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

March 3, 2016

Mr. John A. Dent, Jr.
Site Vice President
Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station
600 Rocky Hill Road
Plymouth, MA 02360-5508

SUBJECT: PILGRIM NUCLEAR POWER STATION – SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 (TAC NOS. MF0777 AND MF0778)

Dear Mr. Dent:

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. ML13063A063), Entergy Nuclear Operations, Inc. (Entergy, the licensee) submitted its OIP for Pilgrim Nuclear Power Station (Pilgrim) in response to Order EA-12-049. At six month intervals following the submittal of the OIP, Entergy submitted reports on its progress in complying with Order EA-12-049. These reports were required by the order, and are listed in the attached safety evaluation (SE). By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the NRC 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 December 16, 2013 (ADAMS Accession No. ML13225A587), and January 26, 2015 (ADAMS Accession No. ML14349A518), the NRC issued an Interim Staff Evaluation (ISE) and audit report on Entergy's progress. By letter dated July 17, 2015 (ADAMS Accession No. ML15202A415), Entergy submitted its compliance letter and Final Integrated Plan (FIP) in response to Order EA-12-049. The compliance letter stated that Entergy had achieved full compliance with Order EA-12-049.

By letter dated February 28, 2013 (ADAMS Accession No. ML13063A097), Entergy submitted its OIP for Pilgrim 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 SE. By letters dated December 5, 2013 (ADAMS Accession No. ML13333A910), and January 26, 2015 (ADAMS Accession No. ML14349A518), the NRC issued an ISE, request for additional information, and audit report, respectively, on Entergy's progress. By letter dated March 26, 2014 (ADAMS Accession No. ML14083A620), the NRC notified all licensees and construction permit holders that the NRC staff is conducting in-office and on-site 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 July 17, 2015 (ADAMS Accession No. ML15202A536), Entergy submitted its compliance letter in response to Order EA-12-051. The compliance letter stated that Entergy had achieved full compliance with Order EA-12-051.

The enclosed SE provides the results of the NRC staff's review of Entergy's strategies for Pilgrim. The intent of the SE is to inform Entergy whether its integrated plans, if implemented as described, will adequately address the requirements of Orders EA-12-049 and EA-12-051. The NRC staff will evaluate implementation of the plans through inspection, Temporary Instruction 191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications /Staffing/ Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML14273A444). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

If you have any questions, please contact Stephen Monarque, Orders Management Branch, Pilgrim Project Manager, at 301-415-1544 or at Stephen.Monarque@nrc.gov.

Sincerely,

Gregory T. Bowman, Chief
Orders Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket No.: 50-293

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

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

ENTERGY NUCLEAR OPERATIONS, INC.

PILGRIM NUCLEAR POWER STATION

DOCKET NO. 50-293

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 nuclear power plants to mitigate such beyond-design-basis external events (BDBEE).

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

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

2.0 REGULATORY EVALUATION

Following the events at Fukushima Dai-ichi 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 mitigation strategies for BDBEE. As directed by the Commission in staff requirements memorandum (SRM) to SECY-12-0025 [Reference 3], the NRC staff issued Orders EA-12-049 and EA-12-051 on March 12, 2012.

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 BDBEE. The initial phase requires the use of installed equipment and resources to maintain or restore core cooling, containment, and SFP cooling capabilities. The transition phase requires providing sufficient, portable, onsite equipment and consumables to maintain or restore these functions until they can be accomplished with resources brought from off site. The final phase requires obtaining sufficient offsite resources to sustain those functions indefinitely. Specific requirements of the order are listed below:

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

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

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

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

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

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

2.2 Order EA-12-051

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

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

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

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

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

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

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

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

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

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

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

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

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

On August 24, 2012, following several NEI submittals and discussions in public meetings with NRC staff, 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. On September 7, 2012, the NRC staff published a notice of the availability of JLD-ISG-2012-03 in the *Federal Register* (77 FR 55232).

3.0 TECHNICAL EVALUATION OF ORDER EA-12-049

By letter dated February 28, 2013 [Reference 10], Entergy Nuclear Operations, Inc. (Entergy, the licensee) submitted its Overall Integrated Plan (OIP) for Pilgrim Nuclear Power Station (Pilgrim, PNPS) in response to Order EA-12-049. By letters dated August 28, 2013 [Reference 11], February 28, 2014 [Reference 12], August 28, 2014 [Reference 13], and February 27, 2015 [Reference 14], the licensee submitted four six-month updates to the OIP. By letter dated August 28, 2013 [Reference 15], 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 16]. By letters dated December 16, 2013 [Reference 17], and January 26, 2015 [Reference 18,] the NRC issued an Interim Staff Evaluation (ISE) and an audit report on the licensee's progress. By letter dated July 17, 2015 [Reference 19], the licensee reported that full compliance with the requirements of Order EA-12-049 was achieved, and submitted a Final Integrated Plan (FIP).

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 from one phase to the next is determined by plant-specific analyses.

While the initiating event is undefined, it is assumed to result in an extended loss of ac power (ELAP) with loss of normal access to the ultimate heat sink (LUHS). Thus, the ELAP with LUHS 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 shutdown 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.

Pilgrim is a boiling-water reactor (BWR) 3 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:

Phase 1

At the initiation of the BDBEE, the reactor scrams, main steam isolation valves (MSIVs) automatically close, feedwater is lost, and safety relief valves (SRVs) automatically cycle to control pressure. The blowdown through the SRVs without make-up results in a decrease in the reactor water level. When reactor water level reaches the reactor pressure vessel (RPV) low-low water level setpoint, the reactor core isolation cooling (RCIC) and high pressure coolant injection (HPCI) systems automatically start and to inject make-up water to the RPV. The RCIC and HPCI systems initially draw water from the condensate storage tank (CST). If the CST is unavailable (the CST is not seismically qualified), operators will manually align RCIC and HPCI suction to the suppression pool (torus). Operators will secure HPCI when the water level in the RPV is restored above the low-low water level trip. This is expected to happen within the first 2 minutes of the event.

During the first 6 hours, the reactor remains isolated and pressurized with RCIC (or HPCI) providing RPV make-up and the SRVs controlling reactor pressure. The operators shed unnecessary battery loads in accordance with station blackout (SBO) procedures. At 1 hour into the event, the operators enter the FLEX Support Guidelines (FSGs) and take actions to prepare for an ELAP. Operators override RCIC trip and isolation signals and place the automatic depressurization system (ADS) in 'inhibit' to prevent automatic initiation, which could prevent operation of RCIC.

At 6 hours into the event, the operators initiate a controlled reactor depressurization by manually cycling the SRVs.

At 9 hours after shutdown, the reactor remains pressurized at approximately 120 per square inch gage (psig) with RCIC providing core cooling, drawing water from the suppression pool (torus). At this time the operators transition the core cooling strategy from RCIC to diesel-powered FLEX pumps, which will be connected from the ultimate heat sink (UHS) to the CST suction line. The reactor coolant system (RCS) injection is via either the HPCI or RCIC pump flow path, by injecting through the idle pump and into the normal pump discharge path to the RPV feedwater lines. Operators further depressurize the RCS to support this operation. An alternate FLEX injection point is to the residual heat removal (RHR) system, which provides a path to inject into the RPV, drywell spray, or torus.

For electrical/instrumentation considerations, load stripping of non-essential loads would begin within 2 hours after the ELAP and be completed within the next 1 hour. With such load stripping, the usable station battery life is extended beyond 8 hours for the station batteries. The plan is to give operators time to align the FLEX generators in order to repower the dc battery chargers well before the batteries approach depletion.

Phase 2

The FLEX portable diesel generator(s) (DGs) will be staged and connected to re-power the "A" and "B" 125 volt dc (Vdc) battery chargers or the "B" 125 Vdc and 250 Vdc battery chargers and 120 volt ac (Vac) distribution panel to maintain critical instruments and vital ac power.

The operators plan to establish subcooled boiling in the core by filling the RPV and then setting injection flow at approximately twice the boil-off rate. This precludes concentrating the minerals from seawater and thereby precludes significant fouling of heat transfer surfaces. Two-phase flow is discharged through the SRVs. Torus water level will be monitored so operators can make adjustments as needed.

At 16 hours after shutdown, the torus will heat up to 280°F. The torus vent will then be opened to provide containment heat removal.

The two required (N) FLEX 86 kilowatt (kW) DGs will be maintained in on-site FLEX storage structures. The third (N+1) FLEX 150 kW DG will be pre-staged in the turbine building truck lock area, which is a protected area in close proximity to the battery charger and switchgear rooms. This will allow for more rapid deployment of the first FLEX DG for ELAP events where that is possible.

A single 150 kW generator is capable of repowering two 125 Vdc battery chargers and the 250 Vdc battery chargers, with associated battery room ventilation and 120 Vac panels. If the pre-staged (N+1) FLEX 150 kW DG is not available, then two FLEX 86 kW DGs would be deployed to repower the chargers of both division simultaneously.

Phase 3

For Phase 3, equipment from the National Strategic Alliance for FLEX Emergency Response (SAFER) Response Centers (NSRC) can be used as a backup to the Phase 2 equipment. There is no immediate reliance on the equipment from NSRC. However, before the torus reaches its maximum intended water level (and if not already in use as a cleaner water source) the station FLEX groundwater wells will be powered by a portable FLEX 20 kW or 86 kW DG and will be used to feed the nominal 21,000 gallon capacity fixed rear axle collector (FRAC) tank. Operators align the suction of the FLEX pump to the FRAC tank, flush the core with water from the FRAC tank, and then reduce injection flow to match boil-off rate. The licensee plans to use the reverse osmosis (RO) or demineralizers provided by SAFER, but such water treatment is not required for more than 30 days due to the low mineral content of the groundwater.

3.2 Reactor Core Cooling Strategies

In accordance with Order EA-12-049, licensees are required to maintain or restore cooling to the reactor core in the event of an ELAP concurrent with a LUHS. 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. For a BWR, the strategy involves adding water and venting steam from the RCS. Consistent with the 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/LUHS) 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., with pumps and hoses) or indirectly (e.g., through the use of FLEX electrical generators and cables repowering robust installed equipment). The equipment available onsite for Phases 1 and 2 is further supplemented in Phase 3 by equipment transported from the NSRCs.

As reviewed in this section, the licensee's core cooling analysis for the ELAP/LUHS event presumes that, in accordance with the endorsed guidance from NEI 12-06, the reactor would have been operating at full power for 100 days prior to the event and that no additional random failures occur. Therefore, the suppression pool is assumed to be available as a water source for core cooling. Make-up of the RPV to replace inventory lost due to blowdown from SRVs and the ongoing system leakage is accomplished through a combination of installed systems and FLEX equipment. The specific means are discussed below. The licensee's strategy for ensuring compliance with Order EA-12-049 for conditions in which the reactor is shut down or being refueled is reviewed separately in Section 3.11 of this evaluation.

3.2.1 Core Cooling Strategy and RCS Make-up for Non-Flooding Event

3.2.1.1 Core Cooling Strategy

3.2.1.1.1 Phase 1

As described in the FIP, when power is lost the reactor scrams, MSIVs automatically close, feedwater is lost, and SRVs cycle to control pressure. The RPV water level will decrease, and when it reaches the RPV low-low water level setpoint, RCIC and HPCI automatically start and inject water to the RPV. The HPCI and RCIC are normally aligned to the CST; however, the CST is not protected for all external events. If the CST is unavailable as a water source, RCIC suction will be manually switched to the suppression pool (torus), which is protected against all events. The HPCI suction will automatically transfer to the torus on low CST level. In accordance with the SBO procedure, HPCI will be secured when the low-low water level trip clears, which is assumed to occur within the first 2 minutes of the event.

The RCIC continues to supply water to the core, and steam is removed via the SRVs and the supply to the RCIC turbine. After an ELAP is declared, which will occur no later than one hour after the initiating event, operators override RCIC trip and isolation signals and inhibit the automatic depressurization system to prevent an uncontrolled reduction in reactor pressure that could prevent operation of RCIC.

When torus temperature reaches 170°F (expected to occur approximately 6 hours after the event), operators perform a controlled depressurization of the reactor to 120 psig by manually operating the SRVs in accordance with Emergency Operating Procedure (EOP) -11 heat capacity temperature level curve.

Entergy has installed a new SRV backup nitrogen supply station to provide an independent, seismically-qualified, pneumatic motive force to extend the operating time of the SRVs. This backup nitrogen supply will allow for the indefinite operation of the SRVs. The RCIC and SRV operation is further discussed in Section 3.2.3.1.1.

3.2.1.1.2 Phase 2

Entergy will set up Phase 2 equipment starting approximately 6 hours into the event and will transition to the Phase 2 equipment approximately 9 hours into the event.

For the transition to Phase 2, core cooling will be via the SRVs and steam-driven RCIC turbine with the RPV pressure at 120 psig. When the torus liquid temperature reaches 235°F (expected to occur approximately 9 hours into the event), the SRVs will be held full open to depressurize the RPV to allow injection from low-pressure FLEX pumps. When RPV pressure is 50 to 100 psi above torus pressure, core cooling will be transitioned from RCIC to the FLEX pumps.

Entergy will set up two FLEX diesel-powered low-pressure pumps at Pilgrim. These two pumps will operate in tandem and draw suction with a suction lift pump from the UHS, Cape Cod Bay. Cleaner sources of water would be used preferentially, if available, but none are robust for all ELAP initiating events. The pump discharge goes through a strainer cart and then into the primary injection point. The primary injection point is located in the CST tank vault. The flow path is via the HPCI or RCIC pump flow path, through the idle pump, and into the normal pump discharge path to the RPV feedwater lines.

To rapidly raise RPV water level above the main steam line elevation, the initial flow rate for the FLEX pumps injecting into the RPV will be 400 gallons per minute (gpm). After the desired water level is reached, flow will be reduced to 180 gpm, which the licensee calculated as being twice the flow rate needed to match core boil-off at 10 hours. Thus, the blowdown from the SRVs during this phase will be a saturated two-phase mixture, which allows some of the liquid in the RPV containing elevated concentrations of dissolved solutes to be replaced by fresh liquid with baseline solute concentrations. The licensee concluded that maintaining injection flow to the RPV at approximately twice the boil-off rate precludes adversely concentrating minerals from seawater, therefore preventing any significant fouling of core heat transfer surfaces. The NRC staff reviewed this conclusion and agreed that the licensee's evaluation supports a reasonable expectation that fouling of heat transfer surfaces would not preclude the FLEX strategy from being successful. To account for the gradual reduction in decay heat with time, operators would reduce injection flow at a prescribed rate via manual speed control of the FLEX pump, thereby maintaining a flow approximately equal to twice the boil-off rate.

As described in the FIP, flow is provided from the UHS to the RPV and a saturated water/vapor mixture exits out of the SRVs to the torus. The licensee evaluated the stresses of water/vapor mixture on SRV tailpipes and determined the stresses were acceptable. The NRC staff performed an audit review of the calculations and determined the SRV tailpipes were adequate to handle the stresses that would result from this strategy.

If the primary connection point for RPV make-up is unavailable, the alternate injection point will be to the RHR system at the existing fire water-to-RHR system cross-tie, through an 8-inch connection and removable spool piece that feeds into the RHR system 18-inch cross-tie. A removable 8-inch FLEX spool piece connector would be installed to accept a 5-inch hose connector from the FLEX low-pressure pumps. Accessibility of the primary and alternate connection points are discussed in Section 3.7.3.1.

3.2.1.1.3 Phase 3

Phase 3 of the licensee's RPV cooling and make-up strategy uses the same primary connection point, alternate connection point, and FLEX pumps as Phase 2. Phase 3 pumps will be on site and available as backups to the Phase 2 pumps.

As described in the FIP, Entergy will transition from sea water to a cleaner source of water. Entergy will use FLEX groundwater well pumps, and a RO unit from SAFER to provide clean water to the 21,000 gallon FRAC tank. By no later than 72 hours, the FRAC tank will be used as the suction source for the FLEX pumps. SAFER is also providing a 20,000 gallon collapsible bladder that may be filled and used in Phase 3.

After switching from seawater to a cleaner source of make-up water, Entergy will continue to provide make-up in excess of the boil-off rate until the RPV has been flushed. After flushing has been completed, the RPV will be allowed to boil down to a stable water level and, thereafter, make-up will be provided to maintain this level.

3.2.2 Variations to Core Cooling Strategy for Flooding Event

There are no variations to the licensee's core cooling strategy for the flooding event.

3.2.3 Staff Evaluations

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

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

3.2.3.1.1 Plant SSCs

Core Cooling and Inventory Control - MODES 1-4 only

NEI 12-06, Section 3.2, states that installed equipment that is designed to be robust with respect to design-basis external events is assumed to be fully available. In addition, Condition 6 of NEI 12-06, Section 3.2.1.3, states that permanent plant equipment contained in structures with designs that are robust with respect to seismic events, floods, and high winds and associated missiles, are available. The Pilgrim Updated Final Safety Analysis Report (UFSAR), Section 12.2.1.1, Revision 27, states that Class I structures, equipment, and components include those whose failure or malfunction might cause or increase the severity of an accident which would endanger the public health and safety. As such, the station Class I structures, equipment, and components have been designed to remain functional during and following the most severe natural phenomena which can be postulated to occur at this site. In addition, Specification M300, "Pilgrim Unit 1 Specification for Piping," Revision 109 [Reference 42], states that piping designated as "Class I Piping" requires tornado protection and Class I seismic design considerations.

Entergy's core cooling FLEX strategies rely on its existing RCIC system to remove heat from the RCS by providing cooling water to the RPV from the torus and relieving pressure from the RPV through the SRVs. In addition, Entergy relies on Class 1E batteries and the dc distribution system and, for Phase 2 core cooling, the UHS, condensate piping, fire protection piping, service water (SW) piping, and RHR piping.

As described in the PNPS UFSAR, Section 4.7.5, Revision 27, the RCIC system, including piping, equipment, and support structures, is designed to Class I specifications. The RCIC pump and portions of piping outside of the drywell are located in the reactor building. The PNPS UFSAR, Section 12.2.1.2, Revision 27, states that reactor building protects all the Class I equipment located inside the building from the effects of a tornado. As described in Entergy's FIP, the RCIC system can also be manually started and operated with a loss of ac and dc electrical power in accordance with PNPS Procedure 5.3.26, "RPV Injection During Emergencies," Revision 26 [Reference 43].

As described in Entergy's FIP, the RCIC takes suction initially from the CST and operates to inject make-up water to the RPV; however, because the CST is not seismically qualified, it is considered unavailable following a BDBEE. If the CST is not available, operators will manually switch the RCIC suction to the suppression pool (torus). In addition to the suction source for the RCIC pump, the torus is the heat sink for reactor vessel SRV discharge and RCIC turbine steam exhaust following a BDBEE. Entergy's UFSAR, Section 12.2.1.2, Revision 27, describes the torus as a Class I structure located within the primary containment structure, which provides protection from all applicable external hazards.

During the ELAP event, RPV pressure control is provided by SRVs. As described in Entergy's UFSAR, Section 4.4.5, Revision 27, the SRVs are located on the main steam lines within the drywell between the reactor vessel and the flow restrictor. Section 12.2.1.2 of the UFSAR, Revision 27, states that the drywell is a Class I structure and that main steam piping located inside a Class I structure and all piping connectors from the reactor vessel up to and including the first isolation valve external to the drywell is all Class I piping. According to Entergy's FIP, SRVs RV-203-3B and RV-203-3C are pilot-actuated and are normally supplied by the essential instrument air system. Following a loss of all ac power, the instrument air compressors are lost and the SRV actuators are supplied by accumulator tanks T-221B and T-221C, which are charged by the backup nitrogen system. The PNPS UFSAR, Section 10.11.3.1, Revision 27, states that Class I equipment requiring air under accident conditions has Class I air accumulators and piping associated with that equipment. In addition, Entergy has installed a new SRV backup nitrogen supply station to provide an independent, seismically-qualified, pneumatic motive force to extend the operating time of SRVs RV-203-3B and RV-203-3C. This backup nitrogen supply will allow for the indefinite operation of the SRVs. As described in Entergy's FIP, PNPS relies on the use of the station batteries and associated 125/250 Vdc distribution systems initially to power required key instrumentation and applicable dc components. In addition, PNPS will use parts of the station 120 Vac power subsystem for Phase 2 and 3 coping strategies. The PNPS UFSAR, Section 12.2.1.2, Revision 27, lists the station battery rooms and the 125/250 Vdc power system as Class I structures and systems respectively.

For Phase 2 core cooling, Entergy places portable pumps in service taking suction from the UHS and injecting into common CST suction line to the HPCI and RCIC Pumps or into the fire water to SW/RHR system cross-tie. The UHS for PNPS comes from Cape Code Bay. Cape

Cod Bay has a surface area of approximately 430 square miles (nautical), or 365,000 acres. The volume of Cape Cod Bay is about 1.6 X 10^{12} cubic feet. As described in Entergy's FIP, Cape Cod Bay is a broad, open-mouthed water body formed by the eastward and then northward extension of Cape Cod out from the coast of Massachusetts and will remain available for any of the external hazards listed in Section 2.6 of the FIP.

For Phase 2 core cooling, the PNPS primary strategy injects water from the UHS into a HPCI/RCIC common suction line from the CSTs. According to the licensee's Drawing M209, "P&ID Condensate & Demineralized Water Storage & Transfer Systems," Revision 67 [Reference 44], the HPCI/RCIC suction line is designated as a Class I piping system. The connection is on piping located in the CST vault which has a removable protective housing to facilitate connection and provide protection from tornado missiles.

Based on the location and design of the credited plant SSCs, as described in Entergy's UFSAR, and if implemented according to Entergy's control strategy, as described in the FIP, the credited plant SSCs should be available to support core cooling during an ELAP, consistent with NEI 12-06, Section 3.2.1.3, Condition 6.

Primary and Alternate Connection Points for Core Cooling

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

As described in Entergy's FIP, and discussed above, the primary connection to supply core cooling water to the RPV via a portable pump is located on the HPCI/RCIC common suction line from the CSTs, which is Class I piping and protected from all applicable hazards. The alternate core cooling strategy injects water into the RHR system at the existing Fire Water to RHR system cross-tie via a removable spool. According to Entergy's FIP, the licensee will use an existing station procedure, PNPS 5.3.26, to install a fire hose adaptor to the lower flange of the fire water system to RHR crosstie pipe connection in a protected area of the auxiliary bay in the reactor building. According to PNPS drawings M218, "P&ID Fire Protection System," Sheet 1, Revision 60 [Reference 45], and M241, "P&ID Residual Heat Removal System," Sheet 1, Revision 88 [Reference 46], the piping spool piece is located on non-Class I piping. However, because the primary strategy relies on all Class I systems and because the reactor building, a Class I structure, provides adequate protection from some hazards for the alternate strategy, there is reasonable assurance that at least one connection should be available following a BDBEE.

Based on the location and design of the FLEX connections, as described in Entergy's FIP, and if implemented according to Entergy's control strategy, as described in the FIP, at least one FLEX connections should be available to support core cooling during an ELAP, consistent with NEI 12-06, Section 3.2.2 and Table C-1.

3.2.3.1.2 Plant Instrumentation

As described in Entergy's FIP, instrumentation for the following parameters is credited for all phases of core cooling and RPV inventory control.

- RPV narrow range level indication is available in the main control room (MCR), cable spreading room instrument racks, and at local instrument racks.
- RPV pressure indication is available in the MCR, cable spreading room instrument racks, and at local instrument racks.

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. This instrumentation is available both prior to and after ac and dc bus load shedding. Availability in Phase 2 and Phase 3 will be maintained by successfully implementing the primary or alternate battery charging FLEX strategy. Furthermore, the NRC staff understands that the locations of the instrument indications would be accessible continuously throughout the ELAP event.

As described in Entergy's FIP, and in accordance with NEI 12-06, Section 5.3.3.1, guidelines for obtaining critical parâmeters locally are provided in an FSG. Portable FLEX equipment is supplied with local instrumentation needed to operate the equipment. The FSGs include the use of the FLEX equipment and instrumentation.

3.2.3.2 Thermal-Hydraulic Analyses

The licensee determined that the strategy for reactor core cooling is adequate based in part on a simplified heat balance analysis. The licensee confirmed this conclusion by a thermal-hydraulic analysis performed using Version 4 of the Modular Accident Analysis Program (MAAP). Both of these analyses were audited by the NRC staff. Because the thermal-hydraulic analysis for the reactor core and containment during an ELAP event are closely intertwined, as is typical of BWRs, both analytical methods included reactor and containment thermal-hydraulics in a single, coupled calculation. This dependency notwithstanding, the NRC staff's discussion in this section of the safety evaluation solely 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 in Section 3.4.4.2 of this evaluation.

The licensee's simplified heat balance analysis used spreadsheet calculations to implement the fundamental conservation laws associated with mass and energy to determine the thermal-hydraulic response of the primary system and containment to an ELAP event. As necessary to determine inputs to the conservation equations, supporting calculations were included for items such as system hydraulics, decay heat, dissolved solute concentration and scale buildup, etc. The NRC staff audited the licensee's simplified heat balance analysis and performed several confirmatory hand calculations to check the licensee's conclusions. The NRC staff did not fully agree with several of the licensee's conclusions, most notably the assertion that the liquid in the RPV would be subcooled by an inlet flow set to twice the boil-off rate. Nevertheless, the NRC staff's audit review determined that the coolant flow supplied by the licensee's mitigating strategy would provide adequate core cooling. Therefore, based on the audit, the NRC staff concluded that the licensee's analytical method appears sound overall and that the calculated results are supportive of the planned mitigating strategy.

The NRC staff also reviewed the licensee's analysis that used Version 4 of the MAAP computer code (MAAP4). The MAAP computer code 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 Daiichi 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, 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 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 an ELAP event. In particular, due to the breadth and complexity of the physical phenomena within the code's calculational 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 NRC staff's 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, an audit review by the NRC staff 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, 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.

The licensee addressed the limitations from the NRC staff's endorsement letter in the FIP. The NRC staff's review of this information, as well as its audit of Pilgrim's plant-specific MAAP4 analysis, confirmed that the licensee had acceptably addressed all limitations from the endorsement letter. In particular, the NRC staff concluded that appropriate inputs and modeling options had been selected for the code parameters expected to have dominant influence for the ELAP event, and further observed that limitations concerning RPV collapsed liquid level and depressurization were satisfied.

The MAAP4 analysis confirmed the overall conservatism of the simplified heat balance method used to build the licensee's FLEX timeline. The NRC staff further performed several confirmatory simulations using the TRACE thermal-hydraulic code to model the intended ELAP mitigating strategy for Pilgrim. The TRACE model included (1) installed components necessary to model the thermal-hydraulics of the reactor and its primary system, (2) FLEX equipment used to provide core cooling during an ELAP event, and (3) a simplified model for the containment and hardened vent. The results of the informal confirmatory simulations demonstrated reasonable agreement with the licensee's MAAP4 analysis and provided additional confirmation of the conservatism of the planned implementation time for key actions in the licensee's mitigating strategy.

Therefore, based on the evaluation above, the licensee's analytical approach should appropriately determine the sequence of events, including time-sensitive operator actions, and 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 make-up 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.

As described in the FIP, the MAAP4 analysis assumed an initial primary system leakage of 25 gpm at the normal operating reactor pressure of 1035 psig. This 25 gpm value is the limiting condition for operation for total primary system leakage from the PNPS Technical Specifications. The MAAP4 analysis assumes that the primary system leakage starts at time zero and varies with reactor pressure. The RPV leakage location is set at the reactor recirculation pump suction nozzle elevation to simulate leakage from the recirculation pump seals. A leak at this location would result in single-phase liquid coolant partially flashing to steam as it is discharged into the drywell, creating a liquid/vapor mixture at the applicable saturation condition in the drywell.

In Calculation No. M1380, "Mechanical Calculation PNPS FLEX Strategy Thermal-Hydraulic Analysis," Revision 0 [Reference 47], total recirculation pump seal leakage is assigned a value of 16 gpm at 75 psig for the purpose of evaluating FLEX make-up water supply requirements after RPV depressurization has been performed. A leakage of 16 gpm at 75 psig corresponds to approximately 60 gpm at the normal operating pressure (1035 psig). This higher leakage value accounts for the potential seal leakage that may occur after RPV depressurization due to internal seal component leakage (commonly referred to as seal face hang up).

Considering the information above, the NRC staff concludes that the leakage rates assumed by Entergy are sufficiently conservative to support successful implementation of its FLEX mitigating strategy. As is typical of the majority of U.S. BWRs, Pilgrim has installed steam-driven pumps (i.e., RCIC and HPCI) capable of injecting into the primary system at a flow rate well in excess of the primary system leakage rate expected during an ELAP, and the other pumps used for core cooling in its FLEX strategy have a similar functional capability. In light of the significant margin available, it is apparent that only gross seal failures not expected under ELAP conditions would be capable of challenging the success of the mitigating strategy.

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 its UFSAR, PNPS's design is such that the control rods provide adequate shutdown margin under all anticipated plant conditions, with the assumption that the highest-worth control rod remains fully withdrawn. Section 3.6.2.4 of the UFSAR specifically notes that shutdown margin is to be calculated for a cold, xenon-free condition to ensure that the most reactive core conditions are bounded.

Based on 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 calculation. Furthermore, the existing calculation 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

For Phase 2 core cooling, the licensee's primary strategy will use two diesel-powered low-pressure FLEX pumps set up in series that take suction from the UHS and discharge into the RCS via the primary or alternate connection points. However, if decay heat is low enough the licensee can instead use one of the two diesel-powered pumps to take suction from two of its three well water pumps (either from the well pumps directly or from a FRAC tank being fed by the well pumps). In accordance with Section 11.2 of NEI 12-06, the licensee performed Calculation No. M1384, "Pilgrim FLEX Hydraulic Analysis," Revision 0 [Reference 48], to confirm that the diesel-powered FLEX pumps and well pumps could provide the required flow rates. The NRC staff performed a review of Calculation M1384 [Reference 48], which uses classical hydraulic analysis head loss and pressure gradient methods and includes all pumps, valves, hoses, strainers, elevations, and line distances.

During its review, the NRC staff noted that the calculation indicated that the net positive suction head available (NPSHa) at the maximum UHS temperature was approximately 0.5 feet (ft) less than the NPSH required (r) for the lift pump (the pump that takes suction directly from the UHS). The NRC staff requested that the licensee clarify this discrepancy or provide a technical justification for accepting the apparent lack of required NPSH. The licensee stated that the NPSHa calculation uses a bounding case approach (maximum required flow rate, pressure losses, and suction elevation), which includes inherent conservatism and design margin. The bounding case for the lift pump assumes 400 gpm constant flow rate; the maximum anticipated flow rate needed initially to flood the reactor core at 9-10 hours into the event. However, after the rapid reflooding of the core, the flow rate is reduced to approximately 200 gpm and continues to decrease with time as decay heat decreases. In addition, the licensee uses the minimum suction water level of (-)7.1 ft mean sea level (msl), which corresponds to the astronomical low tide and only exists briefly at the low ebb of the lowest yearly tide. In contrast, the mean low tide is (-)4.8 ft msl. Along with the conservatism built into the calculation, the licensee noted that the credited pump operating range pump for FLEX strategies is lower (lower flow and lower speeds) than the pumps actual maximum capacity. As such, an operator can vary the pump speed, as-needed, to achieve the desired flow, so that there is no actual penalty on the achievable flow even with mild cavitation. During the audit, the NRC staff performed a walkdown of the licensee's FLEX strategy and noted that the deployment of the portable FLEX pumps, hoses, and connection points was consistent with the licensee's hydraulic analysis. Given the conservative nature of the hydraulic calculation and the design of the pump, the pump should have sufficient capacity to provide the required flow for Phase 2 core cooling.

For Phase 3 core cooling, the licensee will supply well water using at least two of its three wells with their corresponding electric motor-driven well pumps. The well pumps will pump water through an NSRC-supplied RO purification system and then to an onsite FRAC tank (preferred) or an NSRC supplied water bladder. Operators will realigned one of the Phase 2 diesel-powered FLEX pumps to take suction from the FRAC tank or bladder (however, the pump can take suction directly from the RO system if necessary) and discharge into the RPV. In accordance with Section 11.2 of NEI 12-06, the licensee performed Calculation No. M1384, "Pilgrim FLEX Hydraulic Analysis," Revision 0 [Reference 48], to confirm that the diesel- powered FLEX pump and well pumps could provide the required flow rates sufficient for core cooling. The NRC staff performed a review of Calculation M1384 [Reference 48]. The calculation uses classical hydraulic analysis head loss and pressure gradient methods and includes all pumps, valves, hoses, strainers, elevations, and line distances. The calculation shows that the well pumps, in conjunction with the Phase 2 diesel-powered FLEX pumps, should have sufficient capacity to supply the required flow for Phase 3 core cooling.

Based on design of the FLEX pumps, as described in Entergy's Calculation M1384 [Reference 48], consistent with NEI-12-06, Section 11.2, and if implemented according to Entergy's control strategy, as described in the FIP, the FLEX pumps should have sufficient capacity to support core cooling during an ELAP.

3.2.3.6 Electrical Analyses

The Pilgrim electrical FLEX strategies are identical for maintaining or restoring core cooling, containment, and spent fuel pool cooling, except as noted in Sections 3.3.4.4 and 3.4.4.4 of this safety evaluation (SE). Furthermore, the electrical coping strategies are the same for all modes of operation.

Pilgrim has two sets of station batteries, 125 Vdc and 250 Vdc, that power different loads important to its strategies. According to the FIP, the Phase 1 electrical strategy involves load shedding of non-essential loads in accordance with SBO procedures. The load shed would begin within 2 hours after the occurrence of an ELAP/LUHS and be completed within 1 hour thereafter. With load shedding, the usable station Class 1E battery capacity is extended beyond 8 hours.

The licensee's Phase 2 strategy depends on which FLEX 480 Vac 3-phase DGs are available after the event (unavailability of a single set of FLEX equipment could be due to either a maintenance outage or as result of a tornado). Entergy stated in its FIP that Pilgrim has two spatially-separated FLEX equipment storage areas, approximately 2,200 feet apart, for protection against a tornado event. Entergy used nine FLEX storage Sea-Land containers in each area to store FLEX equipment, including the FLEX 480 Vac 3-phase DGs. The FLEX equipment staged in these areas is redundant. Either storage area may therefore be lost to a BDBEE, leaving the second area with adequate equipment to implement the FLEX strategy. The licensee's FIP also identified a number of configurations that provide diverse and flexible options for repowering any of the normal and backup 125 and 250 Vdc station battery chargers, groundwater well pump motors, and portable ventilation fans.

During the audit, the licensee provided dc system analysis Calculations PS258, "125V & 250V DC Load Flow Studies - Fukushima Response Project," Revision 0 [Reference 49]; PS233B, "125 Volt Battery A System Voltage," Revision 1 [Reference 50]; PS233C, "125 Volt Battery B System Voltage," Revision 1 [Reference 51]; and PS233D, "250 Volt Battery System Voltage Calculation," Revision 1 [Reference 52], which verified the capacity of the dc system to supply the required loads during the first phase of the Pilgrim FLEX mitigation strategy plan for an ELAP as a result of a BDBEE. The calculations identified the required loads and their associated ratings (amperage and minimum voltage) and loads that would be shed to ensure battery operation for at least 8 hours. Based on its review of the licensee's calculations, the battery vendor's capacity and discharge rates for the batteries; the guidance in PNPS 5.3.31, "Station Blackout," Revision 16 [Reference 53]; and Procedures 5.9.4, "DC Bus Load Shed & Repower Battery Chargers and Safeguards Panels (FSG-4)," Revision 0, and 5.9.4.1, "DC Load Shedding," Revision 0 [Reference 54], the NRC staff found that the licensee's load shed strategy is acceptable and that the batteries should have sufficient capacity to supply power to required loads for at least 8 hours.

The licensee's transition from Phase 1 to Phase 2 (repowering station battery chargers) will be completed within 8 hours. The licensee will use the FLEX 480 Vac 3-phase 86 kW and/or 150 kW portable trailer-mounted DGs to supply power to any of the five 125 Vdc and 250 Vdc station battery chargers (normal and backup). These chargers provide power to the 125 Vdc and 250 Vdc batteries. The licensee's strategy assumes that the FLEX DGs will be deployed and will repower dc buses and the battery chargers within 8 hours (i.e., before the station batteries fully discharge).

A 150 kW 480 Vac 3-phase DG (N+1) is pre-staged in the turbine building truck lock area, a protected location in close proximity to the battery charger and switchgear rooms that provides for rapid deployment. The 150 kW DG is capable of repowering two 125 Vdc battery chargers and the 250 Vdc battery chargers, with associated battery room ventilation and 120 Vac panels. If the pre-staged 150 kW DG is not available, two 86 kW DGs that are stored in FLEX storage structures (one each per storage area) would be deployed to repower the chargers of both divisions simultaneously prior to the batteries being fully discharged. The 86 kW DGs would be transferred and staged via haul routes and staging areas evaluated for impact of applicable external hazards.

In addition to the other 480 Vac FLEX DGs, two 20 kW 480 Vac 3-phase DGs are also stored in the FLEX storage areas (one each per storage area). These DGs may be used to power the station groundwater wells and can also power the portable battery room exhaust fans (which can also be powered from FLEX 120/240 Vac DGs (e.g., the 86 kW, 150 kW, and NSRC supplied DGs also have 120 Vac 1-phase outputs).

At approximately 16 hours into the event, the licensee plans to make preparations to commence powering of the station groundwater wells with a portable FLEX 20 kW or 86 kW DG for long-term reactor feedwater make-up and boiling strategy. The supply wells each contain a 10 horsepower (hp) submersible 480 Vac 3-phase pump. Each pump motor has a #12 AWG lead cable supplied. The motor starter and electrical connectors are mounted in a NEMA 4X box where the FLEX 480 Vac DG will be connected.

The licensee has provided additional capability to alternatively power 120 Vac safeguard power supply panels (Y3/Y31 or Y4/Y41) from any available FLEX 480 Vac DG or NSRC DG having 120 Vac 1-phase outputs to maintain these systems operating indefinitely. The licensee has similar provisions for safeguarding 120/240 Vac control power supply panels (Y13 or Y14). The electrical connection to the 120/240 Vac 1-phase panels is facilitated by the use of installed 120/240 Vac 1-phase manual transfer switches with plug connectors located in the cable spreading room, vital motor generator set room, and post-accident sampling system area.

For Phase 3, Pilgrim plans to continue the Phase 2 coping strategy with additional assistance provided from offsite equipment/resources, as needed. The offsite resources that will be provided by the NSRCs includes a 1-megawatt (MW) 480 Vac 3-phase turbine generator. The licensee does not require any additional interconnecting cable assemblies to utilize the NSRC low voltage three-phase generator to supply the FLEX distribution system. The output connections on the NSRC turbine marine generator are identical in type, rating, and color coding to those used at PNPS for all single-pole cable assemblies. This generator is of greater capacity than the combined capacity of the licensee's Phase 2 FLEX DGs. Therefore, the NRC staff finds that the Phase 3 turbine generator will provide adequate capacity to supply the minimum required loads (same as Phase 2) to maintain or restore core cooling, SFP cooling, and containment indefinitely following a BDBEE.

The NRC staff reviewed Calculation PS262, "FLEX Diesel Generator Loading," Revision 0A, FSG 5.9.5, "Initial Assessment and FLEX Equipment Staging," Revision 0 [Reference 55], conceptual single line electrical diagrams, the separation and isolation of the FLEX DGs from the Class 1E emergency diesel generators (EDGs), and procedures that direct operators how to align, connect, and protect associated systems and components. Based on the NRC staff's review, the calculations confirmed that the FLEX DGs should have sufficient capacity and capability to supply the necessary loads following a BDBEE.

3.2.4 Conclusions

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

3.3 Spent Fuel Pool Cooling Strategies

NEI 12-06, Table 3-2 and Appendix C, summarize one acceptable approach for the SFP cooling strategies. This approach uses a portable injection source to provide (1) make-up via hoses on the refueling floor capable of exceeding the boil-off rate for the design-basis heat load; (2) make-up via connection to SFP cooling piping or other alternate location capable of exceeding the boil-off rate for the design-basis heat load; and alternatively (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 to account for overspray). This approach also requires a pathway to vent steam from the SFP. The spray capability is not required for SFPs that cannot be drained, due to a substantial portion of the pool being below ground level with no open structures beneath it.

As described in NEI 12-06, Section 3.2.1.7, and JLD-ISG-2012-01, Section 2.1, strategies that have a time constraint to be successful should be identified, and a basis for the conclusion that the time can be reasonably met should be provided. NEI 12-06, Section 3, provides the performance attributes, general criteria, and baseline assumptions to be used in developing the technical basis for the time constraints. Since the event is a BDBEE, the analysis used to provide the technical basis for time constraints for the mitigation strategies may use nominal initial values (without uncertainties) for plant parameters and best-estimate physics data. All equipment used for consequence mitigation may assume to operate at nominal setpoints and capacities. Section 3.2.1.2 of NEI 12-06 describes the initial plant conditions for the at-power mode of operation, Section 3.2.1.3 describes the initial conditions, and Section 3.2.1.6 describes SFP initial conditions.

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

The sections below address the effects of a BDBEE on SFP cooling during operating, pre-fuel transfer or post-fuel transfer operations. The effects of a BDBEE with full core offload to the SFP will be addressed in Section 3.11.

3.3.1 Phase 1

For Phase 1 SFP cooling, the licensee credits the large inventory and heat capacity of the water in the SFP. As described in Section 2.4.1 of Entergy's FIP, the SFP will begin boiling approximately 32 hours following the loss of the SFP cooling. Following the loss of cooling, the SFP will reach spent fuel pool instrumentation (SFPI) Level 2 (10 ft above fuel) in approximately 95 hours. The licensee's initial coping strategy for SFP cooling is to monitor SFP level using instrumentation installed as required by NRC Order EA-12-051.

3.3.2 Phase 2

As described in Section 2.4.2 of Entergy's FIP, transition from Phase 1 to Phase 2 requires initiation of SFP make-up. In accordance with Appendix C to NEI-12-06, the licensee can provide make-up to the SFP using three different methods: make-up via portable hose over the edge of the pool, make-up using existing piping, and make up via portable pump with hose and spray nozzle using existing strategies required by previous NRC Order EA-02-026, Section B.5.b, and 10 CFR 50.54(hh)(2).

The first method for SFP cooling uses demineralized water in the lower volume of the dryer and separator storage pool (below elevation 97 ft) as an initial source of make-up water. The capacity of this lower volume is approximately 34,000 gallons. The licensee's strategy will rely on a portable submersible air-powered diaphragm pump to transfer water from the dryer and separator storage pool to the SFP with a flow rate capacity of 25 gpm. A portable diesel air compressor (DAC) will provide motive power for the submersible pump. A usable volume of 30,000 gallons will provide a 42-hour supply of make-up water at a boil-off rate of 12 gpm. According to Calculation No. M588, "Fuel Pool Decay Heat & Heatup Times," Revision 1 [Reference 56], boil down to 33 ft of water will take approximately 95 hours. The time to boil down in addition to the make-up capability of this method should provide an adequate amount of time to transition to SFP cooling using additional water sources and offsite equipment in Phase 3.

The second method of SFP cooling provides a capability to supply make-up water to the SFP without accessing the refueling floor. The strategy uses the low pressure FLEX pump taking suction from the discharge of the well pumps and injecting into RHR system, flowing through valve 1001-104 into the fuel pool cooling system (RHR/FPC) intertie, and then through valve 19-HO-166 into the FPC system return header, which connects directly to the SFP. The FLEX connection to the RHR system will be fire water to RHR/standby service water (SSW) system cross-tie upstream of valve 10-HO-511. The licensee will use existing station procedure, PNPS 5.3.26, to install a fire hose adaptor to the lower flange of the fire water to RHR crosstie pipe connection at the auxiliary bay 23-ft elevation location.

The second method will use water from the FLEX groundwater wells (via the FRAC tank) after 72 hours and will satisfy the requirements for make-up water at a boil-off rate of 12 gpm. The FLEX wells and FRAC tank will not be used for SFP make-up until after RPV injection has been successfully implemented and when the FLEX wells can support both RPV and SFP make-up needs. The licensee stated that the basis for this approach is that RPV core cooling has the highest and utmost priority during the initial 72 hours, given that the time to boil down to 33 ft of water in the SFP is approximately 95 hours.

The third method uses the capability to provide make-up to the SFP via hose connected to a spray nozzle. This method utilizes existing equipment that was initially intended to support the mitigating strategies required from previous NRC Order EA- 02-026, Section B.5.b, and 10 CFR 50.54(hh)(2). Section 3.2.1.3 of NEI-12-06, Initial Condition 7, states that equipment for 50.54(hh)(2), may be used provided it is reasonably protected from the applicable external hazards per Sections 5 through 9 and Section 11.3 of NEI-12-06 and has predetermined hookup strategies with appropriate procedures/guidance. Entergy's FIP states that the monitor spray nozzle and hoses needed to provide spray and/or make-up to the SFP are kept in an accessible and protected area of the reactor building and refueling floor. In addition, the FIP stated that the PNPS FLEX pumps are equivalent and interchangeable with the B.5.b pump and that the strategy can utilize the UHS as the water source for cases where all preferred water sources capable of delivering the spray flow needed are not available or viable at the time.

3.3.4 Staff Evaluations

3.3.4.1 Availability of Structures, Systems, and Components

3.3.4.1.1 Plant SSCs

NEI 12-06, Section 3.2, states that installed equipment that is designed to be robust with respect to design-basis external events is assumed to be fully available. 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 assumed 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) the SFP cooling system is intact, including attached piping. The PNPS UFSAR, Section 12.2.1.1, Revision 27, states that Class I structures, equipment, and components include those whose failure or malfunction might cause or increase the severity of an accident which would endanger the public health and safety. As such, the station Class I structures, equipment, and components have been designed to remain functional during and following the most severe natural phenomena which can be postulated to occur at this site. In addition, Specification M300, "Pilgrim Unit 1 Specification for Piping," Revision 109 [Reference 57], states that piping designated as "Class I Piping" requires tornado protection and Class I seismic design considerations.

Section 2.4.2 of Entergy's FIP describes three separate methods for SFP cooling used at PNPS. As discussed above, Method 1 uses water from the dryer and separator storage pool via a submersible pump and portable hoses. Method 2 uses a FLEX pump connected via a portable hose to existing installed piping on the RHR, FP, and SFP systems to supply water to the SFP without having to access the refueling floor. Method 3 does not require the use of any existing installed SSCs and is accomplished via portable pumps and hoses.

The dryer and separator storage pool is located in the reactor building. The PNPS UFSAR, Section 12.2.1.2, Revision 27, states that the reactor building is a Class I structure and protects all the Class I equipment located inside the building from the effects of a tornado. Based on the location and design of the dryer and separator storage pool as described in the PNPS UFSAR, and if the SFP cooling strategy is implemented as described in Entergy's FIP, the dryer and separator storage pool should be available to support SFP cooling during an ELAP, consistent with NEI 12-06, Section 3.2, Section 3.2.1.3, Condition 6, and Section 3.2.1.6.

As discussed in Section 3.3.2 of this evaluation, the FLEX connection to the RHR system for Method 2 is located on the fire water to RHR/SSW system cross-tie upstream of valve 10-HO-511. The protection of this FLEX connection and associated piping is discussed in Section 3.2.3.1.1 of this evaluation. Once in the RHR system, SFP make-up water flows through valve 1001-104 into the RHR/FPC intertie and then through valve 19-HO-166 into the FPC system return header, which connects directly to the SFP. According to PNPS Drawings M231, "P&ID Fuel Pool Cooling and Demineralizing System," Sheet 1, Revision 43 [Reference 58], and M241, "P&ID Residual Heat Removal System," Sheet 1, Revision 87 [Reference 59], the piping flow path downstream of valve 1001-104 to the flange downstream of valve 19-HO-146 is non-Class I piping. In addition, PNPS UFSAR, Section 10.4.3, Revision 27, states that except for the pool stainless steel liner, all other equipment in the system is Class II. However, specific to the SFP, NEI 12-06, Section 3.2.1.6, Condition 3 allows the assumption that the SFP cooling system is intact, including attached piping. Based on the location and design of the credited portions of the RHR system piping, and the credited portions of the FPC system piping, as described in the PNPS UFSAR, and if aligned according to Entergy's SFP cooling strategy, as described in the FIP, the credited flow paths should be available to support SFP cooling during an ELAP consistent with NEI 12-06, Section 3.2.1.3, Condition 6, and Section 3.2.1.6.

Primary and Alternate Connections

Section 3.2.2 of NEI 12-06 states that portable fluid connections for core and SFP cooling functions are expected to have a primary and an alternate connection or delivery point (e.g., the primary means to put water into the SFP may be to run a hose over the edge of the pool) and that at a minimum, the primary connection point should be an installed connection suitable for both the on-site and off-site equipment, while the secondary connection point may require reconfiguration if it can be shown that adequate time and resources are available to support the reconfiguration. In addition, Section 3.2.2 states that both the primary and alternate connection points do not need to be available for all applicable hazards, but the location of the connection points should provide reasonable assurance that one connection will be available.

Strategies for SFP cooling at PNPS do not have a primary and alternate connection point for FLEX equipment. Instead, according to Section 2.4.2 of Entergy's FIP, PNPS uses three separate methods for SFP cooling. Method 2 is the only method that uses a FLEX connection on existing installed equipment. As discussed above and in Section 3.2.3.1.1 of this evaluation, the FLEX connection and parts of the FPC system are not designed to or protected from all applicable external hazards. However, because PNPS has two additional methods that are completely independent of each other and rely on portable equipment that is stored in and deployed through locations that are protected from the applicable external hazards, at least one method should be available in accordance with Section 3.2.2 of NEI 12-06.

Ventilation

Bulk boiling in the SFP will create adverse temperature, humidity, and condensation conditions in the refuel floor area. As such, NEI 12-06 requires a ventilation pathway to exhaust the humid atmosphere and mitigate these potential adverse effects. Action 14 of Table 2, "Sequence of Events Timeline," in the licensee's FIP states that procedural guidance (FLEX FSG 5.9.7.1, "Secondary Containment Ventilation," Revision 0) will direct the establishment of a natural, free- circulation ventilation path from the reactor building truck lock (inlet at elevation 23 ft.) to the SFP/refuel floor area reactor building roof hatch (outlet at elevation 158 ft.) to exhaust the humid atmosphere. In the sequence of events timeline, this action is anticipated to occur approximately 32 hours following an ELAP-inducing event but prior to the SFP boiling. During the onsite portion of the audit, the NRC staff performed a walkdown of the area with the licensee's personnel. There are no personnel actions anticipated by the licensee in the SFP/refuel floor area after the ventilation path is opened.

Based on the administrative controls to establish ventilation before bulk boiling occurs, the relatively long time before boiling is anticipated to occur, the existence of a strategy which does not require entry into the SFP area, and the availability of personal protective equipment if manual actions are needed (see RCIC room habitability discussion in Section 3.9.2.3), the proposed ventilation strategy should be sufficient to facilitate the maintenance of SFP cooling following an ELAP-initiating event.

3.3.4.1.2 Plant Instrumentation

In its FIP, the licensee stated that the instrumentation for spent fuel pool level will align with 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 480 Vac FLEX DGs. The NRC staff's review of the SFP level instrumentation, including the primary and back-up channels, the display to monitor the SFP water level, and environmental qualifications to operate reliably for an extended period are discussed in Section 4 of this SE.

3.3.4.2 Thermal-Hydraulic Analyses

NEI 12-06, Section 3.2.1.6, describes SFP initial conditions. Section 3.2.1.6, Condition 4, states that SFP heat load assumes the maximum design-basis heat load for the site. In accordance with NEI 12-06, Entergy performed a thermal-hydraulic analysis of the SFP using the maximum design-basis heat load for the site.

Calculations M588, "Fuel Pool Decay Heat and Heatup Times," Revision 1 [Reference 56], and M907, "Refueling Outage Decay Heat Evaluation," Revision 0 [Reference 60], provide the design-basis SFP heat loads, heatup times, boil-off rates, and boil down times for the SFP following a 20-day refueling outage and a maximum normal spent fuel discharge. For the FLEX strategy evaluation of the SFP heat load, the licensee assumes that the reactor is operating at 100 percent power for 30 days since the last reactor shutdown for refueling with a SFP starting temperature of 125 degrees °F. Given the above assumption, and according to the licensee's calculations, the SFP will begin to boil in approximately in 32 hours with a required make-up rate of 12 gpm. Following the loss of cooling, the SFP will reach SFPI Level 2 (10 ft above fuel) in approximately 95 hours from the loss of normal cooling.

3.3.4.3 FLEX Pumps and Water Supplies

Section 11.2 of NEI 12-06 states that design requirements and supporting analysis should be developed for portable equipment that directly performs a FLEX mitigation strategy for core cooling, containment, and SFP cooling that provides the inputs, assumptions, and documented analysis that the mitigation strategy and support equipment will perform as intended.

As described in Section 2.4.7.2 of Entergy's FIP, Method 1 for SFP cooling uses a submersible air-powered diaphragm pump with a bottom suction and a flow rate capacity of 25 gpm to transfer water from the dryer and separator storage pool to the SFP. The required flow rate to match SFP boil-off is 12 gpm, as discussed in Section 3.3.4.2 of this evaluation. A 125 cubic feet per minute (cfm), 100 pounds per square inch gage (psig) DAC provides required pneumatic pressure source for the air-powered diaphragm pumps used for SFP make-up water, as well as the diaphragm pumps used for diesel fuel transfer, and general dewatering service. According to the licensee's FIP, a single DAC can support these functions simultaneously.

As discussed in Section 3.2.3.5 of this evaluation, the licensee performed Calculation M1384, "Pilgrim FLEX Hydraulic Analysis," Revision 0 [Reference 48], to confirm that the diesel- powered pumps selected for the FLEX injection strategy could provide required seawater flow through the RCIC system flow path to the RPV for Phase 2 and the well pumps could provide water to the FRAC tank in Phase 3. However, the calculation did not provide an analysis of the FLEX pumps capacity to provide RPV injection concurrent with SFP injection or spray cooling. During the audit process, the NRC staff requested the licensee to evaluate the hydraulic capability of the pump in relation to SFP injection and spray cooling including concurrent RPV injection, if applicable. In response, the licensee stated that Calculation M1384 [Reference 48] is based on the bounding, most limiting configuration for the FLEX pumps, which is the tandem FLEX pump arrangement with seawater suction at 400 gpm. The bounding hydraulic case is based on initially injecting the total 400 gpm flow into the FLEX RPV primary injection point. The FLEX strategy assumes that the RPV injection flow will be initiated at the maximum 400 gpm flow rate for up to one hour to flood the RPV; however, after the desired RPV water level is achieved, the licensee intends to reduce the flow rate to 180 gpm (i.e., twice the flow rate necessary to match core boil-off at approximately 10 hours). The licensee stated that the 400 gpm case is intended to bound all possible deployments of the FLEX pumps, including the bounding case of combined FLEX RPV injection with SFP spray using seawater from the UHS.

In the case of a SFP draindown event, together with the ELAP and a loss of all preferred water sources, the licensee stated that the FLEX pumps in the tandem arrangement can deliver 200 to 250 gpm to the SFP spray nozzle. The delivery of 200 to 250 gpm of spray flow to the SFP is based on the previously established hydraulic analysis for the B.5.b strategy in Calculation FP53, "Determine Adequacy of B.5.B Mitigation Strategy," Revision 1 [Reference 61], in accordance with guidance from NEI 06-12, Revision 2, "NRC B.5.b Phase 2 & 3 Submittal Guideline." The licensee stated that the FP53 [Reference 61] analysis determined that the required pump capacity for the SFP spray case is 250 gpm at 150 psig discharge pressure. According to the licensee, the B.5.b pump included in that analysis is identical to the smaller of the two FLEX Pumps (Godwin HL100M) and within the capacity of the larger FLEX pump (Godwin HL110M). The analysis includes all the line losses for the maximum hose run from the pump discharge to the SFP oscillating spray nozzle operating at 75 psig at 250 gpm.

In the event that there is not a SFP draindown, there should be no need to divert any seawater to the SFP during the Phase 2 response for up to at least 95 hours according to Calculation M588 [Reference 56]. As described in Entergy's FIP, after 72 hours SFP make-up water could be delivered at 12 gpm to match boil-off rate by the FLEX injection pump from the FRAC tank, which is replenished from the FLEX groundwater wells.

Based on the design of the FLEX pumps, as described in Entergy's Calculation M1384 [Reference 48], and the NRC staff's audit, and if implemented according to Entergy's SFP control strategy described in its FIP, the FLEX pumps should have sufficient capacity to support SFP cooling during an ELAP.

3.3.4.4 Electrical Analyses

The licensee's OIP and FIP define strategies capable of mitigating a simultaneous loss of all ac power and LUHS resulting from a BDBEE by providing the capability to maintain or restore core cooling (the licensee's strategy for RCS inventory control uses the same electrical strategy as for maintaining or restoring core cooling, containment, and SFP cooling) at the Pilgrim site. Furthermore, the electrical coping strategies are the same for all modes of operation.

The NRC staff performed a comprehensive analysis of the licensee's electrical strategies, which includes the SFP cooling strategy. The NRC staff's review is discussed in detail in Section 3.2.3.6.

3.3.5 Conclusions

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

3.4 Containment Function Strategies

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. Pilgrim is a BWR with a Mark I containment. For this containment type, NEI 12-06 provides guidance that a reliable, hardened vent (or hardened containment vent system (HCVS)) may be used to remove heat and control pressure buildup inside the primary containment.

The licensee performed a containment evaluation, M1380, "PNPS FLEX Strategy Thermal Hydraulic Analysis," Revision 0 [Reference 47], which was based on the boundary conditions described in Section 2 of NEI 12-06. This calculation concluded that the HCVS should be opened to begin removing heat and relieving pressure from the containment atmosphere when the suppression pool temperature approaches 280°F, approximately 16 hours after the occurrence of the ELAP-inducing event. The licensee's calculation demonstrated that employing this strategy maintains the containment parameters of pressure and temperature below the respective design limits of 56 psig and 281°F (shown in Table 5.2-1 of the PNPS UFSAR, Revision 27) for the duration of the ELAP event. Based on its review of the evaluation, the NRC staff noted that the required actions to maintain containment integrity and required instrumentation functions have been developed, and are summarized below.

3.4.1 Phase 1

The licensee's FIP states that during the first 6 hours after shutdown, the reactor remains isolated and pressurized with RCIC providing core cooling drawing water from the suppression pool (torus). As the torus heats up due to blowdown from the SRVs and RCIC operation, the containment will begin to heat up and pressurize (details on the licensee's strategy for core cooling, which directly affects containment heat up and pressurization, are provided in Section 3.2 above). The M1380 containment analysis [Reference 47] predicts that, while following the core cooling strategy specified in the governing procedures, the torus will heat up to 280°F approximately 16 hours after the initiation of the ELAP event. At this time, the HCVS will be opened in accordance with plant EOPs to provide containment heat removal and begin a long-term strategy of reactor feedwater make-up and boiling to protect the core and containment (see Table 2, "Sequence of Events Timeline," Action Item 10, of the licensee's FIP. The opening of the HCVS will prevent any further rise in torus water temperature.

The FIP further states that the PNPS FLEX strategy is based on performing venting via the HCVS for containment heat removal when the drywell or torus approaches the design temperature of 281°F, which corresponds to a saturation pressure of 35 psig. This pressure is well below the primary containment pressure limit of 60 psig, as given in EOP-11, "Figures, Cautions, and Icons," Figure 4. Thus, containment pressure control is also appropriately addressed by invoking this strategy.

With regard to necessary instrumentation to employ the strategies, the FIP states that the Phase 1 coping strategy for containment involves monitoring containment temperature and pressure using installed instrumentation. Specifically, it states that monitoring of drywell and torus pressure and torus water level and temperature will be available via normal plant instrumentation. Control room or cable spreading room indication for low-range drywell pressure, RCIC pump suction pressure ,and HPCI pump suction pressure will also be retained for the duration of the ELAP. The maintenance of these instruments will provide operators with data concerning the key containment parameters consistent with the guidance specified in Table 3-1 of NEI 12-06.

3.4.2 Phase 2

The FIP states that permanently installed plant equipment/features are used to maintain containment integrity throughout the duration of the event; no non-permanently installed equipment is required to maintain containment integrity. Therefore, there is no defined end time for the Phase 1 coping period for maintaining containment integrity.

Regarding instrumentation, the FIP states that, in addition to the instruments identified for Phase 1 containment integrity, ac-powered instruments for torus bottom pressure, wide-range primary containment pressure, low-range primary containment pressure, torus water level, torus water temperature, and HCVS instrumentation will be repowered in Phase 2 using FLEX portable diesel generator(s). The maintenance of these instruments will provide operators with data concerning the key containment parameters consistent with the guidance specified in Table 3-1 of NEI 12-06.

3.4.3 Phase 3

The FIP states that permanently installed plant equipment/features are used to maintain containment integrity throughout the duration of the event; no non-permanently installed equipment is required to maintain containment integrity. Therefore, there is no defined end time for the Phase 1 coping period for maintaining containment integrity.

3.4.4 Staff Evaluations

3.4.4.1 Availability of Structures, Systems, and Components

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

3.4.4.1.1 Plant SSCs

Section 5.1.2 of the PNPS UFSAR, Revision 27, describes the Mark I containment as a pressure suppression system consisting of a drywell; a pressure suppression chamber, which stores a large volume of water; a connecting vent system between the drywell and water pool; isolation valves; vacuum relief system; containment cooling systems; and other service equipment. This section further states that the drywell is a steel pressure vessel in the shape of a light bulb, and the pressure suppression chamber is a torus-shaped steel pressure vessel located below and encircling the drywell.

Section 5.1.3 of the PNPS UFSAR, Revision. 27, states that the secondary containment system includes the reactor building, standby gas treatment system (SGTS), and main stack. It states that the secondary containment is designed to withstand the maximum postulated seismic event. In addition, this section states that the reactor building is designed to provide protection for the engineered safeguards and nuclear safety systems located in the building from all postulated environmental events, including tornadoes.

Furthermore, Section 12.2.1.2 of the PNPS UFSAR, Revision 27, lists the primary containment and secondary containment as being Class I structures which are designed to remain functional during and following the most severe natural phenomena which can be postulated to occur at the site.

The FIP states that the HCVS at PNPS includes an 8-inch air-operated butterfly valve capable of venting the torus airspace through an 8-inch branch line connected between two primary containment isolation valves from the 20-inch torus penetration X-227. The HCVS flow path connects to the 20-inch discharge line downstream of the SGTS filter trains. This portion of the routing is all within the reactor building. The HCVS flow path continues through the 20-inch discharge line to the plant's main stack that includes a buried piping run from the plant out to the main stack's elevated release point.

The HCVS uses the station's 125 Vdc battery power system (maintained for the duration of the event by the repowered chargers from the FLEX DG(s)) and pneumatic pressure normally provided by three parallel sources, plus a backup local source, as follows:

- Liquid Nitrogen make-up system (N2 vaporizers)
- Essential instrument air system branch of the compressed air system
- Backup nitrogen cylinder supply (N2 gas high pressure cylinders)
- Local high pressure cylinder/pneumatic control station

The FIP states that the HCVS meets American Society of Mechanical Engineers Boiler and Pressure Vessel Code (1980 Edition with Winter 1980 Addenda), Section III, Subsection NC, for Nuclear Class 2 requirements up to and including the isolation valve. The piping downstream of the isolation valve meets American National Standards Institute (ANSI) B31.1 (1977 Edition through Winter 1979 Addenda) requirements.

Regarding the power and pneumatic supplies, Section 5.4.7.2 of the PNPS UFSAR, Revision 27, states that both electrical power and valve operator active gas (air or nitrogen) supply are taken from "essential" or reliable sources, or are backed-up to ensure that the system is available during a station blackout or loss of instrument air event.

Based on these UFSAR qualifications, the containment, the HCVS, and the necessary support equipment credited in the strategy are robust, as defined by NEI 12-06, and would be available following an ELAP-inducing event.

3.4.4.1.2 Plant Instrumentation

As stated in Sections 3.4.1 and 3.4.2 above, the licensee's FIP states that drywell and torus pressure and torus water level and temperature will be available via normal plant instrumentation. Control room or cable spreading room indication for low-range drywell pressure, RCIC pump suction pressure, and HPCI pump suction pressure will be available in Phase 1. Furthermore, ac-powered instruments for torus bottom pressure, wide-range primary containment pressure, low-range primary containment pressure, torus water level, torus water temperature, and HCVS instrumentation will also be repowered in Phase 2 using FLEX portable DG(s). The maintenance of these instruments will provide operators with data concerning the key containment parameters consistent with the guidance specified in Table 3-1 of NEI 12-06.

3.4.4.2 Thermal-Hydraulic Analyses

The licensee performed a containment evaluation, M1380, "PNPS FLEX Strategy Thermal Hydraulic Analysis," Revision 0 [Reference 47], which was based on the boundary conditions described in Section 2 of NEI 12-06. This calculation performed numeric computations of the fundamental thermodynamic equations which predict the heat up and pressurization of the containment atmosphere under ELAP conditions. As stated in Section 3.4 above, the calculation concludes that the HCVS should be opened to begin removing heat and relieving pressure from the containment atmosphere when the suppression pool temperature approaches 280°F, approximately 16 hours after the occurrence of the ELAP-inducing event. Employing this strategy was shown in the calculation to maintain the containment parameters of pressure and temperature below the respective design limits of 56 psig and 281°F (shown in Table 5.2-1 of the PNPS UFSAR, Revision 27) for the duration of the ELAP event.

Additionally, the licensee performed verification Calculation ENTGPG012-CALC-001, "Pilgrim Containment Analysis of FLEX Strategy," Revision 0 [Reference 62], utilizing the MAAP4 code to evaluate the results of the M1380 calculation. This verification calculation concluded that, overall, the results of the M1380 [Reference 47] calculation were more conservative than the MAAP4 results, but the MAAP4 results also support the capabilities of the strategies evaluated by the M1380 [Reference 47] calculation.

3.4.4.3 FLEX Pumps and Water Supplies

As discussed in Section 2.5 of Entergy's FIP, permanently-installed plant equipment features are used to maintain containment integrity throughout the duration of the event; no non-permanently installed equipment (i.e., portable equipment) is required to maintain containment integrity.

3.4.4.4 Electrical Analyses

For Phase 3, Entergy plans to continue the Phase 2 coping strategy with additional assistance provided from offsite equipment/resources, as needed. The offsite resources that will be provided by the NSRCs includes a 1-MW 480 Vac 3-phase turbine generator. The licensee does not require any additional interconnecting cable assemblies to utilize the NSRC low voltage 3-phase generator to supply the FLEX distribution system. The output connections on the NSRC turbine marine generator are identical in type, rating, and color coding to those that are used at PNPS for all single-pole cable assemblies. The capacity of this generator is greater than the combined capacity of the licensee's Phase 2 FLEX DGs. Therefore, the NRC staff finds that the Phase 3 turbine generator will provide adequate capacity to supply the minimum required loads (same as Phase 2) to maintain or restore core cooling, SFP cooling, and containment indefinitely following a BDBEE.

3.4.5 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore containment functions following a BDBEE consistent with NEI 12-06, 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, Revision 0, provide the methodology to identify and characterize the applicable BDBEE 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 site-specific BDBEE 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 the guidance described in NEI 12-06 and determined that FLEX equipment should be protected from the following hazards: seismic; severe storms with high winds; snow, ice, and extreme cold; and extreme high temperatures. In accordance with Pilgrim's FIP, flooding is not applicable as Pilgrim is in the category of "dry sites" according to NEI 12-06, Section 6.2.1. This is further discussed in Section 3.5.2, "Flooding," of this SE.

References to external hazards within the licensee's mitigating strategies and this SE are consistent with the guidance in NEI-12-06 and the related interim staff guidance in JLD-ISG-2012-01. Coincident with the issuance of the order, on March 12, 2012, the NRC staff issued a request for information pursuant to Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f) [Reference 63] (hereafter referred to as the 50.54(f) letter), which requested that licensees reevaluate the seismic and flooding hazards at their sites using updated hazard information and current regulatory guidance and methodologies.

The NRC staff requested Commission guidance related to the relationship between the reevaluated flooding hazards provided in responses to the 50.54(f) letter and the requirements for Order EA-12-049 and related rulemaking to address BDBEE (see COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards," dated November 21, 2014). On March 30, 2015, the Commission provided guidance in the SRM to COMSECY-14-0037 [Reference 64]. The Commission approved the staff's recommendations that licensees need to address the reevaluated flooding hazards within their mitigating strategies for BDBEE, and that licensees may need to address some specific flooding scenarios that could significantly damage the power plant site by developing scenario-specific mitigating strategies, possibly including unconventional measures, to prevent fuel damage in reactor cores or SFPs. The NRC staff did not request that the Commission consider making a requirement for mitigating strategies capable of addressing the reevaluated flooding hazards be immediately imposed, and the Commission did not require immediate imposition.

The licensee submitted its Flood Hazard Reevaluation Report (FHRR) [Reference 67] on March 12, 2015, but the NRC staff has not completed its review of the report. The licensee developed its OIP for mitigation strategies in February 2013 [Reference 10] by considering the guidance in NEI 12-06 and its then-current design-basis hazards. Therefore, this safety evaluation makes a safety determination based on the OIP and FIP, and only notes the possibility of future actions by the licensee when the licensee's FHRR identifies a flooding hazard that exceeds the current design-basis flooding hazard.

In accordance with the 50.54(f) letter, licensees were also asked to provide a seismic hazard screening and evaluation report to reevaluate the seismic hazard at their site. The licensee submitted its Seismic Hazard and Screening Report (SHSR) [Reference 65] on March 31, 2014, and the NRC staff completed its review of the report, as documented, by letter dated April 20, 2015 [Reference 66], and discussed in Section 3.5.1 below.

The characterization of the specific external hazards for the plant site is discussed below. In addition, Sections 3.5.1 and 3.5.2 summarize the licensee's activities to address the 50.54(f) seismic and flooding reevaluations.

3.5.1 Seismic

In the Pilgrim UFSAR, Section 2.5.3.3.2, the licensee stated that the Safe Shutdown Earthquake (SSE) maximum horizontal ground acceleration is 0.15 g.

As previously discussed, the NRC issued a 50.54(f) letter that required facilities to reevaluate the site's seismic hazard (i.e., NTTF Recommendation 2.1). In addition, the 50.54(f) letter requested that licensees submit, along with the hazard evaluation, an interim evaluation and actions planned or taken to address the reevaluated hazard where it exceeds the current design-basis.

The licensee submitted its SHSR on March 31, 2014 [Reference 65]. By letter dated April 20, 2015 [Reference 66], the NRC staff completed its review of Pilgrim's SHSR. The NRC staff concluded that the licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance, it appropriately characterized the site given the information available, and met the intent of the guidance for determining the reevaluated seismic hazard. The NRC staff also concluded that Entergy's reevaluated seismic hazard for Pilgrim is suitable for other activities associated with the NTTF Recommendation 2.1, "Seismic."

In reaching this determination, the NRC staff confirmed the licensee's conclusion that the licensee's Ground Motion Response Spectrum (GMRS) exceeds the Safe Shutdown Earthquake (SSE) for the Pilgrim site over the frequency range of 1 to 10 Hertz (Hz). As such, Pilgrim screens in to perform a seismic risk evaluation. The NRC staff also confirmed the licensee's conclusion that because the GMRS exceeds the SSE above 10 Hz, the licensee will perform a high-frequency confirmation of the seismic hazard evaluation, which the licensee indicated would be performed as part of its seismic risk evaluation.

By letter dated December 16, 2014 [Reference 79], the licensee submitted the results of its interim evaluation, including actions taken or planned, to address the higher seismic hazard relative to the design-basis. This interim evaluation, also referred to as the Expedited Seismic Evaluation Process (ESEP), was developed as the process for evaluating the seismic capacity of certain key installed mitigating strategies equipment that is used for core cooling and containment functions to cope with scenarios that involve a loss of all alternating current power and loss of access to the ultimate heat sink to withstand a seismic event up to two times the SSE. Electric Power Research Institute (EPRI) Report 3002000704 (ADAMS Accession No. ML13102A142), provides guidance to licensees for these evaluations. The NRC staff completed its review of Pilgrim's ESEP by letter dated June 16, 2015 [Reference 80]. The NRC staff concluded that the licensee's implementation of the interim evaluation meets the intent of the guidance; the licensee responded appropriately to the 50.54(f) letter and the ESEP assessment provides additional assurance which supports continued plant safety while the longer-term seismic evaluation is completed to support regulatory decision making.

The licensees stated that as the seismic reevaluation activities are completed, the licensee will enter appropriate issues into the corrective action program. The licensee has appropriately screened in this external hazard and identified the hazard levels for reasonable protection of the FLEX equipment.

3.5.2 Flooding

The site is located on the southwest coast of Cape Cod Bay. The site's general elevation is 23 ft above msl elevation. In its UFSAR, Section 2.4.4.2, the licensee stated that the extreme storm tide is +13.5 ft msl and the extreme low tide is -10.1 ft msl. The datum relationship at the site is that msl is +4.8 ft above mean low water (mlw) level. In its FIP, the licensee stated, in part, that it has been calculated that the 100 year storm could produce a still water level of +15.8 ft mlw. This is a combination of storm surge combined with astronomical high tide. The hydrometeorological section of the U.S. Weather Bureau has established a standard northeaster for New England. Using this storm, the peak storm surge, having a return frequency of 1,000 years, is 6.6 ft.

The concurrence of peak storm surge with an astronomical high tide of +11.7 ft mlw would give an extreme storm tide level of +18.3 ft mlw, such that +18.3 ft mlw = +13.5 ft msl, with a probability of occurrence of once every 4,000 years. Additionally, the climatological precipitation quantities in Eastern Massachusetts show that the region does not have a wet or a dry season. Monthly averages vary from about 3 inches to 4 1/2 inches at Plymouth. The maximum 24 hour rainfall is 6.88 inches, as stated in UFSAR Table 2.3-16. All Class I structures are designed for flood protection in the event of a maximum probable flood.

Therefore, because Pilgrim is built above the design-basis flood level and is considered a "dry site" by the guidance in NEI 12-06, Section 6.2.1, Entergy is not required to evaluate flood-induced challenges.

Pilgrim's FHRR [Reference 67] states that flooding due to local intense precipitation (LIP) and the combined effect flood (i.e., a combination of storm surge and wave effects) are the only flood mechanisms that result in inundation at the Pilgrim site. Plant walkdowns have confirmed that inundation associated with these two flood events will not impact systems, structures, or components important to safety. In addition, the FIP states that in response to the re-evaluated flood elevations that resulted from the LIP and the combined effect flood, which consisted of wind-generated waves in conjunction with the probable maximum storm surge, the licensee performed an assessment to determine the impact of inundation at affected locations due to the LIP and due to the combined effect flood. The results of the licensee's evaluation determined that there are no impacts to equipment important to safety as a result of the reevaluated flood elevations. As a result, no interim flood mitigating measures are planned. The NRC staff has not completed its review of Pilgrim's FHRR. The licensee's FHRR addresses a beyond- design- basis flooding event. Thus, this assessment uses the FIP in its evaluation. Based on the subsequent review of Pilgrim's FHRR, additional future actions may be required by the licensee, consistent with the Commission's regulations, to address flood hazards that may exceed the current design-basis hazard.

The licensee has stated that as the flooding reevaluation activities are completed, the licensee will enter appropriate issues into the corrective action program. Furthermore, the licensee has appropriately screened out this external hazard and identified the hazard levels for reasonable protection of the FLEX equipment.

3.5.3 <u>High Winds</u>

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 first part of the evaluation of high wind challenges is determining whether the site is potentially susceptible to different high wind conditions to allow characterization of the applicable high wind hazard. The second part is the characterization of the applicable high wind threat.

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 10^{-6} per year probability, the site should address hazards due to extreme high winds associated with hurricanes.

The screening for high wind hazard associated with tornadoes should be accomplished by comparing the site location to NEI 12-06, Figure 7-2, from U.S. NRC, "Tornado Climatology of the Contiguous United States," NUREG/CR-4461, Revision 2, February 2007; if the recommended tornado design wind speed for a 10^{-6} per year probability exceeds 130 mph, the site should address hazards due to extreme high winds associated with tornadoes.

The licensee described in its FIP that Pilgrim does not screen out for hurricanes; rather the unique location of Pilgrim on the southwest coast of Cape Cod Bay has historically sheltered the site from hurricane winds. Pilgrim is subject to hurricanes, with the highest sustained wind value being 87 mph. In the UFSAR, Table 2.3-18, the licensee stated that the maximum 5 minute sustained wind speed of 87 mph was due to the hurricane of 1938. Therefore, Pilgrim's design-basis does not meet the NEI 12-06 definition of "sites with the potential to experience severe winds from hurricanes based on winds exceeding 130 mph." The applicable wind hazards are bounded by the tornado event.

The licensee described in its FIP, that severe tornado activity in eastern Massachusetts is not common. The tornado design criteria for Pilgrim is included in Appendix H of the UFSAR and is summarized as follows:

According to the licensee's analysis in the UFSAR, the velocity components are applied as a 300 mph horizontal wind applied over the full height of the structure. The pressure differential is applied as a 3 psi positive (bursting) pressure occurring in 3 seconds. The missiles are applied, as follows:

- A 4 inch x 12 inch x 12 ft long wood plank (108 pound (lb)) traveling end-on at 300 mph over the full height of the structure.
- A 3 inch diameter Schedule 40 pipe 10 ft long traveling end-on at 100 mph over the full height of the structure.
- A passenger auto (4,000 lb) traveling end-on at 50 mph with a contact area of 20 square feet (ft^2) and at a height not greater than 25 ft above ground.

Entergy conservatively used its design values for tornados which bounds the NEI 12-06 criteria, which is 165 mph. The FLEX strategy considers high winds and complies with the requirements of NEI 12-06 and American Society of Civil Engineers (ASCE) 7-10, "Minimum Design Loads for Buildings and Other Structures," for structures that store FLEX equipment.

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

3.5.4 Snow, Ice, and Extreme Cold

As discussed in NEI 12-06, Section 8.2.1, all sites should consider the temperature ranges and weather conditions for their site in storing and deploying their FLEX equipment consistent with normal design practices. All sites outside of Southern California, Arizona, the Gulf Coast, and Florida are expected to address deployment for conditions of snow, ice, and extreme cold. All sites located north of the 35^{th} 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 NEI 12-06, Figure 8-2, should address the impact of ice storms.

Entergy stated in its FIP, that the guidelines provided in NEI 12-06, Section 8.2.1, determined that an assessment of extreme cold conditions must be performed for sites above the 35th parallel. Pilgrim is located above the 35th parallel; therefore, the effects of snow, ice, and extreme cold have been considered for the storage and deployment of FLEX equipment.

The licensee further stated that the historical lowest recorded temperature for Pilgrim is -14°F in UFSAR Table 2.3-15. Pilgrim's historical low seawater temperature is 28°F in UFSAR Figure 2.4-2. The maximum 24 hour snowfall is 16 inches in UFSAR Table 2.3-17. As noted in UFSAR Section 2.3.6, a few times each winter a weather situation favorable for ice glaze formation develops. During the period of record 1928 to 1936, the site area experienced between six and eight storms, which deposited ice glaze 0.25 inches thick or more.

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

3.5.5 Extreme Heat

In NEI 12-06, Section 9, states that all sites will address high temperatures. Virtually every state in the lower 48 contiguous United States has experienced temperatures in excess of 110°F. Many states have experienced temperatures in excess of 120°F. In this case, sites should consider the impacts of these conditions on deployment of the FLEX equipment.

The licensee stated in its FIP, that the design bases temperature for the heating, ventilation, and air conditioning (HVAC) system design ambient temperature is 88°F, and this represents a standard 1 percent exceedance value with a short-term peak design temperature of 102°F, as described in UFSAR Table 10.9-2. The 1 percent value would be expected to be exceeded for a total of 30 hours during the summer months (June to September) based on the American Society of Heating Refrigeration and Air Conditioning Engineers design standards. The Pilgrim site historical highest recorded temperature is also noted to be 102°F from UFSAR Table 2.3-15. The FLEX equipment will be procured to function in high temperatures and consideration will be given to the impacts of these high temperatures on equipment storage and deployment; however, extreme high temperatures are not expected to impact the utilization of off-site resources or the ability of personnel to implement the required FLEX strategies.

In summary, based on information 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, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.6 Planned Protection of FLEX Equipment

3.6.1 Protection from External Hazards

Entergy stated in its FIP, that Pilgrim has two spatially separated FLEX equipment storage areas, approximately 2,200 feet apart. Entergy used nine FLEX Storage Sea-Land Containers in each area to store FLEX equipment. Storage Sea-Land Containers are metal cargo shipping containers. The FLEX equipment staged in these areas is redundant. Either storage area may therefore be lost to a BDBEE, leaving the second area with adequate equipment to implement the FLEX strategy. The storage areas for the Sea-Land Containers are in a north-south alignment per NEI 12-06 and the individual Sea-Land Container axial alignment is in the order of 90 degrees for additional benefit of orientation.

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

3.6.1.1 Seismic

Entergy's OIP for mitigation strategies, described that the FLEX equipment storage strategy is based on the use of seismically-rugged, diverse, spatially-separated locations. In its FIP, the licensee described that the portable FLEX equipment will be stored in Sea-Land Containers (International Standards Organization (ISO) Cargo Containers).

During the audit process, the NRC staff reviewed Calculation No. C15.0.3665, "Supplementary Evaluation of FLEX Storage Containers for Seismic and Snow Loads," Revision 0 [Reference 68], for the evaluation of FLEX storage containers for seismic and snow loads. The licensee determined that the site's design-basis seismic response was bounded by the design, fabrication, and testing requirements associated with the Sea-Land Containers. Calculation C15.0.3665 documented that the testing requirements for the Sea-Land Containers as defined in ISO 1496-1, "Series 1 freight containers – Specification and testing – Part 1: General cargo containers for general purposes," bounds the site's design basis seismic response using methodology and load combinations outlined in ASCE 7-10. The licensee's evaluations included:

- Roof evaluation;
- Side wall evaluation;
- End wall evaluation;
- Rigidity evaluation – transverse (evaluated potential racking of container);
- Rigidity evaluation – longitudinal (evaluated potential racking of container); and
- Floor evaluation.

The FIP described that the FLEX portable equipment is stored in a manner that withstands seismic events. The equipment that is in Sea-Land Containers is secured with tie-downs and anchorage so as to not be displaced or dislodged from seismic motion within the limited confined space of these containers that inherently limit movement.

Calculation Number C15.0.3665 described that the FLEX equipment would be stored in two sets of Sea-Land Containers, each set containing a full complement of equipment required to implement the FLEX coping strategy. In order to protect the equipment from seismic interactions, sufficient clearance may be provided around the equipment, such that the calculated sliding due to seismic loading would not impact with adjacent equipment. Where sufficient clearance was not available due to space limitations within the Sea-Land Containers, softeners may be placed between adjacent items on a case-by-case basis (e.g., boat bumper between equipment trailer fenders and Sea-Land side wall). Where this method is employed, evaluation of the contacted subcomponents shall be made to ensure that the interaction will not adversely affect the performance of the equipment. Alternatively, smaller items may be strapped together with interposing softeners such that they act as a single mass for purposes of evaluating sliding and overturning. Protection from damage due to seismic interactions may also be provided by securing the equipment within the Sea-Land Containers using straps or similar devices to prevent relative movement of adjacent items.

In addition, the FIP described that pre-staged equipment within the plant is stored in low profile Job-Boxes that are secured as-needed. Job-Boxes are metal boxes with wheels. These wheels are locked to prevent movement of the box and the box is secured with wrapping. Very large mobile equipment, such as the pre-staged 150 kW generator in the turbine building trucklock and the debris removal wheel loader, are situated to preclude potential affects by the movement or damage of surrounding structures or debris sources. The wheel loader is normally stored outside in a designated area to preclude damage from seismic interaction with surrounding components and/or structures.

3.6.1.2 Flooding

As discussed in Section 3.5.2, "Flooding," of this SE, the licensee screened as a "dry site" and therefore does not need to address the protection of FLEX equipment with regard to a flooding hazard.

3.6.1.3 High Winds

For high wind conditions, Entergy determined in its FIP that the site is bounded for wind hazards by the tornado event. During the audit process, the NRC staff reviewed Calculation No. C.15.0.3642, "Evaluation of FLEX Storage Containers for Wind Loads," Revision 0 [Reference 69]. Entergy performed a wind-loading analysis of the FLEX Storage Sea-Land Container storage configuration. The containers were evaluated to demonstrate no effects for sustained wind speeds of 105 mph based on hurricane wind loading, and were shown to have capabilities to withstand significantly higher intermittent winds up to 180 mph. In the calculation, the licensee determined that the Sea-Land Containers will not slide or overturn when subjected to hurricane wind loading prescribed in the UFSAR, using methodology contained ASCE 7-10 provided certain conditions were satisfied. The close grouping (there is a defined spacing between Sea-Land Containers) and alignment of storage containers is such that individual tie- downs are not required. The potential for more damaging tornado conditions was addressed by having two widely separated (2,200 feet of separation) redundant FLEX storage sites. The calculation also assumed a minimum ballast weight for the Sea-Land Containers that is uniformly distributed and the steel base structure of the Sea-Land Containers should bear directly on asphalt pavement.

The FIP described that the licensee's FLEX strategy included sheltering of the debris removal vehicles in the reactor and turbine building truck-locks during predicted severe weather events to ensure their availability.

3.6.1.4 Snow, Ice, and Extreme Cold and Extreme Heat

Entergy stated in its FIP that the portable FLEX equipment will be stored in two spatially separated FLEX Equipment Storage Areas. The storage areas consist of nine FLEX storage

Sea-Land Containers in each area. The two (north and south) FLEX storage areas are on the edges of existing paved parking lots. The equipment is sheltered, maintained dry, and protected from wind, snow, and ice.

During the audit process, the NRC staff reviewed Entergy's calculation for the evaluation of FLEX storage containers for seismic and snow loads, Calculation No. C15.0.3665 [Reference 68]. The licensee determined that the site's design basis for snow and ice loading of the Sea-Land Containers was bounded by the design, fabrication, and testing requirements associated with the Sea-Land Containers. Calculation No. C15.0.3665 [Reference 68] documented that the testing requirements for the Sea-Land Containers as defined in ISO 1496-1, "Series 1 freight containers – Specification and testing – Part 1: General cargo containers for general purposes," bounds the site's design-basis snow/ice loading values using methodology and load combinations outlined in ASCE 7-10. The licensee's evaluations included:

- Roof evaluation;
- Side wall evaluation;
- End wall evaluation;
- Rigidity evaluation – transverse (evaluated potential racking of container);
- Rigidity evaluation – longitudinal (evaluated potential racking of container); and
- Floor evaluation.

The FIP described that the licensee's FLEX strategy included sheltering of the debris removal vehicles in the reactor and turbine building truck-locks during predicted severe weather events to ensure their availability.

The licensee's OIP [Reference 10] described that the stored FLEX equipment in the Sea-Land Containers are supplied with ac power for equipment heaters and lighting, one Sea-Land Container is environmentally controlled, and the others are ventilated. In addition, the OIP stated that the stored equipment will be provided with a heated enclosure and/or diesel engine block (internal) heaters, as needed, to ensure equipment operability or prevent degradation under all temperature conditions. Also, the storage provided for FLEX equipment will be configured to meet the requirements identified in NEI 12-06, Section 11.

The OIP also described that FLEX equipment will be stored at diverse locations that are robust for weather-related and extreme temperature events, and include heating and environmental controls, where needed.

The FIP described that the FLEX equipment would be procured to function in high temperatures and consideration will be given to the impacts of these high temperatures on equipment storage and deployment

3.6.2 <u>Reliability of FLEX Equipment</u>

Section 3.2.2 of NEI 12-06 states, in part, that in order to assure reliability and availability of the FLEX equipment, the site should have sufficient equipment to address all functions at all units on-site, plus one additional spare (i.e., an N+1 capability, where "N" is the number of units on-site). It is also acceptable to have a single resource that is sized to support the required functions for multiple units at a site (e.g., a single pump capable of all water supply functions for a dual unit site). In this case, the N+1 could simply involve a second pump of equivalent capability. In addition, it is also acceptable to have multiple strategies to accomplish a function, in which case the equipment associated with each strategy does not require an additional spare. The existing 50.54(hh)(2) pump and supplies can be counted toward the N+1, provided it meets the functional and storage requirements outlined in NEI 12-06.

In its FIP Entergy stated that the portable FLEX equipment will be stored in two spatially- separated FLEX equipment storage areas. Either storage area may be lost to a BDBEE, leaving the second area with adequate equipment to implement the licensee's FLEX strategy. The FLEX equipment staged in these areas is redundant. The storage areas for the Sea-Land Containers are in a north-south alignment in accordance with NEI 12-06. The storage areas support the location of nine FLEX storage Sea-Land Container in each area.

In addition, Entergy stated that the required FLEX low pressure injection pumps will be maintained at the on-site FLEX storage locations. Four FLEX low pressure injection pumps (two FLEX low pressure injection pumps in tandem are needed for N sets of equipment) are required to be stored onsite to satisfy the N+1 requirement.

Entergy also stated that two required (N) FLEX 86 kW DGs would be maintained in on-site FLEX storage structures. The third (N+1) FLEX 150 kW DG would be pre-staged in the turbine building truck lock area, which is a protected area in close proximity to the battery charger and switchgear rooms. This would allow for more rapid deployment of the first FLEX DG for ELAP events where that is possible. The intent is to begin recharging the batteries with the pre-staged (N+1) FLEX DG if it is available after the event. A single 150 kW generator is capable of repowering two 125 Vdc battery chargers and the 250 Vdc battery chargers, with associated battery room ventilation and 120 Vac panels. If the pre-staged (N+1) FLEX DG is not available, then two FLEX 86 kW DGs would be deployed to repower the battery chargers of both division simultaneously prior to the batteries becoming depleted.

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

3.6.3 Conclusions

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

3.7 Planned Deployment of FLEX Equipment

3.7.1 Means of Deployment

In its FIP, Entergy indicated that debris removal equipment includes a debris removal wheel loader in order to remove debris from the needed travel paths. The debris removal wheel loader will also be available to deal with more significant debris conditions. The debris removal wheel loader is normally stored outside in a designated area to preclude damage from seismic interaction with surrounding components, and/or structures. The licensee's FLEX strategy includes sheltering of the debris removal vehicles in the reactor and turbine building truck-locks during predicted severe weather events to ensure their availability.

The FIP also described that two three-quarter ton pickup trucks with trailer towing attachments and bed-mounted 100-gallon fuel storage tanks with a transfer pumps will be stored onsite. One pickup truck will be stored in each of the spatially separated FLEX equipment storage areas.

3.7.2 Deployment Strategies

In its FIP, the licensee indicated that pre-determined, preferred haul paths have been identified and documented in the FSGs. The normal deployment routes to transport FLEX equipment are via the normal site roadways and access points with an alternate haul path via the shorefront. These haul paths have been reviewed for potential soil liquefaction and have been determined to be stable following a seismic event. The deployment routes will be accessible during all modes of operation. Additionally, the preferred haul paths minimize travel through areas with trees, power lines, narrow passages, etc. to the extent practical. However, severe storms and high winds can cause debris from distant sources to interfere with planned haul paths. Debris removal equipment will be used to clear obstructions between the FLEX storage areas and the deployment locations.

During the audit process, the licensee identified the two FLEX storage areas on the edges of existing paved parking lots. Winter weather events are predictable. The site has snow plows mounted and road sanders pre-staged prior to snow/ice events. Since the FLEX storage areas are contiguous to existing employee parking areas, plowing and sanding are routine activities. Also, the site has contracts with local providers to augment on-site capabilities.

Following a BDBEE and subsequent ELAP event, FLEX coping strategies will require the routing of hoses and cables through various barriers in order to connect FLEX equipment to plant fluid and electric systems. For this reason, certain barriers (gates and doors) will be opened and remain open.

Vehicle access to the protected area is via the double gated sally-port at the security building. As part of the security access contingency, the sally-port gates will be manually controlled to allow delivery of FLEX equipment (e.g., generators, pumps) and other vehicles such as debris removal equipment into the protected area.

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

3.7.3 FLEX Connection Points

3.7.3.1 Mechanical Connection Points

RCS Strategy - Primary

As discussed in Section 3.2.3.1.1 of this evaluation, the primary FLEX connection point is in the HPCI/RCIC common suction line located in the CST vault. The CST vault has a removable protective housing to facilitate connection and provides hardened protection. The CST vault is adjacent to the CSTs. There is a FLEX connection enclosure above the vault and valves within the vault that are manipulated. The CSTs are assumed to fail during a seismic event. If the CSTs fail, there would be concerns with transient flooding and debris. The FLEX enclosure missile design bounds the potential debris effects from a CST failure.

The licensee described that for flooding, it would be a transient wave or flow of water that would drain naturally into the storm water system and directly into Cape Cod Bay from Grade Level. The CST vault access manhole has a limited-leakage cover that would result in minimal water entering the vault. The licensee has considered that if dewatering of the vault were needed for any reason, the FLEX Godwin pump is capable of performing the required suction lift with an available suction hose and would quickly remove all water from the vault. There are also available FLEX air-operated submersible diaphragm pumps and associated air compressors to perform any dewatering needed in any areas.

The licensee also described that the considerations for debris include steel plating from the CSTs may need to be removed to access the FLEX connection and vault. The FLEX debris removal high-capacity wheel loader and debris removal tools are available for this purpose. The tools available from FLEX storage include cutting, clamping, and tow hitching items that were selected to handle such scenarios quickly in combination with the FLEX pickup trucks or the primary debris removal wheel loader.

The licensee stated that this type of debris removal is included in the allocated time and resources for these types of activities in the FLEX staffing study.

RCS Strategy - Alternate

As discussed in Section 3.2.3.1.1 of this evaluation, the licensee described that the alternate FLEX connection point will use the RHR system at the existing fire water to RHR system cross- tie 8-inch connection via a removable spool in the auxiliary bay (at elevation 23 ft) water treatment area via 8-inch fire water manual isolation gate valve 10-HO-511 that feeds into the RHR system 18-inch cross-tie. This area is inside of a Class 1 building.

3.7.3.2 Electrical Connection Points

According to the FIP, the licensee has made modifications to facilitate the electrical connections required to repower any of the station battery chargers (normal and backup) directly from the FLEX DGs. This will be accomplished utilizing ac power transfer switches and portable cable connections located in the A and B switchgear rooms, which serve to completely disconnect from the normal 480 Vac bus source to allow the external 480 Vac feed from the FLEX 480 Vac

DGs. Electrical connection points for the 480 Vac FLEX DGs will be missile protected and enclosed within the seismic Category 1 structure of the dc power battery rooms and switchgear rooms. All 480 Vac 3-phase 4-conductor cables for the 480 Vac FLEX DGs will be provided with 4-wire 100 amp plugs, connectors, and receptacles for 125 and 250 Vdc battery chargers and well pumps. The licensee plans to pre-stage the required cabling in the vicinity of the battery charger and switchgear rooms.

The licensee's Phase 2 strategy depends on which FLEX 480 Vac 3-phase DGs are available after the event (unavailability of a single set of FLEX equipment could be due to either a maintenance outage or as result of a tornado). Entergy stated in its FIP, that Pilgrim has two spatially-separated FLEX equipment storage areas, approximately 2,200 feet apart. Entergy used nine FLEX storage Sea-Land Containers in each area to store FLEX equipment, including the FLEX 480 Vac 3-phase DGs. The FLEX equipment staged in these areas is redundant. Either storage area may therefore be lost to a BDBEE, leaving the second area with adequate equipment to implement the FLEX strategy. The licensee's FIP also identified a number of configurations that provide diverse and flexible options for repowering any of the normal and backup 125 and 250 Vdc station battery chargers, groundwater well pump motors, and portable ventilation fans. The licensee's Phase 2 strategy depends on which FLEX 480 Vac 3-phase DGs are available after the event. The licensee's FIP identified a number of configurations that provide diverse and flexible options for repowering any of the normal and backup 125 and 250 Vdc station battery chargers, groundwater well pump motors, and portable ventilation fans. For specific details, see the primary strategy to repower battery chargers discussion in Section 2.3.2 of the FIP regarding the various FLEX 480 Vac DG configurations that would be used depending on which FLEX 480 Vac DGs are available following a BDBEE.

3.7.4 Accessibility and Lighting

In its FIP, Entergy described that following a BDBEE, emergency lighting is retained for the main control room. For the first eight hours, emergency lights are fed from the (125 Vdc "A" and "B" battery system) station batteries; after eight hours the battery chargers are powered from a FLEX DG, which carries the dc loads. If additional load shedding is performed to extend the 125 Vdc "A" battery system even longer, then for at least the first seven hours the emergency lighting is maintained off of the 125 Vdc "A" battery system. After seven hours, emergency lighting could be transferred from the 125 Vdc "A" battery system to the 125 Vdc "B" battery system in order to extend the 125 Vdc "A" battery system life.

Entergy also states that there are several emergency lighting units (ELU) located throughout the plant to illuminate pathways and alternate shutdown panels. However, operations personnel are instructed to have a flashlight as a backup in the event an ELU is not operating. Existing plant procedures include guidance to accomplish tasks outside of the main control room when normal lighting is not available. This same strategy would apply to a BDBEE. Alternate shutdown toolboxes are staged in the elevation 23 ft. and 37 ft. in the switchgear rooms. These toolboxes contain keys, tools, flashlights, and other gear necessary for the operators to carry out their required tasks. In addition, there will be sufficient numbers of walkie-talkies available to provide communications between the various locations throughout the plant.

In addition, the FIP described that there are two FLEX storage depots. Each location will contain: three 110 Vac, 1,900 Lumen, Scene Star, LED, tripod-mounted lighting fixtures; five battery powered lights; and a trailer-mounted light tower, with four light fixtures powered by an integral diesel generator. In summary; there are total of six LED light fixtures, six diesel generators, 1,200 feet of cord, plus two diesel-powered light towers, ten portable battery powered LED lights, and two pickup trucks with directionally mounted LED flood lights for area setup. There will be 14 LED portable battery powered lighting distributed between the control room annex, EDG rooms, battery areas, technical support center, off-site support center, trucklock, and the switchgear room access. Each of these lights has three detachable individual units.

The FIP also described that an assessment of installed emergency lighting demonstrated that adequate lighting is available for access to the torus vent controls.

3.7.5 Access to Protected and Vital Areas

In its FIP, the licensee stated that following a BDBEE and subsequent ELAP event, FLEX coping strategies would require the routing of hoses and cables through various barriers in order to connect FLEX equipment to plant fluid and electric systems. In particular, Attachment 1 of FSG-5.9.5, "Initial Assessment and FLEX Equipment Staging," addresses security implementation of FLEX strategies and the use of security personnel in response to the BDBEE. This suspension of normal administrative controls is acknowledged and is acceptable during the implementation of FLEX coping strategies.

Entergy also described that security doors and gates that rely on electric power to operate opening and/or locking mechanisms are barriers of concern. The security force will initiate an access contingency upon loss of the security diesel and all ac/dc power as part of the Security Plan. Access to the owner controlled area, site protected area, and areas within the plant structures will be controlled under this access contingency as implemented by security personnel.

In its FIP, the licensee further described that vehicle access to the protected area is via the double gated sally-port at the security building. As part of the security access contingency, the sally-port gates will be manually controlled to allow delivery of FLEX equipment (e.g., generators, pumps) and other vehicles such as debris removal equipment into the protected area.

3.7.6 Fueling of FLEX Equipment

As stated in Entergy's FIP, the primary source of fuel oil for the portable equipment will be the EDG fuel oil day tanks. These two tanks are maintained with a minimum of 444 gallons of diesel fuel each (a total of 888 gallons) and are seismically mounted and housed in the tornado- protected EDG rooms. The contents are accessible via manways, which are located on top of the tanks. The elevation of the manway is significantly higher than the maximum postulated flood level on the north side of the site.

In its FIP, Entergy also stated that a second source for fuel oil will be the two EDG underground diesel fuel oil storage tanks. Each tank is maintained with a minimum of 19,800 gallons. These tanks are protected from high wind tornado missiles by virtue of the underground location, and they are also protected from seismic and flooding events. The contents are accessible via flanges on top of the tanks. The elevation of these access locations is at or slightly above the maximum postulated flood level on the north side of the site. The temporary maximum flooding levels would not significantly affect these tanks or the quality of the diesel fuel.

In addition, Entergy stated that a third source of fuel oil are the SBO diesel generator fuel oil storage tanks. The minimum fuel storage maintained in these tanks is 36,800 gallons. The contents are accessible via flanges on top of the tanks. The elevation of these access locations is below the maximum postulated flood level on the south side of the site. Therefore, these tanks are not the preferred source of diesel fuel, but are available and would not be significantly compromised by minor water intrusion.

The licensee described that diesel fuel will be pumped from one or more of these tanks into a truck-mounted 100 gallon (nominal) fuel tank and transported to the FLEX equipment locations. The fuel will then be pumped from the truck-mounted tank into the fuel tanks of the essential equipment using a truck-mounted 12 Vdc electric pump. For refueling non-essential equipment, it is anticipated that the truck-mounted tank and pump will be used to fill a smaller wheeled tank, which may then be transported and utilized by personnel responsible for this equipment. Fuel transfer carts and pumps are stored in the FLEX storage areas.

Entergy stated that diesel fuel in the fuel oil storage tanks is routinely sampled and tested to assure that fuel oil quality is maintained to American Society for Testing and Materials standards. This sampling and testing surveillance program also assures the fuel oil quality is maintained for operation of the station EDGs. Fuel oil in the fuel tanks of portable diesel engine driven FLEX equipment will be maintained in the Preventative Maintenance program in accordance with the EPRI maintenance templates.

Based on a fuel consumption study performed, the licensee determined that an eight-hour refueling cycle is feasible and adequate to ensure operation of the FLEX equipment. On-site fuel resources are more than adequate to support the continuous operation of FLEX equipment and support vehicles well beyond 72 hours. The eight-hour cycle includes one or two refills of essential equipment based on run times. It also includes two refills of the portable wheeled tank and concludes that these two refills of the smaller tank are adequate to supply non-essential equipment. Essential diesel driven FLEX equipment will be kept fueled during storage. The fuel consumption study conservatively assumes that the essential diesel driven equipment fuel tanks are maintained at a minimum specified level at the beginning of the event.

It is anticipated that the eight-hour refueling cycle may be required for an indefinite period. For the first 72 hours after deployment, calculated diesel fuel usage is approximately 2,900 gallons. There are over 40,000 gallons of protected stored diesel fuel in the DG fuel oil day and storage tanks which could provide onsite diesel driven FLEX equipment diesel fuel for greater than 30 days. Additionally, Entergy's "SAFER Response Plan for Pilgrim Nuclear Power Station," Revision 0, dated December 17, 2014 [Reference 70], provides a process for obtaining fuel from offsite sources before onsite sources are used up. Thus, the NRC staff finds it reasonable that Entergy has sufficient time to obtain fuel from off-site to support Phase 3 FLEX equipment.

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, 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 Pilgrim SAFER Plan

There are two NSRCs (Memphis area and Phoenix area) to support utilities during BDBEEs. Entergy has established contracts with the Pooled Equipment Inventory Company (PEICo) to participate in the process for support of the NSRCs, as required. Each NSRC holds five sets of equipment, four of which will be able to be fully deployed when requested. The fifth set will have equipment in a maintenance cycle. In addition, on-site FLEX equipment hose and cable end fittings are standardized with the equipment supplied from the NSRC. Requests to the NSRC will be directed by the licensee's FLEX procedures. The plan is documented in Entergy's "SAFER Response Plan for Pilgrim Nuclear Power Station," Revision 0, dated December 17, 2014 [Reference 70].

By letter dated September 26, 2014 [Reference 71], the NRC staff issued its staff assessment of the NSRCs, which were established in response to Order EA-12-049. In its assessment, the NRC 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 NRC staff concluded in its assessment that licensees can reference the SAFER program and implement their SAFER response plans to meet the Phase 3 requirements of Order EA-12-049.

3.8.2 Staging Areas

The licensee stated in its FIP that in the event of a BDBEE and subsequent ELAP/LUHS condition, equipment would be moved from an NSRC to a local assembly area established by the SAFER team. As described in the Pilgrim SAFER response plan, equipment can be taken to the Pilgrim site and staged at Staging Area B, located at the I&S parking lot (north) and the employee parking lot (south). Equipment can be delivered by helicopter if ground transportation is unavailable. Communications will be established between the Pilgrim plant site and the SAFER team via satellite phones and required equipment moved to the site as needed. First arriving equipment will be delivered to the site within 24 hours from the initial request. The order in which equipment is delivered is identified in the Pilgrim's SAFER Response Plan. In addition, the NRC staff confirmed the locations of Staging Area C in the Pilgrim SAFER response plan. Specifically, Staging Area C is designated as New Bedford Airport, located approximately 47 miles from Staging Area B. The plan identifies primary and alternate driving routes.

3.8.3 Conclusions

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

3.9 Habitability and Operations

3.9.1 Equipment Operating Conditions

3.9.1.1 Loss of Ventilation and Cooling

Following a BDBEE and subsequent ELAP event at Pilgrim, ventilation that provides cooling to occupied areas and areas containing required equipment will be lost. The licensee performed a loss of ventilation analysis, as shown in Calculation No. M1411, "Temperature Response of Key Rooms During an ELAP Event," Revision 0 [Reference 72], to quantify the maximum steady state temperatures expected in specific areas related to FLEX implementation to ensure the environmental conditions remain acceptable for personnel habitability or accessibility and within equipment limits. The key areas identified for all phases of execution of the FLEX strategy activities are the MCR, RCIC room, switchgear and battery rooms, and containment.

The NRC staff reviewed Calculation No. M1382, "MCR Heatup for Extended Loss of AC Power (FLEX)," Revision 0 [Reference 73]. The licensee's analysis used Generation of Thermal- Hydraulic Information in Containments (GOTHIC) code, which showed that by opening Door 145 (MCR to Stairway 8) within 30 minutes of an ELAP event, the MCR temperature will be kept under 110°F over a period of 72 hours following an ELAP. 110°F is the limit for unrestricted human performance as specified in NUMARC, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," NUMARC-87-00, Revision 1, August 1991. The GOTHIC analysis assumed a 102°F outside temperature and loss of offsite power heat loads for the MCR. Based on temperatures remaining below 120°F (the temperature limit identified in NUMARC-87-00 for indefinite survivability of electronic equipment), the NRC staff finds that the equipment in the MCR will not be adversely impacted by the loss of ventilation as a result of an ELAP event.

The licensee does not anticipate that the RCIC room will require occupation by personnel during an ELAP event. The only case where personnel would be required to enter the RCIC room would be during Phase 1 if remote operation fails. The licensee identified two evaluations that modeled RCIC room temperature. The first evaluation was a GOTHIC analysis and the other evaluation was performed by General Electric (GE) as part of a station blackout study. The GOTHIC results indicate temperatures of 124.5°F for the RCIC Pump quadrant, 137.7°F for the RCIC pump quadrant mezzanine, and 121.8°F for the RCIC valve station at 10 hrs. The GE evaluation indicates temperatures of 112°F for a realistic 10 lbm/hr steam leakage rate and 137.5°F for an extreme 70 lbm/hr leakage rate at 10 hrs. The RCIC isolation valves will not close in the first 10 hrs, but if personnel access is required, the licensee would use mitigating actions, such as deploying portable fans, water sprays, self-contained breathing equipment, and exercising reduced stay times.

The licensee stated that the expected maximum temperature in the battery rooms with loss of ventilation is 112.5°F for lower battery room B and 115.5°F for upper battery room A. The Pilgrim Station 125 Vdc and 250 Vdc batteries were purchased for specified operating temperatures of 60°F to 105°F in accordance with Specification E10A. This range ensures the batteries have adequate capacity over the expected design temperature range. The operating temperature range for lead acid batteries is in excess of 122°F, which is above the maximum expected calculated battery room temperature of 115.5°F. As a result of its review, the NRC staff did not identify any issues with ventilation of the battery rooms.

The three 125 Vdc battery chargers are located in the lower and upper switchgear rooms. The maximum calculated temperature for these areas is 118.3°F in the upper switchgear room. The 125 Vdc battery chargers have an operating ambient temperature range of 32°F to 122°F based on Solidstate Controls, Inc. Document No: SCI-QA-14.2 (Pilgrim Vendor Manual V-1188). Therefore, the maximum calculated temperature does not exceed the operating range of Pilgrim's 125 Vdc battery chargers (D11, D12, and D14).

The two 250 Vdc battery chargers are located in the lower and upper switchgear rooms. The maximum calculated temperature for these areas is 118.3°F in the upper switchgear room. The 250 Vdc battery chargers have an operating ambient temperature range of 32°F to 104°F at full load based on Exide Power System Document No: USF 260-3-200 (Pilgrim Vendor Manual V0265). The Pilgrim 250 Vdc battery chargers have a procedurally-controlled operating limitation of 160 amps (A) dc output (Procedure 8.9.8.3, Section 6 Caution). Therefore, the 250 Vdc battery charger output would be limited to 80 percent (160A/200A) of the full load rating. In addition, after approximately 27 hours in service, the loading on the 250 Vdc battery charger will decrease to approximately 100A, or 50 percent of the unit rating, since the 250 Vdc battery will be fully charged and connected loads plus float current would be less than 100A. This reduction in charger loading has two advantages. First, it decreases heat load, thereby lowering the area temperature. Second, it increases the 250 Vdc battery charger acceptable operating temperature to beyond 140°F (the derating factor for 140°F operation is 0.64 or 128 A). Assuming an operating ambient temperature of 122°F, which is above the maximum calculated temperature of 118.3°F, the derating factor is 0.83. Therefore, the maximum calculated temperature does not exceed the operating range of Pilgrim's 250 Vdc battery chargers (D13 and D15).

Pilgrim Calculation M1304, "Vital MG Set Room Temperature during a Loss of Ventilation Event," Revision 0 [Reference 74], showed that operation up to 130°F is acceptable in accordance with station procedure and action would need to be taken to prevent temperature exceeding 130°F. If the vital MG set room temperature exceeded 130°F operation, then the licensee would need to take action to load shed the vital MG set.

The licensee provided an evaluation in Engineering Change (EC) 61625, "PNPS FLEX Strategy Final Integrated Plan (FIP) Supplemental Item response to NRC FIP Question for Order EA-12-049 – EQ profile of FLEX Strategy Equipment Within Containment," Revision 0 [Reference 78], to show that the electrical equipment in containment will function in the high temperature environment for as long as it is needed to provide the FLEX function.

As part of its evaluation, the licensee reviewed equipment subjected to FLEX post-BDBEE ambient conditions in the drywell and wetwell to assess the functionality of the selected instruments/devices under elevated temperatures and pressures for an extended duration. The selected devices are those that FLEX strategies depend on to be functional after a BDBEE. These FLEX ambient conditions are, in some aspects, somewhat more severe than the design basis accident (DBA) conditions for which the equipment was originally qualified.

The licensee's evaluation showed that the equipment meets the required DBA conditions, but also have shown capabilities, either through testing or analysis, that exceed those conditions and can be expected to perform their required functions under post-beyond-design-basis conditions for an extended period of time.

Based on its review of the essential station equipment required to support the FLEX mitigation strategy, which is located in the MCR, RCIC room, switchgear and battery rooms, and containment, the NRC staff finds that the electrical equipment should perform their required functions at the expected temperatures as a result of loss of ventilation during an ELAP event.

3.9.1.2 Loss of Heating

The licensee stated that the expected minimum temperature in the battery rooms with loss of heating is between 70°F to 85°F. The Pilgrim Station 125 Vdc and 250 Vdc batteries were purchased for specified operating temperatures of 60°F to 105°F per Specification E10A. This range ensures the batteries have adequate capacity over the expected design temperature range.

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

3.9.1.3 Hydrogen Gas Accumulation in Vital Battery Rooms

An additional ventilation concern that is applicable to Phases 2 and 3 is the potential buildup of hydrogen in the battery rooms as a result of loss of ventilation during an ELAP event. Off- gassing of hydrogen from batteries is only a concern when the batteries are charging. Once a 480 Vac power supply is restored in Phase 2 and the station Class 1E batteries begin re-charging, power is also provided to two 2,500 cubic foot per minute (CFM) FLEX portable ventilation fans, one in each dc power system battery room, to prevent any significant hydrogen accumulation.

The NRC staff reviewed the licensee's evaluation titled, "Hydrogen Production after Return to Service of Battery Chargers," Revision 1, dated October 6, 2015 [Reference 75], to verify that hydrogen gas accumulation in the vital battery rooms will not reach combustible levels while HVAC is lost during an ELAP as a result of a BDBEE. The purpose of the licensee's evaluation was to determine the time to reach a 2 percent hydrogen concentration in the B battery room after both 125 Vdc B and 250 Vdc battery chargers are returned to service and to determine the required air flow to maintain a less at 2 percent hydrogen concentration. The licensee's evaluation is equally applicable to the A battery room, since the room volume is similar and there is only a single 60-cell 125 Vdc battery.

According to the licensee's evaluation, it will take approximately 2 hours for the B battery room to reach a 2 percent hydrogen concentration after the 125 Vdc B battery and 250 Vdc battery chargers being returned to service. The licensee's evaluation determined, and the NRC staff confirmed, that an air flow of 31 CFM will be required to ensure the B battery room hydrogen concentration will not exceed 2 percent. The 2,500 CFM FLEX fans, which will be deployed at the time battery chargers are being returned to service, are repowered and are capable of 1,500 CFM based on the proposed installation configuration (i.e., placed at each of the battery room exhaust ducts).

Based on its review of the licensee's analysis, the NRC staff concluded that hydrogen accumulation in the vital battery rooms should not reach the combustibility limit for hydrogen

(4 percent) during an ELAP as a result of a BDBEE, since it is assumed that 2,500 CFM FLEX fans will be deployed and operational within the calculated times before hydrogen gas accumulation reaches 2 percent in the vital battery rooms.

3.9.2 Personnel Habitability

3.9.2.1 Main Control Room

As stated in Section 3.9.1.1 above, the licensee performed Calculation M1382 [Reference 73] to demonstrate that, with some compensatory actions taken, the temperature in the MCR would not exceed the 110°F limit specified in NUMARC-87-00 in accordance with NEI 12-06, Section 3.2.1.8. Specifically, the licensee used the GOTHIC code, Version 7.2b, to model the heatup of the MCR under ELAP conditions.

Case 2 of the calculation assumed that the temperature of the control building was 105°F and the ambient outdoor temperature was 102°F. The only compensatory action credited in the analysis was the removal of MCR ceiling tiles. This action is directed by site Procedure No. 2.4.149, "Loss of Control Room Air Conditioning," Revision 11 [Reference 75]. Under these conditions, the analysis showed that the MCR maximum temperature in the first 72 hours following an ELAP-inducing event was 108.36°F. As such, this does not exceed the 110°F limit specified in NUMARC-87-00, and the MCR should be sufficiently habitable for operators to carry out the mitigating strategies under ELAP conditions.

3.9.2.2 Spent Fuel Pool Area

See Section 3.3.4.1.1 above for the discussion of ventilation and habitability considerations in the SFP area.

3.9.2.3 Other Plant Areas

As stated in the licensee's FIP and detailed in Section 3.9.1.1 above, occupation of the RCIC room by personnel should not be required during an ELAP event. However, the licensee has determined that if it is necessary for an operator to perform an action in the RCIC room, the environmental conditions could necessitate protective measures, such as portable fans, water sprays, self-contained breathing equipment, and reduced stay times. These provisions will be available and employed to support any necessary actions.

3.9.3 Conclusions

Based on the evaluation above, 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, 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 3.2.1.3, states that cooling and make-up 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 Entergy's planned water sources to verify that each water source was robust as defined in NEI 12-06.

3.10.1 Reactor Coolant System Make-Up

Phase 1

In its FIP, Entergy stated that the CST (if it is available) or the suppression pool (torus) would provide the initial cooling water to the reactor coolant system. Because the CST is not seismically qualified, it is not considered available for the BDBEE. If the CST is available, it is the preferred suction source for HPCI and RCIC. The RCIC suction will be manually switched to the suppression pool. The suppression pool is located within the reactor building and is classified as a seismic Category 1 structure.

Phase 2

In its FIP, Entergy described the Phase 2 FLEX strategy that is implemented after approximately 9 hours. As part of Phase 2, core cooling would transition from the RCIC taking suction from the suppression pool to diesel-powered FLEX low pressure injection pumps which will take suction from the ultimate heat sink (Cape Cod Bay) and connect to the CST suction line (in the CST vault) or the RHR system. With Cape Cod Bay being utilized as the water source, the loss of upstream or downstream dams is not applicable. Cape Cod Bay provides a low quality but large volume of water for the licensee's Phase 2 strategy.

The FIP stated that the FLEX strategy, depending on the BDBEE scenario, will utilize raw water of progressively lower quality, including in the extreme case raw seawater is considered for the base case for up to 72 hours, where the injection is controlled at two times the boil-off rate. Establishing a flowrate of approximately twice that necessary to compensate for boil-off would result in the discharge of a saturated liquid and vapor mixture to the wetwell via the open SRVs. In effect, this procedure would flush coolant having a high concentration of dissolved solutes from the reactor vessel and replace it with fresh coolant having reduced solute concentrations. As a result, the accumulation of adverse concentrations of dissolved minerals can be avoided. Considerations are necessary for the corrosion and potential stress-corrosion mechanisms that affect nickel and ferrous alloy materials when exposed to high levels of chlorides and dissolved oxygen. The licensee determined that these corrosion effects are longer-term concerns and are not considered to preclude the successful completion of the FLEX strategy during and following the BDBEE.

Phase 3

The transition to long-term mitigation (approximately 72 hours into the event) will be completed by transferring the suction of the FLEX pump to a nominal 21,000 gallon, epoxy-coated steel water storage tank (FRAC tank) to provide reactor make-up with the FLEX pump discharging to the RPV via the CST suction line (or alternate RHR injection point) to begin a long-term reactor feedwater make-up and boiling strategy. A water treatment system from the NSRC will be utilized to demineralize the make-up water, but is not initially required for the FLEX groundwater well source, based on its sufficiently low mineral content. The RPV will be flushed with purified water from the FRAC tank to the torus (via SRVs) and then the RPV will be allowed to boil down to a stable water level. The plant will be in a stable condition with outside resources available to maintain stable conditions indefinitely.

The FRAC tank is seismically designed and is heavily reinforced and internally baffled to reduce sloshing effects, but is not specifically hardened for the most extreme tornado missile hazards. As an alternative, in the event the FRAC tank is unusable, there will be a backup, nominal 20,000 gallon, collapsible water storage bladder tank. The bladder tank will be provided by the NSRC and will be capable of deployment within the 72 hour period before its required usage for water storage and as the feed source for the FLEX injection pump.

3.10.2 Suppression Pool Make-Up

Phase 1

In its FIP, the licensee stated the suppression pool does not need any make-up for Phase 1. The torus contains approximately 84,000 ft^3 of water. At approximately 9 hours into the event, RCIC would be secured and cooling would be supplied by diesel-powered FLEX low pressure injection pumps taking suction from Cape Cod Bay.

Phase 2

Based on a review of the licensee's FIP, suppression pool make-up is not required for Phase 2. At approximately 9 hours into the event, when the licensee transitions from Phase 1 to Phase 2, RCIC would be secured and cooling would be supplied by diesel-powered FLEX low pressure injection pumps taking suction from Cape Cod Bay.

Phase 3

Based on a review of the licensee's FIP, suppression pool make-up is not required for Phase 3. At approximately 72 hours into the event, when the licensee transitions from Phase 2 to Phase 3, the suction source for the diesel-powered FLEX low pressure injection pumps would be transferred from Cape Cod Bay to the FRAC tank or the bladder tank.

3.10.3 Spent Fuel Pool Make-Up

The licensee stated in its FIP that any water source available is acceptable for use as make-up to the SFP; however, the initial source of SFP make-up water may be provided by storage of demineralized water in the lower volume of the dryer and separator storage pool. The capacity of this lower volume is a nominal 34,000 gallons. A usable volume of 30,000 gallons will provide a 42 hour supply of make-up water at a boil-off rate of 12 gpm. The total heatup time to boiling and available make-up water supply is then 74 hours. At 72 hours, water from the FLEX groundwater wells (FRAC tank or the bladder tank) will be used for both the RPV and SFP make-up water requirements, unless other preferred sources are also available.

3.10.4 Containment Cooling

The licensee does not provide direct injection into the torus for containment cooling. As discussed in Section 2.5.1 of Entergy's FIP, when the torus heats up to 280°F at 16 hours after shutdown, the torus vent AO-5025 is opened to provide containment heat removal and begin a long-term strategy of reactor feedwater make-up and boiling to protect the core and containment.

3.10.5 Conclusion

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, as endorsed by JLD-ISG-2012-01, and should adequately addresses 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 a BDBEE occurring during power operations. This is appropriate, as plants typically operate at power for 90 percent or more of the year. When the BDBEE occurs with the plant at power, the mitigation strategy initially focuses on the use of a pump coupled to a steam-powered turbine to provide the water 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 make-up 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 make-up to the SFP. The licensee's analysis shows that following a full core offload to the SFP, about 78 hours are available to implement make-up 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 make-up to the SFP within that time.

When a plant is in a shutdown mode in which steam is not available to operate the steam-powered pump such as RCIC (which typically occurs when the RCS has been cooled below about 300°F), another strategy must be used for decay heat removal. On September 18, 2013, NEI submitted to the NRC a position paper entitled "Shutdown/Refueling Modes" [Reference 81], which described methods to ensure plant safety in those shutdown modes. By letter dated September 30, 2013 [Reference 82], (ADAMS Accession No. ML13267A382) the NRC staff endorsed this position paper as a means of meeting the requirements of the order.

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

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

3.12 Procedures and Training

Procedures

The licensee stated in its FIP that the inability to predict actual plant conditions that require the use of FLEX equipment makes it impossible to provide specific procedural guidance. As such, the FSGs will provide guidance that can be employed for a variety of conditions. Clear criteria for entry into FSGs will ensure that FLEX strategies are used only as directed for BDBEE conditions, and are not used inappropriately in lieu of existing procedures. When FLEX equipment is needed to supplement EOPs or Abnormal Procedures (APs) strategies, the EOP or AP, Severe Accident Mitigation Guidelines (SAMGs), or Extreme Damage Mitigation Guidelines (EDMGs) will direct the entry into and exit from the appropriate FSG procedure.

The FIP also stated that FSGs will provide available, pre-planned FLEX strategies for accomplishing specific tasks in the EOPs or APs. The FSGs will be used to supplement (not replace) the existing procedure structure that establishes command and control for the event.

In addition, the FIP stated that procedural Interfaces have been incorporated into Procedure 5.3.31, "Station Blackout," to the extent necessary to include appropriate reference to FSGs and provide command and control for the ELAP. Additionally, procedural interfaces have been incorporated into the following APs to include appropriate reference to FSGs:

- 5.2.1, "Earthquake"
- 5.2.2, "High Winds (Hurricane)"

The licensee stated in its FIP that FSG maintenance will be performed by the Operations Department. In accordance with site administrative procedures, NEI 96-07, Revision 1, "Guidelines for 10 CFR 50.59 Implementation," and NEI 97-04, Revision 1, "Design Bases Program Guidelines," are to be used to evaluate changes to current procedures, including the FSG, to determine the need for prior NRC approval. However, in accordance with the guidance and examples provided in NEI 96-07, Revision 1, changes to procedures (EOPs, APs, EDMGs, SAMGs, or FSGs) that perform actions in response events that exceed a site's design-basis should screen out. Therefore, changes to the procedure steps that recognize that an ELAP/LUHS has occurred and that direct actions to ensure core cooling, SFP cooling, or containment integrity should not require prior NRC approval.

Training

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

In addition, the FIP stated that 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.

The FIP stated that care has been taken to not give undue weight (in comparison with other training requirements) to operator training for BDBEE accident mitigation. The testing/evaluation of operator knowledge and skills in this area has been similarly weighted.

In addition, the FIP stated that ANSI/ANS 3.5, "Nuclear Power Plant Simulators for use in Operator Training," certification of simulator fidelity is considered to be sufficient for the initial stages of the BDBEE scenario until the current capability of the simulator model is exceeded. Full scope simulator models will not be upgraded to accommodate FLEX training or drills.

Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has adequately addressed the procedures and training associated with FLEX because the procedures have been issued and a training program has been established and will be maintained consistent with NEI 12-06, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.13 Maintenance and Testing of FLEX Equipment

The licensee stated in its FIP, that maintenance and testing of FLEX equipment is governed by the Entergy Preventive Maintenance (PM) Program as described in EN-DC-324, "Preventive Maintenance Program," Revision 15 [Reference 77]. The Entergy PM Program is consistent with the Institute of Nuclear Power Operations AP-913 and utilizes the EPRI PM Basis Database as an input in development of fleet specific Entergy PM Basis Templates. Based on this, the Entergy fleet PM program for FLEX equipment follows the guidance NEI 12-06, Section 11.5.

Also, the FIP stated that PMs have been developed for both the "Standby" condition and the "Deployed" condition for the FLEX portable and support equipment. The FIP stated that the Entergy PM Basis Templates include activities such as:

- Periodic static inspections
- Operational inspections
- Periodic functional verifications
- Periodic performance verification tests

The licensee stated that the Entergy PM Basis Templates provide assurance that stored or pre- staged FLEX equipment is being properly maintained and tested. In those cases where EPRI templates were not available for the specific component types, PM actions were developed based on manufacturer provided information/recommendations.

Additionally, the FIP stated that the Emergency Response Organization performs periodic facility readiness checks for equipment that is outside the jurisdiction of the normal PM program and considered a functional aspect of the specific facility emergency preparedness (EP) communications equipment, such as uninteruptible power supplies, radios, batteries, battery chargers, and satellite phones. These facility functional readiness checks provide assurance that the EP communications equipment outside the jurisdiction of the PM Program is being properly maintained and tested.

The licensee also stated in its FIP, that the unavailability of equipment and applicable connections that directly perform a FLEX mitigation strategy for core, containment, and SFP will be managed such that risk to mitigating strategy capability is minimized. Maintenance/risk guidance conforms to the guidance of NEI 12-06 as follows:

- Portable FLEX equipment may be unavailable for 90 days provided that the site FLEX capability (N) is available.
- If portable equipment becomes unavailable such that the site FLEX capability (N) is not maintained, initiate actions within 24 hours to restore the site FLEX capability (N) and implement compensatory measures (e.g., repair equipment, use of alternate suitable equipment or supplemental personnel) within 72 hours.

The licensee stated that work management procedures will reflect allowed outage times as outlined above.

Conclusions

The NRC staff finds that the licensee has adequately addressed equipment maintenance and testing activities associated with FLEX equipment because a maintenance and testing program has been established and will be maintained consistent with NEI 12-06, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.14 Alternatives to NEI 12-06, Revision 0

The licensee did not propose any alternatives to NEI 12-06, Revision 0.

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, will 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 20], Entergy submitted its OIP for Pilgrim in response to Order EA-12-051. By email dated June 20, 2013 [Reference 21], the NRC staff sent a request for additional information (RAI) to the licensee. By letters dated July 19, 2013 [Reference 22], August 28, 2013 [Reference 24], February 28, 2014 [Reference 25], August 28, 2014 [Reference 26], and February 27, 2015 [Reference 27], Entergy submitted its

RAI responses and the first four six-month updates to the OIP. The NRC staff's review of the licensee's submittals led to the issuance of the Pilgrim ISE and RAI dated December 5, 2013 [Reference 23].

The OIP describes the strategies and guidance to be implemented by the licensee for the installation of reliable SFP level instrumentation which will function following a BDBEE, including modifications necessary to support this implementation, pursuant to Order EA-12-051. By letter dated July 17, 2015 [Reference 28], Entergy submitted its compliance letter in response to Order EA-12-051, stating that it had achieved full compliance with the order.

The licensee has installed a SFP level instrumentation system designed by MOHR. The NRC staff reviewed the vendor's SFP level instrumentation system design specifications, calculations and analyses, test plans, and test reports. The NRC staff issued a vendor audit report dated August 27, 2014 [Reference 31]. Refer to Section 2.2 above for the regulatory background for this section.

4.1 Levels of Required Monitoring

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

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

In its OIP and later by letter dated July 17, 2015, Entergy identified the levels of required monitoring for PNPS. Entergy stated that the level at which reliable suction loss occurs due to uncovering the coolant inlet pipe or any weirs or vacuum breakers associated with suction loss is established based on the siphon break elevation which is at 115 ft., 8 in. This level is higher that the level at which the normal fuel pool cooling pumps lose required NPSH assuming saturated conditions in the pool. Therefore, the licensee identified elevation 115 ft. 8 in. as Level 1.

In its OIP, the licensee stated that Level 2 would be set at an elevation of 102 ft. 8 in., which is approximately 10 feet above Level 3. In its letter dated July 19, 2013, the licensee provided a sketch depicting the elevations identified as Levels 1, 2, and 3 and the minimum sensor range. The NRC staff reviewed this sketch and notes that Level 2 has been adjusted from 102 ft., 8 in. to 111 ft., 3 in.

In its OIP, the licensee stated that other hardware stored in the SFP will be evaluated to ensure that it does not adversely interact with the SFP instrument probes during a seismic event. In its letter dated June 20, 2013, the NRC staff requested information regarding the impact from other irradiated hardware stored in the SFP in the identification of the elevation for Level 2. In its letter dated July 19, 2013, Entergy stated that Level 2 had been adjusted to account for materials stored in the SFP by specifying Level 2 at the Technical Specification minimum limit.

In its letter dated July 17, 2015, the licensee restated that Level 2 is identified as elevation 111 ft., 3 in.

In its OIP, the licensee stated that Level 3 would be set at an elevation of 92 ft., 8 in., which corresponds to the highest point of any fuel rack seated in the SFP. In its letter dated July 19, 2013, the licensee revised this elevation to 93 ft., 10 in. which is above the highest point of any spent fuel storage rack seated in the SFP and above the bottom of the SFP gate.

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

4.2 Evaluation of Design Features

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

4.2.1 Design Features: Instruments

In its OIP, the licensee stated that both the primary and backup Instrument channels are permanently fixed channels and that each instrument channel will be capable of monitoring SFP water level over a single continuous span from above Level 1 to within 1 foot of the top of the spent fuel racks (Level 3).

In its letter dated July 19, 2013, the licensee provided a sketch depicting the elevations identified as Levels 1, 2, and 3 and the minimum sensor range. In addition, the licensee stated that the SFP level instrumentation lower instrument span or probe bottom would extend down to at least three inches below the upper limit of the range of Level 3 to account for channel accuracy or instrument loop uncertainty.

Based on the discussion above, the NRC staff finds that, if implemented appropriately, the licensee's proposed design, with respect to the number of channels and measurement range for its SFP, is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and adequately addresses the requirements of the order.

4.2.2 Design Features: Arrangement

In its letter dated July 19, 2013, Entergy stated that physical separation of the two channels will be accomplished by separately routing cable and conduit as much as practical and that the use of conduit on the refueling floor will provide additional protection from damage due to debris during a BDB event. Entergy also stated that the primary instrument (Channel A) will be in the southwest corner of the SFP and the backup instrument (Channel B) will be in the northwest corner of the SFP. Locating the new instruments in the corners of the SFP takes advantage of missile and debris protection inherent in the corners.

In its letter dated July 17, 2015, Entergy further explained that PNPS primary and backup SFP level instrument probes are spatially separated and installed within one foot of separate SFP corners. Corner locations provide inherent protection of the probes. Loop separation for cable routing away from the probes maintains the same relative spatial separation distance as the SFP corner mounting locations. Loop routing on the SFP floor is limited with prompt exit to below the SFP floor. Probe top section and loop cabling are protected by metallic raceway and the probe mounting bracket structure itself, all of which incorporate a low profile design.

Concrete curbs in the vicinity that rise a few inches above floor elevation provide additional inherent protection. Additional protection is provided by the auxiliary bridge, which is generally positioned at the west end of the SFP above the probes. As described, reasonable protection of the SFP level function is provided from potential SFP area overhead structure missiles.

During the on-site audit visit, the NRC staff walked down the SFP area and the route for the primary and back-up cables and reviewed the drawing provided by Entergy of the SFP area that showed the location and placement of the primary and backup SFPI, and the routing of the cables. The NRC staff also reviewed Engineering Change Package 45088, "Fukushima – Spent Fuel Pool Level Instrumentation," Revision 0 [Reference 29], which describes the arrangement for the SFPI as discussed in Section 3.1.2.2, "Arrangement." The walk down included the MCR where Entergy indicated the locations for the SFPI display cabinet, the electrical power source, and the connections for the displays. The NRC staff observed the cables were mostly separated by more than 1 foot apart using conduits and existing cable trays. The cable routing areas were also protected from internal and external missiles.

The NRC staff concludes that there is sufficient channel separation within the SFP area between the primary and back-up level instruments, sensor electronics, and routing cables to provide reasonable protection against loss of indication of SFP level due to missiles that may result from damage to the structure over the SFP.

Based on the discussion above, the NRC staff finds that, if implemented appropriately, Entergy's proposed arrangement for the SFP level instrumentation is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and adequately addresses the requirements of the order.

4.2.3 Design Features: Mounting

By letter dated July 17, 2015, Entergy also stated that the entire PNPS SFP instrument loop (equipment from the SFP to the MCR) is mounted and designed to requirements equal to or greater than seismic Category I requirements. As such, the SFP instrument loops are designed and installed to retain their design configuration during and following maximum requirements of the PNPS seismic design bases.

During the week of October 6, 2014, the NRC staff reviewed Enercon Calculation C15.0.3625, "Spent Fuel Pool Level Probe LE-4816A and LE-4816B Mounting Bracket Evaluation," Revision 0 [Reference 30], and Drawing C2901, "Pilgrim Spent Fuel Pool Probe Mounting Bracket Details Civil," Revision 0 [Reference 32]. The NRC staff also saw the proposed location for the SFPI and mounting brackets on the SFP area. The NRC staff was able to verify that the calculations done for the SFPI mounting bracket include consideration of static weight loads and hydrodynamic loads, including sloshing. The NRC staff issued an audit report, dated January 26, 2015 [Reference 18], to document the results of its review.

Based on the discussion above, the NRC staff finds that, if implemented appropriately, Entergy's proposed mounting design is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and 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 are not already covered by existing quality assurance requirements. In JLD-ISG-2012-03, the NRC staff found the use of this quality assurance process to be an acceptable means of meeting the augmented quality requirements of Order EA-12-051.

In its OIP, Entergy 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; and
- audits.

If implemented appropriately, this approach is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and adequately addresses the requirements of the order.

4.2.4.2 Instrument Channel Reliability

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

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

- seismic effects on instrument channel components used during and following a potential seismic event for only installed components.

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

During the MOHR vendor audit, the NRC staff reviewed the SFPI technical and design information. Activities that were performed in support of this vendor audit included detailed analysis and calculation discussions, equipment demonstration, and discussions with the MOHR vendor staff on specific topics. The NRC staff also attended a presentation by MOHR vendor staff on the technical attributes and testing results of the instrumentation and witness a hands-on demonstration of MOHR vendor staff operating the equipment. The NRC staff included a summary of the SFPI environmental qualification and reliability design documents reviewed in the audit report dated August 27, 2014 [Reference 31].

By letter dated July 17, 2015, Entergy provided its evaluation of the BDB environmental conditions at the site areas where the SFPI will be located. Entergy's bridging document between vendor technical information and licensee's use provided the SFPI testing parameters, testing results and/or analysis and the licensee's evaluation as it relates to the SFPI and its use at PNPS. During the MOHR vendor audit, the NRC staff reviewed the temperature, humidity, radiation seismic and shock and vibration qualification for the instrumentation. The NRC also reviewed the information provided by the licensee in their bridging document. The NRC staff noted that there is consistency between the SFPI test results and analysis presented to the NRC staff during the vendor audit and the information used by the licensee. The NRC staff also noted that the SFPI testing parameters envelope the expected BDB conditions at the site. The entire PNPS SFPI loop (equipment from the SFP to the MCR) is designed and qualified to PNPS environmental conditions.

The licensee also addressed the electromagnetic interference/radio-frequency interference in this letter and the bridging document where PNSP states that FSGs governing the use of the SFPI are expected to include a cautionary statement to preclude radio usage within close proximity to the displays.

Based on the discussion above, the NRC staff finds that, if implemented appropriately, the licensee's proposed instrument qualification process is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and adequately addresses the requirements of the order.

4.2.5 Design Features: Independence

In its letter dated July 19, 2013, the licensee stated that the conceptual design provided two independent level instruments in the SFP with cabling routed to two display/processors mounted in the MCR annex by the door to the MCR. The control room annex is classified as a mild environment. Power for each channel is provided from independent 120 Vac, 60 Hz sources.

In its letter dated July 17, 2015, the licensee indicated that the SFP instrument loops have highly-reliable independent power sources and loop independence is achieved by incorporation of two permanently installed, physically independent, and physically separated loops (with loop separation in accordance with existing plant design-basis requirements) that are designed and installed to seismic Category I requirements.

During the on-site audit, the NRC staff verified that the cables were mostly separated by more than 1 foot using conduits and existing cable trays and that the cable routing areas were protected from internal and external missiles.

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

4.2.6 Design Features: Power Supplies

In its letter dated July 17, 2015, the licensee indicated that the two PNPS SFP instrument loops are powered from diverse ac power sources. Power is supplied for one loop (LI-4816B) from 120 Vac panel YI and for the other loop (LI-4816A) from 120 Vac panel Y2. The licensee further explained that the two PNPS SFP instrument channels incorporate independent plant power sources not only originating from different buses, but also from different power divisions. The SFPI also incorporates loop-specific stand-alone backup battery power of sufficient capacity. The permanently installed replaceable and rechargeable backup batteries are configured for an analyzed seven-day capacity. A third power alternative is available through external connections and cables, included for each battery panel supplying each SFP processor/display panel to permit powering the system from an external dc source independent of plant sources. The NRC staff also reviewed the diagram showing the independent normal power supplies and the independent backup batteries provided in this letter.

During the MOHR vendor audit, the NRC staff reviewed Document No. 1-0410-7, "MOHR EFP-IL SFPI System Battery Life Report," Revision 2, which indicated that the backup-power battery packs were tested to full discharge at several discharge rates to determine the battery capacity. The test data showed that the backup-power source can provide at least 7-day battery life with minimum power mode using an average sample rate of 15 samples per hour. Based on test results, the MOHR vendor determined that the SFPI's replaceable batteries, used for instrument channel power, have sufficient capacity to maintain the level indication function for longer than 7 days.

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

4.2.7 Design Features: Accuracy

In its letter dated July 17, 2015, the licensee stated that the SFP instrument loops have a high certified design accuracy of equal to or better than +/- 3 inches which is not affected by power interruption, as supported by vendor test documentation. As such, the SFP instrument loops have been documented to maintain their designed accuracy following power interruption or change in power source without recalibration being required.

During the MOHR vendor audit, the NRC staff reviewed the results from testing performed on the probe at 500°F in saturated steam (100 percent relative humidity) that showed a system accuracy of approximately 0.5 in. MOHR Document No. 1-0410-15, "MOHR EFP-IL-SFPI System Uncertainty Analysis," states, in part, that the EFP-IL-SFPI MOHR system, configured with a maximum length of transmission cable of 1000 ft., stays within the level measurement accuracy of +/- 3 in. Regarding the effects of the environmental conditions on the instrument, MOHR document No. 1-0410-3, "MOHR EFP-IL SFPI Proof of Concept Report," Revision 0, states that the effects of temperature and humidity are insignificant with regard to measurement accuracy.

Based on the discussion above, the NRC staff finds that, if implemented appropriately, the licensee's proposed instrument accuracy is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and adequately addresses the requirements of the order.

4.2.8 Design Features: Testing

In its letter dated July 19, 2013, the licensee stated that the instrument automatically monitors the integrity of its level measurement system using in-situ capability. Deviation of measured test parameters from manufactured or as-installed configuration beyond a configurable threshold prompts operator intervention. The licensee also stated that each instrument electronically logs a record of measurement values over time in non-volatile memory that is compared to demonstrate constancy, including any changes in pool level, such as that associated with the normal evaporative loss/refilling cycle. The channel level measurements can be directly compared to each other (i.e., regular cross-channel comparisons). Any existing permanently installed SFP level instrumentation or other direct measurements of SFP level may be used for diagnostic purposes if cross-channel comparisons are anomalous. In its letter dated July 17, 2015, Entergy also indicated that the probe itself is a perforated tubular coaxial waveguide with defined geometry and it is not calibrated.

The NRC staff reviewed MOHR documents 1-0410-12, "MOHR EFP-IL Signal Processor Operator's Manual;" 1-0410-13, "MOHR EFP-IL Signal Processor Technical Manual;" and 1-0410-14, "MOHR SFP-1 Level Probe Assembly Technical Manual." These documents provided the testing and calibration procedures for the SFPI. MOHR's SFPI design can be calibrated in-situ without removal from its installed location. The system is calibrated using a CT-100 device and processing of vendor scanned files. The MOHR vendor documents also provide recommended calibration intervals to be followed by users of this technology.

Based on the discussion above, the NRC staff finds that, if implemented appropriately, the licensee's proposed SFP instrumentation design allows for testing consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and adequately addresses the requirements of the order.

4.2.9 Design Features: Display

In its letter dated July 17, 2015, the licensee stated the PNPS SFP instrument loop displays are located in the PNPS MCR. Level is displayed continuously when on primary ac power and on demand when on backup dc power. As such, the SFP water level indication can be monitored by trained personnel from the MCR, either continuously or on demand. During the onsite audit, the NRC staff visited the MCR where the licensee identified the locations of the SFPI display cabinets, the electrical power sources, and connections for the display. All are within the MCR envelope.

The guidance in NEI 12-02 for "Display" specifically mentions the control room as an acceptable location for SFP instrumentation displays, as it is occupied or promptly accessible, outside the area surrounding the SFP, inside a structure providing protection against adverse weather, and outside of any very high radiation areas or locked high radiation areas during normal operation.

Based on the discussion above, the NRC staff finds that, if implemented appropriately, the licensee's proposed location and design of the SFP instrumentation displays is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and adequately addresses the requirements of the order.

4.3 Evaluation of Programmatic Controls

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

4.3.1 Programmatic Controls: Training

Guidance document NEI 12-02 specifically addresses the use of the SAT for training personnel in the use and the provision of alternate power to the primary and backup SFP instrument channels. In its OIP, the licensee indicated that the SAT will be used to identify the population of staff to be trained and to determine both the initial and continuing elements of the required training. The licensee also stated that training will be completed prior to placing the instrumentation in service.

In its letter dated July 17, 2015, the licensee further explained that two PNPS instrumentation and control maintenance technicians received training on the MOHR EFP-IL SFP Level Monitoring System at MOHR's facilities. Training has been provided to operators and appropriate members of the emergency response organization and chemistry and radiation protection personnel through presentation EC-45088, "Fukushima SFP Instrumentation" [Reference 29], and Section 2.6.13 of System Training Manual 1-73, "SFP Instrumentation." Training on alternate power sources (seven day battery capacity, external dc power source capability, primary ac safety-related EDG, and battery-backed power source restoration per FLEX strategies) has also been addressed.

Based on the discussion above, the NRC staff finds that, if implemented appropriately, the licensee's proposed plan to train personnel in the use and the provision of alternate power to the primary and backup instrument channels, including the approach to identify the population to be trained is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and adequately addresses the requirements of the order.

4.3.2 Programmatic Controls: Procedures

In its letter dated July 17, 2015, the licensee stated that the calibration and test procedure developed by MOHR was provided in its technical manual. The objectives were to measure system performance, determine if there is a deviation from normal tolerances, and if so, return the system to normal tolerances. Diagnostic procedures developed by the vendor are provided as automated and semi-automated routines in the system's software alerting the operator to abnormal deviation in selected system parameters, such as battery voltage, 4-20 mA loop continuity, and time-domain reflectometry waveform of the transmission cable. The technical objective of the diagnostic procedures is to identify system conditions that require operator attention to ensure continued reliable liquid level measurement. Manual diagnostic procedures were also provided in the event that further workup is determined to be necessary.

The PNPS Maintenance Procedure 8.E.19 has been revised to address the functional check of the SFP level instruments. The procedure allows a technician trained in the EFP-IL system maintenance to ensure that system functionality is maintained. Additionally, Operations Procedure 2.2.85, "Fuel Pool Cooling and Filtering System," provides instructions for operation of the equipment.

During the vendor audit, the NRC staff reviewed MOHR documents, 1-0410-12, "MOHR EFP-IL Signal Processor Operator's Manual;" 1-0410-13, "MOHR EFP-IL Signal Processor Technical Manual;" and 1-0410-14, "MOHR SFP-1 Level Probe Assembly Technical Manual;" which provide the testing and calibration procedures for the SFPI. These documents also provide recommended calibration and testing intervals to be followed by users of this technology.

Based on the discussion above, the NRC staff finds that, if implemented appropriately, the licensee's procedure development is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and adequately address the requirements of the order.

4.3.3 Programmatic Controls: Testing and Calibration

In its letter dated July 19, 2013, the licensee stated that it plans to perform channel functional and calibration tests in accordance with the operations procedures, with limits established in consideration of MOHR's vendor equipment specifications and at appropriate frequencies established equivalent to or more frequently than existing SFPI. Manual calibration and operator performance checks are planned to be performed in a periodic scheduled fashion with additional maintenance on an as-needed basis when flagged by the system's automated diagnostic testing features. The licensee also stated that SFPI channel/equipment maintenance/preventative maintenance and testing program requirements to ensure design and system readiness are planned to be established in accordance with Entergy's processes and procedures taking into consideration the vendor recommendations to ensure that appropriate regular testing, channel checks, functional tests, periodic calibration, and maintenance are performed.

The licensee further explained that permanent installation coupled with stocking of adequate spare parts reasonably diminishes the likelihood that a single channel is out-of-service for an extended period of time, and greatly diminishes the likelihood that both channels are out- of- service for an extended period of time. The licensee also provided a table showing planned compensatory actions for unlikely extended out-of-service events. The table indicated the required restoration action and the compensatory action if the required restoration action cannot be completed within specified time, for one or both channels out of service. As part of the restoration actions, the licensee's process requires a report to be presented to the on-site Safety Review Committee within 14 days. The report shall outline the planned alternate method of monitoring, the cause of the non-functionality, and the plans and schedule for restoring the instrumentation channel(s) to functional status. The NRC staff reviewed the information provided in this table and noted that the licensee's restoration and compensatory actions and the timing for these actions follow the guidance provided in NEI 12-02 addressing out-of-service channels.

Based on the discussion above, the NRC staff finds that, if implemented appropriately, the licensee's proposed testing and calibration plan is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and adequately addresses the requirements of the order.

4.4 Conclusions for Order EA-12-051

In its letter February 4, 2013, the licensee stated that they would meet the requirements of Order EA-12-051 by following the guidelines of NEI 12-02, as endorsed by JLD-ISG-2012-03. In the evaluation above, the NRC staff finds that, if implemented appropriately, the licensee has conformed to the guidelines of NEI 12-02, as endorsed by JLD-ISG-2012-03. In addition, the NRC staff concludes that if the SFP level instrumentation is installed at Pilgrim Nuclear Power Station according to the licensee's proposed design, it should adequately address the requirements of Order EA-12-051.

5.0 CONCLUSION

In August 2013, the NRC staff started auditing the licensee's progress on Orders EA-12-049 and EA-12-051. The NRC staff conducted its onsite audit in October 2014. The licensee reached its final compliance date on May 20, 2015, and has declared that Pilgrim is in compliance with the orders. The purpose of this safety evaluation is to document the strategies and implementation features that the licensee is using to comply with the orders. Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and proposed designs that, if implemented appropriately, will 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 is in compliance with the orders.

6.0 REFERENCES

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

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

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

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

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

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

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

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

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

10. Pilgrim Nuclear Power Station - Overall Integrated Plan in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order EA-12-049), dated February 28, 2013 (ADAMS Accession No. ML13063A063)

11. Pilgrim Nuclear Power Station's First Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order EA-12-049), dated August 28, 2013 (ADAMS Accession No. ML13247A411)

12. Pilgrim, Second Six Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order EA-12-049), dated February 28, 2014 (ADAMS Accession No. ML14069A320)

13. Pilgrim, Third Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order EA-12-049), dated August 28, 2014 (ADAMS Accession No. ML14253A189)

14. Pilgrim Nuclear Power Station's Fourth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order EA-12-049), dated February 27, 2015 (ADAMS Accession No. ML15069A225)

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

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

17. Letter from Jeremy S. Bowen (NRC) to John Dent, Jr., dated December 16, 2013, Pilgrim Nuclear Power Station – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigating Strategies) (ADAMS Accession No. ML13225A587)

18. Letter from Stephen Monarque (NRC) to Mr. John Dent, Jr., dated January 26, 2015, Pilgrim Nuclear Power Station – Report for the Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (ADAMS Accession No. ML14349A518)

19. Pilgrim Nuclear Power Station's Notification of Full Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events, Submittal of Final Integrated Plan, Responses to NRC Interim Staff Evaluation Open and Confirmatory Items, and Responses to FLEX/SFPI Audit Report Items, dated July 17, 2015 (ADAMS Accession No. ML15202A415)

20. Pilgrim Nuclear Power Station – Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order EA-12-051), dated February 28, 2013 (ADAMS Accession No. ML13063A097)

21. Letter from Richard V. Guzman (NRC) to the Pilgrim Site Vice President, dated June 20, 2013, Pilgrim Nuclear Power Station – Request for Additional Information on the Overall Integrated Plan for Reliable Spent Fuel Pool Instrumentation (Order EA-12-051) (ADAMS Accession No. ML13165A276)

22. Pilgrim, Response to Request for Additional Information for the Overall Integrated Plan in Response to the Commission Order Modifying Licenses with Regard to Requirements for Reliable Spent Fuel Pool Instrumentation," dated July 19, 2013 (ADAMS Accession No. ML13207A142)

23. Letter from Nadiyah Morgan (NRC) to the Site Vice President, Pilgrim Nuclear Power Station – Interim Staff Evaluation and Request for Additional Information Regarding the Overall Integrated Plan For Implementation of Order EA-12-051, "Issuance of Order to Modify Licenses with Regard to Reliable Spent Fuel Instrumentation," dated December 5, 2013 (ADAMS Accession No. ML13333A910)

24. Pilgrim Nuclear Power Station's First Six-Month Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order EA-12-051), dated August 28, 2013 (ADAMS Accession No. ML13247A411)

25. Pilgrim Nuclear Power Station's Second Six-Month Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order EA-12-051), dated February 28, 2014 (ADAMS Accession No. ML14069A307)

26. Pilgrim – Third Six-Month Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order EA-12-051), dated August 28, 2014 (ADAMS Accession No. ML14253A208)

27. Pilgrim – Fourth Six-Month Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order EA-12-051), dated February 27, 2015 (ADAMS Accession No. ML15069A224)

28. Pilgrim Nuclear Power Station's, Notification of Full Compliance with Order EA-12-051, Order Modifying Licenses with Regard to Requirements for Reliable Spent Fuel Pool Instrumentation, dated July 17, 2015 (ADAMS Accession No. ML15202A536)

29. Engineering Change Package 45088, "Fukushima – Spent Fuel Pool Level Instrumentation," Revision 0

30. Enercon Calculation C15.0.3625, "Spent Fuel Pool Level Probe LE-4816A and LE-4816B Mounting Bracket Evaluation," Revision 0

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

32. Drawing C2901, “Pilgrim Spent Fuel Pool Probe Mounting Bracket Details Civil,” Revision 0

33. Document No. 1-0410-7, “MOHR EFP-IL SFPI System Battery Life Report,” Revision 2

34. MOHR Document No. 1-0410-15, “MOHR EFP-IL-SFPI System Uncertainty Analysis”

35. MOHR Document No. 1-0410-3, “MOHR EFP-IL SFPI Proof of Concept Report” Revision 0

36. MOHR Document, 1-0410-12, “MOHR EFP-IL Signal Processor Operator’s Manual”

37. MOHR Document 1-0410-13, “MOHR EFP-IL Signal Processor Technical Manual”

38. MOHR Document 1-0410-14, “MOHR SFP-1 Level Probe Assembly Technical Manual”

39. PNPS Maintenance Procedure 8.E.19, “Fuel Pool and Skimmer Surge Tank Instruments – Critical Maintenance,” Revision 39

40. Operations Procedure 2.2.85, “Fuel Pool Cooling and Filtering System,” Revision 91

41. Flex Support Guideline (FSG) 5.9.7.1, “Secondary Containment Ventilation,” Revision 0

42. Specification M300, “Pilgrim Unit 1 Specification for Piping,” Revision 109

43. PNPS Procedure 5.3.26, “RPV Injection During Emergencies,” Revision 26

44. Drawing M209, “P&ID Condensate & Demineralized Water Storage & Transfer Systems,” Revision 67

45. PNPS Drawing M218, “P & ID Fire Protection System,” Sheet 1, Revision 60

46. PNPS Drawing M241, “P & ID Residual Heat Removal System,” Sheet 1, Revision 88

47. Calculation No. M1380, “Mechanical Calculation PNPS FLEX Strategy Thermal-Hydraulic Analysis,” Revision 0

48. Calculation No. M1384, “Pilgrim FLEX Hydraulic Analysis,” Revision 0

49. Calculation PS258, “125V & 250V DC Load Flow Studies - Fukushima Response Project,” Revision 0

50. Calculation PS233B, “125 Volt Battery A System Voltage,” Revision 1

51. Calculation PS233C, “125 Volt Battery B System Voltage,” Revision 1

52. Calculation PS233D, “250 Volt Battery System Voltage Calculation,” Revision 1

53. PNPS 5.3.31, "Station Blackout," Revision 16

54. Procedures 5.9.4, "DC Bus Load Shed & Repower Battery Chargers and Safeguards Panels (FSG-4)," Revision 0, 5.9.4.1, "DC Load Shedding," Revision 0

55. Calculation PS262, "FLEX Diesel Generator Loading," Revision 0A, FSG 5.9.5, "Initial Assessment and FLEX Equipment Staging," Revision 0

56. Calculation No. M588, "Fuel Pool Decay Heat & Heatup Times," Revision 1

57. Specification M300, "Pilgrim Unit 1 Specification for Piping," Revision 109

58. PNPS Drawing M231, "P & ID Fuel Pool Cooling and Demineralizing System," Sheet 1, Revision 43

59. PNPS Drawing M241, "P & ID Residual Heat Removal System", Sheet 1, Revision 87

60. Calculation No. M907, "Refueling Outage Decay Heat Evaluation," Revision 0

61. Calculation No. FP53, "Determine Adequacy of B.5.B Mitigation Strategy," Revision 1

62. Calculation ENTGPG012-CALC-001, "Pilgrim Containment Analysis of FLEX Strategy, Revision 0

63. Request for Information Pursuant to Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident, March 12, 2012 (ADAMS Accession No. ML12053A340)

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

65. Pilgrim, Entergy's Seismic Hazard and Screening Report (CEUS Sites), Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Seismic Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichil Accident, March 31, 2014 (ADAMS Accession No. ML14092A023)

66. Pilgrim Nuclear Power Station – Staff Assessment of Information Provided Pursuant to Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f), Seismic Hazard Reevaluations Relating to Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident, April 20, 2015 (ADAMS Accession No. ML15051A336)

67. Pilgrim – Entergy's Required Response of the Near Term Task Force Recommendation 2.1: Flooding-Hazard Reevaluation Report, March 12, 2015 (ADAMS Accession No. ML15075A082)

68. Calculation No. C15.0.3665, “Supplementary Evaluation of FLEX Storage Containers for Seismic and Snow Loads,” Revision 0

69. Calculation No. C.15.0.3642, “Evaluation of FLEX Storage Containers for Wind Loads,” Revision 0

70. SAFER Response Plan for Pilgrim Nuclear Power Station, Revision 0, dated December 17, 2014

71. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), “Staff Assessment of National SAFER Response Centers established in response to Order EA-12-049,” September 26, 2014 (ADAMS Accession No. ML14265A107)

72. Calculation No. M1411, “Temperature Response of Key Rooms During an ELAP Event,” Revision 0

73. Calculation No. M1382, “MCR Heatup for Extended Loss of AC Power (FLEX),” Revision 0

74. Pilgrim Calculation M1304, “Vital MG Set Room Temperature during a Loss of Ventilation Event,” Revision 0

75. “Hydrogen Production after Return to Service of Battery Chargers,” Revision 1, dated October 6, 2015

76. Procedure No. 2.4.149, “Loss of Control Room Air Conditioning,” Revision 11

77. EN-DC-324, “Preventive Maintenance Program,” Revision 15

78. Engineering Change EC 61625, “PNPS FLEX Strategy Final Integrated Plan (FIP) Supplemental Item response to NRC FIP Question for Order EA-12-049 – EQ profile of FLEX Strategy Equipment Within Containment,” Revision 0

79. Pilgrim's Expedited Seismic Evaluation Process Report (CEUS Sites), Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, dated December 16, 2014 (ADAMS Accession No. ML14357A061)

80. Pilgrim Nuclear Power Station – Staff Review of Interim Evaluation Associated with Reevaluated Seismic Hazard Implementing Near-Term Task Force Recommendation 2.1 (TAC No. MF5262), dated June 16, 2015 (ADAMS Accession No. ML15154A975)

81. NEI Position Paper “Shutdown/Refueling Modes”, dated September 18, 2013 (ADAMS Accession No. ML13273A514)

82. NRC Staff Letter endorsing NEI Position Paper “Shutdown/Refueling Modes”, dated September 30, 2013 (ADAMS Accession No. ML13267A382)

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Date: March 3, 2016

By letter dated February 28, 2013 (ADAMS Accession No. ML13063A097), Entergy submitted its OIP for Pilgrim 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 SE. By letters dated December 5, 2013 (ADAMS Accession No. ML13333A910), and January 26, 2015 (ADAMS Accession No. ML14349A518), the NRC issued an ISE, request for additional information, and audit report on Entergy's progress. By letter dated March 26, 2014 (ADAMS Accession No. ML14083A620), the NRC notified all licensees and construction permit holders that the NRC staff is conducting in-office and on-site 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 July 17, 2015 (ADAMS Accession No. ML15202A536), Entergy submitted its compliance letter in response to Order EA-12-051. The compliance letter stated that Entergy had achieved full compliance with Order EA-12-051.

The enclosed SE provides the results of the NRC staff's review of Entergy's strategies for Pilgrim. The intent of the SE is to inform Entergy whether its integrated plans, if implemented as described, will adequately address the requirements of Orders EA-12-049 and EA-12-051. The NRC staff will evaluate implementation of the plans through inspection, Temporary Instruction 191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications /Staffing/ Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML14273A444). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

If you have any questions, please contact Stephen Monarque, Orders Management Branch, Pilgrim Project Manager, at 301-415-1544 or at Stephen.Monarque@nrc.gov.

Sincerely,

/RA/

Gregory T. Bowman, Chief
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Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket No.: 50-293

Enclosure:
Safety Evaluation

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ADAMS Accession No. ML16008B077 ***via email**

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