95th percentile means that the actual rainfall is expected to exceed the predicted rainfall only 5 percent of the time. This warning time and the associated site actions were previously evaluated by the NRC staff and documented in Section 3.3 of the MSA staff assessment.

2. A threshold flow rate of 25,000 cfs (which occurs approximately 5-hours prior to flow reaching the design flow capacity and 27-hours before the consequential flood occurs), and confirmation that storm remains consistent with a 24-hour 9.05 inches rainfall forecast. If these conditions are met, then Robinson will shut down the plant.

The staff notes that the second monitoring trigger has been revised from the one previously evaluated and documented in the staff's MSA evaluation. However, because of the consistent methodology and approach, the staff agrees that it is still consistent with the guidelines provided by NEI 15-05 and Appendix G of NEI 12-06, Revision 2, and finds it acceptable.

Once the second monitoring trigger is met, the licensee is expected to shut down the plant using existing procedures that will be revised to provide clarification for plant activities based on this threshold. During the review, the NRC staff asked about the expected completion date for revising the procedures. In its response as part of the audit, the licensee stated that the action is being tracked by NTM 02117149-01, “RNP Flooding IA Procedure Revisions and Validation” and is expected to be completed by December 31, 2020. In addition, by letter dated January 23, 2020, the licensee submitted a letter which described the remaining actions to be completed at the site and confirmed tracking of those activities as regulatory commitments.

3.3.3.2 Reevaluated Hazard FLEX Response Strategy

As floodwaters from the streams and rivers event continue to rise, they eventually exceed the site grade of 225 ft. MSL and reach the consequential flood elevation of 226.6 ft. MSL. As described in Updated Final Safety Analysis Report Section 2.4, Robinson was licensed as a dry site, and therefore, the buildings are not designed to withstand external flooding events. At this point, it is conservatively assumed that floodwater will impact key SSCs that perform KSFs.

Among the impacted SSCs, the SDAFW pump is assumed to be flooded and can no longer be run. The SDAFW pump provides makeup water to the SG, which in turn is removing decay heat from the reactor that has been shut down, following the monitoring trigger described in Section 3.3.3.1 of this staff assessment. The licensee’s FLEX strategy relies on the use of two diesel-powered intermediate pressure FLEX pumps which take suction from six available AFW tanks and the CST. These FLEX pumps provide feedwater to the SGs when the SDAFW pump is assumed to be flooded and can no longer be run, and either one of these FLEX pumps is capable of supplying the required water flow to the SG. The FLEX AFW centrifugal pumps are rated at 300 gallons per minute (gpm) at 1000 pounds per square-inch (psi) discharge pressure.

Because the revised streams and rivers hazard no longer causes failure of the UHS, the licensee will deploy a portable low-pressure FLEX pump to use Lake Robinson as the long-term source of cooling water after the depletion of the water in the six AFW tanks and the CST, and refill the suction inventory. In its MSA, the licensee stated that the pumps were not permanently installed, and therefore pre-staged on trailers before the event. In its IA, the licensee stated it has permanently installed the pumps on top of two concrete pads. The concrete pads and pumps are located outdoors in an area southwest of the condensate storage tanks (see Figure 3.3-2).

The NRC staff reviewed EC 413616 and the associated plant sketch, and verified with the licensee that installation of the concrete pads at the site had been completed. The concrete pads are approximately 13 ft. x 23 ft. x 8 in. with several tie down anchors. The finished elevation of slab is designed to be 226.63 ft. or higher. Therefore, when considering that the most vulnerable component of the pump is approximately 3 ft. above the ground, a total flood protection of approximately 229.63 ft. is available. Therefore, when comparing 229.63 ft. against 228.9 ft., and considering all the inherent conservatisms and assumptions embedded in the development of the reevaluated flood hazard, it can be reasonably concluded that the pumps are not impacted by the PMF flood elevations.

Because the site is assumed to be in an ELAP condition, it relies on the safety-related batteries for direct-current (dc) power. The safety-related batteries and associated dc distribution systems are on the second floor of the RAB, and are not expected to be impacted as a result of the flooding event. With regards to fuel, Robinson uses two portable tankers that are stored in the FLEX storage building with a total of 800 gallons of diesel fuel. This amount of fuel is sufficient in order to allow FLEX Phase 3 offsite resources to arrive. In addition, any available existing fuel at the site is available for use. The staff notes that the FLEX storage building is located north of the power block at elevation 244 ft. MSL, therefore no impact is expected as a result of the streams and rivers event.

With regards to the SFP cooling KSF, the licensee stated in the IA that the boil-off to approximately 10 ft. above the fuel racks will occur approximately 23-hours after the ELAP event (assuming full core offload and 150 F° initial conditions). Recession of flood waters to site grade (based on the revised streams and rivers event) is expected to occur approximately 21 hours after the ELAP. Before the hazard revision, the recession of flood water was expected to occur approximately 20 hours after the ELAP.

As a result of the increased recession period of 1 hour, the NRC staff understands that the SPF cooling strategy needs to be implemented in a shorter period of time (2 hours versus 3 hours, when compared to the MSA). As a result, the NRC staff sought to confirm if the SFP strategy was still reasonably expected to be implemented.

The licensee's strategy is to deploy a portable FLEX pump to provide SFP makeup from the lake or the discharge canal when the floodwaters have receded to a level equal to site grade. The pump discharge hose can be connected to the SFP cooling system, placed directly into the SFP, or connected to spray monitor nozzles on the SFP operating floor that spray water into the SFP. The NRC staff notes that 10 ft. of water above the fuel assemblies provides sufficient shielding from the fuel assemblies, which will allow operators to access the SFP operating floor.

Based on the conclusions reached by the staff in the MSA staff assessment related to the anticipatory actions by the licensee, and the defense-in-depth capability of the site's deepwell pumps, the staff finds that the availability of 2 hours to complete the remaining SPF cooling actions is reasonably close to the original strategy such that SFP cooling is not expected to be impacted by the revised streams and rivers reevaluated hazard described in the IA. Any changes necessary to the FLEX procedures as a result of the increased recession time will be captured in the revised site procedures. Completion of this activity is being tracked by NTM 02117149-01, "RNP Flooding IA Procedure Revisions and Validation" and is expected to be completed by December 31, 2020.

The licensee did not identify any other changes to the MSA strategy for the containment integrity KSF as a result of the streams and rivers event, from what is described in the May 9, 2018, MSA staff assessment.

3.3.3.3 <u>Conclusion on Feasible Mitigation Response for "Low" Likelihood Events</u>

The NRC concludes that based on the information provided by the licensee in the IA, as confirmed by its own independent analysis, Robinson has demonstrated a feasible approach for addressing a flood hazard of 228.9 ft. MSL. As a result, the flood response to the "low likelihood" streams and river event is considered to be adequate, and provides reasonable assurance that key SSCs that provide KSFs will continue to perform their intended function for the duration of the event.

3.4 Streams and Rivers Conclusion

The NRC staff has evaluated the information provided in the IA submittal related to the revised FLEX strategies, as evaluated against the reevaluated streams and rivers hazard described in Section 3.3 of this staff assessment. The NRC staff finds that the equipment and actions in the revised FLEX strategy, if implemented as described, are reasonably protected against the streams and rivers combined hazard event. Furthermore, the NRC staff has determined that the strategies to maintain core cooling, containment integrity (as appropriate), and spent fuel pool cooling can be appropriately implemented upon revision of plant procedures and FLEX support guidelines (FSGs). The NRC staff made its determination based upon:

- the licensee has an effective strategy to respond to “high likelihood” floods up to a level of 221.7 ft. MSL,

- the licensee has a feasible strategy to respond to “low-likelihood” floods above 221.7 ft. MSL and up to 228.9 ft. MSL,

- the staff has inspected, audited, and reviewed, as appropriate, pertinent provision of the licensee’s strategy and found it acceptable,

- the licensee has identified the remaining actions to be completed, and the strategy to address the reevaluated streams and rivers, as a regulatory commitment by letter dated January 23, 2020.

Therefore, the NRC staff concludes that the licensee has demonstrated the capability, if implemented as described, to deploy strategies against postulated beyond-design-basis events for the streams and rivers combined event, including associated effects and flood event duration.

4.0 RISK-INFORMED REGULATORY INSIGHTS

In addition to the analysis described above, the NRC staff used additional risk-informed insights to identify if further regulatory actions needed to be implemented at the site. The risk-insights sought to better inform the staff and the SMRP whether the information provided by the licensee was sufficient, or whether additional measures were warranted consistent with the NRC’s backfit process.

To provide insights on whether substantial safety enhancements could be achieved in the context of a backfit analysis, the staff considered qualitative risk insights associated with implementing the licensee’s proposed flood response strategy.

Consistent with NUREG/BR-0058, regulatory initiatives involving new requirements to prevent core damage should result in a reduction of at least $1x10^{-5}$ per year in the estimated mean value core damage frequency (CDF) (i.e., the CDF before the proposed regulatory change should exceed the CDF after the change by at least $1x10^{-5}$) to justify proceeding with further analyses. The evaluation of CDF reduction associated with Robinson’s proposed flood response strategy is determined by two factors: the frequency of the flood against which the site is not protected (i.e., frequency of flood reaching the consequential flood elevation at 226.6 ft.) and the probability of successful mitigation when flood reaches the consequential flood elevation.

The frequency of the flood reaching the consequential flood elevation has not been provided in the licensee's submittal. In general, the state-of-practice analyses are not suitable to provide a usable estimation of flood frequency in these very low frequency ranges. However, because the consequential flood elevation (226.6 ft.) is about 5 ft. higher than the CDB flood elevation (221.7 ft.), the frequency of flood reaching consequential flood elevation is judged to be significantly lower than the CDB flood frequency of 10^{-4} per year[2]. The NRC staff further notes that the CDB flood frequency of 10^{-4} per year is associated with a 95 percent confidence interval, which provides additional confidence in the very low frequency of flood reaching 226.6 ft.

As such, the consequential flood is judged to have an approximate frequency of exceedance on the order of 10^{-5}. Considering the low event frequency for the consequential flood and the actions committed to by the licensee to cope with the event, additional regulatory actions are not likely to result in reductions in CDF by at least $1x10^{-5}$ and therefore, not provide a substantial increase in the protection of public health and safety, and the common defense and security

With regards to implementation of the alternate mitigating strategies for LIP, and streams and rivers, the NRC staff notes that it may conduct future inspections to confirm the implementation of activities (e.g., Inspection Procedure 71111.01, "Adverse Weather protection"), as noted in the September 1, 2015 letter (ADAMS Accession No. ML15174A257).

In summary, the NRC staff concludes that it is impractical to show that a CDF reduction of at least $1x10^{-5}$ per year can be achieved through additional regulatory actions beyond the licensee's proposed flood response strategy.

5.0 SENIOR MANAGEMENT REVIEW PANEL

In accordance with the September 21, 2016, Phase-2 decisionmaking memo, the staff met with the SMRP and presented the results of the review with the recommendation that the streams and rivers flood mechanism be treated as a Group 1 hazard. The staff notes that only the streams and rivers flood-causing mechanism was in the scope of the SMRP, and evaluated as part of the integrated assessment. All other hazards were evaluated under the focused evaluation process described in NEI 16-05. The SMRP members asked questions and provided input to the technical team related to the Path 5 streams and rivers flood hazard. The SMRP approved the staff's recommendation that the streams and rivers flood hazard should be classified as a Group 1 hazard, meaning that no further response or regulatory action is required.

6.0 AUDIT REPORT

The NRC staff previously issued a generic audit plan dated July 18, 2017 (ADAMS Accession No. ML17192A452), that described the NRC staff's intention to conduct audits related to IAs and issue an audit report that summarizes and documents the NRC's regulatory audit of the licensee's IA. The NRC staff activities have been limited to performing the reviews described above including the audit of calculation packages and procedures that supported the licensee's submittal, and the issuance of information needs dated May 13, 2019, July 9, 2019, and August 15, 2019 (ADAMS Accession Nos. ML19197A303, ML19191A252, and ML19288A010, respectively). The staff determined that the information provided during the audit process served to verify statements that the licensee made in its December 19, 2018, submittal. The

[2] Consistent with Regulatory Guide 1.59, Revision 2, "Design Basis Floods for Nuclear Power Plants." ADAMS Accession No. ML003740388

staff concludes that the licensee's December 19, 2018, submittal and the staff's independent analysis described above are enough to support regulatory decisionmaking. Because this staff assessment appropriately summarizes the results of the documents that the staff audited, the NRC staff concludes that a separate audit report is not necessary, and that this document serves as the final audit report described in the July 18, 2017, letter.

6.0 CONCLUSION

The NRC staff has concluded that the licensee has adequately demonstrated that feasible flood protection, if appropriately implemented, exists for the LIP. For the dam failures, storm surge, and seiche flood-causing mechanisms, the staff agrees that these hazards are bounded by the streams and rivers combined event. For the streams and rivers flood mechanism, the staff also agrees that the licensee has an effective protection strategy for floods up to 221.7 ft. MSL and a feasible mitigation strategy for higher, less frequent floods up to 228.9 ft. MSL.

With appropriate consideration of NRC backfit requirements and guidance, the staff also developed further risk insights that supplemented an engineering and flood-frequency based approach to regulatory decisionmaking for the streams and rivers flood hazard. In doing so, the NRC staff concluded that the very low frequency of flooding at the consequential flood elevation, and the inherent conservatisms in the flood hazards provide a level of assurance commensurate with the safety significance, and their importance to public health and safety. Based on the above, in accordance with Phase 2 of the process outlined in the 50.54(f) letter, the NRC staff concludes that additional regulatory actions associated with the streams and rivers reevaluated flood hazard, are not warranted.

The staff notes that the Robinson seismic probability risk assessment (SPRA) was recently submitted to the NRC in response to NTTF Recommendation 2.1, "Seismic." As a result, the staff has not yet completed its review and is not making a determination with respect to potential flooding risks that may be altered, heightened, or proceed differently under the recently evaluated seismic hazard. The staff's evaluation of the Robinson's SPRA is expected to be completed before the end of calendar year 2020.

Finally, the NRC staff notes that the licensee has satisfactorily completed providing responses to the 50.54(f) activities associated with the reevaluated flood hazards.

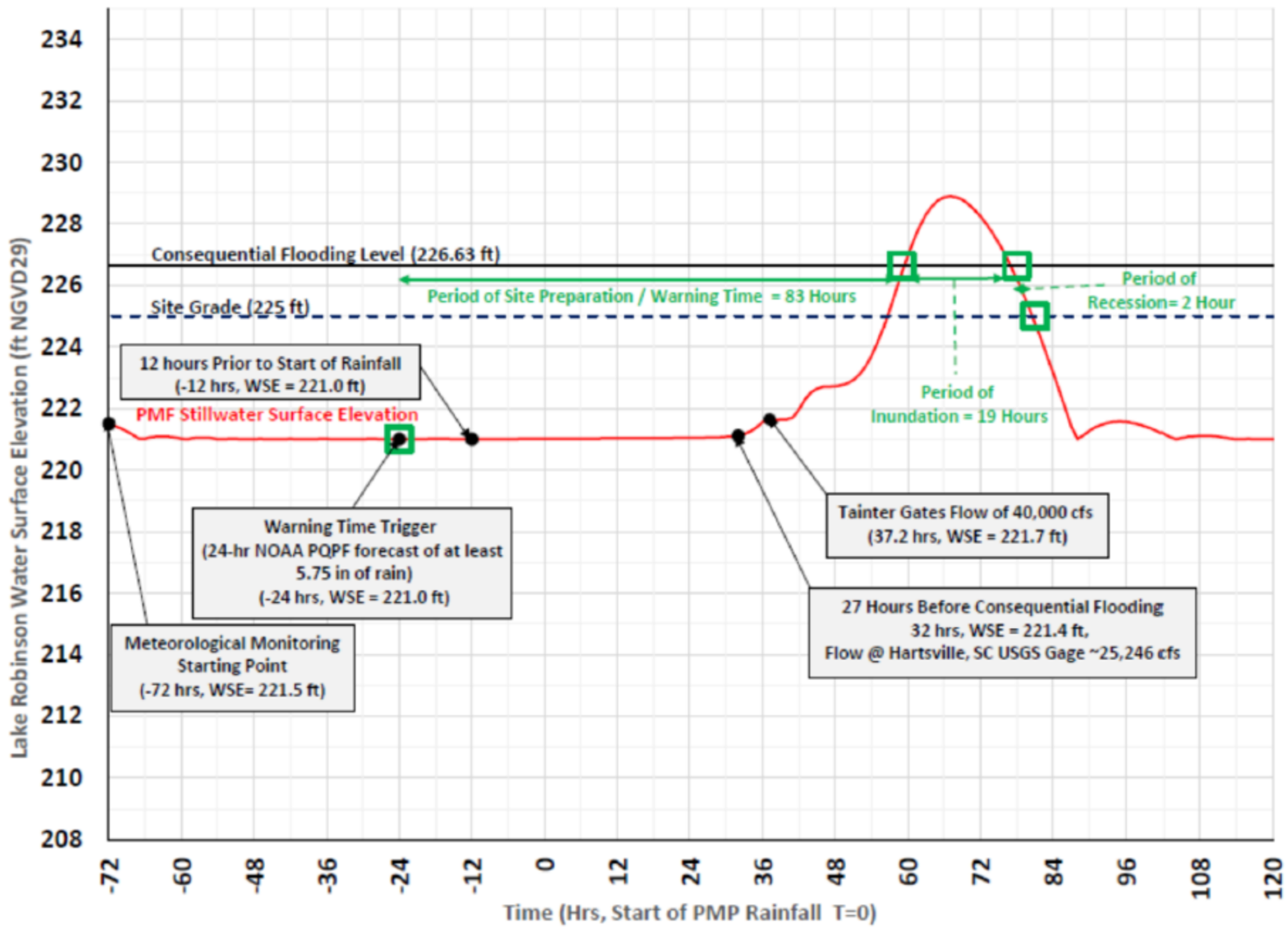

Figure 3.3-1 Reevaluated Streams and Rivers Timeline

Figure 3.3-2 – Approximate location of FLEX AFW pumps

SUBJECT: H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2 – STAFF ASSESSMENT OF FLOOD HAZARD FOCUSED EVALUATION AND INTEGRATED ASSESSMENT (EPID NO. L-2018-JLD-0172) DATED MARCH 20, 2020

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