UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
1600 E LAMAR BLVD
ARLINGTON, TX 76011-4511

September 09, 2014

EA-14-088

Mr. Jeremy Browning, Site Vice President
Arkansas Nuclear One
Entergy Operations, Inc.
1448 SR 333
Russellville, AR 72802-0967

SUBJECT: ARKANSAS NUCLEAR ONE – NRC INSPECTION REPORT 05000313/2014009 AND 05000368/2014009; PRELIMINARY YELLOW FINDING

Dear Mr. Browning:

On August 1, 2014, the U.S. Nuclear Regulatory Commission (NRC) completed an inspection at the Arkansas Nuclear One, Unit 1 and Unit 2. The enclosed inspection report presents the results of this inspection. A final exit briefing was conducted with you and other members of your staff on August 1, 2014.

The enclosed inspection report discusses a finding that has preliminarily been determined to be Yellow, meaning a finding of substantial safety significance. As described in Section 1R01 of the enclosed report, the Unit 1 and Unit 2 auxiliary and emergency diesel fuel storage buildings could have failed to protect safety-related equipment from flooding due to degraded flood barriers.

The preliminary risk significance was determined using NRC Inspection Manual Chapter 0609, Appendix M, "Significance Determination Process Using Qualitative Criteria." The NRC normally uses probabilistic risk assessment methods and tools to characterize the risk significance of findings via the existing significance determination process (SDP) appendices. For this issue, due to the uncertainties associated with extreme flooding events and corresponding impacts to the site, we determined that existing probabilistic risk assessment tools do not provide for a reasonable estimate of this complex finding's risk significance in a time frame consistent with the NRC timeliness goals for SDP evaluations. In these instances, Appendix M specifies that a bounding (i.e., worst-case) analysis should be conducted using the best available information, followed by the consideration of appropriate qualitative factors in determining the significance of the associated finding.

Therefore, in conducting an initial bounding analysis, the NRC developed an estimate for the frequency of a significant flooding event that would challenge the Arkansas Nuclear One facility using reference material developed by the U.S. Army Corps of Engineers, predicted flood height information, and actual flood data collected by stream gages over the last 75 years. After reviewing the features of the watershed and the 500-year flood data, the NRC qualitatively determined that the change in core damage frequency was less than 1 x 10^{-4}/year. This indicated that the significance of the subject finding is no higher than Yellow.

Once a bounding analysis is completed, Appendix M requires that the risk significance be established using qualitative factors. During this review, we determined that flooding in the Unit 1 and Unit 2 auxiliary and fuel oil storage buildings could result in a complete loss of all risk-significant components necessary for accident mitigation (conditional core damage probability of 1.0). Additionally, alternative mitigating strategies would likely not be available because equipment and connections could be submerged. Based on the evaluation of these and other qualitative factors prescribed by Appendix M and documented in this report, we determined that the preliminary significance of the subject finding was Yellow, a finding of substantial safety significance.

The causes for the degraded flood barriers included inadequate design, construction, and maintenance of those barriers. Examples included over 100 unsealed or degraded penetrations, un-isolable floor drains, and open ventilation ductwork. The inspection team noted that strategies to mitigate a flooding event at the site were deficient and would have required emergency response personnel to identify and implement ways to prevent water intrusion to over 100 unknown sources of in-leakage during a flooding event. Therefore, we did not include credit for mitigation in our risk assessment.

Your staff conducted extensive reviews of these issues in root cause evaluations, documented in Condition Reports CR-ANO-C-2013-01304 and CR-ANO-C-2014-00259. Corrective actions included: sealing penetrations, implementing compensatory measures, and adding appropriate instructions to procedures.

The finding was assessed based on the best available information using the applicable Significance Determination Process. The final resolution of this finding will be conveyed in separate correspondence. This finding also constitutes an apparent violation of NRC requirements and is being considered for escalated enforcement action in accordance with the NRC Enforcement Policy, which appears on the NRC's Web site at: http://www.nrc.gov/about-nrc/regulatory/enforcement/enforce-pol.html.

In accordance with NRC Inspection Manual Chapter 0609, "Significance Determination Process," we intend to complete our evaluation and issue our final determination of safety significance within 90 days from the date of this letter. The NRC's significance determination process is designed to encourage an open dialogue between your staff and the NRC; however, the dialogue should not affect the timeliness of our final determination.

At the exit meeting, you and your staff expressed concerns with the NRC-derived frequency range of 1 x 10^{-3}/year to 1 x 10^{-6}/year for the probable maximum precipitation and flood events considered in our qualitative evaluation. Your staff indicated that based on their research, a more realistic frequency value was 1 x 10^{-5}/year to 1 x 10^{-6}/year. The NRC risk analysts reviewed the upper confidence limits from your flood frequency curve that ranged from 3.7 x 10^{-5}/year to 9.1 x 10^{-5}/year, for flooding at site grade elevation, and determined that the range of uncertainty in your frequency estimate is well within the frequency range used by the NRC. Therefore, no change in the preliminary determination of the safety significance of this finding was made.

During the exit meeting, conducted on August 1, 2014, you requested a regulatory conference to discuss this finding and apparent violation. As such, a regulatory conference to discuss the apparent violation will be conducted at the U.S. Nuclear Regulatory Commission, Region IV office, in Arlington, Texas. The regulatory conference should be held within 30 days of the receipt of this letter and we encourage you to submit supporting documentation, such as your proposed flood frequency and supporting basis, at least one week prior to the conference in an effort to make the conference more efficient and effective. This conference will be open to public observation in accordance with Section 2.4, "Participation in the Enforcement Process," of the NRC Enforcement Policy. The NRC will issue a public meeting notice and press release to announce the conference.

Please contact Greg Werner by phone at 817-200-1574 and in writing within 10 days from the issue date of this letter to confirm your intentions to participate in a regulatory conference. If we have not heard from you within 10 days, we will continue with our final significance determination and enforcement decision.

Because the NRC has not made a final determination in this matter, a Notice of Violation will not be issued for this inspection finding at this time. In addition, please be advised that the number and characterization of the apparent violation may change based on further NRC review.

This finding also had a cross-cutting aspect in the area of human performance related to maintaining design margins. Specifically, the licensee did not design, construct, and/or maintain over 100 flood barriers to ensure design margins were sustained.

If you disagree with a cross-cutting aspect assignment in this report, you should provide a response within 30 days of the date of this inspection report, with the basis for your disagreement, to the Regional Administrator, Region IV; and the NRC resident inspector at the Arkansas Nuclear One facility.

In accordance with 10 CFR 2.390, "Public Inspections, Exemptions, Requests for Withholding," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC's Public Document Room or from the Publicly Available Records System (PARS) component of the NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

Marc L. Dapas
Regional Administrator

Docket Nos.: 50-313, 50-368
License Nos.: DPR-51, NPF-6

Enclosure:
Inspection Report 05000313/2014009 and 05000368/2014009
Attachment 1: Supplemental Information
Attachment 2: Detailed Risk Evaluation

cc w/ encl: Electronic Distribution

U.S. NUCLEAR REGULATORY COMMISSION
REGION IV

Docket:	05000313; 05000368
License:	DPR-51; NPF-6
EA:	EA-14-088
Report:	05000313/2014009; 05000368/2014009
Licensee:	Entergy Operations, Inc.
Facility:	Arkansas Nuclear One, Unit 1 and Unit 2
Location:	Junction of Hwy. 64 West and Hwy. 333 South Russellville, Arkansas
Dates:	February 10 through August 1, 2014
Inspectors:	B. Tindell, Senior Resident Inspector J. Melfi, Project Engineer
Risk Analyst:	D. Loveless, Senior Reactor Analyst
Approved By:	G. Werner, Chief Project Branch E Division of Reactor Projects

Enclosure

SUMMARY OF FINDINGS

IR 05000313/2014009; 05000368/2014009; 02/10/2014 – 08/01/2014; Arkansas Nuclear One; Adverse Weather Protection.

The inspection activities described in this report were performed between February 10 and August 1, 2014, by the senior resident inspector at Arkansas Nuclear One, along with an inspector and a senior reactor analyst from the NRC's Region IV office. One finding that has preliminarily been determined to be of substantial safety significance (Yellow) for Unit 1 and Unit 2 is documented in this report. The finding is also an apparent violation of NRC requirements and is being considered for escalated enforcement action in accordance with the NRC Enforcement Policy.

The significance of inspection findings is indicated by their color (Green, White, Yellow, or Red), which is determined using Inspection Manual Chapter 0609, "Significance Determination Process." Their cross-cutting aspects are determined using Inspection Manual Chapter 0310, "Components Within the Cross-Cutting Areas." Violations of NRC requirements are dispositioned in accordance with the NRC Enforcement Policy. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process."

Cornerstone: Mitigating Systems

- Apparent Violation. The inspectors identified a finding of preliminary substantial safety significance (Yellow) for the failure to design, construct, and maintain the Units 1 and 2 auxiliary and emergency diesel fuel storage buildings in accordance with the safety analysis reports' description of internal and external flood barriers so that they could protect safety-related equipment from flooding. Two apparent violations were associated with this finding:

    - Contrary to 10 CFR Part 50, Appendix B, Criterion III, "Design Control," the licensee failed to assure that regulatory requirements and the design basis were correctly translated into specifications, drawings, procedures, and instructions, and that design changes were subjected to design control measures commensurate with those applied to the original design.

    - Contrary to 10 CFR Part 50, Appendix B, Criterion V, "Instructions, Procedures, and Drawings," the licensee failed to prescribe documented instructions for activities affecting quality and accomplish activities affecting quality in accordance with drawings.

  The licensee entered these issues into the corrective action program as Condition Reports CR-ANO-C-2013-01304 and CR-ANO-C-2014-00259. The licensee resolved the safety concern by replacing the degraded seals or parts, installing penetration seals, implementing compensatory measures, and/or incorporating instructions into procedures.

  The inspectors determined that the finding was more than minor because it was associated with the protection against external factors attribute of the mitigating systems cornerstone and adversely affected the cornerstone objective to ensure the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Specifically, the performance deficiency resulted in the vulnerability to flooding of safety-related equipment necessary to maintain core cooling in the auxiliary and emergency diesel fuel storage buildings. The inspectors used Inspection Manual Chapter 0609, Attachment 0609.04, "Initial Characterization of Findings," dated June 19, 2012, and Appendix A, "The Significance Determination Process (SDP) for Findings At-Power," dated June 19, 2012, to evaluate the significance of the finding. In accordance with Appendix A, Exhibit 4, the inspectors determined that a detailed risk evaluation was necessary because, if the flood barriers were assumed to be completely failed, two or more trains of a multi-train system would be degraded during an external flood.

The NRC risk analysts determined that the finding should be evaluated in accordance with NRC Inspection Manual Chapter 0609, Appendix M, "Significance Determination Process Using Qualitative Criteria," April 12, 2012. Appropriate quantitative significance determination process tools did not exist to provide a reasonable estimate of the significance because a plant-specific flood hazard analysis did not exist and was not expected to be available until sometime in 2015. The risk analysts used NRC Inspection Manual Chapter 0609, Appendix M, Table 4.1, "Qualitative Decision-Making Attributes for NRC Management Review," to determine the preliminary safety significance of the finding. The following were the dominant considerations in reaching a preliminary risk determination conclusion:

- With respect to the auxiliary and emergency diesel fuel storage buildings, there were more than 100 unknown ingress pathways for a flooding event, therefore if an external flood above grade level were to occur, the buildings would flood.

- The unexpected rate of flooding would likely be beyond the licensee's capability to prevent or mitigate as equipment and connections associated with alternative mitigating strategies, could be submerged.

- All reactor core cooling and makeup could fail due to significant flooding of the auxiliary and emergency diesel fuel storage buildings.

- The change in core damage frequency was quantitatively bounded below 2×10^{-3} and qualitatively determined to likely be less than 1×10^{-4}. The bounding and qualitative results are based on the frequency of the probable maximum flood event and a loss of all equipment needed for core cooling and makeup.

This finding was preliminarily determined to be of substantial safety significance (Yellow) for Unit 1 and Unit 2, as determined by a Significance and Enforcement Review Panel.

This finding had a cross-cutting aspect in the area of human performance related to maintaining design margins. Specifically, the licensee did not design, construct, and/or maintain over 100 flood barriers to ensure design margins were sustained [H.6]. (Section 1R01)

REPORT DETAILS

1. REACTOR SAFETY

Cornerstones: Initiating Events, Mitigating Systems, and Barrier Integrity

1R01 Adverse Weather Protection (71111.01)

Readiness to Cope with External Flooding

a. Inspection Scope

On August 1, 2014, the inspectors completed an inspection of the station's readiness to cope with external flooding. After reviewing the licensee's flooding analysis, the inspectors chose two plant areas that were susceptible to flooding:

- Unit 1 and Unit 2, auxiliary building
- Unit 1 and Unit 2, emergency diesel fuel storage building

The inspectors reviewed plant design features and licensee procedures for coping with flooding. The inspectors walked down the selected areas to inspect the design features, including the material condition of seals, drains, and flood barriers. The inspectors evaluated whether credited operator actions could be successfully accomplished.

These activities constituted one sample of readiness to cope with external flooding, as defined in Inspection Procedure 71111.01.

b. Findings

Introduction. The inspectors identified a finding of preliminary substantial safety significance (Yellow) for the failure to design, construct, and maintain the Unit 1 and Unit 2 auxiliary and emergency diesel fuel storage buildings in accordance with the safety analysis reports' description of internal and external flood barriers so that they could protect safety-related equipment from flooding. Two apparent violations were associated with this finding:

- Contrary to 10 CFR Part 50, Appendix B, Criterion III, "Design Control," the licensee failed to assure that regulatory requirements and the design basis were correctly translated into specifications, drawings, procedures, and instructions, and that design changes were subjected to design control measures commensurate with those applied to the original design.
- Contrary to 10 CFR Part 50, Appendix B, Criterion V, "Instructions, Procedures, and Drawings," the licensee failed to prescribe documented instructions for activities affecting quality and accomplish activities affecting quality in accordance with drawings.

Description. This finding dispositions the flooding issues revealed by the March 31, 2013, stator drop event, and also addresses additional flooding concerns identified post event. The licensee and NRC inspectors subsequently conducted flooding walkdowns and identified additional flood paths. The stator drop event and the previous follow-up actions are discussed in NRC Augmented Inspection Team Report 05000313; 368/ 2013011 (ML13158A242) and NRC Augmented Inspection Team Follow-up Report 05000313; 368/2013012 (ML14083A409 and Errata ML14101A219).

Unit 1, Safety Analysis Report, Amendment 26, Section 5.1.6, "Flooding," defined the design basis for external flooding and stated, in part, that the seismic class 1 structures are designed for the maximum probable flood level at elevation 361 feet above mean sea level (MSL). All seismic class 1 systems and equipment are either located on floors above elevation 361 feet MSL or protected. Sections 5.3.2 and 5.3.5.2 identified the auxiliary and emergency diesel fuel storage buildings as seismic class 1 structures.

Unit 2, Safety Analysis Report, Amendment 25, Section 3.4.4, "Flood Protection," defined the design basis for external flooding and stated, in part, that seismic category 1 structures were designed for the probable maximum flood. All category 1 systems and equipment were either located on floors above elevation 369 feet MSL, or are protected. Table 3.2-2, "Seismic Categories of Systems, Components, and Structures," identified the auxiliary and emergency diesel fuel storage buildings as seismic class 1 structures.

At the end of the inspection period, the following deficient flood protection features had been identified:

1. Unsealed Conduits

   Based on its flooding walkdowns, the licensee identified over 100 unsealed conduits that penetrated flood barriers for the Unit 1 and Unit 2 auxiliary and emergency diesel fuel storage buildings between 335 feet MSL and 361 feet MSL. These unsealed conduits could have allowed floodwater to pass through flood barriers. Unit 1 Drawing A-304, "Wall and Floor Penetrations Key Plan," Revision 1, and Unit 2 Drawing A-2002, "Architectural Schematic, Fire and Flood Protection Plans and Sections," Revision 10, referenced which walls, ceilings, and floors were flood barriers that required seals. Unit 1 Drawing A-337, "Wall and Floor Penetrations Enclosure Details," Revision 9, and Unit 2 Drawing Series E-2073, "Electrical Penetration Sealing Details," Revision 3, showed seal installation details that met flood protection requirements. The inspectors determined that the licensee failed to install seals in numerous conduits that could be subjected to flooding. The licensee corrected the deficiencies by installing flood seals.

2. Degraded Seals

   The March 31, 2013, stator drop event revealed degraded hatch seals that allowed fire water in the turbine building to leak into the Unit 1 auxiliary building. During extent of condition reviews, the licensee identified 13 degraded hatches for Unit 1 and Unit 2 at 354 feet MSL (site grade elevation). The licensee determined that some hatch seals were degraded from age and some hatch seals were rolled out of place upon installation. From its extent of condition review, the licensee also identified that the building expansion joint between the auxiliary building and containment buildings was significantly degraded and could be subjected to external floodwater by backflooding through un-isolable floor drains.

The inspectors determined that the degraded hatch seals failed to protect safety-related systems from flooding, and that the licensee failed to establish instructions that prescribed how to adequately inspect, replace, and test the seals. The licensee corrected the hatch seal deficiencies by establishing adequate instructions, replacing the seals, and smoke testing the hatches or seal welding the hatches shut. The licensee implemented compensatory measures to plug the floor drains upon notification of a flood to prevent external floodwater from impacting the auxiliary building to containment building expansion joint.

3. Ventilation Penetration

During extent of condition reviews for the degraded hatches, the licensee identified ventilation ductwork that penetrated the Unit 1 auxiliary building flood barrier at 354 feet MSL. The ductwork was designed to have isolation capability; however, during construction, the ductwork blind flange was not fabricated and procedural instructions to isolate this flooding pathway were never developed. Drawing M-2186, "Heating, Ventilating and Air-Conditioning, Hot Material Machine Shop and Drumming Station," Revision 6, specified a blind flange for isolation of the ductwork in case of a flood.

The inspectors determined that the licensee failed to stage the blind flange and translate the design for flange installation into Procedure OP-1203.025, "Natural Emergencies," Revision 37. The licensee corrected the condition by fabricating a flange and revising the procedure.

4. Floor Drains

During extent of condition reviews for the degraded hatches, the licensee identified that floor drains at 354 feet MSL from the turbine building and old radwaste building sump were routed to the Unit 1 auxiliary building and the lines did not contain isolation valves in case of flooding. The inspector determined that the licensee failed to translate the design requirement to have isolation capability into specifications and drawings for the floor drain system. The licensee corrected the condition by installing a blind flange on the old radwaste building sump drain line and implemented compensatory measures to plug the drain line from the turbine building upon notification of a flood.

5. Auxiliary Building Extension

During extent of condition reviews for the degraded hatches, the licensee identified that some Unit 2 auxiliary building extension pipe penetrations between 335 feet MSL and 354 feet MSL were not sealed between the turbine building and auxiliary building extension. Unit 2 Drawing A-2002, "Architectural Schematic, Fire and Flood Protection Plans and Sections," Revision 10, referenced which walls, ceilings, and floors are flood barriers that required seals. Unit 2 Drawing Series A-2600, "Fire Barrier Penetration Seal Details," Revision 5, showed seal installation details that met flood barrier requirements.

The inspectors determined that the licensee failed to install seals for pipe penetrations that could be subjected to floodwater. The licensee designed the auxiliary building extension to be watertight in order to protect the auxiliary building because the buildings were connected by a non-watertight door below the design flood elevation. The unsealed pipe penetrations combined with the non-watertight door could lead to flooding of the Unit 2 auxiliary building. The licensee corrected the condition by modifying the non-watertight door connecting the auxiliary building and the extension, so that if the Unit 2 auxiliary building extension flooded, the Unit 2 auxiliary building would not flood.

6. Non-Watertight Door and Hatch

During extent of condition reviews for the degraded hatches, the licensee identified non-watertight Unit 1 Hatch 522 and Unit 2 Door 253 that could be subjected to floodwater at 358 feet MSL. The licensee found that the door and hatch in the area between the Unit 1 and Unit 2 auxiliary building and containments could be subject to external floodwater because the area was below the design flood level, and the area floor drains were connected to Lake Dardanelle without backwater (check) valves. The inspectors determined that the licensee failed to translate design requirements into specifications and drawings for the Hatch 522 and Door 253. The licensee implemented compensatory measures to plug the floor drains upon notification of a flood.

7. Abandoned Equipment

During a flooding walkdown, the inspectors identified unsealed abandoned pipes that penetrated the Unit 1 auxiliary building flood barrier at 354 feet MSL. The inspectors discovered two pipes that penetrated the auxiliary building from the turbine building that were open on both ends. The licensee cut the pipes as part of a modification to abandon the waste solidification system. However, the design change failed to protect the Unit 1 auxiliary building from floodwater, a design requirement. The licensee corrected the condition by installing a blind flange and a pipe cap to seal the pipes.

8. Decay Heat Vault Drain Valves

The March 31, 2013, stator drop event revealed an open decay heat vault drain valve that allowed fire water internal to the auxiliary building to leak into Unit 1 decay heat vault B at 317 feet MSL. Unit 1, Safety Analysis Report, Amendment 26, Section 5.3.2, “Auxiliary Building,” stated, in part, that the floor area at elevation 317 feet containing engineered safeguards equipment was partitioned into separate rooms to provide protection in the event of flooding due to a pipe rupture. In addition, the auxiliary building, which contains the decay heat removal vaults, is classified as seismic category 1 and is a safety-related structure; thereby the decay heat removal vaults are also safety-related. Each decay heat vault room contains a decay heat removal pump (low head safety injection) that is needed for accident mitigation.

The licensee determined that the reach rod for the valve was loose, so that the position indication was inaccurate, and that the condition applied to both Unit 1 decay heat vaults' drain valves. The inspectors identified that valve position indicated that the valve was closed for approximately 36 degrees of valve rotation. Consequently, when the valve indicated closed, it could actually be open. As stated above, the Unit 1 Safety Analysis Report indicated that the decay heat vaults were designed to be watertight, and the auxiliary building was designated seismic category 1 (safety-related), which includes the decay heat vaults; however, the inspectors determined that the vault drain valves were classified as non-safety-related components.

The inspectors determined that the licensee failed to identify the loose reach rods during daily operation or surveillance testing, correct the inaccurate position indication, and properly classify the vault drain valves as safety-related. The licensee corrected the deficiencies by replacing the reach rods and ensuring the position indication was accurate. In addition, the licensee initiated Condition Report CR-ANO-C-2014-01477 to document the inspectors concerns with maintenance and classification of the vault drain valves.

9. Startup transformer 2 Buswork

   The inspectors identified that startup transformer 2 buswork was installed at 360.5 feet MSL. The licensee credited offsite power for Unit 1 and Unit 2 through startup transformer 2 up to the design flood level of 361 feet MSL, as an alternating current power source for vital and non-vital loads. The licensee implemented compensatory actions to seal the buswork upon notification of a flood.

Due to the number and relatively large area of unsealed penetrations affecting both Unit 1 and Unit 2 auxiliary buildings at plant grade or below, an external flood could cause an inflow of approximately 2,000 gallons per minute and overwhelm the total sump pump capacity of 300 gallons per minute. For unsealed penetrations, the inspectors calculated the inflow by creating a matrix of the penetrations, with a static head of water at the penetration given a flood height of 354 feet, 1 inch MSL. The inspectors calculated the potential flow through those unsealed penetrations using the Bernoulli and Darcy Weisbach equations, with the penetration lengths, number of elbows and other restrictions, as indicated on plant drawings, being included in the calculations. The inspectors estimated the flow through hatches by calculating the flowrate through the hatches during the stator drop event based on water volume and time and applying that potential flowrate to the remainder of hatches and doors. The static head of water on the hatches during the stator drop could approximate a flood height of 354 feet, 1 inch MSL. The Unit 1 and Unit 2 emergency diesel fuel storage building had 14 unsealed conduits that penetrated the flood barrier, and the inflow could overwhelm the sump pump capacity of 15 gallons per minute. The inspectors determined that the auxiliary and emergency diesel fuel storage buildings could flood if water level exceeded site grade elevation.

All core makeup and cooling pumps are below plant grade level inside of the auxiliary building. Some mitigating pumps are inside of watertight rooms internal to the auxiliary building, such as the decay heat removal pumps and the Unit 2 emergency feedwater pumps. The inspectors noted that the rooms were designed and constructed to protect against internal flooding, which is of limited depth and duration. If the auxiliary building flooded from an external flood, the static pressure from the height of water could exceed the design of the watertight rooms and they could also flood, regardless of the position of the decay heat vault drain valves. Therefore, the inspectors concluded that, for Unit 1 and Unit 2, the licensee failed to protect safety-related systems below the design flood level from external floodwater, including equipment inside of vaults. Most importantly, all long-term core makeup and cooling could have failed during an external flood.

In addition to the loss of mitigating pumps, other significant mitigating equipment was affected by the deficient flooding barriers. The emergency diesel fuel storage building could have flooded, submerging the Unit 1 and Unit 2 diesel fuel oil transfer pumps, which could have starved the emergency diesel generators of fuel. Unit 1 and Unit 2 spent fuel pool cooling could have been lost because both units' pumps are in the auxiliary building below flood elevation and are not flood protected. Spent fuel pool makeup would be available from fire protection and service water. Unit 2 outside containment isolation valves were affected because breakers for the valves could be submerged, however the valves were accessible for manual operation and the inside containment isolation valves would be available. Unit 1 and Unit 2 containment spray systems could be submerged. Unit 1 and Unit 2 portable recovery equipment, connections, and other recovery strategies, such as gravity feeding tanks, could be unavailable due to submergence from flooding.

The licensee had previous identification opportunities for the performance deficiency, including minor water leakage into the auxiliary building through seals, which was sometimes treated as nuisance groundwater leakage. NRC Information Notice 07-01, "Recent Operating Experience Concerning Hydrostatic Barriers," contained information about vulnerabilities due to unsealed conduits and lack of flood barrier maintenance, but the licensee only addressed flood barriers between manholes in the yard and the auxiliary building. For the auxiliary building hatch seals, the licensee had been performing 10-year inspection on all hatches, but no condition reports were generated prior to the March 31, 2013, stator drop event, despite the degraded seals.

The licensee designated the degraded turbine building hatch seals as a significant condition adverse to quality and performed a root-cause evaluation as part of the condition reporting process (Condition Report CR-ANO-C-2013-01304). The evaluation focused on preventative maintenance for hatch seals. The licensee also initiated flooding extent of condition reviews outside of the root cause evaluation. From its extent of condition reviews, the licensee identified significant flooding barrier issues related to design and construction. In addition, during walkdowns, the licensee discovered unsealed conduits. Independently, during their respective walkdowns, the inspectors identified unsealed abandoned equipment that penetrated the flood barrier. The licensee performed low level causal evaluations and limited extent of condition reviews for the design and construction issues. The inspectors challenged the licensee that the flooding design and construction issues were a separate significant condition adverse to quality. Subsequently, the licensee initiated a second root cause evaluation in February 2014, as documented in Condition Report CR-ANO-C-2014-00259.

The NRC and licensee identified multiple floodwater paths into the auxiliary building after the licensee had performed flooding walkdowns, as directed by the March 12, 2012, 50.54(f) letter, concerning actions to be taken by licensees that resulted from the Fukushima Dai-ichi nuclear power plant event. The licensee failed to properly identify all flood protection features, as specified in NEI 12-07, "Guidelines for Performing Walkdowns of Plant Flood Protection Features," Revision 0. The essential flood protection features that should have been included, as part of its flooding walkdowns, included auxiliary building floors and ceilings, flood drain system routing, the auxiliary building extension, and offsite power buswork. As a result of the partial walkdowns, additional deficient flood protection features were not identified. The licensee entered this issue into their corrective action program as Condition Reports CR-HQN-2014-00059 and CR-ANO-C-2014-00259. Corrective actions included plans to re-perform the reviews of essential flood protection features, identify those features that were initially not identified, complete the missed portions of the walkdown, and submit corrected information to the NRC.

The licensee determined that the failure to properly identify all flood protection features was due, in part, to incomplete information on flooding barriers; some information not being maintained current; and inadequate oversight of the contractor performing the flood protection walkdowns.

Analysis. The failure to design, construct, and maintain the Unit 1 and Unit 2 auxiliary and emergency diesel fuel storage buildings so that they would protect safety-related equipment from flooding was a performance deficiency. This performance deficiency was more than minor because it was associated with the protection against external factors attribute of the mitigating systems cornerstone and adversely affected the cornerstone objective to ensure the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences, and was, therefore, a finding. Specifically, the performance deficiency resulted in the vulnerability of risk-significant equipment in the auxiliary and emergency diesel fuel storage buildings to flooding.

The inspectors used Inspection Manual Chapter 0609, Attachment 0609.04, "Initial Characterization of Findings," dated June 19, 2012, and Appendix A, "The Significance Determination Process (SDP) for Findings At-Power," dated June 19, 2012, to evaluate the significance of the finding. In accordance with Appendix A, Exhibit 4, the inspectors determined that a detailed risk evaluation was necessary because, if the flood barriers were assumed to be completely failed, therefore two or more trains of a multi-train system would be degraded during an external flood. The preliminary risk significance was determined using NRC Inspection Manual Chapter 0609, Appendix M, "Significance Determination Process Using Qualitative Criteria," dated April 12, 2012. The NRC normally uses probabilistic risk assessment methods and tools to characterize the risk significance of findings via the existing significance determination process appendices. For this issue, due to the uncertainties associated with extreme flooding events and corresponding impacts to the site, we determined that existing probabilistic risk assessment tools do not provide for a reasonable estimate of this complex finding's risk significance in a time frame consistent with the NRC timeliness goals for significance determination process evaluations. Appendix M specifies that a bounding (i.e., worst-case) analysis should be conducted using the best available information, followed by the consideration of appropriate qualitative factors in determining the significance of the associated finding. The risk analysts used NRC Inspection Manual Chapter 0609, Appendix M, Table 4.1, "Qualitative Decision-Making Attributes for NRC Management Review," to evaluate these qualitative factors. Based on the evaluation of the qualitative factors prescribed by Appendix M and documented in this report, we determined that the preliminary significance of the subject finding was Yellow, a finding of substantial safety significance. The detailed risk evaluation, including assumptions, is documented in Attachment 2 of this report.

This finding had a cross-cutting aspect in the area of human performance related to maintaining design margins. Specifically, the licensee did not design, construct, and/or maintain over 100 flood barriers to ensure design margins were sustained [H.6].

Enforcement. The inspectors identified two apparent violations associated with the performance deficiency. As a result of these apparent violations, the Unit 1 and Unit 2 auxiliary and emergency diesel fuel storage buildings could allow floodwater to submerge safety-related equipment.

Design

Title 10 CFR Part 50, Appendix B, Criterion III, "Design Control," states, in part, that measures shall be established to assure that applicable regulatory requirements and the design basis, as defined in § 50.2 and as specified in the license application, for those structures, systems, and components to which this appendix applies, are correctly translated into specifications, drawings, procedures, and instructions. Design changes shall be subject to design control measures commensurate with those applied to the original design.

Unit 1, Safety Analysis Report, Amendment 26, Section 5.1.6, "Flooding," defined the design basis and stated, in part, that the seismic class 1 structures are designed for the maximum probable flood level at elevation 361 feet MSL. All seismic class 1 systems and equipment are either located on floors above elevation 361 feet or protected. Sections 5.3.2 and 5.3.5.2 identified the auxiliary building and emergency diesel fuel storage vault, both quality-related, as seismic class 1 structures.

Unit 2, Safety Analysis Report, Amendment 25, Section 3.4.4, "Flood Protection," defined the design basis and stated, in part, that seismic category 1 structures were designed for the probable maximum flood. All category 1 systems and equipment were either located on floors above elevation 369 feet, or are protected. Table 3.2-2, "Seismic Categories of Systems, Components, and Structures," identified the auxiliary building and emergency diesel fuel storage vault, both quality-related, as seismic class 1 structures.

Unit 1, Safety Analysis Report, Amendment 26, Section 5.3.2, "Auxiliary Building," stated, in part, that the floor area at elevation 317 feet containing engineered safeguards equipment was partitioned into separate rooms to provide protection in the event of flooding due to a pipe rupture.

Contrary to the above, as of March 31, 2013, the licensee failed to assure that applicable regulatory requirements and the design basis were correctly translated into specifications, drawings, procedures, and instructions and that design changes were subject to design control measures commensurate with those applied to the original design. Specifically, the licensee failed to assure that safety-related equipment below the design flood level was protected in the following examples:

a. The licensee failed to include a flooding procedural step to install a blind flange in a ventilation duct that penetrated the Unit 1 auxiliary building below the design flood level.

b. The licensee failed to design the floor drain system with isolation capability so that drains from the turbine building and radwaste storage building, which are non-flood protected structures, would not drain into the Unit 1 auxiliary building in a flood.

c. The licensee failed to design the Unit 1 Hatch 522 and Unit 2 Door 253, which allow access to the area between the auxiliary buildings and containment buildings, to withstand the design flood level.

d. The licensee failed to seal open penetrations into the Unit 1 auxiliary building below the design flood level that were created when the licensee abandoned portions of the waste solidification system.

e. The licensee failed to assure that the Unit 1 decay heat vault drain valves were specified as safety-related, as required to maintain the vaults watertight.

Construction and Maintenance

Title 10 CFR Part 50, Appendix B, Criterion V, "Instructions, Procedures, and Drawings," states, in part, that activities affecting quality shall be prescribed by documented instructions, procedures, or drawings of a type appropriate to the circumstances and shall be accomplished in accordance with these instructions, procedures, or drawings.

Unit 1 Quality Drawing A-304, Sheet 1, "Wall and Floor Penetrations Key Plan," Revision 1, and Unit 2, Quality Drawings A-2002, "Architectural Schematic, Fire and Flood Protection Plans and Sections," Revision 10, prescribed walls, ceilings, and floors as flood barriers that required seals.

Unit 1, Quality Drawing A-337, "Wall and Floor Penetrations Enclosure Details," Revision 9, and Unit 2 Quality Drawing Series E-2073, "Electrical Penetration Sealing Details," Revision 3, prescribed conduit seal installation details that would act as a barrier to floodwater. Unit 2 Quality Drawing Series A-2600, "Fire Barrier Penetration Seal Details," Revision 5, prescribed pipe penetration seal details that would act as a barrier to floodwater.

Contrary to the above, as of March 31, 2013, the licensee did not prescribe activities affecting quality by documented instructions or procedures and accomplish activities affecting quality in accordance with drawings. Specifically, the licensee failed to assure that safety-related equipment below the design flood level was protected in the following examples:

a. The licensee failed to install seals in conduits that penetrated flood barriers for the Unit 1 and Unit 2 auxiliary and emergency diesel fuel storage buildings.

b. The licensee failed to install seals in pipe penetrations that penetrated flood barriers for the Unit 2 auxiliary building extension.

c. The licensee failed to, for the Unit 1 and Unit 2 auxiliary building hatches and building expansion joints between the building and containment: (1) provide appropriate seal inspection criteria; (2) establish a replacement frequency for the seals; and (3) develop post-maintenance test procedures to verify the effectiveness of the seals after they were reinstalled.

The licensee entered these issues into the corrective action program as Condition Reports CR-ANO-C-2013-01304 and CR-ANO-C-2014-00259. For the identified conditions in both violations, the licensee has replaced the degraded seals or parts, installed penetration seals, implemented compensatory measures, or added appropriate instructions to procedures. Because this finding has been preliminarily determined to be of substantial safety significance (Yellow) for Unit 1 and Unit 2, it is being treated as an apparent violation in accordance with the NRC's Enforcement Policy, and its final significance will be dispositioned in future correspondence: AV 05000313/2014009-01; 05000368/2014009-01, "Inadequate Flood Protection for Auxiliary and Emergency Diesel Fuel Storage Buildings."

1R04 Equipment Alignment (71111.04)

Partial Walkdown

a. Inspection Scope

The inspectors performed a partial system walk-down of the following risk-significant system:

- May 14, 2014, Unit 1, decay heat vault floor drains

The inspectors reviewed the licensee's procedures and system design information to determine the correct lineup for the system. They visually verified that critical portions of the system were correctly aligned for the existing plant configuration.

These activities constituted one partial system walk-down sample as defined in Inspection Procedure 71111.04.

b. Findings

No findings were identified.

4. OTHER ACTIVITIES

Cornerstones: Initiating Events, Mitigating Systems, Barrier Integrity, Emergency Preparedness, Public Radiation Safety, Occupational Radiation Safety, and Security

4OA2 Problem Identification and Resolution (71152)

Annual Follow-up of Selected Issues

a. Inspection Scope

The inspectors selected one issue for an in-depth follow-up:

- On April 24, 2014, the inspectors reviewed Condition Report CR-HQN-2014-00059 related to deficiencies with the licensee's flooding walkdowns.

  The inspectors assessed the licensee's problem identification threshold, cause analyses, extent of condition reviews and compensatory actions. The inspectors verified that the licensee appropriately prioritized the planned corrective actions.

These activities constitute completion of one annual follow-up sample as defined in Inspection Procedure 71152.

b. Findings

No findings were identified.

4OA3 Follow-up of Events and Notices of Enforcement Discretion (71153)

(Closed) Licensee Event Report 05000313/2014-01-00, Inadequate External Flood Protection for Safety-Related Equipment Located Below the Design Basis Flood Elevation

The NRC and licensee identified numerous deficient design features and procedures for protection against flooding. Examples included missing conduit seals, degraded or missing gaskets, roof leaks, groundwater intrusion, cross-connected floor drains, and a segment of an offsite power bus that was below the design external flood level. The potential existed for floodwater to migrate into the auxiliary building where pumps and equipment required for safe shutdown were located. The licensee identified root causes involving a lack of configuration control and a lack of robust design for flood barriers. The inspectors documented a finding in Section 1R01 of this inspection report that covered the deficient conditions discussed in the event report.

These activities constitute completion of one event follow-up sample, as defined in Inspection Procedure 71153.

4OA5 Other Activities

(Closed) Unresolved Item 05000313/2013011-005, "Flood Barrier Effectiveness"

As documented in NRC Augmented Inspection Team Report 05000313; 368/2013011, additional inspection was required to determine the causes and impact of the degraded flood hatch seals and the partially open decay heat vault B drain isolation valve that were revealed by the March 31, 2013, stator drop event. NRC Augmented Inspection Team Follow-up Report 05000313; 368/2013012 discussed that the inspectors had not completed their evaluation of the licensee's extent of condition for the degraded flood barriers. This report documents numerous deficient flood protection barriers that made the Unit 1 and Unit 2 auxiliary and emergency diesel fuel storage buildings susceptible to flooding. Refer to Section 1R01 of this report for a detailed description of the findings and apparent violations.

4OA6 Meetings, Including Exit

Exit Meeting Summary

On August 1, 2014, the inspectors presented the inspection results to Mr. J. Kowalewski, Senior Vice President and Chief Operating Officer, Entergy Southern Regional Operations, and other members of the licensee staff. The licensee acknowledged the issues presented. The licensee confirmed that any proprietary information reviewed by the inspectors had been returned or destroyed.

SUPPLEMENTAL INFORMATION

KEY POINTS OF CONTACT

Licensee Personnel

J. Browning, Site Vice President
D. James, Director, Regulatory and Performance Department
S. Pyle, Manager, Regulatory Assurance

LIST OF ITEMS OPENED, CLOSED, AND DISCUSSED

Opened

05000313/2014009-01; 05000368/2014009-01	AV	Inadequate Flood Protection for Auxiliary and Emergency Diesel Fuel Storage Buildings (Section 1R01)

Closed

05000313/2013011-05	URI	Flood Barrier Effectiveness (Section 4OA5)
05000313/2014-01-00	LER	Inadequate External Flood Protection for Safety-Related Equipment Located Below the Design Basis Flood Elevation (Section 4OA3)

LIST OF DOCUMENTS REVIEWED

Section 1R01: Adverse Weather Protection

Procedures

Number	Title	Revision
2203.008	Natural Emergencies	24
1203.025	Natural Emergencies	37

Miscellaneous

Number	Title	Revision
6600-A-2031	Specification for Installation of Penetration Seals	8
ER-ANO-2002-0968	2P-133 Abandon in place	0
ER-ANO-2002-0052	Abandon Waste Solidification	0

Condition Reports (CRs)

CR-ANO-2-2013-00904	CR-ANO-C-2013-02846	CR-ANO-C-2011-00727
CR-HQN-2013-00854	OE-NOE-2007-00076	CR-ANO-C-2014-00857

Section 1R04: Equipment Alignment

Procedures

Number	Title	Revision
OP-1015.003A	Unit 1 Operations Logs	82
OP-1015.003A	Unit 1 Operations Logs	88
OP-1203.025	Natural Emergencies	41
OP-6010.002	QACAT and ENVQ Component Classification	4
EN-DC-308	Safety and Quality Classification of Replacement Parts	3
EN-DC-167	Classification of Structures, Systems and Components	5
EN-DC-115	Engineering Change Process	15

Drawings

Number	Title	Revision
A-100, Sheet 1	Turbine & Auxiliary Building Floor Plant – El. 354'-0" Precast Concrete Panel Schedule	27
A-107, Sheet 1	Architectural Auxiliary Building Floor Plans El 317'-0" & 335'-0"	26
A-401, Sheet 2	Architectural Door Schedule	13
A-401, Sheet 3	Architectural Door Schedule	12
A-401A, Sheet 1	Architectural Hatch Schedule and Details	2

Miscellaneous

Number	Title	Revision
97-R-1002-01	Engineering Report Data Sheet - ECCS Leakage Quantities to the Auxiliary Building	1
M-83	Piping Class Summary Arkansas Nuclear One - Unit 1	20

Miscellaneous

Number	Title	Revision
ULD-0-TOP-22	ANO Component Classification Topical	0
LER 90-004-01	Missing Backwater Valve in Floor Drain Created a Condition Which Could Have Prevented the Fulfillment of the Safety Function of the Emergency Feedwater System	1
QAPM	Quality Assurance Program Manual	24

Condition Reports (CRs)

CR-ANO-1-2013-01286 CR-ANO-C-2014-00259

Section 4OA2: Problem Identification and Resolution

Procedures

Number	Title	Revision
EN-LI-102	Corrective Action Process	23

Drawings

Number	Title	Revision
M-2186, Sheet 1	Heating, Ventilation & Air Conditions Hot Mach. Shop & Drumming Station Plan El 354'-0"	6
M-005, Sheet 1	Equipment Location Ground Floor Plan	33
M-006, Sheet 1	Equipment Location Plan Below Grade	32
M-213, Sheet 1	Piping & Instrument Diagram, Dirty Radioactive Waste Drainage & Filtration	60
M-213, sheet 2	Piping & Instrument Diagram, Laundry Waste and Containment & Aux. Building Sump Drainage	28

Miscellaneous

Number	Title	Date/ Revision
CALC-95-R-0024-01	Basic Requirements for the Component Database on Station Doors and Hatches	9
CALC-ANO1-CS-12-00003	Arkansas Nuclear One Unit I Flooding Walkdown Submittal Report for Resolution of Fukushima Near-Term Task Force Recommendation 2.3: Flooding	0
CALC-ANO2-CS- 12-00002	Arkansas Nuclear One Unit 2 Flooding Walkdown Submittal Report for Resolution of Fukushima Near-Term Task Force Recommendation 2.3: Flooding	0
0CAN061202	Entergy's Response to NRC Request for Information (RFI) Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendations 2.1 and 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident	June 8, 2012
1CAN111202	Flooding Walkdown Report - Entergy's Response to NRC Request for Information (RFI) Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident Arkansas Nuclear One - Unit 1	November 27, 2012
2CAN111202	Flooding Walkdown Report - Entergy's Response to NRC Request for Information (RFI) Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident Arkansas Nuclear One - Unit 2	November 27, 2012
0CAN111302	Supplemental Response NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendations 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident Arkansas Nuclear One – Units 1 and 2	November 26, 2013
NEI 12-07	Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features,	0
ULD-0-TOP-17	ANO Flooding Topical	0

Condition Reports (CRs)

CR-ANO-C-2013-00259

CR-ANO-C-2014-01304

Qualitative Risk Evaluation
Inadequate Flood Protection for Auxiliary and Emergency Diesel Fuel Storage Buildings

Conclusions

1. The failure to design, construct, and maintain the Unit 1 and Unit 2 auxiliary and emergency diesel fuel storage buildings in accordance with the safety analysis reports description of internal and external flood barriers so that they could protect safety-related equipment from flooding was a performance deficiency.

2. An established flood hazard curve that can be used to credibly assess the range of flood frequencies needed to characterize the flooding impact from the performance deficiencies for the Arkansas Nuclear One site does not exist. Therefore, the NRC determined that the finding should be evaluated in accordance with Inspection Manual Chapter 0609, Appendix M, “Significance Determination Process Using Qualitative Criteria.”

3. A Significance and Enforcement Review Panel determined that the finding was of substantial safety significance (Yellow) based on their evaluation of the Appendix M attributes. Specifically, the following were the dominant considerations in reaching the preliminary risk determination conclusion:

    a. There were more than 100 ingress pathways such that an external flood above grade level would significantly impact the auxiliary building for each unit. Upon flooding of the auxiliary buildings, the emergency feedwater, high pressure injection, spent fuel pool cooling, diesel fuel oil transfer, and decay heat removal systems would be affected, resulting in the loss of all reactor makeup and cooling pumps.

    b. There was no preplanned defense in depth measure that protects the auxiliary building from a postulated external flood.

    c. Most of the degraded conditions have existed since initial construction, and the licensee had several opportunities to identify the finding during this period.

    d. Alternative mitigating strategies would not be effective because equipment and connections would be submerged. Therefore, there was negligible likelihood that the licensee’s recovery actions would successfully mitigate the performance deficiency.

    e. The NRC preliminarily determined that the change in core damage frequency was quantitatively bounded at less than 2×10^{-3}/year and qualitatively determined to likely be less than 1×10^{-4}/year, indicating that the finding could be no higher than Yellow significance.

4. The licensee did not provide a complete risk evaluation. However, it provided a draft estimated flood hazard curve. The NRC determined that the confidence interval for this flood hazard curve corroborated the upper bound of Yellow for the finding’s significance.

Details

A. Summary of Issue:

On March 31, 2013, following the Unit 1 stator drop event, a ruptured fire header created a fire water leak inside the turbine building train bay. The water leaked into the auxiliary building through two closed hatches in the train bay. The leaking hatches were designed to prevent floodwater from entering the auxiliary building. This event caused the licensee and the NRC to investigate the site's flood readiness, as discussed in the NRC Augmented Inspection Team Report 05000313;368/2013011 (ML13158A242) and the NRC Augmented Inspection Team Follow-Up Report 05000313;368/2013012 (ML14083A409 and Errata ML14101A219). While the licensee identified significant issues during the Fukushima flooding walkdowns, the inspectors noted that the Fukushima walkdowns were insufficient to identify all of the deficiencies in flood barriers at the site.

Degraded Conditions:

1. During the flooding walkdowns, performed between October 2012 and May 2014, the licensee identified over 100 unsealed conduits that penetrated flood barriers for the auxiliary and emergency diesel fuel storage buildings.

2. The March 31, 2013, stator drop event revealed degraded hatch seals that allowed fire water in the turbine building to leak into the auxiliary building.

3. During extent of condition reviews for the degraded hatch seals (Condition 2) performed between April and June 2013, the licensee identified degraded flood barrier seals for 13 hatches, two building expansion joints, doors, conduits, and pipe penetrations.

4. During extent of condition reviews for the degraded hatch seals, on February 12, 2014, the licensee identified that ventilation ductwork that penetrates the auxiliary building flood barrier in turbine building Room 72 was designed with isolation capability, but was not included in the flooding procedure.

5. During extent of condition reviews for the degraded hatch seals, on November 12, 2013, the licensee identified that a floor drain from turbine building Room 72 and the old radwaste building sump (in the yard) was routed to the auxiliary building and was unisolable.

6. The inspectors identified, on January 23, 2014, unsealed abandoned equipment piping in turbine building room 72 that penetrated the auxiliary building flood barrier.

7. During extent of condition reviews for the degraded hatch seals, on April 20, 2013, the licensee identified that auxiliary building extension pipe penetrations were not sealed.

8. During extent of condition reviews for the degraded hatch seals on April 25, 2013, the licensee identified non-flood protected doors and hatches in the area between the containment and the auxiliary building that could be subjected to floodwater.

9. The March 31, 2013, stator drop event revealed an open decay heat vault drain valve that allowed fire water in the auxiliary building to leak into the internal flooding protected vault. The valve was left open due to inadequate maintenance of the reach rod, and was incorrectly classified as non-safety-related.

The inspectors determined that each of these degraded conditions could be characterized by one of two violations, and a performance deficiency. Each violation covers degraded conditions that could independently result in the flooding of the auxiliary building and damage the same risk-significant equipment.

Background and Requirements for Unit 1 and Unit 2 Safety Analysis Reports:

Site grade elevation is 354 feet MSL. The probable maximum precipitation event results in a flood to 358 feet MSL as described in Unit 1 Safety Analysis Report Section 2.4.4.3 and Unit 2 Safety Analysis Report Section 2.4.3.5. The design flood level is 361 feet MSL, as a result of precipitation and a failure of the Ozark Dam, which produces a wave. The effect of run up from waves breaking at the plant was evaluated and is described in the Unit 2 Safety Analysis Report Section 2.4.3.6. Unit 2 Safety Analysis Report Section 3.4.4 states that the maximum probable flood would take from two days to several weeks to develop. The auxiliary and emergency diesel fuel storage buildings are designed to withstand flooding up to 361 feet MSL.

Due to the lack of physical barriers and procedural controls, the turbine building was not protected from a flood, and there are no other walls or dikes that would prevent a flood at site grade elevation from entering the site. The licensee's flood protection strategy did not include any temporary barriers, such as sandbagging.

For internal flood concerns, the Unit 1 floor area at elevation 317 feet MSL, which contains engineered safeguards equipment, was partitioned into separate rooms to provide protection in the event of flooding due to a pipe rupture.

Inspectors' Observations and Assumptions:

- Each unit has two 75 gpm auxiliary building sump pumps, for a total of 150 gpm per unit.
- Given a flood height above 354 feet MSL, Unit 1 and Unit 2 auxiliary buildings will be inundated with water.
- The auxiliary buildings are cross-connected between units at the 354 foot MSL elevation.
- Both trains of the Unit 1 decay heat vault drain valves were inadequately maintained so that they may be left open. If the auxiliary building floods, the decay heat vaults will flood because they were not designed to withstand submergence pressure.
- Unit 1 and Unit 2 containment spray pumps are inside the auxiliary building vaults and would be submerged in a flooding event.

- Unit 1 and Unit 2 reactor coolant system pressure control in the form of heaters and vent valves would be unaffected by flooding.

- Unit 1 and Unit 2 reactor coolant pumps and safety injection tanks would be unaffected by flooding.

- Unit 1 and Unit 2 steam generators would likely have water inventory.

- The Unit 1 and Unit 2 atmospheric dump valves would be unaffected by flooding.

- Unit 1 and Unit 2 containment cooling, via the safety-related containment coolers, would be unaffected by flooding.

- The Unit 1 emergency feedwater system pumps are in an open area on the 335 foot MSL elevation in the auxiliary building and would be submerged in a flooding event.

- There were unsealed conduits between the Unit 2 turbine building and the emergency feedwater system flood vaults.

- The Unit 2 emergency feedwater system pumps are in separate flood vaults on the 335 foot MSL elevation and would be submerged in a flooding event.

- The Unit 2 emergency feedwater system flood vault drains lead to the turbine building which would be flooded.

- The licensee's flood planning protection strategy did not provide for protecting the turbine building from flooding.

- At the time of the March 31, 2013, stator drop event, there were only 24 vendor-owned sandbags onsite.

- The failure frequency of the circulating water system expansion joints resulting in a major internal flood, was estimated at 4.9×10^{-5}/year per unit using Energy Power Reliability Institute Report 3002000079 "Pipe Rupture Frequencies for Internal Flooding PRA," Revision 3.

- The failure frequency of the circulating water system piping resulting in a major internal flood was estimated at 1.9×10^{-3}/year per unit using Energy Power Reliability Institute Report 3002000079 "Pipe Rupture Frequencies for Internal Flooding PRA," Revision 3.

- The NRC risk analysts assumed that the risk from internally initiated flooding would be bounded by the risk associated with external flooding because of the operators' ability to limit and/or mitigate the extent of internal flooding. However, the risk analysts noted that the risk from internally initiated flooding alone was likely Greater-than-Green.

- The Unit 1 and Unit 2 turbine building basements and the auxiliary building basements are not cross-connected, therefore internal floods are unit-specific.

- A circulating water system pipe break in the Unit 2 turbine building could produce severe flooding in the Unit 2 auxiliary building because there were large and numerous unsealed conduits in the Unit 2 turbine building basement.

- Given a flood height above 354 feet MSL, the emergency diesel fuel storage building would flood at a rate beyond the capacity of the building sump pump (15 gpm).

- Flooding of the emergency diesel fuel storage building would cause the fuel oil transfer pumps to fail, limiting, without mitigation, the fuel oil available to the emergency diesel generators to the volume maintained in the day tanks.

- Following the postulated external flood event, without mitigation, the emergency diesel generators would run for approximately 1 - 2 hours until the fuel in the day tank is exhausted.

- Following a postulated external flood event, offsite power would be available provided:

    a. Plant personnel completed the modifications to startup transformer 2 to seal the buswork prior to the arrival of flood waters;

    b. The flooding event area of influence is sufficiently removed from the site itself (i.e., the storm(s) that causes flooding at the site are not expected to include local effects, such as grid instabilities leading to loss of offsite power);

    c. Startup transformer 2 continues to operate despite being partially submerged;

    d. Flood carried debris does not impact the function of startup transformer 2 and the associated cabling; and

    e. Flooding in the switchyard controls does not prevent the supply of power from the switchyard buses to startup transformer 2.

- The alternate ac diesel generator is not designed to operate following an external flood event. The generator skid is mounted at the 354 foot MSL elevation.

- A postulated external flood event would not directly affect power to the containment isolation valves in Unit 1.

- A postulated flood would not directly affect power to the inside containment isolation valves in Unit 2. Power would be lost to some significant containment isolation valves, such as the outside containment shutdown cooling suction isolation valve.

- Unit 1 and Unit 2 outside containment isolation valves are physically located above the design basis flood elevation, so manual operation of the valves would be possible.

- The following assumptions were made regarding alternative mitigating strategies equipment, i.e., B.5.b, following a postulated flood event:

    a. Procedural guidance required plant operators to consider moving the B.5.b pump prior to flood waters arriving onsite.

    b. B.5.b equipment was normally stored below site grade elevation.

    c. Upon flooding, all proceduralized connections for B.5.b equipment and all preplanned staging platforms for B.5.b pumps would be underwater.

    d. Potential sources of pressurized water for accident mitigation included the service water and firewater systems.

    e. All potential connections for feeding water to the Unit 2 steam generators and/or reactor coolant system would be underwater.

    f. There were feedwater system drains and vents that could potentially be used to provide water to the Unit 1 steam generators. Use of these drains and vents were not proceduralized, nor were the parts required for such connections immediately available to station operators.

    g. Operators would not be able to gravity feed water to the reactor coolant system from the refueling water tank because valves required to reposition were inside the decay heat vaults and would be submerged at approximately the same time as the pumps. There were no available proceduralized methods for makeup to the refueling water tank. In addition, reactor coolant system vent capability would not be able to maintain the system depressurized to the extent required to facilitate gravity feed.

B. Statement of the Performance Deficiency:

The failure to design, construct, and maintain the Unit 1 and Unit 2 auxiliary and emergency diesel fuel storage buildings in accordance with the safety analysis reports' description of internal and external flood barriers, so that they could protect safety-related equipment from flooding, was a performance deficiency.

The licensee failed to seal flood barrier penetrations, including conduits, pipe penetrations, and abandoned equipment. The licensee installed unisolable external floor drains that drained into the auxiliary building, and installed ventilation ductwork that penetrated the auxiliary building. Procedures did not ensure these flood pathways would be isolated during a flooding event. In addition, the licensee failed to adequately maintain penetration seals, including hatches, building expansion joints, doors, conduits, pipe penetrations, and drain valves. As a result, the safety-related and risk important equipment inside of the auxiliary and emergency diesel fuel storage buildings may not have been protected during a flooding event.

C. Significance Determination Basis:

Reactor Inspection for Initiating Events, Mitigating Systems or Barrier Integrity Cornerstones

(a) Screening Logic

Minor Question: In accordance with NRC Inspection Manual Chapter 0612, Appendix B, "Issue Screening," the subject performance deficiency is more than minor because it is associated with the protection against external factors attribute of the mitigating systems cornerstone, and adversely affected the cornerstone objective to ensure the reliability of systems that respond to initiating events to prevent undesirable consequences, and was therefore a finding. The performance deficiency resulted in the vulnerability of safety-related and risk-significant equipment in the auxiliary and emergency diesel fuel storage buildings to external flooding.

Initial Characterization: In accordance with Inspection Manual Chapter 0609, Attachment 4, "Initial Characterization of Findings," the inspectors used Inspection Manual Chapter 0609, Appendix A, "The Significance Determination Process (SDP) for Findings At-Power," Exhibit 2, "Mitigating Systems Screening Questions," dated June 19, 2012, to evaluate the significance of the finding.

Issue Screening: Using Appendix A, Exhibit 2 and Exhibit 4, "External Events Screening Questions," the inspectors determined that a detailed risk evaluation was necessary because, if the flood barriers were assumed to be completely failed, the resulting condition would degrade two or more trains of a multi-train system during an external flood.

Results: The NRC risk analysts determined that the finding should be evaluated in accordance with Inspection Manual Chapter 0609, Appendix M, "Significance Determination Process Using Qualitative Criteria." Appropriate probabilistic risk assessment tools did not exist to provide a reasonable estimate of the risk significance for this complex finding in a timeframe consistent with the timeliness goals for risk evaluations. The use of Appendix M is appropriate because it is intended to be used when "the probabilistic risk assessment (PRA) methods and tools, including the existing significance determination process appendices, cannot adequately address the finding's complexity or provide a reasonable estimate of the significance due to modeling and other uncertainties within the established significance determination process timeliness goal of 90 days or less."

(b) Appendix M Approach:

NRC staff evaluated the finding in accordance with NRC Inspection Manual Chapter 0609, Appendix M, "Significance Determination Process Using Qualitative Criteria."

A. Initial Bounding Evaluation (Step 4.1.1):

To perform a bounding risk evaluation, the NRC reactor analysts used hand calculations and graphing software.

Characterization of the Flood Hazard

An established flood hazard curve that can be used to credibly assess the range of flood frequencies needed to characterize the flooding impact from the performance deficiencies for the Arkansas Nuclear One site does not exist. Furthermore, there are no standard techniques or consensus methods to extrapolate flood frequencies into the ranges relevant to this significance determination process. Most literature available on extrapolating flood frequencies is not intended to provide high confidence beyond the available historical record (typically, 100 years or less). In some cases, additional confidence may be provided if the information is coupled with more refined methods or additional data, which does not exist at Arkansas Nuclear One. Even in these cases, the level of confidence in predicting the frequency of extreme floods well beyond the historical record is very limited.

The uncertainty bounds associated with the use of stream flow gauge data for frequency extrapolation of extreme events is significantly wide. This is compounded by the fact that the data alone cannot capture additional uncertainty in the behavior of a watershed under such circumstances (i.e., the characteristics of a flood could be significantly altered for events in excess of a 1,000 year return period when compared to observed events within 100 years or so). In other words, the underlying physical behavior of the watershed could be grossly mischaracterized by such extrapolations.

The Arkansas Nuclear One site lies on the Arkansas River on the shores of Lake Dardanelle. The river is controlled by the U.S. Army Corps of Engineers to maintain navigable channels throughout the year. Normal river level is maintained between 336 and 338 feet MSL at the site. The Safety Analysis Report for Unit 1 and Unit 2, in describing the site, states, in part, that the site elevation is 354 feet MSL; the flood from a probable maximum precipitation event is 358 feet MSL; and the design-basis flood is 361 feet MSL.

Site design basis documents state that the 500-year return flood is 340 feet MSL. Given the 500-year return is the only valid point of information on the hazard curve, and the 500-year flood is estimated to be below site elevation, the NRC risk analysts can state that the frequency of a flood impacting the site is bounded on the upper end by 2×10^{-3}/year. With the fundamental assumption that the upper bound risk must be lower than that from the 500-year return flood, the NRC risk analysts looked for qualitative information that may assist in bounding the risk of an external flood at the site.

The NRC risk analysts noted that the value of the flood frequency was the area of greatest uncertainty. Probable maximum precipitation and probable maximum flood events are highly site-specific and thus it is problematic to assume generic values. The available literature indicates that the frequency of extreme events can vary significantly between 1×10^{-3}/year to 1×10^{-6}/year (see References [1] and [2] below), although some will claim that values of 1×10^{-6}/year and below can be credibly predicted, depending on the tools used. From discussions between the experts on extreme frequency assessment, extrapolating beyond a 500 to 1000-year return period is considered to be significantly limited in terms of predicting higher return period floods [2]. The current state-of-practice, state-of-art with respect to extreme flood frequency estimation was also discussed at a workshop organized by the NRC and other Federal Agencies, which included many of the experts currently available in this field. The prevailing view from the workshop participants was that significant uncertainty exists as to extreme flood event frequency estimates; and extrapolating beyond a limited range with available historical data is questionable (See Reference [3] below).

References:

[1] Jeff Harris, Gary Brunner, "Approximating the Probability of the Probable Maximum Flood," Conference Paper, World Environmental and Water Resources Congress 2011

Note: Both authors work at the U.S. Army Corps of Engineers and they state that "USACE [U.S. Army Corps of Engineers] institutional range for probability of the PMF [probable maximum flood] is $1x10^{-3}$ to $1x10^{-6}$"

[2] U.S. Department of the Interior, Bureau of Reclamation, "Guidelines for Evaluating Hydrologic Hazards", June 2006

Note: The approach the licensee is using is characterized as "at-site streamflow data" and given the significant uncertainty associated with this approach in terms of flood frequency extrapolations from a limited set of data, this approach would receive minimal credit in arriving at an overall risk estimate for probable maximum flood. Reference 2 contains the following statement: "Many factors can affect the equivalent independent record length for the optimal case. For example, gaged streamflow records in the western United States only rarely exceed 100 years, and extrapolation beyond twice the length of record, or to about 1 in 200 AEP [annual exceedance probability], is generally not recommended (Interagency Advisory Committee on Water Data [IACWD], 1982)."

[3] USNRC, NUREG/CP-0302, "Proceedings of the Workshop on Probabilistic Flood Hazard Assessment (PFHA)," 2013

Note: Comments in the panel discussions included, "The applicability of Bulletin 17B ["Guidelines for Determining Flood Flow Frequency"] [the method being used by the licensee] was intended to be limited. This bulletin was designed for applications such as levee and floodplain management, and was not intended for extending estimates to 1-in-10,000 events and for identifying outliers. Agencies understand that more complex methods are needed for extreme flood events."

Therefore, the NRC risk analysts estimated the flood hazard at Arkansas Nuclear One by comparing four different curves to represent the variability from available experts:

(1) Using the upper bound estimate of 1×10^{-3}/year to characterize the hazard at the site;

(2) Using an estimate that a probable maximum precipitation event that results in the 10,000-year return flood could appropriately characterize the hazard at the site;

(3) Using an estimate that a probable maximum precipitation event that results in the 100,000-year return flood could appropriately characterize the hazard at the site; and

(4) Using the lower bound estimate of 1×10^{-6}/year, assuming this would be the lower limit that could appropriately characterize the hazard at the site.

For each of these assumptions, the NRC risk analysts hand fit a curve approximating the flood hazard at the site. These curves are provided in Figure 1.

Flood Elevations of Concern

The site elevation at Arkansas Nuclear One is approximately 354 feet MSL. Defined flood elevations are shown in Figure 2. According to the inspectors, any water with a driving head of a few inches could result in flooding of the auxiliary and emergency diesel fuel storage buildings. Section 2.4.4.3, "Design Flood Elevation," of the Unit 1 Safety Analysis Report indicates that waves of about 2.5 feet could reach the site. However, this wave action was developed using a bounding analysis of the probable maximum wave breaking at the 353 foot MSL elevation contour. It should be noted that the licensee has requested a contractor to re-evaluate the flood hazard at Arkansas Nuclear One as part of the submittal in response to the 50.54(f) letter on the Fukushima Lessons-Learned Recommendation 2.1 for flooding. The initial draft information provided by the licensee indicates a reduction in the height of the flood level as compared to the design bases flood level of 361 feet MSL. This information has not been reviewed by the NRC and may be subject to changes prior to final submittal.

The NRC risk analysts assumed that smaller wave action could result in large amounts of water inundating the site area with an average flood elevation near 353 feet MSL. Alternatively, the NRC risk analysts assumed that a driving head of 6 inches would be sufficient to produce unrecoverable flooding in the buildings should no waves be produced. Figure 3 shows the intersection of the estimated hazard curves and elevations 353 feet (assuming wave action) and 354.5 feet (assuming no wave action).

Assumptions for Bounding Evaluation

The NRC risk analysts made the following critical assumptions in evaluating the bounding risk associated with the performance deficiency:

a) Any amount of water onsite in the ranges shown on Figure 3 (above 353 feet MSL, with wave action) would produce unrecoverable flooding damage in the auxiliary and emergency diesel fuel storage buildings.

b) Flooding of the auxiliary building would prevent all front-line process systems from performing the following functions:

   (i) Reactor Coolant System Inventory Control;

   (ii) Reactor Core Heat Removal; and

   (iii) Containment Pressure Control

c) Alternative mitigating strategies were not credited for the bounding evaluation because:

   (i) Procedural guidance required plant operators to consider moving the B.5.b pump prior to flood waters arriving onsite.

   (ii) B.5.b equipment was normally stored below site grade elevation.

   (iii) Upon flooding, all proceduralized connections for B.5.b equipment and all preplanned staging platforms for B.5.b pumps would be underwater.

   (iv) Upon flooding, all potential connections for feeding water to the Unit 2 steam generators and/or reactor coolant system would be underwater.

   (v) There were feedwater system drains and vents that could potentially be used to provide water to the Unit 1 steam generators. However, use of these drains and vents were not proceduralized, nor were the parts required for such connections immediately available to station operators.

   (vi) Operators would not be able to gravity feed water to the reactor coolant system from the refueling water tank because valves required to reposition were inside the decay heat vaults and would be submerged at approximately the same time as the pumps. There were no available proceduralized methods for makeup to the refueling water tank. In addition, reactor coolant system vent capability would not be able to maintain the system depressurized to the extent required to facilitate gravity feed.

(vii) Additional short-term planning by the emergency response organization has not traditionally been credited in the significance determination process.

d) Internal flooding scenarios were not dominant because the pipe rupture frequencies in combination with the failure of systems or operators to isolate the leaks were smaller than the external flood frequencies. The NRC risk analysts determined qualitatively that the performance deficiency's effect on internal flooding could be characterized as Greater-than-Green. This result, while qualitative in nature, would be added to the results from an external flood. However, it would not be expected to change the result of the bounding analysis.

Quantification of Bounding Risk

Given the assumptions described above, the NRC risk analysts determined that the conditional core damage probability for a flood resulting in water onsite at Arkansas Nuclear One was 1.0 for Unit 1 and Unit 2. Therefore, the NRC risk analysts used the qualitative development of the risk hazard to determine the upper bound on risk from the subject performance deficiency. As shown in Figure 4, the NRC risk analysts determined that the upper bound change in core damage frequency was likely between 1.8×10^{-5} and 1.5×10^{-3} over a 1-year assessment period, depending on the estimated hazard used and on the selection of wave action.

By review of the specific watershed and the height of the 500-year return flood, the NRC risk analysts assumed that the frequency for a probable maximum flood in the Arkansas River watershed was most likely in the lower end of this range. Therefore, the NRC risk analysts concluded, qualitatively, that the upper bound change in core damage frequency was less than 1×10^{-4}/year. The bounding and qualitative results are based on the frequency of the probable maximum flood event and a loss of all equipment needed for core cooling and makeup.

B. <u>The effectiveness of one or more Defense-in-Depth elements impacted (Step 4.2.1.1)</u>.

There was no preplanned defense-in-depth measure that protects the auxiliary building from a postulated external flood given the subject performance deficiency. All penetration seals, hatches, and doors provide a single barrier to flooding. The in-leakage into the building could overwhelm the installed and reasonably available temporary pumping capacity.

To date, the licensee has discovered external flood protection degradations in 13 hatches, two building joints, over 100 small and large conduits, one ventilation duct, approximately ten pipe penetrations, two floor drains, and two abandoned pipes. The inspectors developed a spreadsheet indicating all auxiliary building open flow paths and estimated the total area of these flood flow paths at over 4 ft^2. The emergency diesel fuel storage building had multiple unsealed conduits that could inundate the installed sump pump.

C. <u>A reduction in Safety Margin can be quantified (Step 4.2.1.2)</u>.

The design flood elevation is 361 feet MSL. As described in both the preceding sections of this qualitative risk evaluation and below, any water above plant grade of 354 feet MSL would result in the loss of all reactor makeup and cooling pumps, potentially leading to core damage.

D. <u>The extent to which the condition of the performance deficiency affects other equipment (Step 4.2.1.3)</u>.

Flooding of the auxiliary buildings and the emergency diesel fuel storage building at Arkansas Nuclear One could result in failure of the emergency feedwater pumps, high pressure injection pumps, spent fuel pool cooling pumps, diesel generator fuel oil transfer pumps, decay heat removal pumps, and reactor building spray pumps. In summary, all reactor makeup and cooling pumps could be submerged.

One source of offsite power would be available provided preparatory steps were taken by the licensee and that flood affects did not impact the offsite grid stability/availability nor degrade site components. Of potential concern is that, at flood elevations above 354 feet MSL, the operating startup transformer 2 could be partially submerged by flood waters.

If demanded, and assuming no mitigation, the emergency diesel generators would run for approximately 1 - 2 hours until the day tanks were exhausted. Fuel oil transfer pumps would likely be submerged, so no fuel makeup would be available.

Reactor coolant system pressure control via pressurizer heaters and vent valves would not be impacted by flooding.

Unit 1 containment isolation would be unaffected. Unit 2 containment isolation through inside containment isolation valves would be unaffected. Unit 1 and Unit 2 containment cooling through safety-related containment coolers would be unaffected by flooding.

Unit 1 and Unit 2 spent fuel pool cooling would be lost, but makeup from service water or fire protection would likely be available for the majority of flood elevations.

Alternative mitigating strategies may be available for use in Unit 1, however:

a) Procedural guidance only required plant operators to consider moving the B.5.b pump prior to flood waters arriving onsite.

b) B.5.b equipment was normally stored below site grade elevation.

c) Upon flooding, all proceduralized connections for B.5.b equipment and all preplanned staging platforms for B.5.b pumps would be under water.

d) All potential connections for feeding water to the Unit 2 steam generators and/or reactor coolant systems would be underwater.

e) There are feedwater system drains and vents that could potentially be used to provide water to the Unit 1 steam generators. However, use of these drains and vents were not proceduralized, nor were the parts required for such connections immediately available to station operators.

f) Operators would not be able to gravity feed water to the reactor coolant system from the refueling water tank because valves required to reposition were inside the decay heat vaults and would be submerged at approximately the same time as the pumps. There were no available proceduralized methods for makeup to the refueling water tank. In addition, reactor coolant system vent capability would not be able to maintain the system depressurized to the extent required to facilitate gravity feed.

Procedure 1203.025, “Natural Emergencies,” Section 6, “Flood,” provided guidance to operators for flood preparation. The entry conditions for the procedure are as follows:

A. Lake Dardanelle level is greater than 340 feet MSL and rising or

B. Forecasted lake level at site is greater than 350 feet MSL.

Significant steps in the procedure include:

- Shutdown the plant when directed by plant management
- Installing a jumper to supply Startup Transformer SU-2 directly from the 161 KV transmission line (Note: The transformer will be partially submerged once flood waters arrive on site.)
- Align decay heat removal for shutdown cooling
- Remove equipment from service and de-energize power supplies to below-grade equipment
- Secure the diesel fuel vault
- Inspect below-grade areas for leakage
- Close and secure watertight doors
- Isolate decay heat rooms

- Consider relocating B.5.b pump to higher ground

E. Degree of degradation of failed or unavailable components (Step 4.2.1.4).

All degraded equipment would be submerged, unavailable to respond upon demand, and not recoverable.

F. Period of time the performance deficiency existed; and if opportunity to identify the finding during such period was missed (Step 4.2.1.5).

Exposure time

The degraded conditions have existed since initial construction with two exceptions:

- The unsealed abandoned equipment modification was performed in 2002, affecting flood protection from 2002 through identification and repair.

- The inadequate maintenance described in the performance deficiency was associated with seal inspection and replacement and vault drain valves.

The licensee has replaced some seals, but the majority of seals inspected after the stator drop event were degraded due to aging and had not been inspected for more than a year. The inadequate maintenance on the decay heat drain valves has resulted in known leakage of the valves and some valve leak test failures over the past 10 years.

Therefore, in accordance with the Risk Assessment of Operational Events Handbook, Volume 1, "Internal Events," Revision 2, Section 2.6, "Exposure Time Greater than 1 Year," the maximum exposure time was set to 1 year.

Previous identification opportunities

The licensee identified that the Fukushima-related flood protection walkdowns were inadequate. The walkdowns, which were conducted by contractors, did not result in the identification of numerous flood protection deficiencies as described in Section A, "Details," above, including: unsealed flood barrier pipe penetrations in the auxiliary building extension; doors and hatches that were not designed as flood doors or not properly maintained to ensure the seals functioned as designed; the outside drains to the auxiliary building did not include isolation capability, which could allow flood water to flow into the building; the startup transformer 2 buswork was not installed above the design flood elevation of 361 feet MSL, which could allow water into the buswork; and, unsealed abandoned equipment piping that penetrated the auxiliary building flood barrier. The contractors did identify during the inaccessible equipment walkdowns, missing conduit seals.

The licensee had previously identified minor water leakage into the auxiliary building, but sometimes treated this condition as groundwater leakage. Therefore, there have been longstanding leaks into the auxiliary building through conduits from manholes in the yard and through a pipe penetration from the turbine building that could become more severe during a flood above plant grade.

The licensee abandoned the old radwaste building sump pump in 2002, but left the associated flowpath open and failed to recognize that this configuration created a vulnerability to flooding.

The licensee has discovered several significant flood-related issues in the past that provided opportunities to identify the full extent of condition. In 1977, the licensee recognized that the auxiliary building extension needed to be flood protected and added a hatch for a stairwell, but failed to flood protect the rest of the building. In 1990, the licensee identified that the floor drains for both trains of Unit 2 high pressure safety injection were cross-connected. In 1990, the licensee identified that a backwater (check) valve was missing in the Unit 2 emergency feedwater floor drain line, which drains to the turbine building. Licensee actions to evaluate and address these issues represented opportunities to review the design of the floor drain system.

There were multiple opportunities to identify these flooding vulnerabilities from reviews of external operating experience information. For example, NRC Information Notice 07-01, "Recent Operating Experience Concerning Hydrostatic Barriers," that was the most recent and relevant, documents inadequate design, construction, and maintenance of conduit and other penetration seals. The licensee evaluated the information notice, but only addressed a small portion of the operating experience. The licensee credited a 1996 inspection for conduits in manholes, but failed to consider other penetrations, or the lack of a maintenance program for penetrations.

The licensee had been performing 10-year inspections of all flood hatches, and had identified degraded seals as a result of the inspection, but no condition reports were generated, and corrective actions were limited to a single hatch seal. The hatches that passed water following the March 31, 2013, stator drop event had been inspected in 2007, but the seals had not been replaced. In 2011, during the Fukushima-related flood protection walkdowns, the licensee identified that some of the conduit silicon seals were degraded due to aging; however, the licensee did not visually inspect hatch seals. In 2011, the licensee identified water intrusion past a hatch and another un-level hatch, indicating a bad seal, but the hatches were not repaired until after the stator drop event.

The inspectors identified that prior to the stator drop event; the licensee had failed to identify loose reach rods for the decay heat vault drains, which resulted in misleading position indications, during normal operation or the annual valve tests. Even though the licensee did replace the reach rods, the inspectors identified that the licensee did not institute a preventative maintenance activity to either replace the reach rods or check the position indication accuracy on any frequency. The valves are ball valves, so position indication is critical to determine if the valves are closed. In addition to the above, the inspectors identified that the closed position indication spanned approximately 36 degrees of the valves' rotation. The licensee determined that 15 degrees of rotation for the valve off of the closed seat could allow the valve to be significantly open, but the licensee did not modify the position indication so that it was more accurate and repeatable, until the inspectors identified the issue.

In February 2014, the inspectors determined that the licensee had failed to identify a significant condition adverse to quality related to flood protection. The licensee had identified numerous conditions adverse to quality for inadequate design and construction of flood barriers as a result of the extent-of-condition review of the March 31, 2013, stator drop event and Fukushima-related flood protection walkdowns. The licensee had performed low level causal evaluations and limited extent-of-condition reviews. However, the inspectors concluded that the evaluations and corrective actions lacked timeliness and rigor. As a result, the licensee initiated a second root cause that identified significant flood barrier issues.

In summary, the inspectors concluded that the licensee had a number of opportunities to identify and correct existing vulnerabilities to flooding due to plant equipment configurations; however, the licensee failed to take advantage of these opportunities.

G. The likelihood that the licensee's recovery actions would successfully mitigate the performance deficiency (Section 4.2.1.6).

There was negligible likelihood that the licensee's recovery actions would successfully mitigate the performance deficiency.

The licensee had no proceduralized actions to prevent the turbine building from flooding, which was the major flowpath for water to get into the auxiliary building. In addition, the licensee had essentially no sandbags or other means to dam floodwater onsite.

The licensee did identify actions, and develop procedures for those actions, to find and fix auxiliary and emergency diesel fuel storage building leaks once the floodwater was onsite. However, the instructions were non-specific; no materials were staged; there were no specific tools identified for use; and, there was no training planned or conducted.

The licensee did not have a proceduralized means to place temporary sump pumps in the buildings. Even if the licensee did place temporary pumps in the buildings, given the previously unrecognized vulnerability for significant auxiliary flooding (i.e., over 4 ft^2 of total area, that would allow floodwater in the turbine building to flood the auxiliary building), it is reasonable to conclude that the licensee would likely have underestimated the amount of water that would enter the auxiliary building upon site flooding. Therefore, the NRC concluded that the licensee's mitigating strategy of using temporary sump pumps, to supplement the permanently installed sump pumps, would likely have been ineffective.

In addition, equipment and connections used for compensatory actions and alternative mitigating strategies would likely be submerged, rendering these functions ineffective. The licensee would have to anticipate alternative mitigating strategies were needed before the flood water was onsite, so that an equipment platform for temporary pumps would be built and suction pathways and injection valves opened before they were submerged. As described above, it is unlikely that the licensee would have anticipated the auxiliary building flooding, so no credit for recovery actions/mitigation strategies was given. In addition, the provisions for alternate core inventory makeup could be unavailable.

The NRC risk analysts noted that in NRC Inspection Report 05000285/2010007 (ML102800342) a similar performance deficiency was dispositioned. In this final significance determination, the agency stated:

> "It is clear that a robust and well performing emergency response organization is a vital part of the defense-in-depth approach required by the NRC, and our decision here does not reflect a concern that the emergency response organization at the Fort Calhoun Station is not capable of the kind of forward-thinking and protective response that we require of power reactor licensees. However, the Agency has not traditionally provided credit for possible solutions that could be provided by the emergency response organization unless the actions were proceduralized and/or provided in clear planning guidance. While the NRC Inspection Manual and the Risk Assessment of Operational Events Handbook are silent on the subject, we do not consider short-term planning in advance of an external initiator to be a valid input to a risk evaluation used to disposition an enforcement action in accordance with the Significance Determination Process."

H. <u>Additional qualitative circumstances associated with the finding that regional management should consider in the evaluation process (Table Section 4.1)</u>.

No additional qualitative circumstances associated with the finding were identified that regional management should consider in the evaluation process.

In accordance with Appendix M, Section 4.2, "Attributes," the Significance and Enforcement Review Panel determined that the preliminary significance of the subject finding was of substantial safety significance (Yellow), based on a full and detailed consideration of the attributes described in this qualitative risk evaluation.

(c) <u>Licensee's Risk Evaluation</u>:

The licensee did not provide a complete risk evaluation for review by the NRC risk analysts. However, the licensee provided a draft estimated flood hazard curve on May 15, 2014.

The credibility of the extrapolated flood frequency results for the range of interest with the available data and methodology is highly limited, given the current state-of-practice in probabilistic flood hazard assessment. The licensee's curve (see Figure 5) is based on an extrapolation of 75 years of data. The curve is based, in part, on a revised probable maximum flood that was 40 percent lower than the one developed by the U. S. Army Corps of Engineers and presented in the safety analysis report. Existing guidance on the application of the specific approach used by the licensee, i.e., the U.S. Department of Interior Geological Survey Bulletin 17B, "Guidelines for Determining Flood Flow Frequency," indicated the subject approach was not intended to provide sufficient confidence beyond the 100-year to 500-year return period range. In addition, the NRC risk analysts noted that the licensee's curve did not converge with the 500-year flood, despite the fact that the 500-year flood occurred once during the 75 years considered.

The licensee's flood hazard curve suggests that a flood of the Arkansas River bringing the level of Lake Dardanelle to elevation 340 feet MSL represented approximately the 7700-year return flood (1.3×10^{-4}/year). Given that a storm in May 1943 provided a peak floodwater flow equivalent to an elevation of about 342 feet MSL, the NRC risk analysts performed a binomial test on the data. The NRC risk analysts determined that there was less than a 1 percent probability that there would be one or more occurrences of a flood to elevation 340 feet MSL in 75 years, if such a flood were actually the 7700-year return flood. Therefore, the NRC risk analysts rejected the null hypothesis that the probability of exceedance was 1.3×10^{-4}/year. At a significance level of $\alpha = 0.05$, the NRC risk analysts rejected the null hypothesis that the probability of exceedance was $\leq x$ for all $x \leq 0.000685$ (1460-year return flood). Using the same techniques, the NRC risk analysts determined that there was a 14 percent probability that there would be one or more occurrences of a 340 foot MSL elevation flood in 75 years, if this flood was the 500-year flood as indicated by the U.S. Army Corps of Engineers. Therefore, the Corps' original hypothesis that the 500-year flood was 340 feet MSL could not be rejected.

As shown in Figure 6, the licensee's partial development of its flood hazard curve indicates that the mean frequency of exceedance for a flood at site elevation 354 feet MSL was very close to 1×10^{-6}/year. This includes five orders of magnitude between the lower and upper 95th confidence limits. The NRC risk analysts also identified the following issues with the licensee's curve development:

1. The licensee's documentation clearly indicated that the extrapolated probable maximum flood curve was an estimate.

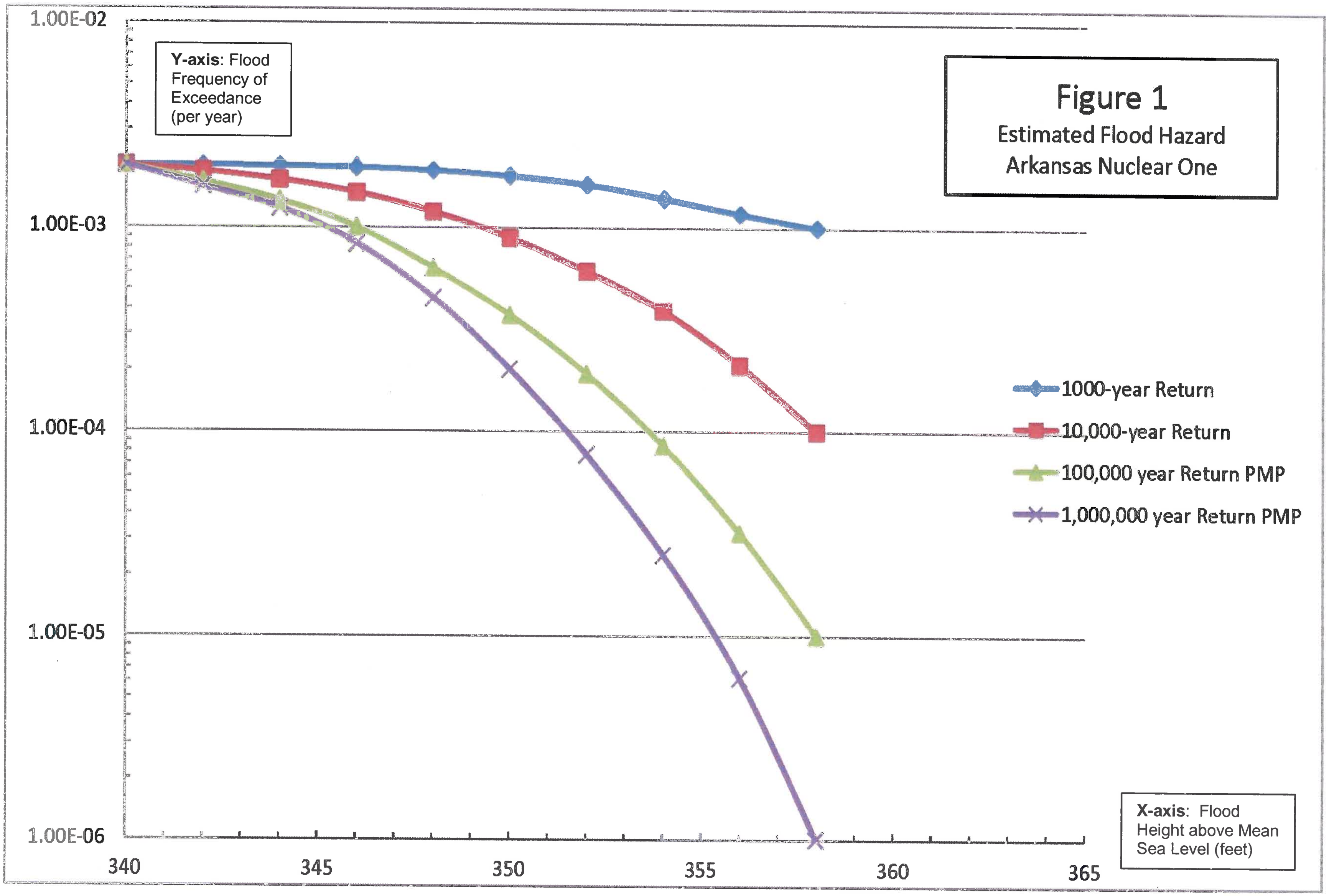
2. The probable maximum flood used in the frequency estimation is 40 percent lower than that provided by the U.S. Army Corps of Engineers and documented in the safety analysis report. This appears to be based on a draft licensee response to the NRC-required flooding re-evaluation per 50.54(f) that indicates the current licensing basis is conservative.

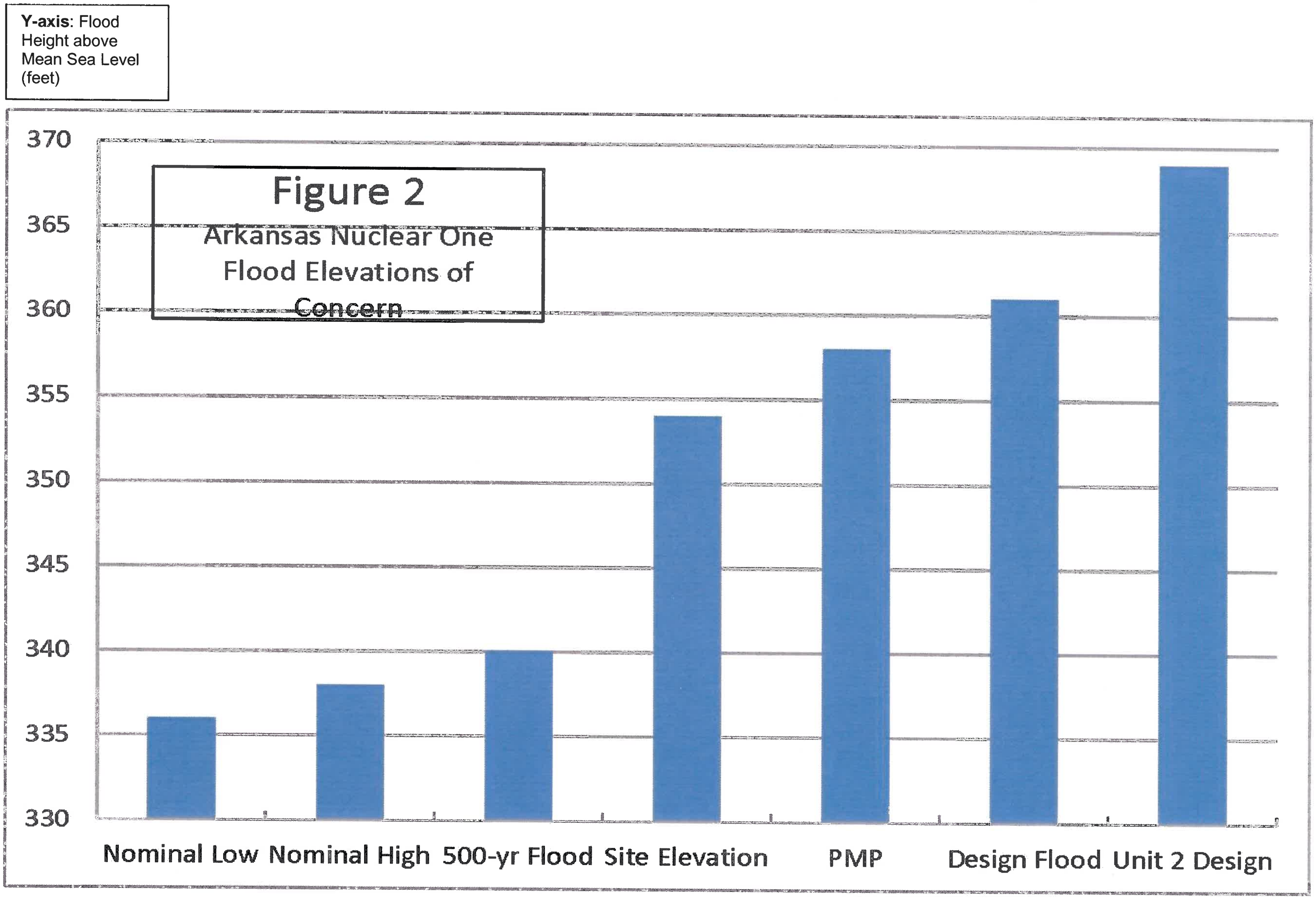
3. In lieu of U.S. Army Corps of Engineers data, the licensee used an assumption that the lake bottom was at the minimum channel depth throughout. The licensee considers this to be a conservative assumption because the channel is maintained deeper than the minimum channel depth; however, the NRC risk analysts noted that the channel is the lowest point in the lake and is a very small portion of the area of a lake.

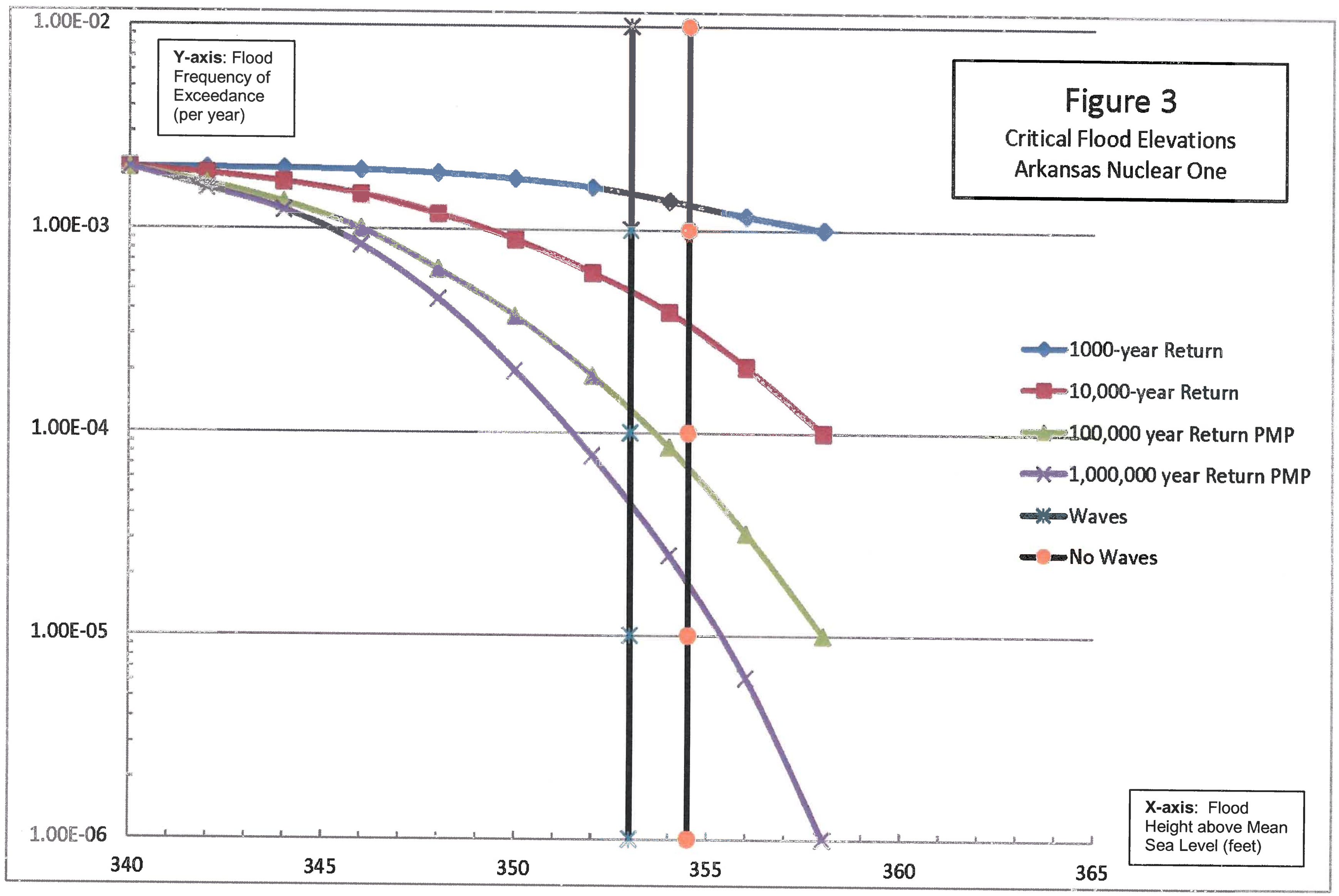
4. There are no standard techniques or consensus methods to extrapolate flood frequencies into the ranges relevant to this risk evaluation. Most of the literature available on extrapolating flood frequencies is not intended to provide high confidence beyond the available historical record (typically, 100 years or less).

5. Finally, in graphing the licensee's contractor data, it does not converge with the 500-year flood data from the U.S. Army Corps of Engineers. Of note, the 500-year flood was one of the six significant floods that occurred in the 75 years of data available. The licensee's curve suggests that this was approximately the 7700-year flood.

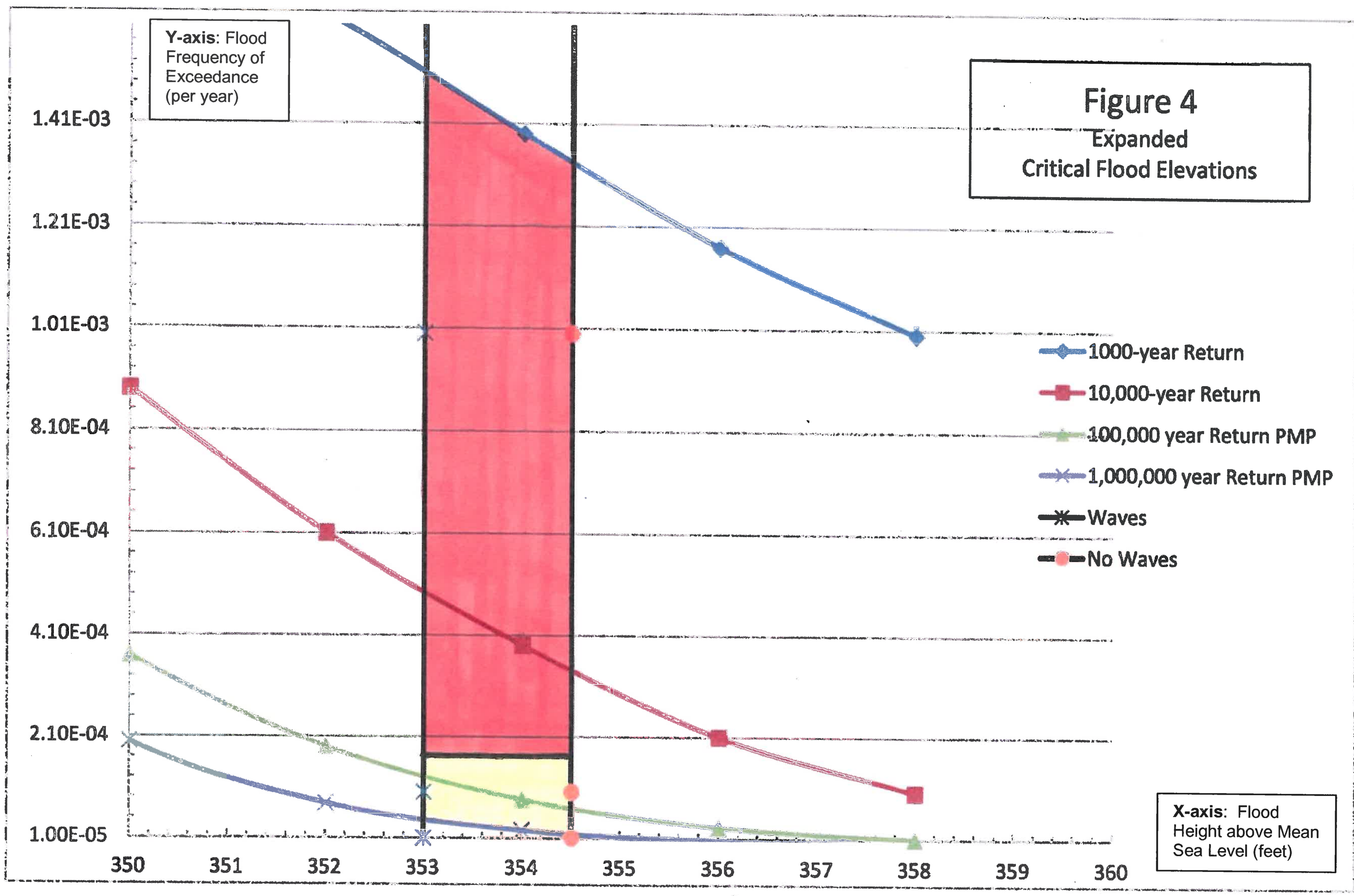
Applying the 90th and 95th percentile upper confidence hazard curve frequencies from the licensee's curve provide conditional core damage frequencies of 3.7×10^{-5}/year to 9.1×10^{-5}/year. Both represent upper bounds of Yellow significance.


1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
340
345
350
355
360
365
Y-axis: Flood Frequency of Exceedance (per year)
Figure 1
Estimated Flood Hazard
Arkansas Nuclear One
1000-year Return
10,000-year Return
100,000 year Return PMP
1,000,000 year Return PMP
X-axis: Flood Height above Mean Sea Level (feet)

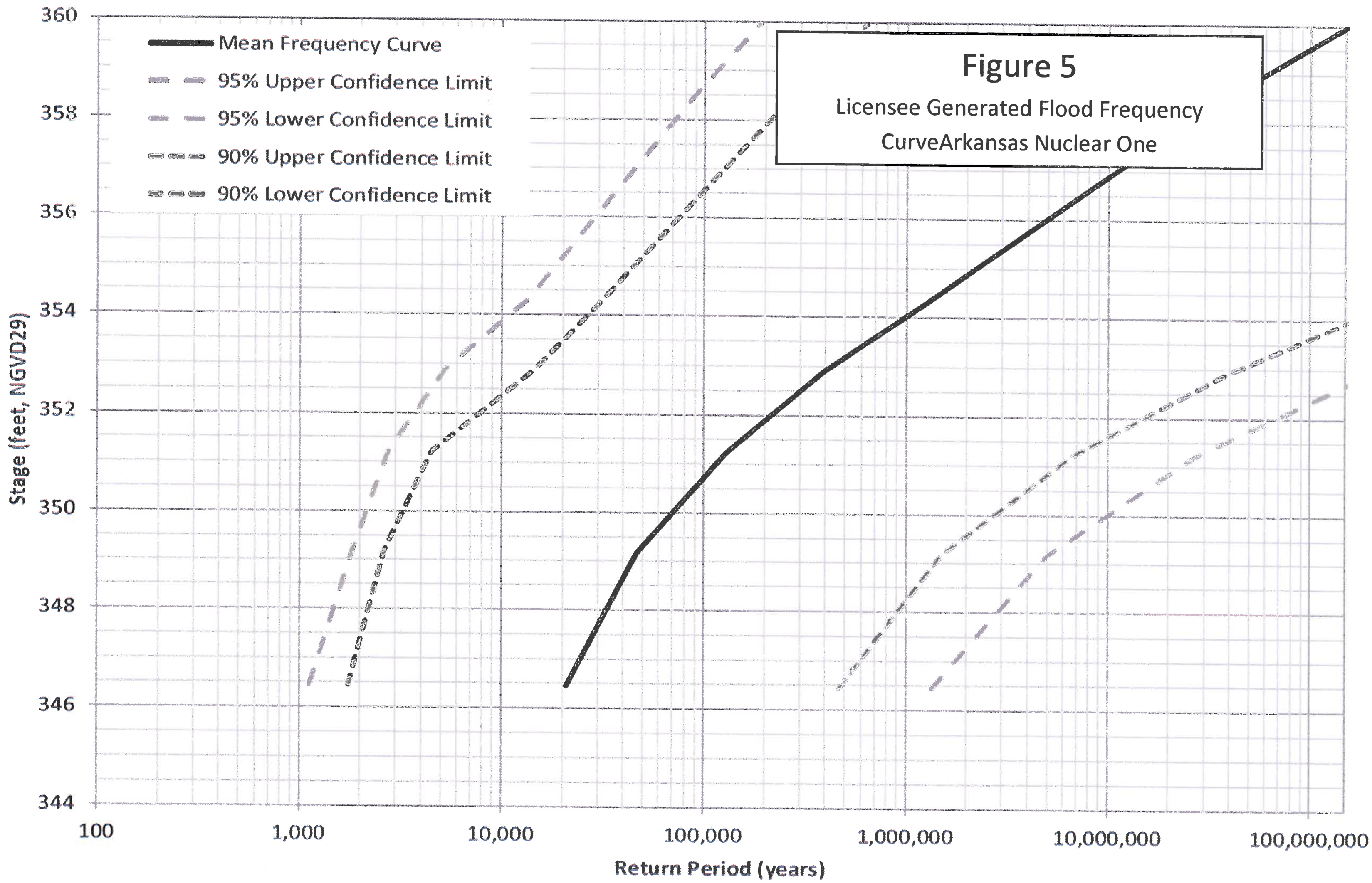

Y-axis: Flood Height above Mean Sea Level (feet)
Figure 2
Arkansas Nuclear One Flood Elevations of Concern
370
365
360
355
350
345
340
335
330
Nominal Low
Nominal High
500-yr Flood
Site Elevation
PMP
Design Flood
Unit 2 Design



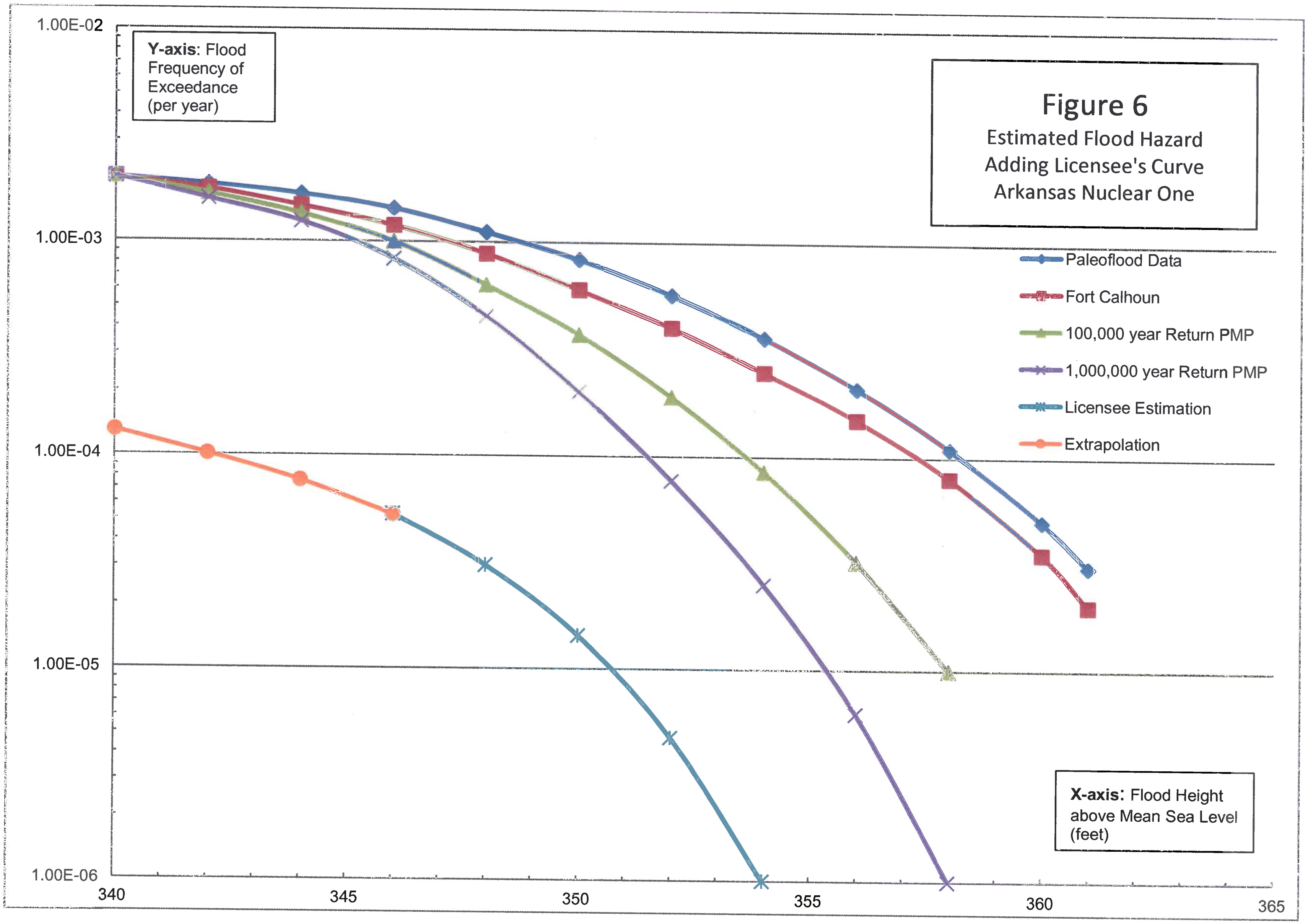
Y-axis: Flood Frequency of Exceedance (per year)
Figure 3
Critical Flood Elevations
Arkansas Nuclear One
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1000-year Return
10,000-year Return
100,000 year Return PMP
1,000,000 year Return PMP
Waves
No Waves
340
345
350
355
360
365
X-axis: Flood Height above Mean Sea Level (feet)



Y-axis: Flood Frequency of Exceedance (per year)
Figure 4
Expanded
Critical Flood Elevations
1.41E-03
1.21E-03
1.01E-03
8.10E-04
6.10E-04
4.10E-04
2.10E-04
1.00E-05
350
351
352
353
354
355
356
357
358
359
360
1000-year Return
10,000-year Return
100,000 year Return PMP
1,000,000 year Return PMP
Waves
No Waves
X-axis: Flood Height above Mean Sea Level (feet)



360
358
356
354
352
350
348
346
344
Stage (feet, NGVD29)
100
1,000
10,000
100,000
1,000,000
10,000,000
100,000,000
Return Period (years)
Mean Frequency Curve
95% Upper Confidence Limit
95% Lower Confidence Limit
90% Upper Confidence Limit
90% Lower Confidence Limit
Figure 5
Licensee Generated Flood Frequency
CurveArkansas Nuclear One



1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
Y-axis: Flood Frequency of Exceedance (per year)
Figure 6
Estimated Flood Hazard
Adding Licensee's Curve
Arkansas Nuclear One
Paleoflood Data
Fort Calhoun
100,000 year Return PMP
1,000,000 year Return PMP
Licensee Estimation
Extrapolation
X-axis: Flood Height above Mean Sea Level (feet)
340
345
350
355
360
365

In accordance with 10 CFR 2.390, "Public Inspections, Exemptions, Requests for Withholding," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC's Public Document Room or from the Publicly Available Records System (PARS) component of the NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

/RA/

Marc L. Dapas
Regional Administrator

Docket Nos. 50-313, 50-368
License Nos. DPR-51, NPF-6

Enclosure:
Inspection Report 05000313/2014009 and 05000368/2014009
Attachment 1: Supplemental Information
Attachment 2: Detailed Risk Evaluation

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DOCUMENT NAME: S:\RAS\ACES\ENFORCEMENT_EA CASES - OPEN\ANO - Flooding Issue\EA-14-088_ANO 2014009 BT-BC_Prelim SDP.docx
ADAMS ACCESSION NUMBER: ML14253A122

☑ SUNSI Review By:		ADAMS ☑Yes ☐ No	☑ Publicly Available ☐ Non-Publicly Available		☑Non-Sensitive ☐ Sensitive		Keyword: EA-14-088
OFFICE	SRI:DRP/E	RI:DRP/E	SRA:DRS	RSLO	SPAO	ACES	C:ORA/ACES
NAME	BTindell	JMelfi	DLoveless	BMaier	VDricks	RBrowder	VCampbell
SIGNATURE	Telephone	e-mail	e-mail	/BTharakan for/	e-mail	/RA/	e-mail
DATE	8/14/14	8/13/14	8/21/14	8/18/14	8/13/14	8/15/14	8/20/2014
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DATE	8/20/2014	8/18/14	8/26/2014	8/26/20214	09/8/14	9/9/14	

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Letter to Jeremy Browning from Marc L. Dapas dated September 9, 2014

SUBJECT: ARKANSAS NUCLEAR ONE – NRC INSPECTION REPORT 05000313/2014009 AND 05000368/2014009; PRELIMINARY YELLOW FINDING

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