



**ENERGY NUCLEAR**  
*Engineering Report Cover Sheet*

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**2017 FOCUSED EVALUATION FOR EXTERNAL FLOODING AT ARKANSAS NUCLEAR ONE**

**Engineering Report Type:**

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**Applicable Site(s)**

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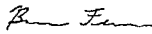
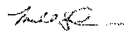
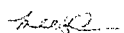
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Note 1: Design Verification is required for all safety-related Project Reports. A review is adequate for non-safety-related Project Reports.

**ENERCON***Excellence—Every project. Every day.***REVISION STATUS SHEET****PAGE 3 OF 14****2017 FOCUSED EVALUATION FOR EXTERNAL  
FLOODING AT ARKANSAS NUCLEAR ONE****REPORT NO.: ENTCORP043-REPT-001****REVISION: 0****PROJECT REPORT REVISION STATUS**

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# **ARKANSAS NUCLEAR ONE FLOODING FOCUSED EVALUATION**

## **SUMMARY**

### **1 EXECUTIVE SUMMARY**

The Arkansas Nuclear One (ANO) site has reevaluated its flooding hazard in accordance with the NRC's March 12, 2012, 10 CFR 50.54(f) request for information (RFI) (Reference 1). The RFI was issued as part of implementing lessons learned from the Fukushima Dai-ichi accident; specifically, to address Recommendation 2.1 of the NRC's Near-Term Task Force report. This information was submitted to the NRC in a flood hazard re-evaluation report (FHRR) on September 14, 2016 (Reference 2) and is provided in the Mitigating Strategies Flood Hazard Information (MSFHI) documented in the NRC's "Interim Staff Response to Reevaluated Flood Hazards" letter dated December 2, 2016 (Reference 8). No changes to the flooding analysis have been performed since the issuance of the MSFHI letter and this flooding analysis will serve as input to this Focused Evaluation (FE). There is one (1) mechanism that was found to exceed the design basis flood level at ANO. This mechanism is listed below and included in this FE:

#### **1. Local Intense Precipitation (LIP)**

Associated effects (AE) and flood event duration (FED) parameters are assessed and submitted as a part of the Mitigating Strategies Assessment (MSA). This FE concludes all vulnerabilities due to the LIP mechanism are addressed by permanent flooding protection, and available physical margin is demonstrated to be adequate to protect Key SSCs. This FE followed Path 2 of NEI 16-05, Rev. 1 and utilized Appendix B for guidance on evaluating the site strategy. This submittal completes the actions related to External Flooding required by the March 12, 2012 10 CFR 50.54(f) letter.

## 2 BACKGROUND

On March 12, 2012, the NRC issued Reference 1 to request information associated with Near-Term Task Force (NTTF) Recommendation 2.1 for flooding. The RFI (Reference 1) directed licensees, in part, to submit a FHRR to reevaluate the flood hazards for their sites using present-day methods and guidance used for early site permits and combined operating licenses. For Arkansas Nuclear One, Units 1 and 2, the FHRR was submitted on September 14, 2016 (Reference 2).

Following the Commission's directive to NRC Staff in Reference 3, the NRC issued a letter to industry (Reference 6) indicating that new guidance is being prepared to replace instructions in Reference 3 and provide for a "graded approach to flooding reevaluations" and "more focused evaluations of local intense precipitation and available physical margin in lieu of proceeding to an integrated assessment." NEI prepared the new "External Flooding Assessment Guidelines" in NEI 16-05 (Reference 4), which was endorsed by the NRC in Reference 5. NEI 16-05 indicates that each flood-causing mechanism not bounded by the design basis flood (using only stillwater and/or wind-wave run-up level) should follow one of the following five assessment paths:

- Path 1: Demonstrate Flood Mechanism is Bounded Through Improved Realism
- Path 2: Demonstrate Effective Flood Protection
- Path 3: Demonstrate a Feasible Response to LIP
- Path 4: Demonstrate Effective Mitigation
- Path 5: Scenario Based Approach

Non-bounded flood-causing mechanisms in Paths 1, 2, or 3 would only require an FE to complete the actions related to external flooding required by the March 12, 2012 10 CFR 50.54(f) letter. Mechanisms in Paths 4 or 5 require an Integrated Assessment.

### 3 TERMS AND DEFINITIONS

- AE – Associated Effects
- AIMS – Assumptions, Inputs, and Methods
- APM – Available Physical Margin
- CDB – Current Design Basis
- FED – Flood Event Duration
- FHRR – Flood Hazard Re-evaluation Report
- FIAP – Flooding Impact Assessment Process
- FLEX – Diverse and flexible coping strategies covered by NRC order EA-12-049
- HHA – Hierarchal Hazard Assessment
- HMR – Hydrometeorological Report
- Key SSC – A System Structure or Component relied upon to fulfill a Key Safety Function
- KSF – Key Safety Function, i.e. core cooling, spent fuel pool cooling, or containment function.
- LIP – Local Intense Precipitation
- MSA – Mitigating Strategies Assessment as described in NEI 12-06 Rev 2, App G
- MSFHI – Mitigating Strategies Flood Hazard Information
- NGVD29 – National Geodetic Vertical Datum of 1929 (equivalent to Mean Sea Level at this location)
- NTTTF – Near Term Task Force commissioned by the NRC to recommend actions following the Fukushima Dai-ichi accidents
- PMP – Probable Maximum Precipitation
- RFI – Request for Information
- VBS – Vehicle Barrier System

## 4 FLOOD HAZARD PARAMETERS FOR UNBOUNDED MECHANISMS

The NRC has completed the "Interim Staff Response to Reevaluated Flood Hazards" (Reference 8) which contains the MSFHI related to ANO's FHRR (Reference 2). In Reference 8, the NRC states that the "staff has concluded that the licensee's reevaluated flood hazard information, as summarized in the enclosure, is suitable for the assessment of mitigation strategies developed in response to Order EA-12-049 (i.e., defines the mitigating strategies flood hazard information described in Nuclear Energy Institute (NEI) guidance document NEI 12-06, 'Diverse and Flexible Coping Strategies (FLEX) Implementation Guide', [Reference 7]) for ANO. Further, the NRC staff has concluded that the licensee's reevaluated flood hazard information is a suitable input for other assessments associated with Near-Term Task Force Recommendation 2.1 'Flooding.'" The enclosure to Reference 8 includes a summary of the CDB and reevaluated flood hazard parameters. In Table 1 of the enclosure to Reference 8, the NRC lists the following flood-causing mechanisms for the design basis flood:

- Local Intense Precipitation;
- Streams and Rivers;
- Failure of Dams and Onsite Water Control/Storage Structures;
- Storm Surge;
- Seiche;
- Tsunami;
- Ice Induced Flooding; and
- Channel Migrations/Diversions.

In Table 2 of the enclosure to Reference 8, the NRC lists flood hazard information (specifically stillwater elevation and wind-wave run-up elevation) for the following flood-causing mechanism that is not bounded by the design basis hazard flood level:

### 1. Local Intense Precipitation (LIP)

This is the reevaluated flood-causing mechanism that should be addressed in the external flooding assessment. The non-bounding flood mechanism for ANO is described in detail in Reference 2, the FHRR. The following summarizes how the unbounded mechanism was addressed in this external flooding assessment:

	<b>Flood Mechanism</b>	<b>Summary of Assessment</b>
<b>1</b>	Local Intense Precipitation	Path 2 was determined to be pursued for ANO since passive protection features are solely relied upon to maintain of KSFs (see FIAP Path Determination Table, Section 6.3.3 of NEI 16-05).



## **5 OVERALL SITE FLOODING RESPONSE**

### **5.1 DESCRIPTION OF OVERALL SITE FLOODING RESPONSE**

The HHA approach described in NUREG/CR-7046 (Reference 15) was used for the evaluation of the LIP and resultant water surface elevations at ANO. Due to anticipated unconfined flow characteristics, a two-dimensional hydrodynamic computer model, FLO-2D, was used. Permanent protection features such as characterized topographic and man-made features that affected runoff from a LIP were modeled. Surface drainage is constricted in some locations by the perimeter Vehicle Barrier System (VBS) that fully encompasses the site. Gaps in the VBS for the intake canal, the discharge canal, the northwest access road and several pedestrian openings on the south access road southeast of the intake building are included in the FLO-2D model. Potential pathways for water intrusion into buildings/structures through gaps in doors and hatches were evaluated for each unit in Enclosure 1, Section 5.2, of the FHRR (Reference 2).

This FE demonstrates that no doors, buildings, or propagation pathways that contain Key SSCs are impacted by floodwaters during the LIP event. The calculated ponding levels are below the controlling CDB event, which is a PMF from the Arkansas River coincident with dam failure and wind-generated waves. Any other buildings that are inundated by floodwaters or the propagation of floodwaters do not contain any Key SSCs or equipment that would affect the ability to maintain any of the KSFs. This includes the Turbine Building, which is further evaluated in Appendix 1.

### **5.2 SUMMARY OF PLANT MODIFICATIONS AND CHANGES**

None.

## 6 FLOOD IMPACT ASSESSMENT

### 6.1 LOCAL INTENSE PRECIPITATION – PATH 2

#### 6.1.1 Description of Flood Impact

The controlling design basis flood, PMF from the Arkansas River coincident with dam failure and wind-generated waves, bounds all re-evaluated LIP flooding elevations listed in Table 1 of the Interim Staff Response (Reference 8). Manual actions in the Turbine Buildings for the controlling PMF that cannot be credited for a LIP are further evaluated in Appendix 1. It was determined that no Key SSCs were impacted by LIP floodwater ingress into the Turbine Building via the Train Bay Doors.

**Table 1 – Flood Height Comparison**

Re-evaluated LIP from FHRR	CDB LIP	Controlling CDB
LIP flooding depths at representative locations range from 351.4 ft to 357.7 ft NGVD29	Not Included <sup>(1)</sup>	361.0 ft <sup>(2)</sup> NGVD29 (stillwater)

<sup>(1)</sup>Flood elevations due to LIP were not specifically evaluated as part of the CDB flood hazard evaluation, but were identified as being screened out as a flood hazard due to the height of flood protections at ANO.

<sup>(2)</sup>Manual actions in the Turbine Buildings for the controlling PMF cannot be credited in the event of a LIP, but this does not affect Key SSCs. See Appendix 1 for justification.

#### 6.1.2 Adequate APM Justification and Reliability Flood Protection

Site topography and building external flood boundaries are Type 1 features that were designed and constructed to mitigate (or minimize) the ponding effects of a LIP. These are already credited as part of the ANO design basis flood protection and therefore per Appendix B of NEI 16-05, a reliability analysis to reconstitute all aspects of the original barrier design is not required. There are no active components credited.

The FHRR evaluated areas that were potentially vulnerable to flooding (maximum water surface elevation above 354 ft NGVD29) and it was determined that the only location where water ingress may have potentially impacted Key SSCs is the Turbine Building via the Train Bay Doors. Section 5.2 of the FHRR concludes that no SSCs important to safety were impacted. Appendix 1 of this Focused Evaluation was created as an elaboration on the existing conclusion in the FHRR. As discussed in Appendix 1, the maximum elevation of the LIP reaches 354.4 ft NGVD29 at the Train Bay doors for a duration of approximately 1 hour. The at-grade elevation of the Turbine Building is 354 ft NGVD29 and does not contain any safety related equipment.

As indicated in Table 1, there is substantial margin between the maximum LIP flooding depths and the controlling CDB flood level. However, since flooding inside the Turbine Building has only been evaluated up to 354.4 ft NGVD29 for a LIP event, APM is considered zero. Zero APM is considered acceptable per NEI 16-05, Appendix B, Section

B.1 since the AIMS used in the LIP analysis were conservative. The following are several of the conservatisms used in the LIP analysis (Reference 9):

1. Roof drains connected to subsurface drainage systems are assumed to be blocked and potential storage resulting from roof parapet walls was conservatively not incorporated.
2. Grid cells representing buildings were represented in FLO-2D by manually adjusting (increasing) grid element elevations. This ensures runoff from the roofs freely flows to adjacent ground grid elements, and flows around the building footprint.
3. Small openings in each VBS block were conservatively assumed to be blocked (i.e., the VBS is impervious).

### **6.1.3 Adequate Overall Site Response**

No manual actions are required for this flood mechanism at ANO.

## 7 CONCLUSION

The Local Intense Precipitation (LIP) flood mechanism is included the ANO CDB in detail, however the CDB does not include an elevation and therefore is considered not bounded. This is the only flooding mechanism that was not bounded by the ANO FHRR. The ANO FHRR (Reference 2, Enclosure 1, Section 5.1) concluded that no interim actions are required to ensure the plant's safe shutdown equipment will be capable of performing their key safety functions. The site's passive permanent flooding protection features were determined to be reliable, as the LIP flood elevations are below that of the controlling CDB flood. There are no active components or required site response.

The site determined that all vulnerabilities due to the LIP mechanism are considered to be addressed by protection, and available physical margin was demonstrated to be adequate to protect Key SSCs. This places ANO in Path 2 to address this unbounded flooding mechanism.

This submittal completes the actions related to External Flooding required by the March 12, 2012, 10 CFR 50.54(f) letter.

## 8 REFERENCES

1. OCNA031208, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident; dated March 12, 2012.
2. OCAN091602, Flooding Hazard Re-evaluation Report – Required Response for Near-Term Task Force (NTTF) Recommendation 2.1 Arkansas Nuclear One – Units 1 and 2 Docket Nos. 50-313 and 50-368 License Nos. DPR-51 and NPF-6, dated September 14, 2016.
3. NRC Staff Requirements Memoranda to COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards", dated March 30, 2015.
4. Nuclear Energy Institute (NEI), Report NEI 16-05 [Rev 1], External Flooding Assessment Guidelines, dated June 2016.
5. U.S. Nuclear Regulatory Commission, JLD-ISG-2016-01 [Rev 0], Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flood Hazard Reevaluation; Focused Evaluation and Integrated Assessment, dated July 11, 2016.
6. OCNA091501, Coordination of Requests for Information Regarding Flooding Hazard Reevaluations and Mitigating Strategies for Beyond-Design-Basis External Events, dated September 1, 2015.
7. Nuclear Energy Institute (NEI), Report NEI 12-06 [Rev 2], Diverse and Flexible Coping Strategies (FLEX) Implementation Guide, dated December 2015.
8. OCNA121601, Arkansas Nuclear One, Units 1 and 2 – Interim Staff Response To Reevaluated Flood Hazards Submitted In Response To 10 CFR 50.54(f) Information Request – Flood-Causing Mechanism Reevaluation (CAC Nos. MF8379 AND MF8380), dated December 2, 2016.
9. CALC-ANOC-CS-14-00010, Rev. 000, Arkansas Nuclear One Flooding Hazard Re-Evaluation – Local Intense Precipitation – Generated Flood Flow and Elevations.
10. OP-1203.025, Rev. 061, Natural Emergencies.
11. OP-2203.008, Rev. 042, Natural Emergencies.
12. OP-5000.028, Rev. 000, Passive Barrier Breach Permitting Process.
13. M-2186 Sh. 1, Rev. 006 (Including Markups from EC 50396 and EC 50519), Heating, Ventilating & Air Conditioning Hotmtl Mach. Shop & Drumming Station Plan EI 354'-0".
14. EC-50519, Rev. 000, 2VSF-38 Flood Barrier Modify Drumming Station Duct Using Quick Latches to Ease Installation of Flood Barrier IAW OP-1203.025.
15. NUREG-7046, Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America, November 2011.
16. NEI 15-05, Rev. 6, Warning Time for Local Intense Precipitation Events.

## Appendix 1 – Turbine Building Flooding

This purpose of this appendix is to provide a supporting evaluation of the conclusion in the FHRR that no SSCs important to safety were impacted by LIP floodwater ingress into the Turbine Building via the Train Bay Doors (Reference 2, Section 5.2). This evaluation is based on information that was previously provided to the NRC via a white paper in December 2016.

Although ANO SSCs important to safety are flood protected up to Elevation 361', "Natural Emergencies" procedures, OP-1203.025 (Reference 10) for Unit 1 and OP-2203.008 (Reference 11) for Unit 2 were reviewed to identify any potential manual actions that are required for external flooding (PMF) that cannot be credited for a LIP.

Three (3) flood barriers were determined to be potentially vulnerable. The first two, hatches HTC-492 and HTC-493 (Train Bay to drumming station), were identified as a potential vulnerability if the hatches were out-of-position open for access during a LIP event. They are normally closed and not impacted during normal plant alignment. Compensatory actions are controlled via Procedure OP-5000.028 Attachment 6 (Reference 12), which has provisions to close HTC-492 and HTC-493 in the event of a severe thunderstorm. Per NEI 15-05 (Reference 16), thunderstorms typically do not have the capacity to produce a consequential rain event for most sites but are used as a predictor for LIP events and therefore are inherently covered. In the event flooding from precipitation did start to occur, the compensatory actions that were identified prior to breaching, such as closing the hatches, would be taken. Note that Attachment 6 of OP-5000.028 lists hatches HTC-492 and HTC-493 as examples, but this requirement applies to all barrier impairments.

The third potential vulnerability is a ventilation duct that is sealed prior to a flooding event. OP-1203.025 drives an action to install a blind flange in place of ductwork. The blind flange is shown on Detail A of EC-50519 Markup to drawing M-2186 Sh. 1, (Reference 13). Since this action would not be completed in the event of a LIP, additional investigation was conducted. Based on walkdowns, pictures, and EC-50519 (Reference 14), the connection is at Elevation 354'-4" (354.33') and is normally connected with a neoprene gasket. The FLO-2D model showed that the elevation of the water at the Train Bay Doors would only be at its peak (354.4') for approximately 30 minutes (Reference 2, Enclosure 1, pages A-22 & A-23). The duct is in Room 72 and is through normally closed doors, so the flooding pathway from the Train Bay Doors to this connection is tortuous. Given the small elevation difference of <0.1', short duration of flood exceedance, tortuous pathway to the connection, and protection from the normally connected neoprene gasket, floodwaters due to a LIP are not expected to leak into this vent.

Therefore, the conclusion that no key SSCs important to safety are impacted by the LIP floodwater ingress into the Turbine Building via the Train Bay Doors is supported.