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

December 18, 2017

Mr. Bryan C. Hanson
Senior Vice President
Exelon Generation Company, LLC
President and Chief Nuclear Officer
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: JAMES A. FITZPATRICK NUCLEAR POWER PLANT – 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. MF1077 AND MF1076; EPID NOS. L-2013-JLD-0009 AND L-2013-JLD-0010)

Dear Mr. Hanson:

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. ML13063A287), Entergy Nuclear Operations, Inc. (Entergy), submitted an OIP for the James A. FitzPatrick Nuclear Power Plant (FitzPatrick) in response to Order EA-12-049. By letter dated March 31, 2017 (ADAMS Accession No. ML17082A283), the NRC staff issued a license amendment reflecting the transfer of the FitzPatrick operating license from Entergy to Exelon Generation Company, LLC. By letter dated November 30, 2017 (ADAMS Accession No. ML17313A077), the NRC staff issued a license amendment reflecting the ownership transfer of the FitzPatrick operating license from Exelon Generation Company, LLC to Exelon FitzPatrick, LLC. Exelon Generation Company (Exelon, the licensee) continues to be the operator of FitzPatrick. At six month intervals following the submittal of the OIP, Entergy submitted reports on its progress in complying with Order EA-12-049 at FitzPatrick. These reports were required by the order, and are listed in the attached safety evaluation. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated February 21, 2014 (ADAMS Accession No. ML14007A681), and December 14, 2016 (ADAMS Accession No. ML16343A011), the NRC

issued an Interim Staff Evaluation (ISE) and audit report, respectively, regarding the progress towards Order EA-12-049 compliance at FitzPatrick. By letter dated August 29, 2017 (ADAMS Accession No. ML17241A248), Exelon submitted a compliance letter and Final Integrated Plan 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 28, 2013 (ADAMS Accession No. ML13060A447), Entergy submitted an OIP for FitzPatrick in response to Order EA-12-051. At six month intervals following the submittal of the OIP, Entergy 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 December 12, 2013 (ADAMS Accession No. ML13338A645), and December 14, 2016 (ADAMS Accession No. ML16343A011), the NRC staff issued an ISE and audit report, respectively, regarding the progress towards Order EA-12-051 compliance at FitzPatrick. By letter dated March 26, 2014 (ADAMS Accession No. ML14083A620), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-051 in accordance with NRC NRR Office Instruction LIC-111, similar to the process used for Order EA-12-049. By letter dated August 29, 2017 (ADAMS Accession No. ML17241A249), Exelon 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 Exelon's strategies for FitzPatrick. The intent of the safety evaluation is to inform Exelon regarding whether or not its integrated plans, if implemented as described, appear to adequately address the requirements of Orders EA-12-049 and EA-12-051. The staff will evaluate implementation of the plans through inspection, using Temporary Instruction 2515-191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications/Staffing/Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML15257A188). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

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

Sincerely,

Mohamed K. Shams, Chief
Beyond-Design-Basis Management Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket No.: 50-333

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

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UNITED STATES
**NUCLEAR REGULATORY COMMISSION**
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

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

EXELON FITZPATRICK, LLC

EXELON GENERATION COMPANY, LLC

JAMES A. FITZPATRICK NUCLEAR POWER PLANT

DOCKET NO. 50-333

## 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.

Enclosure

## 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 of operation.

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

On December 10, 2015, following submittals and discussions in public meetings with NRC staff, the Nuclear Energy Institute (NEI) submitted document NEI 12-06, Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," [Reference 6] to the NRC to provide revised specifications for an industry-developed methodology for the development, implementation, and maintenance of guidance and strategies in response to the Mitigation Strategies order. The NRC staff reviewed NEI 12-06, Revision 2, and on January 22, 2016, issued Japan Lessons-Learned Directorate (JLD) Interim Staff Guidance (ISG) JLD-ISG-2012-01, Revision 1, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," [Reference 7], endorsing NEI 12-06, Revision 2, with exceptions, additions, and clarifications, as an acceptable means of meeting the requirements of Order EA-12-049, and published a notice of its availability in the *Federal Register* (81 FR 10283).

2.2 Order EA-12-051

Order EA-12-051, Attachment 2, [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), submitted its OIP for James A. FitzPatrick Nuclear Power Plant (JAF, FitzPatrick) in response to Order EA-12-049. By letter dated March 31, 2017 [Reference 40], the NRC staff issued a license amendment reflecting the transfer of the FitzPatrick operating license from Entergy to Exelon Generation Company, LLC. By letter dated November 30, 2017 [Reference 63], the NRC staff issued a license amendment reflecting the ownership transfer of the FitzPatrick operating license from Exelon Generation Company, LLC to Exelon FitzPatrick, LLC. Exelon Generation Company (Exelon, the licensee) continues to be the operator of FitzPatrick. By letters dated August 28, 2013 [Reference 11], February 28, 2014 [Reference 12], August 28, 2014 [Reference 13], February 27, 2015 [Reference 14], August 28, 2015 [Reference 15], February 26, 2016 [Reference 16], August 25, 2016 [Reference 17], and February 28, 2017 [Reference 18], Entergy submitted six-month updates to the OIP. By letter dated August 28, 2013 [Reference 19], 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 42]. By letters dated February 21, 2014 [Reference 20], and December 14, 2016 [Reference 21], the NRC issued an Interim Staff Evaluation (ISE) and an audit report regarding progress toward Order EA-12-049 compliance at FitzPatrick. By letter dated August 29, 2017 [Reference 22], Exelon 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.

FitzPatrick is a General Electric (GE) boiling-water reactor (BWR), Model 4, with a Mark I containment. The licensee's three-phase approach to mitigate a postulated ELAP event, as described in the FIP, is summarized below.

At the onset of an ELAP, the reactor is assumed to trip from full power. The main condenser is unavailable due to the loss of circulating water. Decay heat is initially removed when the safety relief valves (SRVs) open on high pressure and dump steam from the reactor pressure vessel (RPV) to the suppression pool (torus). Makeup to the RPV is primarily provided by the reactor core isolation cooling (RCIC) turbine-driven pump, taking a suction from the Condensate Storage Tanks (CSTs). The licensee expects the plant operators to take manual control of the SRVs and to eventually begin a controlled cooldown and depressurization of the reactor. The cooldown is stopped when reactor pressure reaches a control band of approximately 200 pounds per square inch gauge (psig) to 400 psig, to ensure sufficient steam pressure to operate the RCIC pump. The RPV makeup is expected to be provided from the RCIC system for approximately 22 hours, until the inventory in the CSTs is depleted, at which point RPV makeup will be transitioned to a diesel-driven fire pump (DDFP), taking suction from Lake Ontario, the UHS for the plant.

In order to remove energy from the torus, the licensee plans to align an existing vent path. The licensee's FIP refers to this vent path as the [NRC] Generic Letter 89-16 vent. This pathway uses, in part, a portion of the standby gas treatment system (SGTS) to establish a flow path to the outside environment. The venting will be initiated at a pressure of approximately 10 psig in the torus, which is well below the primary containment pressure limit (PCPL) of 62 psig. This venting is expected to begin at approximately 5.5 hours into the event and is expected to continue until equipment from obtained offsite resources can be set up to establish shutdown cooling.

The FitzPatrick SFP is located in the Reactor Building. The licensee has three methods to provide SFP makeup. The licensee plans to perform an initial setup of the necessary hoses and support equipment as early as possible into the event, but prior to the applicable areas of the Reactor Building reaching 120 degrees Fahrenheit (°F). The licensee also plans to vent the Reactor Building within 5 hours of the event. Thus, the licensee will be able to initiate SFP makeup from outside the vicinity of the SFP once these setup actions are complete. The SFP will initially heat up due to the unavailability of the normal cooling system. The licensee has calculated that, for a normal (plant operating) SFP heat load, boiling could start as soon as 32.7 hours after the start of the ELAP. To makeup to the SFP, the licensee has a primary and two alternate strategies. The primary makeup strategy is to use a DDFP to supply water to the SFP via hose connections and installed piping systems.

The backup methods use hoses run from the discharge of the DDFPs to the SFP area to allow direct hose makeup or connection to monitor spray nozzles.

The operators will perform a dc bus load shed that will be completed approximately 90 minutes into the event. This will extend the useable battery life to approximately 9.5 hours. Following dc load stripping and prior to battery depletion, one 200-kilowatt (kW), 600 Volts-ac (Vac) FLEX diesel generator (DG) will be deployed. The FLEX DG will be used to repower Division 1 or Division 2 essential battery chargers prior to depletion of the batteries. The licensee estimates

that there will be approximately one hour of margin between deployment of the FLEX DG and battery depletion.

In addition, a National Strategic Alliance for FLEX Emergency Response (SAFER) Response Center (NSRC) will provide high capacity pumps and large combustion turbine generators (CTGs) which could be used to provide backup equipment and to allow restoration of one residual heat removal (RHR) shutdown cooling train for long-term core cooling in Phase 3 of the event.

Below are specific details on the licensee's strategies to restore or maintain core cooling, containment, and SFP cooling capabilities in the event of a BDBEE, and the results of the staff's review of these strategies. The licensee's FIP states that the plan was based on the NRC-endorsed guidance of NEI 12-06, Revision 4. Since the NRC has not yet published an endorsement of NEI 12-06, Revision 4, in the *Federal Register*, the NRC staff evaluated the licensee's strategies against the endorsed NEI 12-06, Revision 2, guidance, with a clarification provided in Section 3.14 of this safety evaluation.

## 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 DGs 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.

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, the unit would have been operating at full power prior to the event. Therefore, the suppression pool may be credited as the heat sink for core cooling during the event. Maintenance of sufficient RPV inventory, considering steam release from the SRVs and 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 event are discussed in further detail below. The licensee's strategy for ensuring compliance with Order EA-12-049 for conditions where the unit is shut down or being refueled is reviewed separately in Section 3.11 of this safety evaluation.

### 3.2.1 Core Cooling Strategy and RPV Makeup

#### 3.2.1.1 Phase 1

The FitzPatrick FIP states that the injection of cooling water into the RPV in Phase 1 will be accomplished through the RCIC system. Because the turbine for the RCIC pump is driven by steam from the RPV, operation of the RCIC system further assists the SRVs with RPV pressure control. The RCIC system suction is initially lined up to the CSTs. The CSTs are partially below

grade and the below grade portions are considered to be a protected source of water for the ELAP event. The RCIC pump is protected from all applicable hazards.

According to the licensee's FIP, pressure control of the RPV is accomplished using the pneumatically-operated SRVs. The SRV controls are powered from the 125 Volts-dc (Vdc) buses. Within 1 hour after the initiation of the event, operators will utilize the SRV's to depressurize the RPV to 400-600 psig at a rate of less than 100°F per hour. After this point, at around 2.5 hours, the RPV pressure is further lowered and maintained between 200 and 400 psig. This RPV pressure is sufficient to allow for continued operation of the RCIC system. There is a nitrogen system in place to allow the continued operation of the SRV's for at least 24 hours after the initiation of the ELAP event.

The station batteries and the Class 1E 125 Vdc distribution system provide power to RCIC components and instrumentation. According to the sequence of events presented in the licensee's FIP, an initial load shed is performed, followed by an additional load shed. FLEX load shedding is completed 90 minutes into the event. This load shedding will extend the battery capacity to power the Phase I systems and instrumentation up to 9.5 hours and allow time for the FLEX DGs to be deployed.

3.2.1.2 Phase 2

The licensee's FIP states that RCIC will continue to be used until it is necessary to transfer RPV makeup to an installed DDFP. A hose will be connected between the fire system and the RHR service water (RHRSW) system to establish a flow path, with appropriate valve manipulations, for injection into the RPV. To allow the low pressure DDFP to have the capacity to inject the needed flow of coolant water (approximately 150 gallons per minute (gpm)) the RPV will be depressurized to approximately 50 psig.

The alternate core cooling strategy involves using a second permanently installed DDFP. This strategy provides a completely independent flow path to the RPV. Either DDFP can be used with either injection path for additional flexibility. According to the licensee's FIP, Lake Ontario provides a large volume of water sufficient to provide makeup indefinitely. Other non-robust clean water sources are present on site. These are not credited in the strategy, but could be used in lieu of raw lake water, if available.

In order to remove energy from the suppression pool, the licensee plans to open the containment vent at a pressure of 10 psig. Since the strategy does not involve RCIC taking suction from the suppression pool, RCIC net positive suction head is not a concern.

According to the licensee's FIP, the available nitrogen supply in the containment atmosphere dilution (CAD) tanks is capable of supplying nitrogen to accommodate the necessary SRV actuations for the first 120 hours, after which the NSRC compressor would be available. However, the CAD tanks are not protected from tornado missiles. To preserve nitrogen in the event of damage to the CAD tanks, the FLEX Support Guidelines (FSGs) will direct that certain valves be closed within two hours of the initiation of the event. This protects sufficient nitrogen to support 72 hours of SRV operation. After this time, an NSRC compressor would be available.

In the event that raw water is used to provide core cooling, the licensee's FIP indicates that the site strategy is consistent with the guidance contained in BWR Owners Group (BWROG) report BWROG-TP-14-006, "Fukushima Response Committee Raw Water Issue: Fuel Inlet Blockage from Debris." This guidance contains direction to maintain the RPV water level at the level of

the moisture separator drains to ensure that core cooling is maintained while considering the possible clogging of fuel element orifices and filters.

3.2.1.3 Phase 3

According to the licensee's FIP, the Phase 3 strategy would be to maintain and supplement/replace the Phase 2 strategy with Phase 3 equipment. The Phase 3 equipment begins to arrive from the NSRC within 24 hours of the NSRC notification. It can then be deployed to replace Phase 2 components. The Phase 2 connection points are compatible with the equipment that will be arriving from the NSRC. For core cooling, the NSRC-supplied medium flow/low pressure pump would be combined with the suction lift booster pump to inject water into the RPV, if needed.

The licensee's FIP also describes using the medium flow/low pressure pump with the suction lift booster pump to establish RHR shutdown cooling. This would allow for long term closed loop cooling of the RPV. The NSRC 4160 Vac CTGs would be used to supply the electrical power needed to establish this cooling mechanism.

3.2.2 Variations to Core Cooling Strategy for Flooding Event

There are no variations in the licensee's strategy for a flooding event.

3.2.3 Staff Evaluations

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

Guidance document NEI 12-06 describes 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 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

Phase 1

In the licensee's FIP, Section 2.3.4.1 describes the RCIC system as consisting of a steam-driven turbine pump that takes suction from the CSTs and utilizes RPV steam to drive the turbine. The turbine exhaust is directed to the suppression pool. The RCIC system operates automatically when the reactor water level reaches a "low-low" water level following the ELAP event. The system operates independently of the ac power, service air, and external cooling water systems. It relies on power from the station's 125 Vdc batteries for operation of valves and controls. It is located in the Reactor Building which, according to the licensee's FIP, is protected from all applicable external hazards. According to Table 2 of the licensee's FIP, the CSTs are protected from all postulated external events. For a high wind (tornado) event they are protected up to a specific level and the volume of water below that level corresponds to approximately 192,000 gallons. Thus, this volume is used as in the licensee's analysis for RPV makeup and the licensee estimates that it will provide RPV cooling for 22 hours. Based on the FIP description, the NRC staff finds that the RCIC system and the CSTs 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.

Section 2.3.4.2 in the licensee's FIP describes the operation of the SRVs for RPV pressure control. The SRVs require dc control power from the station's batteries and pneumatic pressure to operate. The SRVs have accumulators to support operation for a set number of cycles. For non-tornado events, the licensee determined that 127 SRV actuations will be required over a period of 120 hours. According to the licensee, the CAD tanks would provide the nitrogen needed for operation of the SRVs for this period of time. For tornado-related ELAP events, the CAD tanks are expected to not be available, therefore administrative controls are in place that will ensure that only 2-stage SRVs are used for pressure control. This operation, combined with procedurally directed valve manipulations, would allow for 72 hours of nitrogen availability for the SRVs. The licensee states that this would provide sufficient time for an NSRC-supplied compressor to become available. The SRVs and controls are located in the Reactor Building, which is protected from all applicable external hazards. Additionally, the SRVs are safety-related. Based on the FIP description, the NRC staff finds the SRVs and support systems (with the partial exception of the CAD tanks, as described above) 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.

Phase 2

The licensee's RPV makeup strategy for Phase 2 transitions from the RCIC system to the use of one of two permanently-installed DDFPs. Operators are directed by FSGs to align one of the DDFPs to the RHRSW system using a pre-staged fire hose, prior to the CSTs depleting. Each DDFP is located in a separate bay inside the Seismic Category I Screenwell Building, which is protected from all applicable external hazards. The DDFPs are powered by diesel-fueled internal combustion engines, and utilize 24 Vdc battery powered control and starting systems. Each DDFP can operate for at least 8 hours without refueling and a fuel tank is located in each diesel fire pump room. According to the licensee's FIP, the DDFPs and the piping necessary to implement the strategy are seismically robust. Based on the FIP description, the NRC staff concludes that the DDFPs are robust and would be expected to be available at the start of an ELAP event consistent with NEI 12-06, Section 3.2.1.3. The availability of the FLEX connection points for the DDFPs and the water sources for the strategy are discussed in Sections 3.7 and 3.10 of this safety evaluation, respectively.

Phase 3

The licensee's Phase 3 RPV inventory strategy does not rely on any additional installed plant SSCs other than those discussed in Phase 1 and 2. However, the licensee can use one of the DDFPs or an NSRC-supplied pump to connect to robust plant systems that will support shutdown cooling.

#### 3.2.3.1.2 Plant Instrumentation

The licensee's plans to monitor instrumentation in the Main Control Room (MCR) to support FLEX cooling strategy. The instrumentation is powered by station batteries and will be maintained for indefinite coping via battery chargers powered by the FLEX DGs and/or the NSRC CTGs in later phases of the event. A more detailed evaluation of the instrumentation power supply is contained in Section 3.2.3.6 of this safety evaluation.

As described in the FIP, the following MCR instrumentation will be relied upon to support the core cooling and inventory control strategy:

- RPV level (wide range)
- RPV pressure
- Suppression pool level
- Suppression pool temperature

The NRC staff concludes that the instrumentation identified by the licensee to support its core cooling strategy is consistent with the recommendation specified in the endorsed guidance of NEI 12-06.

According to the licensee's FIP, instrumentation is initially powered by station batteries during the ELAP event. In Phase 2, the batteries are charged by use of a FLEX DG which provides power to the battery chargers through emergency buses. Based upon the information provided by the licensee, the NRC staff understands that the locations of the instrument indications would be accessible continuously throughout the ELAP event.

According to the licensee's FIP, alternate access points for monitoring key parameters have been identified. This is in accordance with the provisions of NEI 12-06 Section 5.3.3.1, which specifies that guidelines for obtaining critical parameters locally should be provided in a reference source. During the audit process the staff reviewed FitzPatrick guideline FSG-006, "Loss of Vital Instrumentation or Control Power," Revision 0, to confirm that it provides alternate methods for obtaining critical parameters if key parameter instrumentation is unavailable.

3.2.3.2 Thermal-Hydraulic Analyses

The licensee's mitigating strategy for reactor core cooling is based, in part, on a thermal-hydraulic analysis performed using Version 4 of the Modular Accident Analysis Program (MAAP). Because the thermal-hydraulic analysis for the reactor core and containment during an ELAP event are closely intertwined, as is typical of BWRs, FitzPatrick has addressed both in a single, coupled calculation. This dependency notwithstanding, the NRC staff's discussion in this section focuses on the licensee's analysis of reactor core cooling. The NRC staff's review of the licensee's analysis of containment thermal-hydraulic behavior is provided subsequently in Section 3.4.4.2 of this safety evaluation.

The MAAP is an industry-developed, general-purpose thermal-hydraulic computer code that has been used to simulate the progression of a variety of light water reactor accident sequences, including severe accidents such as the Fukushima Dai-ichi event. Initial code development began in the early 1980s, with the objective of supporting an improved understanding of and predictive capability for severe accidents involving core overheating and degradation in the wake of the accident at Three Mile Island Nuclear Station, Unit 2. Currently, maintenance and development of the code is carried out under the direction of the Electric Power Research Institute (EPRI).

To provide analytical justification for their mitigating strategies in response to Order EA-12-049, a number of licensees for BWRs and pressurized-water reactors (PWRs) completed analysis of the ELAP event using Version 4 of the MAAP code (MAAP4). Although MAAP4 and predecessor code versions have been used by industry for a range of applications, such as the analysis of severe accident scenarios and probabilistic risk analysis (PRA) evaluations, the NRC

staff had not previously examined the code's technical adequacy for performing best-estimate simulations of the ELAP event. In particular, due to the breadth and complexity of the physical phenomena within the code's calculation domain, as well as its intended capability for rapidly simulating a variety of accident scenarios to support PRA evaluations, the NRC staff observed that the MAAP code makes use of a number of simplified correlations and approximations that should be evaluated for their applicability to the ELAP event. Therefore, in support of the reviews of licensees' strategies for ELAP mitigation, the NRC staff audited the capability of the MAAP4 code for performing thermal-hydraulic analysis of the ELAP event for both BWRs and PWRs. The NRC staff's audit review involved a limited review of key code models, as well as confirmatory analysis with the TRACE code to obtain an independent assessment of the predictions of the MAAP4 code.

To support the NRC staff's review of the use of MAAP4 for ELAP analyses, in June 2013, EPRI issued a technical report entitled "Use of Modular Accident Analysis Program (MAAP) in Support of Post-Fukushima Applications." The document provided general information concerning the code and its development, as well as an overview of its physical models, modeling guidelines, validation, and quality assurance procedures.

Based on the NRC staff's review of EPRI's June 2013 technical report, as supplemented by further discussion with the code vendor, audit review of key sections of the MAAP code documentation, and confirmation of acceptable agreement with NRC staff simulations using the TRACE code, the NRC staff concluded that, under certain conditions, the MAAP4 code may be used for best-estimate prediction of the ELAP event sequence for BWRs. The NRC staff issued an endorsement letter dated October 3, 2013 [Reference 23], which documented these conclusions and identified specific limitations that BWR licensees should address to justify the applicability of simulations using the MAAP4 code for demonstrating that the requirements of Order EA-12-049 have been satisfied.

During the audit process, the NRC staff verified that the licensee's MAAP4 calculation, along with an associated addendum, addressed the limitations from the NRC staff's endorsement letter. The licensee utilized the generic roadmap and response template that had been developed by EPRI to support consistency in individual licensee's responses to the limitations from the endorsement letter. In particular, based upon review of the MAAP4 calculation documentation, the staff concluded that appropriate inputs and modeling options had been selected for the code parameters expected to have dominant influence for the ELAP event. The NRC staff further observed that the limitations imposed in the endorsement letter, particularly those concerning the RPV collapsed liquid level being maintained above the reactor core and the primary system cooldown rate being maintained within technical specification limits, were satisfied. Specifically, the licensee's analysis calculated that operators would maintain the collapsed liquid level in the reactor vessel 9 feet above the top of the active fuel region throughout the analyzed ELAP event. By maintaining the reactor core fully covered with water, adequate core cooling is assured for this event. Additionally, the licensee's fulfillment of the endorsement letter condition regarding the primary system cooldown rate signifies that thermally induced volumetric contraction and other changes in primary system thermal-hydraulic conditions should proceed relatively slowly with time, which supports the NRC staff's confidence in the predictions of the MAAP4 code. Furthermore, that the licensee should be capable of maintaining the entire reactor core submerged throughout the ELAP event is consistent with the staff's expectation that the licensee's flow capacity for primary makeup (i.e., installed RCIC pump and, subsequently, FLEX pumps) should be sufficient to support adequate heat removal from the reactor core during the analyzed ELAP event, including potential losses due to expected primary leakage.

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 Recirculation Pump Seals

An ELAP event would result in the interruption of cooling to the recirculation pump seals, potentially resulting in increased leakage due to the distortion or failure of the seals, elastomeric O-rings, or other components. Sufficient primary makeup must be provided to offset recirculation pump seal leakage and other expected sources of primary leakage, in addition to removing decay heat from the reactor core.

The licensee's calculations for FitzPatrick assumed an initial total seal leakage rate at normal RPV operating pressure of 61 gpm. This leakage rate was based on the failure of both recirculation pump seals (18 gpm per seal) plus 25 gpm primary system boundary leakage, consistent with FitzPatrick Technical Specification 3.4.4. According to the licensee's FIP, the RCIC system or the FLEX pump will provide sufficient cooling flow to compensate for any reactor coolant lost in addition to maintaining sufficient coolant in the RPV.

In the MAAP analysis, the licensee discussed system response to the variation of seal leakage rate as a function of RPV pressure in the thermal hydraulic simulation. The initial seal leakage rate was assumed to be 36 gpm (18 gpm per seal) plus the TS leakage. According to the licensee's FIP, the seal leakage is reduced in the analysis after one hour to reflect the procedurally-driven closure of the recirculation water pump inlet and outlet isolation valves. The licensee concluded that the RPV water level continued to be above the top of the active fuel throughout the simulation period.

The NRC staff concludes that the leakage rate of 61 gpm is reasonable based on a review of the content in NRC Generic Letter 91-07 [Reference 52]. Gross seal failures are not anticipated to occur during the postulated ELAP event. As is typical of the majority of U.S. BWRs, FitzPatrick has an installed steam-driven pump (i.e., RCIC) capable of injecting into the primary system at a flow rate well in excess of the primary system leakage rate expected during an ELAP event, and the other pumps used for core cooling in its FLEX strategy have a similar functional capability. The licensee's analysis shows that, at the limiting pressure, the FLEX pump is able to inject at a rate which maintains adequate margin. In addition, the staff also concludes that the makeup capability margin that is available adequately compensates for any potential leakage of the recirculation pump isolation valves (and then the recirculation pump seals) that may not be reflected in the licensee's analysis.

Based upon the discussion above, the NRC staff concludes that the recirculation pump 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

As described in Section 3.6.4.1 of the FitzPatrick Final Safety Analysis Report (FSAR) [Reference 57], the control rods are of such number and reactivity worth that the insertion of all but the control rod of highest worth is sufficient to make the fuel subcritical under the most reactive core condition. Thus, the control rods provide adequate shutdown margin under all

anticipated plant conditions, while assuming that the highest-worth control rod remains fully withdrawn. FitzPatrick Technical Specification, Section 1.1 (Definitions), further clarifies that shutdown margin is to be calculated for a cold, xenon-free condition to ensure that the most reactive core conditions are bounded. The licensee's FIP evaluation of shutdown margin reflects these considerations.

Based on the FIP and the NRC staff's audit review, the licensee's ELAP mitigating strategy maintains the reactor within the envelope of conditions analyzed by the licensee's existing shutdown margin evaluation. Furthermore, the evaluation retains conservatism because the guidance in NEI 12-06 permits analyses of the beyond-design-basis ELAP event to assume that all control rods fully insert into the reactor core.

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

When the RCIC pump is no longer available, a DDFP is used to inject water from Lake Ontario into the RPV. FitzPatrick has two permanently installed DDFPs located in the Screenwell Building and one of these two pumps would be used for RPV makeup. This transition would likely occur approximately 22 hours into the event, based on the assumptions used in the licensee's analysis. As described previously in this safety evaluation, both of the DDFPs are protected from all applicable external hazards and are considered to be robust. According to the licensee's FIP, the DDFPs each have a capacity of 2500 gpm at 125 psig discharge pressure. This compares to the maximum required RPV and SFP makeup flows of 150 gpm and 50 gpm (or 250 gpm for SFP spray), respectively.

To verify that the DDFP capacity is within requirements, the licensee performed hydraulic analysis JAF-CALC-15-00012, "Hydraulic Analysis of Phase 2 FLEX Strategies," Revision 0, to verify the volumetric flow rate and head needed to remove decay heat following a BDBEE. The NRC staff reviewed the licensee's analysis during the audit process and was able to confirm that the DDFP capacity was within the required capacity. During the onsite audit, the NRC staff conducted a walk down of the location of the DDFPs, hose locations, and the primary and alternate connection points to confirm that they are consistent with the assumptions in the hydraulic analysis and FIP.

Based on the NRC staff's review of the DDFP's pumping capabilities at FitzPatrick, as described in the FIP and in JAF-CALC-15-00012, the NRC staff concludes that the DDFP should perform as intended to support RPV makeup during an ELAP event, consistent with the provisions of NEI 12-06, Section 11.2. Section 3.10 of this safety evaluation contains a discussion of the capacity, availability, and robustness of each water source.

#### 3.2.3.6 Electrical Analyses

The licensee's electrical strategies provide power to the equipment and instrumentation used to mitigate the postulated events. The electrical strategies described in the FIP maintain the key safety functions of core cooling, SFP cooling and containment in an integrated manner and any specifics regarding the electrical aspects of the containment and SFP cooling key safety functions are noted in Sections 3.3.4.4 and 3.4.4.4 of this safety evaluation.

During the first phase of an ELAP event, FitzPatrick would rely on the safety-related Class 1E batteries to provide power to key instrumentation and applicable dc components. According to the licensee's FIP, the FitzPatrick Class 1E station batteries and associated dc distribution systems are located within safety-related structures designed to meet applicable design-basis external hazards. In addition, the FIP states that the batteries will be capable of supplying the necessary power for 9.5 hours, sufficient time to transition to the Phase 2 strategy. During the audit process the NRC staff reviewed the licensee's abnormal operating procedure (AOP) AOP-49, "Station Blackout," Revision 21, and FSG-002, "ELAP DC Bus Load Shed and Management," Revision 0, to confirm that the licensee has procedures that direct operators to conserve dc power during the event by stripping non-essential loads. Operators will strip or shed unnecessary loads to extend battery life until backup power is available in Phase 2. According to AOP-49, the plant operators would complete initial load shedding of the batteries within 30 minutes from the onset of the event. Operators would then complete additional load shedding within 1.5 hours from the onset of the event.

As part of its mitigating strategies, the licensee is crediting two Class 1E 125 Vdc batteries (Battery "A" and Battery "B"). Both of these batteries were manufactured by Exide Technologies. The station batteries are model NCN-35 with a nominal capacity of 2552 ampere-hours (AH).

The NEI White Paper, "EA-12-049 Mitigating Strategies Resolution of Extended Battery Duty Cycles Generic Concern" [Reference 44], provides guidance for calculating extended duty cycles of batteries (i.e., beyond 8 hours). This paper was endorsed by the NRC [Reference 45]. 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 [Reference 46]. The testing provided additional validation that the NEI white paper method was technically acceptable. During the audit process, the NRC staff reviewed the licensee's battery calculations and confirmed that they had followed the guidance in the NEI white paper.

Specifically, the NRC staff reviewed the licensee's dc coping calculation JAF-CALC-15-00045, "Station Service Batteries A and B Discharge Capacity during Extended Loss of AC Power," Revision 0, which verified the capability of the dc system to supply power to the required loads during the first phase of the FitzPatrick FLEX mitigation strategy plan. 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 within 1.5 hours for the station batteries to ensure battery operation for at least 9.5 hours. Based on its review of the licensee's calculation, the NRC staff found that Battery "A" should have sufficient capacity to supply power for at least 9.5 hours while Battery "B" should have sufficient capacity for at least 10 hours.

Therefore, based on the licensee's FIP, and confirmed by its review of the licensee's analysis, procedures, and the battery vendor's capacity and discharge rates for the Class 1E station batteries, the NRC staff finds that the FitzPatrick dc systems have adequate capacity and capability to power the loads required to mitigate the consequences during Phase 1 of an ELAP, provided that necessary load shedding is completed within the times assumed in the licensee's analysis.

The licensee's Phase 2 strategy includes repowering the Class 1E battery chargers within 8 hours after initiation of an ELAP to maintain availability of instrumentation to monitor key parameters. The licensee's strategy relies on one 200 kW, 600 Vac FLEX DG. The licensee has a total of two 200 kW, 600 Vac FLEX DGs (one stationary and one portable). Only one of

the FLEX DGs are required for the Phase 2 electrical strategy. The 600 Vac FLEX DG would provide power to the battery chargers and other selected loads.

The NRC staff reviewed the licensee's FIP, calculation JAF-CALC-15-00031, "FLEX Strategy - Portable Generator System Sizing," "Revision 0, conceptual single line diagrams, and the method for establishing separation and isolation of the FLEX DGs from the Emergency Diesel Generators (EDGs). In the FIP, the licensee noted that the expected loading on the FLEX DG would be 148 kW. The licensee took the FLEX cable lengths into consideration (i.e., ensured that the voltage drop did not exceed the minimum voltage required at the limiting component). Based on its review of JAF-CALC-15-00031, the NRC staff confirmed that a 200 kW FLEX DG is adequate to support the electrical loads required for the licensee's Phase 2 strategies. The staff also confirmed that guidelines FSG-001, "Initial Assessment and FLEX Equipment Staging," Revision 0, and FSG-002 provide direction for staging and connecting a FLEX DG to energize the electrical buses to supply required loads within the required timeframes.

For Phase 3, the licensee plans to continue the Phase 2 coping strategy with additional assistance provided from offsite equipment/resources. The offsite resources that will be provided by an NSRC includes two 1-megawatt (MW) 4160 Vac CTGs, one 1000 kW 480 Vac CTG, one 480 Vac to 600 Vac transformer, and distribution panels (including cables and connectors). During the audit process the staff reviewed calculation JAF-CALC-15-00031 which showed that the expecting loading on the 4160 Vac CTGs would be limited to 1208 kW. While this loading is within the capability of the 4160 Vac CTGs, the licensee will control loading and unloading of the CTGs by guideline FSG-007, "Long Term Reactor Vessel Cooling," Revision 0. This guideline will use two CTGs to power the applicable safety-related bus to support the support the starting requirements of an RHR pump motor. In addition, through the use of a 480 Vac to 600 Vac step up transformer, the NSRC 480 Vac CTG can be used as a Phase 2 backup, if necessary.

The Phase 3 4160 Vac CTGs would supply power to one RHR pump, related valves, and miscellaneous required loads when connected in parallel. The miscellaneous required loads include the battery chargers, various room coolers, and exhaust fans. Licensee guideline FSG-007 provides direction for connecting the NSRC-supplied CTGs to the FitzPatrick electrical buses to supply required loads within the required timeframes. Based on its review, the NRC staff finds that the equipment being supplied from the NSRC(s) should have sufficient capacity and capability to supply the required loads during Phase 3.

Based on its review, the NRC staff finds that the Class 1E station batteries should have sufficient capacity to support the licensee's strategy, and that the FLEX DGs and NSRC-supplied CTGs should have sufficient capacity and capability to supply the necessary loads during an ELAP event.

3.2.4 Conclusions

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

In NEI 12-06, Section 3.2.1.1 provides the acceptance criterion for satisfactory performance of strategies regarding 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 a full core offloaded to the SFP is addressed in Section 3.11 of this safety evaluation.

#### 3.3.1 Phase 1

The licensee stated in its FIP that no actions are required during ELAP Phase 1 for SFP makeup because the time to boil is sufficient to enable deployment of Phase 2 equipment. Adequate SFP inventory exists to provide radiation shielding for personnel well beyond the time of boiling. The licensee determined that for normal operation the SFP water inventory will heat up from an initial 114°F to 212°F in 32.7 hours. The FSGs will direct operators to take actions to ensure that SFP makeup provisions are established such that makeup can begin prior to boiling. During this time, the licensee will also monitor SFP water level using reliable SFP level instrumentation installed per Order EA-12-051.

#### 3.3.2 Phase 2

During Phase 2, the licensee's FIP states that the DDFP will be in operation around the 22 hour mark after ELAP initiation. This pump will be able to supply lake water to the SFP. The makeup to the SFP can be achieved using three different methods: (1) the use of the DDFP fire hose connection to the permanent piping for the RHRSW and RHR systems located in the Screenwell Building, (2) direct hose routing from the DDFP to the SFP, or (3) direct hose routing from the DDFP to the spray monitor nozzles. The connections for these methods are described in Section 3.7.3.1 of this safety evaluation.

The licensee's FIP, Section 2.4.2, states that SFP spray capability is not required at FitzPatrick, based on a structural evaluation that has been performed for the FitzPatrick SFP. Thus, the licensee categorizes the retention of SFP spray capability in the plan as "defense-in-depth." As described in JLD-ISG-2012-01, Revision 1 [Reference 7], the NRC staff accepts this approach if a SFP integrity evaluation is completed which demonstrates that a seismic event would have a very low probability of inducing a crack in the SFP or its piping systems so that spray would not

be needed to cool the spent fuel. This evaluation must use the reevaluated seismic hazard that is described in Section 3.5.1 of this safety evaluation if its magnitude is higher than the site's safe shutdown earthquake (SSE).

Regarding the SFP integrity evaluation, as part of the process to develop and evaluate responses to an NRC Request for Information issued pursuant to Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f) [Reference 25] (hereafter referred to as the 50.54(f) letter), the NRC staff worked with industry to develop a method of predicting the susceptibility of a SFP to cracking. The primary input considers the seismic stresses that the SFP was designed to survive compared to the seismic stresses from a seismic event that has some probability of occurring at the site. By letter dated February 23, 2016 [Reference 58], the NEI submitted a request for the NRC staff to approve guidance for a SFP evaluation based on the February 2016 EPRI report 3002007148, "Seismic Evaluation Guidance Spent Fuel Pool Integrity Evaluation." The EPRI report is a generic study performed for nuclear power plants with low-to-moderate seismic ground motions (peak spectral accelerations less than 0.8g) to address the NRC 50.54(f) letter provision requesting an evaluation of the SFP that considers all seismically induced failures that could lead to rapid draining. Based on the NRC staff's assessment letter dated February 18, 2016 [Reference 60], the peak spectral acceleration for the SSE and the reevaluated ground motion response spectra are less than 0.8g at FitzPatrick; thus, the NRC staff finds that EPRI 3002007148 is applicable to the licensee's site. Section 3.3 of EPRI 3002007148 provides guidance on specific site parameters, structural parameters, and nonstructural parameters that a licensee should confirm on a site-specific basis to ensure that the report's conclusions apply. By letter dated March 17, 2016 [Reference 59], the NRC staff endorsed the EPRI report as an acceptable method of performing seismic evaluations of SFPs in responding to the 50.54(f) letter. By letter dated December 22, 2016 [Reference 61], the licensee confirmed that the FitzPatrick SFP met the parameters in Section 3.3 of the EPRI report to affirm that the report was applicable to the site and to confirm that the FitzPatrick SFP was seismically adequate in accordance with the NTTF Recommendation 2.1 seismic evaluation criteria. By letter dated March 22, 2017 [Reference 62], the NRC staff concluded that the licensee responded appropriately to the 50.54(f) letter regarding the SFP evaluation. Specifically, the NRC review noted that the licensee's submittal: (1) appropriately evaluated and screened the SFP SSCs; and demonstrated that the FitzPatrick SFP structure is sufficiently robust and can withstand ground motions with peak spectral acceleration less than or equal to 0.8g, and (2) adequately evaluated the non-structural considerations of the FitzPatrick SFP whose failure could lead to potential drain-down due to a seismic event.

Based on the structural evaluation and demonstration of conformance to the EPRI 3002007148, Section 3.3 criteria, the NRC staff concludes that the licensee has demonstrated structural integrity for the FitzPatrick SFP, in accordance with the provisions of JLD-ISG-2012-01, Revision 1.

3.3.3 Phase 3

The FIP states that SFP cooling can be maintained indefinitely using the makeup strategies described in Phase 2 above. However, NSRC equipment will be available during Phase 3 as a backup to the onsite 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 FIP and noted that SFP boiling could begin as early as 32.7 hours during a normal, non-outage situation. The staff also noted that the licensee's sequence of events timeline presented in the FIP indicates that operators will establish SFP makeup prior to boiling and therefore prior to the point where the SFP area habitability becomes challenged.

As described in the licensee's FIP, the licensee's Phase 1 SFP cooling strategy does not require any operator actions. However, the licensee does establish a ventilation path to cope with temperature, humidity and condensation from evaporation and/or boiling of the SFP. According to the FIP, the operators are directed to open designated doors in the Reactor Building within 5 hours of ELAP initiation to establish the ventilation path.

The licensee's Phase 2 and Phase 3 SFP cooling strategy involves the use of the DDFP (or possibly an NSRC-supplied pump for Phase 3), with suction from Lake Ontario, to supply water to the SFP. The FSGs direct operators to complete hose runs into the Reactor Building prior to 5.7 hours for environmental habitability considerations. Based on its FIP review, the staff concludes that the timing and scope of the actions presented are feasible for maintenance and restoration of the SFP cooling function. The NRC staff's evaluation of the robustness and availability of FLEX connection points is discussed in Section 3.7.3.1 of this safety evaluation. Furthermore, the NRC staff's evaluation of the robustness and availability of Lake Ontario for an ELAP event is discussed in Section 3.10 of this safety evaluation.

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 safety evaluation.

3.3.4.2 Thermal-Hydraulic Analyses

As described in FIP, Section 2.16, at the maximum design heat load the SFP will boil in approximately 8.1 hours and boil off to a level to top of fuel in 65 hours from initiation of the event with no operator action. This heat load corresponds to a full core offload. For this heat load, the licensee conservatively determined that a SFP makeup flow rate of at 60 gpm will maintain adequate SFP level. The licensee states, and the staff agrees, that this is well within

the capability of a DDFP. For the maximum heat load scenario, the licensee indicated that outage risk planning would direct operators to take more expedient action to stage SFP makeup upon ELAP initiation. Consistent with the guidance in NEI 12-06, Section 3.2.1.6, the NRC staff finds the licensee has considered the maximum design-basis SFP heat load.

3.3.4.3 FLEX Pumps and Water Supplies

As described in the FIP, the SFP cooling strategy relies on a DDFP to provide SFP makeup during Phase 2. In the FIP, Section 2.3.10.1 describes the hydraulic performance criteria (e.g., flow rate, discharge pressure) for the DDFP. The DDFP is the same pump used for core cooling and RPV makeup as described above, and the licensee's analysis reflected simultaneous makeup to the RPV and SFP. The staff also notes that the performance criteria of the NSRC-supplied pump specified in the licensee's FIP will fulfill the SFP makeup function if the DDFP were to fail.

3.3.4.4 Electrical Analyses

The licensee's mitigating strategies for the SFP do not rely on electrical power except for power to SFP level instrumentation. The licensee's electrical SFP cooling strategy for all phases is to monitor SFP level using instrumentation installed for Order EA-12-051. This instrumentation is evaluated in Section 4 of this safety evaluation.

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.

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 guidance document, NEI 12-06, Table 3-1, 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.

FitzPatrick has a GE BWR with a Mark I containment. According to the licensee's FIP, the containment safety function is maintained primarily by design features of the containment structure, isolation valves, and venting system. For the postulated conditions the containment function is also dependent upon operator actions the most significant of which is the venting of the suppression pool at a pre-determined setpoint (10 psig). During the audit process the NRC staff reviewed the licensee's containment evaluation, JAF-CALC-15-00044, "FitzPatrick Nuclear Plant Containment Analysis of FLEX Strategies," Revision 3. The calculation analyzed the strategy of using the steam driven RCIC pump to provide RPV makeup from the CSTs and the transfer of energy from the RPV to the suppression pool via the SRVs. The licensee's analysis reflects venting the suppression pool to atmosphere to limit suppression pool temperature and control containment pressure. The analysis concluded that the containment parameters of

pressure and temperature remain well below the respective FSAR Section 5.2, Table 5.2-1, design limits of 56 psig and 309°F for the drywell for the analysis run time of 120 hours. The design temperature limit of 220°F for the torus is exceeded at approximately 12 hours. A justification for exceeding this temperature design limit is discussed in Section 3.4.4.1.1 of this safety evaluation.

Based on a review of the licensee's FIP, supplemented by the audit review of the licensee's calculations, the NRC staff notes that actions to maintain containment integrity and the required instrumentation functions have been developed, and are summarized below.

3.4.1 Phase 1

The FIP states during Phase 1, containment integrity is maintained using the normal plant design features of the containment, such as the containment isolation valves and the containment vent. In accordance with NEI 12-06, the containment is assumed to be isolated following the event. The suppression pool venting will commence when containment pressure reaches approximately 10 psig, which is predicted to occur at approximately 5.5 hours into the event according to the containment analysis.

Until the hardened containment vent system (HCVS) is installed and operable in accordance with Order EA-13-109, the existing SGTS (i.e., Generic Letter 89-16 vent) will be used. This vent path is available to protect the containment function during all phases of the BDBEE response. During the audit process, the NRC staff reviewed the availability of the Generic Letter 89-16 vent by reviewing Engineering Change (EC) document EC 52736, "Fukushima FLEX Basis EC," Revision 0, Attachment 6.029. The vent path is described in the licensee's FIP, Section 2.5.4.1. In summary, the torus is vented by using the torus vent line that connects to the SGTS. From the SGTS, filter train access hatches are opened allowing the torus to vent to the SGTS room. The SGTS room doors to the outside are then opened, allowing the torus to vent to the atmosphere after certain valves are manually manipulated.

Operators will monitor key containment parameters, including drywell pressure, suppression pool water level, and suppression pool temperature via normal plant instrumentation.

3.4.2 Phase 2

The strategy to maintain containment integrity for Phase 2 is maintain the Phase 1 strategy of providing cooling water to the RPV and venting the suppression pool using the vent system.

3.4.3 Phase 3

Phase 3 will continue with the Phase 2 strategy. Off-site equipment provided by the NSRC will be used to supplement Phase 2 FLEX equipment as needed. In addition, NSRC-provided equipment can be used to provide cooling water and electric power to the RHR system permitting the operation of one loop of RHR shutdown cooling and therefore supporting the containment function.

3.4.4 Staff Evaluations

3.4.4.1 Availability of Structures, Systems, and Components

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

Section 5.2.3.2 of the FitzPatrick FSAR describes the GE Mark I pressure suppression system with two large chambers. The design employs a low leakage pressure suppression containment system which houses the RPV, the reactor coolant recirculation loops, and other branch connections of the reactor primary system. Primary containment consists of a drywell, a pressure suppression chamber (torus) which stores a large volume of water (suppression pool), a connecting vent system between the drywell and the suppression pool, primary containment isolation valves, and a vacuum relief system. The drywell is a steel pressure vessel with a spherical lower portion 65 feet in diameter, and a cylindrical upper portion 35 feet-7 inches in diameter. The overall height is approximately 111 feet. The drywell is designed for an internal pressure of 56 psig coincident with a maximum design temperature of 309°F, while also considering the applicable dead weight and seismic loads. The FSAR states that in accordance with the ASME Code, Section III, the maximum allowable drywell pressure is 62 psig. Thermal stresses in the steel shell due to longitudinal temperature gradients are taken into account in the design. The drywell is also designed for 2.0 psig external pressure at 309°F.

The pressure suppression chamber (wetwell or torus) is a steel pressure vessel in the shape of a torus encircling the drywell, with a major diameter of approximately 108 feet and a cross-sectional diameter of 29.5 feet. The pressure suppression chamber contains approximately 105,600 cubic feet of water and has a net air space above the water pool of approximately 114,000 cubic feet. The suppression chamber transmits seismic loading to the reinforced concrete foundation slab of the Reactor Building. Space is provided between the concrete in the Reactor Building and the torus for inspection and maintenance. In the FSAR, Table 5.2-1, gives the pressure suppression chamber an internal design pressure of 56 psig and the design temperature of the pressure suppression chamber as 220°F.

The containment is designed as a seismic Category I structure. The staff notes that being a seismic Category I structure, the containment has been designed to maintain its function following all beyond design basis external hazards.

As stated previously, the suppression chamber design temperature of 220°F is exceeded at approximately 12 hours after the start of the ELAP event. Containment analysis JAF-CALC-15-00044 predicts that a maximum suppression chamber temperature of 264°F would be reached at 21.3 hours after the start of the ELAP event using the existing Generic Letter 89-16 vent and a maximum suppression chamber temperature of 275°F would be reached at 21.75 hours after the start of the ELAP event using the HCVS that will be installed in the future in accordance with Order EA-13-109. As the event progresses, the suppression chamber temperature gradually drops, but remains slightly above the design value of 220°F for both cases for the duration of the ELAP event.

During the audit process, the NRC staff questioned the design temperature exceedance. The licensee performed calculation JAF-CALC-14-00021, "Suppression Pool Stress Evaluation Due to a FLEX Event," Revision 0, in order to confirm the structural integrity of the torus for the ELAP event. The NRC staff reviewed this analysis during the audit process. Based on this calculation, the licensee determined that the structural integrity of the torus is satisfactory at the peak suppression chamber temperature associated with the FLEX strategy.

Containment Vent (Generic Letter 89-16)

FitzPatrick will rely on the existing Generic Letter 89-16 vent for venting during a BDBEE until the HCVS is installed. The Generic Letter 89-16 vent path is available to protect the containment function during all phases of the BDBEE response. The licensee's FIP describes the manual actions necessary to implement the venting strategy. The containment vent strategy and the interim manual actions to initiate venting through the Generic Letter 89-16 vent is reflected in the licensee's FIP timeline and is expected to be completed within 5.5 hours of event initiation.

Based on the licensee's FIP, the FitzPatrick FSAR description, and supplemented by calculation reviews, the staff concludes that the containment, the containment vent (Generic Letter 89-16), and the necessary support equipment credited in the strategy are robust, as defined by NEI 12-06, and would be available following the postulated ELAP event.

#### 3.4.4.1.2 Plant Instrumentation

In NEI 12-06, Table 3-1, specifies that containment pressure, suppression pool level, and suppression pool temperature are key containment parameters for BWRs, which should be monitored by repowering the appropriate instruments.

The licensee's FIP states that MCR 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 these containment parameters, would be available using alternate methods.
Based on this information, the staff concludes that the licensee should have the ability to appropriately monitor the key containment parameters as delineated in NEI 12-06, Table 3-1.

#### 3.4.4.2 Thermal-Hydraulic Analyses

The licensee's FIP states that conservative evaluations have concluded that containment temperature and pressure will remain below containment design. During the audit process, the NRC staff reviewed the licensee's supporting calculation, JAF-CALC-15-00044, "FitzPatrick Nuclear Plant Containment Analysis of FLEX Strategies," Revision 3, which was based on the boundary conditions described in Section 2 of NEI 12-06. This calculation utilized the MAAP computer code, version 4.0.5, to perform numeric computations of the fundamental thermodynamic equations which predict the heat up and pressurization of the containment atmosphere under ELAP conditions. Four cases were run utilizing the existing vent installed under Generic Letter 89-16. A fifth case was run using the new hardened containment vent system that will be installed to meet the requirements of NRC Order EA-13-109.

The calculation shows that the containment reaches 10 psig at roughly 5.5 hours when the suppression chamber vent was assumed to be opened. The maximum containment pressure

reached is 18.2 psig at roughly 24 hours, which is less than the maximum design pressure of 56 psig. The maximum drywell temperature reached is 284°F at approximately 22.3 hours, which is below the maximum drywell temperature of 309°F. These maximum values calculated are well below the FSAR design parameters stated above in Table 5.2-1, so the licensee has adequately demonstrated that there is significant margin before a limit would be reached. The 220°F design limit for the suppression chamber was exceeded at approximately 12 hours. A justification for exceeding this temperature limit is discussed in Section 3.4.4.1.1 of this safety evaluation. The licensee determined that the structural integrity of the existing suppression chamber subject to the increased temperature associated with the FLEX strategy is satisfactory.

Based on the licensee's FIP, supplemented by a review of the licensee's calculations and evaluations, the NRC staff concludes that the licensee has demonstrated that the containment venting strategy, using the Generic Letter 89-16 vent, should provide for maintenance of the containment safety function during the postulated ELAP/loss of normal access to the UHS event.

3.4.4.3 FLEX Pumps and Water Supplies

No FLEX pump or water supplies are credited for containment integrity coping strategies.

3.4.4.4 Electrical Analyses

The licensee's Phase 1 coping strategy is to monitor containment pressure and temperature using installed instrumentation, and maintain containment integrity using normal design features of the containment. 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 safety evaluation and is adequate to ensure continued containment monitoring.

The licensee's Phase 2 coping strategy is to continue monitoring containment pressure and temperature using installed instrumentation and maintaining containment integrity. The licensee's strategy to repower instrumentation using a 200 kW FLEX DG is identical to what was described in Section 3.2.3.6 of this safety evaluation and is adequate to ensure continued containment monitoring.

The licensee's Phase 3 strategy is to continue its Phase 2 strategy throughout the event. FitzPatrick will receive offsite resources and equipment from an NSRC following an ELAP event. This equipment includes two 4160 Vac 1 MW CTGs, a 480 Vac 1000 kW CTG, and a 480 Vac to 600 Vac transformer. Given the capacity of these CTGs, the NRC staff finds that it is reasonable to expect that the licensee could utilize these resources to supply power to equipment to maintain containment indefinitely.

In summary, based on its review, the NRC staff determined that the electrical equipment available onsite (e.g., Class 1E station batteries and 200 kW FLEX DGs) supplemented with the electrical equipment that will be supplied from an NSRC, there is sufficient capacity and capability to supply the required loads to maintain containment.

3.4.5 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore containment functions following an

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

### 3.5 Characterization of External Hazards

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

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

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

References to external hazards within the licensee's mitigating strategies and this safety evaluation 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 50.54(f) letter [Reference 24], 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 56]. 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 53]). The Commission provided guidance to the staff in an SRM to COMSECY-14-0037 [Reference 25]. 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 43], 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 6]. The NRC staff endorsed Revision 2 of NEI 12-06 in JLD-ISG-2012-01, Revision 1 [Reference 7]. The licensee's MSAs will evaluate the mitigating strategies described in this safety evaluation using the revised seismic hazard information and, if necessary, make changes to the strategies or equipment. Licensees will submit the MSAs for NRC staff review.

The licensee developed its OIP for mitigation strategies by considering the guidance in NEI 12-06 and the site's design-basis hazards. Therefore, this safety evaluation 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 stated that the design-basis earthquake corresponds to 0.15g. As described in the FitzPatrick FSAR, Section 2.6, the design-basis earthquake criteria for the site is 0.15g peak horizontal ground acceleration combined with a vertical component that corresponds to two-thirds of the horizontal component, or 0.10g. The FitzPatrick FSAR uses the terminology of design basis earthquake. As acknowledged in the licensee's FIP, the design-basis earthquake corresponds to the SSE, using the current NRC terminology. For the purposes of this safety evaluation the terms are interchangeable, but the SSE terminology will generally be used.

It should be noted that the actual seismic hazard involves a spectral graph of the acceleration versus the frequency of the motion. Peak acceleration in a certain frequency range, such as the numbers above, is often used as a shortened way to describe the hazard.

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

3.5.2 Flooding

The FitzPatrick site grade elevation is generally 272 feet mean sea level (MSL) based on the United States Lake Survey Datum 1935 (USLS35). Unless otherwise stated, all elevations regarding flooding considerations in this safety evaluation are given with respect to MSL on the USLS35 datum.

In its FIP, the licensee described the current design basis limiting site flooding event. This event is postulated to occur coincident with maximum recorded Lake Ontario level, maximum

precipitation induced increase to lake level, maximum wind setup, and maximum wave run up. This level is 260 feet MSL. In addition, the FIP discusses a current licensing basis flood elevation of 262 feet MSL. For the FitzPatrick flooding analyses, the Screenwell Building is treated differently from the other critical plant structures since it is hydraulically connected to the lake but not susceptible to wave action. The Screenwell Building probable maximum level is 255 feet MSL. The licensee also stated in the FIP that groundwater in-leakage is not a concern and will not impact FLEX strategies due to the presence of water stops and seals below grade in the Reactor Building.

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

3.5.3 High Winds

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

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

The screening for high wind hazard associated with tornadoes should be accomplished by comparing the site location to NEI 12-06, Figure 7-2, from U.S. NRC, "Tornado Climatology of the Contiguous United States," NUREG/CR-4461, Revision 2, February 2007; if the recommended tornado design wind speed for a 1E-6/year probability exceeds 130 mph, the site should address hazards due to extreme high winds associated with tornadoes using the current licensing basis for tornados or NRC Regulatory Guide 1.76, Revision 1.

Regarding the determination of applicable extreme external hazards, the licensee's FIP states that that the FitzPatrick site is located approximately seven miles northeast of the City of Oswego, New York. The NRC staff estimated the site location at 43° 31' 21" North latitude and 76° 23' 56" West longitude. Based on that location, 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 licensee's FIP states that the design basis tornado consists of a tangential wind velocity of 300 mph, with a translational velocity of 60 mph. The FitzPatrick FSAR, Section 12.4.5, lists the following design tornado missiles: (1) a wood utility pole – 40 feet long and 12 inches in diameter weighing 50 pounds per cubic foot, and (2) an automobile – not more than 25 feet above the ground, having a contact area of 30 square feet and weighing one ton. Both of these design missiles have an assumed velocity of 150 mph.

The licensee's FIP indicates that tornado hazards are the only high wind hazards applicable to FitzPatrick. The NRC staff notes that the site is beyond the range of high winds from a

hurricane per NEI 12-06, Figure 7-1. The NRC staff concludes that a hurricane hazard is not applicable and need not be addressed, consistent with the licensee's assessment.

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

3.5.4 Snow, Ice, and Extreme Cold

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

In its FIP, regarding the determination of applicable extreme external hazards, the licensee stated that the site is located approximately seven miles northeast of the City of Oswego, New York. In addition, the FIP states that the site is located within the region characterized by EPRI as ice severity level 5 (NEI 12-06, Figure 8-2, Maximum Ice Storm Severity Maps). Consequently, the site is subject to severe icing conditions that could cause catastrophic destruction to electrical transmission lines. The FIP also states that the site is located within the region characterized by the National Oceanographic and Atmospheric Administration as subject to significant accumulations during three-day snowfalls. The plant's design basis for snow load is 50 pounds per square foot (psf) and the FLEX Equipment Storage Buildings (FESBs) are designed for 60 psf snow load, consistent with local New York State building codes. The licensee concludes that the plant screens in for an assessment for snow, ice, and extreme cold hazard. In its FIP, the licensee stated that extreme low temperatures of -23°F are considered in the development of the FLEX coping strategy. The -23°F temperature bounds the lowest recorded temperature in Oswego, New York of -21°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

The licensee's FIP notes that, as per NEI 12-06 Section 9.2, all sites are required to consider the impact of extreme high temperatures. The licensee's FIP notes that the highest recorded temperature for FitzPatrick is 100°F for the time period from 1860 to 1950 and the highest recorded temperature for Oswego, New York is 97°F. The plant site screens in for an assessment for extreme high temperature hazard. The licensee's FIP states that high temperatures of 100°F are considered in the development of the FLEX coping strategy and the maximum design temperature of the FESBs is 120°F.

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

The licensee's FIP states that the FLEX equipment will be protected in two structures, both designed to the provisions of American Society of Civil Engineers (ASCE) standard ASCE 7-10. The use of two structures is done primarily to ensure sufficient ("N") FLEX equipment availability following a tornado event by providing separation in accordance with NEI 12-06, consideration 7.3.1.1.c. The licensee refers to the two structures as the "N" FESB and the "N+1" FESB. The "N" FESB is located within the protected area close to the deployment locations of the equipment and the "N+1" FESB is located outside the protected area. During the audit process the NRC staff reviewed the "N+1" FESB location, which is across Lake Road from the main FitzPatrick power block buildings, near the site wellness center, on owner controlled property. Below are additional details on how FLEX equipment is protected from each of the applicable external hazards.

3.6.1.1 Seismic

According to the licensee's FIP, the FESBs are designed for seismic loading determined per ASCE 7-10. The licensee performed an evaluation that showed that both buildings are erected to withstand an equivalent seismic capacity of up to 1.55 times the SSE. Based on the licensee's FIP description, the NRC staff concludes that both FESBs are robust for seismic considerations.

The licensee's FIP states that a calculation was performed that evaluated the rigid body sliding and rocking of unanchored equipment to determine the required separation distance of the equipment within the FESBs to ensure that they protected from seismic interactions. The minimum spacing of equipment within the FESBs is governed by the maximum displacement of the equipment during sliding and rocking. According to the licensee, this calculation shows the equipment will not slide or rock. In addition, for access purposes, the equipment is located with a minimum of 18-inch spacing to prevent seismic interactions. As a result, no equipment tie downs have been provided in the FESBs.

Section 5.3.1.2 of NEI 12-06 states that large FLEX equipment should be secured as appropriate to protect them during a seismic event and that stored equipment and structures should be evaluated and protected from seismic interactions. During the audit process, the NRC staff reviewed evaluation, JAF-CALC-16-00019, "Rocking and Sliding Evaluation of Equipment Inside FLEX Equipment Storage Buildings," Revision 0, to confirm the licensee's FIP assessment of potential seismic interactions of stored equipment. The NRC staff review concludes that the licensee's evaluation demonstrates that the stored equipment is sufficiently protected from seismic interactions.

Based on the licensee's FIP description, the NRC staff concludes that the equipment in each building is protected such that it should be deployable after a seismic event.

3.6.1.2 Flooding

Since the site grade at FitzPatrick is generally above the design and licensing basis lake flooding levels, the storage and deployment locations are passively protected from flooding. Both of the FESBs, the haul paths, and the "A" staging areas are all located at an elevation that is above the postulated lake level under a flooding scenario. According to the licensees' FIP, the flooding assessment includes the impacts of recent International Joint Commission plans to expand the lake level regulated band by up to 2 inches on the high side. In addition, the licensee's FIP discussed the revised Local Intense Precipitation (LIP) analysis stemming from the licensee's 50.54(f) letter flooding activities. According to the licensee, the revised higher LIP flooding levels will not impact the ability to implement the FLEX strategy using equipment from the "N" storage facility. The ability to implement the FLEX strategy under potential LIP re-evaluated flood hazard conditions will be evaluated separately by the NRC in response to the 50.54(f) letter.

During the audit process, the NRC staff was able to observe the FESB locations, projected haul paths, and FLEX equipment deployment locations. The staff observed that the local terrain at the site is consistent with the licensee's assessment of the FLEX strategy viability under postulated design-basis flooding conditions.

3.6.1.3 High Winds

The licensee utilizes two storage facilities for the Phase 2 FLEX equipment. The use of two structures is primarily used to provide protection from tornado high winds and missiles via separation in accordance with NEI 12-06, Section 7.3.1.1.c. This approach is acceptable for non-hurricane sites such as FitzPatrick, consistent with NEI 12-06 Section 7.2.1. The separation distance for the two FESBs was calculated to be 950 feet for the site-specific tornado hazard in the vicinity of the FitzPatrick site. The licensee then adjusted the required separation to 1400 feet to account for the predominant tornado path orientation. According to the licensee's FIP the two building are separated by over 2000 feet, thus meeting the required separation distance. During the onsite audit the NRC staff was able to walk down the licensee's FESB locations to confirm sufficient separation. The licensee utilized a wind speed of 165 mph in the design of both FESBs in order to bound the ASCE 7-10 required wind loading for the buildings.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

According to the licensee's FIP, if the BDBEE occurs during the winter, cold temperatures would not affect the accessibility of equipment inside any plant buildings. In addition, the site would have ample warning of impending snow and ice storms and will take appropriate precautions per existing plant practice such as preparing for salting roads and walkways, preparing/staging snowplowing vehicles. Administrative controls are used to ensure FLEX pathways are maintained clear of snow and ice.

The licensee's compliance letter states that both "N" and "N+1" FESBs are designed to 60 psf snow load which is in excess of the plant's design basis snow loading. Normal snow removal practices are used to keep paths around site clear. The "N+1" FESB is equipped with a front

end loader that can be used for snow removal. Deployment of equipment from the "N" FESB can be accomplished by hand or by the use of small carts such that snow accumulation following the event is not expected to impede deployment.

According to the licensee's FIP, to ensure that the FLEX equipment is likely to function when called upon, the inside of the FESBs will be maintained at 40°F during the winter months. In addition the licensee determined the duration of time until stagnant water within the hoses and existing pipes freeze and determined the minimum flow rate at which the water will remain unfrozen. During extreme cold conditions, the flow rates in hose and pipes are maintained above the values to prevent freezing. If flow through a hose or pipe is stopped for a period of time, the hose or pipe is drained to prevent the stagnant water from freezing. The licensee's compliance letter indicates that the intake flow rate for FLEX, is considerably less than the minimum intake flow rate evaluated in an existing FitzPatrick frazil ice study, and it can be concluded that there will not be a frazil ice concern during a BDBEE event.

According to the licensee's FIP, the extreme high ambient temperature for FitzPatrick of 100°F is bounded by the design of the FESBs, where a maximum indoor temperature limit of 120°F was used with respect to the extreme ambient temperature. Protection of the FLEX equipment from impacts due to extreme high ambient temperatures during storage is provided by natural circulation through louvers and/or fans to maintain necessary airflow to maintain the indoor temperature within the maximum design temperature of 120°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 3.2.2.16 of NEI 12-06 states, in part, that in order to assure reliability and availability of the FLEX equipment, the site should have sufficient equipment to address all functions at all units on-site, plus one additional spare (i.e., an "N+1" capability, where "N" is the number of units on site). It is also acceptable to have a single resource that is sized to support the required functions for multiple units at a site (e.g., a single pump capable of all water supply functions for a dual unit site). In this case, the "N+1" could simply involve a second pump of equivalent capability. In addition, it is also acceptable to have multiple strategies to accomplish a function, in which case the equipment associated with each strategy does not require an additional spare.

The licensee's strategy uses two storage buildings to, in part, ensure the "N+1" provision is met. Specifically, a FLEX DG, motor control center (MCC) bucket, nitrogen bottles, diesel fuel transfer skid, and the hoses/cables required to implement the strategy are stored in each FESB (or in some cases another robust plant structure) to provide this provision, with "N" capability being available following a postulated tornado event. The licensee's strategy incorporates the use of two installed DDFPs (permanent plant equipment) for RPV and SFP makeup. These pumps provide an element of this provision since they are both located in a robust structure and each one is capable of meeting the required hydraulic capability.

After the issuance of NEI 12-06, Revision 0, NEI, on behalf of the commercial nuclear power industry, submitted a letter to the NRC [Reference 54] proposing an alternative regarding the quantity of spare hoses and cables to be stored on site. The alternative proposed was that either: (a) 10 percent additional lengths of each type and size of hoses and cabling necessary for the "N" capability plus at least one spare of the longest single section/length of hose and cable be provided, or (b) that spare cabling and hose of sufficient length and sizing to replace the single longest run needed to support any FLEX strategy. By letter dated May 18, 2015 [Reference 55], 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 NEI alternative for spare hoses and cables was later incorporated into the NRC-endorsed NEI 12-06, Revision 2 and is also reflected in NEI 12-06, Revision 4. The NEI alternative postulates that the most probable cause for degradation/damage to hoses and cables would occur during deployment of the equipment.

The licensee has elected to store the majority of their FLEX equipment in two separate FESBs. During the audit process, the NRC staff questioned whether there are hoses and cables to support deployment from either storage facility, including an allowance for sufficient spares. The licensee clarified that that hoses and cables (including a spare 10 percent) are stored in the "N+1" FESB to support deployment from that location. Hoses and cables for deployment from the "N" FESB are stored in various locations, either in protected structures or, in the case of the electrical cables, in the "N" FESB.

Since the licensee's plan for spare hoses and cables, as clarified during the audit process, appears to be consistent with the provisions of NEI 12-06, Revision 2 and Revision 4, and the FIP states that the licensee conforms to NEI 12-06, Revision 4, with no alternatives, the NRC staff concludes that the quantity of spare hoses and cables for FLEX at FitzPatrick is acceptable.

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 includes a sufficient quantity of FLEX equipment to provide for RPV makeup and core cooling, SFP makeup, and maintaining containment consistent with the "N+1" recommendation in Section 3.2.2.16 of NEI 12-06.

### 3.7 Planned Deployment of FLEX Equipment

The licensee's deployment strategy would depend on whether they are using equipment from the "N" FESB or the "N+1" FESB. The "N" FESB has a more limited deployment as the FLEX DG can be run in place. In addition the DDFPs are installed plant equipment. Thus, equipment deployment consists primarily of running hoses and cables. If the licensee was utilizing the "N+1" equipment, the FLEX DG would have to be accessed in its storage location and moved to its appropriate staging area using the stored towing and debris removal equipment, as appropriate.

#### 3.7.1 Means of Deployment

According to the licensee's FIP, a much smaller debris removal effort is required to establish the FLEX connections when deploying from the "N" FESB. This is because the "N" FLEX DG can be run from its storage location without movement, limiting the required deployment activities to running hoses and cables versus relocating large pieces of FLEX equipment. Thus the major

piece of debris removal equipment, the FLEX front end loader, is stored in the "N+1" FESB. Smaller debris removal equipment is stored in the "N" FESB, consistent with the strategy. The "N+1" FLEX DG would be moved with its towing vehicle, a heavy duty pickup that is also stored in the "N+1" FESB.

3.7.2 Deployment Strategies

According to the licensee's FIP, soil liquefaction along the deployment routes was evaluated and the soil was determined to be stable. The licensee's compliance letter also states that a subsurface exploration was performed to evaluate the engineering properties of the subsurface soils within the two proposed FLEX storage building sites, Staging Area "B" (the Phase 3 equipment staging area at the FitzPatrick site), helicopter landing zone, and along the proposed travel paths. Based on the current and past explorations performed in the project area, the overall liquefaction potential for the locations previously listed is low. For a postulated earthquake scenario the analyses indicate that some minor ground deformations (estimated at less than 1 inch) could occur following an earthquake due to isolated pockets of loose/soft materials, should these materials become fully saturated. During construction of the FESBs, any loose/soft or otherwise unsuitable soil overburden that was encountered was replaced with compacted fill, eliminating the potential for liquefaction under the building's foundation. For the staging area, helicopter landing zone and the travel paths, such minor ground deformations due to strong shaking would not be expected to render the travel paths, the staging area and the helicopter landing zone inaccessible.

According to the licensee's FIP, the use of the DDFPs to access the UHS ensures that the strategy is not impacted by the possibility of frazil ice. This is accomplished primarily by design of the lake intake components. The licensee's assessment also notes that the flow velocities associated with FLEX implementation would be low enough to preclude an adverse impact from frazil ice.

3.7.3 Connection Points

3.7.3.1 Mechanical Connection Points

Core Cooling and RPV Makeup

In the licensee's FIP, Sections 2.3.5.1 and 2.3.5.2, describe the primary and alternate core cooling/RPV makeup connection points for the DDFP. The DDFP will supply lake water to the connection points using fire hose pre-staged inside the Screenwell Building. The Screenwell Building is a Seismic Category I structure, which is protected from all applicable external hazards. The primary connection point is at a FLEX connection on the combined RHRSW crosstie to the RHR system. For this connection, water is injected through the "A" loop of the RHR system. If necessary, the non-seismic portion of the fire protection piping will be isolated to prevent a piping failure from adversely affecting the capabilities of the seismic piping to deliver cooling water to the RPV.

The alternate connection point uses the other DDFP, hoses, and two adapters to connect to an expansion joint (that needs to be removed) in the RHRSW system. This flow path allows the DDFP to be connected to the discharge of an RHRSW pump. The RHRSW system will then be procedurally aligned to the RHR system and RPV injection will be available via the "B" loop of the RHR system.

Both of these connection points for the DDFPs are located in a protected structure and the flow paths are designed to be fully independent.

SFP Cooling

In the licensee's FIP, Section 2.4.2, describes three methods for SFP makeup. Similar to core cooling/RPV makeup, a DDFP is also used for SFP cooling. The first method has a primary and alternate connection to permanent piping through the RHRSW system. The DDFP's primary connection is through the RHRSW/RHR crosstie connection described in the core cooling section. From there, lake water can be directed to the RPV and/or the SFP cooling system. For the alternate piping connection, using the second DDFP, the same connection as described above for the alternate core cooling/RPV makeup function is utilized, with the makeup water being directed to the SFP from the RHRSW system.

The second method uses temporary hoses that are placed over the side of the SFP. Either DDFP can be used in this method. From the pump being used, the hose will run through the Screenwell Building, the Turbine Building, and the Administration Building to the Reactor Building. At the base of the Reactor Building stairs, the hose will be split via a Y-connection, and two hoses will then be routed up to the Reactor Building refuel floor where they can be used to establish SFP makeup flow.

The third method is described as using one of the hoses from the Y-connection at the base of the Reactor Building stairs and being connected with an additional hose to the spray monitor already pre-staged on the SFP refuel floor. The hose used for the spray monitor connection will already be pre-staged for the spray monitor nozzles. All of the FLEX connections for SFP makeup are located inside Seismic Category I buildings and are protected from all applicable external hazards.

3.7.3.2 Electrical Connection Points

During Phase 2, the licensee's FLEX strategy to re-power the station's battery chargers requires the use of a 200 kW, 600 Vac DG. Two FLEX DGs are available but only one is necessary. One FLEX DG ("N"), is a fixed installation located inside the "N" FESB on the north side of the Screenwell Building. The other FLEX DG ("N+1") is portable and is stored outside the protected area in the "N+1" FESB. The "N+1" DG and cable trailer would be deployed to a location near the "N" FESB. For the primary strategy, operators would route cables through the Screenwell Building north roll-up door to a MCC bucket in MCC 254. For the alternate strategy, operators would route cables through the Screenwell Building north roll-up door to an MCC bucket in MCC 264. Each MCC has three space options available for the MCC bucket to be inserted (only 1 space is required). The licensee will store one MCC bucket in each FESB. The MCC bucket will be restrained in the staging location to prevent it from being damaged. Guidelines FSG-001 and FSG-002 provide direction for staging and connecting a 200 kW FLEX DG to energize the FitzPatrick electrical buses. The licensee performed a phase rotation check on the electrical buses during Refuel Outage RF22 to ensure proper phase rotation existed between the FLEX DGs and the FitzPatrick electrical buses. In addition, the connections and cables are color coded to ensure that proper phase rotation is maintained.

For Phase 3, the licensee will receive two 1 MW 4160 Vac CTGs and one 1000 kW 480 Vac CTG from an NSRC. The NSRC-supplied 4160 Vac CTGs can be connected to the 4160 Vac buses via two diverse connection points. Connections can be established to either Class 1E 4160 Vac Switchgear 71H05 (Bus 10500) or Switchgear 71H06 (Bus 10600). The cabling to

make the connection is supplied with the NSRC generators. Cabling for the connections is color-coded. Guideline FSG-007 provides direction for staging and connecting the 4160 Vac CTGs. Guideline FSG-007 also provides direction to verify proper phase rotation of the 4160 Vac CTGs.

3.7.4 Accessibility and Lighting

According to the licensee's FIP, part of the standard gear/equipment of operators with duties in the plant (outside the MCR) includes flashlights. Thus, flashlights would be available to operations personnel immediately following the start of the event. During the audit process the NRC staff reviewed plant procedure EN-OP-115, "Operator Rounds," Revision 1, to confirm this requirement. According to the licensee, the use of flashlights will provide enough illumination to accomplish FLEX manual operator actions. Additionally, the licensee's FIP also states that the Reactor Building, Turbine Building, and Screenwell Building are provided with 8 hour uninterruptible power supply-backed emergency lighting, some of which is repowered by the 600 VAC FLEX DG. Portable lighting is available in the Control Room and in emergency lockers for on-shift personnel. Additional portable lights, flashlights, and head lamp lights are located on the electrical cable trailer stored in the "N+1" FESB. Additionally, the licensee's FIP notes that mobile lighting towers will be provided by the NSRC as part of the Phase 3 generic equipment inventory. Based on the FIP description, the NRC staff concludes that sufficient lighting should be available to implement the licensee's strategy.

3.7.5 Access to Protected and Vital Areas

According to the licensee's FIP, access to the protected area during a BDBEE is addressed in the station FSGs and support procedures. This is accomplished with the support of the security force. During the audit process the NRC staff confirmed that the licensee has contingencies in place to provide access to areas required for the ELAP response if the normal access control systems are without power.

3.7.6 Fueling of FLEX Equipment

In the licensee's FIP, Section 2.9.4, states that four underground EDGs each have about 13,500 gallons of usable fuel for a total of 54,000 gallons. According to the licensee, the underground EDG fuel oil storage tanks contain sufficient fuel oil to support all Phase 2 strategies and beyond. Fuel can be removed from the tanks and delivered to diesel fuel users using the diesel fuel transfer skid. One such skid is located in each FESB. The diesel fuel transfer skid consists of a pump and appropriate hose fittings, along with a relief valve that recirculates back to the fuel tank. Additional fuel oil that will be needed for the DDFPs and the 600 VAC FLEX DG will be stored with the equipment.

The licensee stated in its FIP, that the total fuel consumption rate is approximately 41.3 gallons per hour. The licensee analyzed that the on-site available fuel oil will be able to support operation of FLEX equipment for 55 days before off-site fuel oil will be needed. Additionally, the licensee's FIP states that all FLEX equipment will be stored fueled. Diesel fuel in the EDG fuel tanks is currently maintained for operation of the station EDGs and is therefore routinely sampled and tested to assure fuel oil quality is maintained in accordance with FitzPatrick Technical Specification 5.5.10. The licensee indicated that the fuel oil in the fuel tanks of diesel-engine driven FLEX equipment will be maintained via the site Preventative Maintenance (PM) program in accordance with the EPRI maintenance templates. During the audit process, the NRC staff conducted a walk down of the fuel storage locations for the DDFPs and FLEX DG, to

confirm the accessibility of fuel oil during the ELAP event. The NRC staff also reviewed the FSGs to identify the FLEX equipment to be used and accompanying fuel consumption rates. Based on the availability of the fuel oil and the accessibility to refuel the FLEX equipment, the NRC staff finds that the overall FLEX refueling strategy is acceptable for the FitzPatrick site.

#### 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 FitzPatrick SAFER Plan

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

There are two NSRCs, located near Memphis, Tennessee and Phoenix, Arizona, established to support nuclear power plants in the event of a BDBEE. Each NSRC holds five sets of equipment, four of which will be able to be fully deployed to the plant when requested. The fifth set allows removal of equipment from availability to conduct maintenance cycles. In addition, the plant's FLEX equipment hose and cable end fittings are standardized with the equipment supplied from the NSRC.

By letter dated September 26, 2014 [Reference 26], 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 reviewed the licensee's SAFER response plan during the audit process and noted that it 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. Two of these staging areas are described as a primary area (Staging Area "C") and an alternate (Staging Area "D"), if required. These two locations are offsite areas (within about 25 miles of the plant) utilized for receipt of ground transported or airlifted equipment from the NSRCs. From these areas, 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. Staging Area "C" is located at the Syracuse Hancock International Airport which is approximately 39 miles from the FitzPatrick site. Staging Area "B" is located at the contractor parking lot in the southwest corner of the site. The FitzPatrick FIP does not discuss provisions for Staging Area "D". However, during the site audit the NRC staff reviewed the licensee's SAFER response plan, AREVA document 38-9247576-000, "SAFER Response Plan for James A. FitzPatrick Nuclear Power Plant," Revision 1, dated September 9, 2015, and noted that Staging Area "D" is Whitford's Airport, located in Weedsport, New York.

If ground transportation is unavailable, the use of helicopters to transport equipment from Staging Area "C/D" to Staging Area "B" is recognized as a potential need within the FitzPatrick SAFER plan. The licensee's FIP states that equipment can be taken from Staging Area "C" to Staging Area "B" at the FitzPatrick site by helicopter if ground transportation is unavailable. The FitzPatrick helicopter landing zone is located on the south side of the plant. The licensee's SAFER plan also has provisions for helicopter considerations at the Oswego County Airport.

#### 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 the postulated ELAP event at FitzPatrick, ventilation that provides cooling to occupied areas and areas containing required equipment will be lost. Per the guidance given in NEI 12-06, FLEX strategies must be capable of execution under the adverse conditions (unavailability of installed plant lighting, ventilation, etc.) expected following a BDBEE resulting in an ELAP.

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 performed loss of ventilation analyses to quantify the maximum steady state temperatures expected in specific areas of the plant related to FLEX implementation to ensure the environmental conditions remain acceptable for personnel habitability and equipment performance regarding the FLEX strategy.

The key areas identified for all phases of execution of the FLEX strategy activities are the MCR, RCIC room, battery rooms, dc equipment rooms, switchgear rooms, the DDFP rooms, the SFP area, and primary containment. The licensee evaluated these areas to determine the temperature profiles following the event. The results of the licensee's room heat-up evaluations have concluded that temperatures remain within acceptable limits.

MCR and Relay Room

According to the licensee's FIP, the MCR and relay room are predicted to stay below 110°F for the first 120 hours of the event. During the audit process the staff reviewed the licensee's calculation, JAF-CALC-14-MISC-04509, "Main Control Room Heat-Up During an Extended Loss of AC Power," Revision 0, which modeled the temperature transient response for 120 hours and determined what actions are needed to maintain habitability in the MCR and operability of the equipment in the MCR following an ELAP. The calculation uses the GOTHIC (Generation of Thermal-Hydraulic Information for Containments) Version 7.2b computer program. The GOTHIC calculation for the MCR showed that temperature will not exceed the upper habitability limit of 110°F considering a loss of ventilation for 120 hours after the onset of a BDBEE. Therefore, according to the licensee, no operator actions or supplemental FLEX equipment are required for FLEX mitigation strategies for the initial 120 hours following the BDBEE. After this period of time, sufficient offsite resources would be available through the FitzPatrick Emergency Response Organization (ERO) and the NSRC-provided equipment to mitigate the possibility of the MCR temperature exceeding 110°F after 120 hours following the event. The NRC staff finds that it is reasonable to expect that the licensee could utilize these resources to reduce or maintain temperatures within these rooms to ensure that required electrical equipment survives indefinitely.

According to the licensee's FIP, in order to mitigate high MCR temperature, cooling can be provided by restarting normal ventilation using the NSRC 4160 VAC CTG as a power source. This will provide at least 1,920 cubic feet per minute (cfm) of outside air to the MCR and 1,300 cfm to the relay room. This is equivalent to 1 air exchange per hour for both rooms. With the maximum external ambient temperature at FitzPatrick being 100°F and accounting for diurnal variations, this air exchange will maintain the heat up of the MCR and relay rooms below the habitability temperature of 110°F. Additionally, AOP-49, "Station Blackout," Revision 20, requires opening all MCR panel doors within 30 minutes of the beginning of an SBO to minimize heat-up of the components contained in the MCR panels.

Based on MCR 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) and the availability of the NSRC equipment in Phase 3, the NRC staff expects that the equipment in the MCR and relay room should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

RCIC Pump Room

According to the licensee's FIP, with the doors open, the RCIC room stays below the limiting temperature for at least 24 hours. The limiting room temperature for this evaluation is 150°F to ensure operability of the EG-M module for the turbine governor. With the RCIC room doors open, the temperature is expected to reach 137°F at 24 hours. In addition, the licensee's FIP states that the RCIC room temperature remains below 150°F throughout 60 hours after the event; therefore, the EG-M will not be impacted due to room temperature during the initial 24 hours. Although room temperature is still increasing at 24 hours, the credited FLEX strategy only utilizes RCIC for 24 hours and it is not expected to continue operation past this point. During the audit process, the staff reviewed calculation JAF-CALC-15-00046, "RCIC Room Heat-Up for an Extended Loss of ac Power (FLEX)," Revision 0, which modeled the temperature transient response in the RCIC enclosure for 24 hours during ELAP conditions. The staff confirmed the results were consistent with the licensee's FIP description. The staff

also reviewed licensee guideline, FSG-001, "Initial Assessment and FLEX Equipment Staging," Revision 0, to confirm that the room doors would get opened during the ELAP event.

Based on expected room temperature remaining below 150°F (the design limit for the EG-M module) and the procedure-driven mitigating actions to ensure doors are open, the NRC staff finds that the required RCIC pump function should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Battery and DC Equipment Rooms

According to the licensee's FIP, the battery and dc equipment rooms are predicted to stay below 110°F for the first 120 hours of the event. During the audit process the staff reviewed the licensee's calculation, JAF-CALC-14-00027, "Temperature Evaluation of Battery Room and DC Equipment Room During Extended Loss of Offsite Power (FLEX)," Revision 0, which modeled the temperature transient response for 120 hours. The licensee's acceptance criterion for equipment operability is to maintain room temperature below the upper limit of 110°F during extreme hot summer conditions.

The licensee's battery and dc equipment room calculation determined that during extreme heat conditions the room temperature will reach a peak temperature of approximately 109°F at 120 hours after loss of ac power. Operator action is required to open fire doors within 10 hours after the event. The maximum temperature given above includes this operator action and the staff confirmed that FSG-001 would open the necessary doors consistent with the licensee's FIP description. According to the licensee, following 120 hours, NSRC equipment can be used to repower plant ventilation. The NRC staff finds that it is reasonable to expect that the licensee could utilize these resources to reduce or maintain temperatures within these rooms to ensure that required electrical equipment survives indefinitely.

Based on the above, the NRC staff finds that the licensee has shown that it can maintain the battery and dc equipment room temperatures 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 licensee has also demonstrated that the maximum temperature limit of the Class 1E station batteries, as specified by the battery manufacturer (Exide Technologies) (120°F) should not be exceeded. Therefore, the NRC staff finds that the electrical equipment located in the battery and dc equipment rooms should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Switchgear Rooms

According to the licensee's FIP, the steady state temperatures of the relevant switchgear rooms are predicted to stay below 120°F for the event. During the audit process the staff reviewed the licensee's calculation, JAF-CALC-15-00020, "Steady-State Temperature in El. 272' Electrical Bays and El. 272' EDG Switchgear Rooms During Phase 2 of Response to BDBEE," Revision 0, which determined the steady-state temperature in these locations. The calculation showed that the steady-state temperature of the east electrical bay would be 104.8°F during the Phase 2 alternate electrical strategy. The calculation showed that the steady-state temperature of the east electrical bay bounds the steady-state temperature of the west electrical bay. In addition, the steady-state temperature of EDG switchgear room "A" would be 105.6°F during the licensee's Phase 2 electrical strategy. The calculation showed that the steady-state

temperature of EDG switchgear room "A" bounds the steady-state temperature of EDG switchgear room "B".

FitzPatrick will receive offsite resources and equipment from an NSRC within 72 hours after the onset of an ELAP event. According to its FIP, the licensee plans to restore the switchgear room ventilation using the NSRC CTGs during Phase 3. The NRC staff finds that it is reasonable to expect that the licensee could utilize these resources to reduce or maintain temperatures within the switchgear rooms to ensure that required electrical equipment survives indefinitely.

Based on the above, the NRC staff finds that the licensee has shown that it can maintain switchgear room temperatures below 120°F, which is 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. Therefore, the NRC staff finds that the electrical equipment located in the switchgear rooms should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Diesel Driven Fire Pump Rooms

According to the licensee's FIP, the ambient condition of the DDFP rooms must remain within the operating range of the pumps. During the audit process the staff reviewed the licensee's calculation, JAF-CALC-15-00006, "Diesel Fire Pump Room Heatup for Extended Loss of Offsite Power (FLEX)," Revision 0, which modeled the temperature in the DDFP rooms and determined the cooling load required to maintain the existing DDFP rooms within an allowed temperature range. In addition, calculation MDA-86-0724-CB, "Diesel Fire Pump Room Ventilation Requirements," Revision 0, determined that the maximum allowed ambient temperature in the east and west DDFP rooms would be 119°F.

Calculation JAF-CALC-15-00006 assumed that the plant ventilation system for the DDFPs will not be operable in Phase 2, and determined that the doors to the Screenwell Building need to be opened while the DDFPs are operating. Additionally, calculation JAF-CALC-15-00006 determined that the east and west DDFP rooms will indefinitely remain within the allowed temperature range if the doors to the east and west DDFP rooms are opened prior to operation of the pumps. Room heating during extreme cold is not a concern due to the large heat load coming off of the operating DDFP.

According to the licensee's FIP, the DDFPs have exhaust piping to remove the diesel exhaust from the pump rooms. The piping exits the building through the north wall of the Screenwell Building and extends approximately a foot beyond the building wall. The exhaust pipe has a flapper at the end to prevent weather or animals from entering. If a missile were to impact the exhaust pipe outside the Screenwell Building, the pipe could simply be cut off at the wall. The diesel exhaust piping is non-seismic. Calculation JAF-CALC-15-00006 calculated the buoyancy driven natural circulation through the open DDFP room doors and determined that if a seismic event were to incapacitate the diesel exhaust piping, there is sufficient air exchange to prevent a buildup of diesel exhaust in either DDFP room that could choke the diesel engine.

Based on the above, the NRC staff finds that the licensee has shown that it can maintain the DDFP room temperature 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.

Therefore, the NRC staff finds that the electrical equipment located in the DDFP rooms should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

SFP Area

The licensee's strategy for the SFP area is to establish a Reactor Building vent path and run any necessary hoses before the area becomes impacted by boiling water. The only equipment in the immediate area needed to accomplish the strategy are the SFP level instrumentation components installed to comply with Order EA-12-051. The ability of the SFP level instruments to function during the postulated event is described in Section 4.0 of this safety evaluation.

Containment

The FitzPatrick FLEX strategy credits the use of the solenoid operated SRVs to control RPV pressure. The SRVs operate as part of the automatic depressurization system (ADS). During the audit process, the staff reviewed Attachment 6.037 of EC52736, "ELAP Conditions on SRVs." This evaluation addressed the performance of the SRV solenoid operated valves and supporting equipment during ELAP conditions. For the FitzPatrick FLEX strategy, the SRVs initially cycle in a normal manner at their electric lift setpoints to control RPV pressure. Subsequently, the SRVs are manually cycled between valves to evenly distribute heat discharged to the torus. The SRVs would also be used to perform an RPV depressurization to allow injection of water from low pressure sources. The licensee's analysis showed that the design limits of the SRV SOVs and the ADS control panel will not be exceeded during an ELAP event. In addition to the SRVs, the FitzPatrick FLEX strategy credits fourteen instruments that are critical to the strategy. The staff reviewed Attachment 6.035 of EC52736, "ELAP Conditions on Critical Instruments," which evaluated the performance of these instruments during ELAP conditions to ensure proper operation throughout the event. The licensee's evaluation showed that the accident profile for each critical instrument fully bounds the ELAP profiles in thermal equivalency and peak temperature.

Additionally, FitzPatrick will receive offsite resources and equipment from an NSRC within 72 hours after the onset of an ELAP event. The NRC staff finds that it is reasonable to expect that the licensee could utilize these resources to reduce or maintain temperatures within containment to ensure that required electrical equipment survives indefinitely. Nonetheless, plant operators will continue to monitor containment parameters and perform additional actions that may be required to reduce containment temperature and pressure.

Based on temperatures remaining below the design limits of equipment and the availability of offsite resources after 72 hours, the NRC staff finds that the electrical equipment in the containment should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Based on its review of the essential station equipment required to support the FLEX mitigation strategy, which are primarily located in the MCR, relay room, RCIC room, battery and dc equipment rooms, switchgear rooms, DDFP rooms, the SFP area, and containment, the NRC staff finds that the electrical equipment should perform their required functions during the postulated event.

3.9.1.2 Loss of Heating

The licensee stated in its FIP, that heat tracing is not required for any equipment used for FLEX after the initiation of the ELAP event. The FLEX equipment is protected from low temperatures and freezing during normal plant operation using electric heaters. Such heaters are provided for all diesel engine blocks. The licensee also described in its FIP, that the FESBs will maintain a temperature above 40°F for the winter months. Space heaters powered by offsite power will be used to provide this minimum temperature prior to any external event. The licensee also indicated that the hoses and pipes will be drained of stagnant water to prevent freezing, and for operation during extreme cold conditions, the hoses and piping will maintain consistent flow rates to also prevent freezing. Based on the above, the NRC staff finds that the equipment used for FLEX should perform their required functions as a result of loss of normal heating that could occur during the postulated ELAP event.

The FitzPatrick Class 1E station battery rooms are located in plant structures such that they will not be exposed to extreme low temperatures. At the onset of the event, the 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 recharging. Temperatures in the battery rooms are not expected to be sensitive to extreme cold conditions due to their location, the concrete walls isolating the rooms from the outdoors, and lack of forced outdoor air ventilation during early phases of the ELAP event.

During the audit process, the NRC staff reviewed licensee calculation JAF-CALC-14-00027, "Temperature Evaluation of Battery Room and DC Equipment Room During Extended Loss of Offsite Power (FLEX)," Revision 0. The licensee's calculation showed that with a constant (i.e., diurnal fluctuations conservatively not considered) extreme outdoor temperature of -23°F that the station battery rooms will remain above the minimum required temperature (65°F) for at least 120 hours. The licensee will receive offsite resources and equipment from an NSRC within 72 hours after the onset of an ELAP event. The NRC staff finds that it is reasonable to expect that the licensee could utilize these resources to increase or maintain temperatures within the station battery rooms to ensure that the station batteries survive indefinitely.

Based on the above, the NRC staff finds that the FitzPatrick station batteries should perform their required functions while considering the loss of normal room heating during an ELAP event.

3.9.1.3 Hydrogen Gas Control in Vital Battery Rooms

An additional ventilation concern for the battery rooms in Phases 2 and 3 of the event is the potential buildup of hydrogen as a result of loss of ventilation. Off-gassing of hydrogen from batteries is only a concern when the batteries are charging. According to the licensee's FIP, the hydrogen buildup in the battery rooms will remain below 2 percent for at least 120 hours into the postulated event. Specifically, the licensee's analysis concluded that the battery rooms would exceed 2 percent hydrogen by volume at 128.3 hours after initiation of an ELAP event. The licensee plans to restore power to the ventilation fans in the battery rooms before this time. The staff reviewed FSG-007, "Long Term Reactor Vessel Cooling," Revision 0, and confirmed that it provides guidance for energizing the battery rooms exhaust fans using the NSRC-supplied CTGs. Additionally, the licensee stated in its FIP that the battery room exhaust fans could be energized using a Phase 2 600 Vac DG to provide further assurance that hydrogen concentration in the station battery rooms would not reach the point of combustibility. During the audit process, the staff reviewed the licensee's guideline FSG-002, "ELAP DC Bus Load

Shed and Management," Revision 1, to confirm that it includes a note to provide ventilation for the battery and charger rooms within 120 hours of initiating a battery charge. The NRC staff finds the licensee's plan has adequate provisions to ensure that a flammability limit (4 percent) should not be reached in the battery rooms during an ELAP event.

3.9.2 Personnel Habitability

3.9.2.1 Main Control Room

As described in Section 3.9.1.1 of this safety evaluation, the MCR temperature profiles were determined in calculation JAF-CALC-14-MISC-04509. The MCR calculation predicts that with no mitigating actions taken, the MCR temperatures will not exceed the upper habitability limit of 110°F considering a loss of ventilation for 120 hours after the onset of the BDBEE. After this period of time, the licensee states that sufficient offsite resources are available through the ERO and the NSRC-provided equipment to mitigate the MCR temperature after this time.

Based on the expected temperature response in the MCR remaining below the limit of 110°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 MCR habitability), the staff finds it reasonable that operators can safely enter and occupy the MCR during an ELAP event. The staff finds the above strategies are consistent with NEI 12-06, Section 3.2.2, such that station personnel can perform the necessary actions to support the FLEX mitigation strategy during an ELAP event.

3.9.2.2 Spent Fuel Pool Area and Reactor Building

According to the licensee's FIP, all deployment actions in the Reactor Building will be performed early in the event. During the audit process the staff reviewed the licensee's calculation JAF-CALC-15-00025, "Reactor Building Heatup During Extended Loss of AC Power (ELAP)," Revision 0, which determined the temperature profiles at all levels of the Reactor Building following an ELAP. The calculation evaluates two cases, one in which doors at the refuel floor and at grade are opened, and one in which the exhaust vent is opened in addition to the doors. Both cases include propping open a number of interior doors. Based on the results of this calculation, to minimize the area temperatures in the Reactor Building, the following manual actions would be performed:

- Ensure Doors R-227-3 (RCIC enclosure stairway side fire door) and R227-4 (RCIC enclosure RHR side fire door) remain open
- Open Doors R-369-1, R-369-2, R-272-1, and R-272-2

Under this scenario, the temperature on the refuel floor will reach 120°F at 13.6 hours into the event. All manual actions at the refueling floor will be completed by 5 hours into the event according to the sequence of events in the licensee's FIP. According to the licensee, the following actions evaluated in the calculation may be performed and are considered defense-in-depth (not required):

- Open Reactor Building exhaust duct dampers 66AOV-101A, 66AOV-101B, and 66AOD-106A or 106B

The staff concludes that the licensee's actions will ensure that station personnel can perform the necessary strategy elements in the Reactor Building, from a habitability perspective, to support the FLEX mitigation strategy during the postulated ELAP event.

3.9.2.3 Other Plant Areas

Certain areas in the plant may be considered a hot environment if the BDBEE occurs during the summer. The licensee's FIP states that all elevations of the Reactor Building could become very hot over the course of the event and thus all equipment deployment actions will be performed early in the event.

Individual room heat-up calculations were performed for the RCIC room, the battery rooms, and the switchgear rooms, where there were equipment operability concerns. None of these rooms require personnel access during a FLEX event after the initial equipment setup and deployment.

Operator actions required later in the event in all buildings are subject to applicable site and fleet procedures in order to mitigate the risks of working in a hot environment. Following a BDBEE, site procedures, FSGs, and applicable site conditions will be used to determine operator stay times and need for personnel protection such as ice vests.

If the BDBEE occurs during the winter, the licensee's FIP states that cold temperatures would not affect the accessibility of equipment inside any plant buildings. There is no expected debris generation outdoors due to an extreme cold event. Snow and ice, as they relate to personnel routes to the FESBs and equipment deployment routes, are a consideration. However, FitzPatrick would have ample warning of impending snow and ice storms and will take appropriate precautions per existing plant practice such as preparing for salting roads and walkways, preparing/staging snowplowing vehicles, etc. An administrative procedure and the FSGs are used to ensure FLEX pathways are maintained clear of snow and ice.

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

Condition 3 of NEI 12-06, Section 3.2.2.5 states that cooling and makeup water inventories are considered available if they are contained in systems or structures with designs that are robust with respect to seismic events, floods, and high winds, and associated missiles. The NRC staff reviewed the licensee's planned water sources to verify that each water source was robust as defined in NEI 12-06.

3.10.1 RPV Make-Up

Phase 1

As described in the FIP, the CSTs are the normal suction for the RCIC pump. The FIP states that the two CSTs will provide about 192,000 gallons of core cooling and RPV makeup and are protected for all postulated BDBEEs. This volume of water corresponds to the tank levels below

which tornado missile protection is provided and should last approximately 22 hours. Should the tanks not be impacted by a tornado missile, a larger volume would be available. Once the CSTs are close to depletion, the core cooling and RPV makeup function will transition to one of the DDFPs.

Phase 2

During Phase 2, the licensee will transition from the RCIC pump to a DDFP to provide makeup water to the RPV. The DDFPs use Lake Ontario as their suction source. The available volume from Lake Ontario will provide an essentially unlimited amount of water throughout the ELAP event. The plant intake uses a long offshore tunnel well underwater in Lake Ontario. The configuration of the intake allows debris to settle prior to traveling up to the DDFP suction, providing inherent filtering of the raw water to be used for RPV and SFP makeup. According to the licensee's FIP, while the water in Lake Ontario is categorized as raw water, it is fresh water of generally good quality and low salinity.

Phase 3

For Phase 3, RPV makeup strategy is the same as the Phase 2 strategy.

3.10.2 Suppression Pool Make-Up

In its FIP, the licensee did not discuss any required suppression pool makeup for Phases 1, 2 or 3. The staff notes that both the RCIC pump and DDFP(s) use an external suction source throughout the event.

3.10.3 Spent Fuel Pool Make-Up

Phase 1

No SFP makeup is required in Phase 1.

Phase 2

Phase 2 makeup to the SFP is from Lake Ontario using one of two DDFPs. The Lake Ontario makeup source is described above in Section 3.10.1 of this safety evaluation. This source is fully robust and provides an essentially unlimited supply to support indefinite coping.

Phase 3

In its FIP, the licensee noted that the Phase 3 SFP cooling strategy is the same as the Phase 2 strategy.

3.10.4 Containment Cooling

No FLEX pump or water supplies are required for containment integrity coping strategies.

3.10.5 Conclusions

Based on the evaluation above, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain satisfactory water sources

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

### 3.11 Shutdown and Refueling Analyses

Order EA-12-049 requires that licensees must be capable of implementing the mitigation strategies in all modes. In general, the discussion above focuses on an ELAP occurring during power operations. This is appropriate, as plants typically operate at power for 90 percent or more of the year. When the ELAP occurs with the plant at power, the mitigation strategy initially focuses on the use of the steam-driven RCIC pump to provide the water initially needed for decay heat removal. If the plant has been shut down and all or most of the fuel has been removed from the RPV and placed in the SFP, there may be a shorter timeline to implement the makeup of water to the SFP. However, this is balanced by the fact that if immediate cooling is not required for the fuel in the reactor vessel, the operators can concentrate on providing makeup to the SFP. The licensee's analysis shows that following a full core offload to the SFP, about 65 hours are available to implement makeup before boil-off results in the water level in the SFP dropping far enough to uncover fuel assemblies, and 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 a steam-powered pump such as RCIC (which typically occurs when the RPV has been cooled below about 300°F), another strategy must be used for decay heat removal. The NRC-endorsed strategy is described in NEI 12-06. Section 3.2.3 provides guidance to licensees for reducing shutdown risk by incorporating FLEX equipment in the shutdown risk process and procedures. Considerations in the shutdown risk assessment process include maintaining necessary FLEX equipment readily available and potentially pre-deploying or pre-staging equipment to support maintaining or restoring key safety functions in the event of a loss of shutdown cooling. In the FIP, the licensee stated that it would follow this guidance. The FIP also describes the licensee's outage risk planning process. Specifically the licensee has enhanced the shutdown risk process and procedures by incorporating the FLEX equipment. Consideration has been given in the shutdown risk assessment process to: (1) maintaining FLEX equipment necessary to support shutdown risk processes and procedures readily available, and (2) how FLEX equipment could be deployed or pre-deployed/pre-staged to support maintaining or restoring the key safety functions in the event of a loss of shutdown cooling.

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

According to the licensee's FIP, 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 ensures that FLEX strategies are used only as directed, and are not used inappropriately in lieu of existing procedures. When FLEX equipment is needed to supplement

Emergency Operating Procedure or AOP strategies, the applicable procedures and guidelines direct the entry into and exit from the appropriate FSG. The FSGs are used to supplement (not replace) the existing procedure structure that establishes command and control for the event. Procedural interfaces have been incorporated into the station blackout procedure to the extent necessary to include appropriate reference to FSGs and provide command and control for the ELAP.

3.12.2 Training

In its FIP, the licensee stated that the Exelon 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. Initial training has been provided and periodic training will be provided to site emergency response leaders on beyond-design-basis 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.

3.12.3 Conclusions

In NEI 12-06, Section 11.4 describes an acceptable approach to procedure development relating to the implementation FLEX strategies. The staff concludes that the licensee's FIP describes a program consistent with the provisions of NEI 12-06, and is therefore acceptable. Similarity, the staff concludes that the training program provisions described in the licensee's FIP are consistent with the provisions of NEI 12-06, Section 11.6, and are therefore acceptable.

3.13 Maintenance and Testing of FLEX Equipment

As a generic issue, the NEI submitted a letter to the NRC dated October 3, 2013 [Reference 47], which included EPRI Technical Report 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment." By letter dated October 7, 2013 [Reference 48], 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 a fleet procedure has been developed to address PM using EPRI templates or manufacturer provided information/recommendations, equipment testing, and the unavailability of equipment. The PM templates for the major FLEX equipment including the FLEX DGs have also been issued.

According to the licensee, the EPRI PM templates for FLEX equipment conform to the guidance of NEI 12-06, providing assurance that stored or pre-staged FLEX equipment are being properly maintained and tested. The EPRI templates are used for equipment where applicable. However, in those cases where EPRI templates were not available, PM actions were developed based on manufacturer provided information/recommendations and the site PM program.

The licensee's FIP also provides a description of the unavailability controls for FLEX equipment. The staff review notes that these controls generally correspond to the provisions of NEI 12-06, Revision 4. The use of NEI 12-06, Revision 4 as the basis for the licensee's FLEX plan development is assessed in Section 3.14 of this safety evaluation.

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

### 3.14 Alternatives to NEI 12-06, Revision 2

The licensee states in its FIP that the FitzPatrick plan is based on the provisions of NEI 12-06, Revision 4 [Reference 49], with no alternate approaches. In a letter to NEI dated February 8, 2017 [Reference 50], the NRC staff stated that JLD-ISG-2012-01, Revision 2 [Reference 51] had been issued and had been made publicly available. This ISG revision endorsed NEI 12-06, Revision 4, with exceptions, clarifications and additions. However, the NRC letter to the NEI also cautioned that JLD-ISG-2012-01, Revision 2, is not intended to be referenced by licensees in submittals to the NRC, and that the NRC staff would not make use of this ISG revision, until all applicable Congressional Review Act (CRA) requirements have been met. Currently, the CRA requirements for JLD-ISG-2012-01, Revision 2 have not been met.

Regarding NEI 12-06, Revision 4, the NRC staff conducted a thorough review, with numerous stakeholder interactions, that ultimately resulted in the exceptions, clarifications and additions discussed in the NRC's letter dated February 8, 2017. Based on that review, the NRC staff concludes that following the provisions of NEI 12-06, Revision 4, with the exceptions, clarifications, and additions contained in JLD-ISG-2012-01, Revision 2, is an acceptable alternative to NEI 12-06, Revision 2 at FitzPatrick. This conclusion includes the licensee's proposed unavailability controls, as described in the FitzPatrick FIP.

In conclusion, the NRC staff finds that if this alternative is implemented as described by the licensee, it 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 28, 2013 [Reference 27], Entergy submitted an OIP for FitzPatrick in response to Order EA-12-051. By letter dated August 29, 2013 [Reference 28], the NRC staff sent a request for additional information (RAI) to Entergy. Entergy provided a response by letter dated October 3, 2013 [Reference 29]. By letter dated December 12, 2013 [Reference 30], the NRC staff issued an ISE and RAI regarding Order EA-12-051 compliance at Fitzpatrick.

By letters dated August 28, 2013 [Reference 31], February 28, 2014 [Reference 32], August 28, 2014 [Reference 33], February 27, 2015 [Reference 34], August 28, 2015 [Reference 35], February 26, 2016 [Reference 36], August 25, 2016 [Reference 37], and February 28, 2017 [Reference 38], Entergy submitted status reports for the OIP and the ISE RAI. The OIP describes the strategies and guidance to be implemented at FitzPatrick for the installation of reliable SFP level instrumentation which will function following a BDBEE, including modifications necessary to support this implementation, pursuant to Order EA-12-051. By letter dated August 29, 2017 [Reference 39], Exelon reported that full compliance with the requirements of Order EA-12-051 was achieved.

The licensee has installed a SFP level instrumentation system designed by MOHR Test and Measurement, LLC (MOHR). The NRC staff reviewed the vendor's SFP level instrumentation system design specifications, calculations and analyses, test plans, and test reports during a vendor audit. The staff issued an audit report for the MOHR system on August 27, 2014 [Reference 41].

The staff performed an onsite audit to review the implementation of SFP level instrumentation related to Order EA-12-051 at FitzPatrick. The scope of the audit included verification of: (a) whether the site's seismic and environmental conditions are enveloped by the equipment qualifications, and (b) whether the equipment installation meets the order requirements and vendor's recommendations, and (c) whether the program features meet the order requirements.

By letter dated December 14, 2016 [Reference 21], the NRC issued an audit report regarding the licensee's progress toward order compliance at FitzPatrick.

### 4.1 Levels of Required Monitoring

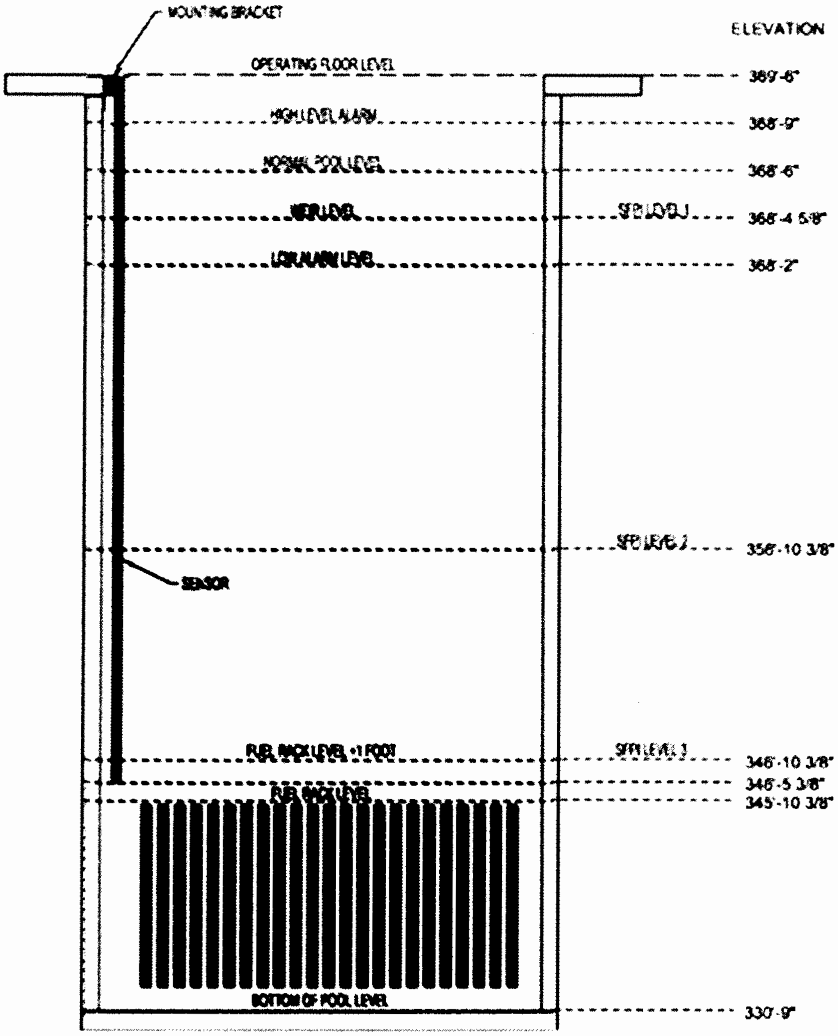
Attachment 2 of Order EA-12-051 states, in part:

> 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 eighth six month update letter dated February 28, 2017 [Reference 38], the licensee identified the SFP levels of monitoring as follows:

- Level 1 corresponds to plant elevation 368 feet 4-5/8 inches
- Level 2 corresponds to plant elevation 356 feet 10-3/8 inches
- Level 3 corresponds to plant elevation 346 feet 10-3/8 inches

In its eighth six month update letter, the licensee provided a sketch depicting the SFP levels of monitoring as illustrated below.




Regarding to the Level 1 designation, in its OIP, the licensee stated that Level 1 is established based on the weir plate/siphon break elevation which is 368 feet 4-5/8 inches. For the Level 2 designation, in its eighth six month update letter, the licensee stated that Level 2 represents the range of water level where any necessary operations in the vicinity of the SFP can be completed without significant dose consequences from direct gamma radiation from the stored spent fuel. The licensee also stated that irradiated equipment and materials are permanently stored in the SFP and hung on the SFP walls and that specific procedures control these items stored in the SFP.

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

- Level 1: According to NEI 12-02, Level 1 corresponds to a level that is adequate for normal SFP cooling system operation. It is the higher of the level at which reliable suction loss occurs due to uncovering of weirs or vacuum breakers or where the required net positive suction head for SFP cooling pump operation occurs. According to the licensee's OIP, the net positive suction head level is lower than the weir-related level. Therefore, the licensee's Level 1 description represents the higher of the two points described in NEI 12-02 for Level 1, and is therefore acceptable.

- Level 2: The licensee has designated Level 2 as 11 feet above the highest point of any fuel rack seated in the SFP. The NRC staff notes that the licensee's Level 2 designation is higher than the provision of 10 feet above the highest point of the fuel racks seated in the SFP as described in NEI 12-02, and is therefore acceptable.

- Level 3: The licensee has designated Level 3 as 1 foot above the highest point of any fuel rack seated in the SFP where fuel remains covered. The staff concludes that this is consistent with the NEI 12-02 provision of a level nominally (i.e., +/- 1 foot) corresponding to the highest point of any fuel rack seated in the SFP.

Based on the evaluation above, the NRC staff finds that the licensee's selection of Levels 1, 2 and 3 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 Evaluation of Design Features

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

4.2.1 Design Features: Instruments

In its OIP, the licensee stated that the primary and backup instruments are permanent fixed channels. Each channel will provide level indication through the use of guided wave radar technology. The instrument provides a single continuous span from above Level 1 to within 1 foot of the top of the spent fuel racks. The NRC staff notes that the measurement range specified for the licensee's instrumentation will fully cover Levels 1, 2, and 3, as designated in Section 4.1 of this safety evaluation.

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

4.2.2 Design Features: Arrangement

In its OIP, the licensee stated that the instrument channels will be physically separated by routing instrument cables in separate conduits, trays, or raceways, locating sensors on opposite sides of the pool near the corners, etc. Physical channel separation will be maintained down through and including each channel display/processor where convergence may be allowed so that display/processors can be located in close proximity or side by side. The licensee further

stated that separation of the channels/probes reduces the potential for falling debris or missiles affecting both channels of instrumentation. This placement coupled with separate routing paths for cables and the use of rigid conduit provides reasonable protection against falling debris and structural damage.

In its RAI response letter dated October 3, 2013 [Reference 29], the licensee provided a figure depicting the approximate locations of the SFP level instrumentation level probes with the inside dimensions of the SFP. In this figure, the SFP level instrumentation probes are located at the opposite ends of the SFP and are shown to be greater than 25 feet apart. The cables for each channel are physically separated and routed to the display locations in opposite directions.

In addition, in its eighth six month update letter, the licensee described the final locations of the SFP level instrumentation, in which the level probes are located at the northwest and southwest corners of the SFP. The level displays, battery enclosures, and power conditioners are located in the relay room.

Based on the licensee's description, and confirmed by a walk down conducted during the onsite audit, the staff concludes that that there is sufficient physical separation between the primary and backup SFP level instrumentation channels' level probes, 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 SFP level instrumentation, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.3 Design Features: Mounting

In its eighth six month update letter the licensee stated that the probe mounting bracket is designed to meet Seismic Category I requirements with all Interaction Ratios less than 1.0. Conservative hydrodynamic forces (sloshing) within the pool, caused by a seismic event, are used as input to the SFP level instrumentation mounting bracket design to ensure the probe will remain in place and functional during and after a BDBEE. The actual hydrodynamic loads at FitzPatrick are bounded by the loads given in NAI-1725-004, "Seismic Induced Hydraulic Response in the CGS [Columbia Generating Station] Spent Fuel Pool," which are based on seismic responses applicable to the San Onofre Nuclear Generating Station and the Columbia Generating Station. According to the licensee, a FitzPatrick-specific calculation was developed to structurally qualify the SFP level instrumentation probe mounting bracket. This calculation was performed as a safety-related calculation that shows the mounting bracket is structurally and seismically adequate.

In its eighth six month update letter the licensee stated that equipment installed in the relay room was analyzed as augmented quality and incorporated Seismic Category I requirements. All components and anchorage for mounting the level displays, battery enclosures, and power conditioners are designed to meet Seismic Category I requirements. The licensee further stated that based on vendor documentation and drawings, the evaluation performed in the engineering change package for the heaviest equipment shows that the natural frequency falls above 100 Hertz in the rigid range. All of the supports are structurally adequate and seismically qualified. The relay room is a safety-related structure, per FSAR Section 12.2.2, and contains safety-related equipment in the installation area. Therefore, all components and anchorage for

mounting the level displays, battery enclosures and power conditioners are designed to meet Seismic Category I requirements.

The NRC review concludes that the licensee's design criteria and the methodology used to estimate and test the total loading on the mounting devices were adequately chosen. This includes the design-basis maximum seismic loads and the hydrodynamic loads that could result from pool sloshing. The site-specific seismic analyses demonstrated that the SFP level instrumentation's mounting design is satisfactory to allow the instrument to function per design following the maximum seismic ground motion. The assumptions, analysis, and modeling used in the sloshing analysis for the sensor mounting bracket are also acceptable.

Based on the evaluation above, the NRC staff finds that the licensee's proposed mounting design for the SFP level instrumentation 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:

- 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 level instrumentation will not experience failures during beyond-design-basis conditions of temperature, humidity, emissions, surge, and radiation, and (2) to verify those tests envelope the plant-specific requirements.

During the vendor audit [Reference 41], the NRC staff reviewed the MOHR SFP level instrumentation's qualifications and testing for temperature, humidity, radiation, shock and vibration, seismic, and electromagnetic compatibility. During the site audit, the staff further reviewed the anticipated seismic, radiological, and environmental conditions at FitzPatrick to confirm they were bounded by the qualification and testing conditions performed by the vendor. Below is the staff's assessment of the equipment reliability of FitzPatrick SFP level instrumentation.

4.2.4.2.1 Radiation, Temperature, and Humidity

SFP Area

In its eighth six month update letter the licensee stated that Calculation JAF-CALC-14-00025, "Spent Fuel Instrumentation Shielding Calculation," provides an analysis of the maximum expected radiological conditions to the probe standoff material and the $SiO_2$ cable and Rockbestos cable near the SFP. According to the licensee, this calculation shows that based on both the 40-year normal operation and 7-day accident (SFP water at Level 3) dose from the fuel and irradiated control blades, the total integrated dose of 2.0E+08 rads to the probe is less than the minimum dose limit of the standoff material of 2.0E+09 rads. The combined normal and accident dose of 2.1E+07 rads is less than the dose limit of 1.0E+08 rads for the $SiO_2$ cable and 2.0E+08 rads for the Rockbestos cable.

Outside of SFP Area

In its eighth six month update letter the licensee stated that the relay room, where the SFP level instrumentation electronics equipment is located, is considered a mild environment. According to the licensee, the electronics equipment will function in this low radiation environment and the ELAP will not cause conditions to exceed the mild environment radiological limits for the relay room.

In its eighth six month update letter the licensee stated that the relay room is within the MCR ventilation boundary. The licensee stated that a calculation determined that the maximum temperature in the relay room, for a configuration in which no ventilation is provided and the equipment inside is powered, will be 110°F after 93 hours and 112.5°F after 144 hours. The

normal operating temperature of the relay room is 75°F. The SFP level instrumentation vendor, MOHR, has successfully tested its system electronics to a nominal temperature range of 14°F to 131°F. Therefore, the licensee stated that the sensor electronics would be capable of continuously performing its required function under the expected temperature conditions.

In its eighth six month update letter 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). Humidity in the relay room is normally regulated by the Relay Room Ventilation and Cooling (RRHV) system at 40-50 percent. During an ELAP, the RRHV system is no longer available. Assuming the relay room is isolated from outside air, the temperature is expected to increase and the RH is expected to decrease because the heat loads are dominated by the sensible heat of electrical equipment. Therefore, the maximum temperature of 112.5°F and humidity of 50 percent is still bounded by the 47 degrees Centigrade (°C) (116.6 °F) and 71 percent RH test case. In the event outside air is introduced to the relay room, due to open doors or RRHV system connections to other rooms, the American Society of Heating, Refrigerating and Air-Conditioning Engineers defines the 0.4 percent dehumidification condition to be 80.5°F dry-bulb, 72.4°F dew point, and approximately 67 percent RH for Syracuse, New York. Similarly, 84.8°F dry-bulb, 75.4°F wet-bulb (wb), and approximately 65 percent RH is defined for a 0.4 percent evaporation conditions. These conditions are bounded by the 32°C (89.6°F) and 96 percent RH test case. Hence, the operational humidity range of 5–95 percent RH encompasses all expected conditions for the relay room and the sensor electronics are capable of continuously performing their required function under the expected humidity conditions.

The staff review concludes that the equipment's design limits envelop the anticipated FitzPatrick's conditions of radiation, temperature, and humidity during (and after) a postulated BDBEE. The staff also finds that the equipment's environmental testing has demonstrated that the SFP level instrumentation should maintain its functionality under expected beyond-design-basis conditions at FitzPatrick.

4.2.4.2.2 <u>Shock and Vibration</u>

In its eighth six month update letter the licensee stated that the vendor adequately addressed the requirements for general robustness of the enclosures. According to the licensee, 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 are 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 indicator and battery enclosures will be mounted in the relay room. The equipment is not affixed or adjacent to any rotating machinery that would cause vibration effects in the area of installation. The new instrument mounting components and fasteners are seismically qualified and designed as rigid components inherently resistant to vibration effects. There are no expected impacts from adjacent objects during the BDBEE or design-basis earthquake requirements imposed by NEI 12-02.

The NRC staff performed an audit at MOHR facility for shock and vibration testing of the SFP level instrumentation sensors and electronics components. The staff found that the shock and vibration test results were satisfactory. The staff concludes that the SFP level instrumentation

at FitzPatrick should fulfill its design functions with respect to shock and vibration, if it is implemented in accordance with the licensee's description.

4.2.4.2.3 Seismic

In its eighth six month update letter the licensee stated that the vendor prepared a series of generic seismic qualification reports for the SFP level instrument which bound FitzPatrick's seismic criteria. The qualification reports envelop all components of the new SFP level instrumentation required to be operational during a BDBEE and post event. Therefore, the SFP instrumentation and electronic units are acceptable for use at FitzPatrick.

During the site audit the NRC staff reviewed the FitzPatrick seismic inputs and related calculations and concludes that the SFP level instrumentation was tested to seismic conditions that envelop FitzPatrick's design basis maximum ground motion. In addition, the staff notes that seismic qualification of the SFP level instrumentation mounting is addressed in Section 4.2.3 of this safety evaluation.

In summary, the NRC staff finds the FitzPatrick SFP level instrumentation qualification process to be adequate. However, the staff has learned of operating experience at other nuclear facilities, in which the MOHR's SFP level instrumentation experienced failures of the filter coil (or choke). 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 vendor has developed and qualified substitute components that are less susceptible to transient electrical events. According to the licensee's eighth six month update letter, the licensee had implemented the vendor recommended repair at FitzPatrick for both SFP level instrumentation channels. On a generic basis, the NRC staff has previously reviewed the vendor's modified equipment qualifications. The temperature and humidity ratings of the replacement parts envelop the expected beyond-design-basis environmental conditions of the FitzPatrick relay room areas, where the electronics equipment is located. There is no indication that new electromagnetic emissions would be introduced by the replacement parts. The mass differences are not sufficient to alter the seismic, shock, and vibration response characteristics. Thus, the staff concludes that FitzPatrick has adequately addressed this industry operating experience and notes that the site corrective action program should control any potential future quality issues.

Based on the evaluation above, the NRC staff finds that the licensee's 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

In its OIP, the licensee described the SFP level instrumentation channel's physical independence. According to the licensee, independence is obtained by physical separation of components between channels. The licensee further stated that the instrument channels shall be physically separated by routing instrument cables in separate conduits, trays, or raceways, locating sensors on opposite sides of the pool near the corners, etc. Physical channel separation will be maintained down through and including each channel display/processor where convergence may be allowed so that display/processors can be located in close proximity or side-by-side.

In its eighth six month update letter the licensee stated that each instrument channel is normally powered from a 120 Vac plant distribution panel. The distribution panel for the primary Loop "A" [Channel "A"] receives power from a different 600 Vac bus than the distribution panel for the backup Loop "B" [Channel "B"]. Therefore, loss of any one 600 Vac bus does not result in loss of normal 120 Vac power for both instrument channels.

The NRC staff noted, and confirmed during the onsite audit and walk down, that with the licensee's design, the loss of one level instrument channel would not affect the operation of other channel under BDBEE conditions. The staff finds that the licensee's 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

In its eighth six month update letter the licensee provided a detailed description of the normal power supplies for the SFP level instrumentation. Specifically, the licensee stated that Loop "A" 120 Vac power is from Distribution Panel 71RRACA8 on the east wall of the relay room. Distribution Panel 71RRACA8 is fed from 71MCC-332 on 600 Vac bus 13300, which is in turn fed from 4160 Vac bus 10300. Bus 10300 is fed from the Normal Station Service Transformer (NSST) T-4 (Winding "Y") during normal plant operation and from Reserve Station Service Transformer (RSST) T-3 (Winding "Y") during start-up, shut down, and standby via an offsite source. Loop "B" 120 Vac power is from Distribution Panel 71AC10 on the north wall of the relay room. Distribution Panel 71AC10 is normally fed from 71MCC-342 on 600 Vac bus 13400, which is in turn fed from 4160 Vac bus 10400. Bus 10400 is fed from the NSST T-4 (Winding "Y") during normal plant operation and from RSST T-2 (Winding "Y") during start-up, shut down, and standby via an offsite source.

In its eighth six month update letter the licensee stated that per MOHR Report 1-0410-7, "MOHR EFP-IL System Battery Life Report," Revision 2, the instrument testing demonstrates the battery capacity is sufficient for 7 days continuous operation using conservative instrument power requirements. According to the licensee, the permanent installed battery capacity of seven days is consistent with NEI 12-02 duration without reliance on or crediting of a potentially more rapid FLEX program power restoration.

According to NEI 12-02, replaceable batteries should have sufficient capacity to support reliable instrument channel operation until off-site resources can be deployed by the mitigating strategies resulting from Order EA-12-049. This provision of NEI 12-02 reflects a similar requirement contained in Order EA-12-051, regarding power supplies and offsite resources. The NRC staff concludes that the 7 day battery capability provides sufficient time to deploy offsite resources. The staff also concludes that the channels are arranged such that the loss of one normal electrical power supply will not result in a loss of power to both channels. Thus, 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

In its eighth six month update letter the licensee stated that the accuracy specified in MOHR Report 1-0410-12, "EFP-IL Signal Processor Operator's Manual," Revision 1, is 3 inches, which is within the limit of ±1 foot set by NEI 12-02. The probe is designed to produce accurate level indication in boiling and frothing (multiphase) environments. MOHR Report 1-0410-10, "MOHR

EFP-IL SFPI System Power Interruption Report," Revision 1, concludes that the accuracy is not affected by an interruption in power. The licensee further stated that the Factory Acceptance Test (FAT) was performed by MOHR on FitzPatrick's SFP level instrumentation system by comparing the test bed water level measured by calibrated manometer with the water level measured by SFP level instrumentation probes. Three measurements which correspond to SFP water Level 1, 2, and 3 were collected. The fourth measurement was taken at the level specified by FitzPatrick. The FAT test results demonstrated that the water levels measured by the SFP level instrumentation probes are within ±3 inches of the calibrated manometer reading.

Based on the MOHR test results presented by the licensee, the NRC staff concludes that the SFP level instrumentation design accuracy does consider the expected performance under both normal and beyond-design-basis conditions. The staff also concludes that, if implemented properly, the instrument channels should maintain their accuracy following a change or interruption of power source without the need of recalibration.

The 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 addresses the requirements of the order.

4.2.8 Design Features: Testing

In its eighth six month update letter the licensee stated that the instrument automatically monitors the integrity of its level measurement system using in-situ capability. Deviation of measured test parameters from manufactured or as-installed configuration beyond a configurable threshold prompts operator intervention. The probe itself is a perforated tubular coaxial waveguide with defined geometry and is not calibrated. Channel design provides capability for calibration or validation against known/actual SFP level.

The NRC staff reviewed the licensee's description of the SFP level instrumentation's testing features and concludes that the system design allows for testing and calibration, including functional testing and channel checks. Therefore, it appears to be consistent with the NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.9 Design Features: Display

In its eighth six month update letter the licensee stated that the relay room and MCR are both considered to be mild environments. Since they are within the same building, the environments are essentially the same. According to the licensee, personnel will not be continuously stationed at the display; it will be monitored periodically.

In its eighth six month update letter the licensee also stated that the primary and backup SFP level instrumentation displays will be located in the relay room. The panels are deemed promptly accessible since the relay room is directly below the MCR and is within the same building (Administration Building). The stairway down to the relay room is accessed via an interior fire door from the MCR. The MCR personnel can access this area in approximately 1 minute. An allowance of 10 minutes is provided in the staffing analysis to account for unforeseen obstructions to the travel path. This is less than the 30 minute time to read the level for portable instruments specified by Section 3.1 of NEI 12-02.

The NRC staff reviewed the licensee's description of the display features of the SFP level instrumentation and concludes that the displays are located in a location that is appropriate and accessible, with characteristics as described in Section 3.9 of NEI 12-02. Thus, the staff finds that the licensee's proposed location and design of the SFP level instrumentation displays appear to be consistent with the 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 SAT process will be used to identify the population to be trained and to determine both the initial and continuing elements of the required training. Training will be completed prior to placing the instrumentation in service.

Guidance document NEI 12-02 specifies that the SAT process can be used to identify the population to be trained, and also to determine both the initial and continuing elements of the required training. The NRC staff finds that the licensee's plan to train personnel in the operation, maintenance, calibration, and surveillance of the SFP level instrumentation, including the approach to identify the population to be trained, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

#### 4.3.2 Programmatic Controls: Procedures

In its OIP, the licensee stated that procedures for maintenance and testing will be developed using regulatory guidelines and vendor instructions. In its eighth six month update letter, the licensee noted that procedures have been developed to address SFP level instrumentation operation (both normal and abnormal response), calibration, test, maintenance, and inspection.

During the onsite audit, the staff confirmed that the necessary procedures have been established for the testing, surveillance, calibration, operation, maintenance, and abnormal responses for the primary and backup SFP level instrument channels. Based on the licensee's description of the programmatic controls of procedures, confirmed by the audit review, the staff finds that the licensee's proposed procedures appear to be consistent with NEI 12-02, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

#### 4.3.3 Programmatic Controls: Testing and Calibration

In its eighth six month update letter the licensee stated that a channel calibration check (operator rounds) will be performed daily to validate that the MOHR instruments (both channels) are displaying the correct SFP level within the accuracy of the instruments and that the date stamp on the display is indicating correctly. In addition, a channel check or panel functional check will be performed yearly to check each channel against each other for comparison and to perform functional assessments of each panel.

In its eighth six month update letter the licensee described the compensatory measures that would be applied for the SFP level instrument channel(s) out-of-service (OOS). This letter states that for a single channel OOS, there is a 90 day allowed outage time before compensatory measures are implemented (immediately). For both channels OOS, there is a 24 hour allowed outage time before compensatory measures are implemented within 72 hours.

During the audit process the NRC staff reviewed the licensee's EDSO-5, "Site Implementation of Diverse and Flexible Coping Strategies (FLEX) and Spent Fuel Pool Instrumentation (SFPI) Program," Revision 1, Attachment 10.1. This document provides the administrative controls for instrument channel OOS as below.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. The primary or back-up SFPLI does not meet the functional requirements | A.1 Restore SFPLI to functional status | 90 days |
| B. Action A.1 completion time not met | B.1 Implement compensatory measures | Immediately |
| C. The primary and back-up SFPLI's do not meet the functional requirements | C.1 Initiate action to restore one of the channels of instrumentation.<br><br>AND<br><br>C.2 Implement compensatory measures | 24 hours<br><br><br><br>72 hours |

The NRC staff review concludes that the licensee's testing and calibration plan appears to be consistent with the vendor recommendations. Additionally, compensatory actions for instrument channel(s) OOS appear to be consistent with the guidance described 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 letter dated August 29, 2017 [Reference 39], 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 FitzPatrick according to the licensee's design, it should adequately address the requirements of Order EA-12-051.

## 5.0 CONCLUSION

In August 2013 the NRC staff started audits of the licensee's progress on Orders EA-12-049 and EA-12-051. The staff conducted an onsite audit at FitzPatrick in October 2016 [Reference 21]. The licensee reached its final compliance date on June 30, 2017, for Orders EA-12-049 and EA-12-051, and has declared that the reactor is 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 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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Date: December 18, 2017

SUBJECT: JAMES A. FITZPATRICK NUCLEAR POWER PLANT – 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. MF1077 AND MF1076; EPID NOS. L-2013-JLD-0009 AND L-2013-JLD-0010) DATED December 18, 2017

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