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

September 19, 2016

Vice President, Operations
Arkansas Nuclear One
Entergy Operations, Inc.
1448 S.R. 333
Russellville, AR 72802

SUBJECT: ARKANSAS NUCLEAR ONE, UNITS 1 AND 2 – SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 (CAC NOS. MF0942, MF0943, MF0944, AND MF0945)

Dear Sir or Madam:

On March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design-Basis External Events" and Order EA-12-051, "Order to Modify Licenses With Regard To Reliable Spent Fuel Pool Instrumentation," (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML12054A736 and ML12054A679, respectively). The orders require holders of operating reactor licenses and construction permits issued under Title 10 of the *Code of Federal Regulations* Part 50 to modify the plants to provide additional capabilities and defense-in-depth for responding to beyond-design-basis external events, and to submit for review Overall Integrated Plans (OIPs) that describe how compliance with the requirements of Attachment 2 of each order will be achieved.

By letter dated February 28, 2013 (ADAMS Accession No. ML13063A151), Entergy Operations, Inc. (Entergy, the licensee) submitted its OIP for Arkansas Nuclear One (ANO), Units 1 and 2 in response to Order EA-12-049. At six month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-049. These reports were required by the order, and are listed in the attached safety evaluation. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated February 25, 2014 (ADAMS Accession No. ML14007A459), and September 1, 2015 (ADAMS Accession No. ML15236A340), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated May 28, 2014 (ADAMS Accession No. ML14140A514), the NRC staff provided Entergy with an update to the Order EA-12-049 audit activities at ANO. By letter dated January 12, 2016 (ADAMS Accession No. ML16014A396), Entergy submitted a compliance letter and Final Integrated Plan (FIP) in response to Order EA-12-049. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-049. By letter dated September 1, 2016 (ADAMS Accession No. ML16224A106), Entergy provided a supplement to the FIP.

By letter dated February 28, 2013 (ADAMS Accession No. ML13063A015), Entergy submitted its OIP for ANO in response to Order EA-12-051. At six month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-051. These reports were required by the order, and are listed in the attached safety evaluation. By letters dated October 29, 2013 (ADAMS Accession No. ML13281A502), and September 1, 2015 (ADAMS Accession No. ML15236A340), the NRC issued an ISE, request for additional information and audit report, respectively, on the licensee's progress. By letter dated March 26, 2014 (ADAMS Accession No. ML14083A620), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-051 in accordance with NRC NRR Office Instruction LIC-111, similar to the process used for Order EA-12-049. By letters dated April 14, 2015, and January 12, 2016 (ADAMS Accession Nos. ML15105A248 and ML16012A280, respectively), Entergy submitted compliance letters in response to Order EA-12-051 for ANO Units 1 and 2, respectively. The compliance letters stated that the licensee had achieved full compliance with Order EA-12-051.

The enclosed safety evaluation provides the results of the NRC staff's review of Entergy's strategies for ANO. The intent of the safety evaluation is to inform Entergy on whether or not its integrated plans, if implemented as described, provide a reasonable path for compliance with Orders EA-12-049 and EA-12-051. The staff will evaluate implementation of the plans through inspection, using Temporary Instruction 191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications/Staffing/ Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML15257A188). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

If you have any questions, please contact Peter Bamford, Orders Management Branch, ANO Project Manager, at 301-415-2833 or at Peter.Bamford@nrc.gov.

Sincerely,

Mandy K Halter

Mandy Halter, Acting Chief
Orders Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos.: 50-313 and 50-368

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

TABLE OF CONTENTS

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO ORDERS EA-12-049 AND EA-12-051

ENTERGY OPERATIONS, INC.

ARKANSAS NUCLEAR ONE, UNITS 1 AND 2

DOCKET NOS. 50-313 AND 50-368

1.0 INTRODUCTION

The earthquake and tsunami at the Fukushima Dai-ichi nuclear power plant in March 2011, highlighted the possibility that extreme natural phenomena could challenge the prevention, mitigation and emergency preparedness defense-in-depth layers already in place in nuclear power plants in the United States. At Fukushima, limitations in time and unpredictable conditions associated with the accident significantly challenged attempts by the responders to preclude core damage and containment failure. During the events in Fukushima, the challenges faced by the operators were beyond any faced previously at a commercial nuclear reactor and beyond the anticipated design-basis of the plants. The U.S. Nuclear Regulatory Commission (NRC) determined that additional requirements needed to be imposed at U.S. commercial power reactors to mitigate such beyond-design-basis external events (BDBEEs).

On March 12, 2012, the NRC issued Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" [Reference 4]. This order directed licensees to develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and spent fuel pool (SFP) cooling capabilities in the event of a BDBEE. Order EA-12-049 applies to all power reactor licensees and all holders of construction permits for power reactors.

On March 12, 2012, the NRC also issued Order EA-12-051, "Order Modifying Licenses With Regard to Reliable Spent Fuel Pool Instrumentation" [Reference 5]. This order directed licensees to install reliable SFP level instrumentation (SFPLI) with a primary channel and a backup channel, and with independent power supplies that are independent of the plant alternating current (ac) and direct current (dc) power distribution systems. Order EA-12-051 applies to all power reactor licensees and all holders of construction permits for power reactors.

2.0 REGULATORY EVALUATION

Following the events at the Fukushima Dai-ichi nuclear power plant on March 11, 2011, the NRC established a senior-level agency task force referred to as the Near-Term Task Force (NTTF). The NTTF was tasked with conducting a systematic and methodical review of the NRC regulations and processes and determining if the agency should make additional improvements to these programs in light of the events at Fukushima Dai-ichi. As a result of this review, the NTTF developed a comprehensive set of recommendations, documented in SECY-11-0093, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," dated July 12, 2011 [Reference 1]. Following interactions with stakeholders, these recommendations were enhanced by the NRC staff and presented to the Commission.

On February 17, 2012, the NRC staff provided SECY-12-0025, "Proposed Orders and Requests for Information in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Tsunami," [Reference 2] to the Commission. This paper included a proposal to order licensees to implement enhanced BDBEE mitigation strategies. As directed by staff requirements memorandum (SRM)-SECY-12-0025 [Reference 3], the NRC staff issued Orders EA-12-049 and EA-12-051.

In the following safety evaluation (SE) there are references to the Arkansas Nuclear One, Units 1 and 2 (ANO-1 and ANO-2), Updated Final Safety Analysis Reports (UFSARs). The UFSARs describe the facility, design bases, operational limits, and safety analyses, and are required to be maintained current for each operating reactor site in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.71(e). The licensee uses the term Safety Analysis Report (SAR) in their site documentation to describe this report for each ANO unit. The NRC will use the term UFSAR in this SE when referring to the ANO reports, to avoid confusion, and to be consistent with the terminology of the applicable regulation.

2.1 Order EA-12-049

Order EA-12-049, Attachment 2, [Reference 4] requires that operating power reactor licensees and construction permit holders use a three-phase approach for mitigating BDBEEs. The initial phase requires the use of installed equipment and resources to maintain or restore core cooling, containment and SFP cooling capabilities. The transition phase requires providing sufficient, portable, onsite equipment and consumables to maintain or restore these functions until they can be accomplished with resources brought from off site. The final phase requires obtaining sufficient offsite resources to sustain those functions indefinitely. Specific requirements of the order are listed below:

1) Licensees or construction permit (CP) holders shall develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and SFP cooling capabilities following a beyond-design-basis external event.

2) These strategies must be capable of mitigating a simultaneous loss of all alternating current (ac) power and loss of normal access to the ultimate heat sink [UHS] and have adequate capacity to address challenges to core cooling, containment, and SFP cooling capabilities at all units on a site subject to this Order.

3) Licensees or CP holders must provide reasonable protection for the associated equipment from external events. Such protection must demonstrate that there is adequate capacity to address challenges to

core cooling, containment, and SFP cooling capabilities at all units on a site subject to this Order.

4) Licensees or CP holders must be capable of implementing the strategies in all modes of operation.

5) Full compliance shall include procedures, guidance, training, and acquisition, staging, or installing of equipment needed for the strategies.

On August 21, 2012, following several submittals and discussions in public meetings with NRC staff, the Nuclear Energy Institute (NEI) submitted document NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Revision 0 [Reference 6] to the NRC to provide specifications for an industry-developed methodology for the development, implementation, and maintenance of guidance and strategies in response to the Mitigation Strategies order. The NRC staff reviewed NEI 12-06 and on August 29, 2012, issued its final version of Japan Lessons-Learned Directorate (JLD) Interim Staff Guidance (ISG) JLD-ISG-2012-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" [Reference 7], endorsing NEI 12-06, Revision 0, with comments, as an acceptable means of meeting the requirements of Order EA-12-049, and published a notice of its availability in the *Federal Register* (77 FR 55230).

2.2 Order EA-12-051

Order EA-12-051, Attachment 2, [Reference 5] requires that operating power reactor licensees and construction permit holders install reliable SFP level instrumentation. Specific requirements of the order are listed below:

All licensees identified in Attachment 1 to the order shall have a reliable indication of the water level in associated spent fuel storage pools capable of supporting identification of the following pool water level conditions by trained personnel: (1) level that is adequate to support operation of the normal fuel pool cooling system, (2) level that is adequate to provide substantial radiation shielding for a person standing on the spent fuel pool operating deck, and (3) level where fuel remains covered and actions to implement make-up water addition should no longer be deferred.

1. The spent fuel pool level instrumentation shall include the following design features:

1.1 Instruments: The instrumentation shall consist of a permanent, fixed primary instrument channel and a backup instrument channel. The backup instrument channel may be fixed or portable. Portable instruments shall have capabilities that enhance the ability of trained personnel to monitor spent fuel pool water level under conditions that restrict direct personnel access to the pool, such as partial structural damage, high radiation levels, or heat and humidity from a boiling pool.

1.2 Arrangement: The spent fuel pool level instrument channels shall be arranged in a manner that provides reasonable protection of the level indication function against missiles that may result from damage to the structure over the spent fuel pool. This protection may be provided by locating the primary instrument channel and fixed portions of the backup instrument channel, if applicable, to maintain instrument channel separation within the spent fuel pool area, and to utilize inherent shielding from missiles provided by existing recesses and corners in the spent fuel pool structure.

1.3 Mounting: Installed instrument channel equipment within the spent fuel pool shall be mounted to retain its design configuration during and following the maximum seismic ground motion considered in the design of the spent fuel pool structure.

1.4 Qualification: The primary and backup instrument channels shall be reliable at temperature, humidity, and radiation levels consistent with the spent fuel pool water at saturation conditions for an extended period. This reliability shall be established through use of an augmented quality assurance process (e.g., a process similar to that applied to the site fire protection program).

1.5 Independence: The primary instrument channel shall be independent of the backup instrument channel.

1.6 Power supplies: Permanently installed instrumentation channels shall each be powered by a separate power supply. Permanently installed and portable instrumentation channels shall provide for power connections from sources independent of the plant AC and DC power distribution systems, such as portable generators or replaceable batteries. Onsite generators used as an alternate power source and replaceable batteries used for instrument channel power shall have sufficient capacity to maintain the level indication function until offsite resource availability is reasonably assured.

1.7 Accuracy: The instrument channels shall maintain their designed accuracy following a power interruption or change in power source without recalibration.

1.8 Testing: The instrument channel design shall provide for routine testing and calibration.

1.9 Display: Trained personnel shall be able to monitor the spent fuel pool water level from the control room, alternate shutdown panel, or other appropriate and accessible location. The display shall provide on-demand or continuous indication of spent fuel pool water level.

2. The spent fuel pool instrumentation shall be maintained available and reliable through appropriate development and implementation of the following programs:

2.1 Training: Personnel shall be trained in the use and the provision of alternate power to the primary and backup instrument channels.

2.2 Procedures: Procedures shall be established and maintained for the testing, calibration, and use of the primary and backup spent fuel pool instrument channels.

2.3 Testing and Calibration: Processes shall be established and maintained for scheduling and implementing necessary testing and calibration of the primary and backup spent fuel pool level instrument channels to maintain the instrument channels at the design accuracy.

On August 24, 2012, following several NEI submittals and discussions in public meetings with NRC staff, the NEI submitted document NEI 12-02, "Industry Guidance for Compliance With NRC Order EA-12-051, To Modify Licenses With Regard to Reliable Spent Fuel Pool Instrumentation," Revision 1 [Reference 8] to the NRC to provide specifications for an industry-developed methodology for compliance with Order EA-12-051. On August 29, 2012, the NRC staff issued its final version of JLD-ISG-2012-03, "Compliance with Order EA-12-051, Reliable Spent Fuel Pool Instrumentation" [Reference 9], endorsing NEI 12-02, Revision 1, as an acceptable means of meeting the requirements of Order EA-12-051 with certain clarifications and exceptions, and published a notice of its availability in the *Federal Register* (77 FR 55232).

3.0 <u>TECHNICAL EVALUATION OF ORDER EA-12-049</u>

By letter dated February 28, 2013 [Reference 10], Entergy submitted its Overall Integrated Plan (OIP) for ANO Units 1 and 2 in response to Order EA-12-049. By letters dated August 28, 2013 [Reference 11], February 27, 2014 [Reference 12], August 28, 2014 [Reference 13], February 24, 2015 [Reference 14], and August 28, 2015 [Reference 15], the licensee submitted six-month updates to the OIP. By letter dated August 28, 2013 [Reference 16], the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" [Reference 39]. By letters dated February 25, 2014 [Reference 17], and September 1, 2015 [Reference 18], the NRC issued an Interim Staff Evaluation (ISE) and an audit report on the licensee's progress. Additionally, by letter dated May 28, 2014 [Reference 48], the NRC staff provided Entergy with an update to the Order EA-12-049 audit activities at ANO. By letter dated January 12, 2016 [Reference 19], the licensee reported that full compliance with the requirements of Order EA-12-049 was achieved, and submitted a Final Integrated Plan (FIP). By letter dated September 1, 2016, Entergy provided a supplement to the FIP [Reference 60].

3.1 <u>Overall Mitigation Strategy</u>

Attachment 2 to Order EA-12-049 describes the three-phase approach required for mitigating BDBEEs in order to maintain or restore core cooling, containment and SFP cooling capabilities.

The phases consist of an initial phase (Phase 1) using installed equipment and resources, followed by a transition phase (Phase 2) in which portable onsite equipment is placed in service, and a final phase (Phase 3) in which offsite resources may be placed in service. The timing of when to transition to the next phase is determined by plant-specific analyses.

While the initiating event is undefined, it is assumed to result in an extended loss of ac power (ELAP) with loss of normal access to the UHS. Thus, the ELAP with loss of normal access to the UHS is used as a surrogate for a BDBEE. The initial conditions and assumptions for the analyses are stated in NEI 12-06, Section 3.2.1, and include the following:

1. The reactor is assumed to have safely shut down with all rods inserted (subcritical).
2. The DC power supplied by the plant batteries is initially available, as is the AC power from inverters supplied by those batteries; however, over time the batteries may be depleted.
3. There is no core damage initially.
4. There is no assumption of any concurrent event.
5. Because the loss of AC power presupposes random failures of safety-related equipment (emergency power sources), there is no requirement to consider further random failures.

Unit 1 (ANO-1) is a Babcock & Wilcox (B&W) pressurized-water reactor (PWR) and Unit 2 (ANO-2) is a Combustion Engineering (CE) PWR. Both units have large dry ambient pressure containments. The FIP describes the licensee's three-phase approach to mitigate a postulated ELAP event. As described further in Section 3.14.2, the approach is somewhat different if the plant receives warning of a pending flood.

<u>Phase 1</u>

At the onset of an ELAP both reactors are assumed to trip from full power. The Reactor Coolant Pumps (RCPs) coast down and flow in the reactor coolant system (RCS) transitions to natural circulation. Operators will take prompt actions to minimize RCS inventory losses by isolating potential RCS letdown paths. The initial FLEX strategy for reactor core cooling is to release steam from the steam generators (SGs) using the main steam safety valves or atmospheric dump valves (ADVs) and to add water to the SGs via the turbine driven emergency feedwater (TDEFW) pumps. The emergency feedwater (EFW) system includes the safety-related qualified condensate storage tank (QCST) as the initial water supply to the TDEFW pumps. The RCS cooldown and depressurization would be initiated at approximately 8 hours for ANO-1 and at 2 hours for ANO-2. The licensee's FIP states that [active] RCS makeup with borated coolant would be initiated [in Phase 2] by 6 hours for ANO-1 and 17.5 hours for ANO-2.

The mitigating strategy for ANO-1 would delay RCS cooldown and depressurization for up to 8 hours from the initiation of the ELAP event. By 8 hours into the event, the licensee could provide sufficient RCS makeup to maintain a stable pressurizer level despite thermally induced contraction of the RCS inventory that would occur as the RCS is gradually cooled down. Maintaining a stable pressurizer level for the B&W-designed ANO-1 reactor assures that adequate core cooling can be provided via natural circulation. In contrast, based upon differences in plant configuration, the CE-designed reactor at ANO-2 is capable of maintaining stable natural circulation flow in the RCS despite the thermally induced contraction. The licensee plans a cooldown and depressurization of the RCS to a hot leg temperature of 350°F beginning at 2 hours into the ELAP event, without first establishing active RCS makeup using FLEX equipment. As the RCS at ANO-2 is depressurized past the safety injection tank (SIT) pressure, passive injection of SIT inventory will replenish some of the RCS volume lost to thermal contraction and system leakage. The main source of system leakage would be from RCP seals.

The QCST should be capable of providing at least 4 hours of EFW supply to each unit in the event that it is compromised due to a wind/missile event and at least 7 hours for other events for which it remains intact. Following depletion of the QCST and any other surviving condensate sources, for certain postulated BDBEEs, the diesel-driven fire pump would be used to provide suction to the TDEFW pumps from the emergency cooling pond (ECP) or Lake Dardanelle. The diesel-driven fire pump starts automatically on loss of ac power and would require valve operation to align the pump's discharge to each unit's service water header, which supplies each unit's EFW header.

Stripping of non-essential dc loads would be completed within 3 hours into the event. This load shedding would extend the battery powered monitoring function to at least 9 hours following the event initiation for the ANO-1 and ANO-2 station batteries. Prior to battery depletion, a portable generator would repower battery chargers to ensure instrumentation remains available throughout the event.

Phase 2

The transition into Phase 2 for reactor core heat removal would occur as portable resources are utilized. The TDEFW pump at each unit is assumed to remain available as long as steam is available for powering the pump and a source of supply water is maintained. As core decay heat diminishes following the reactor trip, the rate of steam generation will gradually diminish such that continuous operation of the TDEFW pump will no longer be possible. In preparation for the eventual unavailability of the TDEFW pump, one diesel-driven FLEX SG makeup pump per unit would be staged to deliver feedwater to both SGs at each unit.

Prior to depletion of the QCST, a portable diesel-driven pump (i.e., the FLEX inventory transfer pump) would be staged to transfer inventory to the QCST from the ECP, which is the qualified backup water supply. In addition, discharge flow from the FLEX inventory transfer pump can be supplied directly to the suction of each unit's FLEX SG makeup pump.

In events where the QCST and the borated water storage tank (BWST) maintain their integrity following the BDBEE (non-wind/missile events), the licensee's strategy is to backfill the QCST from the BWST utilizing hoses and FLEX tie-ins. Backfilling from the BWST provides additional time to stage the FLEX inventory transfer pump and the hose required to transfer water from the ECP to the QCST. In particular, connection of the BWST to the QCST for a gravity-drain backfill should increase the coping duration up to 25 hours for the QCST following a BDBEE prior to needing replenishment from the FLEX inventory transfer pump.

The Phase 2 strategy for each units' core heat removal following a wind/missile event is as described for Phase 1. In this case the diesel-driven fire pump is credited with providing a water source to the TDEFW pump, after the available QCST volume is depleted. When sufficient steam pressure is no longer available to drive the TDEFW turbine, two portable, diesel-driven pumps (one FLEX SG makeup pump per unit) capable of providing the required feed rate to the SGs would be used. Hoses would be provided to connect the suction of the FLEX SG makeup pump to the QCST tie-in connections and the discharge manifold of the pump to either the primary or alternate tie-in connections in the EFW system.

For ANO-1, the RCS inventory control strategy relies on re-powering one of the three ANO-2 charging pumps from a portable FLEX diesel generator and cross-connecting of the charging pump to the ANO-1 high pressure injection (HPI) system. This strategy is considered an alternate method of compliance per the guidelines of NEI 12-06 because: (1) it does not utilize a portable pump, and (2) the injection flow path from the ANO-2 charging pumps to ANO-1 is not fully diverse and independent. This alternate method of compliance is assessed in Section 3.14 of this SE. The ANO-1 thermal-hydraulic analysis determined that an RCS makeup flow of at least 35 gallons per minute (gpm) at a pressure of 2100 pounds per square inch absolute (psia) should be aligned to the RCS within 6 hours following the initiation of the ELAP. The ANO-2 charging pump would be provided suction from the ANO-2 boric acid makeup tanks (BAMTs) and then from the ANO-2 refueling water tank (RWT), which contain a sufficient inventory of borated water to supply both units well into Phase 3. ANO-1 would not commence an RCS cooldown until adequate RCS inventory has been restored, which the licensee calculated as requiring 2 hours of injection time. At this point, 8 hours into the ELAP event, ANO-1 would initiate an RCS cooldown and depressurization at a rate of approximately 20°F/hour. Cooldown and depressurization would be completed when the ANO-1 RCS hot leg temperature reaches 350°F. Two banks of pressurizer heaters for ANO-1 are capable of being repowered from the FLEX portable diesel generator (PDG) to maintain adequate subcooling margin during the RCS cooldown and thereafter.

According to the licensee's FIP, the intended FLEX strategy would use a single ANO-2 charging pump to supply RCS makeup to both units, alternating flow between them. Since the strategy for ANO-2 RCS makeup utilizes existing piping from the ANO-2 charging pumps to the RCS, there is no tie-in connection required to fulfill the strategy. The ANO-2 charging pump can inject into the ANO-2 RCS via routes on either the normal charging system or via high-pressure safety injection (SI) piping.

The electrical portion of the Phase 2 coping strategy has the main goal of repowering one train of battery chargers for each unit, battery room ventilation fans, ANO-1 pressurizer heaters, one ANO-2 charging pump and other critical loads. For ANO-1, the primary connection is to a 480 Volts ac (VAC) electrical safety load center which can be used to repower one train of battery chargers, or alternate motor control centers which can accomplish the same task. For ANO-2, the primary connection would be to a 480 VAC electrical safety load center which can be used to repower the battery chargers, or alternate connections to a different 480 VAC electrical safety load center which can accomplish the same task. For both units, this strategy provides train diversity in that provisions have been made to repower the required equipment through different electrical paths should one or the other be out of service. This strategy would require one FLEX PDG to power both units. The 480 VAC FLEX PDG and the required power cables would be transported from one of the ANO FLEX storage buildings to its deployed position near the post-accident sampling system (PASS) building.

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

Phase 3

To support continuation of the safety functions required by Order EA-12-049 for an indefinite coping period, additional pumps, electrical generators, and other equipment would be delivered to the site in Phase 3 from the National SAFER (Strategic Alliance for FLEX Emergency Response) Response Center (NSRC). The specific equipment requested by the licensee is described in Table 4 of the licensee's FIP. In particular, the mobile water treatment system delivered by the NSRC would provide a Phase 3 method for removing impurities from alternate fresh water supplies that may be used over an extended period of time to mitigate an ELAP event. Additionally, a mobile boration unit would be delivered, which would provide a method for preparing borated coolant for an indefinite period.

SFP Cooling

There are two independent SFPs at ANO. The pools for both units are similar in design and are not interconnected. The basic FLEX strategy for maintaining SFP cooling is to monitor SFP level and provide makeup water to the SFP sufficient to restore a normal SFP level. For Phase 1, SFP cooling is not challenged early in the event for either unit. The initial coping strategy for SFP cooling is to monitor SFP level using instrumentation installed as required by NRC Order EA-12-051. In the event of an ELAP, the pool would begin to heat-up and eventually start to boil. During Phase 1, makeup hoses and oscillating monitor nozzles would be staged prior to commencement of boiling to ensure that once makeup capability is established in Phase 2, that the SFP water inventory can be replenished readily.

At ANO-1, for the normal operating decay heat load, the time to boil is calculated to be 9.15 hours, and for the maximum credible heat load, the time to boil is calculated to be 3.87 hours. The associated boil-off rates for these two scenarios result in a required makeup flow rate of approximately 27 gpm and 65 gpm, respectively, to replace any boil-off losses in the SFP.

At ANO-2, for the normal operating decay heat load, the time to boil is calculated to be 4.17 hours, and for the maximum credible heat load, the time to boil is calculated to be 2.19 hours. The ANO-2 SFP has a smaller volume and a higher decay heat load than the ANO-1 SFP. The associated boil-off rates for these two scenarios result in a required makeup flow rate of approximately 42 gpm and 79 gpm, respectively, to replace any boil-off losses in the SFP.

The Phase 2 baseline capabilities required for SFP cooling are makeup via hoses on the fuel floor (direct makeup), makeup via connection to SFP cooling piping (hardened makeup), and spray capability via monitor nozzles from the refueling floor using a portable pump. The Phase 2 strategy initiates makeup to the SFP without accessing the refueling floor by using the existing SFP cooling piping which discharges into the pool. Hoses are connected from the FLEX SFP makeup pump to an installed hose connection to provide the required makeup without accessing the refueling floor. Suction to the FLEX SFP makeup pump would be taken from the available sources of water. The FLEX SFP makeup pump is trailer mounted and would be towed to the staging area by towing vehicles.

The long-term phase of the SFP FLEX cooling strategy is reliant on maintaining makeup/boil off as done in Phase 2. The NSRC equipment would be used to provide higher quality water as needed to make up to the SFP until repairs to plant systems or procurement of alternate means of removing SFP decay heat are sufficient to allow the transition from the FLEX equipment to another means of SFP cooling.

Containment Cooling

With an ELAP initiated while either ANO unit is in Modes 1-4, containment cooling for that unit is lost for an extended period of time. Containment temperature and pressure would slowly increase. The licensee's FIP states that structural integrity of the reactor containment building due to increasing containment pressure would not be challenged during the first 120 hours of an ELAP event.

Below are specific details on the licensee's strategies to restore or maintain core cooling, containment, and SFP cooling capabilities in the event of a BDBEE, and the results of the staff's review of these strategies. The NRC staff evaluated the licensee's strategies against the endorsed guidance in NEI 12-06, Revision 0.

3.2 Reactor Core Cooling Strategies

In accordance with Order EA-12-049, licensees are required to maintain or restore cooling to the reactor core in the event of an ELAP concurrent with a loss of normal access to the UHS. Although the ELAP results in an immediate trip of the reactor, sufficient core cooling must be provided to account for fission product decay and other sources of residual heat. Consistent with endorsed guidance from NEI 12-06, Phase 1 of the licensee's core cooling strategy credits installed equipment (other than that presumed lost to the ELAP/loss of normal access to the UHS) that is robust in accordance with the guidance in NEI 12-06. In Phase 2, robust installed equipment is supplemented by onsite FLEX equipment, which is used to cool the core either directly (e.g., pumps and hoses) or indirectly (e.g., FLEX electrical generators and cables repowering robust installed equipment). The equipment available onsite for Phases 1 and 2 is further supplemented in Phase 3 by equipment transported from the NSRCs.

To adequately cool the reactor core under ELAP conditions, two fundamental physical requirements exist: (1) a heat sink is necessary to accept the heat transferred from the reactor core to coolant in the RCS, and (2) sufficient RCS inventory is necessary to transport heat from the reactor core to the heat sink via natural circulation. Furthermore, inasmuch as heat removal requirements for the ELAP event consider only residual heat, the RCS inventory should be replenished with borated coolant in order to maintain the reactor in a subcritical condition as the RCS is cooled and depressurized.

As reviewed in this section, the licensee's core cooling analysis for the ELAP/loss of normal access to the UHS event (non-flood scenario) presumes that, per endorsed guidance from NEI 12-06, both units would have been operating at full power prior to the event. Therefore, the SGs may be credited as the heat sink for core cooling. Maintenance of sufficient RCS inventory, despite ongoing system leakage expected under ELAP conditions, is accomplished through a combination of installed systems and FLEX equipment. The specific means used by the licensee to accomplish adequate core cooling are discussed in further detail below.

3.2.1 Core Cooling Strategy and RCS Makeup

3.2.1.1 Core Cooling Strategy

3.2.1.1.1 Phase 1

The licensee's FIP states that core cooling in Phase 1 for each unit will be accomplished by transferring residual heat to the SGs via natural circulation flow in the RCS. This energy transfer will vaporize liquid on the secondary side of the SGs, with the generated steam vented via the SG safety valves or ADVs, thereby carrying off the residual heat. To maintain sufficient SG inventory to support this form of heat removal, the licensee stated that the installed TDEFW system will automatically start to supply feedwater to the SGs.

Initially the source of feedwater would be the QCST, which the licensee stated contains an initial minimum usable volume to support residual heat removal for ANO-1 and ANO-2 for at least 4 hours in the event it is compromised due to a wind-borne missile strike. If the QCST is undamaged, its water supply should be sufficient for 7 hours following the ELAP/loss of normal access to the UHS event. The non-safety-related CSTs may be gravity drained to supply a clean condensate source as well, though they are not credited. After depletion of the available condensate sources, the diesel-driven fire pump would be used in certain scenarios such as a wind/missile event, to provide suction to the TDEFW pumps from the ECP or Lake Dardanelle. The diesel-driven fire pump starts automatically on a loss of ac power and would require valve manipulation to align the pump to each unit's service water header, which would in turn supply each unit's EFW header.

ANO-1 will delay a cooldown and depressurization of the RCS until Phase 2. ANO-2 will initiate a symmetric RCS cooldown using both SGs by 2 hours into the ELAP event. Per the FIP, ANO-2 would establish a cooldown rate of 75°F per hour and would terminate the cooldown at an RCS hot leg temperature of 350°F. ANO-2 is capable of undergoing the planned RCS cooldown and depressurization prior to establishing active RCS makeup per its FLEX mitigating strategy. To implement the intended RCS cooldown, local manual actions may be necessary to control both the TDEFW pump and SG ADVs within 2 hours of event initiation. These actions ensure that: (1) the RCS cooldown proceeds at the intended rate, and (2) the cooldown is terminated at the targeted endpoint and SG pressure is henceforth maintained within its intended control band.

For ANO-2, the licensee's FIP states that stopping the cooldown at an RCS temperature of 350°F would preclude injection of the nitrogen cover gas from the SITs into the RCS. Furthermore, the licensee determined that a cooldown to this RCS temperature should ensure functionality of the TDEFW pump. Both the description in the FIP, as well as the FLEX Developed Strategy (FDS)-002, "Unit 2 Extended Loss of AC Power," Revision 1, refer to the criterion for cooldown termination as being an RCS temperature of 350°F, without further specification. By letter dated September 1, 2016 [Reference 60], the licensee subsequently confirmed that the RCS temperature discussed above corresponds to the hot leg temperature, indication for which should be available throughout the analyzed ELAP event. The NRC staff further confirmed that the cooldown terminus temperature of 350°F in the ANO-2 thermal-hydraulic calculation is associated with the core outlet (i.e., effectively the RCS hot leg temperature). During its audit review, the NRC staff noted that, while maintaining RCS hot leg temperature above 350°F provides some confidence that nitrogen would not be injected from the SITs, hot leg temperature is not directly linked to the SG pressure. In particular, the SG pressure associated with a given RCS hot leg temperature will vary depending upon the subcooling present in the RCS cold leg. As such, the NRC staff further assessed FDS-002, observing that the procedure contains additional guidance that operators should maintain RCS pressure above 230 psia prior to isolating the SITs and above 80 psia thereafter as necessary to support operation of the TDEFW pump. As a result, the NRC staff considered the procedural guidance for avoiding SIT cover gas injection and ensuring the functionality of the TDEFW pump to be satisfied.

For both units, the RCS cooldown limits the adverse effects of high temperature coolant on RCP shaft seal performance and reduces SG pressure such that a portable feedwater pump can be used for eventual feedwater injection when the TDEFW pump becomes unavailable.

3.2.1.1.2 Phase 2

The mitigating strategy for ANO-1 would depressurize and symmetrically cool down the RCS to a hot leg temperature of 350°F using both SGs once the RCS has been refilled and a continuing source of RCS makeup has been established. The licensee's FLEX strategy calls for makeup to be supplied to ANO-1 by an installed ANO-2 charging pump through hoses and inter-unit cross-connection piping to one of two connection points on the ANO-1 HPI system. The licensee's analysis concluded that, by 8 hours into the ELAP event, the FLEX strategy can restore the normal operating level in the pressurizer such that the RCS cooldown may commence. In conducting the cooldown, operators would be directed to proceed at a rate of 20°F per hour. A gradual cooldown is necessary such that a 44-gpm ANO-2 charging pump can inject liquid volume into the system at rate offsetting both RCS leakage and the thermal contraction of the RCS inventory in response to the cooldown, thereby maintaining pressurizer level.

For ANO-1, passive injection from the nitrogen-pressurized core flood tanks may not occur during the analyzed ELAP event, and thus it is not credited by the licensee. During Phase 1, operators would not depressurize the RCS, and RCS pressure would be expected to remain well above the core flood tank injection pressure. Prior to the point at which the subsequent RCS cooldown and depressurization would result in core flood tank injection, plant operators would be procedurally permitted to isolate the core flood tanks. At this time in the analyzed ELAP event, an ANO-2 charging pump should be in operation, which should be capable of maintaining adequate RCS inventory. To prevent injection of the nitrogen cover gas from the core flood tanks into the RCS, the licensee's FLEX procedures direct operators to maintain the RCS pressure above 325 pounds per square inch gauge (psig) until the core flood tanks have been isolated. The ANO-1 cooldown is also controlled to maintain SG pressure greater than 80 psig to ensure continued functionality of the TDEFW pump.

In its FIP, the licensee stated that its Phase 2 core cooling strategy for each unit would continue to use the SGs as a heat sink, with each unit's TDEFW pump continuing to supply feedwater from the QCST symmetrically to both SGs. Prior to depletion of the QCST, the licensee intends to stage and align a portable diesel-driven FLEX pump to transfer inventory from the ECP to the QCST (if intact) or directly to each unit's FLEX SG makeup pump. However, the licensee stated that if the QCST is compromised by a missile event, it may not be possible to complete this evolution prior to depletion of the QCST. Therefore, as necessary, following depletion of, or damage to, the QCST, the licensee would intend to align the discharge of the diesel-driven fire pump directly to the suction of the TDEFW pump at each unit to provide makeup flow to the SGs. However, in the seismically induced ELAP event, the diesel-driven fire pump and fire header are not credited. In this analyzed scenario, wherein a robust source of unborated water is not readily available and the BWST is intact, the licensee's credited strategy includes gravity-drain backfilling the QCST from the BWST utilizing hoses and FLEX tie-ins. The licensee determined that this strategy should extend the time to stage the FLEX inventory transfer pump to 25 hours. By letter dated September 1, 2016 [Reference 60], the licensee provided conclusions of an analysis that reflects the use of a limited quantity of borated water from the BWST as an interim means for feeding the SGs during analyzed ELAP scenarios. The conclusion of the analysis was that using BWST water should not result in adverse effects. In particular, the licensee's evaluation concluded that excessive degradation of the materials used to fabricate the SGs should not occur, nor should using BWST water result in the precipitation of boric acid. Further, the licensee's letter dated September 1, 2016, provided a description of the procedure to ensure that borated water would not be used in preference to unborated water. Specifically, as soon as flow from the ECP is established using FLEX equipment, the licensee would transition the source of SG makeup to this source of unborated water. The NRC staff audited the licensee's evaluation of the use of borated water for SG makeup and found it reasonable for the beyond-design-basis ELAP event. The NRC staff observed the potential for reduced margins for boric acid precipitation in the event of feeding the SGs asymmetrically with borated water, but concluded that the remaining margin should be sufficient for the analyzed ELAP event.

Although, if available, the licensee would continue to use each unit's installed TDEFW pump in Phase 2, consistent with the guidance in NEI 12-06, the licensee has the capability to use portable, onsite FLEX equipment to provide feedwater symmetrically to both SGs through primary and alternate connection points. Specifically, the licensee has 4 diesel-driven SG makeup pumps onsite, which satisfies the "N+1" redundancy criterion for the two operating units at ANO. Each pump is capable of providing 300 gpm, which can be pumped at a total developed head of 650 feet (approximately 282 pounds per square inch differential (psid)) for the two pumps assigned to ANO-1, and at 710 feet (approximately 308 psid) for the two pumps assigned to ANO-2. Therefore, following the planned SG depressurizations, these FLEX SG makeup pumps should be capable of providing adequate feedwater flow to the SGs during the analyzed ELAP event.

In preparation for the eventual unavailability of the TDEFW pumps as reactor core decay heat diminishes, one diesel-driven FLEX SG pump per unit would be staged to provide feedwater symmetrically to both SGs. Hoses would be available to connect the suction of the FLEX SG makeup pumps to the QCST tie-in connections. The pump discharge manifold would then be connected to either the primary or alternate tie-in connections in the EFW system. Per its FIP, the licensee expects that operators will be capable of controlling SG pressure high enough to support TDEFW pump operation for both units through 72 hours in the analyzed ELAP event. However, in light of the importance of maintaining continuous feed flow to the SGs during an ELAP event, particularly with respect to ANO-1, the licensee's plan indicates that the FLEX SG makeup pumps should be staged and aligned as resources permit, specifically within approximately 24 hours for ANO-1.

3.2.1.1.3 Phase 3

The reactor core cooling strategy in Phase 3 is a continuation of the strategy from Phase 1 and 2 that relies upon the SGs to remove decay heat for an indefinite coping period. However, in Phase 3, onsite equipment would be supplemented as needed with equipment provided by the NSRCs. With respect to core cooling, the additional NSRC-supplied equipment would include pumps capable of supplying feedwater to the SGs and a reverse osmosis / ion exchange system to facilitate a long-term supply of purified water. Additional pumps and hoses would also be available to assist in replenishing the QCST or supplying cooling water directly to the TDEFW or FLEX SG makeup pump suction. As necessary to facilitate the use of higher quality water for reactor core cooling, the NRC staff expects that the licensee would begin using the water purification equipment from the NSRC as soon as practical considering the overall event response prioritization. The licensee's FIP further discusses the capability for restoring the installed shutdown cooling system using the 4160 VAC generators provided by the NSRC.

3.2.1.2 RCS Makeup Strategy

3.2.1.2.1 Phase 1

Following initiation of the ELAP event, operators would verify isolation of normal letdown and other isolable flow paths to conserve RCS inventory. However, under ELAP conditions, RCS inventory would tend to diminish gradually due to leakage through RCP seals and other leakage points. Thermal contraction from an RCS cooldown, if conducted in the absence of active RCS makeup, would result in a further volumetric reduction of the RCS inventory, to the extent that the pressurizer would drain and a vapor void would form in the upper head of the reactor vessel.

ANO-1 is a B&W PWR with once-through SGs and lowered RCS loops. In order to maintain natural circulation in the RCS loops for this design configuration, it is important for plant operators to avoid taking actions that tend to drain the pressurizer. For this reason, the licensee intends to delay the RCS cooldown for ANO-1 until the FLEX RCS makeup strategy can adequately refill the RCS.

For ANO-2, which is a CE PWR with inverted U-tube SGs, the initial RCS cooldown may be started two hours into the event, even though RCS makeup will not be initiated until well into Phase 2. Despite the potential for draining the pressurizer and voiding the reactor vessel upper head due to ongoing RCS leakage and the volumetric contraction associated with the RCS cooldown, thermal-hydraulic analysis indicates that natural circulation should be maintained for this RCS configuration throughout Phase 1 of the analyzed ELAP event. For ANO-2, timely cooldown and depressurization of the RCS can significantly extend the expected coping time under ELAP/loss of normal access to the UHS conditions because it: (1) reduces the potential for damage to RCP seals, and (2) allows borated coolant stored in the nitrogen-pressurized SITs to passively inject into the RCS to offset the system volume reduction and add negative reactivity.

3.2.1.2.2 Phase 2

By 6 hours into the event, the licensee would repower one of three ANO-2 charging pumps using a FLEX generator and align the discharge of this pump to one of two connection points on the ANO-1 HPI system using hoses and inter-unit cross-tie piping. The initial suction source for the ANO-2 charging pump would be the ANO-2 BAMTs. By initiating FLEX RCS makeup to ANO-1 by 6 hours into the analyzed ELAP event, the licensee calculates that it should be able to refill the RCS such that a cooldown can be initiated by 8 hours into the event. Thereafter, the 44-gpm FLEX RCS makeup rate should allow the RCS cooldown to proceed at 20°F per hour. Upon depletion of the ANO-2 BAMTs, the next suction source for the charging pumps would be the ANO-2 RWT, which the licensee's FIP asserted would provide a sufficient volume of borated coolant for 72 hours. Alternatively, the licensee stated that FLEX hoses could be used to connect the ANO-1 BWST to FLEX connection points on the charging pump common suction header. If the BWST is available (i.e., undamaged and not gravity-drained to the QCST) its inventory could also be used for providing RCS makeup.

In Phase 2, RCS makeup to ANO-2 would also be established. Specifically, by 17.5 hours into the event, the licensee stated that RCS makeup to ANO-2 would be initiated, using the same ANO-2 charging pump and suction sources (ANO-2 BAMTs and RWT) as described for ANO-1. In particular, because a single pump would be used to supply flow to both units, at this point, the licensee plans to alternate the flow of the ANO-2 charging pump between ANO-1 and ANO-2.

3.2.1.2.3 Phase 3

The licensee's FIP states that ANO will use NSRC-supplied equipment as part of its long-term strategy for providing borated coolant for RCS makeup. Each unit will use a similar Phase 3 strategy, with the equipment quantities described below being applicable to a single unit. The licensee will use an NSRC low-pressure medium-flow pump to take suction from the intake canal via four parallel suction hoses. The pump discharge will be routed to an NSRC-supplied mobile water treatment system, which is capable of providing flow at 125 gpm. The resulting purified water would be directed to an NSRC-supplied mobile boration unit, where powdered boric acid would be added. Once adequately mixed, the licensee stated that the prepared borated coolant would be supplied to the RWT, BWST, and BAMTs via an NSRC-supplied high pressure injection pump. These tanks could then supply the installed ANO-2 charging pumps as described in the Phase 2 strategy. Alternatively, the licensee has RCS injection tie-ins that are compatible with NSRC equipment, such that an NSRC-supplied high pressure injection pump could be used to inject the output of the mobile boration unit directly via the FLEX RCS injection flow path. Acquisition of the mobile boration unit and the capability to inject its output using NSRC-supplied equipment ensures diverse capability for providing long-term RCS makeup in accordance with the requirements of Order EA-12-049.

3.2.1.3 Variations to Core Cooling Strategy for Flooding Event

For a flooding event the licensee's strategy contains some differences as compared to the strategy for other external events. The current licensing basis flood for ANO provides approximately 5 days of warning time before the site is flooded and access becomes restricted. The postulated flood then persists for a period of up to 5 days. During this time both of the ANO units would be shut down and two platforms would be built to pre-stage one set of FLEX equipment, including the associated hoses and cables. The equipment that would be pre-staged would be taken from the FLEX storage building constructed at an elevation that is below the projected design basis flood elevation. The second FLEX storage building is located above the projected flood elevation. Thus, the licensee plans to pre-stage the FLEX equipment that would otherwise be flooded, in accordance with NEI 12-06 provision 6.2.3.1.1.c. The licensee does not plan to pre-stage the remaining backup set of equipment, stored above the flood level, even though the deployment paths for that equipment would be inundated for a period of up to 5 days. The licensee's FIP identifies the pre-staging strategy as an alternative to NEI 12-06, and the NRC's evaluation of the strategy is contained in Section 3.14.2 of this SE.

3.2.1.4 Variations to Core Cooling Strategy for Wind/Missile event

For the Order EA-12-049 wind/missile event, three tanks (QCST, RWT and BWST), which are located outside of protected plant structures, have been evaluated in terms of their ability to resist, in a limited manner, the wind/missile loading. The QCST is not qualified to resist the current site design basis tornado missiles hazard. In order to support the licensee's FLEX strategy this tank has been evaluated to show that its lower portion would survive the tornado missile event, providing a limited volume of water for the TDEFW pumps. Subsequently, the diesel-driven fire pump, housed in the tornado-protected intake structure, will be credited for providing makeup water to TDEFW pump for SG makeup as described in Phase 1, Section 3.2.1.1.1. The re-evaluation for the RWT and BWST volumes shows that there would be a minimum 100,962 gallons available in each tank to support the FLEX strategy after the postulated tornado event.

For the Order EA-12-049 re-evaluation of the three tanks, the licensee has elected to use Regulatory Guide 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," Revision 1. This differs from the site design basis wind/missile loading, which is generally more restrictive. Thus, since the licensee is not using the design-basis hazard criteria in accordance with the provisions of NEI 12-06, Section 7.3.1.1.a, nor do the three tanks meet the NEI 12-06 definition of "robust," the re-evaluation constitutes an alternative to the guidance. The licensee's justification for this analysis method alternative is discussed further in Section 3.14.3 of this SE.

3.2.2 Staff Evaluations

3.2.2.1 Availability of Structures, Systems, and Components (SSCs)

Guidance document NEI 12-06 provides guidance that the baseline assumptions have been established on the presumption that other than the loss of the ac power sources and normal access to the UHS, installed equipment that is designed to be robust with respect to design-basis external events is assumed to be fully available. Installed equipment that is not robust is assumed to be unavailable. Below are the baseline assumptions for the availability of SSCs for core cooling during an ELAP caused by a BDBEE.

3.2.2.1.1 Plant SSCs

In NEI 12-06, Section 3.2 states that installed equipment that is designed to be robust with respect to design-basis external events is assumed to be fully available. In addition, Condition 6 of NEI 12-06, Section 3.2.1.3, states that permanent plant equipment contained in structures with designs that are robust with respect to seismic events, floods, and high winds, and associated missiles, are available. The ANO-1 and ANO-2 UFSARs refer to both seismic "class" and seismic "category" in their text. For consistency within this SE, the terminology seismic "category" will be used when describing the seismic classification of systems, structures, and components.

ANO-1

The ANO-1 UFSAR, Section 5.1.4.2, states, in part, that all seismic category 1 systems and equipment are designed to withstand simultaneous seismic loadings in horizontal and vertical directions and the combination of gravity loads, operating loads, and applicable operating temperatures and pressure, without loss of function. Section 5.1.5 of the UFSAR states that components in seismic category 1 buildings are inherently tornado protected by virtue of their being housed in tornado resistant structures. Section 5.1.6 of the UFSAR states the seismic category 1 structures are designed for the maximum probable flood level.

Entergy's phase 1 core cooling FLEX strategies for ANO-1 rely on its existing TDEFW pump, EFW system piping, SGs, ADVs, and QCST. In addition, the licensee relies on its Class 1E batteries and dc distribution system, and for wind/missile events relies on its diesel-driven fire pump to provide makeup water from the ECP.

The TDEFW pump control and throttle valves, and other system valves are powered by the Class 1E 125 VDC batteries and associated DC distribution system. However, operators can locally align, start, and control the TDEFW system using existing station procedures if necessary. The ANO-1 UFSAR, Section 5.1.2.1.2 states that the EFW system including the TDEFW pump, valves, and connecting piping is a seismic category 1 system. The TDEFW pump is located in the seismic category 1 portion of the ANO-1 Auxiliary Building, which provides protection against all applicable external hazards. However, portions of the turbine exhaust piping and portions of the seismic category 1 main steam lines supplying steam to the pump turbine are located outdoors without protection from tornado missiles.

During the audit process, the staff questioned the survivability of the exhaust and steam supply piping during a tornado event and the licensee's ability to credit the TDEFW pump as available during an ELAP following a tornado. As a result, the licensee identified several intervening structures that provide limited missile protection for the pump turbine exhaust piping. The licensee also noted that the exhaust piping has an in-line rupture disc that provides an alternate vent path in the unlikely event that the exhaust line is pinched closed.

For the steam piping, the licensee performed an evaluation, documented in Engineering Report CALC-ANOC-CS-15-00004, "ANO Units 1 and 2 ADV Intervening Structures Evaluation for FLEX Implementation," Revision 0, which determined the EFW steam supply piping for both units is reasonably protected from tornado generated missiles in all directions by adjacent structures and equipment. During the onsite audit of the licensee's FLEX strategies, the staff walked down the affected steam supply and exhaust piping and performed a review of CALC-ANOC-CS-15-00004. Based on the walkdown and evaluation review, the NRC staff concludes that, for the purposes of assessing Order EA-12-049, the TDEFW pump should function after a tornado missile event, as the licensee's plan assumes.

The two ANO-1 SGs transfer decay heat from the RCS to the atmosphere during an ELAP. As described in the ANO-1 UFSAR, Section 5.1.2.1.2, the SGs are seismic category 1 components. The SGs are located in the seismic category 1 reactor containment building, which provides protection from all applicable external hazards. The ANO-1 UFSAR, Section 5.1.2.1.2, states that the main steam piping, including the branch headers that contain the ADVs, out to and including the first isolation valves, are seismic category 1 components. The ADVs branch off of the main steam piping upstream of the main steam isolation valves (MSIVs). However, the ANO-1 licensing basis does not credit functionality of the ADVs following a missile strike, therefore, the ADVs are not protected from tornado-generated missiles. As a result, the licensee identified several intervening structures that could provide reasonable missile protection for the ADVs. The licensee performed an evaluation, documented in Engineering Report CALC-ANOC-CS-15-00004, "ANO Units 1 and 2 ADV Intervening Structures Evaluation for FLEX Implementation," Revision 0, which concluded that, given the limited exposure of the ADVs and associated safety-related block valves, the presence of intervening structures, piping, and pipe supports afford reasonable protection against a missile impact. During the onsite audit of the licensee's FLEX strategies, the staff walked down the affected ADVs, associated piping, and access routes, and performed a review of CALC-ANOC-CS-15-00004. Based on the walkdown and evaluation review, the NRC staff concludes that, for the purposes of assessing Order EA-12-049, the ANO-1 ADVs should function after a tornado missile event, as the licensee's plan assumes.

The primary source of cooling water for Phase 1 core cooling comes from the QCST (shared between units for FLEX). The ANO-1 UFSAR, Section 5.1.2.1.2 states that the EFW system including the QCST is a seismic category 1 system. The licensee stated in its FIP that the QCST is protected from seismic, extreme heat, extreme cold, and flooding events. However, only the bottom 5' of the QCST is protected from tornado-generated missiles by a concrete shield wall. While this portion of the tank is protected, an additional volume of water would be required to continue the core cooling capability during an ELAP following a tornado missile strike. For this event, the licensee plans to credit the diesel-driven firewater pump to supply water from the ECP or Lake Dardanelle to the suction of the TDEFW pump.

Following a tornado missile strike, the QCST must provide sufficient inventory to allow time to manually align the diesel-driven firewater pump from the SW system to the EFW system. The licensee stated that time requirement to align the firewater pump to the EFW suction for both units is approximately 4 hours. The licensee performed CALC-ANOC-CS-13-00012, "ANO FLEX Tank Tornado Missile Impact Evaluation," Revision 0 to evaluate the availability of the inventory in the QCST. In addition, the licensee performed calculation CALC-13-E-0005-51, "ANO FLEX Drain Time of Tanks due to Missile Puncture" which determined the drain down time and resulting volume in the QCST in the event of a missile strike in the unprotected region of the tank. From the results of CALC-ANOC-CS-13-00012, CALC-13-E-0005-51, and the inherent protection of the QCST appendages by the existing 5' missile barrier wall, the licensee determined that QCST should provide the necessary inventory to allow operators sufficient time to align the diesel-driven fire pump to the suction of the TDEFW pumps. The diesel-driven fire pump and its associated day tank is located in the seismic category 1 intake structure, and is protected from tornado winds and missiles.

During the audit of the licensee's FLEX strategies, the staff walked down the QCST, the SW/EFW cross tie and diesel-driven firewater pump, and reviewed CALC-ANOC-CS-13-00012 and CALC-13-E-0005-51. No deficiencies were noted in this review. The staff also reviewed the finite element analysis (FEA) for the QCST. The review of the FEA analysis for this tank, and two other tanks, is discussed further in section 3.14.3 of this safety evaluation.

The ECP is a 14-acre pond, which the licensee uses as its UHS. The ECP provides the suction source for the diesel-driven firewater pump. The licensee stated in its FIP that the ECP is located entirely within the site boundary, and is protected for all BDBEEs.

The licensee relies on its safety-related Class 1E batteries and DC distribution system to power required key instrumentation and applicable DC components. The ANO-1 UFSAR, section 5.1.2.1.2 states that the control boards, switchgear, load centers, batteries, transformers, and cable runs serving seismic category 1 equipment are designed as seismic category 1 components. The batteries are located in the seismic category 1 Auxiliary Building and are protected from all applicable external hazards.

For Phase 2 core cooling, in addition to the SSCs discussed above, the licensee relies on the ANO-1 BWST. For inventory control, the licensee relies on the ANO-1 HPI system, ANO-2 charging system, including charging pumps, and associated piping and valves, the BAMTs, and the ANO-2 RWT.

For non-wind/missile events, the licensee's Phase 2 core cooling strategy relies on gravity draining the ANO-1 BWST to the QCST to extend the TDEFW pumps suction source inventory while the licensee deploys and aligns the onsite portable pumps for SG injection. The ANO-1 UFSAR, section 5.1.2.1.2 describes the BWST as a seismic category 1 vessel and all connecting piping is located in a seismic category 1 structure. However, the ANO-1 BWST is not protected from high winds or tornado-generated missiles, and requires heaters to maintain the water temperature to prevent the precipitation of boric acid out of solution. For high wind/tornado events, the licensee plans to use the diesel-driven firewater pump to supply water to the suction of the TDEFW pumps as described above for Phase 1 core cooling. The water in the BWST is not credited for RCS inventory control during an ELAP, however it is credited for SG makeup (gravity feed to QCST) during non-wind/missile events. The licensee performed calculation CALC-14-E-0002-10, "ANO FLEX - Extreme Cold Weather Evaluation," Revision 0, to determine how long the BWST would remain above freezing following the loss of power to the tank heaters. The calculation shows that the BWST will remain above freezing for at least 27 hours, at which point gravity feed to the QCST will terminate. During the audit of the licensee's mitigating strategies, the staff performed a review of CALC-14-E-0002-10 and concluded that the licensee's analysis was reasonable and that the BWST should be available as described in the licensee's strategy.

For Phase 2 inventory control, licensee's strategy relies on one of the three ANO-2 charging pumps for high-pressure injection into the RCS. The strategy calls for cross connecting the Unit 2 charging system to the Unit 1 HPI system via high-pressure hoses and a crosstie header. The ANO-1 UFSAR, Section 5.1.2.1.2 states that safety injection system, including the high-pressure injection pumps, valves, and connecting piping, is a seismic category 1 system and is protected from all applicable external hazards. The ANO-2 charging pumps will be repowered using PDGs. The ANO-2 UFSAR Table 3.2-2 lists the charging pumps as seismic category 1 components. The charging pumps are located in the seismic category 1 portion of the ANO-2 Auxiliary Building and are protected from all applicable external hazards.

The ANO-2 charging pumps initially take suction from the ANO-2 BAMTs. The ANO-2 UFSAR, Table 3.2-2 lists the BAMTs as seismic category 1 tanks. The tanks are located in the seismic category 1 portion of the ANO-2 Auxiliary Building and are protected from all applicable external hazards.

Prior to the depletion of the ANO-2 BAMTs, operators will swap the suction of the charging pump from the BAMTs to the ANO-2 RWT. The ANO-2 UFSAR, Table 3.2-2 lists the RWT as a seismic category 1 tank. The tank is located outside and is not protected from tornado-generated missiles, and requires heaters to maintain the water temperature to prevent the precipitation of boric acid out of solution. Similar to the BWST calculation, the licensee evaluated the RWT in calculation CALC-14-E-0002-10 and determined that the inventory in the RWT would remain above 40°F for at least 72 hours following the loss of the tank heaters. As described above for the QCST, the licensee evaluated the RWT to ensure that it would remain functional following a high wind or tornado event, and therefore be considered robust, as defined in NEI 12-06. The evaluation identified several tank appendages that needed modifications because of vulnerabilities to damage from potential tornado missile strikes. The licensee concluded that with the proposed modifications, the RWT should be capable of providing the amount of borated water needed for RCS inventory control during an ELAP following a high wind or tornado event for a period of 72 hours. As with the QCST, the licensee's evaluation of the RWT for wind/missile events is discussed in section 3.14.3 of this safety evaluation.

In addition to the SSCs discussed above, during Phase 3 core cooling, the licensee, if needed, may rely on the ANO-1 decay heat removal (DHR) system, which is part of the low-pressure safety injection system, as an alternate method for removing decay heat and/or cooling down the RCS to cold shutdown. The ANO-1 UFSAR, Section 5.1.2.1.2 states that the safety injection system, including the low-pressure injection (LPI) pumps, decay heat removal heat exchangers, valves, and connecting piping is a seismic category 1 system. The SI system is located in the seismic category 1 portion of the ANO-1 Auxiliary Building and the ANO-1 Reactor Building and is protected from all applicable external hazards.

The NRC staff concludes that: (1) based on the location and design of the credited plant SSCs as described in Entergy's UFSAR and FIP, and (2) if aligned and utilized in accordance with Entergy's control strategy as described in the FIP, the credited plant SSCs should be available to support core cooling and inventory control for ANO-1 during an ELAP, consistent with NEI 12-06, Section 3.2.1.3, Condition 6.

ANO-2

The ANO-2 UFSAR, section 3.1.1, states that all structures, systems, and components designated as seismic category 1 are designed so that there is no loss of function following the Design Basis Earthquake. Section 3.3 of the UFSAR states that seismic category 1 structures were designed for the most severe local wind phenomena and tornado effects that can be expected to occur at the site. Section 3.4 of the UFSAR states that seismic category 1 structures were designed to protect safety-related equipment from external flooding. In addition, UFSAR Table 3.2-2 and Table 3.3-1 lists the seismic classification and tornado protection of the ANO-2 SSCs respectively.

Entergy's Phase 1 core cooling FLEX strategies for ANO-2 rely on its existing TDEFW pump, SGs, and ADVs to remove heat from the RCS using water from the QCST. The licensee initially relies on its existing SITs for RCS inventory control. In addition, the licensee relies on its Class 1E batteries and DC distribution system, and may rely on its diesel-driven fire pump to provide makeup water to the QCST from the ECP.

The TDEFW pump control and throttle valves, and other system valves are powered by the Class 1E 125V DC batteries and associated DC distribution system. However, operators can manually align, start, and control the TDEFW system using existing station procedures if necessary. The licensee states in its FIP that the EFW system pumps, valves, and connecting piping are designed, constructed, and maintained in accordance with seismic category 1 requirements, as described in the ANO-2 UFSAR. The TDEFW pump is located in the seismic category 1 portion of the Auxiliary Building, which provides protection against all applicable external hazards. However, portions of the turbine exhaust piping and portions of the seismic category 1 main steam lines supplying steam to the pump turbine are located outdoors without protection from tornado missiles. Similar to ANO-1, the licensee conducted an evaluation for ANO-2, documented in Engineering Report CALC-ANOC-CS-15-00004, "ANO Units 1 and 2 ADV Intervening Structures Evaluation for FLEX Implementation," Revision 0, which determined the EFW steam supply piping for both units is reasonably protected from tornado generated missiles in all directions by adjacent structures and equipment. In addition, the ANO-2 UFSAR Table 3.5-8 states that, even though the main steam piping does not have physical tornado missile protection, a postulated missile cannot destroy the integrity of lines.

During an onsite audit of the licensee's FLEX strategies, the staff walked down the affected steam supply and exhaust piping, and performed a review of CALC-ANOC-CS-15-00004, as previously described. In addition, the staff noted that the NRC performed an independent evaluation of a licensee analysis of the tornado missile effects on the outdoor seismic category 1 main steam piping during the review of the ANO-2 operating license and concluded that the piping can withstand the tornado missile impact without a loss of function. This review was documented in NUREG 0308, "Safety Evaluation Report Related to Operation of Arkansas Nuclear One, Unit 2" (ADAMS Accession No. ML102850078).

The two ANO-2 SGs transfer decay heat from the reactor core to the atmosphere during an ELAP. As described in the ANO-2 UFSAR Table 3.2-2, the SGs are seismic category 1 components. The SGs are located in the seismic category 1 reactor containment building, which provides protection from all applicable external hazards.

Steam is released to the atmosphere through the ADVs. The ANO-2 UFSAR, Table 3.2-2 describes the ADVs as seismic category 1 components. The valves branched off of the seismic category 1 main steam piping upstream of the MSIVs. However, the ADVs are located in a portion of the Auxiliary Building that is not protected from tornado-generated missiles. As a result, the licensee identified several intervening structures that could provide reasonable missile protection for the ADVs. The licensee performed an evaluation, documented in Engineering Report CALC-ANOC-CS-15-00004, "ANO Units 1 and 2 ADV Intervening Structures Evaluation for FLEX Implementation," Revision 0, which determined the ADVs and associated piping are reasonably protected from tornado generated missiles.

The licensee stated in its FIP that operation of ANO-2 ADVs and their safety-related block valves are available via platforms with more than one ladder providing means of access. The licensee stated that the ladders for each platform are adequately separated such that a single missile should not damage multiple access points. A missile strike directly to the platform is unlikely based on the surrounding intervening structures, but in the event of such an impact, the missile should cause limited damage that should not impede access to the ADVs and the safety-related block valves. During an onsite audit of the licensee's FLEX strategies, the staff walked down the affected ADVs, associated piping, and access routes, and performed a review of CALC-ANOC-CS-15-00004. The staff conclusion for ANO-2 is the same as for ANO-1 regarding ADV availability as it relates to the mitigating strategies order.

The primary source of cooling water for Phase 1 core cooling comes from the QCST. The QCST evaluation is described in the ANO-1 portion of this safety evaluation section. Similarly, the ECP is evaluated in the ANO-1 section.

For Phase 1 inventory control, the licensee relies on passive injection from the SITs. The ANO-2 UFSAR, Table 3.2-2 lists the SITs as seismic category 1 components. In addition, the SITs are located in the seismic category 1 containment structure and are protected from all applicable external hazards.

The licensee relies on its safety-related Class 1E batteries and DC distribution system to power required key instrumentation and applicable DC components. The ANO-2 UFSAR, section 8.3.1.4.6, states that the batteries and DC control centers are located in seismic category 1 rooms.

In addition to the SSCs discussed above, for Phase 2 core cooling the licensee relies on the ANO-1 BWST. For inventory control, the licensee relies on the ANO-2 charging system including charging pumps, and associated piping and valves, the BAMTs, and the ANO-2 RWT. These components were evaluated in the ANO-1 section of this safety evaluation.

For Phase 2 inventory control, licensee's strategy relies on one of the three ANO-2 charging pumps for high-pressure injection in to the RCS. These components were evaluated in the ANO-1 section of this safety evaluation.

In addition to the SSCs discussed above, during Phase 3 core cooling the licensee, if needed, may rely on the ANO-2 Shutdown Cooling (SDC) system as an alternate method for removing decay heat and/or cooling down the RCS to cold shutdown. The ANO-2 UFSAR, Section 3.6.4.5.1.2.1, states that the SDC system is classified as seismic category 1 including piping and components. The ANO-2 UFSAR, Table 3.3-1 lists the SDC system as being located in the seismic category 1 portion of the Auxiliary Building and protected from all applicable external hazards.

The NRC staff concludes that: (1) based on the location and design of the credited plant SSCs, as described in Entergy's UFSAR and FIP, and (2) if aligned and utilized in accordance with Entergy's control strategy as described in the FIP, the credited plant SSCs should be available to support core cooling and inventory control for ANO-2 during an ELAP, consistent with NEI 12-06, Section 3.2.1.3, Condition 6.

3.2.2.1.2 Primary and Alternate Connection Points for Core Cooling

Section 3.2.2 of NEI 12-06 states that the portable pumps for core and SFP cooling functions are expected to have a primary and an alternate connection or delivery point. At a minimum, the primary connection point should be an installed connection suitable for both the on-site and off-site equipment but the secondary connection point can require reconfiguration if the licensee can show that adequate time and resources are available to support the reconfiguration. NEI 12-06, Table D-1 states that primary and alternate injection points are required to establish capability to inject through separate divisions/trains (i.e., should not have both connections in one division/train). In addition, Section 3.2.2 states that both the primary and alternate connection points do not need to be available for all applicable hazards, but the location of the connection points should ensure that one connection would be available.

ANO-1

As described in the licensee's FIP, for Phase 2 core cooling the licensee provides water to the SGs from the QCST or UHS via a portable FLEX SG makeup pump discharging to the EFW system. The primary connection is on the discharge piping of the TDEFW pump. The alternate connection is on the discharge piping of the motor-driven EFW pump. Both connections are located in the seismic category 1 ANO-1 Auxiliary Building and are protected from all applicable external hazards.

The QCST has four connection points, two suction and two fill. The suction connections are located on spare lines; one in the north valve pit and the other in the south valve pit. The fill connections are located in the annulus between the tank and its missile shield wall on spare lines. The fill connections tie in downstream of existing valves and consist of a check valve and a threaded hose connection. The four connections are protected from all applicable hazards except floods. The licensee stated that the flood event has a 5-day warning time and that necessary pumps and hoses will be pre-staged and connected. The isolation valves will be accessible via T-handle reach rods. By letter dated September 1, 2016 [Reference 60], the licensee indicated that reach rods will be installed prior to a flooding event during site preparations for a flood. This installation will be controlled by the ANO-1 and ANO-2 emergency response procedures. The NRC staff verified that procedures OP-1203.025, and OP-2203.008, "Natural Emergencies," Revisions 59 and 40, respectively, for ANO-1 and ANO-2, direct the implementation of a model work order (model work order number 402438).

Gravity draining the ANO-1 BWST into the QCST allows delaying actions of staging a portable pump to refill the QCST. The connection provides access to the BWST's borated water inventory utilizing hoses to provide flow to the QCST as well as to the suction of the ANO-2 charging pump or a portable FLEX pump if needed.

As described in the licensee's FIP, the ANO-1 inventory control strategy uses the ANO-2 charging pumps and a series of hoses to establish RCS injection through the ANO-1 Makeup and Purification system. The primary suction sources for the ANO-2 charging pumps are the ANO-2 BAMTs and the ANO-2 RWT, both of which rely on installed piping. The alternate suction source is the ANO-1 BWST, which can be connected to the common suction header of the ANO-2 charging pumps with hoses. The ANO-2 charging pump suction tie-in is installed upstream of ANO-2 charging pumps on the suction header located in the seismic category 1 portion of ANO-2 Auxiliary Building and is protected from all applicable external hazards.

This tie-in could be used to provide inventory to the ANO-2 charging pumps from the BWST or any other available borated water source following a BDBEE via hoses. The tie-in can also provide access to the borated water inventory of the RWT or BAMTs as the suction source for a portable FLEX pump.

Downstream of the ANO-2 charging pumps there is a connection point for a high pressure hose on the common charging pump discharge header. In addition, there is an available connection point on a drain line at the discharge of each pump. All of the discharge connections are located in the seismic category 1 ANO-2 Auxiliary Building and are protected from all applicable external hazards. The common charging pump discharge header tie-in or the drain connection on the selected charging pump can be connected to the ANO-2 to ANO-1 crosstie.

On the ANO-1 side of the crosstie, there are two FLEX connections that provide RCS injection during an ELAP. The primary connection for RCS injection is located downstream of the primary makeup pumps and connects to the loop "B" HPI line. The alternate connection for RCS makeup connects to the loop "A" HPI line. Both connections are located in the seismic category 1 portions of the ANO-1 Auxiliary Building and are protected from all applicable external hazards. The two connections are on separate trains and should provide the necessary diversity.

In order to connect from the ANO-2 charging pumps to the ANO-1 HPI, the licensee uses a FLEX charging pump crosstie pipe, which is not connected to any existing plant piping. The crosstie begins in ANO-2 Access Area 2040, passes from ANO-2 to ANO-1 through Stairwells 2001 and 1, respectively, and terminates in ANO-1 Access Area 20. There are two routes to connect each end of the crosstie to the respective system (ANO-1 HPI, ANO-2 charging pumps).

During the onsite audit, the staff walked down the proposed crosstie and hose routes. The staff noted that although the licensee has primary and alternate connections to the ANO-1 HPI system, the crosstie acts as a single flow path. This consideration is evaluated in section 3.14.1 of this safety evaluation.

The NRC staff concludes that: (1) based on the location and design of the FLEX connections, as described in Entergy's FIP, and (2) if aligned and utilized according to Entergy's control strategy as described in the FIP, at least one FLEX connection should be available to support core cooling and inventory control at ANO-1 during an ELAP, consistent with NEI 12-06, Section 3.2.2 and Table D-1.

<u>ANO-2</u>

As described in the licensee's FIP, for Phase 2 core cooling the licensee provides water to the SGs from the QCST or UHS via a portable FLEX SG makeup pump discharging to the EFW system. The primary tie-in connection is located on the discharge line of the motor-driven EFW pump. The alternate tie-in connection is located on the discharge line of the TDEFW pump.

Both connections are located in the seismic category 1 portion of the ANO-2 Auxiliary Building and are protected from all applicable external hazards.

The QCST is shared between both units as a suction source for FLEX SG pumps. The connections to the QCST are discussed above for ANO-1.

Gravity draining the ANO-1 BWST into the QCST allows delaying actions of staging a portable pump to refill the QCST. The connections to the BWST are discussed above for ANO-1.

As described in the licensee's FIP, the ANO-2 inventory control strategy uses the ANO-2 charging pumps taking suction from the BAMTs and RWT and discharging through the existing charging system flow path. However, the ANO-2 charging pumps are also used to support ANO-1 inventory control. As a result, the licensee has installed additional discharge and suction connections on the ANO-2 charging system. The connections are discussed above for ANO-1.

For low power modes (i.e., Modes 5 or 6) the licensee installed primary and alternate connection on the "A" and "B" HPSI pump discharge lines respectively. Both connections are in the seismic category 1 portion of the ANO-2 Auxiliary Building and are protected from all applicable external hazards. Although the primary function of the connections is to provide a flow path for RCS injection in lower modes, the connections are compatible with NSRC equipment and may be used to provide RCS injection in Modes 1 through 4 after NSRC equipment is delivered to the site following an ELAP.

The NRC staff concludes that: (1) based on the location and design of the FLEX connections, as described in Entergy's FIP, and (2) if aligned and utilized according to Entergy's control strategy, as described in the FIP, at least one FLEX connection should be available to support core cooling and inventory control in ANO-2 during an ELAP, consistent with NEI 12-06, Section 3.2.2 and Table D-1.

3.2.2.1.3 Plant Instrumentation

Per the FIP, the following instrumentation credited for FLEX will be available following the stripping of non-essential loads:

- RCS hot leg temperature
- core exit thermocouple temperature
- SG pressure
- once-through Steam Generator Level (ANO-1)
- SG wide-range water level (ANO-2)
- QCST level
- pressurizer level
- RCS wide-range pressure (ANO-1)
- pressurizer pressure (ANO-2)
- reactor vessel level monitoring system indication
- low-level neutron flux monitoring (source range instruments)

The instrumentation available to support the licensee's strategies for core cooling and RCS inventory during the ELAP event is generally consistent with and in some cases exceeds the recommendations specified in the endorsed guidance of NEI 12-06. However, the available indicators of RCS temperature (i.e., hot leg and core exit thermocouples) would tend reflect hot side temperatures only. In this regard, the NRC staff notes that, considering the licensee's strategy to maintain natural circulation in the RCS for both units, via the saturation relationship of water, available SG pressure indication should allow deduction of the RCS cold leg temperature. Based upon the information provided by the licensee, the NRC staff understands that indication for the above instruments would be available and accessible continuously throughout the ELAP event.

As recommended by Section 5.3.3 of NEI 12-06, the licensee has developed procedural guidance with instructions and information to obtain readings locally (e.g., at containment penetrations and instrument racks) for the majority of the plant instrumentation listed above. These instructions are contained in 1FSG-007, "Loss of DC Power" and 2FSG-007, same title, for ANO-1 and ANO-2, respectively. Exceptions to this statement include instrumentation for the reactor vessel level monitoring system and low-level neutron flux, which is not included as required instrumentation in NEI 12-06.

3.2.2.2 Thermal-Hydraulic Analyses

The two operating units at ANO have different designs and would respond differently to an ELAP event. In particular, ANO-1 is a B&W-designed reactor with once-through SGs and the lowered RCS loop configuration, whereas ANO-2 is a CE-designed reactor with inverted U-tube SGs. According to intrinsic design differences, the licensee has adopted different strategies to mitigate the ELAP event for each unit. Furthermore, based in part on the differences in design and mitigating strategies, the licensee has applied different methods for performing the thermal-hydraulic analysis to demonstrate the adequacy of its strategies for reactor core cooling and RCS inventory. As a result, the NRC staff's evaluation will treat the thermal-hydraulic analysis for each unit separately.

ANO-1

In the analysis of the ELAP event performed by the PWR Owners Group (PWROG) in WCAP-17601-P, "Reactor Coolant System Response to the Extended Loss of AC Power Event for Westinghouse, Combustion Engineering and Babcock & Wilcox NSSS Designs," the RELAP5/MOD2-B&W code was chosen for the evaluation of B&W-designed plants such as ANO-1. The RELAP5/MOD2-B&W code, as described in AREVA topical report BAW-10164-PA, "RELAP5/MOD2-B&W - An Advanced Computer Program for Light Water Reactor LOCA and Non-LOCA Transient Analysis," Revision 6 (proprietary), is a general purpose thermal-hydraulic code that is capable of modeling accident scenarios including large- and small-break loss-of-coolant accidents (LOCAs), as well as a range of operational transients. The RELAP5/MOD2-B&W code is an adaption of the two-fluid, non-equilibrium RELAP5/MOD2 code developed at the Idaho National Engineering Laboratory. Although RELAP5/MOD2-B&W has been approved for performing certain design-basis transient and accident analyses, the NRC staff had not previously examined its technical adequacy for performing best-estimate simulations of the ELAP event. Therefore, in support of mitigating strategy reviews to assess compliance with Order EA-12-049, the NRC staff evaluated licensees' thermal-hydraulic analyses, including a limited review of the significant assumptions and modeling capabilities of the RELAP5/MOD2-B&W code and other thermal-hydraulic codes used for these analyses.

Based upon this review, the NRC staff questioned whether RELAP5/MOD2-B&W and other codes used to analyze ELAP scenarios for PWRs would provide reliable coping time predictions in the reflux or boiler-condenser cooling phase of the event because of challenges associated with modeling complex phenomena that could occur in this phase, including boric acid dilution in the intermediate leg loop seals, two-phase leakage through RCP seals, and primary-to-secondary heat transfer with two-phase flow in the RCS. In particular, for B&W PWRs with once-through SGs, the boiler-condenser cooling mode is said to exist when vapor boiled off from the reactor core flows up through the saturated, stratified hot legs, around the hot leg bends, and then down into the once-through SG tubes, where it is condensed by EFW sprayed onto the SG tubes. Unlike PWRs with inverted U-tube SGs that undergo reflux cooling (i.e., wherein the majority of condensation occurs on the uphill side of the SG tubes, with the resulting condensate flowing back downhill into the reactor vessel via the hot legs), for B&W reactors in the boiler-condenser cooling mode, the condensate continues to drain downward through the once-through SGs and into the intermediate legs.

Due to the B&W RCS design configuration, at the time natural circulation ceases in the RCS (i.e., hot leg bends are sufficiently voided), the once-through SG tubes remain full of water. The presence of this stagnant liquid precludes effective heat transfer via boiler-condenser cooling, since it prevents vapor from penetrating down into the SG tubes being sprayed by EFW flow. In this condition, degraded primary-to-secondary heat transfer conditions may occur, persisting until either: (1) sufficient RCS volume is restored to restart natural circulation, or (2) sufficient RCS volume is lost such that steam from the hot legs can enter the once-through SG tubes to permit adequate, continuous condensation heat transfer via boiler-condenser cooling. Owing to the relatively low RCS leakage rate considered during the analyzed ELAP event, if this situation occurs prior to the establishment of FLEX RCS makeup, a significant period of time may elapse, during which primary-to-secondary heat transfer may be significantly degraded, as illustrated in simulations conducted for B&W reactors in both WCAP-17601-P and WCAP-17792-P, "Emergency Procedure Development Strategies for the Extended Loss of AC Power Event for all Domestic Pressurized Water Reactor Designs" (proprietary). These simulations show the potential for RCS re-pressurization in excess of 2000 psia after RCS loop flow stagnates, with the RCS pressure in some cases remaining in this vicinity for many hours. Extensive re-pressurization of the RCS following a loss of natural circulation should be avoided for a number of reasons, including the potential to lift a safety or relief valve on the pressurizer and the potential for elevated RCS temperatures induced by the re-pressurization to result in RCP seal degradation and increased RCS leakage.

Furthermore, the NRC staff observed that the modeling capability of the RELAP5/MOD2-B&W code with respect to two-phase primary-to-secondary heat transfer for B&W reactors had not been sufficiently benchmarked to support best-estimate calculations for the ELAP event. As noted in BAW-10164-PA, limited benchmarking of the models for two-phase heat transfer across the SG was undertaken because the RCS pressure response during a LOCA tends to be dominated by the mass and energy loss from the break effluent, even down into the size range of the most limiting small break. However, considering the much lower RCS leakage rates associated with the analyzed ELAP event, heat transfer to the once-through SGs becomes the primary means of energy removal from the RCS. Furthermore, the analytical modeling techniques used in the calculations in WCAP-17601-P and WCAP-17792-P for B&W reactors were not adequately documented (e.g., modeling of SG tube wetting by auxiliary feedwater), and in some cases, the calculated results did not appear to match ostensible descriptions (e.g., the B&W simulations apparently did not use the 75°F per hour cooldown rate described in the Section 4.2.1 of WCAP-17601-P). As a result, the NRC staff could not credit the generic B&W coping time results from WCAP-17601-P and WCAP-17792-P beyond the point at which natural circulation ceases and RCS loop flow stagnates.

Likewise, the licensee did not credit boiler-condenser cooling to extend its credited coping time, but instead performed analysis intended to demonstrate that the ANO-1 strategy will be successful by taking actions to maintain natural circulation in all RCS loops and establish FLEX RCS makeup early in the event. In particular, for the B&W reactor design, prudent objectives for plant operators to prolong the duration of natural circulation flow in the RCS include:

- Maintaining adequate pressurizer level, which suppresses void formation in the RCS loop piping and the potential for an associated increase in flow resistance to interrupt natural circulation. Initiating RCS makeup early in the ELAP event prevents RCS leakage from draining the pressurizer. Delaying the RCS cooldown until RCS makeup is restored, and thereafter conducting a slow cooldown within the volumetric capacity of the FLEX RCS makeup source prevents thermally induced contraction of the RCS from draining the pressurizer.

- Maintaining adequate subcooling in the RCS loops, which similarly suppresses void formation in the RCS loops and the associated potential to interrupt natural circulation. Using the SGs to cool down the RCS with normal plant equipment unavailable would substantially degrade the RCS subcooling margin, potentially beneath minimum values considered desirable or necessary to support natural circulation. By delaying the RCS cooldown until critical steps within the FLEX strategy can be accomplished (e.g., restoration of pressurizer heaters, establishing FLEX RCS makeup), adequate subcooling margin to support natural circulation can be preserved during the RCS cooldown.

- Maximization of the elevation at which primary-to-secondary heat transfer occurs, since increasing the height of the heat sink relative to the heat source promotes natural circulation flow. In the B&W reactor design, upon demand, the EFW system sprays feedwater onto the once-through SG tubes at their upper elevation near the upper tubesheet. This elevation is significantly higher than the water level maintained by the main feedwater system during normal operation. Per the ANO-1 FLEX strategy, the FLEX pumps used for SG makeup would discharge into EFW system piping and hence accrue a similar benefit. In the event that adequate subcooling margin were lost, the licensee's procedures would also direct raising the SG water level, which has a similar objective.

Based upon the result of a generic calculation from WCAP-17601-P, in the absence of FLEX RCS makeup, the licensee concluded that 8.3 hours would be available prior to the pressurizer being drained by ongoing RCS leakage under ELAP conditions. Whereas, the licensee's mitigating strategy directs that FLEX RCS makeup be established by 6 hours into the ELAP event, along with restoration of the pressurizer heaters. Conceptually, the NRC staff considered the B&W analysis from WCAP-17601-P to be appropriate for determining the time to drain the pressurizer. However, the generic analysis contains some variables that may not reflect appropriate and conservative plant-specific parameter values (e.g., for RCP seal leakage). In order to evaluate a specific ANO-1 case, the NRC staff performed a confirmatory evaluation of this scenario using the TRACE thermal-hydraulic code. The results of the NRC staff's simulations indicated that the pressurizer could drain by approximately 5.3 hours into the event, significantly earlier than predicted in WCAP-17601-P. However, throughout the intervening period between the draining of the pressurizer and the initiation of FLEX RCS makeup at 6 hours, the NRC staff's simulations predicted that natural circulation would continue in all RCS loops, without appreciable voiding in the hot leg bends and only slight voiding in the reactor vessel upper head. The staff further noted that neither the thermal-hydraulic analysis performed by the licensee nor the NRC staff explicitly credited isolation of the controlled bleed-off (CBO) flow from the Flowserve N-Seal RCP seals installed at ANO-1. As discussed further in Section 3.2.3.3 of this evaluation, for at least the 6-7 hour duration over which the N-Seal design was tested, CBO isolation would be expected to decrease leakage well below the flow rate considered in the calculations. Thus, despite differences in the analytical results, the NRC staff's audit review supports the licensee's strategy for initiating RCS makeup for ANO-1 by 6 hours into the ELAP event.

The licensee's thermal-hydraulic analysis further concluded that providing FLEX RCS makeup at a rate of 35 gpm (note that the actual capacity of the ANO-2 charging pump is 44 gpm) would maintain adequate pressurizer level at an RCS cooldown rate of 20°F per hour. The NRC staff's confirmatory simulations using TRACE support this conclusion.

Therefore, based on the evaluation above, the NRC staff concludes that the licensee's analytical approach for ANO-1 should appropriately determine the sequence of events for reactor core cooling, including time-sensitive operator actions, and the required equipment to mitigate the analyzed ELAP event, including pump sizing and cooling water capacity.

ANO-2

In the analysis of the ELAP event performed by the PWROG in WCAP-17601-P, the Combustion Engineering Nuclear Transient (CENTS) code was chosen for the evaluation of CE-designed plants, such as ANO-2. Although the documented strategy for ANO-2 in the licensee's FIP relies upon a plant-specific analysis in lieu of immediately referencing the results calculated in WCAP-17601-P, the evaluation models and analytical methods used to support the ANO-2 analysis derive directly from those in WCAP-17601-P. The licensee's plant-specific analysis incorporates some changes intended to better capture ANO-2's planned mitigating strategy, such as revising the RCS cooldown endpoint to be a hot leg temperature of 350°F as opposed to an SG pressure of 120 psia. However, significant similarity remains between the ANO-2 plant-specific analysis and the WCAP-17601-P evaluation model for CE reactors; in particular, the licensee's plant-specific analysis was also performed with the CENTS code.

The CENTS code, as described in Westinghouse topical report WCAP-15996, "A Technical Description Manual for the CENTS Code" (ADAMS Accession No. ML053320174), is a general-purpose thermal-hydraulic computer code that the NRC staff has previously reviewed and approved for calculating the behavior of the RCS and secondary systems of PWRs designed by

CE and Westinghouse during non-LOCA transients. Although CENTS has been approved for performing certain design-basis non-LOCA transient analyses, the NRC staff had not previously examined its technical adequacy for performing best-estimate simulations of the ELAP event. Therefore, in support of mitigating strategy reviews to assess compliance with Order EA-12-049, the NRC staff evaluated licensees' thermal-hydraulic analyses, including a limited review of the significant assumptions and modeling capabilities of CENTS and other thermal-hydraulic codes used for these analyses.

Based upon this review, the NRC staff questioned whether CENTS and other codes used to analyze ELAP scenarios for PWRs would provide reliable coping time predictions in the reflux or boiler-condenser cooling phase of the event because of challenges associated with modeling complex phenomena that could occur in this phase, including boric acid dilution in the intermediate leg loop seals, two-phase leakage through RCP seals, and primary-to-secondary heat transfer with two-phase flow in the RCS. In particular, for PWRs with inverted U-tube SGs, the reflux cooling mode is said to exist when vapor boiled off from the reactor core flows out the saturated, stratified hot legs and condenses on SG tubes, with the majority of the condensate forming on the uphill side of the tubes and subsequently draining back into the reactor vessel via the hot legs in countercurrent fashion. A specific concern arose with the use of CENTS for ELAP analysis because NRC staff reviews for previous non-LOCA applications had imposed a condition limiting the code's heat transfer modeling in natural circulation to the single-phase liquid flow regime. This condition was imposed due to the lack of benchmarking for the two-phase flow models that would become active in LOCA scenarios. Although the RCS leakage rates in an analyzed ELAP event are significantly lower than what is typically evaluated for limiting small-break LOCA scenarios, nevertheless, over the extended duration of an ELAP event, two-phase natural circulation flow may eventually be reached in the RCS, dependent upon the timing of reestablishing RCS makeup.

In the PWROG's Core Cooling Position Paper, which was provided in a letter dated January 30, 2013 [Reference 52], the PWROG recommended that the reflux or boiler-condenser cooling phase be avoided under ELAP conditions because of uncertainties in operators' ability to control natural circulation following reflux cooling and the impact of dilute pockets of water on criticality. Due to the challenge of resolving the above issues within the compliance schedule specified in Order EA-12-049, the NRC staff agreed that PWR licensees should provide makeup to the RCS prior to entering the reflux or boiler-condenser cooling phase of an ELAP, such that reliance on thermal-hydraulic code predictions during this phase of the event would not be necessary. However, the PWROG's Core Cooling Position Paper did not fully address the staff's issues with CENTS, and in particular, lacked a quantitative definition for the threshold of entry into reflux cooling.

To address the NRC staff's remaining concerns associated with the use of CENTS to simulate the two-phase natural circulation flow that may occur during an ELAP for CE-designed PWRs, the PWROG submitted a white paper in response to an NRC request for additional information (RAI), originally dated September 25, 2013 [Reference 53]. A revised version, dated November 26, 2013, was also submitted [Reference 54]. The white paper focused on comparing several small-break LOCA simulations using the CENTS code to analogous calculations performed with the CEFLASH-4AS code, which was previously approved for analysis of design-basis small-break LOCAs under the conservative Appendix K paradigm for CE-designed reactors. The analyses in the CENTS white paper generally showed that CENTS' predictions were similar or conservative relative to CEFLASH-4AS for key figures of merit for conditions where natural circulation is occurring in the RCS, including predictions of RCS loop flow rates and the timing of the transition to reflux cooling. The NRC staff's review of the analyses in the white paper included performing confirmatory simulations with the TRACE code. In particular, the staff's TRACE simulations generally showed reasonable agreement with the predictions of CENTS regarding the fraction of the initial RCS mass remaining at the transition to reflux cooling. Therefore, as documented in a letter dated October 7, 2013 [Reference 55], the NRC staff endorsed the approach in the PWROG's white paper as an appropriate means for applying the CENTS code to beyond-design-basis ELAP analysis, with the limitation that reliance upon CENTS is limited to the phase of the event before reflux cooling begins.

Quantitatively, as proposed in the PWROG's white paper, the threshold for entry into reflux cooling is defined as the point at which the 1-hour centered time-average of the flow quality passing over the SG tubes' U-bend exceeds one-tenth (0.1) in any RCS loop. Considering this criterion relative to the RCS loop flow predictions of both the CENTS and TRACE codes, the NRC staff agreed that it provides a reasonable definition for the threshold of entering reflux cooling for the purpose of analyzing the beyond-design-basis ELAP event. Both the NRC staff and industry analysts acknowledged the adoption of this definition as a practical expedient for analyzing a slow-moving ELAP event. Inasmuch as the transition of flow in the RCS loops from natural circulation to reflux cooling is a gradual process that would occur over multiple hours for the analyzed ELAP event, lacking a quantitatively defined threshold, objective and consistent treatment would not be possible. As discussed further in Section 3.2.3.4 of this evaluation, a second metric for ensuring adequate coping time is associated with maintaining sufficient natural circulation flow in the RCS to support adequate mixing of boric acid.

Applying the one-tenth flow quality criterion to the analyses completed in WCAP-17601-P, the November 20, 2013, revision of the PWROG's white paper on CENTS determined ELAP coping times prior to entering the reflux cooling mode for each CE reactor included in WCAP-17601-P. For the generic WCAP-17601-P analysis case corresponding to ANO-2, a coping time of 30.3 hours was identified prior to entering reflux. The generic analysis further determined that two-phase natural circulation flow would begin at 21.9 hours into the ELAP event. However, as noted above, the licensee performed additional plant-specific analysis to more accurately model ANO-2's planned mitigating strategy, including revision of the RCS cooldown endpoint to reflect a hot leg temperature of 350°F as opposed to an SG pressure of 120 psia. Based upon this plant-specific analysis, the licensee concluded that 18.5 hours would be available prior to reaching two-phase natural circulation flow, and further stated that RCS makeup would be initiated per the ANO-2 mitigating strategy at 17.5 hours. (Note that, although the discussion of the ANO-2 analysis in the licensee's FIP focuses largely on maintaining single-phase natural circulation, the NRC staff's review of the CENTS code determined that entry into two-phase natural circulation could be permitted during the beyond-design-basis ELAP event, as long as adequate RCS makeup is initiated prior to entering the reflux cooling mode.)

In reviewing the above analyses, the NRC staff observed that neither the generic WCAP-17601-P analysis nor the ANO-2 plant-specific analysis reflected the existing ANO-2 procedural guidance in FDS-002 to isolate or vent the SITs prior to depressurizing the RCS below 230 psia. The NRC staff expected that consideration of SIT isolation at an RCS pressure of 230 psia would significantly curtail the liquid mass passively injected by the SITs, thereby reducing the available coping time prior to entering reflux cooling. The NRC staff further observed that both the simulations in WCAP-17601-P and the licensee's plant-specific analysis assumed an RCP seal leakage rate significantly in excess of that subsequently endorsed by the NRC staff for the Flowserve N-9000 seals installed at ANO-2, which would tend to increase the coping time available to ANO-2 prior to entering reflux cooling. The material provided by the licensee during the audit did not resolve the net effect of these two countervailing impacts. Therefore, during the audit, the NRC staff performed confirmatory simulations for ANO-2 with the TRACE code to investigate the net impact on coping time. The confirmatory simulations were based on an input deck generated from a mixture of plant-specific sources and generic information applicable to CE reactors. The results of the staff's simulations and follow-up scaling calculations indicated that, with the SITs isolated at an RCS pressure of 230 psia and considering the leakage expected for ANO-2 with N-9000 RCP seals, the time to enter the reflux cooling mode may be reduced from approximately 30 hours to approximately 20 hours. Inasmuch as the licensee's mitigating strategy would initiate FLEX RCS makeup to ANO-2 by 17.5 hours into the event, the results of the NRC staff's calculation confirmed that the timing of this action should be sufficient to avoid entry into the reflux cooling mode for the analyzed ELAP event.

Therefore, based on the evaluation above, the NRC staff concludes that the licensee's analytical approach for ANO-2 should appropriately determine the sequence of events for reactor core cooling, including time-sensitive operator actions, and the required equipment to mitigate the analyzed ELAP event, including pump sizing and cooling water capacity.

3.2.2.3 Reactor Coolant Pump (RCP) Seals

Leakage from RCP seals is among the most significant factors in determining the duration that a PWR can cope with an ELAP event prior to initiating RCS makeup. An ELAP event would interrupt cooling to the RCP seals, potentially resulting in increased leakage and the failure of elastomeric O-rings and other components, which could further increase the leakage rate. As discussed above, as long as adequate inventory is maintained in the RCS, natural circulation can effectively transfer residual heat from the reactor core to the SGs and limit local variations in boric acid concentration. Along with cooldown-induced contraction of the RCS inventory, cumulative leakage from RCP seals governs the duration over which natural circulation can be maintained in the RCS. Furthermore, the seal leakage rate at the depressurized condition can be a controlling factor in determining the flow capacity requirement for FLEX pumps to offset ongoing RCS leakage and recover adequate system inventory.

As noted above, Flowserve N-9000 seals are installed on the RCPs at both ANO units. The N-9000 seal is a product in Flowserve's N-seal line of hydrodynamic seals that was developed by Flowserve in the 1980s. One of the design objectives for the N-seal was to provide low-leakage performance under loss-of-seal-cooling conditions during events such as a station blackout. On August 5, 2015, in support of licensees using Flowserve RCP seals, the PWROG submitted to the NRC staff a white paper describing the response of the Flowserve N-Seal RCP Seal Package to a postulated ELAP [Reference 56].

The N-Seal white paper contains information regarding the expected leakage rates over the course of an ELAP event for each PWR at which Flowserve N-Seals are currently installed. Leakage rates as a function of time were assigned based upon a comparison of plant-specific thermal profiles relative to the thermal margin demonstrated in a test of N-Seal performance under simulated station blackout conditions that was conducted by Flowserve in 1988. According to measured data from this test, following CBO isolation at 0.5 hours, over the course of the succeeding period of 6 to 7 hours during which CBO isolation was maintained, the average seal leakage rate was slightly less than 0.05 gpm. Although the NRC staff agreed that it is appropriate to allow credit for demonstrated performance, during its review of the Flowserve white paper, the staff questioned the extrapolation of evidence from a limited test period of 6 to 7 hours to the indefinite coping period associated with the ELAP event. While the NRC staff ultimately agreed with the credit Flowserve's N-Seal white paper allowed for CBO isolation in determining the short-term thermal exposure profile of seal elastomers, the staff did not endorse direct application of the average leakage rate measured with the CBO isolated in the 1988 test for an indefinite period in the absence of demonstrated long-term seal performance. By letter dated November 12, 2015 [Reference 57], the staff endorsed the leakage rates described in the white paper for the beyond-design-basis ELAP event, subject to certain limitations and conditions.

Due to differences in plant design and mitigating strategies, the specific RCP seal leakage rate for each unit and its compliance with the conditions in the NRC staff's endorsement letter are discussed separately below.

ANO-1

As a consequence of delaying the ANO-1 RCS cooldown to 8 hours, plant-specific calculations performed by Flowserve in its white paper determined that the ANO-1 FLEX scenario exceeds the design margin demonstrated in the 1988 station blackout test early in the event. In particular, according to the values listed in Table 3a of the Flowserve white paper, the analyzed seal leakage rate for ANO-1 is assumed to increase from 1.5 gpm to 3.2 gpm per pump at approximately 7.5 hours into the ELAP event. Considering each unit has 4 RCPs and accounting for another 1 gpm of additional RCS leakage would result in an initial total RCS leakage rate of 7 gpm, which would increase to approximately 13.8 gpm after 7.5 hours.

During the audit, the NRC staff considered the status of the licensee's conformance with the Flowserve N-Seal white paper and the limitations and conditions in the NRC staff's endorsement letter. The licensee's FIP states that the plant design and planned mitigation strategy of ANO-1 are consistent with the calculation performed by Flowserve, as summarized in Table 1 of the white paper, and that the peak cold-leg temperature is based on the lowest main steam safety valve lift pressure. The NRC staff audited the applicable information from the Flowserve white paper against the ANO-1 plant design and the mitigating strategy and determined that they were generally consistent. This includes the peak cold-leg temperature prior to the RCS cooldown assumed in Flowserve's analysis, which is equivalent to the saturation temperature corresponding to the lowest setpoint for SG safety valve lift pressure in the ANO-1 UFSAR.

However, the NRC staff did not agree that the analysis for ANO-1 satisfies one aspect of the white paper: the position that leakage flow should be assumed to have a density of 62 pounds mass per cubic foot (lbm/ft^3). The licensee did not follow this position, which resulted in a lower mass leakage rate than expected. The staff further did not agree with the licensee position that neglecting the effect of depressurization (e.g., decreasing the RCP seal leakage rates) in its analysis would bound the effect of water density because, based upon test results, the

Flowserve white paper prescribes that leakage be modeled as constant in time. Therefore, the NRC staff performed confirmatory simulations using the TRACE code (as described above in Section 3.2.3.2), assuming constant RCP leakage rate at the fixed density specified in the Flowserve white paper. Based upon the results of these simulations, the NRC staff considered the intent of the white paper endorsement letter's condition on the leaking fluid's density to be satisfied inasmuch as: (1) natural circulation was maintained in all RCS loops throughout the analyzed ELAP event, even during the intervening period between the draining of the pressurizer and the time at which the licensee's mitigating strategy would establish FLEX RCS makeup, and (2) no credit for CBO isolation was taken in determining the RCP seal leakage rates.

ANO-2

By virtue of ANO-2 completing its RCS cooldown to 350°F by 4 hours into the ELAP event, the plant-specific calculations performed by Flowserve in its white paper determined that the ANO-2 FLEX scenario does not exceed the design margin demonstrated in the 1988 station blackout test, such that increased leakage during the ELAP event due to elastomer failure or other causes is not expected. Under this condition, according to the values listed in Table 3a of the Flowserve white paper, assuming a leakage rate of 1.5 gpm per RCP would be appropriate for ANO-2. Considering each unit has 4 RCPs and accounting for another 1 gpm of additional RCS leakage would result in a total RCS leakage of approximately 7 gpm throughout the analyzed ELAP event. Unlike ANO-1, ANO-2 does not have the capability to remotely isolate CBO flow during an ELAP event.

The NRC staff audited the licensee's conformance with the Flowserve white paper, including the limitations and conditions of the associated endorsement letter. The NRC staff's audit of the applicable information from the Flowserve white paper against the ANO-2 plant design and the mitigating strategy in the licensee's FIP verified general consistency. One discrepancy noted by the staff was that the white paper input for ANO-2 does not appear to reflect the minimum main steam safety valve lift setpoint listed in Table 5.5-11 of the UFSAR. However, the NRC staff calculated the impact of this discrepancy according to the method developed in Flowserve's white paper and concluded that it should not affect the RCP seal leakage rates for the analyzed ELAP event.

The NRC staff compared the assumed leakage rates in the licensee's analysis for ANO-2 to the endorsed values from the Flowserve white paper. The NRC staff observed that the licensee's analysis for determining the threshold for entry into reflux cooling did not credit the installation of the Flowserve N-Seals. Instead, the leakage rates for ANO-2 were based on the assumption that RCP seal leakage would occur at an initial rate of 15 gpm (i.e., a rate just below that which would trigger closure of excess flow check valves in the CBO lines) at the RCS temperature and pressure conditions applicable when sub-cooling decreases below 50°F. Modeling RCP seal leakage in this manner was intended to conservatively envelop the potential for seal instability at low inlet sub-cooling conditions to result in "pop-open" failure. Thermal-hydraulic analysis indicates that the RCS sub-cooling margin decreases below 50°F at approximately 3 hours into the event, which is assumed to trigger seal leakage at 15 gpm per RCP. The ANO-2 analysis predicts the peak leakage rate of 15 gpm to initiate during the RCS cooldown. As the RCS cooldown and depressurization continue, the leakage rate is assumed to decrease in accordance with the choked flow correlation used in the licensee's CENTS analysis.

Considering the leakage rates from the licensee's CENTS analysis, as well as confirmatory simulations performed by the NRC staff with the TRACE code (see Section 3.2.3.2 above), the NRC staff concluded that the analytically assumed leakage rates are conservative relative to the expected leakage rate for Flowserve N-9000 seals during the analyzed ELAP event.

Combined Long-Term RCP Seal Leakage Rates

By 17.5 hours into the ELAP event, the licensee's FIP states that RCS makeup would be initiated for ANO-2, and one installed ANO-2 charging pump would be responsible for providing RCS makeup to both units in alternating fashion. As noted above, the analyzed ELAP event considers a total net leakage rate for both units of approximately 20.8 gpm, which is well below the 44-gpm capacity of the installed charging pump. Considering solely the impact of RCS leakage, the available flow capacity allows sufficient time for operators to realign the injection flow path between units as necessary to implement the intended strategy. The NRC staff further observed that the combined leakage rate is similarly well within the expected capacity of the NSRC-supplied equipment for water purification and batching additional borated coolant.

As noted above in Section 3.2.1.2.1 of this evaluation, in addition to compensating for RCS leakage, additional makeup flow would be required to offset RCS thermal contraction during the ANO-1 cooldown. As discussed above in Section 3.2.3.2.1, confirmatory simulations performed by the NRC staff using the TRACE code support the licensee's conclusion that a flow of 35 gpm would be sufficient to offset leakage and thermal contraction for ANO-1 during the ANO-1 cooldown. This flow is within the capacity of the ANO-2 charging pump prior to initiating makeup to ANO-2 at 17.5 hours. The licensee's FIP further concluded that the ANO-1 RCS cooldown could be completed by 16.5 hours into the event, such that a flow rate of 20 gpm could be provided to ANO-2 at 17.5 hours into the event.

However, based on its review of the licensee's strategy, the NRC staff estimated that completion of the ANO-1 cooldown would not occur until approximately 18-20 hours into the ELAP. Therefore, from approximately 17.5 to perhaps 20 hours, injection from a single ANO-2 charging pump would need to provide sufficient flow to maintain both units in natural circulation, offsetting RCS leakage for both units and thermal contraction from the ANO-1 cooldown. Assuming the reduced RCS leakage rate applicable to Flowserve N-9000 seals, an RCS makeup flow rate of approximately 7 gpm would be necessary for ANO-2. However, even at this reduced leakage rate, when allowing for the time needed for flowpath realignment to support alternating the FLEX RCS makeup flow between units, it was not clear to the NRC staff whether the available RCS makeup flow would be sufficient to maintain the pressurizer level within its procedural control band for ANO-1 and simultaneously provide the makeup necessary for ANO-2. By letter dated September 1, 2016 [Reference 60], the licensee responded to this concern by providing an additional calculation that reflected the impact of terminating RCS makeup flow to ANO-1 for two hours starting at 17 hours into the ELAP event. The results of the calculation indicated that the pressurizer level at ANO-1 would be maintained within its control band during this time (and prior thereto). Because the leakage rates assumed in the licensee's calculation for ANO-1 were not consistent with the values endorsed in the Flowserve N-Seal white paper, the NRC staff performed confirmatory calculations to estimate the impact of the slightly higher leakage rates associated with the white paper. Ultimately, the NRC staff's confirmatory calculations supported the licensee's conclusion that the ANO-1 pressurizer level could be maintained within its control band despite a flow interruption of at least 2 hours to support providing makeup to ANO-2. The NRC staff further concluded that, subsequent to the ANO-1 cooldown, alternating FLEX RCS makeup flow between ANO-1 and ANO-2 would be sufficient to maintain natural circulation flow in the RCS loops of both units.

Therefore, based upon the discussion above, the NRC staff concludes that the RCP seal leakage rates assumed in the licensee's thermal-hydraulic analysis for ANO-1 and ANO-2 may be applied to the beyond-design-basis ELAP event.

3.2.2.4 Shutdown Margin Analyses

In an analyzed ELAP event, the loss of electrical power to control rod drive mechanisms is assumed to result in an immediate reactor trip with the full insertion of all control rods into the core. The insertion of the control rods provides sufficient negative reactivity to achieve subcriticality at post-trip conditions. However, as the ELAP event progresses, the shutdown margin for PWRs is typically affected by several primary factors:

- the cooldown of the RCS and fuel rods adds positive reactivity
- the concentration of xenon-135, which (according to the core operating history assumed in NEI 12-06) would
  - initially increase above its equilibrium value following reactor trip, thereby adding negative reactivity
  - peak at roughly 12 hours post-trip and subsequently decay away gradually, thereby adding positive reactivity
- the passive injection of borated makeup from nitrogen-pressurized accumulators due to the depressurization of the RCS, which adds negative reactivity

At some point following the cooldown of the RCS, PWR licensees' mitigating strategies generally require active injection of borated coolant via FLEX equipment. In many cases, boration would become necessary to offset the gradual positive reactivity addition associated with the decay of xenon-135; but, in any event, borated makeup would eventually be required to offset ongoing RCS leakage. The necessary timing and volume of borated makeup depend on the particular magnitudes of the above factors for individual reactors.

The specific values for these and other factors that could influence the core reactivity balance that are assumed in the licensee's current calculations could be affected by future changes to the core design. However, NEI 12-06, Section 11.8 states that "[e]xisting plant configuration control procedures will be modified to ensure that changes to the plant design ... will not adversely impact the approved FLEX strategies." Inasmuch as changes to the core design are changes to the plant design, the staff expects that any core design changes, such as those considered in a core reload analysis, will be evaluated to determine that they do not adversely impact the approved FLEX strategies, especially the analyses which demonstrate that re-criticality will not occur during a FLEX RCS cooldown.

During the audit, as described below, the NRC staff reviewed the licensee's shutdown margin calculation for each unit.

ANO-1

The licensee concluded that adequate shutdown margin could be achieved without crediting the boron injected via the core flood tanks. Based upon the licensee's planned mitigating strategy and procedural guidance for core flood tank isolation, the NRC staff considers the lack of credit appropriate. The licensee's FIP further states that calculations documented in WCAP-17601-P are the basis for concluding that ANO-1 would have adequate shutdown margin during an ELAP event. The NRC staff noted that the inputs and assumptions in WCAP-17601-P affecting core reactivity (i.e., xenon worth, moderator temperature coefficient, rod worth, boron worth, and Doppler coefficient) have not been demonstrated as bounding for ANO-1 or any other specific plants. Furthermore, the inputs and assumptions relevant to determining core reactivity in the B&W analysis cases were not identified in WCAP-17601-P or the material available during the NRC staff's audit of ANO-1. As a result, based on the FIP reference to shutdown margin acceptability, the NRC staff was not able to verify documented assumed analytical values to compare against plant-specific values for the current operating cycle as well as future operating cycles.

In addition, the NRC staff noted that neither the assumed leakage rates nor the cooldown profile in WCAP-17601-P are representative or bounding with respect to determining the limiting shutdown margin for the analyzed ELAP event scenario for ANO-1. In particular, the FIP-cited analysis contained in Section 5.3.3.1.1.1 of WCAP-17601-P does not involve a deliberate RCS cooldown, and furthermore, owing to degraded primary-to-secondary heat transfer, actually undergoes a significant re-pressurization and heatup of the RCS that persists for an extended period. Furthermore, the cited analysis does not include a zero-leakage assumption for the RCP seals. A zero-leakage assumption is typically conservative with respect to a shutdown margin calculation, since assuming no leakage: (1) maximizes the mass of boron required to be injected into the RCS, and (2) maximizes the time required to vent the RCS, if necessary, to permit injection of the required mass of boron. As a result, the NRC staff sought further information to evaluate the ELAP event shutdown margin at ANO-1.

In response to the concerns identified by the NRC staff above, the licensee performed a revised shutdown margin calculation for ANO-1. This calculation (CALC-13-E-0005-55, "Unit 1 FLEX Reactivity Calculation," Revision 0) was reviewed during the audit process. A summary of this calculation was provided in the licensee's letter dated September 1, 2016 [Reference 60]. The calculation computed that approximately 7300 gallons of borated coolant from the BAMTs would be required to ensure adequate shutdown margin for ANO-1. The calculation further determined that injection of this volume of coolant could be completed within an injection time of approximately 2.8 hours. Because the licensee's revised shutdown margin analysis considered a no-leakage case, the injection time was assumed to begin concurrent with the RCS cooldown at 8 hours into the event (i.e., RCS makeup would refill RCS volume created by thermally induced contraction), and to be completed within 11 hours of event initiation. Based upon its review, the NRC staff identified two main issues regarding the licensee's calculation that were not sufficiently addressed.

- First, the calculation was not consistent with procedural direction in FDS-001, "Unit 1 Extended Loss of AC Power," Revision 1, for controlling pressurizer water level. In particular, injection per the schedule considered in the ANO-1 revised shutdown margin calculation would exceed the upper limit of pressurizer level control band in FDS-001. Enforcing analytical consistency with the level control band in FDS-001 would extend the time required for injecting the required volume of borated coolant. However, considering the assumed operating history specified in NEI 12-06, the NRC staff's confirmatory simulations indicated that correction of this issue should not extend the required injection period past the time at which the core xenon concentration would decrease below its equilibrium value during the operating cycle.

- Second, the calculation did not specifically address the potential for core flood tank injection. The boron concentration of the core flood tanks is less than half the concentration of the BAMTs. As a result, substitution of some fraction of the volume assumed to be injected by the BAMTs with coolant from the core flood tanks would likely extend the time required for RCS boration, potentially requiring RCS venting to ensure injection of a sufficient quantity of boron. The NRC staff performed confirmatory simulations to assess the significance of this issue. The staff's simulations indicated that the analyzed range of RCS leakage rates should result in the RCS pressure remaining sufficiently high to prevent core flood tank discharge prior to the injection of sufficient inventory from the BAMTs to provide the required shutdown margin. The NRC staff observed that the licensee's thermal-hydraulic calculations for ANO-1 further support this conclusion.

Based upon the licensee's revised shutdown margin calculation for ANO-1, as supplemented by the confirmatory review performed by the NRC staff, the NRC staff concluded that the licensee's strategy for ensuring adequate shutdown margin for ANO-1 should be effective for the analyzed ELAP event.

ANO-2

Based upon its thermal-hydraulic calculations, the licensee concluded that adequate shutdown margin could be achieved for ANO-2 at an RCS hot leg temperature of 350°F solely through the injection of borated coolant from the SITs. In particular, the licensee's calculation recommended that at least 20,000 lbm of SIT inventory be injected to ensure that a shutdown margin of 1 percent $\Delta\rho$ would be achieved. Whereas, for the conditions considered in the licensee's simulation, the calculation predicted that almost 70,000 lbm of SIT inventory would be injected within the first 12 hours of the ELAP event. As noted above, however, the ANO-2 thermal-hydraulic analysis did not model isolation of the SITs at an RCS pressure of 230 psia, as directed by ANO-2's current FLEX procedures. Furthermore, the analysis did not consider a scenario with no RCS leakage. As previously noted, a no-leakage case is typically limiting for shutdown margin calculations under ELAP conditions, particularly in scenarios where the source of boration is passive injection of SIT inventory. As a result, the NRC staff determined that the ANO-2 thermal-hydraulic calculation had taken excessive credit for SIT injection and, hence, overestimated the expected contribution of SIT injection to the required shutdown margin for the analyzed ELAP event.

During the audit, the NRC staff assessed the impact of these issues by performing additional confirmatory simulations with the TRACE code. The NRC staff's confirmatory simulations considered a scenario with no RCS leakage and isolation of the SITs at an RCS pressure of 230 psia, as specified in the ANO-2 FLEX procedures. The results of the confirmatory review for this scenario indicated that, while the licensee's calculations had overestimated injection from the SITs, isolating the SITs as RCS pressure reaches 230 psia should be sufficient to ensure the injection of at least 20,000 lbm of SIT inventory. The NRC staff's confirmatory calculations further indicated that the required boron should be injected prior to 12 hours, before even the peak negative reactivity contribution due to the post-trip buildup of xenon-135. As a result, the NRC staff concluded that the licensee's strategy for relying upon SIT injection to provide adequate shutdown margin for ANO-2 should be effective for the analyzed ELAP event.

RCS Venting

Toward the end of an operating cycle, when RCS boron concentration reaches its minimum value, some PWR licensees may need to vent the RCS to ensure that their FLEX strategies can inject a volume of borated coolant that is sufficient to satisfy shutdown margin requirements in cases where minimal RCS leakage occurs. At the time of the onsite audit, the licensee had not performed calculations for either unit to determine whether RCS venting would be necessary to support achieving adequate shutdown margin during an ELAP event. Understanding the need for RCS venting is necessary because completion of this action can extend the time required to complete RCS boration to the required concentration.

During the audit, the licensee qualitatively discussed its capability to conduct RCS venting in the case that letdown from the RCS is necessary. The licensee stated that both units have procedural guidance to prevent a water-solid RCS by providing an upper limit for pressurizer level. For both units, the licensee's FLEX procedures direct that, if the calculated boration volume exceeds the RCS free volume, that RCS vent paths should be opened to allow letdown. As necessary, ANO-1 operators could choose to open high-point vents on the RCS hot legs, the pressurizer, or the reactor vessel upper head; whereas, ANO-2 operators could choose to open high-point vents on the pressurizer or the reactor vessel upper head. Once the required volume of borated coolant has been injected, procedures direct that the RCS vent path be secured. Both units have procedural guidance to maintain a pressurizer bubble to prevent water solid conditions. However, should water solid conditions occur that lead to reactor pressure in excess of 2450 psia, ANO-1 operators would open the pressurizer power-operated relief valve to prevent lifting of a pressurizer safety valve. ANO-2 would open emergency core cooling system vent valves.

The NRC staff considered the licensee's procedures for avoiding water-solid conditions appropriate and further observed that, even if RCS free volume is not exceeded, refilling the RCS to near its normal operating point or beyond could result in significant re-pressurization of the RCS. For this reason, operation of RCS high-point vents could further be beneficial to control undesirable RCS pressure increases, particularly following the temperature reduction associated with an RCS cooldown.

Boron Mixing

The NRC staff's audit review of the licensee's shutdown margin calculation determined that credit was taken for uniform mixing of boric acid during the ELAP event. The NRC staff had previously requested that the industry provide additional information to justify that borated makeup would adequately mix with the RCS volume under natural circulation conditions potentially involving two-phase flow. In response, the PWROG submitted a proprietary position paper, dated August 15, 2013 [Reference 58], which provided test data regarding boric acid mixing under single-phase natural circulation conditions and outlined applicability conditions intended to ensure that boric acid addition and mixing during an ELAP would occur under conditions similar to those for which boric acid mixing data is available. By letter dated January 8, 2014 [Reference 59], the NRC staff endorsed the above position paper with three conditions:

- The required timing and quantity of borated makeup should consider conditions with no RCS leakage and with the highest applicable leakage rate.
- Adequate borated makeup should be provided either (1) prior to the RCS natural circulation flow decreasing below the flow rate corresponding to single-phase natural circulation, or (2) if provided later, then the negative reactivity from the injected boric acid should not be credited until one hour after the flow rate in the RCS has been restored and maintained above the flow rate corresponding to single-phase natural circulation.
- A delay period adequate to allow the injected boric acid solution to mix with the RCS inventory should be accounted for when determining the required timing for borated makeup. Provided that the flow in all loops is greater than or equal to the corresponding single-phase natural circulation flow rate, a mixing delay period of one hour is considered appropriate.

Because credit is taken for uniform boric acid mixing under natural circulation flow, the NRC staff determined that the boric acid mixing position paper, including the conditions in the endorsement letter, is applicable to both units at ANO. During the audit review, the licensee confirmed that ANO will comply with the August 15, 2013, position paper on boric acid mixing, including the conditions imposed in the staff's corresponding endorsement letter. However, as discussed above, the NRC staff's audit review observed that the boration calculations for both units (as described in the FIP) do not comply with the first condition from the staff's endorsement letter, since they did not consider conditions with no RCS leakage. As discussed above, this issue was resolved for ANO-1 through the performance of a revised shutdown margin calculation that considered a case with no RCS leakage. For ANO-2, the NRC staff was able to perform confirmatory analysis for the no-leakage case, and these confirmatory calculations demonstrated acceptable results. The second condition from the endorsement letter is satisfied by ANO-1, since the times of 6 hours for initiating RCS makeup should precede RCS loop flow decreasing below the single-phase natural circulation flow rate. For ANO-2, the second and third conditions are both satisfied, since SIT injection provides the boration required for shutdown margin prior to the flow in the RCS loops decreasing below the single-phase natural circulation flow rate, accounting for a one-hour delay period for mixing. Finally, the compliance of ANO-1 with the third criterion has been confirmed by the NRC staff's audit of the licensee's revised shutdown margin calculation, as discussed above.

Therefore, based on the evaluation above, the NRC staff concluded that the sequence of events in the proposed mitigating strategy should result in acceptable shutdown margin for the analyzed ELAP event.

3.2.2.5 FLEX Pumps and Water Supplies

As described in the licensee's FIP, the licensee credits three portable pumps in its core cooling FLEX strategies; two SG pumps (one for each unit) and an inventory transfer pump (shared between units). The FLEX SG makeup pumps are trailer-mounted, diesel engine driven pumps. The FLEX SG makeup pumps would provide a back-up SG injection method in the event that the TDEFW pump can no longer perform its function. The site has four FLEX SG pumps on site (two in each FLEX building), which satisfies the "N+1" provision. The FLEX inventory transfer pumps are also trailer-mounted, diesel-driven pumps. The inventory transfer pump is used to refill the QCST from the ECP for the duration of Phase 2. In addition, the inventory transfer pump's discharge line can be connected to the suction of the portable SFP makeup pump. The site has two inventory transfer pumps on site (one in each FLEX building), which satisfies the "N+1" provision.

In accordance with NEI 12-06, Section 11.2, the licensee performed CALC-13-E-0005-09, "ANO-1 FLEX Phase 2 Steam Generator Makeup Pump Sizing", Revision 1, CALC-13-E-0005-12, "ANO FLEX Phase 2 Inventory Transfer Pump Sizing", Revision 1, and CALC-14-E-0002-04, "ANO-2 FLEX Phase 2 Steam Generator Makeup Pump Sizing", Revision 0 to determine the hydraulic demand of the FLEX pumps in order to provide the performance requirements for proper selection and procurement of pumps. The licensee's calculation uses classical hydraulic analysis head loss and pressure gradient methods, and includes all pumps, valves, hoses, strainers, elevations, and line distances for the FLEX Strategy water supply using the most limiting set of conditions for SG and RCS injection. The calculation determined the minimum required flow rate, minimum discharge pressure, and minimum net positive suction head available (NPSHa) for a pump to be able to perform its required function. Comparison of the actual pump performance data and the sizing criteria of the calculation shows that FLEX SG and inventory transfer pumps should have the capacity needed to perform the required function for core cooling and inventory control.

The NRC staff concludes that: (1) based on the design of the FLEX pumps, as described in the licensee's calculations, and (2) if aligned and operated according to the strategy for core cooling and inventory control, as described in the FIP, the FLEX pumps should have sufficient capacity to support core cooling during an ELAP.

The NRC staff review concludes that the licensee has demonstrated that its FLEX portable pumps should be capable of supporting the licensee's FLEX strategies, if implementation is performed as described by the licensee.

3.2.2.6 Electrical Analyses

The ANO-1 and ANO-2 electrical FLEX strategies are similar for each unit. Furthermore, the electrical coping strategies are the same for all modes of operation.

In its FIP, the licensee stated that after determining that the off-site power is unlikely to be restored and emergency diesel generators cannot be restarted for a period greater than the Station Blackout (SBO) coping time, it is expected that the ANO operators would declare ELAP within 1 hour after the onset of an ELAP/loss of normal access to the UHS event.

The ANO-1 and ANO-2 safety-related batteries will be used to initially power required key instrumentation and other required dc components. Power supplied to the TDEFW pump, valve operators, and other necessary support systems is independent of ac power sources. Manual load shedding of non-essential dc bus loads would ensure battery life is extended to at least 9 hours. Per the licensee's proposed strategy, a PDG would be deployed by plant staff to repower battery chargers prior to battery depletion to ensure instrumentation remains available throughout the event.

The NRC staff reviewed the summaries of the licensee's dc system calculations: CALC-13-E-0005-14, "ANO-1 FLEX Battery Load Shed Calculation," Revision 0, and CALC-14-E-0002-07, "ANO-2 FLEX Battery Load Shed Calculation," Revision 0, and verified the capability of the vital batteries (D06 and D07 for ANO-1 and 2D11 and 2D12 for ANO-2) to supply dc power to the required loads and ac power through the vital Inverters to the critical instrumentation during Phase 1 of the ANO-1 and ANO-2 FLEX mitigation strategies plan. These calculations assumed that all manual load shedding would be completed within 3 hours of the start of the ELAP event per FIP Table 1, "ANO-1 Sequence of Events Timeline," FIP Table 2, "ANO-2 Sequence of Events Timeline," and procedures 1FSG-4, "Unit 1 Extended Loss of AC Power DC Load Management," Revision 1 and 2FSG-004, "Unit 2 Extended Loss of AC Power DC Management," Revision 1. The licensee's analyses identified the required Phase 1 loads and non-essential loads that would be shed to ensure battery operation for at least 9 hours before battery voltage will drop below the minimum voltage limit of 105 Volts direct current (VDC). In Section 2.17 of its FIP, the license stated that a Phase 2 FLEX PDG is expected to be deployed, staged, and energized to power the battery chargers within 6 hours of initiation of the ELAP event to ensure continuous power to the required instrumentation.

ANO-1 has C&D Technologies model LCR-21 batteries that have a capacity of 1442 Ampere Hours (AH) at an 8-hour discharge rate to 1.81 VDC at 77.0°F. ANO-2 has C&D Technologies model LCR-31 batteries that have a capacity of 2069 AH at an 8-hour discharge rate to 1.81 VDC at 77.0°F. ANO-1 and ANO-2 battery calculations used an 80 percent aging factor, a 1.11 temperature correction factor, and 6 percent design margin consistent with the recommendations in the applicable industry standard (Institute of Electrical and Electronics Engineers (IEEE) Standard 485-2010 "Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications"). The NRC finds that the licensee performed the above calculations for battery sizing and load profile analyses consistent with IEEE Standard 485-2010.

The NRC staff review also determined that licensee's battery sizing analysis is consistent with an NEI white paper regarding battery duty cycles, "EA-12-049 Mitigating Strategies Resolution of Extended Battery Duty Cycles Generic Concern," dated August 27, 2013 [Reference 22], which was endorsed by the NRC in a letter dated September 16, 2013 [Reference 23].

To further confirm extended battery duty cycles, the NRC sponsored testing at Brookhaven National Laboratory that resulted in the issuance of NUREG/CR-7188, "Testing to Evaluate Extended Battery Operation in Nuclear Power Plants," [Reference 24]. The purpose of this testing was to examine whether existing vented lead acid batteries can function beyond their defined design basis (or beyond-design basis if existing SBO coping analyses were utilized) duty cycles in order to support core cooling. The study evaluated battery performance availability and capability to supply the necessary dc loads to support core cooling and instrumentation requirements for extended periods of time.

The testing provided an indication of the amount of time available (depending on the actual load profile) for batteries to continue to supply dc power to the core-cooling equipment beyond the original duty cycles for a representative plant. The testing also demonstrated that battery availability can be significantly extended using load shedding techniques to allow more time to recover ac power. The testing further demonstrated that battery performance is consistent with battery manufacturing performance data.

Based on information contained in NUREG/CR-7188, and its review of the licensee's analysis, the battery vendor's specifications for the capacity and discharge rates for the batteries, as well as the controlling procedures/guidelines, the NRC staff concludes that the ANO-1 and ANO-2 vital batteries should have adequate capacity to power the instruments and other essential loads until the battery chargers are energized by the FLEX PDGs, provided that the necessary load shedding is completed within the times analyzed in the licensee's calculations.

In its FIP, the licensee stated that the required instrumentation is available prior to and after load stripping of the dc and ac buses during Phase 1 and that the strategy for both units assures the availability of the required instrumentation during Phases 2 and 3 to re-power the vital 480 VAC buses including the Class 1E battery chargers.

During Phase 2, the licensee will deploy, stage, and connect a FLEX 480 VAC PDG to repower ANO-1 and ANO-2 480 VAC buses simultaneously to ensure power is available to one train of battery chargers for each unit (prior to depletion of the station batteries), battery room ventilation fans, pressurizer heaters on ANO-1, one charging pump on ANO-2, and other critical loads. The NRC staff reviewed the summary of CALC-13-E-0005-06, "ANO FLEX Diesel Sizing Calculation," Revision 1, which showed that one (1) 480 VAC, 800 kilowatt (kW) rated generator will have adequate capacity to power the Phase 2 FLEX running loads of 511.09 kW (572.38 kilovolt Amperes (kVA)) for both ANO-1 and ANO-2 simultaneously. The licensee has an additional PDG of the same rating to satisfy the "N+1" criteria.

The NRC staff reviewed the FLEX PDG sizing calculation, primary and alternate electrical power supply sketches, the separation and isolation of the FLEX PDG from the Class 1E emergency DGs, and procedures that direct operators how to align, connect, and protect associated systems and components. Based on the NRC staff's review, the calculations confirmed that one 800 kW FLEX PDG should have sufficient capacity and capability to supply the necessary loads during Phase 2 of an ELAP event.

For Phase 3, the licensee plans to continue its Phase 2 coping strategy with additional resources provided from offsite. Table 4 of the FIP shows that the ANO site will receive four 4160 VAC, 1.0 megawatt (MW) combustion turbine generators from the NSRC. In addition, the generic equipment listing in the site's SAFER response plan, reviewed during the site audit, shows that ANO will also receive a 480 VAC, 800 kW turbine generator that could be used as replacement for the PDGs as a defense-in-depth feature. The licensee's calculation

CALC-13-E-0005-06, discussed above, also evaluates Phase 3 loads. According to the licensee's calculation, the minimum required Phase 3 total running loads equate to 746.48 kW for ANO-1 and 728.83 kW for ANO-2. The licensee's calculation confirmed that the Phase 3 FLEX combustion turbine generators will have sufficient capacity and capability to supply the necessary loads following an ELAP/loss of normal access to the UHS event. The licensee's calculation shows that one 4160 VAC combustion turbine generator will be connected to bus A3 as primary power source and another 4160 VAC combustion turbine generator will be connected to bus A4 as a secondary (alternate) power source for ANO-1. Similarly, one 4160 VAC combustion turbine generator will be connected to bus 2A3 as the primary power source and another 4160 VAC combustion turbine generator will be connected to bus 2A4 as the secondary (alternate) power source for ANO-2. Based on the above, the NRC staff finds that the Phase 3 combustion turbine generators should provide adequate capacity to supply power to the minimum required loads to maintain or restore core cooling, SFP cooling, and containment indefinitely following an ELAP.

Based on its review, the NRC staff finds that the plant batteries used in the strategy should have sufficient capacity to support the licensee's strategy, and that the FLEX DGs that the licensee plans to use should have sufficient capacity and capability to supply the necessary loads during an ELAP event.

3.2.3 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that should maintain or restore core cooling during an ELAP event consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, considering the alternatives discussed in Section 3.14 of this SE, and should adequately address the requirements of the order.

3.3 Spent Fuel Pool Cooling Strategies

In NEI 12-06, Table 3-2 and Appendix D, summarize an acceptable approach consisting of three separate capabilities for the SFP cooling strategies. This approach uses a portable injection source to provide the capability for 1) makeup via hoses on the refueling floor capable of exceeding the boil-off rate for the design basis heat load; 2) makeup via connection to spent fuel pool cooling piping or other alternate location capable of exceeding the boil-off rate for the design basis heat load; and 3) spray via portable monitor nozzles from the refueling floor using a portable pump capable of providing a minimum of 200 gpm per unit (250 gpm if overspray occurs). During the event, the licensee selects the method to use based on plant conditions. This approach also requires a strategy to mitigate the effects of steam from the SFP, such as venting.

As described in NEI 12-06, Section 3.2.1.7 and JLD-ISG-2012-01, Section 2.1, strategies that have a time constraint to be successful should be identified and a basis provided that the time can be reasonably met. In NEI 12-06, Section 3 provides the performance attributes, general criteria, and baseline assumptions to be used in developing the technical basis for the time constraints. Since the event is beyond-design-basis, the analysis used to provide the technical basis for time constraints for the mitigation strategies may use nominal initial values (without uncertainties) for plant parameters, and best-estimate physics data. All equipment used for consequence mitigation may be assumed to operate at nominal setpoints and capacities. In

NEI 12-06, Section 3.2.1.2 describes the initial plant conditions for the at-power mode of operation; Section 3.2.1.3 describes the initial conditions; and Section 3.2.1.6 describes SFP initial conditions.

Guidance document NEI 12-06, Section 3.2.1.1 provides the acceptance criterion for the analyses serving as the technical basis for establishing the time constraints for the baseline coping capabilities to maintain SFP cooling. This criterion is keeping the fuel in the SFP covered with water.

The ELAP causes a loss of cooling in the SFP. As a result, the pool water will heat up and eventually boil off. The licensee's response is to provide makeup water. The timing of operator actions and the required makeup rates depend on the decay heat level of the fuel assemblies in the SFP. The sections below address the response during operating, pre-fuel transfer or post-fuel transfer operations. Refueling and shutdown modes are addressed in Section 3.11.

The NRC staff reviewed the licensee's FIP to determine whether the strategies outlined in the FIP, if implemented appropriately, will maintain or restore SFP cooling following a BDBEE. As part of its review, the NRC staff reviewed simplified flow diagrams, engineering drawings, summaries of calculations for sizing the FLEX pumps, and summaries of calculations that addressed the heat up rates of the SFP following the loss of normal cooling functions during an ELAP. In addition, the NRC staff discussed the SFP cooling mitigation strategy for an ELAP event with the licensee's staff and performed a walk-down of the licensee's SFP cooling strategies during an onsite audit. The walk-down focused on the areas where FLEX equipment will be stored, deployed and operated, the connection points to the existing piping systems, and the hose runs from the staged and deployed FLEX pumps. The licensee's basic FLEX strategy for maintaining SFP cooling is to monitor SFP level and provide makeup water sufficient to maintain the normal SFP level.

3.3.1 Phase 1

For Phase 1 SFP cooling, the licensee credits the large inventory and heat capacity of the water in the SFP. The licensee performed a calculation (discussed in more detail in Section 3.3.4.2 of this evaluation) that determines the SFP time to boil for ANO-1 and ANO-2. For ANO-1 the time to boil is 9.15 hours for the normal operating heat load and 3.87 hours for the maximum credible heat load. For ANO-2 the time to boil is 4.17 hours for the normal operating heat load and 2.19 hours for the maximum credible heat load. The licensee's initial coping strategy for SFP cooling is to allow evaporative cooling of the SFP while monitoring SFP level using instrumentation installed as required by NRC Order EA-12-051. Although SFP makeup is commenced during Phase 2, the licensee plans to deploy makeup hoses and oscillating monitor nozzles prior to commencement of boiling to ensure that makeup capability is available for Phase 2.

3.3.2 Phase 2

In accordance with NEI 12-06, Table 3-1 and Appendix D, the licensee has developed three baseline SFP cooling strategies. The strategies use a portable injection source to provide makeup via connection to existing piping, makeup via hoses on the refueling floor, and makeup via spray using portable monitor nozzles from the refueling floor.

The licensee's first method provides water at a rate that matches boil-off to the SFP. The source of this water is from the QCST or the ECP via the FLEX inventory transfer pump which discharges to the QCST or directly to the suction of the SFP makeup pump. The SFP makeup pump discharges through a fire hose connected to existing SFP cooling piping. For ANO-1, the licensee connects fire hose from the discharge of the SFP makeup pump to the SFP coolers outlet drain. For ANO-2, the licensee connects fire hose from the discharge of SFP makeup pump to a new FLEX SW system tie-in the Auxiliary Building. The licensee plans to store the required adapters, necessary tools, and the hose in the FLEX Storage Buildings. This method provides the capability to supply makeup water to the SFP without accessing the refueling floor.

The licensee's second method provides water at a rate that matches boil-off to the SFP using FLEX SFP makeup pump. The FLEX SFP makeup pump can take suction either from the QCST or directly from the ECP via the FLEX inventory transfer pump. In this method, the FLEX SFP pump discharges through fire hoses directly into the SFP. The licensee has installed a new 4" riser pipe to eliminate the need to route hose up stairwells. The riser is shared by both units and runs from ground elevation up to the SFP elevation. Prior to the onset of bulk boiling the licensee will connect and deploy hoses from the riser to SFP area and then split into separate hose runs for both SFPs. Once the FLEX SFP makeup pump is deployed, the licensee will deploy a hose from the pump discharge and connect it to the lower end of the riser.

The licensee's third method provides water at a rate of 250 gpm (to account for over spray) to each SFP using the FLEX SFP makeup pump (one pump for both units). In this method, the pump suction is aligned in a similar manner to the licensee's second method. The pump discharge utilizes the riser pipe described for the licensee's second method, but discharges to the SFP through a fire hose connected to a monitor spray nozzle. The spray monitor and discharge hose will be deployed prior to the onset of bulk boiling.

3.3.3 Phase 3

For Phase 3 SFP cooling, the licensee plans to continue using Phase 2 strategies and equipment, and augment as necessary with the additional equipment received from the NSRC.

3.3.4 Staff Evaluations

3.3.4.1 Availability of Structures, Systems, and Components

The baseline assumptions established in NEI 12-06 presume that, other than the loss of the ac power sources and normal access to the UHS, installed equipment that is designed to be robust with respect to design basis external events is, in general, is assumed to be fully available. Installed equipment that is not robust is, in general, is assumed to be unavailable.

3.3.4.1.1 Plant SSCs

Condition 6 of NEI 12-06, Section 3.2.1.3, states that permanent plant equipment contained in structures with designs that are robust with respect to seismic events, floods, and high winds, and associated missiles, are available. In addition, Section 3.2.1.6 states that the initial SFP conditions are: 1) all boundaries of the SFP are intact, including the liner, gates, transfer canals, etc., 2) although sloshing may occur during a seismic event, the initial loss of SFP inventory does not preclude access to the refueling deck around the pool and 3) SFP cooling system is intact, including attached piping.

The licensee's method 2 and method 3 for SFP cooling use only portable equipment and piping installed solely for FLEX and do not require any connections to existing plant SSCs. The licensee's first method for ANO-1 requires attaching a fire hose to the SFP cooler's outlet drain The connection is not on seismic category 1 pipe; however, by letter dated September 1, 2016 [Reference 60], the licensee stated that it had performed calculation CALC-89-E-0098-01, "Assessment of SF Pool Cooling Line HCC-12-6 for Maximum Earthquake," Revision 0, which provides an analysis of the piping and shows that the pipe would withstand design-basis earthquake forces and maintain its pressure boundary, thereby meeting the NEI 12-06 definition of robust. In addition, the connection is located in the seismic category 1 ANO-1 Auxiliary Building, which provides protection for all external hazards. The licensee's first method for ANO-2 connects a fire hose from the discharge of the FLEX pump to a new FLEX SW system tie-in. The tie-in is located on seismic category 1 SW piping within the seismic category 1 ANO-2 Auxiliary Building and is protected from all applicable external hazards.

Based on the location and design of the credited portions of the SFP cooling system piping, and if aligned and utilized in accordance with Entergy's SFP cooling strategy as described in the FIP, the credited flow paths should be available to support SFP cooling during an ELAP consistent with NEI 12-06, Section 3.2.1.3, Condition 6, and Section 3.2.1.6.

3.3.4.1.2 Plant Instrumentation

In its FIP, the licensee stated that the instrumentation for SFP level will meet the requirements of Order EA-12-051. Furthermore, the licensee stated that these instruments will have initial local battery power with the capability to be powered from the FLEX PDGs. The NRC staff's review of the SFPLI, including the primary and back-up channels, the display to monitor the SFP water level and environmental qualifications to operate reliably for an extended period are discussed in Section 4 of this SE.

3.3.4.2 Thermal-Hydraulic Analyses

NEI 12-06, Section 3.2.1.6, Condition 4, states that SFP heat load assumes the maximum design-basis heat load for the site. In accordance with NEI 12-06, the licensee performed CN-SEE-II-12-43, "Determination of the Time to Boil in the Arkansas Nuclear One (ANO) 1 & 2 Spent Fuel Pools after an Earthquake," Revision 2, which uses the normal operating SFP heat load. Following the loss of ac power, the pool will begin to heat up and reach the bulk boiling temperature of 212°F in 9.15 hours for ANO-1 and 4.17 hours for ANO-2. In order to maintain adequate shielding, the licensee maintains at least 15 feet of water above the fuel racks. If cooling is not restored, the water level will reach 15 feet above the top of the fuel in 47.65 hours for ANO-1, and 24.74 hours for ANO-2. In order to match the inventory lost from boiling, a makeup rate of greater than 42 gpm for ANO-1 and 80 gpm for ANO-2 must be established. Deployment of a SFP makeup strategy with a flow rate that exceeds boil-off rate within 24 hours of the loss of SFP cooling will provide for adequate makeup to restore the SFP level and maintain an acceptable level of water for shielding purposes.

3.3.4.3 FLEX Pumps and Water Supplies

The FLEX SFP makeup pump is a trailer-mounted, diesel-driven pump that is stored in the FLEX storage building. The FLEX SFP makeup pump can take suction from the QCST or the ECP via the FLEX inventory transfer pump. When SFP spray is required, flow from the FLEX inventory transfer pump is split between the SFP makeup pump and the QCST (for SG feed). The site has two SFP makeup pumps ant two inventory transfer pumps (one in each FLEX building), which satisfies the "N+1" provision of NEI 12-06.

In accordance with NEI 12-06, Section 11.2, the licensee performed CALC-13-E-0005-10, "ANO FLEX Phase 2 Spent Fuel Pool Makeup and Spray Pump," Revision 1, and CALC-13-E-0005-12, "ANO FLEX Phase 2 Inventory Transfer Pump Sizing", Revision 1, to determine the hydraulic demand of the FLEX pumps in order to provide the performance requirements for proper selection and procurement of pumps. The licensee's calculation uses classical hydraulic analysis head loss and pressure gradient methods, and includes all pumps, valves, hoses, strainers, elevations, and line distances for the FLEX strategy water supply using the most limiting set of conditions for SFP cooling. The calculation determined the minimum required flow rate, minimum discharge pressure, and minimum NPSHa for a pump to be able to perform its required function. Comparison of the actual pump performance data and the sizing criteria of the calculation shows that FLEX SFP makeup and inventory transfer pumps should have the capacity needed to perform the required function for core cooling and inventory control.

Based on design of the FLEX pumps, as described in the licensee's calculations performed consistent with NEI-12-06, Section 11.2, and if aligned and operated according to Entergy's strategy for core cooling and inventory control, as described in the FIP, the FLEX pumps should have sufficient capacity to support SFP cooling during an ELAP.

3.3.4.4 Electrical Analyses

The licensee is not crediting any electrical equipment to maintain or restore spent fuel pool cooling, beyond the spent fuel pool level instrumentation which is discussed elsewhere in this SE and thus, further electrical analysis evaluation is not necessary.

3.3.5 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore SFP cooling following an ELAP consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.4 Containment Function Strategies

The industry guidance document, NEI 12-06, Table 3-2 provides some examples of acceptable approaches for demonstrating the baseline capability of the containment strategies to effectively maintain containment functions during all phases of an ELAP event. One such approach is for a licensee to perform an analysis demonstrating that containment pressure control is not challenged.

The licensee performed containment evaluations, CALC-13-E-0005-02, "ANO-1 MAAP Containment Analysis for BDBEE", Revision 0 and CALC-14-E-0002-01, "ANO-2 FLEX MAAP Containment Analysis", Revision 0, which are based on the boundary conditions described in Section 2 of NEI 12-06. Calculation CALC-13-E-0005-02 concludes that the containment parameters of pressure and temperature remain well below the respective ANO-1 UFSAR Section 1.4.13 and Table 14-39 design limits of 59 psig and 286°F for more than 7 days. Calculation CALC-14-E-0002-01 concludes that the containment parameters of pressure and temperature remain well below the respective UFSAR Table 6.2-7 design limits of 59 psig and 300°F for ANO-2, for more than 7 days. From its review of the evaluation, the NRC staff notes that the required actions to maintain containment integrity and required instrumentation functions have been developed, and are summarized below.

3.4.1 Phase 1

As indicated above, calculations were performed for each unit. Based on the results of these evaluations, no actions are required to ensure maintenance of containment integrity through Phase 1 for an event which occurs when the SGs are available. For ANO-1, containment integrity will be established per 1FSG-016, "Containment Isolation and Closure". For ANO-2, procedure EOP-2202.008, "Station Blackout," addresses containment integrity. Containment venting through an identified penetration or access hatch is required for events which occur when SGs are not available depending on decay heat, RCS temperature, and RCS level at the time of the event.

3.4.2 Phase 2

The phase 2 coping strategy for both units is to continue monitoring containment temperature and pressure using installed instrumentation.

3.4.3 Phase 3

The phase 3 coping strategy is to use the containment cooler units to maintain containment design parameters indefinitely. Both the ANO-1 and ANO-2 containment coolers are provided cooling water by the SW system. In addition, containment coolers are powered from each safety related 480 VAC train.

By utilizing pre-engineered, temporary modifications following a simultaneous ELAP and loss of normal access to the UHS, flow can be re-established to the containment coolers utilizing the SW system piping. For ANO-1, a pump supplied by the NSRC would connect to blind flanges installed on a newly installed service water to fire water cross-tie. The pre-fabricated replacement flanges are stored onsite. Five blind flanged connections are provided on this cross-tie and used as the connection points for NSRC pump injection for containment cooling. These flanges may be replaced with pre-fabricated flanges with hose connections. For ANO-2, the top flange on any of the large SW pump strainers may be removed and replaced with a pre-fabricated replacement flange with hose connections, similar to the case of ANO-1.

The NSRC is providing a low pressure/high flow dewatering pump and booster pump, which will be used, if required, to provide water to the containment coolers as described above. The water source for the NSRC pump would be provided by the ECP or Lake Dardanelle. The licensee has developed procedures (FSGs) to control the establishment of containment cooling once Phase 3 equipment is in place.

The Phase 3 coping strategy described above requires power-to restore the containment coolers. The connection of the NSRC 4160 VAC generator to the existing 4160 VAC electrical bus can be made with temporary cable and connections and is described in Section 3.2.3.6 above.

3.4.4 Staff Evaluations

3.4.4.1 Availability of Structures, Systems, and Components

Guidance document NEI 12-06 baseline assumptions have been established on the presumption that other than the loss of the ac power sources and normal access to the UHS, installed equipment that is designed to be robust with respect to design-basis external events is assumed to be fully available. Installed equipment that is not robust is assumed to be unavailable. Below are the baseline assumptions for the availability of SSCs for maintaining containment functions during an ELAP.

3.4.4.1.1 Plant SSCs

The ANO-1 and ANO-2 SW systems are described in their respective plant UFSARs (Unit 1 – 9.3.2.1, Unit 2 – 9.2.1). For each unit, the SW system provides cooling water flow to the engineered Safety Feature (ESF) equipment, including the containment coolers. According to the ANO-1 UFSAR, Section 5.1.2.1.2, the ANO-1 SW system is classified as seismic category 1. This designation applies to the portions of the system that are necessary for the safety function of the system, such as the containment coolers. For ANO-2, UFSAR Table 3.2-2 classifies the SW system as seismic category 1, for the portions related to the ESF function, which includes the pumps, associated piping for ESF loads, and containment cooling. By letter dated September 1, 2016, the licensee indicated that the emergency response organization would be available to coordinate any necessary isolation of the seismic and non-seismic portions of the service water systems needed to support the containment cooling function, if required.

The containment cooling system is described in UFSAR Sections 6.3 for ANO-1 and 6.2.2 for ANO-2. According to the ANO-1 UFSAR, Section 5.1.2.1.2, the ANO-1 containment (reactor building) cooling system is classified as seismic category 1. For ANO-2, UFSAR Table 3.2-2 classifies the containment cooling system as seismic category 1, for the portions including the fans, service water cooling coils, and supply ductwork. Both units' containment coolers are located in the seismic category 1 containment building and thus should be available to support phase 3 operations after a BDBEE.

3.4.4.1.2 Plant Instrumentation

In NEI 12-06, Table 3-2, specifies that containment pressure is a key containment parameter which should be monitored by repowering the appropriate instruments. The licensee's FIP states that control room instrumentation will be available due to the coping capability of the station batteries and associated inverters in Phase 1, or the PDGs deployed in Phase 2. If no ac or dc power was available, FIP Section 2.3.6 states that key credited plant parameters, including containment pressure, would be available using a voltmeter. During the audit the NRC staff verified that the licensee had developed guidance via FSGs to perform this alternative containment pressure assessment.

3.4.4.2 Thermal-Hydraulic Analyses

CALC-13-E-0005-02, "ANO-1 MAAP Containment Analysis for BDBEE", Revision 0, uses the Modular Accident Analysis Program (MAAP) Version 4.0.7. The RCP seal leakage was assumed to be 2 gpm per pump. An additional leakage of 1 gpm was assumed to account for unidentified leakage sources. Results show the peak pressure is 23.7 psia at 120 hours and the peak temperature is 216°F at 120 hours. This is below the containment design limits of 73.7 psia (59 psig) and 286°F.

CALC-14-E-0002-01, "ANO-2 FLEX MAAP Containment Analysis", Revision 0, uses the Modular Accident Analysis Program (MAAP) Version 4.0.8. The RCP seal leakage was assumed to be 15 gpm per pump. An additional leakage of 1 gpm was assumed to account for unidentified leakage sources. Results show that containment pressure slowly increases over the ELAP event to a peak pressure of 21.9 psia at 120 hours. This is below the containment design limits of 73.7 psia (59 psig). According to the licensee's calculation the containment temperature stays below the design limit of 300°F at all times with a calculated value of approximately 192°F at 120 hours.

3.4.4.3 FLEX Pumps and Water Supplies

For Phase 1 and Phase 2, with each unit operating within the boundary conditions of NEI 12-06, Section 2, the MAAP analysis demonstrates that there are no mitigation strategies for which FLEX pumps or water supplies are required to maintain containment pressure and temperature below design limits for at least 120 hours. Even at 120 hours, while containment temperature and pressure are slowly increasing, there is ample margin to the exceedance of containment temperature and pressure limits based upon a trend review of the licensee's analysis. Eventually, in Phase 3, the licensee will utilize an NSRC-supplied pump to supply cooling water to the containment coolers in order to support the indefinite coping requirement of Order EA-12-049 for maintenance regarding the containment function.

3.4.4.4 Electrical Analyses

The licensee's Phase 1 strategy for containment is to monitor containment temperature and pressure using installed instrumentation. The licensee's Phase 2 strategy is to continue monitoring containment temperature and pressure using installed instrumentation. The NRC staff finds that the licensee's Phase 2 electrical strategy to repower instruments is adequate to allow continued containment parameter monitoring.

The licensee's Phase 3 coping strategy, as discussed in Section 2.5.3 of the FIP, is to utilize containment coolers to maintain containment parameters indefinitely. The containment coolers are powered from each safety-related 480 VAC train. Two 4160 VAC 1 MW combustion turbine generators for each unit will be provided from an NSRC in order to supply power to either of the two Class 1E 4160 VAC buses on each unit. Additionally, by restoring the Class 1E 4160 VAC bus, power can be restored to the Class 1E safety-related 480 VAC train via the 4160/480 VAC transformers to power selected 480 VAC loads including the containment coolers.

The NRC staff reviewed the summary of ANO Calculation 13-E-0005-06 (EC-48342), "ANO FLEX Diesel Sizing Calculation," Revision 1, conceptual single line electrical diagrams and sketches, the separation and isolation of the FLEX PDGs from the Class 1E emergency diesel generators, and procedures that direct operators how to align, connect, and protect associated systems and components. Based on its review of the summary of the calculation, as described in Section 3.2.3.6 of this SE, the NRC staff confirmed that two 1 MW 4160 VAC turbine generators per unit should provide sufficient capacity and capability to supply the necessary loads following an ELAP to maintain or restore containment.

3.4.5 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore containment functions following an ELAP event consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.5 Characterization of External Hazards

Sections 4 through 9 of NEI 12-06 provide the methodology to identify and characterize the applicable BDBEEs for each site. In addition, NEI 12-06 provides a process to identify potential complicating factors for the protection and deployment of equipment needed for mitigation of applicable site-specific external hazards leading to an ELAP and loss of normal access to the UHS.

Characterization of the applicable hazards for a specific site includes the identification of realistic timelines for the hazard, characterization of the functional threats due to the hazard, development of a strategy for responding to events with warning, and development of a strategy for responding to events without warning.

The licensee reviewed the plant site against NEI 12-06 and determined that FLEX equipment should be protected from the following hazards: seismic; external flooding; severe storms with high winds; snow, ice and extreme cold; and extreme high temperatures.

References to external hazards within the licensee's mitigating strategies and this SE are consistent with the guidance in NEI-12-06 and the related NRC endorsement of NEI 12-06 in JLD-ISG-2012-01. Guidance document NEI 12-06 directed licensees to proceed with evaluating external hazards based on currently available information. For most licensees, this meant that the OIP used the current design-basis information for hazard evaluation. Coincident with the issuance of Order EA-12-049, on March 12, 2012, the NRC staff issued a Request for Information pursuant to 10 CFR 50.54(f) [Reference 20] (hereafter referred to as the 50.54(f) letter), which requested that licensees reevaluate the seismic and flooding hazards at their sites using updated hazard information and current regulatory guidance and methodologies. Due to the time needed to reevaluate the hazards, and for the NRC to review and approve them, the reevaluated hazards were generally not available until after the mitigation strategies had been developed. The NRC staff has developed a proposed rule, titled "Mitigation of Beyond-Design-Basis Events," hereafter called the MBDBE rule, which was published for comment in the Federal Register on November 13, 2015 [Reference 49]. The proposed MBDBE rule would make the intent of Orders EA-12-049 and EA-12-051 generically applicable to all present and future power reactor licensees, while also requiring that licensees consider the reevaluated hazard information developed in response to the 50.54(f) letter.

The NRC staff requested Commission guidance related to the relationship between the reevaluated flooding hazards provided in response to the 50.54(f) letter and the requirements for Order EA-12-049 and the MBDBE rulemaking (see COMSECY-14-0037, Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards" [Reference 45]). The Commission provided guidance in an SRM to COMSECY-14-0037 [Reference 21]. The Commission approved the staff's recommendations that licensees would need to address the reevaluated flooding hazards within their mitigating strategies for BDBEEs, and that licensees may need to address some specific flooding scenarios that could significantly damage the power plant site by developing scenario-specific mitigating strategies, possibly including unconventional measures, to prevent fuel damage in reactor cores or SFPs. The NRC staff did not request that the Commission consider making a requirement for mitigating strategies capable of addressing the reevaluated flooding hazards be immediately imposed, and the Commission did not require immediate imposition. In a letter to licensees dated September 1, 2015 [Reference 40], the NRC staff informed the licensees that the implementation of mitigation strategies should continue as described in licensee's OIPs, and that the NRC SEs and inspections related to Order EA-12-049 will rely on the guidance provided in JLD-ISG-2012-01, Revision 0, and the related industry guidance in NEI 12-06, Revision 0. The hazard reevaluations may also identify issues to be entered into the licensee's corrective action program consistent with the OIPs submitted in accordance with Order EA-12-049.

As discussed above, licensees are reevaluating the site seismic and flood hazards as requested in the NRC's 50.54(f) letter. After the NRC staff approves the reevaluated hazards, licensees will use this information to perform flood and seismic mitigating strategies assessments (MSAs) per the guidance in NEI 12-06, Revision 2, Appendices G and H [Reference 50]. The NRC staff endorsed Revision 2 of NEI 12-06 in JLD-ISG-2012-01, Revision 1 [Reference 51].

The licensee's MSAs will evaluate the mitigating strategies described in this SE using the revised seismic hazard information and, if necessary, make changes to the strategies or equipment. Licensees will submit the MSAs for NRC staff review.

The licensee developed its OIP for mitigation strategies by considering the guidance in NEI 12-06 and the site's design-basis hazards. Therefore, this SE makes a determination based on the licensee's OIP and FIP. The characterization of the applicable external hazards for the plant site is discussed below.

3.5.1 Seismic

In its FIP, the licensee described the current site design-basis seismic criteria, including a description of the design-basis earthquake (DBE). The current NRC terminology for the DBE is the safe shutdown earthquake (SSE), and the terms are used interchangeable in this SE. As described in the ANO-1 and ANO-2 UFSARs, (Sections 2.7.2/5.1.4.1 for Unit 1 and 2.5.2/3.7 for

Unit 2), the DBE seismic criteria for the site is 0.20g peak horizontal ground acceleration and 0.133g peak ground acceleration acting vertically. It should be noted that the actual seismic hazard involves a spectral graph of the acceleration versus the frequency of the motion. Peak acceleration in a certain frequency range, such as the numbers above, is often used as a shortened way to describe the hazard.

As the licensee's seismic reevaluation activities are completed, the licensee is expected to assess the mitigation strategies to ensure they can be implemented under the reevaluated hazard conditions as will potentially be required by the proposed MDBDE rulemaking. The licensee has appropriately screened in this external hazard and identified the hazard levels to be evaluated.

3.5.2 Flooding

The licensee stated in its FIP, that the types of events evaluated to determine the worst potential flood included; (1) probable maximum flood (PMF) due to flood flow at Dardanelle Dam yielding a water level at 358 feet (ft.) mean sea level (msl), (2) catastrophic failure of the closest dam upstream of Dardanelle Dam yielding a water level of 361 ft. msl, and (3) the effect of wind induced waves. The current licensing basis provides about 5 days' notice prior to flooding of the site. The units would be shut down in accordance with the plants natural emergencies procedures and certain FLEX equipment would be pre-staged during the 5 day warning period. As described in the ANO-1 and ANO-2 UFSARs (Sections 8.3.1.1.7.2 and 9.5.4.1, respectively), the flood persistence for the current licensing basis (CLB) flood is between 2 and 5 days.

As the licensee's flooding reevaluation activities are completed, the licensee is expected to assess the mitigation strategies to ensure they can be implemented under the reevaluated hazard conditions as will potentially be required by the proposed MDBDE rulemaking. The licensee has appropriately screened in this external hazard and identified the hazard levels to be evaluated.

3.5.3 High Winds

The screening for high wind hazards associated with hurricanes should be accomplished by comparing the site location to NEI 12-06, Figure 7-1 (Figure 3-1 of U.S. NRC, "Technical Basis for Regulatory Guidance on Design Basis Hurricane Wind Speeds for Nuclear Power Plants," NUREG/CR-7005, December, 2009); if the resulting frequency of recurrence of hurricanes with wind speeds in excess of 130 mph exceeds 1E-6 per year, the site should address hazards due to extreme high winds associated with hurricanes.

The screening for high wind hazard associated with tornadoes should be accomplished by comparing the site location to NEI 12-06, Figure 7-2, from U.S. NRC, "Tornado Climatology of the Contiguous United States," NUREG/CR-4461, Revision 2, February 2007; if the recommended tornado design wind speed for a 1E-6/year probability exceeds 130 mph, the site should address hazards due to extreme high winds associated with tornadoes.

The licensee stated in its FIP, that Figures 7-1 and 7-2 from NEI 12-06 were used for this assessment. The ANO site is located at latitude 35° 18' N; therefore, ANO is not susceptible to hurricanes based on its location in Arkansas. The plant site is north of the final contour line shown in Figure 7-1 of NEI 12-06. It was determined that the ANO site has the potential to experience damaging winds caused by a tornado exceeding 130 mph. Figure 7-2 of NEI 12-06 indicates a maximum wind speed of 200 mph for Region 1 plants, including ANO, which is located at latitude 35°18' N, longitude 93° 13' W. Therefore, high wind hazards are applicable to the ANO site.

In summary, (1) based on Figure 7-1 of NEI 12-06, ANO is not susceptible to hurricanes, so that hazard is screened out, and (2) based on local data and Figure 7-2 of NEI 12-06, ANO has the potential to experience damaging winds so the tornado high wind hazard is screened in. Guidance document NEI 12-06 requires an evaluation of external hazards that are considered credible for a specific site. This includes evaluating storms (e.g., hurricanes, high-winds, and tornadoes) for the protection and deployment of FLEX equipment and offsite resources. NEI 12-06.

Therefore, high-wind hazards are applicable to the plant site. The licensee has appropriately screened in the high-wind hazard and characterized the hazard in terms of wind velocities and wind-borne missiles.

3.5.4 Snow, Ice, and Extreme Cold

As discussed in NEI 12-06, Section 8.2.1, all sites should consider the temperature ranges and weather conditions for their site in storing and deploying their FLEX equipment consistent with normal design practices. All sites outside of Southern California, Arizona, the Gulf Coast and Florida are expected to address deployment for conditions of snow, ice, and extreme cold. All sites located north of the 35th Parallel should provide the capability to address extreme snowfall with snow removal equipment. Finally, all sites except for those within Level 1 and 2 of the maximum ice storm severity map contained in Figure 8-2 should address the impact of ice storms.

The ANO site is located at approximately latitude 35° 18' N, therefore, the FLEX strategies consider the impedances caused by extreme snowfall with snow removal equipment, as well as the challenges that the extreme cold temperature may present. As defined by Figure 8-2 of NEI 12-06 (Reference 3.1.3), the ANO site is not in a level 1 or 2 region. Therefore, the FLEX strategies consider the hindrances caused by ice storms. In summary, based on the available local data and Figures 8-1 and 8-2 of NEI 12-06, the hazards of snow, ice, and extreme cold temperatures are screened in for the ANO site. The extreme low temperature documented in the ANO UFSAR, -15°F, is used as the initial low temperature in the analysis of tanks (QCST, BWST, and RWT) and the gravity drain hose temperatures. A review of historical meteorological data dating back to 1945 indicated that the lowest 72-hour average temperature ever recorded at nearby Fort Smith, Arkansas, was 6°F. In addition, the historical meteorological data only recorded 9 hours below 0°F. In summary, based on the available local data and Figures 8-1 and 8-2 of NEI 12-06, the plant site does experience significant amounts of snow, ice, and extreme cold temperatures; therefore, the hazard is screened in. The licensee has appropriately screened in the hazard and characterized the hazard in terms of expected temperatures.

3.5.5 Extreme Heat

Per NEI 12-06, all sites are required to address extreme high temperatures. Therefore, for FLEX equipment, the ANO site considered the site maximum expected temperatures with respect to the specification, storage, and deployment requirements, including ensuring adequate ventilation or supplementary cooling, if required. According to the licensee's FIP, at the ANO site the maximum temperature recorded was 115°F.

All Phase 2 FLEX equipment is stored in two FLEX storage buildings such that initial exposure to the extreme temperature prior to ELAP would be mitigated. The FLEX equipment has been procured to function in high temperatures and consideration has been given to the impacts of these high temperatures on equipment storage and deployment. The licensee has appropriately screened in the hazard and characterized the hazard in terms of expected high temperatures.

3.5.6 Conclusions

Based on the evaluation above, the NRC staff concludes that the licensee has developed a characterization of external hazards that is consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order in regard to the characterization of external hazards.

3.6 Planned Protection of FLEX Equipment

3.6.1 Protection from External Hazards

Two pre-engineered metal storage buildings house the portable FLEX equipment used to support Phase 2 of the FLEX response design requirements set in NEI 12-06. The buildings are located at a distance of over 2,000 ft. from each other perpendicular to the prominent tornado paths in order to provide adequate tornado separation. This separation reasonably assures that at least one of the storage buildings would be available following a BDBEE, thereby assuring at least "N" sets of FLEX equipment would be available to respond to the event. Due to this separation, the buildings are not tornado missile protected. Also, the installation of the two FLEX storage buildings does not introduce any new tornado missiles that are not already included in both the ANO-1 and ANO-2 UFSARs. The buildings are designed to meet local building codes using a service level wind speed of 130 mph.

Section 5.3.1 of NEI 12-06 states that large portable FLEX equipment should be tied down as appropriate and that it should be evaluated and protected from seismic interactions as to ensure that unsecured components do not damage the equipment. The licensee performed an evaluation to determine the minimum separation distance between equipment within the building to ensure that equipment would not interact with each other due to tipping or sliding during a seismic event. Large portable FLEX equipment housed in the FLEX storage buildings stored at a distance equal to or greater than this minimum separation distance would not be required to be tied down. Tie-down points are provided in the building slab for equipment that may be stored closer together. Furthermore, the FLEX equipment housed in the FLEX storage buildings is not required to be tied down due to wind. Since the FLEX storage buildings were built to withstand 130 mph winds, the licensee used NRC RG 1.76, Revision 1, to determine the tornado width at which 130 mph winds are predicted to occur. Based on its evaluation, the licensee determined that ANO's FLEX buildings are separated by more than the calculated tornado width at which 130 mph winds (FLEX buildings wind design criterion) would be predicted to occur in a tornado with maximum 230 mph winds. Therefore, the licensee concludes that the FLEX equipment staged in ANO's FLEX storage buildings is not required to be tied down (based on potential wind damage) and the FLEX equipment would not be exposed to the wind for two scenarios:

1. A tornado takes a path between the FLEX storage buildings such that neither building is impacted by winds greater than 130 mph.
2. A tornado takes a path such that one FLEX storage building and its contents is damaged by tornado winds and the other FLEX building and its contents "survives" based on the separation distance.

Debris removal equipment is also stored inside the FLEX storage buildings in order to be reasonably protected from the applicable external events such that the equipment is likely to remain functional and deployable to clear obstructions from the pathway between the FLEX equipment storage location and its deployment location(s). This includes mobile equipment such as a front end loader, or tow vehicle, that are stored inside the FLEX storage buildings. Deployments of the FLEX and debris removal equipment from the FLEX storage buildings are not dependent on offsite power. All actions are accomplished manually. Guidance document NEI 12-06, Rev 0, stipulates that provisions for an additional set of portable onsite equipment is essential to ensure that the "N" set of FLEX equipment would remain deployable. During the audit, the NRC staff verified that the licensee has two sets of towing and debris removal equipment (one set in each FLEX storage building), as specified in EC [Engineering Change] 44045, "ANO FLEX Storage Building," Revision 0, to account for the potential loss of one FLEX storage building due to a tornado winds/missiles and confirmed this meets the provisions of NEI 12-06, Revision 0.

Below are additional details on how FLEX equipment is protected from each of the external hazards.

3.6.1.1 <u>Seismic</u>

Implementation of the FLEX coping strategy is structured to be achievable following a seismic event, including storage and deployment of FLEX equipment, and utilization of installed SSCs that are seismically robust as defined in NEI 12-06. According to the licensee's FIP, the FLEX storage buildings, and interaction with equipment within, are evaluated for the seismic event per NEI 12-06, Section 5.3.1.1.b. The licensee's compliance letter dated January 12, 2016, clarified that the design wind forces are larger than the resultant forces of the respective SSE accelerations and therefore, the ANO FLEX buildings are qualified for the site SSE accelerations. During the audit process the NRC staff reviewed the licensee's evaluation and noted that the wind loading case induced reaction forces in the governing design elements (braces) which were a minimum of double (2x) the magnitude induced by the SSE loading case. Thus, the NRC staff concludes that the FLEX storage buildings should have adequate capacity to provide protection of the equipment and facilitate its deployment following a seismic event, up to and including an SSE-level earthquake.

The conditions of the equipment deployment paths following a BDBEE were assessed. A subsurface exploration was performed to evaluate the engineering properties of the subsurface soils within the two proposed FLEX storage building sites, NSRC staging area (the Phase 3 equipment staging area), and along the travel paths. The potential for soil liquefaction along the equipment deployment paths was determined to be low; therefore, no mitigation or ground improvements were deemed necessary in these areas.

3.6.1.2 Flooding

The CLB for the combined effects flood mechanism provides 5 days' notice prior to flooding of the ANO site. The CLB for combined effects is 360.5 ft. msl with splash effects up to 368 ft. msl (splash effects are only considered against the face of the Auxiliary Building and do not apply to the platform faces with very small surface areas when compared to the wall of the Auxiliary Building). For the ANO FLEX strategy, portable equipment would be pre-staged during the five day period on flood staging platforms. This includes the staging of any required hoses and cables, which would be secured using sandbags. It also includes setup of diesel refueling equipment. As part of the pre-staging for the flood BDBEE, a panel for connecting the temporary cables is located on the roof of the PASS building at elevation 369 ft. and piping penetrations are located on the outer walls of the PASS building for connecting hoses to prevent the need to open the flood door on the PASS buildings north wall. Therefore, in a flood BDBEE, pre-staging of equipment is completed to provide assurance that the FLEX strategy would be successful if implemented.

3.6.1.3 High Winds

The FLEX storage buildings are located at a distance of over 2,000 ft. from each other perpendicular to the prominent tornado paths in order to provide adequate tornado separation. Due to this separation, the buildings are not tornado missile protected. The buildings are designed to meet local building codes using a service level wind speed of 130 mph.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

Operators monitor and record average ECP temperatures once per shift. The minimum allowable average ECP temperature is 34°F. Based on monitoring the ECP temperature once per shift, and the ability to take mitigating actions on low temperature prior to the ELAP, 34°F is deemed to be a reasonable and conservative ECP temperature during the extreme cold weather event. Due to the potential for ice formation on the ECP surface, an axe or some other tool would be made available during periods of extreme cold weather in order to puncture the surface ice to allow deployment of the FLEX inventory transfer pump suction line.

Phase 2 FLEX equipment is stored in the FLEX storage buildings, such that initial exposure to the extreme temperature prior to ELAP would be mitigated. Equipment which cannot tolerate storage in the low temperature conditions has been provided with block heaters. The FLEX equipment has been procured to function in high temperatures and consideration has been given to the impacts of these high temperatures on equipment storage and deployment.

3.6.2 Reliability of FLEX Equipment

Section 3.2.2 of NEI 12-06 states, in part, that in order to assure reliability and availability of the FLEX equipment, the site should have sufficient equipment to address all functions at all units on-site, plus one additional spare (i.e., an "N+1" capability, where "N" is the number of units on site). It is also acceptable to have a single resource that is sized to support the required functions for multiple units at a site (e.g., a single pump capable of all water supply functions for a dual unit site). In this case, the "N+1" could simply involve a second pump of equivalent capability. In addition, it is also acceptable to have multiple strategies to accomplish a function, in which case the equipment associated with each strategy does not require an additional spare.

For the SG makeup strategy the licensee has four SG makeup pumps, one for each unit plus two additional to meet the "N+1" provision, two inventory transfer pumps where only one is required to supply water from Lake Dardanelle, or the ECP, to the QCST or SFP makeup pump, which meets the "N+1" provision. For SFP makeup the licensee provided two SFP makeup pumps, either of which can supply the makeup need for both SFPs to meet the "N+1" provision. No portable pumping equipment is required for RCS makeup except the inventory transfer pumps as noted above. The alternative use of the installed ANO-2 charging pumps is addressed in Section 3.14.1 of this SE.

The electrical repowering strategy requires one FLEX PDG to power both units instead of one FLEX PDG per unit. This is in accordance with the provisions of Section 3.2.2 of NEI 12-06 which states that, it is also acceptable to have a single resource that is sized to support the required functions for multiple units at a site. Therefore, the NRC staff finds that having two FLEX PDGs available satisfies the "N+1" provision of NEI 12-06.

Based on the number of portable FLEX pumps, FLEX diesel generators, and support equipment identified in the FIP and during the audit review, the NRC staff finds that, if implemented appropriately, the licensee's FLEX strategies include a sufficient equipment for RCS makeup and boration, SFP makeup, and maintaining containment, consistent with the "N+1" recommendation in Section 3.2.2 of NEI 12-06.

3.6.3 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should protect the FLEX equipment during a BDBEE consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.7 Planned Deployment of FLEX Equipment

3.7.1 Means of Deployment

The licensee stated in its FIP, that debris removal equipment is stored inside the FLEX storage buildings to be protected from the severe storm and high wind hazards such that the equipment remains functional and deployable to clear obstructions from the pathway between the FLEX storage buildings and the deployment location(s). To implement the coping strategies beyond the initial plant capabilities, the pathway would be suitably cleared to allow for the deployment of onsite FLEX equipment between the FLEX storage building(s) and various staging locations. The stored FLEX equipment includes a front end loader to clear obstructions from haul paths and the loaders and heavy duty pickup trucks to tow FLEX equipment from the FLEX storage buildings location to the point of use.

3.7.2 Deployment Strategies

In its FIP, the licensee stated that pre-determined, preferred haul paths have been identified and documented in the FSGs. These haul paths have been reviewed for potential soil liquefaction and have been determined that soil liquefaction would not preclude FLEX implementation. Additionally, the haul paths attempt to avoid areas with trees, power lines, narrow passages, etc. when practical. However, high winds can cause debris from distant sources to interfere with planned haul paths.

The potential impairments to required access are: (1) doors and gates, and (2) site debris blocking personnel or equipment access. The coping strategy to maintain site accessibility through doors and gates is applicable to all phases of the FLEX coping strategies, but is immediately required as part of the activities required during Phase 1. Doors and gates serve a variety of barrier functions on the site. Other barrier functions include fire, flood, radiation, ventilation, tornado, and high energy line break. As barriers, these doors and gates are typically administratively controlled to maintain their function as barriers during normal operations. Following a BDBEE and subsequent ELAP event, FLEX coping strategies require the routing of hoses and cables to be run through various barriers in order to connect FLEX equipment to station fluid and electric systems.

For the SG makeup strategy, the FLEX inventory transfer pump would refill the QCST from the ECP for the duration of the Phase 2 coping time using hose connections provided at the QCST. The FLEX inventory transfer pump would be transported from one of the FLEX storage buildings to the staging platform located near the ECP. A hose would be routed from the FLEX inventory transfer pump discharge to the QCST tie-in connection. If the QCST is compromised due to a missile strike, the diesel-driven fire pump would be used to provide suction to the TDEFW pumps from the ECP or Lake Dardanelle. The fire water system to SW system cross-tie piping is located in the ANO-1 intake structure at plant grade elevation 354 ft. The FLEX SG makeup pumps would be transported from one of the FLEX storage buildings to the staging location west of the PASS building. Before the operating conditions of the TDEFW pump can no longer be maintained, hoses would be provided to connect the suction of the FLEX SG makeup pump to the QCST tie-in connection. Hoses would then be routed from the FLEX SG makeup pumps' discharges to either the primary or alternate connection for the ANO-1/2 SGs. The primary and alternate FLEX SG makeup pump discharge connections are located within the seismic category 1, tornado missile protected auxiliary building of each unit. The primary and alternate connection points inject through separate trains of EFW. The FLEX inventory transfer pump and the FLEX SG makeup pumps would be stored in the FLEX storage buildings and are, therefore, protected from the applicable BDBEE hazards.

The FLEX RCS strategy relies on the utilization of the ANO-2 charging pumps for RCS makeup in Modes 1 through 4, therefore no deployment of FLEX equipment is required for phase 2, except for the inventory transfer pump and PDG.

The FLEX PDG and temporary cables would be deployed from one of the FLEX storage buildings and connected to connection points (boxes) on or within the PASS building. One connection box is located on the PASS building roof at elevation 369 ft. and ties into a second connection box inside the PASS building at elevation 354 ft. The connection box on the roof represents the flood-protection connection point and would be accessed in advance of the flood event via access ladder. The temporary cables from the FLEX PDG staged on the flood protected platform can be pulled up the ladder manually or via rope ties. The second connection box, located inside the seismic Category I missile-protected PASS Building, serves as the primary connection option following a seismic or tornado wind/missile BDBEE.

For all non-flood BDBEEs, the flood door on the west wall of the PASS building would be opened to pull electrical cables from the FLEX PDG to the connection box inside. This door would remain open following non-flood BDBEEs for staging of Phase 2 electrical equipment. In the event a missile strike or seismic event renders the exterior door inoperable, new bolted, water-tight, steel plate penetration assemblies are installed which can be easily unbolted following the applicable event to feed the cables through from the outside of the building, to be pulled through to the connection point inside. Since both proposed motor control centers (MCCs) and the related battery chargers and inverters are Class 1E-qualified and installed inside seismic category I, missile-protected structures, the equipment is assumed to be available following a BDBEE. In addition, the new permanent conduit and equipment required to support this strategy has been designed consistent with the plants design basis requirements.

For Phase 3, the connection of the NSRC 4160 VAC generator to the existing 4160 VAC electrical bus can be made with temporary cable and connections. Personnel would first pull electrical cable through the plant up to switchgear rooms A3 or A4 and 2A3 or 2A4. Each unit has an identified point for connection of the NSRC 4160 VAC generators, which are capable of powering all unit-specific Class 1E loads for the FLEX strategy. The FLEX PDG would be stored in the FLEX storage buildings and is, therefore, protected from the BDBEE hazards.

3.7.3 FLEX Electrical Connection Points

For Phase 2, the licensee has developed a primary and alternate strategy for supplying power to equipment required to provide core cooling, containment, and SFP cooling using a combination of permanently installed, seismically robust components and cable reels stored in seismically robust FLEX storage buildings. A FLEX PDG and temporary power-cables are required to repower one of ANO-2 three charging pumps through diverse connections.

For ANO-1, the licensee installed a new safety-related air circuit breaker in 480 VAC Load Center B5. The circuit breaker allows a connection point for the 480 VAC FLEX PDG, allowing ac power to be distributed to ANO-1 safeguard loads during Phase 2. The licensee would utilize Load Center B5 as the primary connection point. This connection repowers whichever 125 VDC battery bank (006 or 007) was utilized during Phase 1, along with other critical loads (a battery room exhaust fan and pressurizer heaters). This allows a battery charger on the B5 bus, either D03A or D03B, to be repowered to charge Class 1E battery bank D07. An existing cross-tie between B5 and B6 allows the repowering of a battery charger on the B6 bus, either D04A or D04B, for Class 1E battery bank 006, if desired. In addition, this breaker would allow additional buses and non-essential loads on those buses to be repowered. The alternative strategy to repower the critical loads is to align the 480 VAC FLEX PDG with three new, dedicated breakers in 480 VAC MCCs B55, B61, and B65. ANO-1 and ANO-2 termination panels (TB1113/TB1114 and 2TB1008) are installed in the corridor outside the switchgear rooms on elevation 372' to split the incoming cables from the 480 VAC FLEX PDG and branch them to: 1) the load center, and three MCCs for ANO-1, and 2) 480 VAC load centers 2B5 and 2B6 for ANO-2.

The licensee's approach for ANO-2 is similar to ANO-1, utilizing the same connection points mounted on and within the PASS Building and providing connections to Load Center 2B5 and 2B6 via spare cubicles.

To provide for the repowering of a charging pump for the ANO-1 strategy and the battery charger and other critical loads for the ANO-2 strategy, the licensee installed new breakers in existing spare cubicles located in Load Centers 2B5 and 2B6. The newly installed breaker in 2B6 would support the primary strategy, and the newly installed breaker in 2B5 would support the alternate strategy. The 2B6 load center provides power to the 2P-36B and 2P-36C (swing) charging pumps. The 2B6 load center can also power the 2B5 load center through existing cross-tie breakers. The 2B5 load center provides power to the 2P-36A and 2P-36C charging pumps. As a result, any of the three ANO-2 charging pumps are capable of being powered to support the ANO-1 and ANO-2 FLEX strategies.

The licensee would deploy the FLEX PDGs and temporary cables from one of the FLEX storage buildings to areas near connection points (boxes) on or within the PASS building. One connection box is located on the PASS building roof at elevation 369' and ties into a second connection box inside the PASS building at elevation 354'. The connection box on the roof represents the flood-protection connection point and would be accessed in advance of the flood event via an access ladder. The temporary cables from the FLEX PDGs staged on the flood protected platform can be pulled up the ladder manually or via rope ties. The second connection box, located inside the seismic Category 1 missile-protected PASS Building, serves as the primary connection following a seismic or tornado wind/missile BDBEE.

For all non-flood BDBEEs, the flood door on the west wall of the PASS building would be opened to allow pulling electrical cables from the FLEX PDG to the connection box inside. This door would remain open following non-flood BDBEEs for staging of Phase 2 electrical equipment. In the event that a missile strike or seismic event renders the exterior door inoperable, the licensee installed new bolted, water-tight, steel plate penetration assemblies which can be unbolted following the applicable event to feed the power cables through from the outside of the building to the connection point inside. Since both the proposed MCCs and the related battery chargers and inverters are all Class 1E and installed inside seismic Category 1, missile-protected structures, the equipment is assumed to be robust, protected and available following a BDBEE. In addition, the new permanent conduit and equipment required to support this strategy has been designed consistent with the plant's design basis requirements.

The licensee's Phase 2 strategy relies on a FLEX PDG to power the existing installed electrical distribution system of both units. A 480 VAC PDG will supply power within 6 hours and will enable re-powering one train of battery chargers for each unit (prior to depletion of the station batteries), battery room ventilation fans, pressurizer heaters on ANO-1, one charging pump on ANO-2, and other critical loads. Temporary cables from the FLEX PDG would connect the PDG to PASS building temporary power connection (TPC) panels, each of which connects to a common distribution panel inside the robust PASS building. The following describes how the installed cables are routed from the common distribution panel in the protected PASS building to unit-specific distribution panels in each unit's auxiliary building.

- ANO-1 – ANO-1 distribution panel connects with installed cable to primary B5 load center breaker tie-in and three alternate B6 motor control center breaker tie-ins.

- ANO-2 – ANO-2 distribution panel connects with installed cable to primary load center 2B6 breaker tie-in and alternate load center 2B5 breaker tie-in.

Breaker tie-ins provide the means to re-power either 480 VAC Train. All cables and panels located inside the PASS and auxiliary buildings are robust for all BDBEEs.

For the flooding event at the ANO site, the licensee plans to deploy the FLEX Phase 2 480 VAC PDG on a new, elevated PASS platform that is located outdoors near the PASS building. The platform is above the maximum flood level. There is one PASS building TPC panel mounted on the PASS building roof. Secured temporary cables from the PDG on the platform will be routed to the new TPC panel on the PASS building roof. According to the licensee, the PASS platform is portable and can be installed within five day notice of an impending flood.

The licensee's cable deployment strategy during a flood scenario includes the acquisition and storage of 250-foot temporary cables that can be routed from the PDG staged on the PASS platform, down to the ground level and covered in sandbags as it is routed towards the PASS building, and secured to existing permanent fixtures as they ascend the PASS building to connect to the connection panel on the roof. These cables eliminate the submergence of the locking connectors that are used during the non-flood scenario. The route for the submerged cables includes a delay fence and a security fence, both of which extend above the flood elevation and act as debris filters, as well as a tight path between the BWST and the PASS building, further reducing the chance for debris large enough to drag the cables. The licensee would utilize existing permanent structures to tie off the cables and provide strain relief such that the force on the cables would not remove the mounting of the connection panel from the PASS roof.

In its FIP, the licensee stated that the Phase 3 NSRC 4160 VAC generators would be located adjacent to the ANO-1 reactor building equipment hatch for ANO-1 and just west of the bowling alley rollup door on ANO-2 turbine building, both on elevation 354'. The connection of the NSRC 4160 VAC generator to the existing 4160 VAC electrical bus can be made with temporary cable and connections. The craft would first pull electrical cable through the plant up to switchgear rooms A3 or A4 and 2A3 or 2A4. Each unit has an identified point for connection of the NSRC 4160 VAC generators.

3.7.4 Accessibility and Lighting

The licensee stated in its FIP, that lighting during Phase 1 would be limited to the 6-hour battery backed emergency lights and portable flashlights and lanterns. Phase 2 equipment includes portable diesel-powered light towers and battery operated lighting with 12-18 hour battery life before recharging attached to the pumps. Portable flashlights and helmet lights would be required for work in some areas of the plant (limited to indoor areas where lighting was not determined to be vital).

3.7.5 Access to Protected and Vital Areas

The licensee stated in its FIP, that doors and gates serve a variety of barrier functions on the site. Security doors and gates that rely on electric power to operate opening and/or locking mechanisms are barriers of concern. The security force would initiate an access contingency upon loss of the security diesel and all ac/dc power as part of the security plan and security procedures. Access to the owner controlled area, site protected area, and areas within the plant structures would be controlled under this access contingency as implemented by security personnel. The licensee has contingencies in place to provide access to areas required for the ELAP response if the normal access control systems are without power.

3.7.6 Fueling of FLEX Equipment

The licensee stated in its FIP, that the FLEX strategies for maintenance and/or support of safety functions involve several elements including the supply of fuel to necessary diesel-powered generators, pumps, hauling vehicles, etc. The portable components that rely on diesel fuel are stored with at least 10 hours of fuel supply. Before this fuel supply is depleted, diesel fuel from the onsite, underground, diesel fuel oil storage tanks would be utilized to refill FLEX equipment diesel tanks. Based on the electrical strategy, each diesel fuel oil transfer pump can be repowered utilizing the Phase 2 FLEX PDG via the respective MCCs. Two inch flanged hose connections located downstream of the P-16 pumps and downstream of the 2P-16 pumps are utilized normally for cross-connecting the ANO-1 and ANO-2 fuel oil systems and are credited as part of the Phase 2 FLEX strategy. Following a BDBEE, hose(s) would be connected and routed from the connection point either through the upper door (in a flood scenario) or through the lower door (in other scenarios) to the Phase 2 staging locations. One of the four pumps may then be repowered and used to transfer fuel to the Phase 2 FLEX equipment. This strategy will be implemented approximately 6 hours following a BDBEE. The earliest time needed to refuel equipment is approximately 9.5 hours after the initiation of the event (to refuel the diesel-driven fire pump).

The licensee also stated in its FIP that as the majority of FLEX equipment would be located west of the PASS building, the hydraulic requirements for providing fuel to this FLEX equipment from the P-16 and 2P-16 diesel fuel oil transfer pumps are bounded by the existing hydraulic requirements of those pumps. The P-16 and 2P-16 pumps currently discharge fuel oil to the emergency diesel generator (EDG) day tanks located in the EDG rooms in the ANO-1 and ANO-2 auxiliary buildings at elevation 369 ft. The highest elevation the FLEX equipment would be staged is on the flood platform, which is designed above the 361 ft. CLB probable maximum flood elevation, but below elevation 369 ft. where the existing fuel lines terminate. Therefore, it is reasonable that the P-16 and 2P-16 pumps would provide adequate flow to the FLEX staging area west of the PASS building for refueling FLEX equipment.

A flood platform is constructed in close proximity to the ECP for staging of the Phase 2 FLEX inventory transfer pump and can accommodate pre-staging of sufficient diesel fuel to operate the pump for 72 hours. The diesel fuel would be stored in barrels on the platform. Beyond 72 hours, offsite resources, including boats, could be used to refuel the FLEX inventory transfer pump, if necessary.

In addition, fuel from the diesel fuel oil storage tanks can be transferred to a FLEX trailer mounted 500 gallon fuel tank. This tank would be used to supply fuel to Phase 2 portable FLEX equipment which require diesel fuel to operate and not located in the staging area west of the PASS building, as in the case of the diesel-driven fire pump. Additionally, smaller fuel caddies with manual pumps are available to be staged with equipment such as the communications diesels, in order to extend run time of equipment having smaller fuel tanks.

The strategy described above for resupplying the diesel powered portable FLEX components involved transferring diesel fuel directly to the components from the diesel fuel oil storage tanks via hoses. If a BDBEE occurs during extreme cold temperatures, the fuel may be susceptible to gelling. Thus a separate strategy, as described below, is utilized during extreme cold ambient temperatures.

The initial fuel supply in the portable FLEX equipment stored in the FLEX storage buildings have chemical additives that lower the cloud point of the fuel below -15°F. Once the initial fuel supply in the portable equipment is depleted at approximately 10 hours, fuel would be transferred from the diesel fuel oil storage tanks to portable FLEX fuel trailers via the existing fuel storage hoses. Prior to filling the fuel trailers each time, chemical additives would be poured into the trailers and then the trailers filled with fuel from the vaults to prevent fuel gelling. The fuel trailers would then be transferred to the portable equipment staging locations to refuel equipment. With the use of fuel trailers, the hoses from the T-57 and 2T-57 underground fuel oil storage tanks can be returned to the diesel fuel vaults once the fuel trailers have been filled, thus protecting the hoses from the elements and preventing fuel gelling when the hoses are not in continuous use.

For ANO-1, the minimum volume of fuel available in each underground fuel oil storage tanks is 20,000 gallons. For ANO-2, the minimum volume of fuel available in each underground fuel oil storage tanks is 22,500 gallons. For ANO-1, the EDGs are rated at 2600 kW and the ANO-2 EDGs are rated at 2850 kW. Per the ANO-1 UFSAR, Section 8.3.1.1.7.2, and ANO-2 UFSAR, Section 9.5.4.1, there is sufficient diesel fuel in the onsite EDG storage tanks to power a combined ANO-1 and ANO-2 load of 5450 kW for 7 days of continuous operation with one fuel oil storage tank per unit unavailable. The following FLEX equipment would be operated following a BDBEE to directly maintain core cooling, containment integrity, and SFP cooling:

- One 800 kW PDG for both units,
- One ANO-1 SG makeup pump,
- One ANO-2 SG makeup pump,
- One SFP makeup and spray pump, and
- One inventory transfer pump.

Based on the pump specifications, the SG makeup pumps are approximately 250 hp, and the SFP makeup and spray and inventory transfer pumps are each approximately 100 hp. Based on the size of the FLEX equipment (800 kW + 700 hp*0.746 kW/hp = 1322 kW), there is sufficient diesel fuel onsite to power the diesel-driven FLEX equipment well beyond 72 hours since the combined FLEX equipment load would be well below the rating of a single EDG. After existing plant sources of fuel are exhausted, there would be ample time to have additional fuel provided from offsite resources as necessary during Phase 3.

The emergency preparedness (EP) communications diesel generators total fuel consumption for continuous operation requirement for a 72 hour period is approximately 346 gallons.

3.7.7 Conclusions

The NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should allow deploying the FLEX equipment following a BDBEE consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.8 Considerations in Using Offsite Resources

3.8.1 ANO SAFER Plan

There are two NSRCs (Memphis area and Phoenix area) established to support nuclear power plants in the event of a BDBEE. In its FIP, the licensee stated that it has established contracts with Pooled Equipment Inventory Corporation (PEICo) to participate in the process for support from the NSRCs as required. Each NSRC holds five sets of equipment, four of which will be able to be fully deployed to the plant when requested. The fifth set allows removal of equipment from availability to conduct maintenance cycles. In addition, the plant's FLEX equipment hose and cable end fittings are standardized with the equipment supplied from the NSRC.

By letter dated September 26, 2014 [Reference 26], the NRC staff issued its staff assessment of the NSRCs established in response to Order EA-12-049. In its assessment, the staff concluded that SAFER has procured equipment, implemented appropriate processes to maintain the equipment, and developed plans to deliver the equipment needed to support site responses to BDBEEs, consistent with NEI 12-06 guidance; therefore, the staff concluded in its assessment that licensees can reference the SAFER program and implement their SAFER Response Plans to meet the Phase 3 requirements of Order EA-12-049.

3.8.2 Staging Areas

The licensee stated in its FIP, that in the event of a BDBEE and subsequent ELAP/loss of normal access to the UHS condition, equipment would be moved from the NSRC to a local assembly area at either the Morrilton Airport ("C" Staging Area) or Clarksville Airport ("D" Staging Area) established by the SAFER team. The equipment can be taken to the ANO site "B" Staging Area (Cooling Tower Parking Lot) or staged at the FLEX storage building 1 where it would be deployed to the protected area for final setup. Communications would be established between the ANO plant site and the SAFER team via satellite phones and required equipment moved to the site as needed. First arriving equipment would be delivered to the site within 24 hours from the initial request. The order at which equipment is delivered is identified in ANO's SAFER Response Plan. Use of helicopters to transport equipment is recognized as a potential need within the ANO SAFER Plan and is provided for.

3.8.3 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should allow utilization of offsite resources following a

BDBEE consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01 and should adequately address the requirements of the order.

3.9 Habitability and Operations

3.9.1 Equipment Operating Conditions

3.9.1.1 Loss of Ventilation and Cooling

Following a BDBEE and subsequent ELAP event at ANO-1 and ANO-2, ventilation that provides cooling to occupied areas and areas containing required equipment will be lost. The licensee reviewed the local environmental effects resulting from a loss of ventilation. Portable electric fans with local portable generators may be used to provide ventilation to the control rooms. In Phase 3 NSRC provided turbine generators will be used to repower heating, ventilation, and air conditioning as directed by the Technical Support Center. The key areas identified for execution of the FLEX strategy activities are the ANO-1 and ANO-2 TDEFW Pump Rooms, Main Control Rooms (MCRs), Battery Rooms, Electrical Equipment Rooms, and Containment.

ANO-1 TDEFW Pump Room

The NRC staff reviewed the summary of Calculation CALC-10-E-0010-03 (EC28372), "ANO-1 EFW Room GOTHIC Heat-up Calculation," Revision 0. In this calculation, the licensee analyzed the TDEFW Pump room temperature heat-up following actuation of EFW and loss of normal heating, ventilating and air conditioning (HVAC). In its FIP, the licensee stated that this calculation determined that the temperature in the TDEFW pump room does not exceed 120°F over the duration of the analysis period of 72 hours. The maximum expected temperature (120°F) does not exceed the maximum temperature limit of 120°F as identified in NUMARC-87-00,"Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," Revision 1, for electronic equipment to be able to survive indefinitely. The licensee also stated in its FIP that following plant cooldown and depressurization, SG makeup could be transitioned from the TDEFW pump to the onsite portable FLEX SG makeup pump, if necessary.

ANO-2 TDEFW Pump Room

The NRC staff reviewed the summary of the revised ANO Calculation CALC-14-E-0002-03, "ANO-2 FLEX Heat Up," Revision 0, which showed that the ANO-2 TDEFW room temperature will reach a peak temperature of 152°F in 120 hours and will exceed the acceptance limit of 150°F. By letter dated January 12, 2016 [Reference 19], the licensee stated that the TDEFW pump will be secured within 72 hours if NSRC equipment had not yet been placed into service to cool the room by transitioning to the FLEX SG makeup pump. As such, the licensee stated that no additional actions are needed for this room. By letter dated January 12, 2016, the licensee also stated that CALC-91-E-0139-01 [Unit 2 Heat-up of Room 2024 (2P7A) with No Room Cooling," Revision 2], showed that operation of the TDEFW pump is not challenged up to 150°F. During the audit process the licensee also indicated that according to Woodward Governor Company, the EGM controls can be operated in an environment range of -60°F to 150°F.

Based on the licensee's calculations and the licensee's plans for TDEFW pump operation, the NRC staff finds that the ANO-1 and ANO-2 TDEFW pump systems should remain functional as long as they are operated in accordance with the planned strategy.

ANO-1 MCR

The NRC staff reviewed the summary of calculation CALC-13-E-0005-01, "ANO-1 FLEX Heat-Up," Revision 1, which showed that by performing mitigating actions the temperature in the MCR would not exceed 110°F for the first 120 hours. These mitigating actions are: 1) shedding any permanent lighting in favor of portable lighting 6 hours after the event; 2) opening certain MCR doors within 6 hours after the event; and 3) staging a fan to supply a minimum of 10,000 cubic feet per minute (cfm) of air in a doorway to exhaust air from MCR no later than 10 hours after the event. Long-term (i.e., after 120 hours) ventilation and cooling capability would be accomplished by plant operators repowering existing safety-related HVAC equipment utilizing the NSRC 4160 VAC FLEX combustion turbine generators. The staff verified that the licensee's applicable FSG provides procedural direction for operators to block open the required MCR doors until temporary forced ventilation is installed.

ANO-2 MCR

The licensee's calculation CALC-14-E-0002-03, "ANO-2 FLEX Room Heat-Up," Revision 0, analyzed room temperatures using GOTHIC [Generation of Thermal Hydraulic information in Containments] software. This calculation showed that by performing mitigating actions the temperature in the ANO-2 MCR would not exceed 110°F for the first 120 hours. The calculation specified certain mitigating actions to control and maintain peak temperatures to this level. These actions are: 1) opening selected doors, and 2) staging two fans to supply a minimum of 12,000 cfm of air in the area. Long-term (i.e., after 120 hours) ventilation and cooling capability would be accomplished by plant operators repowering existing safety-related HVAC equipment utilizing the NSRC 4160 VAC FLEX combustion turbine generators. The staff verified that the licensee's applicable FSG directs operators to block open selected MCR doors during implementation of this procedure until temporary forced ventilation is installed.

The mitigating actions discussed above will ensure that MCR temperatures for both ANO-1 and ANO-2 are lower than the maximum temperature limit of 120°F as identified in NUMARC-87-00,"Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," Revision 1, for electronic equipment to be able to survive indefinitely. Therefore, the NRC staff finds that the electrical equipment in the ANO-1 and ANO-2 MCRs should not be adversely impacted by high temperatures due to a loss of ventilation as a result of an ELAP event.

ANO-1 and ANO-2 Station Battery Rooms

The ANO-1 and ANO-2 safety-related batteries are manufactured by C&D Technologies. By letter dated July 1, 2016, the NRC staff previously documented a review of vendor manual information for similar safety-related batteries at Millstone Unit 2 [Reference 25]. This information establishes a maximum ambient operating temperature of 120°F for C&D batteries. The testing results indicate that the battery cells will perform as required in excess of 200 days at temperatures up to 122°F.

For ANO-1, the NRC staff reviewed the summary of calculation CALC-13-E-0005-01, "ANO-1 FLEX Heat-Up," Revision 1, for ANO-1 vital battery room temperature. In this calculation the licensee determined that the ANO-1 vital battery rooms may experience maximum peak temperatures of 101°F and 113°F, respectively, at 72 hours due to a loss of ventilation during an ELAP event. The licensee's compensatory measures included opening selected doors and deploying portable fans which will lower the room temperatures. In CALC-13-E-0005-01, the licensee established the maximum ambient temperature acceptance limit of 122°F for the ANO-1 vital battery rooms. Based on the analyzed peak room temperatures (101°F and 113°F) compared to battery ambient temperature acceptance limit of 122°F, the NRC staff finds that there should not be any adverse effects on battery performance due to higher expected room temperature, assuming that the licensee's compensatory measures are performed as projected.

The NRC staff reviewed the calculation CALC-14-E-0002-03, "ANO-2 FLEX Room Heat Up", Revision 0 and licensee evaluation on effects of high room temperature on the ANO-2 vital battery performance due to a loss of ventilation during an ELAP event. Table 2-1 of this calculation shows that the two battery room temperatures will reach 105°F and 106°F at 120 hours into the ELAP and will stay below the calculation's acceptance criteria (120°F) for the entire transient. The licensee's compensatory measures included opening selected doors and deploying portable fans which will lower the room temperatures. Based on the analyzed peak room temperature being below the battery ambient temperature acceptance limit of 120°F, the NRC staff finds that there should not be any adverse effects on battery performance due to higher expected room temperature, assuming that the licensee's compensatory measures are performed as projected.

ANO-1 Electrical Equipment Rooms

The NRC staff reviewed the summary of calculation CALC-13-E-0005-01 to assess the expected temperatures in the electrical equipment rooms within the ANO-1 Auxiliary Building due to loss of ventilation as a result of an ELAP. This calculation concluded that the analyzed peak temperatures for the Switchgear Rooms (99 and 100) and DC Equipment Room (109) are below 122°F. In Attachment 2 of CALC-13-E-0005-01, the licensee performed a detailed component review and established a revised maximum ambient temperature limit for electrical equipment in the three rooms listed above at 50°C (122°F). As such, the temperature limit of the ANO-1 electrical equipment located in rooms 100, 109 and 99 bounds the expected room temperature at 72 hours. The licensee's applicable FSG directs operators to take actions consistent with the temperature analysis including blocking open electrical equipment doors and providing temporary ventilation via a 10,000 cfm fan. These actions are also reflected in Table 1 of the licensee's FIP. Long-term cooling (i.e. after 72 hours), is accomplished by plant operators repowering safety-related HVAC equipment which are protected from all applicable BDBEEs. Based on above, the NRC staff finds that the above analyzed room temperatures should remain below the electrical equipment maximum ambient temperature limit of 122°F. In addition, licensee mitigation actions such as opening selected doors, deploying portable fans and plan repower HVAC equipment during Phase 3 will maintain the electrical equipment room temperatures below the equipment qualification maximum ambient temperature limits. For a flooding scenario with a 5 day persistence, it may be more difficult to perform the long-term actions at 72 hours to establish cooling. For this scenario, by letter dated January 12, 2016 [Reference 19], the licensee indicated that alternative capabilities for deploying NSRC equipment would be available. In addition, the licensee also indicated that the warning time postulated for the flooding scenario would allow the opportunity to make any necessary alternative plans, including the potential to use "SeaLand containers " as staging platforms, and arrange for corporate resources to deploy equipment, if needed. The NRC staff also notes that in this case the licensee would preemptively shut down both reactors to simplify event response.

ANO-2 Electrical Equipment Rooms

The NRC staff reviewed the maximum ambient temperature acceptance limits in Attachment 2 of CALC-14-E-0002-03 for electrical equipment (switchgears, small transformer etc.) rooms. This equipment is installed inside the ANO-2 Auxiliary Building. In Attachment 2, the licensee established a maximum ambient temperature acceptance limit of 50°C (122°F) for the electrical equipment rooms. In Table 2-1 of CALC-14-E-0002-03, the licensee determined that room temperature at 120 hours will remain below the acceptance limit of 122°F for all of the applicable rooms. However, the postulated peak temperatures at 3 hours exceed the acceptance limit of 122°F. The licensee's evaluation assumed that short-term (less than 8 hours) temperature excursions above 120°F are acceptable up to 150°F, consistent with NUMARC 87-00. The licensee discussed following mitigation actions to control and maintain room temperatures within the acceptance limits at 120 hours: 1) opening selected doors, and 2) staging two temporary portable fans to supply a minimum of 12,000 cfm of air in the area. Based on the licensee's evaluation, the NRC staff finds that higher room temperatures in the equipment rooms due to a loss of ventilation during an ELAP should not adversely impact equipment function and as such the credited electrical equipment will remain functional. Long-term cooling (i.e. after 120 hours), and ventilation is accomplished by plant operators repowering safety-related HVAC equipment which are protected from all applicable BDBEEs.

Thus, the NRC staff finds that the licensee's mitigation actions such as opening selected doors and deploying portable fans and repowering plant HVAC equipment during phase 3 should lower and maintain the room temperatures such that equipment in the room would remain functional for the ELAP duration.

ANO-1 Containment

The licensee's calculation for containment parameters, CALC-13-E-0005-02, "ANO-1 MAAP Containment Analysis for BDBEE," Revision 0, indicates that containment will reach a maximum temperature of 215.8°F at 120 hours and a maximum pressure of 23.7 psia at 120 hours. In the evaluation, the licensee stated that the environmentally qualified (EQ) equipment inside the ANO-1 containment had been evaluated to withstand a peak temperature of 283.9°F and a peak pressure of 53.96 psig (68.65 psia). By letter dated September 1, 2016 [Reference 60], the licensee provided further information, evaluating the thermal degradation of the applicable equipment inside containment for a profile representative of ELAP conditions, using the Arrhenius methodology for components not bounded by the EQ profile. This evaluation demonstrated that the equipment vendor's qualification testing of nonmetallic materials bounds the postulated plant ELAP parameters after the appropriate adjustments are made for the ELAP profile. Based upon that evaluation, the licensee concluded that the FLEX equipment inside containment will perform as intended under ELAP conditions. In addition, the ANO-1 mitigation strategy for a non-flood scenario specifies that NSRC equipment will arrive onsite in time to lower containment temperature and pressure well before the 120 hour analysis timeframe. For a flooding scenario, the timeframe to establish containment cooling could be longer due the flood persistence of up to 5 days, however that would be offset by the unit being shutdown prior to the ELAP occurring.

ANO-2 Containment

The NRC staff reviewed CALC-14-E-0002-01, "ANO-2 MAAP Containment Analysis for BDBEE," Revision 0, which indicated that the peak containment pressure for Modes 1 - 4 is 21.9 psia at 120 hours and peak containment temperature is 257.6°F within 120 hours. In the evaluation, the licensee stated that the ANO-2 EQ equipment (cables, penetration assemblies, connections and terminations associated with the instrumentations) inside Unit 2 Containment has been evaluated to withstand a peak containment temperature of 285°F and a peak containment pressure of 57.6 psig (72.29 psia). Thus, according to the licensee, equipment design limits bound the expected peak FLEX temperature and pressure. By letter dated September 1, 2016 [Reference 60], the licensee provided further information, evaluating the thermal degradation of the applicable equipment inside containment for a profile representative of ELAP conditions, using the Arrhenius methodology for components not bounded by the EQ profile. This evaluation demonstrated that the equipment vendor's qualification testing of nonmetallic materials bounds the postulated plant ELAP parameters after the appropriate adjustments are made for the ELAP profile. Based upon that evaluation, the licensee concluded that the FLEX equipment inside containment will perform as intended under ELAP conditions. In addition, similar to ANO-1, the mitigation strategy for an ANO-2 non-flood scenario specifies that NSRC equipment will arrive onsite in time to lower containment temperature and pressure well before the 120 hour analysis timeframe. For a flooding scenario the timeframe to establish containment cooling could be longer due to the flood persistence of up to 5 days, however that would be offset by the unit being shutdown prior to the ELAP occurring.

Based on the review of the essential station equipment required to support the FLEX mitigation strategy, which are primarily located in the MCRs, TDEFW Rooms, Station Battery Rooms, Auxiliary Building Electrical Equipment Rooms, and containments for ANO-1 and ANO-2, the NRC staff finds that the credited electrical equipment should perform their required functions at the expected temperatures and pressures as a result of loss of ventilation during an ELAP event.

3.9.1.2 Loss of Heating

The licensee performed Calculation CALC-14-E-0002-10, Revision 0, "ANO-FLEX - Extreme Cold Weather Evaluation," Revision 0. The licensee determined that there are no short-term concerns for the Control Room during cold weather. Long-term control room temperature control will be provided by using Phase 3 NSRC electric generators to repower the heating, air-conditioning, and ventilation systems as required and directed by the Technical Support Center.

During cold weather, the ANO-1 and ANO-2 vital battery rooms would be at normal operating temperature at the onset of the event and the temperature of the electrolyte in the cells would build up due to the heat generated by the batteries discharging and during re-charging. Furthermore, the battery rooms are located internal to the plant inside the Auxiliary Building, leading to a long time frame required for outside temperatures to cause the electrolyte in the cells to drop below the minimum design limit of 60°F. Therefore, reaching the minimum cell temperature limit is not expected. Long-term (i.e. after 120 hours), ventilation and cooling capability will be accomplished by plant operators repowering existing safety-related HVAC equipment utilizing the NSRC 4160 VAC FLEX combustion turbine generators.

Based on its review of the licensee's battery room loss of ventilation assessment, the NRC staff finds that the ANO-1 and ANO-2 safety-related batteries should perform their required functions at the expected temperatures as a result of loss of heating during an ELAP event.

3.9.1.3 Hydrogen Gas Control in Vital Battery Rooms

In its FIP, the licensee stated that an additional ventilation concern applicable to Phase 2 is the potential buildup of hydrogen in the battery rooms. Off-gassing of hydrogen from batteries is only a concern when the batteries are charging. Once the Phase 2 480 VAC FLEX PDG is available and the station Class 1E batteries begin recharging, power is also restored to the battery room ventilation exhaust fans on both units to maintain hydrogen accumulation below 1 percent.

Based on its review of the FIP, the NRC staff finds that hydrogen accumulation in the safety-related battery rooms should not reach the combustibility limit (4 percent) during an ELAP since the licensee plans to repower the battery room exhaust fans when the battery chargers are repowered during Phase 2.

3.9.2 Personnel Habitability

3.9.2.1 Main Control Room

To evaluate the ANO-1 MCR, the licensee performed Calculation CALC-13-E-0005-01. The calculation models various actions to mitigate the loss of normal ventilation due to an ELAP. The analysis concluded that by performing mitigating actions the temperature in the MCR would not exceed 110°F for the first 120 hours. Mitigating actions are addressed in CFSG-005 and 1FSG-004. These actions are:

- Shedding any permanent lighting in favor of portable lighting 6 hours after the event,
- Opening select doors to establish a ventilation path within 6 hours after the event,
- Staging a minimum of 10,000 cfm fan of air in the doorway at 10 hours after the event.

To evaluate the ANO-2 MCR, the licensee performed calculation CALC-14-E-0002-03. The calculation models various actions to mitigate the loss of normal ventilation due to an ELAP. The calculation concludes that by performing mitigating actions the temperature in the MCR would not exceed 110°F for the first 120 hours. Guidelines CFSG-005 and 2FSG-004 address the mitigating actions. These actions are:

- Shedding any permanent lighting in favor of portable lighting 6 hours after the event,
- Opening select doors to establish a ventilation path no later than 4 hours after the event,
- Placing a 12,000 cfm fan in a doorway to provide ventilation for the MCR no later than 10 hours after the event.

Long-term (i.e. after 120 hours) ventilation and cooling capability is accomplished by repowering existing safety-related heating, ventilating and air conditioning (HVAC) equipment, which is protected from all BDBEEs. There is margin remaining on the load capacity of the NSRC FLEX electrical generators and low pressure/high flow pumps that can be utilized to accommodate repowering the necessary fans/chiller units and support supplying necessary cooling water to equipment. Long-term habitability can be assured by monitoring of MCR conditions, heat stress countermeasures, and rotation of personnel to the extent feasible. In addition, FLEX support guidelines provide guidance for control room staff to evaluate MCR temperature and take actions as necessary. Bags containing door stops, rope, and cutting tools are included in the MCR FLEX kit and on mechanical trailers to assist in blocking open doors.

3.9.2.2 Spent Fuel Pool Area

The NRC staff reviewed the licensee's calculation on habitability on the SFP refuel floor. This calculation and the FIP indicate that boiling begins at approximately 9 hours (ANO-1) and 4 hours (ANO-2) during a normal, non-outage situation. The staff noted that the licensee's sequence of events timeline in the FIP indicates that operators will deploy hoses and align makeup within 9 hours for ANO-1 and 4 hours for ANO-2 from event initiation to ensure the SFP area remains habitable for personnel entry.

As described in the licensee's FIP, the licensee's Phase 1 SFP cooling strategy does not require any anticipated actions. However, the licensee does establish a ventilation path to cope with temperature, humidity, and condensation from evaporation and/or boiling of the SFP. The vent pathway normally consists of a low point and a high point opening to the atmosphere to create a stack effect to facilitate the flow of steam out of the SFP area and out of the high point vent. ANO plans to open various doors and the turbine building roof access hatches on each unit to establish ventilation paths.

3.9.2.3 Other Plant Areas

For ANO-1, calculation CALC-10-E-0010-03 determined the room temperature heat-up within the ANO-1 TDEFW pump room following actuation of EFW and loss of normal HVAC. This calculation determined that the temperature in the EFW pump room does not exceed 120°F over the duration of the analysis period of 72 hours. A temperature of less than 120°F is deemed acceptable for infrequent occupancy to allow local operation of turbine-driven EFW pump controls as required.

Following plant cooldown and depressurization, SG makeup can be transitioned to onsite portable FLEX SG makeup pump, if necessary, and occupancy of this room would not be required.

For ANO-2, calculation CALC-91-E-0139-01, determined the room temperature heat-up within the ANO-2 TDEFW pump room (Room 2024) following actuation of EFW and loss of HVAC. The calculation determined that the room temperature would reach 150°F approximately 108 hours into the event. The only time the operators need to access the room is when the RCS is undergoing cooldown, from hour 2 to approximately hour 5, according to Table 2 of the licensee's FIP. During this period of time, the temperature is calculated to be approximately 125°F. This temperature is deemed acceptable for infrequent occupancy to allow local operation of TDEFW pump controls as required. Following plant cooldown and depressurization, SG makeup can be transitioned to onsite portable FLEX SG makeup pump, if necessary, and occupancy of this room would not be required.

ADV Penthouse

Continuous, local manual control of the ADVs is not required for operation. Initial cooldown may require frequent valve adjustments and pressure monitoring; however, after the initial transient, ADV position would be effectively constant once SG pressure had been "dialed in" within the desired operating band. Only small, infrequent adjustments would be needed to compensate for changes in decay heat. For ANO-1, calculation CALC-13-E-0005-01, "ANO-1-FLEX Heat-Up," Revision 1, was performed by the licensee to model the worst case ADV area temperature responses following a BDBEE. The calculation models various actions to mitigate the loss of normal ventilation due to an ELAP. The results of the calculations show that for ANO-1, the temperatures in the ADV area remain below 128°F with no compensatory actions up to 120 hours post-event. There are no additional required actions to cope with ADV area temperatures at ANO-1 as the temperatures do not challenge the personnel habitability limits.

For ANO-2, CALC-14-E-0002-03, "ANO-2 FLEX Room Heat-Up," Revision 0, determined at least one door is to be opened no later than 3 hours to mitigate the temperature increase in the ADV room. The ADV penthouse was evaluated with two different cases. The first case evaluated the ADV penthouse with a 49 square foot ventilation path opened in the roof at 24 hours following a BDBEE, and the second case evaluated the ADV penthouse without the opened roof ventilation' path. In both cases, a selected door is opened at 3 hours. In both cases, the peak temperature in the ADV penthouse remains below the acceptance criteria for personnel habitability of 150°F. With the door and roof vent open, the ADV penthouse temperature does not exceed 130°F. As discussed above, long term SG pressure control by manual ADV operation is not expected to require continuous operator action.

Auxiliary Building

The Auxiliary Building electrical equipment rooms selected for the analysis are rooms that would have operating equipment required for the FLEX coping strategy (battery rooms, switchgear rooms, MCC room, and dc electrical equipment room). In CFSG-005, attachment 5 addresses mitigating actions to establish ventilation to electrical equipment rooms.

For ANO-1, the analysis (Calculation CALC-13-E-0005-01, "ANO-1-- FLEX Heat-Up," Revision 1) determined that mitigating actions are required to meet the acceptance criteria for the first 120 hours after the event. These mitigating actions consist of opening a combination of auxiliary building doors no later than 10 hours after the event, staging a 10,000 cfm fan, and exhausting air into the turbine building by 10 hours into the event.

For ANO-2, the analysis (Calculation CALC-14-E-0002-03, "ANO-2 FLEX Room Heat-Up," Revision 0) determined that mitigating actions are required to meet the acceptance criteria for the first 120 hours. These mitigating actions consist of opening select doors no later than 3 hours after the event, and placing a 12,000 cfm fan at a selected door by 10 hours into the event to exhaust air from the electrical equipment area. Long-term (i.e. after 120 hours) ventilation and cooling capability is accomplished by repowering existing safety-related HVAC equipment, which is protected from all BDBEEs, supported by NSRC-supplied electrical generators and cooling water pumps.

3.9.3 Conclusions

The NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore equipment and personnel habitability conditions following a BDBEE consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.10 Water Sources

3.10.1 Steam Generator Make-Up

In its FIP, the licensee stated that the QCST provides an EFW water source to the SGs at the initial onset of the event. It is normally aligned to provide emergency makeup to the SGs. The QCST meets the requirements in NEI 12-06 for protection from seismic, high winds, extreme heat, extreme cold, and flooding events. The QCST is susceptible to tornado missile strikes in accordance with the plants CLB. While the bottom 5 ft. of inventory in the QCST is protected from the design basis tornado missiles due to the presence of a 5-ft tall, concrete shield wall, additional volume is required of the QCST for FLEX following a tornado missile strike event. Following a BDBEE tornado missile strike, the QCST must provide sufficient inventory to allow time to manually align the diesel-driven firewater pump crosstie to the EFW suction.

The ECP and Lake Dardanelle are the water supplies to be used when the initial QCST volume is no longer available. The ECP has approximately 22.8 million gallons of storage capacity and is a source of water for the UHS. At a conservative consumption rate of 850 gpm (the transfer pump sizing criteria based on 250 gpm spray to each unit's SFP as well as 350 gpm to account for decay heat at both units), over 18 days of inventory is present within the ECP. The FLEX inventory transfer pump can use this source of water to transfer water from the ECP to the QCST or to the suction of the portable SFP makeup pump. Lake Dardanelle is the normal source of water for the UHS. For the TDEFW pumps and QCST, the use of inventory from Lake Dardanelle or the ECP is part of the CLB and is, therefore, acceptable for use.

For FLEX, non-standard inventory refers to the use of water that has not been demineralized for the purposes of feeding the ANO SGs. Lake Dardanelle and the ECP are the only non-standard water sources credited for all BDBEEs. Following a BDBEE, these sources of water would be used for SG makeup, which would require interfacing with the QCST, TDEFW pumps, SGs, and Phase 2 FLEX equipment.

For ANO-1, an analysis determined that the effects on the heat transfer capabilities using Lake Dardanelle or the ECP water as a long-term source of coolant for the SGs was negligible. The analysis conservatively assumed that makeup to the SGs is initiated 30 minutes following the BDBEE and continues for 120 hours. The analysis indicated that after approximately 120 hours, the heat transfer capabilities of each SG was reduced by 0.4 percent and 0.5 percent using ECP and Lake Dardanelle water, respectively. The SGs are designed to remove heat from the RCS at full power conditions. This decrease in heat transfer capability of less than 1 percent is deemed acceptable as the heat transfer requirements decrease exponentially after shutdown.

For ANO-2, an analysis determined that the effects on the heat transfer capabilities using Lake Dardanelle or the ECP water as a long-term source of coolant for the ANO-2 SGs. The analysis indicated that after approximately 120 hours, the heat transfer capabilities of each SG was reduced by 0.45 percent and 0.6 percent when using ECP and Lake Dardanelle water, respectively. Heat transfer reduction of less than 1 percent is acceptable because the SGs are capable of removing more heat than the minimum required with a 1 percent heat transfer loss.

Other sources of water that are not credited but may be used, if available after a BDBEE, are: the ANO-1 and ANO-2 CSTs, the ANO-1 and ANO-2 reactor makeup water tanks (RMWTs), and the raw water holdup tank

3.10.2 Reactor Coolant System Make-Up

In its FIP, the licensee listed the following water sources that can be used for RCS makeup:

ANO-2 Safety Injection Tanks

ANO-2 has large accessible volume in the SITs and is implementing a cooldown and depressurization strategy consistent with the PWROG core cooling recommendations for the ELAP scenario. Based on this recommendation, ANO-2 would initiate a cooldown 2 hours after the event. ANO-2 does not require RCS makeup early in the event as the inventory from the four SITs is sufficient for RCS makeup during a cooldown. The volume of the ANO-2 SITs is passively injected into the ANO-2 RCS to make up for volume contraction during cooldown and is adequate to maintain required inventory for 17.5 hours.

ANO-1 Borated Water Storage Tank

The BWST is located outside the reactor building and the auxiliary building. The BWST is a seismic Category I tank, but it is subject to wind/missile events. The tank contains a minimum of 2,270 ppm boron in solution. The BWST is subject to wind/missile events, and crediting a portion of this volume is an alternate strategy, as discussed in Section 3.14.3 of this SE. According to the licensee's FIP, the BWST nominal technical specification minimum level corresponds approximately to a volume of 370,100 gallons.

ANO-2 Boric Acid Makeup Tanks

Two BAMTs, located in the auxiliary building at elevation 386 ft. provide a source of boric acid solution for injection into the RCS. The BAMTs meet the requirements in NEI 12-06 for protection from seismic, wind/missile, extreme heat, extreme cold, and flooding events. The minimum total volume available is 20,358 gallons at a boron concentration of 6,125 parts per million (ppm). The BAMTs are the preferred borated water source for the RCS injection strategies.

ANO-2 Refueling Water Tank

The RWT, located west of the containment auxiliary building, is a 505,000 gallon capacity stainless steel tank. The tank was built to meet seismic Category I requirements, but is subject to wind and missile strikes. The RWT is subject to wind/missile events, and crediting a portion of this volume is an alternate strategy, as discussed in Section 3.14.3 of this SE. During Modes 1 through 4, the RWT borated volume is maintained between 384,000 and 503,300 gallons as required by Technical Specifications, at a boron concentration between 2,500 and 3,000 ppm.

Other sources of borated water that are not credited but may be used for RCS makeup, if available after a BDBEE, include the ANO-1 boric acid addition tank and core flood tanks.

3.10.3 Spent Fuel Pool Make-Up

The water supply for SFP makeup is the ECP or Lake Dardanelle as discussed in Section 3.10.1 above.

3.10.4 Containment Cooling

The licensee stated in its FIP that the structural integrity of the reactor containment building due to increasing containment pressure would not be challenged during the first 120 hours of an ELAP event, after which equipment from the NSRC will be available to provide cooling from the UHS.

3.10.5 Conclusions

The NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain satisfactory water sources following a BDBEE consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01 and should adequately address the requirements of the order.

3.11 Shutdown and Refueling Analyses

Order EA-12-049 requires that licensees must be capable of implementing the mitigation strategies in all modes. In general, the discussion above focuses on an ELAP occurring during power operations. This is appropriate, as plants typically operate at power for 90 percent or more of the year. When the ELAP occurs with the plant at power, the mitigation strategy initially focuses on the use of the steam-driven TDEFW pump to provide the water initially needed for decay heat removal. If the plant has been shut down and all or most of the fuel has been removed from the RPV and placed in the SFP, there may be a shorter timeline to implement the makeup of water to the SFP. However, this is balanced by the fact that if immediate cooling is not required for the fuel in the reactor vessel, the operators can concentrate on providing makeup to the SFP.

When a plant is in a shutdown mode in which steam is not available to operate the steam-powered pump and allow operators to release steam from the SGs (which typically occurs when the RCS has been cooled below about 300°F), another strategy must be used for decay heat removal. On September 18, 2013, NEI submitted to the NRC a position paper entitled "Shutdown/Refueling Modes" [Reference 41], which described methods to ensure plant safety in those shutdown modes. By letter dated September 30, 2013 [Reference 42], the NRC staff endorsed this position paper as a means of meeting the requirements of the order.

The position paper provides guidance to licensees for reducing shutdown risk by incorporating FLEX equipment in the shutdown risk process and procedures. Considerations in the shutdown risk assessment process include maintaining necessary FLEX equipment readily available and potentially pre-deploying or pre-staging equipment to support maintaining or restoring key safety functions in the event of a loss of shutdown cooling. The NRC staff concludes that the position paper provides an acceptable approach for demonstrating that the licensees are capable of implementing mitigating strategies in shutdown and refueling modes of operation.

In its FIP, the licensee stated that ANO would abide by the NEI position paper entitled "Shutdown/Refueling Modes" addressing mitigating strategies in shutdown and refueling modes. During the audit process, the NRC staff observed that the licensee had made progress in implementing this position paper.

Based on the information above, the NRC staff concludes that the licensee has developed guidance that if implemented appropriately should maintain or restore core cooling, SFP cooling, and containment following a BDBEE in shutdown and refueling modes consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.12 Procedures and Training

Procedures

In its FIP, the licensee stated that FLEX developed strategies (FDSs) are focused on maintaining or restoring key plant safety functions under the conditions of an ELAP and loss of normal access to the UHS and are not tied to any specific damage state or mechanistic assessment of external events. The FDSs are analogous to an Emergency Operating Procedure (EOP) and would be directed from the governing procedure/document in use at time of the BDBEE. This would be an EOP (Station Blackout) or abnormal operating procedure (AOP) (Loss of Decay Heat Removal or Loss of Shutdown Cooling/Lower Mode Functional Recovery). As the strategy is implemented, the FLEX documents (FDSs and FSGs) would be performed in conjunction with the controlling procedures in use.

The FSGs are guidelines that provide strategies relying on the use of installed and onsite portable equipment and resources to maintain or restore core cooling, containment, and SFP cooling capabilities during certain beyond design basis events. An FSG would be utilized in conjunction with (in parallel with) an ANO FDS. Procedural Interfaces have been incorporated into the station blackout procedures for each unit, to the extent necessary, to include appropriate reference to FDSs and provide command and control for the ELAP. The inability to predict actual plant conditions that require the use of FLEX equipment makes it impossible to provide specific procedural guidance. As such, the FDSs/FSGs would provide guidance that can be employed for a variety of conditions. Clear criteria for entry into FDSs/FSGs would ensure that FLEX strategies are used only as directed for BDBEE conditions, and are not used inappropriately in lieu of existing procedures. When FLEX equipment is needed to supplement EOPs or AOPs, the EOP or AOP would direct the entry into and exit from the appropriate FDS/FSG. FLEX strategy support guidelines have been developed in accordance with PWROG guidelines. FLEX support guidelines provide available, pre-planned FLEX strategies for accomplishing specific tasks in the EOPs or AOPs. The FSGs would be used to supplement (not replace) the existing procedure structure that establishes command and control for the event. The FSGs and FDSs have been reviewed and validated by the involved groups to the extent necessary to ensure the strategy is feasible. Validation was accomplished via table-tops of guidelines, walk-throughs, and/or drills of the guidelines.

Training

In its FIP, the licensee stated that ANOs Nuclear Training Program has a tracking action in place to assure personnel training in the mitigation of BDBEE is adequate and maintained. These programs and controls are being developed and are planned to be implemented in accordance with the systematic approach to training (SAT) process. Initial compliance training has been provided and periodic training is planned to be provided to site emergency response leaders on BDBEE emergency response strategies and implementing guidelines. Personnel assigned to direct the execution of mitigation strategies for BDBEE have received the necessary training to ensure familiarity with the associated tasks, considering available job aids, instructions, and mitigating strategy time constraints.

Based on the description provided above, the NRC staff concludes that the licensee's established procedural guidance meets the provisions of NEI 12-06, Section 11.4 (Procedure Guidance). Similarly, the NRC staff concludes that the training plan, including use of the SAT process for the groups most directly impacted by the FLEX program, meets the provisions of NEI 12-06, Section 11.6 (Training).

3.13 Maintenance and Testing of FLEX Equipment

As a generic issue, NEI submitted a letter to the NRC dated October 3, 2013 [Reference 43], which included Electric Power Research Institute (EPRI) Technical Report 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment." By letter dated October 7, 2013 [Reference 44], the NRC endorsed the use of the EPRI report and the EPRI database as providing a useful input for licensees to use in developing their maintenance and testing programs. In its FIP, the licensee stated that they would conduct maintenance and testing of the FLEX equipment in accordance with the industry letter.

The NRC staff finds that the licensee has adequately addressed equipment maintenance and testing activities associated with FLEX equipment because a maintenance and testing program has been established and will be maintained in accordance with NEI 12-06, Section 11.5.

3.14 Alternatives to NEI 12-06, Revision 0

3.14.1 Use of Installed Charging Pumps and Cross-Tie

For ANO-1 and ANO-2, the RCS inventory control strategy relies on re-powering one of the three ANO-2 charging pumps from a FLEX portable diesel generator. For ANO-1, the strategy further relies upon cross-connecting the charging pump to the ANO-1 HPI system. This strategy is considered an alternate method of compliance because it does not utilize a portable pump per the guidelines of Section 3.2.2(13) of NEI 12-06, Revision 0. Furthermore, the injection flow path for ANO-1 relies upon a section of cross-tie piping that does not satisfy the NEI 12-06 requirements for diversity and independence of flow paths. The justification for this alternative method is provided as follows.

The NRC Order EA-12-049 (Reference 3.1.2) states that the initial phase requires the use of installed equipment and resources to maintain or restore core cooling. The transition phase requires providing sufficient, portable, onsite equipment and consumables to maintain or restore these functions until they can be accomplished with resources from off site. In NEI 12-06, Revision 0, Section 3.2.2.13, further requires that all plants include the ability to use portable pumps for RCS makeup.

The licensee's proposed use of an ANO-2 charging pump for RCS inventory control (which supports core cooling) for both ANO-1 and ANO-2 contains some features that provide for the use of portable onsite FLEX equipment. A portable FLEX generator and temporary power cables are used to repower one of three charging pumps through diverse connections. Further, the charging pumps are robust for all BDBEEs and thus would be expected to be available for BDBEE response. Any of the three pumps can supply the required makeup flow for both units and any of the pumps can be isolated from ANO-2's main charging pump header in case of failure. For ANO-1 specifically, high pressure hoses are used to make the final connections to the permanently installed cross-tie header, which is robust for all BDBEE's. The NRC staff observes that any reduction in flexibility caused by using installed pumps in lieu of portable ones is mitigated by the ability to provide early makeup flow, which is especially important for ANO-1.

While the use of the installed ANO-2 charging pumps generally results in a diverse means of delivering RCS makeup flow, there is an installed cross-tie that allows the use of the ANO-2 charging pumps to feed the ANO-1 RCS, when the associated hoses are installed. This cross-tie provides a single point of piping that, if it were to fail, would inhibit RCS makeup flow from reaching ANO-1. Thus it does not fully meet the intent of NEI 12-06, Table D-1 provisions for injection through separate trains. Based on the installation of the cross-tie piping in a seismically robust manner, within seismically qualified and missile-protected buildings, and due to the limited amount of common piping, the NRC staff views the alternative as acceptable, and therefore concludes that the ANO-1 strategy for RCS inventory control is acceptable.

3.14.2 Pre-staging FLEX Equipment for Floods

Per the FIP, the licensee has two platforms to be used during a flood event. One platform is 21'x 50' with a deck elevation at 363' msl, above the PMF level of 361' msl, and will be staged north of the QCST. A 16'x 20' platform is permanently installed near the ECP for the FLEX inventory transfer pump. The platforms generally only have enough room to accommodate one set of FLEX equipment and thus the licensee's plan only pre-stages "N" sets of equipment before the flood cuts off normal access to the site. This pre-staging is listed as an alternative in the licensee's FIP.

Upon notification of predicted flood conditions at the ANO site, pre-staging of equipment is conducted under the guidance of a model work order. The work order is activated once the natural emergency procedures OP-1203.025 and OP-2203.008 direct the activities to commence. In addition, the Entergy corporate severe weather procedure EN-FAP-EP-010 has generic checklists for preparation of the site for severe weather conditions that may be beneficial as the site commences pre-staging of FLEX equipment. These procedures require notification to the Entergy Corporation headquarters to identify and request additional support equipment. Equipment from the corporation would be dispatched to the ANO site to assist. This equipment includes water vessels capable of moving heavy equipment, supplies, consumables, etc., to areas susceptible to flood waters, at any flood depth or level. This additional equipment would be available to assist in maintenance and refueling of equipment during all conditions as necessary.

In the extreme licensing basis flood there is 5 days of time following initial notification to perform actions to prepare for the flood. Station natural emergencies procedures have been revised to reference a model work order for flood preparations that reflect the capabilities of the FLEX equipment and provide for the flood preparation actions to ensure the plant can respond to an ELAP event should one occur in a flood condition. Included in these improvements are the actions that direct the notification to the Entergy Corporation. Activation of the corporate Emergency Response Center would drive pre-staging the equipment at or near the ANO site that is necessary (airboats, vessels, etc.) to maintain and refuel the FLEX equipment. This equipment is available throughout the Entergy service territory and can be readily delivered to the ANO site in an expeditious manner.

Depending on the actual conditions expected to be experienced during the flooding event the preparation activities would be different (e.g., storm conditions may make pre-staging the backup equipment unadvisable). Nevertheless, the model work order includes the following considerations as part of the determination of the appropriate preparation activities:

1. The use of a portable "SeaLand" container functioning as a temporary platform. The container is of the same approximate height as the FLEX platforms and cribbing can be used to ensure a level surface. The interior of the container can be loaded with material (sand, concrete blocks, etc.) to ensure container stability during rising water levels. These containers are readily available on site and the capability to relocate the containers is accomplished with common commercially available equipment.

2. Since both units would shutdown and cooldown in response to rising flood levels, two FLEX SG makeup pumps can accommodate the required flows for this scenario and additional generator capacity can be staged on the PASS FLEX platform. Currently, the strategy stages three pumps and one portable diesel generator on the platform. It is acceptable to remove one pump and replace with an additional diesel generator as the platform can take this load combination and can accommodate the placement of the additional diesel generator.

Therefore, the NRC staff concludes that there are sufficient options available to site decision makers to deploy the appropriate site-based and NSRC equipment as required, using corporate or NSRC-supplied resources. These decisions would be made considering actual site and equipment conditions as well as the actual flooding scenario that may be presented. Based on the flexibility and capability afforded by the licensee's broad-based emergency response organization, the staff finds the licensee's plans to be acceptable.

3.14.3 Use of the QCST, ANO-1 BWST and the ANO-2 RWT Following Design Basis Missile Strike

The NRC staff reviewed the licensee's analyses, including a finite element analysis (FEA) for the QCST, RWT, and BWST during a high wind/missile event. For these three tanks, the licensee used a methodology that differs from the plant's design-basis regarding the tornado evaluation input parameters. Specifically, the licensee utilized Regulatory Guide (RG) 1.76, Revision 1, versus the parameters in the ANO design basis. Since NEI 12-06, Revision 0 defines "robust" as meeting or exceeding the plant's design basis, the use of RG 1.76, Revision 1 does not meet this definition for ANO. Therefore the licensee proposed the use of RG 1.76, Revision 1 as an alternative to NEI 12-06. The QCST was analyzed up to the second course elevation and the RWT/BWST combination was evaluated to ensure that they would contain a minimum usable volume of 100,000 gallons after a tornado missile impact. The FEA is documented in Tobolski Watkins Engineering, Inc. Document Number 2013-0771-DC-002, "Arkansas Nuclear One – Tank Impact Analysis: Phase 2 FEA Report," Revision 5, dated March 27, 2015. During the audit process the licensee generated a supplemental engineering report CALC-ANOC-CS-15-00005, "FLEX Tornado Missile Impact Analysis, NRC Correspondence," Revision 0. The NRC review of the FEA calculation and supplemental report concluded that the licensee had used appropriate assumptions and methodology for the analysis of the three tanks. Further, the NRC staff finds the use of RG 1.76, Revision 1, to be acceptable because it reflects the current NRC review standard in this topic area. This conclusion applies only to the evaluation of this BDB order, not generally to the site's existing licensing and/or design basis.

3.14.4 Reduced Set of Hoses and Cables as Backup Equipment

In its FIP, the licensee proposed an alternative approach to the NEI 12-06 guidance for hoses and cables. In NEI 12-06, Section 3.2.2 states that in order to assure reliability and availability of the FLEX equipment required to meet these capabilities, the site should have sufficient equipment to address all functions at all units on-site, plus one additional spare, i.e., an "N+1" capability, where "N" is the number of units on-site. Thus, a single-unit site would nominally have at least two portable pumps, two sets of portable ac/dc power supplies, two sets of hoses & cables, etc. The NEI, on behalf of the industry, submitted a letter to the NRC [Reference 46] proposing an alternative regarding the quantity of spare hoses and cables to be stored on site. The alternative proposed was that either a) 10 percent additional lengths of each type and size of hoses and cabling necessary for the "N" capability plus at least one spare of the longest single section/length of hose and cable be provided or b) that spare cabling and hose of sufficient length and sizing to replace the single longest run needed to support any FLEX strategy. By letter dated May 18, 2015 [Reference 47], the NRC agreed that the alternative approach is reasonable, but that the licensees may need to provide additional justification regarding the acceptability of various cable and hose lengths with respect to voltage drops, and fluid flow resistance. Part of the basis for the approval of the NEI alternative is that a licensee would have "N" capability assured for all postulated BDBEEs, including tornados.

The ANO FIP indicates that the licensee plans to use the alternative for the SFP makeup and charging hoses, where "N" sets of the hoses are stored in fully protected portions of the Auxiliary Buildings. The FIP indicates that the spare length of the charging hoses needed to meet the provisions of the alternative are stored in a fully protected structure. The FIP further indicates that the spare hose lengths for the SFP makeup strategy are stored in the FLEX storage buildings such that enough hose to meet the alternative is stored in each FLEX storage building. The NRC staff finds that the licensee's storage plan for the SFP makeup and charging hoses meets the requirement to have "N" sets of hoses and cables fully protected from all hazards. The staff also finds that the licensee's plan maintains sufficient, protected spare hoses consistent with the alternative. Therefore, the licensee's plan for the SFP makeup and charging hoses as described in the FIP, is acceptable. For any other portion of the strategy (i.e. other than the SFP makeup and charging hose storage described above) for which hoses and cables are exclusively stored in the FLEX storage buildings, full "N" sets would be required in each building. Based on this clarification, the NRC staff approves the licensee's proposed alternative as being an acceptable method of compliance with the order.

In conclusion, the NRC staff finds that although the guidance of NEI 12-06 has not been met in these cases, if the alternatives are implemented as described by the licensee, they should meet the requirements of the order.

3.15 Conclusions for Order EA-12-049

Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance to maintain or restore core cooling, SFP cooling, and containment following a BDBEE which, if implemented appropriately, should adequately address the requirements of Order EA-12-049.

4.0 TECHNICAL EVALUATION OF ORDER EA-12-051

By letter dated February 28, 2013 [Reference 27], the licensee submitted its OIP for ANO-1 and ANO-2 in response to Order EA-12-051. By letter dated June 26, 2013 [Reference 28], the NRC staff sent a request for additional information (RAI) to the licensee. The licensee provided a response by letter dated July 25, 2013 [Reference 29]. By letter dated October 29, 2013 [Reference 30], the NRC staff issued an ISE and RAI to the licensee.

By letters dated August 28, 2013 [Reference 31], February 27, 2014 [Reference 32], August 28, 2014 [Reference 33], February 24, 2015 [Reference 34], and August 28, 2015 [Reference 35], the licensee submitted status reports for the Integrated Plan. The Integrated Plan describes the strategies and guidance to be implemented by the licensee for the installation of reliable SFPLI which will function following a BDBEE, including modifications necessary to support this implementation, pursuant to Order EA-12-051. By letters dated April 14, 2015 [Reference 37], and January 12, 2016 [Reference 38], the licensee reported that full compliance with the requirements of Order EA-12-051 had been achieved for ANO-1 and ANO-2, respectively.

The licensee has installed a SFPLI system designed by MOHR Test and Measurement, LLC (MOHR) at ANO-1 and ANO-2. The NRC staff generically reviewed the MOHR SFPLI system design specifications, calculations and analyses, test plans, and test reports during a vendor audit. The staff issued an audit report on August 27, 2014 [Reference 36] to document that review.

The staff also performed an onsite audit at ANO to review the implementation of SFPLI. The scope of the audit included verification of whether the (a) site's seismic and environmental conditions are enveloped by the equipment qualifications, (b) equipment installation meets the order requirements and vendor's recommendations, and (c) program features meet the order requirements. By letter dated September 1, 2015 [Reference 18], the NRC issued an audit report on the licensee's progress toward meeting the requirements of Order EA-12-051.

4.1 Levels of Required Monitoring

In its OIP, the licensee stated that Level 1 is the level adequate to support operation of the normal fuel pool cooling system. It is the higher of the level at which reliable suction loss occurs due to uncovering the coolant inlet pipe or any weirs or vacuum breakers associated with suction loss. This level, is established for ANO-1 based on nominal coolant inlet pipe elevation (as it does not incorporate a vacuum or siphon breaker) and is established for ANO-2 based on nominal vacuum (or siphon) breaker elevation. The elevation associated with this level is 397 feet 5.21 inches for ANO-1 and is 401 feet 0 inches for ANO-2. Level 2 is the level adequate to provide substantial radiation shielding for a person standing on the spent fuel pool operating deck. Level 2 is elevation 385 feet 11.5675 inches ± 1 foot for ANO-1 and Level 2 is elevation 388 feet 3.3125 inches ± 1 foot for ANO-2. Level 3 is the level at which fuel remains covered and actions to implement water addition should no longer be delayed. The licensee's compliance letters dated April 14, 2015 [Reference 37], and January 12, 2016 [Reference 38], for ANO-1 and ANO-2 respectively, specify that Level 3 corresponds to the level associated with the highest point of any fuel rack seated in the spent fuel pool ± 1 foot. According to the licensee, the highest point (nominal) of any fuel rack seated in the spent fuel pool is 375 feet 11.5675 inches for ANO-1 and 378 feet 3.3125 inches for ANO-2. Guidance document NEI 12-02 specifies that Level 3 corresponds nominally to the highest point of any fuel rack seated in the spent fuel pool ± 1 foot. It stipulates that Level 3 is defined in this manner so as to provide the maximum range of information to operators, decision makers and emergency response personnel, and that designation of this level should not be interpreted to imply that actions to initiate water make-up must or should be delayed until this level is reached. NEI 12-02 also specifies that all three levels must be monitored by the selected instrument.

The NRC staff notes that the designated Level 1 is adequate for normal SFP cooling system operation and it is also adequate to ensure the required fuel pool cooling pump NPSH. This level also represents the higher of the two points described in NEI 12-02, Section 2.3.1 for Level 1. The designated Level 2 range using the first of the two options described in NEI 12-02 for Level 2, which is 10 feet ± 1 foot above the highest point of any fuel rack seated in the SFP. The licensee's designated Level 3 range corresponds nominally (± 1 foot) to the highest point of any fuel rack seated in the SFP.

Based on the discussion above, the NRC staff finds that the licensee's proposed Levels 1, 2 and 3 are consistent with NEI 12-02, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2 Evaluation of Design Features

Order EA-12-051 required that the SFPLI shall include specific design features, including specifications on the instruments, arrangement, mounting, qualification, independence, power supplies, accuracy, testing, and display. Below is the staff's assessment of the design features of the SFPLI at ANO.

4.2.1 Design Features: Instruments

In its OIP, the licensee stated that for both the ANO-1 and ANO-2 SFPs, that both the Primary and Backup Instrument Channels will utilize permanently-installed instruments, and that each instrument channel will be capable of monitoring SFP water level over a single continuous span from above Level 1 to within 1 foot of the top of the spent fuel racks (Level 3).

In its letter dated July 25, 2013, the licensee further stated that the SFP level lower instrument span or probe bottom extends down to at least three inches below the upper limit of the range of Level 3 to account for channel accuracy or instrument loop uncertainty. Therefore, the SFP level probe bottom/span extends down to at least elevation 376 feet 8.5675 inches for ANO-1 and 379 feet 0.3125 inches for ANO-2. The licensee indicated that the SFP level upper instrument span encompasses the level associated with the normal water level high alarm.

The NRC staff notes that the range specified for the licensee's instrumentation will cover the licensee-designated Levels 1 and 2. However, the staff also notes that the lower instrument span does not extend fully down to the top of the spent fuel racks, stopping approximately 9 inches above that level. This lower range of monitoring falls within the NEI 12-02 provision of the highest point of any fuel rack seated in the spent fuel pool plus or minus one foot. Thus, the staff finds that this level provides the maximum range of information to operators, decision makers and emergency response personnel consistent with the intent of NEI 12-02. Further, the staff notes that even though the licensee has specified Level 3 as a range of values (i.e. ± 1 foot) operational action must be taken based on a specific value or setpoint. The licensee takes action to initiate/align water make-up per procedures FDS-001 and FDS-002, for ANO-1 and ANO-2 respectively, at an elevation of 15 feet above the top of the fuel seated in the racks. Since this is well before Level 3 is approached, the staff also concludes that actions to initiate water make-up are not delayed unnecessarily.

The NRC staff finds that the licensee's design, with respect to the number of channels and measurement range for its SFP, is consistent with the intent of NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.2 Design Features: Arrangement

In its OIP, the licensee provided approximate instrument locations for ANO-1 and ANO-2. As specified in Order EA-12-051, separation of the channels/probes provides a method to protect against missiles affecting both channels of instrumentation. By letters dated July 25, 2013 [Reference 29] and August 28, 2013 [Reference 31], the licensee stated that cables on the SFP floor would be routed in protective metal raceway. The licensee's OIP also states that additional protection may also be afforded by objects in the vicinity which rise above the floor grade (e.g. SFP curbs and/or SFP Bridge tracks/rails). The location of the display/processors is in the MCR.

In its OIP, the licensee also provided sketches depicting the proposed locations of the instruments. For ANO-1, the licensee proposed to implement one fixed primary level instrument in the northeast corner of the SFP and the backup level instrument in the northwest corner of the SFP. For ANO-2, the licensee proposed to implement one fixed primary level instrument in the southeast corner of the SFP and the backup level instrument in the southwest corner of the SFP.

In its letter dated July 25, 2013, the licensee stated that each level measurement channel is physically separated and independent, from level sensor through the display/read-out device. In the vicinity of the SFP, level sensors and cabling maintain spatial separation to minimize the potential for falling debris or missiles to impact both channels with level sensors located near opposite corners of the SFP and with cable routing both maintaining this relative separation and incorporating seismically mounted protective metal raceway until exiting the SFP area. By letter dated August 28, 2014 [Reference 33], the licensee updated the description of the ANO-2 SFP area cable routing relative spatial separation. One channel's floor penetration location (and related cable routing) was revised due to interference on the elevation below. The change resulted in a decrease in the relative spatial separation between the two channels (i.e., spatial separation less than the SFP's short side corner separation distance). However, spatial separation was maintained at approximately 75 percent of the distance original planned.

In its letter dated August 28, 2014, the license further stated that an exclusion zone of two square feet around the probe is the minimum clearance required to prevent any tools or devices from disturbing the function of the probe.

The NRC staff noted, and verified by walkdown during the onsite audit, that there is sufficient channel separation within the SFP area between the primary and back-up level instruments, sensor electronics, and routing cables to provide reasonable protection of the level indication function against missiles that may result from damage to the structure over the SFP.

The NRC staff finds that the licensee's arrangement for the SFPLI, if implemented appropriately, is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.3 Design Features: Mounting

In its OIP, the licensee stated that both the primary and backup system installation will incorporate seismic category 1 mounting to meet the NRC JLD-ISG-2012-03 and NEI 12-02 guidance requirements. Other hardware stored in the SFP will be evaluated to ensure that it does not adversely interact with the SFP instrument probes during a seismic event.

In its letter dated July 25, 2013, the license stated that the loading on the probe mount and probe body includes both seismic and hydrodynamic loading using seismic response spectra that bound the ANO units' design-basis maximum seismic loads applicable to the installation location(s). The static weight load is also accounted for but is insignificant in comparison to seismic and hydrodynamic loads. Seismic loading response of the probe and mount is separately modeled using finite element modeling software. The fluid motion profile in the pool at the installation site and resultant distributed hydrodynamic loading terms are added to the calculated seismic loading terms in the finite element model to provide a conservative estimate of the combined seismic and hydrodynamic loading terms for the probe and probe mount, specific to the chosen installation location for the probe. The proximal portion of the level probe is designed to be attached near its upper end to a seismic category 1 mounting bracket. The bracket may be bolted and/or welded to the SFP deck and/or SFP liner/wall according to the requirements of the particular installation per seismic category 1 requirements.

In its letter dated April 14, 2015, the licensee further stated that the site-specific seismic analysis performed for ANO bounds the site's seismic criteria. The qualification report envelopes all components of the new SFPLI required to be operational during a BDBEE and post-event. The licensee also stated that the seismic qualification report, in combination with certain NAI [Numerical Applications, a division of Zachry Nuclear Engineering, Inc.] reports applicable to the installation, adequately bound the hydrodynamic loads associated with sloshing for ANO. Calculations for both units account for sloshing and shows that the SFP instrumentation (SFPI) probe mounting bracket is structurally adequate and seismically qualified as all Interaction Ratios (IR) are less than one (1.0). The licensee's letter dated April 14, 2015, also indicates that the seismic qualification of system enclosures (display/processor, battery) was documented and that equipment and raceways are installed/mounted to ANO seismic category I requirements.

The staff verified the licensee's response during the audit process by a site walkdown and by reviewing the following:

- Calculation NAI 1791-003, "Seismic Induced Hydraulic Response in the Arkansas Nuclear One Spent Fuel Pool," Revision 0 concludes that an estimate of the slosh heights along the SFP wall calculated as the average collapsed liquid level 0-12 in. from the wall. The peak slosh height estimated was about 4.3 in. which is considerably less than the approximate 17.9 ft. calculated for the design reference case. Analysis of the ANO SFP has revealed that the ANO SFP hydrodynamic response is substantially lower than the hydrodynamic response calculated for the generic reference case which was used for the probe design.

- Calculation CALC-13-E-0005-07, "Design of SFPI Probe Mounting Bracket," Revision 0 for ANO-1 and Calculation CALC-14-E-0002-11, "ANO-2 Design of SFPI Probe Mounting Bracket," Revision 0 for ANO-2 demonstrate the adequacy of the probe mounting brackets' seismic design.

- In EC 44046, "ANO-1 Spent Fuel Pool Level Instrumentation Upgrade," Revision 0 and EC 48348, "ANO-2 Spent Fuel Pool Level Instrumentation Upgrade," Revision 0, the licensee stated that the probe mounting bracket is qualified to meet structural design and seismic category 1 requirements. Anchorage into concrete meets the site design requirements. The anchorage of control room equipment, including the electrical boxes, displays and transformers and the support design for conduits meets seismic category 1 requirements.

- In its Calculation CALC-14-E-0002-15, "ANO-2 Seismic Qualification of Control Room Panels 2C501-1 & 2C501-2," Revision 0, the licensee stated that the anchorage to concrete control room equipment, including the battery enclosures, displays, sub-panels and transformer enclosures meets seismic category 1 requirements.

The NRC staff finds that the licensee addressed the appropriate SFPI mounting requirements. Specifically, the site-specific seismic analyses demonstrated that the SFPLI's mounting design is satisfactory to allow the instrument to function following the maximum postulated seismic ground motion.

Based on the discussion above, the NRC staff finds the licensee's proposed mounting design is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.4 Design Features: Qualification

4.2.4.1 Augmented Quality Process

In its OIP, the licensee stated that augmented quality requirements will be applied to all components in the instrumentation channels for:

- design control
- procurement document control
- instructions, procedures, and drawings
- control of purchased material, equipment, and services
- inspection, testing, and test control
- inspections, test, and operating status
- nonconforming items
- corrective actions
- records
- audits

In its letter dated April 14, 2015, the licensee further stated that the SFPI channels have been designated as augmented quality per the Entergy processes covering procurement, design, and installation. As such, the SFP instrument channels will have demonstrated reliability at the applicable environmental extremes.

The NRC staff noted that the licensee's proposed augmented quality assurance process is consistent with NEI 12-02, as endorsed, by JLD-ISG-2012-03. If implemented appropriately, this approach is consistent with NEI 12-02 guidance, and should adequately address the requirements of the order.

4.2.4.2 Instrument Channel Reliability

4.2.4.2.1 Temperature, Humidity, and Radiation

In its OIP, the licensee stated that components in the area of the SFP will be designed for the temperature, humidity, and radiation levels expected during normal, event, and post-event conditions for no fewer than seven days post-event or until off-site resources can be deployed by the mitigating strategies resulting from Order EA-12-049. Equipment located in the SFP will be qualified to withstand a total accumulated dose of expected lifetime at normal conditions plus accident dose received at post event conditions with SFP water level within 1 foot of the top of the fuel rack seated in the SFP. The metal probe and cable in the spent fuel pool area are robust components that are not adversely affected by expected radiation, temperature, or humidity. The areas selected for display/processor installation are considered mild environments, such that personnel access is not prohibited by radiation, temperature, or humidity, and are readily accessible by operators during or after a BDBEE.

In its letter dated April 14, 2015, the licensee further stated that the primary and backup SFPI channel displays for ANO-1 and ANO-2 are located in the MCR. According to the licensee's calculation, successful implementation of the FLEX strategy results in a peak MCR temperature of 110°F for ANO-1 during an ELAP. Likewise, the peak temperature under ELAP conditions for the ANO-2 MCR was calculated to be 110°F. The SFPI vendor successfully tested its system electronics to a nominal temperature range of 14°F to 131°F and a humidity range of 5 percent to 95 percent relative humidity (RH). The MCR is regulated by the HVAC system to normally operate at 75°F with a nominal RH of 43 percent for ANO-1 and 50 percent for ANO-2 although it fluctuates through an estimated range of 30-60 percent. During an ELAP, the HVAC system is no longer available. Prior to the doors from the MCR to the turbine building being opened at 4 hours, the relative humidity is expected to drop as temperature rises, because the heat loads in the MCR are dominated by the sensible heat of electrical equipment. At 4 hours, the doors from the MCR to the turbine building will be opened, exposing the MCR to atmospheric humidity. Under circumstances in which extreme heat is anticipated at ANO, the worst-case outside conditions are expected to be at 43 percent RH (103°F db/83°F wb) according to the ANO-1 UFSAR or 30 percent RH (105°F db/77.5°F wb), per the licensee's site calculation. These conditions are bounded by the 47°C (116.6°F) and 71 percent RH test case presented in MOHR qualification report.

According to the licensee's letter dated April 14, 2015, the SFP is expected to remain at or above the minimum ambient temperature of the Auxiliary Building (60°F) as called out in ANO-1 UFSAR Section 9.7.2.1 and ANO-2 UFSAR Section 9.4.3.1. Maximum accident condition of the spent fuel pool is taken to be 212°F boiling borated water/steam at atmospheric pressure. Based on the vendor analysis results, the sensitive materials in the probe body will not be challenged under the required conditions. The licensee's calculations establish a worst case dose of approximately 4.87E+07 rad to the probe to ascertain the acceptability of the probe's radiation-sensitive materials. According to the licensee, the calculations determine conservative source terms and dose rates at key instrument locations, for both a 7 day accident scenario and 40-year integrated dose.

The NRC staff notes that the licensee addressed the equipment reliability of SFPLI with respect to temperature, humidity and radiation. The staff finds that the equipment qualification envelops the expected radiation, temperature, and humidity conditions and thus the SFPI should maintain its functionality during the postulated BDBEE conditions.

4.2.4.2.2 Shock and Vibration

In its letter dated April 14, 2015, the licensee stated that the probe and repairable head are considered inherently resistant to, and were evaluated to be adequately designed for, resilience against, shock and vibration. The probe mounting components and fasteners are seismically qualified and designed as rigid components inherently resistant to vibration effects. The probes will be affixed to the bracket using a machine screw connection designed with proper thread engagement and lock washers. The indicator and battery enclosures will be mounted in the control room. The equipment is not affixed or adjacent to any rotating machinery that would cause vibration effects in the area of installation. The new instrument mounting components and fasteners are seismically qualified and designed as rigid components inherently resistant to vibration effects.

Based on the onsite audit walkdown at the ANO site and the information contained in the licensee's letter dated April 14, 2015, the staff finds that the features described by the licensee should provide adequate resistance to shock and vibration. The staff had previously reviewed the shock and vibration test report during a vendor audit, and by letter dated August 27, 2014 [Reference 36], found it to be acceptable. Thus the staff finds that the licensee has adequately addressed the equipment reliability of the SFPLI with respect to shock and vibration.

4.2.4.2.3 Seismic

In its OIP, the licensee stated that the instrument channel components will be rated by the manufacturer for seismic effects at levels commensurate with those of postulated design-basis event conditions in the area of instrument channel component use using one or more of the following methods:

- demonstration of seismic motion will be consistent with that of existing design basis loads at the installed location;

- demonstration of seismic reliability using methods that predict equipment performance (e.g., analysis, testing, combination thereof, or use of experience data) where demonstration should be based on the guidance in Sections 7, 8, 9, and 10 of [IEEE Standard 344-2004], or a substantially similar industrial standard;

- demonstration of proposed devices that are substantially similar in design to models that have been previously tested for seismic effects in excess of the plant design basis at the location where the instrument is to be installed (g-levels and frequency ranges); or

- seismic qualification using seismic motion consistent with that of existing design basis loading at the installation location.

In its letter dated April 14, 2015, the licensee further stated that a site-specific seismic analysis, was performed that bounds ANO's seismic criteria. According to the licensee, the qualification report envelops all components of the SFPLI required to be operational during a BDBEE and post-event

The NRC staff reviewed the licensee's justification of the equipment reliability of SFPLI with respect to seismic qualifications during the audit process. The staff review finds that the equipment's seismic qualifications envelop the expected ANO conditions during a postulated seismic event. The site-specific seismic analyses demonstrated that the SFPLI's mounting design is satisfactory to allow the instrument to function per design following the maximum seismic ground motion. The SFPLI's mounting design is discussed in Section 4.2.3 of this SE. During the onsite audit, the staff also reviewed the vendor's factory acceptance test reports and found the SFPI design and qualification process acceptable.

4.2.4.2.4 Operating Experience

During the audit process the staff learned that there were incidents at other nuclear facilities, in which the MOHR's SFPI equipment experienced failures of the filter coil (or choke). The staff requested that Entergy address the impact of MOHR's SFPI equipment failures on the ANO SFP level instruments and to describe any actions/measures taken to address this operating experience. In response, the licensee stated that the SFPI equipment failures were addressed under the site corrective action program by generating CR-HQN-2015-00345 CA-5, CA-6, and CA-7. Per CR-HQN-2015-00345 CA-5, both ANO-2 SFPI units were returned to the vendor who refurbished them and returned them to ANO. In CR-HQN-2015-00345 CA-6 and CA-7, the licensee stated that the vendor's root cause analysis determined the cause to be failure of a passive power filtering component (choke) with no other susceptible components identified. The vendor identified and qualified a replacement choke filter with equivalent form, fit, and function but that was more electrically rugged and not susceptible to their witnessed failure mode. The ANO-1 SFPI units were returned to the MOHR facilities, repaired, and sent back to ANO. They were then reinstalled and returned to service.

After the design change, the staff reviewed MOHR Qualification Report "EFP-IL MOD 1 Modification Package," Revision 0, dated July 16, 2015. In this report, MOHR provided its evaluation of the following hardware modifications:

- In-place replacement of the miniature T1 surface mount choke on the 01-EFP-IL-50001 board with an equivalent component.
- In-place replacement of the miniature T1 surface mount choke on the 01-EFP-IL-50006 board with an equivalent component.
- Incorporation of a fusible link in the 01-EFP-IL-50204 cable assembly.
- Full electrical isolation added to the 01-EFP-IL-50007 (USB interface) board.

The NRC staff found that the vendor adequately addressed the modified equipment qualifications. Specifically, the temperature and humidity ratings of the replacement parts envelop the expected MCR conditions during a postulated BDBEE. There is no indication that new electromagnetic emissions introduced by the replacement parts and the mass differences are not sufficient to alter the seismic, shock, and vibration response characteristics.

Based on the discussion above, the NRC staff finds the licensee's proposed instrument qualification process to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.5 Design Features: Independence

In its OIP, the licensee stated that the primary instrument channel will be independent of the backup instrument channel. Independence is obtained by physical separation of components between channels and the use of normal power supplied from separate 480V buses. Independence of power sources is described in Section 11. The two permanently mounted instruments in the pool are physically separated.

In its letter dated July 25, 2013, the licensee further stated that the SFP level measurement system channel independence reasonably precludes the potential for a common-cause event to adversely affect both channels. Independence requirements are achieved by incorporation of two permanently installed, physically independent, and physically separated channels, which incorporate independent plant power sources as well as channel-specific stand-alone replaceable battery power and which also incorporate channel interconnecting cabling routed in seismically mounted raceway. Each level measurement channel is physically separate and independent from level sensor through the display/read-out device. Further SFP level instrument channels' physical separation is described in Subsection 4.2.2, "Design Features: Arrangement".

In its letter dated August 28, 2015, the licensee further stated that installation of physically independent, and physically separated channels that are supplied from opposing power division safety-related vital power sources assures that channels are independent from a power supply assignment perspective.

The NRC staff finds that the licensee adequately addressed the instrument channel independence for both ANO-1 and ANO-2. The primary instrument channel is physically and electrically independent of the backup instrument channel. The instrument channels' physical separation is discussed in Section 4.2.2 of this SE. With the licensee's proposed power arrangement, the electrical functional performance of each level measurement channel would be considered independent of the other channel, and the loss of one power supply would not affect the operation of other independent channel under BDB event conditions.

Based on the discussion above, the NRC staff finds the licensee's proposed design, with respect to instrument channel independence, is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.6 Design Features: Power Supplies

In its OIP, the licensee stated that each instrument channel is normally powered from 120 VAC plant power to support continuous monitoring of SFP level. The primary channel receives power from a different 480 VAC bus than the backup channel. Therefore, loss of any one 480 VAC bus does not result in loss of normal 120 VAC power for both instrument channels. On loss of normal 120 VAC power, each channel's UPS automatically transfers to a dedicated backup battery. If normal power is restored, the channel will automatically transfer back to the normal ac power. The backup batteries are maintained in a charged state by commercial-grade uninterruptible power supplies. The batteries are sized to be capable of supporting intermittent monitoring for a minimum of 3 days of operation. This provides adequate time to allow the batteries to be replaced or until off-site resources can be deployed by the mitigating strategies resulting from Order EA-12-049. The licensee further stated that an external connection permits powering the system from any portable dc source and instrument accuracy and performance are not affected by restoration of power or restarting the processor.

In its letter dated August 28, 2015, the licensee further stated that for ANO-1, the primary channel 120 VAC power is supplied from Panel RS3, which is a Class 1E inverter-backed panel supplied from 125 VDC Bus D01. The backup channel 120 VAC power is supplied from Panel RS4, which is a Class 1E inverter-backed panel supplied from 125 VDC Bus D02. For ANO-2, the primary channel 120 VAC power is being supplied from Panel 2RS1, which is a Class 1E inverter-backed panel supplied from 125V VDC Bus 2D01. The backup channel 120 VAC power is being supplied from Panel 2RS2, which is a Class 1E inverter-backed panel supplied from 125 VDC Bus 2D02.

During the onsite audit, the staff inquired how the SFPLI power is restored following an ELAP event and prior to the depletion of the back-up batteries. In the ANO-2 compliance letter dated January 12, 2016 [Reference 38], the licensee provided a response, applicable to both ANO-1 and ANO-2, as follows:

> The primary independent AC power source design provides expected timely restoration per FLEX strategies during a beyond-design-bases external event (BDBEE) from sources independent of plant sources (e.g. FLEX portable diesel generators). BDBEE FLEX strategy normal power path restoration for one SFPI channel (e.g., one vital DC power bus/train) is expected to be rapid (e.g., within hours via on-site 480 VAC portable diesel generators) with normal power path restoration for the other SFPI channel (e.g., both vital DC power buses/trains) still expected timely per Phase 3 FLEX strategies (e.g., within days via off-site National Strategic Alliance for FLEX Emergency Response Center 4160 VAC portable diesel generators). SFPI permanently installed battery capacity is analyzed to cover reasonably long duration (e.g., seven days). Installed rechargeable battery capacity for a full seven days coupled with FLEX power restoration strategies precludes the need for crediting rapid restoration, battery replacements, stocking of battery spare stock, and the alternate external DC power source capability. As stated above restoration of normal power path to one SFPI channel is expected to be rapid and it is also noted that alternate external DC power source capability is provided for both SFPI channels via a battery cable that allows for connection of an external DC source or battery. As such, the SFP instrument channels have highly reliable power sources, originating from separate power sources, with power capability independent from plant sources, and with on-board battery capacity analyzed for reasonably long duration (e.g., seven days) or reasonable offsite resource availability time frames. An installed alternate power source is provided for instrument channel power with sufficient capacity to maintain the level indication function for reasonably long duration including until offsite resource availability is reasonably assured.

Also, according to ANO's letter dated January 12, 2016:

> The following FLEX support guides (FSGs) have been generated in association with implementation of NRC Order EA-12-049 FLEX strategies to repower the normal 480 VAC (and a single bus/train of normal 125 VDC and its downstream 120 VAC) power supply to the SFPI with portable equipment following an ELAP event.
>
> - 1FSG-004 – ANO-1 ELAP DC Load Management
> - 2FSG-004 – ANO-2 ELAP DC Load Management

Attachment 2 of the above FSGs ensures that 120 VAC Vital Panel Breakers which feed SFPI are not shed as part of the DC Load Shed strategy to preserve Station Vital Batteries. For ANO-1, the breakers are RS3 Bkr #7 and RS4 Bkr #7. For ANO-2, the breakers are 2RS1 Bkr #1 and 2RS2 Bkr #1.

Attachment 3 of the above FSGs restores power to 480 VAC Vital Load Centers via on-site 480 VAC portable generators (with 1FSG-004 Attachment 4 providing an alternate connection method for ANO-1). For ANO-1, the load centers are B5 and B6. For ANO-2, the load centers are 2B5 and 2B6.

The subsequent attachment (1FSG-004, Attachment 5, 2FSG-004, Attachment 4) restores power to a single 125 VDC Bus (ANO-1: D01 or D02; ANO-2: 2D01 or 2D02). This in turn restores power to one of the SFPI 120 VAC Vital Panel Breakers presented above under the Attachment 2 discussion (ANO-1: RS3 Bkr #7 or RS4 Bkr #7; ANO-2: 2RS1 Bkr #1 or 2RS2 Bkr #1).

Beyond the above FSGs, Phase 3 FLEX strategies provide greater power capacity (e.g., via off site National Strategic Alliance for FLEX Emergency Response Center or NSRC 4160 VAC generators) and provide the ability and expectation of repowering the other SFPI channel (e.g., both vital DC power buses/trains) in a reasonably timely fashion (e.g., within seven days).

The NRC staff found that the licensee adequately addressed the staff's question with regard to power restoration following an ELAP event and prior to the depletion of the back-up batteries. The restoration of AC power source via FLEX strategies using FLEX portable diesel generators and/or NSRC generators would be sufficient to ensure the SFPI maintains its functionality during a postulated BDBEE.

Based on the discussion above, the NRC staff finds the licensee's proposed power supply design is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.7 Design Features: Accuracy

In its OIP, the licensee stated that the absolute system accuracy is better than ± 3 inches. This accuracy is applicable for normal conditions and the temperature, humidity, chemistry, and radiation levels expected for BDBEE conditions.

In its letter dated July 25, 2013, the licensee stated that the SFP level instrument channel accuracy across the entire measured span under all applicable conditions is planned to be specified to be less than three inches. Minimum level sensor range or measured level span is depicted on Figure 1 for ANO-1 (24'-3.4325") and Figure 2 for ANO-2 (22'-7.6875"). As such, minimum instrument channel accuracy relative to measured level span is approximately 1.03 percent span for ANO-1 and 1.10 percent span for ANO-2. This is a conservative bounding instrument channel accuracy with the vendor estimating expected instrument channel accuracy to be considerably better.

In its letter dated April 14, 2015, the licensee further stated that ANO-1 PO-10393246 and ANO-2 PO-10412526 impose a requirement for absolute system accuracy for Level measurement equal or better than ± 3 inches applicable for normal conditions and BDBEE conditions (e.g., temperature, humidity, chemistry, radiation levels, boiling water and/or steam environment, post-shock/vibration, post-seismic).

The licensee has demonstrated that the instrument channels' accuracy is not significantly affected by BDB conditions. If implemented properly, the instrument channels will maintain the designed accuracy following a power source change or interruption without the need of recalibration. Therefore, the NRC staff finds the licensee's proposed instrument accuracy is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.8 Design Features: Testing

In its letter dated July 25, 2013, the licensee stated that the instrument automatically monitors the integrity of its level measurement system using in-situ capability. Deviation of measured test parameters from manufactured or as-installed configuration beyond a configurable threshold prompts operator intervention. Periodic calibration checks of the signal processor electronics can be achieved through the use of standard measurement and test equipment. The probe itself is a perforated tubular coaxial waveguide with defined geometry and is not calibrated. It is planned to be periodically inspected electromagnetically using time-domain reflectometry at the probe hardline cable connector to demonstrate that the probe assembly meets manufactured specification and visually to demonstrate that there has been no mechanical deformation or fouling. Each instrument electronically logs a record of measurement values over time in non-volatile memory that is compared to demonstrate constancy, including any changes in pool level, such as that associated with the normal evaporative loss/refilling cycle. The channel level measurements can be directly compared to each other (i.e., regular cross-channel comparisons). Any existing permanently installed SFPLI or other direct measurements of SFP level may be used for diagnostic purposes if cross-channel comparisons are anomalous.

The NRC staff noted that the SFPLI is adequately designed to provide the capability for routine testing and calibration including in-situ testing/calibration. By comparing the levels in the instrument channels and the maximum level allowed deviation for the instrument channel design accuracy, the operators could determine if recalibration or troubleshooting is needed. The staff finds that the licensee's proposed SFPI design allows for testing consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.9 Design Features: Display

In its OIP, the licensee stated that the primary and backup instrument displays will be located in the MCR. According to the licensee, for both normal and expected beyond design basis conditions, the displays are in mild environments that are: (1) promptly accessible to plant staff and decision makers properly trained in the use of the equipment such that station operators can obtain SFP level data trends and report those to decision makers within 30 minutes of request; (2) outside the area surrounding the SFP floor and protected from the environmental and radiological sources resulting from an event impacting the SFP; (3) inside a seismic structure that provides protection from adverse weather or flooding; and (4) outside of any high radiation area or locked high radiation area during normal or expected beyond-design-basis conditions.

The NRC staff noted that the licensee's description for the display location is consistent with the provisions of NEI 12-02 for an appropriate and accessible location. If implement properly, the displays will provide continuous indication of SFP water level. The displays are located in seismically qualified buildings and the accessibility of the MCR following an ELAP event is considered acceptable. Therefore, the staff finds that the licensee's proposed location and design of the SFPI displays is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.3 Evaluation of Programmatic Controls

Order EA-12-051 specified that the spent fuel pool instrumentation shall be maintained available and reliable through appropriate development and implementation programmatic controls, including training, procedures, and testing and calibration. Below is the NRC staff's assessment of the programmatic controls for the spent fuel pool instrumentation.

4.3.1 Programmatic Controls: Training

In its OIP, the licensee stated that the SAT will be used to identify the population to be trained and to determine both the initial and continuing elements of the required training. Training will be completed prior to placing the instrumentation in service.

The NRC staff finds that the use of the SAT to identify the training population and to determine both the elements of the required training is acceptable. The licensee's proposed plan to train personnel in the operation, maintenance, calibration, and surveillance of the SFPI and the provision of alternate power to the primary and backup instrument channels, including the approach to identify the population to be trained, is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.3.2 Programmatic Controls: Procedures

In its letter dated July 25, 2013, the licensee stated that the vendor recommended inspection, maintenance, and repair procedures for the SFP liquid level measurement system have been developed. These are for the most part specific to the system's proprietary electronics, subject to relevant industry standards for electronics fabrication and inspection and vendor's quality management system. Where relevant, standards for naval shipboard liquid level indicating equipment have been used to develop procedures for operation, abnormal response, and administrative controls.

For Unit 1, in its letter dated February 24, 2015, the licensee further stated that a new ANO-1 procedure, OP-1304.223, "Unit 1 Spent Fuel Pool Level Instrumentation Channel Functional Test," has been implemented. The ANO-1 Technical Requirements Manual (TRM) has been revised to include actions to be taken for the primary and back-up SFP level instruments with respect to functionality (new TRM 3.10.1). In addition, ANO-1 procedure OP-1015.003A, "Unit 1 Operations Logs," has been revised to add the new SFP level instruments. An operations procedure was not required based on the simple indication function and use. A preventative maintenance task has been established for scheduling and implementing necessary functional testing in accordance with ANO-1 TRM requirements. The testing provides for calibration or validation of the primary and backup ANO-1 SFP level instrument channels against known/actual SFP level to maintain design accuracy within limits established. The testing also provides for ANO-1 SFP level instrument cross channel comparison. This is augmented by routine operations monitoring.

For Unit 2, in its letter dated January 12, 2016, the licensee further stated that a new ANO-2 procedure, OP-2304.271, "Unit 2 Spent Fuel Pool Level Instrumentation Channel Functional Test," has been implemented. The ANO-2 TRM has been revised to include actions to be taken for the primary and back-up SFP level instruments with respect to functionality (new TRM 3.10.1). In addition, ANO-2 procedure OP-1015.003B, "Unit 2 Operations Logs," has been revised to add the new SFP level instruments. An operations procedure was not required based on the simple indication function and use. A preventative maintenance task has been established for scheduling and implementing necessary functional testing in accordance with ANO-2 TRM requirements. The testing provides for calibration or validation of the primary and backup ANO-2 SFP level instrument channels against known/actual SFP level to maintain design accuracy within limits established. The testing also provides for ANO-2 SFP level instrument cross channel comparison. This is augmented by routine operations monitoring.

During the onsite audit, the staff inquired about procedures covering the SFPI power restoration following an ELAP event and prior to the depletion of the back-up batteries. In response, the licensee stated that procedures 1FSG-004, "Extended Loss of AC Power DC Load Management" 2FSG-004, "ELAP DC Bus Load Shed and Management" were being developed. These FSGs have now been implemented by the licensee.

Based on the review of the licensee's procedures during the onsite audit as well as the licensee's submittal descriptions, the NRC staff finds that the licensee has established procedures for the testing, surveillance, calibration, and operation of the primary and backup SFP level instrument channels. Therefore, the licensee's proposed procedures are consistent with NEI 12-02, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.3.3 Programmatic Controls: Testing and Calibration

In its OIP, the licensee stated that testing and calibration processes will be developed consistent with the guidelines of NRC JLD-ISG-2012-03 Revision 0, NEI 12-02 Revision 1, and vendor instructions.

In its letter dated July 25, 2013, the licensee stated that:

> Operator performance tests (functional checks) are automated and/or semi-automated (requiring limited operator interaction) and are performed through the instrument menu software and initiated by the operator. There are a number of other internal system tests that are performed by system software on an essentially continuous basis without user intervention but can also be performed on an on-demand basis with diagnostic output to the display for the operator to

review. Other tests such as menu button tests, level alarm, and alarm relay tests are only initiated manually by the operator. Operator performance checks are described in detail in the Vendor Operator's Manual, and the applicable information is planned to be contained in plant operating procedures.

Operator performance tests are planned to be performed periodically as recommended by the equipment vendor, for instance quarterly but no less often than the calibration interval of two years.

Channel functional tests per operations procedures with limits established in consideration of vendor equipment specifications are planned to be performed at appropriate frequencies established equivalent to or more frequently than existing SFPI.

Manual calibration and operator performance checks are planned to be performed in a periodic scheduled fashion with additional maintenance on an as-needed basis when flagged by the system's automated diagnostic testing features.

Channel calibration tests per maintenance procedures with limits established in consideration of vendor equipment specifications are planned to be performed at frequencies established in consideration of vendor recommendations.

Periodic (e.g., quarterly or monthly) review of the system level history and log files and routine attention to any warning message on the system display is recommended by the vendor. Formal calibration checks are recommended by the vendor on a two-year interval to demonstrate calibration to external NIST [National Institute of Science and Technology]-traceable standards. Formal calibration check surveillance interval and timing would be established consistent with applicable guidance [i.e., NEI 12-02 Section 4.3; on a refueling outage interval basis and within 60 days of a planned refueling outage considering normal testing scheduling allowances (e.g., 25%)]. Items such as system batteries are planned to be assessed under the Preventive Maintenance (PM) Program for establishment of replacement frequency. Surveillance/PM timing/performance are planned to be controlled via tasks in the PM Program.

The licensee also stated that the SFPI channel/equipment maintenance/preventative maintenance and testing program requirements to ensure design and system readiness are planned to be established in accordance with Entergy's processes and procedures and in consideration of vendor recommendations to ensure that appropriate regular testing, channel checks, functional tests, periodic calibration, and maintenance is performed (and available for inspection and audit). Subject maintenance and testing program requirements are planned to be developed during the SFPI modification design process.

In its letter dated February 24, 2015, the licensee further stated that permanent installation of both primary and backup SFPI channels coupled with vendor stocking of adequate spare parts reasonably diminishes the likelihood that a single channel is (are) out-of-service for an extended period of time. Compensatory actions for unlikely extended out-of-service events are summarized as follows:

# Channel(s) Out-of-Service	Required Restoration Action	Compensatory Action if Required Restoration Action Not Completed within Specified Time
1	Restore channel to functional status within 90 days	Immediately implement compensatory measures
2	Restore one channel to functional status within 24 hours	Within 48 hours implement compensatory measures

In its letter dated January 12, 2016, the licensee provided a comprehensive list of SFPI related preventive maintenance tasks and procedures.

Based on the review of the licensee's procedures during the onsite audit and the licensee's submittal description, the NRC staff notes that the licensee has addressed the necessary testing and calibration of the primary and backup SFP level instrument channels to maintain the instrument channels at the design accuracy. The testing and calibration are consistent with the vendor recommendations. Additionally, compensatory actions for instrument channel(s) out-of-service are consistent with the provisions of NEI 12-02.

Thus, the NRC staff finds that the licensee's proposed testing and calibration plan is consistent with NEI 12 02, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.4 Conclusions for Order EA-12-051

In its letters dated April 14, 2015, and January 12, 2016, the licensee stated that they would meet the requirements of Order EA-12-051 by following the guidelines of NEI 12-02, as endorsed by JLD-ISG-2012-03. In the evaluation above, the NRC staff finds that, if implemented appropriately, the licensee's plans conform to the guidelines or intent of NEI 12-02, as endorsed by JLD-ISG-2012-03. In addition, the NRC staff concludes that if the SFPLI is installed at ANO-1 and ANO-2 according to the licensee's proposed design, it should adequately address the requirements of Order EA-12-051.

5.0 CONCLUSION

In August 2013, the NRC staff started audits of the licensee's progress on these two orders. The staff conducted an onsite audit in April 2015. The licensee reached its final compliance date on November 13, 2015, and has declared that both of the reactors are in compliance with the orders. The purpose of this SE is to document the strategies and implementation features that the licensee has committed to and which NRC staff has evaluated to be satisfactory for compliance with these orders. The NRC staff will conduct an onsite inspection to verify that the licensee has implemented the strategies and equipment to demonstrate compliance with the orders. Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and proposed designs, which if implemented appropriately, should adequately address the requirements of Orders EA-12-049 and EA-12-051.

6.0 REFERENCES

1. SECY-11-0093, "Recommendations for Enhancing Reactor Safety in the 21st Century, the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," July 12, 2011 (ADAMS Accession No. ML11186A950)

2. SECY-12-0025, "Proposed Orders and Requests for Information in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Tsunami," February 17, 2012 (ADAMS Accession No. ML12039A103)

3. SRM-SECY-12-0025, "Proposed Orders and Requests for Information in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Tsunami," March 9, 2012 (ADAMS Accession No. ML120690347)

4. Order EA-12-049, "Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," March 12, 2012 (ADAMS Accession No. ML12054A736)

5. Order EA-12-051, "Issuance of Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation," March 12, 2012 (ADAMS Accession No. ML12054A679)

6. Nuclear Energy Institute document NEI 12-06, Revision 0, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," August 21, 2012 (ADAMS Accession No. ML12242A378)

7. JLD-ISG-2012-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," August 29, 2012 (ADAMS Accession No. ML12229A174)

8. Nuclear Energy Institute document NEI 12-02, "Industry Guidance for Compliance with NRC Order EA-12-051, To Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation," Revision 1, August 24, 2012 (ADAMS Accession No. ML12240A307)

9. JLD-ISG-2012-03, "Compliance with Order EA-12-051, Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation," August 29, 2012 (ADAMS Accession No. ML12221A339)

10. Entergy letter to NRC, "Arkansas Nuclear One, Units 1 and 2, Overall Integrated Plan in Response to March 12, 2012, Commission Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," February 28, 2013 (ADAMS Accession No. ML13063A151)

11. Entergy letter to NRC, "Arkansas Nuclear One, Units 1 & 2, First Six-Month Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," August 28, 2013 (ADAMS Accession No. ML13241A414)

12. Entergy letter to NRC, "Arkansas Nuclear One, Units 1 and 2, Second Six-Month Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," February 27, 2014 (ADAMS Accession No. ML14059A229)

13. Entergy letter to NRC, "Arkansas Nuclear One, Units 1 and 2, Third Six-Month Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," August 28, 2014 (ADAMS Accession No ML14241A660)

14. Entergy letter to NRC, "Arkansas Nuclear One, Units 1 and 2, Fourth Six-Month Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) February 24, 2015 (ADAMS Accession No. ML15056A137)

15. Entergy letter to NRC, "Arkansas Nuclear One, Units 1 & 2, Fifth Six-Month Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," August 28, 2015 (ADAMS Accession No. ML15243A416)

16. Letter from Jack R. Davis (NRC) to All Operating Reactor Licensees and Holders of Construction Permits, "Nuclear Regulatory Commission Audits of Licensee Responses to Mitigation Strategies Order EA-12-049," August 28, 2013 (ADAMS Accession No. ML13234A503)

17. Letter from Jeremy S. Bowen NRC to Entergy "Arkansas Nuclear One, Units 1 and 2, Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC Nos. MF0942 and MF0943)," February 25, 2014 (ADAMS Accession No. ML14007A459)

18. Letter from Peter Bamford, NRC to Entergy "Arkansas Nuclear One, Units 1 and 2 - Report for the Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and EA-12-051," September 1, 2015 (ADAMS Accession No. ML15236A340)

19. Entergy letter to NRC, "Arkansas Nuclear One, Units 1 and 2 - Notification of Full Compliance with NRC Order EA-12-049 Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (BDBEEs)," January 12, 2016 (ADAMS Accession No. ML16014A396)

20. U.S. Nuclear Regulatory Commission, "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," March 12, 2012 (ADAMS Accession No. ML12053A340)

21. SRM-COMSECY-14-0037, "Integration of Mitigating Strategies For Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards," March 30, 2015 (ADAMS Accession No. ML15089A236)

22. Letter from Nicolas Pappas (NEI) to Jack R. Davis (NRC), "EA-12-049 Mitigating Strategies Resolution of Extended Battery Duty Cycles Generic Concern," dated August 27, 2013 (ADAMS Accession No. ML13241A186)

23. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), Regarding Battery Life Issue NEI White Paper, dated September 16, 2013 (ADAMS Accession No. ML13241A188)

24. NUREG/CR-7188,"Testing to Evaluate Extended Battery Operation in Nuclear Power Plants," May 2015 (ADAMS Accession No. ML15148A418)

25. Letter from Mandy Halter (NRC) to David A. Heacock, dated July 1, 2016, regarding Millstone Power Station, Units 2 and 3 - Safety Evaluation for Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and EA-12-051 (ADAMS Accession No. ML16099A171)

26. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), "Staff Assessment of National SAFER Response Centers Established In Response to Order EA-12-049," September 26, 2014 (ADAMS Accession No. ML14265A107)

27. Entergy letter to NRC, "Arkansas Nuclear One, Units 1 and 2, Overall Integrated Plan in Response to March 12, 2012, Commission Order Modifying License with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051), February 28, 2013 (ADAMS Accession No. ML13063A015)

28. NRC letter to Entergy, "Arkansas Nuclear One, Units 1 and 2, Request for Additional Information, Overall Integrated Plan In Response to 3/12/12 Commission Order Modifying License With Regard to for Reliable Spent Fuel Pool Instrumentation (Order EA-12-051)," June 26, 2013 (ADAMS Accession No. ML13156A313)

29. Entergy letter to NRC, "Arkansas Nuclear One, Units 1 & 2, Response to Request for Additional Information for the Overall Integrated Plan in Response to the Commission Order Modifying Licenses with Regard to Requirements for Reliable Spent Fuel Pool Instrumentation," July 25, 2013 (ADAMS Accession No. ML13207A269)

30. NRC letter to Entergy, "Arkansas Nuclear One, Units 1 and 2 - Interim Staff Evaluation and Request for Additional Information Regarding the Overall Integrated Plan for Implementation of Order EA-12-051, Reliable Spent Fuel Pool Instrumentation," October 29, 2013 (ADAMS Accession No. ML13281A502)

31. Entergy letter to NRC, "Arkansas Nuclear One, Units 1 & 2, First Six-Month Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with

Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051)," August 28, 2013 (ADAMS Accession No. ML13241A415)

32. Entergy letter to NRC, "Arkansas Nuclear One, Units 1 and 2, Second Six-Month Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051)," February 27, 2014 (ADAMS Accession No. ML14059A230)

33. Entergy letter to NRC, "Arkansas Nuclear One, Units 1 and 2, Third Six-Month Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051)," August 28, 2014 (ADAMS Accession No. ML14246A209)

34. Entergy letter to NRC, "Arkansas Nuclear One, Units 1 and 2, Fourth Six-Month Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051)," February 24, 2015 (ADAMS Accession No. ML15056A153)

35. Entergy letter to NRC, "Arkansas Nuclear One, Unit 2 - Fifth Six-Month Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool (SFP) Instrumentation (Order Number EA-12-051)," August 28, 2015 (ADAMS Accession No. ML15243A417) (ANO-2 only)

36. Letter from John Boska (NRC) to Lawrence J. Weber dated August 27, 2014 regarding Donald C. Cook Nuclear Plant, Units 1 and 2 – Report for the Onsite Audit of Mohr Regarding Implementation of Reliable Spent Fuel Instrumentation Related to Order EA-12-051 (ADAMS Accession No. ML14216A362)

37. Entergy letter to NRC, "Arkansas Nuclear One, Unit 1 - Completion of Required Action by NRC Order EA-12-051 Reliable Spent Fuel Pool Level (SFP) Instrumentation," April 14, 2015 (ADAMS Accession No. ML15105A248)

38. Entergy letter to NRC, "Arkansas Nuclear One, Unit 2 - Completion of Required Action by NRC Order EA-12-051 Reliable Spent Fuel Pool Level (SFP) Instrumentation Arkansas Nuclear One – Unit 2," January 12, 2016 (ADAMS Accession No. ML16012A280)

39. NRC Office of Nuclear Reactor Regulation Office Instruction LIC-111, Regulatory Audits, dated December 16, 2008 (ADAMS Accession No. ML082900195).

40. Letter from William Dean (NRC) to Power Reactor Licensees, "Coordination of Requests for Information Regarding Flooding Hazard Reevaluations and Mitigating Strategies for Beyond-Design Bases External Events," September 1, 2015 (ADAMS Accession No. ML15174A257)

41. NEI Position Paper: "Shutdown/Refueling Modes," September 18, 2013 (ADAMS Accession No. ML13273A514)

42. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), regarding NRC endorsement of NEI Position Paper: "Shutdown/Refueling Modes," September 30, 2013 (ADAMS Accession No. ML13267A382)

43. Letter from Nicholas Pappas (NEI) to Jack R. Davis (NRC) regarding FLEX Equipment Maintenance and Testing dated October 3, 2013 (ADAMS Accession No. ML13276A573)

44. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), regarding NRC endorsement of the use of the EPRI FLEX equipment maintenance report, dated October 7, 2013 (ADAMS Accession No. ML13276A224)

45. COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards," dated November 21, 2014 (ADAMS Accession No. ML14309A256)

46. Letter from Nicholas Pappas (NEI) to Jack R. Davis (NRC) regarding alternate approach to NEI 12-06 guidance for hoses and cables, dated May 1, 2015 (ADAMS Accession No. ML15126A135)

47. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), regarding NRC endorsement of NEI's alternative approach to NEI 12-06 guidance for hoses and cables, dated May 18, 2015 (ADAMS Accession No. ML15125A442)

48. NRC letter to Entergy, "Arkansas Nuclear One, Units 1 and 2 - Update Regarding Audit Activities Associated with Order EA-12-049 (Mitigation Strategies)," dated May 28, 2014 (ADAMS Accession No. ML14140A514)

49. U.S. Nuclear Regulatory Commission, "Mitigation of Beyond-Design-Basis Events," *Federal Register*, Vol. 80, No. 219, November 13, 2015, pp. 70610-70647.

50. Nuclear Energy Institute document NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Revision 2, December 31, 2015 (ADAMS Accession No. ML16005A625)

51. JLD-ISG-2012-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," Revision 1, January 22, 2012 (ADAMS Accession No. ML15357A163)

52. Letter from Jack Stringfellow (PWROG) to NRC, regarding WCAP 17601-P, Revision 1 and PWROG Core Cooling Position Paper, Revision 0, dated January 30, 2013 (ADAMS Accession No. ML13042A010)

53. Letter from Jack Stringfellow (PWROG) to NRC, regarding Request for Additional Information on CENTS Code, dated September 25, 2013 (ADAMS Accession No. ML13297A165, proprietary, non-public)

54. Letter from Jack Stringfellow (PWROG) to NRC, regarding Request for Additional Information on CENTS Code, dated November 26, 2013 (ADAMS Accession No. ML14218A046)

55. Letter from Jack R. Davis (NRC) to Jack Stringfellow (PWROG) regarding Use of CENTS Code in ELAP Analysis, dated October 7, 2013 (ADAMS Accession No. ML13276A555)

56. Letter from Jack Stringfellow (PWROG) to NRC, regarding Flowserve White Paper on N-Seal RCP Seal Package Response to ELAP, dated August 5, 2015 (ADAMS Accession No. ML15222A356)

57. Letter from Jack R. Davis (NRC) to Jack Stringfellow (PWROG), regarding Flowserve White Paper on N-Seal RCP Seal Package Response to ELAP, dated November 12, 2015 (ADAMS Accession No. ML15310A094)

58. "Westinghouse Response to NRC Generic Request for Additional Information (RAI) on Boron Mixing in Support of the Pressurized Water Reactor Owners Group (PWROG)," dated August 15, 2013 (ADAMS Accession No. ML13235A139, proprietary, non-public)

59. Letter from Jack R. Davis (NRC) to Jack Stringfellow (PWROG), regarding Boron Mixing, dated January 8, 2014 (ADAMS Accession No. ML13276A183)

60. Entergy letter to NRC, "Additional Questions Associated with the Notification of Full Compliance with NRC Order EA-12-049 Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis-External Events (BDBEEs)," dated September 1, 2016 (ADAMS Accession No. ML16250A008)

Principal Contributors: B. Heida
J. Lehning
M. Levine
M. McConnell
J. Miller
K. Nguyen
P. Sahay
B. Titus
P. Bamford
D. Johnson

Date: September 19, 2016

By letter dated February 28, 2013 (ADAMS Accession No. ML13063A015), Entergy submitted its OIP for ANO in response to Order EA-12-051. At six month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-051. These reports were required by the order, and are listed in the attached safety evaluation. By letters dated October 29, 2013 (ADAMS Accession No. ML13281A502), and September 1, 2015 (ADAMS Accession No. ML15236A340), the NRC issued an ISE, request for additional information and audit report, respectively, on the licensee's progress. By letter dated March 26, 2014 (ADAMS Accession No. ML14083A620), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-051 in accordance with NRC NRR Office Instruction LIC-111, similar to the process used for Order EA-12-049. By letters dated April 14, 2015, and January 12, 2016 (ADAMS Accession Nos. ML15105A248 and ML16012A280), Entergy submitted compliance letters in response to Order EA-12-051 for ANO Units 1 and 2, respectively. The compliance letters stated that the licensee had achieved full compliance with Order EA-12-051.

The enclosed safety evaluation provides the results of the NRC staff's review of Entergy's strategies for ANO. The intent of the safety evaluation is to inform Entergy on whether or not its integrated plans, if implemented as described, provide a reasonable path for compliance with Orders EA-12-049 and EA-12-051. The staff will evaluate implementation of the plans through inspection, using Temporary Instruction 191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications/Staffing/ Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML15257A188). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

If you have any questions, please contact Peter Bamford, Orders Management Branch, ANO Project Manager, at 301-415-2833 or at Peter.Bamford@nrc.gov.

Sincerely,
/RA/
Mandy Halter, Acting Chief
Orders Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos.: 50-313 and 50-368
Enclosure:
Safety Evaluation
cc w/encl: Distribution via Listserv

DISTRIBUTION:
PUBLIC
JLD R/F
RidsNrrDorlLpl4-2 Resource
RidsNrrLASLent Resource
RidsAcrsAcnw_MailCTR Resource
RidsRgn4MailCenter Resource
PBamford, NRR/JLD
RidsNrrPMANO Resource

ADAMS Accession No. ML16224A106 ***via email**

OFFICE	NRR/JLD/JOMB/PM	NRR/JLD/LA	NRR/JLD/JCBB/BC	NRR/JLD/JERB/BC
NAME	PBamford	SLent	JQuichocho, w/comments*	SBailey*
DATE	08/19/16	08/29/16	08/24/16	09/08/16

OFFICE	NRR/JLD/JOMB/BC(A)
NAME	MHalter
DATE	9/19/16

OFFICIAL RECORD COPY