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

November 14, 2016

Mr. C. R. Pierce
Regulatory Affairs Director
Southern Nuclear Operating Company, Inc.
P. O. Box 1295, Bin 038
Birmingham, AL 35201-1295

SUBJECT: VOGTLE ELECTRIC GENERATING 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. MF0714, MF0715, MF0723, AND MF0724)

Dear Mr. Pierce:

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

By letter dated February 27, 2013 (ADAMS Accession No. ML13059A382), Southern Nuclear Operating Company, Inc. (SNC, the licensee) submitted its OIP for Vogtle Electric Generating Plant, Units 1 and 2 (VEGP, Vogtle) in response to Order EA-12-049. At six month intervals following the submittal of the OIP, SNC submitted reports on its progress in complying with Order EA-12-049. These reports were required by the order, and are listed in the attached safety evaluation. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all operating power licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated January 16, 2014 (ADAMS Accession No. ML13339A781), and August 25, 2015 (ADAMS Accession No. ML15210A510), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated November 20, 2015, (ADAMS Accession No. ML15324A243), SNC submitted a compliance letter for Vogtle, Unit 1. By letter dated May 23, 2016 (ADAMS Accession No. ML16146A607), SNC submitted a compliance letter and Final Integrated Plan for Vogtle, Units 1 and 2 in response to Order EA-12-049. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-049.

By letter dated February 27, 2013 (ADAMS Accession No. ML13059A386), SNC submitted its OIP for VEGP in response to Order EA-12-051. At six month intervals following the submittal of the OIP, SNC submitted reports on its progress in complying with Order EA-12-051. These reports were required by the order, and are listed in the attached safety evaluation. By letter dated March 26, 2014 (ADAMS Accession No. ML14083A620), the NRC notified all operating power 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 November 4, 2013 (ADAMS Accession No. ML13280A381), and August 25, 2015 (ADAMS Accession No. ML15210A510), the NRC staff issued an ISE and request for additional information and audit report, respectively, on the licensee's progress. By letters dated December 1, 2014 (ADAMS Accession No. ML14336A587), and November 20, 2015 (ADAMS Accession No. ML15324A243), SNC reported that full compliance with the requirements of Order EA-12-051 was achieved for Units 1 and 2, respectively.

The enclosed safety evaluation provides the results of the NRC staff's review of SNC's strategies for VEGP. The intent of the safety evaluation is to inform SNC on whether or not its integrated plans, if implemented as described, appear to adequately address the requirements of Orders EA-12-049 and EA-12-051. The NRC staff will evaluate implementation of the plans through inspection, using Temporary Instruction 2515/191, "Inspection of the Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications /Staffing/ Multi-Unit Dose Assessment Plans," Revision 1 (ADAMS Accession No. ML15257A188). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

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

Sincerely,

Mandy K Halter

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

Docket Nos.: 50-424 and 50-425

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

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

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

SOUTHERN NUCLEAR OPERATING COMPANY, INC.

VOGTLE ELECTRIC GENERATING PLANT, UNITS 1 AND 2

DOCKET NOS. 50-424 AND 50-425

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

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

2.0 REGULATORY EVALUATION

Following the events at the Fukushima Dai-ichi nuclear power plant on March 11, 2011, the NRC established a senior-level agency task force referred to as the Near-Term Task Force (NTTF). The NTTF was tasked with conducting a systematic and methodical review of the NRC

regulations and processes and determining if the agency should make additional improvements to these programs in light of the events at Fukushima Dai-ichi. As a result of this review, the NTTF developed a comprehensive set of recommendations, documented in SECY-11-0093, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," dated July 12, 2011 [Reference 1]. Following interactions with stakeholders, these recommendations were enhanced by the NRC staff and presented to the Commission.

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

2.1 Order EA-12-049

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

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

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

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

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

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

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

2.2 Order EA-12-051

Order EA-12-051, Attachment 2, [Reference 5] requires that operating power reactor licensees and construction permit holders install reliable 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 [Reference 8] to the NRC to provide specifications for an industry-developed methodology for compliance with Order EA-12-051. On August 29, 2012, the NRC staff issued its final version of JLD-ISG-2012-03, "Compliance with Order EA-12-051, Reliable Spent Fuel Pool Instrumentation" [Reference 9], endorsing NEI 12-02, Revision 1, as an acceptable means of meeting the requirements of Order EA-12-051 with certain clarifications and exceptions, and published a notice of its availability in the *Federal Register* (77 FR 55232).

3.0 TECHNICAL EVALUATION OF ORDER EA-12-049

By letter dated February 27, 2013 [Reference 10], SNC submitted an Overall Integrated Plan (OIP) for Vogtle Electric Generating Plant, Units 1 and 2 (Vogtle,VEGP) in response to Order EA-12-049. By letters dated August 27, 2013 [Reference 11], February 26, 2014 [Reference 12], August 26, 2014 [Reference 13], February 26, 2015 [Reference 14], August 27, 2015 [Reference 34], and February 25, 2016 [Reference 35], SNC submitted six-month updates to the OIP. By letter dated August 28, 2013 [Reference 15], the NRC notified all operating power reactor licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" [Reference 32]. By letters dated January 16, 2014 [Reference 16], and August 25, 2015 [Reference 17], the NRC issued an Interim Staff Evaluation (ISE) and an audit report on the licensee's progress, respectively. By letter dated May 23, 2016 [Reference 18], the licensee reported that full compliance with the requirements of Order EA-12-049 was achieved, and submitted a Final Integrated Plan (FIP).

3.1 Overall Mitigation Strategy

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

While the initiating event is undefined, it is assumed to result in an extended loss of ac power (ELAP) with a loss of normal access to the UHS (LUHS). Thus, the ELAP with loss of normal access to the UHS is used as a surrogate for a BDBEE. The initial conditions and assumptions for the analyses are stated in NEI 12-06, [Reference 6] Section 3.2.1, and include the following:

1. The reactor is assumed to have safely shut down with all rods inserted (subcritical).
2. The dc power supplied by the plant batteries is initially available, as is the ac power from inverters supplied by those batteries; however, over time the batteries may be depleted.
3. There is no core damage initially.

4. There is no assumption of any concurrent event.
5. Because the loss of ac power presupposes random failures of safety-related equipment (emergency power sources), there is no requirement to consider further random failures.

Vogtle, Units 1 and 2 are Westinghouse pressurized-water reactors (PWRs) with dry ambient pressure containments. The FIP describes SNC'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. Core decay heat is removed by adding water to the steam generators (SGs) and releasing steam from the SGs to the atmosphere. The water will initially be added by the turbine-driven auxiliary feedwater (TDAFW) pump, taking suction from the condensate storage tanks (CSTs). Eventually, the RCS will be cooled down, which will reduce the RCS and SG pressures. When the TDAFW pump can no longer operate due to the lowering SG pressure, a FLEX pump (also taking suction from the CSTs) will be used to add water to the SGs. If the CSTs are depleted, the reactor makeup water storage tank (RMWST) can supply makeup water to the CSTs using another FLEX pump. The nuclear service cooling water (NSCW) basins serve as alternate supplies of makeup water to the CSTs.

Borated water will be added to the RCS for reactivity control. Initially, boron will be injected using the safety injection accumulators, followed by injection using a motor-driven FLEX pump, powered by a FLEX generator, taking suction from the boric acid storage tank (BAST) or refueling water storage tank (RWST).

FLEX generators will be used to reenergize the installed battery chargers to keep the necessary dc buses energized, which will then keep the 120 volt ac instrument buses energized. The licensee will use the industry National Strategic Alliance of FLEX Emergency Response (SAFER) Response Centers (NSRCs) for supplies of Phase 3 equipment at Vogtle, with the intent of reenergizing certain plant safety buses and establishing long-term cooling from the UHS, as necessary.

In the postulated ELAP event, the SFPs will initially heat up due to the unavailability of the normal cooling system. During the initial phase of an ELAP, gravity feed from the RWST will be established as needed for SFP makeup. For Phase 2, a FLEX pump drawing water from the NSCW basins will be used to add water to the SFPs of both units to maintain level as the pools boil. There will be three paths available for SFP makeup; via hoses directly discharging into the pools; via connections to the existing SFP makeup lines; or via hoses directed to portable spray monitors positioned around the SFPs. The makeup flow to the SFP will maintain a sufficient amount of water above the top of the fuel assemblies for cooling and shielding. The long term strategy for SFP makeup is to continue the strategies described above. When supplemented by portable equipment delivered from off-site (NSRC), water from the Savannah River can be used to replace depleted on-site seismic category 1 water inventories. However, the associated actions are not relied upon in the FLEX strategy during the first 72 hours following ELAP.

Vogtle has large dry containment buildings and utilizes low leakage seals on the RCPs. Should the event occur with the plant in MODES 1-4 (power operation, startup, hot standby, hot shutdown), the low leakage seals will limit the leakage inside the containment. This ensures that

containment pressure and temperature remain within design limits without active containment cooling until well beyond 72 hours. Since SNC did not identify any time sensitive Phase 3 actions, instructions for connection and utilization of NSRC equipment for long term coping or recovery will be provided by technical support center (TSC) personnel who will have assessed the condition of the plant and infrastructure, plant accessibility, and additional available offsite resources (both equipment and personnel) following the BDBEE.

3.2 Reactor Core Cooling Strategies

The guidance in NEI 12-06 provides for licensees to maintain or restore cooling to the reactor core in the event of an ELAP concurrent with a LUHS. Although the ELAP results in an immediate trip of the reactor, sufficient core cooling must be provided to account for fission product decay and other sources of residual heat. 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 due to the ELAP and 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 with loss of normal access to the UHS event presumes that, per endorsed guidance from NEI 12-06, both units would have been operating at full power prior to the event. Therefore, the SGs may be credited as the heat sink for core cooling during the ELAP and 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 and 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 Makeup

3.2.1.1 Core Cooling Strategy

3.2.1.1.1 Phase 1

As stated in SNC's FIP [Reference 18], the heat sink for core cooling in Phase 1 would be provided by the four SGs, which would be fed simultaneously by the TDAFW pump with inventory supplied by the CSTs. The CSTs are robust for all applicable hazards. The licensee

calculated that the CST water volume is sufficient to remove residual heat from the reactor for approximately 89 hours, including the sensible heat associated with the RCS cooldown starting at 8 hours.

As discussed in the FIP [Reference 18], following closure of the main steam isolation valves, as would be expected in an ELAP event, steam release from the SGs to the atmosphere will be the method of heat removal. This would be accomplished by the main steam safety valves (MSSVs) or the SG atmospheric relief valves (ARVs). The licensee plans to operate their ARV's by dispatching personnel to manually position the valves under the direction of a control room operator. The licensee has confirmed that this flowpath is robust with respect to all external hazards, including earthquakes and windborne missiles.

The licensee's Phase 1 strategy directs operators to commence a cooldown and depressurization of the RCS within 8 hours of the initiation of the ELAP and LUHS event. Over a period of approximately 3 hours, Vogtle would gradually cool down the RCS from post-trip conditions until obtaining a SG pressure of approximately 300 pounds per square inch gage (psig). A minimum SG pressure of 300 psig is set to avoid the injection of nitrogen gas from the safety injection accumulators into the RCS. The cooldown and depressurization of the RCS significantly extends the expected coping time under ELAP and 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 accumulators to inject into the RCS to offset cooldown-related volume changes system leakage.

3.2.1.1.2 Phase 2

In its FIP [Reference 18], SNC states that the primary strategy for core cooling in Phase 2 would use the SGs as a heat sink, with SG secondary inventory being supplied by the TDAFW pump. Although TDAFW pump is expected to remain functional throughout Phase 2, SNC has acted in accordance with NEI 12-06 in obtaining three diesel driven SG FLEX pumps that are capable of backing up this essential function.

According to SNC's calculations, the CST is capable of supplying SG makeup for a minimum of 89 hours. In the event of a failure of the TDAFW pump, or if adequate steam pressure cannot be maintained, a backup source of secondary makeup is available in Phase 2. SNC stated that a portable diesel-driven FLEX pump would be deployed near the AFW pump house with suction from the CST, or as an alternate from the RMWST. This pump will be staged and connected at approximately 12 hours. This pump would discharge via hoses routed to a primary or secondary connection. The primary connection point is in the Train C AFW pump room on the TDAFW pump discharge header. The alternate connection point is located in the Train A AFW pump room on the motor driven AFW discharge cross tie. Both of these connections provide the ability to feed all four SG's simultaneously. Both connection points are located inside the AFW pumphouse which is robust to all applicable hazards.

The licensee's FIP [Reference 18], states that its core cooling strategy is to rely initially on the TDAFW pump taking suction from the CST. Prior to the depletion of the water in the CST, makeup water can be provided from either the RMWST or the NSCW basins. The RMWST contains 148,000 gallons of demineralized water and is the primary source of makeup to the CST. Each of the NSCW basins contains approximately 3,670,000 gallons of water and is the alternate source of CST makeup. Both the primary and alternate sources are robust to all

applicable hazards. Transferring water from the RMWST to the CST's will require the use of a FLEX pump. The licensee will need to use the portable FLEX Submersible Pump to transfer water from the NSCW basins to the CSTs.

3.2.1.1.3 Phase 3

As discussed in the SNC FIP [Reference 18], the licensee's core cooling strategy for Phase 3 is a continuation of the Phase 2 strategy with additional offsite equipment provided by NSRC. Core cooling will continue to be provided by the SGs with feedwater supplied by Phase 3 equipment provided by the NSRC. The Phase 3 pumps from the NSRC can connect to the Phase 2 connection points and inject into the SGs to provide cooling. In addition, water purification from the NSRC can be used to provide cleaner water to reduce the amount of degradation of heat transfer in the SGs. The plant parameters will be maintained with SG pressure at approximately 120 psig and RCS cold leg temperatures at approximately 350 degrees Farenheit (°F). Maintaining these parameters will support the continued integrity of the RCP seals.

3.2.1.2 RCS Makeup Strategy

3.2.1.2.1 Phase 1

Following the reactor trip at the start of the ELAP and LUHS event, operators will isolate RCS letdown pathways and confirm the existence of natural circulation flow in the RCS. A small amount of RCS leakage will occur through the low-leakage RCP seals, but because the expected inventory loss would not be sufficient to drain the pressurizer prior to the RCS cooldown, its overall impact on the RCS behavior will be minor. Although the RCS cooldown planned for implementation starting at 8 hours into the event would be expected to drain the pressurizer and create a vapor void in the upper head of the reactor vessel, ample RCS volume should remain to support natural circulation flow throughout Phase 1. There is no need to initiate boration during this period, since the reactor operating history assumed in the endorsed NEI 12-06 FIP [Reference 6] guidance implies that a substantial concentration of xenon-135 would be present in the reactor core. Nevertheless, as operators depressurize the RCS, some fraction of the borated inventory from the nitrogen-pressurized accumulators would be expected to passively inject. Following depressurization of the SGs to 300 psig, the licensee plans to vent the accumulators to prevent the injection of nitrogen gas. The accumulators may be vented at any point during the ELAP scenario through the use of solenoid operated valves powered by the 125 Volt direct current (Vdc) system. These valves are operated from the main control room.

3.2.1.2.2 Phase 2

In Phase 2, RCS injection is accomplished with portable Boron Injection FLEX Pump. In the course of cooling and depressurizing the SGs to a target pressure of 300 psig, a significant fraction of the accumulator liquid inventory will inject into the RCS, filling volume vacated by the thermally induced contraction of RCS coolant and system leakage. As stated in SNC's FIP [Reference 18], no additional action is required for RCS inventory control in phase 2. However, the shutdown margin evaluation determined that it is necessary to initiate boron injection during phase 2. Thus, in order to ensure long-term subcriticality, RCS boration will commence using a portable high-pressure FLEX pump approximately 12 hours after the initiation of the ELAP event. With low-leakage Westinghouse SHIELD® seals installed on all RCPs, Vogtle calculates

that FLEX RCS makeup is not necessary to prevent the onset of reflux cooling for >72 hours into the event.

The primary method of boration in Phase 2 is a portable high-pressure FLEX pump with a capacity of 20 gallons per minute (gpm) at a minimum 1213.9 ft. of head. The pump will be aligned to take suction from either the BAST (primary) or the RWST (alternate). Both the BAST and the RWST are seismically qualified and hardened against windborne missiles. The FLEX RCS pump can be aligned to discharge to connection points on either of the residual heat removal (RHR) pump discharge lines which go to the RCS cold legs. Both the primary and alternate RCS connection points are robust to all applicable hazards.

Depending on whether the primary (BAST) or alternate (RWST) suction source is used for the boration will determine whether or not it is necessary to open the reactor vessel head vents to letdown water from the RCS for the necessary volume addition. Operation of the head vents can be achieved from the main control room using 125 Vdc operated valves.

3.2.1.2.3 Phase 3

The Phase 3 strategy for indefinite RCS inventory control and subcriticality is simply a continuation of the Phase 2 strategy, with backup pumps and water treatment equipment supplied by the NSRC. Water treatment facilities delivered by the NSRC may be used to purify water from the Savannah River to replenish depleted demineralized water supplied and a mobile boration skid may be used to replenish the borated water in the RWST.

3.2.2 Variations to Core Cooling Strategy for Flooding Event

In its FIP [Reference 18], the licensee stated that VEGP is above the design-basis flood level. Additionally, there is no large, enclosed, or partially enclosed body of water adjacent to the site. Thus, Vogtle is considered a dry site and the Flex storage building and deployment path located within the Owner Control Area would not be adversely affected by the external flooding events. SNC's core cooling and makeup strategy implementation remain the same for a flooding event. Refer to Section 3.5.2 of this safety evaluation (SE) for further discussion on flooding.

Therefore, there are no significant variations necessary to support the core cooling and RCS inventory strategies for a flooding event.

3.2.3 Staff Evaluations

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

Guidance document NEI 12-06 [Reference 6] provides guidance that the baseline assumptions have been established on the presumption that other than the LUHS, 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 Phase 1

The licensee's Phase 1 core cooling FLEX strategies for VEGP. Units 1 and 2, rely on its existing SGs, TDAFW pump, AFW system piping, MSSVs, and ARVs to remove heat from the RCS using water from the CSTs. In addition, SNC relies on its station batteries, and 125 Vdc distribution system for powering critical instrumentation and remote TDAFW pump operation. For Phase 1 RCS inventory control, the licensee relies on its existing safety injection (SI) accumulators.

The licensee's primary core cooling strategy uses the TDAFW pumps at each unit to supply water to all four SGs. The TDAFW pump auto starts following a reactor trip. If needed, operators can manually start the TDAFW pump using existing station procedures. Operators can control flow to the four SGs through individual dc motor-operated control valves from the control room or at the local control panels located in the AFW pump rooms. In addition, manual or automatic speed control for the TDAFW pump is provided in the control room and at the local control panels. As described in the FIP [Reference 18], Updated Final Safety Anlysis Report (UFSAR) Table 3.2.2-1, and UFSAR Section 3.5.1.4, the TDAFW pump, and applicable steam supply and AFW piping and valves are Seismic Category 1, tornado protected components. The TDAFW pump is located within the Seismic Category 1 AFW pump house and is protected from all applicable external hazards. The applicable steam supply and AFW piping and valves are located within portions of the Seismic Category 1 containment building, control building, auxiliary building, and AFW pump house, and are protected from all applicable external hazards. Based on the location and design of the TDAFW pump, and the applicable steam and AFW piping, as described in the FIP [Reference 18], and the UFSAR, the TDAFW pump and associated systems should be available to support Phase 1 core cooling during an ELAP.

For Phase 1 core cooling the TDAFW pump draws suction from the CST and discharges to the SGs. As described in Table 3.2.2-1 of the UFSAR, the SGs are Seismic Category 1 components. The SGs are located in the Seismic Category 1 containment building and are protected from all applicable external hazards. As described in the licensee's FIP [Reference 18], UFSAR Table 3.2.2-1, and UFSAR Table 3.5.1-7, the CSTs are Seismic Category 1, tornado protected structures. Based on the design and location of the SGs and CSTs, as described in the FIP [Reference 18], and the UFSAR, these components should be available to support Phase 1 core cooling during an ELAP.

During the initial stages of Phase 1 core cooling, heat generated by the reactor is dissipated by steam release through the spring-loaded MSSVs. As described in the FIP [Reference 18], UFSAR Table 3.2.2-1, and UFSAR Section 3.5.1.4, the MSSVs are Seismic Category 1, tornado protected components. The MSSVs are located on the main steam piping upstream of the main steam isolation valves in the Seismic Category 1 auxiliary building and are protected from all applicable external hazards. Once operators begin the RCS cooldown, personnel will manually operate ARVs to release steam and facilitate depressurization of the RCS. As described in the FIP [Reference 18], UFSAR Table 3.2.2-1, and UFSAR Section 3.5.1.4, the ARVs are Seismic Category 1, tornado protected components. The ARVs are located on the main steam piping upstream of the main steam isolation valves in the Seismic Category 1 auxiliary building and are protected from all applicable external hazards. Based on the location and design of the MSSVs and ARVs, as described in the FIP [Reference 18], and the UFSAR, the MSSVs and ARVs should be available to support Phase I core cooling during an ELAP.

During Phase 1 core cooling, the licensee relies on the station batteries and the 125-Vdc distribution system to power key instrumentation and AFW control valves. As described in the FIP [Reference 18], UFSAR Table 3.2.2-1, and UFSAR Section 3.5.1.4, the Class 1E 125-V-dc system is a Seismic Category 1, tornado protected system. As described in Section 8.3.2.1.1 of the UFSAR, all the components of the Class 1E 125-Vdc systems, including batteries, are housed in Seismic Category 1 structures and are protected from all applicable external hazards. Based on the location and design of the Class 1E 125-Vdc systems, as described in the FIP [Reference 18], and the UFSAR, the 125-Vdc systems, including the batteries, should be available to support Phase I core cooling during an ELAP.

For Phase 1 RCS inventory control, the licensee relies on passive injection from the SI accumulators. As described in Table 3.2.2-1 of the UFSAR, the SI accumulators are Seismic Category 1 components. The SI accumulators are located in the Seismic Category 1 containment building and are protected from all applicable external hazards. Based on the location and design of the SI accumulators, as described in the FIP [Reference 18], and the UFSAR, the accumulators should be available to support Phase I inventory control during an ELAP.

Core Cooling Phase 2

The licensee's Phase 2 core cooling strategy relies on the continued use of the TDAFW pump supplying water to the SGs from the CSTs and relieving heat to the atmosphere through the ARVs. In addition, the licensee's core cooling strategy relies on the RMWST and the NSCW basins. For Phase 2 inventory control, the licensee does not credit any additional makeup beyond the SI accumulator volume that was added in Phase 1. However, the licensee does rely on parts of the RHR system, reactor vessel head vent system (RVHVS), the BAST, and the RWST for reactivity control.

The licensee's primary Phase 2 strategy for maintaining reactor core cooling remains the same as Phase 1 and is dependent upon the continued operation of the TDAFW pump supplying the SGs from the CSTs and relieving heat through the ARVs. As described in the FIP [Reference 18], the TDAFW pump is capable of feeding the steam generators provided there is adequate steam pressure available to drive the turbine and an adequate supply of water in the CSTs. As described above for Phase 1, the SGs, TDAFW pump, ARVs, and CSTs should be available to support Phase 2 core cooling during an ELAP.

For continued operation of the TDAFW pumps, the licensee plans to provide makeup water to the CST via a portable pump from the RMWST or the NSCW basins. As described in the FIP [Reference 18], and Table 3.2.2-1of the UFSAR, the RMWST and NSCW basins are Seismic Category 1 structures. In addition, as described in the FIP [Reference 18], UFSAR Table 3.5.1-7, and UFSAR Section 3.5.1.4, the RMWST and NSCW basins are protected from tornado winds and tornado-generated missiles. Based on the design of the RMWST and NSCW basins, as described in the FIP [Reference 18], and the UFSAR, the water sources should be available to support Phase 2 core cooling during an ELAP.

During Phase 2, the licensee plans to inject boron into the RCS via a portable pump in order to control reactivity and maintain sub-criticality margin. The portable pump will take suction from either the BAST or RWST and discharge to a connection downstream of each RHR pump on the piping that injects to the RCS cold legs. As described in the FIP [Reference 18], and Table 3.2.2-1 of the UFSAR, the applicable RHR system is a Seismic Category 1 system located in portions of the Seismic Category 1 auxiliary and containment buildings, and is protected from all applicable hazards. As described in the FIP [Reference 18], and UFSAR Tables 3.2.2-1 and 3.5.1-7, the BASTs and RWST are Seismic Category 1, tornado protected structures. Based on the design and location of the RHR system, BASTs, and RWST, as described in the FIP [Reference 18], and the UFSAR, the RHR system, BASTs, and RWST should be available to support Phase 2 reactivity control during an ELAP.

During injection of boric acid, the licensee may need to open a letdown path through the RVHVS to maintain RCS level. As described in the FIP [Reference 18], the applicable RVHVS components are Seismic Category 1 components located within the Seismic Category 1 containment building, and are protected from all applicable external hazards. Based on the design and location of the RVHVS, as described in the FIP [Reference 18], the applicable RVHVS components should be available to support Phase 2 reactivity control during an ELAP.

Core Cooling Phase 3

For Phase 3 core cooling and RCS inventory control, the licensee will use the NSRC equipment to supplement the onsite portable equipment, as necessary, using the same existing SSCs as discussed above for Phases 1 and 2.

3.2.3.1.2 Plant Instrumentation

According to the FIP [Reference 18], the following instrumentation would be relied upon to support the licensee's core cooling and RCS inventory control strategy:

- RCS hot leg temperature (T-hot, Wide Range)
- RCS cold leg temperature (T-cold, Wide Range)
- RCS pressure
- Reactor Vessel Level Indicating System (RVLIS)
- SG Narrow Range Level (SGs 1-4))
- SG pressure (SGs 1-4)
- TDAFW Pump flow to SGs 1-4
- Neutron flux (Source and Intermediate Range)
- CST Level

- Containment pressure
- CETs (Core Exit Thermocouples)

All of these instruments are powered by installed safety-related Station Batteries, with the exception of the CST level, which can be read locally. The A-Train and B-Train batteries provide power to the required instruments. To prevent a loss of vital instrumentation, operators will extend battery life to a minimum of 12 hours by shedding unnecessary loads. The load shedding will be completed within 45 minutes from start of ELAP event. A FLEX DG (480 V) (one per unit) will be deployed within 10 hours from ELAP event initiation. This leaves a margin of at least 2 hours prior to depletion of the associated batteries.

The licensee's FIP states that, as recommended by Section 5.3.3 of NEI 12-06 [Reference 6], procedures have been developed to read the above instrumentation locally using a portable instrument, where applicable. Guidance document FLEX Support Guideline (FSG)-007, "Loss of Instrumentation or Control Power," Revision 0 [Reference 44] provides guidance for obtaining alternate readings for the following parameters:

- RCS hot leg temperature (T-hot, Wide Range)
- RCS pressure (Wide Range)
- SG Level
- SG pressure
- TDAFW Pump flow
- CETs (Core Exit Thermocouples)
- Containment Temperature
- Containment Pressure
- Pressurizer Pressure
- Pressurizer Temperature
- RWST Level

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

The instrumentation available to support the licensee's strategies for core cooling and RCS inventory during the ELAP event is consistent with the recommendations specified in the endorsed guidance of NEI 12-06 [Reference 6]. Based on the information provided by the licensee, the NRC staff understands that indication for the above instruments would be available and accessible continuously throughout the ELAP event.

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

The licensee concluded that its mitigating strategy for reactor core cooling would be adequate based, in part, on a generic thermal-hydraulic analysis performed for a reference Westinghouse four-loop reactor using the NOTRUMP computer code. The NOTRUMP code and corresponding evaluation model were originally submitted in the early 1980s as a method for performing licensing-basis safety analyses of small-break loss-of-coolant accidents (LOCAs) for Westinghouse PWRs. Although NOTRUMP has been approved for performing small-break LOCA analysis under the conservative Appendix K paradigm and constitutes the current

evaluation model of record for many operating PWRs, the NRC staff had not previously examined its technical adequacy for performing best-estimate simulations of the ELAP event. Therefore, in support of mitigating strategy reviews to assess compliance with Order EA-12-049, the NRC staff evaluated licensees' thermal-hydraulic analyses, including a limited review of the significant assumptions and modeling capabilities of NOTRUMP and other thermal-hydraulic codes used for these analyses. The NRC staff's review included performing confirmatory analyses with the TRACE code to obtain an independent assessment of the duration that reference reactor designs could cope with an ELAP event prior to providing makeup to the RCS.

Based on its review, the NRC staff questioned whether NOTRUMP and other codes used to analyze ELAP scenarios for PWRs would provide reliable coping time predictions in the reflux or boiler-condenser cooling phase of the event because of challenges associated with modeling complex phenomena that could occur in this phase, including boric acid dilution in the intermediate leg loop seals, two-phase leakage through RCP seals, and primary-to-secondary heat transfer with two-phase flow in the RCS. Due to the challenge of resolving these issues within the compliance schedule specified in Order EA-12-049, the NRC staff requested that industry provide makeup to the RCS prior to entering the reflux or boiler-condenser cooling phase of an ELAP, such that reliance on thermal-hydraulic code predictions during this phase of the event would not be necessary.

Accordingly, the ELAP coping time prior to providing makeup to the RCS is limited to the duration over which the flow in the RCS remains in natural circulation, prior to the point where continued inventory loss results in a transition to the reflux or boiler-condenser cooling mode. In particular, for PWRs with inverted U-tube SGs, the reflux cooling mode is said to exist when vapor boiled off from the reactor core flows out the saturated, stratified hot leg and condenses on SG tubes, with the majority of the condensate subsequently draining back into the reactor vessel in countercurrent fashion. Quantitatively, as reflected in documents such as the PWR Owners Group (PWROG) report PWROG-14064-P, Revision 0, "Application of NOTRUMP Code Results for Westinghouse Designed PWRs in Extended Loss of AC Power Circumstances," industry has proposed defining this coping time as the point at which the one-hour centered time-average of the flow quality passing over the SG tubes' U-bend exceeds one-tenth (0.1). As discussed further in Section 3.2.3.4 of this evaluation, a second metric for ensuring adequate coping time is associated with maintaining sufficient natural circulation flow in the RCS to support adequate mixing of boric acid.

With specific regard to NOTRUMP, preliminary results from the NRC staff's independent confirmatory analysis performed with the TRACE code indicated that the coping time for Westinghouse PWRs under ELAP conditions could be shorter than predicted in WCAP 17601-P, "Reactor Coolant System Response to the Extended Loss of AC Power Event for Westinghouse, Combustion Engineering and Babcock & Wilcox NSSS Designs." Subsequently, a series of additional simulations performed by the NRC staff and Westinghouse identified that the discrepancy in predicted coping time could be attributed largely to differences in the modeling of RCP seal leakage. (The topic of RCP seal leakage will be discussed in greater detail in Section 3.2.3.3 of this SE.) These comparative simulations showed that when similar RCP seal leakage boundary conditions were applied, the coping time predictions of TRACE and NOTRUMP were in adequate agreement. From these simulations, as supplemented by review of key code models, the NRC staff obtained sufficient confidence that the NOTRUMP code may be used in conjunction with the WCAP-17601-P evaluation model for performing best-estimate simulations of ELAP coping time prior to reaching the reflux cooling mode.

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

During the audit, the NRC staff evaluated a comparison of the generic analysis values from WCAP-17601-P and PWROG-14064-P to the Vogtle plant-specific values. The NRC staff concurred that the generic plant parameters were bounding for the analyzed event. Vogtle has installed low-leakage SHIELD shutdown seals; therefore, the seal leakage expected for Vogtle is significantly less than assumed in the generic NOTRUMP analysis case. The NRC staff concluded that the licensee could maintain natural circulation flow in the RCS for approximately 46 hours for single phase and greater than 72 hours for two-phase during the ELAP event prior to requiring RCS makeup. The RCS makeup would be available per the licensee's mitigating strategy for shutdown margin at approximately 12 hours, thus, the licensee's strategy for RCS makeup provides sufficient margin to the onset of reflux cooling.

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

3.2.3.3 Reactor Coolant Pump (RCP) Seals

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

As discussed in its FIP [Reference 18], SNC credits Generation 3 SHIELD low leakage seals for FLEX strategies including RCS inventory control and boration. The low leakage seals limit the total RCS leak rate to no more than 5 gpm (1 gpm per RCP seal and 1 gpm of unidentified RCS leakage in accordance with Technical Specification).

The SHIELD low leakage seals are credited in the FLEX strategies in accordance with the four conditions identified in the NRC's endorsement letter of TR-FSE-14-1-P, "Use of Westinghouse SHIELD Passive Shutdown Seal for FLEX Strategies," dated May 28, 2014 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14132A128). In its FIP [Reference 18], the licensee describes compliance with each condition of SHIELD seal use as follows:

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

This condition is satisfied because, as stated in FIP, the RCPs for VEGP Units 1 and 2 are Westinghouse Model 93A-1.

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

As stated in the FIP, the maximum steady-state RCP seal temperature during an ELAP response is expected to be the RCS cold leg temperature corresponding to the lowest SG safety relief valve setting of 1185 pounds per square inch gage (psig). This results in a RCS cold leg temperature of approximately 567°F to 569°F.

(3) The maximum RCS pressure during the ELAP (notwithstanding the brief pressure transient directly following the reactor trip comparable to that predicted in the applicable analysis case from WCAP-17601-P) is as follows: For Westinghouse Models 93 and 93A-1 RCPs, RCS pressure is limited to 2250 psia [per square inch absolute]; for Westinghouse Model 93A RCPs, RCS pressure is to remain bounded by Figure 7.1-2 of TR-FSE-14-1-P, Revision 1.

As stated in FIP, normal operating pressure for Unit 1 and Unit 2 is 2250 psia. Allowing for the possibility of a brief pressure transient directly following the reactor trip, the NRC staff concludes that the licensee's mitigating strategy of cooling the reactor core via the main steam safety valves and SG Atmospheric Relief Valves (ARVs) will maintain reactor pressure within limiting value for Model 93A-1.

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

VEGP's FIP and supporting calculations assume a constant Westinghouse SHIELD RCP seal package leakage rate of 1 gpm per RCP, plus 1 gpm of unidentified RCS leakage, for a total RCS leakage of 5 gpm. As stated in the FIP, the actual seal leakage rate expected during an ELAP event would exceed this value for a brief period (in the order of 10 minutes based on LTR-FSE-14-29) prior to actuation of the SHIELD seal. As noted previously, VEGP's calculation indicates that reflux cooling would not be entered for 72 hours into the event, even if FLEX RCS makeup flow were not provided as planned. In that VEGP's mitigating strategy directs RCS makeup to begin approximately 12 hours after event initiation, ample margin exists to

accommodate the small additional volume of leakage that is expected to occur before actuation of the SHIELD seal.

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

3.2.3.4 Shutdown Margin Analyses

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

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

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; otherwise, borated makeup would eventually be required to offset ongoing RCS leakage. The necessary timing and volume of borated makeup depend on the particular magnitudes of the above factors for individual reactors.

The specific values for these and other factors that could influence the core reactivity balance that are assumed in the licensee's current calculations could be affected by future changes to the core design. However, NEI 12-06 [Reference 6], Section 11.8 states that "[e]xisting plant configuration control procedures will be modified to ensure that changes to the plant design ... will not adversely impact the approved FLEX strategies." Inasmuch as changes to the core design are changes to the plant design, the NRC staff expects that any core design changes, such as those considered in a core reload analysis, will be evaluated to determine that they do not adversely impact the approved FLEX strategies, especially the analyses which demonstrate that re-criticality will not occur during a FLEX RCS cooldown.

In the Vogtle FIP [Reference 18], the shutdown margin section and the shutdown margin calculation LTR-FSE-12-26 describes the strategy necessary to maintain shutdown margin following the initiation of the ELAP event. In both documents, SNC stated that FLEX options would supply negative reactivity by injecting borated water into the RCS employing the Boron

Injection FLEX Pump. This will guarantee that a shutdown margin of 1 percent is preserved following cooldown to the initial threshold (a SG pressure of 300 psig) and xenon decay. In order to make sure that acceptable boric acid concentration is supplied to the RCS, injection is provided for reactivity control starting at approximately 12 hours following the initiation of the ELAP event. The primary means of providing borated water in Phase 2 is the Boron Injection FLEX Pump taking suction from the BAST with injection from the RWST being an alternate. The analysis provided demonstrated that adequate shutdown margin would be provided with the use of either water source, but a head vent letdown path will be needed if injection is from the RWST. The vent can be repowered by a 125 Vdc power supply that will be powered by the FLEX electrical strategy. The applicable valves can be operated from the Main Control Room. LTR-FSE-12-26 shows that the injection of approximately 5500 gallons, with a boric acid concentration minimum of 7000 ppm, of borated water from the BAST would meet the shutdown margin requirement of 1 percent at limiting cycle conditions. The BAST has a usable capacity of 46,000 gallons which ensures adequate borated water is available for further cooldown. No credit is given to boron injection from the SI accumulators in this calculation.

Toward the end of an operating cycle, when RCS boron concentration reaches its minimum value, some PWR licensees may need to vent the RCS to ensure that their FLEX strategies can inject a volume of borated coolant that is sufficient to satisfy shutdown margin requirements. The licensee's FIP concluded that, because the RCS volume shrinks as it cools down, the required volume of boric acid solution could be injected without having to vent the RCS, provided that the injection is from the BAST. The volume of borated coolant required to provide adequate shutdown margin is larger when taking suction upon the RWST, which, for an equivalent pumping capacity, extends the overall time required for boration. The larger Injection volume may further necessitate additional letdown from the RCS as described above.

The NRC staff's audit [Reference 17] review considered whether the licensee had followed recommendations from the PWROG's position paper and the associated conditions imposed in the NRC staff's endorsement letter. Regarding the first condition, the NRC staff's audit [Reference 17] review found that the licensee's shutdown margin calculation had considered an appropriate range of RCS leakage rates in determining the limiting condition for the shutdown margin analysis. Furthermore, the NRC staff concluded that the licensee's plan to initiate RCS makeup by 12 hours satisfies the second two conditions. Therefore, the NRC staff concludes that the licensee's calculation conforms to the intent of the PWROG position paper, including the intent of the additional conditions imposed in the NRC staff's endorsement letter.

The NRC staff's audit [Reference 17] review of the licensee's shutdown margin calculation determined that credit was taken for uniform mixing of boric acid during the ELAP event. The NRC staff had previously requested that the industry provide additional information to justify that borated makeup would adequately mix with the RCS volume under natural circulation conditions potentially involving two-phase flow. In response, the PWROG submitted a position paper, dated August 15, 2013 (withheld from public disclosure due to proprietary content), which provided test data regarding boric acid mixing under single-phase natural circulation conditions and outlined applicability limits intended to ensure that boric acid addition and mixing during an ELAP would occur under conditions similar to those for which boric acid mixing data is available. By letter dated January 8, 2014 (ADAMS Accession No. ML13276A183), the NRC staff endorsed the above position paper with three conditions:

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

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

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

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

> Condition 3: A delay period adequate to allow the injected boric acid solution to mix with the RCS inventory should be accounted for when determining the required timing for borated makeup. Provided that the flow in all loops is greater than or equal to the corresponding single-phase natural circulation flow rate, a mixing delay period of 1 hour is considered appropriate.

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

During the audit review, SNC confirmed that Vogtle will comply with the August 15, 2013, position paper on boric acid mixing, including the above conditions imposed in the NRC staff's corresponding endorsement letter. The NRC staff's audit [Reference 17] review indicated that the licensee's shutdown margin calculations are generally consistent with the PWROG's position paper, including the three additional conditions imposed in the NRC staff's endorsement letter.

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

3.2.3.5 FLEX Pumps and Water Supplies0

As described in its FIP [Reference 18], the licensee credits four portable pumps for each unit in its core cooling and reactivity control FLEX strategies; a SG FLEX pump, a makeup FLEX pump, a FLEX submersible pump, and a boron injection FLEX pump. The SG FLEX pump is a trailer-mounted, diesel engine driven, centrifugal pump, and this pump can take suction from the CSTs or the RMWST and provides a backup SG injection method in the event that the TDAFW pump can no longer perform its function. The licensee has three SG FLEX pumps on site,

which satisfies the N+1 requirement. The makeup FLEX pump is a trailer-mounted, diesel engine driven, positive centrifugal pumps, and this pump can take suction from the RMWST or the NSCW basins and provides a method to refill the CSTs. The licensee has three makeup FLEX pumps onsite, which satisfies the N+1 requirement. The FLEX submersible pump is a hydraulic-driven, centrifugal pump. The hydraulic driving unit is trailer mounted and powered by a diesel engine. The licensee uses the FLEX submersible pump to draw water from the NSCW basins and discharge to the SFP or to the CSTs. The licensee has four FLEX submersible pumps and two hydraulic units, which provide a motive force for the pumps, onsite, and satisfies the N+1 requirement. The boron injection FLEX pumps is a skid mounted, electric-driven (powered from the 480 V FLEX generator), centrifugal pump. The boron injection pump can take a suction from the BASTs or the RWST and provides a method for injecting boron into the RCS for reactivity control. The licensee has three boron injection FLEX pumps on site, which satisfies the N+1 requirement.

In accordance with NEI 12-06 [Reference 6], Section 11.2, the licensee performed the following calculations:

- AXDT005, "FLEX Portable System Phase 2 Core Cooling Subsystem Operating Modes 1-5 with Steam Generators Available," Version 2.0 [Reference 45]
- AX4DT108, "FLEX Portable System Phase 2 Core Cooling Subsystem Sizing Criteria for the Steam Generator FLEX Pump," Version 2.0 [Reference 46]
- AX4DT109, "FLEX Portable System Phase 2 Core Cooling Subsystem CST Cross-Connect Evaluation," Version 1.0 [Reference 47]
- AX4DT112, "FLEX Portable System Phase 2 Tank Makeup Subsystem CST Makeup Sizing Criteria for the CST FLEX Pump," Version 1.0 [Reference 48]
- AX4DT113, "FLEX Portable System Phase 2 Tank Makeup Subsystem, CST Makeup Sizing Criteria for the NSCW Sump Pump," Version 2.0 [Reference 49]
- X4CPS0173, "Required Makeup Flows and Water Availability for a Beyond Design Basis External Event at Vogtle Electric Generating Plant", Version 2.0 [Reference 50]
- AX4DT100, "Sizing Criteria for the Boron Injection Pump," Version 2.0 [Reference 51]

The NRC staff reviewed the calculations to determine if the licensee used standard evaluation methods, and proper assumptions and inputs, and compared the results of the calculation to the actual design specifications of the procured pumps. The licensee's calculations uses classical hydraulic analysis head loss and pressure gradient methods and include all pumps, valves, hoses, strainers, elevations, and line distances for the FLEX strategy water supply using the most limiting set of conditions for SG and RCS injection. The calculations determined the minimum required flow rate, minimum discharge pressure, and minimum net positive suction head available (NPSHa) for a pump to be able to perform its required function. The comparison of the actual pump performance data and the sizing criteria of the calculation shows that the SG FLEX pumps, makeup FLEX pumps, FLEX submersible pumps, and boron injection FLEX pumps should have the capacity needed to perform the required function for supporting core cooling and reactivity control.

Based on the NRC staff's review of the FLEX pumping capabilities at Vogtle, as described in the above hydraulic analyses and the FIP [Reference 18], the NRC staff concludes that the portable FLEX pumps should perform as intended to support core cooling and RCS inventory control during an ELAP event, consistent with NEI 12-06 [Reference 6], Section 11.2.

3.2.3.6 Electrical Analyses

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

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

According to the licensee's FIP, operators would declare an ELAP following a loss of offsite power, loss of all emergency diesel generators, and the loss of any ac power with a simultaneous loss of access to the UHS. The plants indefinite coping capability is attained through the implementation of pre-determined FLEX strategies that are focused on maintaining or restoring key plant safety functions. A safety function-based approach provides consistency with, and allows coordination with, existing plant emergency operating procedures (EOPs). The FLEX strategies are implemented in support of EOPs using FLEX Support Guidelines (FSGs) and Strategy Implementation Guides (SIGs).

During the first phase of the ELAP event, VEGP would rely on the Class 1E station batteries to provide power to key instrumentation for monitoring parameters and power to controls for SSCs used to maintain the key safety functions (Reactor core cooling, RCS/PCS inventory control, and Containment integrity). The VEGP Class 1E station batteries and associated dc distribution systems are located within the control building and auxiliary building, which are Seismic Category I structures. The Class 1E station batteries are therefore protected from the applicable extreme external hazards. Vogtle Procedures 19100-1 (Unit 1), "ECA - 0.0 Loss of All AC Power," Version 2.2 [Reference 52] and 19100-2 (Unit 2), "ECA - 0.0 Loss of all AC Power," Version 3.2 [Reference 53] directs plant operators to conserve dc power during the event by stripping non-essential loads. Operators will strip or shed unnecessary loads to extend battery life until backup power is available. The plant operators would commence load shedding within 15 minutes and complete load shedding within 45 minutes from the onset of an ELAP and LUHS event.

Each unit at VEGP has four Class 1E station batteries (A, B, C, and D) that were manufactured by C&D Technologies. Vogtle, Unit 1 batteries 1AD1B and 1BD1B are model LCY-39 with a capacity of 1862 ampere-hours (A-H), battery 1CD1B is model LCR-17 with a capacity of 976 A-H, and battery 1DD1B is model KCR-21 with a capacity of 698 A-H. VEGP Unit 2 batteries 2AD1B and 2BD1B are model LCY-37 with a capacity of 1764 A-H, battery 2CD1B is model LCR-17 with a capacity of 976 A-H, and battery 2DD1B is model KCR-21 with a capacity of 698 A-H. The licensee noted and the NRC staff confirmed that the useable Class 1E station battery capacity could be extended up for a minimum of 12 hours by shedding non-essential loads.

In its FIP [Reference 18], SNC noted that it had followed the guidance in NEI White Paper, "EA-12-049 Mitigating Strategies Resolution of Extended Battery Duty Cycles Generic Concern," (ADAMS Access No. ML13241A186) when calculating the duty cycle of the batteries. This paper was endorsed by the NRC (ML13241A188). In addition to the White Paper, the NRC sponsored testing at Brookhaven National Laboratory that resulted in the issuance of NUREG/CR-7188, "Testing to Evaluate Extended battery Operation in Nuclear Power Plants," in May of 2015. The testing provided additional validation that the NEI White Paper method was technically acceptable. The NRC staff reviewed the licensee's battery calculations and confirmed that they had followed the guidance in the NEI White Paper.

The NRC staff reviewed SNC's dc coping calculations X3CF14, "Class 1E Battery Station Blackout Extended Coping Time Study," Version 2.0 [Reference 54] and X3CF02, "Class 1E Battery Systems," Version 22 [Reference 55], which verified the capability of the dc system to supply power to the required loads during the first phase of the VEGP FLEX mitigation strategy plan for an ELAP as a result of a BDBEE. The licensee's evaluation identified the required loads and their associated ratings (ampere (A) and minimum required voltage) and the non-essential loads that would be shed within 45 minutes to ensure battery operation for at least 12 hours.

Based on the NRC staff's review of the licensee's analysis, the battery vendor's capacity and discharge rates for the Class 1E station batteries, and the licensee's procedures, the NRC staff finds that the VEGP, Units 1 and 2, dc systems have adequate capacity and capability to power the loads required to mitigate the consequences during Phase 1 of an ELAP as a result of a BDBEE provided that necessary load shedding is completed within the times assumed in the licensee's analysis.

The licensee's Phase 2 strategy includes repowering 480 Vac buses within 10 hours after initiation of an ELAP using portable 350-kilowatt (kW) (one per unit) 480 Vac FLEX diesel generators (DGs). The portable 480 Vac FLEX DGs would supply power to an installed 480Vac FLEX switchboard. In its FIP [Reference 18], SNC stated the FLEX Switchboard distributes power to one battery charger for each of the four 125 Vdc Switchgear (providing continuity of power for critical instrumentation, remote TDAFW pump operation, lighting in the "horseshoe" area of the Main Control Room), and one portable FLEX pump (Boron Injection or RCS Makeup, as needed). In addition to the 480 Vac FLEX Switchboard, the 480 Vac FLEX DG would supply power to a fuel oil transfer pump, the SFP level indication system, and the plant public address system.

The NRC staff reviewed SNC's Calculation AX3DT120, "FLEX Portable System, Units 1 & 2 480V Diesel Generator Sizing Calculation," Version 1.0 [Reference 56], conceptual single line diagrams, and the separation and isolation of the FLEX DGs from the emergency diesel generators (EDGs). Based on the NRC staff's review, the VEGP, Units 1 and 2 minimum required loads for the Phase 2, 350 kW FLEX DGs are 257 kW and 252 kW, respectively. Therefore, one 350 kW FLEX DG per unit is adequate to support the electrical loads required for Phase 2 strategies.

If one ("N") of the two FLEX DGs becomes unavailable or is out of service for maintenance, the other ("N+1") FLEX DG would be deployed to continue to support the required loads. The "N+1" FLEX DG is identical to the "N" FLEX DG, thus ensuring electrical compatibility and sufficient electrical capacity in an instance where substitution is required. Since the "N+1" FLEX DG is

identical and interchangeable with the "N" FLEX DG, the NRC staff finds that the licensee has met the provisions of NEI 12-06, Revision 2 [Reference 6] for spare equipment capability regarding the Phase 2 FLEX DGs.

For Phase 3, the licensee plans to continue the Phase 2 coping strategy with additional assistance provided from offsite equipment/resources. The offsite resources that will be provided by an NSRC includes four (two per unit) 1-megawatt (MW) 4160 Vac combustion turbine generators (CTGs), two (one per unit) 1100 kW 480 Vac CTGs, and distribution panels (including cables and connectors). Each portable 4160 Vac CTGs is capable of supplying approximately 1 MW, but two CTGs will be operated in parallel to provide a total of approximately 2 MW. The NRC staff reviewed SNC's Calculation AX3DT119, "FLEX Portable System 4160V FLEX Diesel Generator Sizing Calculation," Version 1.0 [Reference 57]. Based on the NRC staffs review, the minimum required loads for the Phase 3, 4160 Vac CTGs are 1280 kW for each unit. Based on the margin available for the 4160 Vac CTGs and the 480 Vac CTGs providing backup to the Phase 2 portable FLEX DGs, the NRC staff finds that the 4160 Vac and 480 Vac equipment being supplied from an NSRC has sufficient capacity and capability to supply the required loads.

3.2.4 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that should maintain or restore core cooling and RCS inventory during an ELAP event consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.3 Spent Fuel Pool Cooling Strategies

In NEI 12-06 [Reference 6], Table 3-2 and Appendix D, summarize an approach consisting of two separate capabilities for the SFP cooling strategies. This approach uses a portable injection source to provide the capability for 1) makeup via hoses on the refueling floor capable of exceeding the boil-off rate for the design basis heat load; and 2) makeup via connection to spent fuel pool cooling piping or other alternate location capable of exceeding the boil-off rate for the design-basis heat load. However, in JLD-ISG-2012-01, Revision 1 [Reference 7], the NRC staff did not fully accept this approach, and added another requirement to either have the capability to provide spray flow to the SFP, or complete an SFP integrity evaluation, which demonstrates that a seismic event would have a very low probability of inducing a crack in the SFP or its piping systems so that spray would not be needed to cool the spent fuel. The evaluation must use the reevaluated seismic hazard described in Section 3.5.1 below if it is higher than the site's current safe shutdown earthquake (SSE). During the event, the licensee selects the SFP makeup method to use based on plant conditions. This approach also requires a strategy to mitigate the effects of steam from the SFP, such as venting.

As described in NEI 12-06 [Reference 6], Section 3.2.1.7, and JLD-ISG-2012-01, Section 1.1, strategies that must be completed within a certain period of time should be identified and a basis that the time can be reasonably met should be provided. In NEI 12-06 [Reference 6], Section 3, provides the performance attributes, general criteria, and baseline assumptions to be used in developing the technical basis for the time constraints. Since the event is beyond-design-basis, the analysis used to provide the technical basis for time constraints for the mitigation strategies may use nominal initial values (without uncertainties) for plant parameters,

and best-estimate physics data. All equipment used for consequence mitigation may be assumed to operate at nominal setpoints and capacities. In NEI 12-06, Section 3.2.1.2 describes the initial plant conditions for the at-power mode of operation; Section 3.2.1.3 describes the initial conditions; and Section 3.2.1.6 describes SFP initial conditions.

In NEI 12-06 [Reference 6], Section 3.2.1.1 provides the acceptance criterion for the analyses serving as the technical basis for establishing the time constraints for the baseline coping capabilities to maintain SFP cooling. This criterion is keeping the fuel in the SFP covered with water.

The ELAP causes a loss of cooling in the SFP. As a result, the pool water will heat up and eventually boil off. The licensee's response is to provide makeup water. The timing of operator actions and the required makeup rates depend on the decay heat level of the fuel assemblies in the SFP. The sections below address the response during operating, pre-fuel transfer or post-fuel transfer operations. The effects of an ELAP with full core offload to the SFP is addressed in Section 3.11. The licensee has decided to provide the spray flow described in JLD-ISG-2012-01.

Part of the licensee's FIP defines strategies capable of mitigating a simultaneous ELAP and LUHS by providing the capability to maintain or restore SFP cooling at all units on the VEGP site. The NRC staff reviewed the licensee's FIP to determine whether the strategies outlined in the FIP, if implemented appropriately, would maintain or restore SFP cooling following the ELAP and LUHS. As part of its review, the NRC staff reviewed simplified flow diagrams, engineering drawings, summaries of calculations for sizing the FLEX pumps, and summaries of calculations that addressed the heat up rates of the SFP following a loss of normal cooling functions, during an ELAP.

While the licensee's FIP [Reference 18] identifies specific strategies, because of the inability to anticipate all possible scenarios, the strategies are also diverse and flexible to encompass a wide range of possible conditions. According to the licensee, its FIP strategies have been incorporated into the site emergency operating procedures in accordance with established EOP change processes and their impact to the design basis capabilities of the unit evaluated under 10 CFR 50.59.

The NRC staff discussed the SFP cooling portion of the VEGP mitigation strategy for an ELAP event with SNC and performed a walk-down of the licensee's SFP cooling strategies during an onsite audit. The walk-down focused on the areas where SFP cooling FLEX equipment will be stored, deployed, and operated, the connection points to the existing piping systems, and the hose runs from the deployed FLEX pumps. The licensee's basic FLEX strategy for maintaining SFP cooling is to monitor SFP level utilizing the SFPLI installed in accordance with NRC Order EA-12-051 and initiating SFP makeup as soon as resources are available but prior to SFP water level reaching 15 feet above the top of the fuel.

3.3.1 Phase 1

For Phase 1 SFP cooling, the licensee credits the large inventory and heat capacity of the water in the SFP. Following the loss of SFP cooling, the SFP will slowly heat up and eventually begin to boil. Based on the data provided in the licensee's calculation, using the most limiting non-outage, normal decay heat load and SFP starting temperature, the SFP would begin to boil in

approximately 14.14 hours after the loss of SFP cooling with the level reaching 15 feet above the fuel in approximately 55.21 hours. The licensee's initial coping strategy for SFP cooling is to allow evaporative cooling of the SFP while monitoring SFP level using instrumentation installed as required by NRC Order EA-12-051. Although SFP makeup is commenced during Phase 2, the licensee plans to begin deployment of makeup hoses at least 6 hours prior to the SFP reaching 200 °F in order to minimize personnel entering the area during a high heat and humidity conditions which may occur in later phases. Based on the data provided in calculation X4CPS0173 [Reference 50], using the most limiting non-outage, normal decay heat load and SFP starting temperature, the SFP would heat up to 200 °F in approximately 12.63 hours after the loss of SFP cooling. Even though the licensee does not anticipate providing makeup to the SFP during Phase 1, the licensee does have the capability to gravity feed to the SFPs from the RWST in MODES 1-5, which can be established immediately following a loss of power using existing plant procedures. As described in the FIP [Reference 18], the makeup flow rate using the RWST is approximately 75 gpm, assuming the RWST is near its Technical Specifications minimum volume of 686,000 gallons.

3.3.2 Phase 2

In accordance with NEI 12-06 [Reference 6], Table 3-1 and Appendix D, the licensee has developed three baseline SFP cooling strategies. The strategies use a portable injection source to provide makeup via connection to spent fuel pool cooling piping without having to access the refueling floor, via hoses on the refueling floor, and via spray using portable monitor nozzles from the refueling floor. As described in the FIP [Reference 18], personnel will align a FLEX submersible pump drawing water from the NSCW basins and discharging to the SFPs of both units to maintain a sufficient amount of water above the top of the fuel assemblies for cooling and shielding purposes.

The licensee's first method provides water at a rate that matches boil-off directly to the SFP from the NSCW basin via the SFP FLEX submersible pump discharging through a fire hose. As described in the FIP [Reference 18], the licensee will deploy hoses inside the fuel handling building prior to the SFP reaching 200 °F in order to minimize the need for personnel access to the SFP area, which may have degraded environmental conditions during an ELAP.

The licensee's second method provides water at a rate that matches boil-off to the SFP using SFP FLEX submersible pump taking suction from the NSCW basin and discharging through fire hoses connected to an adapter located on the SFP makeup line from the reactor makeup water system. The isolation valves for makeup are located in the auxiliary building with accessibility from the yard. This method would allow the licensee to provide makeup water to the SFP without having to access to the SFP.

The licensee's third method provides water at a rate of 250 gpm, to account for over spray, to each SFP using the SFP FLEX submersible pump taking suction from the NSCW basin and discharging to the SFP through a fire hose connected to a monitor spray nozzle. The spray strategy consists of deploying a hose to a pre-determined location in the SFP area, splitting flow into two separate hoses for each SFP, which connect to spray monitors located in the two most accessible corners of each SFP. As described in the FIP [Reference 18], the licensee will deploy the monitor nozzles and associated hoses prior to the SFP reaching 200 °F in order to minimize the need for personnel access to the SFP area, which may have degraded environmental conditions during an ELAP.

3.3.3 Phase 3

For Phase 3 SFP cooling, the licensee plans to continue using Phase 2 strategies and equipment. Personnel will continue monitoring SFP level and adding inventory as necessary using the SFP FLEX submersible pump. Once NSRC equipment arrives on site, the licensee can use the equipment to draw water from the Savannah River to replace depleted on-site Seismic Category 1 water inventories. As described in the FIP [Reference 18], as resources become available, the licensee can take action to transition away from extended Phase 2 coping strategies. Instructions for connection and utilization of NSRC equipment for long-term coping or recovery will be provided by the licensee's TSC personnel who will have assessed the condition of the plant and infrastructure, plant accessibility, and additional available offsite resources following the BDBEE.

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 [Reference 6], 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.

As described in the licensee's FIP [Reference 18], the licensee's Phase 1 SFP cooling strategy does not require any operator actions. However, the licensee does have the capability, if needed, to gravity feed the SFPs from the RWST in MODES 1-5, which can be established immediately following a loss of power using existing plant procedures. In addition, the licensee establishes a ventilation path to cope with temperature, humidity, and condensation from evaporation and/or boiling of the SFP. Personnel will establish a primary ventilation path by manually opening the personnel door on the south wall of the auxiliary building. Personnel can establish an alternate ventilation path by opening doors that allow steam to escape through the hot machine shop, and adjacent corridor and passage to the outdoors. Either vent path should be sufficient for the initial coping efforts because of the relatively large openings provided. As described in its FIP, the licensee will establish a ventilation path no later than 6 hours prior to the onset of boiling in the SFP.

The licensee's Phase 2 and Phase 3 SFP cooling strategy involves the use of the SFP FLEX submersible pump with suction from the NSCW basin, to supply water to the SFP. Part of the licensee's strategy relies on the parts of the reactor makeup water system piping. As described in the FIP [Reference 18] and UFSAR Table 3.2.2-1, the applicable portions of the reactor makeup water system piping are Seismic Category 1 components located in portions of the Seismic Category 1 auxiliary building, and are protected from all applicable external hazards. The NRC staff's evaluation of the robustness and availability of FLEX connections points for the FLEX pump is discussed in Section 3.7.3.1 below. Furthermore, the NRC staff's evaluation of the robustness and availability of the UHS for an ELAP event is discussed in Section 3.10.3.

3.3.4.1.2 Plant Instrumentation

In its FIP [Reference 18], 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 SFPLI, including the primary and back-up channels, the display to monitor the SFP water level and environmental qualifications to operate reliably for an extended period are discussed in Section 4 of this SE.

3.3.4.2 Thermal-Hydraulic Analyses

In accordance with NEI 12-06 [Reference 6], the licensee performed Calculation X4CPS0173, "Required Makeup Flows and Water Availability for a Beyond Design Basis External Event at Vogtle Electric Generating Plant", Version 2.0 [Reference 50] to determine the SFP heat up times and boil off rates given the design-basis operating decay heat load of 2.861×10^7 British thermal units per hour (Btu/hr). The calculation determined that, with no operator action following a loss of SFP, cooling the pool would boil in approximately 14.14 hours and reach the top of the fuel in 106.94. Makeup water at a rate of 61.45 gpm is needed to maintain water level once bulk boiling commences.

3.3.4.3 FLEX Pumps and Water Supplies

As described in its FIP [Reference 18], SNC's SFP cooling strategy relies on a FLEX submersible pump to provide SFP makeup during Phase 2. The pump is a hydraulic-driven, centrifugal pump. The hydraulic driving unit is trailer mounted and powered by a diesel engine. The FLEX submersible pumps take a suction from the NSCW basins and discharge to the SFP via one of the three methods discussed in Section 3.3.2 of this evaluation.

The licensee performed Calculations AX4DT009 "FLEX Portable System, Spent Fuel Pool Subsystem", Version 1.0 [Reference 58], and AX4DT118, "FLEX Portable System: Phase 2 Spent Pool Cooling Pump Sizing Using NSCW Basin as Primary Source and CST or RMWST as Alternate Source," Version 1.0 [Reference 59] to determine the required hydraulic performance of the FLEX submersible pump. The NRC staff reviewed the calculations to determine if the licensee used standard evaluation methods, and proper assumptions and inputs, and compared the results of the calculation to the actual design specifications of the procured pumps. The licensee's calculation used classical hydraulic analysis head loss and pressure gradient methods, and includes all pumps, valves, hoses, strainers, elevations, and line distances for the FLEX strategy water supply using the most limiting set of conditions for SFP makeup. The calculation determined the minimum required flow rate, minimum discharge pressure, and minimum NPSHa for a pump to be able to perform its required function. Comparison of the actual pump performance data and the sizing criteria of the calculation shows that FLEX SFP submersible pumps should have the capacity needed to perform the required function for supporting phase 2 SFP cooling.

As described in the FIP [Reference 18], the licensee's long-term strategy for SFP cooling is to continue the Phase 2 strategy. However, once supplemented by portable equipment delivered from the NSRC, the licensee can, if needed, supply water from the Savannah River to depleted on-site Seismic Category 1 water inventories.

3.3.4.4 Electrical Analyses

The licensee's FIP defines strategies capable of mitigating a simultaneous ELAP and LUHS resulting from a BDBEE, by providing the capability to maintain or restore core cooling, containment, and SFP cooling at all units on the VEGP site.

The NRC staff performed a comprehensive analysis of the licensee's electrical strategies, which includes the SFP cooling strategy. The licensee's Phase 1 strategy is to monitor SFP level using installed instrumentation (the capability of this instrumentation is described in other areas of this SE). SNC's Phase 2 strategy is to continue monitoring SFP level and repower SFPL instrumentation using the 480 Vac FLEX DG, if necessary. The licensee's procedures NMP-OS-019-362, "Vogtle Unit 1 SIG-2, 480V Power," Version 3.1 and NMP-OS-019-382, "Vogtle Unit 2 SIG-2, 480V Power," Version 2.0 provide guidance to energize the SFPLI system from a 480 Vac FLEX DG. The licensee's Phase 3 strategy is to provide power to the SFP cooling system using an NSRC supplied 4160 Vac CTG, if necessary. The NRC staff reviewed SNC's Calculations AX3DT120 and AX3DT119, and determined that the 480 Vac FLEX DGs and 4160 Vac CTGs being supplied from an NSRC have sufficient capacity and capability to supply SFP instrumentation and cooling systems.

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

3.3.5 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that if implemented appropriately should maintain or restore SFP cooling following an ELAP consistent with NEI 12-06 [Reference 6] guidance as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.4 Containment Function Strategies

The industry guidance document, NEI 12-06 [Reference 6], Table 3-2, provides some examples of acceptable approaches for demonstrating the baseline capability of the containment strategies to effectively maintain containment functions during all phases of an ELAP event. One such approach is for a licensee to perform an analysis demonstrating that containment pressure control is not challenged. Both Vogtle, Units 1 and 2 are Westinghouse pressurized-water reactors (PWRs) with dry ambient pressure containments.

The licensee performed Containment Evaluation, X4CPS0175, "Containment Integrity Analysis for FLEX Coping Strategies," Version 2, [Reference 60] which was based on the boundary conditions described in Section 3 of NEI 12-06 [Reference 6]. This calculation analyzed the strategy containment isolation, low leakage reactor coolant pump seals, and monitoring containment parameters and concluded that the containment parameters of pressure and temperature remain well below the respective UFSAR Section 6.2, TABLE 6.2.1-1 design limits of 52 psig and 381 °F for more than 72 hours. From its review of the evaluation, the NRC staff noted that the required actions to maintain containment integrity and required instrumentation functions have been developed, and are summarized below.

In response to NRC staff questions, the licensee indicated containment integrity during refueling operations will be assured by following the guidance in NEI position paper for shutdown/refueling modes (ADAMS Accession No. ML13267A382), as endorsed by the NRC (ADAMS Accession No. ML13267A382).

3.4.1 Phase 1

The OIP and FIP [Reference 18] indicate the Phase 1 containment mitigation strategy, during an ELAP, is to assume the containment will be completely isolated following the event. As such, there are no Phase 1 coping strategies required for maintaining containment integrity for operating Modes 1 through 4 beyond monitoring containment pressure. Containment parameters are monitored through Procedure 19200-C, "Critical Safety Function Tree".

3.4.2 <u>Phase 2</u>

Phase 2 includes the employment of FLEX DGs to charge station batteries (discussed in Section 3.2.3.6) the containment is assumed to be completely isolated following the event. As such, there are no Phase 1 coping strategies required for maintaining containment integrity for operating Modes 1 through 4 beyond monitoring containment pressure. Containment parameters are monitored through Procedure 19200-C, "Critical Safety Function Tree".

3.4.3 <u>Phase 3</u>

The Vogtle "Phase 3" strategy is to continue monitoring containment parameters in accordance with Procedure 19200-C. Guidance document NEI 12-06, Revision 2 [Reference 6], indicates in Table 3-2, PWR FLEX Baseline Capability Summary, recommends Containment Spray or alternate heat removal method or analysis demonstrating that containment pressure control is not challenged. The licensee chose to demonstrate that containment pressure control would not be challenged. Calculation X4CPS0175 [Reference 60], Figure 1 and Figure 2 show that containment temperature and pressure are increasing slowly. At 120 hours the containment pressure is 5.7 psig and the containment temperature is 213.2°F. The containment design pressure is 52 psig and the containment atmosphere design temperature is 381°F. The licensee argued that since decay heat is continued to be removed from the reactor core and the containment, it is not expected that containment design pressure will be exceeded.

The NRC staff reviewed Calculation X4CPS0175 [Reference 60] during the audit. The NRC staff noted that the slope of the containment pressure curve was nearly a straight line and that pressure increased less than 1°F between 100 and 120 hours. Considering that decay heat continues to be removed from containment using other strategies, NRC staff concurs that it is unlikely the pressure would increase from 5.7 psig to the design limit of 52 psig before action could be taken to reduce the containment pressure.

The licensee does have a defense-in-depth strategy. As discussed in FIP [Reference 18] Section 2.3.3, Phase 3 Strategy [Electrical], two 1M 4kV turbine generators will be used to repower either A or B Train 4kV 1E busses. Procedures NMP-OS-019-361 and NMP-OS-019-381 provide guidance for repowering the busses. The licensee stated that the Containment Coolers were considered among the loads that can be supported.

During the audit the licensee indicated they have flanged fittings available to connect a FLEX or NSRC pump to the NSCW system. This will permit establishing cooling water flow to one or more containment coolers. The licensee indicated that guidance is available to the TSC on the Phase 3 options.

3.4.4 Staff Evaluations

3.4.4.1 Availability of Structures, Systems, and Components

Guidance document NEI 12-06 [Reference 6] baseline assumptions have been established on the presumption that other than the ELAP and LUHS, installed equipment that is designed to be robust with respect to design-basis external events is assumed to be fully available. Installed equipment that is not robust is assumed to be unavailable. Below are the baseline assumptions for the availability of SSCs for maintaining containment functions during an ELAP.

3.4.4.1.1 Plant SSCs

Containment

In the VEGP UFSAR, Section 6 describes the containment building as a steel-lined, reinforced, prestressed concrete structure housing the nuclear steam supply system (NSSS). It is designed to minimize radioactive fission product release from the NSSS to the environs subsequent to postulated design-basis accidents. The containment design pressures are +52 psig and -3 psig and the containment atmospheric design temperature is 381 °F. The Containment is a Seismic Category 1 structure. In the UFSAR, Table 3.5.1-5 provides design criteria for tornado missiles. In the VEGP UFSAR, Section 6.2.1 provides additional description and discussion of design capabilities of the containment.

Containment Fan Coolers

The containment fan cooler system consists of redundant fan cooler units provided for post-accident containment atmosphere heat removal and pressure reduction. The Containment Coolers are Seismic Category 1 components which are also protected from the effects due to the design basis tornado (UFSAR, Table 3.2.2-1, Containment Coolers). The Containment Coolers are Seismic Category 1 components, which are also protected from the effects due to the design-basis tornado (UFSAR, Table 3.2.2-1, Section 3.5.1.4). The containment fan coolers reject heat to the NSCW system.

Nuclear Service Cooling Water

The NSCW system provides cooling water for the containment coolers, control building essential chiller condensers, various engineered safety features (ESF) pump coolers, standby diesel generator jacket water coolers and the component cooling water and auxiliary component cooling water heat exchangers and transfers the heat removed from these systems to the UHS. In the UFSAR, Table 3.2.2-1 indicates the NSCW is a Seismic Category 1 safety-related system. With the exception of the NSCW tower fan cells, protection of essential safety-related systems or components against tornado missiles that could enter through any openings in the exterior walls or roofs of Category 1 structures is provided by missile barriers and protective structures designed to withstand and absorb missile impact.

3.4.4.1.2 Plant Instrumentation

The Vogtle FIP indicated that instruments monitoring containment pressure remain available following specified load shed actions outlined in plant procedures. Analysis X3CF14, "Class 1 E Battery Station Blackout Extended Coping Time Study", Version 2.0, dated May 27, 2015 [Reference 54] indicates this strategy provides a minimum of two channels of instrumentation for a minimum of 12 hours from Station batteries, which allows for the installation of the 480V FLEX DGs by 1 0 hours after the start of the event. Only a single channel is needed for FLEX strategy. The containment pressure instrumentation credited in the strategy are:

CTMT Pressure	PI-937	A-Train Battery
	PI-936	B-Train Battery

Contingencies for alternate instrumentation monitoring are provided to the control room team following a BDBEE. Procedural guidance is provided for establishing alternate indications for essential instrumentation. Vogtle, Unit 1 (2) FSG-7, "Loss of Vital Instrumentation Or Control Power" [reference 44], provides guidance for obtaining containment vital parameters if normal instrumentation is not available.

In NEI 12-06 [Reference 6], Table 3-2, specifies that containment pressure is a key containment parameter which should be monitored by repowering the appropriate instruments. The licensee's FIP [Reference 18] states that control room instrumentation would be available due to the coping capability of the station batteries and associated inverters in Phase 1, or the portable DGs deployed in Phase 2. If no ac or dc power was available, the FIP states that key credited plant parameters, including containment pressure, would be available using alternate methods.

3.4.4.2 Thermal-Hydraulic Analyses

The licensee performed X4CPS0175, "Containment Integrity Analysis for FLEX Coping Strategies, Version 2" to demonstrate that the containment response following a postulated ELAP event does not challenge design limits until well after availability of off-site equipment and implementation of strategies to control pressure and temperature. The analysis used the Modular Accident Analysis Program (MAAP) PWR Version 4.0.5 analysis software for the containment analysis. The guidance provided in the position paper entitled "Use of Modular Accident Analysis Program (MAAP) in Support of Post-Fukushima Applications" (ADAMS Accession No. ML13190A201), as endorsed by the NRC (ADAMS Accession No. ML13275A318) was used to support the performance of ELAP containment analyses.

The assumed reactor coolant leakage is 5 gpm, consisting of 1 gpm RCP seal leakage and 1 gpm from unidentified sources. At roughly 9.5 hours, the lower containment compartment temperature is approximately 170°F. The peak containment temperature is approximately 213°F with a peak pressure of 20.4 psia (5.7 psig).

Appendix J of the calculation addressed the NRC's concerns and limitations regarding the use of the MAAP computer code as presented by NRC letter dated October 3, 2013, to NEI, (ADAMS Accession No. ML13275A318).

3.4.4.3 FLEX Pumps and Water Supplies

The licensee does not plan to use any water sources for mitigating containment pressure or temperature during an ELAP event. However, their defense-in-depth plan would utilize water from the NSCW basins. This is discussed above in Section 3.2.3.5, FLEX Pumps and Water Supplies.

3.4.4.4 Electrical Analyses

The licensee performed a containment evaluation based on the boundary conditions described in Section 2 of NEI 12-06 [Reference 6] to determine the temperature and pressure increase in the containment vessels resulting from an ELAP as a result of a BDBEE. Based on the results of its evaluation, the licensee developed required actions to ensure maintenance of containment integrity and required instrumentation continues to function. With an ELAP initiated, while either VEGP units are 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. Structural integrity of the reactor containment building due to increasing containment pressure will not be challenged during the first few days of an ELAP and LUHS event. However, with no cooling in the containment, temperatures in the containment are expected to rise and could reach a point where continued reliable operation of key instrumentation might be challenged. The licensee's evaluations have concluded that containment temperature and pressure will remain below containment design limits and that key parameter instruments subject to the containment environment will remain functional. Therefore, actions to reduce containment temperature and pressure and to ensure continued functionality of the key parameters will not be required immediately.

The licensee's Phase 1 coping strategy for containment involves initiating and verifying containment isolation in accordance with procedures 19100-1 and 19100-2 following an ELAP and LUHS. Phase 1 also includes monitoring containment pressure using installed equipment. Control room indication for containment pressure and containment temperature is available for the duration of the ELAP and LUHS.

The licensee's Phase 2 coping strategy is to continue monitoring containment pressure using installed instrumentation. The 480 Vac FLEX DGs will power the battery chargers, which will maintain dc bus voltage for continued availability of instrumentation needed to monitor containment pressure.

The licensee's Phase 3 coping strategy is to continue monitoring containment pressure, and use NSRC supplied equipment as necessary. If necessary, an NSRC supplied 4160 Vac CTGs could repower the containment cooling fans and the component cooling water pumps to restore containment cooling.

Based on its review, the NRC staff determined that the electrical equipment available onsite (e.g., 480 Vac FLEX DGs) supplemented with the equipment that will be supplied from an NSRC (e.g., 480 Vac and 4160 Vac CTGs), there is sufficient capacity and capability to supply the required loads to reduce containment temperature and pressure, if necessary, to ensure that the key components including required instruments remain functional.

3.4.5 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore containment functions following an ELAP event consistent with NEI 12-06 [Reference 6] guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.5 Characterization of External Hazards

Sections 4 through 9 of NEI 12-06 [Reference 6] provide the methodology to identify and characterize the applicable BDBEEs for each site. In addition, NEI 12-06 [Reference 6] provides a process to identify potential complicating factors for the protection and deployment of equipment needed for mitigation of applicable site-specific external hazards leading to an ELAP and 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 [Reference 6] and determined that FLEX equipment should be protected from the following hazards: seismic; external flooding; severe storms with high winds; snow, ice and extreme cold; and extreme high temperatures.

References to external hazards within the licensee's mitigating strategies and this safety evaluation are consistent with the guidance in NEI-12-06 [Reference 6] and the related NRC endorsement of NEI 12-06 in JLD-ISG-2012-01. The guidance in NEI 12-06 [Reference 6] directed licensees to proceed with evaluating external hazards based on currently available information. For most licensees, this meant that the OIP used the current design basis information for hazard evaluation. Coincident with the issuance of Order EA-12-049, on March 12, 2012, the NRC staff issued a Request for Information pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Section 50.54(f) [Reference 19] (hereafter referred to as the 50.54(f) letter), which requested that licensees reevaluate the seismic and flooding hazards at their sites using updated hazard information and current regulatory guidance and methodologies. Due to the time needed to reevaluate the hazards, and for the NRC to review and approve them, the reevaluated hazards were generally not available until after the mitigation strategies had been developed. The NRC staff has developed a proposed rule, titled "Mitigation of Beyond-Design-Basis Events," hereafter called the MBDBE rule, which was published for comment in the *Federal Register* on November 13, 2015 [Reference 42]. The proposed MBDBE rule would make the intent of Orders EA-12-049 and EA-12-051 generically applicable to all present and future power reactor licensees, while also requiring that licensees consider the reevaluated hazard information developed in response to the 50.54(f) letter.

The NRC staff requested Commission guidance related to the relationship between the reevaluated flooding hazards provided in response to the 50.54(f) letter and the requirements for Order EA-12-049 and the MBDBE rulemaking (see COMSECY-14-0037, Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards" [Reference 39]. The Commission provided guidance in an SRM to COMSECY-14-0037 [Reference 20]. The Commission approved the staff's recommendations

that licensees would need to address the reevaluated flooding hazards within their mitigating strategies for BDBEEs, and that licensees may need to address some specific flooding scenarios that could significantly damage the power plant site by developing scenario-specific mitigating strategies, possibly including unconventional measures, to prevent fuel damage in reactor cores or SFPs. The NRC staff did not request that the Commission consider making a requirement for mitigating strategies capable of addressing the reevaluated flooding hazards be immediately imposed, and the Commission did not require immediate imposition. In a letter to licensees dated September 1, 2015 [Reference 33], the NRC staff informed the licensees that the implementation of mitigation strategies should continue as described in licensee's OIPs, and that the NRC safety evaluations and inspections related to Order EA-12-049 will rely on the guidance provided in JLD-ISG-2012-01, Revision 0, and the related industry guidance in NEI 12-06, Revision 0. The hazard reevaluations may also identify issues to be entered into the licensee's corrective action program consistent with the OIPs submitted in accordance with Order EA-12-049.

As discussed above, licensees are reevaluating the site seismic and flood hazards as requested in the NRC's 50.54(f) letter. After the NRC staff approves the reevaluated hazards, licensees will use this information to perform flood and seismic mitigating strategies assessments (MSAs) per the guidance in NEI 12-06, Revision 2, Appendices G and H [Reference 6]. The NRC staff endorsed Revision 2 of NEI 12-06 in JLD-ISG-2012-01, Revision 1 [Reference 7]. The licensee's MSAs will evaluate the mitigating strategies described in this SE using the revised seismic hazard information and, if necessary, make changes to the strategies or equipment. Licensees will submit the MSAs for NRC staff review.

The licensee developed its OIP for mitigation strategies by considering the guidance in NEI 12-06 [Reference 6] and the site's design-basis hazards. Therefore, this SE makes a determination based on the licensee's OIP and FIP. The characterization of the applicable external hazards for the plant site is discussed below.

3.5.1 <u>Seismic</u>

In its FIP, the licensee stated that seismic hazards are applicable to the site and as discussed in the UFSAR, the SSE is 0.20g. It should be noted that the actual seismic hazard involves a spectral graph of the acceleration versus the frequency of the motion. Peak acceleration in a certain frequency range, such as the number above, is often used as a shortened way to describe the hazard.

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

3.5.2 <u>Flooding</u>

In its FIP [Reference 18], SNC stated that Vogtle is built above the design-basis flood level. The limiting design-basis flood-causing mechanism is dam failures. As stated in the Vogtle UFSAR Chapter 2 (Section 2.4.2), the flood elevation for dam failures is 168 feet mean sea level (MSL) while the elevation of the control building, containment buildings, diesel generator buildings, and

all safety-related structures is approximately 220 feet msl. Contours and grading in the Units 3 and 4 construction area are controlled to prevent impact on flooding analysis. The site is not adjacent to a large, enclosed, or partially enclosed body of water. The licensee concluded in its FIP, that in accordance with NEI 12-06 [Reference 6] (Section 6.2.1) Vogtle is considered a dry site and would not be adversely affected by external flooding.

The licensee did not describe any in-leakage concerns due to groundwater; however, in the NRC's assessment of SNC's response to the 50.54 (f) information request [Reference 43], the NRC staff determined that other associated effects on the site caused by hydrodynamic loading, debris, sediment, groundwater ingress or adverse weather conditions are insignificant or not applicable to the dam failure flooding on the Savannah River and noted that there is no onsite water control/storage structures that could cause dam failure related floods.

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

3.5.3 High Winds

In NEI 12-06 [Reference 6], Section 7, provides the NRC-endorsed screening process for evaluation of high wind hazards. This screening process considers the hazard due to hurricanes and tornadoes.

The screening for high wind hazards associated with hurricanes should be accomplished by comparing the site location to NEI 12-06 [Reference 6], 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 using the current licensing basis for hurricanes.

The screening for high wind hazard associated with tornadoes should be accomplished by comparing the site location to NEI 12-06 [Reference 6], 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 using the current licensing basis for tornados or Regulatory Guide 1.76, Revision 1.

In its FIP [Reference 18], regarding the determination of applicable extreme external hazards, SNC stated that the site is located at approximately 33° 09' 19" North latitude and 81° 46' West longitude. The location of VEGP is situated between the 160 mph and 170 mph contours shown in Figure 7-1 of NEI 12-06 [Reference 6]; therefore hurricanes are applicable to VEGP. The licensee also stated that for hurricanes, the VEGP (UFSAR, Section 2.3.1.2.5) indicates that the site is located approximately 100 miles inland from the Atlantic coast; so the effects from hurricanes or tropical depressions are considerably diminished.

As shown in Figure 7-2 of NEI 12-06 [Reference 6], the recommended tornado design wind speed for the 10^{-6} /year probability level for the 2 latitude/longitude block where VEGP is located is 172 mph. Therefore, tornado hazards, including missiles produced by these events, are applicable to VEGP.

The licensee stated that the design-basis tornado has a probability of occurrence of about 10^{-7} /per year. For the site region, the 10^{-7} probable tornado would have a maximum wind speed of about 360 mph, which is considered 290 mph rotational and 70 mph translational (Regulatory Guide 1.76, 1974). Safety-related systems and components are protected by missile barriers.

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

3.5.4 Snow, Ice, and Extreme Cold

As discussed in NEI 12-06 [Reference 6], Section 8.2.1, all sites should consider the temperature ranges and weather conditions for their site in storing and deploying FLEX equipment consistent with normal design practices. All sites outside of Southern California, Arizona, the Gulf Coast and Florida are expected to address deployment for conditions of snow, ice, and extreme cold. All sites located north of the 35th Parallel should provide the capability to address extreme snowfall with snow removal equipment. Finally, all sites except for those within Level 1 and 2 of the maximum ice storm severity map contained in Figure 8-2 should address the impact of ice storms.

In its FIP [Reference 18], SNC stated that in accordance with NEI 12-06 [Reference 6] Section 8.2.1 guidance, extreme snowfall is not a concern for VEGP which is located in the southeastern U.S. Snow is infrequent in the site region and heavy snow is very rare. The highest 24 hour snowfall on record was 13.7 inches in February of 1973 (UFSAR, Section 2.3.1.2.3). The average annual snowfall is only about 1 inch and the maximum probable winter precipitation is 19 inches over a 48 hour period. Thus, even in the unlikely scenario of an ELAP coincident with a maximum probable snowfall, snow removal could be easily accomplished with the normal debris removal equipment (e.g., wheeled loader).

In its FIP [Reference 18], SNC stated that the VEGP site is located within the region characterized by the Electric Power and Resource Institute (EPRI) as ice severity level 5 (NEI 12-06, Figure 8-2). As such, the site is subject to severe icing conditions that could also cause catastrophic destruction to electrical transmission lines. While freezing rain resulting in heavy ice loading in the site region is considered rare (UFSAR, Section 2.3.1.2.4), NEI guidelines still dictate that the storage and deployment of VEGP FLEX equipment must consider the impact of severe icing due to the EPRI study.

In its FIP [Reference 18], SNC stated that the normal daily minimum temperature ranges from 34°F in December and January to 70°F in July (UFSAR, Section 2.3.2.1.2). An extreme minimum temperature of 3°F was recorded in February 1899. Based on historical records, the temperature remains below freezing all day on the average of only 1 day each January. About one-half of the days in December, January, and February have minimum temperatures below freezing.

Icing does not occur on the lower reaches of the Savannah River based on records of minimum temperature from 1961 to 1980 (UFSAR, Section 2.4.7). Therefore, there is no risk of ice blockage of the Savannah River, frazil ice, or freezing of the below grade UHS water source in the nuclear service cooling water basins.

In summary, based on the available local data and Figures 8-1 and 8-2 of NEI 12-06 [Reference 6], the plant site does experience significant amounts of ice, and extreme cold temperatures; therefore, the hazard is screened in. The licensee has appropriately screened in the hazard and characterized the hazard in terms of expected temperatures.

3.5.5 Extreme Heat

The licensee stated in its FIP [Reference 18] that the Vogtle site normal daily maximum temperature ranges from 58°F in January to 91 °F in July. An extreme maximum of 106°F was recorded in July 1952. Based on a 14-year record, the average number of days in a year on which temperatures of 90°F and above occur is 62, ranging to approximately two-thirds of the days in July (UFSAR, Section 2.3.2.1.2).

Extreme high temperatures are not expected to impact the ability of personnel to implement the required FLEX strategies. Site industrial safety procedures currently address activities with a potential for heat stress to prevent adverse impacts on personnel.

In summary, based on the available local data and the guidance in Section 9 of NEI 12-06 [Reference 6], the plant site does experience extreme high temperatures. The licensee has appropriately screened in the high temperature hazard and characterized the hazard in terms of expected temperatures.

3.5.6 Conclusions

Based on the evaluation above, the NRC staff concludes that the licensee has developed a characterization of external hazards that is consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order in regard to the characterization of external hazards.

3.6 Planned Protection of FLEX Equipment

3.6.1 Protection from External Hazards

Below are additional details on how FLEX equipment is protected from each of the applicable external hazards while stored in the FLEX storage building. The licensee indicated in its FIP that most FLEX equipment is stored in the FLEX storage building, but the boron injection FLEX pumps and RCS makeup pumps are stored near their staging areas in the auxiliary building.

3.6.1.1 Seismic

In its FIP [Reference 18], SNC stated that the FLEX equipment is stored in a single 12,000 square foot concrete, tornado-missile protected structure that meets the plant's design-basis for the SSE. Additionally, the FLEX storage building has a 5,200 square foot (4750 square foot usable) mezzanine which is seismically robust.

In its FIP [Reference 18], SNC stated that large portable FLEX equipment such as pumps and power supplies are secured, as required, inside the FLEX storage building to protect them during a seismic event. The FLEX storage building has tie downs integrated into the floor slab for this purpose. These tie downs are used to secure any equipment that is not considered stable to ensure the stored FLEX equipment remains protected from damage during a seismic event. Additionally, fire piping and heating, ventilation, and air conditioning (HVAC) were designed and installed to meet the FLEX storage building specifications (seismic, wind, etc.). The lighting, conduits, electrical, and fire detection components were not seismically installed because they are considered insignificant and not able to damage FLEX equipment and only required functional before the event.

3.6.1.2 Flooding

In its FIP [Reference 18], SNC stated that the FLEX storage building is located outside of the protected area but within the owner controlled area. This location is significantly above the upper-bound flood stage elevation. The FLEX Storage Building was designed and constructed to prevent water intrusion.

3.6.1.3 High Winds

In its FIP [Reference 18], SNC stated that the logistics of equipment removal for maintenance and after a BDBEE was considered in the design of the building. Two tornado missile-resistant equipment doors are provided and located 180° around the perimeter of the building from each other. The door opening size provides a minimum clearance for equipment of 14 ft. in height and 16 ft. in width. The design also includes two personnel entry/exit doors. The tornado-resistant doors are designed to resist, and be operational during and after tornado wind pressure loads and tornado-missile loads. All tornado missile-resistant equipment access and personnel access doors have the ability to be operated manually in the case of a loss of power.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

In its FIP [Reference 18], SNC stated that the HVAC systems are designed to maintain the following indoor conditions: Heating: minimum indoor temperature of 50°F; and Cooling: maximum indoor temperature of 100°F.

3.6.2 Reliability of FLEX Equipment

Section 3.2.2 Step16 of NEI 12-06 [Reference 6] 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.

Each site should have N sets of FLEX hoses and cables. In addition, each site should have spare hose and cable in a quantity that meets either of the two methods described below:

Method 1: Provide additional hose or cable equivalent to 10 percent of the total length of each type/size of hose or cable necessary for the "N" capability. For each type/size of hose or cable needed for the "N" capability, at least 1 spare of the longest single section/length must be provided.

Method 2: Provide spare cabling and hose of sufficient length and sizing to replace the single longest run needed to support any single FLEX strategy.

In its FIP [Reference 18], the licensee stated that NEI 12-06 [Reference 6] invokes an N+1 requirement for the FLEX equipment that directly performs a FLEX mitigation strategy for core cooling, containment, or SFP cooling in order to assure reliability and availability of the FLEX equipment required to meet the FLEX strategies. Sufficient equipment is available 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 equipment required by FLEX strategies for all units on-site. Where a single resource is sized to support the required function of both units a second resource is available to meet the + 1 capability. In addition, where multiple strategies to accomplish a function have been developed, the equipment associated with each strategy does not require N+ 1 capability.

The licensee further stated that the N+1 requirement does not apply to the FLEX support equipment, vehicles, and tools. However, these items are subject to inventory checks, requirements, and any associated maintenance and testing.

In its FIP, the licensee provided a table that listed the portable FLEX equipment, including quantity and performance criteria for the FLEX equipment.

In Record of Decision Severe Accident Management, dated March 9, 2015, Attachment 1, "Selecting the Correct Amount of Cable and/or Hose for (+1) Strategy Capability," [Reference 87] SNC states that it will comply with either methods 1 or 2.
Based on the number of portable FLEX pumps, FLEX DGs, and support equipment identified in the FIP, the NRC staff finds that, if implemented appropriately, the licensee's FLEX strategies include a sufficient number of portable FLEX pumps, FLEX DGs, and sufficient lengths of hoses and cables for RCS makeup and boration, SFP makeup, and maintaining containment consistent with the N+1 recommendation in Section 3.2.2.16 of NEI 12-06 [Reference 6].

3.6.3 Conclusions

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

3.7 Planned Deployment of FLEX Equipment

In its FIP [Reference 18], SNC stated that multiple haul routes will be available from the FLEX storage building to any staging area. The appropriate haul routes have been evaluated for access as discussed in NEI 12-06 [Reference 6], Section 5.3.2 (including liquefaction).

3.7.1 Means of Deployment

In its FIP [Reference 18], SNC stated that the equipment being transported for Phase 2 strategies will be towed by a heavy duty pickup truck and a small semi-tractor. The wheeled loader can also be used to tow equipment. The tires for these vehicles and trailers are designed to withstand small debris punctures and razor wire cuts/penetration (i.e., large commercial/military grade, run-flat, non-pneumatic tires). Debris clearing equipment is stored in the FLEX storage building. This provides the equipment with direct access to the critical travel paths providing timely debris removal.

The licensee determined that all haul paths can support a minimum of two lanes of normal vehicular traffic. This will decrease the likelihood of a path being completely blocked, as well as reduce the time it will take to clear any debris. The possibility exists to move off of the roadway to avoid debris along a majority of the deployment route paths. Alternative routes into the power block area exist on the north and west sides of the plant that could be utilized.

The licensee performed a debris assessment for the site to determine debris removal equipment requirements. It was determined that the debris removal equipment should be capable of moving large debris such as automobiles, trees, pieces of buildings, switchyard structures, and concrete barriers, in addition to general assorted small debris. Based on this assessment, it was determined that a medium wheeled loader with the appropriate blade and horsepower can move the postulated debris in a single maneuver which simplifies and speeds the debris removal effort. This is because of its articulated steering and the capability of using a variety of tools which can be specific to the task. Various tools make this wheeled loader: a fork lift; a hoist; a modified version of a bulldozer; or a bucket lift. All tools are stored in the FLEX storage building.

During the NRC audit, the NRC staff reviewed SNC's strategy to deploy FLEX equipment during ice hazards. The licensee issued Condition Report to revise VEGP, "Cold Weather Checklist," procedure to incorporate a check of roads and access routes in the owner control area and protected area for icing conditions and designate a sand procurement location and deploy ice melt from warehouse.

3.7.2 Deployment Strategies

The licensee stated in its FIP [Reference 18], that for the travel paths, analyses indicate that there are potentially liquefiable soils below the design groundwater level, and that some settlement may occur along the travel paths following an earthquake. The magnitude of the settlement expected to occur is not anticipated to make the road impassable for the selected haul vehicles and wheeled loader.

The licensee stated that icing does not occur on the lower reaches of the Savannah River based on records of minimum temperature from 1961 to 1980 (UFSAR, Section 2.4.7). Therefore, the licensee concluded that there is no risk of ice blockage of the Savannah River, frazil ice, or freezing of the below grade UHS water source in the NSCW basins.

3.7.3 Connection Points

3.7.3.1 Mechanical Connection Points

Section 3.2.2.17 of NEI 12-06 [Reference 6] states that the portable pumps for core and SFP functions are expected to have primary and alternate connection or delivery points. At a minimum, the primary connection point should be an installed connection suitable for both the on-site and off-site equipment but the secondary connection point can require reconfiguration if the licensee can show that adequate time and resources are available to support the reconfiguration. In addition, NEI 12-06 [Reference 6], Table D-1 states that primary and alternate injection points should establish capability to inject through separate divisions/trains (i.e., should not have both connections in one division/train). The licensee's FIP describes the use of four portable pumps that connect to existing plant system piping via FLEX connections to support core cooling, reactivity control, and SFP cooling

SG FLEX Pump

The licensee credits the SG FLEX pump as a backup to the TDAFW pumps for SG injection. The SG FLEX pump can take a suction from the CSTs or the RMWST and discharges to the TDAFW pump discharge piping or the motor-driven AFW pump cross header.

The primary suction connection point for the SG FLEX pump is located in the CST valve house on the TDAFW suction line from CST-1. Section 3.8.4.1.8 of the UFSAR states that the CST valve house is a Seismic Category 1 structure, which provides tornado-generated missile protection for piping and equipment. The alternate suction connection for the SG FLEX pump is the RMWST drain line located in the moat adjacent to the RMWST valve gallery. The licensee responded to the NRC staff's questions and described that the RMWST drain line and upstream piping is seismic category 1E. However, the piping immediately downstream of the drain valves is non-seismic piping. The licensee performed an analysis that determined all of the drain lines meet seismic category 1E requirements. In addition, none of the piping is protected from tornado winds and tornado-generated missiles. The licensee stated that if the RMWST is unavailable, the SG FLEX pump can draw suction directly from the NSCW basins when aligned in series with a FLEX Submersible pump.

The primary connection point for the SG FLEX pump discharge is on the AFW "C" train, TDAFW pump discharge header. The connection is located in the TDAFW pump room. As described in the FIP and Table 3.2.2-1 of the UFSAR, the TDAFW pump room is a Seismic Category 1 structure, and provides protection from all applicable external hazards. The alternate connection point is located in the "A" train AFW pump room on the motor-driven AFW (MDAFW) pump discharge header cross-tie line. As described in the FIP and Table 3.2.2-1 of the UFSAR, the AFW pump room is a Seismic Category 1 structure, and provides protection from all applicable external hazards.

Makeup FLEX Pump

The licensee credits the makeup FLEX pump as a method to provide makeup water to the CSTs from the RMWST or the NSCW basins. The primary suction connection for the makeup FLEX pump is the RMWST drain line discussed above for the SG FLEX pump. The alternate suction

is directly from the surface of the NSCW basins.

The primary connection points for the makeup FLEX pump are fill connections located on each CST. The alternate connection points are on drain lines of each CST. The licensee's FIP describes the primary and alternate connections as seismically qualified. The licensee responded to the NRC staff's questions and described that the drain and fill lines and upstream piping is seismic category 1E. However, the piping immediately downstream of the fill and drain line valves is non-seismic piping. The licensee performed an analysis that determined all of the drain and fill lines meet seismic category 1E requirements. In addition, none of the piping is protected from tornado winds and tornado-generated missiles. The licensee stated that if the CST cannot be refilled, the SG FLEX pump can draw suction directly from the NSCW basins, when aligned in series with a FLEX Submersible pump, and discharge directly to the SG discharge connection points.

Boron Injection FLEX pump

The licensee credits the boron injection FLEX pump as a method for adding borated water to the RCS for inventory and reactivity control. The boron injection pump can take a suction from the BASTs or the RWST and discharges to the RCS. In Section 2.4.5 of its FIP, the licensee discusses the site mechanical FLEX connections including location and protection from applicable external hazards. In Section 2.4.5, the licensee does not discuss the FLEX connections for the suction of the boron injection FLEX pump. The licensee responded to the NRC staff's questions and stated that there are a total of four suction connections available per unit. All suction locations are located in the Seismic Category 1E, tornado missile protected auxiliary building. Two connections are to the boric acid storage tank, and two suction connection points to the RWST. The licensee uses existing plant equipment on part of the chemical and volume control system (CVCS) and the RHR system for the suction connection points. Both CVCS and RHR are Seismic Category 1E systems.
As described in the FIP, the primary and alternate connection points for the boron injection FLEX pump are located downstream of each RHR pump on RHR piping that discharges to each RCS cold leg. The connections are located in the Seismic Category 1 auxiliary building and are protected from all applicable external hazards.
FLEX Submersible Pump

The licensee credits the FLEX submersible pump as a method to provide makeup water to the SFP. The FLEX submersible pump is lowered into the NSCW basin where it takes a direct suction from the basin water. The FLEX submersible pump discharges to the SFP via hoses and portable spray monitors on the SFP deck, or via hose connected to the SFP makeup piping from the reactor makeup water system. The FLEX connection on the SFP piping is located in the Seismic Category 1 auxiliary building and is protected from all applicable external hazards.

3.7.3.2 <u>Electrical Connection Points</u>

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. There are three

portable 480 Vac FLEX DGs provided for the licensee's Phase 2 strategy. The 480 Vac FLEX DG staging location for VEGP, Unit 1 is on east end of the alley way (between the control building and turbine building). The 480 Vac FLEX DG staging location for VEGP, Unit 2 is on the west end of the alley way (between control building and turbine building).

The licensee's strategy is to use permanently installed connection boxes (primary and alternate) to connect the 480 Vac FLEX DGs to permanently installed 480 Vac FLEX switchboards. The primary 480 Vac FLEX DG connection boxes are installed on the north wall outside the control building adjacent to the main steam tunnel. The alternate 480 Vac FLEX DG connection boxes are installed in the Train "A" vertical chases at grade level inside the control building. The 480 Vac FLEX switchboards are connected to one of the two Class 1E battery chargers per train. Permanently installed Class 1E, seismically qualified FLEX transfer switches transfers power from the normal Class 1E source to the 480 Vac FLEX Switchboard for each of the battery chargers via permanently installed cables. The 480 Vac FLEX Switchboard also distributes power for one portable FLEX pump (Boron Injection or RCS Makeup), and a 120 Vac receptacle distribution panel. A safety-related seismically qualified transfer switch is also used to align the D train battery to control room lighting. In addition, the 480 Vac FLEX switchboards have the capability to be crosstied between units. Procedures NMP-OS-019-362, "Vogtle Unit 1, SIG-2 480V Power," [Reference 61] and NMP-OS-019-382, "Vogtle Unit 2, SIG-2 480V Power," [Reference 62], provide direction for connecting the 480 Vac FLEX DGs. Procedures NMP-OS-019-396, "FLEX Boron Injection Pump Operating Instructions," Version 1.0 [Reference 63] and NMP-OS-019-397, "RCS Makeup FLEX Pump Operating Instructions," Version 1.0 [Reference 64] provide direction for verifying proper phase rotation when the FLEX pumps are powered by the 480 Vac FLEX DG.

For Phase 3, the licensee will receive four (two per unit) 1 MW 4160 Vac and two (one per unit) 1100 kW 480 Vac CTGs from an NSRC. The two 1-MW 4160 Vac CTGs could be connected to either A or B train 4160 Vac vital buses. The NSRC supplied 4160 Vac CTGs for both units will be staged north of their respective diesel generator building. The NSRC supplied 480 Vac CTGs will be staged in the vicinity of the portable 480 Vac FLEX DGs and provide backup power, if necessary. Procedures NMP-OS-019-361 (Unit 1), "Vogtle Unit 1 SIG-1, 4160V Power," Version 1.0 [Reference 65] and NMP-OS-019-381 (Unit 2), "Vogtle Unit 2 SIG-1, 4160V Power," Version 1.0 [Reference 66] provide direction for connecting an NSRC supplied 4160 Vac CTG. Procedure NMP-OS-019-002, "TSC Support for Beyond Design Basis Events," Version 2.0 [Reference 67] provide direction for verifying proper phase rotation when powering equipment from an NSRC supplied CTG.

3.7.4 Accessibility and Lighting

In its FIP [Reference 18], SNC stated that in order to validate the adequacy of supplemental lighting and the adequacy and practicality of using portable lighting to perform FLEX strategy actions it was confirmed that all operators are required to have flashlights. In addition, the main control room (MCR) and maintenance shop include a stock of flashlights and batteries to further assist the SNC staff responding to a BDBEE event during low light conditions. The majority of areas for ingress/egress and deployment of FLEX strategies contain emergency lighting fixtures (Appendix “R” lighting) consisting of a battery, battery charger and associated light fixtures. These emergency lights are designed and periodically tested to insure the battery pack will provide a minimum of eight (8) hours of lighting with no external ac power sources. Therefore, these currently installed emergency lighting fixtures provide lighting to light pathways for 8 hours. Prior to the depletion of the Appendix "R" lighting, portable battery powered lighting could be deployed to support the FLEX strategy tasks.

SNC further described in its FIP [Reference 18] that there are no emergency lighting fixtures in the yard outside of the protected area to provide necessary lighting in those areas where portable FLEX equipment is to be deployed. Therefore, the large FLEX pumps and diesel generators are outfitted with light plants that are powered from either their respective diesel generators or batteries in order to support connection and operation. In addition to the lights installed on the FLEX equipment, portable light plants are available to be deployed from the FLEX storage building as needed to support night time operations.

In addition, SNC stated that installed ballasts on MCR light fixtures provide reduced illumination for 90 minutes. The strategy calls for operator action to align MCR lighting in the "Horseshoe" area to the associated unit's D battery. Analysis indicates that execution of specified load shed actions directed in plant procedures ensures a continued reliable source of illumination for a minimum of 14 hours until the 480V FLEX DG will be available to repower the battery charger that supplies the D battery which powers the MCR lighting. To align MCR lighting in the "Horseshoe" area to the associated Unit's D battery, operators manipulate breakers on a single 120V Instrument ac panel and position two control switches at readily accessible locations in the control building.

3.7.5 Access to Protected and Vital Areas

During the audit process, the licensee provided information describing that access to protected areas will not be hindered. The licensee has contingencies in place to provide access to areas required for the ELAP response if the normal access control systems are without power.

3.7.6 Fueling of FLEX Equipment

In its FIP [reference 18], SNC stated that the four underground diesel fuel oil storage tanks (DFOSTs) are seismically qualified and have a nominal capacity of 80,000 gallons each. The VEGP technical specifications require that each DFOST contains at least 68,000 gallons of fuel. The stored quantity of fuel in any selected DFOST will meet the fuel demand for all of the diesel driven FLEX equipment well past 72 hours. The Phase 2 support strategy includes repowering an existing diesel fuel oil transfer pump to refill a FLEX fuel tanker from the chosen DFOST. Hoses are connected to vent connections in the existing pump discharge piping. Temporary FLEX cables with quick connect terminations will supply power from a 480V FLEX DG to the

existing pump motor cables. A FLEX fuel tanker will be towed to each diesel-driven FLEX component that needs refueling. An on board dc powered pump will dispense fuel oil from the tanker. The haul routes for transporting fuel are the same haul routes for deployment of the FLEX equipment, which are evaluated for accessibility following screened in external hazards.

All four DFOSTs have been sampled to determine sulfur content and all were found to be in excess of 200 parts per million (ppm). At the current usage rate of fuel oil it will be years before the sulfur content in the DFOSTs reaches 15 ppm (Ultra Low Sulfur Diesel fuel). The debris removal equipment, tow vehicles and diesel lights are the only FLEX equipment that require ultra-low sulfur diesel. Because of how long it will take to reduce the sulfur content in the DFOST's a sufficient quantity of ultra-low sulfur fuel oil will be maintained to operate the equipment listed above for a minimum of 72 hours. A fixed fuel tanker, stored in the FLEX storage building, is used to keep the equipment, requiring ultra-low sulfur, fueled. The 500 gallon capacity fuel tanker is sufficient to keep the FLEX equipment requiring ultra-low sulfur fueled for at least 72 hours.

3.7.7 Conclusions

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

3.8 Considerations in Using Offsite Resources

3.8.1 VEGP SAFER Plan

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

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

By letter dated September 26, 2014 [Reference 21], the NRC staff issued its assessment of the NSRCs established in response to Order EA-12-049. In its assessment, the NRC staff concluded that SAFER has procured equipment, implemented appropriate processes to maintain the equipment, and developed plans to deliver the equipment needed to support site responses to BDBEEs, consistent with NEI 12-06 [Reference 6] 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.

In its FIP [Reference 18], SNC stated that on-site FLEX equipment hose and cable end fittings are standardized with the equipment supplied from the NSRC. In the event of an ELAP and LUHS event, equipment will be moved from an NSRC to a local assembly area established by the SAFER team. FLEX strategy requests to the NSRC will be directed by FLEX procedures.

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), which are offsite areas (within about 25 miles of the plant) utilized for receipt of ground transported or airlifted equipment from the NSRCs. From Staging Areas C and/or D, the SAFER team will transport the Phase 3 equipment to the on-site Staging Area B for interim staging prior to it being transported to the final location in the plant (Staging Area A) for use in Phase 3. For VEGP Alternate Staging Area D is described as an intermediate staging area approximately 25 miles from the site. Staging Area C is the Barnwell Regional Airport, South Carolina. Staging Areas A and B were referred to as the plant site staging area.

In its FIP [Reference 18], SNC stated that the local assembly area (Staging Area "C") is the Barnwell Regional Airport, South Carolina. From there, equipment can be delivered to the Vogtle site by helicopter if ground transportation routes are not available. Communications will be established between the Vogtle plant site and the SAFER team via satellite phones and required equipment moved to the site as needed. First arriving equipment will be delivered to the site within 24 hours from the initial request. The order at which equipment is delivered is identified in the Vogtle "Site Response Plan."

SNC further stated that NSRC personnel will commence delivery of a pre-selected equipment set from the NSRC upon notification by the plant site. Plans are to deliver equipment from offsite sources via truck or air lift. Typically deliveries will go by truck using preselected routes and with any necessary escort capabilities to ensure timely arrival at the plant site staging area or to an intermediate staging area approximately 25 miles from the site. The delivery of equipment from the intermediate staging area will use the same methodology. These areas are designed to accommodate the equipment being delivered from the NSRC. Depending on time constraints, equipment can be flown commercially to a major airport near the plant site and trucked or air lifted from there to the staging areas. The use of helicopter delivery is typically considered when routes to the plant are impassable and time considerations for delivery will not be met with ground transportation. Multiple pre-selected routes are one method to circumvent the effects of seismic events, floods, etc. and these routes will take into account potentially impassible areas such as bridges, rivers, heavily wooded areas and towns. The drivers will have the routes marked and will be in communication with the NSRC to ensure that the equipment arrives on time.

3.8.3 Conclusions

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

3.9 Habitability and Operations

3.9.1 Equipment Operating Conditions

3.9.1.1 Loss of Ventilation and Cooling

Following a BDBEE and subsequent ELAP event at VEGP, ventilation providing cooling to occupied areas and areas containing FLEX strategy equipment will be lost. As discussed in the guidance given in NEI 12-06 [Reference 6], FLEX strategies must be capable of execution under the adverse conditions expected following a BDBEE resulting in an ELAP and LUHS event. The primary concern with regard to ventilation is the heat buildup that 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 within equipment design limits for the equipment to remain functional.

The key areas identified for all phases of execution of the FLEX strategy activities are the MCR, TDAFW Pump Room, Vital Battery and Switchgear Rooms, and Containment. The licensee evaluated these areas to determine the maximum steady state temperatures expected in specific areas related to FLEX implementation to ensure the environmental conditions remain acceptable within equipment design limits for the equipment to remain functional.

Main Control Room

The NRC staff reviewed SNC Calculation X4C1531S05, "Main Control Room Heatup During an Extended Loss of AC Power," Version 1.0 [Reference 68], which modeled the MCR temperature transient for the first 72 hours following a BDBEE resulting in an ELAP. The calculation showed that the expected MCR temperature will remain below 109°F if the Unit 2 side MCR access doors is blocked open within 3 hours, and a portable fan is deployed within 15 hours and additional doors are blocked open on the Unit 1 MCR side. Procedure NMP-OS-019-370, "Vogtle Unit C SIG-10, Ventilation," Version 1 [Reference 69] provides guidance for opening doors and providing portable ventilation to minimize MCR temperature increases after a loss of ventilation and cooling due to ELAP.

Based on temperatures remaining below 120°F (the temperature limit, as identified in NUMARC-87-00, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," Revision 1, for electronic equipment to be able to survive indefinitely), the NRC staff finds that the electrical equipment in the MCR will not be adversely impacted by the loss of ventilation as a result of an ELAP event.

TDAFW Pump Room

The NRC staff reviewed SNC Calculation X4C1593S03, "Vogtle Auxiliary Feedwater Pump House Heatup Evaluation During an Extended Loss of all AC Power," Version 1.0 [Reference 70], which modeled the TDAFW pump room temperature transient for the first 72 hours following a BDBEE resulting in a ELAP. The calculation showed that the expected TDAFW pump room temperature will remain below 116°F without any mitigating actions being taken. The temperature rise in the room is mitigated by natural circulation with the entryway, which is

at a lower temperature than the TDAFW pump room. The circulation path is through the air intake opening on the south wall.

Based on temperatures remaining below 120°F (the temperature limit, as identified in NUMARC-87-00, Revision 1, for electronic equipment to be able to survive indefinitely), the NRC staff finds that the electrical equipment and controls in the TDAFW room will not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Vital Battery and Switchgear Rooms

The NRC staff reviewed SNC Calculation X4C1533V02, "Vogtle DC Equipment Rooms Heat Up after an Extended Loss of All AC Power," Version 2.0 [Reference 71], which modeled the vital battery and switchgear rooms temperature transient for the first 7 days following a BDBEE resulting in a ELAP.

For the vital battery rooms, Calculation X4C1533V02 [Reference 71] showed that the expected temperature will remain below 95°F if battery room doors are opened within 1 hour and portable ventilation is provided when the 480 Vac FLEX DGs are available. Procedures NMP-OS-019-362 [Reference 61] and NMP-OS-019-382 [Reference 62] provides guidance for opening doors and setting up portable ventilation to minimize battery room temperature increases after a loss of ventilation and cooling due to an ELAP event.

Based on the above, the NRC staff finds that the licensee's ventilation strategy will maintain the battery room temperature below the maximum temperature limit (122°F) of the batteries, as specified by the battery manufacturer (C&D Technologies). Therefore, the NRC staff finds that the VEGP vital batteries should perform their required functions at the expected temperatures as a result of loss of ventilation during an ELAP event.

For the switchgear rooms, Calculation X4C1533V02 [Reference 71] showed that the expected temperature will remain below 108°F if switchgear room doors are opened within 1 hour and portable ventilation is provided when the 480 Vac FLEX DG is available. Procedures NMP-OS-019-362 [Reference 61] and NMP-OS-019-382 [Reference 62] provides guidance for opening doors and setting up portable ventilation to minimize switchgear room temperature increases after a loss of ventilation and cooling due to an ELAP event.

Based on temperatures remaining below 120°F (the temperature limit, as identified in NUMARC-87-00, Revision 1, for electronic equipment to be able to survive indefinitely), the NRC staff finds that the equipment in the switchgear rooms will not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Containment

The NRC staff reviewed SNC Calculation AX4DT123, "Evaluation of Operability of Electrical Equipment in Containment Relied Upon For A BDBEE (FLEX Event)," Version 1.0 [Reference 72]. The calculation showed temperature profile observed during the FLEX event is bounded by the design basis analysis or by environmental qualification testing for all modes of operation to ensure operation of critical electrical components inside the containment. In its FIP [Reference 18], SNC stated that the expected containment temperature and pressure will remain below the design basis limits beyond 120 hours, because of the significant margin to the design-basis

limits. Since the containment design limits are not exceeded, then the equipment in containment is expected to remain operable.

Based on the expected temperature and pressure not approaching containment design-basis limits, the NRC staff finds that the required electrical equipment in the containment will not be adversely impacted by a loss of ventilation as a result of an ELAP event.

3.9.1.2 Loss of Heating

In its FIP [Reference 18], SNC stated that historically the temperature at the site remains below freezing all day on the average of only 1 day in January and one-half of the days in December, January, and February have minimum temperatures below freezing. Therefore, extreme cold is not considered to be a significant concern for the site.

The impact on the performance of the vital batteries based on low temperatures is minimal. The vital batteries are located in the interior of the Control Building such that outside air temperature would not impact battery performance. The vital batteries are normally maintained between 70-77°F. In addition, during battery discharge the battery will be producing heat which will keep electrolyte temperature above the room temperature. Therefore, the NRC staff finds that VEGP vital batteries should perform their required functions as a result of loss of heating during an ELAP event.

3.9.1.3 Hydrogen Gas Control in Vital Battery Rooms

An additional ventilation concern that is applicable to 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. The NRC staff reviewed SNC Calculation, X3CF16, "Class 1E Battery Hydrogen Generation after an Extended Loss of AC Power (ELAP)," Version 3.0 [Reference 73], to verify that hydrogen gas accumulation in the 125 Vdc Vital Battery rooms will not reach combustible levels while HVAC is lost during an ELAP. In its FIP [Reference 18], SNC stated that opening battery room doors open at 1 hour ensures that the time to 2 percent hydrogen concentration in the battery rooms is well beyond 30 days. The off-gassing of hydrogen from batteries is only a concern when the batteries are charging. Procedures NMP-OS-019-362 [Reference 61] and NMP-OS-019-382 [Reference 62] provide guidance for opening doors and setting up portable ventilation to provide cooling and prevent a buildup of hydrogen in the battery rooms.

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

3.9.2 Personnel Habitability

3.9.2.1 Main Control Room

Under ELAP conditions with no mitigating actions taken, Calculation X4C1531 S05, "Main Control Room Heatup During an Extended Loss of AC Power", Version 1.0 [Reference 68] projects the control room temperature to surpass 110°F (the assumed maximum temperature for efficient human performance as described in NUMARC 87-00) in less than 4 hours. The Phase 1 FLEX strategy will be to block open selected doors within 3 hours. This strategy

establish a natural ventilation path providing enough ventilation to keep MCR temperature below 110°F until power can be provided for a portable fan. By 15 hours, the licensee plans to deploy portable ventilation and block open additional doors. The licensee determined that as discussed in NUMARC 87-00, the equipment in the MCR can be exposed to thermal environments of 120°F. Since the temperature in the MCR will be maintained less than 110°F the electrical equipment is expected to remain operable.

During cold weather, the ventilation flow can be limited to keep the MCR at a habitable temperature. During hot weather, if the outside temperature is above 98°F, then the doors will not be opened until the MCR temperature is in excess of the outside temperature. Note that on the infrequent days when the peak daily outside temperature is above 98°F, this temperature is normally only exceeded for a limited time during the afternoon hours. In addition, there is on average a 20°F difference between the daily high and low temperatures.

3.9.2.2 Spent Fuel Pool Area

In its FIP [Reference 18], SNC stated the SFP bulk boiling will create adverse temperature, humidity, and condensation conditions in the SFP area which requires a ventilation vent pathway to exhaust the humid atmosphere from SFP area. During the audit process the licensee indicated they did not have a calculation to determine the SFP room temperature. All operator activities in the SFP area will be completed before the SFP reaches 200°F. The ELAP activities will be completed no later than 6 hours prior to reaching 200°F. The primary pathway will be established by manually opening the personnel door on the south wall of the Auxiliary Building. An alternate ventilation path can be established by opening doors that allow steam to escape through the hot machine shop and adjacent corridor and passage to outdoors. The licensee indicated that either vent path will be sufficient for the initial coping efforts due to the relatively large openings provided. Establishing the vent path will occur no later than 6 hours prior to boiling in the SFP. Licensee Procedures 19200-1 [Reference 52] and 19200-2 [Reference 53] and NMP-OS-019-368, "Vogtle Unit C SIG-8, Spent Fuel Pool Makeup," Version 1 [Reference 74] ensure a ventilation path is established before the Spent Fuel Pool exceeds 200°F.

3.9.2.3 Other Plant Areas

TDAFW Pump Room

During operation, there can be a considerable heat load within the room from the steam turbine and associated piping. The licensee evaluated the operation of TDAFW without forced ventilation for the ELAP and LUHS condition in calculation X4C1593S03, "Vogtle Auxiliary Feedwater Pump House Heatup Evaluation During an Extended Loss of all AC Power", Version 1.0 [Reference 70]. This calculation determined that with no supplemental ventilation, the room would heat up to a maximum of 116°F during the first 72 hours of operation.

The calculation shows the temperature rise in this room is mitigated by natural circulation. An open damper provides air flow via heat-induced natural circulation. It is sufficient to maintain accessibility of the room for manual operation and to maintain equipment temperatures within operating limits. The licensee determined a temperature of 116°F is deemed acceptable for infrequent occupancy to allow local operation of pumps. The acceptance criteria for personal habitability for short intervals of exposure is 150°F, which is derived from an aero medical

laboratory report titled "Human Tolerance for Short Exposures to Heat" (Air Technical Service Command Engineering Division, Wright Field, Dayton, Ohio, Serial No. TSEAL-3-695-49A, "Human Tolerance for Short Exposures to Heat", 28 February 1945).

During the audit, NRC staff walked down areas to verify cooling strategies, and the NRC staff verified that there are no HELB sensors in the TDAFW room that would trip steam to the TDAFW pump.

Battery and Switchgear Rooms

During the ELAP event, the 125V dc and inverter-fed 120V ac electrical distributions are energized and maintain power to instrumentation and controls for core cooling, containment, and SFP cooling functions. Analysis X4C1533V02, "Vogtle DC Equipment Rooms Heat Up after an Extended Loss of All AC Power", Version 2.0 [Reference 71] determined that the maximum temperature in the switchgear and battery rooms over a period of 7 days from the start of the BDBEE is 108°F and 95°F respectfully. The licensee determined this requires that the doors to the switchgear and battery rooms be propped open within 1 hour from the start of the event. Although not required for equipment protection, fans are available to allow for additional mixing of air from the switchgear and battery rooms with the large volume of the adjacent non-train switchgear room on Level "B" in the Control Building.

Operators are procedurally directed to open the switchgear and battery room doors within 1 hour and to stage and start room fans as part of the FLEX Switchgear energization. Procedures NMP-OS-019-362 and NMP-OS-019-382, attachment 7 [References 61 and 62] provide guidance for establishing 125VDC Switchgear and Battery Room ventilation. The licensee preformed an evaluation of equipment in the switchgear and battery rooms determined that this equipment will operate with no perceptual change in life expectancy when operating at the maximum temperatures for up to 7 days. Since temperatures in and around the switchgear and battery rooms will remain less than 110°F, no specific action is needed to address habitability. Since continuous occupation is not needed for operation of this equipment, operators can withdraw to a cooler area between equipment checks.

Main Steam Valve Rooms

In response to NRC staff questions, SNC indicated the maximum normal temperature in main steam valve rooms is expected to be 115°F; abnormal temperature is 126°F. In responding to the ELAP scenario, shift operators will be dispatched to manually reposition Atmospheric Relief Valves for steam generator depressurization. Manual operation of these valves is considered to be relatively light work of short duration. The manual operating station is located near openings in the vertical walls that communicate the ambient outdoor environment via security grating. Continuous standby in the area is not required and operators can cycle in and out of the room as necessary to make minor adjustments directed by the MCR operator. The licensee expects, based the experience of shift operators, that the main steam valve rooms would be accessible and habitable during these activities.

3.9.3 Conclusions

The NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore equipment and personnel habitability conditions

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

3.10 Water Sources

Initial Condition 3 of NEI 12-06 [Reference 6], Section 3.2.1.3, states that cooling and make-up water inventories contained in systems or structures with designs that are robust for the applicable hazard(s) are available. The NRC staff reviewed SNC's planned water sources to verify that each water source was robust as defined in NEI 12-06 [Reference 6].

In its FIP [Reference 18], SNC provided a comprehensive list of onsite water sources considered for core cooling and SFP cooling coping strategies. This table considers each source's design robustness with respect to seismic events, high winds, and associated missiles. Only the CST, RMWST, RWST, NSCW, and Savannah River meet the qualification guidelines of NEI 12-06 [Reference 6] for an injection source that can be credited for the ELAP and LUHS event. Other tanks and basins are included in the table to provide a comprehensive list of site water sources. These non-creditable water sources may be available for injection, depending on the cause of the event, and although these are not credited, they will be considered for use during an actual event.

During the review, it was noted that the BASTs were not included on the list of credited onsite water sources but are credited as the source of water for RCS injection. However, in Section 2.4.4.9 of its FIP, the licensee described the BASTs as seismic category 1 tanks that are protected against externally generated missiles by the auxiliary building.

3.10.1 Steam Generator Make-Up

In its FIP [Reference 18], SNC provided the following information in regards to SG makeup water sources: Initially, core decay heat is removed by adding water to the SGs and releasing steam from the SGs from the main steam safeties to the atmosphere. The water will initially be added by the TDAFW pump, taking suction from the CSTs. Each unit has two (2) CSTs, each with a credited inventory equal to 340,000 gallons of demineralized water. Based on the minimum volume of water available, the credited volume in the CSTs can support core cooling and heat removal requirements in MODES 1 through 4 for a minimum 89 hours. Prior to depletion, the CSTs can be provided makeup from the RMWST (primary method) or one of the two NSCW basins (alternate method). The preferred source of makeup for SG injection is the RMWST. The RMWST contains de-mineralized water with a minimum inventory of 148,000 gallons that is capable of providing at least 30 additional hours of makeup after depletion of the CSTs. The NSCW basins contain 3,361,500 gallons per unit.

3.10.2 Reactor Coolant System Make-Up

In its FIP [Reference 18], SNC stated that Vogtle has installed safe shutdown/low leakage RCP seals for the RCPs. No Phase 1 actions are required for inventory control. With RCP shutdown seals and the injection of accumulator inventory, analyses demonstrates that natural circulation in the RCS can be maintained for at least 70 hours without reliance upon FLEX RCS injection.

The licensee further stated that at 8 hours, depressurization of the SGs is initiated via local operation of ARVs. The RCS cooldown occurs at the same time as the SGs are depressurized.

This enables boration via accumulators and boron injection FLEX pump to maintain sub-criticality margin. No credit is taken for boron added from the SI accumulators.

In addition, SNC stated that at approximately 12 hours, the portable boron injection FLEX pump is available to initiate supplemental boration (with letdown as necessary) transferring water from the BASTs to the RCS to ensure adequate boration and maintain sub-criticality following RCS cooldown. The BAST is the primary suction source for the boron injection FLEX pump. The BAST has a minimum required volume of 36,674 gallons. The RWST is also available as a source of borated water for boron injection if needed and has a minimum capacity of 686,000 gallons and has the capacity to supply borated water to the RCS for 47 days after the BAST is depleted. For RCS injection beyond 72 hours, boron mixing equipment (delivered from the NSRC) can be employed to restore the RWST inventory

3.10.3 Spent Fuel Pool Make-Up

In its FIP [Reference 18], SNC indicated that at the onset of the event plant procedures can be used to align the RWST with up to 75 gpm via gravity drain to maintain SFP level until the FLEX submersible pump is aligned to the NSCW basins. The RWST has a minimum capacity of 686,000 gallons. The NSCW basins are the preferred source of makeup to the SFP with a minimum capacity in each basin of 3,361,500 gallons of water. The borated water inventory in the RWST is available as a backup source for SFP cooling. When supplemented by portable equipment delivered from off-site (NSRC), water from the Savannah River can be used to replace depleted on-site seismic category 1 water inventories.

3.10.4 Containment Cooling

In its FIP, SNC stated that it is expected that containment temperature and pressure will remain below the design-basis limits beyond 120 hours, because of the significant margin to the design-basis limits. Since the containment design limits are not exceeded, then the equipment in containment is expected to remain operable. Containment coolers, when supplemented by portable equipment delivered from off-site, can be aligned to maintain containment integrity. Since no time sensitive Phase 3 actions have been identified, instructions for connection and utilization of NSRC equipment for long-term coping or recovery will be provided by TSC personnel.

3.10.5 Conclusions

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

3.11 Shutdown and Refueling Analyses

Order EA-12-049 requires that licensees must be capable of implementing the mitigation strategies in all modes. In general, the discussion above focuses on an ELAP occurring during power operations. This is appropriate, as plants typically operate at power for 90 percent or more of the year. When the ELAP occurs with the plant at power, the mitigation strategy initially focuses on the use of the steam-driven TDAFW pump to provide the water initially needed for

decay heat removal. If the plant has been shut down and all or most of the fuel has been removed from the RPV and placed in the SFP, there may be a shorter timeline to implement the makeup of water to the SFP. However, this is balanced by the fact that if immediate cooling is not required for the fuel in the reactor vessel, the operators can concentrate on providing makeup to the SFP. The licensee's analysis shows that following a full core offload to the SFP, about 27 hours are available to implement makeup before boil-off results in the water level in the SFP dropping to a level of 15 feet above the top of the fuel, and the licensee has stated that they have the ability to implement makeup to the SFP within that time.

When a plant is in shutdown mode in which steam is not available to operate the TDAFW pump and allow operators to release steam from the SGs (which typically occurs when the RCS has been cooled below about 300 °F), another strategy must be used for decay heat removal. The NRC-endorsed strategy is described in NEI 12-06. Section 3.2.3 provides guidance to licensees for reducing shutdown risk by incorporating FLEX equipment in the shutdown risk process and procedures. Considerations in the shutdown risk assessment process include maintaining necessary FLEX equipment readily available and potentially pre-deploying or pre-staging equipment to support maintaining or restoring key safety functions in the event of a loss of shutdown cooling. In its FIP [Reference 18], SNC stated that it would follow this guidance. During the audit process, the NRC staff observed that the licensee had made progress in implementing this guidance.

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

3.12 Procedures and Training

3.12.1 Procedures

In its FIP [Reference 18], SNC stated that the plant indefinite coping capability is attained through the implementation of pre-determined strategies (FLEX strategies) that are focused on maintaining or restoring key plant safety functions. The FLEX strategies are not tied to any specific damage state or mechanistic assessment of external events. Rather, the strategies are developed to maintain the key plant safety functions based on the evaluation of plant response to the coincident ELAP and LUHS event. A safety function-based approach provides consistency with, and allows coordination with, existing plant EOPs. FLEX strategies are implemented in support of EOPs using FSGs and SIGs. The SIGs were developed to have operator actions in the field included in a separate "operator friendly" procedure format. The FSGs and SIGs together are equivalent to the PWROG generic FSGs. The FSGs and SIGs, have been incorporated into the VEGP EOPs in accordance with established EOP change processes, and their impact to the design basis capabilities of the unit evaluated under 10 CFR 50.59.

During the on-site audit, NRC staff reviewed several plant procedures related to mitigation strategies (EOPs, Abnormal Operating Procedures, FSGs, SIGs and other plant procedures) and did not identify any concerns with the procedures.

3.12.2 Training

Training has been developed and delivered to the target populations (Operations, Maintenance, Security, and Emergency Response Organization (ERO) staff) using the systematic approach to training (SAT) process. The licensee's training satisfies the applicable requirements of NEI 12-06 [Reference 6], Section 11.6. The SNC general population is trained using the National Academy of Nuclear Training electronic Learning (NANTeL) courses provided by the Emergency Response Training Development (ERTD) Working Group (INPO facilitated). The ERTD conducted a job analysis to identify common training topics and coordinated the design and development of common training materials. The licensee staff responsible for the implementation of the FSGs also complete additional NANTeL training provided by the ERTD working group. The ERO decision makers receive additional training on directing actions and implementing strategies following a BDBEE.

3.12.3 Conclusions

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

3.13 Maintenance and Testing of FLEX Equipment

In its FIP [Reference 18], SNC provided the following information in regards to maintenance and testing of FLEX equipment:

FLEX equipment (including support equipment) is subjected to initial acceptance testing and to periodic maintenance and testing utilizing the guidance provided in INPO AP 913, Equipment Reliability Process, to verify proper function. The standard EPRI industry PM process (similar to the Preventive Maintenance Basis Database) is used to establish the maintenance and testing actions for FLEX equipment. This provides assurance that stored or pre-staged FLEX equipment is being properly maintained and tested.

The EPRI FLEX maintenance templates (where provided) were used to develop the specific maintenance and testing guidance for the associated FLEX equipment. In the absence of an EPRI FLEX template, existing maintenance templates (where available) were used to develop the specific maintenance and testing guidance. For all other equipment not covered by a maintenance template, manufacturer OEM or industry standards were used to determine the recommended maintenance and testing.

The PM Templates include activities such as:

- Functional Test and Inspection
- Fluid Filter Replacement
- Fluid Analysis
- Generator Load Test
- Component Operational Inspection
- Standby Walkdown

The unavailability of FLEX equipment and applicable connections that directly perform a FLEX mitigation strategy for core, containment, and SFP is managed such that risk to mitigating strategy capability is minimized. The maintenance and risk guidance conforms to the guidance of NEI 12-06 [Reference 6]. The unavailability of FLEX equipment and connections is controlled using the tracking application in the Shift Operations Management System as discussed in Procedure NMP-OS-019-013, "Beyond Design Basis Equipment Unavailability Tracking," Version 1.0 [Reference 75]. FLEX equipment and connections will not normally be used for purposes other than emergency response. It is permissible, however, to pre-stage and/or use FLEX equipment and connections provided the following requirements are met:

- Permission is received from the Shift Manager or Emergency Director.
- The proper action to restore the equipment to an available status is determined and the status of the affected equipment and/or connection is tracked.

FLEX equipment and resources may be allocated when requested to support a beyond design basis emergency event at another nuclear site provided the following requirements are met:

- Permission is received from the Site Duty Manager.
- The status of the allocated equipment is tracked and unavailability actions implemented.

The NRC staff finds that the licensee has adequately addressed equipment maintenance and testing activities associated with FLEX equipment because a maintenance and testing program has been established in accordance with NEI 12-06 [Reference 6], Section 11.5.

3.14 Alternatives to NEI 12-06, Revision 2

The licensee did not propose any alternatives to NEI 12-06, Revision 2 [Reference 6].

3.15 Conclusions for Order EA-12-049

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

4.0 TECHNICAL EVALUATION OF ORDER EA-12-051

By letter dated February 27, 2013 [Reference 22], the licensee submitted its OIP for VEGP in response to Order EA-12-051. By letter dated June 18, 2013 [Reference 23], the NRC staff sent a request for additional information (RAI) to the licensee. The licensee provided its response by letter dated July 17, 2013 [Reference 24]. By letter dated November 4, 2013 [Reference 25], the NRC staff issued an Interim SE to the licensee. By letter dated August 25, 2015 [Reference 17], the NRC issued an audit report on the licensee's progress.

By letters dated August 27, 2013 [Reference 26], February 26, 2014 [Reference 27], August 26, 2014 [Reference 28], and February 26, 2015 [Reference 29], the licensee submitted status reports for the Integrated Plan. The Integrated Plan described the strategies and guidance to be implemented by the licensee for the installation of reliable SFPLI which will function following a BDBEE, including modifications necessary to support this implementation, pursuant to Order

EA-12-051. By letters dated December 1, 2014 [Reference 30], and November 20, 2015 [Reference 31], the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved for Unit 2 and Unit 1, respectively.

The licensee installed a SFPLI system designed by Westinghouse. The NRC staff audited Westinghouse's SFPLI design and test results in support of SNC's OIP for Order EA-12-051. During this audit, the NRC staff reviewed the vendor's SFPLI system design specifications, calculations and analyses, test plans, and test reports. The NRC staff issued an audit report on August 18, 2014 [Reference 38].

The NRC staff performed an onsite audit to review the implementation of SFPLI related to Order EA-12-051. The scope of the audit included verification of site's seismic and environmental conditions enveloped by the equipment qualifications; equipment installation met the requirements and vendor's recommendations; and program features met the requirements. By letter dated August 25, 2015 [Reference 17], the NRC issued an audit report on the licensee's progress. Refer to Section 2.2 above for the regulatory background for this section.

4.1 Levels of Required Monitoring

In its OIP, the licensee stated that:

> Fuel pool level when suction loss occurs can be conservatively defined as the SFP cooling system low level set point of 217 feet (ft.) 0 inches (in.) which is above the elevation at the top of the fuel pool cooling system suction line that is at approximately 214 ft. 11 in.

In its letter dated July 17, 2013 [Reference 24], the licensee stated, in part, that

> Level 1 is established as the SFP cooling system low level set point of 217"-0", which is above the elevation at the top of the fuel pool cooling system suction line that is at approximately 214'-11". Two trains supply Unit 1 and Unit 2 spent fuel pool cooling water. When adjusted for saturated steam conditions, the pool level needed to meet the NPSH required is 214"-6" for Train A and 219'-6" for Train B but only one train is required for operation. Thus, the two points described in NEI 12-02 for loss of NPSH for the VEGP Spent Fuel Pool are 214'-11" and 214'-6" and the HIGHER of the two is 214'-11". However, VEGP conservatively selects Level 1 as 217'-0" since it is the normal low level set point for the SFP Cooling system.

In its OIP, the licensee stated that Level 2 would be set at a plant elevation of 203 ft. 9-1/8 in., which is approximately 10 ft. above the highest point of the fuel racks for both units at elevation 193 ft. 9-1/8 in. The licensee also stated that Level 3 would be set at plant elevation of 193 ft. 9-1/8 in., which is the nominal level of the highest fuel rack. In its letter dated July 17, 2013 [Reference 24], the licensee provided a sketch depicting elevations identified as Level 1, 2, and 3 the level measurement range and the top of the tallest fuel storage rack.

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

- Level 1 is above the elevation at the top of the SFP cooling system suction lines. Thus, the designated Level 1 setpoint would allow the licensee to identify a level in the SFP adequate to support operation of the normal SFP cooling system and represent the higher of the options described in NEI 12-02.

- Level 2 meets first option described in NEI 12-02 for Level 2, which is 10 feet (+/- 1 foot) above the highest point of any fuel rack seated in the spent fuel pools. The designed Level 2 represents the range of water level where any necessary operations in the vicinity of the SFP can be completed without significant dose consequences from direct gamma radiation from the SFP consistent with NEI 12-02.

- Level 3 is above the highest point of any fuel storage rack seated in the spent fuel pool. This level allows the licensee to initiate water make-up with no delay in complying with the NEI 12-02 guidance for the highest point of the fuel racks in the SFP. Compliance with the NEI 12-02 guidance with regards to the highest point of the fuel racks conservatively meets the Order EA-12-051 requirement for a level where the fuel remains covered.

Based on the discussion above, the NRC staff finds that the licensee's proposed Levels 1, 2, and 3 are 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 SFPLI shall include specific design features, including specifications on the instruments, arrangement, mounting, qualification, independence, power supplies, accuracy, testing, and display. Refer to Section 2.2 above for the requirements of the order in regards to the design features. Below is the NRC staff's assessment of the design features of the SFPLI.

4.2.1 Design Features: Instruments

In its OIP [Reference 22], SNC stated that for both Units 1 and 2, the primary and backup instrument channels will consist of fixed components. The measurement range will be continuous from a SFP level elevation of 219 ft. 0 in. to the top of the fuel racks at an elevation of 193 ft. 9-1/8 in.

The NRC staff noted that the specified measurement range will cover Level 1, 2, and 3 as described in Section 4.1 above. Based on the evaluation above, the NRC staff finds that the licensee's design, with respect to the number of channels and measurement range for its SFP, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.2 Design Features: Arrangement

In its OIP [Reference 22], SNC stated that:

> SFP level probes will be installed separate from each other in the SFP. Primary and backup level indication will be installed in the Main Control Room, at the

alternate shutdown panel, or another appropriate and accessible location that complies with the NEI12-02 characteristics.

In its OIP [Reference 22], SNC provided a drawing that shows the proposed location for the instrument channels. For Unit 2, the two level sensors would be separately located in the northwest corner and southwest corner of its SFP. For Unit 1, the two level sensors would be separately located in the northeast corner and southeast corner of its SFP.

In its letter dated July 17, 2013 [Reference 24], the licensee provided a marked-up plant drawing for each unit, which shows a plan view of the SFP area, inside dimensions of the SFP, the locations of the level sensors, and associated mounting brackets. In its letters dated December 1, 2014 [Reference 30] and November 20, 2015 [Reference 31], the licensee stated that a plan view sketch of the SFP area is provided as Figure 1 of the letters. The sketch depicts the placement of the primary and alternate level sensors, and the routing of cables that extend toward the location of the electronics. Physical separation of the primary and alternate channels to the extent practicable and comparable to the short side of the pool, is use to provide reasonable protection of the level indication function against missiles that may result from the damage to the structure over the SFP.

During the onsite audit, the NRC staff observed that the cable from the pool side level sensor to the wall crossing the walkway was routed in the flexible conduit. The NRC staff expressed its concern that flexible conduit does not provide sufficient protection from damages caused by traffic and internal missiles. In response to the NRC staff's concern, the licensee generated Technical Evaluation Quality Record #921511, in which it stated that Vogtle will add additional protection to the Unit 2 flexible conduit and either use rigid conduit or install additional protection to the Unit 1 flexible conduit.

In its letter dated November 20, 2015 [Reference 31], SNC informed the NRC staff that the Work Order SNC680490 was issued to perform the design enhancement, and this action has been completed. The conduit design was enhanced prior to installation incorporating ridged conduit all the way to the sensor. The NRC staff found the licensee's response acceptable because it addressed the NRC staff's concern about potential damages caused by traffic and internal missiles.

Guidance document NEI 12-02 recommends mounting the sensors on locations separated by a distance comparable to the shortest length of a side of the pool, if practical. During the onsite audit, the NRC staff observed that the locations chosen by the licensee are physically separated by a distance comparable to the shortest length of a side of the pool to provide protection and to minimize the possibility of a single event or missile damaging both channels. The NRC staff also 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 finds that, if implemented appropriately, the licensee's proposed arrangement for the SFPLI 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 <u>Design Features: Mounting</u>

In its OIP, the licensee stated that:

> Per NEI 12-02 Section 3.3, the new equipment will be mounted to maintain the current Seismic Class of the Spent Fuel Pool which is Seismic Class I. Thus, the new equipment will be seismically qualified to Class I. In addition, the mounting of the primary and backup channel components throughout the plant will meet the criteria of the structure it will be routed through or attached to.

In its letters dated December 1, 2014 [Reference 30] and November 20, 2015 [Reference 31], SNC stated that:

> The mounting bracket will be attached to the SFP concrete floor utilizing expansion-type concrete anchor bolts. The level sensor consists of a stranded stainless steel cable level probe that is threaded on the top end. The probe attaches (threads) into a coupling that is secured to the mounting bracket launch plate and extends down into the pool. The attachment to the signal cable is via a coaxial connection on the top side of the launch plate coupling. The level sensor (probe) is designed to be attached near its upper end to the mounting bracket. The mounting bracket will be attached to the SFP concrete floor utilizing expansion-type concrete anchor bolts. The mounting bracket to the SFP structure concrete floor anchorage is designed to meet the requirements of the Vogtle design and licensing basis for Seismic Category I components including seismic loads, static weight loads and hydrodynamic loads.

The licensee also stated that the analyses used to verify the design criteria and methodology for seismic testing of the SFP instrumentation and the electronics units, including, design-basis maximum seismic loads and the hydrodynamic loads that could result from pool sloshing or other effects that could accompany such seismic forces was provided in the Attachment "Describes Requirements for Structural Integrity and Reliability" to these two letters.

During the onsite audit, the NRC staff reviewed the mounting specifications and seismic analyses for the SFPLI, including the methodology and design criteria used to estimate the total loading on the mounting devices. The NRC staff also reviewed the design inputs and the methodology used to qualify the structural integrity of the affected structures for each of the SFPLI mounting attachments. Based on its review, the NRC staff found that the criteria established by the licensee adequately account for the appropriate structural loading conditions, including seismic and hydrodynamic loads. The NRC staff reviewed X2CK06.21.01, "Seismic Analysis of The SFP Mounting Bracket at Farley Nuclear Plant And Vogtle Electric Generating Plant," Revision 1 [Reference 76]; X2CK06.21, "Evaluation of Anchorage for The Probe Mount In The Fuel Handling Bldg. for SFP Instrumentation," Revision 1 [Reference 77]; X2CK02.07.03.04, "Anchorage for The Sensor Head [Transmitter] Mount Assembly for Spent Fuel Pool Level Instrumentation," Revision 1 [Reference 78]; and X2CK02.07.03.05, "Anchorage for the Electronic Enclosure for Spent Fuel Pool Level Instrumentation," Revision 1 [Reference 79].

During the onsite audit, the NRC staff observed that an anchor bolt for one of the Unit-2 SFPLI channel's pull box was missing. In response, SNC stated that due to the interference, the concerned pull box was mounted to the mounting support thru the back of the box at one location as allowed by typical type II junction box support Drawing AX2D94V052-JB-2, "CAT-I Type Conduit Support Type JB-2," Revision 1. The NRC staff reviewed Drawing AX2D94V052-JB-2, "CAT-I Type Conduit Support Type JB-2," Revision 1 [Reference 80] and Work Order SNC 570499 and found it to be acceptable.

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

In its OIP [Reference 22], the licensee stated that augmented quality requirements, similar to those applied to fire protection, will be applied to the components installed in response to Order EA-12-051. The NRC staff finds that, if implemented appropriately, the licensee's approach is 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 Temperature, Humidity, and Radiation

In its OIP [Reference 22], the licensee stated that:

> The components/cables/connections for both primary and backup channels will be reliable at the temperature, humidity, and radiation levels consistent with the spent fuel pool water at saturation conditions for seven (7) days. Saturation temperature at the bottom of the SFP assuming normal water level will be approximately 250°F. Post event temperature at sensors located above the SFP is assumed to be 212°F. Post event humidity in the fuel pool floor near and above the SFP is assumed to be 100% with condensing steam. The components/cables/connections will be qualified for expected conditions at the installed location assuming the SFP has been at saturation for an extended period. The components/cables/connections located in the vicinity of the SFP will be qualified to withstand peak and total integrated dose radiation levels for their installed location assuming that post event SFP water level is equal to the top of irradiated fuel for a time no greater than six (6) hours.

In its letter dated July 17, 2013 [Reference 24], the licensee stated that:

> Two independent guided wave radar instrumentation systems will be installed per unit for the SFP level monitoring. They will be purchased as commercial-grade equipment and qualified to operate under the normal and Beyond Design Basis (BDB) environments as required by NRC Order EA-12-051 and the guidance of NEI 12-02. The equipment will be qualified seismically (IEEE 344) and environmentally (IEEE 323). The "in-pool" components and transmitter will be qualified to ANSIIISA-S71.03 Class SA 1 (Shock) and ANSIIISA-S71.03 Class VC2 (Vibration). These qualifications will be performed to bounding conditions.
>
> As part of the design change process, the seismic qualification for the equipment will be reviewed by SNC for the specific location at Plant Vogtle to ensure that the bounding conditions envelope the specific plant conditions. An instrument/equipment qualification calculation will be prepared to document the radiation as a function of the water level covered on the top of spent fuel during normal operation and BDB conditions. Equipment robustness and reliability will be assured through the use of conservative design margins and a seismic qualification process that will confirm accurate instrumentation performance following a seismic event. However, the specific method or combination of methods that would be used to confirm the reliability of the permanently installed equipment has not yet been determined by the instrumentation manufacturer.

In its letters dated December 1, 2014 [Reference 30] and November 20, 2015 [Reference 31], the licensee stated that the information used to confirm the reliability of the permanently installed equipment such that following a seismic event the instrument will maintain its required accuracy is provided in the Attachment, "Describes Requirements for Structural Integrity and Reliability", to these letters.

During the onsite audit, SNC provided testing results included in Westinghouse document EQ-369 Revision 2, 2X6AN10-00084 and SNC Site Acceptance Test Report SNC576693, "SAM-U2-SFP SAT Test," Revision 0. As discussed in SNC576693, SNC's SFPLI passed all the design acceptance criteria.

During the onsite audit, SNC also provided the NRC staff the following documents and a summary of each document:

- Calculation X6CCB17 "Radiation Dose at the Spent Fuel Pool (SFP) Instrumentation During Beyond Design Basis Event Per NEI 12-02," Revision 1 [Reference 81], which determines the radiation levels at the SFP instrumentation locations for normal conditions and during the design basis event.

- DOEJ-VDSNC521783-M003, "Room Temperature Evaluation for Spent Fuel Pool Instrumentation System (SFPIS) during Extended Loss of AC Power Event per NEI12-06," Revision 1 [Reference 82], which evaluates the ambient temperature for those rooms which contain equipment/components of the SFPLI System during an extended loss of AC power event.

The NRC staff reviewed Calculation X6CCB17, "Radiation Dose at the Spent Fuel Pool (SFP) Instrumentation During Beyond Design Basis Event Per NEI 12-02," Revision 1; and DOEJ-VDSNC521783-M003, "Room Temperature Evaluation for Spent Fuel Pool Instrumentation System (SFPIS) during Extended Loss of AC Power Event per NEI12-06," Revision 1. The NRC staff noted that the calculated integrated doses, temperature, and humidity for both the normal condition and post BDB event for the locations where the SFPLI System located are enveloped by the acceptable limits.

During the onsite audit, the NRC staff inquired about an assessment of potential susceptibilities of Electromagnetic Interferences (EMI) and Radio-Frequency Interference (RFI) in the areas where the SFP instruments are located and how to mitigate those susceptibilities. In response, the licensee stated that DOEJ-VDSNC521783-J001, evaluates the electromagnetic compatibility (EMC) design verification test results of the Westinghouse Spent Fuel Pool Level Instrumentation System (SFPLIS) installed under DCP SNC521783 to satisfy the requirements of NRC Order EA-12-051. The Site Acceptance Test (SAT) report includes the EMI Testing for radio susceptibility of the installed SFPLI. Based on the DOEJ and the SAT results, the SFPLI is not affected by EMI/RFI.

The Unit 1 SAT will include testing for radio susceptibility of the installed SFPI. Based on the results from the testing, additional restrictions will be implemented as necessary.

The NRC staff found the response acceptable and verified it by reviewing Work Order #SNC567993, "SAM-U2-SFP SAT Test". The licensee will perform EMI/RFI SAT for Unit 1 and based on the results of testing, the licensee will implement additional restriction as necessary.

During the onsite audit, the NRC staff also inquired about the final configuration of Vogtle SFPLI cable connectors (straight or 90 degree) and modification (if any) to the connectors as resulted from Westinghouse's recent life-upgrade tests for the connectors. In response to the NRC staff's request, the licensee stated that final configuration of Vogtle SFPLI cable connectors consists of a straight connector at the transmitter, and a 90 degree connector at the probe. No modifications were required to be made to the connectors, as a result of Westinghouse's recent tests. Drawings 2X6AN10-00120 shows the cable configuration and 2X6AN10-00119 shows connector details.

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

4.2.4.3 <u>Instrument Channel Reliability</u>

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

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

- effects of shock and vibration on instrument channel components used during any applicable event for only installed components, and
- seismic effects on instrument channel components used during and following a potential seismic event for only installed components.

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

The NRC staff reviewed the Westinghouse SFPLI's qualification and testing during the vendor audit for temperature, humidity, radiation, shock and vibration, and seismic [Reference 38], and the NRC staff found the Westinghouse SFPLI design and qualification process acceptable. The NRC staff further reviewed the anticipated VEGP's environmental conditions during the onsite audit [Reference 17] and found that the licensee adequately addressed the qualification process.

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

4.2.5 Design Features: Independence

In its OIP [Reference 22], SNC stated that the primary and backup instrument channels are of the same technology, are permanently installed, and separated by distance or barriers, and use independent power supplies from different buses/switchgear.

In its letter dated July 17, 2013 [Reference 24], SNC stated that:

> Each level measurement system will be designed and installed to achieve physical and spatial separation and electrical independence. Independent power sources will be provided from separate 120V AC Distribution Panels, for both SFP level monitoring channels for each Vogtle Unit. Dedicated conduit will be used to provide physical separation between the probes and the transmitters. From the transmitters to the readouts the separation will be in accordance with Plant Vogtle electrical design criteria, RG 1.75 and IEEE 384. Different penetrations in the SFP room wall and other walls will be used for the level signals from the sensors to the transmitters and to the readout devices, which will be mounted in separate enclosures.

In its letters dated December 1, 2014 [Reference 30] and November 20, 2015 [Reference 31], the licensee provided the NRC the configuration of the power supply source for each channel for Units 1 and 2. Specifically, the licensee stated that the VEGP, Unit 1 Primary Channel 1NCPSFP01 normal AC power is supplied from 1NLP29-12, fed from MCC 1ABC "A" Train, fed from SWGR 1AB05, and fed from SWGR 1AA02. The Unit 1 Alternate Channel 2 1NCSFP02 normal ac power is supplied from 1NLP32-12, fed from MCC 1BBC "B" Train, fed from SWGR 1BB07, and fed from SWGR 18A03.

The licensee also stated that the Unit 2 Primary Channel normal ac power is provided from 2NLP29 (Emergency "A" Train) Lighting distribution Panel from spare single pole 20A circuit breaker number 12. The Unit 2 Alternate Channel normal ac power is provided from 2NLP32 (Emergency "B" Train) Lighting Distribution Panel from spare single pole 20A circuit breaker number 12.

During the onsite audit, the NRC staff verified that the electrical independence between power supply sources by performing a walkdown and reviewing the following drawings:

- 2X3DG030-1, "Lighting Panel Riser Diagram Unit 2," Revision 16 [Reference 83];
- 2X3D-AA-F03A, "One Line Diag. 480V Motor Control Center 2ABC 2-1805-S3-ABC," Revision 18 [Reference 84];
- 2X3D-AA-F04A, "One Line Diag. 480V Motor Control Center 2BBC 2-1805-S3-BBC," Revision 18 [Reference 85]; and
- 2X3D-AA-A01A, "Main One Line Unit 2," Revision 19 [Reference 86].

The NRC staff found that the licensee has adequately addressed the instrument channel independence, including the power sources. With the licensee's proposed power arrangement, the electrical functional performance of each level measurement channel would be considered independent of the other channel, and the loss of one power supply would not affect the operation of other independent channel under BDB even conditions. The instrument channel physical separation is discussed in Section 4.2.2 of this SE.

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

4.2.6 <u>Design Features: Power Supplies</u>

In its OIP [Reference 22], SNC stated that:

> Each channel will normally be powered from independent (different buses/switchgear) 120V AC power sources and will have a dedicated battery backup. The battery backup will be dedicated to each channel, should have the capability of automatically switching and operating on backup batteries and will have manual switching as a minimum. A minimum battery life of 24 hours will be provided to allow for power restoration from portable equipment.

In its letters dated December 1, 2014 [Reference 30], and November 20, 2015 [Reference 31], the licensee stated that the results of the calculation depicting the battery backup duty cycle requirements demonstrated that its capacity is sufficient to maintain the level indication function, until offsite resource availability is reasonably assured.

Guidance document NEI 12-02 specifies that electrical power for each channel be provided by different sources and that all channels have the capability of being connected to a source of power independent of the normal plant power systems. The NRC staff reviewed the SFPLI power supply configuration and noted that upon a loss of normal power, the UPS arrangement would provide power for level indication until the power is restored by portable generators provided for Order EA-12-049.

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

4.2.7 Design Features: Accuracy

In its OIP [Reference 22], the licensee stated that:

> Instrument channels will be designed such that they will maintain their design accuracy without recalibration following a power interruption or change in power source. SNC plans for the instrument design accuracy to be within ± 1 inch, or as close as reasonably achievable, over the entire range for the expected environmental and process conditions. Accuracy will consider SFP post event conditions, e.g., saturated water, steam environment, or concentrated borated water. Additionally, the instrument accuracy of the Guided Wave Radar (GWR) technology will be sufficient to allow trained personnel to determine when the actual level exceeds the specified level of each indicating range (levels 1, 2 and 3) without conflicting or ambiguous indication. The accuracy will be within the resolution requirements of Figure 1 of NEI 12-02.

In its letters dated December 1, 2014 [Reference 30] and November 20, 2015 [Reference 31], SNC stated that analysis verifying that the proposed instrument performance is consistent with these estimated accuracy normal and BDB values along with demonstration that the channels will retain these accuracy performance values following a loss of power and subsequent restoration of power.

During the onsite audit, SNC provided the SAT report which was attached to work order SNC576693, "SAM-U2-SFP SAT Test," Revision 0. Page 8 of SNC576693 shows the Loss of Power Test and Power Restoration of System test results. The SAT accuracy was within those specified by Westinghouse (+/- 3 in.)

The NRC staff noted that SNC adequately addressed instrument channel accuracy through a combination of statements in the OIP and in the final compliance letter as well as the SAT report test results. The 3-inch design accuracy is more conservative than the 1-foot accuracy specified by NEI 12-02 for SFP Level 2 and Level 3. With SNC's proposed design and controls, the instrument channels should maintain their accuracy during both normal and BDB event conditions.

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

4.2.8 Design Features: Testing

In its OIP [Reference 22], the licensee stated that:

> Instrument channel design will provide for routine testing and calibration consistent with Order EA-12-051 and the guidance in NEI 12-02.

In its letter dated July 17, 2013 [Reference 24], the licensee stated that:

> Plant procedures will provide instructions to enable in-situ testing and calibration of the equipment. A post-calibration channel check between the two channels for the SFP level instruments will be completed per plant procedures. Existing permanently installed SFP level indication is provided by a ruled scale mounted on the side of the SFP. The two channels from the SFP level instruments may at times be cross-checked against this visual indication. An evaluation of the output from available level instrumentation will be used when determining the frequency of calibration activities on SFP level instruments.

In accordance with SNC's July 17, 2013 [Reference 24] letter, the NRC staff noted that by comparing the levels in the instrument channels and the maximum level allowed deviation, the operators could determine if recalibration or troubleshooting is needed. The NRC staff also noted that the licensee's proposed design has the ability to be tested and calibrated in-situ, consistent with the provision of NEI 12-02.

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

4.2.9 Design Features: Display

In its letters dated December 1, 2014 [Reference 30] and November 20, 2015 [Reference 31], the licensee stated that:

> The location of the display panels for VEGP Unit 2 is in room R-126 of the Control Building. The location of the display panels for Vogtle Unit 1 is in room R-152 of the Control Building. The locations described in response to RAI-11 (a) have been evaluated considering the accident conditions described in NEI 12-02 and NEI 12-06, using design inputs from Westinghouse, existing Station Blackout evaluations and NUMARC-8700, *Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors,* dated November 20, 1987. The results of the evaluation performed, to determine accessibility of the SFPLI displays following an ELAP event, indicate the displays can be accessed without unreasonable delay and without placing station personnel at undue risk with regards to temperature, humidity, and radiation levels. The location of the display panels for Vogtle Unit 2 in room R-126 of the Control Building is approximately 180 feet from the West exit of the Control Room. The location of the display panels for Vogtle Unit 1 in room R-152 of the Control Building is approximately 100 feet from the East exit of the Control Room. Using a conservative walking pace of 1 mph, the Vogtle Unit 1 and Unit 2 display locations will require less than 10 minutes to access the display location, to perform local function and return to the Control Room. Validation performed determined the actual time for Vogtle Unit 2 is 3.5 minutes. With the displays located outside the Radiation Controlled Area, the substantial structures between the SFP and the pathway to the display, combined with the short transit duration, personnel traveling the pathways shown in Figure 2 will not require heroic means with the SFP at Level 3 or above. The display location remains habitable

> considering the minimal time required to access the displays, distance from the SFP, substantial structures, and the lack of heat producing equipment within the room during accident conditions. Both locations will allow for prompt, non-heroic access to the displays from the Control Room. Operators are directed to periodically monitor the displays at two hour intervals during accident conditions.

During the onsite audit, the NRC staff verified that the SFPLI display locations should be promptly accessible and should remain habitable.

Guidance document NEI 12-02 specifies that the SFP level indication be displayed at an appropriate and accessible location. An appropriate and accessible location shall include: occupied or promptly accessible to the appropriate plant staff, outside of the area surrounding the SFP floor, inside a structure providing protection against adverse weather, and outside of any high radiation areas during normal operation. Since the licensee has installed the indicators in an appropriate and accessible location where they are able to be monitored by trained personnel, the NRC staff finds that the licensee's proposed display location acceptable.

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

4.3 Evaluation of Programmatic Controls

Order EA-12-051 specified that the spent fuel pool instrumentation shall be maintained available and reliable through appropriate development and implementation 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 that:

> A systematic approach will be used to identify the population to be trained and to determine both the initial and continuing elements of the required training. Personnel will complete training prior to being assigned responsibilities associated with this instrument.

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

4.3.2 Programmatic Controls: Procedures

In its letter dated July 17, 2013 [Reference 24], the licensee stated that:

> Procedures for inspection, maintenance, repair, operation, abnormal response, and administrative controls associated with the SFP level instrumentation will be developed in accordance with existing controlled station administrative and technical procedures that govern procedure development. These procedures ensure standardization of format and terminology and ease of use along with assurance of a consistent level of quality.

In its letters dated December 1, 2014 [Reference 30] and November 20, 2015 [Reference 31], the licensee stated that procedures have been developed to ensure these objectives:

Procedure	Objectives to be achieved
1) System Rounds	Weekly rounds are performed to confirm the SFPLIS agrees with the local level indication that the SFPLIS channels are in agreement and that there are no battery alarms.
2) Calibration and Test	To verify that the system is within the specified accuracy, is functioning as designed, and is appropriately indicating SFP water level.
3) Maintenance	To establish and define scheduled and preventive maintenance requirements and activities necessary to minimize the possibility of system interruption.
4) Repair	Work orders will be generated if repairs are necessary using the vendor manual as the basis for the work order.
5) Operation	To provide sufficient instructions for operation and use of the system plant operation staff.
6) Responses	To define the actions to be taken upon observation of system level indications, including actions to be taken at the levels defined in NEI 12-02. With Unit 1 in compliance with Order EA-12-049, Operations procedures have integrated the full capability of the Unit 1 & Unit 2 SFP level indication systems.

During the onsite audit, the licensee provided a list of procedures identified to date. The NRC staff reviewed these procedures and noted that they were developed, using the guidelines and vendor instructions, in order to address the testing, calibration, maintenance, operation and abnormal response, in accordance with the provisions of NEI 12-02.

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

4.3.3 Programmatic Controls: Testing and Calibration

In its OIP, the licensee stated that:

> Processes will 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. Testing and calibration of the instrumentation will be consistent with vendor recommendations and any other documented basis. Calibration will be specific to the mounted instrument and the monitor. Out of service time as identified in NEI 12-02 will be incorporated consistent with the programmatic process used for compliance with NRC Order EA-12-049.

In letters dated December 1, 2014 [Reference 30] and November 20, 2015 [Reference 31], the licensee stated that:

> While the SFP is operating within design basis and at normal level, the indicators are compared to fixed marks within the SFP by visual observation to confirm indicated level weekly. A periodic calibration verification is performed within 60 days of a refueling outage considering normal testing scheduling allowances (e.g., 25%). Calibration verification is not required to be performed more than once per 12 months. These calibration requirements are consistent with the guidance provided in NEI 12-02 section 4.3. Periodic calibration verification procedures are in place based on information provided by Westinghouse in WNA-TP-04709-GEN, "Spent Fuel Pool Instrumentation System Calibration Procedure." Preventive maintenance procedures to include tests, inspection and periodic testing of batteries have been developed based on recommendation from Westinghouse. A condition report will be initiated and addressed through the SNC's Corrective Action Program and the out of service (OOS) condition will be tracked in accordance with procedure NMP-OS-019-013. Provisions associated with OOS or non-functional equipment including allowed outage times and compensatory actions are consistent with the guidance provided in Section 4.3 of NEI 12-02. If one OOS channel cannot be restored to service within 90 days, appropriate compensatory actions, including the use of alternate suitable equipment, will be taken. If both channels become OOS, actions would be initiated within 24 hours to restore one of the channels to operable status and to implements appropriate compensatory actions, including the use of alternate suitable equipment and/or supplemental personnel, within 72 hours.
>
> Additionally, if both channels are OOS, a condition report will be initiated and addressed through the SNC's Corrective Action Program and the OOS condition will be tracked in accordance with procedure NMP-08-019-013. SNC will maintain sufficient spare parts for the SFPIS, taking into account the lead time and availability of spare parts, in order to expedite maintenance activities, when

necessary, to provide assurance that a channel can be restored to service within 90 days.

Guidance document NEI 12-02 contains provisions for the establishment of processes that will maintain the SFPLI at their design accuracy. It also contains provisions for the control of surveillance and OOS time for each channel. Based on the licensee's OIP and compliance letter, the NRC staff finds that the licensee's proposed testing and calibration processes are consistent with vendor recommendations and the provisions of NEI 12-02. Further, the licensee's proposed restoration actions and compensatory measures for the instrument channel(s) out-of-service are consistent with NEI 12-02.

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

4.4 Conclusions for Order EA-12-051

In its letters dated December 1, 2014 [Reference 30], and November 20, 2015 [Reference 31], the licensee stated that they would meet the requirements of Order EA-12-051 by following the guidelines of NEI 12-02, as endorsed by JLD-ISG-2012-03. In the evaluation above, the NRC staff finds that, if implemented appropriately, the licensee has conformed to the guidance in NEI 12-02, as endorsed by JLD-ISG-2012-03. In addition, the NRC staff concludes that if the SFPLI is installed at Vogtle 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 NRC staff conducted an onsite audit in May 2015 [Reference 17]. The licensee reached its final compliance date on March 27, 2016, and has declared that both of the reactors are in compliance with the orders. The purpose of this safety evaluation is to document the strategies and features that the licensee has committed to implement. Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and proposed designs that if implemented appropriately should adequately address the requirements of Orders EA-12-049 and EA-12-051. The NRC staff will conduct an onsite inspection to verify that the licensee has implemented the strategies and equipment to demonstrate compliance with the orders.

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

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85. Drawing 2X3D-AA-F04A, "One Line Diag. 480V Motor Control Center 2BBC 2-1805-S3-BBC," Revision 18

86. Drawing 2X3D-AA-A01A, "Main One Line Unit 2," Revision 19

87. Record of Decision Severe Accident Management, dated March 9, 2015, Attachment 1, "Selecting the Correct Amount of Cable and/or Hose for (+1) Strategy Capability"

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Date: November 14, 2016

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Sincerely,

/RA/

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