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

March 15, 2017

Mr. Adam C. Heflin
President, Chief Executive Officer,
and Chief Nuclear Officer
Wolf Creek Nuclear Operating
Corporation
P.O. Box 411
Burlington, KS 66839

SUBJECT: WOLF CREEK GENERATING STATION – FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT (CAC NO. MF7992)

Dear Mr. Heflin:

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 November 8, 2016 (ADAMS Accession No. ML16321A424), Wolf Creek Nuclear Operating Corporation (WCNOC, the licensee) submitted the mitigation strategies assessment (MSA) for Wolf Creek Generating Station. 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 Wolf Creek MSA.

Enclosure 1 transmitted herewith contains Security-Related Information. When separated from Enclosure 1, this document is decontrolled.

The NRC staff has concluded that the Wolf Creek 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 No. MF7992.

If you have any questions, please contact me at 301-415-1056 or at Lauren.Gibson@nrc.gov.

Sincerely,

Lauren Kate Gibson

Lauren K. Gibson, Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Enclosures:
1. Staff Assessment Related to the Mitigating Strategies for Wolf Creek (non-public)
2. Staff Assessment Related to the Mitigating Strategies for Wolf Creek (redacted)

Docket No. 50-482

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STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION RELATED TO MITIGATION STRATEGIES FOR WOLF CREEK GENERATING STATION, AS A RESULT OF THE REEVALUATED FLOODING HAZARD NEAR-TERM TASK FORCE RECOMMENDATION 2.1- FLOODING CAC NO. MF7992

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 (CLB) 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

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 Wolf Creek Generating Station (Wolf Creek) mitigating strategies for beyond-design-basis external events.

2.0 BACKGROUND

By letter dated March 10, 2014 (ADAMS Accession No. ML14077A280), as supplemented by letter dated May 20, 2015 (ADAMS Accession No. ML15147A516), Wolf Creek Nuclear Operating Corporation (WCNOC, the licensee) submitted its flood hazard reevaluation report (FHRR) . The licensee provided a revised FHRR on January 19, 2016 (ADAMS Accession No. ML16032A189). By letter dated December 24, 2015 (ADAMS Accession No. ML15357A180), the NRC issued an interim staff response (ISR) letter for Wolf Creek. The ISR letter provided the reevaluated flood hazard mechanisms that exceeded the current design basis (CDB) for Wolf Creek and flood parameters that are suitable input for the mitigating strategies assessment (MSA). For Wolf Creek, the mechanisms listed as not bounded by the CDB in the ISR letter are local intense precipitation (LIP) and failure of dams and onsite water control/storage structure. By letter dated November 8, 2016 (ADAMS Accession No. ML16321A424), WCNOC submitted the Wolf Creek MSA for review by the NRC staff.

3.0 TECHNICAL EVALUATION

3.1 Wolf Creek's FLEX Strategies

The licensee stated in its MSA that Wolf Creek's FLEX strategy is described in the document, "Wolf Creek Nuclear Operating Corporation Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)."[1] The licensee's flood evaluation for FLEX accounted for all flood hazards with the exception of the LIP flood and Upstream Dam Failure from the Neosho River flood event as discussed in the Wolf Creek's FHRR document. The licensee stated in its MSA that the FLEX strategies would not be impacted by the above flood events.

A brief summary of the licensee's FLEX strategies is as follows:

- For Phase 1, decay heat is removed via steam release to the atmosphere through the SG Atmospheric Valves (ARVs). The Turbine Driven Auxiliary Feedwater (TDAFW) pump will provide makeup flow to the SGs, taking suction from the Condensate Storage Tank (CST). Natural circulation is maintained in the reactor coolant system (RCS) as

[1] Subsequently, the licensee provided the final integrated plan for Wolf Creek by letter dated January 19, 2017 (ADAMS Accession No. ML17026A194). The NRC staff is evaluating the strategies in the plan and will document the review in a safety evaluation. The purpose of the safety evaluation is to ensure the licensee has developed guidance and proposed designs which, if implemented appropriately, will adequately address the requirements of Order EA-12-049. An inspection will confirm compliance with the order.

operators cool the plant. Operators take actions (shed loads) to prolong the vital battery life.

- For Phase 2, SG makeup would be via a FLEX core cooling pump, which is staged within 8 hours. Around the 18 hour mark, makeup to the CST is initiated from the Ultimate Heat Sink (UHS). A FLEX generator is also deployed by the 8 hour mark to power the battery chargers or other loads. RCS makeup is initiated around the 14 hour mark via a FLEX RCS Makeup pump taking suction from the Boric Acid Tank (BAT) . Around the 43 hour mark, the BAT is depleted and the FLEX RCS pump is aligned to the Refueling Water Storage Tank (RWST). SFP makeup is initiated around the 34 hour mark via a FLEX SFP Makeup pump taking suction from the UHS (through the CST).
- For Phase 3, the licensee will receive equipment from the National SAFER Response Center (NSRC) to continue the same FLEX strategies from Phase 2. The equipment will not be impacted since Phase 3 starts 24 hours into the event, at the earliest, and is not required to be implemented until 72 hours.

3.2 Evaluation of Flood Protection Features

LIP Flood

MSA Section 2.1 described the reevaluated LIP as a maximum flood height of 1,100.5 ft. mean sea level (MSL) around the power block. The CDB LIP flood around the power block is 1,099.9 ft. MSL. The MSA indicated that there are 11 door sill locations, designated as pathways for safe shutdown equipment, where the elevation would be exceeded by LIP flood water for up to 1.23 hours before receding from the power block area, based on the calculations provided in the Wolf Creek FHRR. The licensee stated in the MSA that the results of the revised LIP will require an interim action of instructing operators to place quick dam barriers at the above door sill locations to protect the areas with the safe shut down equipment from the any potential water penetration through the door sills. The licensee stated in the MSA that the revised LIP flood event would allow for a minimum of one-hour warning time to deploy the quick dam barriers prior to the event. The interim action will be in place until the licensee completes physical modifications around the plant site to allow for water diversion up to the new maximum flood height. The quick dam barriers will be placed in the buildings in which the affected door sills are located. The licensee indicated in the MSA that the revised LIP flood event would not cause an ELAP event on site. The licensee assumed that the LIP flood would begin 90 minutes after the FLEX initiating event has occurred. The overall FLEX strategy does not require any additional operator actions for at least 6 hours, when formal damage assessment of the site is completed. The licensee concluded in the MSA that the current FLEX strategies for deploying FLEX equipment for Phase 2 would not be impacted by the revised LIP flood evaluation due to the time margin accounted in the overall strategy, which is much greater than the 1.23 hours needed for the LIP flood to recede from the power block area.

The NRC staff reviewed the licensee's assessment of the reevaluated LIP event as compared to existing FLEX strategies in the Wolf Creek OIP. The NRC staff finds that accounting for the LIP flood occurring after the ELAP event, that there will be about 4.5 hours available before formal site assessment for FLEX deployment is required. The margin allows more than adequate time to account for a LIP flood event and eventual recession to allow for successful deployment of FLEX equipment to the designated areas within the power block. The NRC staff also noted that the licensee will use the interim action of prompting operators to place quick dam barriers at the door sill pathways where the safe shutdown equipment are located. This interim action would not impact the FLEX deployment strategy since the quick dam barriers would be deployed one

hour before the LIP flood event. Based on the time available to initiate site assessment and flood protection actions after the ELAP event, the NRC staff finds the licensee has adequately assessed the MFSHI for the LIP flood event and that the applicable FLEX strategies can be implemented as described in the OIP.

Upstream Dam Failure from the Neosho River

MSA Section 2.2 described the reevaluated hazard elevation for Failure of Dams and Onsite Water Control/Storage Structures as [redacted] due to the potential for Upstream Dam Failure from the Neosho River. This flood elevation is higher than the CDB hazard elevation of [redacted] The Wolf Creek site grade at safety-related buildings is 1,099.5 ft. MSL, which gives a flood elevation margin of [redacted] The licensee further stated that the topographical features in the area of Coffey County Lake would not allow the flood waters to reach the Wolf Creek site. Therefore, the licensee ruled out the upstream dam failure from the Neosho River as a credible flood hazard for Wolf Creek.

The NRC that the licensee has adequately assessed the upstream dam failure mechanism for the impact on the FLEX strategies and that the applicable FLEX strategies can be implemented as currently designed.

Conclusion

The NRC staff has reviewed the information provided in the Wolf Creek MSA related to the original FLEX strategies, as evaluated against the reevaluated hazards described in Section 3.2.3 of this Staff Assessment, and found that the licensee has adequately assessed the MFSHI for the reevaluated LIP and the Upstream Dam Failure from the Neosho River flood events to determine that the FLEX Strategy can be implemented as currently designed. The NRC staff made its determination based upon:

- Time margin available to deploy FLEX equipment after the LIP flood water has receded from the power block area;
- Interim action of placing quick dam barriers with one hour warning time prior to the LIP flood event to protect the door sills before FLEX equipment is deployed and staged;
- Flood levels not reaching site grade for Upstream Dam Failure from the Neosho River flood events.

Therefore, the NRC staff concludes that the licensee has demonstrated the capability to deploy FLEX strategies, as modified, against a postulated beyond-design-basis event for the above flood events, as described in NEI 12-06, Revision 2 and ISG-2012-01, Revision 1.

3.3 Evaluation of Flood Event Duration

Regarding the flood event duration (FED) parameters needed to perform the MSA for flood hazards not bounded by the current design basis (CDB), the staff reviewed information provided by WCNOC in the FHRR (Rev 1), the MSA, and the response to a request for additional information dated May 20, 2015 (ADAMS Accession No. ML15147A516). The FED parameters for the flood-causing mechanisms not bounded by the CDB are summarized in Table 3.3.

For the LIP event, the licensee stated that the flood water maintains a depth above 11 door sills that are pathways to safe shutdown equipment for a period of inundation up to 1.23 hours after the start of the LIP rainfall based on the calculations used to develop the FHRR. The licensee defined a warning time of 1 hour and a period of recession of 8.76 hours. For the LIP event flooding, the maximum water elevations and inundation periods for different locations across the power block are listed in Table 3-3 of the FHRR, Rev 1. The licensee used results from a 2-dimentional numerical modeling method to determine the inundation duration and period of recession parameters. The staff confirmed that the licensee's reevaluation of the inundation periods for LIP and associated drainage uses present-day methodologies and regulatory guidance.

For dam failure, the licensee used the volume method which assumes to transport the total upstream reservoir storage volume instantaneously, and conservatively, to the WCNOC plant site without attenuation. As a result, the licensee found that a flood elevation margin for this postulated dam failure event is [redacted] Due to topographical features in the area of Coffey County Lake, results from the volume method do not encroach into the lake such that the flood waters postulated by the volume method never approach the site as shown by Figure 3-15 of the FHRR. Based on this information, the licensee screened out dam failure from further evaluation in the FHRR. Correspondingly, the licensee concluded that upstream dam failure from the Neosho River is not a credible hazard for further consideration in the MSA, and that the FED parameters for this flood causing mechanism are not applicable. The staff noted that the licensee's application of the volume method follows guidelines provide by the Interim Staff Guidance (ISG) for dam failure (ADAMS Accession No. ML13151A153). Therefore, the staff agrees with the licensee's conclusion that the FED parameters for dam failure are appropriate for the purposes of the MSA.

In summary, the staff agrees with the licensee's conclusion related to determining the FED parameters, as the approach is consistent with the guideline provided by Appendix G of NEI 12-06, Revision 2. Based on this review, the staff determined that the licensee's FED parameters are reasonable and acceptable for use in the MSA.

3.4 Evaluation of Associated Effects

The staff reviewed the information provided by WCNOC regarding reevaluated associated effects (AE) parameters for flood hazards not bounded by the CDB. The AE parameters related to water surface elevation (i.e., stillwater elevation with wind waves and runup 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 3.4.

For the LIP event, the licensee provided the estimation of the hydrostatic and hydrodynamic loads in the FHRR. This estimation is based on the result of a 2-dimentional numerical modeling method as described in FHRR. The licensee also stated that the other associated effects, including sediment deposition and erosion, debris, groundwater ingress, and other associated effects, were screened out because the associate effects of them are minimal due to shallow flow depths, relatively slow flow velocities, and the flow directions, which are away from safety-related structures, systems and components. However, they reported the concurrent site condition for winds of 38.65 miles per hour in the MSA. The staff confirmed the licensee's statements by reviewing the licensee-provided LIP model's input and output files. The staff verified that the inundation depths and flow velocities are accurate and the modeling is

reasonable for use as part of the MSA. Correspondingly, the staff agrees with the licensee's assessment of the AE parameters for LIP.

For the hydrologic dam failure event, the licensee concluded that upstream dam failure from the Neosho River is not considered a credible hazard for further consideration in the MSA, and that the FED parameters for this flood-causing mechanism are not applicable. The staff noted that the licensee's application of the volume method follows guidelines provided by the ISG for dam failure analysis. Correspondingly, the staff agrees with the licensee's conclusion regarding the FED parameters for the dam failure event.

In summary, the staff concludes the licensee's methods were appropriate and the AE parameter results are reasonable for use in the MSA.

4.0 CONCLUSION

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

- The FLEX strategies are not affected by the impacts of the ISR flood levels (including impacts due to the environmental conditions created by the ISR flood levels).
- The deployment of the FLEX strategies, as described in the FIP, which is under review by the NRC staff and subject to subsequent inspection, is not affected by the impacts of the ISR flood levels.
- Associated effects and FED are reasonable and acceptable for use in the Wolf Creek MSA, and have been appropriately considered in the MSA.

Therefore, the NRC staff concludes that the licensee has followed the guidance in Appendix G of 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 LIP and upstream dam failure, including associated effects and flood event duration.

Table 3.3. Flood Event Durations for Flood-Causing Mechanisms Not Bounded by the CDB

Flood-Causing Mechanism	Time Available for Preparation for Flood Event	Duration of Inundation of Site	Time for Water to Recede from Site
Local Intense Precipitation and Associated Drainage	1 hour	1.23 hours	8.76 hours
Failure of Dams and Onsite Water Control/Storage Structures (1)	Not Applicable	Not Applicable	Not Applicable

Source: (Letters dated May 20, 2015, and November 8, 2016 (ADAMS Accession No. ML15147A516 and ML16321A424, respectively) and FHRR (ML16032A191))
Notes:

(1) The FED parameters for dam failure event are not applicable due to a flood elevation margin of [redacted]

TABLE 3.4. ASSOCIATED EFFECTS PARAMETERS NOT DIRECTLY ASSOCIATED WITH TOTAL WATER HEIGHT FOR FLOOD-CAUSING MECHANISMS NOT BOUNDED BY THE CDB

Associated Effects Parameter	Local Intense Precipitation and Associated Drainage	Failure of Dams and Onsite Water Control/Storage Structures [1]
Hydrodynamic loading at plant grade	64 lb/ft for hydrostatic 25 lb/ft for hydrodynamic	Not Applicable
Debris loading at plant grade	Minimal	Not Applicable
Sediment loading at plant grade	Minimal	Not Applicable
Sediment deposition and erosion	Minimal	Not Applicable
Concurrent conditions, including adverse weather - Winds	38.65	Not Applicable
Groundwater ingress	Minimal	Not Applicable
Other pertinent factors (e.g., waterborne projectiles)	Minimal	Not Applicable

Source: (Letters dated May 20, 2015, and November 8, 2016 (ADAMS Accession No. ML15147A516 and ML16321A424, respectively) and FHRR (ML16032A191))

Notes:

(1) The FED parameters for dam failure event is not applicable due to a flood elevation margin of [redacted]

WOLF CREEK GENERATING STATION – FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT DATED March 15, 2017

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