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

July 5, 2016

Mr. Mano Nazar
President
and Chief Nuclear Officer
Nuclear Division
NextEra Energy
P.O. Box 14000
Juno Beach, FL 33408-0420

SUBJECT: ST. LUCIE PLANT, UNITS 1 AND 2 - SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 (CAC NOS. MF0984, MF0985, MF0990, AND MF0991)

Dear Mr. Nazar:

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. ML13063A020), Florida Power and Light Company (FPL, the licensee) submitted its OIP for St. Lucie Plant, Units 1 and 2 (St. Lucie), in response to Order EA-12-049. At six month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-049. These reports were required by the order, and are listed in the enclosed safety evaluation. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated February 6, 2014 (ADAMS Accession No. ML14002A124), and February 27, 2015 (ADAMS Accession No. ML15035A670), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letters dated May 14, 2015 (ADAMS Accession No. ML15140A080), and December 10, 2015 (ADAMS Accession No. ML15351A009), FPL submitted compliance letters to Order EA-12-049 for Units 1 and 2, respectively. In addition, the December 10, 2015, letter, as supplemented by letter dated

March 21, 2016 (ADAMS Accession No. ML16096A338), provided the St. Lucie Final Integrated Plan (FIP) in response to the order. The compliance letters stated that the licensee had achieved full compliance with Order EA-12-049.

By letter dated February 28, 2013 (ADAMS Accession No. ML13063A026), the licensee submitted its OIP for St. Lucie in response to Order EA-12-051. At six month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-051. These reports were required by the order, and are listed in the enclosed safety evaluation. By letters dated November 19, 2013 (ADAMS Accession No. ML13274A473), and February 27, 2015 (ADAMS Accession No. ML15035A670), the NRC issued an ISE and audit report, respectively, on the licensee's progress. By letter dated March 26, 2014 (ADAMS Accession No. ML14083A620), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-051 in accordance with NRC NRR Office Instruction LIC-111, similar to the process used for Order EA-12-049. By letters dated May 12, 2015 (ADAMS Accession No. ML15140A393), and December 10, 2015 (ADAMS Accession No. ML15350A394), FPL submitted compliance letters to Order EA-12-051 for Units 1 and 2, respectively. In addition, as stated above, the December 10, 2015 (ADAMS Accession No. ML15351A009), letter, as supplemented by letter dated March 21, 2016 (ADAMS Accession No. ML16096A338), provided the St. Lucie FIP in response to the order. The compliance letters stated that the licensee had achieved full compliance with Order EA-12-051.

The enclosed safety evaluation provides the results of the NRC staff's review of FPL's strategies for St. Lucie. The intent of the safety evaluation is to inform FPL on whether or not its integrated plans, if implemented as described, provide a reasonable path for compliance with Orders EA-12-049 and EA-12-051. The staff will evaluate implementation of the plans through inspection, using Temporary Instruction 191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications/Staffing/ Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML14273A444). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

If you have any questions, please contact Jason Paige, Orders Management Branch, St. Lucie Project Manager, at 301-415-5888 or at Jason.Paige@nrc.gov.

Sincerely,

Mandy K Halter

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

Docket Nos.: 50-335 and 50-389

Enclosure:
Safety Evaluation

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

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

FLORIDA POWER AND LIGHT COMPANY

ST. LUCIE PLANT, UNITS 1 AND 2

DOCKET NOS. 50-335 AND 50-389

1.0 INTRODUCTION

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

On March 12, 2012, the NRC issued Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12054A736). This order directed licensees to develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and spent fuel pool (SFP) cooling capabilities in the event of a BDBEE. Order EA-12-049 applies to all power reactor licensees and all holders of construction permits for power reactors.

On March 12, 2012, the NRC also issued Order EA-12-051, "Order Modifying Licenses With Regard to Reliable Spent Fuel Pool Instrumentation" (ADAMS Accession No. ML12054A679). This order directed licensees to install reliable SFP level instrumentation with a primary channel and a backup channel, and with independent power supplies that are independent of the plant alternating current (AC) and direct current (DC) power distribution systems. Order EA-12-051 applies to all power reactor licensees and all holders of construction permits for power reactors.

2.0 REGULATORY EVALUATION

Following the events at the Fukushima Dai-ichi nuclear power plant on March 11, 2011, the NRC established a senior-level agency task force referred to as the Near-Term Task Force (NTTF). The NTTF was tasked with conducting a systematic and methodical review of the NRC regulations and processes and determining if the agency should make additional improvements to these programs in light of the events at Fukushima Dai-ichi. As a result of this review, the NTTF developed a comprehensive set of recommendations, documented in SECY-11-0093, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," dated July 12, 2011 (ADAMS Accession No. ML11186A950). Following interactions with stakeholders, these recommendations were enhanced by the NRC staff and presented to the Commission.

On February 17, 2012, the NRC staff provided SECY-12-0025, "Proposed Orders and Requests for Information in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Tsunami," (ADAMS Accession No. ML12039A103) to the Commission. This paper included a proposal to order licensees to implement enhanced BDBEE mitigation strategies. As directed by Staff Requirements Memorandum (SRM)-SECY-12-0025 (ADAMS Accession No. ML120690347), the NRC staff issued Orders EA-12-049 and EA-12-051.

2.1 Order EA-12-049

Order EA-12-049, Attachment 2 (ADAMS Accession No. ML12054A736), requires that operating power reactor licensees and construction permit holders use a three-phase approach for mitigating BDBEEs. The initial phase requires the use of installed equipment and resources to maintain or restore core cooling, containment and SFP cooling capabilities. The transition phase requires providing sufficient, portable, onsite equipment and consumables to maintain or restore these functions until they can be accomplished with resources brought from off site. The final phase requires obtaining sufficient offsite resources to sustain those functions indefinitely. Specific requirements of the order are listed below:

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

2) These strategies must be capable of mitigating a simultaneous loss of all 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 (ADAMS Accession No. ML12242A378) to the NRC to provide specifications for an industry-developed methodology for the development, implementation, and maintenance of guidance and strategies in response to the Mitigation Strategies order. The NRC staff reviewed NEI 12-06 and on August 29, 2012, issued its final version of 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" (ADAMS Accession No. ML12229A174), endorsing NEI 12-06, Revision 0, with comments as an acceptable means of meeting the requirements of Order EA-12-049, and published a notice of its availability in the *Federal Register* (77 FR 55230).

2.2 Order EA-12-051

Order EA-12-051, Attachment 2, (ADAMS Accession No. ML12054A679) requires that operating power reactor licensees and construction permit holders install reliable SFP level instrumentation (SFPLI). Specific requirements of the order are listed below:

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

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

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

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

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

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

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

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

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

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

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

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

On August 24, 2012, following several NEI submittals and discussions in public meetings with NRC staff, the NEI submitted document NEI 12-02, "Industry Guidance for Compliance With NRC Order EA-12-051, To Modify Licenses With Regard to Reliable Spent Fuel Pool Instrumentation," Revision 1 (ADAMS Accession No. ML12240A307) to the NRC to provide specifications for an industry-developed methodology for compliance with Order EA-12-051. On August 29, 2012, the NRC staff issued its final version of JLD-ISG-2012-03, "Compliance with Order EA-12-051, Reliable Spent Fuel Pool Instrumentation" (ADAMS Accession No. ML12221A339), endorsing NEI 12-02, Revision 1, as an acceptable means of meeting the requirements of Order EA-12-051 with certain clarifications and exceptions, and published a notice of its availability in the *Federal Register* (77 FR 55232).

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

By letter dated February 28, 2013 (ADAMS Accession No. ML13063A020), Florida Power and Light (FPL, the licensee) submitted its OIP for St. Lucie Plant, Units 1 and 2 (St. Lucie, PSL), in response to Order EA-12-049. By letters dated August 28, 2013 (ADAMS Accession No. ML13242A274), February 26, 2014 (ADAMS Accession No. ML14064A192), August 27, 2014 (ADAMS Accession No. ML14253A184), February 23, 2015 (ADAMS Accession No. ML15071A365), and August 20, 2015 (ADAMS Accession No. ML15244B203), the licensee submitted six-month updates to the OIP. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated February 6, 2014 (ADAMS Accession No. ML14002A124) and February 27, 2015 (ADAMS Accession No. ML15035A670), the NRC issued an Interim Staff Evaluation (ISE) and an audit report on the licensee's progress. By letters dated May 14, 2015 (ADAMS Accession No. ML15140A080), and December 10, 2015 (ADAMS Accession No. ML15351A009), as supplemented by letter dated March 21, 2016 (ADAMS Accession No. ML16096A338), 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 <u>Overall Mitigation Strategy</u>

Attachment 2 to Order EA-12-049 describes the three-phase approach required for mitigating BDBEEs in order to maintain or restore core cooling, containment and SFP cooling capabilities. The phases consist of an initial phase (Phase 1) using installed equipment and resources, followed by a transition phase (Phase 2) in which portable onsite equipment is placed in service, and a final phase (Phase 3) in which offsite resources may be placed in service. The timing of when to transition to the next phase is determined by plant-specific analyses.

While the initiating event is undefined, it is assumed to result in an extended loss of AC power (ELAP) with loss of normal access to the 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.

St. Lucie is a Combustion Engineering (CE) pressurized-water reactor (PWR); with a dry ambient pressure containment. The FIP describes the licensee's three-phase approach to mitigate a postulated ELAP event.

At the onset of an ELAP both reactors are assumed to trip from full power. The reactor coolant pumps (RCPs) coast down and flow in the reactor coolant system (RCS) transitions to natural circulation. Operators will take prompt actions to minimize RCS inventory losses by isolating potential RCS letdown paths. Decay heat is removed by steaming from the steam generators (SGs) through the atmospheric dump valves (ADVs) or main steam safety valve (MSSV), and make-up to the SGs is initially provided by the turbine-driven auxiliary feedwater (TDAFW) pump taking suction from the condensate storage tank (CST). Subsequently, the operators would begin a controlled cooldown and depressurization of the RCS by operating the SG ADVs. The RCS cooldown would commence at a rate of 75 degrees Fahrenheit (°F)/hr within 2 hours of the initiation of the ELAP event. At this cooldown rate, the intended RCS cooldown could be completed within an additional 2.5 to 3 hours. According to the licensee's revised FIP, the SGs are depressurized in a controlled manner to about 120 pounds per square inch atmosphere (psia). This SG depressurization will also reduce RCS temperature and pressure. Therefore, during the depressurization, operators would monitor RCS pressure and ensure that it is maintained above 170 psia during Phase 1 to avoid injection of the nitrogen cover gas from the safety injection tanks (SITs) into the RCS. The reduction in RCS temperature will further result in inventory contraction in the RCS, with the result that the pressurizer level is expected to indicate empty for some time. Some leakage from the RCP seals is also expected. However, passive injection of SIT inventory will maintain natural circulation in the RCS throughout Phase 1 without reliance upon FLEX RCS injection.

As noted above, to prevent injection of nitrogen cover gas from the SITs, the licensee intends to temporarily halt the plant cooldown in Phase 1 at a RCS pressure of 170 psia. When electrical power is restored to motor-operated SIT outlet valves in Phase 2, the SITs can be isolated, permitting (if necessary) resumption of the plant cooldown to the target SG pressure of 120 psia. Once a SG pressure of 120 psia has been reached, the initial cooldown will be terminated, eventually resulting in approximate RCS temperature and pressure conditions in the range of 350 °F and 150 psia.

The water supply for the TDAFW pump is initially from the CST. The fully protected inventory of both CSTs can be shared between Unit 1 and Unit 2 and will provide 17 hours of residual heat removal per unit. Prior to emptying, the operators will deploy a FLEX CST pump to restore CST inventory. The FLEX CST pump will draw water from the most preferable, available water supply that is available and discharge it to the CST. The preferable water sources are discussed below in Section 3.10, Water Sources.

The dc bus load stripping will be initiated within the first hour to ensure safety-related battery life is extended to 21.5 hours for Unit 1 and 14.9 hours for Unit 2. Following dc load stripping and prior to battery depletion, two FLEX portable 405 kilowatt (kW), 480 volt alternating current (VAC) diesel generators (DGs) (one per unit) will be deployed from the FLEX Equipment Storage Building (FESB) and connected to repower a station 480 VAC bus to power battery chargers within 9 hours of the onset of an ELAP.

The RCS make-up and boron addition will conservatively be initiated within 11 hours of the ELAP/LUHS event to ensure that natural circulation, reactivity control, and boron mixing is maintained in the RCS. When electrical power is restored to one installed charging pump per unit from a FLEX 480 VAC diesel generator, additional borated coolant can be injected into the RCS to ensure that adequate shutdown margin is provided at an RCS temperature of 350 °F, assuming xenon-free conditions. Make-up to the RCS would also compensate for inventory contraction caused by the RCS cooldown and ongoing RCS leakage. The boric acid make-up tanks would be the preferred water source for the charging pumps, with the refueling water tanks (RWTs), if available, serving as a backup supply.

In addition, a National SAFER (Strategic Alliance of FLEX Emergency Response) Response Center (NSRC) will provide high capacity pumps and large turbine-driven DGs per unit to cool the cores in the long-term. There are two NSRCs in the United States.

The SFP for each unit is located in the unit's fuel handling building (FHB). The SFP will initially heat up due to the unavailability of the normal cooling system. To maintain SFP cooling capabilities, the licensee calculated that for the maximum design heat load (plant shutdown, full core offload), the SFP will reach a bulk temperature of 200 °F in approximately 5 hours (Unit 1) or 6 hours (Unit 2) and boil off to a level 6 inches above the top of fuel in 45 hours for Unit 1 and 50 hours for Unit 2 unless additional make-up water is supplied to the SFP. The licensee plans to complete deployment of hoses and spray nozzles as a contingency for SFP make-up within 3 hours from event initiation to ensure the SFP area remains habitable for when personnel entry is required. Make-up water would be provided by using a FLEX SFP pump taking suction from the preferred water source of the Fort Pierce Utilities Supply Line or the backup source from the Intake Canal. Ventilation of the generated steam is accomplished by block opening two personnel doors at the operating deck elevation of the FHB and opening the double door at the ground elevation of the FHB to establish natural circulation that is completed within 3 hours from event initiation.

For Phases 1 and 2 the licensee's calculations demonstrate no actions are required to maintain containment pressure below design limits. The maximum containment pressures reached for Unit 1 and Unit 2 were calculated to be 4.2 per square inch gage (psig) (at 120 hours) and 4.1 psig (at 119.5 hours), respectively, remaining well below the design basis limit of 44 psig. During Phase 3, containment cooling will be maintained by establishing shutdown cooling (SDC) which will require an NSRC pumping system capable of cooling the component cooling water (CCW) heat exchanger that in turn cools the SDC heat exchanger. To repower these components, including the low pressure safety injection (LPSI) pumps, a NSRC 4.16 KVAC generator will be utilized.

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

3.2 Reactor Core Cooling Strategies

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 an 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. Consistent with endorsed guidance from NEI 12-06, Phase 1 of the licensee's core cooling strategy credits installed equipment (other than that presumed lost to the ELAP/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., pumps and hoses) or indirectly (e.g., FLEX electrical generators and cables repowering robust installed equipment). The equipment available onsite for Phases 1 and 2 is further supplemented in Phase 3 by equipment transported from the NSRCs.

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

As reviewed in this section, the licensee's core cooling analysis for the ELAP/LUHS event presumes that, per endorsed guidance from NEI 12-06, both units would have been operating at full power prior to the event. Therefore, the SGs may be credited as the heat sink for core cooling during the ELAP/LUHS event. Maintenance of sufficient RCS inventory, despite ongoing system leakage expected under ELAP conditions, is accomplished through a combination of installed systems and FLEX equipment. The specific means used by the licensee to accomplish adequate core cooling during the ELAP/LUHS event are discussed in further detail below. The licensee's strategy for ensuring compliance with Order EA-12-049 for conditions where one or more units are shut down or being refueled is reviewed separately in Section 3.11 of this evaluation.

3.2.1 Core Cooling Strategy and RCS Make-up

3.2.1.1 Core Cooling Strategy

3.2.1.1.1 Phase 1

Immediately following the trips of the reactor and RCPs resulting from the initiating external event, RCS temperature and pressure will stabilize at no-load conditions. That is, the RCS pressure will initially remain near its operating value (i.e., approximately 2250 psia), while the post-trip RCS cold-leg temperature value (i.e., approximately 545 °F) will stabilize slightly above the saturation temperature associated with the pressure of the lowest MSSV lift setpoint. Core cooling would be accomplished by natural circulation flow in the RCS using the SGs as the heat sink. The SG inventory make-up would be promptly initiated using the TDAFW pump taking suction from the CST, with steam vented via the MSSVs or ADVs. The fully protected inventory of both CSTs can be shared between Unit 1 and Unit 2 and will provide 17 hours of residual heat removal per unit.

The Unit 1 ADVs are air-operated valves. The instrument air system that supports these valves is not robust to all hazards considered under Order EA-12-049, and in the event instrument air is unavailable, MSSV operation will initially control SG pressure. Because the MSSVs are opened by system pressure at a fixed setpoint to provide protection against overpressurization, no operator action would be required. Within 2 hours of event initiation, the Unit 1 ADVs will be connected to the fully-protected ADV compressed gas backup supply to provide the capability for local manual operation using handloader. The Unit 2 ADVs are DC powered and may be operated remotely throughout the ELAP event.

Operators will verify feedwater flow is aligned to all SGs and take control of the ADVs to commence an RCS cooldown at 75 °F/hr within 2 hours of the initiation of the ELAP event. At this cooldown rate, the intended RCS cooldown to an SG pressure of 120 psia could be completed within an additional 2.5 to 3 hours. However, according to the licensee's shutdown margin calculation, to avoid injection of the nitrogen cover gas from the SITs into the RCS, operators should temporarily halt plant depressurization in Phase 1 prior to RCS pressure of 170 psia. In order to maintain RCS pressure above 170 psia prior to SIT isolation or venting, operators may need to terminate the SG depressurization before reaching 120 psia. It is also possible that a SG pressure of 120 psia may be reached, but that subsequent SG repressurization may be required to maintain reactor pressure above 170 psia as heat transfer from the reactor vessel upper head results in a gradually decreasing RCS pressure trend (for a fixed SG pressure) during this phase of the ELAP event.

3.2.1.1.2 Phase 2

The licensee's primary strategy in Phase 2 is to continue to cool the RCS by feeding the SGs with the TDAFW pump and releasing steam through the ADVs at a controlled rate. After the SITs are isolated by repowering valves in Phase 2, RCS pressure may be reduced below 170 psia, and operators may resume SG depressurization, if necessary. Once a SG pressure of 120 psia has been reached, the initial cooldown will be terminated, eventually resulting in approximate RCS temperature and pressure conditions in the range of 350 °F and 150 psia.

A Phase 2 portable diesel-driven pump (FLEX SG pump) will be deployed as a backup for the TDAFW pump. The FLEX SG pump will be supplied from the CST and connected to the discharge line of the TDAFW pump. The licensee stated that a FLEX SG pump will be readied as resources become available, and the sequence of events in the FIP lists this action as occurring within 12 hours of event initiation.

A FLEX CST pump will be deployed to restore CST inventory before it is depleted. The FLEX CST pump will draw water from the most preferable water supply that is available and discharge it to the CST. Water sources for mitigating the ELAP event are discussed further in Section 3.10 of this evaluation. The FLEX CST pump will be connected to one CST, and the other unit's CST will be filled simultaneously via CST cross-tie piping. Deployment of the FLEX CST pump is expected to be completed by 13 hours into the event.

3.2.1.1.3 Phase 3

Although the initial delivery of NSRC equipment is scheduled to reach plant sites within 24 hours of notification, the licensee's FIP does not formally credit the receipt of NSRC equipment until 72 hours after the event begins. Much of the NSRC equipment is expected to serve as backup to onsite equipment. However, the licensee's FIP mentions the deployment of several specific pieces of NSRC equipment that would be used to restore normal SDC.

First, an NSRC pumping system will provide at least 5000 gallon per minute (gpm) per unit to cool the CCW heat exchanger, which in turn cools the SDC heat exchanger. Per the FIP, this flow rate would provide the capacity to remove the heat loads in effect at 72 hours into an ELAP event. Hand calculations performed by the NRC staff during the audit confirm that the licensee's assumptions regarding heat exchanger performance appear to be consistent with the information provided in Updated Final Safety Analysis Report (UFSAR) Tables 9.3-28 (Unit 1) and 5.4-4 (Unit 2).

Second, an NSRC 4.16 KVAC generator will repower one LPSI pump and other loads required to support residual heat removal via normal SDC. According to the licensee's FIP, SDC will be established by 120 hours following event initiation.

3.2.1.2 RCS Make-up Strategy

3.2.1.2.1 Phase 1

Cooldown and depressurization of the RCS significantly extends the expected coping time under ELAP/LUHS conditions because it (1) reduces the potential for damage to RCP seals (as discussed in Section 3.2.3.3) and (2) allows coolant stored in the nitrogen-pressurized SITs to inject into the RCS to offset system leakage.

Upon diagnosis of a loss of all AC power, operators will transition to Emergency Operating Procedure (EOP)-10 "Station Blackout." Operators will isolate RCS letdown and controlled bleed off (CBO) flow within 10 minutes of event initiation. These actions greatly reduce RCS inventory loss and delay or reduce the temperature rise at the RCP seals following the loss of seal cooling. With credit for passive injection of SIT inventory, analyses demonstrate that natural circulation in the RCS will be maintained throughout Phase 1 without reliance upon FLEX RCS injection.

Passive injection from the SITs in Phase 1 would add considerable boron to the RCS. The licensee determined that a reduction of RCS pressure to approximately 170 psia would result in the injection of sufficient boron from the SITs to maintain adequate shutdown margin for both units at 350 °F without credit for injected boron from other sources. The licensee determined that the depressurization should be temporarily halted at an RCS pressure of 170 psia to avoid the possibility of injection of the nitrogen cover gas from the SITs into the RCS. Furthermore, according to its FIP, the licensee projects that the SITs could be isolated by approximately 11 hours into the event. In light of these facts, based upon our audit of the licensee's calculations, the NRC staff expects that isolating the SITs would not necessarily allow injection of all the boron required to maintain the reactor subcritical at 350 °F under xenon-free conditions. In particular, depending upon the rate of RCS leakage, the heat loss from the reactor vessel upper head, and other factors, RCS pressure may remain well above the value of approximately 182 psia that would be required to inject sufficient boron into the RCS to ensure adequate shutdown margin. Therefore, as discussed in the following section of this evaluation, credit is necessary for additional RCS boration in Phase 2 via the licensee's FLEX strategy to ensure subcriticality at 350 °F under xenon-free conditions.

3.2.1.2.2 Phase 2

As noted above, to prevent injection of nitrogen cover gas from the SITs, the licensee intends to temporarily halt the plant cooldown in Phase 1 at a RCS pressure of 170 psia. When electrical power is restored to motor-operated SIT outlet valves in Phase 2, the SITs can be isolated, permitting resumption of the plant cooldown to the target SG pressure of 120 psia. In addition, when electrical power is restored to one installed charging pump per unit from a FLEX 480 VAC diesel generator, additional borated coolant can be injected into the RCS to ensure that adequate shutdown margin is provided at an RCS temperature of 350 °F, assuming xenon-free conditions. Make-up to the RCS would also compensate for inventory contraction caused by the RCS cooldown and ongoing RCS leakage. According to information provided by the licensee during the audit, sufficient charging system alignments are possible such that diverse flowpaths (i.e., normal charging flowpath or auxiliary high-pressure safety injection header) to the reactor vessel can be achieved. Per the licensee's revised FIP, the boric acid make-up tanks (BAMTs) would be the preferred water source for the charging pumps, with the RWTs, if available, serving as a backup supply. The licensee's procedure FLEX Support Guideline (FSG)-01 would ensure that RCS venting is controlled, via the reactor coolant gas venting system vents (i.e., from the reactor vessel upper head or pressurizer), as the charging pumps refill the RCS.

Per the sequence of events in the licensee's FIP, requisite supporting actions are expected to be completed such that additional boration can be commenced via the licensee's FLEX strategy by approximately 11 hours into the ELAP event. Based on the prior operating history assumed in the endorsed NEI 12-06 guidance, providing additional borated make-up in this timeframe should allow the licensee to stay well ahead of the decay of core xenon, providing significant reactivity margin even to the time at which the core xenon concentration would be expected to return to its equilibrium value during the operating cycle.

The FIP further states that, prior to undertaking an additional RCS cooldown by depressurizing the SGs below 120 psia, borated water would be added to compensate for the positive reactivity associated with the RCS cooldown (again considering xenon-free conditions). The RCS make-up necessary to support the additional cooldown would again be provided by the installed charging pumps drawing suction on the boric acid make-up tanks or RWTs.

3.2.1.2.3 Phase 3

Per EOP-10, after a sufficient quantity of boric acid has been injected into the RCS during Phase 2 to ensure adequate shutdown margin at cold conditions (the licensee conservatively assumed a temperature of 50 °F), RCS inventory would be controlled in Phase 3 by starting and stopping charging pumps as needed. However, as required to satisfy Order EA-12-049, the arrival of additional equipment from offsite response centers in Phase 3 will provide additional capability and redundancy to supplement the Phase 2 strategies and equipment.

3.2.2 Variations to Core Cooling Strategy for Flooding Event

In its FIP, Section 2.10.2, the licensee states that reevaluated flood heights for storm surge, tsunami and seiche will all remain below the power block elevation (+18.3ft PSL Datum) and the flood protection level (+19.3ft PSL Datum). The local intense precipitation (LIP) assessment indicated some internal flooding would occur. However, the licensee stated that this new flood hazard will remain below the current licensing basis (CLB) internal flood hazard volumes and that FLEX equipment deployment was designed to avoid these areas. Therefore, there are no variations to the core cooling strategy in the event of a flood. Refer to Section 3.5.2 of this safety evaluation (SE) for further discussion on flooding.

3.2.3 Staff Evaluations

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

Guidance document NEI 12-06 provides 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

In its FIP, the licensee provided descriptions for the permanent plant SSCs to be used to support core cooling for Phase 1 and 2. The TDAFW pump will automatically start and will deliver AFW flow to the SGs from the CSTs following an ELAP. In the event that the TDAFW pump fails to start, the licensee indicated that there are existing procedures that direct the operators to manually reset and start the pump without needing electrical power for motive force or control. The licensee stated that the TDAFW pump is qualified to supply above the design-basis AFW flow requirements to the SGs and is protected from the external events, as defined in NEI 12-06. The TDAFW pumps are installed in an outdoor environment within the safety-related steam trestle. The CSTs supply the SGs through the TDAFW pumps during Phase 1 and Phase 2 after an ELAP is declared. Both tanks have the capability of being cross-connected to feed the TDAFW pump to provide 465,950 gallons of usable volume for make-up to the SGs, which equals 17 hours of residual heat removal capabilities per unit. The CSTs are both safety-related and within tornado missile protected structures. During the onsite audit, the NRC staff walked down the TDAFW pump and verified that it should be available during an ELAP event.

In addition to the existing inventory to the CSTs, the licensee identified additional on-site water sources that will be available after a particular external event, which will provide make-up to the CSTs through the FLEX CST pump. These additional water sources are discussed below in Section 3.10.

Based on the design of the CSTs and the diverse water sources as described above, these water sources should be available to support core cooling during an ELAP caused by a BDBEE, which appears to be consistent with Condition 4 of NEI 12-06, Section 3.2.1.3. Additionally, due to the design and locations of the primary and alternate AFW connection points, as described below in Section 3.7.3.1 and in the FIP, at least one of the connection points should be available to support core cooling through a portable FLEX SG pump during an ELAP caused by a BDBEE, which appears to be consistent with NEI 12-06, Section 3.2.2 and Table D-1.

RCS Inventory Control

The FIP describes that the permanent charging pumps for each unit are aligned to provide RCS make-up for Phase 2 after being repowered from the FLEX 480 VAC DG around the 11 hour mark after an ELAP is declared. The charging pumps are safety-related and are protected from the external hazards as defined in NEI 12-06. However, the staff notes that the licensee's strategy of repowering installed charging pumps to provide RCS makeup to mitigate an ELAP event conflicts with the guidance provided in NEI 12-06, Section 3.2.2(13) that calls for the use of portable equipment. Therefore, the use of the charging pumps is considered an alternative to NEI 12-06 and is discussed below in Section 3.14.

The licensee described that the preferred borated water sources for RCS make-up are the RWTs and BAMTs. The water sources for RCS inventory control are discussed below in Section 3.10. In summary, based on the design of the RWTs and BAMTs, and the availability of charging pumps after the FLEX 480 VAC DG is connected, a borated water source should be available to support RCS inventory control through the charging pumps during an ELAP caused by a BDBEE, which appears to be consistent with Condition 3 of NEI 12-06, Section 3.2.1.3. Additionally, due to the design and location of the primary and alternate RCS injection connection points, as described below in Section 3.7.3.1 and in the FIP, which appears to be consistent with NEI 12-06, Section 3.2.2 and Table D-1, at least one of the diverse connection points should be available to support RCS injection through the FLEX SG pump during an ELAP that occurs in non-operating modes.

3.2.3.1.2 <u>Plant Instrumentation</u>

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

- Auxiliary Feedwater Flow
- SG Water Level (Narrow Range)
- SG Pressure
- RCS Hot Leg Temperature
- RCS Cold Leg Temperature
- Core Exit Thermocouples
- CST Level
- Pressurizer Lever
- Reactor Vessel Level
- Neutron Flux
- RCS Wide Range Pressure
- Containment Pressure
- Containment Temperature
- DC Bus Voltage

- Safety Injection Tank Level
- Spent Fuel Pool Level (local indication at FHB)
- Refueling Water Tank Level
- Refueling Cavity Level

The instrumentation available at St. Lucie to support the licensee's strategies for core cooling and RCS inventory during an ELAP event appears to be consistent with and in some cases exceeds the recommendations specified in the endorsed guidance of NEI 12-06. Based upon the information provided by the licensee, the NRC staff understands that indication for the above instruments would be available and accessible continuously throughout the ELAP event.

As recommended by Section 5.3.3 of NEI 12-06, FSG-07 provides instructions and information to obtain readings locally at the transmitter, or at the transmitter outputs at the reactor auxiliary building (RAB) side of containment penetrations for instruments inside containment, and scaling sheets to convert to the process values.

3.2.3.2 Thermal-Hydraulic Analyses

In the analysis of the ELAP event performed by the Pressurized Water Reactor Owners Group (PWROG) in WCAP-17601-P, which the licensee relies upon, the Combustion Engineering Nuclear Transient (CENTS) code was chosen for the evaluation of CE-designed plants such as St. Lucie. The CENTS code, as described in Westinghouse topical report WCAP-15996-A (ADAMS Accession No. ML053320174), is a general-purpose thermal-hydraulic computer code that the NRC staff has previously reviewed and approved for calculating the behavior of the RCS and secondary systems of pressurized-water reactors (PWRs) designed by CE and Westinghouse during non-loss-of-coolant accident (non-LOCA) transients. Although CENTS has been approved for performing certain design-basis non-LOCA transient analyses, the NRC staff had not previously examined its technical adequacy for performing best-estimate simulations of an ELAP event. Therefore, in support of mitigating strategy reviews to assess compliance with Order EA-12-049, the NRC staff evaluated licensees' thermal-hydraulic analyses, including a limited review of the significant assumptions and modeling capabilities of CENTS and other thermal-hydraulic codes used for these analyses.

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

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

To address the NRC staff's remaining concerns associated with the use of CENTS to simulate the two-phase natural circulation flow that may occur during an ELAP for CE-designed PWRs, the PWROG submitted a white paper entitled "Westinghouse Response to NRC Generic Request for Additional Information (RAI) on CENTS Code in Support of the Pressurized Water Reactor Owners Group (PWROG) (PA-ASC-1187)" (ADAMS Accession No. ML14218A083). This white paper was originally submitted on September 24, 2013, and a revised version was resubmitted on November 20, 2013. The white paper focused on comparing several small-break LOCA simulations using the CENTS code to analogous calculations performed with the CEFLASH-4AS code, which was previously approved for analysis of design-basis small-break LOCAs under the conservative Appendix K paradigm for CE-designed reactors. The analyses in the CENTS white paper generally showed that CENTS' predictions were similar or conservative relative to CEFLASH-4AS for key figures of merit for conditions where natural circulation is occurring in the RCS, including predictions of RCS loop flow rates and the timing of the transition to reflux cooling. The NRC staff's review of the analyses in the white paper included performing confirmatory analyses with the TRACE code. In particular, the staff's TRACE simulations generally showed reasonable agreement with the predictions of CENTS regarding the fraction of the initial RCS mass remaining at the transition to reflux cooling. Therefore, as documented in a letter dated October 7, 2013 (ADAMS Accession No. ML13276A555), the NRC staff endorsed the approach in the PWROG's white paper as an appropriate means for applying the CENTS code to beyond-design-basis ELAP analysis, with the limitation that reliance upon CENTS is limited to the phase of the event before reflux cooling begins.

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

Applying the one-tenth flow quality criterion to the analyses completed in WCAP-17601-P, the November 20, 2013, revision of the PWROG's white paper on CENTS determined ELAP coping times prior to entering the reflux cooling mode for each CE reactor included in WCAP-17601-P. Unlike the generic calculations performed for reactors designed by other vendors, the analysis for CE plants in WCAP-17601-P was generally conducted at a plant-specific level. (One exception is that a single analysis was used to represent four plants of similar design, including St. Lucie, Unit 1.) With respect to St. Lucie, coping times of 24.7 hours for Unit 1 and 18.7 hours for Unit 2 were identified, by which RCS make-up should be provided. These coping times are both well in excess of the time at which the licensee intends to initiate RCS make-up according to its FIP (i.e., 11 hours). The NRC staff performed confirmatory simulations with the TRACE code for St. Lucie using an input deck generated from a mixture of plant-specific sources and generic information applicable to CE reactors. The results of the staff's calculations indicated that more than 20 hours should be available prior to either unit entering the reflux cooling mode, thereby confirming the appropriateness of the licensee's mitigating strategy. It should further be understood that both the simulations in WCAP-17601-P and the NRC staff's confirmatory calculations are expected to significantly underestimate the actual coping time available to St. Lucie because (1) these simulations assumed an RCP seal leakage rate significantly in excess of that subsequently endorsed by the NRC staff for the Flowserve N-9000 seals installed at St. Lucie and (2) no credit is taken for CBO isolation. As a result, the NRC staff considers the licensee's strategy for ensuring sufficient RCS make-up to avoid reflux cooling as having ample margin for mitigating the analyzed ELAP event.

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

3.2.3.3 Reactor Coolant Pump (RCP) Seals

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

As noted above, Flowserve N-9000 seals are installed on the RCPs at St. Lucie. The N-9000 is a hydrodynamic seal that was developed by Flowserve in the 1980s. One of the design objectives for the N-9000 seal was to provide low-leakage performance under loss-of-seal-cooling conditions during events such as a station blackout. In support of its customers' efforts to address the ELAP event (which similarly involves a loss of seal cooling) in accordance with

Order EA-12-049, on August 3, 2015, Flowserve submitted to the NRC staff its "White Paper on the Response of the N-Seal Reactor Coolant Pump (RCP) Seal Package to Extended Loss of All Power (ELAP)" (ADAMS Accession No. ML15222A366). The N-Seal white paper contains information regarding the expected leakage rates over the course of an ELAP event for each PWR at which Flowserve N-Seals are currently installed. In a letter dated November 12, 2015 (ADAMS Accession No. ML15310A094), the staff endorsed the leakage rates described in the white paper for the beyond-design-basis ELAP event, subject to certain limitations and conditions.

During the audit, the licensee addressed the status of its conformance with the white paper. In particular, the licensee confirmed that the plant design and planned mitigation strategy for St. Lucie is consistent with the information assumed in the calculation performed by Flowserve, which is summarized in Table 1 of the white paper. Additionally, the peak cold-leg temperature prior to the RCS cooldown assumed in Flowserve's analysis was found to be equivalent to the saturation temperature corresponding to the lowest setpoint for MSSV valve lift pressure. Based on its audit review, the NRC staff further considered the endorsement letter's condition on the density of the coolant leaking from the RCS to be addressed inasmuch as (1) a conservative RCP seal leakage assumption was used for the determination of the time to enter reflux cooling and (2) shutdown margin calculations considering maximum RCS leakage were performed on an appropriate volumetric basis.

According to measured data from Flowserve's 1988 N-Seal station blackout test, following CBO isolation at 0.5 hours, over the course of the succeeding period of 6 to 7 hours during which CBO isolation was maintained, the average seal leakage rate was slightly less than 0.05 gpm. The licensee indicated that these results are applicable to St. Lucie, since the FLEX strategies for both units would isolate CBO flow within 10 minutes of the event. Although the NRC staff agreed that it is appropriate to allow credit for demonstrated performance, during its review of the Flowserve white paper, the staff questioned the extrapolation of evidence from a limited test period of 6 to 7 hours to the indefinite coping period associated with the ELAP event. Therefore, while the NRC staff ultimately agreed with the credit Flowserve's N-Seal white paper allowed for CBO isolation in determining the short-term thermal exposure profile of seal elastomers, the staff did not endorse direct application of the average leakage rate measured with the CBO isolated in the 1988 test for an indefinite period in the absence of demonstrated long-term seal performance.

Ultimately, the plant-specific calculations performed by Flowserve in its white paper determined that the St. Lucie FLEX scenario does not exceed the design margin demonstrated in the 1988 station blackout test, such that increased leakage during the ELAP event due to elastomer failure or other causes is not expected. Under this condition, according to the values listed in Table 3a of the Flowserve white paper, assuming a leakage rate of 1.5 gpm per RCP prior to CBO isolation would be appropriate. Considering each unit has 4 RCPs and accounting for another 1 gpm of additional RCS leakage would result in a total RCS leakage of 7 gpm. Comparing the assumed leakage rates in the licensee's analysis to the endorsed values from the Flowserve white paper, the NRC staff determined the following:

- Comparing the assumed leakage rates in the licensee's analysis to the endorsed values from the Flowserve white paper, the NRC staff observed that the licensee's analysis for determining the threshold for entry into reflux cooling did not credit the installation of the Flowserve N-Seals. Instead, the leakage rates were based on the assumption that RCP seal leakage would occur at an initial rate of 15 gpm (i.e., a rate just below that which would trigger closure of excess flow check valves in the CBO lines) at the RCS temperature and pressure conditions applicable when subcooling decreases below 50 °F. Modeling RCP seal leakage in this manner was intended to envelop the potential for seal instability at low inlet subcooling conditions to result in "pop-open" failure. Thermal-hydraulic analysis indicates that the RCS subcooling margin decreases below 50 °F at approximately 3 hours into the event. At this juncture, the RCS cooldown is being conducted, which results in the RCS approaching saturation because the pressurizer heaters are not powered during the ELAP event. As the RCS cooldown and depressurization continue, the leakage rate is assumed to decrease in accordance with the choked flow correlation used in the licensee's CENTS analysis. Comparing the leakage rates from the licensee's CENTS analysis, as well as confirmatory analysis performed by the NRC staff with the TRACE code (see Section 3.2.3.2 above), the NRC staff concluded that the analytically assumed leakage rates are conservative relative to the expected leakage rate for Flowserve N-9000 seals during the analyzed ELAP event.

- Regarding the licensee's shutdown margin analysis, as discussed further below, the NRC staff concluded that the maximum leakage rate analyzed by the licensee is reasonable, and that the possibility of slightly increased leakage rates would not be expected to have a significant effect on the calculated results.

Therefore, based on the evaluation above, the NRC staff concludes that the RCP seal leakage rates assumed in the licensee's thermal-hydraulic and shutdown margin analyses may be applied to the beyond-design basis ELAP event for the site.

3.2.3.4 <u>Shutdown Margin Analyses</u>

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

- the cooldown of the RCS and fuel rods adds positive reactivity
- the concentration of xenon-135
    - initially increases above its equilibrium value following reactor trip, thereby adding negative reactivity
    - peaks at roughly 12 hours and subsequently decays away gradually, thereby adding positive reactivity
- the injection of borated make-up from passive accumulators due to the depressurization of the RCS, which adds negative reactivity

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

The NRC staff requested that the industry provide additional information to justify that borated make-up would adequately mix with the RCS volume under natural circulation conditions potentially involving two-phase flow. In response, the PWROG submitted a position paper, dated August 15, 2013 (withheld from public disclosure due to proprietary content), which provided test data regarding boric acid mixing under single-phase natural circulation conditions and outlined applicability conditions intended to ensure that boric acid addition and mixing during an ELAP would occur under conditions similar to those for which boric acid mixing data is available. In a letter dated January 8, 2014 (ADAMS Accession No. ML13276A183), the NRC staff endorsed the above position paper with three conditions:

- The required timing and quantity of borated make-up should consider conditions with no RCS leakage and with the highest applicable leakage rate.

- Adequate borated make-up should be provided either (1) prior to the RCS natural circulation flow decreasing below the flow rate corresponding to single-phase natural circulation, or (2) if provided later, then the negative reactivity from the injected boric acid should not be credited until one hour after the flow rate in the RCS has been restored and maintained above the flow rate corresponding to single-phase natural circulation.

- A delay period adequate to allow the injected boric acid solution to mix with the RCS inventory should be accounted for when determining the required timing for borated make-up. Provided that the flow in all loops is greater than or equal to the corresponding single-phase natural circulation flow rate, a mixing delay period of one hour is considered appropriate.

The NRC staff audited the licensee's shutdown margin calculations, including consideration of whether the licensee had followed recommendations from the PWROG's position paper and the associated conditions imposed in the NRC staff's endorsement letter. The licensee performed separate calculations for Units 1 and 2 due to differences in plant design, notably including the difference in SIT pressure. The licensee's shutdown margin calculations included analysis to determine minimum quantities of SIT injection in order to satisfy shutdown margin requirements, as well as maximum quantities of SIT injection for determining the RCS pressure necessary to prevent injection of the nitrogen cover gas into the RCS. For both units, the licensee determined that a reduction in RCS pressure to 182 psia would be capable of providing the required boron concentration to maintain adequate shutdown margin at 350 °F. The licensee further calculated the volumes of borated coolant from the boric acid make-up tanks and refueling water tanks to ensure adequate shutdown margin to a conservatively low temperature of 50 °F. The licensee's calculations further determined that the initial RCS cooldown and depressurization should be halted prior to allowing RCS pressure to decrease below approximately 170 psia to avoid the potential for injection of the SIT nitrogen cover gas. Following isolation of the SITs in Phase 2, system depressurization could proceed to the target SG pressure of 120 psia.

The NRC staff's audit review confirmed that the licensee's shutdown margin calculations generally used acceptable calculation methods and were generally consistent with the guidance endorsed for analysis of the ELAP event. Furthermore, a number of conservative assumptions were applied, particularly with respect to considering the range of variation for SIT injection.

Two specific areas of the shutdown margin calculation that the NRC staff audited in detail included (1) the maximum RCS leakage rate assumed in the licensee's shutdown margin calculations and (2) the licensee's use of RCS free volume as a criterion for determining whether or not RCS venting would be necessary to inject the quantity of boric acid required to ensure adequate shutdown margin.

With regard to the maximum RCS leakage rate, the NRC staff noted that the endorsed Flowserve N-Seal white paper references a CBO flow rate slightly in excess of the maximum rate assumed in the licensee's shutdown margin calculations. However, several audit observations mitigated this issue, particularly the fact that the licensee's emergency operating procedures direct CBO isolation in response to station blackout conditions. According to the NRC staff's understanding, the licensee normally maintains the CBO relief isolation valve in the closed position. Therefore, it is reasonable to expect that CBO isolation should reduce the RCP seal leakage rate to well below the value assumed in the licensee's shutdown margin calculation for a duration at least as long as that demonstrated during the 1988 N-Seal station blackout test (i.e., 6 to 7 hours). Furthermore, based on our audit, the NRC staff does not expect that a slight increase in RCS leakage would have a significant adverse effect on the licensee's shutdown margin calculations. In this regard, the staff noted in particular that the licensee's precautions against SIT nitrogen cover gas injection were ultimately based upon maintaining RCS pressure sufficiently high until SIT isolation could be effected, as opposed to consideration of available RCS free volume.

With regard to the determination of whether RCS venting is necessary to inject the required volume of borated coolant to ensure adequate shutdown margin, the NRC staff observed that the licensee's method solely considered the availability of RCS free volume. The staff observed that if this simplified criterion were actually implemented, it could lead to undesirable increases in RCS pressure at reduced RCS temperatures in some scenarios where a high-pressure charging pump may refill the RCS to a point approaching water-solid conditions. For this reason, even in cases where the licensee's calculation concluded that venting the RCS would be unnecessary, the NRC staff could not necessarily agree. However, the NRC staff observed that the licensee has the capability to vent the RCS if needed via reactor coolant gas vent system vent paths from both the reactor vessel upper head and pressurizer. These vent paths contain 7/16" orifices that limit the rate at which RCS coolant can be let down, and the valves in the flowpath are operated by DC power. Furthermore, the licensee's FLEX procedures (e.g., FSG-01, FSG-08)) direct RCS venting well before the RCS approaches water-solid conditions. Therefore, the NRC staff concluded that the licensee should have appropriate means for venting the RCS under ELAP conditions if needed to prevent undesirable pressure increases.

In NEI 12-06, Section 11.8.2, states that plant configuration control procedures will be modified to ensure that changes to the plant design will not adversely impact the approved FLEX strategies. Inasmuch as changes to the core design constitute changes to the plant design, the NRC staff expects that any changes to the core design, such as those evaluated in a typical core reload analysis, will be evaluated to determine that they do not adversely impact the FLEX strategies, especially the analyses which demonstrate that no recriticality will occur during a FLEX RCS cooldown.

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

3.2.3.5 FLEX Pumps and Water Supplies

The FIP described the two FLEX CST pumps as each being rated for 500 gpm and can provide make-up to the CSTs from the several water sources as described in SE Section 3.2.3.1.1 for supplying the SGs during Phase 2 once the initial CSTs inventory is depleted. The FLEX CST pump is a trailer-mounted, diesel driven centrifugal pump that is stored in the FESB. The FLEX CST pump is deployed by towing the trailer to one of several designated locations near the selected water source and then connecting to that source and the affected unit's CST. In the case of both units being affected, the CST make-up with be implemented on a single unit's CST and the other unit's CST will be filled through the cross tie. The FLEX CST pump is required to support the reactor core cooling and heat removal strategy prior to CST depletion time of 17 hours as described in FIP Section 3.2.1. The licensee described that the single FLEX CST pump flow capacity of 500 gpm exceeds the flow requirement for the TDAFW pumps or FLEX SG pumps for reactor core heat removal on both units that is approximately 2 x 136 gpm. Two FLEX CST pumps are available to satisfy N+1 requirement as specified in NEI 12-06 guidance.

The FIP described the three portable FLEX SG pumps as being rated for 300 gpm (at 475 psig). The FLEX SG Pump is a trailer-mounted, diesel engine driven centrifugal pump that is stored in the FESB. The FLEX SG pump will provide a backup SG injection method in the event that the TDAFW pump can no longer perform and will also draw suction from the CST. Three FLEX SG pumps are available to satisfy N+ 1 requirement as specified in NEI 12-06 guidance. The same FLEX SG pumps are available to satisfy the RCS make-up capability for Modes 5/6 without SGs available.

In its FIP, the licensee identified that the CSTs, the onsite make-up water sources in SE Section 3.2.3.1.1, and the intake canal as the water sources to be used for the FLEX SG, FLEX SFP, and FLEX CST pumps, as applicable, for the respective SG, RCS and SFP make-ups for all three Phases after an ELAP is declared. These water sources are described in more detail in SE Section 3.10 below.

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, containment, and SFP that provides the inputs, assumptions, and documented analysis that the mitigation strategy and support equipment will perform as intended. During the audit review, the licensee provided the following FLEX hydraulic calculations to indicate that the above portable FLEX pumps were capable of performing their functions after a BDBEE event:

- Calculation FPL064-CALC-001, Revision 2, "Steam Generator FLEX Pump Sizing," which evaluated the use of the FLEX SG pump receiving make-up water from the intake canal to supply the SGs for the SG makeup strategy or to provide RWT water to inject into the RCS cold leg during Modes 5/6 for the RCS makeup strategy. The licensee's analysis found that the SG make-up to achieve 300 gpm, the pump would require a total system head of 916 ft., with 13.5 ft. of NPSH available for the SG FLEX pump at the unit 1 intake canal's lowest water level. This figure is bounding for the other secondary water sources to be used for SG make-up. The RCS make-up from the unit 2 RWT would require for the pump to have a total system head of 700 ft., which is more than sufficient to cover the SG make-up scenario as well. The calculation is also based on providing unit 2 RWT water to the unit 1 RCS, giving it the longest route for the SG pump connection to be used for FLEX strategies. The SG pump for RCS make-up also has 64.9 ft. of NPSH available, which is bounded by the SG make-up case.

- Calculation FPL064-CALC-002, Revision 1, "Condensate Storage Tank FLEX Pump Sizing," which evaluated the use of FLEX CST pumps providing make-up to the CST from the intake canal or RWT, TWST, CWST, PWST or Fort Pierce Utilities supply lines. The licensee's analysis found that for the pump to achieve 500 gpm from the RWT to the CST, the FLEX CST pump would require a total system head of 158 ft. with 17 ft. of NPSH available for the pump. The licensee's previous analysis for the FLEX CST pump showed that the pump can deliver 470 ft. of 300 gpm with 1.5 ft. of the required NPSH. The revised analysis for the FLEX CST pump shows that the pump can deliver 275 ft. of 500 gpm with 1.5 ft. of the required NPSH. The unit 2 RWT was used since it has the longest pump run to the unit 2 CST.

The staff also conducted a walkdown of the hose deployment routes for the above FLEX pumps during the audit to confirm the evaluations of the hose distance runs in the above hydraulic analyses.

Note: The available water sources for Phase 2 and 3 FLEX portable pumps are discussed in Section 3.10 of this SE.

Based on the staff's review of the FLEX pumping capabilities at St. Lucie, as described in the above hydraulic analyses and the FIP, the licensee's portable FLEX pumps should have sufficient capacity to support core cooling during an ELAP, which appears to be consistent with the provisions of NEI-12-06, Section 11.2.

3.2.3.6 Electrical Analyses

The licensee's FIP defines 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 at all units at St. Lucie. The St. Lucie electrical FLEX strategies are practically 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 SE. Furthermore, the electrical coping strategies are the same for all modes of operation.

The NRC staff reviewed the licensee's FIP to determine whether the FLEX strategies, if implemented appropriately, should be able to maintain or restore core cooling, containment, and spent fuel pool cooling following a BDBEE. As part of its review, the NRC staff reviewed conceptual electrical single-line diagrams, summaries of calculations for sizing the FLEX diesel and turbine generators and station batteries, and summaries of calculations that addressed the effects of temperature on the electrical equipment credited in the FIP as a result of losing heating, ventilation, and air conditioning (HVAC) during an ELAP as a result of a BDBEE.

According to the licensee's FIP, the St. Lucie operators would declare an ELAP following a loss of offsite power, loss of all emergency diesel generators, and the loss of any alternate AC power with a simultaneous LUHS. In its FIP, the licensee assumes that this determination can be made in less than 1 hour after the onset of an ELAP/LUHS event.

During Phase 1 the St. Lucie safety-related batteries will be used to initially power required key instrumentation and applicable dc components required for monitoring RPV level, atmospheric dump valve operation (Unit 2), and TDAFW pump operation.

The 125 V dc system at St. Lucie, Unit 2 is arranged into two main redundant load groups, SA and SB, and a third service (swing load) group SAB. Load group SA is served by dc buses 2A and 2AA and load group SB by dc buses 2B and 2BB. Load group SAB is served by dc bus 2AB which is normally tied to either (but never both) dc bus 2A or 2B, corresponding to the manner in which the 4.16 kV and 480V AB buses are connected to their respective SA or SB buses. Each of the two 125 V lead-calcium type station safety-related batteries is a C&D Technologies LCY-39 that is rated at 2278 ampere/hour at an 8 hour discharge rate to 1.81 V per cell.

The TDAFW pump is automatically actuated to provide feedwater to the steam generators for the removal of reactor core decay heat following a loss of main feedwater. The TDAFW pump supplies flow to both steam generators through individual dc-powered motor-operated flow control valves (FCVs). Unit 2 also has DC powered solenoid valves upstream of the FCVs that open on an auxiliary feedwater actuation signal. Since required loads are supplied by the safety-related batteries, the licensee plans to shed non-essential loads on the batteries to extend the dc coping time. Load shedding is expected to be completed within 1 hour and 30 minutes from the onset of an ELAP event.

The licensee performed a dc coping study for each unit (FPL064-CALC-004, Rev 3, "Unit 1 Battery Load Shedding Strategy," and FPL064-CALC-005, Rev 3, "Unit 2 Battery Load Shedding"). The calculation showed that the Unit 1 safety-related batteries (with non-essential loads shed within 1 hour and 30 minutes from the onset of an ELAP/LUHS event) could survive approximately 21.5 hours (the calculation showed the battery capacity to be approximately 12 hours for each of the 1A and 1B safety-related batteries. Consideration must be given to the 1-hour duration to accomplish swapping from 1A to 1B station battery (this action is performed without losing power to required instrumentation) and that both sets of batteries are conservatively assumed to be loaded for the initial 90 minutes; therefore, the total available capacity for the Unit 1 safety-related batteries is approximately 21.5 hours).

The calculation also showed that the Unit 2 safety-related batteries (with non-essential loads shed within 1 hour and 30 minutes from the onset of an ELAP/LUHS event) could survive 14.9 hours (the calculation showed the battery capacity to be approximately 9.5 hours and 8 hours for 2A and 2B safety-related batteries respectively. Consideration must be given to the 1 hour duration to accomplish swapping from 2A to 2B station battery and that both sets of batteries are assumed to be loaded for the initial 90 minutes; therefore, the total available capacity for the Unit 2 safety-related batteries is approximately 14.9 hours). The calculated available battery capacity, for both Unit 1 and Unit 2, is sufficient since the licensee expects to have a FLEX 480 VAC diesel generator deployed, staged, and connected as part of its Phase 2 transition to repower a station 480 VAC bus to power battery chargers within 9 hours of the onset of an ELAP event.

Since the licensee is planning to rely on their batteries for greater than 8 hours, NEI white paper, "EA-12-049 Mitigating Strategies Resolution of Extended Battery Duty Cycles Generic Concern" (ADAMS Accession No. ML13241A186), which was endorsed by the NRC (ADAMS Accession No. ML13241A188), is applicable to St. Lucie. In addition to the NEI white paper, the

NRC sponsored testing at Brookhaven National Laboratory that resulted in the issuance of NUREG/CR-7188, "Testing to Evaluate Extended Battery Operation in Nuclear Power Plants," in May of 2015. The purpose of this testing was to examine whether existing vented lead acid batteries can function beyond their defined design-basis (or beyond-design-basis if existing Station Blackout (SBO) coping analyses were utilized) duty cycles in order to support core cooling. The study evaluated battery performance availability and capability to supply the necessary dc loads to support core cooling and instrumentation requirements for extended periods of time.

The testing provided an indication of the amount of time available (depending on the actual load profile) for batteries to continue to supply core-cooling equipment beyond the original duty cycles for a representative plant. The testing also demonstrated that battery availability can be significantly extended using load shedding techniques to allow more time to recover AC power. The testing further demonstrated that battery performance appears to be consistent with manufacturer performance data. According to the NUREG, the projected availability of a battery can be accurately calculated using the Institute of Electrical and Electronics Engineers (IEEE) Standard 485-2010, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications," or using an empirical algorithm described in the report.

Based on the evaluation above, the NRC staff concludes that the licensee's load shed strategy should ensure that the batteries have sufficient capacity to supply power to required loads for at least 21.5 hours for St. Lucie, Unit 1 and 14.9 hours for St. Lucie, Unit 2.

According to the licensee's FIP, the Phase 2 strategy will deploy, stage, and connect a FLEX 480 VAC DG on each unit to repower 480 VAC buses to ensure power is available to the battery chargers prior to depletion of the station batteries. As identified previously, the licensee will perform an extended manual load shedding of the station batteries to ensure that the station batteries remain available until the FLEX 480 VAC DGs repower the 480 VAC buses. The FLEX 480 VAC DGs are 405 kilowatt (kW) standby rating generators that are trailer-mounted with a double-walled diesel fuel tank built into a trailer capable of 12 hours full load fuel supply. Three FLEX 480 VAC DGs are available to satisfy the N+ 1 requirement.

A permanent installed charging pump will be available once repowered from a FLEX 480 VAC DG. The charging pump will be available for borated water injection into the RCS when it becomes necessary to maintain reactor shutdown margin.

The Unit 1 480 VAC buses supply power to battery chargers 1A and 1AA for train "A" and 1B and 1BB for train "B". Each charger has a 300 amp capacity. Two 125 V dc battery chargers operate in parallel on each of the buses. A fifth 125 V dc battery charger on the AB bus provides a backup for the four operating 125 V dc chargers.

The Unit 2 480 VAC buses supply power to battery chargers 2A and 2AA for train "A" and 2B and 2BB for train "B". Each charger has a 300 amp capacity. Two 125 volt dc battery chargers operate in parallel on each of the buses. A fifth 125 V dc battery charger on the SAB bus provides a backup for the four operating 125 V dc chargers.

The NRC staff reviewed the licensee's Phase 2 and 3 FLEX generator calculations and procedures (Engineering Change EC282199, "PSL 2 Fukushima FLEX Strategy Implementation Umbrella Modification Electrical Evaluation White Paper Attachment 'PSL 480V FLEX Diesel-

Generator Sizing’,” Rev. 1, PSL-1-F-J-E-90-0013, “St. Lucie Unit 1 Emergency Diesel Generator 1A and 1B Electrical Loads,” Rev. 7 (EC 279083), PSL-2-FJE-90-0020, “St. Lucie Unit 2 Emergency Diesel Generator 2A and 2B Electrical Loads,” Rev. 11 (EC 279064), the Commercial Technical Manual for the FLEX 480 VAC Portable 405 KW 480 VAC Phase 2 Generator Model Number 350SL Genset, “PSL FLEX 4160 VAC Diesel-Generator Sizing Report,” dated November 19, 2013, “PSL FLEX 480 VAC Diesel-Generator Sizing Report,” dated August 1, 2013, 1-FSG-05, “Initial Assessment and FLEX Equipment Staging,” 1-FSG-99 Appendix D, “480 V Electrical AC Bus Preparations – Phase 2,” 1-FSG-99 Appendix C, “Electrical Bus Preparation – Phase 3,” and 1-FSG-99 Appendix E, “Staging, Installation and Operation of the FLEX 480 V Diesel Generator.” Based on the NRC staff's review, the minimum required loads for Phase 2 equate to 200 kW (234 kVA) for Unit 1 and 197 kW (231 kVA) for Unit 2. Therefore, the NRC staff verified that one 405 kW FLEX DG per unit is adequate to support the electrical loads required for either the primary or the alternate Phase 2 strategies. Furthermore, the licensee's Phase 2 electrical strategy ensures that the safety-related battery chargers will be energized prior to the batteries becoming fully discharged.

According to the licensee's FIP, the Phase 3 strategy includes receiving four (2 per unit) 1-megawatt (MW) 4160 VAC 3-phase turbine generators and two (1 per unit) 1 MW 480 VAC 3-phase turbine generators from an NSRC. These turbine generators could be used to supply power to the battery chargers, ventilation, motor operated valves, and other miscellaneous loads. Additionally, the licensee's Phase 3 strategies for all modes of RCS cooling is to reestablish normal SDC, which will require an NSRC pumping system capable of cooling the CCW heat exchanger that in turn cools the SDC heat exchanger and a NSRC 4160 VAC generator to power CCW and LPSI pumps. The NRC staff reviewed calculations, conceptual single line electrical diagrams, the separation and isolation of the FLEX turbine generators from the Class 1E emergency DGs, and procedures that direct operators how to align, connect, and protect associated systems and components. Each turbine generator is capable of supplying approximately 1 MW, but two turbine generators will be operated in parallel to provide approximately 2 MW (2.5 MVA at .8 pf). Based on the licensee's calculations, the minimum required loads equate to 1134.7 kW for Unit 1 and 1328.9 kW for Unit 2. These minimum required loads would require a generator with a capacity of at least 1650 kW (2062.5 KVA at .8 pf). Sufficient margin exists between the calculated loading and the capacity of the turbine generators being supplied by the NSRC to ensure that the minimum required loads can function as expected. Power cables will be supplied with the NSRC 4160 VAC turbine generators for connection to the St. Lucie Class 1E 4160 VAC buses through the switchgear located in the electrical equipment rooms (EERs) of each unit.

The 480 VAC NSRC turbine generators come with the same style and size connectors as the on-site Phase 2 FLEX generators. Therefore, the licensee's Phase 3 strategy could utilize the Phase 2 electrical connections if needed. The capacity of the NSRC-supplied 480 VAC turbine generator is of greater capacity than the licensee's Phase 2 FLEX DGs. Therefore, the NRC staff concludes that the Phase 3 480 VAC turbine generators should provide adequate capacity to supply electrical loads (same as Phase 2) to maintain or restore core cooling, SFP cooling, and containment indefinitely following an ELAP.

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

3.2.4 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, which appears to be 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

Order EA-12-049 requires that SFP cooling capabilities be maintained or restored as part of an overall strategy to mitigate a BDBEE. In NEI 12-06, Section 3.2.1.1 implements this requirement, in part, by establishing a provision to keep fuel in the SFP covered. In NEI 12-06, Table 3-2 and Appendix D 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 spent fuel pool cooling piping or other alternate location capable of exceeding the boil-off rate for the design basis heat load; and 3) spray via portable monitor nozzles from the refueling floor using a portable pump capable of providing a minimum of 200 gallons per minute (gpm) per unit (250 gpm to account for overspray). This approach will also provide a vent pathway for steam and condensate 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 provided that the time can be reasonably met. In NEI 12-06, Section 3 provides the performance attributes, general criteria, and baseline assumptions to be used in developing the technical basis for the time constraints. Since the event is 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. NEI 12-06, Section 3.2.1.2 describes the initial plant conditions for the at-power mode of operation; Section 3.2.1.3 describes the initial conditions; and Section 3.2.1.6 describes SFP initial conditions.

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

The 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

The FIP described the Phase 1 strategy for the SFP as deploying hoses and fittings on the Fuel Handling Building (FHB) operating deck necessary for make-up or spray strategies while the SFP is starting to heat up and to monitor spent fuel pool level using instrumentation installed as required by NRC Order EA-12-051. The deployment of hoses and fittings would be completed 2 hours after the declaration of an ELAP.

3.3.2 Phase 2

The FIP described the Phase 2 strategies to involve initiating SFP make-up using the hoses and fittings deployed into the FHB in phase 1 or using the hard pipe connections at the ground elevation to direct water supplied by the FLEX SFP pump into the pool. The FLEX SFP pump would be deployed to the east side of the FHB between the units to use the preferred water from the Fort Pierce Utilities supply line. The intake canal would be the backup water source for SFP make-up if the supply line is not available. The intake canal is protected from the external events defined in NEI 12-06. The licensee indicated that the FLEX SFP pump would be deployed to the Unit 2 intake structure to draft water from the intake canal. The required hose lengths and fittings for the suction and ground level discharge of the FLEX SFP pump are located in the fully protected FESB. The FLEX SFP pump is trailer mounted and will be towed to the selected deployment location by a tow vehicle within 23 hours after an ELAP is declared. The discharge of the pump would be connected to a hose connection outside of the FHB or a hose connection at the suction of the SFP pumps inside the FHBs. The licensee also described in the FIP that spray monitors and sufficient hose length required for the SFP spray option are located in the FHB in cabinets at the operating deck level (62 ft. elevation). The hoses to connect these to the ground level FLEX SFP pump discharge will be deployed down from the operating deck elevation to expedite deployment at the same time when ventilation is established for the FHB.

3.3.3 Phase 3

The FIP described that the Phase 3 strategies would continue the SFP cooling and make-up strategy from Phase 2 indefinitely. This will be accomplished by the arrival of additional equipment from offsite response centers in Phase 3, which will provide additional capability and redundancy to supplement the Phase 2 strategies and equipment.

3.3.4 Staff Evaluations

3.3.4.1 Availability of Structures, Systems, and Components

3.3.4.1.1 Plant SSCs

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

During the audit review, the licensee provided calculations Calc PSL-1FJF-13-091, "St. Lucie Unit 1 Cycle 25 Reload EC – SFP Decay Heat," Revision 0 and Calc PSL-2FJF-13-232, "St. Lucie Unit 1 Cycle 21 Reload EC – SFP Decay Heat," Revision 2. The purpose of these calculations are to determine the time after a BDBEE when the SFP exceeds the dry bulb temperature limit for habitability. These calculations and the FIP, indicate that boiling begins at approximately 5 hours for Unit 1 and 6 hours for Unit 2 during a normal, non-outage situation. The staff noted that the licensee's sequence of events timeline in its FIP, indicates that operators will complete deployment of hoses and spray nozzles as a contingency for SFP make-up within 3 hours from event initiation to ensure the SFP area is habitable for personnel entry during deployment. The licensee also referenced Calc NAI-1784-002, "St. Lucie Nuclear Plant Units 1 and 2 Fuel Handling Building Beyond Design Basis Event Analysis on Habitability on the SFP refuel floor," Revision 0, as the document used to develop guidance in the FSGs for deploying and staging equipment specific to the FHB for SFP make-up.

As described in its FIP, the licensee's Phase 1 SFP cooling strategy does not require any anticipated actions other than deployment. However, the licensee does establish a ventilation path to cope with temperature, humidity and condensation from evaporation and/or boiling of the SFP. The operators are directed to block open two personnel doors at the operating deck elevation of the FHB and opening the double door at the ground elevation of the FHB to establish natural circulation. The licensee evaluated that the airflow through these doors would provide adequate vent pathways through which the steam generated by SFP boiling can exit the FHB.

The licensee's Phase 2 and Phase 3 SFP cooling strategy involves use of the FLEX SFP pump and associated hoses and fittings, with suction from the Fort Pierce Utilities supply line or intake canal to supply water to the SFP. The NRC staff's evaluation of the robustness and availability of FLEX connections points for the FLEX SFP pump is discussed in SE Section 3.7.3.1 below. Furthermore, the NRC staff's evaluation of the robustness and availability of the Fort Pierce Utilities supply line and intake canal for an ELAP event is discussed in SE Section 3.10.3.

3.3.4.1.2 Plant Instrumentation

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

3.3.4.2 Thermal-Hydraulic Analyses

Section 11.2 of NEI 12-06 states, in part, that design requirements and supporting analysis should be developed for portable equipment that directly performs a FLEX mitigation strategy for core, containment, and SFP that provides the inputs, assumptions, and documented analysis that the mitigation strategy and support equipment will perform as intended. In addition, NEI 12-06, Section 3.2.1.6, Condition 4 states that SFP heat load assumes the maximum design basis heat load for the site. In accordance with NEI 12-06, the licensee performed a thermal-hydraulic analysis of the SFP as a basis for the inputs and assumption used in its FLEX equipment design requirements analysis. The licensee referenced hydraulic calculation FPL064-CALC-006, "Spent Fuel Pool FLEX Pump Sizing," Revision 1, which indicated that with no operator action following a loss of SFP cooling at the maximum design heat load (plant shutdown, full core offload), the SFP will reach a bulk temperature of 200 °F in approximately 5 hours (Unit 1) or 6 hours (Unit 2) and boil off to a level 6 inches above the top of fuel in 45 hours for Unit 1 and 50 hours for Unit 2 unless additional make-up water is supplied to the SFP. Heat up and boil off times corresponding with the plant operating 100 days following refueling are 27 hours to 200 °F for Unit 1 and 32 hours on Unit 2. Heat up and boil times relating to 6 inches above fuel is at 240 hours for Unit 1 and 271 hours for Unit 2. The calculation concluded that a flow of 82 gpm will replenish the water being boiled on either unit. Deployment of the SFP hose connection from the FLEX SFP pump within 24 hours with a design flow of 250 gpm for each unit's SFP will provide for adequate make-up to restore the SFP level and maintain an acceptable level of water for shielding purposes.

3.3.4.3 FLEX Pumps and Water Supplies

As described in the FIP, the SFP cooling strategy relies one of two FLEX SFP pumps to provide SFP make-up for both units during Phase 2. In the FIP, Section 3.3.4.2 describes the hydraulic performance criteria (e.g., flow rate, discharge pressure) for the FLEX SFP pump. During the audit, the licensee provided calculation FPL064-CALC-006, "Spent Fuel Pool FLEX Pump Sizing," Revision 1, which evaluated the use of the SFP FLEX portable pump for Unit 1 SFP make-up from the Unit 2 intake canal as the most limiting case. The FLEX SFP pump has to deliver 600 gpm to provide each SFP with 300 gpm each. The pump is required to have a total system head of 536ft, with 5.5ft of NPSH available for the pump. The NRC staff noted that the performance criteria of a FLEX pump supplied from an NSRC for Phase 3 would allow the NSRC pump to fulfill the mission of the onsite FLEX SFP pump if the onsite FLEX SFP pump were to fail. As stated above, the SFP make-up rate of 82 gpm and SFP spray rate of 250 gpm both meet or exceed the maximum SFP make-up requirements as outlined in the previous section of this SE.

3.3.4.4 Electrical Analyses

The basic FLEX strategy for maintaining SFP cooling is to monitor the SFP level and provide make-up water to the SFP to maintain substantial radiation shielding and provide for cooling for the spent fuel due to boil-off of the water.

The licensee's FIP defined 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 at all units on the St. Lucie site (the licensee's strategy for RCS inventory control uses the same electrical strategy as for maintaining or restoring core cooling, containment, and spent fuel pool cooling). 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 spent fuel pool cooling strategy. The staff's review is discussed in detail in Section 3.2.3.6 of this SE.

3.3.5 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore SFP cooling following a BDBEE, which appears to be 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

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

In accordance with NEI 12-06, the licensee performed a St. Lucie containment evaluation FPL064-CALC-003, "MAAP Containment Analysis," Revision 0, which was based on the boundary conditions described in Section 2 of NEI 12-06. The calculation concludes that the containment parameters of pressure and temperature remain well below the respective design limits of 44 psig and 264 °F (UFSAR Section 6.2, Table 6.2-1, Summary of Containment Analysis Pressure/Temperature Results and Criteria) for a minimum of 7 days. In addition, essential instruments subject to the containment environment will remain functional for a minimum of 7 days. From its review of the evaluation, the NRC staff noted that the required actions to maintain containment integrity and required instrumentation functions have been developed, and are summarized below.

The NRC staff reviewed calculation FPL064-CALC-003, "MAAP Containment Analysis," Revision 0. The calculation used the Modular Accident Analyses Program (MAAP) 4.0.7 computer code. The calculation forecasts the containment pressures and temperatures (pressures and temperatures are highest in the reactor cavity compartment) initially rise on loss of normal containment cooling to approximately 2 psig and 185 °F, respectively. After the first 12 hours, the rate at which the pressures and temperatures rise greatly reduces and the values almost level off. The maximum containment pressures reached for Unit 1 and Unit 2 were calculated to be 4.2 psig (at 120 hours) and 4.1 psig (at 119.5 hours), respectively, remaining well below the design basis limit of 44 psig. The calculation also indicates the maximum containment temperatures reached for Unit 1 and Unit 2 are 197.5 °F (at 11.5 hours) and 194.9 °F (at 117.6 hours), respectively, which remain below the design limit of 264 °F.

Eventual containment cooling and depressurization to normal values may utilize off-site equipment and resources during Phase 3. For scenarios with SGs removing core decay heat, no specific coping strategy is required for maintaining containment integrity during Phase 1, 2 or 3. Review of once-through-cooling scenarios for Modes 5 and 6 without SGs is discussed in Section 3.11.

3.4.1 Phase 1

The licensee's containment analysis shows that there are no Phase 1 actions required. 1(2)-EOP-10, "Station Blackout" verifies containment isolation. Containment pressure and temperature will be monitored using installed instrumentation.

3.4.2 Phase 2

The licensee's containment analysis shows that there are no Phase 2 actions required. Containment pressure and temperature will continue to be monitored using installed instrumentation. Phase 2 activities to repower instruments are adequate to facilitate continued containment monitoring.

3.4.3 Phase 3

Necessary actions to reduce containment temperature and pressure and to ensure continued functionality of the key parameters will utilize existing plant systems restored by off-site equipment and resources during Phase 3. The most significant need is to provide 4.16kV power to station pumps.

Phase 3 strategies for all modes of maintain containment cooling will be to establish SDC which will require an NSRC pumping system capable of cooling the CCW heat exchanger that in turn cools the SDC heat exchanger and a NSRC 4.16 KVAC generator to power CCW and LPSI pumps.

The Phase 3 coping strategy discussed above is to obtain additional electrical capability and redundancy for on-site equipment until such time that normal power to the site can be restored. This capability will be provided by 1MW 4kV portable combustion turbine generators provided from the NSRC for each St. Lucie unit. Two mobile 4kV combustion turbine generators for each unit will be supplied by NSRC in order to provide power to either of the two Class 1E 4kV buses on each unit. Additionally, by restoring the Class 1E 4kV bus, power can be restored to the Class 1E 480 VAC via the 4160/480 VAC transformers to power selected 480 VAC loads.

No additional specific Phase 3 strategy is required for maintaining containment integrity. With the initiation of SDC to remove core heat, the containment will depressurize without further action.

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 during an ELAP.

3.4.4.1.1 Plant SSCs

St. Lucie uses a large, dry concrete containment building, with its associated containment isolation system. The containment structure is a steel containment vessel surrounded by a reinforced concrete shield building. The two structures are separated by an annular air space. The containment vessel is a low leakage cylindrical steel shell with hemispherical dome and ellipsoidal bottom.

3.4.4.1.2 Plant Instrumentation

In NEI 12-06, Table 3-2, specifies that containment pressure is a key containment parameter which should be monitored by maintaining power to the appropriate instruments. St. Lucie stated in its FIP the key parameters for the containment integrity function are containment pressure and containment temperature, which can be obtained from essential instrumentation.

The above essential instrumentation will be available prior to and after load stripping of the dc and ac buses during Phase 1. All indications will be in the control room (CR). Should any of the signal cabling to the CR indicators be damaged or DC power lost, all process parameters can be obtained at remote locations with hand held devices. Procedure 1(2)-FSG-07 provides location and termination information in the CR for all essential instrumentation. For those containment transmitters where signal integrity is lost between the penetration and the CR, FSGs provide terminal numbers for the transmitter outputs at the (RAB) side of the penetrations. Scaling sheets to convert the transmitter milli-amp output, where applicable, to the process variable are provided as part of the FSG documentation. The hand held devices have built in power supplies which can be used to provide loop power. Portable FLEX equipment is supplied with the local instrumentation needed to operate the equipment. The use of these instruments is detailed in the associated FSGs for use of the equipment. These procedures are based on inputs from the equipment suppliers, operation experience, and expected equipment function in an ELAP.

Based on this information, the licensee should have the ability to appropriately monitor the key containment parameters as delineated in NEI 12-06, Table 3-2.

3.4.4.2 Thermal-Hydraulic Analyses

The NRC staff reviewed calculation FPL064-CALC-003, "MAAP Containment Analysis," Revision 0. This calculation used the MAAP computer code, version 4.0.7. Each unit was analyzed. The analysis covers plant operating Modes 1 through 4 with SGs available and external cooling water provided to maintain CST levels. An initial containment pressure was assumed to be -0.1 psig and an initial containment temperature was assumed to be 119.9 °F. The calculation modeled the containment pressure and temperature over a 120-hour period during an extended loss of AC power event.

The scenario consists of running the TDAFW pumps on an on-demand basis to maintain SG level with suction from the CST for the entire 120 hour duration. Between 10 and 14 hours, both SGs are linearly depressurized to about 300 psia. In the licensee's MAAP analysis, the reactor coolant leakage was assumed to be 1 gpm per RCP and 1 gpm from unidentified sources for a total leakage of 5 gpm. However, based on the NRC-endorsed "White Paper on the Response of the N-Seal Reactor Coolant Pump (RCP) Seal Package to Extended Loss of All Power (ELAP)," it was determined that the expected leakage rate for St. Lucie to be 1.5 gpm per RCP and 1 gpm of additional RCS leakage, which results in a total RCS leakage of 7gpm.

In the licensee's MAAP analysis, the maximum containment pressures reached for Unit 1 and Unit 2 was calculated to be 4.2 psig (at 120 hours) and 4.1 psig (at 119.5 hours), respectively. The calculation also indicates the maximum containment temperatures reached for Unit 1 and Unit 2 are 197.5°F (at 11.5 hours) and 194.9°F (at 117.6 hours), respectively.

The calculation concluded that the containment building remains below the internal design limits of 44 psig and 264°F for both units, so the licensee has adequately demonstrated that there is significant margin before a limit would be reached. During the onsite audit, the NRC staff reviewed and verified the conclusions of the calculation. Comparing the assumed leakage rates in the licensee's MAAP analysis to the endorsed values from the Flowserve white paper, the NRC staff determined that an increase from 5 gpm to 7 gpm would not affect the maximum calculated containment temperatures and pressures significantly. Therefore, the conclusion remains valid.

3.4.4.3 FLEX Pumps and Water Supplies

The NSRC is providing a high capacity low pressure pump which will be used to provide cooling loads via the SDC system as described in Section 3.2.3.5 of this SE.

3.4.4.4 Electrical Analyses

The licensee performed a containment evaluation analysis based on the boundary conditions described in Section 2 of NEI 12-06. Based on the results of this analysis, the licensee developed required actions to ensure maintenance of containment integrity and required instrumentation function. With an ELAP initiated, while either St. Lucie unit is in Modes 1-4, containment cooling for that unit is also lost for an extended period of time. Therefore, containment temperature and pressure will slowly increase. The licensee's analysis concluded that containment temperature and pressure will remain below containment design limits and that essential instruments subject to the containment environment will remain functional for a minimum of seven days. Therefore, actions to reduce containment temperature and pressure and to ensure continued functionality of the key parameters will not be required immediately. Eventual containment cooling and depressurization to normal values may utilize off-site equipment and resources during Phase 3. The most significant need is to provide 4160 VAC power to station pumps.

The Phase 1 coping strategy for containment involves verifying containment isolation per 1(2)-EOP-10 "Station Blackout", and monitoring containment temperature and pressure using installed instrumentation.

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

The Phase 3 coping strategy discussed in Section 3.2.3 of the FIP, is to obtain additional electrical capability and redundancy for on-site equipment until such time that normal power to the site can be restored. This capability will be provided by 4160 VAC turbine generators provided from the NSRC for each St. Lucie unit. Two 4160 VAC turbine generators for each unit will be provided from an NSRC in order to supply power to either of the two Class 1E 4160 VAC buses on each unit. Additionally, by restoring the Class 1E 4160 VAC bus, power can be restored to the Class 1E 480 VAC via the 4160/480 VAC transformers to power selected 480 VAC loads.

The NRC staff reviewed calculation "PSL FLEX 4160 VAC Diesel-Generator Sizing Report," dated November 19, 2013, conceptual single line electrical diagrams, the separation and isolation of the FLEX DGs from the Class 1E emergency DGs, and procedures that direct operators how to align, connect, and protect associated systems and components. Based on its review of the calculation, the NRC staff confirmed that two 1 MW 4160 VAC turbine generators per unit will provide sufficient capacity and capability to supply the necessary loads following an ELAP to maintain core cooling and containment. Refer to Section 3.2.3.6 above for additional analysis.

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, which appears to be 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 BDBEEs for each site. In addition, NEI 12-06 provides a process to identify potential complicating factors for the protection and deployment of equipment needed for mitigation of site-specific external hazards leading to an ELAP and LUHS.

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

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

References to external hazards within the licensee's mitigating strategies and this SE appear to be 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* (10 CFR) Part

50, Section 50.54(f) (ADAMS Accession No. ML12053A340) (hereafter referred to as the 50.54(f) letter), which requested that licensees reevaluate the seismic and flooding hazards at their sites using updated hazard information and current regulatory guidance and methodologies.

The NRC staff requested Commission guidance related to the relationship between the reevaluated flooding hazards provided in responses to the requested information and the requirements for Order EA-12-049 and related rulemaking to address beyond-design-basis external events (see COMSECY-14-0037, Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards" (ADAMS Accession No. ML14309A256). The Commission provided guidance in a SRM to COMSECY-14-0037 (ADAMS Accession No. ML15089A236). The Commission approved the staff's recommendations that licensees need to address the reevaluated flooding hazards within their mitigating strategies for BDBEEs, and that licensees may need to address some specific flooding scenarios that could significantly impact the power plant site by developing scenario-specific mitigating strategies, possibly including unconventional measures, to prevent fuel damage in reactor cores or SFPs. The NRC staff did not request that the Commission consider making a requirement for mitigating strategies capable of addressing the reevaluated flooding hazards be immediately imposed, and the Commission did not require immediate imposition. In a letter to licensees dated September 1, 2015, the NRC staff informed licensees that the implementation of mitigation strategies should continue as described in licensee's OIPs, and that the related NRC safety evaluations and inspections will rely on the guidance provided in JLD-ISG-2012-01, Revision 0 and the related industry guidance in Revision 0 to NEI 12-06. The reevaluations may also identify issues to be entered into corrective action programs consistent with the OIPs submitted in accordance with Order EA-12-049.

By letter dated March 10, 2015 (ADAMS Accession No. ML15083A264), the licensee submitted its flood hazard reevaluation report (FHRR), but the NRC staff review is ongoing. The licensee developed its OIP for mitigation strategies in February 2013 by considering the guidance in NEI 12-06 and its then-current design-basis hazards. Therefore, this SE makes a determination based on the OIP and FIP, and notes the possibility of future actions by the licensee if the licensee's FHRR identifies a flooding hazard which exceeds the current design-basis flooding hazard.

Per 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. By letter dated March 31, 2014 (ADAMS Accession No. ML14099A106), the licensee submitted its seismic hazard screening report (SHSR), the NRC staff has completed a review and the results are discussed in Section 3.5.1 below. The licensee developed its OIP for mitigation strategies by considering the guidance in NEI 12-06 and its then-current design-basis hazards. Therefore, this SE makes a determination based on the OIP and FIP, and only notes the possibility of future actions by the licensee when the licensee's SHSR identifies a seismic hazard which exceeds the current design-basis seismic hazard.

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 its FIP, the licensee stated that seismic hazards are applicable to the site. The maximum horizontal acceleration for the safe shutdown earthquake (SSE) is 0.10g., which was conservatively estimated and set at the legal minimum specified by 10 CFR 100, Appendix A. The maximum vertical acceleration for the postulated SSE is the same as the peak horizontal acceleration. It should be noted that the actual seismic hazard involves a spectral graph of the acceleration versus the frequency of the motion. Peak acceleration in the frequency range that affects structures, such as the numbers above, is often used as a shortened way to describe the hazard.

As previously discussed, the NRC issued a 50.54(f) letter that requested facilities to reevaluate the site's seismic hazard. 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 seismic hazard. The NRC staff completed a review of the St. Lucie SHSR and documented the results by letter dated January 7, 2016 (ADAMS Accession No. ML15352A053). The NRC staff concluded that the licensee responded appropriately and has completed its response to Enclosure 1, of the 50.54(f) letter. Further, the NRC staff review concluded that the reevaluated seismic hazard is bounded by the plants existing design-basis SSE and no further responses or regulatory actions associated with Phase 2 of Near-Term Task Force (NTTF) Recommendation 2.1 "Seismic" are required for St. Lucie.

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

3.5.2 Flooding

Per section 3.4.1 of the UFSAR, plant grade is at elevation +18 ft (Unit 1) and +18.5 ft (Unit 2) and minimum entrance level to all safety related buildings is +19.5 ft. Maximum elevation of roadways is +19.0 feet, thus any ponding of water that might result will be below the building entrances.

The plant is located on Hutchinson Island, a barrier island, situated between the Atlantic Ocean and the Indian River. The plant is situated above the highest possible water levels attainable except for wave run-up resulting from probable maximum hurricane (PMH) considerations. The maximum hurricane surge results in a still water elevation of 17.2 feet above mean low water (MLW) and wind induced waves to 18.0 feet above MLW (Unit 2 UFSAR, Section 2.4.2.2.b).

By letter dated March 10, 2015 (ADAMS Accession No. ML15083A264), the licensee submitted its FHRR. The reevaluation included an updated storm surge assessment, a LIP assessment, and the effects of Tsunami, and Seiche. The results of these assessments indicate the Storm Surge, Tsunami and Seiche flood levels remain below the power block elevation of 18.3 ft and the flood protection level of 19.5 ft. The FIP indicated that the margin to these levels is reduced in comparison with the CLB. However, the LIP assessment indicated that some internal flooding would result from LIP event but the flood volume would not exceed CLB internal flood hazard volumes.

By letter dated September 3, 2015 (ADAMS Accession No. ML15224B451), the NRC staff issued an Interim Staff Response Letter to provide a summary of the NRC Staff's assessment of the reevaluated flood-causing mechanisms described in the FHRR. The NRC staff concluded that the licensee's reevaluated flood hazards information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049 (i.e., defines the mitigating strategies flood hazard information described in guidance documents currently being finalized by the industry and NRC staff). Further, the NRC staff concluded that the licensee's reevaluated flood hazard information is a suitable input for other assessments associated with NTTF Recommendation 2.1, "Flooding". The NRC staff plans to issue a staff assessment documenting the basis for these conclusions at a later time.

As the licensee's flooding 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 to be evaluated.

3.5.3 High Winds

The screening for high wind hazards associated with hurricanes should be accomplished by comparing the site location to NEI 12-06, Figure 7-1 (Figure 3-1 of U.S. NRC, "Technical Basis for Regulatory Guidance on Design Basis Hurricane Wind Speeds for Nuclear Power Plants," NUREG/CR-7005, December, 2009); if the resulting frequency of recurrence of hurricanes with wind speeds in excess of 130 mph exceeds 10^{-6} per year, the site should address hazards due to extreme high winds associated with hurricanes.

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

The licensee stated in its FIP, that current plant design bases address the storm hazards of hurricanes, high winds and tornados. The high wind hazard is applicable for St. Lucie. St. Lucie is a coastal site located in southern Florida. The FIP indicated that St. Lucie is situated near the 240 mph hurricane contour shown in Figure 7-1 of NEI 12-06. In the UFSAR, Section 3.3.2 states that the design tornado has a horizontal rotational wind speed of 300 mph and translational speed of 60 mph. These values indicate that St. Lucie has the potential to experience severe winds from hurricanes and tornadoes with the capacity to do significant damage, which are generally considered to be winds above 130 mph as defined in NEI 12-06 Section 7.2.1.

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

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

The licensee indicated in its FIP that St. Lucie is located in South Florida below the 35th parallel. Per Section 8 of NEI 12-06, the licensee concluded that snow, ice, or extreme cold hazard conditions do not apply to St. Lucie and provisions for this hazard will not be included in the FLEX strategy.

Therefore, snow, ice, and extreme cold are not applicable to the plant site. The licensee has appropriately screened out the snow, ice, and extreme cold hazard.

3.5.5 Extreme Heat

The licensee stated in its FIP, that the climate at St. Lucie is typical of that in southern Florida, being hot and humid in the summer and mild in the winter. Per UFSAR Table 2.3-10, St. Lucie on Hutchinson Island has an average maximum temperature ranges from 72 °F in February to 87 °F in August. In the UFSAR, Tables 2.3-10, Unit 1 and 2.3-37, Unit 2, illustrate the monthly distribution of temperature and extremes recorded in the area. Long-term temperature statistics for West Palm Beach (climate characteristics are very similar to Hutchinson Island) indicate a 101 °F maximum extreme.

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

3.5.6 Conclusions

Based on the evaluation above, the NRC staff concludes that the licensee has developed a characterization of external hazards that appears 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

In its FIP, the licensee described that FLEX equipment will be stored in the FESB, which was verified by the NRC staff by reviewing Procedure 0-OSP-83.05, "FLEX Equipment Inventory, Revision 3. The FESB is protected from the hazards as described above. Below are additional details on how FLEX equipment is protected from each of the external hazards.

3.6.1.1 Seismic

In its FIP, the licensee described that FLEX equipment will be stored in the FESB. In its OIP, the licensee described that all FLEX equipment, including the tow vehicles and debris removal equipment, will be secured for a SSE. During the audit process, the NRC staff verified that FLEX equipment will be secured as appropriate for a potential SSE and will be protected from seismic interactions from other components.

3.6.1.2 Flooding

The plant grade is at elevation +18 ft (Unit 1) and +18.5 ft (Unit 2) and minimum entrance level to all safety related buildings is +19.5 ft. Maximum elevation of roadways is +19.0 feet, thus any ponding of water that might result will be below the building entrances. As noted in Section 3.5.2 of this SE, the plant is situated above the highest possible water levels attainable except for wave run-up resulting from PMH considerations. In addition, the FESB is protected from flooding events. However, during hurricane induced flooding events, access to areas in the plant, as well as access to the FESB, could be restricted due to flood waters. To account for this event, St. Lucie's strategy to maintain core cooling was developed such that access to Phase 2 FLEX equipment and access to environmentally harsh areas would not be required until the flood waters receded.

3.6.1.3 High Winds

As described in Section 3.6.1 of this SE, all FLEX equipment is stored in a building capable of withstanding the site design-basis high wind conditions (including tornado missiles). According to the licensee, this meets the protection guidance for external events identified in NEI 12-06, such as storms with high winds, and tornadoes.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

As stated in the FIP, the guidelines provided in NEI 12-06 exclude the need to consider extreme snowfall at plant sites in the southeastern U.S. below the 35th parallel. St. Lucie is located below the 35th parallel and thus the capability to address impedances caused by extreme snowfall with snow removal equipment need not be provided.

FLEX equipment (i.e., pumps, diesel generators, etc.) has been selected to be capable of operating in hot weather at or in excess of the site extreme maximum of 101 °F which is below the threshold of 110 °F discussed in NEI 12-06. Thus, it is not expected that FLEX equipment and deployment would be affected by high temperatures. Storage of FLEX equipment in the FESB includes ventilation to maintain peak summer temperature at 80 °F at 45 percent humidity inside the building.

3.6.2 Reliability of FLEX Equipment

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

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

3.6.3 Conclusions

Based on the licensee's plan to store all of their onsite portable FLEX equipment in a fully protected structure, the NRC staff review concludes that the licensee has provided a storage location that is appropriately protected from the applicable external hazards for the site in accordance with the provisions of NEI 12-06. Further, the NRC staff concludes that the licensee has stored sufficient equipment to accomplish the elements of their overall strategy that depend on this equipment (primarily Phase 2 operations). Therefore, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should protect the FLEX equipment during a BDBEE, which appears to be 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

The licensee stated in its FIP that pre-determined, preferred haul paths have been identified and documented in the FSGs. Figure 4 of the FIP shows the haul paths from the FESB to the various deployment locations. These haul paths have been reviewed for potential soil liquefaction and have been determined to be stable following a seismic event.

3.7.1 Means of Deployment

The deployment of onsite FLEX equipment to implement coping strategies beyond the initial plant capabilities (Phase 1) requires that pathways between the FESB and various deployment locations be clear of debris resulting from seismic, high wind (tornado), or flooding events. The stored FLEX equipment includes tow vehicles, backhoe/loader and Bobcat equipped with front end bucket and rear tow connections to provide a means to move or remove debris from the needed travel paths. In addition, the tow vehicles will be used to deploy the pumps, DGs, boration units and hose trailers.

Security doors and gates that rely on electric power to operate opening and/or locking mechanisms can be overridden by manual key locks; all operators have access to and security personnel carry the required key to open all doors and gates.

Additionally, the preferred haul paths attempt to avoid areas with trees, power lines, narrow passages, etc. when practical. However, high winds can cause debris from distant sources to interfere with planned haul paths. Debris removal equipment is stored inside the FESB, which protects the equipment from severe storm and high wind hazards such that the equipment remains functional and deployable to clear obstructions from the pathway between the FESB and its deployment location(s).

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 four NSRC receiving locations for St. Lucie and from the various plant access routes may be required. The same debris removal equipment used for on-site pathways will be used to support debris removal to facilitate road access to the site.

3.7.2 Deployment Strategies

In its FIP, the licensee stated that the haul paths were reviewed for potential soil liquefaction. The soil liquefaction analysis concluded that for the postulated ground motions the potential liquefaction results in a ground settlement of 6 to 12 inches. In addition, the restoration of haul paths of this low magnitude is within the capability of the FLEX debris removal equipment. The NRC staff reviewed document Enercon Report FPLSL138, Report of Liquefaction Potential Assessment, Revision 0, to verify the licensee's conclusions and the NRC staff believes that liquefaction should not inhibit the necessary equipment deployment after an earthquake.

For the RCS cooling strategy, the portable, diesel driven FLEX SG pumps provides the backup for the TDAFW pump during Phase 2. The FLEX SG pumps will be staged near the CSTs taking suction from the CST discharge connections located inside the seismic Category I, tornado missile protected CST buildings. To provide make-up to the CST, portable, diesel driven FLEX CST pumps will be deployed near the selected water source and connected to the CST. As stated in the FIP, the selected water sources are based on water quality, with demineralized water being preferred followed by potable water. Section 3.10.1 of this SE summarizes the water sources.

For cases where the CSTs are unavailable, the FLEX SG pump will be deployed and take suction from the Unit 2 intake structure, which provides an indefinite supply of water RCS cooling. The intake structure is protected from the external hazards as listed in Section 3.5 of this SE.

For SFP make-up, the portable FLEX SFP pump will be deployed to the roadway east of the fuel handling buildings at its north or south end dependent of which location of preferred supply water (Fort Pierce Utilities) is available. In case of no availability of this preferred water supply, the FLEX SFP pump will be deployed to the Unit 2 intake structure to take direct suction.

For the electrical strategy, a FLEX 480 VAC generator for both Unit I and Unit 2 will be deployed to the roadway at the southeast corner of the reactor auxiliary buildings.

3.7.3 Connection Points

3.7.3.1 Mechanical Connection Points

Core Cooling (SG) Primary and Alternate Connections

In its FIP, the licensee described the primary connection for the TDAFW pump discharge for SG injection, which is located on the TDAFW pump discharge line in the AFW pump room. A hose will be routed from the FLEX SG pump discharge to the primary connection in the AFW pump room. This connection supports symmetric flow to both SGs. The FIP described the alternate connection for the SG injection as being located on the TDAFW pump discharge line in the AFW pump room. This connection supports symmetric flow to both SGs. A flexible hose will be routed from the FLEX SG pump discharge to the alternate connection. In regards to CST make-up from the various water sources on the St. Lucie site or connection of the CST to the FLEX SG pump directly, the FIP described the connection as being located inside the seismically qualified and missile and flood protection of the CST building. The connection includes a hose coupling suitable for easy connection of a hose supplying water from the FLEX CST pump that draws from one of multiple sources of water to refill the CST. The NRC staff's evaluation of the licensee's hydraulic analyses for the FLEX SG and CST pumps can be found in SE Section 3.2.3.5. Due to the design and locations of the primary and alternate AFW connection points, as described in the FIP, at least one of the connection points should be available to support core cooling through a portable FLEX SG pump during an ELAP caused by a BDBEE, which appears to be consistent with NEI 12-06, Section 3.2.2 and Table D-1.

RCS Inventory Control Primary and Alternate Connections

The licensee described the primary connection for RCS make-up in its FIP as coming from the discharge of the FLEX SG pump and into the RCS as a permanently installed hose connection located downstream of the LPSI pump "A" discharge motor operated valves to the RCS cold legs. The licensee described the primary supply to the FLEX SG pump for RCS make-up being through a permanent hose connection to a tank nozzle allowing borated water from the RWT to be supplied to the FLEX SG pump. In the event that one unit's RWT is damaged, the suction hose to the FLEX SG pump can be routed from the opposite units' RWT alternate connection to provide a borated water source to the FLEX SG pump. The licensee described the alternate connection for the LPSI as a permanently installed hose connection located downstream of the LPSI pump "B" discharge motor-operated valves to the RCS cold legs. The licensee indicated that the alternate supply to the FLEX SG pump for RCS make-up is through a permanent hose connection to a manway installed on the RWT. Due to the design and location of the primary and alternate RCS injection connection points, as described in the FIP, consistent with NEI 12-06, Section 3.2.2 and Table D-1, at least one of the diverse connection points should be available to support RCS injection through the FLEX SG pump during an ELAP that occurs in non-operating modes.

Instrument Air Connections

The FIP described that during an ELAP event with the loss of all AC power and instrument air, reactor core cooling and decay heat will be removed from the SGs for an indefinite time period by manually opening or throttling the SG ADVs. The Unit 1 ADVs are manually operated by positioners in the CR with the assistance of the nitrogen backup bottles that are locally connected by a hand loader. The Unit 2 ADVs controllers will be powered by dc batteries and also operated from the control room. The ADVs for both units are safety-related, missile-protected, seismically qualified valves.

SFP Make-up Primary and Alternate Connections

The FIP described the primary hose connection for the permanent, seismically designed SFP make-up as being located on the outside wall of the FHB. The primary emergency SFP make-up connection is sufficiently sized to maintain SFP level long-term with the loss of SFP cooling and a make-up rate of 250 gpm for SFP boil off and overspray. The new make-up connection to the SFP would not require operators to enter the FHB to initiate make-up strategies. The new backup SFP protected make-up connection line is a 2½-inch 150 lb. class stainless steel line with valve and inlet hose adapter that tees into the existing 8-inch 150 lb. class stainless steel line at the suction of the "A" SFP pump at the ground elevation of the FHB. The existing line is open to the SFP as the normal cooling return header. The new connection is made to provide a backup to the existing outside connection that is not missile protected. Deployment of the hoses and fittings for this connection would occur during Phase 1.

The licensee also described in its FIP, the alternate Phase 2 strategy for providing make-up water from the supply line or intake canal to the SFP. The licensee indicated that the FLEX SFP pumps and associated hoses and fittings will be used to discharge directly to the SFP. The hoses and fittings will be run down to the ground elevation to be connected to the FLEX SFP pump through its discharge hoses and fittings. The SFP make-up hoses will be clamped to the spent fuel handling machine rails to fix their position so that water can be discharged directly into the pool. The licensee also described the spray strategy in the FIP (as required by NEI 12-06 Table D-3 for providing spray at 250 gpm), which is to provide flow through portable spray monitors set up on the FHB operating deck next to the SFP. These spray monitors will spray water from either the supply line or intake canal into the SFP to maintain spent fuel assembly cooling. The FLEX SFP pump and its suction hoses and fittings plus its discharge hoses and fitting that are deployed at ground level are deployed from the FESB. As described in Section 3.3.2 of this SE, the hoses and fittings on the higher elevation of 62 ft. will already be located in the protected FHB.

3.7.3.2 Electrical Connection Points

Electrical connection points are only applicable for Phases 2 and 3 of the licensee's mitigation strategies for a BDBEE. During Phase 2, the licensee has developed a primary and alternate strategy for supplying power to equipment required to maintain or restore core cooling, containment, and SFP cooling using a combination of permanently installed and portable components. The licensee will deploy a 480 VAC portable DG for both Unit 1 and Unit 2 to the roadway at the southeast corner of the reactor auxiliary buildings (RAB) as part of its strategy for transitioning to Phase 2. The Phase 2 FLEX 480 VAC generators have fourteen 400-amp rated, 1-pole camlock connectors (labeled and color coded) fed by one 600 amp circuit breaker. The circuit breaker feeds an individual set of camlock connectors per phase.

Two DG connection cabinets (primary and secondary), outfitted with quick disconnect cam-lock type connectors are mounted inside the RAB (the RAB is a Class 1 structure that is designed to protect against design-basis hazards such as seismic, winds, and flooding) on elevation 43.0'. A third connection cabinet, outfitted with quick disconnect cam-lock type connectors, is mounted in close proximity to the load centers on elevation 43.0'. These connection cabinets will be the interface point between the portable DG and the 480 VAC station electrical distribution system.

Flexible weatherproof cables with weatherproof connectors are installed between the primary or secondary connection cabinets and the portable DGs. The connecting cables are pre-staged near the seismically qualified connection cabinets in a seismically qualified cable storage cabinet. Permanent cables have been installed (routed in existing cable trays and new conduits) between the new connection cabinets and the new circuit breaker that have been installed at the primary load center connection and the third cabinet. In a BDBEE scenario, the portable generator will be connected to one of the two connection cabinets using three 1/conductor #4/0 American Wire Gauge (AWG) color-coded portable cables per phase that are pre-fabricated with matching cam-lock connectors. Portable cables will then be installed between the third connection cabinet and the primary load center connection point.

On Unit 1, an additional 480 VAC 3-phase power distribution panel has been installed to provide power to the SIT MOVs and other loads as deemed necessary requiring cross-tie capabilities during a FLEX scenario. This panel is powered by permanently installed cabling from an existing 100-amp air-frame, 90-amp trip setting breaker located in the swing MCC 1AB. Two 480 VAC 3-phase receptacles, supplied by the power distribution panel, are used for quick connections to selected MOVs during a FLEX scenario. Two cable assemblies, for use with MOVs during a FLEX scenario, comprised of 4-1/conductor #10 AWG SO (Severe Service/Oil Resistant Outer Jacket) cord type cables and a mating plug at one end, are provided and stored locally for quick connection to the receptacles.

For Unit 2, a 3-phase power distribution panel, to be used to provide power to loads requiring cross-tie capabilities during a FLEX scenario will be powered from an existing swing MCC spare compartment. This distribution panel includes seven 480 VAC/3-phase receptacles, to be used for quick connections to SIT MOVs and/or other loads during a FLEX scenario.

The primary connection for the Phase 2 480 VAC FLEX generator is at the 1(2)A2, 480 VAC load center. The 1(2)A charging pump is powered directly from the 1(2)A2 load center. A load center cross-tie to the 1(2)AB load center is also available. The alternate connection is at the 1(2)B2, 480 V load center. The 1(2)B charging pump is powered directly from the 1(2)B2 load center. A load center cross-tie to the 1(2)AB load center is also available.

Phase rotation for the 480 V DGs will be confirmed and controlled using color coded cables and phase rotation meters in the connection cabinets.

Connections for Phase 3 4160 VAC turbine generators will be procedurally controlled by the licensee. The NRC staff reviewed 1(2)-FSG-99, Appendix R, "Staging, Installation, and Operation of the FLEX 4.16 kV CTGs," which provides instructions for procedurally connecting the 4160 VAC FLEX turbine generator to either the 1(2)A3 or 1(2)B3 4160 VAC buses and re-energizing them to power selected loads such as the CCW pumps, containment fan cooler, LPSI pumps, and other loads as required. The primary connection for the Phase 3 4160 VAC turbine generators is at the 1B3/2A3, 4160 VAC switchgear. The 1B/2A LPSI and 1B/2A CCW pumps are powered directly from the 1B3/2A3 switchgear bus. The alternate electrical connection is at the 1A3/2B3, 4160 VAC switchgear. The 1A/2B LPSI pumps and 1A/2B CCW pumps are powered directly from the 1A3/2B3 switchgear bus.

Proper phase rotation will be determined by either 'bumping' a fan or motor prior to final connection or labeling of the bus bar after confirmation via testing.

3.7.4 Accessibility and Lighting

In its FIP, the licensee stated that the potential impairments to required access are: 1) doors and gates, and 2) site debris blocking personnel or equipment access. The coping strategy to maintain site accessibility through doors and gates is applicable to all phases of the FLEX coping strategies, and is immediately required as part of the immediate activities required during Phase 1. Doors and gates serve a variety of barrier functions on the site. One primary function is security and is discussed below. However, other barrier functions include fire, flood, radiation, ventilation, tornado, and high energy line break. As barriers, these doors and gates are typically administratively controlled to maintain their function as barriers during normal operations.

The licensee noted that following an a BDBEE and subsequent ELAP event, FLEX coping strategies require the routing of hoses and cables to be run through various barriers in order to connect beyond-design-basis (BDB) equipment to station fluid and electric systems or require the ability to provide ventilation. For this reason, certain barriers (gates and doors) will be opened and remain open. This deviation of normal administrative controls is acknowledged and is acceptable during the implementation of FLEX coping strategies. The ability to open doors for ingress and egress, ventilation, or temporary cables/hoses routing is necessary to implement the FLEX coping strategies.

In its FIP, the licensee described that CR emergency lighting is powered by the plant batteries and adequate portable lighting is provided to support activities outside of the CR. During an ELAP, it assumed that the majority of plant lighting is lost. Therefore, for the loss of plant lighting, the licensee will utilize flashlights, head lamps and batteries, which are maintained in the CR and in all FLEX cabinets. In addition, battery powered portable mining lamps are staged in the radiation monitor rooms. All of these locations are fully protected from external events as described in 3.5 of this SE.

3.7.5 Access to Protected and Vital Areas

In its FIP, the licensee states that security doors and gates that rely on electric power to operate opening and/or locking mechanisms will be opened using keys that are provided to operations personnel. The security force will initiate an access contingency upon loss of 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. During the audit process, the licensee indicated that FSG procedures will list the doors needed for access and that the shift manager has a key to vital areas under his control, as backup to the normal keys stored in the control room.

3.7.6 Fueling of FLEX Equipment

In its FIP, the licensee stated that the St. Lucie site will utilize the Unit 2 diesel oil storage tanks (DOST) as the primary source of fuel oil for portable equipment. The two DOSTs contains greater than 42,800 gallons of fuel oil and the tanks are protected from all external hazards as defined in Section 3.5 of this SE. The licensee plans to use gravity feeding through the 3" fill connection, which will be protected with two 3" valves mounted inside the DOST building. The FLEX refueler trailer will make connections to the 3" fill connection and provide fuel oil to the transfueler, which is deployed from the FESB. Each transfueler can store about 1,000 gallons of fuel oil, which is then deployed to refill the FLEX equipment fuel tanks throughout the site. The licensee indicated that all diesel fuel oil will be routinely sampled and tested to assure 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 emergency DGs. The licensee's evaluation of the fuel oil to be consumed after declaration of ELAP is about 65 gallons/hour, which can supply the FLEX equipment on site for approximately for 28 days. The licensee also indicated that the fuel oil needed for the large LUHS pump and 4kV generators will be provided from the NSRC. Additionally, operators would obtain fuel oil from off-site sources during Phase 3, if necessary.

During the audit, the staff reviewed the 1-FSG-99 procedure, which described the refueling strategy for the FLEX equipment and the FLEX equipment slated to be used after ELAP. The NRC staff also identified the location of the 3" fill connection and the new 3" valves for the refill process from the DOSTs to the transfuelers. A refueling timeline for major FLEX components has been developed and placed in the FLEX Program Document.

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, which appears to be 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 St. Lucie SAFER Plan

In its FIP, the licensee described that the industry has established two NSRCs to support utilities during BDBEE. Each NSRC holds five sets of equipment, four of which can be fully deployed when requested, the fifth set may have equipment in a maintenance cycle. Equipment is moved from an NSRC to the near site staging area, established by the SAFER team and the utility. Communications are established between the affected nuclear site and the SAFER team and required equipment moved to the site as needed. First arriving equipment, as established during development of the SAFER Response plan, is to be delivered to the site within 24 hours from the initial request. The licensee has signed a contract with SAFER to meet the requirements of NEI 12-06.

By letter dated September 26, 2014 (ADAMS Accession No. ML14265A107), the NRC staff issued its staff assessment of the NSRCs established in response to Order EA-12-049. In its assessment, the staff concluded that SAFER has procured equipment, implemented appropriate processes to maintain the equipment, and developed plans to deliver the equipment needed to support site responses to BDBEEs, which appears to be 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

In general, up to four staging areas for NSRC supplied Phase 3 equipment are identified in the SAFER Plans for each reactor site. These are a Primary (Area C) and an Alternate (Area D, if needed) which are offsite areas (within about 25 miles of the plant) for receipt of ground transported or airlifted equipment from the SAFER centers in Phoenix, Arizona or Memphis, Tennessee. From Staging Areas C and/or D, a near- or on-site Staging Area B is established for interim staging of equipment prior to it being transported to the final location for implementation in Phase 3 at Staging Area A. For St. Lucie, Alternate Staging Area D is Vero Beach Municipal Airport. Staging Area C is the North Palm Beach County Airport. Staging Area B is PSL Parking lot C with alternate at Parking lot B. Staging Area A are at the NSRC equipment connection points in the Intake Structures and Reactor Auxiliary Buildings.

Use of helicopters to transport equipment from Staging Area "C" to Staging Area "B" is recognized as a potential need and is provided for within the St. Lucie SAFER Plan.

3.8.3 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should allow utilization of offsite resources following a BDBEE, which appears to be 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 St. Lucie, ventilation providing cooling to occupied areas and areas containing FLEX strategy equipment will be lost. Per the guidance given in NEI 12-06, FLEX strategies must be capable of execution under the adverse conditions (unavailability of installed plant lighting, ventilation, etc.) expected following a BDBEE resulting in an ELAP.

The primary concern with regard to ventilation is the heat buildup which occurs with the loss of forced ventilation in areas that continue to have heat loads. The licensee performed several loss of ventilation analyses 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 and within equipment qualification limits.

The key areas identified for all phases of execution of the FLEX strategy activities are the CR, TDAFW pump rooms, battery rooms, EERs, and containment. The licensee evaluated these areas to determine the temperature profiles following an ELAP/LUHS event. With the exception of the CR, results of the calculation have concluded that temperatures remain within acceptable limits based on conservative input heat load assumptions for all areas with no actions initially being taken to reduce heat load or to establish either active or passive ventilation (e.g., portable fans, open doors, etc.).

The licensee issued Engineering Change EC282155, "PSL 1 Fukushima FLEX Strategy Implementation Umbrella Modification Electrical and I&C Evaluation White Paper Attachment 'PSL NRC Interim Safety Evaluation (ISE) Confirmatory Item 3.2.1.5.A – Rosemount pressure transmitters credited in an ELAP event will continue to function in the anticipated environmental conditions'," Revision 0 and Engineering Change EC282155, "PSL 1 Fukushima FLEX Strategy Implementation Umbrella Modification Electrical and I&C Supporting White Paper Attachment WP-A0185 – 'Rosemount Transmitters Functionality During ELAP Event'," Revision 0 to show that required instrumentation will function in the high temperature environment as a result of loss of ventilation for as long as it is needed to provide the FLEX function.

FLEX equipment (i.e. pumps, diesel generators, etc.) has been selected to be capable of operating in hot weather at or in excess of the site extreme maximum of 101 °F, which is below the threshold of 110 °F discussed in NEI 12-06. Thus, it is not expected that FLEX equipment and deployment would be affected by high temperatures. Storage of FLEX equipment in the FESB includes ventilation to maintain peak summer temperature at 80 °F at 45 percent humidity inside the building.

Main Control Room

The NRC staff reviewed calculation FPL064-CALC-008, "Control Room Heat-up Following Loss of AC power," Revision 2, which modeled the CR temperature transient through 72 hours following a BDBEE resulting in an ELAP. The calculation uses the GOTHIC version 7.2b computer program (Generation of Thermal-Hydraulic Information for Containments). The acceptance criterion for the calculated temperatures is based on the guidance in NUMARC 87-00, Revision 1, which states that a CR temperature of 120 °F is an acceptable limit for CR equipment operability. The Unit 1 CR analysis bounds the Unit 2 CR, due to similar geometry and lesser heat loads in Unit 2. The CR temperature rise will be mitigated by opening doors (RA52, RA53, RA57, and RA58 on Unit 1 and RA100, RA101, RA105, RA106, RA108 & RA114 on Unit 2) to provide cross-flow at 30 minutes following the ELAP. This is performed under SBO procedures to ensure that the temperatures remain within the acceptable range for equipment and personnel habitability. The calculation demonstrates that a ventilation flow of 13,500 cfm, deployed by 90 minutes following the onset of the event, in addition to the current SBO coping measures, is sufficient to maintain the CR temperature below the 120 °F limit for the duration of an SBO event. A 13,500 cfm portable fan will be staged in the doorway of RA53 to provide ventilation from the outside environment.

The CR GOTHIC calculation shows the CR temperature at 72 hours following the ELAP is 109.7°F. St. Lucie FLEX procedure FSG-5 includes guidance on the coping strategies for HVAC and habitability issues. Based on temperatures remaining below 120 °F (the temperature limit, as identified in NUMARC-87-00, for electronic equipment to be able to survive indefinitely), the NRC staff concludes that the equipment in the CR should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

TDAFW Pumps

The TDAFW pumps are installed in an outdoor environment within the qualified steam trestle. No ventilation fans are required for safety-related design functions or post-ELAP conditions. TDAFW pump bearings do not rely on external cooling systems. Electrical equipment and instrumentation that are relied upon during an ELAP are environmentally qualified for their safety related design function and do not require cooling to be available during the ELAP. The DC powered active valves that admit steam to and pass flow from the TDAFW pumps are qualified to operate under design outdoor environmental conditions. Thus, the TDAFW pumps do not require ventilation to maintain an environment that allows them to achieve the position relied upon for FLEX strategies.

Battery Rooms

Regarding battery room ventilation, the NRC staff reviewed the following calculations/analyses: FPL064-CALC-007, "Electrical Equipment Rooms: 1A, 1B, 1C Heat Up During an Extended Loss of Off-site Power," Revision 1, PSL-1FJM-92-030, "St. Lucie Unit 1 Electrical Heat Loads and Steel Mass Input for Use in Station Blackout Temperature Evaluation of the Control Room," Revision 3, NAI-1474-002, "Station Blackout Control Room and Reactor Auxiliary Building Area Temperature," Revision 1, and FPL064-CALC-008, "Control Room Heatup During an Extended Loss of AC power," Revision 0 and Revision 2.

During normal operations, the RAB HVAC system is designed to limit the maximum inside air temperature below 104 °F. The only heat load in the room is due to lighting following a loss of all AC power. Maximum battery room temperature is based on cell charging temperature limit of 120 °F. There is a very gradual reduction in the room temperature following a loss of all AC power event (less than 1 °F) due to losses through the boundary. The St. Lucie safety-related batteries are manufactured by C&D Technologies. The qualification testing performed by C&D Technologies demonstrated the ability to perform under elevated operating temperature environments. The testing results indicate that the battery cells will perform as required in excess of 200 days under an estimated 122 °F.

The elevated temperature also has an impact by increasing the charging current required to maintain the float charging voltage set by the charger. The elevated charging current will in turn increase cell water loss through an increase in gassing. Based on this, periodic water addition may be required or the float charging voltage reduced per the guidance contained in the C&D Technologies vendor manual. St. Lucie verifies battery electrolyte level on a weekly basis. If battery cell plate uncovery were to occur, failure issues associated with plates being exposed would involve the potential development of sulfation and a subsequent reduction in capacity. If loss or failure of a battery string were to occur, the battery charger has the capability to carry the anticipated loads indefinitely provided AC power remains available to power the charger.

Electrical Equipment Rooms

The NRC staff also reviewed the impact of temperature on electrical equipment in EERs (A, B, and C) during an ELAP. The NRC staff reviewed the following calculations/analyses: FPL064-CALC-007, "Electrical Equipment Rooms: 1A, 1B, 1C Heat Up During an Extended Loss of Off-site Power," Revision 1 and Revision 2, PSL-1FJM-92-030, "St. Lucie Unit 1 Electrical Heat Loads and Steel Mass Input for Use in Station Blackout Temperature Evaluation of the Control Room," Revision 3, NAI-1474-002, "Station Blackout Control Room and Reactor Auxiliary Building Area Temperature," Revision 1, and FPL064-CALC-008, "Control Room Heatup During an Extended Loss of AC power," Revision 0 and Revision 2.

For EERs A and B, an initial temperature of 104 °F (88 °F for EER C) was assumed (maximum design temperature with ventilation). The rest of the reactor building was assumed to be 104 °F (which is conservative since some areas are air conditioned at lower temperatures until the time of an ELAP). The licensee's calculations assumed a maximum outside temperature of 148.5 °F (incorporates the effects of solar radiation).

As mentioned previously, the licensee plans to deploy the Phase 2 480 VAC DGs within 9 hours of initiation of an ELAP event. This will restore power to the EER ventilation fans and prevent the EER temperatures from exceeding 120 °F. A maximum temperature of 120 °F is reached during the first 9 hours of an ELAP event. Based on EER temperatures remaining at or below 120 °F (the temperature limit, as identified in NUMARC-87-00, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," Revision 1, for electronic equipment to be able to survive indefinitely), the NRC staff concludes that the equipment in the EERs should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Steam Trestle Structure

During an ELAP event with the loss of all AC power and instrument air, reactor core cooling and decay heat will be removed from the SGs by manually opening/throttling the SG ADVs. On Unit 1, the throttling will be controlled locally via manual operation of handloaders supplied from backup nitrogen bottles. On Unit 2, power to the SG ADV controllers in the CR will be provided by the safety-related dc batteries. The SG ADVs and SG MSSVs are in the safety-related steam trestle structure. This structure is not subjected to harsh environmental conditions as a result of an ELAP event. Therefore, the NRC staff concludes that the ADVs should perform their required functions as a result of loss of ventilation during an ELAP event.

Reactor Containment Building

The licensee evaluated the reactor containment building post-ELAP conditions at the St. Lucie using MAAP analysis to predict containment pressure and temperature out to 120 hours after the event. The pressure and temperature rise early in the event with temperature slowing to approximately ½ °F per 10-hour rise starting around 20 hours reaching 174 °F (Unit 2) at 120 hours. Pressure similarly rises to 4.2 psig (Unit 1) at 120 hours. According to the licensee's FIP, at 120 hours, the licensee's FLEX strategies incorporate restart of the containment coolers to reduce the reactor containment building temperature and pressure.

The licensee's reliance on the harsh environmental qualification (EQ) for St. Lucie components under 10 CFR 50.49 to justify post-ELAP function includes a comparison of the EQ conditions and post-ELAP conditions. The EQ conditions include reactor containment building pressure and temperature profiles with peak conditions early (within 1 hour) in the timeline post-design basis accident and long term conditions out to 180 days for most components. For the majority of the timeline, qualification test conditions bound the EQ profiles and extend to between 5 and 30 days.

The licensee's reactor containment building post-ELAP analysis provides the basis for continued instrument and equipment functionality during a postulated ELAP event. This analysis coupled with the action to re-power and start containment fan coolers, contained in FSG-05, ensures that environmental conditions of the reactor containment building should not adversely impact equipment functionality.

Based on its review of the essential electrical equipment required to support the FLEX mitigation strategy, which are primarily located in the CR, TDAFWP Rooms, Battery Rooms, EERs, and containment, the NRC staff concludes that the equipment should perform their required functions at the expected temperatures as a result of loss of ventilation during an ELAP/LUHS event.

3.9.1.2 Loss of Heating

As discussed in Section 3.5.4, St. Lucie is located in South Florida below the 35th parallel. Per Section 8 of NEI 12-06, snow, ice, or extreme cold hazard conditions do not apply to St. Lucie. Therefore, provisions for this hazard is not included in the FLEX integrated plan.

3.9.1.3 Hydrogen Gas Control in Vital Battery Rooms

An additional ventilation concern applicable to Phase 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. The licensee plans to repower battery room roof exhausters RV-1 and RV-2 on Unit 1 and Electrical Equipment Room Roof Ventilator RV-3 or Supply Fan HVS-5B on Unit 2 at or before the time the battery chargers are placed into operation to prevent hydrogen accumulation. This would occur when the Phase 2 FLEX 480 VAC DG is deployed and connected to the electrical distribution system. The repowered roof exhausters draw flow from the battery rooms and exhaust the air including any hydrogen generated to the outside atmosphere above the RAB roof. The battery room roof exhausters are fans that are seismically qualified and protected from external hazards as defined in Section 3.5 of this SE. When powered from the 480 V FLEX DG, the battery room roof exhausters are placed in operation to provide ventilation consistent with that provided during normal operation.

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

3.9.2 Personnel Habitability

3.9.2.1 Main Control Room

The NRC staff reviewed calculation FPL064-CALC-008, "Control Room Heat-up Following Loss of AC power," Revision 2, which modeled the CR temperature transient through 72 hours following a beyond-design-basis external event resulting in an ELAP. The calculation uses the GOTHIC version 7.2b computer program (Generation of Thermal-Hydraulic Information for Containments). The acceptance criterion for the calculated temperatures is based on the guidance in NUMARC 87-00, Revision 1, which states that a CR temperature of 110°F is an acceptable limit for CR personnel habitability. The Unit 1 CR analysis bounds the Unit 2 CR, due to similar geometry and lesser heat loads in Unit 2.

As described above in Section 3.9.1.1, the licensee's strategy is to open doors at 30 minutes and deploy a minimum of 13,500 cfm ventilation fan at 90 minutes following the onset of the ELAP. The CR GOTHIC calculation shows the CR temperature at 72 hours following the ELAP is 109.7 °F. The temperature at the 72 hour mark satisfies the acceptance criteria of 110 °F. However, there is a brief 2 minute temperature transient at the beginning of the scenario, in which the CR temperature peaks to 110.9 °F at 90 minutes before additional mitigation strategies can be deployed. This exceeds the acceptance criteria of 110°F for CR habitability. The CR operators will need to follow heat stress guidance outlined in Procedure SA-AA-100-1008, "Heat Stress Control," Revision 2. Based on the temperature transient only slightly exceeding the acceptance limit for a brief period, and the fact that the CR temperature at 72 hours following an ELAP is 109.7 °F, the NRC staff concludes that the long term habitability in the CR should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

3.9.2.2 Spent Fuel Pool Area

Per NEI 12-06 guidance, a baseline capability for spent fuel cooling is to provide a vent pathway for steam and condensate from the SFP. The FLEX strategies for St. Lucie SFP cooling include opening doors and deploying hoses in Phase 1 prior to habitability in the FHB being degraded. The personnel doors at the operating (62 ft.) and ground (19.5 ft.) elevations was selected to allow for air flow and steam venting. The two doors at the 62 ft. elevation have 3 ft. x 7 ft. openings. One is northwest of the SFP surface elevation that is also 62 ft. The other door is south of the SFP on the new fuel storage area south wall that is open to the SFP via a normally open sliding doorway that has a 5.3 ft. x 30 ft. opening. The double door at the 19.5 ft. elevation has an 18 ft. x 15 ft. opening. Steam will be vented out of the FHB via these openings if boiling occurs in the SFP. The timing for the opening of the three personnel doors is provided in the timeline as occurring between 1 and 3 hours following an ELAP. St. Lucie FLEX procedure FSG-5 includes guidance on the coping strategies to establish FHB ventilation.

3.9.2.3 Other Plant Areas

FLEX Equipment Storage Building (FESB)

St. Lucie FLEX procedure FSG-5 includes guidance on the coping strategies for HVAC and habitability issues. In addition existing plant procedures addressing heat stress mitigation actions provide reasonable personnel will be able to implement FLEX mitigation activities.

Existing plant procedures addressing heat stress mitigation actions include:

- Procedure 0005753, Rev 84, Severe Weather Preparations
- Procedure SA-AA-100-1008, "Heat Stress Control," Revision 2

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, which appears to be 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

3.10.1 Steam Generator Make-Up

In its FIP, the licensee stated that for SG make-up, operators will provide water from any of the following sources as prioritized for water quality and availability based upon the BDBEE:

- Condensate Storage Tank
- Treatable Water Storage Tank (TWST)
- Primary Water Tanks (PWT)
- City Water Storage Tanks
- Fort Pierce Utilities Supply Line
- Refueling Water Tanks (RWT)
- Intake Canal

As described in SE Section 3.2.3.1.1, the CSTs provide sufficient inventory to meet Phase 1 requirements for about 17 hours between the inventory (about 465,950 gallons) shared by both CSTs before make-up is required. The qualified inventory excludes unusable volumes below the minimum suction nozzle submergence level. In regards to staging the FLEX CST pump for CST make-up for Phase 2, the operators are directed by the FSGs to make an assessment of water source availability following the applicable hazards identified in Section 3.5 of the FIP. The licensee indicated in its FIP, that at least three water sources (Fort Pierce Utilities supply line, RWTs, and intake canal) would survive all applicable hazards defined in Section 3.5 of this SE for St. Lucie and are credited for use in FLEX strategies. The deployment of each strategy is performed prior to the TDAFW or FLEX SG pump losing suction from the CSTs. The RWTs would supply the demineralized and borated water for RCS cooling up to 110 hours after CST depletion. The RWTs are qualified for seismic and flood hazards, but are not qualified for missile hazards. However, the separation of the RWTs and existing hardened structures as means that would lessen the probability of missile damage to both RWTs. The licensee also described in its FIP, that the use of make-up water from the Fort Pierce Utilities supply line, which have two stations separated at a distance of 1650 ft. to minimize tornado missile impacts. The licensee stated that if one supply station is unavailable due to the tornado missile event, it would be isolated from the underground supply main and the other station would be utilized as the water source. The licensee provided the evaluations of both of these water sources in evaluation PSL ENG-SECS-14-003, Revision 0, EC279993, "NRC Order EA-12-049 Response (Fukushima) PSL Tornado Missile Protected Water Sources." The licensee also indicated in the FIP that the intake canal would be the last resort for providing make-up to the SGs as a protected water source, although the water quality would be severely degraded for the SGs. The NSRC connection for the intake canal would be the NSRC pumping system.

The staff reviewed evaluation EC279993 and walked down the locations of the above water sources to confirm that the licensee did account for the distances and intervening structures for each RWT and the Fort Pierce Utilities supply line connections respectively. The NRC staff recognizes that the licensee has multiple protected water sources available on the site after an ELAP is declared, and therefore, concludes that the above water sources should be adequate for implementation of FLEX strategies for providing make-up to SGs for all three phases.

3.10.2 Reactor Coolant System Make-Up

In its FIP, the licensee stated that for RCS inventory control during Phase 2, the RWTs are the preferred source of borated make-up water for supplying the charging pumps. Each RWT can provide up to 477,360 gallons at a minimum boron concentration of 1900 ppm. The licensee also indicated in its FIP, that the BAMTs would be used to provide make-up borated water to the RCS if the RWTs are unavailable. Both BAMTs are seismically qualified, missile-protected tanks that maintained greater than 8,700 (Unit 1) and 8,750 (Unit 2) gallons at a minimum boron concentration of 5245 ppm (Unit 1) and 5420 ppm (Unit 2). Both water sources are protected from most external hazards, with the one exception in the case of the RWTs as described in SE Section 3.10.1. The NRC staff walked down the locations of the borated water sources to confirm the availability and hazard protection in the instance of RCS make-up for Phase 2.

3.10.3 Spent Fuel Pool Make-Up

In its FIP, the licensee stated that the SFP make-up for Phase 3 would be obtained from either the Fort Pierce Utilities supply line or the intake canal. Both water sources as described in SE Section 3.10.1 are protected from the external hazards as defined in Section 3.5 of this SE through design configuration or location. The licensee stated that the preferred water source will be the Fort Pierce Utilities supply line as available with the intake canal serving as the backup water source.

3.10.4 Containment Cooling

In its FIP, the licensee stated that the Unit 2 intake canal would serve as the backup make-up water source for the FLEX SG pump, which will provide a discharge line for RCS Heat Removal that supports containment cooling prior to deployment of NSRC pump systems. The licensee stated that access to draft intake water is through the hatches downstream of the Unit 2 traveling screens. As described in SE Section 3.10.1, the intake canal is a fully protected water source from all external events.

The licensee stated in its FIP, that the Phase 3 strategy for all modes of maintain containment cooling will be to establish SDC which will require an NSRC pumping system capable of cooling the CCW heat exchanger that in turn cools the SDC heat exchanger and a NSRC 4.16 KVAC generator to power CCW and LPSI pumps. No additional specific Phase 3 strategy is required for maintaining containment integrity. With the initiation of SDC to remove core heat, the containment will depressurize without further action.

3.10.5 Conclusions

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

3.11 Shutdown and Refueling Analyses

Order EA-12-049 requires that licensees must be capable of implementing the mitigation strategies in *all* modes. In general, the discussion above focuses on an ELAP occurring during power operations. This is appropriate, as plants typically operate at power for 90 percent or more of the year. When the ELAP occurs with the plant at power, the mitigation strategy initially focuses on the use of the steam-driven TDAFW pump to provide the water initially needed for decay heat removal. If the plant has been shut down and all or most of the fuel has been removed from the RPV and placed in the SFP, there may be a shorter timeline to implement the 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. In its FIP, the licensee described that the SFP will reach a bulk temperature of 200 °F in approximately 5 hours (Unit 1) or 6 hours (Unit 2) and boil off to a level 6 inches above the top of fuel in 45 hours for Unit 1 and 50 hours for Unit 2 unless additional water is supplied to the SFP. The licensee described a flow of 82 gpm will replenish the water being boiled on either unit. Therefore, the licensee concluded that deployment of the SFP hose connection from the FLEX SFP pump within 24 hours with a design flow of 250 gpm for each unit's SFP will provide for adequate make-up to restore the SFP level and maintain an acceptable level of water for shielding purposes.

When a plant is in a shutdown mode in which steam is not available to operate the steam-powered pump and allow operators to release steam from the SGs (which typically occurs when the RCS has been cooled below about 300 °F), another strategy must be used for decay heat removal. On September 18, 2013 (ADAMS Accession No. ML13273A514), NEI submitted to the NRC a position paper entitled "Shutdown/Refueling Modes," which described methods to ensure plant safety in those shutdown modes. By letter dated September 30, 2013 (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. The licensee stated in its FIP, that St. Lucie will abide by the guidance in the September 18, 2013, position paper. During the audit process, the NRC staff observed that the licensee had made progress in implementing this position paper. Subsequently, the licensee has implemented procedures 1(2)-AOP-99.02 to perform FLEX Strategies applicable to shutdown modes without SG's available.

Containment Analyses

Review of once-through-cooling scenarios for Modes 5 and 6 without SGs indicates containment venting will be required to prevent exceeding containment design conditions.

For Modes 5 and 6 without SGs, FSG-12, Rev 1/0 "Containment Temperature and Pressure Control," establishes a containment ventilation strategy that utilizes the installed emergency escape hatch and FHB doorways to ventilate containment.

The NRC staff reviewed calculation FPL064-CALC-003, "MAAP Containment Analysis," Revision 0. This calculation used the MAAP computer code, version 4.0.7. Each unit was analyzed. The analysis covers plant operating Modes 5 and 6 by utilizing the half-loop mode of MAAP to simulate "feed and bleed" scenario where the RCS is allowed to boil off through an opening in the pressurizer while make-up is provided to the cold leg. An initial containment pressure was assumed to be -0.1 psig and an initial containment temperature was assumed to be 119.9 °F. The calculation modeled the containment pressure and temperature over a 120-hour period during an extended loss of AC power event.

The scenario consist of using a feed and bleed strategy by feeding the RCS with 70 gpm of make-up and venting the RCS through a manway on the pressurizer. The emergency escape hatch will be used to vent the containment at 1 hour. This was substituted for the integrated leak rate test (ILRT) line in the MAAP Containment Analysis due to its short execution time and its greater capacity for venting compared to the ILRT line.

For both Unit 1 and 2, containment pressures rise to the peak value of 4.7 psig around 57 hours. For Unit 1/Unit 2, containment temperatures reach 212 °F in 13.8/13.4 hours, 220 °F in 24.0/23.1 hours, 226 °F in 63.1/62.6 hours, and do not exceed 230 °F.

The containment building remains below the internal design limits of 44 psig and 264 °F for both units.

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

3.12 Procedures and Training

Procedures

Regarding procedures, the licensee stated in the FIP that the inability to predict actual plant conditions that require the use of BDB 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 BDB equipment is needed to supplement emergency operating procedures (EOPs) or abnormal operating procedures (AOPs) strategies, the EOP or AOP will direct the entry into and exit from the appropriate FSG procedure.

FLEX strategy support guidelines have been developed in accordance with PWROG guidelines. The FSGs will provide available, preplanned FLEX strategies for accomplishing specific tasks in the EOPs or AOPs. The FSGs will be used to supplement (not replace) the existing procedure structure that establishes command and control for the event. Procedural interfaces have been incorporated into 1/2 EOP-10, "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 EOPs to include appropriate reference to FSGs:

- 1/2-EOP-15, Functional Recovery

- 1/2-EOP-99, Appendices, Figures, Tables, Data Sheets

The licensee also stated in its FIP, that FSG maintenance will be performed by the Operations Department group via the QI 5-PRJPSL-6, Requirements for Development and Revision of Emergency Operating Procedures. In addition, the licensee stated that validation has been accomplished via walk-throughs or drills of the guidelines and abides by the draft guidance provided by NEI and incorporated into NEI-12-06, Revision 1. The licensee concluded that the results confirm St. Lucie's capability to perform strategies within applicable time frames.

Training

In its FIP, the licensee 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. In addition, personnel assigned to the direct execution of mitigation strategies for BDBEEs have received the necessary training to ensure familiarity with the associated tasks, instructions, and mitigating strategy time constraints. The training plan development was done in accordance with St. Lucie's procedures using the Systematic Approach to Training (SAT).

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

3.13 Maintenance and Testing of FLEX Equipment

As a generic issue, NEI submitted a letter dated October 3, 2013 (ADAMS Accession No. ML13276A573), which included Electric Power Research Institute (EPRI) Technical Report 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment." In a letter dated October 7, 2013 (ADAMS Accession No. ML13276A224), the NRC endorsed the use of the EPRI report and the EPRI database as providing a useful input for licensees to use in developing their maintenance and testing programs. Preventative maintenance templates for the major FLEX equipment have also been issued.

In its FIP, the licensee stated that St. Lucie followed the EPRI generic industry guidance program for maintenance and testing of FLEX equipment, as endorsed by the NRC staff on October 7, 2013. The licensee described that FLEX mitigation equipment has been initially tested to verify performance conforms to the limiting FLEX requirements. The licensee states in its FIP, that preventive maintenance procedures and intervals have been established to ensure FLEX equipment is reliably maintained per manufacturer recommendations. Similarly, in its FIP, the licensee stated that surveillance procedures and intervals have been created for functional and performance testing of applicable FLEX equipment as well as equipment inventory of all required FLEX equipment and spares.

Based on the use of the endorsed program, which establishes and maintains a maintenance and testing program in accordance with NEI 12-06, Section 11.5, the NRC staff concludes that the licensee has adequately addressed equipment maintenance and testing activities associated with FLEX equipment.

3.14 Alternatives to NEI 12-06, Revision 0

The licensee's strategy of repowering installed charging pumps to provide RCS makeup to mitigate an ELAP event conflicts with the guidance provided in NEI 12-06, Section 3.2.2(13) that calls for the use of portable equipment. However, the NRC staff noted that the licensee's strategy involves:

- The capability to use one of three 100%-capacity, redundant pumps for each unit.
- One pump providing 44 gpm, which exceeds the maximum analyzed RCS leakage rate of 7 gpm.
- Diverse injection paths from the discharge of each charging pump are provided through either normal charging system piping or through high pressure safety injection piping.
- Suction can be taken from both the BAMTs and the RWT. The flowpath from the boric acid makeup tanks can either use the boric acid transfer pumps or bypass them with flow draining via gravity.
- Charging pumps that do not require external cooling water.
- A primary and alternate strategy for powering the charging pumps from the FLEX generator. The selected pump could be powered from the portable Phase 2 FLEX generator through either of two LC's which can be cross-connected so that either charging pump can be powered by either connection point.

Having considered the points made above, the NRC staff concludes that the licensee has a strategy to provide RCS makeup that should prevent damage to the core during an ELAP event in accordance with the requirement of Order EA-12-049. Therefore, the NRC staff concludes that the licensee's use of installed charging pumps as an acceptable alternative to NEI 12-06.

3.15 Conclusions for Order EA-12-049

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

4.0 TECHNICAL EVALUATION OF ORDER EA-12-051

By letter dated February 28, 2013 (ADAMS Accession No. ML13063A026), the licensee submitted its OIP for St. Lucie in response to Order EA-12-051. By letter dated July 16, 2013 (ADAMS Accession No. ML13196A079), the NRC staff sent an RAI to the licensee. The licensee provided a response by letter dated July 26, 2013 (ADAMS Accession No. ML13219A838). By letter dated November 19, 2013 (ADAMS Accession No. ML13274A473), the NRC staff issued an ISE and RAI to the licensee. By letter dated February 27, 2015 (ADAMS Accession No. ML15035A670), the NRC issued an audit report on the licensee's progress.

By letters dated August 27, 2013 (ADAMS Accession No. ML13242A006), February 28, 2014 (ADAMS Accession No. ML14064A193), August 27, 2014 (ADAMS Accession No. ML14253A185), February 23, 2015 (ADAMS Accession No. ML15071A265), and August 25, 2015 (ADAMS Accession No. ML15246A143), the licensee submitted status reports for the Integrated Plan. The Integrated Plan describes the strategies and guidance to be implemented by the licensee for the installation of reliable SFP level instrumentation, which will function following a BDBEE, including modifications necessary to support this implementation, pursuant to Order EA-12-051. By letters dated May 12, 2015 (ADAMS Accession No. ML15140A393), and December 10, 2015 (ADAMS Accession No. ML15350A394), the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved.

The licensee has installed a SFP level instrumentation system designed by Westinghouse. The NRC staff reviewed the vendor's SFP level instrumentation system design specifications, calculations and analyses, test plans, and test reports. The staff issued an audit report on August 18, 2014.

The staff performed an onsite audit to review the implementation of SFP level instrumentation related to Order EA-12-051. The scope of the audit included verification of (a) site's seismic and environmental conditions enveloped by the equipment qualifications, (b) equipment installation met the requirements and vendor's recommendations, and (c) program features met the requirements. By letter dated February 27, 2015, the NRC issued an audit report on the licensee's progress. Refer to Section 2.2 above for the regulatory background for this section.

4.1 Levels of Required Monitoring

Three SFP levels were identified in the OIP for reliable SFP instrumentation. These consist of the level required for normal SFP cooling function (56 ft. on both units), the level required to provide approximately 10 ft. of water shielding above the fuel (46 ft. 3 in. on Unit 1 and 46 ft. 5 in. on Unit 2) and the level where the fuel remains covered (37 ft. 3 in. on Unit 1 and 37 ft. 5 in. on Unit 2). The NRC staff reviewed these levels in the ISE and found they were acceptable. The same levels were again confirmed by the licensee in its FIP.

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

4.2 Evaluation of Design Features

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

4.2.1 Design Features: Instruments

In its OIP, the licensee stated that the primary and backup instrument channels will consist of affixed components and that the nominal measured range will be continuous from the normal pool level elevation (60 ft.-0 in. for both units) to the top of the spent fuel racks at elevation 37 ft. 3 in. for Unit 1 and 37 ft. 5 in. for Unit 2 (see Level 3 references above).

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

4.2.2 Design Features: Arrangement

In its letter dated August 28, 2013 (ADAMS Accession No. ML13242A006), the licensee provided two sketches depicting the planned locations of the SFP level probes and the locations of the level instrument components. In this letter, the licensee stated, in part, that the primary and backup instruments in both SFPs would be installed in opposite corners along the south side of each pool with approximately 33 ft of separation. During the onsite audit, walk downs of refueling floors was limited by ongoing work activity. The NRC staff reviewed FPL documents EC280519-E-002, Revision 1 and 8770-G-402-EC280519-009, Sheet 1 to confirm cable routing on refueling floor meets the guidance. Document 8770-G-402-EC280519-009, Sheet 1 shows full detail of the conduit routing.

The NRC staff noted 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 concludes that, if implemented appropriately, the licensee's proposed arrangement for the SFP level instrumentation appears to be consistent with NEI 12-02 guidance, as endorsed, by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.3 Design Features: Mounting

The NRC staff reviewed Westinghouse document CN-PEUS-13-28, "Seismic Analysis of the SFP Mounting Bracket at Point Beach Units 1&2 and Saint Lucie Units 1&2, "Revision 2, during the onsite audit. The document describes the mounting bracket and proposed configuration and includes a site specific structural analysis which considers loading due to wave impingement caused by sloshing induced by seismic activity. The staff verified that the document adequately demonstrated that the proposed bracket and mounting configuration will withstand the anticipated seismic activity including wave impingement from seismically induced sloshing.

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

4.2.4 Design Features: Qualification

4.2.4.1 Augmented Quality Process

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

In its OIP, the licensee stated that augmented quality requirements, similar to those applied to fire protection, would be applied to this project.

If implemented appropriately, this approach appears to be consistent with NEI 12-02 guidance, as endorsed, by JLD-ISG-2012-03 and should adequately address the requirements of the order.

4.2.4.2 Instrument Channel Reliability

NEI 12-02 states:

The instrument channel reliability shall be demonstrated via an appropriate combination of design, analyses, operating experience, and/or testing of channel components for the following sets of parameters, as described in the paragraphs below:

- conditions in the area of instrument channel component use for all instrument components,
- effects of shock and vibration on instrument channel components used during any applicable event for only installed components, and
- seismic effects on instrument channel components used during and following a potential seismic event for only installed components.

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

The NRC staff reviewed the SFPLI qualification testing during the vendor audit at Westinghouse (ADAMS Accession No. ML14211A346). During the on-site audit at St. Lucie, the staff verified proposed equipment locations and verified the anticipated conditions at these locations during BDB events to ensure they are enveloped by the vendor's qualification testing. The NRC staff confirmed site-specific information in its reviews of calculation NAI 1784-003, "St. Lucie Nuclear Plant Units 1 & 2 Fuel Handling Building Beyond Design Basis Event Summary Document" for temperature, humidity and radiation. Seismic qualification was confirmed in document PSL-1FSC-14-009, "Anchorage Qualification for SFP Instrumentation System Upgrades" and CN-PEUS-13-28, "Pool-side bracket Seismic Analysis" which included effects of pool sloshing resulting from seismic activity.

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

4.2.5 Design Features: Independence

As described in Section 4.2.2 above, the primary and backup channels are separated by approximately 33 feet on the south side of the SFP. The cables are then routed directly to the concrete wall, maintaining the same separation and clearly meeting the physical separation criteria to protect against internal missiles.

The NRC staff verified during the onsite audit that the primary and backup instrument transmitters and displays are powered from independent lighting panels which are in turn powered from independent 480V busses.

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

4.2.6 Design Features: Power Supplies

During the onsite audit, the NRC staff confirmed the circuit, lighting panel, MCC and 480V switchgear that power the primary and backup SFPLI channels. The primary channel is powered from 480V Switchgear 1A-2 (SA). The backup channel is powered from 480V Switchgear 1B-2 (SB). The NRC staff further confirmed that the power supply paths for each instrument are completely independent. The licensee also provided this information in an electronic reading room in a summary of audit responses for the SFPLI.

Battery backup for a seven day period, which is part of the Westinghouse supplied equipment, was verified during the Westinghouse vendor audit (ADAMS Accession No. ML14211A346). Testing by Westinghouse demonstrated that accuracy and performance were not impacted when automatically switching to battery power when the normal ac supply is lost. The licensee also stated in its FIP, that a power plug is provided allowing the unit to be powered by a portable generator.

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

4.2.7 Design Features: Accuracy

Accuracy of the instrument was confirmed during the Westinghouse vendor audit (ADAMS Accession No. ML14211A346) to be $\pm$ 3 inches over the entire range for the stated environmental conditions. The NRC staff found that the environmental conditions at the installed FHB locations are within Westinghouse's tested range and similar performance is expected. FHB conditions for BDB events were described in FPL document NAI 1784-003, "St. Lucie Nuclear Plant Units 1 & 2 Fuel Handling Building Beyond Design Basis Event Summary Document."

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

4.2.8 Design Features: Testing

Testing and calibration of the Westinghouse model were reviewed during the vendor audit (ADAMS Accession No. ML14211A346). Westinghouse uses a tool to simulate a change in level that can be accurately verified. The licensee stated in its OIP that it would follow the vendor procedures for calibration and functional tests at the vendor recommended intervals.

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

4.2.9 Design Features: Display

The Westinghouse display was assessed as part of the Westinghouse vendor audit (ADAMS Accession No. ML14211A346). The FPL document NAI 1784-003, "St. Lucie Nuclear Plant Units 1 & 2 Fuel Handling Building Beyond Design Basis Event Summary Document" describes, in part, the temperature, humidity and radiation at the display location. The NRC staff concluded that the area would be habitable for the described conditions.

Following the onsite audit, FPL provided a response on prompt accessibility that stated that the display in the FHB would be accessible within 15 minutes from the CR. However, the NRC staff noted during the on-site audit, the time to reach the FHB from the CR was much less and that 15 minutes allowed for alternate routes if the most direct route was not habitable.

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

4.3 Evaluation of Programmatic Controls

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

4.3.1 Programmatic Controls: Training

In its OIP, the licensee stated, in part, that SAT will be used to identify the population to be trained and to determine both the initial and continuing elements of the required training. Training will be completed prior to placing the instrumentation in service. In its FIP, Section 4.3.1 stated, in part, that training impact resulting from the installation of the SFPLI was reviewed for operations, maintenance, engineering and simulator. The licensee also stated, in part, that training lesson plans, class scheduling and sessions were completed to implement the results of these reviews.

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

4.3.2 Programmatic Controls: Procedures

The licensee listed 6 separate procedures including inspection, test, calibration, maintenance, programmatic controls and system operation and described the objective of each procedure in their response to RAI 13 in its February 28, 2014, update letter (ADAMS Accession No. ML14064A193). The licensee confirmed in Section 4.3.2 of the FIP that FLEX support guideline 0-FSG-11 had been issued to instruct operators on the use of the SFPLI indication following a BDBEE.

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

4.3.3 Programmatic Controls: Testing and Calibration

In its letter dated February 28, 2014 (ADAMS Accession No. ML14064A193), the licensee stated, in part, SFP instrument channel maintenance and testing program requirements to ensure design and system readiness will be established in accordance with FPL's processes and procedures and in consideration of the vendor recommendations.

The licensee also clarified in the February 28, 2014, letter, in RAI response 14b, compensatory actions which must be taken if an instrument channel is not expected to be restored or is not restored within 90 days and if both channels become non-functioning then initiate actions within 24 hours to restore one of the channels of instrumentation and implement compensatory actions within 72 hours. The compensatory actions are to determine the compensatory action if the second unit fails and planned schedule for returning the channel to service. The compensatory action with both units out of service included an alternate method monitoring.

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

4.4 Conclusions for Order EA-12-051

In its letters dated May 12, 2015 (ADAMS Accession No. ML15140A393), and December 10, 2015 (ADAMS Accession No. ML15350A394), 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 concludes that, if implemented appropriately, the licensee's plans conform to the guidance in NEI 12-02, as endorsed by JLD-ISG-2012-03. In addition, the NRC staff concludes that if the SFPLI is installed at St. Lucie according to the licensee's proposed design, it should adequately address the requirements of Order EA-12-051.

5.0 Conclusion

In August 2013 the NRC staff started audits of the licensee's progress on Orders EA-12-049 and EA-12-051. The staff conducted an onsite audit in November 2014 (ADAMS Accession No. ML15035A670). By letter dated December 10, 2015, the licensee notified the NRC that St. Lucie reached its final compliance date, and has declared that both of the reactors are in compliance with the orders. The purpose of this safety evaluation is to document the strategies and implementation features that the licensee has committed to and which NRC staff has evaluated to be satisfactory for compliance with these orders. The NRC staff will conduct an onsite inspection to verify that the licensee has implemented the strategies and equipment to demonstrate compliance with the orders. Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and proposed designs which if implemented appropriately will adequately address the requirements of Orders EA-12-049 and EA-12-051.

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Sincerely,

/RA/

Mandy Halter, Acting Chief
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Office of Nuclear Reactor Regulation

Docket Nos.: 50-335 and 50-389

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