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

May 18, 2017

Mr. Marty L. Richey
Site Vice President
FirstEnergy Nuclear Operating Company
Beaver Valley Power Station
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SUBJECT: BEAVER VALLEY POWER STATION, 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. MF0841, MF0842, MF0799, AND MF0800)

Dear Mr. Richey:

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 27, 2013 (ADAMS Accession No. ML13064A243), FirstEnergy Nuclear Operating Company (FENOC, the licensee) submitted its OIP for Beaver Valley Power Station, Units 1 and 2 (BVPS) 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 January 29, 2014 (ADAMS Accession No. ML13364A166), and November 2, 2015 (ADAMS Accession No. ML15292A139), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated December 16, 2016 (ADAMS Accession No. ML16351A277, non-publicly available), FENOC 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 February 27, 2013 (ADAMS Accession No. ML13059A495), FENOC submitted its OIP for BVPS 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 November 19, 2013 (ADAMS Accession No. ML13297A233), and November 2, 2015 (ADAMS Accession No. ML15292A139), the NRC staff issued an ISE 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 letter dated December 21, 2015 (ADAMS Accession No. ML15355A397), FENOC submitted a compliance letter in response to Order EA-12-051. The compliance letter 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 FENOC's strategies for BVPS. The intent of the safety evaluation is to inform FENOC on whether or not its integrated plans, if implemented as described, appear to adequately address the requirements of Orders EA-12-049 and EA-12-051. The staff will evaluate implementation of the plans through inspection, using Temporary Instruction 2515-191, "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 Milton Valentín-Olmeda, Orders Management Branch, BVPS Project Manager, at 301-415-2864 or at Milton.Valentin-Olmeda@nrc.gov.

Sincerely,

John P. Boska

John P. Boska, Acting Chief
Orders Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos.: 50-334 and 50-412
Enclosure:
Safety Evaluation

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

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

FIRSTENERGY NUCLEAR OPERATING COMPANY

BEAVER VALLEY POWER STATION, UNITS 1 AND 2

DOCKET NOS. 50-334 AND 50-412

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" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12054A736). 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" (ADAMS Accession No. ML12054A679). This order directed licensees to install reliable SFP level instrumentation 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 (ADAMS Accession No. ML11186A950). 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," (ADAMS Accession No. ML12039A103) to the Commission. This paper included a proposal to order licensees to implement enhanced BDBEE mitigation strategies. As directed by the Commission in staff requirements memorandum (SRM)-SECY-12-0025 (ADAMS Accession No. ML120690347), the NRC staff issued Orders EA-12-049 and EA-12-051.

2.1 Order EA-12-049

Order EA-12-049, Attachment 2, (ADAMS Accession No. ML12054A736) 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 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 December 10, 2015, following submittals and discussions in public meetings with NRC staff, the Nuclear Energy Institute (NEI) submitted document NEI 12-06, Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," (ADAMS Accession No. ML16005A625) to the NRC to provide revised 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, Revision 2, and on January 22, 2016, issued Japan Lessons-Learned Directorate (JLD) Interim Staff Guidance (ISG) JLD-ISG-2012-01, Revision 1, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," (ADAMS Accession No. ML15357A163), endorsing NEI 12-06, Revision 2, with exceptions, additions, and clarifications, as an acceptable means of meeting the requirements of Order EA-12-049, and published a notice of its availability in the *Federal Register* (81 FR 10283).

2.2 Order EA-12-051

Order EA-12-051, Attachment 2, (ADAMS Accession No. ML12054A679) 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, Revision 1 "Industry Guidance for Compliance With NRC Order EA-12-051, To Modify Licenses With Regard to Reliable Spent

Fuel Pool Instrumentation," (ADAMS Accession No. ML12240A307) 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" (ADAMS Accession No. ML12221A339), 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 TECHNICAL EVALUATION OF ORDER EA-12-049

By letter dated February 27, 2013 (ADAMS Accession No. ML13064A243), FirstEnergy Nuclear Operating Company (FENOC, the licensee) submitted an Overall Integrated Plan (OIP) for Beaver Valley Power Station, Units 1 and 2 (BVPS, Beaver Valley) in response to Order EA-12-049. By letters dated August 26, 2013 (ADAMS Accession No. ML13238A260), February 27, 2014 (ADAMS Accession No. ML14058A666), August 28, 2014 (ADAMS Accession No. ML14240A285), February 26, 2015 (ADAMS Accession No. ML15057A398), August 27, 2015 (ADAMS Accession No. ML15239A290), February 26, 2016 (ADAMS Accession No. ML16057A103) and August 5, 2016 (ADAMS Accession No. ML16218A279), the licensee submitted six-month updates to the OIP. 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 January 29, 2014 (ADAMS Accession No. ML13364A166), and November 2, 2015 (ADAMS Accession No. ML15292A139), the NRC issued an Interim Staff Evaluation (ISE) and an audit report on the licensee's progress. By letter dated December 16, 2016 (ADAMS Accession No. ML16351A277, non-publicly available), the licensee reported that full compliance with the requirements of Order EA-12-049 was achieved, and submitted a Final Integrated Plan (FIP). In this evaluation, there may be differences between Unit 1 and Unit 2. The differences between the Units are annotated to show to which Unit the information is applicable as follows: Beaver Valley Power Station Unit 1 (BV1) or Beaver Valley Power Station Unit 2 (BV2).

3.1 Overall Mitigation Strategy

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 a 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.

The Beaver Valley, Units 1 and 2, are Westinghouse pressurized-water reactors (PWRs) with dry ambient pressure containments. The licensee's three-phase approach to mitigate a postulated ELAP event, as described in the FIP, is summarized below.

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. Decay heat is removed by steaming to atmosphere from the steam generators (SGs) through the main steam safety valves (MSSVs) or the atmospheric steam dump valves (ASDVs), and makeup to the SGs is initially provided by the unit's turbine-driven auxiliary feedwater pump (TDAFWP) taking suction from the unit's primary plant demineralized water storage tank (PPDWST). Subsequently, the operators would begin a controlled cooldown and depressurization of the RCS by manually operating the SG ASDVs. The SGs would be depressurized in a controlled manner until 520 degrees Fahrenheit (°F) RCS temperature is reached, where the cooldown is stopped to prevent the safety injection (SI) accumulators from actuating. Once the SI accumulators are isolated, cooldown recommences to about 425 °F for BV1 and 445 °F for BV2 over a period of several hours. These temperatures are maintained while the operators borate the RCS from the boric acid tanks (BATs) using a FLEX RCS boration pump (one for each unit). Depressurizing the SGs reduces RCS temperature and pressure. The licensee plans to isolate the SI accumulators and complete this cooldown within 14 hours of the start of the event. Boration of the RCS is completed within 23 hours of the start of the event. Due to installation of RCP low leakage seals, RCS inventory remains in the indicating range of the pressurizer and RCS remains subcooled until the RCS is cooled down to commence RCS boration. Natural circulation remains viable throughout Phase 2.

The operators will perform dc bus load stripping within 3 hours following event initiation to ensure safety-related battery life is extended to 15 hours for BV1 and 17.75 hours for BV2. Prior to 14 hours, one 850-kilowatt (kW), 480 volt alternating current (Vac) generator will be deployed from a FLEX equipment storage building (FESB) to each unit. These portable generators will be used to repower essential battery chargers and repower safety injection accumulator isolation valves and portable FLEX pumps.

The RCS makeup and boration will be initiated within fourteen hours of the ELAP to ensure that natural circulation, reactivity control, and boron mixing is maintained in the RCS. Operators will provide RCS makeup using FLEX RCS boration pumps, one per unit, to deliver water drawn from a FLEX connection on the BATs. There are two BATs per unit. Borated water from the BATs will be injected into the RCS through FLEX connections to the high head safety injection system (one connection on either train).

The water supply for the TDAFW pump is initially from the unit's PPDWST. The PPDWST will provide a minimum of nine hours of RCS decay heat removal, in addition to absorbing the latent heat associated with the planned RCS cooldown. Prior to emptying the PPDWST, the demineralized water storage tank (DWST), if available, would be used/aligned to gravity fill the PPDWST for approximately 48 hours. If the DWST is not available, the operators will place a FLEX pump in service to refill each unit's PPDWST from the UHS, the Ohio River.

Operators will ultimately transition the SG water supply from the TDAFW pump to portable FLEX pumps using water from the UHS, the Ohio River.

In addition, a National Strategic Alliance for FLEX Emergency Response (SAFER) Center (NSRC) will provide high capacity pumps and large turbine-driven DGs which could be used to restore one residual heat removal (RHR) cooling train per unit to cool the cores in the long term. There are two NSRCs in the United States.

The SFP for each unit is located in the unit's fuel handling building (FHB). Upon initiation of the ELAP event, the SFP will heat up due to the unavailability of the normal cooling system. This calculation and the FIP indicate that boiling begins at approximately 18.69 hours for BV1 and 19.54 hours for BV2 during a normal, non-outage situation. The time to boil off to 15 feet (ft.) from the top of the active fuel is approximately 71 hours without any operator actions. Makeup water would be provided using a diesel-driven FLEX makeup pump with a suction from the unit's refueling water storage tank (RWST), the preferred source, or the UHS and discharging through a hose which will be connected to add water to the SFP. Ventilation of the generated steam is accomplished by opening the ground level FHB rollup door and the upper level access door thus establishing a natural draft vent path.

For Phases 1 and 2 the licensee's calculations demonstrate that no actions are required to maintain containment pressure below design limits for over 72 hours. During Phase 3, containment cooling and depressurization, as needed, can be accomplished through a variety of methods using installed and/or portable equipment. The technical support center (TSC) will develop the methodology based on the status of plant equipment.

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 NEI 12-06, Revision 2, guidance.

3.2 Reactor Core Cooling Strategies

Order EA-12-049 requires licensees 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 with 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 with loss of normal access to the UHS event 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 during the ELAP with loss of normal access to the UHS event. 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 during the ELAP with loss of normal access to the UHS event are discussed in further detail below. The licensee's strategy for ensuring compliance with Order EA-12-049 for conditions where one or more units are shut down or being refueled is reviewed separately in Section 3.11 of this safety evaluation (SE).

3.2.1 Core Cooling Strategy and RCS Makeup

3.2.1.1 Core Cooling Strategy

3.2.1.1.1 Phase 1

As stated in Beaver Valley's December 16, 2016, FIP, the heat sink for core cooling in Phase 1 would be provided by the three SGs, which will be fed simultaneously by the unit's TDAFWP with water supplied from the PPDWST. Beaver Valley's PPDWST has a minimum usable capacity of 130,000 gallons. This capacity is sufficient to supply the required water for 9 hours after the initiation of the ELAP event. Both the TDAFWP and the PPDWST are robust to all applicable hazards.

Following the closure of the main steam isolation valves, as would be expected in an ELAP event, steam release from the SGs to the atmosphere would be initially accomplished via the SG MSSVs. During the ELAP event the SG ASDVs will be operated by means of local manual action from the main steam valve room. The licensee has provided procedural guidance for the operation of the ASDVs on both units. Manual operation of the valves can be performed without the need for electric power or compressed air. Communications systems necessary for operators to locally operate the ASDVs have battery backup. Both the MSSVs and ASDVs were designed as Seismic Category I.

The licensee's Phase 1 strategy directs operators to enter Procedure 1[2]OM-53A.1.ECA-0.0 (ECA.0-0), Revision 4, "Loss of All AC Power," upon the diagnosis of a total loss of ac power. Operators will stabilize the plant and maintain mode 3 conditions, delaying the plant cooldown until Phase 2 is initiated.

3.2.1.1.2 Phase 2

The licensee's FIP states that the preferred strategy for core cooling in Phase 2 would be to continue using the SGs as a heat sink, with SG secondary inventory being supplied by the TDAFWP. Although functionality of the TDAFWP is expected throughout Phase 2 per the NEI 12-06 assumptions associated with the analyzed ELAP event, to satisfy provisions of the order, the licensee will deploy a FLEX alternate AFW pump that is capable of backing up this essential function. This pump will be deployed at 14 hours after the initiation of the ELAP event.

According to the licensee's FIP, the supply of water in the each unit's PPDWST can be maintained by a gravity drain from the DWST. The site has one DWST which has a capacity of

530,000 gallons. The DWST is permanently connected to the BV2 unit PPDWST via a hard piped connection, and is also equipped with a connection point capable of connecting to both units PPDWSTs via 4 inch (in.) fire hoses. The DWST is the preferred source of water in Phase 2. However, it is not robust for all applicable hazards.

To provide an unlimited source of secondary makeup in Phase 2, the site will deploy FLEX makeup pumps which will take suction from the Ohio River. The FLEX makeup pumps will be staged at one of two possible locations outside of the protected area (PA). The makeup pumps discharge is connected to permanent piping which runs underneath the PA barriers. The permanent piping is protected from all applicable hazards. Hoses connected to the portable piping can be used to refill the PPDWSTs to maintain core cooling. The licensee has evaluated the use of river water and determined that it can be used to supply the SGs for at least 72 hours without the loss of cooling capability due to fouling of the SG heat transfer surfaces.

In the event that the FLEX alternate AFW pump is required to backup the TDAFWP function, three portable diesel driven pumps rated for a capacity of 400 gallons per minute (gpm) at 425 pounds per square inch gage (psig) are available and stored onsite in storage buildings. Each unit requires one pump while the third pump satisfies the N+1 provisions of NEI 12-06. The licensee's FIP describes the pump primary and alternate connection strategies. On both units the connection for suction to the FLEX alternate AFW pump is from a drain line on the unit's PPDWST. In BV1, the FLEX alternate AFW pump will be aligned to discharge to a primary connection point located on the discharge of the 'A' motor driven AFW pump and an alternate connection point located on the discharge of the 'B' motor driven AFW pump. In BV2 the FLEX alternate AFW pump will be aligned to discharge to a primary connection point located on the discharge of the 'A' motor driven AFW pump and an alternate connection point located on the discharge of the TDAFWP. Both of the connections will allow feed to the unit's three SGs.

3.2.1.1.3 Phase 3

Per its FIP, the licensee's core cooling strategy for Phase 3 begins with a continuation of the Phase 2 strategy with additional offsite equipment provided from an NSRC. Core cooling will continue to be provided by the SGs with feedwater supplied by either the TDAFWP, the FLEX AFW pump, or by Phase 3 equipment provided by the NSRC. Steam will continue to be released by local control of the ASDVs and SG level control will be maintained by locally throttling the associated AFW valves. Water purification equipment from the NSRC will be used to treat feedwater provided to the PPDWST reducing the degradation of the SG heat transfer surfaces and allowing for indefinite coping.

Additionally, the licensee has plans to restore shutdown cooling as an alternate method for core cooling and establishing cold shutdown conditions (<200 °F). By using portable 4160 Vac generators and associated cables provided by the NSRC either of the two Class 1E 4160 Vac buses at each unit may be restored. This will allow selected 480 Vac buses to be restored via the 4160/480 Vac transformers and associated breakers. The diesel powered low-pressure high-flow pumps provided by the NSRC will be utilized to restore the UHS function by pumping water from the Ohio River to connection points on the river water/service water (BV1/BV2) systems. Following the restoration of 4160 Vac and the UHS the licensee plans to restore component cooling water and establish RHR cooling.

Establishing shutdown cooling utilizing the RHR system will require a containment entry as the RHR pumps and isolation valves are located inside the containment structure. This entry will occur following the establishment of containment ventilation by a manner determined by the technical support center.

3.2.1.2 RCS Makeup Strategy

3.2.1.2.1 Phase 1

Following the reactor trip at the start of the ELAP event, operators will isolate RCS letdown pathways and confirm the existence of natural circulation flow in the RCS. A small amount of RCS leakage will occur through the low-leakage RCP seals, but because the expected inventory loss would not be sufficient to drain the pressurizer its overall impact on the RCS behavior will be minor. As the licensee does not plan on commencing a cooldown until Phase 2 actions are underway, ample RCS volume should remain to support natural circulation flow throughout Phase 1. Likewise, there is no need to initiate boration during this period, since the reactor operating history assumed in the endorsed NEI 12-06 guidance implies that a substantial concentration of xenon-135 would be present in the reactor core.

3.2.1.2.2 Phase 2

The licensee stated that in Phase 2, RCS inventory control and boration is accomplished using the FLEX RCS boration pump and associated flexible suction and discharge hoses and fittings. Two boration pumps per unit and the associated hoses are stored and staged in the primary auxiliary buildings (PABs), one for the FLEX N function and another to provide N+1 capability. They are seismically secured and are protected from all applicable hazards. The boration pumps will take suction from the boric acid tank and discharge into the RCS via a primary or secondary connection. The primary connection is located on the discharge of the A charging pump for both units. The secondary connection point is on the discharge of the C charging pump in BV1 and on the discharge of the B charging pump in BV2. The pumps will be powered by the FLEX 480 Vac generator and distribution system.

The BATs contain greater than 11,336 gallons in BV1 and 13,390 gallons in BV2. The boric acid concentration is maintained at a boron concentration of 7,000 to 7,700 parts per million (ppm). The licensee has calculated that a boron injection from the BATs of 6,105 gallons will maintain adequate shutdown margin.

The licensee plans to cool the RCS to a final RCS temperature of 425 °F for BV1and 445 °F for BV2 in two separate steps. The initial cooldown will be stopped at a temperature of 520 °F to ensure that the SI accumulators do not inject. The licensee will deploy a 480 Vac generator to energize and close all three SI accumulator discharge valves. Following the isolation of the SI accumulators, the cooldown will be continued to 425/445 °F BV1/BV2.

With low-leakage RCP shutdown seals installed on all RCPs, the licensee calculates that FLEX RCS makeup is not necessary to prevent the loss of single-phase natural circulation until after the completion of the boration. Therefore, the injection of borated RCS makeup water for reactivity control will be in progress before entry into reflux cooling becomes a concern.

3.2.1.2.3 Phase 3

The Phase 3 strategy for indefinite RCS inventory control and subcriticality is simply a continuation of the Phase 2 strategy, with backup pumps and water treatment equipment supplied by the NSRC. Mobile boric acid units from the NSRC can provide a indefinite supply of boric acid to the site.

3.2.2 Variations to Core Cooling Strategy for Flooding Event

Based on the flooding assessment in the BVPS updated final safety analysis report (UFSAR), the probable maximum flood (PMF) at the site reaches an elevation of 730 ft. mean sea level (MSL). Although all safe shutdown equipment is designed against adverse effects from the PMF they are not all located above the 730 ft. elevation, thus the Beaver Valley site is susceptible to external flooding and is not considered a dry site. The licensee stated that all safety-related structures or equipment are either designed or protected from the PMF flood water and FLEX strategies takes into consideration external flooding. The licensee stated in its FIP, that in accordance with the Flood Hazard Reevaluation Report, the BVPS site is not bounded by two flooding hazards (local intense precipitation (LIP) and wind wave runup concurrent with PMF). The licensee will complete a Flood Mitigating Strategies Assessment (MSA) in accordance with NEI 12-06. The licensee's core cooling and makeup strategy implementation remain unchanged for a flooding event. Refer to Section 3.5.2 of this SE for further discussion on flooding.

3.2.3 Staff Evaluations

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

Guidance document NEI 12-06 provides the baseline assumptions 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.

3.2.3.1.1 Plant SSCs

Core Cooling

The licensee provided descriptions in the FIP for the permanent plant SSCs to be used to support core cooling. The licensee indicated that there are two TDAFWPs, one for each unit, capable of taking steam from and providing feedwater to three SGs. The TDAFWP can automatically start on loss of all ac power and provide makeup water from the unit's PPDWST. BVPS procedures 1OM-53A.1.ECA-0.0 (ISS3), "Loss of All Emergency 4160 VAC AC Power (BV1)," and 2OM-53A.1.ECA-0.0 (ISS2), "Loss of All AC Power, (BV2)," provide operator actions required to start the TDAFWPs from the Control Room (CR) or locally from the AFW pump rooms. The BV1 TDAFWP is located in the BV1 Safeguards Building and the BV2 TDAFWP is located in the BV2 Safeguards Building, which are both protected from all applicable external hazards. The BV1 TDAFWP has two exhaust stacks, which were originally not protected from tornado missile hazards. The licensee made a modification to allow for new exhaust piping to tee into the existing exhaust stacks and creating a tornado missile barrier for the portion that penetrates through the exterior wall. The configuration would allow for an alternate TDAFWP exhaust path for normal operation if the stacks are impacted by tornado missiles.

The licensee's FIP described the PPDWSTs as the water sources for the TDAFWPs and the FLEX Alternate AFW pumps during ELAP events. Each PPDWST contains 160,000 gallons of makeup water credited for FLEX, which will provide SG makeup for about 9 hours before makeup to the PPDWST is needed. The BV1 PPDWST is located in the BV1 PPDWST Building and BV2 PPDWST is located in the BV2 PPDWST Building, which are both protected from all applicable external hazards. The PPDWSTs can be refilled from the Ohio River or the BV2 DWST. The Ohio River has an unlimited supply of water that can be used as a suction source for the FLEX makeup pump to refill the PPDWSTs for 72 hours before the NSRC provides water purification equipment to preserve functionality of the SGs and allow indefinite makeup water to the SGs. The Ohio River is the fully protected water source for all applicable external hazards. The Unit 2 DWST has 600,000 gallons of water and is the preferred water source for refilling the PPDWSTs. The Unit 2 DWST can provide makeup to BV1 and BV2 PPDWSTs through a simultaneous gravity drain to a new FLEX connection, which can be performed for about 48 hours after ELAP event initiation. The BV2 DWST is not protected from high wind missiles.

The licensee also indicated that initially upon loss of ac power, the MSSVs on each SG will provide core cooling and decay heat removal. The ASDVs on each SG in both units will be locally controlled in the Main Steam Valve Rooms during ELAP conditions. The BVPS procedure 1OM-53A.1.2-U, "Local Operation of SG Atmospheric Steam Dump Valves," provides guidance for the local manual operation of the steam dump valves on Unit 1. Procedure 20M-53A.1.A-1.11, "Manual Handpump Operation of Hydraulically Actuated Valves," provides guidance for the local manual operation of the steam dump valves on BV2. The ASDVs are designed as Seismic Category I and protected from all applicable external hazards.

During the audit, the NRC staff reviewed the locations of the permanent SSCs described above to confirm that the SSCs will be protected from all applicable external hazards and have supporting procedures that will direct operators to take action as needed to support the core cooldown FLEX strategy. Based on the design and location of the protected water sources and the permanent plant SSCs as described in the FIP, the NRC staff finds that the licensee's strategy should be available to support core cooling during an ELAP caused by a BDBEE, consistent with Condition 4 of NEI 12-06, Section 3.2.1.3.

RCS Inventory Control

The licensee described in its FIP, that the BATs, two for each unit, are the borated water source for RCS makeup. The BATs are stainless steel, safety-related, and seismically qualified storage tanks. The BATs are located in each unit's PAB, both which are protected from all applicable external hazards. The usable volume is maintained greater than 11,336 gallons for BV1 and 13,390 gallons for BV2. The boron concentration will be kept between 7,000 and 7,700 ppm based upon the License Requirement Surveillance 3.1.8.1 of the License Requirements Manual for each unit. Both BATs are equipped with a FLEX connection point to use each tank as a source for borated water for the FLEX RCS boration pumps.

During the audit, the NRC staff reviewed the locations of the BV1 and BV2 BATs to confirm that the RCS makeup strategy has a protected borated water source available for all applicable external events. Based on the location and the availability of the BATs, the NRC staff finds the licensee's strategy should be available to support RCS inventory control during an ELAP caused by a BDBEE, consistent with Condition 3 of NEI 12-06, Section 3.2.1.3.

3.2.3.1.2 Plant Instrumentation

According to the FIP, the following instrumentation will be relied upon to support the licensee's core cooling and RCS inventory control strategy. The following instruments are monitored from the CR and will be available throughout the event.

- SG level (wide range and narrow range)
- SG pressure
- RCS temperature
- RCS pressure (wide range)
- Core exit thermocouples
- Pressurizer level
- Excore nuclear instruments (source range)
- Reactor vessel level indicating system (RVLIS)
- PPDWST level
- Auxiliary feedwater (AFW) flow rate

All of these instruments are powered by the installed safety-related station batteries. To prevent a loss of vital instrumentation, operators will extend battery life to a minimum of 15 hours for BV1 and 17.75 hours for BV2 by shedding unnecessary loads. The load shedding will be completed prior to 3 hours from the initiation of the ELAP event. A FLEX 480 Vac turbine generator will be deployed to repower the battery chargers within 10 hours from ELAP event initiation. This leaves a margin of at least 5 hours prior to depletion of the associated batteries.

The licensee's FIP states that, as recommended by Section 5.3.3 of NEI 12-06, procedures have been developed to read the above instrumentation locally using portable instruments, where applicable. Further, guidance has been provided for a loss of dc power, or a loss of vital ac distribution in procedure FLEX Support Guideline (FSG)-7, "Loss of Vital Instrumentation Or Control Power." This document provides guidance for obtaining alternate monitoring for the following parameters:

- SG level
- SG pressure
- RCS pressure
- RCS temperature (Core exit thermocouples)

Furthermore, as described in its FIP, the licensee stated that portable FLEX equipment credited in the licensee's mitigating strategies is supplied with the instrumentation necessary to support local equipment operation.

The instrumentation available to support the licensee's strategies for core cooling and RCS inventory during the ELAP event is consistent with the recommendations specified in the endorsed guidance of NEI 12-06. Based on 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.

3.2.3.2 Thermal-Hydraulic Analyses

The FIP states that the mitigating strategy for reactor core cooling is based, in part, on a generic thermal-hydraulic analysis performed for a reference Westinghouse three-loop reactor using the NOTRUMP computer code. The NOTRUMP code and corresponding evaluation model were originally submitted in the early 1980s as a method for performing licensing-basis safety analyses of small-break loss-of-coolant accidents (LOCAs) for Westinghouse PWRs. Although NOTRUMP has been approved for performing small-break LOCA analysis under the conservative Appendix K paradigm and constitutes the current evaluation model of record for many operating PWRs, 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 NOTRUMP and other thermal-hydraulic codes used for these analyses. The NRC staff's review included performing confirmatory analyses with the TRACE code to obtain an independent assessment of the duration that reference reactor designs could cope with an ELAP event prior to providing makeup to the RCS.

Based on its review, the NRC staff questioned whether NOTRUMP 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. This is questioned 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. To resolve these issues within the compliance schedule specified in Order EA-12-049, the NRC staff requested industry to 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.

Accordingly, the ELAP coping time prior to providing makeup to the RCS is limited to the duration over which the flow in the RCS remains in natural circulation, prior to the point where continued inventory loss results in a transition to the reflux or boiler-condenser cooling mode. 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 leg and condenses on SG tubes, with the majority of the condensate subsequently draining back into the reactor vessel in countercurrent fashion. Quantitatively, as reflected in documents such as the PWR Owners Group (PWROG) report PWROG-14064-P, Revision 0, "Application of NOTRUMP Code Results for Westinghouse Designed PWRs in Extended Loss of AC Power Circumstances," industry has proposed defining this coping time as the point at which the one-hour centered time-average of the flow quality passing over the SG tubes' U-bend exceeds one-tenth (0.1). As discussed further in Section 3.2.3.4 of this SE, 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.

With specific regard to NOTRUMP, preliminary results from the NRC staff's independent confirmatory analysis performed with the TRACE code indicated that the coping time for Westinghouse PWRs under ELAP conditions could be shorter than predicted 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." Subsequently, a series of additional simulations performed by the staff and Westinghouse identified that the discrepancy in predicted coping time could be attributed largely to differences in the modeling of

RCP seal leakage. (The topic of RCP seal leakage will be discussed in greater detail in Section 3.2.3.3 of this SE.) These comparative simulations showed that when similar RCP seal leakage boundary conditions were applied, the coping time predictions of TRACE and NOTRUMP were in adequate agreement. From these simulations, as supplemented by review of key code models, the NRC staff obtained sufficient confidence that the NOTRUMP code may be used in conjunction with the WCAP-17601-P evaluation model for performing best-estimate simulations of ELAP coping time prior to reaching the reflux cooling mode.

Although the NRC staff obtained confidence that the NOTRUMP code is capable of performing best-estimate ELAP simulations prior to the initiation of reflux cooling using the one-tenth flow-quality criterion discussed above, the staff was unable to conclude that the generic analysis performed in WCAP-17601-P could be directly applied to all Westinghouse PWRs, as the vendor originally intended. In PWROG-14064-P, Revision 0, the industry subsequently recognized that the generic analysis would need to be scaled to account for plant-specific variation in RCP seal leakage. However, the staff's review, supported by sensitivity analysis performed with the TRACE code, further identified that plant-to-plant variation in additional parameters, such as RCS cooldown terminus, accumulator pressure and liquid fraction, and initial RCS mass, could also result in substantial differences between the generically predicted reference coping time and the actual coping time that would exist for specific plants.

During the audit, the NRC staff evaluated a comparison of the generic analysis values from WCAP-17601-P and PWROG-14064-P to the Beaver Valley plant-specific values. The NRC staff concurred that the generic plant parameters were bounding for the analyzed event. Beaver Valley has installed low-leakage SHIELD shutdown seals. Therefore, the seal leakage expected for Beaver Valley is significantly less than assumed in the generic NOTRUMP analysis case. The NRC staff concluded (based on the licensee evaluation) that the licensee could maintain single-phase natural circulation for at least 40 hours, two-phase natural circulation for at least 60 hours and core uncovery (reflux cooling) for at least 72 hours without RCS makeup. The RCS makeup will be available per the licensee's mitigating strategy for shutdown margin at approximately 14 hours following initiation of ELAP, providing sufficient margin to the onset of reflux cooling.

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

3.2.3.3 Reactor Coolant Pump (RCP) Seals

Leakage from the 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, resulting in increased leakage and the potential for 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.

Per its FIP, the licensee credits Generation 3 SHIELD low leakage seals for FLEX strategies including RCS inventory control and boration. The low leakage seals limit the total RCS leak rate to no more than 4 gpm (1 gpm per RCP seal and 1 gpm of unidentified RCS leakage in accordance with Technical Specifications).

The SHIELD low leakage seals are credited in the FLEX strategies in accordance with the four conditions identified in the NRC's endorsement letter of TR-FSE-14-1-P, "Use of Westinghouse SHIELD Passive Shutdown Seal for FLEX Strategies," dated May 28, 2014 (ADAMS Accession No. ML14132A128). In its FIP, the licensee describes compliance with each condition of SHIELD seal use as follows:

(1) Credit for the SHIELD seals is only endorsed for Westinghouse RCP Models 93, 93A, and 93A-1.

This condition is satisfied as NRC staff verified during the audit that the RCPs for BVPS are Westinghouse Model 93A.

(2) The maximum steady-state RCS cold-leg temperature is limited to 571 °F during the ELAP (i.e., the applicable main steam safety valve setpoints result in an RCS cold-leg temperature of 571 °F or less after a brief post-trip transient).

The maximum steady-state RCP seal temperature during an ELAP response is expected to be the RCS cold leg temperature corresponding to the lowest SG safety relief valve setting of 1,090 pounds per square inch atmospheric (psia). This results in a RCS cold leg temperature of approximately 550 °F .

(3) The maximum RCS pressure during the ELAP (notwithstanding the brief pressure transient directly following the reactor trip comparable to that predicted in the applicable analysis case from WCAP-17601-P) is as follows: For Westinghouse Models 93 and 93A-1 RCPs, RCS pressure is limited to 2,250 psia; for Westinghouse Model 93A RCPs, RCS pressure is to remain bounded by Figure 7.1-2 of TR-FSE-14-1-P, Revision 1.

The normal operating RCS pressure for Westinghouse PWR's is less than 2,250 psia. Allowing for the possibility of a brief pressure transient directly following the reactor trip, the NRC staff concludes that the licensee's mitigating strategy of cooling the reactor core via the main steam safety valves and SG ASDVs will maintain reactor pressure within the limiting value for Model 93A.

(4) Nuclear power plants that credit the SHIELD seal in an ELAP analysis shall assume the normal seal leakage rate before SHIELD seal actuation and a constant seal leakage rate of 1.0 gpm for the leakage after SHIELD seal actuation.

Beaver Valley's FIP and supporting calculations assume a constant Westinghouse SHIELD RCP seal package leakage rate of 1 gpm per RCP, plus 1 gpm of unidentified RCS leakage, for a total RCS leakage of 4 gpm. For the first 10-15 mins the licensee assumed a leakage rate of 3-5 gpm per RCP prior to actuation of the SHIELD seal. As noted in the FIP, BVPS calculation indicates that reflux cooling would not be entered for 72 hours into the event, even if FLEX RCS makeup flow were not provided as planned. In that BVPS mitigating strategy directs RCS makeup to begin approximately 14 hours after event initiation, ample margin exists to accommodate the small additional volume of leakage that is expected to occur before actuation of the SHIELD seal.

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

3.2.3.4 Shutdown Margin Analyses

In the 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. However, 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 NRC 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 recriticality will not occur during a FLEX RCS cooldown.

The BVPS FIP and the shutdown margin calculation, CN-SEE-III-12-69-R describe the strategy necessary to maintain shutdown margin following the initiation of the ELAP event. In both documents, FENOC stated that FLEX options would supply negative reactivity by injecting borated water into the RCS by employing the high pressure, low flow FLEX RCS Boron Pump. This will guarantee that a shutdown margin of 1 percent is preserved following the cooldown to

425/445 °F BV1/BV2 and xenon decay. The initial cooldown is limited to a threshold of 520 °F to maintain sufficient pressure to prevent accumulator injection. This strategy maximizes the injectable borated water volume available. In order to make sure that acceptable boric acid mixing conditions are met in the RCS, injection is provided for reactivity control starting at approximately 14 hours after the initiation of the ELAP event and completed in approximately 8.5 hours. The licensee states that the boration will be completed at 23 hours following the initiation of the ELAP event. Therefore, the required completion time for boration of the RCS by 24 hours is met.

The means of providing borated water in Phase 2 is the unit's FLEX RCS Boron Pump taking suction from two separate BATs at both units. The FLEX RCS Boration Pumps inject the borated water into the Chemical and Volume Control system downstream of the charging pumps. Calculation CN-SEE-III-12-69-R shows that the injection of approximately 6,105 gallons, with a minimum boric acid concentration of 7,000 ppm, of borated water from the BAT would meet the shutdown margin requirement of 1 percent at limiting cycle conditions. The BAT meets this requirement by retaining a usable capacity of 11,336 gallons for Unit 1 and 13,390 gallons for Unit 2 and maintaining a License Requirement Surveillance (3.1.8.1) of boron concentration of between 7,000 and 7,700 ppm for both units. No credit is given to boron injection from the SI accumulators in the shutdown margin calculation.

Toward the end of an operating cycle, when the 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. The licensee's FIP concluded that, the RCS volume is preserved by not allowing SI Accumulator injection to occur, so RCS venting is not necessary.

The NRC staff's audit review considered whether the licensee had followed recommendations from the PWROG's position paper and the associated conditions imposed in the NRC staff's endorsement letter. Regarding the first condition, the NRC staff's audit review found that the licensee's shutdown margin calculation had considered an appropriate range of RCS leakage rates in determining the limiting condition for the shutdown margin analysis. Furthermore, the NRC staff concluded that the licensee's plan to initiate RCS makeup by 14 hours satisfies the second two conditions. Therefore, the NRC staff concludes that the licensee's calculation conforms to the intent of the PWROG position paper, including the intent of the additional conditions imposed in the NRC staff's endorsement letter.

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 position paper, dated August 15, 2013 (withheld from public disclosure due to proprietary content), which provided test data regarding boric acid mixing under single-phase natural circulation conditions and outlined applicability limits 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 (ADAMS Accession No. ML13276A183), the NRC staff endorsed the above position paper with three conditions:

> Condition 1: The required timing and quantity of borated makeup should consider conditions with no RCS leakage and with the highest applicable leakage rate.

This condition is satisfied because the licensee's planned timing for establishing borated makeup acceptably considered both the maximum and minimum RCS leakage conditions expected for the analyzed ELAP event.

> Condition 2: 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.

This condition is satisfied because the licensee's planned timing for establishing borated makeup would be prior to RCS flow decreasing below the expected flow rate corresponding to single-phase natural circulation for the analyzed ELAP event.

> Condition 3: 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 1 hour is considered appropriate.

This condition is satisfied because the licensee's planned timing for establishing borated makeup allows a 1-hour period to account for boric acid mixing; furthermore, during this 1-hour period, the RCS flow rate would exceed the single-phase natural circulation flow rate expected during the analyzed ELAP event.

During the audit review, the licensee confirmed that BVPS will comply with the August 15, 2013, position paper on boric acid mixing, including the above conditions imposed in the staff's corresponding endorsement letter. The NRC staff's audit review indicated that the licensee's shutdown margin calculations are generally consistent with the PWROG's position paper, including the three additional conditions imposed in the NRC staff's endorsement letter.

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

3.2.3.5 FLEX Pumps and Water Supplies

The licensee relies on three different portable FLEX pumps during Phase 2. The licensee plans to use a FLEX Alternate AFW pump to feed the SGs from the PPDWST when the TDAFWP for that unit can no longer be used. Also, the licensee plans to use a FLEX makeup pump to provide makeup water to the PPDWSTs. The FLEX makeup pump will also be used to provide SFP makeup through the spray nozzles at the SFP operating deck. The FLEX RCS boration pump will provide high pressure, low flow RCS makeup from the BATs. In Section 2.3.10 and Table 6.6 of its FIP, the licensee identified the performance criteria (e.g., flow rate, discharge pressure) for the Phase 2 portable pumps. See Section 3.10 of this SE for a detailed discussion of the availability and robustness of each water source.

The FLEX Alternate AFW pumps are portable diesel-driven, two-stage centrifugal pumps. Each FLEX Alternate AFW pump will take suction from the PPDWST on its respective unit. The licensee indicated in its FIP that there are three FLEX Alternate AFW pumps, one for each unit and one to meet N+1 for the site. The FIP states that hydraulic analysis confirms these pumps can maintain SG levels for decay heat removal. Two FLEX Alternate AFW pumps are stored in the FESB. The FESB is protected from all applicable external hazards. The "N+1" pump is located in the Q-Laydown Warehouse, which isn't protected from tornado missiles. The FLEX Alternate AFW pump source connection points on the PPDWSTs are described in Section 3.7.3.1 of this SE. During the audit process, the NRC staff reviewed the licensee's calculation 8700-DMC-1392, Revision 0, "Auxiliary Feedwater System Model Development," which determined the fluid system hydraulic performance. The NRC staff review notes that this calculation assessed different possible lineups based on such variables as connection points and hose paths to determine the flow to ensure that the FLEX Alternate AFW pump procured by the licensee would be adequate for providing injection into the SGs at the required flow rate and discharge pressure.

The licensee's FIP states that the FLEX makeup pumps provide water from the Ohio River to the PPDWST and SFP. The FLEX makeup pumps are trailer mounted, diesel driven centrifugal pumps. There are six FLEX makeup pumps at the BVPS. Each unit uses one FLEX makeup pump to supply makeup water from the Ohio River to the SFP through hoses and nozzles staged at the SFP operating deck, and a second FLEX makeup pump to deliver makeup water from the Ohio River to the PPDWSTs for SG makeup through the new FLEX pipe trench and new FLEX connections on the Unit's PPDWSTs. The remaining two pumps are described to be "N+1," one for each unit, and are stored in the Q-Laydown Warehouse. The licensee has several methods available for connecting the FLEX makeup pumps. These methods are discussed in SE Section 3.7.3.1. During the audit process, the NRC staff reviewed the licensee's calculation 8700-DMC-3534, Revision 2, "Beaver Valley Power Station Unit 1 River Water Model Development and Benchmark," which determined the fluid system hydraulic performance. The NRC staff review notes that this calculation assessed different possible lineups based on such variables as connection points and hose paths to determine the flow to ensure that the FLEX makeup pump would be adequate for providing injection into the SGs at the required flow rate and discharge pressure.

The licensee described in its FIP, that the FLEX RCS boration pumps are motor driven, positive displacement pumps mounted on a cart for deployment. The FLEX RCS boration pumps are powered by the FLEX 480 Vac turbine generator. The licensee indicated that there are four FLEX RCS boration pumps at the BVPS, two of these will serve as "N" and the remaining two pumps serve as "N+1." Two FLEX RCS boration pumps with the associated hoses, cables, and fittings are stored in the BV1 PAB and the other two FLEX RCS boration pumps with the associated hoses, cables, and fittings are stored in BV2 PAB. The FLEX 480 Vac turbine generators are stored in the FESB. Both buildings are protected from all applicable external hazards. The FLEX RCS boration pump source connection points are described in SE Section 3.7.3.1. During the audit process, the NRC staff reviewed the licensee's calculation 8700-DMC-1624, Revision 0, "High Head/Charging and Low Head Safety Injection Proto-Flo Model Development and Validation,", which determined the fluid system hydraulic performance. This calculation assessed different possible lineups based on such variables as connection points and hose paths to determine the flow to ensure that the FLEX RCS boration pump would be adequate for providing injection into the RCS at the required flow rate and discharge pressure.

The staff confirmed that flow rates and pressures evaluated in the hydraulic analyses were reflected in the FIP for the respective SG and RCS makeup strategies based on the capability of the above FLEX pumps and the respective FLEX connections being made as directed by the FSGs. During the onsite audit, the staff also conducted a walk down of the hose deployment routes for the above FLEX pumps to confirm the evaluations of the pump staging locations, hose distance runs, and connection points as described in the above hydraulic analyses and the FIP. The NRC staff notes that the performance criteria for the FLEX Phase 3 NSRC pumps are consistent with the capacities of the FLEX Phase 2 portable pumps.

Based on the staff's review of the FLEX pumping capabilities at BVPS, as described in the above hydraulic analyses and the FIP, the NRC staff concludes that the portable FLEX pumps should perform as intended to support core cooling and RCS inventory control during an ELAP event, consistent with NEI 12-06, Section 11.2.

3.2.3.6 Electrical Analyses

The licensee's electrical strategies provide power to equipment and instrumentation used to mitigate the ELAP and loss of normal access to the UHS. The electrical strategies described in the FIP are practically identical for maintaining or restoring core cooling, containment, and SFP cooling, except as noted in Sections 3.3.4.4 and 3.4.4.4 of this SE.

The NRC staff reviewed the licensee's FIP, conceptual electrical single-line diagrams, and the summary of calculations for sizing the FLEX generators and station batteries. The staff also reviewed the licensee's evaluations that addressed the effects of temperature on the electrical equipment credited in the FIP as a result of the loss of heating, ventilation, and air conditioning (HVAC) caused by the event.

After an ELAP and loss of normal access to the UHS, the plant's indefinite coping capability is attained through the implementation of pre-determined FLEX strategies that are focused on maintaining or restoring key plant safety functions. A safety function-based approach provides consistency and allows coordination with existing plant emergency operating procedures (EOPs). The FLEX strategies are implemented via FSGs in support of EOPs.

During the first phase of an ELAP event, the licensee would rely on the Class 1E station batteries and inverters to provide power to key instrumentation for monitoring parameters and controls for SSCs used to maintain the key safety functions (reactor core cooling, RCS inventory control, and containment integrity). The Class 1E station batteries, inverters and associated dc distribution systems are located within the BV1 and BV2 Service Buildings, which are Seismic Category I structures. As such, the Phase 1 electrical equipment should be appropriately protected during the BDBEE.

The Class 1E batteries will be used to initially power required key instruments and other required loads until backup power (Phase 2) is available. The licensee's strategy is to prolong dc power availability by shedding non-essential loads and by isolating one dc train to preserve the batteries for later use. Plant operators would commence load shedding within 30 minutes of the initiating event, isolate and preserve one dc train of batteries within two hours into the event, and complete load shedding within 3 hours of the initiating event. Procedures 1[2]OM.53E.1.FSG-4 (FSG-4), Revision 1[1], "ELAP DC Bus Load Shed/Management," provide operational guidance to shed non-essential loads within the time assumed in the licensee's analysis. The energized train battery would continue to supply power for at least 9.75 hours (BV1) and 8.5 hours (BV2). Before the energized train battery is depleted to a minimum acceptable voltage, the plant operator would place the preserved train into service. The operator would then isolate the energized train with its depleted battery. The preserved train battery would continue to supply power for the next 7.5 hours (BV1) and 11.25 hours (BV2). In EER 601073010, the licensee's evaluation determined that dc power from batteries will be available for at least 15 hours for BV1 and 17.75 hours for BV2. Procedures 1[2]OM-

53E.1.FSA-10 (FSA-10), Revision 0, "ELAP Battery Management," provide guidance to the plant operators to manage dc battery trains for preservation during an ELAP event. These procedures include a caution note stating that if possible, opposite train batteries should be placed in service prior to removing low voltage batteries in order to maintain essential instrumentation.

The BV1 and the BV2 each has four independent Class 1E station batteries. Batteries BAT-1-3 and BAT-1-4 are model LCY-39 and were manufactured by C&D Technologies. Batteries BAT-1-1, BAT-1-2, BAT-2-1, and BAT-2-2 are model GN-21 and were manufactured by Enersys. Batteries BAT-2-3 and BAT-2-4 are model GN-13 and were manufactured by Enersys.

The NRC staff reviewed the licensee's dc coping calculations 8700-DEC-3582, Revision 0, "FLEX Battery BAT-2-5 Coping Analysis,", 8700-DEC-3583, Revision 0, "FLEX Battery BAT-1-2 Coping Analysis," 8700-DEC-3584, Revision 0, "FLEX Battery BAT-1-3 Coping Analysis," 8700-DEC-3585, Revision 0, "FLEX Battery BAT-1-4 Coping Analysis," 10080-DEC-3578, Revision 0, "FLEX Battery BAT*2-1 Coping Analysis," 10080-DEC-3579, Revision 0, "FLEX Battery*2-2 Coping Analysis," 10080-DEC-3580, Revision 0, "FLEX Battery*2-3 Coping Analysis," and 10080-DEC-3581, Revision 0, "FLEX Battery*2-4 Coping Analysis," that verified the capability of the Class 1E station batteries to supply power to the required loads during Phase 1. The licensee's evaluation identified the required loads and their associated ratings (ampere (A) and minimum required voltage (V)) and the non-essential loads on the batteries that would be shed.

An NEI White Paper, "EA-12-049 Mitigating Strategies Resolution of Extended Battery Duty Cycles Generic Concern," (ADAMS Accession No. ML13241A186) provides guidance for calculating extended duty cycles of batteries (i.e., beyond 8 hours). This paper was endorsed by the NRC (ADAMS Accession No. ML13241A188). In addition to the White Paper, 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," in May 2015. The testing provided additional validation that the NEI White Paper method was technically acceptable. The NRC staff reviewed the licensee's battery calculations and confirmed that they had followed the guidance in the NEI White Paper.

Based on the above analyses and procedures, the NRC staff concludes that the Class 1E station batteries have adequate capacity to supply the required loads until the Phase 2 equipment can be deployed and energize the BV1 and BV2 vital buses.

During Phase 2, the licensee's strategy includes transition from installed equipment to the onsite FLEX equipment. In its FIP, the licensee discussed primary and alternate strategies for supplying power to equipment using a combination of portable FLEX and permanently installed, seismically robust components. The licensee stated that BVPS will use one portable 850 kW 480 Vac FLEX combustion turbine generator (CTG) per unit to power Phase 2 loads. The licensee has a total of three identical FLEX CTGs, which satisfies N+1 guidance in NEI-12-06. The FLEX 480 Vac CTGs are stored in the FESB, which is designed to protect Phase 2 equipment from all applicable external hazards.

The licensee's Phase 2 strategy includes repowering the 480 Vac buses within 15 hours for BV1 and 17.75 hours for BV2 after initiation of an ELAP. Each Phase 2 FLEX CTG would provide power to each unit's battery chargers, inverters, CR fans, emergency switchgear fans, RCS Boration pumps, motor operated Accumulator Isolation Valves, and other required loads. Procedures 1[2]OM-53E.1.FSA-13 (FSA-13), Revision 0[2], "Deploying FLEX 480VAC Generator," provide guidance on deployment and loading of the FLEX 480 Vac CTGs and

Procedures 1/2OM-53E.1.FSOA-2, Revision 2, "Turbine Marine 480 V Generator Operating Aid," provide general guidance for operating the 480 Vac CTGs.

The NRC staff reviewed the FLEX DG Load Tabulation in the FIP and the summary of the Phase 2 CTG sizing calculation 10080-DEC-3586, Revision 0, "FLEX Electrical Load and Voltage Evaluation." These references indicate that the maximum load on the Phase 2 FLEX 850 kW/1060 kilo Volt Ampere (kVA) CTGs would be 210 kVA (BV1 Train A) and 195.1 kVA (BV1 Train B) and 156.1 kVA for BV2 Train A or B. Therefore, the FLEX CTGs and the associated electrical distribution equipment are adequately rated to support Phase 2 loads. During the audit process, the NRC staff also reviewed conceptual single line electrical diagrams, the separation and isolation of the FLEX PTGs from the Class 1E emergency diesel generators (EDGs), and procedures that direct operators how to align, deploy, connect, and protect associated systems and components. Procedure FSA-13 provides guidance on energizing battery chargers using the FLEX 850 kW CTGs to ensure that the critical plant instruments continue to be powered, as well as providing guidance on staging, connecting and energizing the 480 Vac vital buses used to power plant equipment in Phase 2.

Based on its review, the NRC staff concludes that the Phase 2 FLEX 850 kW CTGs should have adequate capability and capacity to power the loads needed during an ELAP.

For Phase 3, the licensee plans to continue the Phase 2 coping strategy with additional assistance provided from offsite equipment/resources. The offsite resources that will be provided by an NSRC include four (2 per unit) 1.0 megawatt (MW) 4160 Vac CTGs, two (one per unit) 1,100 kW 480 Vac CTGs, and distribution panels (including cables and connectors). The 4160 Vac CTGs supplied by an NSRC can supply power to either of the two Class 1E 4160 Vac buses at each unit. Additionally by restoring the Class1E 4160 Vac buses, power can be restored to the Class 1E 480 Vac buses via the 4160/480 Vac transformer to power selected 480 Vac loads. Two NSRC 1.0 MW 4160 Vac CTGs in parallel will provide approximately 2.0 MW/2500 kVA of capacity that should be sufficient to support a RHR Pump, a CCW Pump, a Containment Air Recirculation Fan (if necessary), motor operated valves and additional ventilation and lighting loads.

The NRC staff reviewed the FLEX DG Load Tabulation in the FIP and the summary of the calculation 10080-DEC-3586 which addressed the Phase 3 loading for the NSRC Phase 3 4160 Vac CTGs. The FIP and the calculation showed that the maximum loads would be approximately 1781.1 kVA (BV1 Train A), 1746.8 kVA (BV1 Train B), 1689.3 kVA (BV2 Train A) and 1704.3 kVA (BV2 Train B).

Based on its review of the FIP and the licensee's calculation, the NRC staff finds that the 4160 Vac and 480 Vac CTGs should have sufficient capacity and capability to supply the Phase 3 loads.

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 and turbine generators that the licensee plans to use should have sufficient capacity and capability to supply the necessary loads during an ELAP event.

3.2.4 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that should maintain or restore core cooling and RCS inventory during 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.

3.3 Spent Fuel Pool Cooling Strategies

Table 3-2 and Appendix D of NEI 12-06 summarize an approach consisting of two 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; and 2) makeup via connection to SFP cooling piping or other alternate location capable of exceeding the boil-off rate for the design basis heat load. However, in JLD-ISG-2012-01, Revision 1 (ADAMS Accession No. ML15357A163), the NRC staff did not fully accept this approach, and added another requirement to either have the capability to provide spray flow to the SFP, or complete an SFP integrity evaluation, which demonstrates that a seismic event would have a very low probability of inducing a crack in the SFP or its piping systems so that spray would not be needed to cool the spent fuel. The evaluation must use the reevaluated seismic hazard described in Section 3.5.1 below if it is higher than the site's current Safe Shutdown Earthquake (SSE). During the event, the licensee selects the SFP makeup 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 must be completed within a certain period of time should be identified and a basis that the time can be reasonably met should be provided. 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.

In 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. The effects of an ELAP with full core offload to the SFP is addressed in Section 3.11. The licensee has decided to provide the spray flow described in JLD-ISG-2012-01.

3.3.1 Phase 1

The licensee stated in its FIP that no FLEX equipment will be deployed for Phase 1 during normal operations. The FSGs will direct the operators to establish a vent path in the FHB prior to the SFP water reaching the boiling point. The licensee also indicated that hoses to aid in SFP makeup would be pre-staged during a refueling outage. The licensee will monitor SFP water level using reliable SFP level instrumentation installed per Order EA-12-051.

3.3.2 Phase 2

The licensee stated that, for Phase 2, the FLEX makeup pump (one for each unit) provides makeup water to the SFP, by using borated water from the RWST, if available, or using the Ohio River as the credited water source. The flexible hose is connected from the discharge of the FLEX makeup pump and discharges into the SFP directly at the operating deck or through the FLEX connection in the SFP cooling system piping, all located in the FHB. For the spray option, flexible hoses are deployed from the FESB and are routed from the gated wye fittings outside of the FHB to the SFP spray nozzles staged on the SFP operating deck.

3.3.3 Phase 3

The licensee stated that Phase 2 SFP makeup strategy is continued with the inventory remaining in the RWST or using the Ohio River. The NSRC 4160 Vac generator will be used for long-term cooling of the SFP by repowering one train of normal pool cooling equipment at each Unit. The primary plant component cooling water (CCW) system will be aligned to cool the SFP using one fuel pool heat exchanger.

3.3.4 Staff Evaluations

3.3.4.1 Availability of Structures, Systems, and Components

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 staff reviewed the licensee's time to boil calculation for the SFP. This calculation and the FIP indicate that boiling begins at approximately 18.69 hours for BV1 and 19.54 hours for BV2 hours 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 to the SFP operating decks as a contingency for SFP makeup within nine hours from event initiation while 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 operators are directed by documents 1[2]OM-53E.1.FSG-11 (FSG-11), "Alternate SFP Makeup and Cooling," to open security barriers and chain operated roll up doors in the FHB.

The licensee's SFP cooling strategy involves the use of the FLEX makeup pumps and associated hoses and fittings with suction from the RWST or the Ohio River. The staff's evaluation of the robustness and availability of FLEX connection points for the FLEX makeup pumps is discussed in Section 3.7.3.1 of this SE. Furthermore, the staff's evaluation of the robustness and availability of the RWST and the Ohio River is discussed in Section 3.10.3 of this SE.

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 DGs. The NRC staff's review of the SFP level instrumentation, 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

In NEI 12-06, Section 3.2.1.6 states that SFP heat load assumes the maximum design-basis heat load for the site. In accordance with NEI 12-06, the licensee performed a thermal-hydraulic analysis of the SFP as a basis for the inputs and assumption used in its FLEX equipment design requirements analysis. During the audit, the licensee provided calculation 8700-DMC-1669, Revision 2, "Refueling Outage Time to RCS Boiling and Post Outage Time for SFP Heat-up to 200 Degrees F," which described the thermal-hydraulic analysis of the SFP under ELAP conditions. The calculation concluded that the SFP heat load will reach maximum boiling temperature in approximately 18.69 hours for BV1 and 19.54 for BV2 under normal, no load conditions. The time to boil off to 15 ft. from the top of the active fuel is approximately 71 hours without any operator actions. The licensee also indicated in its FIP, that the SFP makeup will begin around 71 hours into the ELAP event at a flow rate of 110 gpm, which is higher than the design requirement of 18.92 gpm for BV1 and 17.62 gpm for BV2 to replenish the SFP water being boiled off.

The NRC staff reviewed the thermal-hydraulic calculation 8700-DMC-1699 during the audit and concluded that the licensee has conservatively determined a SFP makeup flow rate of at least 110 gpm will maintain an adequate SFP level above the top of the active fuel for an ELAP occurring during normal power operation. Based on the information contained in the FIP and the thermal-hydraulic calculation, the NRC staff finds that the licensee has considered the maximum design-basis SFP heat load, meeting the guidance in NEI 12-06 Section 3.2.1.6.

3.3.4.3 FLEX Pumps and Water Supplies

As described in the FIP, the SFP cooling strategy relies on one of two FLEX makeup pumps (for each Unit) to provide SFP makeup during Phase 2. Each Unit has two FLEX makeup pumps, one for the SFP makeup function and the other for the PPDWST makeup from the Ohio River. The four pumps are stored in the FESB and two additional pumps (identified as "N+1" for each unit) are stored in the Q-Laydown Warehouse. In the FIP, Table 6.6 indicates that there is a hydraulic flow rate of 600 gpm for each FLEX makeup pump. The staff noted that the performance criteria of a FLEX pump supplied from an NSRC for Phase 3 would allow the NSRC pump to fulfill the mission of the FLEX makeup pump if the FLEX makeup pump was to fail. As stated above, either FLEX makeup pump can provide SFP spray flow rate of 250 gpm, which both meets and exceeds the maximum SFP makeup requirements. Furthermore, the staff finds the analysis above is consistent with NEI 12-06 Section 11.2 and the FLEX equipment is capable of supporting the SFP cooling strategy and is expected to be available during an ELAP event.

3.3.4.4 Electrical Analyses

The licensee's basic FLEX strategy for maintaining SFP cooling is to monitor the SFP level and provide makeup water to the SFP.

The licensee's Phase 1 strategy is to monitor SFP level using instrumentation installed in response to the NRC Order EA-12-051. The capability of this instrumentation is described in other areas of this SE. In its FIP, the licensee stated that on loss of normal power, each channel's uninterruptible power supply automatically transfers to a dedicated backup battery that has adequate capacity to supply power for 72 hours.

For Phases 2 and 3, prior to 72 hours power to the SFP level instruments could be provided from any 120 Vac source (including a Phase 2 FLEX 480 Vac CTG via a portable Load Center, the trailer mounted generator designated for CR lighting and ventilation, or one of several portable generators that are stored in the FESB. The licensee plans to use FLEX diesel driven pumps to provide make-up water for the SFP during Phases 2 and 3. Given the small power consumption by the SFP level instruments, the NRC staff concludes that the Phase 2 FLEX 480 Vac 850 kW CTG via a portable Load Center should have adequate capacity to support SFP level instrument load.

Based on its review, the NRC staff finds that the licensee's electrical strategy is acceptable to restore or maintain SFP cooling indefinitely during an ELAP as a result of a BDBEE.

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. Both units were originally designed with sub-atmospheric containments. The licensee previously changed the operating conditions from sub-atmospheric to atmospheric and therefore the staff has analyzed them similar to large dry containments.

The licensee performed a containment evaluation, 10080-DMC-3687, Revision 0, "Containment Temperatures Following an Extended Loss of All Alternating Current Power (ELAP) in Support of FLEX Mitigating Strategies", which was based on the boundary conditions described in Section 2 of NEI 12-06. The calculation analyzed the strategy of isolation and monitoring key containment parameters and concluded that the containment parameters of pressure and temperature remain well below the respective UFSAR Section 5.2.2 design limits of 45 psig and 280 °F for more than 72 hours. From its review of the evaluation, the NRC staff noted that the required actions to maintain containment integrity and required instrumentation functions have been developed, and are summarized below.

Eventual containment cooling and depressurization to normal values may utilize off-site equipment and resources during Phase 3 if onsite capability is not restored.

3.4.1 Phase 1

The Phase 1 strategy is automatic containment isolation and to monitor key containment parameters in accordance with 1/20M-53A.1.ECA-0.0 and 1/20M-53F1.FSG-5 (FSG-5), "Initial Assessment and FLEX Equipment Staging". Calculation 10080-DMC-3687 demonstrates containment pressure remains below 20 psia and the temperature remains below 180 °F for the first 72 hours, therefore no actions to reduce containment temperature or pressure are anticipated during Phases 1 or 2.

3.4.2 Phase 2

The Phase 2 strategy is to continue the Phase 1 strategy of monitoring key containment parameters.

3.4.3 Phase 3

The Phase 3 strategy is to continue the Phase 1 strategy of monitoring containment parameters. If necessary, 4160 VAC turbine generators and large capacity pumps from the NSRC can be used to re-power existing plant equipment. The NSRC supplied diesel powered pumps can be used to inject water into the Service Water system. The RHR pumps, Containment Air Recirculation Fans, CCW pumps, and associated motor operated valves can be used to remove heat from containment. Pre-planned FLEX strategies for containment cooling are provided in 1/2OM.53E1.FSG-12 (FSG-12), "Alternate Containment Cooling". Additional cooling strategies can be generated using 1/2OM-53.FSG-20 (FSG-20), "Alternate FLEX Guideline Creation".

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

Containment

The reactor containment structure is a totally reinforced concrete, steel-lined vessel with a flat base, cylindrical walls, and a hemispherical dome. The containment is designed to withstand seismic events, tornado winds, and tornado missiles. The containment has a volume of 1,751,734 cubic feet, the design pressure is 45 psig and the design temperature is 280 °F.

Residual Heat Removal System (RHRS)

The RHRS is designed to remove residual and sensible heat from the core and reduce the temperature of the RCS during the second phase of reactor cooldown. All piping and components of the RHRS are designed to the applicable codes and standards. The RHRS is a Seismic Category I system. The entire RHRS is located inside the containment with the exception of the line leading to the refueling water storage tank which penetrates the containment.

Containment Air Recirculation Fans

Bulk air cooling of the containment is normally achieved by three air recirculation cooling systems with the recirculated air being cooled on passing through chilled water or river water coil banks. In the event of loss of all normal onsite and offsite power, when the emergency busses are loaded on the EDG, the containment air recirculation fans do not start on the load sequencer and will not be loaded manually on the EDG. Normally water is supplied to the cooling coils from the chilled water system. An alternate source of water is also provided by piping from each river water header. According to Section 5.4.1 of the UFSAR, none of the ventilation system is designed as Seismic Category I, with exception of portions required for containment isolation.

Containment Depressurization System

As described in the license's FIP, BVPS's preferred method to cool containment is the Containment Air Recirculation Fans. In the event the Containment Air Recirculation Fans are not available, the Containment Depressurization System will be available. The Containment Depressurization System consists of a quench spray subsystem and a recirculation spray system. Both subsystems are seismic class I engineered safety systems protected from tornado missiles. The recirculation spray subsystem uses heat exchangers cooled by river water to remove heat from containment.

3.4.4.1.2 <u>Plant Instrumentation</u>

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 portable DGs deployed in Phase 2. If no ac or dc power is available, the FIP states that key credited plant parameters, including containment pressure, are available using alternate methods. Procedure 1OM-53E.FSG-7 (FGS-7), "Loss of Vital Instrumentation or Control Power," directs operators to use 1OM-53E.FSA-22 (FSA-22), "Alternate Containment Pressure Indication," for alternate methods.

3.4.4.2 <u>Thermal-Hydraulic Analyses</u>

The NRC staff reviewed the containment evaluation, 10080-DMC-3687, "Containment Temperatures Following an Extended Loss of All Alternating Current Power (ELAP) in Support of FLEX Mitigating Strategies," which provides a best-estimate of BVPS containment pressure and temperature response during an ELAP. The evaluation used the Modular Accident Analysis Program (Design-Basis Accident version) (MAAP-DBA) computer code. The RCS leakage is assumed to be 1 gpm per RCP (3 RCPs per unit) and 1 gpm unidentified RCS leakage for a total of 4 gpm. The RCP seal leakage is assumed to be to the unit's Pressurizer Relief Tank

(PRT) until the tank is filled when the leakage is assumed to flow from the PRT to the containment. Conservatively, RCS heat load into containment is assumed constant. No credit was taken for RCS cooldown or depressurization during the 168-hour run. The calculation shows the maximum pressure to be 19.3 psia for Unit 1 and 19.2 psia for Unit 2. The peak temperature reached 200 °F in Unit 1 and 206 °F in Unit 2 at 168 hours. This is below the design pressure of 59.7 psia (45 psig). Both units remain below the containment design temperature of 280 °F. Therefore, the licensee has adequately demonstrated that there is significant margin before a limit would be reached.

3.4.4.3 FLEX Pumps and Water Supplies

There are no requirements planned for portable pumps or water supplies to maintain containment integrity during an ELAP. In the event containment cooling is desired during Phase 3, cooling water previously discussed in Section 3.2.3.5, "FLEX Pumps and Water Supplies," will be used.

3.4.4.4 Electrical Analyses

During Phase 1, Class 1E batteries will supply power to the required instruments through Class 1E inverters for at least 15 hours for BV1 and 17.75 hours for BV2. The NRC staff's evaluation of the capacity of the Class 1E batteries is provided in Section 3.2.3.6 of this SE. Based on its review, the staff concludes that the Class 1E batteries should have adequate capacity to supply the required loads.

During Phase 2, the licensee would use a 480 Vac FLEX CTG to power the Class 1E battery chargers, which will in turn power the containment instruments. The NRC staff's evaluation of the capacity and capability of the Phase 2 480 Vac FLEX CTGs is provided in Section 3.2.3.6 of this SE. Based on its review, the NRC staff finds that the Phase 2 480 Vac FLEX CTGs should have adequate capacity and capability to supply power to the Phase 2 instruments for monitoring containment temperature and pressure during Phase 2.

The licensee's Phase 3 strategy includes actions to reduce containment temperature and pressure utilizing existing plant systems restored by off-site equipment and resources. The licensee's strategy would use NSRC supplied 4160 Vac CTGs to repower a RHR pump, a Primary CCW pump, a containment recirculation fan (if available and necessary), to restore and maintain containment cooling to ensure containment pressure and temperature remain within limits. The NRC staff's evaluation of the capacity and capability of the NSRC supplied CTGs is provided in Section 3.2.3.6 of this SE. Based on its review, the NSRC supplied CTGs should have adequate capacity and capability to supply power to the required loads to maintain or restore containment during Phase 3.

Procedure ECA-0.0 provides guidance to the operators to monitor containment temperature and pressure. If containment temperature is greater than 162 °F and pressure is greater than 45 psig, these procedures require the plant operators to follow FSG-12 to lower and maintain pressure and temperature below limits by venting or purging the containment.

Based on above, the NRC staff concludes that the licensee's electrical strategy seems to be acceptable to restore or maintain containment indefinitely during an ELAP as a result of a BDBEE.

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. No hazards were screened out.

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 Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f) (ADAMS Accession No. ML12053A340) (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 (80 FR 70610). 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" (ADAMS Accession No. ML15089A236)). The Commission provided guidance in an SRM to COMSECY-14-0037 (ADAMS Accession No. ML14309A256). 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 impact 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. By letter dated September 1, 2015 (ADAMS Accession No. ML15174A257), 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 MSAs per the guidance in NEI 12-06, Revision 2, Appendices G and H (ADAMS Accession No. ML16005A625). The NRC staff endorsed Revision 2 of NEI 12-06 in JLD-ISG-2012-01, Revision 1 (ADAMS Accession No. ML15357A163). 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 design basis seismic hazard, the SSE. As described in UFSAR Section 2.5, "Seismic Input," the SSE seismic criteria for the site is 0.125 of the acceleration due to gravity (0.125 g) peak horizontal ground acceleration. 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 number above, is often used as a shortened way to describe the hazard. For BV1, it should be noted that the UFSAR uses the term design basis earthquake (DBE), but the current NRC terminology for the DBE is the SSE.

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 MBDBE rulemaking. The licensee has appropriately screened in this external hazard and identified the hazard levels to be evaluated.

3.5.2 Flooding

In its FIP, the licensee described that the current design basis for the limiting site flooding event is the PMF event. The licensee described that the PMF at the BVPS is caused by flooding of the Ohio River, due to high rainfall in the area upstream of the site. The PMF reaches an elevation of 730.0 ft. MSL. The BVPS site grade elevation is 735 ft. While equipment required for safe shutdown is protected for the PMF, not all equipment required for safe shutdown is located above this elevation. Therefore, BVPS is not considered a "dry" site and is susceptible to external flood. The PMF elevation of 730.0 ft. includes the effects of probable maximum precipitation, dam failure, ice jams, and other combined effects such as wind generated waves.

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 MBDBE rulemaking. The licensee has appropriately screened in this external hazard and identified the hazard levels to be evaluated.

3.5.3 High Winds

In NEI 12-06, Section 7, provides the NRC-endorsed screening process for evaluation of high wind hazards. This screening process considers the hazard due to hurricanes and tornadoes.

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 miles per hour (mph) exceeds 1E-6 per year, the site should address hazards due to extreme high winds associated with hurricanes using the current licensing basis for 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 NUREG/CR-4461, Revision 2, "Tornado Climatology of the Contiguous United States," 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 using the current licensing basis for tornados or Regulatory Guide 1.76, Revision 1, "Design Basis Tornado for Nuclear Power Plants."

In its FIP, regarding the determination of applicable extreme external hazards, the licensee stated that the site is located at 40° 37' 24" north latitude and 80° 25' 50" west longitude. In NEI 12-06, Figure 7-2, "Recommended Tornado Design Wind Speeds for the 1E-6/year Probability Level," indicates the site is in a region where the tornado design wind speed exceeds 130 mph. In NEI 12-06, Figure 7-2 indicates a maximum wind speed from a tornado of at least 168 mph for BVPS. Therefore, the plant screens in for an assessment for high winds and tornados, including missiles produced by these events. The licensee also described in its FIP that, in accordance with NEI 12-06, Figure 7-1, wind speed from a hurricane does not exceed 130 mph. Therefore, a hurricane hazard is not applicable and need not be addressed.

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 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.

In its FIP, regarding the determination of applicable extreme external hazards, the licensee stated that the site is located at 40° 37' 24" north latitude and 80° 25' 50" west longitude. In addition, the site is located within the region characterized by the Electric Power Research Institute (EPRI) as ice severity level 3 (NEI 12-06, Figure 8-2, "Maximum Ice Storm Severity Maps"). Consequently, the site is subject to impedances caused by ice storms. In addition, the licensee described that the minimum recorded temperature in the area around the BVPS between 1870 and 1970 was -20 °F.

As described in its FIP, NEI 12-06 discusses the potential for blockage of the intake structure by frazil ice. There are no rapids in the vicinity of the BVPS, so high winds or a rapid drop in air temperature would be required to form frazil ice. The licensee stated that a survey of experience along the upper Ohio River yielded no instances of blockage of intake structures with frazil ice. Therefore, frazil ice is not considered to be a hazard for the BVPS.

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 low temperature hazard and characterized the hazard in terms of expected temperatures.

3.5.5 Extreme Heat

In the section of its FIP regarding the determination of applicable extreme external hazards, the licensee stated that, as per NEI 12-06 Section 9.2, all sites are required to consider the impact of extreme high temperatures. In addition, the licensee described that the maximum recorded temperature in the area around the BVPS between 1870 and 1970 was 103 °F. The plant site screens in for an assessment for extreme high temperature hazard.

In summary, based on the available local data and the guidance in Section 9 of NEI 12-06, the plant site does experience extreme high temperatures. The licensee has appropriately screened in the high temperature hazard and characterized the hazard in terms of expected 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

Most FLEX equipment is stored in the FESB, which is a single 6,000 square foot concrete building, designed to withstand all applicable external hazards for the site. The FESB is located immediately to the west and outside of the PA over a portion of the site of the decommissioned Shippingport Atomic Power Station. The licensee's FIP states that the FESB has equipment to restore power to building lighting and electrical outlets using one of the small portable generators that is stored in the building.

As described in the FIP, with the exception of the N+1 alternate AFW pump and N+1 makeup pumps, all other FLEX equipment is stored in pre-existing, safety related, seismic category 1 buildings. Table 10 of the FIP, "FLEX Storage Locations," describes the on-site storage locations for the FLEX equipment.

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

3.6.1.1 Seismic

In its FIP, the licensee described that the FESB meets the plant's design-basis for the seismic hazard (the SSE). As provided in calculations BVPS-FSB-04 and BVPS-FSB-05, the FESB and its foundation are seismically qualified to the SSE. The FIP also describes that the equipment in the FESB is secured to prevent seismic interaction.

As described in its FIP, with the exception of the N+1 alternate AFW pump and N+1 makeup pumps, all other FLEX equipment is stored in pre-existing, safety-related, seismic category 1 buildings. The pre-existing, safety-related, seismic category 1 buildings were designed to the SSE. The equipment and material stored in the pre-existing, safety-related, seismic category 1 buildings are either seismically secured within the buildings or stored and seismically secured.

The FIP also described that the N+1 alternate AFW pump and N+1 makeup pumps are stored in a dedicated area of the Q-Laydown warehouse. This building is a commercial grade warehouse. The building is not robust with respect to seismic. Per the guidance of paragraph 5.3.1 in NEI 12-06 Revision 2, seismic protection of FLEX equipment is only applicable to the N equipment. The N+1 FLEX equipment does not need to be seismically protected.

3.6.1.2 Flooding

In its FIP, the licensee described that the floor of the FESB is at elevation 735 ft., which is above the elevation of the site design-basis flood (730 ft.). In addition, the FESB was designed and constructed to prevent water intrusion. The equipment and material stored in the pre-existing, safety-related, seismic category 1 buildings are protected from all applicable hazards. Also, during the audit process, the licensee provided a list of procedures that were revised to include operator actions in response of floods.

The FIP also described that the Q-Laydown warehouse, which is used to store the N+1 alternate AFW pump and N+1 makeup pumps in a dedicated area, is a commercial grade warehouse which protects the equipment from flooding. During the audit process, the licensee explained that the Q-Laydown building is located southwest from the BV2 cooling tower in an area with an approximate ground elevation of 774 ft. MSL, above the design-basis flood level.

3.6.1.3 High Winds

In its FIP, the licensee stated that the FESB meets the plant's design-basis for tornado-missile protection. As provided in engineering change package (ECP) 15-0065-001, Revision 0, "FLEX Equipment Storage Building," the FESB is a tornado wind and missile resistant, hardened structure. As described in UFSAR Section 2.7.2, "Tornado Model," the tornado design requires structures and systems to withstand a tornado with a rotational velocity of 300 mph and a translational velocity of 60 mph. This gives the average wind speed of the design tornado model, which is the sum of the rotational and translational velocities, of 360 mph.

As described in the FIP, there are two separate equipment doors on the east and west ends of the building to provide redundant exits to deploy equipment out of the FESB. The wind missile barrier doors are manually operated and open away from the building. The debris removal vehicles are stored in the FESB facing out towards the door and can be used to push the door open in the event that debris is piled against the door. The overhead garage doors are electrically operated but are also equipped with manual chain operators to open the doors.

In addition, the FIP described that there are also two separate main doors, one at the south east corner and one at the north west corner, to allow redundant means of accessing the building. The personnel entrances are protected from tornado wind missiles by concrete labyrinth structures.

As described in its FIP, with the exception of the N+1 alternate AFW pump and N+1 makeup pumps, all other FLEX equipment is stored in pre-existing, safety related, seismic category 1 buildings. The equipment and material stored in the pre-existing, safety-related, seismic category 1 buildings are protected from all applicable site hazards.

The FIP also described that the N+1 alternate AFW pump and N+1 makeup pumps are stored in a dedicated area of the Q-Laydown warehouse. This building is a commercial grade warehouse which is not robust with respect to wind missile hazards. Per the guidance of paragraph 7.3.1 in NEI 12-06 Revision 2, high wind protection of FLEX equipment is only applicable to the N equipment. The N+1 FLEX equipment does not need to be high wind or high wind missile protected.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

In its FIP, the licensee described that all of the buildings used to store FLEX equipment, including the FESB, are climate controlled (heating and ventilation) to protect the FLEX equipment and material from high temperatures, cold temperatures and inclement weather. In addition, as described in ECP 15-0065, the FESB is designed for a maximum external temperature of 103 °F and a minimum external temperature of -20 °F. The FESB includes a non-ducted supply and exhaust HVAC system. The three ventilation fans are to operate during the summer months to provide cooling air flow. During winter, one of the three fans, in conjunction with a unit heater, will operate to provide heating.

As described in its FIP, with the exception of the N+1 alternate AFW pump and N+1 makeup pumps, all other FLEX equipment is stored in pre-existing, safety related, seismic category 1 buildings. The equipment and material stored in the pre-existing, safety-related, seismic category 1 buildings are protected from all applicable site hazards.

The FIP also described that the N+1 alternate AFW pump and N+1 makeup pumps are stored in a dedicated area of the Q-Laydown warehouse. This building is a commercial grade warehouse which protects the equipment from extreme weather.

3.6.1.5 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.

3.6.2 Availability of FLEX Equipment

Section 3.2.2.16 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.

In its FIP, the licensee described that sufficient equipment has been purchased to address all functions at all units on-site, plus additional spares to provide the N+1 capability. Table 6, "PWR Portable Equipment Stored On-Site," of the FIP, contains a listing of the portable equipment stored on-site.

As described in the FIP, in the case of hoses and cables associated with FLEX equipment required for FLEX strategies, the following method as documented in NEI 12-06, Revision 2 to meet N+1 capability has been selected. Hoses and cables are passive components being stored in a protected facility. It is postulated the most probable cause for degradation/damage of these components would occur during deployment of the equipment. Therefore, the N+1 capability is accomplished by having sufficient hoses and cables to satisfy the N capability plus 10 percent spares or at least one length of hose and cable. This 10 percent margin capability ensures that failure of any one of these passive components would not prevent the successful deployment of a FLEX strategy. The N+1 requirement does not apply to the FLEX support equipment, vehicles, and tools. However, these items are covered by a fleet administrative procedure and are subject to inventory checks, requirements, and any maintenance and testing that are needed to ensure they can perform their required functions.

Based on the number of portable FLEX pumps, FLEX DGs, and support equipment identified in the FIP and during the audit review, the NRC staff finds that, if implemented as described, the BVPS's FLEX strategies should include a sufficient number of portable FLEX pumps, FLEX DGs, and equipment for RCS makeup and boration, SFP makeup, and maintaining containment consistent with the N+1 recommendation in Section 3.2.2.16 of NEI 12-06.

3.7 Planned Deployment of FLEX Equipment

In its FIP, the licensee described that pre-determined, preferred haul paths have been identified and documented in FSGs. In addition, the deployment pathways attempt to avoid areas with trees, power lines, and narrow passages, when practical. However, high winds can cause debris from distant sources to interfere with planned haul paths. Debris removal vehicles and equipment are located in the FESB.

In addition, as described in the FIP, the deployment paths to the staging areas for both units are kept clear during normal operation. Debris from various overhead hazards may need to be cleared. However, the expected debris can be cleared with moderately sized equipment.

3.7.1 Means of Deployment

As described in the FIP, all FLEX debris removal equipment and tools needed to deploy FLEX equipment are stored in the FESB and are protected against all applicable hazards. Figure 1, "FESB Equipment Layout," of the FIP, contains a layout of the FESB showing the locations of stored FLEX equipment. Therefore, the FLEX debris removal equipment and tools needed to deploy FLEX equipment will remain functional and deployable after a design-basis event. The equipment will be available to clear obstructions between the FESB and deployment areas allowing equipment deployment. In addition, debris removal equipment and trucks are stored in the same storage facility as the FLEX portable equipment. FLEX deployment/debris removal equipment include two F-350 pickup trucks with snow plows, two CAT 242B3 Skid Steers, one F-450 pickup truck, and two John Deer TH 6x4 Diesel Gator utility vehicles. Chain saws and breaker bars are available to create openings in the ice to access water during cold weather events.

3.7.2 Deployment Strategies

As described in the FIP, the baseline FLEX strategy assumes a normal river water level for the primary staging area for the portable pumps that use the Ohio River as a source. However, there are several terraced levels between the normal river bank and the PA fencing that can also be used to stage portable pumps. Figure 2, "FLEX Storage Locations, Haul Routes, and PA access Points," of the FIP, provides the pre-determined preferred haul paths and deployment locations for FLEX equipment. Also, the licensee explained that deployment equipment includes chain saws and breaker bars to create openings in the ice to access water during cold weather events. In addition, as described in its FIP, the licensee described that the pre-determined, preferred haul paths have been reviewed for potential soil liquefaction and have been determined to be stable following a seismic event.

3.7.3 Connection Points

3.7.3.1 Mechanical Connection Points

Core Cooling (SG) Primary and Alternate Connections

The licensee described in its FIP, the primary connection for the SG makeup function for BV1 as connecting a high pressure fire hose from the discharge of the FLEX Alternate AFW pump to a 3-inch fitting in the AFW Pump Room in the BV1 Safeguards Building. The fire hose from the FLEX Alternate AFW pump can also be connected to an alternate 3-inch fitting on a separate connection point to feed the SGs. Both primary and alternate connection points in the AFW

Pump Room are protected from all applicable external hazards. The suction portion of the FLEX Alternate AFW pump is connected to the BV1 PPDWST 4-inch fitting in the BV1 PPDWST Building, which is protected from all applicable external hazards. The licensee also described in its FIP, that BV2 has similar SG makeup connections as BV1. The primary connection for BV2 is a 3-inch fitting in the 'A' Safeguards Pump Room in the BV2 Safeguards Building connected to the discharge of the FLEX Alternate AFW pump. The alternate connection point for SG makeup for BV2 SGs is located on a 3-inch fitting in the 'B' Safeguards Pump Room in the BV2 Safeguards Building, in which the fire hose is attached from this point to the discharge of the FLEX Alternate AFW pump. Both connection points are protected from all applicable external hazards. The BV2 suction source connection for the FLEX Alternate AFW pump is the PPDWST 4-inch fitting in the BV2 PPDWST Building, which is also protected from all applicable external hazards.

The makeup connection to both the BV1 and BV2 PPDWSTs is a 4-inch fitting in the BV2 PPDWST Building. This connection obtains its makeup source from the Ohio River through the discharge of the FLEX makeup pump or from the gravity drain of the BV2 DWST to this connection point. The PPDWST makeup connection is protected from all applicable external hazards. The licensee described the FLEX pipe trench connection to be encased in 2 ft. of reinforced concrete for seismic and wind missile protection. The FLEX pipe trench and the FLEX makeup pumps allow access to the Ohio River to supply makeup water for the PPDWSTs or SFPs. Fire hoses are connected inside the PA from the other side of the FLEX pipe trench to distribute the Ohio River water through gated wyes and fittings to their designated makeup locations as described above.

The licensee also described the Phase 3 source connections for BV1 and BV2 primary CCW heat exchangers for core cooling using the RHR system. The RHR system is available once the two 1 MW 4160VAC generators, provided from the NSRC, are connected to a distribution panel that repowers the Class 1E 480VAC busses. The water source to the RHR system is made available through the 'A' and 'B' river water header connections upstream from the primary CCW heat exchanger. These two connection points are both located in the BV1 and BV2 PABs and are protected from all applicable external hazards.

RCS Inventory Control Primary and Alternate Connections

The licensee described in its FIP its primary connection for Unit 1 RCS makeup as a ¾ in. flange located in the 'A' Charging Pump cubicle of the BV1 PAB, with a high pressure flexible hose routed from the discharge of the RCS boration pump to this connection point. The alternate connection for RCS makeup is the ¾ in. flange located in the 'C' Charging Pump cubicle of the BV1 PAB, with a high pressure flexible hose routed from the discharge of the RCS boration pump to this connection point. Both connection points are protected from all applicable external hazards. The licensee also described two boric acid source connection points for BV1 RCS makeup in the FIP. The first connection point is a 2 ½ in. Storz fitting in the BAT 'A' Room in the BV1 PAB, in which a fire hose is routed from the connection to the suction of the RCS boration pump. The second connection point is a 2 ½ in. Storz fitting in the BAT 'B' Room in the PV1 PAB, in which a fire hose is routed from the connection to the suction of the RCS boration pump. Both boric acid source connections are protected from all applicable external hazards.

As for BV2 RCS makeup, the licensee described the primary connection as a ¾ in. flange located in the 'A' Charging Pump cubicle of the BV2 PAB, with a high pressure flexible hose routed from the discharge of the RCS boration pump to this connection point. The alternate connection for RCS makeup is the ¾ in. flange located in the 'B' Charging Pump cubicle of the

BV2 PAB, with a high pressure flexible hose routed from the discharge of the RCS boration pump to this connection point. Both connection points are protected from all applicable external hazards. The licensee also described two boric acid source connection points for BV2 RCS makeup in the FIP. The first connection point is a 2 ½ in. Storz fitting in the BAT 'A' Room in the BV2 PAB, in which a fire hose is routed from the connection to the suction of the RCS boration pump. The second connection point is a 2 ½ in. Storz fitting in the BAT 'B' Room in the BV2 PAB, in which a fire hose is routed from the connection to the suction of the RCS boration pump. Both boric acid source connections are protected from all applicable external hazards.

SFP Makeup Primary and Alternate Connections

The licensee described in its FIP, the primary connection for SFP makeup as a 4 in. flexible high temperature hose from the FLEX makeup pump that is routed directly into the SFP deck in the FHB. The licensee described the alternate SFP connection as being located on the SFP cooling system piping in the FHB. The hose connection from the FLEX makeup pump can be made to the SFP cooling system piping on the ground floor. The RWST or Ohio River can supply the SFP makeup water from either strategy. The licensee also described the spray connection, which is a hose connection made outside the FHB at a gated wye fitting. The hose connections are routed to one monitor nozzle and one curtain nozzle, which are deployed to the operating deck and is supplied only by the Ohio River for spray operation. The FHB is protected from all applicable external hazards.

3.7.3.2 Electrical Connection Points

During Phase 2, the licensee's strategy is to supply power to equipment required to maintain or restore core cooling, containment, and SFP cooling using a combination of permanently installed and portable components.

The licensee expects to restore electrical power to one train of electrical equipment utilizing the FLEX 480 Vac, 850 kW CTGs. Procedures FSA-13 and FSG-5 provide guidance on primary and secondary paths for connecting the CTGs to the installed buses. At each unit, Train A is used as the primary connection point and Train B is used as the secondary connection point.

At BV1, the primary connection would be made via the FLEX Receptacle Panel located adjacent to Motor Control Center (MCC) MCC-1-E7 in the Train A EDG Building, and the secondary connection would be via the FLEX Receptacle Panel located adjacent to MCC-1-EB in the Train B EDG Building. At BV2, the connections would be made via the primary FLEX Receptacle Panel located adjacent to MCC-2-E07 in the Train A EDG Building or the secondary FLEX Receptacle Panel located adjacent to MCC-2-E08 in the Train B EDG Building. Both BV1 and BV2 Train A and B EDG Buildings are safety-related structures and as such, all FLEX primary and secondary electrical connection points are protected from site applicable external hazards.

In its FIP, the licensee stated that the 480 Vac CTG is staged outside the EDG Building for its respective unit, two cables per phase would be connected to the FLEX Receptacle Panels and one cable per phase would be connected to a deployable Load Center. The 480 Vac deployable Load Center is used to power additional loads, including the RCS Boration Pump. The 480 Vac deployable Load Center is stored in the FESB. The connection points in the EDG Rooms allow the Phase 2 480 Vac CTGs to back feed through the safety-related 480 Vac system to power one train of vital battery chargers to maintain key parameter information in the CR. The licensee stated that proper phase rotation of the Phase 2 FLEX CTGs, Load Centers, Receptacles, pump and fan motors was verified during post installation testing. All above electrical connections are located in the EDG building which is a safety-related Seismic Category I structure designed to protect equipment from all site applicate external hazards.

For Phase 3, four 4160 Vac CTGs will be provided from an NSRC. Two 4160 Vac CTGs will be used at each unit to supply power to either of the two Class 1E 4160 Vac buses at each unit. By restoring the Class 1E 4160 Vac buses, power can also be restored to the Class 1E 480 Vac buses via the 4160/480 Vac transformers. Two 1.0 MW 4160 Vac CTGs will be staged near the EDG rooms at each unit and connected to a distribution panel (also provided from the NSRC). This area affords the best configuration to connect to one of the two Class1E 4160 Vac buses via cabling from the existing EDGs for each unit. Necessary cables for the above connections will be provided by an NSRC. Once the NSRC 4160 Vac CTGs are staged and connected to one of the 4160 Vac buses, all loads needed for placing the normal RHR system in service would be powered.

Procedure 1[2]OM-53E.1.FSG-14 (FSG-14), "Phase 3 – Indefinite Coping On The Secondary Heat Sink," provides guidance to verify proper phase rotation when connecting NSRC supplied 4.16 kV and 480 Vac CTGs to ensure proper equipment operation.

3.7.4 Accessibility and Lighting

In its FIP, the licensee described that following a BDBEE and subsequent ELAP event, FLEX coping strategies require the routing of hoses and cables through various doors in order to connect FLEX equipment to station fluid and electric systems. In addition, the ability to open doors for ingress and egress, ventilation or temporary cable(s)/hose(s) routing is necessary to implement the FLEX coping strategies. Operations responsible for implementing FLEX strategies have immediate access to keys that provide access to all required areas. Additionally, site protection officers are available to assist with obtaining access.

In its FIP, the licensee described that operators responsible for implementing FLEX related tasks are required to carry flashlights. In addition, battery powered (Appendix R) emergency lights are available. Appendix R battery lights are located throughout the plant. In addition, flashlights, head lamps and generator powered temporary lighting are stored with the FLEX equipment in sufficient quantity to enable execution of the FLEX strategy. The FIP also states that the CR lighting is battery backed and should be available for a couple of hours after the ELAP. Also, there should be flashlights and head lights in the CR.

In its FIP, the licensee described that a trailer mounted DG with external fuel tank, LED lighting, a 5,000 cubic feet per minute (cfm) fan and extension cords is stored in the FESB. This trailer can be towed into position and used to supply the CR with lighting and ventilation when personnel are available to deploy the trailer. The licensee stated there is a similarly configured trailer that can be used to provide lighting by the river or another area as needed.

In addition, the FIP described that there are a number of additional LED lights on stands and extension cords that can be used to supply lighting powered by a 480 Vac DG through a power panel with a step down transformer to other areas and buildings in the plant as needed. Part of the administrative controls is a periodic inventory and battery replacement of the flashlights and head lamps.

3.7.5 Access to Protected and Vital Areas

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

In its FIP, the licensee described that FLEX equipment is stored in the fueled condition. Surveillance testing and periodic inspections require maintaining the equipment fuel tanks greater than three-quarters full. Refueling of FLEX equipment commences in the later stages of Phase 2. The general coping strategy for supplying fuel oil to diesel driven portable equipment being used to cope with an ELAP concurrent with normal access to the UHS, is to draw fuel oil out of any available existing diesel fuel oil tanks on the BVPS site. Table 2, "Diesel Fuel Oil Sources," of the FIP identifies the FLEX and Non-FLEX credited diesel fuel oil sources (tanks) on-site and their respective capacities.

In addition, the FIP described that diesel fuel will be required to support the FLEX equipment for the FLEX strategies. FLEX pumps have onboard fuel tanks that provide the fuel necessary for initial implementation of the strategies. For example, the alternate AFW pumps have a 250 gallon onboard tank. The FLEX makeup pumps have a 100 gallon onboard tank.

The F-450 truck is set up for refueling operations. It has two bed mounted 110 gallon tanks containing diesel fuel. It is prepositioned in the FESB to tow the trailer mounted TransCube that is filled with kerosene. The CTGs run on kerosene or diesel fuel. Once the F-450 is used to deploy this TransCube fuel tank and one of the two remaining tanks (diesel) as the fuel supplies for the 480 Vac DGs, the third TransCube along with the bed mounted tanks can be used to support refueling operations. The truck is also outfitted with ac and dc powered pumps as well as manual pumps and the required hose and fitting for transferring fuel from the truck to equipment fuel tanks. The truck can also take suction from the EDG day tanks to refill the bed mounted tanks or any of the Trans Cubes. Over 1,000 gallons of diesel fuel is immediately available in each of the four EDG day tanks (day tank/skid tank combination at BV1).

The FIP also described that indefinite coping is supported by an existing contract with a large supplier of fuel oils that has multiple storage sites in diverse geographical locations. Existing emergency response organization (ERO) procedures delineate the responsibilities and process for ensuring timely delivery of adequate supplies of diesel fuel from off-site sources.

In its FIP, the licensee described that diesel fuel in the fuel oil storage tanks is routinely sampled and tested to assure fuel oil quality is maintained. This sampling and testing surveillance program also assures the fuel oil quality is maintained for operation of the station EDGs

3.7.7 Conclusions

Based on this evaluation, 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 BVPS SAFER Plan

The industry has collectively established the needed off-site capabilities to support FLEX Phase 3 equipment needs via the SAFER Team. The SAFER team consists of the Pooled Equipment Inventory Company (PEICo) and AREVA Inc. and provides FLEX Phase 3 management and deployment plans through contractual agreements with every commercial nuclear operating company in the United States.

There are two NSRCs, located near Memphis, Tennessee and Phoenix, Arizona, established to support nuclear power plants in the event of a BDBEE. 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 (ADAMS Accession No. ML14265A107), the NRC staff issued its 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.

The NRC staff noted that the licensee's SAFER Response Plan contains (1) SAFER control center procedures, (2) NSRC procedures, (3) logistics and transportation procedures, (4) staging area procedures, which include travel routes between staging areas to the site, (5) guidance for site interface procedure development, and (6) a listing of site-specific equipment (generic and non-generic) to be deployed for FLEX Phase 3.

3.8.2 Staging Areas

In general, up to four staging areas for NSRC supplied Phase 3 equipment are identified in the SAFER Plans for each reactor site. These are a Primary (Area C) and an Alternate (Area D), if available, which are offsite areas (within about 25 miles of the plant) utilized for receipt of ground transported or airlifted equipment from the NSRCs. From Staging Areas C and/or D, the SAFER team will transport the Phase 3 equipment to the on-site Staging Area B for interim staging prior to it being transported to the final location in the plant (Staging Area A) for use in Phase 3. For BVPS, Alternate Staging Area D is the Washington County Airport. Staging Area C is the Beaver County Airport. Staging Area B is the area adjacent to the FESB. Staging Area A is the point-of-use for the FLEX response equipment.

Use of helicopters to transport equipment from Staging Area C to Staging Area B is recognized as a potential need within the BVPS 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 BVPS, ventilation that provides cooling to occupied areas and areas containing required equipment will be lost. The primary concern with regard to ventilation is the heat buildup in areas that continue to have heat loads. The licensee performed an analysis to quantify the maximum steady-state temperatures expected in specific areas related to FLEX implementation to ensure the environmental conditions remain acceptable. The key areas identified for all phases of FLEX are the combined CR, Class 1E Battery Rooms, Emergency Switchgear Areas including Class 1E Battery Charger and Inverter Rooms, BV1 and BV2 TDAFW Pump Rooms, and Containment.

Control Room

In the BVPS EER 600987403, "ELAP Loss of Ventilation Assessment of BVPS1/BVPS2 Control Room," dated September 17, 2015, the licensee determined that the maximum expected room temperatures would be 108 °F in 1 hour for CR, 108 °F at 24 hours (BV1 Computer Room), 91 °F at 24 hours (BV2 Computer Room). The EER concluded that the expected CR temperatures are below CR Equipment Qualification (EQ) temperature of 120 °F limit and equipment in the CR will not be challenged. The FLEX time line in the FIP shows that the CR temperature will be monitored within 0.15 hours and doors will be opened if CR temperature exceeds 104 °F. There are two entrances into the BV1/BV2 combined CR situated on opposite sides of the room. The licensee plans to use a fan powered by a portable DG to establish cross ventilation using outside air. Procedures 1[2]OM-53A.1.ECA-0.0 provide guidance to the operators to monitor CR temperature, to open the CR exterior doors at 104 °F and to install portable gas powered blowers if CR temperature rises to greater than 120 °F to control and maintain CR temperature less than the EQ temperature limit of 120 °F.

Based on temperatures remaining below 120 °F (the temperature limit, 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 NRC staff finds that the electrical equipment in the CR should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

BV1 and BV2 Class 1E Battery Rooms

The Class 1E batteries are located in the BV1 and BV2 Service Buildings. The NRC staff reviewed licensee evaluation EER 600987424, "A Loss of Ventilation Assessment of the BV1 Battery Rooms and Switchgear Areas due to an Extended Loss of AC Power," dated August 16, 2016, and evaluation ERR 600987427, "A Loss of Ventilation Assessment of the BV2 Battery Rooms and Switchgear Areas due to an Extended Loss of AC Power," dated September 11, 2015. These evaluations and the FIP, show that the maximum temperatures would reach 108 °F in 24 hours and 115.4 °F at 12 hours in the BV1 and BV2 battery rooms, respectively, with no forced ventilation. Based on the results of these EERs the licensee concluded that the battery room expected temperature would remain below 125 °F limit for Enersys batteries and 120 °F limit for C&D batteries and that would support battery functionality. The licensee provided a battery manufacturer (Enersys) published Percent of Nominal Life verses Average Operating Temperature plot. From the plot, it appears that these batteries would be available to supply power for a maximum of 2.4 years (12 percent of a nominal 20 years battery life) when operated at a maximum average room temperature of 125 °F during an ELAP event. Procedure FSG-4 provides guidance to energize BV1 and BV2 battery room exhaust and supply fans for forced ventilation and cooling. While the battery vendor's analysis shows that the Class 1E batteries are capable of performing their function up to 125 °F limit (for Enersys batteries) and 120 °F limit (for C&D Technologies batteries), periodic monitoring of electrolyte level may be necessary to protect the battery since the battery may gas more at higher temperatures.

Based on review of the EERs and the mitigating actions in procedure FSG-4 , the NRC staff finds that the electrical equipment in the BV1 and BV2 Class 1E battery rooms should not be adversely impacted due to a loss of ventilation during an ELAP event.

<u>BV1 and BV2 Emergency Switchgear Areas including Vital Battery Charger Room and Inverter Rooms</u>

The licensee performed a loss of ventilation assessment of the emergency switchgear rooms in EERs 600987424 and 600987427 and determined that the temperatures are expected to be 113 °F at 1 hour for BV1 and 111 °F at 1 hour for BV2. The expected room temperature would remain steady-state at 109 °F for both BV1 and BV2 after 16 hours with no forced ventilation. The licensee stated that by crediting heat sinks and by restoring forced ventilation through the emergency switchgear areas of the energized train, the switchgear area ambient temperatures are maintained below equipment limit. Procedure FSG-4 provides guidance to energize emergency switchgear area exhaust and supply fans for forced ventilation and cooling. In EER 600987424, the licensee stated that the BV1 battery charger design specifies a high ambient temperature of 40 °C (104 °F). Because the battery charger design specifies a high ambient temperature of 40 °C (104 °F) and is lower than the expected room temperature of 109 °F, the licensee contacted the battery charger vendor (Ametek). The vendor representative said that the small overage (5 °F) and the short time duration were such that this would have no impact on the ability of the battery charger to perform its intended function. While the battery charger vendor's evaluation shows that the Ametek battery charger is capable of performing their function up to 109 °F limit, periodic monitoring of the Ametek battery charger room temperature may be necessary to ensure that the Ametek battery charger remains functional. Based on its review, the NRC staff concludes that the licensee's evaluation and mitigating actions in Procedure FSG-4 provides reasonable assurance that the equipment in the BV1 and BV2 emergency switchgear areas should remain available during an ELAP.

<u>BV1 and BV2 TDAFW Pump rooms</u>

The NRC staff reviewed EERs 600979836, "BV1 AFW Pump RM," dated July 15, 2015, and 600987430, "Loss of ventilation Assessment of the BV2 Safeguard Building (e.g., Auxiliary Feedwater Pump and Throttle Valve Areas)," dated August 31, 2015. Based on its review, the NRC staff found that there are no electrical or electronic components and controls in the BV1 and BV2 TDAFW Pumps credited for TDAFW pump operation. Therefore, there are no electrical or electronic components and controls for the BVPS TDAFW Pumps that could be adversely affected as a result of a loss of ventilation during an ELAP event. In the FIP, the licensee stated that the environmental conditions remain within equipment qualification limits.

Containment

The licensee produced calculation 10080-DMC-3687, Revision 0, "Containment Temperatures following an Extended Loss of All Alternating Current Power (ELAP)," in support of developing its FLEX Mitigating Strategies. In this calculation, the licensee analyzed the containment pressure and temperature response during an ELAP and determined that, without any mitigating actions, the containment design limits for peak pressure (45 psig) and peak ambient temperature (180 °F) would not be challenged during the first 72 hours. The analysis also showed that the containment conditions stayed below the equipment limits for these timeframes. Therefore, there is adequate time for the licensee to establish containment cooling during Phase 3 using a RHR Pump, a CCW Pump, and containment recirculation fan powered by two NSRC supplied 4160 Vac 1.0 MW CTGs. Procedure ECA-0.0 provides guidance to the plant operators to monitor containment temperature and pressure. If containment temperature is greater than 162 °F and pressure is greater than 45 psig, these procedures direct plant operators to follow guidance in FSG-12 to lower and maintain pressure and temperature below limits by venting or purging the containment. The NRC staff's evaluation of the capacity and capability of the NSRC supplied CTGs is provided in Section 3.2.3.6 of this SE.

Based on its review of the essential station equipment required to support the licensee's FLEX mitigation strategy, which are primarily located in the combined CR, Class 1E Battery Rooms, Emergency Switchgear Areas including Class 1E Battery Charger and Inverter Rooms, BV1 and BV2 TDAFW Pump Rooms, and Containment, the NRC staff finds that the equipment should perform its credited functions at the expected temperatures that result from the loss of ventilation during an ELAP event.

3.9.1.2 Loss of Heating

The licensee indicated in its FIP, that the FESB, BV1 PAB, and BV2 PAB are used for storing FLEX equipment to protect from extreme weather. The FESB and PABs include heating and ventilation systems to maintain building temperatures required to prevent freezing of FLEX equipment. The licensee also stated that no heat tracing is required for the PPDWST, which is used to supply the TDAFW pump, due to the tank being located within a concrete structure that is heated during normal operation. The PPDWST outlet piping is located underground and indoors and is not susceptible to freezing temperatures. The BATs used for RCS makeup are located inside the PAB and are insulated. The location and design of the BATs allow the temperature to remain above 65 °F for more than 40 hours after the ELAP. The licensee did not indicate other permanent SSCs or FLEX equipment that needed heat tracing as part of its overall FLEX strategy.

BV1 and BV2 Vital Battery Rooms

During the audit process, the licensee noted that each vital battery room has a ventilation supply duct that connects to the adjacent emergency switchgear room and a ventilation discharge duct that exhausts to the outside. During extreme low temperatures and with a loss of heating, it is not expected that cold outside air would make its way through the exhaust duct work back into the battery rooms since each exhaust fan has a backdraft damper that is normally closed when the fans are not operating. The heat generated by the batteries should be sufficient to maintain the battery rooms at normal temperatures.

Based on its review of the licensee's vital battery room assessment, the NRC staff finds that the BV1 and BV2 Class 1E 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

An additional ventilation concern that is applicable to Phases 2 and 3 is the potential buildup of hydrogen in the battery rooms as a result of loss of ventilation during an ELAP event. Off-gassing of hydrogen from batteries is only a concern when the batteries are charging. In the FIP, the licensee stated that once a 480 Vac power is restored in Phases 2 and 3, and the station Class 1E batteries begin re-charging, power will also be restored to the vital battery room ventilation fans from the Phase 2 FLEX CTGs or the Phase 3 CTGs to prevent hydrogen accumulation.

Procedure FSA-13 provides guidance to the plant operators to energize the battery room exhaust ventilation after the Phase 2 480 Vac FLEX CTGs are deployed and the batteries are put on charge, to exhaust hydrogen out of the battery rooms and out of the building.

Based on its review of the licensee's battery room ventilation strategy, the NRC staff finds that hydrogen accumulation in the BV1 and BV2 vital battery rooms should not reach the combustibility limit for hydrogen (4 percent) during an ELAP as a result of a BDBEE.

3.9.2 Personnel Habitability

3.9.2.1 Main Control Room

The licensee performed Engineering Evaluation EER600987403 to address the loss of ventilation on the BV1 and BV2 Control Rooms during an ELAP. The evaluation used the MAAP-DBA computer code. The evaluation assumed an initial indoor temperature of 75 °F and a constant 103 °F outdoor ambient air temperature. Selected doors were assumed opened at 15 minutes into the event. The evaluation determined that the BV1/BV2 Control Rooms would reach a maximum temperature of 108 °F at 1 hour. After 6 hours additional personnel would be available to replace control room operators if the room temperature remains excessive, limiting the effects of heat stress. Procedure ECA-0.0 provides guidance for opening selected doors and, if necessary to maintain the Control Room environment, the deployment of portable blowers. Procedure FSG-5 also provides initial direction to establish passive or forced ventilation as required using portable equipment.

The NRC staff considered the evaluation results to be conservative since the daily diurnal temperature variation and forced ventilation using portable equipment were not considered in the evaluation.

3.9.2.2 Spent Fuel Pool Area

Fuel Handling Building

The licensee completed an evaluation (EER600987425) addressing the loss of ventilation in the BV1 FHB during an ELAP. The evaluation used the MAAP 5.01 computer code. Two cases were addressed. The first assuming a full core offload four days after shutdown. The second case assumed a 1/3 core offload 30 days after shutdown. A constant 103 °F outdoor ambient temperature was assumed. The initial indoor air temperature was assumed to be 85 °F.

For Case 1 (full core offload), the working elevation reaches 98 °F at 100 percent relative humidity (RH) at roughly 1 hour. The maximum temperature is reached at approximately one and three quarter's hours. The lower elevation takes a little over 2 hours to reach 96 °F and 100 percent RH.

For Case 2 (normal operation, 30 days after shutdown), the working elevation takes nearly four hours to reach 105 °F and 100 percent RH. The maximum temperature at this elevation is reached at 10 hours. The lower elevation takes more than 12 hours to reach 98 °F and 100 percent RH.

The BV2 FHB was evaluated in EER601059525. The evaluation used similar input data with the exception of unit specific fuel load in the spent fuel pool. For Case 1, the working elevation reached 85 °F and 100 percent RH at roughly 3 and a half hours. For Case 2, the working level reached 90 °F and 100 percent RH at 17 hours.

The licensee used the evaluation to determine the wet-bulb globe temperature (WBGT) and the stay time allowable for work being done at that WBGT. Stay times were based on NUREG-0700, "Human-System Interface Design Review Guidelines," and EPRI NP-4453-L, "Heat Stress Management Program for Power Plants."

Document 1(2)OM-53E.1.FSA-27 (FSA-27), "FLEX Fuel Building Ventilation and Initial Assessment," provides guidance for establishing ventilation flow paths. Based on the above, the NRC staff expects the deployment of FLEX equipment required in the FHB can be accomplished before the local environment presents a hazard to plant personnel.

3.9.2.3 Other Plant Areas

AFW Pump Rooms

The licensee completed evaluation EER600979836, which indicated that the BV1 AFW pump room habitability may be an issue without forced ventilation. The evaluation used the MAAP-DBA Computer Code. The calculation estimates the room temperatures at 90 °F and at 103 °F ambient air temperatures. The calculation determined the Unit 1 AFW Pump room would reach roughly 123 °F at 24 hours without ventilation. With selected doors opened at 1 hour following the ELAP, the room temperature after 24 hours would be 112-119 °F depending on ambient temperature. With temporary portable ventilation installed, the room temperature at 24 hours would be 103-104 °F depending on ambient temperature. Procedure FSG-5 provides guidance to establishing passive and active ventilation. If the BV1 AFW Room cannot be accessed due to environmental conditions, steam to the TDAFW Turbine can be isolated in the BV1 Main Steam Valve Area to control SG levels.

The licensee completed an evaluation (EER600987430) of the BV2 AFW Pump and Throttle Valve area. The evaluation used the MAAP-DBA Computer Code. The calculation assumes an 103 °F ambient air temperature. The calculation determined that the BV2 AFW Pump room would reach roughly 115 °F at 24 hours without ventilation. With selected doors opened at 1 hour following the ELAP, the room temperature after 24 hours would be 114 °F. With temporary portable ventilation installed, the room temperature at 24 hours would be 106 °F depending on ambient temperature. Procedure FSG-5 provides guidance to establishing passive and active ventilation.

Main Steam Valve Area

The licensee completed an evaluation (EER600987426) addressing the loss of ventilation in the BV1 Main Steam Valve Area during an ELAP. The evaluation assumed a constant 103 °F outdoor ambient temperature. The evaluation determined that with select doors and louvers open the steady state dry-bulb temperature would be approximately 116 °F. The WBGT of 100 °F at 44 percent RH was calculated and a stay time of 25 minutes was determined.

Evaluation EER600987429 was performed addressing the loss of ventilation in the BV2 Main Steam Valve Area during an ELAP. The evaluation assumed a constant 103 °F outdoor ambient temperature. The evaluation determined that with select doors and louvers open the steady state dry-bulb temperature would be approximately 123 °F. The WBGT of 102 °F and 34 percent RH was calculated. The evaluation concluded that the environment will be suitable for required operator actions.

Containment

The Phase 3 strategy, as indicated in the FIP, includes a containment entry to ensure operability of the RHR Pumps and motor (located in containment). This is to support the optional strategy of initiating RHR; indefinite core cooling can be maintained by feeding the SGs. Containment entry would only occur after the containment environment is determined to be safe. Phase 3, SAFER turbine generators will permit restoration of some plant equipment. The TSC will determine the preferred method based on systems available. These systems include the Containment Quench Spray System and the Containment Ventilation Systems.

Emergency SWGR/Battery Rooms

Calculation EER 600987424 reviewed an assessment on the loss of ventilation to the BV1 Battery Rooms and Switchgear areas during an extended loss of all ac event. The licensee used the MAAP-DBA computer code to model the areas of concern. The first 24 hour time period of the ELAP was modeled. Ambient temperature was modeled at a constant 103 °F. Initial room temperatures were assumed to be 85 °F. The FLEX DG is assumed to be started at 12 hours. At that time the battery charger and battery room exhaust fan are assumed to be operating. Indoor dew point temperature was assumed to be 85 °F. The maximum temperature in the Emergency Switchgear Room is 113 °F at 1 hour. Following load shedding the temperature drops to less than 110 °F for the remainder of the 24 hour model. The maximum temperature in the Battery Rooms collectively is 108 °F at 24 hours.

Calculation EER 600987427 assessed the loss of ventilation to the Battery Rooms and Switchgear areas during an ELAP for BV2. The BV2 was modeled similar to BV1, using the MAAP-DBA computer code and 103 °F ambient conditions. Again, the heat load in the Switchgear area is reduced following load shedding. The FLEX DG is assumed operating at 12 hours providing the ability to operate the battery rooms exhaust fan. The maximum Emergency Switchgear area temperature was 111 °F at one hour. The maximum battery room temperature was 115 °F.

Initial work to be performed in the areas evaluated is estimated to take less than one hour. The licensee intends to use multiple crews if elevated room temperatures are present to avoid heat related injuries.

The NRC staff reviewed the evaluations and noted that calculations did not consider the diurnal ambient temperature variation. The calculation assumed a constant 103 °F ambient temperature and assumed that the ventilation supply air temperature was also 103 °F. The staff considers this assumption to be conservative.

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

Table 11, "Water Source Availability," of the FIP provides a listing of the various on-site sources of water, including both borated and unborated, along with their respective capacities and the hazards for which they are protected or credited that could be used for SG, RCS and SFP make-up.

3.10.1 Steam Generator Make-Up

As described in the FIP, the PPDWST would be used initially to supply water to all three SGs. The PPDWST is protected from all hazards. The PPDWST will provide a minimum of 9 hours of RCS decay heat removal, in addition to absorbing the latent heat associated with the planned RCS cooldown. Prior to emptying the PPDWST, the DWST, if available, would be used/aligned to gravity fill the PPDWST for approximately 48 hours. If the DWST is not available, the operators will place a FLEX pump in service to refill the PPDWST from the UHS (Ohio River).

3.10.2 Reactor Coolant System Make-Up

In its FIP, the licensee described that RCS inventory control and boration are provided by using a FLEX RCS boration pump to inject borated water into the chemical and volume control system (CVCS). Existing CVCS piping feeds the RCS through the normal charging injection path.
As described in the FIP, the FLEX RCS boration pumps take suction from two separate BATs at both units and inject into the CVCS downstream of the normal CVCS charging pumps. The higher concentration borated water from the BATs is used to limit the amount of borated water needed to achieve the desired shutdown margin. Other borated water sources that could be used are the RWST and SI accumulators. Since the boric acid concentration in these tanks is less than that of the BATs, a larger volume of borated water would have to be used.

3.10.3 Spent Fuel Pool Make-Up

The preferred water source for SFP makeup is the RWST. However, the UHS (Ohio River) is the fully protected source for makeup. Additionally, the UHS is the only pre-planned source that can be used for SFP Spray. The FSGs describe using either the RWST or UHS as a SFP makeup source.

3.10.4 Containment Cooling

In its FIP, the licensee described that containment cooling would not be needed for the first 72 hours following an ELAP event. However, during phase 3, equipment from the NSRC may be required to implement any containment cooldown and depressurization strategy beyond passive ventilation. Potential methodologies are listed in FSG-12. The TSC would determine the best strategy for cooldown and depressurization of the containment based on the event and actual equipment that is available after the event.

3.10.5 Conclusions

Based on the evaluation above, 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 TDAFW 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. The licensee's analysis shows that, following a full core offload to the SFP, about 14.25 hours are available to implement makeup before boil-off results in the water level in the SFP dropping to 15 ft. above the fuel assemblies, and the licensee has stated that they have the ability to implement makeup to the SFP within that time. The staff does not expect any significant increases in radiation levels until the water level drops below 10 ft. above the fuel assemblies.

When a plant is in a shutdown mode in which steam is not available to operate the TDAFW 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. The NRC-endorsed strategy is described in NEI 12-06. Section 3.2.3 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. In its FIP, the licensee stated that it would follow this guidance. During the audit process, the NRC staff observed that the licensee had made progress in implementing this guidance.

Based on the licensee's incorporation of the use of FLEX equipment in the shutdown risk process and procedures, 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

3.12.1 Procedures

In its FIP, the licensee described that the inability to predict actual plant conditions that require the use of FLEX equipment makes it impossible to provide specific procedural guidance. As such, FLEX procedures provide guidance that can be employed for a variety of conditions. Clear criteria for entry into FLEX procedures ensures 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 abnormal operating procedures (AOPs) strategies, the EOP or AOP directs the entry into the appropriate FLEX procedure. FLEX procedures have been developed in accordance with PWROG guidelines. They provide instructions for implementing available, pre-planned FLEX strategies to accomplish specific tasks in the EOPs or AOP's. They are used to supplement (not replace) the existing procedure structure that establishes command and control for the event.

As described in the FIP, the FLEX procedure network is organized in the same manner as the EOP network. The FSGs contain high level information, monitoring and decision points, and are in the same two column format as the EOPs. The FSGs are primarily used in the CR to manage the event. For specific strategy implementation, the FSGs reference FLEX support attachments (FSAs). The FSAs contain the detailed information for actual implementation of the strategies. They are primarily used by the operators in the field to deploy equipment, including hoses and cables and manipulate plant components to accomplish specific tasks. FLEX support operator aids (FSOAs) also known as "hard cards" contain the detailed instructions for FLEX equipment operation. A laminated FSOA is stored with each piece of FLEX equipment.

In addition, the FIP described that FLEX procedures include appropriate interfaces between the various accident mitigation procedures so that overall strategies are coherent and comprehensive. This approach is intended to provide guidance for responding to events while minimizing the need for invoking 50.54(x).

The FIP described that the entry points to the FLEX procedure network are contained in the following plant procedures:

- 1OM-53A.1.ECA-0.0(ISS3), "Loss Of All Emergency 4KV AC Power"
- 1OM-53C.4.1.36.1, "Loss Of All Emergency 4KV AC Power While on Shutdown Cooling"
- 2OM-53A.1.ECA-0.0 (ISSE), "Loss Of All AC Power"
- 2OM-53C.4.2.36.1, "Loss Of All AC Power While Shutdown"

In its FIP, the licensee described that FLEX strategies have been implemented in such a way as to not violate the basis of existing procedures. If or when plant systems are restored, exiting the FSGs and returning to the normal plant operating procedures will be addressed by the plant's ERO and operating staff dependent on the actual plant conditions at the time. Procedure 1[2]OM-53.FSG-13 (FSG-13), "Transition From FLEX Equipment," at each unit also specifically addresses exiting the FLEX procedure network.

The FIP also described that the FSGs have been reviewed and validated by the involved groups to the extent necessary to ensure that the FLEX strategy is feasible. The normal station process for verification and validation of EOP procedures was followed and documented for the verification and validation of the FLEX procedures. Additionally, time sensitive FLEX actions were also validated in accordance with industry guidance as described in Section 2.17, "Sequence of Events," of the FIP.

Maintenance of the FSGs is performed as directed by NOP-SS-3001, "Procedure Review and Approval." In accordance with site administrative procedures, NEI 96-07, Revision 1, "Guidelines for 10 CFR 50.59 Implementation," and NEI 97-04, Revision 1, "Design Basis Program Guidelines," are to be used to evaluate changes to current procedures, including the FSGs, to determine the need for prior NRC approval. However, per the guidance and examples provided in NEI 96-07, changes to procedures (EOPs, AOPs or FSGs) that perform actions in response to events that exceed a site's design-basis should screen out. Therefore, procedure steps which recognize the BDBEE has occurred and which direct FLEX strategy actions to ensure core cooling, containment, or SFP cooling should not require prior NRC approval.

3.12.2 Training

In its FIP, the licensee described that a systematic approach to training (SAT) process was used to assure that personnel proficiency in the mitigation of a BDBEE is developed and maintained. The FIP described that training has been 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 and mitigating strategy time constraints.

The FIP described that the [American National Standards Institute/American Nuclear Society] ANSI/ANS 3.5, "Nuclear Power Plant Simulators for use in Operator Training," certification of simulator fidelity is considered to be sufficient for the initial stages of the BDBEE scenario until the current capability of the simulator model is exceeded. The FIP also described that FLEX training was provided to the ERO (including the chemistry communicator), engineering, maintenance, radiation protection and site protection personnel.

3.12.3 Conclusions

Based on the description above, the NRC staff finds that the licensee has adequately addressed the procedures and training associated with FLEX. The procedures have been issued in accordance with NEI 12-06, Section 11.4, and a training program has been established and will be maintained in accordance with NEI 12-06, Section 11.6.

3.13 Maintenance and Testing of FLEX Equipment

In its FIP, the licensee described that initial component level testing, consisting of factory acceptance testing and site functional testing, was conducted to ensure the portable FLEX equipment can perform its required FLEX strategy design functions. The FIP also described that portable FLEX equipment that directly performs a FLEX mitigation strategy for the core cooling, containment, or SFP cooling is subject to periodic maintenance and testing in accordance with NEI 12-06, Revision 2 and Institute of Nuclear Power Operations (INPO) AP 913, "Equipment Reliability Process," to verify proper function. Additional FLEX support equipment that requires maintenance and testing will have preventive maintenance (PM) to ensure it will perform its required functions during a BDBEE.

In addition, the FIP described that EPRI has completed and issued the "Preventive Maintenance Basis for FLEX Equipment - Project Overview Report." Preventative maintenance templates for the major FLEX equipment including the portable diesel pumps and generators have also been issued.

In addition, the FIP described that PM procedures and test procedures are based on the templates contained within the EPRI Preventive Maintenance Basis Database, or from manufacturer provided information/recommendations when templates were not available from EPRI. The corresponding maintenance strategies were developed and documented. The performance of the PMs and test procedures are controlled through the site work order process. FLEX support equipment not falling under the scope of INPO AP 913 will be maintained as necessary to ensure continued reliability. Performance verification testing of FLEX equipment is scheduled and performed as part of the BVPS PM process.

In its FIP, the licensee described that procedure NORM-LP-7102, "Beaver Valley FLEX Equipment Out of Service Requirements," was established to ensure the unavailability of equipment and applicable connections that directly perform a FLEX mitigation strategy for core cooling, containment, and SFP cooling will be managed such that risk to mitigation strategy capability is minimized. As described in the FIP, the definitions, requirements, and directions for control of FLEX equipment and FLEX facilities are contained in NOP-LP-7100, "FLEX Program for Beaver Valley." Timeliness of restoration actions is commensurate with the significance of the degraded FLEX function. Prioritization of corrective actions is described in NOP-WM-1003, "Nuclear Maintenance Notification, Initiation, Screening and Minor Deficiency Monitoring Process."

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 in accordance with NEI 12-06, Section 11.5.

3.14 Alternatives to NEI 12-06, Revision 2

The licensee has not taken alternatives to NEI 12-06, Revision 2.

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 27, 2013 (ADAMS Accession No. ML13059A495), the licensee submitted its OIP for BVPS in response to Order EA-12-051. By letter dated June 25, 2013 (ADAMS Accession No. ML13059A495), the NRC staff sent a request for additional information (RAI) to the licensee. The licensee provided supplemental information by letters dated July 18, 2013 (ADAMS Accession No. ML13200A122), and August 26, 2013 (ADAMS Accession No. ML13238A259). By letter dated November 19, 2013 (ADAMS Accession No. ML13297A233), the NRC staff issued an ISE and RAI to the licensee. The licensee provided a response by letters dated February 27, 2014 (ADAMS Accession No. ML14058A665), and August 28, 2014 (ADAMS Accession No. ML14240A230).

By letters dated August 26, 2013 (ADAMS Accession No. ML13238A259), February 27, 2014 (ADAMS Accession No. ML14058A665), August 28, 2014 (ADAMS Accession No. ML14240A230), February 26, 2015 (ADAMS Accession No. ML15057A396), and August 18, 2015 (ADAMS Accession No. ML15230A202), 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 SFP level instrumentation, which will function following a BDBEE, including modifications necessary to support this implementation, pursuant to Order EA-12-051. By letters dated July 22, 2015 (ADAMS Accession No. ML15203A101), and December 21, 2015 (ADAMS Accession No. ML15355A397), the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved.

The licensee has installed a SFP level instrumentation system designed by Westinghouse. The NRC staff reviewed the vendor's SFP level instrumentation system design specifications, calculations and analyses, test plans, and test reports. The staff issued an audit report on August 18, 2014 (ADAMS Accession No. ML14211A346).

The staff performed an onsite audit to review the implementation of SFP level instrumentation related to Order EA-12-051. The scope of the audit included verification of (a) site's seismic and environmental conditions enveloped by the equipment qualifications, (b) equipment installation met the requirements and vendor's recommendations, and (c) program features met the requirements. By letter dated November 2, 2015 (ADAMS Accession No. ML15292A139), the NRC issued an audit report on the licensee's progress. Refer to Section 2.2 above for the regulatory background for this section.

4.1 Levels of Required Monitoring

In its letter dated February 27, 2014 (ADAMS Accession No. ML14058A665), the licensee stated that:

> Level 1, the level that is adequate to support operation of the normal fuel pool cooling system, is defined in NEI 12-02 as the higher of the following two points:
>
> (1) The level at which reliable suction loss occurs due to uncovering of the coolant inlet pipe, weir or vacuum breaker (depending on the design), or
>
> (2) The level at which the water height, assuming saturated conditions, above the centerline of the cooling pump suction provides the required net positive suction head (NPSH) specified by the pump manufacturer or engineering analysis.
>
> The coolant inlet pipes for both Unit 1 and Unit 2 are located at elevation (El.) 751'3". Analysis has shown that an elevation of 755' for both units is sufficient to prevent vortexing and loss of suction. Analysis has demonstrated that for Unit 1, an elevation of 758' is required to assure adequate NPSH. For Unit 2, analysis has shown that there is adequate NPSH at an elevation of 755'.
>
> For Unit 1, the higher of the above points is (2). Therefore, Level 1 is at El. 758' for Unit 1.
>
> For Unit 2, the higher of the above points is (1). Therefore, Level 1 is at El. 755' for Unit 2.

In its OIP, the licensee stated that the Level 2 for both units is the indicated level on either primary or backup instrument channel of greater than 752 ft. 0 in. The licensee also stated that this level was selected based on the NEI 12-02 guidance given for this level as 10 ft. (+/- one foot) above the highest point of any fuel rack seated in the SFP.

By letters dated July 22, 2015 (ADAMS Accession No. ML15203A101) and December 21, 2015 (ADAMS Accession No. ML15355A397), the licensee provided sketches for BV1 and BV2, respectively, depicting the Levels 1, 2, and 3 datum points, top of fuel racks, and bottom of measurement ranges. In these sketches, Level 2 for both units is at Elevation 752 ft. The Level 3 for BV1 is at Elevation 742 ft. 6.5 in. and the Level 3 for BV2 is 743 ft. 0.4 in. The top of the fuel rack for BV1 is at Elevation 741 ft. 11 in. and for BV2 is 742 ft. 6.4 in.

The NRC staff found the licensee selection of the SFP measurement level adequate based on the following:

> Level 1 is the level at which the water height, assuming saturated conditions, above the centerline of the cooling pump suction provides the required net positive suction head (NPSH) specified by the pump manufacturer or engineering analysis. BVPS Level 1 for both units represents the higher of the two points described in NEI 12-02 for Level 1.
>
> Level 2 for both units meets the first option described in NEI 12-02, which is 10 ft. (+/- 1 foot) above the highest point of any fuel rack seated in the SFP. The designed Level 2 represents the range of water level where any necessary operations in the vicinity of the SFP can be completed without significant dose consequences from direct gamma radiation from the SFP consistent with NEI 12-02.Level 3 for both units is above the highest point of any fuel storage rack seated in the SFP. The level allows the licensee to initiate water make-up with no delay meeting the NEI 12-02 specifications of the highest point of the fuel racks seated in the SFP. Meeting the NEI 12-02 specifications of the highest point of the fuel racks conservatively meets the Order EA-12-051 requirement of a level where the fuel remains covered.

Based on the evaluation above, the NRC staff finds that the licensee's proposed Levels 1, 2 and 3 appear to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of Order EA-12-051.

4.2 Evaluation of Design Features

Order EA-12-051 required that the SFP level instrumentation shall include specific design features, including specifications on the instruments, arrangement, mounting, qualification, independence, power supplies, accuracy, testing, and display. Refer to Section 2.2 above for the requirements of the order in regards to the design features. Below is the staff's assessment of the design features of the SFP level instrumentation.

4.2.1 Design Features: Instruments

In its OIP, the licensee stated that both the primary and backup instrument channels will consist of fixed components and the measurement range will be continuous from the top of the SFP to the top of the spent fuel racks.

By letters dated July 22, 2015 (ADAMS Accession No. ML15203A101), and December 21, 2015 (ADAMS Accession No. ML15355A397), the licensee provided sketches for BV1 and BV2, respectively, depicting the Levels 1, 2, and 3 datum points, top of fuel rack, and instrument measurement ranges. For BV1, the instrument measurement range is from Elevation 742 ft. 4 in. to Elevation 766 ft. 7.125 in. For BV2, the instrument measure range is from Elevation 743 ft. 0.5 in to Elevation 766 ft. 7.125 in.

The NRC staff noted that the measurement range specified for BV1 instrumentation covers Levels 1, 2, and 3 as described in Section 4.1 above. While the instrument range for BV2 instrumentation covers Levels 1 and 2, it will not cover Level 3. For BV2, the measurement range will be continuous from the plant elevation 766 ft. 7.125 in. to elevation 743 ft. 0.5 in. Level 3 is identified at elevation 743 ft. 0.4 in., about 0.1 in. below the bottom end of the instrument range. In a worst case scenario, the instrument error could take the level measurement off 3 in. and further reduce the instrumentation range. However, the staff noted that the FSGs for BV2 direct operators to assess SFP makeup and cooling and to use makeup water to maintain SFP level for BV2 between 755 ft. and 767 ft., which is far above Level 3 (El. 743 ft. 0.4 in.). Specifically, Procedure FSG-5 directs operators to assess SFP makeup and cooling [Step 5]. Procedure FSG-5 then directs the initiation of Procedure FSG-11, which requires that the SFP level be maintained between 755 ft. and 767 ft. [Step 5]. Even though the BV2 instrument range is potentially 3.1 in. short to cover Level 3, the licensee will make up the SFP level before the water level reaches Level 2. Therefore, the staff finds that the instrument range for BV2 is acceptable.

Based on the evaluation above, the NRC staff finds that the licensee's design, with respect to the number of channels and measurement range for its SFP, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of Order EA-12-051.

4.2.2 Design Features: Arrangement

In its letters dated July 22, 2015 (ADAMS Accession No. ML15203A101), and December 21, 2015 (ADAMS Accession No. ML15355A397), the licensee stated that:

> Within the Unit 1 SFP area, the brackets were mounted as close to the northeast (primary sensor) and southeast (back-up sensor) corners of the SFP, as permanent plant structures allow. Within the Unit 2 SFP area, the brackets are located on the west deck of the southwest corner (primary sensor) and east deck of the northeast corner (back-up sensor), as permanent plant structures allow. Placing the brackets and probes in the corners allows for natural protection from a single event or missile from disabling both systems. The cabling within the SFP area is routed in separate hard-pipe conduit. Site safety related separation requirements will be followed.
>
> The electronics enclosure units (transmitters) are located in an area removed from the SFP environment, which would be accessible in the event of a beyond-design-basis external event (BDBEE) that would restrict access to the SFP. The enclosures for the two instrument channels are separated to minimize the possibility of a single event damaging both channels.
>
> For Unit 1, the primary level indicating transmitter LIT-1FC-200A is located on the west wall of the auxiliary building, general area elevation (El.) 735' 6", just east of

> the stairwell. The backup level indicating transmitter LIT-1FC-200B is located on the west wall of the auxiliary building, general area El. 735' 6", just east of the stairwell. The level transmitters located in the auxiliary building have a local display, although the credited display units will be located in the main control room (MCR). Cabling for each channel is run in separate conduits and cable trays to the control room indicators. The primary electronics enclosure PNL-1FC-200A is located on the south wall of the old Shift Manager's Office in the control room, El. 735' 6". The backup electronics enclosure PNL-1FC-200B is also located on the south wall of the old Shift Manager's Office in the control room, El. 735' 6".
>
> For Unit 2, the primary level indicating transmitter 2FNC-LIT101A is located on the north wall of the BVPS-2 relay room auxiliary building, general area elevation (El.) 755' 6". The backup level indicating transmitter 2FNC-LIT101B is located on the north wall of the BVPS-2 relay room auxiliary building, general area El. 755' 6". The level transmitters located in the auxiliary building have a local display, although the credited display units will be located in the main control room (MCR). Cabling for each channel is run in separate conduits and cable trays to the control room indicators. The primary electronics enclosure 2FNC-PNL101A is located on the south wall of the control room, El. 735' 6". The backup electronics enclosure 2FNC-PNL101B is located on the south wall of the computer room in the control room, El. 735' 6".

During the onsite audit, the staff walked down the primary and backup SFP level instrumentation channels for BV1 and BV2. The NRC staff noted that there is sufficient channel separation between the primary and back-up level instruments, sensor electronics, and routing cables to provide reasonable protection against loss of indication of SFP level due to missiles that may result from damage to the structure over the SFP.

Based on the evaluation above, the NRC staff finds that, if implemented appropriately, the licensee's proposed arrangement for the SFP level instrumentation appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of Order EA-12-051.

4.2.3 Design Features: Mounting

In its letter dated December 21, 2015 (ADAMS Accession No. ML15355A397), the licensee stated that:

> The mounting bracket for the sensing probe will be designed according to the plant design basis, inclusive of loads from a Safe Shutdown Earthquake (SSE). Loads that will be considered in the evaluation of the bracket and its mounting are: 1) Static loads, inclusive of the dead weight of the mounting bracket in addition to the weight of the level sensing instrument, and cabling, 2) Dynamic loads including the seismic load due to excitation of the dead weight of the system in addition to the hydrodynamic effects resulting from the excitation of the SFP water. A response spectra analysis will be performed for the seismic evaluation of the mounting bracket using a Finite Element Analysis (FEA) software and using floor response spectrum at the operating deck elevation (that is, mounting floor elevation). Damping values will be in according to SSE and consistent with the design basis of the station. The material properties that will

be used for the brackets and its mounting will take into consideration the environmental conditions in the SFP area following an event. Hydrodynamic effects on the mounting bracket will be evaluated using TID-7024 (Nuclear Reactors and Earthquakes, dated 1963). Plant acceptance criteria and applicable codes will be used for the design of the bracket and its anchorage. Westinghouse was responsible for designing the instrumentation and mounting including the base plate to Beaver Valley design criteria as part of CN-PEUS-13-25, Seismic Analysis for the SFP Mounting Bracket at Davis-Besse and Beaver Valley Nuclear Stations. Calculation DSC-0348, Spent Fuel Pool Level Instrumentation Mounting Anchor Qualification, qualifies the expansion anchors used to mount the poolside bracket and demonstrates that 3/8" Hilti Kwik-Bolt 3 expansion anchor with a minimum 2.5" embedment will be subjected to a maximum 280 pound force (lbf) tension and 98 lbf shear. The minimum allowable tension is 1,475 lbf and the minimum allowable shear is 1,230 lbf. The resultant interaction ratio is less than 1.0 which is acceptable. Addendum 1 to DSC-0348 demonstrates that the additional load on the anchors due to sloshing results in a maximum considered tension of 1,151.87 lbf. The minimum allowable tension is 1,475 lbf. The interaction ratio is less than 1.0 and is therefore acceptable.

Calculation DSC-0349, Spent Fuel Pool Level Instrumentation Equipment Mounting, qualifies the mounting of the transmitter and electronic enclosure. The pull-out load for the spring nuts is 474.656 lbf and the slip load is 241.982 lbf. The allowable pull-out load is 1,000 lbf and the allowable slip load is 800 lbf. The uniform load for the unit strut support is 623.811 lbf and the axial load is 407.802 lbf. The allowable uniform load is 1,130 lbf and the allowable axial load is 3,050 lbf. The tension per anchor for the primary enclosure is 453.256 lbf and the shear is 310.281 lbf. The tension per anchor for backup enclosure is 594.956 lbf and the shear is 336.256 lbf. The nominal tension for both channels is 1,730 lbf and the nominal allowable shear is 1,230 lbf. The tension for the transmitter bracket anchors is 274.022 lbf and the shear is 54.663 lbf. The nominal allowable tension is 1,730 lbs and the nominal allowable shear is 1,230 lbf. The resulting interaction ratio is less than 1.0 for all items.

The bracket for the level sensor will be attached to the pool deck using installed anchors that will be designed according to the plant existing specification for design of concrete anchors. This is the only support for this instrument. The pedestal will be adjusted to the height of the poolside curb to ensure the SFP bracket extends over the pool horizontally level. The probe attaches to the bracket's support plat via a 1 ½ in. NPT [National Pipe Thread Taper] threaded connection. Non-movable connections of parts will be welded. The attachment of the seismically qualified bracket to the pool deck will be through permanently installed anchors. With permanently installed anchor, the bracket pedestal will be secured to the poolside deck with adequate washers and bolts. The results of the response spectra analysis are contained in Westinghouse calculation CN-PEUS-13-25, "Seismic Analysis of the SFP Mounting Bracket at Davis-Besse and Beaver Valley Nuclear Stations," Revision 1. The GTSTRUDL model and output considers self-weight, dead load of the instrumentation, hydrodynamic effects of the SFP water, and seismic load on the bracket. All members passed code check with interaction ratios below the allowable limit using the applicable requirements per AISC 7th Edition. Considering all of the loads and load

> combinations, all members of the bracket are acceptable. All welds and bolts ae acceptable when compare to their applicable allowable values.

During the onsite audit, the NRC staff reviewed the mounting specifications and seismic analyses for the SFP level instrumentation, including the methodology and design criteria used to estimate the total loading on the mounting devices. The staff also reviewed the design inputs and the methodology used to qualify the structural integrity of the affected structures for each of the SFP level instrumentation mounting attachments. Based on its review, the staff found that the criteria established by the licensee adequately account for the appropriate structural loading conditions, including seismic and hydrodynamic loads.

Based on the evaluation above, the NRC staff finds that the licensee's proposed mounting design appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of Order EA-12-051.

4.2.4 Design Features: Qualification

4.2.4.1 Augmented Quality Process

Appendix A-1 of the guidance in NEI 12 02 describes a quality assurance process for non-safety systems and equipment that are not already covered by existing quality assurance requirements. In JLD-ISG-2012-03, the NRC staff found the use of this quality assurance process to be an acceptable means of meeting the augmented quality requirements of Order EA 12 051.

In its OIP, the licensee stated that instrument channel reliability will be established through the use of an augmented quality assurance process similar to that described in NEI 12-02.

The NRC staff finds that, if implemented appropriately, this approach appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of Order EA-12-051.

4.2.4.2 Instrument Channel Reliability

Section 3.4 of NEI 12-02 states, in part:

> The instrument channel reliability shall be demonstrated via an appropriate combination of design, analyses, operating experience, and/or testing of channel components for the following sets of parameters, as described in the paragraphs below:
>
> - conditions in the area of instrument channel component use for all instrument components,
> - effects of shock and vibration on instrument channel components used during any applicable event for only installed components, and
> - seismic effects on instrument channel components used during and following a potential seismic event for only installed components.

Equipment reliability performance testing was performed to (1) demonstrate that the SFP instrumentation will not experience failures during beyond-design-basis (BDB) conditions of temperature, humidity, emissions, surge, and radiation, and (2) to verify those tests envelope the plant-specific requirements.

The NRC staff reviewed the Westinghouse SFP level instrumentation's qualification and testing during the vendor audit for temperature, humidity, radiation, shock and vibration, and seismic (ADAMS Accession No. ML14211A346). The staff further reviewed the anticipated Beaver Valley's environmental condition during the onsite audit (ADAMS Accession No. ML15292A139). Below is the staff's assessment of the equipment reliability of BVPS SFP level instrumentation.

4.2.4.2.1 Radiation, Temperature, and Humidity

In its letter dated December 21, 2015 (ADAMS Accession No. ML15355A397), the licensee stated that:

> Environmental qualification testing was performed in accordance with IEEE Std. 323-2003, "Qualifying Class 1E Equipment for Nuclear Power Generating Stations."
>
> Temperature and Humidity – Thermal aging and steam testing were performed on the coaxial cables and couplers using a thermal aging oven at a temperature of 212 °F for the calculated age duration of 311 hours plus 10 percent margin, or 343 hours at 219 °F for 206.5 hours plus a 10 percent margin, or 228 hours. The coaxial cables and couplers were coiled and set on separate racks in the thermal oven. The coupler was required to be threaded into the non-preconditioned end of the cable and aged as one assembly. Steam testing was performed in accordance with IEEE Std. 323-2003. The test specimen was exposed to 212 °F (+/- 1.8 °F), 100 percent saturated (+0, -2 percent) for a duration including 10 percent margin of 185 hours. In addition, the connectors were splash tested to determine the appropriate torque level and sealing. The expected temperature of the Spent Fuel Pool in BDBEE condition is 212 °F. This matches the design temperature of 212 °F. The expected humidity is 100 percent. This matches the design humidity of 100 percent. An abnormal operating occurrence would be loss of HVAC in the installed equipment location. For equipment located in the mild environment, seismic is the only postulated consequential event. No BDB conditions were defined for mild-environment equipment. The expected temperature of the transmitter location during abnormal operation is 120 °F. This is below the design temperature of 140 °F. The expected humidity of the transmitter location is 90 percent. This is within the design range of 0-95 percent humidity. It is required that the operators be able to access the Electronic Enclosures located in the Main Control Room in the event of a BDB. The temperature and humidity levels in this area will remain mild during a BDB. Therefore, the area conditions are considered habitable by the operator. The expected temperature of the electronic enclosures located in the Control Room during abnormal is 120 °F. It is below the design temperature of 140 °F. The expected humidity is 50 percent which is within the design range of 0-95 percent.
>
> Radiation – The coaxial cable and coupler underwent radiation aging in accordance with IEEE Std. 323-2003 for service in post-accident radiation conditions. Test specimens were required to be exposed to a minimum of 11 Mrad of Co-60 gamma rays at a dose rate minimum of 0.2 – 0.5 Mrad/hour. The

> bounding dose for location of the transmitters was determined to be 987.6 rad which is less than the 1,000 rad design limit. The bounding dose for the level sensors was determined to be 2.67 Mrad which is less than the 10 Mrad design limit. The bounding dose for the location of the electronics enclosures was determined to be 300 rad which is less than 1,000 rad limit.

During the onsite audit, the NRC staff reviewed Calculations 12241-B-21, Revision 1, "Primary Auxiliary Building and Waste Handling Building Air Conditioning Loads and Air Flow Rates"; 10080-UR(B)-512, Revision 0, "Radiation Levels Following Spent Fuel Pool Drain Down and Environmental Dose to NEI 12-02 SFP Level Instrumentation," and 12241-B-8A, Revision 4, "Control Building Air Conditioning Loads Air Flow Rates." The staff verified that the environmental conditions for both the normal condition and post-BDB event for the locations where the SFPIS located are bounded by the vendor equipment qualification.

4.2.4.2.2 Seismic

In its letter dated December 21, 2015 (ADAMS Accession No. ML15355A397), the licensee stated that:

> Seismic qualification testing was performed in accordance with IEEE Std. 344-2004, which is endorsed by NRC Regulatory Guide 1.100, Revision 3, and IEEE Std. 323-2003. The electronics enclosure was mounted to the test fixture with four 3/8-inch Grade 5 bolts, lock washers, flat washers, and nuts torqued snug tight. The sensor head unit mounting bracket was mounted to the fixture with four 3/8-inch Grade 5 bolts, lock washers, and flat washers torqued snug tight. The sensor head unit was mounted to the sensor head unit mounting bracket with two 1/4 inch-20 bolts and lock washers torqued to 75 in-lbs. The coaxial coupler was torqued hand tight. The launch plate was mounted to the fixture with four 5/16-inch Grade 5 bolts and lock washers torqued snug tight. The sensor head unit mounting bracket was mounted to the coupler using the integral threads in the probe and a lock washer to snug tight. Terminal block attachments within the rear of the sensor head unit were torqued to 8 in-lbs.
>
> Seismic testing was performed on a 4x4-foot independent tri-axial test table using random, multi-frequency acceleration time history inputs. Accelerometers were mounted on the test table and equipment under test. The table drive signal was applied separately and simultaneously in both the horizontal and vertical directions for a duration of 30 seconds with a minimum of 20 seconds of strong motion. The response from the table and the response accelerometers were analyzed at 5 percent critical dampening for each operating basis earthquake (OBE) and safe shutdown earthquake (SSE) test and were plotted at one twelfth octave intervals over the frequency range of 1 to 100 Hz.
>
> Seismic testing of the instrumentation was performed in accordance with IEEE 344-2004. The required response spectra (RRS) included a 10 percent margin recommended by IEEE 323-2003. Seismic testing was performed to the defined SSE and hard rock high frequency (HRHF) spectra. The OBE RRS at 5 percent critical damping was at least 70 percent of the respective SSE seismic level. At a minimum, five successful OBE level tests were required, followed by two successful SSE level tests and one successful HRHF level test. In addition,

> static pull tests were performed on the Radial connectors (straight and 90 degree) to address seismic qualification of the connectors.
>
> The equipment under test (EUT) was powered on during OBE seismic test runs, but was not electrically monitored during the test runs. Functional testing was performed before and after the five successful OBE test runs. The system maintained accuracy after five successful OBE level tests and no loss of power was noted during the test runs. The EUT was powered on during all SSE and HRHF seismic test runs, but was not electrically monitored during the test runs. Functional testing was also performed before and after each successful SSE and HRHF test run. The system maintained accuracy after all SSE and HRHF level tests and no loss of power was noted during the test runs. During the SSE 2, the alternating current (AC) power was removed from the system approximately 15 seconds into the run. This operation was performed to ensure that the uninterruptible power supply (UPS) was able to switch from line power to battery power during a seismic event. The system performed without issue. The EUT met all of the required performance and acceptance criteria and maintained structural integrity during all acceptable OBE test runs, acceptable SSE test runs, and the acceptable HRHF test run to the RRS. Acceptable functionality of the EUT was confirmed upon completion of seismic testing. The post-test inspection performed upon completion of all seismic tests revealed no major structural issues or damage to the EUT.

The NRC staff noted that the licensee adequately addressed the SFP level instrumentation seismic design. The staff audited the Westinghouse SFP instrumentation design verification analyses and performance test results (ADAMS Accession No. ML14211A346) and found the seismic testing of SFP level instrumentation acceptable.

4.2.4.2.3 Shock and Vibration

In its letter dated December 21, 2015 (ADAMS Accession No. ML15355A397), the licensee stated that:

> Shock and Vibration – Seismic testing consisted of five successful OBE tests, two successful SSE tests, and one successful HRHF test. During the second successful SSE level test (281 SSE 2), AC power was cut off to the SFP instrumentation system to ensure that the UPS would reliably switch during a seismic event. No equipment failures were noted as a result of the seismic test runs. Westinghouse performed functional testing of the equipment before and after each SSE and HRHF runs, and the equipment maintained its functionality. In addition, Westinghouse inspected the equipment after the seismic testing and no damage was found. Westinghouse concluded that the system met all requirements, maintaining structural integrity during and after all OBEs, SSEs and HRHF tests.

The NRC staff noted that the licensee adequately addressed the SFP level instrumentation shock and vibration design. The staff audited the Westinghouse SFP instrumentation design verification analyses and performance test results (ADAMS Accession No. ML14211A346) and found the shock and vibration testing of SFP level instrumentation acceptable.

4.2.4.2.4 Electromagnetic Compatibility

In its letter dated December 21, 2015 (ADAMS Accession No. ML15355A397), the licensee stated that:

> Electromagnetic Compatibility (EMC) – Susceptibility, emissions and harmonics testing was performed and the guidance and limits provided in Regulatory Guide 1.180 were used. Continuous monitoring was perform to monitor the performance during the application of EMC susceptibility testing. Performance criterion on this system is determined to be Criterion B.
>
> A radio exclusion zone will be established around the equipment in the SFP. The transmitter and electronics enclosure locations are already established exclusion zones. There are no motors in the vicinity of the equipment that could interfere with the operation of the equipment.

The staff found the licensee adequately assessed the potential radio frequency interference and electromagnetic interference. The licensee will establish an exclusion zone around the equipment in the SFP. The electronics enclosure locations are in the CR where exclusion zones were already established.

Based on the evaluation above, the NRC staff finds that the licensee's proposed instrument qualification process appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of Order EA-12-051.

4.2.5 Design Features: Independence

In its letter dated July 22, 2015 (ADAMS Accession No. ML15203A101), the licensee stated that:

> Within the Unit 1 SFP area, the brackets were mounted as close to the northeast (primary sensor) and southeast (back-up sensor) corners of the SFP, as permanent plant structures allow. Placing the brackets and probes in the corners allows for natural protection from a single event or missile from disabling both systems. The cabling within the SFP area will be routed in separate hard-pipe conduit. Site safety related separation requirements will be followed.

In its letter dated December 21, 2015 (ADAMS Accession No. ML15355A397), the licensee stated that:

> Within the Unit 2 SFP area, the brackets are located on the west deck of the southwest corner (primary sensor) and east deck of the northeast corner (back-up sensor) of the SFP Elevation 767' 10", as permanent plant structures allow. Placing the brackets and probes in the corners allows for natural protection from a single event or missile from disabling both systems. The cabling within the SFP area is routed in separate hard-pipe conduit. Site safety related separation requirements will be followed.

During the onsite audit, the staff performed a walkdown of the SFP level instrumentation channels. The staff noted that the primary instrument channel is independent of the backup instrument channel and consistent with recommendations for channel independence in NEI 12-

02. The NRC staff finds that the licensee's proposed design, with respect to instrument channel independence, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of Order EA-12-051.

4.2.6 Design Features: Power Supplies

In its letter dated February 27, 2014, the licensee stated that:

> Each instrument channel is normally powered by non-class 1E 120 volts alternating current (VAC) distribution panels to support continuous monitoring of the SFP level. The 120 VAC distribution panels for the primary and backup channels at each unit are powered by different 480V buses. Therefore, the loss of any one 480V bus will not result in the failure of both instrument channels.
>
> On loss of normal 120VAC power, each channel's uninterruptible power supply (UPS) automatically transfers to a dedicated backup battery. If normal power is restored, then the channel will automatically transfer back to the normal alternating current (AC) power. The 72-hour backup batteries are maintained in a charged state by UPS. The vendor's calculation has determined that the battery will last from a full charge for greater than 100 hours per Section 5.2.1 of the Westinghouse calculation WNA-CN-00300-GEN, Revision 0, Spent Fuel Pool Instrumentation System Power Consumption.

During the onsite audit, the NRC staff reviewed ECP No. 13-0562-000 DR, Revision 0, "Engineering Change Package Design Report," and one line diagram Nos. 10080-RE-1BC, Revision 10, "One Line Diagram Essential Bus Sheet 1;" 11700-RE-1GB-8, Revision 10, "4160V One Line Diagram Emergency Response Facility Substation Unit No. 1;" 8700-RE-1GA, Revision 9, "Main One Line Diagram ERFS Transformer 3A & 3B;" 12241-RE-1AB-8, Revision 9, "One Line Diagram Standby Diesel 480V Substation 2-5." The staff found that the electrical ac power sources for the primary and backup channels are independent and the loss of power supply from one channel will not result in a loss of ac power for both channels. The staff reviewed the battery duty cycle during the vendor audit and found it to be acceptable.

Based on the evaluation above, the NRC staff finds that the licensee's proposed power supply design appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of Order EA-12-051.

4.2.7 Design Features: Accuracy

In its letter dated December 21, 2015 (ADAMS Accession No. ML15355A397), the licensee stated that:

> The design accuracy is 3" or less for both normal and BDB conditions. Westinghouse calculation WNA-CN-00301-GEN provides the channel accuracy of a wired system with a standard measurement span of 296". The calculated accuracy of the standard system is 0.54 percent of span or 1.60". The cable probe length is 282.625" which is less than the assume value in WNA-CN-00301-GEN, therefore the calculated accuracy of 0.54 percent of span or 1.60" is bounding for Beaver Valley and within the design range. Per Westinghouse procedures, should the calibration verification indicate that the instrument is out of tolerance by more than the designed 3" tolerance a recalibration will be

performed. A periodic calibration verification will be performed within 60 days of a refueling outage considering normal testing scheduling allowances (e.g., 25 percent). Calibration verification will not be required to be performed more than once per 12 months. These calibration requirements are consistent with the guidance provided in NEI 12-02 Section 4.3.

The NRC staff finds that the instrument accuracy of +/- 3 inches is within the accuracy of +/- 1 ft. as recommended in NEI 12-02. The licensee will use the manufacturer's design accuracy as acceptance criteria in procedures which were developed to take corrective action if the accuracy exceed +/- 3 inches.

Based on the evaluation above, the NRC staff finds that the licensee's proposed instrument accuracy appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of Order EA-12-051.

4.2.8 Design Features: Testing

In its letter dated December 21, 2015 (ADAMS Accession No. ML15355A397), the licensee stated that:

> A periodic calibration verification will be performed in-situ to verify that the transmitter is in calibration using a calibration verification tool provided by the manufacturer and in accordance with the plant procedures and manufacturer's recommendations. Should the calibration verification indicate that the transmitter is out of calibration a full-range calibration adjustment will be completed using a calibration test kit. The portable test kit is composed of a replicate probe, coupler and launch plate equivalent to those installed, a replicate coaxial cable of the same electrical length as installed in the pool, a bracket to hold the weight end of the probe cable, simulated pool liner, and a moveable metal target. To perform the calibration, the installed SFPIS [spent fuel pool instrumentation system] coaxial cable is disconnected from the sensor and the replicate test kit coaxial cable is connected. A metal target is used to measure several points along the length of the probe to perform the full-range calibration. The readings displayed on the output display at each point along the probe will be compared to the physical distance measured along the length of the probe cable to determine calibration acceptance. Each component in the instrument channel can be replaced (transmitter included) to restore the instrument loop to service in the event a component failure occurs.
>
> To aid in early detection of any "off normal" readings which could indicate that channel adjustment may be required, a daily channel check using this indication of SFP level will be added to 2OM-54.3.L5, Surveillance Verification Log. The channel check confirms that the two spent fuel pool level instruments are reading within 6 inches of each other to conform the system design accuracy of ± 3 inches per channel. The channel check periodicity and acceptance criteria are controlled within BVPS operating procedures and periodic maintenance programs and may change based on equipment operating experience.
>
> FENOC will perform periodic calibration verifications using a periodic maintenance procedures and manufacturer's guidelines. The periodic calibration verification will be performed within 60 days of a refueling outage considering

> normal testing scheduling allowances (e.g., 25 percent). Calibration verification will not be required to be performed more than once per 12 months. These calibration requirements are consistent with the guidance provided in NEI 12-02, Revision 1, and Section 4.3.
>
> Preventive Maintenance procedures will be in place for periodic replacement of the backup batteries based on manufacturer recommendations and for calibration verification.

The NRC staff noted that the licensee adequately addressed the equipment testing including periodic testing, calibration, and preventive maintenance. These tasks appear to be consistent with the vendor recommendation. The licensee will also perform the channel check to confirm that the two spent fuel pool level instrument channels are reading within the equipment design accuracy.

Based on the evaluation above, the NRC staff finds that the licensee's proposed SFP instrumentation design allows for testing consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of Order EA-12-051.

4.2.9 Design Features: Display

In its OIP, the licensee state that the SFP level instrumentation will provide for display of fuel pool level using an indicator located in the main CR.

The NRC staff notes that the NEI guidance for "Display" specifically mentions the CR as an acceptable location for the SFP instrumentation displays as it is occupied or promptly accessible, outside the area surrounding the SFP, inside a structure providing protection against adverse weather and outside of any very high radiation areas or locked high rad area during normal operation.

Based on the evaluation above, the NRC staff finds that the licensee's proposed location and design of the SFP instrumentation displays appear to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of Order EA-12-051.

4.3 Evaluation of Programmatic Controls

Order EA-12-051 specified that the SFP 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 SFP instrumentation.

4.3.1 Programmatic Controls: Training

In its OIP, the licensee stated that:

> The Systematic Approach to Training will be utilized when developing and implementing training. Training for maintenance and operations personnel will be developed and provided. Training will be provided for the personnel in the used of, and provision of alternate power to, primary and backup instrument

> channels in compliance with the NRC Order EA-12-051 Attachment 2, Section 2.1.

Based on the OIP above, the NRC staff finds that the licensee's plan to train personnel in the operation, maintenance, calibration, and surveillance of the SFP level instrumentation, including the approach to identify the population to be trained, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of Order EA-12-051.

4.3.2 Programmatic Controls: Procedures

In its letter dated December 21, 2015 (ADAMS Accession No. ML15355A397), the licensee stated that:

> ECP 13-0562, Spent Fuel Pool Instrumentation, installs the new hardware and ensures that the appropriate procedures for testing, calibration, operation, and abnormal response issues associated with the primary and backup SFP instrumentation channels are completed. The following is a list of the procedures.
>
> 1/2OM-53C.4A.100.4, *Spent Fuel Pool (b.5.b)*
> 2OM-20.1.E, *Specific Instrumentation and Controls*
> 2OM-20.3.C, *Power Supply and Control Switch List*
> 2OM-20.4.AAB, *Spent Fuel Pool Level High/Low (ARP)*
> 2OM-20.4.T, *Alternate Power to SFPLI [2FNC-LI-LI101A, 101B]*
> 2OM-53A.1.ECA-0.0(ISS2), *Loss of All AC Power (EOP)*
> 2OM-53B.4.ECA-0.0(ISS2), *Loss of All Emergency 4KV AC Power Background*
> 2OM-53C.4.2.20.1, *Spent Fuel Pool Cooling Trouble (AOP)*
> 2OM-20.4.M, *Makeup to the Spent Fuel Pool Using Service Water*
> 2LCP-20-L101A, *Calibration of Fuel Pool Level Instrumentation Loop 2FNC-L101A*
> 2LCP-20-L101B, *Calibration of Fuel Pool Level Instrumentation Loop 2FNC-L101B*
>
> The objectives of each procedural area are described below:
>
> Inspection, Calibration, and Testing – Guidance on the performance of periodic visual inspections, as well as calibration and testing, to ensure that each SFP channel is operating and indicating level within its design accuracy.
>
> - 2LCP-20-L101A, *Calibration of Fuel Pool Level Instrumentation Loop 2FNC-L101A*
> - 2LCP-20-L101B, *Calibration of Fuel Pool Level Instrumentation Loop 2FNC-L101B*
>
> Preventative Maintenance – Guidance on scheduling of, and performing, appropriate preventative maintenance activities necessary to maintain the instruments in a reliable condition. New PMs based on NORM-ER-3733, *FENOC FLEX Spent Fuel Pool Level Monitor*, are listed in the table below.

FLOC	Equipment	PM Type	Interval
NORM-ER-3733	Primary and Secondary Level Sensor transmitter	Calibration	1/Cycle
	Primary and Secondary Level Sensor transmitter	Inspection/Cleaning	1/Cycle

	Primary and Secondary Level Sensor transmitter	Coax Cable Resistance Check	1/Cycle
	Primary and Secondary Battery	Replacement	3Y
	Primary and Secondary Level Sensor transmitter	Replacement	6Y
	Level Sensor Probe	Replacement	7Y
	Primary and Secondary Coaxial Cable, Coupler, and Coax Connector	Replacement	10Y
	Primary and Secondary Electronics Enclosure Components	Replacement	10Y

Maintenance – To specify troubleshooting and repair activities necessary to address system malfunctions.

- 2LCP-20-L101A, *Calibration of Fuel Pool Level Instrumentation Loop 2FNC-L101A*
- 2LCP-20-L101B, *Calibration of Fuel Pool Level Instrumentation Loop 2FNC-L101B*

Programmatic controls – Guidance on actions to be taken if one or more channels is out of service is contained in the program document.

System Operations – To provide instructions for operation and use of the system by plant staff.

- 1/2OM-53C.4A.100.4, *Spent Fuel Pool (b.5.b)*
- 2OM-20.1.E, *Specific Instrumentation and Controls* – List of instruments
- 2OM-20.3.C, *Power Supply and Control Switch List* – List of power supplies and switch positions
- 2OM-20.4.AAB, *Spent Fuel Pool Level High/Low (ARP)* – Actions to be taken in the event of high/low water level
- 2OM-20.4.T, *Alternate Power to SFPLI [2FNC-LI-LI101A, 101B]* – Actions to provide alternate power to the SFP level indicators
- 2OM-53A.1.ECA-0.0(ISS2), *Loss of All AC Power (EOP)* – Emergency procedure for loss of all AC power
- 2OM-53B.4.ECA-0.0(ISS2), *Loss of All Emergency 4KV AC Power Background* – Emergency procedure for loss of all emergency 4KV power
- 2OM-53C.4.2.20.1, *Spent Fuel Pool Cooling Trouble (AOP)* – Abnormal operating procedure for trouble with the SFP cooling system
- 2OM-20.4.M, *Makeup to the Spent Fuel Pool Using Service Water* – Procedure for initiating makeup water to the SFP using service water

Response to inadequate levels – Action to be taken on observations of levels below normal level are addressed in:

- 2OM-20.4.AAB, *Spent Fuel Pool Level High/Low (ARP)*
- 2OM-53C.4.2.20.1, *Spent Fuel Pool Cooling Trouble (AOP)*

- 2OM-20.4.M, *Makeup to the Spent Fuel Pool Using Service Water*
- 2OM-53E.1.FSG-11, *Alternate SFP Makeup and Cooling*

The staff finds the licensee's response acceptable because it provides a list all of the procedures addressing operation, calibration, test, maintenance, and inspection procedures for the SFP level instrumentation. These procedures are consistent with the recommendation from the vendor.

Based on the evaluation above, the NRC staff finds that the licensee's procedure development appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of Order EA-12-051.

4.3.3 Programmatic Controls: Testing and Calibration

In its letter dated December 21, 2015 (ADAMS Accession No. ML15355A397), the licensee stated that:

> The SFPI channel/equipment maintenance/preventative maintenance and testing program requirements to ensure design and system readiness have been established in accordance with FENOC's processes and procedures NORM-ER-3733. The maintenance and testing program requirements for the SFP will be documented in Maintenance program documents and be contained in the Program Implementation Document.
>
> The SFP Level Indication is located in the Main Control Room. To aid in early detection of any "off normal" readings which could indicate that channel adjustment may be required, a daily channel check using this indication of SFP level will be added to 2OM-54.3.L5, Surveillance Verification Log. The channel check confirms that the two spent fuel pool level instruments are reading within 6 inches of each other to conform the system design accuracy of +/- 3 inches per each channel. The channel check periodicity and acceptance criteria are controlled within BVPS operating procedures and periodic maintenance programs and may change based on equipment operating experience.
>
> FENOC will perform periodic calibration verifications using a periodic maintenance procedures and manufacturer's guidelines. The periodic calibration verification will be performed within 60 days of a refueling outage considering normal testing scheduling allowances (e.g., 25 percent).
>
> Both primary and backup SFPI channels incorporate permanent installation (with no reliance on portable, post-event installation) of relatively simple and robust augmented quality equipment. Permanent installation coupled with stocking of adequate spare parts reasonably diminishes the likelihood that a single channel (and greatly diminishes the likelihood that both channels) is (are) out-of-service for an extended period of time. Planned compensatory actions for unlikely extended out-of-service events are summarized as follows:
>
> With 1 of channel out of service, restore channel to functional status within 90 days (or if channel restoration not expected with 90 days, proceed to Compensatory Action). Compensatory action if required restoration action not

> completed within the specified time is to present a report to the on-site safety review committee within the following 14 days. The report shall outline the planned alternate method of monitoring, the cause of the non-functionality, and the plans and schedule for restoring the instrumentation channel(s) to functional status. With 2 channels out of service, initiate action within 24 hours to restore one channel to functional status and restore one channel to functional status within 72 hours. Compensatory action if required restoration action not completed within the specified time, immediately initiate action to present a report to the on-site safety review committee within the following 14 days. The report shall outline the planned alternate method of monitoring, the cause of non-functionality, and the plans and schedule for restoring the instrument channel(s) to functional status.
>
> A condition report will be initiated and addressed through FENOC's Corrective Action Program. Provisions associated with out of service (OOS) or non-functional equipment, including allowed outage times and compensatory actions, will be consistent with the guidance provided in Section 4.3 of NEI 12-02, Revision 1. If one OOS channel can't be restored to service within 90 days, appropriated compensatory actions, including the use of alternate suitable equipment, will be taken. A daily visual inspection of the Spent Fuel Pool Level is performed by Operations. If both channels become OOS, actions would be initiated within 24 hours to restore one of the channels to functional status and to implement appropriate compensatory actions, including the use of alternate suitable equipment and/or supplement personnel within 72 hours.

The NRC staff finds that the compensatory actions for non-functional SFP level instrumentation channels is consistent with those recommended by NEI 12-02.

The NRC staff finds that the licensee's proposed testing and calibration plan appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of Order EA-12-051.

4.4 Conclusions for Order EA-12-051

In its letter dated February 27, 2013 (ADAMS Accession No. ML13059A495), 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 has conformed to the guidance in NEI 12-02, as endorsed by JLD-ISG-2012-03. In addition, the NRC staff concludes that if the SFP level instrumentation is installed at BVPS 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 Orders EA-12-049 and EA-12-051. The staff conducted an onsite audit in November 2, 2015 (ADAMS Accession No. ML15292A139). The licensee reached its final compliance date on December 16, 2016 (ADAMS Accession No. ML16351A277, non-publicly available), and has declared that both of the reactors are in compliance with the orders. The purpose of this safety evaluation is to document the strategies and implementation features that the licensee has committed to. Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and proposed designs that if implemented appropriately should adequately address the requirements of Orders EA-12-049 and EA-12-051. 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.

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Date: May 18, 2017

BEAVER VALLEY POWER STATION, 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
DATED May 18, 2017

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ADAMS Accession No. ML17095A276 ***via email**

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