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

March 23, 2018

Mr. Mark E. Reddemann
Chief Executive Officer
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SUBJECT: COLUMBIA GENERATING STATION – FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT (CAC NO. MF8455; EPID NO. 000495/05000397/L-2016-JLD-0007)

Dear Mr. Reddemann:

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 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. 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 January 25, 2018 (ADAMS Accession No. ML18025B515), Energy Northwest (the licensee) submitted the mitigating strategies assessment (MSA) for Columbia Generating Station (Columbia). 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 Columbia MSA.

The NRC staff has concluded that the Columbia MSA was performed consistent with the guidance described in Appendix G of Nuclear Energy Institute (NEI) NEI-12-06, Revision 2, as endorsed by Japan Lessons-Learned Division (JLD) interim staff guidance (ISG) JLD-ISG-2012-01, Revision 1 (ADAMS Accession No. ML15357A163), and that the licensee has demonstrated

that the mitigation strategies are reasonably protected from reevaluated flood hazard conditions for beyond-design-basis external events.

This letter closes out the NRC's efforts associated with CAC No. MF8455.

If you have any questions, please contact me at 301-415-1617 or at Frankie.Vega@nrc.gov.

Sincerely,

Frankie Vega, Project Manager
Beyond-Design-Basis Management Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Enclosure:
Staff Assessment Related to the
Mitigating Strategies for Columbia

Docket No. 50-397

cc w/encl: Distribution via Listserv

STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO MITIGATION STRATEGIES FOR

COLUMBIA GENERATING STATION

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

RECOMMENDATION 2.1- FLOODING

DOCKET NO. 50-397; EPID NO. 000495/05000397/L-2016-JLD-0007

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), "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. 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 report, which is intended to describe 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 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). As discussed in JLD-ISG-2012-01, Appendix G of NEI 12-06, Revision 2, describes acceptable methods for demonstrating that the reevaluated flooding hazard is addressed within the Columbia Generating Station (Columbia) mitigating strategies for beyond-design-basis external events.

2.0 BACKGROUND

By letter dated October 6, 2016 (ADAMS Accession No. ML16286A309, non-public), Energy Northwest (the licensee) submitted its flood hazard reevaluation report (FHRR) for Columbia. By letter dated December 7, 2016 (ADAMS Accession No. ML16337A111), the NRC issued an interim staff response (ISR) letter for Columbia. The ISR letter included the reevaluated flood hazard mechanisms that exceeded the current design basis (CDB) for Columbia and parameters that are a suitable input for the mitigating strategies assessment (MSA). For Columbia, the mechanisms listed as not bounded by the CDB in the ISR letter are local intense precipitation (LIP) and streams and rivers. The NRC staff subsequently issued the staff assessment of the FHRR for Columbia by letter dated February 21, 2018 (ADAMS Accession No. ML18051A401) containing additional details supporting the NRC staff's conclusions summarized in the ISR letter. The NRC staff review of the flood event duration (FED) and associated effects (AE) parameters associated with the flooding mechanisms not bounded by the CDB is provided below.

3.0 TECHNICAL EVALUATION

3.1 Mitigating Strategies under Order EA-12-049

The NRC staff evaluated the Columbia strategies as developed and implemented under Order EA-12-049, as described in the licensee's final integrated plan (FIP) dated August 17, 2017 (ADAMS Accession No. ML17229B506). The NRC staff's safety evaluation (SE) for Columbia is dated February 22, 2018 (ADAMS Accession No. ML17333A888). The Columbia SE concluded that the licensee has developed guidance and proposed design that, if implemented appropriately, will adequately address the requirements of Order EA-12-049.

A brief summary of Columbia's FLEX strategies, as described in the SE, is listed below:

> Decay heat is removed when the safety relief valves (SRVs) open on high pressure and dump steam from the reactor pressure vessel (RPV) to the suppression pool located in the wetwell. Makeup to the RPV is provided by the reactor core isolation cooling (RCIC) turbine-driven pump, which normally has its suction aligned to the condensate storage tanks (CSTs). Because the CSTs are not designed to survive all applicable hazards, the licensee's mitigating strategy assumes that the RCIC pump suction realigns to the suppression pool. If alternating current (ac) power cannot be restored, the operators

take manual control of the SRVs to perform a controlled cooldown and depressurization of the reactor, at a rate not to exceed 100 degrees Fahrenheit (°F) per hour. The cooldown of the primary system is stopped when reactor pressure reaches a control band of 175 pounds per square inch gauge (psig) to 300 psig to ensure sufficient steam pressure to operate the RCIC pump. When the suppression pool heats up to a predetermined setpoint, operators open the wetwell vent to atmosphere to mitigate the temperature rise. The RPV makeup will continue to be provided from the RCIC system until the gradual reduction in RPV pressure resulting from diminishing decay heat requires a transition to Phase 2 methods. The RCIC injection source will be maintained for as long as possible, since it is a closed loop system using relatively clean suppression pool water. As suppression pool level decreases during venting, makeup water to the suppression pool will be supplied by aligning a portable diesel-driven FLEX pump to take suction from a service water spray pond and pump about 300 gallons per minute (gpm) to the spent fuel pool (SFP). The SFP will be aligned to overflow to the suppression pool. When the RCIC system is no longer available, the preferred RPV makeup supply in Phase 2 comes from aligning the FLEX pump to supply water to the RPV from a service water spray pond.

The reactor has a Mark II containment which is inerted with nitrogen at power. The licensee performed a containment evaluation and determined that opening the wetwell vent to atmosphere will allow containment temperature and pressure to stay within acceptable levels until equipment from a National Strategic Alliance for FLEX Emergency Response (SAFER) Response Center (NSRC) can be set up to provide cooling of the suppression pool.

Columbia has an SFP in its reactor building. The SFP will heat up due to the unavailability of the normal cooling system and the decay heat from the stored fuel assemblies. To maintain SFP cooling capabilities, the licensee stated that the required action is to establish the water injection lineup before the environment on the SFP operating deck degrades due to boiling in the pool so that personnel can access the refuel floor to accomplish the coping strategies.

To makeup to the SFP, the primary FLEX strategy is to connect FLEX hoses to the portable diesel-driven FLEX pump discussed above. The discharge ends of these hoses are either routed all the way to the SFP, with the discharge ends positioned over the edge of the pool, or connected to nozzles that spray the water over the spent fuel, or connected to plant piping that discharges into the SFP.

The operators will perform load stripping of the 125 volt dc [direct current] (Vdc) buses within the initial 60 minutes following event initiation and load stripping of the 250 Vdc bus to ensure safety-related battery life is extended up to 8 hours. Following dc load stripping and prior to battery depletion, a 480 volt ac (Vac) FLEX generator will be used to repower essential battery chargers prior to depletion of the batteries.

In addition, an NSRC will provide high capacity pumps and large turbine-driven electrical generators which could be used to restore a residual heat removal (RHR) cooling train in the long term. There are two NSRCs in the United States.

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

By letter dated January 25, 2018 (ADAMS Accession No. ML18025B515), the licensee submitted the MSA for Columbia for review by the NRC staff. The MSA is intended to confirm that licensees have adequately addressed the reevaluated flooding hazards within their mitigating strategies for beyond-design-basis external events. For Columbia the two flood mechanisms listed as not bounded by the CDB are the LIP and the streams and rivers (probable maximum flood (PMF) in the local drainage basin) mechanisms. Further evaluation of these flooding mechanisms follows below.

3.2.1 Local Intense Precipitation

LIP was not evaluated in the CDB. In the CDB, the limiting site flooding mechanism is the PMF event, for which the flood waters, with wind-driven waves, reach an elevation of 433.3 ft. above mean sea level (MSL), which is the design flood level. The Final Safety Analysis Report states that the approximate finished grade at all Seismic Category I structures except the spray ponds is 440 ft. MSL, and the finished grade for the spray ponds is 434 ft MSL. For the reevaluated LIP, the maximum reevaluated flood elevations exceed the CDB elevation of 433.3 ft. MSL at multiple locations throughout the site. Table 2 of the staff ISR letter identifies 23 points of interest (POI) as having reevaluated hazard elevation values that were representative of several buildings located in the protected area. These reevaluated flood levels range from 435.1 ft. MSL to 443.3 ft. MSL. Site grade and flood protection elevation for Columbia is at an elevation of 441 ft. MSL. The corresponding calculated maximum water depths at these POIs vary between 0.03 ft. and 0.79 ft. FHRR Table 1 provides the complete list of POI elevations and the maximum flooding depths estimated at each POI. In the FHRR the licensee stated that these results do not indicate flooding of Columbia safety-related structures, systems, and components (SSCs).

In its MSA, the licensee stated that the FLEX storage buildings are constructed above the FLEX design-basis flood elevation of 433.3 ft. MSL, and close to the site grade elevation of 441 ft. MSL. As stated above, the maximum water depths expected from a LIP event ranged from 0.03 ft. to 0.79 ft. around the power block, primary FLEX storage building, and deployment routes. Based on this low level of expected ponding, the licensee concluded that the FLEX equipment will be protected and deployable after all LIP flooding events since the equipment is trailer mounted and therefore, FLEX strategies will not be affected by the LIP event. The licensee stated that the "N+1" storage building (Building 600) is also protected against the LIP event but that certain sections of its deployment path would become inundated. The licensee stated that a portion of the vehicle barrier system can be removed to access equipment from the "N+1" building.

The NRC staff reviewed the information provided by the licensee in the MSA and FHRR, along with the information provided in the FIP that confirmed the FLEX design-basis flood. The NRC staff confirmed that the water surface elevations reported in the MSA matches the values in the ISR letter. The NRC staff also evaluated if the reevaluated LIP hazard impacted any of the storage location(s) of FLEX equipment, any staging areas, haul paths, connection points, activities, etc. Based on the staff's review of the FHRR and Columbia's calculation package CE-02-13-22 "Effects of Local Intense Probable Maximum Precipitation Analysis for Columbia Generating Station" the staff agrees that the estimated LIP flooding depths are expected to be low and any water ponding and potential infiltration is not expected to compromise any safety-related SSCs, FLEX equipment or deployment paths. Also, there appears to be sufficient time considering the duration of the LIP flood event and eventual recession of the water before the Phase 2 FLEX equipment is required to be deployed and therefore, no impact is expected to occur as a result of the reevaluated LIP hazard. The NRC staff concludes that the licensee has

adequately assessed the Mitigating Strategies Flood Hazard Information (MSFHI) for the LIP event and that the applicable FLEX strategy can be implemented.

3.2.2 Streams and Rivers

For the streams and rivers PMF mechanism, the maximum reevaluated flood elevation is 432.0 ft. MSL. This elevation is bounded by the FLEX DB flood hazard elevation of 433.3 ft. MSL. In addition, as stated above, the power block and FLEX storage buildings are built above the FLEX design-basis flood elevation of 433.3 ft. MSL, and close to the site grade elevation of 441 ft. MSL. Therefore, the licensee concluded that FLEX strategies can be implemented as intended and all streams and rivers flooding scenarios are bounded by the FLEX design basis.

Based on the staff's review of the FLEX storage locations, deployment paths, staging areas and overall strategy proposed in the FIP, the NRC staff concludes that the FLEX strategies can be successfully implemented considering the MSFHI provided in the ISR.

3.3 Evaluation of Flood Parameters in the MSA

3.3.1 Confirmation of the Flood Hazard Elevations in the MSA

The NRC staff reviewed the flood hazard elevations in the MSA, and confirmed the elevations match values in the NRC's ISR letter. The ISR letter identified that the LIP flood-causing mechanism and the PMF in the local basin mechanism (streams and rivers) is not bounded by the CDB.

3.3.2 Evaluation of Flood Event Duration

3.3.2.1 Local Intense Precipitation

For the LIP flood-causing mechanism, the licensee stated in its MSA letter that there is no need for significant plant preparation and therefore no warning time is credited or deemed necessary since the planned FLEX strategies can be implemented as designed. Additionally, the MSA letter states that the FLEX strategies are not affected by the FED. The MSA letter states that the deployment path near the "N+1" building (Building 600) may be inundated, but that the equipment stored in this building is only used for backup, and that the backup equipment could still be accessed by removing part of the vehicle barrier system if needed. The MSA letter also stated that a full set of FLEX equipment is located in another building (Building 82) where the equipment is protected and available for use after an external flooding event. The NRC staff reviewed the licensee's LIP model during the review of the FHRR. The NRC staff concluded in the FHRR staff assessment that the licensee's modeling and the estimation of the FED parameters are acceptable for use in the MSA as they used present-day methodologies and regulatory guidance.

3.3.2.2 Streams and Rivers (Probable Maximum Flood in the Local Basin)

For the PMF in the local basin mechanism, the licensee stated in its MSA letter that warning time and the FED are not applicable. The MSA letter also states that since the maximum FLEX design elevation of 433.3 ft. MSL bounds the reevaluated hazard of 432 ft. MSL, the FLEX strategies can be implemented as designed.

In summary, the NRC staff reviewed the licensee's assessment of warning time and the FED and determined that the licensee's FED parameters for the LIP flood-causing mechanism are acceptable because the approach used to estimate these parameters is consistent with the guidance provided by Appendix G of NEI 12-06, Revision 2.

3.3.3 Evaluation of Associated Effects

The NRC staff reviewed the information provided in the FHRR regarding the AE parameters needed to perform the additional assessments of plant response for flood hazards not bounded by the CDB. The AE parameters related to water surface elevation (i.e., stillwater elevation with wind waves and run-up effects) were previously reviewed by staff, and were transmitted to the licensee via the ISR. The AE parameters not directly associated with water surface elevation are discussed below and are summarized in Table 3.2.2-1 of this assessment and discussed by hazard mechanism below.

3.3.3.1 Local Intense Precipitation

For the LIP flood-causing mechanism, the licensee concluded in its MSA letter that the AE parameters related to water-borne loads, including hydrostatic, hydrodynamic, debris, and sediment loads, would induce no or minimal impacts to plant operations due to the low LIP water depths and velocities. They also concluded that other associated effects, including sediment deposition and erosion, and concurrent site conditions are not applicable, and effects on groundwater intrusion have no impact at the plant site.

The NRC staff reviewed the LIP modeling in the FHRR and concluded in its FHRR staff assessment that the modeling approach used present-day methodologies and regulatory guidance. Correspondingly, the staff determined that the licensee's assessment of the AE parameters for the LIP flood-causing mechanism are acceptable for use in the MSA.

In summary, the NRC staff determined that the licensee-provided AE parameters for the LIP flood-causing mechanism are acceptable as the approach to estimate these parameters is consistent with the guidance provided by Appendix G of NEI 12-06, Revision 2.

3.3.3.2 Streams and Rivers (Probable Maximum Flood in the Local Basin)

For the PMF in the local basin flood-causing mechanism, the licensee concluded in its MSA letter that the AE parameters related to water-borne loads, including hydrostatic, hydrodynamic, debris, and sediment loads are not applicable to the site due to the wave runup not reaching the site. The licensee also concluded that other AEs, including sediment deposition, erosion, and concurrent site conditions are also not applicable. The MSA letter also stated that groundwater ingress has no impact on the site.

The NRC staff reviewed the PMF in the local basin flood modeling in the FHRR and concluded in its FHRR staff assessment that the modeling approach used present-day methodologies and regulatory guidance. Correspondingly, the NRC staff determined that the licensee's assessment of the AE parameters for the PMF in the local basin flood-causing mechanism are acceptable for use in the MSA.

4.0 CONCLUSION

The NRC staff has reviewed the information provided in the Columbia MSA related to the FLEX strategies, as evaluated against the reevaluated hazards described in Section 3 of this staff assessment, and concludes that:

- The FLEX strategies are not affected by the impacts of the reevaluated flood levels;
- The deployment of the FLEX strategies is not affected by the reevaluated flood levels; and
- Associated effects and FED have been appropriately considered in the Columbia MSA.

Therefore, the NRC staff concludes that the licensee's proposed FLEX strategies should be effective during a postulated beyond-design-basis event for the LIP and streams and rivers flood-causing mechanisms, including AEs and FED. The NRC staff confirmed that the Columbia flood hazard MSA was performed consistent with the guidance in Appendix G of NEI 12-06, Revision 2, as endorsed by JLD-ISG-2012-01, Revision 1. Based on the licensee's appropriate hazard characterization and methodology used in the Columbia MSA evaluation, the NRC staff concludes that the licensee has demonstrated that these mitigation strategies, if appropriately implemented, are reasonably protected from the reevaluated flood hazard conditions.

TABLE 3.2.2-1. ASSOCIATED EFFECTS PARAMETERS NOT DIRECTLY ASSOCIATED WITH TOTAL WATER HEIGHT FOR FLOOD-CAUSING MECHANISMS NOT BOUNDED BY THE CDB.

Associated Effects Factor	Local Intense Precipitation	PMF (Local Basin)
Hydrodynamic loading at plant grade	Minimal	None
Debris loading at plant grade	Minimal	None
Sediment loading at plant grade	None	None
Sediment deposition and erosion	None	None
Concurrent Conditions, including adverse weather	None	None
Groundwater ingress	No Impact Identified	No impact identified
Other pertinent factors (e.g., waterborne projectiles)	None	None

Source: MSA

SUBJECT: COLUMBIA GENERATING STATION – FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT DATED MARCH 23, 2018

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