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

November 28, 2016

Mr. Bryan C. Hanson
Senior Vice President
Exelon Generation Company, LLC
President and Chief Nuclear Officer
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: BRAIDWOOD STATION, UNITS 1 AND 2 – FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT (CAC NOS. MF7898 AND MF7899)

Dear Mr. Hanson:

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).

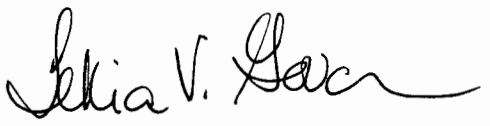
Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazards for their sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses (ADAMS Accession No. ML12056A046). Concurrent with the 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 June 30, 2016 (ADAMS Accession No. ML16182A378), the Exelon Generation Company, LLC (Exelon, the licensee) submitted the mitigation strategies assessment (MSA) for Braidwood Station, Units 1 and 2 (Braidwood). 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 Braidwood MSA.

The NRC staff has concluded that the Braidwood 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. MF7898 and MF7899.

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 Braidwood

Docket Nos. 50-456 and 50-457

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STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION RELATED TO MITIGATION STRATEGIES FOR BRAIDWOOD STATION, UNITS 1 AND 2, AS A RESULT OF THE REEVALUATED FLOODING HAZARD NEAR-TERM TASK FORCE RECOMMENDATION 2.1- FLOODING CAC NOS. MF7898 AND MF7899

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 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 Braidwood Station, Units 1 and 2 (Braidwood) mitigating strategies for beyond-design-basis external events.

2.0 BACKGROUND

By letter dated September 3, 2015, (ADAMS Accession No. ML15211A363), the NRC issued an interim staff response (ISR) letter for Braidwood. The ISR letter provided the reevaluated flood hazard mechanisms that exceeded the current design basis (CDB) for Braidwood and were suitable input for the mitigating strategies assessment (MSA). For Braidwood, the mechanisms listed as not bounded by the CDB in the ISR letter are the probable maximum flood (PMF) on the Mazon River and the cooling pond. After issuance of the ISR, the NRC staff noted two errors in the ISR letter. The ISR letter incorrectly reported the reevaluated hazard elevation for probable maximum flood (PMF) on the Mazon River under the streams and rivers flood-causing mechanism as not bounded. The error has been corrected in the Braidwood staff assessment to indicate that hydrologic dam failure plus PMF on the Mazon River under Failure of Dams and Onsite Water Control/Storage Structures is not bounded. Additionally, the reevaluated hazard elevation for PMF on the cooling pond with waves/runup has been corrected in the Braidwood staff assessment to reflect the elevation reviewed in the Braidwood FHRR by the NRC staff. By letter dated June 30, 2016 (ADAMS Accession No. ML16182A378), the licensee submitted the Braidwood MSA for review by the NRC staff.

3.0 TECHNICAL EVALUATION

3.1 Braidwood's Current FLEX Strategies

Site topography, including but not limited to the cooling pond dike, protect the Braidwood site and the FLEX strategy from the unbounded flood hazards as a result of the PMF on the Mazon River and cooling pond. Therefore, the current FLEX strategies can be successfully deployed as designed for all applicable flood-causing mechanisms and no further actions, including modifications to FLEX, are required.

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

- The site has redundant FLEX diesel generators that can provide the power required for vital instrumentation and all FLEX equipment. The FLEX diesel fuel supply is provided by on-site fuel oil storage tanks, which are not affected by a flooding event.

- The control room indications of vital instruments are initially powered by the station batteries and eventually by the FLEX diesel generators.

- Core cooling is maintained by ensuring adequate reactor coolant system (RCS) inventory for natural circulation with the use of the steam generators for decay heat removal. The diesel-driven auxiliary feedwater pump or the medium pressure FLEX pump with suction from either the condensate storage tanks or the ultimate heat sink provide feedwater to the steam generators.

- RCS inventory is maintained initially by the safety injection accumulator then by the high head FLEX pump. The steam generator steam relief is through the atmospheric dump valves. The refueling water storage tank provides the source for RCS makeup, which will not be affected by a flooding event. A boration skid from the national SAFER response center will provide a long-term boration and makeup source.

3.2. Evaluation of Associated Effects

Flood-related associated effects for Braidwood were assessed during the NRC staff's review of the Braidwood flood hazard reevaluation report (FHRR) (ADAMS Accession No. ML16308A161). In its staff assessment, the NRC staff agreed with the licensee's conclusion that since the site is protected by passive structural features, no actions need to be taken to protect against the PMF of the cooling pond and failure of dams plus PMF on the Mazon River.

3.3 Evaluation of Flood Event Duration

Flood event duration parameters (including warning time and period of inundation) were assessed during the NRC staff's review of the Braidwood FHRR (ADAMS Accession No. ML16308A161). In its staff assessment, the NRC staff agreed with the licensee's conclusion that since the site is protected by passive structural features, no actions need to be taken to protect against the PMF of the cooling pond and failure of dams plus PMF on the Mazon River.

3.4 Evaluation of Flood Protection Features

3.4.1 Mazon River Probable Maximum Flood

As stated in the Braidwood updated final safety evaluation report (USFAR), Section 2.4.2.3, the nominal plant grade and floor elevations are 600.0 ft MSL and 601.0 ft MSL, respectively. The Braidwood MSA, Section 6.1, states that for the PMF on the Mazon River, both the reevaluated maximum stillwater elevation (594.25 ft MSL) and wind-wave run-up elevation (595.83 ft MSL), are not bounded by the current licensing basis (CLB).

The NRC staff reviewed the Braidwood FHRR and noted that two potential failure modes for the site topography, groundwater ingress, and settlement, were assessed and it was determined they were not credible failures. Per the Braidwood UFSAR, the design of safety-related plant structures and all subsurface and foundations are designed to withstand full hydrostatic loads from groundwater assumed to be at plant grade. Additionally, the natural soil strata between the Mazon River and the Braidwood site and a slurry trench would restrict potential seepage into the main plant area from flooding. Furthermore, the Braidwood UFSAR indicates that the predicted settlement of the plant is considered negligible and that settlement has stabilized. The licensee discussed the conservatisms in its hydrologic analysis for the Mazon River and

indicated that the available margin exceeds established criteria for uncertainties in the hydraulic model used to estimate flood level.

Based on the site topography and the design of Braidwood site (e.g., slurry trench and safety-related plant structures), including the available margin, the NRC staff finds the licensee has adequately assessed the ISR flood hazard for the PMF on the Mazon River and the FLEX strategy can be implemented as currently designed.

3.4.2 Cooling Pond Probable Maximum Flood

The Braidwood MSA, Section 6.1, states for the reevaluated maximum stillwater elevation (599.36 ft MSL) for the cooling pond PMF is not bounded by the CLB. The reevaluated maximum wind-wave run-up elevation (601.3 ft-MSL) is bounded by the CDB wind-wave run-up elevation (602.34 ft-MSL).

The NRC reviewed the Braidwood FHRR and noted that the flood protection features associated with this hazard include the following: site topography, grading and slurry trench; northern dike system; and protection against ingress through the essential service water discharge and circulating water discharge pipe and pumping systems. The licensee explained that site topography provides a natural barrier that protects safety-related SSCs to a plant grade elevation of 600 ft MSL and the design of the cooling pond includes a slurry trench that limits seepage from the cooling pond and reduces the potential for groundwater ingress. The NRC staff noted that even with the higher stillwater elevation, per the Braidwood USFAR, the design of safety-related plant structures and all subsurface and foundations were designed to withstand full hydrostatic loads from groundwater assumed to be at plant grade. The licensee also explained that the safety-related classification of the essential service water discharge and circulating water discharge pipe and pumping systems provide adequate flood protection reliability and margin against potential flood water infiltration through these pipe and pumping systems given the insignificant increase in pressure (0.52 psi) created by the reevaluated stillwater elevation.

The Braidwood MSA, Section 6.1, states that the only portion of the FLEX strategy not protected by the dike is the deployment location of the low pressure FLEX pumps at the lake screen house; however, the pump is located at elevation 602.83 ft MSL, which exceeds the CLB and ISR flood level for wind-wave run-up. Thus, the NRC staff finds the deployed location of the low pressure FLEX pump is protected from the ISR level. The licensee explained that the FLEX strategy, as designed, can be successfully implemented because (1) all FLEX equipment is stored and protected above elevation 602 ft MSL; (2) all FLEX equipment and connection points at or below grade elevation are located within safety-related plant structures (i.e., designed to withstand full hydrostatic loads from groundwater assumed to be at plant grade); and (3) all manual actions and haul routes are located at and above grade elevation.

Based on the Braidwood flood protection features discussed above and the design of the plant, and the storage and deployment location of FLEX equipment and connection points, the NRC staff finds the licensee has adequately assessed the ISR flood hazard for the PMF and the FLEX strategy can be implemented as currently designed.

4.0 CONCLUSION

The NRC staff has reviewed the information provided in the Braidwood 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 sequence of events for 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) in such a way that the FLEX strategies cannot be implemented as currently developed, and

- the deployment of the FLEX strategies is not affected by the impacts of the ISR flood levels.

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 PMF on the Mazon River and the cooling pond, including associated effects and flood event duration.

The NRC staff has concluded that the Braidwood 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. MF7898 and MF7899.

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

Sincerely,

/RA/

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 Braidwood

Docket Nos. 50-456 and 50-457

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