UNITED STATES
NUCLEAR REGULATORY COMMISSION
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February 12, 2018

ANO Site Vice President
Arkansas Nuclear One
Entergy Operations, Inc.
N-TSB-58
1448 S.R. 333
Russellville, AR 72802

SUBJECT: ARKANSAS NUCLEAR ONE, UNITS 1 AND 2 – FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT (CAC NOS. MF7894 AND MF7895: EPID L-2016-JLD-0007)

Dear Sir or Madam:

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), (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 May 31, 2017 (ADAMS Accession No. ML17153A295), Entergy Operations, Inc. (the licensee) submitted the mitigation strategies assessment (MSA) for Arkansas Nuclear One, Units 1 and 2 (ANO). The MSAs are intended to confirm that licensees have adequately addressed the reevaluated flooding hazard(s) within their mitigating strategies for beyond-design-basis external events. The purpose of this letter is to provide the NRC's assessment of the ANO MSA.

The NRC staff has concluded that the ANO 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, and that the licensee has demonstrated that the mitigation strategies, if appropriately implemented, 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. MF7894 and MF7895.

If you have any questions, please contact me at 301-415-1132 or by e-mail at Joseph.Sebrosky@nrc.gov.

Sincerely,

Joseph M. Sebrosky, Senior 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 ANO

Docket Nos: 50-313 and 50-368

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STAFF ASSESSMENT RELATED TO THE

MITIGATION STRATEGIES FOR

ARKANSAS NUCLEAR ONE, UNITS 1 AND 2

AS A RESULT OF THE REEVALUATED FLOODING HAZARDS REPORT

NEAR-TERM TASK FORCE RECOMMENDATION 2.1- FLOODING

CAC NOS. MF7894 AND MF7895

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), (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. 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 (SRM) 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, as endorsed, describes acceptable methods for demonstrating that the reevaluated flooding hazard is addressed within the Arkansas Nuclear One, Units 1 and 2 (ANO) mitigating strategies for beyond-design-basis external events.

2.0 BACKGROUND

By letter dated December 2, 2016 (ADAMS Accession No. ML16327A482), the NRC issued an interim staff response (ISR) letter for ANO. The ISR letter provided the reevaluated flood hazards that exceeded the current design basis (CDB) for ANO and were suitable input for the mitigating strategies assessment (MSA) (i.e., the mitigating strategies flood hazard information (MSFHI) described in NEI guidance document NEI 12-06). For ANO, the mechanism listed as not bounded by the CDB in the letter (ISR flood levels) was local intense precipitation (LIP).

By letter dated May 31, 2017 (ADAMS Accession No. ML17153A295), Entergy Operations, Inc. (Entergy, the licensee) submitted its MSA for ANO. 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 LIP, the period of inundation and the period of recession for the water is not bounded by the FLEX design-basis. Specifically, a section of the FLEX deployment route along the North Access Road does not begin to fully recede until after 6 hours. This section is expected to become passible after 9-10 hours, which is considered the period of inundation.

In its MSA, the licensee documented the measures that have been or will be taken to address the LIP event that is not bounded by the CDB. Pre-deployment of a FLEX 480 VAC generator and support equipment are planned. Raising a section of the primary deployment path would be an alternative strategy for addressing the LIP event.

3.0 TECHNICAL EVALUATION

3.1 Mitigating Strategies under Order EA-12-049

The NRC staff evaluated the ANO strategies as developed and implemented under Order EA-12-049, as described in the ANO final integrated plan (FIP) provided by Entergy in a letter dated January 12, 2016 (ADAMS Accession No. ML1604A396). Entergy provided a supplement to the FIP in a letter dated September 1, 2016 (ADAMS Accession No. ML16250A008). The NRC staff's safety evaluation is dated September 19, 2016 (ADAMS Accession No. ML16224A106). The safety evaluation concluded that the licensee has developed guidance and a proposed design that, if implemented appropriately, will adequately address the requirements of Order EA-12-049.

Unit 1 (ANO-1) is a Babcock and Wilcox (B&W) pressurized water reactor (PWR) and Unit 2 (ANO-2) is a Combustion Engineering (CE) PWR. A brief summary of the licensee's FLEX strategies for these units are as follows:

- For Phase 1, the initial FLEX strategy for reactor core cooling is to release steam from the steam generators using the main steam safety valves or atmospheric dump valves and to add water to the steam generators via the turbine driven emergency feedwater (TDEFW) pumps. The RCS [reactor coolant system] cooldown and depressurization would be initiated at approximately 8 hours for ANO-1 and at 2 hours for ANO-2. RCS makeup with borated coolant would be initiated by 6 hours for ANO-1 and 17.5 hours for ANO-2. Maintaining a stable pressurizer level for the B&W-designed ANO-1 reactor assures that adequate core cooling can be provided via natural circulation. In contrast, based upon differences in plant configuration, the CE-designed reactor at ANO-2 is capable of maintaining stable natural circulation flow in the RCS despite the thermally induced contraction.

  Stripping of non-essential dc [direct current] loads would be completed within 3 hours into the event. This load shedding would extend the battery powered monitoring function to at least 9 hours following event initiation at each unit. Prior to battery depletion, a portable generator would repower battery charges to ensure instrumentation remains available throughout the event.

- For Phase 2, the transition would occur as portable and pre-installed resources are utilized. The TDEFW pump at each unit is assumed to remain available as long as steam is available for powering the pump and a source of supply water is maintained. In preparation for the eventual unavailability of the TDEFW pump, one diesel-driven FLEX SG makeup pump per unit would be staged to deliver feedwater to the steam generators of each unit.

  For ANO-1, the RCS inventory control strategy relies on repowering one of the three ANO-2 charging pumps from a portable FLEX diesel generator and cross-connection of the charging pump to the ANO-1 high pressure injection system. The ANO-1 thermal-hydraulic analysis determined that the RCS makeup should be aligned within 6 hours following the initiation of an extended loss of ac [alternating current] power (ELAP).

  The electrical portion of the Phase 2 coping strategy has the main goal of repowering one train of battery chargers for each unit, battery room ventilation fans, ANO-1 pressurizer heaters, one ANO-2 charging pump and other critical loads. This strategy would require one FLEX portable diesel generator to power both units. The 480 VAC [volts alternating current] FLEX portable diesel generator and the required power cables would be transported from one of the ANO FLEX storage buildings to its deployed position near the post-accident sampling system building.

  Deployment and connection of the 480 VAC FLEX portable diesel generator from one of the ANO FLEX storage buildings would be completed within 6 hours of the ELAP event initiation. Therefore, the licensee's timeline specifies that the 480 VAC FLEX portable diesel generator would be supplying power to one ANO-2 charging pump, to the ANO-1 pressurizer heaters and any other FLEX Phase 2 required electrical loads (e.g. battery chargers) at this time.

- For Phase 3, the equipment from a National SAFER [Strategic Alliance of FLEX Emergency Response] Response Center (NSRC) will be transported to a staging area. Phase 3 equipment includes a mobile water treatment system and a mobile boration unit. In its MSA, the licensee indicated that deployment of the NSRC equipment is not impacted by the re-evaluated flood levels since they will have sufficiently receded by the time the Phase 3 strategy is implemented.

3.2 Evaluation of Current FLEX Strategies

By letter dated May 31, 2017 (ADAMS Accession No. ML17153A295), the licensee submitted its MSA for ANO. The MSA is intended to confirm that licensees have adequately addressed the reevaluated flooding hazard(s) within their mitigating strategies for beyond-design-basis external events. In accordance with NEI 12-06, Rev. 2, Section G.4.1, "Assessment of Current FLEX Strategies," the MSA should address whether the FLEX strategies can be implemented based on the ISR. For ANO, the MSA addresses the LIP flood hazard.

The ISR provides reevaluated LIP flood heights in the range of 351.4 feet (ft.) to 357.7 ft. National Geodetic Vertical Datum of 1929 (NGVD29). The equipment stored in FLEX Storage Building (FSB) #1 is at an elevation of 412.8 ft. This elevation is higher than the surrounding area and therefore storage of the equipment is not impacted in this building. The deployment pathway from FSB #1 along the North Access Road has a section, approximately 360 ft. long, where maximum flood heights exceed 5.5 ft. This section only begins to fully recede after 6 hours and is expected to become passible after 9 to 10 hours. Figure 3.0-1 provides a diagram showing the location of the flooded area. Deployment of FLEX equipment, which starts as early as 3 hours could be impacted by these flood heights.

Regarding the equipment stored in FSB #2, the FSB elevation is higher than the expected LIP flood levels at this location; however, there is significant flooding expected between this FSB and May Road. The flood heights can reach greater than 8 ft. and are expected to recede at a later time than the flood area along the North Access Road.

The licensee evaluated flood levels around the FLEX staging area and associated activities around the power block and determined that these activities are not impacted. The licensee's MSA notes that the FLEX design basis flood strategy credits pre-deployment activities several days in advance of the LIP event. As discussed in the staff's September 19, 2016, safety evaluation for FLEX, this includes installation of platforms for the Phase 2 equipment. For the LIP event, based on flood depths, the licensee has determined that the platforms do not need to be erected. The licensee reviewed the associated activities, including the FIP sequence of events timeline, and determined that these activities can be implemented as intended assuming equipment from FSB #1 is staged prior to inundation of the North Access Road haul path from the LIP event.

Based on the maximum LIP reevaluated flood height of 357.7 ft., with the ability to place the FLEX equipment from FSB #1 at its designated staging areas, the staff concludes that, with the exception of the FLEX deployment paths, the FLEX strategies are protected in accordance with the guidance found in Section G.4.1 of NEI 12-06, Rev 2. The evaluation of the LIP impact on the FLEX deployment path can be found in Section 3.3 of this document.

3.2.1 Evaluation of Flood Event Duration

The NRC staff reviewed information provided by in Entergy's MSA regarding the flood event duration (FED) parameters needed to perform the MSA for flood hazards not bounded by the CDB. The FED parameters for the flood-causing mechanisms not bounded by the CDB are summarized in Table 3.2.1-1 and discussed below.

3.2.1.1 Local Intense Precipitation

For the LIP flood-causing mechanism, the licensee stated in its May 31, 2017, MSA letter that the licensee will adopt the warning time procedures followed by the alternative trigger method allowed by NEI 15-05, "Warning Time for Local Intense Precipitation Events," Revision 6, April 8, 2015 (ADAMS Accession No. ML18005A076). The MSA letter states that the periods of inundation vary due to the topography of the site, with the maximum period of inundation equal to 10 hours for LIP. The MSA letter also states that a section of the deployment route along the North Access Road does not begin to fully recede until after 6 hours. The NRC staff reviewed the licensee's LIP model during the review of the licensee flood hazard reevaluation report (FHRR) provided in a letter dated September 14, 2016 (ADAMS Accession No. ML16260A060). By letter dated August 29, 2017 (ADAMS Accession No. ML17230A261), the NRC staff concluded 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.

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

3.2.2 Evaluation of Associated Effects

The NRC staff reviewed the information provided in Entergy's FHRR dated September 14, 2016, regarding the associated effects (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 letter. The AE parameters not directly associated with water surface elevation are discussed below and are summarized in Table 3.2.2-1.

3.2.2.1 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 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, concurrent site conditions, and effects on groundwater intrusion are insignificant at the plant site.

The NRC staff reviewed the LIP modeling as part of reviewing the FHRR and in a letter dated August 29, 2017, concluded 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 guideline provided by Appendix G of NEI 12-06, Revision 2.

3.3 Evaluation of Modified FLEX Strategies

The licensee stated in its MSA, that the overall plant response strategies to an ELAP and LUHS [loss of ultimate heat sink] event using the current FLEX procedures, equipment, and personnel can be implemented with the following modifications to the strategy:

- Pre-deploy the FLEX 480 V generator, supporting trailers, and other equipment to the anticipated staging area for a LIP event. The licensee's MSA states that trigger-point entry conditions will be developed and integrated into the licensee's operational procedures such that manual actions to deploy and operate the equipment would not be impacted by the ponding during a LIP event. The licensee provided an alternative to modify the section of the North Access Road that becomes inundated by raising an approximate 360 ft. long section of the road such that the FLEX strategies could be implemented without the need for prestaging.

The staff notes that based on the FHRR, the flooding around the staging area (see Figure 3.2-1) is minimal and below the ground clearance of the FLEX equipment. The licensee also included a commitment in its MSA to either establish trigger-point entry conditions and appropriate procedural changes to prestage the FLEX equipment or to modify the road such that the deployment path is not affected by the LIP. Since warning time is available prior to the onset of the LIP, the NRC staff finds it reasonable that the modified FLEX strategy (i.e., prestaging of FLEX equipment) can be implemented as intended. Alternatively, the staff notes that modifications to the FLEX strategy would not be needed if the licensee changes the North Access Road elevation such that deployment of the FLEX equipment is not impacted by the LIP event.

4.0 CONCLUSION

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

- impacts to the FLEX strategies have been adequately identified;
- revised sequence of events and FLEX procedures are not required to account for the reevaluated LIP flood hazard if the licensee changes the North Access Road elevation such that the FLEX strategies could be implemented as currently designed without the need for prestaging; and
- the licensee has provided an adequate description and justification of flood protection features (i.e., prestaging of FLEX equipment) necessary to implement the FLEX strategy to account for the reevaluated LIP flood hazard.

Therefore, the NRC staff concludes that the licensee has demonstrated the capability to deploy modified FLEX strategies against a postulated beyond-design-basis event for the LIP flood-causing mechanism, including associated effects and flood event duration, as requested in the COMSECY-14-0037, and affirmed in the corresponding SRM. The NRC staff has reviewed the information presented in the MSA by Entergy for ANO, Units 1 and 2. The NRC staff confirmed that the licensee's 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, methodology used in the MSA evaluation, and the description of its combination of strategies (i.e., current FLEX strategy and modified FLEX strategy); the staff concludes that the licensee has demonstrated that the mitigation strategies, if appropriately implemented, are reasonably protected from reevaluated flood hazard conditions.

Table 3.2.1-1. 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	NEI guideline 15-05 (NEI, 2015a)	10 hours	6 hours

Source: Mitigation Strategies Assessment (MSA) for Arkansas Nuclear One dated May 31, 2017 (ADAMS Accession No.ML17153A295)

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

Associated Effects Factor	Local Intense Precipitation
Hydrodynamic loading at plant grade	N/A
Debris loading at plant grade	N/A
Sediment loading at plant grade	N/A
Sediment deposition and erosion	N/A
Concurrent Conditions, including adverse weather	N/A
Groundwater ingress	N/A
Other pertinent factors (e.g., waterborne projectiles)	N/A

1. Information provided in MSA (ADAMS Accession No.ML17153A295).

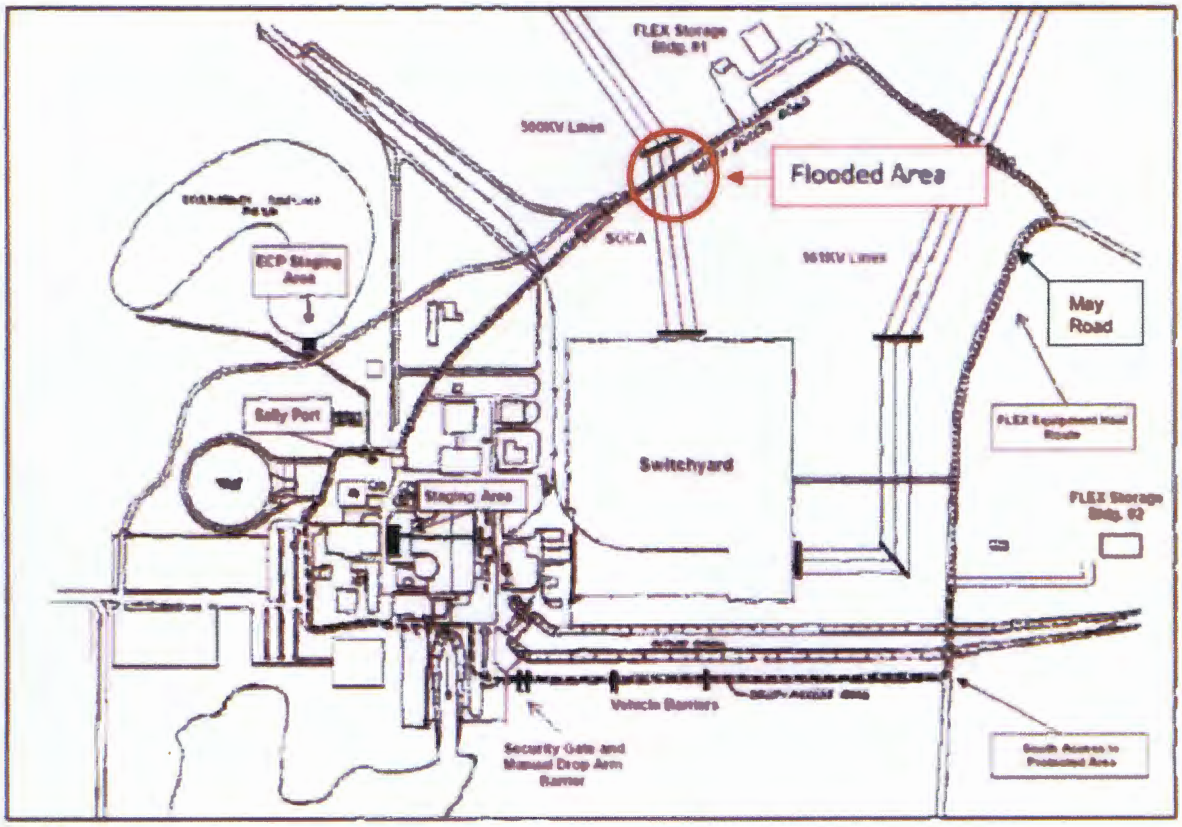

Figure 3.2-1 FLEX Equipment Deployment Routes and Staging Location (adapted from Figure A-1 of Entergy's May 31, 2017, submittal (ADAMS Accession No. ML17153A295))

SUBJECT: ARKANSAS NUCLEAR ONE, UNITS 1 AND 2 – FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT DATED February 12, 2018

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