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

March 27, 2017

Vice President, Operations
Entergy Nuclear Operations, Inc.
Indian Point Energy Center
450 Broadway, GSB
P.O. Box 249
Buchanan, NY 10511-0249

SUBJECT: INDIAN POINT NUCLEAR GENERATING UNIT NOS. 2 AND 3 – 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. MF0737, MF0738, MF0744 AND MF0745)

Dear Sir or Madam:

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

By letter dated February 28, 2013 (ADAMS Accession No. ML13079A348), Entergy Nuclear Operations, Inc. (Entergy, the licensee) submitted its OIP for Indian Point Nuclear Generating Unit Nos. 2 and 3 (Indian Point) 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 24, 2014 (ADAMS Accession No. ML13337A594), December 9, 2014 (ADAMS Accession No. ML14335A642, and February 25, 2016 (ADAMS Accession No. ML16042A388), the NRC issued an Interim Staff Evaluation (ISE) and audit reports on the licensee's progress. By letter dated August 12, 2016 (ADAMS Accession No. ML16235A292), Entergy submitted a compliance letter and Final Integrated Plan (FIP) in response to Order EA-12-049. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-049.

By letter dated February 27, 2013 (ADAMS Accession No. ML13072A082), Entergy submitted its OIP for Indian Point 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 8, 2013 (ADAMS Accession No. ML13298A805), December 9, 2014 (ADAMS Accession No. ML14335A642, and February 25, 2016 (ADAMS Accession No. ML16042A388), the NRC issued an Interim Staff Evaluation (ISE) and audit reports 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 NRR Office Instruction LIC-111, similar to the process used for Order EA-12-049. By letter dated August 12, 2016 (ADAMS Accession No. ML16235A292), Entergy 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 Entergy's strategies for Indian Point. The intent of the safety evaluation is to inform Entergy 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 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 John Boska, Orders Management Branch, Indian Point Project Manager, at 301-415-2901 or by e-mail at John.Boska@nrc.gov.

Sincerely,

Stewart N. Bailey, Chief
Electrical and Reactor Systems Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos.: 50-247 and 50-286

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

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

ENTERGY NUCLEAR OPERATIONS, INC.

INDIAN POINT NUCLEAR GENERATING UNIT NOS. 2 AND 3

DOCKET NOS. 50-247 AND 50-286

1.0 INTRODUCTION

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

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

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

2.0 REGULATORY EVALUATION

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

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

2.1 Order EA-12-049

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

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

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

3) Licensees or CP holders must provide reasonable protection for the associated equipment from external events. Such protection must demonstrate that there is adequate capacity to address challenges to core cooling, containment, and SFP cooling capabilities at all units on a site subject to this Order.

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

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

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

2.2 Order EA-12-051

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

> All licensees identified in Attachment 1 to the order shall have a reliable indication of the water level in associated spent fuel storage pools capable of supporting identification of the following pool water level conditions by trained personnel: (1) level that is adequate to support operation of the normal fuel pool cooling system, (2) level that is adequate to provide substantial radiation shielding for a person standing on the spent fuel pool operating deck, and (3) level where fuel remains covered and actions to implement make-up water addition should no longer be deferred.
>
> 1. The spent fuel pool level instrumentation shall include the following design features:
>
> 1.1 Instruments: The instrumentation shall consist of a permanent, fixed primary instrument channel and a backup instrument channel. The backup instrument channel may be fixed or portable. Portable instruments shall have capabilities that enhance the ability of trained personnel to monitor spent fuel pool water level under conditions that restrict direct personnel access to the pool, such as partial structural damage, high radiation levels, or heat and humidity from a boiling pool.
>
> 1.2 Arrangement: The spent fuel pool level instrument channels shall be arranged in a manner that provides reasonable protection of the level indication function against missiles that may result from damage to the structure over the spent fuel pool. This protection may be provided by locating the primary instrument channel and fixed portions of the backup instrument channel, if applicable, to maintain instrument channel separation within the spent fuel pool area, and to utilize inherent shielding from missiles provided by existing recesses and corners in the spent fuel pool structure.
>
> 1.3 Mounting: Installed instrument channel equipment within the spent fuel pool shall be mounted to retain its design configuration during and

following the maximum seismic ground motion considered in the design of the spent fuel pool structure.

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

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

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

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

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

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

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

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

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

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

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

3.0 TECHNICAL EVALUATION OF ORDER EA-12-049

By letter dated February 28, 2013 [Reference 10], Entergy Nuclear Operations, Inc. (Entergy, the licensee) submitted its Overall Integrated Plan (OIP) for Indian Point Nuclear Generating Unit Nos. 2 and 3 (Indian Point) in response to Order EA-12-049. By letters dated August 27, 2013 [Reference 11], February 27, 2014 [Reference 12], August 27, 2014 [Reference 13], February 27, 2015 [Reference 14], August 28, 2015 [Reference 50], and February 29, 2016 [Reference 51], the licensee submitted six-month updates to the OIP.

By letter dated August 28, 2013 (Agencywide Documents Access and Management System (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" [Reference 36]. By letters dated January 24, 2014 [Reference 16], December 9, 2014 [Reference 17], and February 25, 2016 [Reference 18], the NRC issued an Interim Staff Evaluation (ISE) and audit reports on the licensee's progress. By letter dated August 12, 2016 [Reference 56], Entergy reported that full compliance with the requirements of Order EA-12-049 was achieved, and submitted a Final Integrated Plan (FIP).

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.

Indian Point Unit 2 and Unit 3 are four loop 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. The description applies to both units except where noted otherwise.

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 atmospheric dump valves (ADVs) or main steam safety valves (MSSVs), and makeup to the SGs is initially provided by the unit's turbine-driven auxiliary boiler feedwater (TDABF) pump taking suction from the unit's condensate storage tank (CST). If there is damage to the CST, the operators realign the TDABF pump suction to the site's city water storage tank (CWST). Within approximately 0.5 hours, the operators would begin a controlled cooldown and depressurization of the RCS by manually operating the SG ADVs. The SGs would be depressurized in a controlled manner to about 270 pounds per square inch gage (psig) (275 psig for Unit 3) which corresponds to an RCS cold leg temperature of approximately 415 degrees Fahrenheit (°F). These conditions would be maintained while the operators borate the RCS and isolate the safety injection (SI) accumulators to preclude nitrogen cover gas from being injected into the RCS. Depressurizing the SGs reduces RCS temperature and pressure. The licensee plans to complete this initial cooldown within 3 hours of the start of the event. The reduction in RCS temperature will result in inventory contraction in the RCS, with the result that the pressurizer would drain and a steam void would form in the reactor vessel upper head. The RCS leakage, particularly from the RCP seals, would also contribute to the decrease in RCS liquid volume. However, during the cooldown RCS pressure should drop below the safety injection accumulator pressure of about 640 psig and the injection of some quantity of borated water into the RCS from the accumulators would then occur.

As discussed in its cooldown timeline, the licensee expects to further depressurize the SGs in order to further reduce RCS temperature and pressure. The second cooldown is expected to begin about 22 hours after the ELAP. In addition, as noted in the FIP, by approximately 72 hours into the event, the licensee expects to use FLEX equipment from offsite response centers to restore the residual heat removal (RHR) system and supporting equipment, the operation of which would allow RCS temperature to be reduced below 200 °F. Prior to undertaking the additional cooling and depressurization of the RCS, operators would need to perform a number of supporting actions including injecting additional boric acid into the RCS to avoid the potential for recriticality and isolating the accumulators using electrical power from FLEX generators to avoid the potential for excessive accumulator injection to the point that the nitrogen cover gas could enter the RCS.

The water supply for the TDABF pump is initially from the CST. The CST will provide approximately 24 hours of cooling water to the SGs for RCS decay heat removal (23 hours for Unit 3), in addition to absorbing the latent heat associated with the planned RCS cooldown. Prior to emptying the CST the operators will place a FLEX inventory transfer pump in service to refill the CST from the other available on site water storage tanks. If the operators had to realign the TDABF pump suction to the site's CWST due to damage to the CST, there should also be enough of a water supply to last for 24 hours. Operators will ultimately transition SG makeup from the TDABF pump to a portable FLEX SG makeup pump.

The operators will perform dc bus load stripping within the initial 2 hours following event initiation to ensure safety-related battery life is extended up to 8 hours. Following dc load stripping and prior to battery depletion, one 600-kilowatt (kW), 480 volt alternating current (Vac) generator will be deployed from the site's FLEX equipment storage building (FESB) to each unit. These portable generators will be used to repower essential battery chargers within 8 hours of ELAP initiation, as well as repowering safety injection accumulator isolation valves and key instrumentation.

The RCS makeup and boration will be initiated within 12.7 hours (11.6 hours for Unit 3) of the ELAP to ensure that natural circulation, reactivity control, and boron mixing is maintained in the RCS. Operators will provide reactor coolant makeup using portable FLEX high-pressure diesel-powered pumps, one per unit, to deliver water drawn from a FLEX connection on each unit's refueling water storage tank (RWST). Borated water from the RWST will be injected into the RCS through FLEX piping connections located in the primary auxiliary building (PAB). Boration is expected to be completed within 22 hours.

In addition, a National Strategic Alliance of FLEX Emergency Response (SAFER) Response Center (NSRC) will provide high capacity pumps and large turbine-driven generators which could be used to restore one 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 storage building (FSB). Upon initiation of the ELAP event, the SFP will heat up due to the unavailability of the normal cooling system. The licensee has calculated that boiling could start as soon as 8 hours after the start of the event. The licensee determined that it would take approximately 27 hours for SFP water level to drop to a level requiring the addition of makeup to maintain adequate shielding for the fuel. Initially makeup water to the SFP would be provided using a diesel-driven FLEX pump with suction from the RWST. Ventilation of the generated steam is accomplished by opening the rollup door and the door to the refueling deck 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 120 hours. During Phase 3, containment cooling and depressurization would be accomplished by operating one containment recirculation fan (CRF) and its cooler, with service water for cooling supplied by an NSRC FLEX pump drawing water from the discharge canal, which has a flow path from the Hudson River. The containment recirculation fan would be powered by a 480 Vac 1100 kW turbine-driven generator supplied by the NSRC.

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 0, 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 evaluation.

3.2.1 Core Cooling Strategy and RCS Makeup

3.2.1.1 Core Cooling Strategy

3.2.1.1.1 Phase 1

In Section 2.3.1 of its FIP, the licensee states that immediately following the occurrence of an ELAP/LUHS event, the reactor will trip and the plant will initially stabilize at no-load RCS temperature and pressure conditions, with reactor decay heat removal via steam release to the atmosphere through the SG ADVs or MSSVs. Natural circulation of the reactor coolant system will develop to provide core cooling and the TDABF pump will provide flow to the SGs to make up for steam release, with suction from either the unit's CST or the site's CWST.

Although the TDABF pump automatically actuates, additional operator actions are required to control the feed to the SGs. The TDABF pump can supply 100 percent of the required flow to all four SGs through individual air-operated flow control valves (FCVs). Remote control and operation of the FCVs uses instrument air or can be switched to an installed backup nitrogen supply if needed. In addition, local operation of the FCVs via handwheels is available, if necessary.

The CSTs at Indian Point Units 2 and 3 have a minimum capacity of 295,150 gallons and 292,000 gallons, respectively. Both CSTs are seismically qualified, but are potentially vulnerable to a wind-borne missile strike. If a CST is damaged and unavailable to provide suction to the TDABF pump, then the operators would align the pump suction to the CWST, which has a minimum usable volume of 1.5 million gallons. The CWST is not fully robust against a tornado missile strike. However, for high wind events, either the CST or CWST is credited to survive the external event, based on reasonable separation distance between the tanks and partial shielding from adjacent structures.

Entergy's Phase 1 strategy directs the operators to initiate a cooldown and depressurization of the RCS at approximately 30 minutes after the start of the ELAP event. Over a period of approximately 2.5 hours, operators would gradually cool down the RCS from post-trip conditions by releasing steam from the SGs to the atmosphere until an SG pressure of 270 psig for Unit 2 and 275 psig for Unit 3 is reached. This corresponds to an RCS cold-leg temperature of about 415 °F, which corresponds to an RCS pressure of about 310 pounds per square inch absolute (psia) when saturation conditions are reached. Cooldown and depressurization of the RCS significantly extends the expected coping time under ELAP/LUHS conditions because it (1) reduces the potential for damage to RCP seals (as discussed in Section 3.2.3.3) and (2) allows borated coolant stored in the cold leg accumulators to passively inject into the RCS to offset system leakage and add negative reactivity. The accumulators are normally pressurized to at least 600 psig using a nitrogen cover gas. Stabilizing the RCS at these plant conditions allows steam pressure to remain high enough to support continued use of the TDABF pump, and prevents core recriticality after the decay of xenon. To remove heat, operators will discharge steam through the SG ADVs, which can be operated from the main control board using vital battery power and safety-grade nitrogen backup for the valve actuators. Operators can place installed standby nitrogen bottles in service to extend the operability time of the ADVs to at least 20 hours after the initiating event, and additional nitrogen bottles are stored in the FESB to provide an adequate nitrogen supply for 72 hours.

By terminating the initial RCS cooldown with a minimum RCS pressure of approximately 310 psia, the licensee has determined that injection of the nitrogen cover gas in the accumulators into the RCS will be prevented. The NRC staff's audit found the licensee's calculational methods used in this determination to be appropriate.

3.2.1.1.2 Phase 2

The licensee's FIP states that the primary Phase 2 strategy for core cooling would be to continue using the SGs as a heat sink, with makeup water supplied by the CST or CWST. Operators will deploy a trailer-mounted, diesel-driven FLEX inventory transfer pump at each unit to refill the CST from other available water sources. The licensee explained that during Phase 2, the preferred order of tanks to be used to refill the CST is based on using those with water quality and chemistry that most closely matches that found in the condensate and feed system. From most-preferred to least, these tanks are (1) the Primary Water Storage Tanks (PWSTs), (2) the CWST, (3) the three on-site Fire Water Storage Tanks (FWSTs), and (4) the

RWSTs. All of these tanks, like the CSTs, are susceptible to damage from a tornado missile strike. However, the licensee states that based on reasonable separation of these tanks, shielding from adjacent structures, and the rare occurrence of tornadoes at Indian Point, there is a negligible probability of more than one tank being destroyed by a tornado missile. The licensee therefore concludes that their overall FLEX strategy is sound, since no single tornado missile could prevent fulfillment of the strategy. This crediting of separation characteristics of the makeup water tanks, rather than the use of a robust, fully-protected tank, is identified by the licensee and by the staff as an alternative to the guidance in NEI 12-06.

Following the isolation of the SI accumulators and the completion of RCS boration to satisfy shutdown margin requirements (as described in Section 3.2.1.2 of this safety evaluation (SE)), operators will conduct a second RCS cooldown, to a hot-leg temperature of less than 350 °F (which corresponds to an RCS saturation pressure of approximately 126 psia). This second cooldown will be completed within the first 24 hours of the event.

Prior to commencing the second cooldown, a portable, diesel-driven FLEX SG makeup pump is connected and made available to provide makeup to the SGs in the event that the TDABF pump fails, or when sufficient steam pressure is no longer available to drive the TDABF pump turbine. This portable pump is capable of providing the required feed rate to the steam generators with the discharge of the pump to either the primary or alternate FLEX connection. The pump can take suction from either the CST or, if the CST is lost due to a tornado missile strike, any of the three FWSTs (one at Unit 2 and two at Unit 3). In the event that the FLEX SG makeup pump is being supplied by a FWST, water from the CWST can be transferred to the FWST via installed piping to ensure sufficient SG makeup inventory.

3.2.1.1.3 Phase 3

According to the FIP, the initial Phase 3 core cooling strategy continues to use the SGs as the heat sink, with additional offsite equipment and resources placed into service. In particular, Indian Point will obtain water purification equipment and a mobile boration skid from the NSRC to ensure a long-term source of purified water for makeup to the SGs.

The licensee further stated that Indian Point can transition to Phase 3 core cooling using the RHR system. The NSRC will provide large (1100 kW) combustion turbine generators (CTGs), which will repower RHR pumps, among other equipment. The RHR heat exchangers are cooled by component cooling water (CCW); one CCW pump at each unit will be powered by the unit's Phase 2 FLEX DG. Indian Point will receive a low pressure, high flow dewatering pump, as well as a booster pump if additional suction lift is needed, from the NSRC; these pumps will take suction from the discharge canal and supply cooling water flow to the CCW heat exchangers. Restoring RHR in this way will allow operators to continue to remove decay heat and/or cool down the RCS to cold shutdown conditions.

3.2.1.2 RCS Makeup Strategy

3.2.1.2.1 Phase 1

Under ELAP conditions, RCS inventory will tend to diminish gradually due to leakage through RCP seals and other leakage points. Furthermore, the initial RCS cooldown starting at thirty minutes into the event would result in a significant contraction of the RCS inventory, to the extent that the pressurizer would drain and a vapor void would form in the upper head of the reactor vessel. As is typical of operating PWRs, prior to implementing the Phase 2 FLEX strategy, Indian Point does not have a fully robust capability for active RCS makeup. However, some passive injection from the nitrogen-pressurized accumulators would occur as the RCS is depressurized below the accumulator cover gas pressure, which would result in the addition of borated coolant to the RCS. As discussed further below, the licensee has determined that (1) sufficient reactor coolant inventory would be available throughout Phase 1 to support heat transfer to the SGs via natural circulation without crediting the active injection of RCS makeup, and (2) according to the core operating history specified in NEI 12-06, a sufficient concentration of xenon-135 should exist in the reactor core to ensure subcriticality throughout Phase 1, considering the planned cooldown profile.

3.2.1.2.2 Phase 2

In order to maintain sufficient borated RCS inventory in Phase 2, the licensee's FIP states that a diesel-driven high-pressure FLEX pump would be deployed at each unit to inject borated makeup water from the unit's RWST. The licensee will commence RCS makeup and boration no later than 12.7 hours for Unit 2 and 11.6 hours for Unit 3 after the start of the ELAP event, in order to ensure reactivity control and prevent the onset of reflux cooling.

The Unit 2 and Unit 3 RWSTs will contain a minimum usable volume of 324,000 gallons and 340,000 gallons, respectively, at a boron concentration of between 2400 and 2600 ppm. The RWST is robust to all applicable hazards with the exception of wind-borne missiles. If an RWST is damaged, the FLEX RCS makeup pump can be aligned to the other unit's RWST; each hose connection is capable of providing flow to the suction of both pumps simultaneously. The licensee states that at least one RWST at the site is credited to remain undamaged, based on (1) reasonable separation of components, (2) the low likelihood of a tornado at Indian Point, and (3) partial shielding by adjacent structures. The minimum usable volume for both units' RCS, given the worst-case damage to an RWST, is therefore 324,000 gallons, which still represents sufficient inventory for boration and RCS injection for both units, well into the time at which supplemental equipment from the NSRC would be available.

At Unit 2, the primary path for borated makeup to the RCS is through an installed hose connection downstream of the charging pumps. The alternate path is via another installed connection on the SI system. At Unit 3, the primary RCS makeup connection is on the SI system, upstream of the boron injection tank, and the alternate connection is to the chemical and volume control system (CVCS), downstream of the charging pumps.

To prevent the injection of nitrogen cover gas from the SI accumulators into the RCS, operators will re-power and shut the accumulator isolation valves prior to commencing the second RCS cooldown to 350 °F (which is described in Section 3.2.1.1.2 of this SE).

3.2.1.2.3 Phase 3

In Phase 3, the RCS makeup strategy is a continuation of the Phase 2 strategy, supplemented as needed with equipment provided by an NSRC, including a 500 gallon per minute (gpm) water filtration unit and a mobile boration unit with a 1000-gallon tank. The NRC staff expects that the licensee would begin using purification equipment from the NSRC as soon as practical considering the overall event response prioritization and the necessity to facilitate the use of higher quality water for RCS makeup. Additional boron injection to the RCS may be required prior to initiating the extended RCS cooldown below 340 °F (which is described in Section 3.2.1.1.3 of this SE).

3.2.2 Variations to Core Cooling Strategy for Flooding Event

As described in Section 2.5 of the Unit 2 and Unit 3 Updated Final Safety Analysis Reports (UFSARs) and discussed in Section 3.5.2 below, the most severe flooding conditions using the current design basis determined water level would reach about 14 feet above mean sea level (MSL). Local wave action, due to wind effects, has been determined to add 1 foot to the river elevation, producing a maximum water elevation of about 15 feet above MSL at the Indian Point site, which would not flood the safety-related buildings. The critical site elevation is 15 feet and 3 inches. The licensee stated [Reference 35] that there would be no impact on the FLEX storage locations, staging locations or deployment methods. As the licensee completes its flooding reevaluation activities, the licensee is expected to assess the mitigation strategies to ensure they can be implemented under the reevaluated hazard conditions.

3.2.3 Staff Evaluations

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

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

3.2.3.1.1 Plant SSCs

Turbine Driven Auxiliary Boiler Feedwater Pump
The Phase 1 strategy for reactor core cooling and heat removal relies on the TDABF pump to provide feedwater for SG makeup for core decay heat removal. The TDABF pump automatically actuates but requires additional operator actions to control the feed to the SGs via air-operated flow control valves. The central control room (CCR) has remote control and operation of the flow control valves with the use of instrument air or it can be switched to an installed backup nitrogen supply if needed. However, local operation of the flow control valves via hand wheels is available if necessary.

In the FIP, Section 2.3.4.1 states that the TDABF pump is sized to provide the design-basis AFW flow requirements and is located in a safety-related structure (the auxiliary boiler feed pump building) designed for protection for all applicable external events. Furthermore, UFSAR Section 1.11 for Unit 2 and UFSAR Section 16.1 for Unit 3 indicate that the system design is Seismic Class I, which must remain functional during and following a Safe Shutdown Earthquake (SSE). Based on the location and design of the TDABF pump, the staff finds that it is robust and is expected to be available at the start of an ELAP event consistent with NEI 12-06, Section 3.2.1.3.

SG Atmospheric Dump Valves
In the FIP, Section 2.3.4.2 states that during an ELAP event reactor decay heat will be removed using the SGs for an indefinite time period by releasing steam to the atmosphere via the ADVs. The valves have safety-related air supplies and are provided with a source of safety-related nitrogen to ensure operability following a loss of instrument air.

For Unit 2, ADV operation uses four installed standby nitrogen bottles that are placed in service via hose connections and will provide the needed compressed air to maintain ADV operation for 20 hours prior to requiring bottle replacements. For Unit 3, ADV operation uses four installed standby nitrogen bottles that are placed in service using existing procedures and will provide the needed compressed air to maintain ADV operation for 24 hours prior to requiring bottle replacements. During its onsite audit, the NRC staff performed a walkdown of the installed nitrogen bottles and noted that they are located in the auxiliary boiler feed pump building and are seismically mounted to prevent seismic interaction at the ADV stations. The FIP explained that additional bottles are stored in the FESB to provide an adequate nitrogen supply for 72 hours. Based on Action Item No. 22 in the sequence of events (FIP Table 1) operators will begin to take action to deploy nitrogen bottles for ADV operation from the FESB by 18 hours after the initiating event and complete the actions by 20 hours for Unit 2 and by 24 hours for Unit 3. Based on the location and design of the ADVs and associated backup nitrogen bottles, the staff finds that these components are robust and are expected to be available at the start of an ELAP event consistent with NEI 12-06, Section 3.2.1.3.

3.2.3.1.2 Plant Instrumentation

According to the licensee's FIP, the following instrumentation would be relied upon to support its core cooling and RCS inventory control strategy:

- RCS wide-range cold-leg temperature (T_{cold})
- core exit thermocouples (CETCs) or RCS wide-range hot-leg temperature (T_{hot})
- RCS wide-range pressure
- pressurizer level or Reactor Vessel Level Indication System
- SG narrow-range water level
- SG pressure
- CST level
- RWST level
- auxiliary feedwater flow
- ex-core neutron flux (environmentally qualified at Unit 3 only)
- battery voltage

The instrumentation available to support the licensee's strategies for core cooling and RCS inventory during the ELAP event is consistent with and in some cases exceeds the recommendations specified in the endorsed guidance of NEI 12-06. In particular, ex-core neutron flux monitoring is not required by NEI 12-06. Environmentally qualified ex-core instrumentation is not available at Indian Point Unit 2; in the event that this instrumentation is lost at Unit 2, operators would initiate boron injection to the RCS per FLEX Support Guideline 8 (FSG-8) to ensure that shutdown margin is maintained. Alternate indication (i.e., CETCs, T_{hot} and T_{cold}) is environmentally qualified at both units.

These instruments are initially powered by vital station batteries. In Phase 2, long-term power is established for these essential instruments by recharging station batteries from a portable FLEX DG. The primary monitoring strategy for all of these parameters is to obtain readings from the CCR. Alternatively, FSG-7, "Loss of Vital Instrumentation or Control Power," provides guidance for operators to directly re-power and read instruments using portable equipment. Based on this 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 licensee based its mitigating strategy for reactor core cooling in part on a generic thermal-hydraulic analysis performed for a reference Westinghouse four-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 NRC's 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 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. Due to the challenge of resolving these issues within the compliance schedule specified in Order EA-12-049, the NRC staff requested that industry 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 (such as Indian Point), the reflux cooling mode is said to exist when vapor boiled off from the reactor core flows out the saturated, stratified RCS hot legs and condenses in the SG tubes, with the majority of the condensate subsequently draining back into the reactor vessel through the hot legs 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 evaluation, a second metric for ensuring adequate coping time is associated with maintaining sufficient natural circulation flow in the RCS to support adequate mixing of boric acid.

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.

As identified in the licensee's FIP, Indian Point relies upon the analysis methodology documented in PWROG-14015 and PWROG-14027 for a Category 1 Westinghouse four-loop plant. The PWROG generic analysis methodology and results included use of the four-loop Westinghouse reference plant identified in WCAP-17601. However, the licensee noted that some Indian Point plant parameters were not fully bounded by the parameters assumed in the generic analysis; therefore, the time of 15.6 hours to enter reflux cooling, which was determined by PWROG-14027 for the reference four-loop Category 1 plant, could not be assumed to apply to Indian Point. The licensee therefore applied the methodology described in Section 7 of PWROG-14027 with unit-specific parameters for Indian Point Units 2 and 3. Their analysis, documented in calculations IP-CALC-15-00002 and IP-CALC-15-00003, concluded that the time to enter reflux cooling is 12.7 hours for Unit 2, and 11.6 hours for Unit 3.
The NRC staff noted that the time to enter reflux cooling determined in PWROG-14027-P did not consider the potential for increased leakage due to RCP seal faceplate degradation that is expected to occur in an ELAP event due to the loss of seal cooling. This hydrothermal corrosion phenomenon is discussed in greater detail in the subsequent section of this evaluation. The NRC staff performed confirmatory calculations to determine the expected impact, and concluded that Unit 2 could be expected to enter reflux cooling at approximately

12.7 hours, and Unit 3 would enter reflux cooling at approximately 12.5 hours, in the absence of FLEX RCS injection. The effect of hydrothermal corrosion on coping time was offset by the staff's use of lower assumed RCS leakage rates, based on a more recent set of empirical test results (i.e., those tests which demonstrated the hydrothermal corrosion phenomenon, described more fully in Section 3.2.3.3) than those used in developing PWROG-14015 and PWROG-14027. On the basis of these calculations, the NRC staff concluded that the licensee's conclusions regarding time to enter reflux cooling are valid for use. However, the staff's analysis also indicated that due to the effect of hydrothermal corrosion on the RCP seals, the total RCS leakage rate would gradually increase even after the initial cooldown, potentially stabilizing at approximately 55 gpm after the second RCS cooldown to 340 °F, which exceeds the FLEX RCS makeup pump's credited capacity (per the licensee's FIP) of 40 gpm. The licensee responded by noting that each Hale HP300DJ RCS makeup pump could in fact provide a flow of at least 55 gpm once the RCS has been cooled down to 415 °F and 310 psia. This corresponds to the RCS conditions following the initial RCS cooldown, which would be complete no later than 3 hours into the ELAP event. The licensee provided supporting calculations and pump curves which demonstrate the validity of this conclusion. For Unit 2, see calculation IP-CALC 14-00047, "Hydraulic Analysis of FLEX Strategies Using the RWST as a Source of Water," Rev. 1. For Unit 3, see calculation IP-CALC 13-00045, "Hydraulic Analysis of FLEX Strategies Using the RWST as a Source of Water," Rev. 1. The staff conducted an independent analysis which shows that providing RCS makeup at this rate will adequately preserve RCS inventory and prevent the onset of reflux cooling, even assuming the worst-case impact of hydrothermal corrosion on the RCP seals.

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 Seals

Leakage from RCP seals is among the most significant factors in determining the duration that a PWR can cope with an ELAP event prior to initiating RCS makeup. An ELAP event would interrupt cooling to the RCP seals, resulting in the potential for increased seal leakage and the failure of elastomeric o-rings and other components, which could further increase the leakage rate. As discussed above, as long as adequate inventory is maintained in the RCS, natural circulation can effectively transfer residual heat from the reactor core to the SGs and limit local imbalances in boric acid concentration. Along with cooldown-induced shrinkage 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.

All four Model 93 RCPs installed at each Indian Point unit use standard three-stage Westinghouse seal packages. In accordance with analysis and testing documented in WCAP-10541-P, Revision 2, "Westinghouse Owners Group Report, Reactor Coolant Pump Seal Performance Following a Loss of All AC Power," the ELAP analysis in WCAP-17601-P assumed a leakage rate at nominal post-trip cold leg conditions (i.e., 2250 psia and 550 °F) of 21 gpm for each of the four RCPs, plus an additional 1 gpm of operational leakage. In the WCAP-17601-P analysis, both seal and operational leakage were assumed to vary according to the critical flow correlation modeled in the NOTRUMP code as the reactor was cooled down and depressurized.

Subsequent assessments of RCP seal leakage behavior under ELAP conditions by industry analysts and NRC staff identified several issues with the original treatment of seal leakage from standard Westinghouse seal packages. These concerns are documented in Westinghouse Nuclear Safety Advisory Letter (NSAL) 14-1, dated February 10, 2014, including (1) the initial post-trip leakage rate of 21 gpm does not apply to all Westinghouse pressurized-water reactors due to variation in seal leakoff line hydraulic configurations, (2) seal leakage does not appear to decrease with pressure as rapidly as predicted by the analysis in WCAP-17601-P, and (3) some reactors may experience post-trip cold leg temperatures in excess of 550 °F, depending on the lowest MSSV lift setpoint. To address these issues, the PWROG performed additional analytical calculations using Westinghouse's seal leakage model (i.e., ITCHSEAL). These calculations included (1) benchmarking calculations against data from RCP seal leakage testing and (2) additional generic calculations for several groups of plants (categorized by similarity of first-stage seal leakoff line design) to determine the maximum leakage rates as well as the maximum pressures that may be experienced in the first-stage seal leakoff line piping.

During the audit review, the licensee indicated that Indian Point is deriving their seal leakage assumptions from the generic Westinghouse RCP seal leakage calculations that have been performed by the PWROG. The generic PWROG calculations audited by the staff, including proprietary reports PWROG-14015, "No. 1 Seal Flow Rate for Westinghouse Reactor Coolant Pumps Following Loss of All AC Power," and PWROG-14027, "No. 1 Seal Flow Rate for Westinghouse Reactor Coolant Pumps Following Loss of All AC Power, Task 3: Evaluations of Revised Seal Flow Rate on Time to Enter Reflux Cooling and Time at which the Core Uncovers," classify Indian Point in the fourth generic analysis category (i.e., Category 4) specified in NSAL 14-1. As noted above, the generic analysis category definitions used in these reports were established based on the hydraulic characteristics of the first-stage seal leakoff line. However, the licensee has performed a modification to both units that increases the resistance in the seal leakoff lines, which effectively transition Indian Point to a Category 1 plant. The licensee provided further information which confirmed that the leakoff line hydraulic characteristics for Indian Point are bounded by the assumed characteristics analyzed for Category 1.

To ensure that the generic Category 1 leakage rates are applicable to Indian Point, the NRC staff requested during the audit that the licensee confirm that applicable portions of the first-stage seal leakoff line piping can withstand the maximum pressure experienced during an ELAP event. According to generic calculations performed by Westinghouse using the ITCHSEAL code, Category 1 plants would be expected to experience choked flow at the flow-measurement orifice in the first-stage seal leakoff line, even after completion of the initial RCS cooldown. Therefore, to support application of the generic Category 1 leakage rates, it is necessary for the licensee to demonstrate that a rupture in the pressure boundary of leakoff line piping or components upstream and inclusive of the flow orifice would not occur at Indian Point. During the audit, the licensee informed the NRC staff that the applicable portions of the leakoff line piping and components can tolerate pressures greater than or equal to RCS design pressure (i.e., 2500 psia) at a fluid temperature of over 600 °F. Thus, the licensee's analysis concluded that the functionality of the first-stage seal leakoff lines should not be challenged during an analyzed ELAP event and Category 1 leakage rates should be applicable to Indian Point.

In support of beyond-design-basis mitigating strategy reviews, the NRC staff performed an audit of the PWROG's generic effort to determine the expected seal leakage rates for Westinghouse RCPs under loss-of-seal-cooling conditions. A key audit issue was the capability of Westinghouse's ITCHSEAL code to reproduce measured seal leakage rates under representative conditions. Considering known testing and operational events according to their applicability to the thermal-hydraulic conditions associated with the analyzed ELAP event, the benchmarking effort focused on comparisons of ITCHSEAL simulations to data from WCAP-10541-P that documents an RCP seal leakage test performed in the mid-1980s at Électricité de France's Montereau facility. Comparisons of analytical results to the Montereau data indicated that, while the ITCHSEAL code could not simultaneously obtain good agreement with respect to RCS pressure, the leakage rate simulated by ITCHSEAL could be tuned to reproduce the measured seal leakage rate data. Subsequent to the benchmarking effort, data from an additional RCP seal leakage test at the Montereau facility that had not been documented in WCAP-10541-P was brought to the staff's attention. The leakage rate during this test was significantly higher than that of the test in WCAP-10541-P that had been used to benchmark the ITCHSEAL code. However, conservative margin was identified in the ITCHSEAL analyses (e.g., PWROG-14015-P, PWROG-14027-P), which the staff determined should offset the potential for increased leakage rates observed in the additional Montereau test.

In conjunction with the revised seal leakage analysis that Westinghouse performed for the first-stage seal, as described above, the PWROG's generic effort also sought to demonstrate that the second-stage seal will remain fully closed during the ELAP event. If the second-stage seal were to open, there would be RCS leakage past the second-stage seal in addition to the first-stage seal leakoff line flow that has been considered in the licensee's evaluation. Previous calculations documented in WCAP-10541-P indicated that second-stage seal closure could be maintained under the set of station blackout conditions and associated assumptions analyzed therein. Recent calculations performed by Westinghouse and AREVA in support of PWR licensees' mitigating strategies indicated that both vendors also expected the second-stage seals essentially to remain closed throughout the ELAP event, even when the RCS is cooled down and depressurized in accordance with a typical strategy. Contrary to these analytical calculations, two recent RCP seal leakage tests performed as part of AREVA's seal development program (discussed further below) have indicated that the second-stage seals could open and remain open under ELAP conditions. This unexpected phenomenon occurred near the end of the tests and could not be fully understood and evaluated by the vendors or NRC staff, based upon the limited data available. While considering these limitations, the staff observed that the opening of the second-stage seal did not appear to result in an increase in the total rate of leakage measured during the two AREVA tests.

On March 3, 2015, Westinghouse issued Technical Bulletin (TB) 15-1, "Reactor Coolant System Temperature and Pressure Limits for the No. 2 Reactor Coolant Pump Seal." Through TB 15-1, Westinghouse communicated to affected customers that long-term integrity of Westinghouse-designed second-stage RCP seals could not be supported by the available analysis, and recommended that affected plants execute an extended cooldown of the RCS to less than 350 °F and 400 psig by 24 hours into the ELAP event. Second-stage seal integrity appears necessary to ensure that leakage from Westinghouse-designed RCP seals can be limited to a rate that can be offset by the FLEX equipment typically available for RCS injection under ELAP conditions. The mitigating strategy documented in Indian Point's FIP satisfies Westinghouse's TB 15-1 guidance. The recommendation was amended by Revision 1 of TB 15-1, which was issued on August 29, 2016; Indian Point's strategy likewise satisfies the revised set of recommendations.

The seal leakoff analysis discussed above assumes no failure of the seal design, including the elastomeric o-rings. During the audit review, the licensee confirmed that all installed RCP seal o-rings at Indian Point are the high-temperature-qualified 7228-C type, with the exception of some of the o-ring material in RCP 21, which is of the 7228-B type. The "B" type o-ring material is qualified to temperatures up to 550 °F, as opposed to 570 °F for type "C". The licensee has evaluated the o-rings in RCP 21 to be acceptable for FLEX situations, and confirmed to the staff that only 7228-C equivalent or better o-rings will be used in the future. Therefore, the staff's audit review concluded that o-ring failure under analyzed ELAP event conditions would not be expected.

During the audit review, the licensee confirmed that, following the loss of seal cooling that results from the ELAP event, seal cooling would not be restored. The NRC staff considers this practice appropriate because it prevents thermal shock, which, as described in Information Notice 2005-14, "Fire Protection Findings on Loss of Seal Cooling to Westinghouse Reactor Coolant Pumps," could lead to increased seal leakage.

In addition, the NRC staff audited information associated with the more recent RCP seal leakage testing performed by AREVA. The AREVA testing showed a gradual increase in the measured first-stage seal leakage rate, which post-test inspection and analysis tied to hydrothermal corrosion of silicon nitride (likely assisted by flow erosion). Silicon nitride ceramic is used to fabricate the first-stage seal faceplates currently in operation in Westinghouse-designed RCP seals. This material degradation phenomenon would not have been present in the Montereau testing because that test article's faceplates were fabricated from aluminum oxide (consistent with the seals of actual Westinghouse-designed RCPs of that era). However, hydrothermal corrosion of silicon nitride became an audit focus area because the test data indicated that the long-term seal leakage rate could exceed the values assumed in the licensee's analysis. Academic research reviewed by the industry and NRC staff associated with this general phenomenon indicated that the corrosion rate is temperature dependent.

From the limited information available regarding the recent AREVA tests, as well as several sensitivity calculations performed by the NRC staff during the audit, the NRC staff concluded that (1) the leakage rate for silicon-nitride RCP seals may be lower initially than had been predicted analytically by the PWROG's generic analysis using ITCHSEAL, (2) the RCP seal leakage rate during Phase 2 and/or Phase 3 of the ELAP event may increase beyond the long-term rate predicted analytically by the PWROG, and (3) certain aspects of the seal behavior observed in the AREVA tests did not appear consistent with the expected behavior based on models and theory that formed the basis for the WCAP and PWROG reports discussed above.

The licensee's FIP states that initiating RCS makeup no later than 12.7 hours at Unit 2, and 11.6 hours at Unit 3, would ensure that natural circulation can be maintained in the RCS. Each unit's initial RCS makeup flow capacity of 40 gpm exceeds the total rate of RCS leakage predicted by the PWROG's analysis following RCS depressurization, such that RCS inventory would begin to recover upon restoration of RCS makeup. However, in light of the potential for hydrothermal corrosion behavior, such as observed during the AREVA testing, the NRC staff determined that the mitigating strategy documented in the licensee's FIP could allow the RCP seal leakage rate to increase with time, potentially exceeding the available FLEX injection capacity.

According to Indian Point's FIP, plant operators would cool the RCS to below 350 °F in the RCS cold legs potentially as late as 23 hours into the event. Due to the temperature-dependence of the hydrothermal corrosion reaction discussed above, the time and target temperature of the RCS cooldown have a significant impact on the long-term leakage rate from the RCP seals. At the time of developing the mitigating strategy documented in its FIP, the industry was just starting to consider the potential for hydrothermal corrosion to increase the long-term seal leakage rate and had not specifically analyzed the potential impacts.

Therefore, during the audit, the NRC staff applied empirically-derived hydrothermal corrosion data to perform plant-specific confirmatory calculations for estimating the expected RCP seal leakage rate during the analyzed ELAP event in order to evaluate the licensee's RCS makeup strategy. Based on the staff's calculations, hydrothermal corrosion would result in greater RCS leakage for Indian Point than considered in the licensee's calculations. However, the licensee has demonstrated to the staff that total RCS leakage would not exceed the maximum achievable makeup rate (55 gpm following RCS depressurization to 310 psia) of the FLEX RCS makeup pump, as noted above in Section 3.2.3.2 of this SE.

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

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

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

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

During the audit, the NRC staff reviewed the licensee's shutdown margin calculation. The licensee's analysis conservatively determined that, after the first RCS cooldown (to 415 °F), negative reactivity from (1) residual xenon and (2) passive injection of borated water from the accumulators will maintain adequate shutdown margin in the core for up to 34.6 hours at Unit 2 and 36.1 hours for Unit 3 after the initial reactor trip, even in the most restrictive analyzed case (100 percent power history at core end-of-life, with zero RCS leakage). This extends beyond the time at which the licensee will commence a second RCS cooldown (to about 340 °F), which will commence by 23 hours following reactor trip in order to conform to the guidance in TB 15-1 (see Section 3.2.3.3 of this SE).

Prior to the second cooldown, borated makeup water must be actively injected from the RWST to ensure sufficient shutdown margin, given the positive reactivity added by the second cooldown and by the decay of the remaining xenon. The licensee calculates that at end of life (EOL), approximately 16,700 gallons of water from the RWST, borated to a concentration of at least 2400 ppm, would need to be injected to Unit 2 to maintain the reactor perpetually shut down with a shutdown margin of 1300 pcm, given a cold leg temperature of 340 °F. For Unit 3, the required volume of injected water is approximately 15,700 gallons. (Additional boration would be required prior to a further cooldown below 340 °F.) Administrative controls ensure that this volume will remain valid for future core designs. The total volume is well within the minimum 324,000-gallon volume that the licensee calculated would remain in a single RWST, even assuming the loss of one unit's RWST.

Assuming a 40 gpm capacity (the licensee's original assumption) of both units' FLEX RCS inventory makeup pumps, no more than seven hours of active injection are necessary to pump the required borated volume from the RWST to the RCS. According to the FIP, injection of borated water from the RWST will be initiated no later than 12.7 hours for Unit 2 and 11.6 hours for Unit 3. Therefore, sufficient boration to ensure long-term shutdown margin at 340 °F will be complete prior to 22 hours.

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 in cases where minimal RCS leakage occurs. During the audit, the licensee discussed Indian Point's capability to conduct RCS venting in the case that letdown from the RCS is necessary. The licensee stated that, in this case, operators would follow the direction of guideline FSG-8 to energize and open two reactor head vent valves, which are in series and vent to the PRT. The licensee indicated that the head vent path would be opened in response to high pressurizer level, and closed again on indication of low pressurizer level or when operators have completed the required boron addition. As a backup to the reactor head vent path, operators can open a single pressurizer power-operated relief valve (PORV) to achieve the necessary letdown; use of a PORV in this way would only be done if the reactor head vent valves were for some reason unavailable.

The NRC staff's audit review of the licensee's shutdown margin calculation further 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 conditions intended to ensure that boric acid addition and mixing during an ELAP would occur under conditions similar to those for which boric acid mixing data is available. By letter dated January 8, 2014 (ADAMS Accession No. ML13276A183), the NRC staff endorsed the above position paper with three conditions:

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

During the audit review, the licensee confirmed that Indian Point will comply with the August 15, 2013, position paper on boric acid mixing, including the conditions imposed in the staff's corresponding endorsement letter. The NRC staff verified that the licensee's analyses considered the appropriate range of RCS leakage rates. The NRC staff further confirmed that the licensee would provide RCS makeup prior to RCS loop flow decreasing below the single-phase natural circulation flow rate. Finally, the NRC staff also confirmed that the licensee's calculations adequately incorporated a one-hour delay to account for the mixing time of boric acid in the RCS.

Finally, the NRC staff's audit identified that, while the licensee's analyses demonstrate adequate shutdown margin for an RCS average temperature of 340 °F (or greater), within five days of event initiation, the licensee expects to further cool the RCS to cold shutdown conditions. As a result, maintaining adequate shutdown margin would require the injection of additional boron into the RCS prior to reducing RCS average temperature below 340 °F. The staff's audit identified that the reactivity impacts of the additional cooldown to cold shutdown conditions had not been explicitly analyzed by the licensee. However, considering the time duration available prior to completing the additional cooldown, the NRC staff expects that (1) sufficient equipment (i.e., including both onsite and NSRC-supplied equipment, such as mobile boration units) and supplies of powdered boric acid should be available to prepare the required borated coolant, (2) sufficient time should be available to vent the RCS, if necessary, to allow injection of the volume of borated coolant required to ensure adequate shutdown margin, and (3) sufficient time should be available for the licensee's technical support personnel to determine the boron concentration required to ensure adequate shutdown margin.

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's FLEX strategy relies on three different portable pumps during Phase 2. The FLEX strategies use a portable FLEX SG makeup pump to provide injection into the steam generators when the TDABF pump can no longer perform its function due to low turbine inlet steam flow, a portable FLEX RCS pump to provide injection of borated water to the RCS and a portable FLEX inventory transfer pump to refill a surviving storage tank from available water sources.

In the FIP, Section 2.3.10.1 states that the performance criteria of the FLEX inventory transfer pump is 327 gpm at 165 psi, which is used to refill the CST from other available sources for the duration of Phase 2. The FLEX inventory transfer pump is a trailer-mounted, diesel-driven pump that is stored in the FESB and is deployed by towing the trailer to the designated locations near the selected water source from where suction will take place. There are three FLEX inventory transfer pumps available for the site, consistent with the guidance in NEI 12-06 to provide a spare (N+1) pump. The licensee explained that each FLEX inventory transfer pump is sized to provide a makeup water supply of 327 gpm to the CST to ensure success of its FLEX strategy. The licensee performed hydraulic analyses of the flowpath from each water source to the CST and confirmed that applicable performance requirements are met. During its audit, the staff reviewed the Unit 2 and Unit 3 hydraulic calculations and noted that the FLEX inventory transfer pump was capable of pumping from the PWST or the FWST to the CST at a flowrate of 327 gpm.

In the FIP, Section 2.3.10.2 states that SG water injection capability is provided using a portable FLEX SG makeup pump through a primary and alternate connection. The performance criteria for the FLEX SG makeup pump is 327 gpm at 575 psi. The FLEX SG makeup pump is a trailer-mounted, diesel-driven pump that is stored in the FESB and is deployed to its designated location to provide a back-up SG injection method in the event that the TDABF pump can no longer perform its function due to low turbine inlet steam flow from the SGs. The licensee performed hydraulic analyses to confirm that the FLEX SG makeup pump is sized to provide the minimum required SG injection flowrate to support reactor core cooling and decay heat removal. There are three FLEX SG makeup pumps available for the site, consistent with the guidance in NEI 12-06 to provide a spare (N+1) pump. During its audit, the staff reviewed the Unit 2 and Unit 3 hydraulic calculations and noted that the FLEX SG makeup pump was capable of pumping from the CST to the SGs at a flowrate of 327 gpm, with the reduced SG pressure at the time the pump is placed in service.

In the FIP, Section 2.3.10.3 states that the required delivery pressure to the RCS is approximately 310 psia; thus, accordingly, the FLEX RCS inventory makeup pump is capable of delivering a minimum flow of 40 gpm at a discharge pressure of up to 320 psia. This is a centrifugal pump and the flow rate varies with discharge pressure. The licensee performed hydraulic analyses of the FLEX RCS inventory makeup pump with the associated hoses, installed piping systems, and confirmed that the pump minimum flow rate and head capabilities meet the FLEX strategy requirements for maintaining RCS inventory. The FLEX RCS inventory makeup pump is a trailer-mounted, diesel-driven pump that is stored in the FESB and is deployed to its designated location to provide makeup to the RCS. There are three FLEX RCS inventory makeup pumps available for the site, consistent with the guidance in NEI 12-06 to provide a spare (N+1) pump. During its audit, the staff reviewed the Unit 2 and Unit 3 hydraulic calculations and noted that the FLEX RCS makeup pump was capable of pumping from the RWST to the RCS at 40 gpm, with the reduced RCS pressure at the time the pump is placed in service.

As noted in Section 3.2.3.2 of this SE, the NRC staff expressed a concern about a possible increase in RCS leakage due to hydrothermal corrosion of the RCP seals. The licensee revised the flow calculations for the FLEX RCS inventory makeup pump to demonstrate that the pump was capable of higher injection flow rates if needed. The NRC staff's review of those calculations confirms that the higher injection flow rates should be achievable.

The staff confirmed that flow rates and pressures evaluated in the hydraulic analyses were reflected in the licensee's strategies for the respective SG makeup, RCS makeup and inventory transfer strategies based upon the above FLEX pumps being diesel-driven and the respective FLEX connections being made as directed by the FSGs. In the hydraulic analyses, the licensee stated that the available net positive suction head (NPSHa) exceeded the required NPSH for the pumps. During the onsite audit, the staff 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 FIP.

Based on the staff's review of the FLEX pumping capabilities at Unit 2 and Unit 3, as described in the above hydraulic analyses and the FIP, the licensee has demonstrated that its portable FLEX pumps should perform as intended to support core cooling and RCS makeup during an ELAP, consistent with NEI 12-06, Section 11.2.

3.2.3.6 Electrical Analyses

The licensee's electrical strategies provide power to the equipment and instrumentation used to mitigate the ELAP and LUHS. 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.
According to the licensee's FIP, operators will respond to the event in accordance with emergency operating procedures to confirm reactor coolant system, secondary system, and containment conditions. A transition to procedure 2/3-ECA-0.0, "Loss of All AC Power," Rev. 14/9 will be made upon the indications of the total loss of ac power. This procedure directs isolation of reactor coolant system letdown pathways to conserve inventory, confirmation of natural circulation cooling, verification of containment isolation, reducing dc loads on the station Class 1E batteries, and establishment of electrical equipment alignment in preparation for eventual power restoration.

The Indian Point Phase 1 FLEX mitigation strategy involves relying on installed plant equipment and onsite resources, such as the use of installed Class 1E station batteries, vital inverters, and the Class 1E dc electrical distribution system. This equipment is considered robust and protected with respect to applicable site external hazards since they are located within safety-related, Category 1 structures.

In its FIP, the licensee stated that initial load shedding of all non-essential loads will be initiated within 30 minutes after the occurrence of an ELAP/LUHS and completed within 2 hours into the event. With load shedding, the licensee calculated the useable station battery capacity to be at least 8 hours for the Unit 2 and Unit 3 station batteries. The licensee would conduct the load shed using guideline 2/3-FSG-004, "ELAP DC Bus Load Shed / Management."

In its FIP, the licensee noted that it had followed the guidance in NEI White Paper, "EA-12-049 Mitigating Strategies Resolution of Extended Battery Duty Cycles Generic Concern," (ADAMS Accession No. ML13241A186) when calculating the duty cycle of the station batteries. 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 of 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.

The NRC staff reviewed the licensee's dc coping calculations IP-CALC-14-00076, "Battery Sizing and Voltage Drop Calculation for Extended Loss of AC Power (ELAP)," Rev. 0 and IP-CALC-13-00056, "Battery Sizing and Voltage Drop Calculation for Extended Loss of Power (ELAP)," Rev. 0, which verified the capability of the dc system to supply the required loads during the first phase of the Indian Point FLEX mitigation strategy plan for an ELAP as a result of a BDBEE.

Each Indian Point unit's Class 1E 125 Volt (V) dc system consists of four batteries each fed from a separate battery charger that is fed from a separate ac power panel. The Unit 2 vital batteries were manufactured by C&D Technologies (model KCR-13 with 495 Ampere-Hour (Ah) capacity) and Exide Technologies (models 2GN-17 with 1500 Ah capacity and 2GN-23 with 1584 Ah capacity). The Unit 3 vital batteries were manufactured by C&D Technologies (models LCY-39 with 2400 Ah capacity and KCR-13 with 495 Ah capacity) and Exide Technologies (model EA-11 with 440 Ah capacity). The licensee's evaluation identified the required loads and their associated ratings (ampere (A) and minimum required voltage) and the non-essential loads that would be shed to ensure battery operation for least 8 hours.

Based on the NRC staff's review of the licensee's analysis and procedures, the battery vendor's capacity and discharge rates for the Class 1E station batteries, the NRC staff finds that the Indian Point dc systems have adequate capacity and capability to power the loads required to mitigate the consequences during Phase 1 of an ELAP as a result of a BDBEE provided that a portable 480 Vac FLEX DG energizes the battery chargers prior to the batteries depleting to the minimum acceptable voltage and the dc load shedding is completed within the times assumed in the licensee's analysis.

The licensee's Phase 2 strategy includes re-powering of battery chargers within 8 hours to maintain availability of instrumentation to monitor key parameters. Prior to depletion of the 125 Vdc Class 1E station batteries, operators would repower the safety-related battery chargers using one of the portable 480 Vac, 545 kW FLEX DGs stored on-site. Indian Point has three 480 Vac, 545 kW FLEX DGs that are stored in the FESB. This meets the intent of NEI 12-06 by having a set of electrical equipment to fulfill the required functions for each unit and a spare (N+1). Loads other than the battery chargers which could be powered by a FLEX DG in Phase 2 include a component cooling water pump, the fuel oil transfer pumps, battery room and control building fans, heaters (especially for extreme cold BDBEE), and lighting panels. The licensee would deploy the portable 480 Vac FLEX DGs using guideline 2/3-FSG-005, "Initial Assessment and FLEX Equipment Staging."

The NRC staff reviewed IP-CALC-14-00002, "Phase 2 FLEX Portable Diesel Generator (PDG)," Rev. 0, and IP-CALC-14-00055, "IP2 FLEX Phase 2 Portable Diesel Generator Sizing Calculation," Rev. 0. According to the licensee's calculation, the worst-case total Unit 3 loading of the essential loads powered during the winter and the summer are 534.21 kW and 458.39 kW, respectively. For Unit 2, the worst-case loading of essential loads powered during the winter and the summer are 360 kW and 339 kW, respectively. The results show that the worst-case scenario (winter) essential running loads for each unit fall within the capability of the 545 kW FLEX DG. The licensee's calculations took the FLEX cable lengths into consideration (i.e., ensured that the voltage drop still allowed meeting the minimum voltage required at the limiting component).

Based on its review of the licensee's calculation, conceptual single line electrical diagrams, and station procedures, the NRC staff finds that the licensee's approach is acceptable given the protection and diversity of the power supply pathways, the separation and isolation of the FLEX DGs from the Class 1E emergency diesel generators (EDGs), and availability of procedures to direct operators how to align, connect, and protect associated systems and components. The NRC staff also finds that the FLEX DGs have sufficient capacity and capability to supply the required loads.

For Phase 3, the licensee will receive two (one per unit) 1100 kW 480 Vac CTGs and associated power cables from an NSRC. The NRC staff reviewed licensee calculations IP-CALC-14-00098, "IP3 FLEX Phase 3 Diesel Generator Sizing Calculation," Rev.0, and IP-CALC-14-00056, "IP2 FLEX Phase 3 Portable Diesel Generator (PDG) Sizing/Motor Starting and Phase 2 PDG Motor Starting Calculation," Rev. 0. The results of the calculations showed that the worst-case total loads to be powered by the Phase 3 CTG are 825 kW in winter time and 813 kW in summer time for Unit 2. The results of the calculation showed that the total loads to be powered by the Phase 3 CTG are 740.88 kW in winter time and 734.84 kW in summer time for Unit 3. These loads fall within the rating of the 480 Vac Phase 3 CTG (1100 kW capacity, derated to 1000 kW). The Phase 3 480 Vac CTG could supply power for a component cooling water pump, an RHR pump, a CRF unit, and some of the Phase 2 loads. Generator alignment options are available by implementing restrictions based on the licensee's analyses (IP-CALC-14-00056 and IP-CALC-14-00098) to ensure starting currents on the Phase 3 CTGs are not exceeded. The licensee would deploy the Phase 3 CTGs using guideline 2/3-FSG-014, "Extended Loss of AC Power – Phase 3."

Based on its review, the NRC staff finds that the equipment being supplied from an NSRC has sufficient capacity and capability to supply the required loads during Phase 3.

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

In NEI 12-06, Table 3-2 and Appendix D summarize an acceptable approach consisting of three separate capabilities for the SFP cooling strategies. This approach uses a portable injection source to provide the capability for 1) makeup via hoses on the refueling floor capable of exceeding the boil-off rate for the design basis heat load; 2) makeup via connection to spent fuel pool cooling piping or other alternate location capable of exceeding the boil-off rate for the design basis heat load; and 3) spray via portable monitor nozzles from the refueling floor using a portable pump capable of providing a minimum of 200 gpm per unit (250 gpm if overspray occurs). During the event, the licensee selects the 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. Each Indian Point unit has its own independent SFP, located in separate fuel handling buildings (FSBs). They are not interconnected in any way, and are similar in design. The licensee will monitor SFP water level using reliable SFP level instrumentation installed per Order EA-12-051.

3.3.1 Phase 1

In the FIP, Section 2.4.1 states that during non-outage conditions, the time to boiling in the pool can be as low as 8 hours. The initial coping strategy for spent fuel pool cooling is to monitor spent fuel pool level using instrumentation installed as required by NRC Order EA-12-051 since adequate SFP inventory exists to provide radiation shielding for personnel well beyond the time of boiling.

3.3.2 Phase 2

In the FIP, Section 2.4.2 states that the Phase 2 baseline capabilities required for SFP cooling are to provide makeup via hoses on the refuel floor, makeup via connection to SFP cooling piping, vent pathway for steam from the SFP, and spray capability via monitor nozzles from the refueling floor using a portable FLEX SFP makeup pump.

3.3.3 Phase 3

In the FIP, Section 2.4.3 states that the long-term strategy is reliant on maintaining makeup as done in Phase 2. The NSRC equipment would be used to provide filtered water as needed to makeup to the SFP until alternate means to remove SFP decay heat are sufficient to transition away from the FLEX equipment.

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 calculation on habitability on the SFP refuel floor. This calculation and the FIP indicate that boiling begins at approximately 8 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 and spray nozzles as a contingency for SFP spray within 6.5 hours from event initiation to ensure the SFP area remains habitable for personnel entry and within 7 hours will begin deploying hoses for SFP makeup. The licensee's FLEX strategy involves running hoses from the portable FLEX SFP makeup pump. The hose can either be attached to a hose connection on a pipe in the SFP cooling system, or connected to a section of hard pipe installed on the FSB 95 ft. elevation that will discharge directly into the pool for makeup or spray.

As described in its FIP, the licensee's Phase 1 SFP cooling strategy does not require any operator actions; however, the licensee plans to establish a ventilation path to cope with temperature, humidity and condensation from evaporation and/or boiling of the SFP. The operators are directed to vent the SFP by opening the door to the maintenance outage building and maintenance outage building exit to the plant grounds.

The licensee's Phase 2 and Phase 3 SFP cooling strategy involves the use of the FLEX SFP makeup pump with suction from available water sources (i.e., CST, RWST, PWST or FWST) to supply water to the SFP. The staff's evaluation of the robustness and availability of FLEX connections points for the FLEX pump is discussed in Section 3.7.3.1 below. Furthermore, the staff's evaluation of the robustness and availability of the UHS for an ELAP event is discussed in Section 3.10.3.

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 the FIP, Section 2.4.6 indicates that the SFP will boil in approximately 8 hours and that SFP makeup is not required until 27 hours from initiation of the event considering the maximum design heat load during normal operation.

The licensee's SFP boil-off calculation states that the two bounding scenarios analyzed are: (1) maximum normal operation heat load and (2) the maximum full-core heat load from discharge of all fuel assemblies from the reactor vessel during shutdown. The heat loads, boil-off times, and makeup rates can be found in the table below. Since the decay heat loads for Unit 3 are greater than Unit 2, the licensee appropriately used the bounding heat load (i.e., Unit 3) to be representative for both units.

	Heat Load	Time to boil	Makeup rate
Case 1 (normal)	17.6 million Btu/hr	about 8 hrs	36.50 gpm
Case 2 (full-core)	35 million Btu/hr	about 4 hrs	72.58 gpm

The licensee conservatively determined that a SFP makeup flow rate of at least 250 gpm will maintain adequate SFP level for an ELAP occurring during normal power operation. The staff noted that the SFP FLEX pump is sized to support SFP spray operation and bounds the required makeup rate to account for SFP boil-off. In NEI 12-06, Section 3.2.1.6 states that the SFP heat load assumes the maximum design-basis heat load for the site as one of the initial

SFP conditions. Consistent with this guidance in NEI 12-06, Section 3.2.1.6, the staff finds the licensee has considered the maximum design-basis SFP heat load.

3.3.4.3 FLEX Pumps and Water Supplies

In the FIP, Section 2.4.7.1 indicates that the SFP cooling strategy relies on a FLEX SFP makeup pump to provide makeup and is rated for 250 gpm at 65 psi. The FLEX SFP makeup pump is a trailer-mounted, diesel-driven pump that is stored in the FESB and is deployed to its designated location to provide makeup to the SFP. There are three FLEX SFP makeup pumps available for the site, consistent with the guidance in NEI 12-06 to provide a spare (N+1) pump. The SFP makeup rate of 114 gpm and SFP spray rate of 250 gpm both meet or exceed the maximum SFP makeup requirements as outlined in the previous section of this SE.

During its audit, the NRC staff reviewed the Unit 2 and Unit 3 hydraulic calculations and noted that the FLEX SFP makeup pump was capable of delivering a flow rate of 114 gpm from the RWST to the SFP through the SFP piping connection, and 250 gpm from the RWST to the SFP through fire hoses and the spray monitor nozzles.

During its audit, the staff reviewed the hydraulic calculation for Unit 2 and Unit 3, and was able to confirm that flow rates and pressures evaluated in the hydraulic analyses were reflected in the FIP for the SFP strategy based upon the FLEX SFP makeup pump being diesel-driven taking suction from the RWST and the respective FLEX connections being made as directed by the FSGs. In the hydraulic analyses, the licensee stated that the available net positive suction head (NPSHa) exceeded the required NPSH for the pumps. The licensee relied upon actual piping diagrams, considered FLEX piping components and hose lengths and diameters (suction and discharge) and incorporated hose frictional losses to ensure the FLEX pump can support the SFP cooling safety function. During the onsite audit, the staff conducted a walk down of the hose deployment routes for the FLEX SFP makeup pumps to evaluate the pump staging locations, hose distance runs, and connection points as described in the above hydraulic analyses and FIP. The staff finds that, based on the licensee's calculation, the flow to the SFP should be adequate to provide cooling of the spent fuel.

3.3.4.4 Electrical Analyses

In its FIP, the licensee noted that SFP level will be monitored in all three phases by instrumentation installed in response to NRC Order EA-12-051 (the capability of this instrumentation is described in Section 4 of this SE). The SFP level instrumentation has an independent power supply that has backup battery capacity for at least 72 hours.

Beyond the SFP level instrumentation, no additional electrical components are needed as part of the licensee's Phase 2 and 3 strategies.

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. Indian Point Units 2 and 3 each have a dry ambient pressure containment.

The licensee performed a containment evaluation, IP-CALC-14-00042, Revision 1, MAAP [Modular Accident Analysis Program] 4.0.5 Containment Analysis for an Extended Loss of all AC Power Event (ELAP), for Unit 2 and IP-CALC-13-00081, Revision 2, MAAP 4.0.5 Containment Analysis for an Extended Loss of all AC Power Event (ELAP) for Unit 3, which was based on the boundary conditions described in Section 2 of NEI 12-06. The analyses analyzed the strategy of containment isolation and monitoring containment pressure using installed instrumentation and concluded that the containment parameters of pressure and temperature remain well below the respective UFSAR Section 6.3 design limits of 47 psig and 271 °F for more than 120 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.

3.4.1 Phase 1

The Phase 1 coping strategy for containment involves verifying containment isolation per procedure ECA-0.0, "Loss of All AC Power," and monitoring containment pressure using installed instrumentation.

3.4.2 Phase 2

The Phase 2 coping strategy is to continue monitoring containment pressure using installed instrumentation.

3.4.3 Phase 3

The Phase 3 coping strategy is to continue monitoring containment pressure using installed instrumentation.

If required for maintaining containment integrity, either venting containment or using the CRF coolers for indefinite containment cooling can be established. Restoring containment cooling requires repowering a CRF and providing cooling water to the CRF cooler through its service water connections.

For Unit 2, power may be restored to 480 Vac safety buses 2A, 3A, 5A, or 6A, which provides the capability to operate either CRF-23, CRF-24 or CRF-25 depending on which safety bus is reenergized from the NSRC 480 Vac generator. The source of cooling water comes from the flow of service water via the NSRC low pressure/high flow dewatering pump and booster pump. The water will come from the UHS, using a suction hose dropped into the discharge canal. The discharge canal has a direct flow path from the Hudson River. The pump discharge connections use a manifold which is stored on-site in the FESB and is capable of connecting to a 14 inch flange connection (primary) or to a 20 inch flange connection (alternate) in the service water headers.

For Unit 3, power may be restored to 480 Vac safety bus 2A, 3A, 5A or 6A from the NSRC 480 Vac generator, which will be connected directly to either bus 3A (primary) or bus 6A (alternate) and then the buses may be cross connected as needed to operate one or more of the CRFs. The source of cooling water comes from the flow of service water via the NSRC low pressure/high flow dewatering pump and booster pump. The water will come from the UHS, using a suction hose dropped into the discharge canal. The pump discharge connections use a manifold which is stored on-site in the FESB and is capable of connecting to 16 inch flange connection locations in the service water headers.

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 reinforced concrete vertical right cylinder with a flat base and hemispherical dome. A welded steel liner with a minimum thickness of 0.25 inches is attached to the inside face of the concrete shell to ensure a high degree of leak tightness. The Unit 3 containment free volume is 2,610,000 cubic feet. The ground acceleration for the design earthquake has been determined to be 0.15g applied horizontally and 0.10g applied vertically. For Unit 2, the licensee stated that an evaluation of the effect of tornado loads on the containment structure is documented in Appendix B of the Containment Design Report. For Unit 3, tornado loads consisted of 300 mph tangential wind traveling with a forward velocity of 60 mph. Also considered as a separate and as a combined loading combination was a 3.0 psi pressure drop external to the structure. In addition, horizontal and vertical missile loads were considered.

Containment Recirculation Fan Coolers

The containment air recirculation cooling system is designed to recirculate and cool the containment atmosphere in the event of a loss-of-coolant accident (LOCA). The fan motors are qualified to withstand containment environment conditions following the LOCA, so that the fans can perform their required function during the recovery period. The Unit 2 UFSAR and Unit 3 UFSAR indicate system components and their supports meet the requirement for seismic Class I structures and each component is mounted to isolate it from fan vibration. Instrumentation, pumps, fans, cooling units, valves, motors, cables, and penetrations located inside the containment are selected to meet the most adverse accident conditions to which they may be subjected. These items are either protected from containment accident conditions or are designed to withstand, without failure, exposure to the worst combination of temperature, pressure, and humidity expected during the required operational period.

The CRFs draw air through a cooler which reduces the containment air temperature and removes moisture that may be present. The CRF coolers are supplied by individual lines from the containment service water header. Each inlet line at Unit 2 is provided with redundant motor-operated shutoff valves and drain valves. Similarly, each discharge line at Unit 2 from the cooler is provided with redundant motor-operated shutoff valves and a manual balancing valve. At Unit 3, these valves are manual valves. The valves are located outside containment at both units. This allows each cooler to be isolated individually. The Unit 2 and Unit 3 UFSARs state that the service water piping supplying the CRF coolers is seismic Class I.

3.4.4.1.2 Plant Instrumentation

In NEI 12-06, Table 3-2 specifies that containment pressure is a key containment parameter which should be monitored by repowering the appropriate instruments. Containment pressure indication is available in the CCR throughout the event. The licensee's FIP states that control room instrumentation would 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 was available, the FIP states that key credited plant parameters, including containment pressure, is available using alternate methods.

3.4.4.2 Thermal-Hydraulic Analyses

The NRC staff reviewed the licensee's containment analyses, IP-CALC-14-00042, Revision 1, "IP2 MAAP 4.0.5 Containment Analysis for an Extended Loss of all AC Power Event (ELAP)," and IP-CALC-13-00081, Revision 2, "IP3 MAAP 4.0.5 Containment Analysis for an Extended Loss of all AC Power Event (ELAP)," which are based on the boundary conditions described in Section 2 of NEI 12-06. In these calculations, the licensee utilized the MAAP PWR Version 4.0.5 to model containment response to the ELAP coping strategies and to verify that its proposed FLEX strategy in response to an ELAP event maintains the conditions in containment below the design pressure and temperature. For both units, the assumed initial RCS leakage rate is 68 gpm (16.75 gpm per reactor coolant pump plus 1 gpm for unidentified RCS sources), which varies as a result of RCS pressure changes. Pump seal leakage is reduced to 3.5 gpm per reactor coolant pump after 24 hours, due to the operator actions to reduce RCS pressure and temperature. The Phase 2 RCS makeup pump is assumed to be available at 10 hours and is assumed to be throttled to maintain primary system water level. The staff noted that during Modes 1-4 for both units, the containment design pressure and temperature of 47 psig and 271 °F, respectively, are never exceeded for the 120-hour duration following an ELAP initiating event.

For Unit 2, the maximum containment pressure in the first 120 hours will be 5.2 psig at 120 hours after the event initiation and the maximum containment temperature (reactor cavity) will be 213.2 °F at about 103 hours after event initiation.

For Unit 3, the maximum containment pressure in the first 120 hours will be 5.7 psig at 120 hours after the event initiation. Furthermore, the maximum containment temperature (reactor cavity) will be 247.7 °F at about 1 hour after event initiation and then decreases to less than 230 °F at 120 hours after event initiation.

3.4.4.3 FLEX Pumps and Water Supplies

During its audit, the staff reviewed the licensee's containment analyses for an ELAP event, which were based on the boundary conditions described in Section 2 of NEI 12-06. These evaluations, IP-CALC-14-00042, Revision 1, "MAAP 4.0.5 Containment Analysis for an Extended Loss of all AC Power Event (ELAP)," and IP-CALC-13-00081, Revision 2, "IP3 MAAP 4.0.5 Containment Analysis for an Extended Loss of all AC Power Event (ELAP)," are discussed above.

Based on the containment evaluations, the staff finds that a FLEX pump and water source are not necessary to maintain containment integrity during Phase 1 and 2, and there is sufficient time for off-site resources to arrive and restore containment cooling prior to design limits being exceeded.

3.4.4.4 Electrical Analyses

The licensee performed a containment evaluation based on the boundary conditions described in Section 2 of NEI 12-06. Based on the results of this analysis, the licensee developed required actions to ensure maintenance of containment integrity and required instrumentation function. With an ELAP initiated while either Indian Point unit is in Modes 1-4, containment cooling for that unit is also lost for an extended period of time. Therefore, containment temperature and pressure will slowly increase. The licensee stated that structural integrity of the reactor containment building due to increasing containment pressure will not be challenged during the first 120 hours of an ELAP event. The expected rate of containment temperature rise is low such that no immediate actions are required. However, either venting containment or using the CRF coolers would ensure that temperature and pressure limits are not exceeded and necessary equipment, including credited instruments, located inside containment remains functional throughout the ELAP event.

The licensee's Phase 1 coping strategy for containment involves verifying containment isolation per procedure 2/3 ECA-0.0, and monitoring containment pressure using installed instrumentation. Control room indication using containment intermediate range pressure instruments will be available for the duration of the ELAP. The licensee's strategy to repower instrumentation using the Class 1E station batteries is identical to what was described in Section 3.2.3.6 of this SE and is adequate to ensure continued containment monitoring.

The licensee's Phase 2 coping strategy is to continue monitoring containment pressure using installed instrumentation. The licensee's strategy to repower instrumentation using the 480 Vac FLEX DGs is identical to what was described in Section 3.2.3.6 of this SE and is adequate to ensure continued containment monitoring.

The licensee's Phase 3 coping strategy includes actions to reduce containment temperature and pressure utilizing existing plant systems restored by off-site equipment and resources during Phase 3. The licensee's strategy involves either venting containment or using the CRF coolers for indefinite containment cooling. The CRFs would be supplied power from a 480 Vac CTG supplied from an NSRC, with cooling water supplied by a diesel-powered pump.

For Unit 2, power may be restored to buses 2A, 3A, 5A, or 6A, which provides the capability to operate either CRF-23, CRF-24, or CRF-25 depending on the NSRC 480 Vac CTG bus alignment. The SW supply isolation valves are motor operated valves (MOVs) powered from MCC-26AA (bus 5A breaker 17B, MCC 26A breaker CK7) and the SW supply block valves are powered from MCC-26BB.

For Unit 3, power may be restored to bus 2A, 3A, 5A or 6A from the NSRC 480 Vac CTG, which will be connected directly to either bus 3A (primary) or bus 6A (alternate) and then connected to other buses as needed using normally racked out breakers 3AT6A and 2AT5A and racked in breaker 2AT3A. Under this configuration any of the CRFs can be operated.

Heat removed via the CRF unit and the RHR system as it cools down the RCS as part of the Phase 3 core cooling function will cause containment pressure and temperature to decrease. This will allow containment integrity to be maintained indefinitely.

The NRC staff reviewed the licensee's analyses (IP-CALC-14-00098 and IP-CALC-14-00056) and guidance included in 2/3-FSG-014, and determined that the electrical equipment that will be supplied from an NSRC (i.e., 480 Vac CTGs) have sufficient capacity and capability to supply the required loads to reduce containment temperature and pressure to ensure that key components and instrumentation remain functional.

3.4.5 Conclusions

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

3.5 Characterization of External Hazards

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

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

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

References to external hazards within the licensee's mitigating strategies and this SE are consistent with the guidance in NEI-12-06 and the related NRC endorsement of NEI 12-06 in JLD-ISG-2012-01. Guidance document NEI 12-06 directed licensees to proceed with evaluating external hazards based on currently available information. For most licensees, this meant that the OIP used the current design basis information for hazard evaluation. Coincident with the issuance of Order EA-12-049, on March 12, 2012, the NRC staff issued a Request for Information pursuant to Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f) [Reference 19] (hereafter referred to as the 50.54(f) letter), which requested that licensees reevaluate the seismic and flooding hazards at their sites using updated hazard information and current regulatory guidance and methodologies. Due to the time needed to reevaluate the hazards, and for the NRC to review and approve them, the reevaluated hazards were generally not available until after the mitigation strategies had been developed. The NRC staff has developed a proposed rule, titled "Mitigation of Beyond-Design-Basis Events," hereafter called the MBDBE rule, which was published for comment in the *Federal Register* on November 13, 2015 [Reference 53]. The proposed MBDBE rule would make the intent of Orders EA-12-049 and EA-12-051 generically applicable to all present and future power reactor licensees, while also requiring that licensees consider the reevaluated hazard information developed in response to the 50.54(f) letter.

The NRC staff requested Commission guidance related to the relationship between the reevaluated flooding hazards provided in response to the 50.54(f) letter and the requirements for Order EA-12-049 and the MBDBE rulemaking (see COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards" [Reference 47]. The Commission provided guidance in an SRM to COMSECY-14-0037 [Reference 20]. 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. In a letter to licensees dated September 1, 2015 [Reference 37], the NRC staff informed the licensees that the implementation of mitigation strategies should continue as described in licensee's OIPs, and that the NRC safety evaluations and inspections related to Order EA-12-049 will rely on the guidance provided in JLD-ISG-2012-01, Revision 0, and the related industry guidance in NEI 12-06, Revision 0. The hazard reevaluations may also identify issues to be entered into the licensee's corrective action program consistent with the OIPs submitted in accordance with Order EA-12-049.

As discussed above, licensees are reevaluating the site seismic and flood hazards as requested in the NRC's 50.54(f) letter. After the NRC staff approves the reevaluated hazards, licensees will use this information to perform flood and seismic mitigating strategies assessments (MSAs) per the guidance in NEI 12-06, Revision 2, Appendices G and H [Reference 54]. The NRC staff endorsed Revision 2 of NEI 12-06 in JLD-ISG-2012-01, Revision 1 [Reference 55]. The licensee's MSAs will evaluate the mitigating strategies described in this safety evaluation using the revised flooding and 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 licensee stated that the design basis earthquake (DBE) for the site is fifteen-hundredths of the acceleration due to gravity (0.15g) peak horizontal ground acceleration and 0.10g peak ground acceleration acting vertically. It should be noted that the actual seismic hazard involves a spectral graph of the acceleration versus the frequency of the motion. Peak acceleration in a certain frequency range, such as the numbers above, is often used as a shortened way to describe the hazard. It should also be noted that the current NRC terminology for the DBE is the safe shutdown earthquake (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 the current design basis for the limiting site flooding event. As described in Section 2.5 of the Unit 2 and Unit 3 UFSARs, various flooding conditions were evaluated including a) flooding resulting from runoff generated by a probable maximum precipitation over the entire Hudson River drainage basin upstream of the site, b) flooding caused by the occurrence of an upstream dam failure concurrent with heavy runoff generated by a standard project flood, and c) flooding due to the occurrence of a probable maximum hurricane concurrent with a spring high tide in the Hudson River. The most severe flooding conditions determined water level would reach 14 feet above mean sea level (MSL). Local wave action, due to wind effects, has been determined to add 1 foot to the river elevation, producing a maximum water elevation of 15 feet above MSL at the Indian Point site, which would not flood the safety-related buildings. The critical site elevation is 15 feet and 3 inches.

During the audit process, the licensee stated that the internal flooding evaluation for Unit 3 has been performed using the current licensing basis as documented in the UFSAR and concludes that there are no large internal non-seismically robust flooding sources that would impact the FLEX strategies. In Attachment 1 to the compliance letter [Reference 56], the licensee stated that there are no large internal flood sources that are not seismically robust and do not require ac power (i.e. gravity drain) for Unit 2 that require procedural interface for an ELAP event and FLEX strategy implementation. In Attachment 1 to the compliance letter, the licensee also stated that Indian Point Units 2 and 3 do not rely on ac power to mitigate ground water intrusion.

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 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, "Tornado Climatology of the Contiguous United States," NUREG/CR-4461, Rev. 2, February 2007. If the recommended tornado design wind speed for a 1E-6/year probability exceeds 130 mph, the site should address hazards due to extreme high winds associated with tornadoes using the current licensing basis for tornados or Regulatory Guide 1.76, Rev. 1.

In its FIP, regarding the determination of applicable extreme external hazards, the licensee stated that the site is located at approximately latitude 41°-16' N and longitude 73°-57' W. In NEI 12-06 Figure 7-1, "Contours of Peak-Gust Wind Speeds at 10-m Height in Flat Open Terrain, Annual Exceedance Probability of 1E-6" indicates the site is in a region where the hurricane wind speed exceeds 130 mph. 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. Therefore, the plant screens in for an assessment for high winds and tornados, including missiles produced by these events.

The Unit 2 licensing basis does not include tornado protection for the design of the buildings, structures and components. The Unit 2 wind protection design basis is a structural wind load evaluation because tornadoes were not included in the plant's design basis. The Unit 3 licensing and design basis is that only one tornado borne missile was considered acting at any time simultaneously with the 360 mph tornado wind load. To provide a congruous strategy for tornado events, the licensee stated that the FLEX strategy for addressing tornado and tornado missiles impact on the water storage tanks established with the Unit 3 strategy was also applied to Unit 2.

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 and extreme cold temperatures. 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 approximately latitude 41°-16' N and longitude 73°-57' W, therefore, the FLEX strategies consider the impedances caused by extreme snowfall and challenges of extreme cold temperatures. In addition, the site is located within the region characterized by the Electric Power Research Institute (EPRI) as ice severity level 4 (NEI 12-06, Figure 8-2, Maximum Ice Storm Severity Maps), which is described as susceptible to experience severe damage to power lines and/or the existence of large amounts of ice, therefore, the FLEX strategies consider the impedances caused by ice storms.

The licensee concludes that the plant screens in for an assessment for snow, ice, and extreme cold hazard. The lowest recorded temperature at the Indian Point site was -15 °F.

In summary, based on the available local data and Figures 8-1 and 8-2 of NEI 12-06, the plant site does experience significant amounts of snow, ice, and extreme cold temperatures; therefore, the hazard is screened in. The licensee has appropriately screened in the hazard and characterized the hazard in terms of expected temperatures.

3.5.5 Extreme Heat

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. Summers at the site may bring periods of extremely hot weather. At Indian Point, the maximum temperature recorded was 115 °F. The licensee stated that 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

In its FIP, the licensee stated that all FLEX equipment and supplies will be stored in an existing 10,000 square foot building designated as the FLEX equipment storage building (FESB). The FESB is located south of Unit 3. The existing interim radwaste storage facility (IRWSF) building has been converted to serve as the FESB. The IRWSF was evaluated and modified to meet the requirements for a robust structure as defined in NEI 12-06 as detailed in licensee reports A14058-R-001, "Interim Radwaste Storage Facility Robust Structural Evaluation for FLEX Equipment Storage," Rev. 0, A14058-R-002, "Analysis and Design Modifications of the Interim Radwaste Storage Facility for FLEX Equipment Storage," Rev. 0, and engineering change EC 48763, "Modification of the IRWSF."

The licensee stated that all the required FLEX equipment and N+1 spare equipment such as pumps, FLEX diesel generators, fueling tankers, debris removal equipment, and towing vehicles as well as hoses and cables are stored in the FESB.

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

3.6.1.1 Seismic

The licensee evaluated the FESB for loads associated with an SSE. The evaluations use 0.15g as the horizontal peak ground acceleration and 0.1g as the vertical peak ground acceleration. Both values are in accordance with the plant's current licensing basis for the SSE.

The licensee evaluated the potential for seismic interactions to ensure that unsecured components do not damage the equipment. An evaluation determined that the minimum separation distance between equipment within the building, to ensure that they will not interact with each other due to tipping or sliding during a seismic event, is 15 inches. Therefore, the licensee concluded that as long as the large portable FLEX equipment housed in the FESB is stored at a distance equal to or greater than 15 inches, it is not required to be tied down.

3.6.1.2 Flooding

The FESB is located south of Unit 3 at elevation 115 feet above MSL and is not susceptible to flooding as the current licensing basis flood level is 15 feet above MSL. The FESB was designed to prevent water intrusion.

3.6.1.3 High Winds

The FESB structure has been evaluated for high winds, tornado differential pressure and tornado borne missiles. Modifications to the FESB included the installation of tornado venting louvers, two new tornado missile protected equipment doors, and a new tornado proof personnel door. One wall required reinforcement to increase its tornado wind and missile resistance. The FESB (with these modifications) has been evaluated by the licensee to provide the required protection of the FLEX equipment against the high wind hazard.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

In its FIP, the licensee stated that all Phase 2 FLEX equipment is stored in the FESB such that initial exposure to any extreme temperature prior to an ELAP event will be mitigated. All FLEX pumps and the FLEX DGs are specified to ensure they are capable of starting and operating while exposed to -15 °F and 115 °F temperatures. The FESB is not climate controlled, but it has some louvered areas for ventilation and electrical plugs for block heaters for some equipment. In calculation IP-CALC-14-00033, Rev. 0, the licensee evaluated the potential temperatures inside the FESB. The maximum external temperature considered was 115 °F, the minimum was -15 °F. The calculation states that the maximum temperature inside the FESB will be about 105.5 °F, and the minimum about -6 °F. The NRC staff finds this acceptable, assuming that block heaters maintain acceptable fluid temperatures as stated by the manufacturer, since the licensee has stated that the FLEX equipment is rated to operate within a range of -15 °F to 115 °F.

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 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.

Table 2 in the licensee's FIP lists the type and number of FLEX pumps and generators stored in the FESB. Indian Point has two units, thus three pieces of FLEX equipment are typically needed to meet the N+1 requirement. For makeup to the steam generators, three diesel-driven pumps are provided. One pump will be deployed next to each unit's CST and will be available to feed the steam generators in the event the TDABF pumps fail. For makeup to the reactor coolant system, three diesel-driven pumps are provided. One pump will be deployed near each unit's RWST. In addition, three diesel-driven pumps designated as inventory transfer pumps are provided to refill the CSTs and three diesel-driven pumps are provided for makeup to the SFPs. Lastly, three 600 kW 480 Vac DGs are provided to recharge the batteries and provide power to other essential loads.

In its FIP, the licensee stated that N sets of FLEX hoses and cables are provided with additional spare hose and cable quantities consistent with the NRC endorsement of the NEI guidance entitled "Alternative Approach to NEI 12-06 Guidance for Hoses and Cables" [Reference 48]. This is further discussed in Section 3.14 below.

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 appropriately, the licensee's FLEX strategies include a sufficient number of portable FLEX pumps, FLEX DGs, and equipment for SG makeup, RCS makeup and boration, SFP makeup, and maintaining containment consistent with the N+1 recommendation in Section 3.2.2 of NEI 12-06.

3.7 Planned Deployment of FLEX Equipment

In its FIP, the licensee stated that pre-determined, preferred haul paths have been identified and documented in the FSGs. In Figures 1 and 2 of its FIP, the licensee identified various haul paths from the FESB to the staged locations of the FLEX equipment within the protected area. The haul paths have been selected to avoid areas with trees, power lines, narrow passages, etc. where practicable. After performing the initial damage assessment, debris removal from the haul paths will be initiated to support deployment of the first piece of equipment from the FESB, the 600 kW FLEX DGs.

3.7.1 Means of Deployment

In Table 2 of the FIP, tow and debris removal vehicles are listed. The FLEX equipment includes two pickup trucks to be used as tow vehicles and two four wheel loaders with fork, blade and bucket attachments to be used for debris removal. These vehicles are stored in the FESB such that the equipment remains functional and deployable to clear obstructions from pathways between the FESB and the deployment location(s).

In its FIP, the licensee stated that deployment of the FLEX and debris removal equipment from the FESB is not dependent on off-site power. All actions are accomplished manually.

In its FIP, the licensee stated that the Indian Point site is susceptible to severe damage to power lines and /or existence of large amounts of ice. Therefore the FLEX strategies consider the impedances caused by ice storms. The FLEX strategies also address the impedances caused by extreme snowfall with snow removal equipment.

3.7.2 Deployment Strategies

The licensee evaluated the potential impacts of soil liquefaction and flooding on the haul paths both outside and inside the protected area. In its FIP, the licensee stated that soil liquefaction from the FESB along the various haul routes to the FLEX equipment staging locations around the plant will not preclude FLEX implementation. The licensee also stated that flooding along the haul paths is not a concern, due to the higher elevations of the FESB and the haul paths.

In its FIP, the licensee indicated that the ultimate heat sink, the Hudson River, is accessed from the discharge canal. The UHS is accessed in Phase 3 using NSRC-supplied pumps. The NSRC pumps discharge through the mobile water filtration unit when refilling the CSTs. In its OIP, the licensee stated that a booster pump will be provided from the NSRC to provide additional suction lift as needed. Figures 3 and 4 in the FIP depict a strainer in the discharge canal to keep any floating debris out of the pump suction.

The licensee stated that Phase 3 of the FLEX strategies involves receipt of equipment from offsite sources including an NSRC and various commodities such as fuel and supplies. Delivery of this equipment can be through airlift or via ground transportation. Debris removal for the pathway between the site and the NSRC receiving location and from the various plant access routes may be required. The same debris removal equipment used for on-site pathways will be used to support debris removal to facilitate road access to the site.

3.7.3 Connection Points

3.7.3.1 Mechanical Connection Points

Core Cooling Discharge Connections

In NEI 12-06, Table D-1 states that primary and alternate injection points are required to establish capability to inject through separate divisions/trains. In NEI 12-06, Section 3.2.2 further explains that both the primary and alternate connection points do not need to be available for all applicable hazards, but the location of the connection points should provide reasonable assurance of at least one connection being available.

In the FIP, Section 2.3.5.1 states that the primary FLEX SG makeup pump discharge connection for SG injection is located on the common discharge line downstream of the TDABF pump in the auxiliary feedwater system. The licensee explained that a hose will be routed from the FLEX SG makeup pump discharge to the connection point located inside the auxiliary feedwater building, which is a robust structure with respect to seismic events, floods, high winds, and associated missiles. In the FIP, Section 2.3.5.2 states that the alternate connection for SG injection is located in the main feedwater system inside the turbine building, which is separate from the auxiliary feedwater building. For Unit 2, the alternate connection uses a pre-fabricated assembly, stored in the FESB, that includes a check valve and a vent valve, a hose connection on one end and a threaded connection on the other end to be connected to an existing drain valve. For Unit 3, the alternate connection consists of a globe valve, a check valve and a capped threaded connection.

Given the design and location of the primary and alternate connection points, as described in the above paragraphs, the NRC staff finds that at least one of the connection points should be available to support core cooling FLEX strategies during an ELAP caused by an external event and the injection paths are located on diverse trains, consistent with NEI 12-06, Section 3.2.2 and Table D-1.

RCS Inventory Control Discharge Connections

In NEI 12-06, Table D-1 states that primary and alternate injection points are required to establish capability to inject through separate divisions/trains. In NEI 12-06, Section 3.2.2 further explains that both the primary and alternate connection points do not need to be available for all applicable hazards, but the location of the connection points should provide reasonable assurance of at least one connection being available.

In the FIP, Section 2.3.5.6 states that for Unit 2, the primary connection for the discharge of the FLEX RCS inventory makeup pump is a permanently installed hose connection in the chemical and volume control system. For Unit 3, the primary connection for the discharge of the FLEX RCS inventory makeup pump is a permanently installed hose connection located upstream of the boron injection tank in the safety injection system. In the FIP, Section 2.3.5.7 states that for Unit 2, the alternate connection is a permanently installed connection in the SI system, and for Unit 3, the alternate connection is located in the chemical and volume control system downstream of the charging pumps. The licensee indicated that these connection points are located in the primary auxiliary building for their respective unit, which is a Seismic Class 1 structure. Furthermore, the staff noted that these systems were designed to be Seismic Class

1, which must remain functional during and following a Safe Shutdown Earthquake (see UFSAR Section 1 and 16 for Unit 2 and 3, respectively).

Given the design and location of the primary and alternate connection points, as described in the above paragraphs, the NRC staff finds that at least one of the connection points should be available to support core cooling FLEX strategies during an ELAP caused by an external event and the injection paths are located on diverse trains, consistent with NEI 12-06, Section 3.2.2 and Table D-1.

SFP Cooling and Inventory Control

In NEI 12-06, Table D-3 states, in part, that the baseline capabilities for SFP cooling include makeup via hoses on the refueling floor, spray capability via portable monitor nozzles from the refueling floor and makeup via connection to SFP cooling piping or other alternate location.

In the FIP, Section 2.4.4.1 states that for both units, the primary connection in the SFP cooling system involved the installation of a new 5 inch Storz hose connection to the SFP cooling system, located upstream of the SFP heat exchanger. The licensee explained that this seismically robust connection point is located in an area that is easily accessible and away from other equipment to ensure a clear path to the door for hose routing. In the FIP, Section 2.4.4.2 states that for both units a new stand-alone pipe with a 45 degree elbow on each end is mounted to a support using a heavy duty turntable, which allows for the capability to rotate 90 degrees to keep the pipe and Storz hose connection out of the way of the SFP crane during normal plant operation. Furthermore, an additional alternate strategy utilizes a spray option by providing flow through portable spray monitor nozzles set up on the north side of the SFP to maximize the coverage of the fuel bundles and minimize overspray. The licensee explained that the spray monitor nozzles and the collapsible discharge hose that will be used for the secondary connection will be deployed from its storage location in the FESB.

The NRC staff finds the available connection points including the associated hoses/spray nozzles in the licensee's SFP cooling FLEX strategies are consistent with the baseline capabilities identified in NEI 12-06, Table D-3, to makeup via hoses on the refueling floor, spray capability via portable monitor nozzles from the refueling floor and makeup via connection without access to the refueling floor. In addition, the staff finds that consistent with NEI 12-06, Section 3.2.2, the available connection points are protected from applicable external hazards such that there is reasonable assurance at least one connection point is available during an ELAP event.

3.7.3.2 Electrical Connection Points

Electrical connection points are only applicable for Phases 2 and 3 of the licensee's mitigation strategies for an ELAP.

During Phase 2, the licensee has developed a primary and alternate strategy for supplying power to equipment required to maintain or restore core cooling, containment, and SFP cooling using a combination of permanently installed and portable components. The portable 480 Vac FLEX DGs (one per unit) and the required power cables would be transported from the FESB to either the primary or alternate staging location. The primary and alternate staging locations are in two separate areas. The primary staging location is in the transformer yard and the alternate staging location is the yard to the north of the PAB (near the doors of the containment access facility). The use of the alternate staging location and connections is designed specifically for the case of a beyond-design-basis flood during which access to the primary staging location and connections may not be available.

For Unit 2, the licensee's primary Phase 2 strategy includes connecting the Phase 2 FLEX DG to safety-related 480 Vac switchgear bus 2A. The primary connection point is a permanently installed connection between a new breaker within cubicle 23A at bus 2A and a new power inlet panel. The power inlet panel is located inside the control building and directly outside the switchgear room for Unit 2. Operators would connect the Phase 2 FLEX DG to the power inlet panel using temporary cables. The licensee's alternate Phase 2 strategy for Unit 2 is to connect the Phase 2 FLEX DG in parallel to bus 5A and bus 3A. There are no permanent cable connections for the alternate strategy. Instead, cables would be pulled into the PAB and directly connected to cable stored within the PAB. These cables are stored on three cable carts that are located in the PAB. Additional cables and tools are also located within a FLEX Phase 2 alternate connection cable storage cabinet. The alternate connection requires the lighting bus feeder cables to be removed from the transformers. The tools and parts required for splicing are available in the Phase 2 FLEX alternate connection cable storage cabinet. The actions necessary to perform the alternate connections are contained in the licensee's FLEX procedures (2/3-FSG-005) and the licensee stated that personnel have been trained to perform this activity. Both the connections and the cables are equipped with color-coded cam lock connectors to ensure proper connection. The licensee verified proper phase rotation as part of its post installation and operational checks.

For Unit 3, the licensee's primary Phase 3 strategy includes connecting the Phase 2 FLEX DG to safety-related 480 Vac switchgear bus 5A. The primary connection point is a permanently installed connection between the load side of compartment 19C on switchgear bus 5A and a power inlet panel located inside the control building just outside the switchgear room. Operators would connect the Phase 2 FLEX DG to the power inlet panel using temporary cables. The licensee's alternate Phase 2 strategy for Unit 3 is to connect the Phase 2 FLEX DG in parallel to bus 5A and bus 3A. There are no permanent cable connections for the alternate strategy. Instead, cables would be pulled into the PAB and directly connected to cable stored within the PAB using the same approach as for Unit 2.

After powering the electrical distribution system from either of the primary or alternate strategy/location, buses can be cross-tied through operator manipulation of breakers to allow powering of any battery charger or other essential and optional loads. Guideline 2/3-FSG-005 provides guidance for deploying, connecting, and aligning the Phase 2 FLEX DGs.

For both units, both the connections and the cables are equipped with color-coded cam lock connectors to ensure proper connection. The licensee verified proper phase rotation as part of its post installation and operational checks.

For Phase 3, the licensee will receive two 480 Vac, 1100 kW CTGs (1000 kW derated). The licensee plans to use the Phase 3 CTGs (one per unit) to restore RHR as an alternate method for removing decay heat and/or cooling down the RCS to cold shutdown. Restoration of RHR requires repowering the RHR pump. Heat removal is through the RHR heat exchangers that are cooled by establishing flow through the CCW system. For each unit, the Phase 2 FLEX DG could power one CCW pump. However, each Phase 3 NSRC CTG has the capacity to start a CCW pump, an RHR pump, and a CRF, sequentially.

For Unit 2, options are available to ensure load sharing for integration of the Phase 2 FLEX DG (if available) and the Phase 3 NSRC CTG to supply power to buses 2A, 3A, 5A, and 6A in Phase 3 depending on the availability of the primary connection (bus 3A) or alternate connection (bus 6A).

For Unit 3, power would be restored to bus 2A, 3A, or 6A from the Phase 3 NSRC CTG, which will be connected directly to either bus 3A (primary) or bus 6A (alternate) and then connected to other buses as needed. Power to bus 5A will be maintained on the Phase 2 FLEX DG, if available.

The primary and alternate NSRC CTG locations are in two separate areas. The primary staging location is in the transformer yard. The alternate staging location is west of the turbine loading bay. Either primary or alternate connection breaker can be reached from either CTG location. Guideline 2/3-FSG-014 provides guidance for deploying, staging, connecting, and aligning the Phase 3 CTGs. These guidelines also include guidance for verifying proper phase rotation.

3.7.4 Accessibility and Lighting

In its FIP, the licensee stated that the ability to open doors for ingress and egress, ventilation, or temporary cables/hoses routing is necessary to implement the FLEX coping strategies. Doors and gates serve a variety of barrier functions on the site. One primary function is security and is discussed below. However, other barrier functions include fire, flood, radiation, ventilation, tornado, and high energy line breaks (HELB). As barriers, these doors and gates are typically administratively controlled to maintain their function as barriers during normal operations. Following a BDBEE and subsequent ELAP event, FLEX coping strategies require the routing of hoses and cables to be run through various barriers in order to connect FLEX equipment to station fluid and electric systems. For this reason, certain barriers (gates and doors) will be opened and remain open. This violation of normal administrative controls is acceptable during the implementation of FLEX coping strategies.

The licensee stated that lighting during Phase 1 will be limited to the 8 hour battery-backed emergency lights and portable flashlights and lanterns. Phase 2 equipment includes diesel-powered lighting towers. These towers are only credited for lighting exterior to the plant buildings. Portable flashlights will be used for work in some areas of the plant.

3.7.5 Access to Protected and Vital Areas

In its FIP, the licensee provided information describing that access to protected areas will not be hindered. The licensee stated that the security force will initiate access contingency upon loss of all ac/dc power as part of the security plan. Access to the owner controlled area, the site protected area, and areas within the plant structures will be controlled under the access contingency as implemented by security personnel.

3.7.6 Fueling of FLEX Equipment

In the FIP, Section 2.9.4 states that the source of fuel oil for the portable FLEX equipment is from the emergency diesel generator (EDG) fuel oil storage tanks (FOSTs), and that there are three underground storage tanks per unit, capable of withstanding seismic, flood and high wind events. Based on the design (per UFSAR Section 1 for Unit 2 and UFSAR Section 8 for Unit 3), the location (i.e., underground), and its safety-related classification, the staff finds the tanks are robust and the fuel oil contents should be available to support the licensee's FLEX strategies during an ELAP event.

The licensee indicated that the Unit 2 EDG FOSTs must be maintained with a minimum volume of 19,002 gallons of usable fuel oil and the Unit 3 EDG FOSTs must be maintained with a minimum volume of 17,136 gallons of usable fuel oil. The licensee also explained that the total quantity of diesel fuel required for 72 hours of continuous operation of all FLEX diesel fuel oil components is approximately 8,000 gallons for each unit. During its audit, the staff reviewed the fuel oil consumption calculations for both units and noted the licensee assumed the FLEX equipment will be running at full load continuously and included 20 percent additional fuel oil usage as margin. The staff finds the licensee's assumption conservative because it is not expected that all FLEX equipment will run at full load continuously from the initiation of the ELAP event since the load on the FLEX equipment is expected to decrease as the reactor cools down. The staff noted the expected fuel oil usage provided in the FIP exceeds the estimates in the fuel oil consumption calculations and finds this to be a conservative approach to determine whether the protected on-site fuel oil is sufficient until off-site resources arrive. The licensee explained that the minimum volume of fuel oil that must be maintained in the FOSTs is sufficient to support the licensee's FLEX strategy for greater than six days. Based on the conservative fuel oil consumption rates and the protected fuel oil volume on site, the staff finds the fuel oil contents should be available to support the licensee's FLEX strategies during an ELAP event and that the quantity available is sufficient to support FLEX until off-site resources can provide fuel oil replenishment to the site.

In the FIP, Table 2 indicates that two sets of fuel transportation FLEX equipment, which are stored in the FESB, are available during Phase 2 to support refueling operations for portable diesel-driven FLEX equipment. Each set of equipment includes a trailer-mounted 500-gallon tank, 12 Vdc transfer pump and hose reel. The licensee explained that fuel from the FOSTs will be transferred via the existing fuel oil transfer pump, which will be powered by a Phase 2 FLEX diesel generator, through a 1.5 inch emergency fill connection. Although refueling operation cannot commence until the Phase 2 FLEX DGs are deployed, the staff finds that this will not impact the licensee's FLEX strategy because Phase 1 FLEX equipment will be initially available to respond to an ELAP event and Phase 2 portable FLEX equipment is stored with fuel oil to allow for an initial run before there is a need to be refueled. Based on the available protected equipment to support refueling operation, the available run-time and fuel oil consumption rate for each piece of FLEX equipment, the staff finds that diesel-powered FLEX equipment can be adequately refueled to ensure uninterrupted operation to support the licensee's FLEX strategies.

Unit 2 Technical Specification 5.5.11 and Unit 3 Technical Specification 5.5.12 require a diesel fuel oil testing program, which includes sampling and testing requirements, and acceptance criteria in accordance with applicable American Society for Testing and Materials Standards, for fuel oil in the EDG FOSTs. In the FIP, Section 2.17.6 states that maintenance and testing of

FLEX equipment is governed by the Entergy Preventive Maintenance (PM) Program, which used the EPRI Preventive Maintenance Basis Database in development of fleet specific Entergy PM Basis Templates. The licensee explained that the Entergy PM Basis Templates include activities such as periodic static inspections, operational inspections, fluid analysis, periodic functional verifications, and periodic performance validation tests. Based on the controls established in the Technical Specifications and Entergy's PM Program, the staff finds that the licensee has addressed management of fuel oil quality in the EDG FOSTs and portable FLEX equipment to ensure FLEX equipment will be supplied with quality fuel oil during an ELAP event.

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 Indian Point 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 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 [Reference 23], 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 Indian Point the Alternate Staging Area D is the Danbury Airport and Staging Area C is the Stewart International Airport. Staging Area B is at the FESB.

Use of helicopters to transport equipment from Staging Areas C and D to Staging Area B is recognized as a potential need within the Indian Point 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 Indian Point, 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, which occurs with the loss of forced ventilation in areas that continue to have heat loads. The licensee analyzed the loss of ventilation to quantify the maximum temperatures expected in specific areas related to FLEX mitigation strategy implementation to ensure the environmental conditions remain within equipment qualification limits. The key areas that the licensee identified for all phases of execution of the FLEX strategy are the SFP area (to ensure hoses/spray is routed prior to pool boiling), TDABF Pump Room, Central Control Room, the Control Building (where the switchgear, batteries, battery chargers, and inverters are located), and Containment.

TDABF Pump Room

The licensee explained that temperature switches are provided in the TDABF pump room to close the steam supply isolation valves to the TDABF pump in order to prevent adverse environmental conditions resulting from a high-energy line break. The licensee stated that the normal process limit to isolate the steam supply to the TDABF pump is 150° F and the actual setting for the temperature switches is 143° F, which ensures that they actuate prior to exceeding the process limit. The licensee's evaluations (IP-CALC-14-00039, "FLEX Event Evaluation of Turbine Driven Auxiliary Feed Pump Room Heat-up," Rev. 0 and IP-CALC-13-00064, "FLEX Event Evaluation of Turbine Driven Auxiliary Feed Pump Room Heat-up," Rev. 0) determined that the temperature inside the TDABF pump room will stay below the 143 °F setpoint (at which the steam supply valves could automatically close) with only the action of opening the roll-up door within 30 minutes of the initiation of an ELAP. The evaluations showed that temperature should not exceed 125.2 °F and 129.4 °F for Unit 2 and Unit 3, respectively, at any time during the first 7 days with outside ambient temperature as high as 115 °F. Based on Action Item No. 3 in the sequence of events (FIP Table 1), operators will open the TDABF pump room roll-up door by 30 minutes after the initiation of an ELAP. Based on the expected temperature response in the TDABF pump rooms and operator actions to open the roll-up door to provide ventilation, the staff finds that the TDABF pump should perform its required functions during an ELAP event.

Operation of the TDABF pump can be stopped once the Phase 2 SG makeup pump is in service, if desired. This would allow temperatures in the TDABF pump rooms to become more moderate, though continued TDABF pump operations without HVAC are still possible. Licensee procedures 2/3-ECA-0.0 direct operators to open the roll-up door within 30 minutes of ELAP initiation.

Based on the TDABF pump room temperature remaining below 143 °F (the steam supply valve setpoint) and the availability of the Phase 2 SG makeup pump, the NRC staff finds that the electrical equipment and components in the TDABF pump rooms should not be adversely impacted by a loss of ventilation as a result of an ELAP event.

Central Control Room (CCR)

The licensee's evaluations (IP-CALC-14-00038, "Main Control Room Heat-up for FLEX Event (IP2)," Rev. 0 and IP-CALC-13-00065, "Main Control Room Heat-Up for FLEX Event (IP3)" Rev. 0) determined that the temperature inside the Central Control Room (CCR) will stay below 110 °F for Unit 2 and 120 °F for Unit 3 with only the action to open the doors within 30 minutes into the event. The evaluations showed that temperatures would remain below these values for 72 hours after initiation of an ELAP event without additional ventilation. For Unit 2, the non-credited CCR HVAC system is anticipated to be available and may be restored once the Phase 2 FLEX DG is available to provide power. For Unit 3, the auxiliary CCR HVAC system is assumed to be available, and credited after 72 hours into the event to provide supplemental cooling. Licensee procedures 2/3-ECA-0.0 direct operators to open doors within 30 minutes of ELAP initiation. Based on its review of the licensee's Phase 2 FLEX DG sizing calculations in Section 3.2.3.6 of this SE, the NRC staff finds that the Phase 2 FLEX DGs have adequate capacity to supply the CCR HVAC.

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 CCR will not be adversely impacted by the loss of ventilation as a result of an ELAP event.

SFP Area

The only electrical equipment in the SFP area that the licensee is relying on as part of its FLEX strategies is the SFP level instruments required by NRC Order EA-12-051. The capability of this instrumentation is described in Section 4 of this SE.

Control Building – 15-foot Elevation (480 Vac Switchgear)

Unit 2

Ventilation for the 480 Vac switchgear room on the 15-foot elevation is normally provided by three exhaust fans. These fans draw air across the room from a set of fixed louvers with fire dampers and filters in the opposite corner. Each fan draws 19,950 cubic feet per minute (CFM) of air.

In calculation GMH-00003, "Heat Load Calculations, Cable Spreading Room, Battery Rooms, Electric Tunnel & 480V Switchgear Room," Rev. 6, the licensee evaluated the ventilation requirements for the switchgear room with the DG operation heat load and 3 fans running. The calculation concluded that the temperature can be maintained at 103.6 °F during normal operations and 100.9 °F during DG operation with the Switchgear Room starting temperature at 95 °F. The heat load during DG operations is representative of the FLEX equipment heat loads because less equipment is energized during a FLEX event than during normal operating conditions.

At the initiation of the event, the ambient conditions will be 115 °F during an extreme heat event. The ELAP will cause all ventilation to be lost and the heat loads in the switchgear room will be negligible until power is restored by the FLEX DG to selected equipment. The licensee expects that the switchgear room will begin to equalize with the ambient temperatures over the next 8 hours and that temperature will be in the vicinity of the ambient conditions at 8 hours (approximately 96 °F), when a FLEX DG repowers the switchgear. At this time if the 3 fans are repowered, per calculation GMH-00003, the temperature should be maintained below 120 °F. During the audit the licensee noted that they would consider these fans to be essential equipment in the Unit 2 FLEX strategy. The licensee considered these loads in Calculations IP-CALC-14-00055 and IP-CALC-14-00056 sizing the FLEX DGs.

Unit 3

There are two exhaust fans (Exhaust Fans 33 and 34) on the 15-foot elevation of the Control Building. Per the Unit 3 FLEX Strategy Report (IP-RPT-13-00059, "IP3 FLEX Strategy Development," Rev. 4), Exhaust Fan 34 in the switchgear room is considered an essential component on the FLEX DG load list and will be available within 8 hours of the event. Exhaust Fan 33 in the switchgear room is considered an optional component on the FLEX DG load list. Based on calculation IP3-CALC-CBHV-00996, "Control Building Elevation 15' Maximum Space Temperatures," Rev. 1, during one exhaust fan operation (25,000 CFM), the temperatures on the 15-foot elevation of the Control Building should not exceed 119.7 °F. The licensee considered these loads in Calculations IP-CALC-14-00055 and IP-CALC-14-00056 sizing the FLEX DGs.

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 on the 15-foot elevation of the Control Building will not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Control Building – 33-foot Elevation (Battery, Battery Chargers, Inverters, and Cable Spreading Rooms)

Unit 2

The licensee assumed an average ambient temperature of approximately 96 °F (considering a maximum ambient temperature of 115 °F and sinusoidal day-night temperature fluctuations). In calculation GMH-00012, "Cable Spreading Room Loss of Ventilation," Rev. 0, the licensee concluded that if the cable spreading room is provided with 21,000 CFM of forced ventilation with a starting temperature of 95 °F, the room will reach a steady-state temperature of 105 °F at 50 hours. This calculation assumed that only one of the two 21,000 CFM electrical tunnel exhaust fans was running with all necessary dampers open. The calculation uses the cable spreading room heat load with the EDG in operation, which is lower than the normal operating condition and more representative of an ELAP scenario.

While the FLEX scenario starting ambient temperatures may be slightly higher than analyzed in calculation GMH-00012, the licensee expects that the ambient temperature will approach the design basis ambient temperatures prior to the temperature reaching its steady-state temperature in the cable spreading room. During the audit the licensee noted that they would consider these fans to be essential equipment in the Unit 2 FLEX strategy.

The licensee considered the electrical loads from the exhaust fans in its generator sizing analysis (Calculations IP-CALC-14-00002 (Phase 2 Generator Sizing) and IP-CALC-14-00098 (Phase 3 Generator Sizing)). These calculations showed that the FLEX generators have adequate capacity to support these loads.

The Unit 2 battery rooms would be at their normal operating temperature at the onset of an ELAP event and the temperature of the electrolyte in the cells would build up due to the heat generated by the batteries discharging and during re-charging. The battery rooms are located inside the control building and would not be directly exposed to extreme high and/or low temperatures. Nonetheless, the licensee evaluated the heatup of the battery rooms during a loss of ventilation event in calculation GMH-00013, "Battery Rooms 22 and 24 Loss of Ventilation," Rev. 0. Battery room 22 is considered to have the bounding temperature conditions for the batteries as it is the smallest battery room. The licensee's calculation concluded that the temperature in battery room 22 would reach 119.2 °F within 2 hours if the cable spreading room is 121.8 °F. This cable spreading room temperature is not representative of the expected temperature during a FLEX event since all electrical equipment would be de-energized in the cable spreading room during an ELAP event. Additionally, it is reasonable to assume that the cable spreading room temperature will begin to equalize with the ambient temperatures over the first 8 hours of an ELAP event, until ventilation is restored during Phase 2. Based on this, the cable spreading room temperature should be lower than 121.8 °F assumed in the licensee's calculation. Since the temperature in the cable spreading room will be lower than the temperature in the battery room 2 hours into an ELAP event, opening the battery room doors per the licensee's procedures should provide sufficient air exchange with the cable spreading room to ensure that the battery room temperature does not exceed 120 °F. This is reasonable since the cable spreading room would be at or below its design-basis temperature at the start of the event, and there would be no equipment running (i.e., negligible heat loads) until power is restored to the inverters and battery chargers. The heat loads from the battery rooms will provide a negligible heat addition to the combined battery rooms and cable spreading room volume and should not adversely impact the heatup of the cable spreading room.

In addition to the above, the licensee's guideline (2-FSG-005) provides guidance for establishing battery room ventilation using portable fans powered from a diesel-powered lighting tower within 4 hours after battery charging has commenced.

Unit 3

The licensee's loss of ventilation calculation assumed that one upper and one lower electrical tunnel exhaust fans were operating. Per IP-RPT-13-00059, Rev. 4, one of the two lower electrical tunnel exhaust fans (20,500 CFM typical) and one of the two upper electrical tunnel exhaust fans are considered essential. These fans would be available within 8 hours upon initiation of an ELAP event. The licensee also considers the two cable spreading room exhaust fans to be essential components. With only one cable spreading room exhaust fan in operation (16,500 CFM), the temperatures in the 33 foot elevation of the Control Building are expected to reach 118.5 °F. Operation of two cable spreading room exhaust fans will dissipate heat from the battery rooms with the battery room doors open. According to the licensee's calculation, the temperature with two fans in operation is expected to reach a maximum of 108.9 °F.

Three of the four redundant safety-related batteries, which supply dc power to safe shutdown systems, are each housed in their own individual enclosure within the cable spreading room. Each battery room is constructed of concrete masonry units. Battery rooms 31, 32, and 34 share a common exhaust ductwork system. These rooms are ventilated by two redundant direct-drive, inline centrifugal exhaust fans rated at 910 CFM each.

One of the two battery room exhaust fans is considered an essential component that will be available within 8 hours of initiation of an ELAP event. The capacity of either exhaust fan is sufficient to ventilate all three battery rooms in the Control Building with the second fan provided as a spare.

The licensee considered the electrical loads from the exhaust fans in its generator sizing analysis (Calculations IP-CALC-14-00002 (Phase 2 Generator Sizing) and IP-CALC-14-00098 (Phase 3 Generator Sizing)). These calculations showed that the FLEX generators have adequate capacity to support these loads.

Battery 33 and battery charger 33 are credited as part of the licensee's FLEX strategy. Battery 33 is located in DG 31 Room, while charger 33 is located in the cable spreading room. The licensee does not take credit for DG 31 room ventilation fan number 33. During an ELAP event, the EDGs are assumed not to be functioning. The DG 31 room has large volume, however, to increase volume further, the door that separates DG 31 and DG 32 rooms and the door that separates DG 32 and DG 33 rooms may be opened to increase the room volume further. According to the licensee, the allowable DG room temperature limit is 126 °F. However, this limit assumes that the EDGs are operating. The licensee stated that upon initiation of a FLEX event, the doors separating the EDG rooms may be opened to aid in limiting any heat rise in the DG 31 room. Battery 33 is located in the bottom third of a reinforced concrete structure that is substantially underground. Therefore, because of ground insulation and thermal lag inherent to this configuration, any temperature rise in this area should be constrained. The heat generated by battery 33 will be negligible compared to an operating EDG and therefore the heat load in

DG room 31 is negligible during an ELAP event. Based on the above, the temperature in the DG room 31 should not exceed 120 °F.

During the audit the licensee noted that their procedures will include guidance on opening the battery room doors and the doors separating the EDG cells to ensure that temperatures do not exceed 120 °F.

Based on the above, the NRC staff finds that the licensee has shown that it can maintain the battery rooms and cable spreading rooms temperatures below 120 °F (the temperature limit, as identified in NUMARC-87-00, Revision 1, for electronic equipment to be able to survive indefinitely and also below the maximum temperature limit of the Class 1E station batteries, as specified by the battery manufacturers (C&D Technologies and Exide Technologies)). Therefore, the NRC staff finds that the electrical equipment, including the Class 1E station batteries located on the 33-foot elevation of the Control Building and battery 33 located in the DG-31 room, will not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Containment

Unit 2

The Unit 2 FLEX strategy credits the use of critical instruments and equipment during an ELAP event. The NRC staff reviewed the licensee's analysis (EC50151, "ELAP Conditions on Critical Instruments," dated February 22, 2017) that evaluated the performance of critical instruments and components within containment under ELAP conditions to assure continued operation throughout the event.

According to the licensee's analysis, critical instruments located outside of containment or the Auxiliary Boiler Feed Pump Room will not be adversely affected, as the ELAP does not cause appreciable temperature rise outside of these areas. Additionally, Unit 2 does not have containment accident condition qualified neutron flux instrumentation. Instead, the licensee credits alternative indication and manual actions.

The licensee's evaluation addressed phases 1 and 2 of an ELAP event before reaching Phase 3 when additional capability and redundancy from off-site equipment is made available indefinitely until power, water, and coolant injections systems are restored (the NRC staff's evaluation of the capability of this equipment and the expected loads is discussed in Section 3.4.4.4 of this SE). At Indian Point, Phase 3 equipment is assumed to be available as early as 24 hours after initiation of an ELAP event or as late as 72-120 hours. Given this, the licensee evaluated the expected environmental conditions for 120 hours to ensure its assessment was bounding.

The licensee's evaluation showed that the simulated Design Basis Accident profile for each piece of equipment fully bounds the ELAP profiles in thermal equivalency (duration) and peak temperature (magnitude). As mentioned in Section 3.4.4.4 of this SE, after transitioning to Phase 3, containment temperature and pressure will be reduced using installed plant systems to ensure that key components and instrumentation remain functional indefinitely.

The licensee also evaluated radiation, pressure, and humidity. This was done comparing the worst-case conditions to the ELAP conditions. Since no accident (i.e., no fuel damage) is assumed, the existing radiation evaluations for the components of interest remain bounding. For containment, the pressure (40 psia for ELAP vs. 61 psia for the worst-case condition) and humidity (100 percent for both conditions) also remain bounding. For the auxiliary feedwater building, the pressure (14.7 psia for ELAP vs. 17 psia for the worst-case condition) and humidity (100 percent for both conditions) also remain bounding.

Unit 3

The Unit 3 FLEX strategy credits the use of critical instruments and equipment during an ELAP event. The NRC staff reviewed the licensee's analysis (EC45874, "ELAP Conditions on Critical Instruments," dated February 23, 2017) that evaluated the performance of critical instruments and components within containment under ELAP conditions to assure continued operation throughout the event.

According to the licensee's analysis, critical instruments located outside of containment or the Auxiliary Boiler Feed Pump Room will not be adversely affected, as the ELAP does not cause appreciable temperature rise outside of these areas.

The licensee's evaluation showed that the simulated DBA profile for each piece of equipment fully bounds the ELAP profiles in thermal equivalency (duration) and peak temperature (magnitude). As mentioned in Section 3.4.4.4 of this SE, after transitioning to Phase 3, containment temperature and pressure will be reduced using installed plant systems to ensure that key components and instrumentation remain functional indefinitely.

The licensee also evaluated radiation, pressure, and humidity. This was done comparing the worst-case conditions to the ELAP conditions. Since no accident (i.e., no fuel damage) is assumed, the existing radiation evaluations for the components of interest remain bounding. For containment, the pressure (41 psia for ELAP vs. 57 psia for the worst-case condition) and humidity (100 percent for both conditions) also remain bounding. For the auxiliary feedwater building, the pressure (14.7 psia for ELAP vs. 17 psia for the worst-case condition) and humidity (100 percent for both conditions) also remain bounding.

Based on its review of the essential station equipment required to support the FLEX mitigation strategy, which are primarily located in the SFP Area, TDABF Pump Rooms, Central Control Room, Battery and Inverter Rooms, and Containment, the NRC staff finds that the equipment should perform their required functions at the expected temperatures as a result of loss of ventilation during an ELAP/LUHS event.

The licensee confirmed in FIP Section 2.6.5 that all FLEX pumps and FLEX DGs are specified to ensure they are capable of starting and operating while exposed to 115 °F, which is the postulated maximum ambient temperature at the site. Thus, based on the design specifications of the FLEX pumps and FLEX DGs, the staff finds that this equipment is capable of operating in the extreme high temperatures expected at the site and it is expected that this equipment will function during an ELAP event.

3.9.1.2 Loss of Heating

The Indian Point vital battery rooms are located inside the control building and would not be exposed to extreme high or low temperatures. At the onset of the event, the battery rooms would be at their normal operating temperature and the temperature of the electrolyte in the cells would build up due to the heat generated by the batteries discharging and during re-charging.

The licensee's dc coping calculations IP-CALC-14-00076 and IP3-CALC-13-00056 assumes a minimum battery temperature of 60 °F. This is the temperature of the battery room based on the existing HVAC system design basis. During the worst assumed low temperature environmental conditions, the FLEX strategy starts with an outside temperature of -15 °F and equipment de-energized, therefore the heat contribution from the equipment will reduce over time as the equipment cools down.

Considering the thickness of the walls shared with the outside environment, the change in temperature inside the battery rooms should be negligible during Phase 1 (approximately 8 hours). Therefore, the NRC staff finds that it is reasonable to assume that the battery rooms will remain near their pre-event temperatures during the first phase of the ELAP event until the FLEX generators are deployed and have energized the battery chargers. Once the battery charger is re-energized and is charging the battery, the charger is carrying the dc loads during Phase 2 and 3, which will provide some heating to the battery room. The staff finds that the vital batteries should remain within a temperature range which will allow them to remain functional.

In the FIP, Section 2.6.4 states that analyses were performed to determine if the water in the CST, CWST, FWST, PWST and RWST remains available and unfrozen for the duration of 72 hours, at which time equipment from the NSRC should be available. The licensee explained that its analyses assumed that all tanks were at their lowest permitted operational level and minimum operating temperatures, which the staff noted would yield conservative times to freezing in the tanks. During its audit, the staff reviewed these analyses and noted that the time to reach 32 °F and the amount of ice formation after 72 hours and 120 hours for each of the tanks listed above were determined. Based on its review, the staff finds it reasonable that there is sufficient time (i.e., greater than 35 hours for the limiting tank) before the tanks are impacted by extreme cold conditions for the licensee to deploy and stage Phase 2 FLEX pumps that will take suction from these tanks. In addition, although the water volume can eventually be lost due to freezing and ice formation, the staff finds it reasonable that this volume can be replaced by the availability of NSRC equipment taking suction from the Hudson River via the site discharge canal and being processed through the water filtration unit and/or boration unit.

These analyses also determined the flow rate necessary through hoses to ensure they remain unfrozen and the amount of time any stagnant water in the hoses would begin to freeze. During its audit, the staff reviewed these analyses and noted that the licensee assessed different hose sizes, lengths, and materials used in its FLEX strategies at an ambient temperature of 6 °F and -15 °F. The results indicated that stagnant water in hoses could reach 32 °F within minutes and that the flow through the hoses to support the FLEX strategies exceeds the required flow rate to prevent freezing. In addition, during its audit, the staff reviewed a sample set of the licensee's FSGs and confirmed that precautions are provided to warn operators to limit the amount of time hoses are filled with no flow, to drain hoses once flow has ceased, and that tank freezing can occur during extreme cold conditions.

Based on the expected flow rates through the FLEX pumps to support the licensee's FLEX strategy, and the procedural guidance/warnings provided to operators to limit no flow conditions and to drain hoses during extreme cold conditions, the staff finds the water storage tanks required to support the FLEX mitigation strategy should perform the required functions at the expected temperatures as a result of loss of heating during an ELAP event consistent with NEI 12-06 Sections 3.2.2.12 and 8.3.2.

The licensee confirmed in FIP Section 2.6.4 that all FLEX pumps and FLEX DGs are specified to ensure they are capable of starting and operating while exposed to -15 °F, which is the postulated minimum ambient temperature at the site. Thus, based on the design specifications of the FLEX pumps and FLEX DGs, the staff finds that the portable FLEX equipment is capable of operating in the extreme low temperatures expected at the site and it is expected that this equipment will function during an ELAP event consistent with NEI 12-06 Sections 3.2.2.12 and 8.3.2.

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 Class 1E station 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. The licensee performed calculation IP-CALC-14-00035, "Battery Room 21, 22, 23 and 24 Hydrogen Generation for FLEX Event," Rev. 0, for Unit 2 and calculation IP-CALC-13-00066, "Battery Room Hydrogen Generation of FLEX Event," Rev. 0, for Unit 3 to assess the buildup of hydrogen in the vital battery rooms as a result of loss of ventilation due to an ELAP event. These calculations determined that hydrogen limits would not be reached if normal battery room ventilation was restored or portable ventilation (500 CFM minimum) was established within 4 hours of commencing battery charging. Guideline 2/3-FSG-005 provides direction for repowering the normal battery room ventilation or deploying portable fans to blow air into each Class 1E station battery room if normal battery ventilation is not available. The portable fans would be powered from a diesel-powered lighting tower.

Based on its review, the NRC staff finds that the licensee's strategy is sufficient to prevent hydrogen accumulation in the Class 1E station battery rooms from reaching 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 Central Control Room (CCR)

In the FIP, Section 2.11.1 indicates that an evaluation of the temperature response inside the CCR concluded that the temperature will stay below 110 °F for Unit 2 and 120 °F for Unit 3 with the only action being to open the doors within 30 minutes after initiation of the ELAP event. Based on Action Item No. 2 in the licensee's sequence of events (FIP Table 1) operators will begin to take action to open the room and cabinet doors for the CCR to provide ventilation by 0.4 hours after the initiating event and complete the actions by 0.5 hours.

The staff noted that NUMARC 87-00 indicates a temperature of 110 °F is a conservative limit for CCR habitability in which operator actions would be impacted significantly. Although the expected temperature in the Unit 3 CCR is greater than the limit established in NUMARC 87-00, the staff noted that this temperature response was conservatively calculated. Specifically, for the bounding scenario in the calculation, the licensee considered an initial extreme high outdoor ambient temperature of 115 °F for 12 hours and for the remaining 60 hours of the scenario the outdoor ambient temperature was held constant at 93 °F. The staff finds these assumptions conservative because the maximum design outdoor temperature for the CCR ventilation system is less than 115 °F and it is expected that the outdoor ambient temperature will have a diurnal temperature variation. In addition, the FIP states that the Unit 3 auxiliary CCR HVAC system is available to provide supplemental cooling once the Phase 2 FLEX DG is deployed and available. The staff reviewed UFSAR Section 16 and confirmed that the CCR air conditioning system is a safety-related system that is robust with respect to the site's applicable external hazards. During its audit, the staff reviewed the Unit 3 FLEX strategy development program basis document and noted that the licensee indicated that ice vests are available to help with operator habitability concerns until the CCR temperatures can be lowered.

Based on the conservative temperature response in the Unit 3 CCR, operator actions to open the CCR doors to provide ventilation in accordance with station procedures, availability of ice vests to cope with rising room temperatures, and the ability to repower the auxiliary CCR HVAC system, the staff finds that station personnel can safely occupy and perform the necessary actions to support the FLEX mitigation strategy during an ELAP event, consistent with NEI 12-06, Section 3.2.2. Based on the expected temperature response in the Unit 2 CCR remaining below the limits established in NUMARC 87-00, and operator actions to open the CCR doors to provide ventilation in accordance with station procedures, the staff finds that station personnel can safely occupy the CCR and perform the necessary actions to support the FLEX mitigation strategy during an ELAP event, consistent with NEI 12-06, Section 3.2.2.

3.9.2.2 Spent Fuel Pool Area

In the FIP, Section 2.4.6 states that an analysis determined that during non-outage conditions assuming normal decay heat loads, the time to boil is approximately 8 hours and the time before SFP makeup is needed is approximately 27 hours. In the FIP, Section 2.11.1 states that ventilation of the SFP will be provided by opening the roll-up door and a door to the refueling deck to prevent SFP room pressurization and to discharge steam. Based on Action Item No. 13 in the sequence of events (FIP Table 1) operators will begin by 6.5 hours after the initiating event to establish a SFP ventilation path by propping open doors to the SFP room and complete the actions within 1.5 hours. In addition, Action Item No. 14 in the licensee's sequence of events indicates that operators will also begin by 7 hours after the initiating event to deploy SFP makeup hoses and establish connections within one hour.

Based on the procedural guidance to deploy hoses and open the roll-up door and a door to the refueling deck prior to the SFP boiling, the staff finds the above strategies are consistent with NEI 12-06, Section 3.2.2.11, such that station personnel can safely enter the SFP refuel floor and perform the necessary actions to support the FLEX mitigation strategy during an ELAP event.

3.9.2.3 Other Plant Areas

As discussed in SE Section 3.9.1, the licensee evaluation indicated the temperature inside the TDABF pump room will reach 125.2 °F and 129.4 °F for Unit 2 and Unit 3, respectively, during an ELAP event with only the action of opening the roll-up door to the outside within 30 minutes after the initiating event. In addition, the staff noted that operators will not need to continuously occupy the TDABF pump room and will only be required to enter the room for short durations to control the TDABF pump, the flow control valves and valves to align the TDABF pump suction to the CWST, if necessary. The SG ADV local operating stations are also located in the auxiliary boiler feed pump building, at a higher elevation than the pump room. Following loss of instrument air pressure, operators will control the ADVs locally by aligning a bottled nitrogen supply. Operators can make periodic adjustments to the SG ADV valve positions and then exit to the outdoors through the roll-up door.

Based on the procedural guidance to open the roll-up door to the TDABF pump room for ventilation, and the need for intermittent access without long stay times, the NRC staff finds the above strategies are consistent with NEI 12-06, Section 3.2.2.11, such that station personnel can safely enter, occupy and perform the necessary actions to support the FLEX mitigation strategy during an ELAP event.

3.9.3 Conclusions

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

3.10 Water Sources

3.10.1 Steam Generator Makeup

Phase 1

In the UFSAR, Section 1.11.2 (Unit 2) and UFSAR Section 16.1.2 (Unit 3) indicate that the CSTs are Seismic Class 1 structures, which must remain functional during and following a Safe Shutdown Earthquake. Furthermore, FIP Section 2.15.1 indicates that the FWST and PWST are robust with respect to the seismic event. In the FIP, Section 2.6.2 indicates that according to the design basis, the site is not susceptible to the most severe flooding conditions when considering local wave action, due to wind effects, on the Hudson River. The licensee confirmed (FIP Section 2.15.1) that the CST, CWST, FWST, and PWST are protected from the external flooding hazard. Based on the design and location of the CST, FWST, and PWST, as described in the respective UFSAR and FIP, the staff finds these tanks are robust with respect to the seismic and external flooding hazard and should be available to support an ELAP event following these hazards.

In NEI 12-06, Section 3.2.1.3 states that cooling and makeup water inventories contained in systems or structures with designs that are robust with respect to seismic events, floods, and high winds, and associated missiles must be available. During its audit, the staff reviewed the high wind evaluation for the site's water storage tanks and noted that since the Unit 2 design basis did not consider tornados the licensee assessed the site's water storage tanks against the Unit 3 design-basis tornado wind loads and missiles (i.e., wind load – 300 mph tangential plus 60 mph traverse; missiles – wood plank and automobile). The licensee determined that the FWST, RWST, CST, and PWST from both units and the CWST (shared between units) can withstand tornado wind loads based on the Unit 3 tornado design basis. However, the tanks are not designed to withstand impact from tornado-generated missiles; thus, the licensee's use of non-robust (i.e., unable to withstand tornado-generated missiles) water sources is an alternative to NEI 12-06.

In order to justify its use of non-robust water sources, the licensee performed evaluation IP-RPT-15-00031, Rev. 0, "IP2 Tornado Protection," dated October 2014. The evaluation determined that the predominant tornado path near the site is from southwest to northeast, however some tornadoes also exhibit a west to east path. The licensee reviewed the historical tornado data within 70 miles of the site for the time period from 1950 to 2012, which indicated that a reasonable separation distance that bounds a large majority of tornadoes is a tornado width of 700 feet.

Additionally, the NRC staff walked down the individual tanks and the staff noted that separation, plant grading and intervening structures provide sheltering and protection to the site's water sources. The staff noted that the Unit 3 CST is shielded by plant grading and by the Unit 3 and Unit 1 containment buildings. In addition, based on the licensee's evaluation, the perpendicular distance from the predominant tornado path between the CSTs (Unit 3 and Unit 2) and the CWST is approximately 1650 feet and 1744 feet, respectively. The staff noted that in both instances the distance between the alternate water sources used as a suction supply for the TDABF pump is significantly greater than 700 feet. As described in FIP Section 2.3.1, in the event that a CST is unavailable the licensee explained that it has the ability in the CCR to realign the suction of the TDABF pump to the CWST to ensure feedwater to the steam generators is available during an ELAP event.

Based on protection provided to the site's CSTs by intervening structures, the predominant tornado path and width, and the separation between alternate suction sources for the TDABF pump (i.e., CSTs and CWST), the staff finds the licensee has demonstrated that either the CWST or the CST is capable of surviving a high-wind event, include tornado missiles, and will be available as a suction source for the TDABF pump during Phase 1. Therefore, the NRC staff finds that the licensee's reliance on water sources that are not capable of withstanding the impact of tornado missiles is an acceptable alternative to NEI 12-06.

In the FIP, Section 2.3.10.4 states that the CSTs each have a total capacity of approximately 600,000 gallons and are required to be maintained with a volume greater than or equal to 360,000 gallons per Technical Specification Surveillance Requirement 3.7.6.1 to ensure a minimum usable volume of approximately 295,000 gallons and 292,000 gallons for Unit 2 and 3, respectively. The CWST has a capacity of approximately 1.5 million gallons with a minimum usable volume of approximately 655,000 gallons. The licensee explained that based on its thermal-hydraulic calculations performed for the site, the existing CST minimum usable inventory of 295,150 gallons for Unit 2 and 292,200 gallons for Unit 3 would be able to remove the sensible heat and decay heat for approximately 24 hours and 23 hours, respectively. The staff noted that should either the Unit 2 or Unit 3 CST not be available, the CWST would be available and contains an adequate amount of water to serve as a substitute for the unavailable CST.

Consistent with NEI 12-06 Section 3.2.2.5, with an acceptable alternative as discussed above, the staff finds that if the use of the CSTs and CWST is implemented appropriately and consistent with the FIP, the licensee should have water sources available during the Phase 1 core cooling strategies for SG makeup. In addition, these water sources should provide sufficient time for operators to deploy and stage Phase 2 portable FLEX equipment.

Phase 2

Beyond the CSTs and CWST, the site has several water storage tanks (i.e., two PWSTs, and three FWSTs), which are robust to the external hazards with the exception of tornado missiles, that can be used to support the licensee's FLEX strategy. In the FIP, Section 2.3.10.4 states that each PWST has a capacity of 165,000 gallons with a minimum usable volume of approximately 50,000 gallons for Unit 2 and 47,000 gallons for Unit 3. The Unit 2 FWST has a capacity of approximately 324,900 gallons with a minimum usable volume of approximately 279,000 gallons. Each Unit 3 FWST (two total) has a capacity of 350,000 gallons with a combined minimum usable volume of approximately 600,000 gallons.

Based on the available time that the CSTs or the CWST can provide suction to the TDABF pump, the staff finds it reasonable the licensee has sufficient time to perform a damage assessment of the site and determine the available clean water sources following a high wind event. In addition, the licensee indicated in FIP Section 2.3.7.1 that should it be necessary it is possible to use the Hudson River by pumping from the discharge canal until Phase 3 equipment is available and operational.

In the FIP, Section 2.3.2 states the Phase 2 FLEX inventory transfer pump will be used to refill the CST from other alternate cooling sources of water for the duration of Phase 2 by using hose connections provided at each of the tanks. However, since the water storage tanks at the site are not robust with respect to tornado missiles, the licensee established strategies to ensure sufficient water is available for suction to the FLEX SG makeup pumps. If the Unit 2 CST is lost and the TDABF pump is not available, the inventory of the CWST remains available via transfer using installed piping from the CWST to the Unit 2 FWST. If the Unit 2 FWST is lost and the TDABF pump is not available, water inventory is transferred to a Unit 3 FWST using installed piping from the CWST and the suction of the FLEX inventory transfer pump can draw from the Unit 3 FWST FLEX connection to provide water to the Unit 2 PWST or CST. The staff noted that if the Unit 3 FWST or CST is lost and the TDABF pump is not available, the water inventory from the CWST can be transferred to either surviving Unit 3 FWST using installed piping from the CWST, and the FLEX inventory transfer pump can take suction from the surviving Unit 3 FWST FLEX connection to provide inventory to a surviving tank for Unit 3. Based on the general location of the PWSTs and FWSTs, as noted during its walkdown, the staff noted that the perpendicular distance between these tanks and the CWST from the predominant tornado path significantly exceeds the typical tornado width for the region of 700 feet.

Based on the location of the tanks (i.e., CSTs, FWSTs, PWSTs and CWST) on the site, the distance and the intervening structures (i.e., Units 1, 2 and 3 containment structures) between the tanks, the number of tanks available on site, and the established contingencies in the event certain tanks are not available, the staff finds it reasonable that either the CSTs, PWSTs and FWSTs will survive and have sufficient inventory to support the FLEX strategies, or the CWST will survive and have sufficient inventory for the TDABF pump until the water filtration unit from the NSRC can be deployed. Furthermore, the staff finds that in the unlikely event that there are no surviving water storage tanks, the use of the Hudson River as a makeup water source by pumping from the discharge canal is available, if necessary, until Phase 3 equipment is operational.

The licensee explained that an evaluation was performed to determine if the amount of water contained in the tanks on site is adequate to provide cooling water to the SGs and the SFP until the water filtration units arrive and are operational. The results determined that based on the limiting event (i.e., loss of the CWST), the available water volume, assuming minimum usable volumes, provides an adequate supply of water for at least a period of 72 hours for Unit 2 and 120 hours for Unit 3. The staff finds the licensee's use of minimum usable volumes to be conservative because, in general, water tank level or volume is procedurally maintained greater than the minimal usable volumes and NEI 12-06 allows using the nominal capacity of robust water storage tanks for mitigation strategies. Thus, as described above, based on the capacity and location of the site's water storage tanks, the staff finds it reasonable that there is sufficient clean water available on the site to support FLEX strategies until the water filtration unit arrives, which is expected to occur about 24 hours after the initiating event, and can be deployed. In addition, should it be necessary, the staff noted that the licensee has the FLEX inventory transfer pump available to move water between the units to extend the amount of available time to support steam generator feedwater injection and SFP makeup.

Phase 3

In the FIP, Section 2.3.3 indicates that a 500-gpm water treatment filtration unit will be provided from the NSRC to provide a method to remove impurities from alternate water supplies. Specifically, FIP Section 2.3.10.4 states that the Hudson River provides an indefinite supply of untreated water for the water treatment filtration unit via pumping from the discharge canal. As discussed above, the staff finds it reasonable that there is sufficient clean water available on site to support steam generator feedwater injection until the water treatment filtration unit is delivered by the NSRC and is deployed.

3.10.2 Reactor Coolant System Makeup

Phase 1

In the UFSARs, Section 1.11.2 (Unit 2) and Section 16.1.2 (Unit 3) indicate that the SI accumulators are Seismic Class 1 components, which must remain functional during and following an SSE. The staff noted that the SI accumulators are located inside the containment building and therefore are protected from tornado and flooding events (See UFSAR Section 6.2.3.6 for Unit 2 and UFSAR Section 6.2.3 for Unit 3). Based on the design and location of the SI accumulators, as described in the respective UFSAR and FIP, the staff finds the accumulators are robust with respect to the seismic, high wind and external flooding hazard and should be available to provide RCS makeup during an ELAP event.

Phase 2

In the UFSARs, Section 1.11.2 (Unit 2) and Section 16.1.2 (Unit 3) indicate that the RWSTs are Seismic Class 1 components, which must remain functional during and following a Safe Shutdown Earthquake. In the FIP, Section 2.6.2 indicates that according to the design-basis, the site is not susceptible to the most severe flooding conditions when considering local wave action, due to wind effects, on the Hudson River. The licensee confirmed (FIP Section 2.3.4.8) that the RWSTs are protected from the external flooding hazard. Based on the design and location of the RWSTs, as described in the respective UFSAR, the staff finds the tanks are robust with respect to the seismic and external flooding hazard and should be available to support an ELAP event following these hazards.

In NEI 12-06, Section 3.2.1.3 states that cooling and makeup water inventories contained in systems or structures with designs that are robust with respect to seismic events, floods, and high winds, and associated missiles are available. During its audit, the staff reviewed the high wind evaluation for the site's water storage tanks and noted the RWSTs at the site are designed to withstand the tornado wind loads from the Unit 3 design-basis. However, the tanks are not designed to withstand impact from tornado-generated missiles; thus, the licensee's use of non-robust (i.e., susceptible to tornado-generated missiles) water sources for RCS makeup is an alternative to NEI 12-06. The staff walked down the individual tanks and noted that the separation, plant grading and intervening structures provide sheltering and protection to the site's two RWSTs. Specifically, the staff noted that the Unit 2 RWST is sheltered by the Unit 1 and Unit 2 containments, which provides substantial shelter for the tank. Furthermore, the Unit 2 PWST is directly adjacent to the Unit 2 RWST in the eastward direction, which would offer itself as a barrier for tornado-generated missiles. The staff also noted that the Unit 3 FWST is directly adjacent to the Unit 3 RWST in the eastward direction, which would offer itself as a barrier for tornado-generated missiles. The staff noted that should an RWST be damaged by a tornado missile, an alternate connection for supplying borated water for RCS inventory and reactivity control to both units can be established from the surviving RWST. In the FIP, Section 2.3.5.8 explains that there are four FLEX Storz hose connections on the RWST that are suitable for delivering flow rates for both units if required to supply borated water to the portable FLEX RCS makeup pumps. In the FIP, Section 2.3.4.8 indicates that the inventory from a single RWST is sufficient to provide the makeup for losses to the RCS of both units for approximately 120 hours when the plant is in Modes 1-4, and SGs are available. As noted in Section 3.2.3.2 above, the licensee revised a flow calculation for each unit to demonstrate the capability of increased injection flow to the RCS. If the higher RCS leakage rates exist, the licensee noted that the inventory from a single RWST may only last for 45 hours. However, the licensee has contracted for support equipment from an NSRC which will include mobile boration units and water treatment units. The licensee noted that within 45 hours, they will be capable of providing borated makeup water from this equipment using guideline FSG-014, "Extended Loss of AC Power – Phase 3," Revision 0.

Based on the location and the protection provided to the site's two RWSTs by intervening structures, the staff finds the licensee has demonstrated that at least one of the site's RWSTs will survive a high-wind event, include tornado missiles, and will be available as a suction source for the two FLEX RCS makeup pumps. Therefore, the NRC staff finds that the licensee's reliance on a water source that is not capable of withstanding the impact of tornado missiles is an acceptable alternative to NEI 12-06, and the staff concludes that the licensee is capable of providing RCS makeup with the FLEX RCS makeup pump during Phase 2 of an ELAP event and has demonstrated compliance with Order EA-12-049. Consistent with NEI 12-06, Section 3.2.2.5, with an acceptable alternative as discussed above, the staff finds that at least one RWST should be available, and if implemented appropriately and consistent with the FIP, the licensee should have sufficient borated water available during Phase 2 for RCS injection until the mobile boration unit and water filtration unit is delivered from the NSRC.

<u>Phase 3</u>

In the FIP, Section 2.3.3 states that for RCS injection in Phase 3, boron-mixing equipment will be available to provide makeup capability to the RWST. An NSRC will provide a 500-gpm water treatment filtration unit and a mobile boration unit including a 1,000-gallon capacity tank. Specifically, FIP Section 2.3.10.4 states that the Discharge Canal/Hudson River provides an indefinite supply of untreated water for the water treatment filtration unit and in turn the treated water can be used by the mobile boration unit to ensure sufficient borated water for RCS inventory and reactivity control.

3.10.3 Spent Fuel Pool Makeup

Phases 1, 2 and 3

As discussed in SE Section 3.3, during non-outage conditions assuming normal decay heat, the time to boil is approximately 8 hours and there is approximately 27 hours before make up to the SFP is needed. The licensee explained that SFP cooling through makeup and/or spray will be provided by using a portable FLEX SFP makeup pump with suction from a primary or alternate water source. In its FIP, the licensee stated that the primary source of makeup water to the SFP is the respective unit's RWST. In addition, connections exist to allow feeding both SFPs simultaneously from one RWST should the other unit's RWST be damaged by a tornado-borne missile. The licensee stated that the PWST is a secondary source of water that may be utilized for SFP makeup and is only used for makeup to the SFP if demineralized water inventory required for SG feed from other available sources is adequate and assured. As described in SE Section 3.10.2, the staff finds the RWSTs and PWSTs are robust with respect to the seismic, high wind, and external flooding hazard, and are granted an alternative based on sheltering and separation for the tornado missile hazard. Ultimately, once the water filtration unit and mobile boration unit from the NSRC are available, the licensee can treat and borate the water from the Discharge Canal/Hudson River to ensure adequate water is available for makeup to the SFP.

Based on the FIP and UFSAR, the staff finds that sufficient water contained in the RWSTs, PWSTs and Discharge Canal/Hudson River is expected to be available during an ELAP event consistent with NEI 12-06, Section 3.2.1.3. Due to the water available in the SFP above the fuel assemblies, SFP makeup is not required in Phase 1 and sufficient time is available for deploying and staging Phase 2 FLEX equipment. If implemented appropriately and consistent with the FIP, the licensee should have an adequate source of water available for SFP makeup during Phase 2 to allow for the arrival of off-site equipment from the NSRC. In addition, the staff finds that based on the normal decay heat loads, the licensee has adequate time to perform a damage assessment of the site to determine the availability and quantity of water tanks in order to prioritize their use for SG feedwater injection, RCS inventory control and makeup to the SFP.

3.10.4 Containment Cooling

In its FIP, the licensee stated that for Phases 1 and 2 no actions are required to maintain containment integrity and explained that the structural integrity of the containment building due to increasing containment pressure will not be challenged during the first 120 hours of a BDBEE/ELAP event. For Phase 3, the licensee stated the coping strategy involves either venting the containment or restoring cooling using a CRF and its cooler for indefinite coping. An NSRC-supplied low pressure/high flow pump and booster pump will supply water from the Discharge Canal/Hudson River to the service water system to cool the CRF cooler. In addition, a NSRC-supplied generator will power the cooling equipment needed to maintain containment cooling indefinitely.

Since the structural integrity of the containment building due to increasing containment pressure is not challenged during the first 120 hours of a BDBEE/ELAP event, the staff finds it is not necessary for the licensee to take actions during Phase 1 and 2; thus, a water source is not required to support FLEX strategies to maintain containment integrity. In addition, the staff finds the licensee has sufficient time for the arrival and deployment of off-site resources to support Phase 3 activities to maintain containment integrity.

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, with an alternative to credit tank survival from a tornado-borne missile based on separation and intervening structures, 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 TDABF 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 staff's review of the licensee's analysis shows that following a full core offload to the SFP, about 14 hours are available to implement makeup before boil-off results in the water level in the SFP dropping to 15 feet above the top of the fuel. The staff notes that normal water level is about 24 feet above the top of the fuel, and radiation levels do not increase substantially until water level is less than 10 feet above the top of the fuel. The licensee has stated that they have the ability to implement makeup to the SFP within that time.

When a plant is in a shutdown mode in which steam is not available to operate the TDABF pump and allow operators to release steam from the SGs (which typically occurs when the RCS has been cooled below about 300 °F), another strategy must be used for decay heat removal. On September 18, 2013, NEI submitted to the NRC a position paper entitled "Shutdown/Refueling Modes" [Reference 38], which described methods to ensure plant safety in those shutdown modes. By letter dated September 30, 2013 [Reference 39], the NRC staff endorsed this position paper as a means of meeting the requirements of the order.

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

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 stated 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, the FSGs provide guidance that can be employed for a variety of conditions. Clear criteria for entry into FSGs ensure that FLEX strategies are used only as directed for BDBEE conditions, and are not used inappropriately in lieu of existing procedures. Procedural interfaces have been incorporated into emergency operating procedures 2/3-ECA-0.0, "Loss of All AC Power," to the extent necessary to include appropriate reference to FSGs and provide command and control for the ELAP. Additionally, procedural interfaces have been incorporated into the emergency response guideline procedures and the emergency preparedness procedures to include appropriate references to FSGs.

The licensee stated that the FLEX strategy support guidelines were developed in accordance with the PWROG guidelines. FLEX support guidelines provide available, pre-planned FLEX strategies for accomplishing specific tasks. The licensee further stated that FSGs are used to supplement (not replace) the existing procedure structure that establishes command and control for the event.

In Table 2 of Attachment 1 to the compliance letter, in response to an issue raised in the NRC staff's ISE [Reference 16], the licensee provided information regarding preparations for impending floods and hurricanes. The licensee stated that flood preparation procedures would be implemented on indications of impending flood from rising river levels, a high tide advisory, potential hurricane impact, rainfall greater or equal to five inches per hour, National Oceanographic and Atmospheric Agency (NOAA) flood warning, or actual plant flooding from plant systems. In the event of a hurricane, the plant will be shut down per severe weather procedure OAP-008 "Severe Weather Preparations". Preparations will begin 72 hours prior to the projected arrival of tropical storm winds.

The licensee stated that FSGs have been reviewed and validated by the involved groups to the extent necessary to ensure the strategy is feasible.

3.12.2 Training

In its FIP, the licensee stated that Indian Point's Nuclear Training Program has been revised to assure personnel proficiency in the mitigation of BDBEEs is adequate and maintained. These programs and controls were developed and have been implemented in accordance with the Systematic Approach to Training (SAT) Process.

The licensee stated that initial training has been provided and periodic training will be provided

to site emergency response leaders on BDB emergency response strategies and implementing guidelines. Personnel assigned to direct the execution of mitigation strategies for BDBEEs have received the necessary training to ensure familiarity with the associated tasks, considering available job aids, instructions, and mitigating strategy time constraints. Care has been taken to not give undue weight (in comparison with other training requirements) for operator training for BDBEE accident mitigation. The testing/evaluation of operator knowledge and skills in this area has been similarly weighted.
The licensee also stated that in accordance with NEI 12-06, 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. Full scope simulator models will not be upgraded to accommodate FLEX training or drills.

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 in accordance with NEI 12-06, Section 11.6.

3.13 Maintenance and Testing of FLEX Equipment

As a generic issue, NEI submitted a letter to the NRC dated October 3, 2013 [Reference 40], which included EPRI Technical Report 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment." By letter dated October 7, 2013 [Reference 41], the NRC endorsed the use of the EPRI report and the EPRI database as providing a useful input for licensees to use in developing their maintenance and testing programs.

In its FIP, the licensee stated that maintenance and testing of FLEX equipment is governed by the Entergy PM Program. The Entergy PM Program is consistent with the Institute of Nuclear Power Operations guidance AP-913 and utilizes the EPRI Preventive Maintenance Basis Database as an input in development of fleet-specific Entergy PM Basis Templates. Based on this, the licensee stated that the Entergy fleet PM program for FLEX equipment follows the guidance in NEI 12-06, Section 11.5.

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 0

3.14.1 Reduced Set of Hoses and Cables As Backup Equipment

In its FIP, the licensee took an alternative approach to the NEI 12-06 guidance for hoses and cables. In NEI 12-06, Section 3.2.2 states that in order to assure reliability and availability of the FLEX equipment required to meet these capabilities, the site should have sufficient equipment to address all functions at all units on-site, plus one additional spare, i.e., an N+1 capability, where "N" is the number of units on-site. Thus, a two-unit site would nominally have at least three portable pumps, three sets of portable ac power supplies, three sets of hoses and cables, etc. The NEI on behalf of the industry submitted a letter to the NRC [Reference 48] proposing an alternative regarding the quantity of spare hoses and cables to be stored on site. The alternative proposed was that that either a) 10 percent additional lengths of each type and size of hoses and cabling necessary for the N capability plus at least one spare of the longest single section/length of hose and cable be provided or b) that spare cabling and hose of sufficient length and sizing to replace the single longest run needed to support any FLEX strategy. In its FIP, the licensee committed to following the NEI proposal. By letter dated May 18, 2015 [Reference 49], the NRC agreed that the alternative approach is reasonable, but that the licensees may need to provide additional justification regarding the acceptability of various cable and hose lengths with respect to voltage drops, and fluid flow resistance. The NRC staff approves this alternative as being an acceptable method of compliance with the order.

3.14.2 Separation of Tanks as Protection for Tornado-Borne Missiles

Guidance document NEI 12-06 [Reference 6], Section 3.2.1.3(3), states that cooling and makeup water inventories contained in systems or structures with designs that are robust with respect to seismic events, floods, and high winds and associated missiles are available to use in the FLEX strategies. The tanks at the Indian Point site (external to buildings) which provide the water supplies for the FLEX strategy are not designed to survive the impact from tornado-borne missiles. The NRC staff previously identified this as an alternative to NEI 12-06 in the plant onsite audit report [Reference 18]. The licensee has proposed to credit water sources in outside tanks based on tank separation. As discussed in Section 3.10 above, in case of missile damage to a CST, the licensee has credited the CWST as the backup water supply based on tank separation. In the case of missile damage to an RWST, the licensee has credited the other unit's RWST as the backup water supply based on tank separation and shielding. The NRC staff approves this alternative as being an acceptable method of compliance with the order.

3.14.3 Conclusion

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

3.15 Conclusions for Order EA-12-049

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

4.0 TECHNICAL EVALUATION OF ORDER EA-12-051

By letter dated February 27, 2013 [Reference 24], the licensee submitted its OIP for Indian Point Unit 2 and Unit 3 in response to Order EA-12-051. By letter dated June 25, 2013 [Reference 25], the NRC staff sent a request for additional information (RAI) to the licensee. The licensee provided a response by letter dated August 20, 2013 [Reference 26]. By letter dated November 8, 2013 [Reference 27], the NRC staff issued an ISE and RAI to the licensee.

By letters dated August 27, 2013 [Reference 28], February 27, 2014 [Reference 29], August 27, 2014 [Reference 30], February 27, 2015 [Reference 31], August 28, 2015 [Reference 32], and February 29, 2016 [Reference 33], 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 (SFPLI), which will function following a BDBEE, including modifications necessary to support this implementation, pursuant to Order EA-12-051. By letter dated May 20, 2015 [Reference 34], the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved by Indian Point Unit 3. By letters dated May 20, 2015 [Reference 34, Unit 3], and August 12, 2016 [Reference 35, Unit 2], the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved. By letter dated December 2, 2016 [Reference 53], the licensee submitted responses to the NRC RAIs.

The licensee has installed a SFPLI system designed by Mohr Test and Measurement LLC. The NRC staff reviewed the vendor's SFPLI system design specifications, calculations and analyses, test plans, and test reports. The staff issued a vendor audit report on August 27, 2014 [Reference 22].

The staff performed an onsite audit to review the implementation of SFPLI 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 letters dated December 9, 2014 [Reference 17], and February 25, 2016 [Reference 18], the NRC issued audit reports on the licensee's progress for Unit 3 and Unit 2, respectively. The following evaluation is common for Units 2 and 3 unless otherwise noted. Refer to Section 2.2 above for the regulatory background for this section.

4.1 Levels of Required Monitoring

Attachment 2 of Order EA-12-051 states, in part:

> All licensees identified in Attachment 1 to this 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 [Level 1], (2) level that is adequate to provide substantial radiation shielding for a person standing on the SFP operating deck [Level 2], and (3) level where fuel remains covered and actions to implement make-up water addition should no longer be deferred [Level 3].

In its letter dated February 27, 2015 [Reference 31], the licensee provided sketches depicting the SFP levels of monitoring for Indian Point Unit 2 (Figure 1: Unit 2 SFP Elevation View with Levels Indicated) and Indian Point Unit 3 (Figure 2: Unit 3 SFP Elevation View with Levels Indicated) as shown in this evaluation. In these sketches, the licensee identified the SFP levels of monitoring as below:

- Unit 2
  - Level 1 corresponds to 89 feet, 5 3/8 inches plant elevation
  - Level 2 corresponds to 80 feet, 8¼ inches plant elevation
  - Level 3 corresponds to 70 feet, 8¼ inches plant elevation

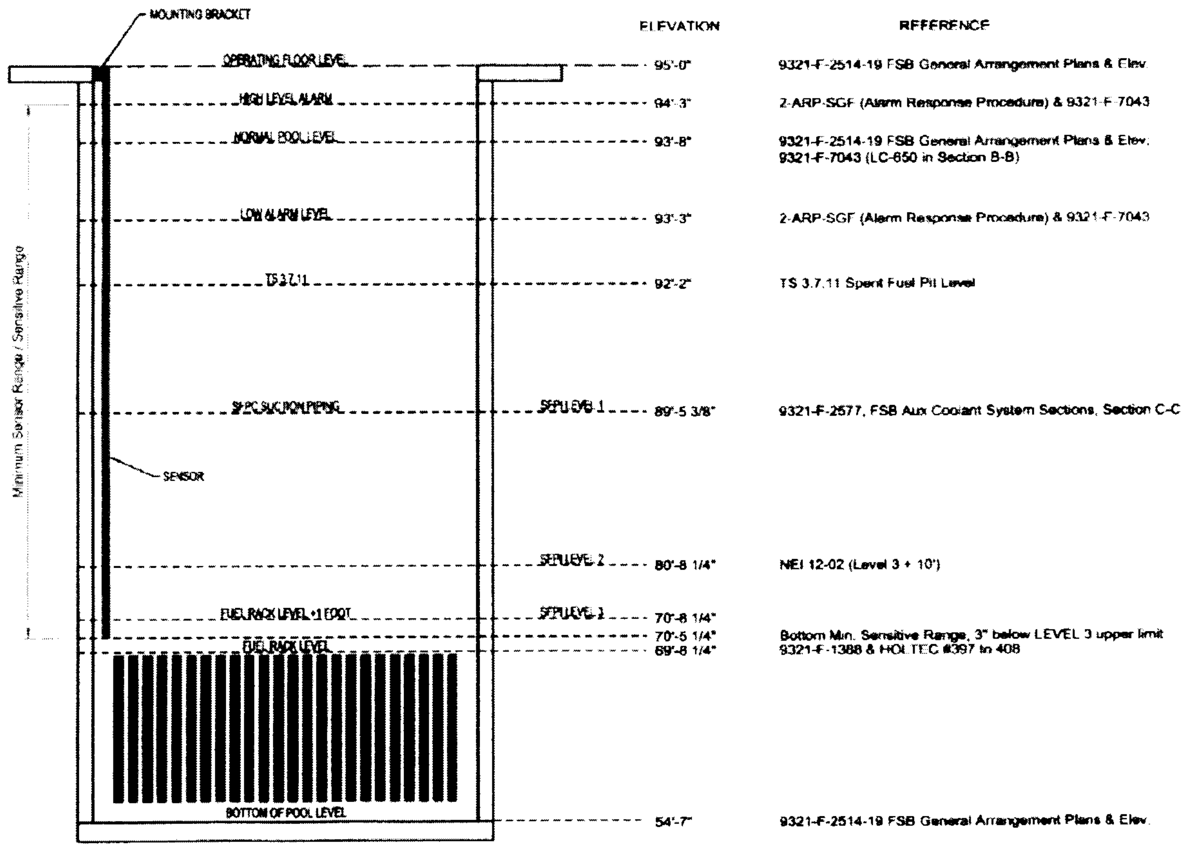

Figure 1: Unit 2 SFP Elevation View with Levels Indicated

- <u>Unit 3</u>
  - Level 1 corresponds to 89 feet, 5 3/8 inches plant elevation
  - Level 2 corresponds to 80 feet, 7½ inches plant elevation
  - Level 3 corresponds to 70 feet, 7½ inches plant elevation

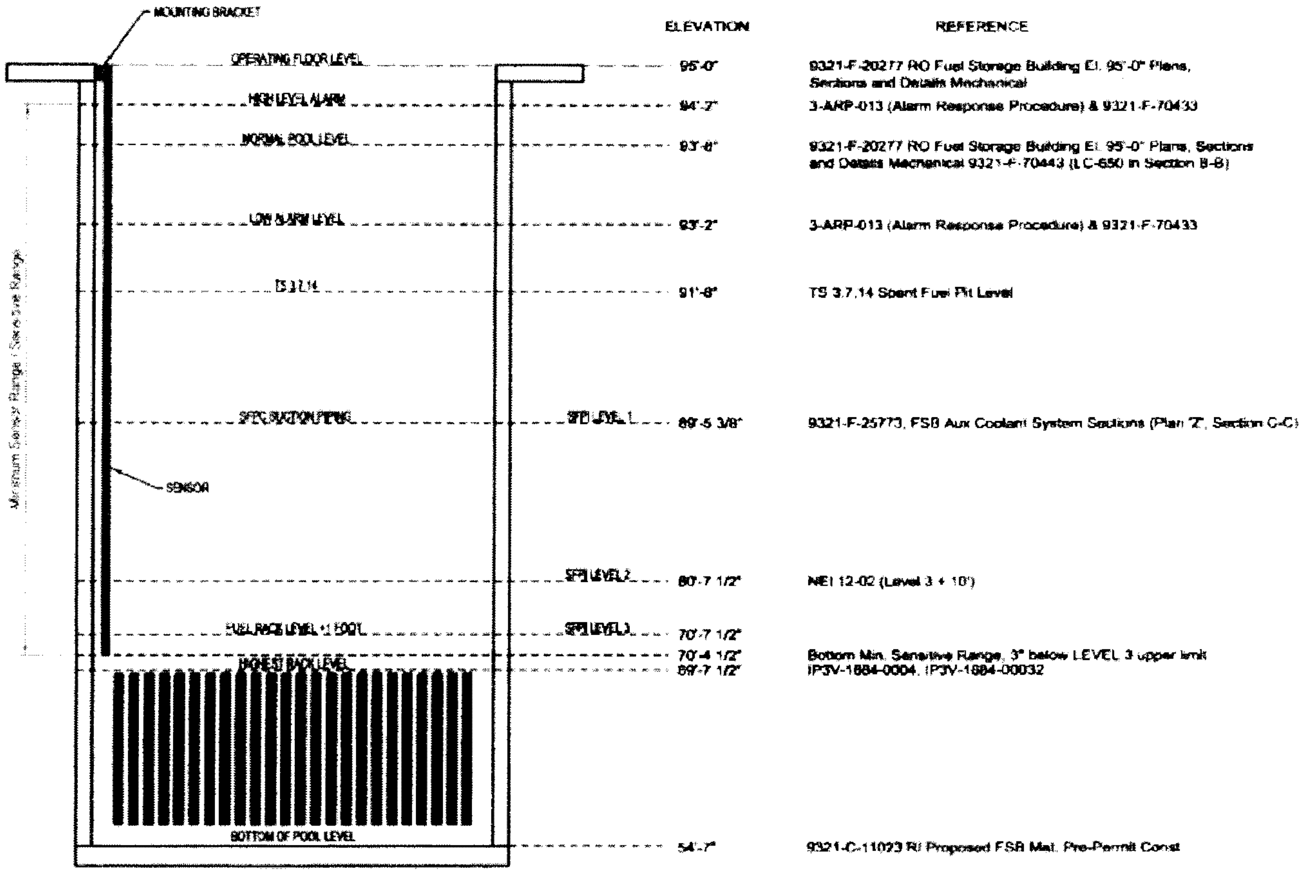

Figure 2: Unit 3 SFP Elevation View with Levels Indicated

The NRC staff's assessment of the licensee selection of the SFP levels of monitoring is as follows.

- Level 1: Per NEI 12-02, Section 2.3.1, Level 1 will be the HIGHER of two points. The first point is the water level at which suction loss occurs due to uncovering of the spent fuel cooling inlet pipe. This was identified by the licensee in its letter dated February 27, 2015 [Reference 31], as 89 feet, 5 3/8 inches plant elevation. The second point is the water level at which loss of spent fuel cooling pump NPSH occurs under saturated conditions. This was identified by the licensee in its OIP as below 89 feet, 5 3/8 inches plant elevation. Indian Point's designated Level 1 (89 feet, 5 3/8 inches plant elevation) is the HIGHER of the above two points; and therefore, consistent with NEI 12-02.

- Level 2 is consistent with the first of the two NEI 12-02 options for Level 2, which is 10 feet (+/- 1 foot) above the highest point of any fuel rack seated in the SFP.
- Level 3 is consistent with NEI 12-02 Level 3, which is 1 foot above the highest point of any fuel rack seated in the SFP where 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 addresses the requirements of the order.

4.2 Evaluation of Design Features

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

4.2.1 Design Features: Instruments

In its OIP, the licensee stated that the primary instrument channel (Channel A) and backup instrument channel (Channel B) are permanent, fixed channels. The instrument channels will provide level indication through the use of Guided Wave Radar (GWR) technology through the principle of Time Domain Reflectometry (TDR). The instrument provides a single continuous span from above Level 1 to within 1 foot of the top of the spent fuel racks.

In its letter dated February 27, 2015 [Reference 31], the licensee provided figures (Figures 1 and 2 in this SE) depicting the Unit 2 SFP sensor's measurement range from 70 feet, 5¼ inches to 94 feet, 3 inches plant elevation and Unit 3 SFP sensor's measurement range from 70 feet, 4½ inches to 94 feet, 2 inches plant elevation. The NRC staff noted that these measurement ranges cover Levels 1, 2, and 3 as described in Section 4.1 above.

The NRC staff finds that the licensee's design, with respect to the number of SFP instrument channels and instrument ranges, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.2 Design Features: Arrangement

Regarding SFPLI arrangement, in its letter dated August 27, 2014 [Reference 29], the licensee provided the final locations of the SFPLI probes and conduit routings of instrument channels for both Unit 2 and Unit 3. The primary instrument (Channel A) is located near the northwest corner of the SFP and the backup instrument (Channel B) is located near the southeast corner of the SFP.

As describing the Unit 2 SFPLI cable routing, in its letter dated December 2, 2016 [Reference 53], the licensee stated that Channel A originates along the north side of the pool. The conduit runs along the north wall until the west wall then heads south along the west wall. It penetrates through the west wall into the Fan House approximately 30 feet north of the doorway into the Fan House. The Channel B route will follow the east wall to the south wall, follow along the south wall and penetrate on the south side of the doorway between the Fan House and the Fuel Storage Building (FSB). Once outside the FSB, the two conduit runs will converge approximately 30 feet north of the door between the FSB and the Fan House. Each channel maintains plant design channelization requirements by remaining in their dedicated conduits. The two channels will be routed along to the hydrogen recombiner panel, which was previously removed from service, with the panel remaining in place. The two indicators are mounted on the panel.

For Unit 3 SFPLI cable routing, in its letter dated December 2, 2016 [Reference 53], the licensee stated that Channel A will penetrate through the west wall into the Fan House. The Channel B route will follow the east wall to the south wall, follow along the south wall and penetrate on the south side of the doorway between the Fan House and the Unit 3 FSB. Once outside the FSB, the two conduit runs will converge near the door between the FSB and the Fan House. Each channel will maintain plant design channelization requirements by remaining in their dedicated conduits. The two channels run down to the 67'-6" elevation of the Primary Auxiliary Building Fan House. Both conduits are routed through the existing penetration south of the door between the Fan House and the upper mezzanine of the pipe penetration area. Once through the penetration they are routed down the hall to the gas analyzer rack, which is part of the retired-in-place hydrogen recombiner panel.

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

Based on the evaluation above, the NRC staff finds that the licensee's arrangement for the SFPLI, if implemented appropriately, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately addresses the requirements of the order.

4.2.3 Design Features: Mounting

Regarding mounting design for the SFPLI probe mounting brackets, in its letter dated December 2, 2016 [Reference 53], the licensee stated that mounting bracket design and Seismic Category 1 mounting analysis are included in modification packages EC 45666 for Unit 3 and EC 50865 for Unit 2. Calculations IP-CALC-13-00082 for Unit 3 and IP-CALC-14-00087 for Unit 2 show that the spent fuel pool instrumentation (SFPI) probe mounting brackets are structurally adequate and seismically qualified as all interaction ratios (IRs) are less than one (1.0).

Related to other SFPLI equipment mounting design for Unit 2, in its letter date December 2, 2016 [Reference 53], the licensee stated that calculation IP-CALC-14-00086 addresses the seismic evaluation of all applicable conduit supports from the probes to the hydrogen recombiner panel. Calculation FCX-00102 addresses the seismic adequacy for mounting of the Mohr signal processor and backup dc battery cabinets on the hydrogen recombiner panel. Engineering change notice ECN 63614 to EC 50865 revises calculation FCX-00102 to include justification for the design of the bolting between the signal processor and the backup dc battery to the retired hydrogen recombiner panel.

As for other SFPLI equipment mounting design for Unit 3, in its letter dated December 2, 2016 [Reference 53], the licensee stated that calculations IP-CALC-13-00083 and IP3-NPD-10077-003.001 address the seismic evaluation of all applicable conduit supports from the probes to the hydrogen recombiner panel. The indicator panel, battery chargers, and isolator are mounted on a unistrut frame, which was analyzed for total loads.

The NRC staff finds that the licensee's proposed mounting design for the SFPLI appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately addresses the requirements of the order.

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 is not already covered by existing quality assurance requirements. Per 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 augmented quality requirements will be applied to all components in the instrumentation channels for the following:

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

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 the order.

4.2.4.2 Equipment 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 components used 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.

During the vendor audit [Reference 22], the NRC staff reviewed the Mohr SFPLI's qualifications and testing for temperature, humidity, radiation, shock and vibration, seismic, and electromagnetic compatibility. The staff further reviewed the anticipated Indian Point's seismic, radiation, and environmental conditions to verify the Indian Point bounding conditions. Below is the staff's assessment of the equipment reliability of the Indian Point SFPLI.

4.2.4.2.1 Radiation, Temperature, and Humidity

4.2.4.2.1.1 Radiation

With regard to radiological conditions at the SFP area related to the SFPLI qualifications, in its OIP the licensee stated that equipment located in the SFP will be qualified to withstand a total accumulated dose of expected lifetime at normal conditions plus accident dose received at post event conditions with SFP water level within 1 foot of the top of the fuel racks seated in the SFP. The licensee stated during the onsite audit that Unit 3 Calculation IP-CALC-13-00072, "Spent Fuel Pool Instrumentation Shielding Calculation," defines a worst case dose of 1.51E+07 rads to the probe, which is bounded by a cumulative dose of the probe service life (40 years) per proprietary Mohr Document 1-0410-2, "MOHR SFP-1 Level Probe Assembly Materials Qualification Report".

For radiological conditions at the Unit 2 hydrogen recombiner cabinets, where the SFPLI electronics equipment is located, in its letter dated December 2, 2016 [Reference 53], the licensee stated that calculation PGI-00412-00 concludes that the Unit 2 hydrogen recombiner panel is located in a mild environment and therefore is an acceptable location for the electronics enclosure and display. The licensee further stated that for Unit 3, calculation IP3-CALC-RAD-0004 indicates that the hydrogen recombiner panel, where the SFPI electronics are located, receives a dose rate of about 2 millirem/hr during normal plant operation. This results in a 40-year total integrated dose (TID) of 7.0E+02 rads, which is significantly lower than the Indian Point harsh environment limit (1.0E+04 rads). This supports the designation of this area as a mild environment and therefore acceptable for the electronics and display to be located.

The NRC staff notes that the licensee adequately addressed the equipment reliability of SFPLI with respect to radiation. The equipment qualification envelops the anticipated radiological conditions at Indian Point during a BDBEE.

4.2.4.2.1.2 Temperature and Humidity

In describing the temperature conditions at the Fan House area related to the SFPLI qualifications, in its letter dated December 2, 2016 [Reference 53], the licensee stated that the Unit 3 SFPI signal processor and display panel will be installed in the Fan House. Per calculation IP-CALC-13-00068, the maximum temperature is 125.7 °F, which is enveloped by the temperature the SFPI electronic equipment is qualified for (131 °F per proprietary Mohr Report 1-0410-1, "MOHR EFP-IL SFPI System Temperature and Humidity Test Report"). The Unit 2 signal processor/display panels will be installed on Elevation 90' of the Unit 2 upper Fan House. Calculation IP-CALC-14-00088 documents that the SFPLI will remain functional during a FLEX scenario, i.e. during extreme summer and winter ambient conditions, since the local ambient temperatures will remain within the allowable operating temperature range of the instruments. The maximum temperature determined in IP-CALC-14-00088 is 122.6 °F. Therefore, according to the licensee, it is reasonable to conclude that conditions in this area will not exceed the 131 °F which the SFPI was qualified to in Mohr Report 1-0410-1.

For the humidity conditions at the Fan House area, in its letter dated December 2, 2016 [Reference 53], the licensee stated that Mohr has successfully tested its system electronics to operate in a humidity range of 5 percent to 95 percent relative humidity (RH). During an extended loss of ac power, the Fan House HVAC systems will no longer be available. Prior to the Fan House access doors being opened (if opened to regulate temperature or allow FLEX hose connections) the relative humidity in the Fan House is expected to drop because the heat loads are dominated by the sensible heat of electrical equipment (fans). Under circumstances in which extreme heat is anticipated at Indian Point, the worst case outside conditions in the plant's design basis are temperatures of 93 °F dry bulb (db) and 75 °F wet bulb (wb), with coincident RH of approximately 43 percent. Thus, in the event a Fan House door is opened to the outdoors, the relative humidity is not expected to challenge the bounding Mohr test case. These conditions are bounded by the 131 °F and 50 percent RH test case presented in Mohr Report 1-0410-1. In the case of high humidity, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers defines a 0.4 percent dehumidification condition to be 79.8 °F db, 73.5 °F dew point, and about 81 percent RH for White Plains, New York. Similarly, 85.4 °F db, 76.6 °F wb, and about 67 percent RH is defined for a 0.4 percent evaporation condition. These conditions are also bounded by the test cases presented in Mohr Report 1-0410-1. Therefore, the operational humidity range of 5 percent to 95 percent encompasses all expected conditions for the SFPI display location. The sensor electronics are capable of continuously performing their required function under the expected humidity conditions.

The NRC staff noted that the licensee adequately addressed the equipment reliability of SFPLI with respect to temperature and humidity. The equipment qualifications envelop the expected Indian Point temperature and humidity conditions during a postulated BDBEE. The equipment environmental testing demonstrated that the SFPLI should maintain its functionality under expected BDB conditions.

4.2.4.2.2 Shock and Vibration

With regard to shock and vibration qualification of the SFPLI, in its letter dated December 2, 2016 [Reference 53], the licensee stated that the vendor testing adequately addresses the requirements for general robustness of the enclosures. The probe and repairable head are essentially a coax cable system that is considered inherently resistant to shock and vibration.

The probes and repairable head were evaluated to be adequately designed for resilience against shock and vibration. The new probe mounting components and fasteners are seismically qualified and designed as rigid components inherently resistant to vibration effects. The probes will be affixed to the bracket using a machine screw connection designed with proper thread engagement and lock washers. The signal processor/display panels and battery backups will be installed in the Fan House. The equipment is not affixed or adjacent to any rotating machinery that would cause vibration effects in the area of installation. The new instrument mounting components and fasteners are seismically qualified and designed as rigid components inherently resistant to vibration effects. Similarly, the effects of shock on the supporting fixtures for the Fan House instruments are not a credible threat; all equipment in the area is qualified seismically such that there are no expected impacts from adjacent objects during the BDBEE or design basis earthquake requirements imposed by NEI 12-02. Even though shock and vibration is not credible for Fan House equipment, it is adequately addressed by vendor test reports.

The NRC staff noted that the licensee adequately addressed the equipment reliability of the SFPLI system with respect to shock and vibration. If implemented appropriately, the SFPLI should provide its design functions.

4.2.4.2.3 Seismic

With regard to Indian Point SFPLI seismic qualification, in its letter dated December 2, 2016 [Reference 53], the licensee stated that Mohr has prepared site-specific seismic qualification reports for the Unit 3 SFPLI, which also bound Unit 2's seismic criteria. The qualification reports envelop all components of the new SFPLI required to be operational during a BDBEE and post-event. Therefore, the licensee stated that the SFP instrumentation and electronic units are acceptable for use at the site. The analyses are contained in the following proprietary Mohr Test and Measurement LLC Reports:

- NAI-1725-005, "Seismic Induced Hydraulic Response in the Indian Point 3 Spent Fuel Pool"
- NAI-1725-003, "GOTHIC Verification and Sensitivity Studies for Predicting Hydrodynamic Response to Acceleration in Rectangular Shaped Pools"
- 1-0410-6, "MOHR EFP-IL SFPI System Seismic Test Report"
- 1-0410-9.17, "MOHR SFP-1 Site-Specific Seismic Analysis Report: Indian Point Energy Center Unit 3 (Unit 3)"

The NRC staff noted that the licensee adequately addressed the equipment reliability of SFPLI with respect to seismic. The SFPLI was tested to the seismic conditions that envelop Indian Point's design basis maximum ground motion. Further seismic qualifications of the SFPLI mounting is addressed in Subsection 4.2.3, "Design Features: Mounting," of this evaluation.

The NRC staff finds that the Indian Point SFPLI qualification process is adequate. However, the staff has learned that there were incidents at other nuclear facilities, in which Mohr's SFPLI experienced failures of the filter coil (also called a choke). The staff requested Indian Point to address the impact of Mohr SFPLI failures on its equipment. The licensee provided a response in a letter dated December 2, 2016 [Reference 53], in which it stated that Mohr has determined the source of the failures is a miniature surface mount common-mode choke component used on the Video and Digicomp printed circuit boards within the EFP-IL Signal Processor. The new boards have equivalent substitute components that are less susceptible to transient electrical events. The substitute components have equivalent size, mass, and solder attachment technique as the original component such that there is no impact to the system mechanical characteristics. The components demonstrate equivalent electrical performance such that electromagnetic compatibility (EMC) characteristics are not significantly changed. Proprietary Mohr Report 1-1010-2, "EFP-IL MOD 1 Modification Package," addresses continued equipment qualification following the repair. The vendor-recommended repair was implemented on the Unit 2 equipment before this equipment was delivered to Unit 2. The vendor repair of the Unit 3 equipment was performed under warrantee repair purchase orders. The Unit 3 failure and subsequent repair for Channel B was captured under the Indian Point corrective action program and a work order. The Unit 3 Channel B equipment was returned to service in May 2015. The Unit 3 Channel A unit did not fail but was removed and sent to Mohr for warrantee repair. The work and repair on Channel A was also captured under the Indian Point corrective action program and a work order. The Unit 3 Channel A equipment was returned to service in July 2015. The factory acceptance test reports for the repaired units are captured under the proprietary Mohr Test Procedure 2014.01 EFP-IL00024 dated May 1, 2015, and EFP-IL00025 dated June 30, 2015.

The NRC staff's assessment of the modification package Mohr EFP-IL MOD 1, Revision 0, dated July 16, 2015, is summarized below.

In EFP-IL MOD 1, Mohr provided evaluation of the following hardware modifications:

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

Below is the summary of the vendor's evaluation of the above modifications:

<u>T1 Choke Replacement Evaluation</u>

<u>Temperature and Humidity</u>
The replacement choke has an operating temperature range of -40 degrees Celsius (°C) to +85 °C, exceeding the -10 °C to +55 °C requirement. Non-condensing humidity does not alter performance of this component.

Electromagnetic Compatibility (EMC)
There is no change to EMC qualification. The choke demonstrates equivalent or higher impedance to common mode noise.

Shock and Vibration
The mass differences are 0.002% and 0.47% for 01-EFP-IL-50001 enclosure mass and the board mass respectively and 0.0003% and 0.18% for 01-EFP-IL-50006 enclosure mass and the board mass respectively.

Seismic
Qualification by similarity to existing qualified equipment is permitted by the Institute of Electrical and Electronics Engineers standard 344-2004. Replacement of the T1 choke does not significantly alter equipment mass, mass distribution, or other mechanical characteristics.

Fusible Link Evaluation:

The 01-EFP-IL-50204 Fusible Link is added to the existing power board power cable. One Fusible Link is used per EFP-IL signal processor.

Temperature and Humidity
The Fusible Link's fuses are rated for -55 °C to +125 °C and 100% relative humidity per MIL-STD-201 Method 106.

Electromagnetic Compatibility (EMC)
There is no change to EMC qualification. The Fusible Link uses insulated wiring and connectors identical in configuration to the remainder of the previously qualified cable assembly and expected emissions are unchanged.

Shock and Vibration
The Fusible Link uses insulated wiring and connectors identical in configuration to the remainder of the cable assembly and is secured using identical tie-down and strain-relief methods which have been previously qualified.

The Fusible Link contributes approximately 0.14% enclosure mass, well within the expected variation of the unmodified EFP-IL signal processor enclosure mass due to manufacturing tolerances of system components.

The connectors are qualified by the manufacturer for vibration conditions per the Electronics Industries Alliance standard EIA 364-28 and shock loading at 50g. The connector rated minimum pull force is 8.0 pound-force (lbf) per wire terminal, for a total rating of 80.0 lbf for the 10 wire connector, equivalent to 2086g loading assuming a Fusible Link mass of 17.4 grams.

The Littelfuse fuse lead axial pull force is rated at 7 pounds per MIL-STD-202, which is equivalent to 182 gram static loading per fuse (two fuses per cable), assuming cable mass of 17.4 grams and conservatively neglecting stress shielding by cable wiring and insulation.

Seismic
The Fusible Link contributes approximately 0.14% enclosure mass, well within the expected variation of the unmodified EFP-IL signal processor enclosure mass due to manufacturing tolerances of system components.

Electrical Isolation Evaluation:

The front panel USB board 01-EFP-IL-50007 has been modified through addition of the component to provide galvanic USB isolation and enhance electrostatic discharge protection (±15 kV)

Temperature and Humidity
The additional component is rated for normal operation at -40 °C to +85 °C. The component is a hermetic plastic BGA package that is not susceptible to elevated humidity.

Electromagnetic Compatibility (EMC)
There is no change to EMC qualification. The isolation technology within the additional component is compliant with applicable standards including radiated emissions limit per International Electrotechnical Commission standard IEC 61000/CISPR 22. The device reduces the equipment's already low radiated emissions when the USB device is in use because it isolates and prevents noise on internal data and power lines from propagating to external devices connected to the front-panel USB port. The device is not active when USB devices are not in use.

Shock and Vibration
There is insufficient mass difference to alter the equipment shock and vibration response characteristics. The additional component is a rugged, compact, encapsulated surface-mount BGA package enveloped in size and mass by other components in the system. Surface mount components as a class are not susceptible to required levels of shock and vibration when mounted within the EFP-IL equipment enclosures.

Seismic
The nominal difference in enclosure mass is trivial at 0.014%, well within the expected variation of EFP-IL signal processor enclosure mass due to manufacturing tolerances of system components.

The NRC staff found the vendor adequately addressed the staff's concern with regard to the modified equipment qualifications. The temperature and humidity ratings of the replacement parts envelop the expected BDB environmental conditions of each unit's Fan House where the electronics equipment is located. Based on the vendor report, there is no indication that new electromagnetic emissions are introduced by the replacement parts. The mass differences are insufficient to alter the seismic, shock, and vibration response characteristics.

4.2.4.2.4 Electromagnetic Compatibility (EMC)

During the onsite audit at Indian Point, the NRC staff enquired as to an assessment of potential susceptibilities of Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) in the areas where the SFP instruments are located and how to mitigate those susceptibilities. In its letter dated December 2, 2016 [Reference 53], the licensee provided a response, in which it stated that the Operations procedures include a cautionary statement to preclude radio usage within close proximity to the displays when taking a reading. In addition, no system voltages being affected or installed are greater than 125 volts, and new instrumentation cables in the Fuel Storage Building and Fan House are being installed in rigid steel conduit where practical to limit the amount of EMI emitted by the new wiring. The isolation transformer being installed in the power circuit of each SFPI circuit will limit the introduction of any noise or harmonics (typically referred to as "total harmonic distortion") into electrical buses that may be generated by the new equipment. The topic notes of EC 50865 for Unit 2 requires that EMI/RFI exclusion zone signs be hung in the area immediately in front of the 22 hydrogen recombiner panel to preclude any EMI/RFI interference for radio or cell phone transmission or use. This also may be affixed to the face of the panel. A sign has been installed at Unit 3.

The NRC staff finds that the licensee adequately addressed the electromagnetic compatibility of the SFPLI. In addition to the equipment design and installation, the radio exclusion zones would provide preventive measure for EMI/RFI susceptibilities.

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 the order.

4.2.5 Design Features: Independence

With regard to the SFPLI independent design, in its letter dated August 20, 2013 [Reference 26], the licensee stated that locating the new instruments in the corners of the SFP takes advantage of missile and debris protection inherent in the corners. Channel A cable will be routed along the east FSB wall and then along the south FSB wall to enter the Fan House, while Channel B is routed along the west FSB wall until it enters the Fan House, maintaining physical separation in each FSB. Channel A and B displays will both be located on hydrogen recombiner panels in each unit's Fan House. Power for each channel is provided from independent existing 120 Vac, 60 hertz (Hz) power sources in the general area of the electronics packages. The primary channel will receive power from a different 480 Vac bus than the backup channel. Backup power for each channel is provided by a separate battery capable of providing continuous display operation for at least 3 days. The battery power will be provided to the display/processor. The design prevents failure of a single channel from causing the alternate channel to fail. Physical separation of the two channels will be accomplished by separately routing cable and conduit as much as practical.

In its letter dated December 2, 2016 [Reference 53], the licensee provided further information on the independence of the SFPLI power sources. In this letter, the licensee stated that for Unit 3, instrument Channel A is being powered from Instrument Bus 31, Circuit 28, and instrument Channel B is being powered from Instrument Bus 32, Circuit 28. For Unit 2, instrument Channel A is being powered from 120 Vac Distribution Panel 1, Circuit 6, and instrument Channel B is being powered from 120 Vac Distribution Panel 2, Circuit 6. The 120 Vac Distribution Panel 1 is powered from 480 Vac Bus 5A via MCC-26A and MCC-26AA. The 120 Vac Distribution Panel 2 is powered from redundant 480 Vac Bus 6A via MCC26B and MCC-26BB. The 480 Vac Bus 5A is backed up by Emergency Diesel Generator 21 while Bus 6A is backed up by Emergency Diesel Generator 23.

The NRC staff noted, and verified during the walkdown, that the licensee adequately addressed the SFPLI channel independence. The instrument channels' physical separation is further discussed in Subsection 4.2.2, "Design Features: Arrangement". With the licensee's proposed design, the loss of one level instrument channel would not affect the operation of the other channel under BDBEE conditions. The 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 the order.

4.2.6 Design Features: Power Supplies

With regard to the SFPLI power supply, in its OIP, the licensee stated that the power supplies for the instrument channels are arranged as follows:

- Each instrument channel is normally powered from a 120/118 Vac 60 Hz plant distribution panel to support continuous monitoring of SFP level. The primary channel will receive power from a different 480 Vac bus than the backup channel. Therefore, loss of any one 480 Vac bus does not result in loss of normal 120 Vac power for both instrument channels.

- On loss of normal 120/118 Vac power, each channel's uninterruptible power supply automatically transfers to a dedicated backup battery. If normal power is restored, the channel automatically transfers back to the normal ac power.

- The backup batteries are maintained in a charged state by commercial-grade uninterruptible power supplies. The batteries are sized to be capable of supporting intermittent monitoring for a minimum of 3 days of operation. This provides adequate time to allow the batteries to be replaced or until off-site resources can be deployed by the mitigating strategies resulting from Order EA-12-049.

- An external connection permits powering the system from any portable power source.

- Instrument accuracy and performance are not affected by restoration of power or restarting the processor.

In its letter dated August 20, 2013 [Reference 26], the licensee further stated that the sample rate estimates have been developed by the vendor using conservative instrument power requirements and measured battery capacity with draw-downs during and following exposure of the batteries to their maximum operating temperature for up to seven days. The instrument configuration is planned to be established for an automated sample rate when under battery power consistent with 7 days continuous operation. Permanent installed battery capacity for 7 days continuous operation is planned consistent with NEI 12-02 duration without reliance on or crediting of potentially more rapid FLEX program power restoration. Batteries are readily replaceable via spare stock without the need for recalibration to maintain accuracy of the instrument. These measures ensure adequate power capacity and margin.

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 addresses the requirements of the order.

4.2.7 Design Features: Accuracy

With regard to the SFPLI design accuracy, in its OIP, the licensee described the accuracy and indication features as follows:

- Accuracy: The absolute system accuracy is better than ± 3 inches. This accuracy is applicable for normal conditions and the temperature, humidity, chemistry, and radiation levels expected for BDBE event conditions.

- Trending: The display trends and retains data when powered from either normal or backup power.

- Restoration after Loss of Power: The system automatically swaps to available power (backup battery power or external dc source) when normal power is lost. Neither the source of power nor system restoration impact accuracy. Previously collected data is retained.

- Diagnostics: The system performs and displays the results of real-time information related to the integrity of the cable, probe, and instrument channel.

In its letter dated August 20, 2013 [Reference 26], the licensee stated that the instrument channel level accuracy will be specified as ± 3.0 inches for all expected conditions. The expected instrument channel accuracy performance would be approximately ±1 percent of span (based on the sensitive range of the detector). In general, relative to normal operating conditions, any applicable calibration procedure tolerances (or acceptance criterion) are planned to be established based on manufacturer's stated/recommended reference accuracy (or design accuracy). The methodology used is planned to be captured in plant procedures and/or programs.

In its letter dated December 2, 2016 [Reference 53], the licensee further stated that Mohr's proprietary Report 1-0410-10, "MOHR EFP-IL SFPI System Power Interruption Report," Rev. 1, describes power interruption testing on the EFP-IL signal processing unit and battery. Test results indicate that no deficits were identified with respect to maintenance of reliable function, accuracy, or calibration as a result of power interruption. The SFPI system's accuracy was maintained without recalibration following the power interruption.

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 the order.

4.2.8 Design Features: Testing

With regard to the SFPLI's testing design feature, in its letter dated August 20, 2013 [Reference 26], the licensee stated that the level instrument automatically monitors the integrity of its level measurement system using in-situ capability. Deviation of measured test parameters from manufactured or as-installed configuration beyond a configurable threshold prompts operator intervention. Periodic calibration checks of the signal processor electronics to extrinsic National Institute of Standards and Technology (NIST)-traceable standards can be achieved through the use of standard measurement and test equipment. The probe itself is a perforated tubular coaxial waveguide with defined geometry and is not calibrated. It is planned to be periodically inspected electromagnetically using TDR at the probe hardline cable connector to demonstrate that the probe assembly meets manufactured specification and visually to demonstrate that there has been no mechanical deformation or fouling. Each instrument electronically logs a record of measurement values over time in non-volatile memory that is compared to demonstrate constancy, including any changes in pool level, such as that associated with the normal evaporative loss/refilling cycle. The channel level measurements can be directly compared to each other (i.e., regular cross-channel comparisons). Direct measurements of SFP level may be used for diagnostic purposes if cross-channel comparisons are anomalous.

For the SFPLI functional test, in its letter dated August 20, 2013 [Reference 26], the licensee stated that performance tests (functional checks) are automated and/or semi-automated (requiring limited operator interaction) and are performed through the instrument menu software and initiated by the operator. Other tests such as menu button tests, level alarm, and alarm relay tests are only initiated manually by the operator. Performance tests are planned to be performed periodically as recommended by the equipment vendor.

The NRC staff finds that the licensee's proposed SFP instrumentation design allows for testing and appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.9 Design Features: Display

With regard to the location of the SFPLI display, in its letter dated August 20, 2013 [Reference 26], the licensee stated that the primary and backup displays will be mounted in each unit's Fan House building.

Related to the accessibility and habitability of the display location, in its letter dated December 2, 2016 [Reference 53], the licensee stated that for Unit 3 the display location can be reached without unreasonable delay utilizing the path to access the 67'-6" elevation of the Fan House which is through the radiological controlled area (RCA) access point into the Primary Auxiliary Building (PAB). A walkdown was performed from the CCR to the display location on the 67'-6" elevation of the Fan House and it was timed at less than or equal to 20 minutes. There are also multiple other pathways to access the display if this primary route is not available following the BDB event. IP-CALC-13-00068, "Fan House Temperature Evaluation for FLEX Event SFP Level Instrument Function," analyzed the temperature conditions of the display location and concluded that although the maximum temperature could reach 125 °F, in an extreme heat condition, it will remain habitable for an operator to access the display and obtain the level information.

The licensee further stated that for Unit 2, the display location can be reached without unreasonable delay utilizing the "normal" path to access the 88'-0" elevation of the Fan House which is through the RCA access point into the PAB and then into the Fan House. The PAB is a Seismic Category I building and the path consists of hallways which can be accessed following a BDB event. A walkdown was performed from the CCR to the display location on the 90'-0" elevation of the Fan House and it was timed at less than or equal to 20 minutes. There are also multiple other pathways (dependent upon the path obstruction) to access the display if this primary route is not available following the BDB event. Procedure EC 50865 evaluated the habitability of this location with an evaluation similar to that which was performed for Unit 3. Entergy does not plan to have an operator continuously stationed at the display but will read the display on an as-needed basis.

The NRC staff finds that the licensee's proposed location and design of the SFPLI displays appear to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.3 Evaluation of Programmatic Controls

4.3.1 Programmatic Controls: Training

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

The NRC staff finds that the licensee's proposed plan to train personnel in the operation and maintenance of the instrument channels, 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 the order.

4.3.2 Programmatic Controls: Procedures

With regard to the procedures related to the SFPLI, in its letter dated December 2, 2016 [Reference 53], the licensee stated that the calibration and test procedures developed by Mohr are provided in the Mohr technical manuals. The objectives are to measure system performance, determine if there is a deviation from normal tolerances, and return the system to normal tolerances. Diagnostic procedures developed by Mohr are provided as automated and semi-automated routines in system software alerting the operator to abnormal deviation in selected system parameters such as battery voltage, 4-20 milliamp loop continuity, and TDR waveform of the transmission cable. The technical objective of the diagnostic procedures is to identify system conditions that require operator attention to ensure continued reliable water level measurement. Manual diagnostic procedures are also provided in the event that further troubleshooting is determined to be necessary. The maintenance procedures developed by Mohr are provided in the technical manual. These allow a technician trained in EFP-IL system maintenance to ensure that system functionality is maintained.

In the same letter above, the licensee also provided a list of the procedures related to the SFPLI as follows:

- For Unit 3, Procedure 3-PT-Q140 provides guidance for performing a Channel Check of the primary and backup SFP level instrument channels, LI-6500-A, SFP Level Indicator Channel A, and LI-6500-B, SFP Level Indicator Channel B. 2-PT-Q096 is the comparable procedure for Unit 2.

- Operator Rounds procedure 3-RND-NUC has been created to check the status of the Unit 3 instrumentation daily. A comparable operator rounds procedure will be developed for Unit 2.

- 3-FSG-011 is a new procedure for Unit 3 which provides actions to restore SFP level using an alternate makeup source for a BDBEE resulting in an ELAP. This procedure includes remote SFP Level Indicator operation, the location of the displays, and cautionary statements such as an EMI/RFI exclusion zone around the displays. 2-FSG-011 is the comparable procedure for Unit 2.

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 the order.

4.3.3 Programmatic Controls: Testing and Calibration

In its OIP, the licensee stated that station procedures and preventive maintenance tasks will be developed to perform required surveillance testing, calibration, backup battery maintenance, functional checks, and visual inspections of the probes.

In its letter dated August 20, 2013 [Reference 26], the licensee stated that SFPI channel/equipment maintenance/preventative maintenance and testing program requirements to ensure design and system readiness are planned to be established in accordance with Entergy's processes and procedures and in consideration of vendor recommendations to ensure that appropriate regular testing, channel checks, functional tests, periodic calibration, and maintenance is performed. Subject maintenance and testing program requirements are planned to be developed during the SFPI modification design process. 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 is out-of-service for an extended period of time.

In its letter dated December 2, 2016 [Reference 53], the licensee further described the SFPLI testing and calibration program as follows:

- Operator Rounds to be performed twice a shift using procedure 3-RND-NUC to check the status of the Unit 3 instrumentation daily. A comparable operator rounds procedure will be developed for Unit 2. These procedures will record the indicated SFP level on each channel and will check that the green status light on each channel is indicating properly. If status light indication is unsatisfactory, the direction is provided to contact system engineering.

- Channel Check will be performed quarterly. For Unit 3, procedure 3-PT-Q140 provides guidance for performing a Channel Check of the primary and backup SFP level instrument channels, LI-6500-A, SFP Level Indicator Channel A, and LI-6500-B, SFP Level Indicator Channel B. 2-PT-Q096 is the comparable procedure for Unit 2. These procedures will be used to record the status of the green system status light, record the level displayed on each channel, convert the displayed level to read in feet and inches and compare this value to the SFP level gauge which is permanently mounted in the SFP. These procedures confirm that each channel of the SFP level indicating system is reading within +/- 3 inches of the actual SFP water level.

- Channel Check/Panel Functional Check will be performed yearly using PMID task 1 to check the status of the green status light, verify the time stamp on the display, verify the correct channel designation is shown on the display, verify the battery status is indicating properly, verify the display is working and the display is showing a proper pool level. This task disconnects the ac sources and confirms the display reverts to battery power and continues to indicate proper level and the battery status icon changes color. AC power is restored and the operator confirms the battery status icon changes back to normal color and the system functions as expected based on display indications and the green status light.

- Signal Processor Clock Battery Replacement will be performed every 10 years using PMID task 2 to prevent failure of the onboard clock battery and adverse impact to the signal processor operating system.

- Flushing of the probe assembly will be performed on an as-needed basis using PMID task 3 to remove boric acid buildup.

During the onsite audit, the NRC staff enquired as to the compensatory actions for extended out-of-service conditions for Indian Point SFPLI. The licensee provided a response in its letter dated December 2, 2016 [Reference 53], in which it stated that compensatory actions for out of service SFPI channel(s) will be controlled by inclusion in the Plant's Technical Requirements Manual (TRM).

Below is the TRM related to the SFPLI:

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. The primary OR back-up spent fuel pool level instrument does not meet the FUNCTIONAL requirements.	A. Restore spent fuel pool level instrument to FUNCTIONAL status	14 days
B. Action A. completion time not met.	B. Present a report to OSRC [On-Site Review Committee] on why out of service with plan to repair and plans for compensatory measures	14 days
C. The primary OR back-up spent fuel pool level instrument does not meet the FUNCTIONAL requirements.	C. Initiate actions to implement compensatory measures such as use of alternate suitable equipment or supplemental personnel	90 days
D. The primary AND backup spent fuel pool level	D. Restore one of the channels of instrumentation	24 hours

instruments do not meet the FUNCTIONAL requirements.		
E. Required Action and associated Completion Time of Condition D not met.	E. Initiate action to implement compensatory measures such as use of alternate suitable equipment or supplemental personnel	Immediately

The NRC staff noted that the licensee adequately addressed necessary testing and calibration for the primary and backup SFPLI to maintain the instrument channels at the design accuracy. The licensee testing and calibration plan appears to be consistent with the vendor recommendations. Additionally, compensatory actions for instrument channel(s) out-of-service appear to be consistent with guidance in NEI 12-02.

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

4.4 Conclusions for Order EA-12-051

In its letters dated May 20, 2015 [Reference 34], and August 12, 2016 [Reference 35], the licensee stated that it met the requirements of Order EA-12-051 by following the guidelines of NEI 12-02, as endorsed by JLD-ISG-2012-03. In the evaluation above, the NRC staff finds that, if implemented appropriately, the licensee's plans conform to the guidelines of NEI 12-02, as endorsed by JLD-ISG-2012-03. Based on the evaluations above, the NRC staff concludes that if the SFP level instrumentation is installed at Indian Point Unit 2 and Unit 3 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 onsite audits in October 2014 [Reference 17], and November 2015 [Reference 18]. The licensee reached its final compliance date on June 14, 2016, 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.

6.0 REFERENCES

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

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

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

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

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

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

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

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

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

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INDIAN POINT NUCLEAR GENERATING UNIT NOS. 2 AND 3 - SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 DATED MARCH 27, 2017

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