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

July 1, 2016

Mr. David A. Heacock
President and Chief Nuclear Officer
Dominion Nuclear Connecticut, Inc.
Innsbrook Technical Center
500 Dominion Boulevard
Glen Allen, VA 23060-6711

SUBJECT: MILLSTONE POWER STATION, UNITS 2 AND 3 – SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 (CAC NOS. MF0858, MF0859, MF0838, AND MF0839)

Dear Mr. Heacock:

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

By letters dated February 28, 2013 (ADAMS Accession No. ML13064A265), and April 30, 2013 (ADAMS Accession No. ML13126A206) Dominion Nuclear Connecticut, Inc. (Dominion, the licensee) submitted its OIP and OIP supplement, respectively, for the Millstone Power Station (MPS) Units 2 and 3 in response to Order EA-12-049. At six-month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-049. These reports were required by the order, and are listed in the enclosed safety evaluations. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated January 31, 2014 (ADAMS Accession No. ML13338A433), and November 17, 2014 (ADAMS Accession No. ML14275A017), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated December 29, 2015 (ADAMS Accession No. ML16005A184), Dominion submitted its compliance letter and its Final Integrated Plan (FIP) for MPS, Unit 2 in response to Order EA-12-049. By letter dated June 23, 2015 (ADAMS Accession No. ML15182A012), Dominion submitted its compliance letter and its

FIP for MPS, Unit 3 in response to Order EA-12-049. Each compliance letter stated that the licensee had achieved full compliance with Order EA-12-049 for the respective Unit.
By letter dated February 28, 2013 (ADAMS Accession No. ML13063A012), Dominion submitted its OIP for MPS, Units 2 and 3 in response to Order EA-12-051. At six month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-051. These reports were required by the order, and are listed in the enclosed safety evaluations. By letters dated October 29, 2013 (ADAMS Accession No. ML13291A115), and November 17, 2014 (ADAMS Accession No. ML14275A017), the NRC staff issued an ISE and audit report, respectively, on the licensee's progress. By letter dated March 26, 2014 (ADAMS Accession No. ML14083A620), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-051 in accordance with NRC NRR Office Instruction LIC-111, similar to the process used for Order EA-12-049. By letters dated December 3, 2015 (ADAMS Accession No. ML15342A113), and January 6, 2015 (ADAMS Accession No. ML15013A170), Dominion submitted its compliance letters in response to Order EA-12-051. The compliance letters stated that the licensee had achieved full compliance with Order EA-12-051.

The enclosed safety evaluations provide the results of the NRC staff's review of Dominion's strategies for MPS, Units 2 and 3. Enclosure 1 contains MPS, Unit 2's safety evaluation and Enclosure 2 contains MPS, Unit 3's safety evaluation. The intent of the safety evaluation is to inform Dominion on whether or not its integrated plans, if implemented as described, provide a reasonable path for compliance with Orders EA-12-049 and EA-12-051. The NRC staff will evaluate implementation of the plans through inspection, using Temporary Instruction 191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications/Staffing/ Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML14273A444). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

If you have any questions, please contact Milton Valentin, Orders Management Branch, MPS Power Station Project Manager, at 301-415-2864 or at Milton.Valentin@nrc.gov.

Sincerely,

Mandy K Halter

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

Docket Nos.: 50-336 and 50-423

Enclosures:
1. MPS, Unit 2 Safety Evaluation
2. MPS, Unit 3 Safety Evaluation

cc w/encl: Distribution via Listserv

If you have any questions, please contact Milton Valentin, Orders Management Branch, MPS Power Station Project Manager, at 301-415-2864 or at Milton.Valentin@nrc.gov.

Sincerely,

/RA/

Mandy Halter, Acting Chief
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Docket Nos.: 50-336 and 50-423

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2. MPS, Unit 3 Safety Evaluation

cc w/encl: Distribution via Listserv

DISTRIBUTION:
PUBLIC
JLD R/F
RidsNrrDorlLp_WB Resource
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MValentin NRR/JLD
RidsNrrPMMPS Resource

ADAMS Accession No. ML16099A171 ***via email**

OFFICE	NRR/JLD/JOMB/PM	NRR/JLD/LA	NRR/JLD/JHMB/BC*	NRR/JLD/JERB/BC*
NAME	MValentin	SLent	MShams	SBailey
DATE	4/8/2016	4/14/2016	4/19/2016	4/22/2016
OFFICE	NRR/JLD/JCBB/BC*	OGC	NRR/JLD/JOMB/BC(A)	
NAME	JQuichocho	BHarris	MHalter	
DATE	4/22/2016	6/07/2016	7/01/2016	

OFFICIAL AGENCY RECORD

MILLSTONE POWER STATION, UNIT 2

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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

DOMINION NUCLEAR CONNECTICUT, INC.

MILLSTONE POWER STATION, UNIT 2

DOCKET NO. 50-336

1.0 INTRODUCTION

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

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

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

2.0 REGULATORY EVALUATION

Following the events at the Fukushima Dai-ichi nuclear power plant on March 11, 2011, the NRC established a senior-level agency task force referred to as the Near-Term Task Force

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

On February 17, 2012, the NRC staff provided SECY-12-0025, “Proposed Orders and Requests for Information in Response to Lessons Learned from Japan’s March 11, 2011, Great Tohoku Earthquake and Tsunami,” [Reference 2] to the Commission. This paper included a proposal to order licensees to implement enhanced BDBEE mitigation strategies. As directed by 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 ac power and loss of normal access to the ultimate heat sink (UHS) and have adequate capacity to address challenges to core cooling, containment, and SFP cooling capabilities at all units on a site subject to this Order.

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

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

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

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

2.2 Order EA-12-051

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

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

structure over the spent fuel pool. This protection may be provided by locating the primary instrument channel and fixed portions of the backup instrument channel, if applicable, to maintain instrument channel separation within the spent fuel pool area, and to utilize inherent shielding from missiles provided by existing recesses and corners in the spent fuel pool structure.

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

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

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

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

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

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

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

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

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

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

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

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

3.0 TECHNICAL EVALUATION OF ORDER EA-12-049

By letters dated February 28, 2013 [Reference 10], and April 30, 2013 [Reference 48] Dominion Nuclear Connecticut, Inc. (DNC, the licensee) submitted an Overall Integrated Plan (OIP) and OIP supplement, respectively, for the Millstone Power Station (MPS), Units 2 and 3, in response to Order EA-12-049. By letters dated August 23, 2013 [Reference 11], February 28, 2014 [Reference 12], August 28, 2014 [Reference 13], March 2, 2015 [Reference 14], and August 27, 2015 [Reference 47] the licensee submitted six-month updates to the OIP. By letter dated August 28, 2013 [Reference 15], the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, “Regulatory Audits” [Reference 36]. By letters dated January 16, 2014 [Reference 16] and October 9, 2014 [Reference 17], the NRC issued an ISE and an audit report, respectively, on the licensee's progress. By letter dated December 7, 2015 [Reference 18], the licensee reported that full compliance with the requirements of Order EA-12-049 was achieved for MPS, Unit 2, and submitted a Final Integrated Plan (FIP) for MPS, Unit 2.

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 loss of normal access to the UHS. Thus, the ELAP with loss of normal access to the UHS is used as a surrogate for a BDBEE. The initial conditions and assumptions for the analyses are stated in NEI 12-06, Section 3.2.1, and include the following:

1. The reactor is assumed to have safely shut down with all rods inserted (subcritical).
2. The dc power supplied by the plant batteries is initially available, as is the ac power from inverters supplied by those batteries; however, over time the batteries may be depleted.
3. There is no core damage initially.
4. There is no assumption of any concurrent event.
5. Because the loss of ac power presupposes random failures of safety-related equipment (emergency power sources), there is no requirement to consider further random failures.

The MPS, Unit 2 is a Combustion Engineering pressurized-water reactor (PWR) with a large dry containment building. The FIP describes the licensee's three-phase approach to mitigate a postulated ELAP event.

As a result of the extreme natural phenomenon that initiates the extended loss of ac power with loss of normal access to the ultimate heat sink (ELAP/LUHS) event, the reactor trips and the plant will initially stabilize at no-load reactor coolant system (RCS) temperature and pressure conditions. The reactor coolant pumps (RCPs) are assumed to trip due to the loss of electrical power, and natural circulation flow develops in the RCS, with reactor decay heat removal via steam release to the atmosphere through the steam generator (SG) safety valves (SVs) and/or the atmospheric dump valves (ADVs). The turbine-driven auxiliary feedwater (TDAFW) pump initially provides feedwater from the condensate storage tank (CST) to maintain sufficient SG inventory.

Operators respond to the ELAP/LUHS event in accordance with emergency operating procedures (EOPs) to confirm RCS, secondary system, and containment conditions. A transition to the station blackout (SBO) EOP is made upon the diagnosis of a loss of ac power. The SBO EOP (along with referenced FLEX support guidelines (FSGs)) directs isolation of RCS letdown pathways, confirmation of natural circulation in the RCS, verification of containment isolation, reduction of dc loads on the station Class 1E batteries, and establishment of electrical equipment alignments in preparation for eventual power restoration. The operators establish local manual control of the SG ADVs and initiate a cooldown of the RCS. As noted in the licensee’s SBO EOP, local manual control of both AFW flow to the SGs and the release of steam from the SG ADVs would be necessary under ELAP conditions.

The Phase 1 FLEX strategy for reactor core cooling and heat removal relies on installed plant equipment and water sources for supplying AFW to the SGs and releasing steam from the SGs to the atmosphere. The MPS, Unit 2 TDAFW pump does not have an automatic-start function and would be manually actuated from the control room following the initiation of an ELAP/LUHS event. Should the pump fail to start or trip while operating, operations personnel would manually reset and start the pump (which does not require electrical power for motive force or control). The licensee stated that sufficient time is available (approximately 1 hour) to perform this local manual action prior to the SG secondary side boiling dry. The AFW system is prealigned for flow to both SGs from the TDAFW pump. Manual control of the TDAFW pump flowrate to the SGs to establish and maintain proper water levels in the SGs is performed locally. Initially, the installed CST provides the water supply for the TDAFW pump. The licensee stated that throttling of the feedwater flow within approximately 1.8 hours would prevent overfilling of the SGs. Steam released from the SGs is controlled locally using installed manual control handwheels on the SG ADVs. An RCS cooldown at a rate of up to 100 degrees Fahrenheit (°F)/hour would commence within 2 hours of event initiation and would be continued for approximately 2 to 3 hours until SG pressure reaches 120 per square inch absolute (psia). At this SG pressure, the RCS cold leg temperature will eventually stabilize at approximately 340 °F. Benefits of the RCS cooldown include (1) limiting the potential for adverse effects of high-temperature coolant on RCP seal performance, (2) reducing SG pressure permits portable FLEX pumps to provide secondary makeup in advance of the TDAFW pump becoming unavailable, and (3) reducing RCS pressure allows the safety injection tanks to passively inject, which increases the available RCS inventory. The licensee stated that terminating the initial cooldown at a SG pressure of 120 psia would prevent nitrogen gas from the safety injection tanks from entering the RCS.

Load stripping of all non-essential loads begins within 45 minutes after the occurrence of an ELAP/LUHS and is completed within the next 30 minutes. With load stripping, the useable Class 1E station battery life is calculated to be 29 hours.

In Phase 2, operators monitor the CST level in the control room or locally using level instruments. After the CST usable volume is depleted, additional water sources included in the FLEX strategy procedures would provide continued makeup to the steam generators.

An AFW pump suction hose connection is installed between the CST and the TDAFW pump for use with the beyond-design-basis (BDB) FLEX strategies. This connection provides a path to allow for an AFW supply to the TDAFW pump other than the CST. A second hose connection is installed between the motor-driven AFW pumps and the CST to provide a path for the CST to be refilled using a portable transfer pump, if required. A portable diesel transfer pump, hoses, fittings, and fuel oil has been pre-staged in the turbine building to facilitate the transfer of water from various sources to the CST. The CST may be refilled from a variety of sources, including the onsite fire system, city water system, the onsite freshwater pond, and various onsite water storage tanks, if available. In the case that these preferred but uncredited water sources are unavailable, the licensee would supply the SG secondary side with salt water from Long Island

Sound. Additionally, SG water injection using a portable AFW pump is provided and is available through both primary and alternate connection locations.

The primary method for providing makeup to the RCS is the BDB RCS injection pump, which would be deployed in sufficient time to support delivery of RCS inventory makeup from the refueling water storage tank (RWST) or another borated suction source within 16 hours of event initiation. For the primary makeup method, a suction hose is connected to the RWST FLEX strategy connection to provide borated RWST water to the suction of the BDB RCS Injection pump. A high-pressure hose is routed from the discharge of the BDB RCS Injection pump to the primary or the alternate RCS injection connection point to provide RCS inventory makeup. The alternate method for makeup to the RCS is performed using the installed "B" or "C" charging pumps. In order to utilize the alternate method using MPS, Unit 2 charging pump, the portable 480 volts of alternating current (Vac) generator is moved onsite from the BDB storage building. This generator powers the 480 Vac vital bus providing power to the charging pump (either pump "B" or "C"). The charging pump can take suction from the RWST or the boric acid storage tanks (BASTs) to replenish the RCS and increase shutdown margin. Deployment and connection of the 480 Vac generator can start after augmented staff arrives onsite after six hours. If makeup is initiated within 16 hours it is likely to result in sufficient makeup to account for the BDBEE.

The Phase 2 FLEX strategy also includes re-powering of vital 120 Vac buses within 16 hours using a portable 480 Vac diesel generator (DG) stored onsite. Prior to depletion of the Class 1E 125 volts of direct current (Vdc) batteries on MPS Unit 2, vital 120 Vac circuits are re-powered to ensure continued availability of instrumentation necessary for monitoring key event parameters. A portable 120/240 Vac DG is available as an alternate to the 480 Vac DG. The augmented staff should arrive on-site within 6 hours of the event's initiation. Once the augmented staff arrives, the restoration of power to the 480 Vac will commence. By implementing the strategy within the proposed time frames, the 480 Vac generator should be available to power the 480 Vac bus on or before 13 hours after the start of an ELAP/LUHS event.

The alternate strategy for repowering 120 Vac loads is the use of a 120/240 Vac generator as a backup to the 480 Vac generator for instrumentation purposes. For the 120/240 Vac generator back-up strategy, new breakers were installed in vital 120 Vac panels VA20 and VA40 that are connected to the new supply cables from portable generators.

To support continuation of the safety functions required by the order for an indefinite coping period, additional pumps, diesel generators, and other equipment would be delivered to the site in Phase 3 from the National SAFER (Strategic Alliance for FLEX Emergency Response) Response Center (NSRC). The specific equipment requested by the licensee is described in Table 2 of the licensee's FIP. In particular, the reverse osmosis / ion exchange system delivered by the NSRC would provide a Phase 3 method for removing impurities from alternate fresh water supplies that may be used over an extended period of time to mitigate an ELAP event. Additionally, a mobile boration unit would be delivered, which would provide a method for preparing borated coolant for an indefinite period.

The basic FLEX strategy for maintaining SFP cooling is to monitor SFP level and provide sufficient makeup water to the SFP to maintain adequate SFP level. The MPS, Unit 2 has a single dedicated SFP (i.e., not shared with the other units onsite).

For Phase 1, licensee calculations have determined that with no operator action following a loss of SFP cooling at the maximum design heat load, the MPS, Unit 2 SFP reaches 212 °F in approximately 6 hours and could boil down to a level 10 feet above the top of fuel within 30 hours of event initiation. The Phase 1 coping strategy for spent fuel pool cooling is to monitor spent fuel pool level using instrumentation installed as required by NRC Order EA-12-051.

The Phase 2 strategy is to initiate SFP makeup within 24 hours of the event by running a branch hose from the BDB High Capacity pump to the BDB SFP makeup connection located in the SFP skimmer cage in the MPS, Unit 2 auxiliary building. The strategy provides sufficient makeup water to the SFP to restore the normal SFP level. The BDB SFP makeup connection piping ties into an existing SFP makeup line which discharges directly into the SFP. Makeup water is provided from either the RWST or from one branch of the MPS, Unit 2 distribution manifold being supplied from the BDB high capacity pump.

The alternate FLEX strategy for making up the SFP level is in accordance with existing procedures using systems already installed at MPS, Unit 2. These include use of the site fire header and the auxiliary feedwater supply to the SFP. Also, an available alternate FLEX strategy consists of deploying a hose directly to the SFP area. Additionally, as required by NEI 12-06, spray monitors and sufficient hose length required for the SFP spray option are located in the BDB storage building.

During Phase 3, additional low pressure/high flow pumps are available from the NSRC as a backup to the onsite BDB high capacity pumps. The NSRC also provides two 4160 Vac generators which can be used to re-power SFP cooling systems if emergency buses are available or restored.

With an ELAP/LUHS initiated while MPS, Unit 2 is in modes 1-4, containment cooling is also lost for an extended period of time. Therefore, containment temperature and pressure slowly increase. Structural integrity of the containment is not challenged due to increasing containment pressure. 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 instrument transmitters might be challenged.

Conservative evaluations have concluded that containment temperature and pressure remain below containment design limits and that key parameter instruments subject to the containment environment remain functional for a minimum of 7 days. Therefore, actions to reduce containment temperature and pressure and to ensure continued functionality of the key parameters are not required immediately and may utilize offsite equipment during Phase 3 if onsite capability is not restored.

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

3.2 Reactor Core Cooling Strategies

Order EA-12-049 requires licensees to maintain or restore cooling to the reactor core in the event of an ELAP concurrent with a loss of normal access to the UHS. Although the ELAP results in an immediate trip of the reactor, sufficient core cooling must be provided to account for fission product decay and other sources of residual heat. Consistent with endorsed guidance from NEI 12-06, Phase 1 of the licensee's core cooling strategy credits installed equipment (other than that presumed lost to the ELAP with loss of normal access to the UHS) that is robust in accordance with the guidance in NEI 12-06. In Phase 2, robust installed equipment is supplemented by onsite FLEX equipment, which is used to cool the core either directly (e.g., pumps and hoses) or indirectly (e.g., FLEX electrical generators and cables repowering robust installed equipment). The equipment available onsite for Phases 1 and 2 is further supplemented in Phase 3 by equipment transported from the NSRCs.

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

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

3.2.1 Core Cooling Strategy and RCS Makeup

3.2.1.1 Core Cooling Strategy

3.2.1.1.1 Phase 1

The licensee's FIP states that core cooling in Phase 1 will be accomplished by transferring residual heat to the SGs via natural circulation flow in the RCS. This energy transfer will vaporize liquid on the secondary side of the SGs, with the generated steam being vented via the SG safety valves or ADVs, thereby carrying off the residual heat. To maintain sufficient SG inventory to support this form of heat removal, the licensee stated that the installed TDAFW system will be manually actuated from the control room to supply feedwater to the SGs. Initially the source of feedwater would be the CST, which the licensee stated contains a minimum usable volume that is sufficient to support residual heat removal throughout Phase 1.

The licensee stated that, in response to Order EA-12-049, MPS, Unit 2 has adopted a new emergency procedure revision directing an early RCS cooldown in the event of an ELAP. Specifically, within 2 hours of event initiation, operators would be directed to cool down the RCS at up to 100 °F/hr to a target minimum SG pressure of approximately 120 psia. Considering the saturation relationship for water, this SG pressure would correspond to an RCS cold leg temperature slightly above 340 °F. According to the information presented in the licensee's FIP, the NRC staff understands that the RCS cooldown would proceed in a symmetric manner using both of the plant's SGs, and that symmetric SG heat removal would be maintained throughout the analyzed ELAP event.

To implement the intended RCS cooldown, local manual actions are necessary to control both the TDAFW pump and SG ADVs within 2 hours of event initiation. These actions ensure that (1) the RCS cooldown proceeds at the intended rate, (2) the cooldown is terminated at the targeted endpoint and SG pressure is henceforth maintained within its intended control band, and (3) SG water level remains within its desired control band. The licensee noted in particular that, while the TDAFW pump may be manually started from the main control room (MCR), local throttling of TDAFW flow should begin within 1.8 hours of event initiation to avoid overfilling the SGs.

The licensee established the SG depressurization terminus of 120 psia with the objective of preventing injection of the nitrogen cover gas from the safety injection tanks (SITs) into the RCS. The licensee's FIP states that, prior to depressurizing further, operators would need to isolate or vent the SITs. According to the licensee's FLEX procedures, reenergizing the "B" train electrical bus using a FLEX diesel generator would allow two SITs to be isolated and would permit all four SITs to be vented. Per the sequence of events in the licensee's FIP, although the task itself is not mentioned, setup of the equipment necessary to support SIT isolation and venting should be completed within approximately 12.5 hours of event initiation. During the audit, the NRC staff observed that, while nitrogen injection from the SITs would not be predicted in a calculation using best-estimate parameters, little margin would exist to accommodate long-term containment heatup in a scenario with more limiting SIT parameters that are within the range allowed by the MPS, Unit 2 Technical Specifications (TS). Isolating or venting the SITs promptly following the restoration of electrical power provides confidence that potential adverse consequences of nitrogen injection into the RCS (e.g., including interruption of natural circulation flow in the RCS and impedance of vapor condensation) can be avoided for the analyzed ELAP event.

3.2.1.1.2 Phase 2

The licensee stated that its Phase 2 core cooling strategy would continue to use the SGs as a heat sink, with the TDAFW pump continuing to supply feedwater. The licensee's FIP states that the usable inventory of the CST (i.e., 142,746 gallons) would be depleted by 8.4 hours into the ELAP event, and that from this point, an additional 5.3 hours of time would exist prior to SG dryout. The strategy in the licensee's FIP calls for the completion of supporting activities to allow the CST to be refilled using FLEX equipment by approximately 7 hours into the event.

During the audit, the NRC staff performed independent confirmatory calculations to verify the licensee's conclusions regarding CST depletion and SG dryout, including simulations using the TRACE thermal-hydraulic code. The staff's best-estimate simulations with TRACE, which considered decay heat and the sensible heat associated with the RCS cooldown, indicated that a volume of approximately 143,000 gallons would be pumped into the SGs by approximately 6 hours into the analyzed ELAP event. The NRC staff's simulation agrees well with calculated best-estimate results for SG feedwater demand during an ELAP event for other plants of similar power level that are reported in WCAP-17601-P. Furthermore, based on additional time-to-dryout calculations reported in WCAP-17601-P, the staff expected that, if the CST were depleted at 6 hours, an additional period of approximately 2-3 hours should be available prior to SG dryout for the analyzed ELAP event. While the staff's estimate suggests that the actual margin available may be less than the licensee's expectation, acceptable margin exists in both the staff's estimates and the licensee's estimates. The differences between the staff and licensee analysis would only result in the potential for additional cycling of the TDAFW pump during an actual event. Therefore, the NRC staff concluded that the licensee's strategy for providing makeup to the CST within 7 hours should be sufficient to prevent SG dryout.

The licensee's FIP states that the CST may be refilled from a number of sources, including the onsite fire system, the city water system, the 3-million-gallon onsite freshwater pond (inventory shared with Unit 3), and additional onsite water storage tanks that may be available. Though of undesirable quality, salt water from Long Island Sound is the credited, robust supply of SG feedwater under ELAP conditions, and its use would be necessary if preferred non-robust sources of water are disabled by the initiating event or become unavailable. The licensee further stated that a FLEX hose is connected between the CST and the TDAFW pump, and that this hose would provide a path to allow the TDAFW pump to take suction on a supply of water provided directly from FLEX equipment (e.g., the BDB high-capacity pump).

Although, if available, the licensee would continue to use the installed TDAFW pump in Phase 2, consistent with the guidance in NEI 12-06, the licensee has the capability to use portable, onsite FLEX equipment to provide feedwater to both SGs through primary and alternate connection points. Specifically, the licensee has three BDB AFW pumps onsite (which satisfies the N+1 redundancy criterion for the two operating units at the MPS site), each of which is capable of providing 300 gallons per minute (gpm) at 450 per square inch differential (psid) [pressure differential]. Therefore, following the SG depressurization planned in Phase 1, these BDB AFW pumps should be capable of providing adequate feedwater flow to the SGs during the analyzed ELAP event.

3.2.1.1.3 Phase 3

The reactor core cooling strategy in Phase 3 is a continuation of the strategy from Phases 1 and 2 that relies on the SGs to remove decay heat for an indefinite coping period. However, in Phase 3, onsite equipment will be supplemented as needed with equipment provided by the NSRCs. With respect to core cooling, the additional NSRC-supplied equipment would include pumps capable of supplying feedwater to the SGs and a reverse osmosis / ion exchange system to facilitate a long-term supply of purified water. Additional pumps and hoses would also be available to assist in replenishing the CST or supplying cooling water directly to the TDAFW or BDB AFW pump suction. As necessary to facilitate the use of higher quality water for reactor core cooling, the NRC staff expects that the licensee would begin using the water purification equipment from the NSRC as soon as practical considering the overall event response prioritization. The licensee's FIP further discusses the capability for restoring the installed shutdown cooling system using 4160-Volt generators provided by the NSRC. However, the licensee's FIP considers these steps as recovery actions that are not required for indefinite coping.

3.2.1.2 RCS Makeup Strategy

3.2.1.2.1 Phase 1

Following initiation of the ELAP event, operators would verify isolation of normal letdown and other isolable flowpaths to conserve RCS inventory. However, under ELAP conditions, RCP seal cooling would be lost, and RCS inventory would tend to diminish gradually due to leakage through RCP seals and other leakage points. Furthermore, the initial RCS cooldown starting by 2 hours into the event would be expected to result in a significant contraction of the RCS inventory, to the extent that the pressurizer would drain and a vapor void would form in the upper head of the reactor vessel. Cooldown and depressurization of the RCS significantly extends the expected coping time under ELAP/LUHS conditions because it (1) reduces the potential for damage to RCP seals (as discussed in Section 3.2.3.3) and (2) allows borated coolant stored in the nitrogen-pressurized SITs to passively inject into the RCS to offset the system volume reduction and add negative reactivity.

As is typical of operating PWRs, prior to implementing the Phase 2 FLEX strategy, MPS, Unit 2 does not have the capability for active RCS makeup. However, passive injection from the SITs would occur as the RCS is depressurized below the SIT cover gas pressure, which would result in the addition of borated coolant to the RCS. As discussed further below, the licensee has determined that (1) sufficient reactor coolant inventory would be available throughout Phase 1 to support heat transfer to the SGs via natural circulation without crediting the active injection of RCS makeup, and (2) according to the core operating history specified in NEI 12-06, sufficient negative reactivity should exist in the reactor core to ensure subcriticality throughout Phase 1, considering the planned cooldown profile.

3.2.1.2.2 Phase 2

The licensee stated that within 16 hours, its FLEX strategy for providing RCS makeup would be capable of providing borated inventory to the RCS to support the objectives of maintaining natural circulation flow in the RCS and adequate reactor shutdown margin. The licensee's primary strategy for RCS makeup would be a single BDB RCS injection pump, which can deliver a flow of 45 gpm at a discharge pressure of 2,000 per square in gauge (psig) [pressure gauge]. The BDB RCS injection pump would take suction on the 370,000-gallon RWST (which is not missile protected) or a 1,000-gallon FLEX portable batching tank. If taking suction upon the RWST, a hose would be connected from a connection point off of the RWST to the BDB RCS injection pump suction. A high-pressure hose would further be connected from the pump discharge to the primary connection point on safety injection system piping or the alternate injection point on normal charging system piping. During the onsite audit, the NRC staff considered the licensee's method for batching borated coolant using the portable batching tank and concluded that the net rate of RCS injection that could be supported would exceed the expected long-term leakage rate for the analyzed ELAP event, considering the time required for filling the tank, mixing the powdered boric acid into solution, and injecting the mixture into the RCS.

As its backup Phase 2 strategy, the licensee would have the capability to provide RCS makeup using either the "B" or "C" installed charging pump. One installed charging pump could be repowered by the licensee's FLEX 480 Vac generator. The suction source for the charging pumps would be either the RWST (if available) or the two boric acid storage tanks. The MPS, Unit 2 Final Safety Analysis Report (FSAR) indicates that the two installed boric acid storage tanks contain a combined volume of approximately 13,000 gallons. Similar to the strategy with the BDB RCS injection pump, an installed charging pump could inject via either the normal charging flowpath or the safety injection flowpath. As discussed further in Section 3.14 of this evaluation, reliance upon the charging pumps to satisfy the requirements of Order EA-12-049 is considered an alternate strategy, since the use of installed equipment does not conform to the guidance of NEI 12-06, Revision 0.

3.2.1.2.3 Phase 3

In Phase 3, the licensee's RCS makeup strategy is a continuation of the Phase 2 strategy, supplemented as needed with equipment provided by the NSRC.

The licensee's FIP states that MPS, Unit 2 would request a mobile boration unit from the NSRCs for use in Phase 3. Due to the alternate RCS makeup strategy implemented by the licensee in Phase 2, the mobile boration unit is most significant in the analyzed scenario wherein the RWST is unavailable due to a missile strike. In this scenario, once the charging pumps have drained the 13,000 gallons of inventory in the boric acid storage tanks (at 44 gpm, an approximate injection time of 4.9 hours), the onsite FLEX equipment remaining for providing

RCS makeup would consist of a single BDB RCS injection pump drawing suction on a portable 1, 000-gallon batching tank. Thus, acquisition of the mobile boration unit would ensure diverse capability for providing long-term RCS makeup in accordance with the requirements of Order EA-12-049.

The NRC staff expects that the licensee would, as necessary to facilitate the use of higher quality water for RCS makeup, begin using the water purification equipment from the NSRC as soon as practical, considering the overall event response prioritization.

3.2.2 Variations to Core Cooling Strategy for Flooding Event

Depending on the initiating event, different sets of mitigating equipment may be available, but in all cases the available equipment should be sufficient to mitigate the analyzed ELAP event based on the NRC staff's audit review. For the flood-induced ELAP event, the staff noted in particular that the presence of water on site could result in the need for actions to set up certain equipment earlier than for ELAP events triggered by other causes. When site flooding is projected, for instance, the licensee would deploy its FLEX AFW pump in advance of the arrival of floodwaters. However, recognizing the potential for such variations, the licensee intends to follow the same basic sequence of events (as described in Table 4 of its FIP) regardless of whether the initiating event is a flood or other natural hazard.

3.2.3 Staff Evaluations

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

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

3.2.3.1.1 Plant SSCs

Core Cooling

In its FIP, the licensee provided descriptions for the permanent plant SSCs to be used to support core cooling for Phases 1 and 2 of the mitigation strategies. The Unit 2 TDAFW pump will be manually started and will deliver AFW flow to both SGs following an ELAP/LUHS event. In the event the TDAFW pump fails to start, procedures direct the operators to manually reset and start the pump (which does not require electrical power for motive force or control). The licensee indicated that operators can manually start the pump within 1 hour after declaration of ELAP and initiate flow prior to steam generator dryout. The TDAFW pump is capable of providing feedwater flow that exceeds the design-basis AFW flow requirements. The TDAFW pump is also located in a safety-related, Class I structure that is protected from all external hazards. The licensee also described in its FIP that the atmospheric dump valves (ADVs) are manually controlled by operators using installed handwheels for an indefinite time period after ELAP is declared and loss of instrument air. The SG ADVs are safety-related, Seismic Category I, and are missile-protected inside of the Enclosure Building. The sections of the SG ADV vent pipes and silencer that are located in the East and West Penetration Rooms within the Enclosure Building at elevation 38'-6" and the piping outbound of the silencers have been modified to restrain the silencer and connecting piping such that the boundary anchor sustains seismic and tornado/missile loads within design capability while maintaining functionality of the downstream piping.

The licensee described six water sources in its FIP that are credited as part of the overall SG makeup strategy after ELAP. The Unit 2 CST is described as the primary preferred source of SG feedwater and it is a safety-related, Seismic Category I tank that is protected from the site's applicable hazards. The licensee stated that the Unit 2 CST can be refilled from onsite water sources including the Primary Water Storage tank (PWST), the Condensate Hotwell, the Fire protection/City Water system, the Onsite freshwater pond, and Long Island Sound. The PWST would be the water source used to makeup to the CST once the CST inventory becomes depleted. The PWST is available to makeup to the CST if it survives the external hazard. After the PWST, the Condensate Hotwells would be used with the assistance of FLEX pumps. The four hotwells are located in a Seismic Category I structure and are protected from external hazards. The fire protection system has two fire water storage tanks that can be connected with a hose to a fire hydrant to refill the CST. The City Water fills the fire water storage tanks and the licensee indicated that the hose can tap directly to the City Water system line if needed in case the fire water storage tanks are unavailable after ELAP. The Onsite Freshwater pond is an untreated water source that requires the use of a suction strainer. The Long Island Sound is the Ultimate Heat Sink designated salt-water source and is not a recommended in the licensee's analysis as a source of makeup water for the Steam Generators until all available freshwater sources have been depleted.

The NRC staff reviewed the plant SSCs and water sources described in the FIP available for core cooling. Based on the design and locations of the TDAFW pumps and ADVs, the diverse water sources as described above, and the Long Island Sound, as described in the FIP, the staff finds that the plant SSCs and water sources should be available to support core cooling during an ELAP caused by a BDBEE, consistent with Condition 4 of NEI 12-06, Section 3.2.1.3. Additionally, due to the design and locations of the primary and alternate AFW connection points, as described below in Section 3.7.3.1 and in the FIP, the staff finds that at least one of the connection points should be available to support core cooling through a portable FLEX pump during an ELAP caused by a BDBEE, consistent with NEI 12-06, Section 3.2.2 and Table D-1.

RCS Inventory Control

In its FIP, the licensee described that the Unit 2 RWST is the preferred source of borated water for RCS makeup. The RWST is a stainless steel, safety-related, Seismic Category I storage tank that is robust to the site's applicable hazards, except tornado missiles. For all ELAP events that involve tornado missiles, prior to transitioning to FLEX equipment, the licensee will use the two BASTs to fulfill the RCS makeup function. The BASTs are safety-related tanks located at the (-) 5 ft. elevation of the Auxiliary Building, which is missile-protected.

Based on the design and availability of the Unit 2 RWST and Unit 2 BASTs as described in the FIP, the staff finds that a borated water source should be available to support RCS inventory control during an ELAP caused by a BDBEE, consistent with Condition 3 of NEI 12-06, Section 3.2.1.3. Additionally, due to the design and location of the primary and alternate RCS injection connection points, as described in below in safety evaluation (SE) Section 3.7.3.1 and in the FIP, the staff finds that at least one of the connection points should be available to support RCS injection through the FLEX pump during an ELAP caused by a BDBEE, consistent with NEI 12-06, Section 3.2.2 and Table D-1.

3.2.3.1.2 Plant Instrumentation

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

- AFW flowrate
- SG water level
- SG pressure
- RCS temperature
- RCS pressure
- core exit thermocouple temperature
- CST level
- pressurizer level
- reactor vessel level monitoring system indication
- excore nuclear instrumentation

The instrumentation available to support the licensee's strategies for core cooling and RCS inventory during the ELAP event is consistent with and in some cases exceeds the recommendations specified in the endorsed guidance of NEI 12-06. 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. The licensee's FIP describes the location of indications for the above instrumentation that are available under ELAP conditions. Indication is typically available in the control room as well as the remote shutdown panel, while indication for some instruments is located in an instrument rack room adjacent to the control room. The licensee has evaluated the control room habitability for BDBEE, as described in section 3.9.2.1.

As recommended by Section 5.3.3 of NEI 12-06, the licensee's FLEX procedures (i.e., FSG-7, "Loss of Vital Instrumentation") provide instructions and information to obtain readings locally (e.g., at containment penetrations and instrument racks). 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.

3.2.3.2 Thermal-Hydraulic Analyses

In the analysis of the ELAP event performed by the Pressurized-Water Reactor Owners Group (PWROG) in WCAP-17601-P, which the licensee relies upon, the CENTS code was chosen for the evaluation of combustion engineering (CE)-designed plants such as MPS, Unit 2. The CENTS code, as described in Westinghouse topical report WCAP-15996-A, is a general-purpose thermal-hydraulic computer code that the NRC staff has previously reviewed and approved for calculating the behavior of the RCS and secondary systems of PWRs designed by CE and Westinghouse during non-loss-of-coolant accident (non-LOCA) transients. Although CENTS has been approved for performing certain design-basis non-LOCA transient analyses, the NRC staff had not previously examined its technical adequacy for performing best-estimate simulations of 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 CENTS and other thermal-hydraulic codes used for these analyses.

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

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

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

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

Applying the one-tenth flow quality criterion to the analyses completed in WCAP-17601-P, the November 20, 2013, revision of the PWROG's white paper on CENTS determined ELAP coping times prior to entering the reflux cooling mode for each CE reactor included in WCAP-17601-P. Unlike the generic calculations performed for reactors designed by other vendors, the analysis for CE plants in WCAP-17601-P was generally conducted at a plant-specific level. One exception is that a single analysis was used to represent four plants of similar design, including MPS Unit 2. With respect to MPS, Unit 2, a coping time of 24.7 hours was calculated, by which

RCS makeup should be provided. This coping time is well in excess of the time at which the licensee intends to initiate RCS makeup according to its FIP (i.e., 16 hours). The NRC staff performed confirmatory simulations with the TRACE code for MPS, Unit 2 using an input deck generated from a mixture of plant-specific sources and generic information representative of CE-designed reactors. The results of the staff's calculations indicated that more than 20 hours should be available prior to entering the reflux cooling mode, thereby confirming the appropriateness of the licensee's mitigating strategy. It should be further understood that both the simulations in WCAP-17601-P and the NRC staff's confirmatory calculations are expected to significantly underestimate the actual coping time available to MPS, Unit 2 because these simulations assumed an RCP seal leakage rate significantly in excess of that subsequently endorsed by the NRC staff for the Flowserve N-9000 seals installed at MPS, Unit 2. As a result, the NRC staff considers the licensee's strategy for ensuring sufficient RCS makeup to avoid reflux cooling as having ample margin for mitigating the analyzed ELAP event.

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

3.2.3.3 Reactor Coolant Pump Seals

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

As noted above, four-stage Flowserve N-9000 seals are installed on the RCPs at MPS, Unit 2. The N-9000 is a hydrodynamic seal developed by Flowserve in the 1980s. One of the design objectives for the N-9000 seal was to provide low-leakage performance under loss-of-seal-cooling conditions during events such as a station blackout. In support of its customers' efforts to address the ELAP event (which similarly involves a loss of seal cooling) in accordance with Order EA-12-049, on August 3, 2015, Flowserve submitted to the NRC staff its "White Paper on the Response of the N-Seal Reactor Coolant Pump (RCP) Seal Package to Extended Loss of All Power (ELAP)," (ADAMS Accession No. ML15222A366). The N-Seal white paper contains information regarding the expected leakage rates over the course of an ELAP event for each PWR at which Flowserve N-Seals are currently installed. By letter dated November 12, 2015 (ADAMS Accession No. ML15310A094), the staff endorsed the leakage rates described in the white paper for the beyond-design-basis ELAP event, subject to certain limitations and conditions.

The licensee's mitigating strategy does not explicitly credit the leakage rate expected for the Flowserve N-9000 seals. Nevertheless, during the audit, the NRC staff considered the status of the licensee's conformance with the white paper and the limitations and conditions in the NRC staff's endorsement letter. In particular, as noted in the Flowserve white paper, the licensee confirmed that the plant design and planned mitigation strategy of MPS, Unit 2 are consistent with the information assumed in the calculation performed by Flowserve, as summarized in Table 1 of the white paper. The NRC staff's audit of the applicable information from the Flowserve white paper against the strategy in the licensee's FIP further verified consistency. Additionally, the peak cold-leg temperature prior to the RCS cooldown assumed in Flowserve's analysis was found to be equivalent to the saturation temperature corresponding to the lowest setpoint for main steam safety valve lift pressure in the MPS, Unit 2 FSAR. Based on its audit review, the NRC staff further considered the intent of the endorsement letter's condition on the density of the coolant leaking from the RCS to be satisfied inasmuch as a conservative RCP seal leakage assumption was used for the determination of the time to enter reflux cooling.

The plant-specific calculations performed by Flowserve in its white paper indicate that the MPS, Unit 2 FLEX scenario does not exceed the design margin demonstrated in a station blackout test conducted by Flowserve in 1988, such that increased leakage due to elastomer failure or other causes is not expected during the analyzed ELAP event.

Comparing the assumed leakage rates in the licensee's thermal-hydraulic analysis to the endorsed leakage rate values from the Flowserve white paper, the NRC staff observed that the licensee's analysis for determining the threshold for entry into reflux cooling did not credit the installation of the Flowserve N-Seals. Instead, the leakage rates were based on the assumption that RCP seal leakage would occur at an initial rate of 15 gpm at the RCS temperature and pressure conditions applicable when subcooling decreases below 50°F. Modeling RCP seal leakage in this manner was intended to envelop the potential for seal instability at low inlet subcooling conditions to result in "pop-open" failure, as described in WCAP-16175-P-A. Because leakage rates in excess of 15 gpm would be expected to trigger closure of the controlled bleed-off line excess flow check valves (i.e., which should isolate the majority of RCP seal leakage), the "pop-open" failure mode was assumed to occur upon loss of subcooling margin, resulting in leakage at the maximum rate that would not be expected to trigger closure of the excess flow check valves. Thermal-hydraulic analysis indicates that the RCS subcooling margin decreases below 50 °F at approximately 3 hours into the event as the RCS cooldown is being conducted. Cooling down the RCS under ELAP conditions results in the RCS approaching saturation because the pressurizer heaters are not powered. As the RCS cooldown and depressurization continue, the analytical leakage rate decreases in accordance with the choked flow correlation[1] used in the CENTS code. Considering the leakage rates from the licensee's CENTS analysis, as well as confirmatory analysis performed by the NRC staff with the TRACE code (see Section 3.2.3.2 above), the NRC staff concluded that these

[1] A choked flow correlation is used to estimate the maximum fluid velocity across a restrictive cross-sectional flow area.

analytically assumed leakage rates are conservative relative to the leakage rate for Flowserve N-9000 seals that is expected during the analyzed ELAP event.

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

3.2.3.4 Shutdown Margin Analyses

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

- the cooldown of the RCS and fuel rods adds positive reactivity
- the concentration of xenon-135, 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 injection of borated makeup from passive accumulators due to the depressurization of the RCS, which adds negative reactivity

At some point following the cooldown of the RCS, PWR licensees' mitigating strategies generally require active injection of borated coolant via FLEX equipment. In many cases, boration would become necessary to offset the gradual positive reactivity addition associated with the decay of xenon-135; but, in any event, borated 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.

In support of its review of the mitigating strategy for MPS, Unit 2, the NRC staff audited the licensee's shutdown margin calculation. The shutdown margin calculation concluded that for a typical MPS, Unit 2 core design, no additional boration would be necessary to ensure at least 1 percent shutdown margin under xenon-free conditions for RCS cold leg temperatures above 315 °F. In light of the post-cooldown target SG pressure of 120 psia, the staff expects the RCS cold leg temperature to remain above this value (i.e., in the range of approximately 340-350 °F). As described in the sequence of events in Table 4 of the licensee's FIP, the licensee's FLEX strategy is capable of providing indefinite coping capability without cooling the RCS to cold shutdown conditions. However, in support of transitioning to shutdown cooling mode as a recovery action, the licensee's calculation further concluded that increasing the RCS boron concentration by less than 100 particles per million (ppm) would be sufficient to ensure 1 percent shutdown margin at cold shutdown conditions, even at the limiting end-of-cycle condition.

As described in its FIP, the licensee's shutdown margin calculation for MPS, Unit 2 assumed uniform mixing of boric acid. The NRC staff requested that the industry provide additional information to justify that borated makeup would adequately mix with the RCS volume under natural circulation conditions potentially involving two-phase flow. In response, the PWROG submitted a position paper, dated August 15, 2013 (withheld from public disclosure due to proprietary content), which provided test data regarding boric acid mixing under single-phase natural circulation conditions and outlined applicability conditions intended to ensure that boric acid addition and mixing during an ELAP would occur under conditions similar to those for which boric acid mixing data is available. By letter dated January 8, 2014 [Reference 48], the NRC staff endorsed the above position paper with the following three conditions:

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

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

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

The NRC staff's audit 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 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 16 hours satisfies the second two conditions. In fact, satisfaction of these positions is trivial in this case inasmuch as the licensee stated that MPS, Unit 2 has the capability to maintain adequate shutdown margin indefinitely at RCS temperature conditions corresponding to the target SG pressure of 120 psia without injection of additional boron. Therefore, the NRC staff concludes that the licensee's calculation conforms the intent of the PWROG position paper, including the intent of the additional conditions imposed in the NRC staff's endorsement letter.

Towards 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 in analyzed cases where minimal RCS leakage occurs. In particular, the licensee's FIP discusses the potential for water-solid conditions in the RCS (i.e., RCS completely filled with liquid-phase water). The NRC staff considers water-solid conditions undesirable, particularly due to the potential for significantly repressurizing the RCS with FLEX injection at reduced temperatures, which was not explicitly considered in the WCAP-17601-P analysis cited by the licensee. Thus, the NRC staff expects that the licensee will control operation of FLEX RCS injection flow and RCS vents, per its existing procedures, to avoid potentially adverse impacts associated with water-solid operation. During the audit, the licensee stated that the reactor head vent lines contain dc-powered valves that would initially be deenergized by load shedding activities during Phase 1 of the FLEX mitigating strategy to extend the life of station batteries. However, the licensee stated that the head vents can be reenergized via FSG-8, if needed, and opened remotely from the MCR under ELAP conditions to support the addition of borated coolant to ensure adequate reactor shutdown margin.

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

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

3.2.3.5 FLEX Pumps and Water Supplies

For SG makeup, the licensee described in its FIP that the BDB High Capacity pump, which is sized to provide AFW to both MPS, Unit 2 and MPS, Unit 3 TDAFW pumps and makeup water to MPS, Unit 2 and MPS, Unit 3 SFP simultaneously. The BDB High Capacity pump is a trailer-mounted, diesel driven centrifugal pump and it is deployed by towing the trailer to a designated draft location near the selected water source as described in SE Section 3.10. The licensee stated that only one BDB High Capacity pump is required to implement the Phase 1 and Phase 2 reactor core cooling and heat removal strategy for both MPS, Unit 2 and MPS, Unit 3. Two BDB High Capacity pumps are stored in the BDB Storage Building and available to satisfy the N+1 requirement. The licensee also described in its FIP, that the BDB AFW pump, serves as a backup to the Unit 2 TDAFW pump if it is unavailable due to insufficient turbine inlet steam flow from the SGs. The BDB AFW pump is a trailer-mounted, diesel driven centrifugal pump that is deployed from the BDB Storage Building. The licensee stated that there are three BDB AFW pumps, one for each Unit and one additional pump, to satisfy the N+1 requirement in NEI 12-06.

For RCS makeup, the licensee described in its FIP, that the BDB RCS Injection pump is designated to provide RCS makeup at 100 psi above the current reactor vessel head to allow for RCS injection. The licensee indicated that Unit 2 is capable of receiving RCS makeup from either one BDB RCS Injection pump, which takes suction from the RWST or a portable mixing tank as described in SE Section 3.10, or by repowering a Charging pump, which can take suctioni from the RWST or the BASTs. The licensee stated that there are two BDB RCS Injection pumps that are stored in the BDB Storage Building and the one Charging pump to meet the N+1 requirement for RCS makeup as described in NEI 12-06. The licensee also described in its FIP the Portable Boric Acid Mixing tanks, which are deployed from the BDB Storage Building provide a suction source for the Unit 2 BDB RCS Injection pumps. Dilution water is added to the mixing tank by either a portable transfer pump, or from a branch line from the BDB High Capacity pump header taking suction from a clean water source. Bags of powdered boric acid are mixed with dilution water to achieve the proper concentration for maintaining adequate shutdown margin while making up RCS inventory. The clean water mixing tank dilution sources are used in the same priority as the potential AFW sources as described in SE Section 3.10.

Section 11.2 of NEI 12-06 states that design requirements and supporting analysis should be developed for portable equipment that directly performs a FLEX mitigation strategy for core, containment, and SFP that provides the inputs, assumptions, and documented analysis that the mitigation strategy and support equipment will perform as intended. During the audit review, the licensee provided a FLEX hydraulic calculation (Calculation 13-015, Rev. 0, "MP2 & MP3 FLEX Strategy Hydraulic Calculations"), which evaluated the use of the FLEX pumps providing makeups to the SG, RCS, and SFP respectively. The calculations indicate that the above portable FLEX pumps were capable of performing their functions after a BDBEE event

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

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

3.2.3.6 Electrical Analyses

The licensee's FIP [Reference 18] defined strategies capable of mitigating a simultaneous loss of all alternating current (ac) power and loss of normal access to UHS resulting from a BDBEE by providing the capability to maintain or restore core cooling at MPS, Unit 2. The licensee's strategy for RCS inventory control uses the same electrical strategy as 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. Furthermore, the electrical coping strategies are the same for all modes of operation.

The NRC staff reviewed the licensee's FIP to determine whether the FLEX strategies, if implemented appropriately, should maintain or restore core cooling, containment, and spent fuel pool cooling following a BDBEE. As part of its review, the NRC staff reviewed conceptual electrical single-line diagrams, summaries of calculations for sizing the FLEX diesel and turbine generators and station batteries, and summaries of calculations that addressed the effects of temperature on the electrical equipment credited in the FIP as a result of losing heating, ventilation, and air conditioning (HVAC) during an ELAP as a result of a BDBEE. The NRC staff also reviewed the separation and isolation of the FLEX generators from the Class 1E emergency diesel generators (EDGs) and procedures that direct operators how to align, connect, and protect associated systems and components.

According to the licensee's FIP, operators respond to the ELAP/LUHS event in accordance with EOPs to confirm RCS, secondary system, and containment conditions. A transition to EOP 2530, "Station Blackout," is made upon the diagnosis of the total loss of ac power. This procedure (along with referenced FSGs) directs isolation of RCS letdown pathways, confirmation of natural circulation cooling, verification of containment isolation, reduction of dc loads on the station Class 1E batteries, and establishment of electrical equipment alignment in preparation for eventual power restoration.

The MPS, Unit 2 Phase 1 FLEX mitigation strategy involves relying on installed plant equipment and onsite resources, such as use of installed Class 1E station batteries, vital inverters, and the Class 1E dc electrical distribution system. This equipment is considered robust and protected with respect to applicable site external hazards since they are located within safety-related, Class 1 structures. As part of its Phase 1 FLEX mitigation strategy, the licensee will monitor containment temperature procedurally and, if necessary, reduce containment temperature to ensure that key containment instruments remain within analyzed limits for equipment qualification (See Section 3.4.4.4 for further information on the licensee's containment cooling strategy). The dc power from the station batteries will be needed in an ELAP to power loads such as shutdown system instrumentation, control systems, and re-powered AOVs and MOVs. The FSG-4, "ELAP DC Bus Load Shed and Management," Rev. 0, directs operators to conserve dc power during the event by stripping, or load shedding, nonessential loads dc loads. The plant operators would commence load shedding nonessential dc loads within 45 minutes after the occurrence of an ELAP/LUHS event. The licensee expects load shedding completed within 30 minutes. The MPS, Unit 2 vital batteries contain 60 cells each and were manufactured by C&D Technologies (model LCR-33) with a capacity of 2320 ampere-hour. The licensee noted and the staff confirmed that the useable station battery capacity could be extended up to 29 hours for Unit 2 by load shedding non-essential loads.

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

Based on the evaluation above, the NRC staff concludes that the MPS load shed strategy should ensure that the batteries have sufficient capacity to supply power to required loads for at least 29 hours.

During the onsite portion of the audit, the NRC staff reviewed the summary of the licensee's dc system analysis (Calculation 2013-ENG-04408E2, "MP2 BDB Battery Calculation," Rev. 0) to verify the capability of the dc system to supply the required loads during the first phase of the MPS 2 FLEX mitigation strategies plan. The licensee's evaluation identified the required loads and their associated ratings (ampere (A) and minimum required voltage) and the loads that would be shed within 75 minutes to ensure battery operation for least 29 hours.

As part of its plan to extend the battery discharge time for MPS, Unit 2, the licensee plans to cross-tie both vital 125 V dc buses. The NRC staff was concerned that closing the dc tiebreaker between dc buses 201A and 201B could result of a significant electrical arc due to the difference in voltage between batteries 201A and 201B at the time of the breaker closure. Based on this concern, the staff requested the licensee to provide an assessment of any adverse impacts as a result of closing the dc tie breakers during an ELAP event. In response to the NRC staff's request, the licensee noted that the installed dc cross-tie at MPS, Unit 2 utilizes General Electric (GE) breakers that are 1600 A frame breakers with an 800 A trip coil rating. These breakers are designed for switching loads up to 800 A and quench a fault current up to 50,000 A without causing any arc flashes outside the switchgear assembly. Therefore, as long as the circulating current is less than 800 A, the breaker will close and the battery voltage will equalize without any cause for personnel safety concerns. The licensee also noted that the MPS, Unit 2 cross-tie is implemented each refueling outage in Mode 5 with a slight voltage differential between the dc buses with no issues having occurred to date. Vital batteries 201A and 201B are the same size and made by the same manufacturer. The battery duty cycles for these batteries are almost identical as verified by comparing the battery terminal voltage at 75 minutes after initiation of an ELAP event. The licensee's evaluation of the design-basis calculations indicated that the battery terminal voltages track together throughout the battery cycle and that the terminal battery voltage difference is minimal. Based on this information, the NRC staff finds that the dc cross-tie breakers should close as expected when implementing the cross-tie between dc buses 201A and 201B.

Based on the staff's review of the licensee's analysis, the battery vendor's capacity and discharge rates for the batteries, and the licensee's procedures, the NRC staff finds that the MPS Unit 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 re-powering vital 120 Vac buses within 16 hours using a portable 500-kilowatt (kW) 480 Vac FLEX diesel generator (DG) stored in a robust beyond design basis (BDB) storage building located onsite. Based on this, the licensee's transition to Phase 2 would occur much earlier than the calculated depletion of the Class 1E 125 V dc batteries, the portable 480 Vac FLEX DG would supply power to MPS Unit 2 vital 120 Vac circuits providing continuity of key parameter monitoring and other required loads. A portable

23.3 kW 120/240 Vac FLEX DG is available for instrumentation purposes as an alternate to the 480 Vac DG. The licensee's FLEX DG sizing calculation 2013-ENG-04383E2, "MP2 BDB – FLEX 4160V, 480V, and 120 Vac System Loading Analysis," Rev. 1, identified the required loads to be 296.03 kW for the 480 Vac FLEX DG and 4.24 kW for the 120/240 Vac FLEX DG. The 480 Vac DG is available to power Bus 22F within 13 hours after the start of an ELAP/LUHS event. The cabling for the 480 Vac DG would run from a breaker on Bus 22F in the East 480 Vac Switchgear Room to a connection box located on the north wall of the adjacent MPS Unit 1 Cable Vault. The new connection includes a plug-in connection rated at 600 A.

The portable, trailer mounted 480 Vac FLEX DG would be transported from the BDB Storage Building to a location outside in the east courtyard between MPS, Units 1 and 2. The deployment route was evaluated as part of the mitigation strategies. Color-coded cables required for connection will be stored in the MPS Unit 1 Cable Vault and are run from the MPS, Unit 1 Cable Vault to the portable FLEX DG through two new exterior penetrations at the 25 feet elevation in the MPS, Unit 1 cable vault. The cables would be connected to the plug-in connection box located in the MPS unit 1 Cable Vault. Additionally, Appendix 8 of FSG-20, "Energizing Bus 22F from a BDB 480 Vac Generator," Rev. 0, provides direction for ensuring proper phase rotation before attempting to power equipment from the 480 Vac FLEX DG. For the alternate strategy, the licensee installed new breakers in Vital 120 Vac Panels VA20 and VA40 that would be connected to the FLEX DG using new supply cables. These breakers are open when power to the panel is being supplied from in-house inverters. The licensee would close these breakers when supplying power from the 120/240 Vac FLEX DG. The new connections include two single-phase, 120 Vac 100 A plug receptacles feeding an 80 A breaker in VA20 and a 70 A breaker in VA40. Plant operators would deploy the cables from the BDB Storage Building along with the 120/240 Vac FLEX DG. The cables would run from the new receptacles, which are connected to the new breakers, through the "B" and "A" dc Switchgear rooms and exit the building through the exterior entrance to the "A" dc Switchgear Room. The 120/240 Vac FLEX DG would be deployed to the same general area (courtyard) as the 480 Vac FLEX DG outside of the exterior east door to this area.

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

For Phase 3, MPS, Unit 2 plans to continue the Phase 2 coping strategy with additional assistance provided from offsite equipment/resources. The offsite resources that will be provided by the NSRCs includes two 1-MW 4160 Vac combustion turbine generators, a distribution panel (including cables and connectors), and a 480 Vac combustion turbine generator per unit.

Each 4160 Vac combustion turbine generator is capable of supplying approximately 1 megawatt (MW) but two combustion turbine generators will be operated in parallel to provide approximately 2 MW (2.5 MVA at 0.8 power factor (pf)). Per calculation 2013-ENG-04383E2, "MP2 BDB – FLEX 4160V, 480V, and 120Vac System Loading Analysis," Rev. 1, the total loads for Phase 3 equals 895 kW. The components necessary to implement the various containment cooling options and for continuation of the Phase 2 coping strategy have been included in the calculations to support the sizing of the 4160 Vac combustion turbine generators. FSG-15, "4160 Vac Repowering Using NSRC Generator," Rev. 0, provides direction for ensuring proper phase rotation before attempting to power equipment from the 4160 Vac combustion turbine generators. The 480 Vac combustion turbine generator has a capacity of 800 kW and would serve as a backup to the Phase 2 480 Vac FLEX DG. Based on its review, the NRC staff finds that the 4160 Vac equipment being supplied from the NSRCs 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, if implemented appropriately, should maintain or restore core cooling 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

NEI 12-06, Table 3-2 and Appendix D, summarize an acceptable approach consisting of three separate capabilities for the SFP cooling strategies. This approach uses a portable injection source to provide the capability for 1) makeup via hoses on the refueling floor capable of exceeding the boil-off rate for the design basis heat load; 2) makeup via connection to spent fuel pool cooling piping or other alternate location capable of exceeding the boil-off rate for the design basis heat load; and 3) spray via portable monitor nozzles from the refueling floor using a portable pump capable of providing a minimum of 200 gpm per unit (250 gpm if overspray occurs). During the event, the licensee selects the method to use based on plant conditions. This approach also requires a strategy to mitigate the effects of steam from the SFP, such as venting.

As described in NEI 12-06, Section 3.2.1.7 and JLD-ISG-2012-01, Section 2.1, strategies that have a time constraint to be successful should be identified and a basis that the time can be reasonably met should be provided. NEI 12-06, Section 3 provides the performance attributes, general criteria, and baseline assumptions to be used in developing the technical basis for the time constraints. Since the event is 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.

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

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

3.3.1 Phase 1

The licensee stated in its FIP that no operator action is needed for Phase 1 other than monitoring the SFP level using instrumentation installed as required by NRC Order EA-12-051. The licensee's evaluation of the SFP concluded that without operator action following a loss of SFP cooling at the maximum design heat load, the MPS, Unit 2 SFP inventory reaches 212 °F in approximately 6 hours and boils off to a level of 10 ft. above the top of fuel in 30 hours from declaration of ELAP.

3.3.2 Phase 2

The licensee stated in its FIP that the Phase 2 strategy is to initiate SFP makeup within 24 hours of the event by running a branch hose from the BDB High Capacity pump to the BDB SFP makeup connection located in the SFP Skimmer Cage in the MPS, Unit 2 Auxiliary Building.

The BDB SFP piping connection ties into the existing SFP makeup piping that discharges into the SFP. Makeup to the SFP will be provided from the RWST or from one branch of the MPS, Unit 2 distribution manifold being supplied from the BDB High Capacity pump. The BDB High Capacity pump is trailer mounted and is towed to an available draft point by one of the BDB tow vehicles also located within the protected BDB Storage Building. Required hose lengths and fittings are located in the BDB Storage Building. The licensee also stated in its FIP that alternate makeup to the SFP would include use of the site fire header and the Auxiliary Feedwater supply to the Spent Fuel Pool. Also, an available alternate FLEX strategy consists of deploying a hose directly to the spent fuel pool area. Additionally, spray monitors and sufficient hose length required for the SFP Spray Option are located in the BDB Storage Building.

3.3.3 Phase 3

The licensee stated in its FIP, that the NSRC will provide additional Low Pressure/High Flow pumps to backup to the onsite BDB High Capacity pumps to continue to makeup to the SFP. The NSRC will also provide two 4160 Vac generators which can be used to re-power SFP cooling systems if emergency buses are available or restored.

3.3.4 Staff Evaluations

3.3.4.1 Availability of Structures, Systems, and Components

3.3.4.1.1 Plant SSCs

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

The NRC staff reviewed the licensee's calculation on habitability on the SFP refuel floor. The calculation and the FIP indicate that boiling begins at approximately 6 hours during a normal, non-outage situation. The staff noted that the licensee's sequence of events timeline in its FIP indicates that operators will deploy hoses and spray nozzles as a contingency for SFP makeup within 24 hours after event initiation to ensure the SFP area remains habitable for personnel entry.

As described in the licensee's FIP, the licensee's Phase 1 SFP cooling strategy does not require any anticipated actions. However, the licensee does establish a ventilation path prior to the 6 hour mark to cope with temperature, humidity, and condensation from evaporation and/or boiling of the SFP. The operators are directed by the FSG-05 to open the Auxiliary Building rollup door located on the 14' - 6" level of the Auxiliary Building among the immediate actions after ELAP is declared. Guideline FSG-05 also directs operators to open additional doors at the 71' elevation to provide both a vent path for steam and allows for a flow path of cool air to enter the area from the lower level rollup door and exit through higher elevations of the SFP area of the Auxiliary Building, thus creating a chimney effect to vent steam from the SFP area resulting from boiling. The strategy also allows for portable fans from the BDB Storage Building to be positioned at the Auxiliary Building rollup door to enhance the ventilation.

The licensee's Phase 2 and Phase 3 SFP cooling strategy involves use of the BDB High Capacity pump with associated hoses and fittings taking suction from the Long Island Sound or the Onsite Freshwater Pond. The licensee also stated that the SFP can be made up from one branch of the MPS Unit 2 distribution manifold to access the city water. The staff's evaluation of the robustness and availability of FLEX connections points for the FLEX pump is discussed in Section 3.7.3.1 below. Furthermore, the staff's evaluation of the robustness and availability of the UHS for an ELAP event is discussed in Section 3.10.3.

3.3.4.1.2 Plant Instrumentation

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

3.3.4.2 Thermal-Hydraulic Analyses

Section 11.2 of NEI 12-06 states, in part, that design requirements and supporting analysis should be developed for portable equipment that directly performs a FLEX mitigation strategy for core, containment, and SFP that provides the inputs, assumptions, and documented analysis that the mitigation strategy and support equipment will perform as intended. In addition, NEI 12-06, Section 3.2.1.6, Condition 4 states that SFP heat load assumes the maximum design-basis heat load for the site. In accordance with NEI 12-06, the licensee performed a thermal-hydraulic analysis of the SFP as a basis for the inputs and assumption used in its FLEX equipment design requirements analysis. The licensee evaluated the SFP with the maximum design-basis heat loads to conclude that the minimum time to boiling is 6 hours with loss of normal SFP cooling with bulk boiling temperature of 212 °F in the SFP. During the audit, the licensee provided Calculation 13-015, Rev. 0, "MP2 & MP3 FLEX Strategy Hydraulic Calculations," which concluded that the flowrate of 75 gpm is needed to makeup to the SFP using the BDB High Capacity pump. The licensee also concluded that the required SFP makeup is needed within 24 hours of a declaration of an ELAP. The NRC staff evaluated the calculation during the audit and verified, by reviewing the licensee's analysis, that the BDB High Capacity pump is capable of providing the necessary flow needed for SFP makeup.

Based on the information contained in the FIP and the above hydraulic analysis, the staff finds that the licensee has provided a thorough analysis that considered maximum design-basis SFP heat load during operating, pre-fuel transfer or post-fuel transfer operations, the basis for assumptions and inputs used in determining the design requirements for FLEX equipment used in SFP cooling consistent with NEI 12-06 Section 3.2.1.6, Condition 4 and Section 11.2.

3.3.4.3 FLEX Pumps and Water Supplies

As described in the FIP, the SFP cooling strategy relies on the BDB High Capacity pump to provide SFP makeup during Phase 2. In the FIP, Section 2.4.7 describes the hydraulic performance criteria (e.g., flow rate, discharge pressure) for the BDB High Capacity pump. The staff noted that the performance criteria of FLEX pumps supplied from an NSRC for Phase 3 would allow the NSRC pumps to fulfill the mission of the onsite FLEX pump if the BDB High Capacity pump was to fail. As stated in the FIP, the SFP makeup rate of 250 gpm and SFP spray rate of 250 gpm both meet or exceed the minimum SFP makeup requirements as outlined in the previous section of this SE.

3.3.4.4 Electrical Analyses

The licensee's FIP defines strategies capable of mitigating a simultaneous loss of all ac power and loss of normal access to UHS, resulting from a BDBEE, by providing the capability to maintain or restore core cooling, containment, and spent fuel pool cooling at all units on the MPS site. Furthermore, the electrical coping strategies are the same for all modes of operation.

The staff performed a comprehensive analysis of the licensee's electrical strategies, which includes the SFP cooling strategy. The only electrical components credited by the licensee as part of its FLEX mitigation strategies, outside of instrumentation to monitor SFP level (which is described in other areas of this SE), are two 4160 Vac combustion turbine generators and a distribution panel (including cables and connectors) that will be supplied by an NSRC. According to the licensee's FIP, these generators could be used to re-power spent fuel pool cooling systems, if necessary. The staff reviewed calculation 2013-ENG-04383E2, "MP2 BDB – FLEX 4160V, 480V, and 120Vac System Loading Analysis," Rev. 1, and determined that the 4160 Vac equipment being supplied from the NSRCs has sufficient capacity and capability to supply spent fuel pool cooling systems, if necessary.

3.3.5 Conclusions

The NRC staff concludes that the licensee has developed guidance that if implemented appropriately, should maintain or restore SFP cooling following an ELAP consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and adequately addresses the requirements of the order.

3.4 Containment Function Strategies

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

In accordance with NEI 12-06, the licensee performed a containment evaluation referenced in ETE-CPR-2012-0009, Revision 3 "BDB Guidance Document for ELAP Mitigating Strategies, Unit 2," which was based on the boundary conditions described in Section 2 of NEI 12-06. The calculation concludes that the containment parameters of pressure and temperature remain well below the respective design limits of 54 psig and 289 °F (FSAR Section 5.2, Containment General Description) for a minimum of 7 days. In addition, essential instruments subject to the containment environment will remain functional for a minimum of 7 days. From its review of the evaluation, the NRC staff noted that the required actions to maintain containment integrity and required instrumentation functions have been developed, and are summarized below.

The NRC staff reviewed calculation MISC-11793, "Evaluation of Long Term Containment Pressure and Temperature Profiles Following Loss of Extended AC Power (ELAP)," Revision 0. The calculation uses the Generation of Thermal-Hydraulic Information for Containments

(GOTHIC) version 7.2a computer program. The calculation forecasts the Containment pressure and temperature (pressures and temperatures are highest in the reactor cavity compartment) initially rise on loss of normal containment cooling to approximately 17 psia and 156 °F, respectively. After the first 20 minutes, the pressure and temperature decreases sharply due to the low, initially assumed containment humidity, along with the RCP seal LOCA initiation which is assumed to occur upon loss of RCS subcooling (once the pressurizer empties). Following the sharp decrease, the containment temperature and pressure then gradually increases at a steady state. The maximum Containment pressure reached was calculated to be 28.28 psia (at 168 hours), remaining well below the design-basis limit of 54 psig. The calculation also indicates the maximum Containment temperature reached was 198.7 °F (at 168 hours), which remains below the design limit of 289 °F.

Eventual containment cooling and depressurization to normal values will utilize off-site equipment and resources during Phase 3 if onsite capability is not restored.

3.4.1 Phase 1

The licensee indicated in its FIP that Phase 1 would involve initiating and verifying containment isolation as instructed in EOP 2530, "Station Blackout." The licensee also stated that containment temperature and pressure would be monitored from the Main Control Room using installed instrumentation.

The results of the containment analysis confirm that the containment function is not challenged early in the event. Therefore, no Phase 1 actions are required to maintain containment integrity.

3.4.2 Phase 2

In its FIP, the licensee indicated that Phase 2 activities would be to repower key instrumentation required to continue containment monitoring and also return the instrumentation necessary to monitor containment sump level. The operators will continue to monitor containment pressure and temperature using installed instrumentation.

3.4.3 Phase 3

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

The Phase 3 coping strategy discussed above is to obtain additional electrical capability and redundancy for on-site equipment until such time that normal power to the site can be restored. This capability will be provided by two mobile 1MW 4.16kV generators and a distribution panel from the NSRC for Unit 2. Two mobile 4.16kV generators will be brought in from the NSRC in order to supply power to the Class 1E 4.16kV Vac bus. The licensee also indicated that power can be restored to the Class 1E 480 Vac through the 4160/480 Vac transformers to power selected 480 Vac loads.

If the service water (SW) pumps are not available, then Low Pressure/High Flow diesel driven pumps (up to 5,000 gpm) from the NSRC are available to provide flow to existing site heat exchangers in order to remove heat from the containment atmosphere.

The licensee discussed several options (listed below) which provide operators with the ability to reduce the containment temperature. These operator actions are directed per FSG-12, "Alternate Containment Cooling." Each of these options requires the restoration of multiple support systems to effectively remove heat from the containment thus reducing containment temperature and pressure.

Ventilation Cooling Option (Preferred)

The preferred option is to establish containment ventilation cooling using a Containment Air Recirculation (CAR) Fan, powered from the 480 Vac temporary generator. The RBCCW and SW, (either from temporary pumps from the NSRC or installed plant equipment, if available) are powered from 4160 Vac temporary generators from the NSRC. This option is preferred since it does not "wet" the components inside containment. Once power is restored to the 4160 Vac and 480 Vac buses, a SW pump, RBCCW pump and a CAR fan are started, if available. The fans circulate air through their heat exchangers transferring containment heat to the RBCCW System, which in turn transfers the heat to the SW System and the UHS. If a SW pump is unavailable, low pressure/high flow pumps from the NSRC supplies the SW header through hose connections.

Electrical System Requirements:

The CAR fan motor is 480 Vac, 75 HP and can be powered using the 480 Vac generator deployed from the onsite BDB Storage Building. The SW and an RBCCW pumps, however, require the 4160 Vac generators from the NSRC to be available. The 4160 Vac generators from the NSRC are sized to support these loads in support of containment cooling.

Component Cooling System Requirements:

The RBCCW system is required to provide a heat sink for the CAR fan coolers. It then transfers the heat load through the SW system to the UHS. The RBCCW flow is manually controlled by throttling valves to the components being cooled.

Service Water Cooling System Requirements:

It is assumed that the SW pumps at the intake structure are NOT available to be restarted, (starting one of the installed SW pumps is preferred). Therefore, this strategy includes the installation of a high-volume (minimum 4,000 gpm), low-pressure diesel-driven pump from the NSRC. To supply the SW header in case the SW pumps are unable to be restarted, there are 2

12-inch inspection flanges in the seismic Category 1 Intake Structure. Either one can be removed and replaced with an adapter (stored in the BDB Storage Building) designed to connect to the discharge of the low pressure/high flow pump from the NSRC. The SW piping is seismic and safety-related. This source of SW can also be used for providing an UHS for SFP Cooling and Decay Heat Removal from the Reactor Core. The SW valves are manually aligned to distribute SW to the RBCCW heat exchanger.

Once cooling water flow is established to a CAR fan coil unit, operators starts either the "B" or “D” CAR fan. These fans are powered from the station's emergency buses, which are repowered when the 480 Vac temporary generator is running.

3.4.4 Staff Evaluations

3.4.4.1 Availability of Structures, Systems, and Components

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

3.4.4.1.1 Plant SSCs

The containment for Unit 2 consists of a concrete cylindrical structure and concrete foundation slab that is conventionally reinforced with high strength reinforcing steel. A continuous access gallery is provided beneath the base slab for installation of vertical tendons. A one-quarter inch thick welded steel liner is attached to the inside surface of the concrete shell to ensure a high degree of leak-tightness. The floor liner is installed on top of the structural slab and is then covered with concrete.

The Reactor Building Component Cooling Water (RBCCW) system is required to provide a heat sink for the containment air recirculation fans. It then transfers the heat load through the SW system to the UHS. The RBCCW flow is manually controlled by throttling valves to the components being cooled.

The safety-related and seismic protected SW header and piping are used for SFP Cooling from the UHS by removing 1 of 2 12-inch inspection flanges in the Seismic Category 1 Intake Structure. An adapter is placed onto the header with connection to the discharge of the low pressure/high flow pump from the NSRC.

3.4.4.1.2 Plant Instrumentation

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

The above essential instrumentation will be available prior to and after load stripping of the dc and ac buses during Phase 1. All indications will be in the Control Room (CR). Should any of the signal cabling to the CR indicators be damaged or dc power lost, all process parameters can be obtained at remote locations with portable meters. Procedure FSG-07 provides location and termination information in the CR for all essential instrumentation. Instrumentation providing containment sump level indication is available in the CR for Phases 2 and 3 for the containment cooling spray option. Also, instrumentation for use in Phase 3 containment cooling options, such as SW flow rate (either from plant equipment or portable pump), RBCCW flow rate, RBCCW temperature, and RBCCW pressure is available to the operators once the instruments are repowered from temporary generators installed prior to implementing this strategy. The use of these instruments is detailed in the associated FSGs for use of the equipment. These procedures are based on inputs from the equipment suppliers, operation experience, and expected equipment function in an ELAP.

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

3.4.4.2 Thermal-Hydraulic Analyses

The licensee stated in its FIP that the containment temperature and pressure remain below containment design limits and that key parameter instruments subject to the containment environment remain functional for a minimum of seven days. The licensee stated that the containment temperature is procedurally monitored and, if necessary, the containment temperature is reduced so that key containment instruments will remain within their analyzed limits for equipment qualification.

Calculation MISC-11793, Rev.0, “Evaluation of Long Term Containment Pressure and Temperature Profiles Following Loss of Extended AC Power (ELAP),” used the GOTHIC (Generation of Thermal-Hydraulic Information for Containments) 7.2a computer program. The analysis evaluates the containment response with the plant initially at full power in Mode 1 at the time of a BDBEE, and bounds plant configurations in Modes 1 through 4 with steam generators available. The limiting containment initial conditions (i.e. Pressure, Temperature and Humidity) are assumed to correspond to the value used for the plant specific limiting peak pressure analysis. The calculation modeled the containment pressure and temperature over a 168-hour period during an extended loss of AC power event.

TDAFW pump begins supplying SG makeup at 600 seconds (10 minutes). A continuous source of SG secondary makeup is assumed to be available. Plant cooldown at a rate of 75 °F/hr commences at 7200 seconds (2 hours) by manual operation of ADVs. The assumed reactor coolant leakage is 15 gpm per RCP.

The maximum containment pressure reached for Unit 2 was calculated to be 28.78 psia, remaining well below the design-basis limit of 54 psig. The calculation also indicates the maximum Containment temperature reached for Unit 2 is 198.7 °F, which remains below the design limit of 289 °F. The NRC staff's audit review found the licensee's thermal-hydraulic analysis to be in adequate conformance with applicable guidance documents (e.g., NEI 12-06, the NRC staff's endorsement letter regarding the use of MAPP). Therefore, based on the evaluation above, the licensee's analytical approach should appropriately determine the adequacy for supporting FLEX strategies within 7 days.

3.4.4.3 FLEX Pumps and Water Supplies

The NSRC is providing a low pressure/high capacity pump which will be used to provide cooling flow from Long Island Sound to the SW system. The licensee also indicated in its FIP, that a low pressure/medium flow pump would also be available from the NSRC.

3.4.4.4 Electrical Analyses

The licensee performed a containment evaluation based on the boundary conditions described in Section 2 of NEI 12-06. Based on the results of this analysis, the licensee developed required actions to ensure maintenance of containment integrity and required instrumentation function. With an ELAP initiated, while either MPS Unit is in Modes 1-4, containment cooling for that unit is also lost for an extended period of time. Therefore, containment temperature and pressure will slowly increase. Structural integrity of the reactor containment building due to increasing containment pressure will not be challenged during the first several weeks of an ELAP/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 for a minimum of seven days. Therefore, actions to reduce containment temperature and pressure and to ensure continued functionality of the key parameters will not be required immediately.

The licensee’s Phase 1 coping strategy for containment involves initiating and verifying containment isolation per EOP 2530, Station Blackout. These actions ensure containment isolation following an ELAP/LUHS. Phase 1 also includes monitoring containment temperature and pressure using installed instrumentation. Control room indication for containment pressure and containment temperature is available for the duration of the ELAP/LUHS.

The licensee’s Phase 2 coping strategy is to continue monitoring containment temperature and pressure using installed instrumentation. Phase 2 activities to repower key instrumentation are required to continue containment monitoring and also return the instrumentation necessary to monitor containment sump level.

The licensee evaluated several options to provide operators with the ability to reduce the containment temperature. Each of these options would require the restoration of multiple support systems to remove heat from the containment thus reducing containment temperature and pressure. The various containment cooling strategy options are discussed in Section 2.5.3 of the licensee's FIP. To reduce containment temperature and ensure continued functionality of the key parameters, the licensee will utilize existing plant systems that will be powered by a combination of onsite (480 Vac FLEX DG) and offsite equipment during Phase 3. This capability will be provided by two 1 MW, 4160 Vac combustion turbine generators and a distribution panel, which will be brought in from the NSRC in order to supply power to the 24D Class 1E 4160 Vac buses on each unit. Additionally, by restoring the Class 1E 4160 Vac bus, power can be restored to the Class 1E 480 Vac bus 22F via the 4160/480 Vac transformers to power selected 480 Vac loads.

The staff reviewed calculation 2013-ENG-04383E2, "MP2 BDB – FLEX 4160V, 480V, and 120Vac System Loading Analysis," Rev. 1, and determined that the electrical equipment available onsite (i.e., 480 Vac FLEX DG) supplemented with the electrical equipment that will be supplied from the NSRCs (i.e., 480 Vac and 4160 Vac combustion turbine generators) has sufficient capacity and capability to supply the required loads to reduce containment temperature and pressure, if necessary, to ensure that key instrumentation remains functional.

3.4.5 Conclusions

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

3.5 Characterization of External Hazards

Sections 4 through 9 of NEI 12-06, Revision 0, provide the methodology to identify and characterize the applicable BDBEEs for each site. In addition, NEI 12-06 provides a process to identify potential complicating factors for the protection and deployment of equipment needed for mitigation of site-specific external hazards leading to an ELAP and loss of normal access to the UHS.

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

The licensee reviewed the plant site against NEI 12-06 and determined that FLEX equipment should be protected from the following hazards: seismic, external flooding, severe storms with high winds, snow, ice and extreme cold, and extreme high temperatures. No external hazards, from those described in NEI 12-06, were screened out.

References to external hazards within the licensee's mitigating strategies and this SE are consistent with the guidance in NEI-12-06 and the related interim staff guidance in JLD-ISG-

2012-01 [Reference 7]. Coincident with the issuance of the order, on March 12, 2012, the NRC staff issued a Request for information Pursuant to Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f) [Reference 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.

The NRC staff requested Commission guidance related to the relationship between the reevaluated flooding hazards provided in responses to the requested information and the requirements for Order EA-12-049 and related rulemaking to address BDBEEs (see COMSECY-14-0037, Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards" [Reference 52].) The Commission provided guidance in a SRM to COMSECY-14-0037 [Reference 20]. The Commission approved the staff's recommendations that licensees need to address the reevaluated flooding hazards within their mitigating strategies for BDBEEs, and that licensees may need to address some specific flooding scenarios that could significantly impact the power plant site by developing scenario-specific mitigating strategies, possibly including unconventional measures, to prevent fuel damage in reactor cores or SFPs. The NRC staff did not request that the Commission consider making a requirement for mitigating strategies capable of addressing the reevaluated flooding hazards be immediately imposed, and the Commission did not require immediate imposition. In a letter to licensees dated September 1, 2015 [Reference 39], the NRC staff informed the licensees that the implementation of mitigation strategies should continue as described in licensee's OIPs, and that the related NRC SEs and inspections will rely on the guidance provided in JLD-ISG-2012-01, Rev. 0 [Reference 7] and the related industry guidance in Revision 0 to NEI 12-06 [Reference 6]. The reevaluations may also identify issues to be entered into corrective action programs consistent with the OIPs submitted in accordance with Order EA-12-049.

The licensee has submitted its flood hazard reevaluation report (FHRR) [Reference 21], and the NRC staff has completed its review and the results are discussed in Section 3.5.2 below. The licensee developed its OIP for mitigation strategies in February 2013 [Reference 10] by considering the guidance in NEI 12-06 and its then-current design-basis hazards. Therefore, this SE makes a determination based on the OIP and FIP, and notes the possibility of future actions by the licensee if the licensee's FHRR identifies a flooding hazard that exceeds the current design-basis flooding hazard.

Per the 50.54(f) letter, licensees were also asked to provide a seismic hazard screening and evaluation report to reevaluate the seismic hazard at their site. The licensee submitted its seismic hazard screening report (SHSR) [Reference 22] in March 2014, and the NRC staff has completed a review and the results are discussed in Section 3.5.1 below. Therefore, this SE makes a determination based on the OIP and FIP, and notes the possibility of future actions by the licensee if the licensee's SHSR identifies a seismic hazard that exceeds the current design-basis seismic hazard.

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

3.5.1 Seismic

In its FIP, the licensee stated that seismic hazards are applicable to the site. From the SHSR for MPS, Unit 2, the design-basis earthquake (referred to as safe-shutdown earthquake (SSE) in this report) is defined as the maximum credible earthquake at the plant site that can reasonably be predicted from geologic and seismic evidence and is chosen to have a peak horizontal ground acceleration of 0.17g and a vertical acceleration of 0.11 g.

As previously discussed, the NRC issued a 50.54(f) letter [Reference 19] that requested facilities to reevaluate the site's seismic hazard. In addition, the 50.54(f) letter requested that licensees submit, along with the hazard evaluation, an interim evaluation and actions planned or taken to address the reevaluated hazard where it exceeds the current design-basis seismic hazard.

By letter dated March 31, 2014 [Reference 22], the licensee submitted its SHSR for MPS, Units 2 and 3 to the NRC. The licensee concluded in its report that the Individual Plant Examination of External Events (IPEEE) is adequate for seismic screening purposes and both MPS, Units 2 and 3 screen out of conducting additional seismic risk evaluations.

The NRC endorsed industry guidance "Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," provides the criteria used to determine if the licensee's IPEEE submittal is adequate to use for seismic screening purposes. If one or more of the criteria are not deemed adequate, the staff may still decide that the overall IPEEE analysis is adequate to support its use for seismic screening. The NRC staff reviewed Dominion's submittal and determined that additional information was needed to determine the IPEEE adequacy for seismic screening of MPS Unit 2.

By letter dated July 16, 2014 [Reference 45], the NRC issued an RAI to the licensee to determine the IPEEE adequacy for seismic screening. Dominion submitted its RAI response by letter dated July 21, 2014 [Reference 46]. The NRC letter identified that an audit may be needed to support this activity. Accordingly, the NRC conducted an audit on October 23, 2014, at the NEI facilities in Rockville, MD. During the audit, the staff was able to obtain the needed information in order to make a conclusion on whether the IPEEE is adequate to support its use for seismic screening for MPS, Unit 2.

The NRC staff completed its review of the licensee's SHSR, as documented by letter dated December 15, 2015 [Reference 47]. This assessment was later supplemented by letter dated March 15, 2016 [Reference 28]. The NRC staff reviewed the information provided by the licensee for the reevaluated seismic hazard for the MPS site. Based on its review, the NRC staff concluded that the licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance, it appropriately characterized the site given the information available, and met the intent of the guidance for determining the reevaluated seismic hazard. The NRC staff concluded that the licensee demonstrated that the IPEEE plant level high confidence of low probability of failure (HCLPF) spectra (IHS) could be used for comparison with the ground motion response spectrum (GMRS) for the screening determination. Based on the preceding analysis, the staff concluded that the licensee provided an acceptable response to Requested Information Items (1) - (3), (5) - (7) and the comparison portion of (4) identified in Enclosure 1 of the 50.54(f) letter. Further, the licensee's reevaluated seismic hazard is acceptable to address other actions associated with NTTF Recommendation 2.1: Seismic.

In reaching this determination, and as stated in the October 27, 2015 letter, the NRC staff confirmed that a seismic risk evaluation (Item 8) is not merited. Further, the NRC staff confirmed the licensee's conclusion that the licensee's GMRS for the MPS site exceeds the IHS over the frequency range of above 10 Hertz (Hz). Therefore, high-frequency (HF) confirmation portion of Item (4) is merited. A SFP evaluation (Item 9) is merited because the SFP was not included in the IPEEE program. A relay chatter evaluation will be needed for the IPEEE submittal to meet the SPID acceptance criteria if Dominion plans to rely on IPEEE results in its mitigation strategies assessment with respect to the reevaluated hazard.

The NRC review and acceptance of either a SFP evaluation and a HF confirmation or a SFP evaluation, HF confirmation and an IPEEE relay chatter review for MPS will complete the Seismic Hazard Evaluation identified in Enclosure 1 of the 50.54(f) letter. As the license's seismic reevaluation activities are completed, the licensee will address any potential safety related issues by implementing appropriate corrective actions.

Based on the information available for this review, the NRC staff concludes that the licensee has appropriately screened in this external hazard and identified the hazard levels to be evaluated.

3.5.2 Flooding

In its FIP, the licensee described that the limiting site flooding event for MPS, Unit 2 is the tidal flooding from passing hurricanes. For a probable maximum hurricane, the maximum still water level was determined to be +19.2 feet mean sea level (msl) with an associated wave run-up elevation of +21.7 feet msl. The design of MPS, Unit 2 reflects the decision to provide flood protection up to elevation +22 feet msl minimum for the containment, turbine, and auxiliary buildings.

In its August 27, 2015, fifth six-month update [Reference 49], the licensee provided information on its review of large internal flooding sources and determined that there were none that prevented the implementation of BDB strategies.

In Attachment 2 of its compliance letter, the licensee stated that MPS, Unit 2 does not have a subsurface groundwater removal system installed. The licensee also stated in its FIP, that, since there are no major rivers or streams in the vicinity of the station, the effects of potential seismically induced dam failures are not applicable.

The flood reevaluation considered eight potential flood-causing mechanisms including a combined effect flood required by the 50.54(f) letter. The reevaluation showed that the current design-basis flood levels are exceeded for the following potential flood mechanisms: local intense precipitation, tsunami flooding, and the combined effect flood. Combined effects flooding due to storm surge is the bounding event that exceeds the current licensing basis flood level.

In its FHRR, the licensee described existing and interim actions taken to minimize flooding of plant buildings important to nuclear safety as a result of the increased flood levels from the combined effects flood. In addition, the licensee will perform an integrated assessment to validate existing and/or develop new mitigating strategies in response to the combined effects flooding which may compromise existing flood protection and challenges in the MPS, Unit 2 turbine building.

The NRC staff plans to issue an interim staff response letter to provide a summary of the NRC Staff's assessment of the reevaluated flood-causing mechanisms described in the FHRR. The NRC staff also plans to issue a staff assessment documenting the detailed basis for the conclusions to be issued in the interim staff response letter at a later time.

As the licensee's flooding reevaluation activities are completed, the licensee will take action to address any potential safety issues. Based on the information available for this review, the licensee has appropriately screened in this external hazard and identified the hazard levels to be evaluated.

3.5.3 High Winds

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

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

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

In its FIP, regarding the determination of applicable extreme external hazards, the licensee stated that MPS is located on the north shore of the Long Island Sound. As such, it is exposed to tropical storms and hurricanes coming off the Atlantic Ocean. According to a statistical study by Simplon and Lawrence (1971), the 50-mile segment of coastline on which MPS is located, was crossed by five hurricanes during the 1886 to 1970 period. Based on observations from Montauk Point (located about 23 miles southeast of MPS on the eastern tip of Long Island), the maximum reported wind speed in the region was associated with the passage of a hurricane during which sustained winds of 115 mph, with short-term gusts up to 140 mph (Dunn and Miller 1960) were observed.

According to a study of tornado occurrences during the period of 1955 through 1967 (augmented by 1968 – 1981 storm data reports), the mean tornado frequency in the one-degree (latitude-longitude) square where the MPS site is located is determined to be approximately 0.704 per year. The tornado model used for design purposes at Millstone, Unit 2 has a 360 mph wind velocity.

The NRC staff reviewed applicable guidance to confirm that the high-wind hazards identified by the licensee are applicable to the plant site. Therefore, the licensee has appropriately screened in the high wind hazard and characterized the hazard in terms of wind velocities and wind-borne missiles.

3.5.4 Snow, Ice, and Extreme Cold

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

The MPS site is located north of the 35th Parallel. In its FIP, regarding snow, ice and extreme cold, the licensee stated that the mean annual snowfall at the present Bridgeport location is 25.3 inches, with totals (based on data from 1932 through 1990) ranging from 8.2 inches in the 1972-1973 season, to 71.3 inches in the 1933-1934 season. The maximum monthly snowfall, occurring in February 1934, was 47.0 inches. Since 1949, both the maximum measured snowfall in 24 hours (16.7 inches), and the greatest snowfall in one storm (17.7 inches) occurred during the same storm in February 1969. The maximum measured snowfall in 24 hours (16.7 inches) was matched again in January 1978. For the time period following the reported values in the FSAR, the National Weather Service reported a maximum measured snowfall in 24 hours of 18.5 inches in February 2013. An average of 18.5 hours of freezing rain and 8.5 hours of freezing drizzle occur annually in the region. In the 32-year period from 1949-to 1980, all cases of freezing precipitation were reported as light (less than 0.10 inch per hour), except for 1 hour of moderate (0.10 to 0.30 inch per hour). Winters are moderately cold, but seldom severe. Minimum daily temperatures during the winter months are usually below freezing, but subzero readings are observed, on the average, less than 1 day every 2 years. Below zero temperatures have been observed in each winter month, with an extreme minimum of -20 °F occurring in February 1934.

The NRC staff reviewed the applicable guidance in NEI 12-06 and confirmed that the information provided by the licensee is accurate. In summary, based on the available local data and Figures 8-1 and 8-2 of NEI 12-06, the plant site does experience significant amounts of snow, ice, and extreme cold temperatures; therefore, the hazard is screened in. Therefore, the licensee has appropriately screened in the hazards of snow, ice, and extreme cold.

3.5.5 Extreme Heat

In the section of its FIP regarding the determination of applicable extreme external hazards, the licensee stated that, as per NEI 12-06 section 9.2, all sites are required to consider the impact of extreme high temperatures.

The licensee stated in its FIP that due to the proximity of Long Island Sound and the Atlantic Ocean, the heat of summer is moderated. Temperatures of 90 °F or greater occur an average of 7 days per year at Bridgeport, while temperatures of 100 °F or greater have occurred only in July and August; with an extreme maximum of 104°F occurring in July 1957.

The NRC staff referred to applicable guidance in NEI 12-06 and confirmed that the information provided by licensee is accurate. Based on the available local data and the guidance in Section 9 of NEI 12-06, the plant site does experience extreme high temperatures. Therefore, 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 adequately addresses the requirements of the order in regard to the characterization of external hazards.

3.6 Planned Protection of FLEX Equipment

3.6.1 Protection from External Hazards

In its FIP, the licensee stated that the BDB equipment is stored in a single 10,000 square foot concrete building that meets the plant's design-basis for tornado-missile and earthquake protection. The location is above the upper-bound flood stage elevation for MPS, Units 2 and 3. The BDB storage building was designed and constructed to protect the BDB equipment from the hazards applicable to the MPS site.

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

3.6.1.1 Seismic

In its FIP, the licensee stated that the BDB storage building was evaluated for the effect of local seismic ground motions consistent with the MPS GMRS developed for the original site licensing basis and found to have adequate structural margin to remain functional (i.e., collapse is not expected and access to the interior retained). Analysis of components stored in the BDB storage building has been performed to determine appropriate measures to prevent seismic interaction. The fire protection and HVAC systems in the BDB storage building are seismically installed. The lighting, conduits, electrical, and fire detection components are not seismically installed, but are considered not able to damage BDB equipment.

3.6.1.2 Flooding

In its FIP, the licensee stated that the BDB storage building is located on the northeast side of the northern most overflow parking lot along the plant access road. This location is above the upper-bound flood stage elevation for MPS, Units 2 and 3 (which is the limiting site evaluation).

In Attachment 2 of its compliance letter, the licensee stated that MPS, Unit 2 could potentially be impacted by a storm surge once it rises to and above the plant grade elevation of 14.5 feet msl. Under these conditions, deployment of BDB equipment and refueling of deployed equipment around MPS, Unit 2 would not be possible. Based on the MPS, Unit 3 FSAR flood surge analysis (which is the limiting site evaluation) the maximum time at which MPS storm surge would exceed the plant grade elevation would be approximately 8 hours. The only BDB component that may require deployment and operation during that time is the diesel powered BDB AFW pump. This pump will be pre-deployed prior to closure of the MPS, Unit 2 flood gates. Per the specification for the pump, a 24-hour fuel tank is provided with the pump and the pump is stored in the fueled condition in the BDB storage building. The 24-hours is more than sufficient time to allow the storm surge to subside and will facilitate refueling from available onsite fuel sources when required.

In Attachment 2 of its Compliance Letter [Reference 18], the licensee stated that during a hurricane flooding, pre-deployment of the BDB AFW pump to inside the turbine building truck bay, inside the turbine building flood gates, is required and provisions have been established to vent the diesel exhaust and to increase ventilation to avoid overheating the BDB AFW pump.

In its FIP, the licensee stated that the areas of the North American continent most susceptible to tsunamis are those bordering the Pacific Ocean and the Gulf of Mexico. MPS is located on the North Atlantic coastline where there is an extremely low probability of tsunamis. Therefore, in the original licensing and license renewal review processes, tsunamis were not considered to be a credible natural phenomena which might affect the safety of either unit at the MPS site. Likewise, flooding due to ice jams was not considered a possibility since the site is not located on a river.

3.6.1.3 High Winds

In its FIP, the licensee stated that the BDB storage building meets the plant's design-basis for tornado-missile protection. The licensee also stated that debris removal equipment is available to clear haul paths of debris coming from high winds. This equipment is stored in the BDB storage building.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

In its FIP, the licensee indicated that HVAC equipment is installed in the BDB storage building. In response to an audit question, the licensee stated that the BDB storage building would be temperature controlled.

3.6.2 Reliability of FLEX Equipment

In its FIP, the licensee stated that sufficient equipment has been purchased to address each function at the operating units, plus one additional spare, i.e., an N+1 capability. Therefore, where a single resource is sized to support the required function of both operating units, a second resource has been purchased to meet the +1 capability. In addition, where multiple strategies to accomplish a function have been developed, (e.g., two separate means to repower instrumentation) the equipment associated with each strategy does not require N+1 capability. The N+1 capability applies to the portable FLEX equipment that directly supports maintenance of the key safety functions identified in Table 3-2 of NEI 12-06. FLEX support equipment that indirectly supports maintenance of the key safety function only requires N capability. FLEX support equipment includes equipment used for debris removal, towing of FLEX equipment, lighting, fuel transfer, alternate connection adapters, and communications in support of maintenance of the key safety functions.

In its FIP, the licensee stated that in the case of hoses and cables associated with FLEX equipment required for FLEX strategies, an alternate approach to meet the N+1 capability has been selected. Details of this alternate strategy is discussed in Section 3.14.

The licensee also stated in its FIP that the alternate strategy for providing RCS makeup under ELAP conditions is by repowering an installed charging pump. This is an alternative to the guidance in NEI 12-06, Revision 0 and is discussed in Section 3.14.

The NRC staff looked at the number of portable FLEX pumps, FLEX DGs, and support equipment identified in the FIP. Based on its review, the NRC staff finds that, if implemented appropriately, the licensee's FLEX strategies include a sufficient number of portable FLEX pumps, FLEX DGs, and equipment for RCS makeup and boration, SFP makeup, and maintaining containment consistent with the N+1 recommendation in Section 3.2.2 of NEI 12-06, with the exception of hoses and cables and the installed charging pump. Refer to Section 3.14 for acceptance of the alternate strategies.

3.6.3 Conclusions

Based on its evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should protect the FLEX equipment during a BDBEE. These strategies are consistent with NEI 12-06 guidance, as endorsed, by JLD-ISG-2012-01. These strategies, in combination with the alternative strategies described in Section 3.14, should adequately addresses the requirements of the order.

3.7 Planned Deployment of FLEX Equipment

In its FIP, the licensee stated that the deployment of onsite BDB equipment in Phase 2 requires that pathways between the BDB storage building and various deployment locations be clear of debris resulting from BDB events. Pre-determined haul paths have been evaluated and are identified in the FLEX support guideline, FSG-5.

Phase 3 of the FLEX strategies involves the receipt of equipment from offsite sources including the NSRC and various commodities such as fuel and supplies. Delivery of this equipment can be through airlift or via ground transportation. The licensee stated in its compliance letter that the NSRC local staging areas, access route evaluations, and transportation evaluations to the site have been completed and documented in the SAFER Trip Report for MPS Power Station. The SAFER Response Plan for MPS has also been finalized.

3.7.1 Means of Deployment

In its FIP, the licensee stated that the debris removal equipment includes mobile equipment such as a front-end loader and tow vehicles (tractors) equipped with front-end buckets and rear tow connections for moving or removing debris from the needed travel paths. A front-end loader is also available to deal with more significant debris conditions. Deployment of the debris removal equipment and the Phase 2 BDB equipment from the BDB storage building is not dependent on offsite power. The building equipment doors are hydraulically operated with a battery backup and can also be opened manually.

Debris removal for the pathway between the site and the NSRC receiving "staging areas" locations and from the various plant access routes may be required for Phase 3. The same debris removal equipment used for onsite pathways may also be used to support debris removal to facilitate road access to the site once necessary haul routes and transport pathways onsite are clear. In a letter dated September 22, 2014 (ADAMS Accession No. ML14268A245), the licensee described how personnel from the onshift staff have been designated and trained to accomplish the debris removal function. Therefore, the NRC staff concludes that debris removal could be accomplished in a timely manner in order to allow the deployment of FLEX equipment.

3.7.2 Deployment Strategies

The licensee stated in its FIP that pre-determined haul paths have been evaluated and are identified in FSG-5. Figures 13 and 14 of the FIP show the haul paths from the BDB storage building to the various deployment locations. These haul paths have been reviewed for potential soil liquefaction and have been determined to be stable following a seismic event.

In Attachment 2 of its compliance letter, the licensee stated that MPS, Unit 2 could potentially be impacted by a storm surge once it rises to and above the plant grade elevation of 14.5 feet msl. Under these conditions, deployment of BDB equipment and refueling of deployed equipment around MPS, Unit 2 would not be possible. Based on the MPS, Unit 3 FSAR flood surge analysis (which is the limiting site evaluation), the maximum time at which MPS storm surge would exceed the plant grade elevation would be approximately 8 hours. The only BDB component that may require deployment and operation during that time is the diesel powered BDB AFW pump. This pump will be pre-deployed prior to closure of the MPS, Unit 2 flood gates. Per the specification for the pump, a 24 hour fuel tank is provided with the pump and the pump is stored in the fueled condition in the BDB storage building. Twenty-four hours is more than sufficient time to allow the storm surge to subside and will facilitate refueling from available onsite fuel sources when required.

Phase 3 of the FLEX strategies involves the receipt of equipment from offsite sources including the NSRC and various commodities such as fuel and supplies. Delivery of this equipment can be through airlift or via ground transportation. Debris removal for the pathway between the site and the NSRC receiving "Staging Areas" locations and from the various plant access routes may be required. The same debris removal equipment used for onsite pathways may also be used to support debris removal to facilitate road access to the site once necessary haul routes and transport pathways onsite are clear. Access to the UHS at the intake structure can be accomplished utilizing a low pressure/high flow pump provided by the NSRC.

In regards to frazil ice, the licensee stated during the audit process that both the Unit 2 and Unit 3 MPS FSARs discuss frazil ice in relation to the intake structure and indicate that at <2 feet per second (fps), frazil ice will form and float to the surface. Therefore, given the size of the installed suction strainer, flow is limited to ½ fps so frazil ice will not form around the strainer. Additionally, should a strainer become clogged, procedure “C OP 200.16, Attachment 7” identifies the need and process to change out the strainer.

3.7.3 Connection Points

3.7.3.1 Mechanical Connection Points

Core Cooling (SG) Primary and Alternate Connections

In its FIP, the licensee described that the primary connection for SG makeup as using a seismically designed 3-inch diameter pipe connection through a tee into the 6-inch AFW pump discharge header to feed both SGs using the BDB AFW pump. The licensee indicated that the 3-inch pipe connection is located in the AFW Valve Cage (14'- 6" level of the Turbine Building) and is protected by flood gates to a level of 22 ft. The 14’-6” level of the Turbine Building is seismically protected and the wall of the AFW valve cage shares a wall with the safety-related Auxiliary Building. The BDB AFW pump will be deployed and staged near the Turbine Building Railway Access early into the ELAP event and allow for a hose connection from the discharge portion of the BDB AFW pump to the 3-inch pipe connection and deliver more than 300 gpm of AFW to the SGs at pressures of greater than 300 psig. The licensee described the alternate SG makeup connection as using two 2-inch flanged connections for the SG pump for injection into the two SGs. The operators would be required to remove two blind flanges and install two flanges with a 2.5inch hose connection (one connection for each of the two SGs). The flow rate is controlled by manual valves downstream of each connection. The connections are located in the east penetration room of the Auxiliary Building, which is protected from all applicable external hazards.

RCS Inventory Control Primary and Alternate Connections

In its FIP, the licensee described the primary RCS makeup as a 3-inch stainless steel pipe connection that tees into the existing 3-inch safety injection line located in the West Penetration Room in the Auxiliary Building. The 3-inch pipe RCS makeup connection is routed up to the 14' - 6" floor elevation in the West Penetration Room and through a new penetration into the Turbine Building in the AFW valve cage. Two new safety-related manual isolation valves and a nonsafety-related check valve are located in the West Penetration Room at Elevation 14' - 6". The licensee indicated that the hose connection located in the AFW valve cage is suitable for coupling to the high pressure discharge hose from the BDB RCS Injection pump. The RCS makeup piping in the Auxiliary Building is safety-related (through the second manual isolation valve), seismically designed and located in an area that provides high wind and associated missile protection. The hose connection described above is for the primary SG makeup connection and is protected from all applicable hazards. The BDB RCS Injection pump is located outside the Turbine Building truck bay and a 1.5-inch hose is run from the discharge of the pump to the new hose connection located in the AFW valve cage. The alternate RCS connection is described in the FIP as utilizing the Hydrostatic Test Connection in the Charging Header. The licensee indicated that the discharge valves for all the charging pumps are closed and the operators are required to remove the blind flange upstream of Charging Hydrostatic Test Connector isolation valve and replace it with a hose adapter. The 775 ft. of the 1.5-inch discharge hose is connected from the BDB RCS Injection Pump to the hose adapter. This connection would allow makeup flow to the RCS through the normal charging header.

Additionally, the licensee described the connection for the BDB RCS Injection pump using a hose connection from the BDB RCS Injection pump running outside the RWST valve pit and into the RWST pipe chase to provide RWST water for RCS makeup. The licensee indicated that the RCS makeup supply piping in the RWST pipe chase is safety-related (through the second manual isolation valve), seismically qualified, and is protected from high wind and missile hazards.

SFP Makeup Primary and Alternate Connections

In its FIP, the licensee described the primary SFP makeup connection as a pipe connection for the SFP that ties into an existing emergency SFP makeup line to the SFP. The primary SFP hose connection is located inside of the SFP Skimmer Cage located at elevation 14'-6" of the Auxiliary Building. The licensee described the SFP hose connection as being sufficiently sized to restore SFP level over an indefinite period of time with the loss of SFP cooling and a makeup rate of 250 gpm. The licensee described the alternate SFP makeup connection as using the portable spray monitors to provide flow to the SFP. The operators will have to connect a hose from the BDB High Capacity pump to the SFP operating deck and the hose can either be ran directly over the side of the pool or to portable spray monitors. The two spray monitors are connected through a Y-connection that splits the pump discharge and spray water into the SFP to maintain water level.

3.7.3.2 Electrical Connection Points

In its FIP, the licensee stated that the 120/240 Vac and 480 Vac FLEX DGs and the120 Vac connecting cables are stored in the BDB Storage Building and are, therefore, protected from the BDB external event hazards. For MPS, Unit 2, the primary Phase 2 electrical strategy involves deploying one 480 Vac FLEX DG to the courtyard area between MPS, Units 1 and 2. The 480 Vac FLEX DG has a set of color-coded cables that are stored in the MP Unit 1 Cable Vault, would be connected from the deployed generators to 480 Vac Bus 22F. In accordance with the color-coded cables, Appendix 8 of FSG-20, “Energizing Bus 22F from a BDB 480 Vac Generator,” Rev. 0, provides direction for ensuring proper phase rotation before attempting to power equipment from the 480 Vac FLEX DG. According to the licensee’s FIP and FSGs, the licensee would run cables from the deployed generator through an exterior penetration to the 25 foot level in the MPS, Unit 1 cable vault. The cables would then be connected to the plug-in connection/receptacles box located along the north wall of the MPS, Unit 1 Cable Vault. The licensee’s alternate Phase 2 electrical strategy would be to deploy one 120/240 Vac FLEX DG to the courtyard area between MPS, Units 1 and 2 adjacent to the deployed 480 Vac DG. The 120/240 Vac FLEX DG has two output circuits. Each of the two output circuits on the 120/240 Vac FLEX DG include an output breaker, weatherproof receptacles, flexible and weatherproof cable with weatherproof connectors at both ends. Cabling would be run from the 120/240 Vac FLEX DG through the exterior entrance of the “A” dc switchgear room, through the “A” and “B” dc switchgear rooms to a receptacle panel. The cables are connected to two single-phase, 120Vac, 100 A plug receptacles feeding an 80 A breaker in VA20 and a 70 A breaker in VA40.

In its FIP, the licensee also stated that in order to meet the required 4160 Vac load requirements during Phase 3, two 1 MW 4160 Vac combustion turbine generators and a distribution panel will be deployed to the area near the existing EDG buildings and connected to Emergency Bus 24D. The NSRC supplied cables would be connected to the output breakers of the 1MW 4160 Vac combustion turbine generators to the 4160 Vac distribution panel. Color-coded cables would run from the distribution panel through the exterior door of the “B” EDG room and would then be connected in the cabinet C39 in the “B” EDG Room. Guideline FSG 14, “4160 Vac Repowering Using RRC Generator,” Rev. 0, provides direction for ensuring proper phase rotation before attempting to power equipment from the 4160 Vac combustion turbine generators. The output cables from the EDG would be lifted from the terminal box and replaced with the cables from the 4160 Vac combustion turbine generator. Electrical connections are protected from all applicable hazards due to their location.

3.7.4 Accessibility and Lighting

In its FIP, the licensee 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, a lighting study was completed. Tasks evaluated included traveling to/from the various areas necessary to implement the FLEX strategies, making required mechanical and electrical connections, performing instrumentation monitoring, equipment operation, and component manipulation. The areas reviewed contain emergency lighting fixtures (Appendix "R" lighting) designed to provides a minimum of eight hours of lighting with no external ac power sources. Therefore, these currently installed emergency lighting fixtures provide adequate lighting to light pathways and implement the BDB strategies for Phase 1 mitigation strategy activities for 8 hours. Prior to the depletion of the Appendix "R" lighting units, portable battery powered remote area lighting system (RALS) would be deployed to support the FLEX strategy tasks. These RALSs are rechargeable LED lighting systems designed to power the LED lights for a minimum of 7 hours at 6000 lumens or a maximum of 40 hours at 500 lumens. The large portable BDB 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, portable light plants are included in the FLEX strategies. These portable diesel powered light plants can be deployed from the BDB storage building as needed to support nighttime operations. Additional portable light plants are available from the NSRC. In addition the BDB storage building also includes a stock of flashlights and headband lights to further assist the staff responding to an ELAP/LUHS event during low light conditions.

3.7.5 Access to Protected and Vital Areas

The licensee acknowledges the importance in maintaining the ability to open doors for implementation of the FLEX strategies. For that reason, the FIP states that certain doors will be opened and will remain open. Doors and gates relying on electric power are described to be of concern. The FIP explains that a contingency access plan implemented by security personnel would initiate after losing the electric power keeping these doors and gates closed. Based on the information provided in the FIP, 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, the licensee stated that the FLEX equipment is stored in the fueled condition. Fuel tanks are typically sized to hold 24 hours of fuel. Once deployed during a BDBEE, a fuel transfer truck (Ford F-350) refuels this equipment in the first 24 hours or sooner, as required. The general coping strategy for supplying fuel oil to the BDB portable pumps and generators is to draw fuel oil out of any available existing diesel fuel oil tanks on the MPS site. Fuel sources for the BDB portable pumps and generators during Phase 2 and Phase 3 are provided from two 12,000 gallon (TS minimum) seismic category I, missile protected day tanks located above the maximum postulated flood elevation and two 32,760 gallon below-ground seismic category I missile protected fuel oil storage tanks located above the maximum postulated flood elevation. Diesel fuel in the fuel oil storage tanks is routinely sampled and tested to assure fuel oil quality is maintained to American Society for Testing Materials (ASTM) standards. Portable equipment powered by diesel fuel is designed to use the same low sulfur diesel fuel oil as the installed EDGs. The fuel transfer truck has a capacity of 1,100 gallons and has a self-powered transfer pump. The fuel transfer truck is deployed from the BDB storage building to refill the diesel fuel tanks of BDB equipment and to the various diesel fuel tank storage locations where it is refueled by either gravity fill or pumped full. Based on a fuel consumption study, a conservative combined fuel consumption rate for the Phase 2 BDB equipment was determined to be 120 gal/hr. The fuel transfer truck has sufficient capacity to support continuous operation of the major BDB equipment. At this conservative fuel consumption rate, the fuel oil storage tanks have adequate capacity to provide the onsite BDB equipment with diesel fuel for greater than 30 days. The NSRC is also able to provide diesel fuel for diesel-operated equipment, thus providing additional margin. Provisions for receipt of additional diesel fuel from offsite sources are in place to supply the diesel powered Phase 3 strategy equipment.

3.7.7 Conclusions

After its analysis, 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 adequately addresses the requirements of the order.

3.8 Considerations in Using Offsite Resources

3.8.1 MPS SAFER Plan

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

There are two National SAFER Response Centers (NSRCs), located near Memphis, TN and Phoenix, AZ established to support nuclear power plants in the event of a BDBEE.

By letter dated September 26, 2014 [Reference 23], the NRC staff issued its assessment of the NSRCs established in response to Order EA-12-049. In its assessment, the staff concluded that SAFER has procured equipment, implemented appropriate processes to maintain the equipment, and developed plans to deliver the equipment needed to support site responses to BDBEEs, consistent with NEI 12-06 guidance; therefore, the staff concluded in its assessment that licensees can reference the SAFER program and implement their SAFER Response Plans to meet the Phase 3 requirements of Order EA-12-049.

In its FIP, the licensee stated that it has established contracts with the PEICo to participate in the process for support of the NSRCs, as required. Each NSRC holds five sets of equipment: four of which are able to be fully deployed when requested, and the fifth set has equipment in a maintenance cycle. In addition, onsite BDB equipment hose and cable end fittings are standardized with the equipment supplied from the NSRC.

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 and an Alternate, which are offsite areas (within about 25 miles of the plant) utilized for receipt of ground transported or airlifted equipment from the SAFER centers. From Staging Area C, an onsite Staging Area B is established for interim staging of equipment prior to it being transported to the final location for implementation in Phase 3 at Staging Area A. The staff confirmed the location of these staging areas in the MPS SAFER Response Plan.

In its FIP, the licensee stated that in the event of a BDBEE and subsequent ELAP/LUHS condition, equipment is moved from an NSRC to a local assembly area established by the SAFER team. From there, equipment can be taken to the MPS site and staged at the SAFER onsite Staging Area "B" near the BDB Storage Building by helicopter if ground transportation is unavailable. Communications are established between MPS and the SAFER team via satellite phones and required equipment moved to the site, as needed. First arriving equipment is delivered to the site within 24 hours from the initial request. The order in which equipment is delivered is identified in the MPS's SAFER Response Plan.

3.8.3 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should allow utilization of offsite resources following a BDBEE consistent with NEI 12-06 guidance, as endorsed, by JLD-ISG-2012-01, and adequately addresses 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 MPS, Unit 2, ventilation that provides cooling to occupied areas and areas containing required equipment will be lost. The key areas identified for all phases of execution of the FLEX strategy activities are the MCR, the Control Room A/C Equipment Room, the East 480 Vac Load Center Room, the Turbine Driven Auxiliary

Feedwater (TDAFW) Pump Room, Enclosure Building (East and West Penetration Rooms - location of the ADVs), Auxiliary Building (Motor Control Center -MCC B61 Enclosure, Charging Pump Cubicles, East and West dc Switchgear Rooms), and Turbine Building (Upper 4160 Vac Switchgear Room, Truck Bay area).

The NRC staff reviewed evaluation ETE-CPR-2012-0009, Rev. 3 to verify that equipment remains operable as part of the MPS, Unit 2 mitigation strategy for an ELAP and will not be adversely affected by increases in temperature as a result of loss of HVAC. Procedure EOP-35-FSG-05, provides guidance to allow for personnel habitability after a loss of ventilation and cooling due to ELAP. Personnel habitability is discussed in section 3.9.2.

Main Control Room

For the MCR, the licensee noted that equipment operability for instrumentation cabinets will be ensured by maintaining the cabinet temperature below 120 °F, the design limit, by opening cabinet doors within 30 minutes after the onset of an ELAP event. The licensee's evaluation showed that these actions will maintain internal cabinet temperatures below 110 °F for the duration of the ELAP/LUHS scenario, which is below the conservative limit for Control Room habitability of 110 °F as documented in NUMARC 87-00. The licensee also noted that the MCR doors can be opened to provide additional cooling if required.

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

Control Room A/C Equipment Room

With regard to the Control Room A/C Equipment Room, the licensee's calculation MISC-11806, "MPS-2 Heat-up Analysis of the Control Room A/C Mechanical Equipment Room (EQ-A52) and the Cable Vault Area (EQ A40) Following an ELAP BDB Scenario," shows that the post ELAP temperature will rise above the design limit of equipment in the room if no compensatory actions are taken. Therefore, the licensee would open a door and place the ventilation system in the 480 Vac Switchgear Room into service soon after restoring 480 Vac power. The licensee would also have to deploy a portable fan in the doorway. The licensee would also monitor room temperatures as directed by FSGs (at least once per shift) to insure equipment survivability. With these compensatory actions, the temperature in the Control Room A/C Equipment Room would remain below 120 °F.

Based on temperatures remaining below 120 °F (the temperature limit, as identified in NUMARC-87-00 for electronic equipment to be able to survive indefinitely), the equipment in the Control Room A/C Equipment Room should not be adversely impacted by the loss of ventilation as a result of an ELAP event given that the licensee takes the compensatory actions described above.

East 480 Vac Load Center Room

For the East 480 Vac Load Center Room, the licensee's calculation shows that post ELAP temperature will remain below 120 °F by opening a door within 2 hours of losing mechanical cooling. Within 8 hours upon restoration of 480 Vac power, the licensee would restore power to Fans F-52 and F-142 to reduce and maintain temperature in this room below 104 °F (the design limit of equipment in this room). Alternatively, the licensee could deploy a 2000 cubic feet per minute (cfm) portable fan and flexible ducting to reduce temperatures (assuming outside temperature was at or below 86 °F.

Based on temperatures remaining below 120 °F (the temperature limit, as identified in NUMARC-87-00, for electronic equipment to be able to survive indefinitely), the equipment in the East 480 Vac Load Center Room should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

TDAFW Pump Room

For the Unit 2 TDAFW pump rooms, the licensee noted that the steady-state normal operating temperature for this room, with no credit for the ventilation fan, has been calculated to 130 °F during the summer time. This projected temperature is less the TDAFW pump room design temperature of 135 °F. Since this room is not expected to experience a greater heat load during an ELAP/LUHS scenario, the licensee noted that no compensatory cooling measures are required for this room. However, the licensee stated during the audit that compensatory measures, such as opening doors and/or use portable fan units, will be applied to bring the area temperature down to the 110 °F, primarily for supporting human habitability (discussed in Section 3.9.2). The licensee also discussed during the audit that operators would rotate out of the TDAFW and will utilize ice vests to combat the high temperatures in the room.

Enclosure Building (East and West Penetration Rooms - location of the ADVs)

The licensee's calculation NAI-1732-001, Rev.0, "MPs Enclosure Building Habitability Analysis," showed that for the worst-case scenario (i.e., no compensatory measures to open doors, etc.), the maximum temperature in the vicinity of the ADVs would be 125 °F within 3 to 5 minutes following the onset of an ELAP. Subsequently, the licensee's calculation showed that temperature would drop to below 120°F within an hour and decrease to around 110 °F at 24 hours.

Based on temperatures remaining with equipment limits and quickly dropping below 120 °F (the temperature limit, as identified in NUMARC-87-00 for electronic equipment to be able to survive indefinitely), the NRC staff finds that the equipment in the Enclosure Building (East and West Penetration Rooms - location of the ADVs) will not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Auxiliary Building (Motor Control Center - MCC B61 Enclosure, Charging Pump Cubicles, East and West DC Switchgear Rooms)

For the MCC B61 Enclosure, the licensee's calculation shows that the post ELAP area temperature will remain below the equipment design limit of 122 °F. As a matter of precaution, the licensee plans to open the enclosure door to MCC B61 within 4 hours of the onset of an ELAP. Soon after restoring 480 Vac power, the licensee plans to repower the A/C for air conditioning and close the enclosure door to cool the enclosure. Alternatively, the licensee could utilize a 500 cfm fan and flexible ducting to cool the enclosure. The alternative would require opening a number of doors in addition to deploying the fan and flexible ducting.

For the Charging Pump Cubicles, the licensee's calculation shows that post ELAP temperature will remain below 120 °F without taking any compensatory actions.

For the East/West switchgear rooms, the licensee's calculation shows that post ELAP temperature will remain below 120 °F by opening several doors within 30 minutes of losing mechanical cooling. Soon after 480 Vac power is restored, the licensee would repower Fan 54B to restore temperature in this room to below 104 °F (the design limit of equipment in this room).

Based on temperatures remaining below design limits and/or 120 °F (the temperature limit, as identified in NUMARC-87-00 for electronic equipment to be able to survive indefinitely), the equipment in the Auxiliary Building (Motor Control Center - MCC B61 Enclosure, Charging Pump Cubicles, East and West DC Switchgear Rooms) should not be adversely impacted by the loss of ventilation as a result of an ELAP event given that preventive actions are taken as described above.

Battery Rooms

The Millstone Unit 2 safety-related batteries were manufactured by C&D Technologies. One battery room is located adjacent to the East dc Switchgear room and the other is adjacent to the West dc Switchgear room.

The qualification testing performed by C&D Technologies demonstrated the ability to perform under elevated operating temperature environments. The testing results indicate that the battery cells will perform as required in excess of 200 days under an estimated 122°F.

As part of its review, the NRC staff reviewed calculation 2013-ENG-04409E2, "Millstone Station Unit 2 Beyond Design Basis – FLEX Electrical Equipment Heat Release Analysis," Rev. 1. This calculation shows that at the onset of an ELAP event, the East and West dc Switchgear room temperatures will rise. Starting with a maximum room temperature of 104 °F, the predicted temperature rise will remain below 120 °F with the predicted heat gains due to the battery discharge, before the licensee exercises compensatory measures as directed by Appendix 14 of EOP 2541. The compensatory measures include opening doors and operators periodically monitoring Switchgear room temperatures. These compensatory measures would restore temperatures to 104 °F or below.

After an ELAP event has been declared, Appendix 36 of EOP 25 FSG-20 would direct staff to open battery room doors within 75 minutes. Appendix 14 of EOP 25 FSG 20 would directed staff to monitor temperature in these areas every 4 hours and to provide compensatory cooling (e.g., supplemental fans) as required to maintain temperature until normal ventilation is restored.

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

Based on its review of the licensee's Battery Room assessment, the NRC staff finds that the Millstone Unit 2 safety-related batteries should perform their required functions at the expected temperatures as a result of loss of ventilation during an ELAP event.

Turbine Building (Upper 4160 Vac Switchgear Room, Truck Bay area)

The design limit for equipment in the Upper 4160 Vac Switchgear Room is 122 °F. The licensee's calculation showed that the maximum temperature in the Upper 4160 Vac Switchgear Room would be 117.9 °F following an ELAP without crediting any compensatory actions.

Based on temperatures remaining below the design limit and below 120 °F (the temperature limit, as identified in NUMARC-87-00 for electronic equipment to be able to survive indefinitely), the NRC staff finds that the equipment in the Upper 4160 Vac Switchgear Room will not be adversely impacted by the loss of ventilation as a result of an ELAP event.

3.9.1.2 Loss of Heating

The licensee indicated in the FIP that it will utilize heat tracing for FLEX components that require cold weather packages and small electrical generators. These components protect the FLEX equipment from damage due to extreme cold weather and help assure equipment reliability as well as to power heat tape circuits. Heat tape and portable heating equipment are stored in the BDB Storage Building for additional low temperature mitigation. Based on the licensee's analysis, in the event of an ELAP, battery room temperatures are expected to rise due to discharge and nearby passive heat sinks with loss of ventilation. Therefore, reaching the minimum battery temperature limit of 60 °F is not expected.

Based on its review of the licensee's battery room assessment, the NRC staff finds that Millstone Unit 2 safety-related batteries should perform their required functions at the expected temperatures as a result of loss of heating during an ELAP event.

3.9.1.3 Hydrogen Gas Control in Vital Battery Rooms

An additional ventilation concern that is applicable to Phases 2 and 3, is the potential buildup of hydrogen in the battery rooms as a result of loss of ventilation during an ELAP event. Off-gassing of hydrogen from batteries is only a concern when the batteries are charging. In order to prevent a buildup of hydrogen in the battery rooms, the licensee's procedures direct plant operators to energize the battery room exhaust fans. These fans would be powered from the 480 Vac bus connected to the BDB 480 Vac FLEX DG. The battery room exhaust fans will exhaust battery room air through the normal exhaust flow path to prevent hydrogen accumulation.

In its FIP, the licensee stated that the major components for FLEX strategies are provided with cold weather packages and small electrical generators to protect the equipment from damage due to extreme cold weather and help assure equipment reliability as well as to power heat tape circuits, if necessary. Heat tape and portable heating equipment (BDB support equipment) are stored in the BDB Storage Building for additional low temperature mitigation, as needed.

Based on its review, the NRC staff concludes that the licensee has demonstrated that hydrogen accumulation in the 125 V dc vital battery rooms should not reach the combustibility limit for hydrogen (4 percent) during an ELAP as a result of a BDBEE since the licensee plans to repower the battery room exhaust fans when the battery chargers are repowered during Phase 2.

3.9.2 Personnel Habitability

3.9.2.1 Main Control Room

The NRC staff reviewed calculation 07-ENG-04264M2, Revision 0, "MP2 Control Room Loss of Ventilation GOTHIC Temperature Analysis," which modeled the CR temperature transient through 72 hours following a BDBEE resulting in an ELAP. The calculation uses the GOTHIC version 7.2a computer program (Generation of Thermal-Hydraulic Information for Containments). The acceptance criterion for the calculated temperatures is based on the guidance in NUMARC 87-00, Revision 1, which states that a CR temperature of 110°F is an acceptable limit for CR personnel habitability.

Calculation 07-ENG-04264M2, Revision 0 assumes restoration of the 480 Vac at 14 hours, which results in a significance increase in the CR temperature. Repowering of CR HVAC soon after restoration of 480 Vac will ensure that the area temperatures remain well below the habitability temperature limit of 110 °F for the duration of the ELAP event. Operators are directed per EOP 25 FSG-05 to restore CR HVAC within 15 minutes following the restoration of 480 Vac in order to cool the room before the temperature exceeds the 110 °F setpoint.

Also, in accordance with the existing SBO procedures, instrumentation cabinet doors must be opened within 30 minutes after the onset of an ELAP event. This would allow for adequate air mixing and would maintain internal cabinet temperatures in equilibrium with the Control Room temperature which has been calculated to not exceed 110 °F during the initial 14 hours of the ELAP/LUHS scenario. The licensee also noted that the CR doors can be opened to provide additional cooling if needed.

3.9.2.2 Spent Fuel Pool Area

In its FIP, the licensee described the ventilation-related actions to prevent excessive steam accumulation utilizes available doors (both rollup and personnel doors) in the Auxiliary Building. The Auxiliary Building rollup door is on the 14' - 6" level of the Auxiliary Building. Two additional doors at the 71' elevation would also be opened. The opening of these doors after ELAP is declared provide both a vent path for steam and allows for a flow path of cool air to enter the area from the lower level rollup door and exit through higher elevations of the SFP area of the Auxiliary Building, thus creating a chimney effect to vent steam from the SFPI area resulting from boiling in the SFP. If needed, portable fans can also be positioned at the Auxiliary Building rollup door to enhance the ventilation. Procedure EOP 25 FSG-05 provides instructions for operators to implement this method of ventilation for the SFP and cooling for personnel habitability. The above actions would take place prior to the 6 hour mark for boiling in the SFP to begin and improve habitability for operators to later connect hoses and spray monitor for SFP makeup 22 hours into the ELAP event.

3.9.2.3 Other Plant Areas

Turbine Building

In the event of a potential hurricane storm surge, one BDB AFW pump will be pre-deployed into the Turbine Building truck bay area prior to closure of the Turbine Building flood gates. In this case, provisions to vent the diesel exhaust and increase ventilation is required. To support the operation of the AFW pump in the Turbine Building truck bay, the large rollup (Railroad Access) door located on the 14.5’ elevation of the Turbine Building will be opened and extended at least four feet above the top elevation of the flood gate. Additionally, a door located on the 72’ elevation of the Turbine Building will be opened allowing air to circulate through the Turbine Building at the location of the pre-deployed BDB AFW pump via EOP 25 FSG-03, “Alternate Low Pressure Feedwater.” The BDB AFW pump exhaust shall be directed outside (over the closed flood gate and through the door opening) using high temperature flexible duct prior to operating the pump in the Turbine Building truck bay. The exhaust hose must be extended sufficiently away from the door opening to prevent blowback into the Turbine Building.

3.9.3 Conclusions

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

3.10 Water Sources

Identification of credited water sources for the FLEX response strategies is included in the previous sections for each individual strategy.

In its FIP, the licensee listed the available water sources as follows:

- CST – 142,700 gallons (protected against all applicable hazards)
- Long Island Sound (UHS) – unlimited supply (protected against all applicable hazards)
- Primary Water Storage Tank - 100,000 gallons (protected against flooding and low/high temperatures)
- Condenser Hotwell – 71,000 gallons (protected against tornado/hurricane and low/high temperatures)
- Site Fire Water System – 490,000 gallons (protected against flooding and low/high temperatures)
- City Domestic Water Supply – unlimited supply (protected against flooding, tornado/hurricane, and low/high temperatures)
- Onsite Freshwater Pond – 3,000,000 gallons (protected against seismic, tornado/hurricane and low/high temperatures)
- Refueling Water Storage Tank (RWST) – 370,000 gallons (protected against seismic, flooding, and low/high temperatures)

3.10.1 Steam Generator Make-Up

In its FIP, the licensee stated the following:

> The primary water source for the AFW supply is the CST, which is a seismic, wind/tornado and missile protected designed tank. The normal volume in the CST is at least 225,000 gallons, with a TS minimum required volume of 165,000 gallons. Note: due to the height of the piping connection, the minimum usable volume is 142,746 gallons.
>
> The CST may be refilled from a variety of sources, including the onsite fire system, city water system, the onsite freshwater pond, and various other onsite water sources.

The next preferred source for filling the CST is the primary water storage tank (PWST). The PWST has a 150,000 gallons net capacity with a normal level of 100,000 gallons. This is a non-safety-related water supply… [not protected for seismic or tornado missiles].

A limited source of feed water can be obtained from the condenser hotwells (71,000 gallons). Each of the four hotwells has a 2-inch drain line that can be connected to a portable pump suction. …The hotwell is located in a seismic structure, and is robustly protected from winds and missiles.

There are two fire water storage tanks that can be used to makeup to the CST or provide suction to the BDB high capacity pump using a site fire protection system hydrant. Each tank has a useable volume of 245,000 gallons. This is a non-seismic non-safety-related water supply. The fire water storage tanks are filled through a domestic water line fed from the city water system.

If the fire water storage tanks are not available but the offsite city water supply is intact, the CST can be replenished from the BDB High Capacity pump discharge manifold when the Pump suction is connected to a fire hydrant that is connected to the city water supply.

The onsite freshwater pond is an untreated water source and requires the use of a suction strainer. For every foot of depth there are approximately 1.06 million gallons in the pond. Even at the driest times the pond should maintain a 3 feet minimum depth. Therefore, it is assumed that approximately 3 million gallons of storage capacity would be available. Assuming that this water is evenly divided between MPS Units 2 and 3, 1,500,000 gallons of water would be available for use as an AFW water supply.

In event of an extreme storm surge there is a possibility that this water supply may become brackish due to the close proximity and limited elevation change to Long Island Sound. In this event, the onsite pond would be used only after other available clean onsite sources had been expended.

3.10.2 Reactor Coolant System Make-Up

MPS Unit 2 is equipped with one RWST located at grade level. The tanks are stainless steel, safety-related, seismic Category I storage tanks, but are not protected from missiles. During "at power" operations, MPS Unit 2's RWST volume is maintained greater than 370,000 gallons at a boron concentration of approximately 2,700 ppm. The RWST is the preferred borated water source for the RCS injection strategies.

Water with a higher boron concentration than the RWST may be available for RCS makeup from the BASTs. The BASTs are 6,600 (each) gallons, insulated, temperature-controlled, storage tanks that store water of approximately 2.5 to 3.5 weight percent (4,300 to 6,100 ppm) boric acid concentration. With boric acid concentrations in the BASTs less than or equal to 3.5 weight percent, tank heaters are not required to prevent boron precipitation at auxiliary building ambient temperatures. The BASTs are safety-related, seismically designed and located in the missile protected auxiliary building.

In the event that both RWSTs and the BASTs are unavailable or become depleted, portable Boric Acid Mixing Tanks are available to provide a suction source for the BDB RCS injection pumps. These mixing tanks are deployed, as needed, from the onsite BDB storage building to a position near the MPS Unit 2 BDB RCS injection pump. Dilution water is added to the mixing tank by either a portable transfer pump, or from a branch line from the BDB high capacity pump header (water thief) taking suction from a clean water source. Bags of powdered boric acid are mixed with dilution water to achieve the proper concentration for maintaining adequate shutdown margin while making up RCS inventory. The clean water mixing tank dilution sources are used in the same priority as the potential AFW sources. The Long Island Sound (or the onsite freshwater pond if it becomes contaminated with water from the Long Island Sound) would only be used for RCS make-up as a last resort.

Each portable borated water tank is equipped with an agitator to facilitate mixing of the boric acid, although complete dissolution of the powdered boric acid is not required since agitation continues throughout the injection process. The maximum boron concentration that is mixed in one of these mixing tanks is less than the concentration at which precipitation concerns occur, even at temperatures down to 32 °F; however, a heater is also available to prevent tank freezing, if necessary.

3.10.3 Spent Fuel Pool Make-Up

In its FIP, the licensee indicated that makeup water to the SFP is through the BDB high capacity pump taking suction from Long Island Sound or from several other water sources that can be connected to the suction of the BDB high capacity pump. The license stated that the BDB High Capacity pump is deployed by towing the trailer to a designated draft location near the selected water source. The initial source designated in the FIP is the from a site fire system hydrant supplied by the two fire water storage tanks, which have a useable volume of 245,000 gallons each. However, these tanks are non-seismic, nonsafety-related components and the treated water supply is supplied from a domestic water line fed from the city water system. The BDB High Capacity pump is also capable of taking direct suction from the fire hydrant connected to the city water supply if the fire water tanks are unavailable. The next available water source is the Onsite Freshwater Pond, which is an untreated water source and requires the use of a suction strainer. Access to the Onsite Freshwater pond is located from the west (plant side) side of the security barriers adjacent to the school house and contains about 1.06 million gallons per foot into the pond. The licensee estimated that the Onsite Freshwater Pond should have about 3 feet of minimum depth during the driest times on site. The last water source that is available for SFP makeup is the Long Island Sound, which is a saltwater source. The Long

Island Sound is protected from all applicable hazards and will only be used if the onsite water sources are unavailable for SFP makeup.

3.10.4 Containment Cooling

In its FIP, the licensee stated that NRSC portable generators are used to restore power to containment ventilation system fans and repowering SW pumps or using a low pressure/high flow pump from the NRSC to provide cooling to the heat exchangers in order to remove heat from the containment atmosphere. Filling the containment sump from the RWST and establishing containment spray from the containment spray pump, while not preferred, can establish containment spray functionality.

3.10.5 Conclusions

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 adequately addresses the requirements of the order.

3.11 Shutdown and Refueling Analyses

Order EA-12-049 requires that licensees must be capable of implementing the mitigation strategies in all modes. In general, the discussion above focuses on 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 30 hours are available to implement makeup before boil-off results in the water level in the SFP dropping far enough to uncover fuel assemblies, and the licensee has stated that they have the ability to implement makeup to the SFP within that time.

When a plant is in a shutdown mode in which steam is not available to operate the steam-powered pump and allow operators to release steam from the SGs (which typically occurs when the RCS has been cooled below about 300 °F), another strategy must be used for decay heat removal. On September 18, 2013, NEI submitted to the NRC a position paper entitled “Shutdown/Refueling Modes” [Reference 40], which described methods to ensure plant safety in those shutdown modes. By letter dated September 30, 2013 [Reference 41], the NRC staff endorsed this position paper as a means of meeting the requirements of the order.

The position paper provides guidance to licensees for reducing shutdown risk by incorporating FLEX equipment in the shutdown risk process and procedures. Considerations in the shutdown risk assessment process include maintaining necessary FLEX equipment readily available and potentially pre-deploying or pre-staging equipment to support maintaining or restoring key safety functions in the event of a loss of shutdown cooling. The NRC staff concludes that the position paper provides an acceptable approach for demonstrating that the licensees are capable of implementing mitigating strategies in shutdown and refueling modes of operation. In its FIP, the licensee stated that MPS, Unit 2 is abiding by the NEI position paper.

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

3.12 Procedures and Training

In its FIP, the licensee stated that the FSGs provide guidance that can be employed for a variety of conditions. Criteria for entry into FSGs ensures that FLEX strategies are used only as directed for BDBEE conditions, and are not used inappropriately in lieu of existing procedures. When BDB equipment is needed to supplement EOPs or abnormal operating procedures (AOPs), the EOP or AOP directs the entry into and exit from the appropriate FSG procedure. The FIP states that FLEX support guidelines have been developed in accordance with PWROG guidelines. The FSGs provide instructions for implementing available, preplanned FLEX strategies to accomplish specific tasks in the EOPs or AOPs. FSGs should be used to supplement (not replace) the existing procedure structure that establishes command and control for the event. Procedural Interfaces have been incorporated into EOP 2530, Station Blackout, to the extent necessary to include appropriate reference to FSGs and provide command and control for the ELAP. Also, procedural interfaces have been incorporated into the following procedures to include appropriate reference to FSGs: Procedure AOP 2560, Storms, High Winds and High Tides; AOP 2578, Loss of Refuel Pool and Spent Fuel Level; and AOP 2583, Loss of All AC Power During Shutdown Conditions.

In its FIP the licensee stated that Dominion's nuclear training program has been revised to assure personnel proficiency in utilizing FSGs and associated BDB equipment for the mitigation of BDB external events. The licensee stated that it has developed and implemented programs and controls in accordance with the systematic approach to training (SAT) process. Full scope simulator models have not been upgraded to accommodate FLEX training or drills. Where appropriate, integrated FLEX drills are organized on a team or crew basis and conducted periodically; with all time-sensitive actions are evaluated over a period of not more than eight years. It is not required to connect/operate permanently installed equipment during these drills.

During the audit, the staff was able to see procedures and training documents. Based on this review, the NRC staff concludes that the licensee has developed procedures and training guidance associated with FLEX that, if implemented appropriately, should be in accordance with NEI 12-06, Section 11.6.

3.13 Maintenance and Testing of FLEX Equipment

As a generic issue, NEI submitted a letter to the NRC dated October 3, 2013 [Reference 42], which included Electric Power Research Institute (EPRI) Technical Report 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment." By letter dated October 7, 2013 [Reference 43], the NRC endorsed the use of the EPRI report and the EPRI database as providing a useful input for licensees to use in developing their maintenance and testing programs.

In its FIP, the licensee stated that factory acceptance testing and site acceptance testing, was conducted to ensure the portable FLEX equipment can perform its required FLEX strategy design functions. Factory acceptance testing was done to verify that the portable equipment performance conformed to the manufacturers rating for the equipment as specified in the purchase order. Also, vendor test documentation was verified as part of the receipt inspection process for each of the affected pieces of equipment and included in the applicable vendor technical manuals. Site acceptance testing confirmed factory acceptance testing to ensure portable FLEX equipment delivered to the site performed in accordance with the FLEX strategy functional design requirements. Portable BDB equipment that directly performs a FLEX mitigation strategy for the core cooling, containment, or SFP cooling is subject to periodic maintenance and testing in accordance with NEI 12-06 and Institute of Nuclear Power Operations (INPO) AP 913, “Equipment Reliability Process”, to verify proper function. The licensee also stated that preventive maintenance will be provided for other FLEX support equipment.

The FIP states that the licensee uses EPRI’s Preventive Maintenance (PM) Basis for FLEX Equipment guidance and maintenance templates for the major FLEX equipment including the portable diesel pumps and generators. Corresponding maintenance strategies were developed and documented. The performance of the PMs and test procedures are controlled through the site work order process. It is stated that performance verification of FLEX equipment is scheduled and performed as part of the PM process. The licensee stated that a fleet procedure was established to reduce the risk for unavailability of equipment and applicable connections that directly perform a FLEX mitigation strategy for core cooling, containment, and SFP cooling. Maintenance/risk guidance were described to conform to the guidance of NEI 12-06.

After reviewing the licensee’s programs, the NRC staff finds that the licensee has developed guidance for equipment maintenance and testing activities associated with FLEX equipment that, if implemented as described, should be in accordance with NEI 12-06, Section 11.5.

3.14 Alternatives to NEI 12-06, Revision 0

3.14.1 Reduced Set of Hoses and Cables As Backup Equipment

In its FIP, the licensee took an alternative approach to the NEI 12-06 guidance for hoses and cables. NEI 12-06, Section 3.2.2 states that in order to assure reliability and availability of the FLEX equipment required to meet these capabilities, the site should have sufficient equipment to address all functions at all units on-site, plus one additional spare, i.e., an N+1 capability, where "N" is the number of units on-site. Thus, a single-unit site would nominally have at least two portable pumps, two sets of portable ac/dc power supplies, two sets of hoses and cables, etc. The NEI on behalf of the industry submitted a letter to the NRC [Reference 50] proposing an alternative regarding the quantity of spare hoses and cables to be stored on site. The alternative proposed was that that either a) 10 percent additional lengths of each type and size of hoses and cabling necessary for the N capability plus at least one spare of the longest single section/length of hose and cable be provided or b) that spare cabling and hose of sufficient length and sizing to replace the single longest run needed to support any FLEX strategy. The licensee has committed to following the NEI alternative approach. By letter dated May 18, 2015 [Reference 51], the NRC agreed that the alternative approach is reasonable, but the licensees may need to provide additional justification regarding the acceptability of various cable and hose lengths with respect to voltage drops, and fluid flow resistance. The NRC staff approves this alternative as being an acceptable method of compliance with the order. Based on the use of the alternative in accordance with the NRC's endorsement letter, the NRC staff approves this alternative for DNC, if implemented as described, as an acceptable method of compliance with the order.

3.14.2 Use of Installed Charging Pump

In its FIP, the licensee stated that its backup strategy of repowering an installed charging pump to provide RCS makeup under ELAP conditions is an alternative to the guidance in NEI 12-06, Revision 0. In particular, NEI 12-06 calls for N+1 pieces of onsite portable FLEX equipment (i.e., one spare piece of equipment beyond the minimum required to satisfy a given function for all units at a site) to satisfy the requirements of Order EA-12-049 in Phase 2. As described above, the primary means of Phase 2 RCS makeup for MPS 2 involves a single onsite portable pump (i.e., the BDB RCS injection pump), with the strategy of repowering an installed charging pump essentially serving the backup function that would have been provided by the spare piece of equipment specified in the NEI 12-06 guidance.

As noted in the MPS, Unit 2 FIP, the licensee has the capability to select one of two 100 percent-capacity, redundant charging pumps (i.e., pump "B" or "C") to repower for providing RCS makeup under ELAP conditions. As described in the MPS, Unit 2 FSAR, the flow capacity for an installed charging pump is 44 gpm, which is comparable to the 45-gpm-capacity BDB RCS injection pump. In addition, diverse injection flowpaths from either charging pump are provided through either the normal charging system piping or through high-pressure safety injection system piping.

As noted in the evaluation, the available suction sources for the BDB RCS injection pump and the repowered charging pump are not identical. In particular, the licensee's FIP describes the charging pump as having the capability to draw suction on the RWST or boric acid storage tanks, but not the portable boric acid batching tank. For a scenario in which the RWST is unavailable due to a wind-borne missile strike, the remaining inventory of borated coolant available for injection via the charging pumps (i.e., the boric acid storage tanks) is significantly reduced relative to the primary strategy. However, the MPS2 BASTs can be filled from the

MPS3 RWST in accordance with EOP 25 FSG-20, Appendix 26. Additionally, the installed Batch Tank can be used to makeup to the BASTs. Based upon (1) the licensee's existing installation of low-leakage RCP seals, (2) the significant shutdown margin available for MPS 2 and the reactivity worth of the highly concentrated solution in the boric acid tanks, and (3) the licensee's decision to request delivery of a mobile boration unit from the NSRCs, the NRC staff concluded that the licensee's Phase 2 strategy, if implemented as described, could satisfy the intent of Order EA-12-049 with respect to supporting adequate RCS makeup capability for an indefinite period. Therefore, the NRC staff finds the licensee's use of an installed charging pump to be an acceptable alternative to NEI 12-06, and the staff concludes that the licensee's strategy should provide adequate RCS makeup for the analyzed ELAP event.

3.15 Conclusions for Order EA-12-049

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

4.0 TECHNICAL EVALUATION OF ORDER EA-12-051

By letter dated February 28, 2013 [Reference 24], the licensee submitted its OIP for MPS, Units 2 and 3 in response to Order EA-12-051. By letter dated June 26, 2013 [Reference 25], the NRC staff sent a Request for Additional Information (RAI) to the licensee. The licensee provided a response by letter dated July 26, 2013 [Reference 26]. By letter dated October 29, 2013 [Reference 27], the NRC staff issued an Interim Staff Evaluation and RAI to the licensee. The licensee provided a response by letter dated February 28, 2014 [Reference 31]. By letter dated November 17, 2014 [Reference 17], the NRC issued an audit report on the licensee's progress.

By letters dated October 25, 2012 [Reference 29], August 23, 2013 [Reference 30], February 28, 2014 [Reference 31], August 26, 2014 [Reference 32], March 2, 2015 [Reference 33], and August 24, 2015 [Reference 34], the licensee submitted status reports for the Integrated Plan. The Integrated Plan describes the strategies and guidance to be implemented by the licensee for the installation of reliable SFP level instrumentation, which will function following a BDBEE, including modifications necessary to support this implementation, pursuant to Order EA-12-051. By letter dated December 3, 2015 [Reference 37], the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved.

The licensee has installed a SFP level instrumentation system designed by Westinghouse. The NRC staff reviewed the vendor's SFP level instrumentation system design specifications, calculations and analyses, test plans, and test reports. The staff issued an audit report on this technology on August 18, 2014 [Reference 36].

The staff performed an onsite audit to review the implementation of SFP level instrumentation related to Order EA-12-051. The scope of the audit included verification of (a) site's seismic and environmental conditions enveloped by the equipment qualifications, (b) equipment installation met the requirements and vendor's recommendations, and (c) program features met the requirements. By letter dated November 17, 2014 [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 [Reference 24], the licensee described the levels for Unit 2; Level 1 is elevation 36 feet 0 inches. Level 2 is elevation 22 feet 5 inches. Level 3 is elevation 12 feet 5 inches. The licensee stated in its letter dated August 23, 2013 [Reference 30] that a calculation confirmed minimum net positive suction head for the SFP cooling pump is 16.75 feet. The licensee provided a table in its July 26, 2013, RAI response [Reference 26] illustrating the levels and the instrument span. The NRC staff previously confirmed these elements were consistent with the guidance criteria in the ISE.

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 adequately address the requirements of the order.

4.2 Evaluation of Design Features

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

4.2.1 Design Features: Instruments

In its OIP, the licensee stated that the primary and backup instrument channels, for both units, would use fixed instruments providing a continuous level measurement over the entire range. The licensee stated that for Unit 2, the measurement range will be from approximately elevation 37ft. 0 in. to elevation 12ft. 5 in. (for a total indicated range of approximately 24ft. 7 in.).

In its letter dated July 26, 2013 [Reference 26], the licensee provided two tables (one for each unit) depicting the SFP elevations identified as Levels 1, 2, and 3 and the SFP level instrument span. These figures showed that the instrument range for MPS, Unit 2 would be approximately 24.5 ft.

Based on the discussion above, the NRC staff finds that, if implemented as described, the number of channels and measurement range for its SFP should be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should address the requirements of the order.

4.2.2 Design Features: Arrangement

The primary and backup instruments are located at the east and west ends of the Unit 2 SFP. Cabling exits the SFP area from the respective east and west ends, maintaining maximum separation. The primary transmitter is located in the north end of the cable vault and the indicator is toward the south end of the cable vault near the stairwell to the control room. The indicator is accessible from the control room. The backup transmitter is in the control room HVAC area and the indicator is in the east switchgear room. The indicator is accessible from the control room.

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

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

4.2.3 Design Features: Mounting

In its December 3, 2015, letter [Reference 37], the licensee stated:

> The level sensing probe is attached to the mounting bracket, which is anchored to the SFP structure at the concrete curb using concrete expansion anchors. The anchorage to the Seismic Category I SFP structure concrete curb is designed to meet the requirements of the MPS Power Station (MPS) design and licensing basis for Seismic Category I components including seismic loads, static weight loads and hydrodynamic loads.
>
> Each of the additional SFP Level Instrumentation System components required to be mounted/anchored are attached to plant structures consistent with the MPS design and licensing basis for Seismic Category I components, and include consideration of design basis maximum seismic loads and static weight loads.

The NRC staff reviewed the seismic analysis in Westinghouse calculation CN-PEUS-14-3, which covers generic design for Surry Power Station, Unit Nos. 1 and 2 (Surry), North Anna Power Station, Units 1 and 2 (North Anna) and MPS, Unit 3, as it informed the staff of the design methodology used for MPS Unit 2. The staff also reviewed Westinghouse calculation CN-PEUS-14-6, which covers MPS, Unit 2 because the design differs from the generic. Dominion calculation ENG-04069CG covers structural mounting details based on WEC analyses, including the hydrodynamic loading for the mounting brackets.

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

4.2.4 Design Features: Qualification

4.2.4.1 Augmented Quality Process

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

By letter dated February 28, 2013 [Reference 24], the licensee stated that instrument channel reliability shall be established by use of an augmented quality assurance process similar to that described in NEI 12-02.

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

4.2.4.2 Instrument Channel Reliability

NEI 12-02 states:

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

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

The NRC staff reviewed the qualification testing of the Westinghouse SFPLI during the vendor audit for temperature, humidity, seismic, radiation and electromagnetic interference (EMI)

[Reference 36]. The staff further reviewed the anticipated site conditions for MPS during the on-site audit.

Temperature and Humidity

The anticipated temperature in the SFP area during a BDB event is 212° F condensing based pool boil-off. In its December 3, 2015 letter [Reference 37], the licensee stated, in part, that the probe, cable and coupler were tested to 212° F and 100 percent relative humidity for 185 hours.

In its March 2, 2015 letters [Reference 33], the licensee stated, in part, that the maximum temperature for Unit 2 primary electronics in the east switchgear room and secondary electronics in the control room air condition room are 104° F and 110° F respectively under normal operating conditions. Under BDB conditions, temperatures will be held at 120° F for both areas using compensatory measures including opening doors, portable fans and flexible venting. Relative humidity will not exceed 95 percent. The electronics were tested to operate continuously at 120 ° F 95 percent residual heat (RH) and up to 140° F 95 percent RH under extreme conditions.

During the MPS on-site audit the NRC staff reviewed Dominion Gothic calculations MISC-11806 for Unit 2. The staff confirmed Dominion's basis for the peak temperatures for each of the condition locations. The staff also confirmed the local equipment anticipated temperature and humidity are bounded by the WEC qualification testing.

Radiation

Radiation test results supplied by Westinghouse in test report EQ-QR-269 have qualified the coupler and coaxial connecting cable to greater than 10^7 RAD and the electronics were qualified to 10^3 RAD. The staff confirmed the Westinghouse testing during the Westinghouse vendor audit [Reference 36].

In its March 2, 2015, letter [Reference 33], the licensee stated regarding Unit 2:

> In the SFP area where the coupler and coaxial cable are located, the dose analysis resulted in a 7-day integrated dose of 2.7E6 RAD and a 40- year integrated dose of 880 RAD. In the Auxiliary Building where the SFPLI system sensor transmitters are located, the dose analysis resulted in a 7-day integrated dose of 81 RAD and 40-year integrated dose of 700 RAD.

During the on-site audit at MPS, the NRC staff reviewed Dominion Calculation CALC-RA-0045, Rev. 1 "Radiological Evaluation following a Beyond Design Basis MPS2 SFP Draindown for NEI 12-02" and verified that the source term was consistent with that stated in NEI 12-02 and that the calculated integrated 7 day dose is less than the tested values of 1E7 in the SFP area and 1E3 for the electronics. For MPS 2, the electronics are located one floor below the MCR.

During the on-site audit at MPS, the NRC staff performed a confirmatory review of Dominion Calculation CALC-RA-0046, Rev. 0, “Radiological Evaluation following a Beyond Design Basis MPS3 SFP Draindown for NEI 12-02” and verified that the source term was consistent with that stated in NEI 12-02 and that the calculated integrated 7 day dose is less than the tested values of 1E7 in the SFP area and 1E3 for the electronics in the Aux Bldg.

Seismic

The NRC staff reviewed the Westinghouse seismic qualification testing during the Westinghouse vendor audit [Reference 36]. In its February 28, 2014, letter [Reference 31], the licensee stated:

> Testing and analysis is conducted by Westinghouse to provide assurance that the equipment will perform reliably under the worst-case credible design basis loading at the location where the equipment will be mounted. MPS Power Station Procurement Specification IC-1210, Rev. 1, provides the design requirements applicable to the installed location for the equipment. Section 7 of Westinghouse document WNA-PT-00188-GEN, Rev. 1, "Spent Fuel Pool Instrumentation System (SFPIS) Standard Product Test Strategy," provides the overall test strategy for the SFPIS system, and addresses the design criteria and methodology for seismic testing of the SFP instrumentation and the electronics units. The test strategy includes seismic response spectra that envelope the design basis maximum seismic loads and includes applicable hydrodynamic loading that could result from conditions such as seismic-induced sloshing effects. In accordance with WNA-PT-00188-GEN, the applicable guidance in Sections 7, 8, 9 and 10 of IEEE Standard 344-2004, "IEEE Recommended Practice for Seismic Qualification of Class IE Equipment for Nuclear Power Generating Stations," by testing.

During the on-site audit, the NRC staff reviewed the MPS Procurement Specification IC-1210, Rev. 1. The NRC staff also performed a confirmatory review of the seismic analysis in Westinghouse calculation CN-PEUS-14-3 which covers the generic design for Surry, North Anna, and MPS, Unit 3 including the hydrodynamic loading for the mounting brackets. Westinghouse calculation CN-PEUS-14-6 covering the unique MPS, Unit 2 design was reviewed, as well. Dominion calculation ENG-04069CG covered structural mounting details based on the Westinghouse analyses.

Shock and Vibration

In its December 3, 2015, letter [Reference 37], the licensee stated:

> Components of both instrumentation channels are permanently installed and fixed to rigid, structural walls or floors of Seismic Category I structures and are not subject to anticipated shock or vibration inputs. The display enclosure utilizes a NEMA-4X rated stainless steel housing to aid in protecting internal components

> from vibration induced damage according to Westinghouse report WNA-TR-03149-GEN. Therefore, in accordance with Nuclear Regulatory Commission (NRC) Order EA-1 2-051, NEI guidance, and as clarified by the Interim Staff Guidance, the probe, coaxial cable, and mounting brackets are inherently resistant to shock and vibration loadings.

The NRC staff found this response acceptable, because the stainless steel housing should adequately address the potential reliability concern of SFP level instrumentation with respect to shock and vibration.

<u>Electromagnetic Interference</u>

The NRC reviewed the EMI qualification testing during the Westinghouse vendor audit [Reference 34]. During the on-site audit at MPS, the NRC staff raised a question regarding potential hand-held radio transmissions to interfere with the instrument probe.

In its December 3, 2015, letter, the licensee stated:

> The base configuration necessary to meet Criterion B (instrument will function before and after an Electro-Magnetic Compatibility (EMC) event) was confirmed during EMC qualification testing performed by Westinghouse. NRC representatives audited the Westinghouse test documents. As a result Westinghouse specified materials, installation, and grounding requirements necessary to ensure the installed SFPLI system meets the tested Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) qualifications. These requirements and characteristics are detailed in Westinghouse proprietary letter LTR-EQ-14-32, Rev. 2 dated August 1, 2014, which is available for review upon request.
>
> Additionally, placards have been installed in the Unit 2 Auxiliary Building. The placards read, "Be aware that use of hand-held radios within 3 ft. may cause interference with the SFP level channels. The reading returns to normal when radio usage is stopped."

The NRC staff found this response acceptable, because it defines the distance to avoid potential SFP level channel disturbances caused by hand-held radios.

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

4.2.5 Design Features: Independence

The following location description compiled by the NRC staff is supported by sketches provided by the licensee in its December 3, 2015, and January 6, 2015, letters [References 37 and 58], sketches provided by the licensee during the on-site audit and NRC staff observations during the on-site SFPLI system walkdowns:

The primary and backup instruments are located at the east and west ends of the Unit 2 SFP. Cabling exits the SFP area from the respective east and west ends, maintaining maximum separation. The primary transmitter is located in the north end of the cable vault and the indicator is toward the south end of the cable vault near the stairwell to the control room. The backup transmitter is in the control room HVAC area and the indicator is in the east switchgear room.

The NRC staff noted that there is sufficient channel separation within the SFP area between the primary and back-up level instruments 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.

In its December 3, 2015, and January 6, 2015, letters [References 37 and 58], the licensee stated, in part, that the instrument channels are normally powered from separate 120 Vac lighting panels that are powered from different 480 Vac buses. Use of these power sources ensures that, during normal operating conditions, the loss of one bus will not result in the functional loss of both instrument channels.

The NRC staff confirmed both the physical and electrical independence during the SFPLI walkdowns at the MPS on-site audit.

Based on the discussion above, the NRC staff finds that, if implemented accordingly, the instrument channel independence should be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.6 Design Features: Power Supplies

In its January 6, 2015, letter [Reference 57], the licensee stated:

> The instrument channels are normally powered from separate 120 Vac lighting panels that are powered from different 480 Vac buses. Use of these power sources ensures that, during normal operating conditions, the loss of one bus will not result in the functional loss of both instrument channels.
>
> Back-up power for each instrument channel is provided by a sealed lead acid battery located in each display cabinet, which is maintained in a charged state by commercial-grade UPS's (electrical switchover unit). At full charge, the batteries

> are capable of supporting the channel operations for approximately 101 hours or 4.2 days, per Westinghouse calculation WNA-CN-00300-GEN.
>
> Onsite BDB equipment includes several small electric generators, which can provide, if necessary, a portable power source within the 4.2 day battery operating timeframe and maintain instrument channel operation until off-site resources can be deployed. Each display cabinet is furnished with an external connection and manual transfer switch, which provides the ability to use an alternate 120 Vac power source to repower the channel.

The NRC staff confirmed the planned power sources during the on-site audit. Based on the discussion above, the NRC staff finds that, if implemented accordingly, the licensee's proposed power supply design should 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 December 3, 2015, compliance letter [Reference 37], the licensee stated, in part, the level measurement channels provide measurement accuracy to within +/- 3 inches of the actual surface of the SEP water. Actual instrument channel accuracy is documented within Westinghouse calculation WNA-CN-00301-GEN. This accuracy is maintained without the need for recalibration following an interruption or change in power source as described in Westinghouse report WNATR- 03 149.

The NRC staff reviewed the accuracy of the Westinghouse system during the vendor audit and found the Westinghouse system meets the criteria in NEI 12-02. The staff's review is documented in the Westinghouse vendor audit report [Reference 36].

Based on the discussion above, the NRC staff finds that, if implemented accordingly, the licensee's proposed instrument accuracy should 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

The NRC staff reviewed the testability of the Westinghouse system during the Westinghouse vendor audit [Reference 36]. During the on-site audit at MPS, the NRC staff confirmed that the licensee will follow the vendor recommended procedures.

In its December 3, 2015, compliance letter [Reference 37], the licensee stated, in part, that the new SFPLI system is comprised of fixed sensors, transmitters, and display cabinets. This system can be tested and calibrated in-situ without removing the sensor probe from the pool or removing other equipment from the permanently installed locations, or may be remotely calibrated using a calibration fixture.

The licensee also stated, in part, in its December 3, 2015, compliance letter that procedures for calibration and test, maintenance, repair, operation, and normal and abnormal responses have been provided by Westinghouse. Corresponding site-specific procedures have been developed based on these vendor guidelines (see Section 4.3 below) and a Recurring Task Evaluation has been prepared and approved to evaluate, prepare, and implement the stated Preventative Maintenance procedures at the vendor recommended frequencies.

Based on the discussion above, the NRC staff finds that, if implemented accordingly, the licensee's proposed SFP instrumentation design should allow 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

The capabilities of the Westinghouse display were reviewed and found to meet the criteria of NEI 12-02 during the Westinghouse vendor audit [Reference 36].

The Unit 2 primary transmitter is located in the north end of the cable vault and the indicator is toward the south end of the cable vault near the stairwell to the control room. The indicator is accessible from the control room. The Unit 2 backup transmitter is in the control room HVAC area and the indicator is in the east switchgear room. Both the primary and backup indicators are accessible from the control room.

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

4.3 Evaluation of Programmatic Controls

Order EA-12-051 specified that the SFPI 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, for both units, in part, that the Systematic Approach to Training (SAT) Process will be used to identify the population to be trained and to determine both the initial and continuing elements of the required training.

In its December 3, 2015, letter, the licensee stated, in part, that to provide sufficient instructions for operation and use of the system by plant staff personnel, Knowledge Based Training is conducted during initial Operator Qualification and has been integrated into the Continuing Operations Training Program. Training includes FLEX Support Guideline, EOP 25 FSG-11, "Alternate SFP Makeup and Cooling," that defines the actions to be taken upon observation of system level indications, including actions to be taken at the levels defined in NEI 12-02. Guideline EOP 25 FSG-11 also addresses the alternate power provisions for the SFP level instruments.

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

4.3.2 Programmatic Controls: Procedures

In its January 6, 2015, letter [Reference 57], the licensee stated, in part, that procedures for system inspection, calibration and test, maintenance, repair, operation, and normal and abnormal responses have been provided by Westinghouse. Corresponding site specific procedures are being developed based on these vendor guidelines.

In its January 6, 2015, letter the licensee also provided the following list of procedures with the technical objective for each:

1) System Inspection -- To verify the system components are in place, complete, and in the correct configuration, and that the sensor probe is free from significant boric acid deposition.

2) Calibration and Test -- To verify that the system is within specified accuracy, is functioning as designed, and is properly indicating SFP level.

3) Maintenance -- To establish and define scheduled and preventative maintenance requirements and activities necessary to minimize the possibility of interruption.

4) Repair -- To specify troubleshooting steps and component repair and replacement activities in the event of a system malfunction.

5) Operation -- To provide sufficient instructions for operation and use of the system by plant staff personnel.

6) FLEX Support Guideline (FSG) -- 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.

Based on the discussion above, the NRC staff finds that, if implemented accordingly, the licensee's procedure development should 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 January 6, 2015, letter [Reference 57], the licensee stated its approach for testing and calibration:

> If the plant staff determined a need to confirm that the two channels are performing as expected, the two channels may be read at their display locations. While the SFP is operating within design basis and at normal level, the indicators are compared to each other, and if a discrepancy exists can be compared to an existing narrow range SFP level instrument. The periodic calibration verification will be performed within 60 days prior to 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 Section 4.3 of NEI 12-02. Periodic calibration verification procedures provided by Westinghouse in WNA-TP-04709-GEN, "Spent Fuel Pool Instrumentation System Calibration Procedure" (Reference 10) are in place. Site specific calibration verification procedures are being developed based on Westinghouse document WNA-TP-04709-GEN, which is available for review upon request. Preventive maintenance procedures which include tests, inspection and periodic replacement of the backup batteries have been provided by Westinghouse. A corresponding site specific preventative maintenance is being developed using recommended vendor guidance.

Regarding out-of-service times for the SFPLI, the licensee stated in its January 6, 2015 letter that:

> Provisions associated with out-of-service (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 implement appropriate compensatory actions, including the use of alternate suitable equipment and/or supplemental personnel, within 72 hours.
>
> Sufficient spare parts will be maintained for the MPS3 SFP Level Instrumentation System, 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.

The NRC staff confirmed the Westinghouse testing and calibration approach during the Westinghouse vendor audit [Reference 36].

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

4.4 Conclusions for Order EA-12-051

In its letter dated December 3, 2015 [Reference 37], the licensee stated that it would meet the requirements of Order EA-12-051 by following the guidelines of NEI 12-02, as endorsed, by JLD-ISG-2012-03. In the evaluation above, the NRC staff finds that, if implemented appropriately, the licensee has conformed to the guidelines of NEI 12-02, as endorsed, by JLD-ISG-2012-03. In addition, the NRC staff concludes that if the SFP level instrumentation is installed at MPS, Unit 2 according to the licensee's proposed design, it should adequately address the requirements of Order EA-12-051.

5.0 CONCLUSION

Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and proposed designs which, if implemented appropriately, will adequately address the requirements of Orders EA-12-049 and EA-12-051.

6.0 REFERENCES

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

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

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

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

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

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

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

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

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

10. Letter, Dominion Nuclear Connecticut, Inc., Millstone Power Station, Units 2 and 3, "Response to March 12, 2012, Commission Order to Modify Licenses With Regard To Requirements for Mitigation Strategies for Beyond Design Basis External Events, EA-12-049," February 28, 2013 (ADAMS Accession No. ML13064A265)

11. Letter, Dominion Nuclear Connecticut, Inc., Millstone, Units 2 and 3, "Six-Month Status Report in Response to March 12, 2012, Commission Order to Modify Licenses With

Regard To Requirements for Mitigation Strategies for Beyond Design Basis External Events (Order Number EA-12-049)," August 23, 2013 (ADAMS Accession No. ML13242A011)

12. Letter, Dominion Nuclear Connecticut, Inc., Millstone Power Station Unit 2, "Six-Month Status Report in Response to March 12, 2012, Commission Order to Modify Licenses With Regard To Requirements for Mitigation Strategies for Beyond Design Basis External Events (Order Number EA-12-049)," February 28, 2014 (ADAMS Accession No. ML14069A013)

13. Letter, Dominion Nuclear Connecticut, Inc., Millstone, Unit 2, "Six-Month Status Report in Response to March 12, 2012, Commission Order to Modify Licenses With Regard To Requirements for Mitigation Strategies for Beyond Design Basis External Events (Order Number EA-12-049)," August 28, 2014 (ADAMS Accession No. ML14251A016)

14. Letter, Dominion Nuclear Connecticut, Inc., Millstone, Unit 2, "Six-Month Status Report in Response to March 12, 2012, Commission Order to Modify Licenses With Regard To Requirements for Mitigation Strategies for Beyond Design Basis External Events (Order Number EA-12-049)," March 2, 2015 (ADAMS Accession No. ML15069A231)

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

16. Letter from Jeremy S. Bowen (NRC) to David Heacock (President and Chief Nuclear Officer), Dominion Nuclear Connecticut, Inc. - Interim Staff Evaluation Relating to Overall Integrated Plan is Response to Order EA-12-049 (Mitigation Strategies)," January 31, 2014 (ADAMS Accession No. ML13338A433)

17. Letter from Stephen Monarque (NRC) to David Heacock (President and Chief Nuclear Officer), Dominion Nuclear Connecticut, Inc. – Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and EA-12-051," November 17, 2014 (ADAMS Accession No. ML14275A017)

18. Letter, Dominion Nuclear Connecticut, Inc., Millstone, Unit 2 "Compliance Letter and Final Integrated Plan in Response to the March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design Basis External Events (Order Number EA-12-049)," December 29, 2015 (ADAMS Accession No. ML16005A184)

19. U.S. Nuclear Regulatory Commission, "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and

9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," March 12, 2012, (ADAMS Accession No. ML12053A340)

20. SRM-COMSECY-14-0037, “Staff Requirements – COMSECY-14-0037 – Integration of Mitigating Strategies For Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards," March 30, 2015, (ADAMS Accession No. ML15089A236)

21. Letter, Dominion Nuclear Connecticut, Inc., Millstone Power Station Units 2 and 3 “Flood Hazard Reevaluation Report in Response to March 12, 2012 Information Request Regarding Flooding Aspects of Recommendation 2.1,” March 12, 2015 (ADAMS Package Accession No. ML15078A203)

22. Letter, Dominion Nuclear Connecticut, Inc., Millstone, Units 2 and 3 “Response to March 12, 2012 Information Request Seismic Hazard and Screening Report (CEUS Sites) for Recommendation 2.1,” March 31, 2014 (ADAMS Accession No. ML14092A417)

23. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), "Staff Assessment of National SAFER Response Centers Established In Response to Order EA-12-049," September 26, 2014 (ADAMS Accession No. ML14265A107)

24. Letter, Dominion Nuclear Connecticut, Inc., “Overall Integrated Plan In Response to March 12, 2012 Commission Order Modifying Licenses With Regard To Requirements For Reliable Spent Fuel Pool Instrumentation (Order EA-12-051),” February 28, 2013 (ADAMS Accession No. ML13063A012)

25. Letter from James Kim (NRC) to David A. Heacock (President and Chief Nuclear Officer), Dominion Nuclear Connecticut, Inc. - "Millstone Power Station, Units 2 and 3 – Request For Additional Information Regarding the Overall Integrated Plan for Implementation of Order EA-12-051, Reliable Spent Fuel Pool Instrumentation (TAC Nos. MF0838 and MF0839)," June 26, 2013 (ADAMS Accession No. ML13175A242).

26. Letter, Dominion Nuclear Connecticut, Inc., Millstone Power Station Units 2 and 3, “March 12, 2012 Commission Order Modifying Licenses With Regard To Requirements For Reliable Spent Fuel Pool Instrumentation (Order EA-12-051) Response to Request for Additional Information (RAI),” July 26, 2013, (ADAMS Accession No. ML13213A015).

27. Letter from James Kim (NRC) to David A. Heacock (President and Chief Nuclear Officer), Dominion Nuclear Connecticut, Inc., "Millstone Power Stations, Units 2 and 3 – Interim Staff Evaluation and Request For Additional Information Regarding the Overall Integrated Plan for Implementation of Order EA-12-051, Reliable Spent Fuel Pool Instrumentation (TAC Nos. MF0838 and MF0839)," October 29, 2013 (ADAMS Accession No. ML13291A115)

28. Letter from Frankie G. Vega (NRC) to David A. Heacock (President and Chief Nuclear Officer – Dominion Nuclear Connecticut, Inc.), “Millstone Power Station, Units 2 and 3 –

Supplement to Staff Assessment of Information Provided Pursuant to Title 10 of the Code of Federal Regulations Part 50, Section 50.54(f), Seismic Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," March 15, 2016 (ADAMS Accession No. ML16057A785)

29. Letter, Dominion Nuclear Connecticut, Inc., "Initial Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051)," dated October 25, 2012 (ADAMS Accession No. ML12307A182)

30. Letter, Dominion Nuclear Connecticut, Inc., "Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051)," dated August 23, 2013 (ADAMS Accession No. ML13242A014)

31. Letter, Dominion Nuclear Connecticut, Inc., "Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051)," dated February 28, 2014 ADAMS Accession No. ML14069A011)

32. Letter, Dominion Nuclear Connecticut, Inc., Millstone, Units 2 and 3 "Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051)," dated August 26, 2014 (ADAMS Accession No. ML14245A400)

33. Dominion Nuclear Connecticut, Inc., Millstone, Unit 2 "Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051)," dated March 2, 2015 (ADAMS Accession No. ML15069A230)

34. Letter, Dominion Nuclear Connecticut, Inc., "Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051)," dated August 24, 2015 (ADAMS Accession No. ML15244B182)

35. Letter, Dominion Nuclear Connecticut, Inc., Millstone, Units 2 and 3 "Supplement to Overall Integrated Plan in Response to march 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," April 30, 2013 (Adams Accession No. ML13126A206)

36. Letter from Jason Paige (NRC) to Joseph Shea, "Watts Bar Plant Units 1 and 2 – Report for the Westinghouse Audit in Support of Reliable Spent Fuel Pool Instrumentation Related to Order EA-12-051 (TAC Nos. MF0951 and MF1178)," August 18, 2014 (ADAMS Accession No. ML14211A346)

37. Letter, Dominion Nuclear Connecticut, Inc., Millstone, Unit 2, "Compliance Letter in Response to the March 12, 2012 Commission Order Modifying Licenses with regards to Reliable Spent Fuel Pool Instrumentation (EA-12-051)," December 3, 2015 (ADAMS Accession No. ML15342A113)

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

39. Letter from William Dean (NRC) to Power Reactor Licensees, "Coordination of Requests for Information Regarding Flooding Hazard Reevaluations and Mitigating Strategies for Beyond-Design Bases External Events," September 1, 2015 (ADAMS Accession No. ML15174A257)

40. NEI Position Paper: "Shutdown/Refueling Modes", dated September 18, 2013 (ADAMS Accession No. ML13273A514)

41. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), regarding NRC endorsement of NEI Position Paper: "Shutdown/Refueling Modes", September 30, 2013 (ADAMS Accession No. ML13267A382)

42. Letter from Nicholas Pappas (NEI) to Jack R. Davis (NRC) regarding FLEX Equipment Maintenance and Testing, October 3, 2013 (ADAMS Accession No. ML13276A573)

43. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), regarding NRC endorsement of the use of the EPRI FLEX equipment maintenance report, October 7, 2013 (ADAMS Accession No. ML13276A224)

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45. Letter from Michael Balazik (NRC) to David Heacock, President and Chief Nuclear Officer, Dominion Nuclear Connecticut, Inc. Millstone Power Station Unit 2 "Request for Additional Information Associated with Near-Term Task Force Recommendation 2.1, Seismic hazard and Screening Report," July 16, 2014 (ADAMS Accession No. ML14195A034)

46. Letter from David Heacock (Chief Nuclear Officer, Dominion Nuclear Connecticut Inc.,) to U.S. Nuclear Regulatory Commission, Dominion Nuclear Connecticut, Inc. Millstone Power Station Unit 2, "Response to Request for Additional Information Regarding Seismic Hazard and Screening Report for Seismic Recommendation 2.1," July 21, 2014 (ADAMS Accession No. ML14204A620)

47. Letter from Frankie G. Vega (NRC) to David A. Heacock (President and Chief Nuclear Officer – Dominion Nuclear Connecticut, Inc.), "Millstone Power Station, Units 2 and 3 – Staff Assessment of Information Provided Pursuant to Title 10 of the Code of Federal Regulations Part 50, Section 50.54(f), Seismic Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," December 15, 2015 (ADAMS Accession No. ML15328A268)

48. Letter, Dominion Nuclear Connecticut, Inc. to NRC, "Millstone Power Station Units 2 and 3, Supplement to Overall Integrated Plan in Response to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)", April 30, 2013 (ADAMS Accession No. ML13126A206)

49. Letter, Dominion Nuclear Connecticut, Inc., Millstone Power Station Unit 2, "Fifth Six-Month Status Report in Response to March 12, 2012, Commission Order to Modify Licenses With Regard To Requirements for Mitigation Strategies for Beyond Design Basis External Events (Order Number EA-12-049)," August 27, 2015 (ADAMS Accession No. ML15246A123)

50. Letter from Nicholas Pappas (NEI) to Jack R. Davis (NRC), "Alternative Approach to NEI 12-06 Guidance for Hoses and Cables," May 1, 2015 (ADAMS Accession No. ML15126A135)

51. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), regarding response to NEI's request for "Alternative Approach to NEI 12-06 Guidance for Hoses and Cables," May 18, 2015 (ADAMS Accession No. ML15125A442)

52. COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards," dated November 21, 2014 (ADAMS Accession No. ML14309A256)

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MILLSTONE POWER STATION, UNIT 3

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

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

DOMINION NUCLEAR CONNECTICUT, INC.

MPS POWER STATION, UNIT 3

DOCKET NO. 50-423

1.0 INTRODUCTION

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

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

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

2.0 REGULATORY EVALUATION

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

On February 17, 2012, the NRC staff provided SECY-12-0025, "Proposed Orders and Requests for Information in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Tsunami," [Reference 2] to the Commission. This paper included a proposal to order licensees to implement enhanced BDBEE mitigation strategies. As directed by 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 ac power and loss of normal access to the ultimate heat sink [UHS] and have adequate capacity to address challenges to core cooling, containment, and SFP cooling capabilities at all units on a site subject to this Order.

3) Licensees or CP holders must provide reasonable protection for the associated equipment from external events. Such protection must demonstrate that there is adequate capacity to address challenges to

core cooling, containment, and SFP cooling capabilities at all units on a site subject to this Order.

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

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

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

2.2 <u>Order EA-12-051</u>

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

> All licensees identified in Attachment 1 to the order shall have a reliable indication of the water level in associated spent fuel storage pools capable of supporting identification of the following pool water level conditions by trained personnel: (1) level that is adequate to support operation of the normal fuel pool cooling system, (2) level that is adequate to provide substantial radiation shielding for a person standing on the spent fuel pool operating deck, and (3) level where fuel remains covered and actions to implement make-up water addition should no longer be deferred.
>
> 1. The spent fuel pool level instrumentation shall include the following design features:
>
> 1.1 Instruments: The instrumentation shall consist of a permanent, fixed primary instrument channel and a backup instrument channel. The backup instrument channel may be fixed or portable. Portable instruments shall have capabilities that

enhance the ability of trained personnel to monitor spent fuel pool water level under conditions that restrict direct personnel access to the pool, such as partial structural damage, high radiation levels, or heat and humidity from a boiling pool.

1.2 Arrangement: The spent fuel pool level instrument channels shall be arranged in a manner that provides reasonable protection of the level indication function against missiles that may result from damage to the structure over the spent fuel pool. This protection may be provided by locating the primary instrument channel and fixed portions of the backup instrument channel, if applicable, to maintain instrument channel separation within the spent fuel pool area, and to utilize inherent shielding from missiles provided by existing recesses and corners in the spent fuel pool structure.

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

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

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

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

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

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

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

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

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

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

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

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

3.0 TECHNICAL EVALUATION OF ORDER EA-12-049

By letters dated February 28, 2013 [Reference 10], and April 30, 2013 (Agencywide Documents and Access Management System (ADAMS) Accession No. ML13126A206) Dominion Nuclear Connecticut, Inc. (DNC, the licensee) submitted an Overall Integrated Plan (OIP) and OIP supplement, respectively, for the Millstone Power Station (MPS), Units 2 and 3, in response to Order EA-12-049. By letters dated August 23, 2013 [Reference 11], February 28, 2014 [Reference 53], August 28, 2014 [Reference 54], and March 2, 2015 [Reference 55], the licensee submitted six-month updates to the OIP. By letter dated August 28, 2013 [Reference 15], the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office

Instruction LIC-111, “Regulatory Audits” [Reference 38]. By letters dated October 29, 2013 [Reference 16] and October 9, 2014 [Reference 17], the NRC issued an ISE and an audit report, respectively, on the licensee's progress. By letter dated June 23, 2015 [Reference 18], the licensee reported that full compliance with the requirements of Order EA-12-049 was achieved for MPS, Unit 3, and submitted its Final Integrated Plan (FIP) for MPS, Unit 3.

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 loss of normal access to the UHS. Thus, the ELAP with loss of normal access to UHS is used as a surrogate for a BDBEE. The initial conditions and assumptions for the analyses are stated in NEI 12-06, Section 3.2.1, and include the following:

1. The reactor is assumed to have safely shut down with all rods inserted (subcritical).
2. The dc power supplied by the plant batteries is initially available, as is the ac power from inverters supplied by those batteries; however, over time the batteries may be depleted.
3. There is no core damage initially.
4. There is no assumption of any concurrent event.
5. Because the loss of ac power presupposes random failures of safety-related equipment (emergency power sources), there is no requirement to consider further random failures.

MPS, Unit 3 is a Westinghouse four loop pressurized-water reactor (PWR) with a large dry sub atmospheric containment building. The FIP describes the licensee's three-phase approach to mitigate a postulated ELAP event as follows:

Following the occurrence of an ELAP/LUHS event, the reactor will trip and the plant will initially stabilize at no-load reactor coolant system (RCS) temperature and pressure conditions, with reactor decay heat removal via steam release to the atmosphere through the steam generator (SG) safety valves (SVs) and/or the atmospheric dump valves (ADVs). Natural circulation of the RCS will develop to provide core cooling and the turbine-driven auxiliary feedwater (TDAFW) pump provides flow from the demineralized water storage tank (DWST) to the SGs to make-up for steam release. The operators will begin isolation of RCS letdown pathways, confirmation of natural circulation cooling, verification of containment isolation, reduction of dc loads on the station Class 1E batteries, and establishment of electrical equipment alignment in preparation for eventual power restoration. The operators establish manual control of the SG ADVs and within the first 2 hours initiate a rapid cooldown of the RCS to minimize inventory loss through the reactor coolant pump (RCP) seals.

The TDAFW pump automatically starts on the loss of offsite power condition, and does not require either ac or dc electrical power to provide auxiliary feedwater (AFW) to the SGs. In the event that the TDAFW pump does not start on demand or trips after start, the operator will locally reset the turbine and the pump will be restarted. Sufficient time (approximately 1.1 hours) will be available to restart the TDAFW pump to prevent SG dry-out. The AFW system is pre-aligned for flow to all SGs from the TDAFW pump. Operators will take manual control of TDAFW pump flowrate to the SGs to establish and maintain proper water levels. Steam release from the SGs will be controlled locally using the air-operated SG ADVs. The RCS cooldown will be initiated at a maximum rate of 100 degrees Fahrenheit (°F)/hour to a SG minimum pressure of 290 per square inch gauge (psig), which corresponds to an RCS core inlet temperature of approximately 419 °F. The rapid RCS cooldown minimizes adverse effects of high temperature coolant on RCP shaft seal performance.

Initially, AFW water supply is provided by the installed DWST. The tank has a minimum usable capacity of approximately 312,800 gallons based on plant technical specification (TS) minimum volume and provides a suction source to the TDAFW pump for a minimum of 22.8 hours of RCS decay heat removal assuming an RCS cooldown at 100 °F/hour to a minimum SG pressure of 290 psig. After depletion of the inventory in the DWST, the DWST level is replenished from various other onsite sources. The SG water injection using a portable AFW pump is also provided and is available through both primary and alternate connection locations.

Load stripping of all non-essential loads would begin within 45 minutes after the occurrence of an ELAP/LUHS and completed within the next 30 minutes. With load stripping, the useable Class 1E station battery life is calculated to be 14 hours.

RCS makeup is initiated within 16 hours of the ELAP/LUHS event using the beyond-design-basis (BDB) RCS injection pump to add borated water to the RCS for inventory control taking suction from the refueling water storage tank (RWST) or from another borated suction source for the remainder of the event.

The RCS natural circulation is maintained until approximately 24 hours at which time reflux cooling begins. Keff is calculated to be less than 0.99 at RCS conditions described for approximately 25 hours.

The FIP states that, during Phase 2, the Operations staff will monitor the DWST levels. The usable volume of the DWST is depleted in 22.8 hours, but there are still 6.8 hours to deploy another makeup source before the steam generators dry out. Other options include the condensate storage tank (CST).

The Phase 2 FLEX strategy also includes re-powering of vital 120 volts of direct current

(Vdc) busses within 14 hours using a portable 120/240 volts of alternating current (Vac) diesel generator (DG) stored onsite. Prior to depletion of the Class 1E 125 Vdc batteries, vital 120 Vac circuits will be re-powered to provide key parameter monitoring instrumentation. A portable 480 Vac DG is available as an alternate to the 120/240 Vac DG.

The Phase 3 Strategy for core cooling and decay heat removal includes additional equipment available from the National SAFER (Strategic Alliance for FLEX Emergency Response) Response Center (NSRC) to provide backup to the BDB high capacity pumps as well as the BDB AFW pumps. Additionally, a reverse osmosis/ion exchanger water processing system will be provided from the NSRC to provide a method to remove impurities from alternate fresh water supplies to the TDAFW pump or the BDB AFW pump.

The MPS, Unit 3 has a dry sub-atmospheric containment. Conservative 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 for a minimum of 7 days. Therefore, actions to reduce containment temperature and pressure and to ensure continued functionality of the key parameters will not be required immediately and will utilize offsite equipment during Phase 3 if onsite capability is not restored. When containment cooling is required, mobile 4160 Vac generators supplied by the NSRC will provide power to one of the Class 1E 4160 Vac busses and one of the Class 1E 480 Vac busses. The operators plan to run the containment air recirculation (CAR) fans and use installed pumps or NSRC supplied pumps to establish water flow to the CAR system heat exchanger.

The basic FLEX strategy for maintaining SFP cooling is to monitor SFP level and provide sufficient makeup water to the SFP to maintain the normal SFP level. MPS, Unit 3 has a single dedicated SFP. An evaluation estimates that with no operator action following a loss of SFP cooling at the maximum design heat load, the SFP will reach 212 °F in approximately 10 hours and boil off to a level 10 feet above the top of fuel in 50 hours from initiation of the event. The Phase 1 coping strategy is to monitor SFP level using instrumentation installed as required by NRC Order EA-12-051. The Phase 2 strategy is to initiate SFP makeup within the first 24 hours by running a branch hose from the BDB high capacity pump to the BDB SFP makeup connection inside the Unit 3 fuel building loading bay for the addition of makeup water to the SFP as it is needed to maintain the normal level. Makeup water will be provided from either the RWST or from one branch of the Unit 3 distribution manifold being supplied from the BDB high capacity pump.

An alternate FLEX strategy consists of deploying a hose directly to the SFP area. Additionally, spray monitors and sufficient hose length required for the SFP spray option are located in the BDB storage building.

During Phase 3, additional low pressure / high flow pumps will be available from the NSRC as a backup to the onsite BDB high capacity pumps. Additionally, the NSRC will also provide two 4160 Vdc generators which can be used to re-power SFP cooling systems if emergency buses are available or restored.

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

3.2 Reactor Core Cooling Strategies

Order EA-12-049 requires licensees to maintain or restore cooling to the reactor core in the event of an ELAP concurrent with a loss of normal access to the UHS. Although the ELAP results in an immediate trip of the reactor, sufficient core cooling must be provided to account for fission product decay and other sources of residual heat. Consistent with endorsed guidance from NEI 12-06, Phase 1 of the licensee's core cooling strategy credits installed equipment (other than that presumed lost to the ELAP with loss of normal access to the UHS) that is robust in accordance with the guidance in NEI 12-06. In Phase 2, robust installed equipment is supplemented by onsite FLEX equipment, which is used to cool the core either directly (e.g., pumps and hoses) or indirectly (e.g., FLEX electrical generators and cables repowering robust installed equipment). The equipment available onsite for Phases 1 and 2 is further supplemented in Phase 3 by equipment transported from the NSRCs.

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

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

3.2.1 Core Cooling Strategy and RCS Makeup

3.2.1.1 Core Cooling Strategy

3.2.1.1.1 Phase 1

As described in the FIP, when power is lost the reactor trips and the plant will initially stabilize at no-load RCS temperature and pressure conditions. Natural circulation will develop in the RCS and be maintained throughout Phase 1 to provide core cooling. The SGs are the heat sink and SG safety valves (SVs) and/or ADVs will release steam for reactor decay heat removal.

The TDAFW pump automatically starts on the loss of off-site power condition and does not rely on ac or dc electrical power to provide AFW to the SGs. The TDAFW pump is aligned to provide flow from the DWST to all SGs to make up for steam release. The TDAFW pump flowrate will be manually controlled from the pump cubicle in the engineered safety features (ESF) building.

Manual control of ADVs will be taken from the Main Steam Valve Building (MSVB). The air supplies to these valves were modified such that a pneumatic hose and remotely located tank can be connected to allow for remote operation of the ADVs. Manual hand wheel operation of the Atmospheric Dump Bypass Valves (ADBVs) is also available if the compressed air supply for ADV operations is expended.

Within 2 hours of an ELAP event, operators would initiate an RCS cooldown by depressurizing the SGs at the maximum allowable rate (i.e., 100 °F/hr) until a SG pressure of about 290 psig is reached. A RCS cooldown minimizes the effects of high temperature on RCP shaft seal performance and reduces SG pressure such that a portable pump may be used for AFW injection if the TDAFW pump became unavailable. The licensee stated that SG pressure is maintained greater than 290 psig to prevent nitrogen gas from the safety injection accumulator from entering the RCS.

3.2.1.1.2 Phase 2

The licensee’s primary strategy in Phase 2 is to continue to cool the RCS by feeding the SGs with the TDAFW pump and releasing steam through the ADVs at a controlled rate to maintain an SG pressure of 290 psig.

Operators will monitor DWST level from the control room or via local instrumentation. The DWST has a usable volume of 312,800 gallons that the licensee calculated would be depleted in 22.8 hours. As the DWST nears depletion, the CST would be the next preferred source for AFW; however, it is not protected for all external events. Alternatively, a high capacity transfer pump will be deployed within 10 hours of ELAP initiation. This pump will draw water from the most preferable water supply that is available and discharge it to the DWST via primary or alternate connection points. As described in Table 3 of the licensee’s FIP, additional fresh water sources should be available in analyzed ELAP scenarios where the CST cannot be credited. However, if necessary, salt water from Long Island Sound could be used for feeding the SGs. Water sources for mitigating the ELAP event are discussed further in Section 3.10 of this evaluation.

Additionally, a portable AFW pump will be set up within 24 hours as a backup to the TDAFW pump. The portable AFW pump will take suction from the DWST or another water source via the high-capacity transfer pump, and it can provide AFW to the SGs via primary or alternate connections.

3.2.1.1.3 Phase 3

The licensee stated that it would attempt to continue cooling the RCS in Phase 3 by feeding the SGs with the TDAFW pump for as long as possible and releasing steam through the ADVs. However, the diminishing rate of steam generation due to the gradual decrease in core decay heat implies that it will eventually become necessary to transition to Phase 2 and/or Phase 3 FLEX equipment as the primary core cooling strategy to satisfy the order's requirement for indefinite coping.

Per the FIP, the NSRC will provide a backup for the high-capacity transfer pump and portable AFW pump for each unit. The NSRC will also provide a water treatment unit that can be used to provide a clean source of water to the TDAFW pump or portable AFW pump. As necessary to facilitate the use of higher quality water for reactor core cooling, the NRC staff expects that the licensee would begin using the water purification equipment from the NSRC as soon as practical considering the overall event response prioritization.

Alternately, the licensee could restore residual heat removal (RHR) cooling in Phase 3. This activity would require NSRC generators to restore 4160 Vac so that portions of Reactor Plant Component Cooling Water and Service Water Systems can be restored to support a transition to RHR for core cooling. The Emergency Contingency Action (ECA) ECA 35 EOP-0.0 directs the use of FLEX Support Guideline (FSG) ECA 35 FSG-10 to isolate or vent the accumulators prior to taking actions that could depressurize the RCS past the point where the injection of the nitrogen cover gas could occur. However, the licensee's FIP considers the transition to RHR cooling as a recovery action that is not required for indefinite coping in response to the order.

3.2.1.2 RCS Makeup Strategy

3.2.1.2.1 Phase 1

Under ELAP conditions, RCS inventory will tend to diminish gradually due to leakage through RCP seals and other leakage points. Furthermore, the initial RCS cooldown starting at 2 hours into the event would result in a significant contraction of the RCS inventory, to the extent that the pressurizer would drain and a vapor void would form in the upper head of the reactor vessel. As is typical of operating PWRs, prior to implementing the Phase 2 FLEX strategy, MPS 3 does not have a fully robust capability for active RCS makeup.

Dominion determined that sufficient reactor coolant inventory would be available throughout Phase 1 to support heat transfer to the SGs via natural circulation without crediting the active injection of RCS makeup. The ECA 0.0 directs isolation of RCS letdown pathways and verification of RCS isolation. The RCS inventory loss is assumed to be through RCP seal leakage and operational leakage. MPS, Unit 3 replaced two of four Westinghouse-designed seals with Flowserve N-seals and replaced the remaining two Westinghouse seals with Flowserve N-seals during the spring 2016 outage. Passive injection from the safety injection accumulators would occur as operators depressurize the RCS below the nitrogen cover gas pressure, which helps offset cooldown-induced inventory contraction and system leakage.

Dominion further indicated that, according to the core operating history specified in NEI 12-06, a sufficient concentration of xenon-135 should exist in the reactor core to ensure subcriticality throughout Phase 1, considering the planned cooldown profile. A cooldown to 290 psig in the SGs will correspond to an RCS core inlet temperature of approximately 419 °F. In addition to replenishing the RCS coolant volume, the passive injection from the nitrogen-pressurized safety injection accumulators would increase the boron concentration of the coolant in the RCS.

3.2.1.2.2 Phase 2

Per the FIP, RCS makeup is initiated within 16 hours of the ELAP/LUHS event. The RWST is the preferred source of borated makeup water. Makeup will be provided to the RCS using one of two 45-gallons per minute (gpm) BDB RCS injection pumps via primary or alternate connection points located in the ESF building. Per the licensee's FIP, each BDB RCS injection pump is capable of injecting at pressures up to 2000 psig [pounds per square inch gauge].

The RWST is protected from all natural phenomena considered under Order EA-12-049 except for the high wind/tornado hazard. If the RWST is unavailable, the two Boric Acid Storage Tanks (BASTs) can be used through the connection on the suction side of "A" safety injection pump. Alternately, water from the RWST can provide a borated water source through FLEX portable boric acid mixing tanks. Lastly, the portable boric acid mixing tanks can be used to mix non-borated water with bags of powdered boric acid to provide a borated RCS makeup water source. To ensure consistency with its shutdown margin calculations, the licensee's procedures for batching borated coolant directs operators to target a mixture concentration greater than or equal to the minimum RWST concentration (i.e., approximately 2,700 particles per million (ppm) boron or greater). As described in Table 3 of the licensee's FIP, additional fresh water sources for batching borated coolant should be available in analyzed ELAP scenarios where the RWST cannot be credited. However, if necessary, salt water from Long Island Sound could be used for mixing borated coolant. Water sources for mitigating the ELAP event are discussed further in Section 3.10 of this evaluation.

3.2.1.2.3 Phase 3

In Phase 3, the RCS makeup strategy is a continuation of the Phase 2 strategy, supplemented, as needed, with equipment provided by the NSRC. The NSRC will provide a high-pressure injection pump and mobile boration unit as backup for RCS makeup and boration requirements. As necessary, to facilitate the use of higher quality water for RCS makeup, the NRC staff expects that the licensee would begin using purification equipment from the NSRC as soon as practical considering the overall event response prioritization.

3.2.2 Variations to Core Cooling Strategy for Flooding Event

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

3.2.3 Staff Evaluations

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

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

3.2.3.1.1 Plant SSCs

Core Cooling

In its FIP, the licensee provided descriptions for the permanent plant SSCs to be used to support core cooling for Phase 1 and 2. The Unit 3 TDAFW pump will automatically start and will deliver AFW flow to all four SGs following an ELAP/LUHS event. In the event that the TDAFW pump fails to start, procedures direct the operators to manually reset and start the pump (which does not require electrical power for motive force or control). The licensee indicated that operators can manually start the pump within 1.1 hours after declaration of ELAP and initiate flow prior to steam generator dryout. The TDAFW pump is capable of providing feedwater flow that exceed the design-basis AFW flow requirements. The TDAFW pump is also located in a safety-related, Class I structure that is protected from all external hazards. The licensee also described in the FIP that the atmospheric dump valves (ADVs) are manually throttled by operators for an indefinite time period after ELAP is declared and loss of instrument air. The air supply system has been modified to allow the connection of an installed bank of air bottles in a lower level of the MSVB so that the ADVs can be controlled in a more accessible area. Operation of the SG atmospheric dump bypass valves (ADBVs) is an alternative for core cooling if the SG ADVs are unavailable. The SG ADVs and the ADBVs are all safety-related, seismic Category I valves, and are missile-protected inside of the MSVB. The sections of the SG ADV and ADBV exhaust pipes that are located above the MSVB roof are not missile-protected. However, there are four SG ADV flow pathways and four SG atmospheric dump bypass valve flow pathways. Therefore, the licensee credited in the FLEX strategy for core cooling the diverse flow pathway to ensure functional capability during a tornado initiated ELAP.

The licensee described four water sources that are credited as part of the overall SG makeup strategy after ELAP in its FIP. The Unit 3 DWST is described as the primary preferred source of SG feedwater and it is a safety-related, Seismic Category I tank that is protected from all applicable hazards. The licensee stated that the DWST can be refilled from onsite water sources including the Fire protection/City Water system, the Onsite freshwater pond, and Long Island Sound. The fire protection system has two fire water storage tanks that can be connected with a hose to a fire hydrant to refill the DWST. The City Water fills the fire water storage tanks and the licensee indicated that the hose can tap directly to the City Water system line if needed in case the fire water storage tanks are unavailable after ELAP. The Onsite Freshwater pond is an untreated water source that requires the use of a suction strainer. The Long Island Sound is the Ultimate Heat Sink designated salt-water source and is not a recommended in the licensee's analysis as a source of makeup water for the SFP until all available freshwater sources have been depleted.

Based on the design and locations of the TDAFW pumps and ADVs, the diverse water sources as described above, and the Long Island Sound as described in the FIP, the staff finds that the plant SSCs and water sources should be available to support core cooling during an ELAP caused by a BDBEE, consistent with Condition 4 of NEI 12-06, Section 3.2.1.3. Additionally, due to the design and locations of the primary and alternate AFW connection points, as described below in SE Section 3.7.3.1 and in the FIP, the staff finds that at least one of the connection points should be available to support core cooling through a portable FLEX pump during an ELAP caused by a BDBEE, consistent with NEI 12-06, Section 3.2.2 and Table D-1.

RCS Inventory Control

In its FIP, the licensee described that the Unit 3 RWST is the preferred source of borated water for RCS makeup. The RWST is a stainless steel, safety-related, Seismic Category I storage tank that is robust to the site's applicable hazards, except tornado missiles. For all ELAP events that involve tornado missiles, the licensee will use the BASTs (two for the Unit) to fulfill the RCS makeup function. The BASTs are safety-related, seismically designed and are located at the 43 ft. elevation of the Auxiliary Building, which is missile-protected. The licensee indicated that gravity drain lines are provided from the BASTs to the Safety Injection pump suction header.

Based on the design and availability of the Unit 3 RWST and Unit 3 BASTs, as described in the FIP, the staff finds that a borated water source should be available to support RCS inventory control during an ELAP caused by a BDBEE, consistent with Condition 3 of NEI 12-06, Section 3.2.1.3. Additionally, due to the design and location of the primary and alternate RCS injection connection points, as described in below in SE Section 3.7.3.1 and in the FIP, the staff finds that at least one of the connection points should be available to support RCS injection through the FLEX pump during an ELAP caused by a BDBEE, consistent with NEI 12-06, Section 3.2.2 and Table D-1.

3.2.3.1.2 Plant Instrumentation

According to the licensee's FIP, the following key parameters are credited and available, as described below, for all phases of reactor core cooling and decay heat removal strategy.

- FW Flowrate – AFW flowrate indication is available in the Main Control Room and Auxiliary Shutdown Panel (ASP).
- SG Water Level – Narrow range (NR) and Wide range (WR) level indication is available in the MCR and at the ASP for all SGs throughout the event.
- SG Pressure – SG pressure indication is available in the MCR and at the ASP panel. SG pressure indication is available for all SGs throughout the event.
- RCS Temperature – RCS hot-leg and cold-leg temperature indications are available in the MCR and at the ASP panel once FLEX electrical power is restored to vital ac buses by 10 hours into the event.
- RCS Pressure – RCS wide range pressure indication is available in the MCR and at the ASP panel throughout the event.
- Core Exit Thermocouple Temperature – Core exit thermocouple temperature indications are available throughout the event at the Inadequate Core Cooling (ICC) cabinets in the instrument rack room adjacent to the MCR.
- DWST Level – DWST water level indication is available in the MCR, at the ASP, and locally at the tank throughout the event.
- Pressurizer level: Pressurizer level indication is available in the MCR and at the ASP throughout the event.
- Reactor Vessel Level Monitoring System (RVLMS) - RVLMS indication is available from the ICC cabinet throughout the event.
- Excore Nuclear Instruments – Indication of nuclear source range activity is available in the MCR and ASP throughout the event.

The instrumentation available to support the licensee's strategies for core cooling and RCS inventory during the ELAP event is generally consistent with and in some cases exceeds the recommendations specified in the endorsed guidance of NEI 12-06. However, the NRC staff noted that RCS temperature indication would only become available after FLEX equipment is used to repower vital ac buses by 10 hours into the event, which is not consistent with NEI 12-06. However, prior to this time, the licensee should be able to infer RCS cold-leg temperature from the steam generator pressure for the analyzed ELAP event, since natural circulation is expected to be maintained in the RCS. Furthermore, by this same logic, the indication from the core exit thermocouples should serve as a reasonable indication for RCS hot-leg temperature for the analyzed ELAP event. As a result, the NRC staff considered the intent of the endorsed guidance from NEI 12-06 to be satisfied.

All FLEX portable equipment is equipped with the necessary local instrumentation to operate the equipment, and operation is detailed in the FSGs.

FSG-7, Loss of Vital Instrumentation or Control Power includes instructions for obtaining critical parameters locally in the unlikely event that all AC and DC power is lost.

3.2.3.2 Thermal-Hydraulic Analyses

MPS, Unit 3 concluded that its mitigating strategy for reactor core cooling would be adequate based in part on 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. In the Pressurized-Water Reactor Owners Group (PWROG) Core Cooling Position Paper, which was provided in a letter dated January 30, 2013, the PWROG recommended that the reflux or boiler-condenser cooling phase be avoided because of uncertainties in operators' ability to control natural circulation following reflux boiling and the impact of the diluted pockets of water on criticality. Due to the challenge of resolving the above issues within the compliance schedule specified in Order EA-12-049, the NRC staff requested that PWR licensees 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 PWROG-sponsored Technical 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," and WCAP-17792-P, "Emergency Procedure Development Strategies for the Extended Loss of AC Power Event for all Domestic Pressurized Water Reactor Designs." Subsequently, a series of additional simulations performed by the staff and Westinghouse identified that the discrepancy in predicted coping time could be attributed largely to differences in the modeling of RCP seal leakage. The topic of RCP seal leakage is 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. Further discussion of the staff's review, including conditions and limitations regarding the application of the NOTRUMP code to analysis of the ELAP event, may be found in the NRC staff's endorsement letter on this subject, dated June 16, 2015 (ADAMS Accession No. ML15061A442).

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

Dominion performed a site-specific applicability review of the generic analysis in Section 5.2.1 of WCAP-17601 and found the overall results to be bounded by the model and inputs used in WCAP-17601 and associated analytical codes. During the audit, the NRC staff confirmed the similarity of the parameters in the reference analysis from WCAP-17601-P to the applicable values for MPS 3.

However, the leakage rate boundary condition assumed in the generic Westinghouse thermal-hydraulic analysis differs from the plant-specific condition for MPS 3. Whereas the generic Westinghouse four-loop analysis assumed an RCS leakage rate commensurate with four Westinghouse-designed RCP seals, two of the four seals at MPS 3 have been replaced by Flowserve NX seals, which would have a lower leakage rate. Dominion has further committed to replacing the remaining two Westinghouse standard RCP seals with Flowserve NX seals during the spring 2016 outage. Therefore, the NRC staff's SE considers the post-outage plant configuration with Flowserve NX seals installed on all four RCPs.

Based on information from WCAP-17601-P and PWROG-14027-P, reflux cooling was estimated to occur at 15.6 hours for the Westinghouse four-loop reference case assuming leakage rates for standard Westinghouse-designed RCP seals. The licensee subsequently performed an additional scaling analysis to consider its existing plant-specific RCP seal configuration with two of the four Westinghouse-designed seals replaced by Flowserve N-seals. The licensee determined that this configuration would increase the estimated time to reflux cooling to approximately 24 hours. Although the licensee expected that this configuration would provide sufficient margin to reflux cooling, as noted above, following its spring 2016 outage, the licensee will have Flowserve N-seals on all four RCPs, which should provide an additional, significant increase in the coping time prior to entering reflux cooling in the RCS. Per its FLEX strategy, MPS 3 will begin RCS inventory makeup within 16 hours of the onset of the ELAP condition, which the NRC staff concludes should provide ample margin to the time where reflux cooling is expected for the analyzed ELAP event considering the configuration with four Flowserve NX seals installed.

The NRC staff's audit review found the licensee's thermal-hydraulic analysis to be in adequate conformance with applicable guidance documents (e.g., NEI 12-06, the NRC staff's endorsement letter regarding the NOTRUMP code, WCAP-17601-P, PWROG-14207-P). Therefore, based on the evaluation above, the licensee's analytical approach should appropriately determine the sequence of events, including time-sensitive operator actions, and the required equipment to mitigate the analyzed ELAP event, including pump sizing and cooling water capacity.

3.2.3.3 Reactor Coolant Pump Seals

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

MPS, Unit 3 is a four-loop Westinghouse pressurized-water reactor with one Westinghouse RCP in each loop. The RCPs at MPS 3 originally used standard three-stage Westinghouse seal packages. MPS, Unit 3 has since replaced the four Westinghouse-designed RCP seals with low-leakage Flowserve NX seals with the Abeyance feature. The licensee further stated that it intends to install additional NX seals in place of the two remaining Westinghouse RCP seals during the spring 2016 outage.

The NX seal is a product in Flowserve's N-seal line of hydrodynamic seals that was developed in the 1980s. One of the design objectives for the N-seal was to provide low-leakage performance under loss-of-seal-cooling conditions during events such as a station blackout. In support of its customers' efforts to address the ELAP event (which similarly involves a loss of seal cooling) in accordance with Order EA-12-049, on August 3, 2015, Flowserve submitted to the NRC staff its "White Paper on the Response of the N-Seal Reactor Coolant Pump (RCP) Seal Package to Extended Loss of All Power (ELAP)," (ADAMS Accession No. ML15222A366). The N-Seal white paper contains information regarding the expected leakage rates over the course of an ELAP event for each PWR at which Flowserve N-Seals are currently installed. By letter dated November 12, 2015 (ADAMS Accession No. ML15310A094), the staff endorsed the leakage rates described in the white paper for the beyond-design-basis ELAP event, subject to certain limitations and conditions.

During the audit, the NRC staff considered the status of the licensee's conformance with the Flowserve N-Seal white paper and the limitations and conditions in the NRC staff's endorsement letter. In particular, as noted in the Flowserve white paper, the licensee confirmed that the plant design and planned mitigation strategy of MPS 3 are consistent with the information assumed in the calculation performed by Flowserve, as summarized in Table 1 of the white paper. The NRC staff's audit of the applicable information from the Flowserve white paper against the strategy in the licensee's FIP further verified consistency. Additionally, the peak cold-leg temperature prior to the RCS cooldown assumed in Flowserve's analysis was found to be equivalent to the saturation temperature corresponding to the lowest setpoint for SG safety valve lift pressure in the MPS 3 Final Safety Analysis Report (FSAR). Based on its audit review, the NRC staff further considered the intent of the endorsement letter's condition on the density of the coolant leaking from the RCS to be satisfied inasmuch as ample margin is available between the time that the licensee's mitigating strategy would supply RCS makeup and the time at which entry to reflux cooling would be expected to occur for the analyzed ELAP event.

Therefore, based on 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.

3.2.3.4 Shutdown Margin Analyses

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

- the cooldown of the RCS and fuel rods adds positive reactivity

- the concentration of xenon-135, which (according to the core operating history assumed in NEI 12-06) would
    - initially increase above its equilibrium value following reactor trip, thereby adding negative reactivity
    - peak at roughly 12 hours post-trip and subsequently decay away gradually, thereby adding positive reactivity

- the passive injection of borated makeup from nitrogen-pressurized accumulators due to the depressurization of the RCS, which adds negative reactivity

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

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

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

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

During the audit review, Dominion confirmed that MPS 3 will comply with the August 15, 2013, position paper on boric acid mixing, including the conditions imposed in the staff's corresponding endorsement letter. The NRC staff's audit review concluded that these conditions should be satisfied since (1) the licensee's analyses considered the appropriate range of RCS leakage conditions, (2) the licensee would initiate FLEX RCS makeup prior to RCS flow decreasing below the single-phase natural circulation flow rate, and (3) the licensee's plan for initiating RCS makeup would allow a one-hour delay period for boric acid mixing within the RCS.

During the audit, the NRC staff reviewed the licensee's shutdown margin calculation. The licensee's analysis determined that the injection of borated coolant is required by 25 hours into the event to ensure that recriticality can be avoided as the core xenon concentration decays away. According to the FIP, borated water will be injected into the RCS no later than 16 hours into the event. The licensee calculated that approximately 6500 gallons of 2700 ppm borated water from the RWST would be adequate to meet 1 percent shutdown margin requirements for RCS conditions commensurate with SG pressure of 290 psig (i.e., RCS cold leg temperature of approximately 419 °F). Although the RWST is not fully robust, the shutdown margin calculation considered this source of borated coolant as bounding other potential sources. The NRC staff considered this assessment reasonable because the boron concentration of other sources used for active FLEX injection is expected to be greater than or equal to this value. In particular, the BAST concentration is expected to be at least 6600 ppm boron, and plant operators would be procedurally directed to mix to a concentration of 2700 ppm boron using the portable batching tanks. The licensee's calculations do not credit the boron that may be injected passively from the safety injection accumulators (minimum concentration of 2600 ppm boron).

Per EOP 35 ECA-FSG-08, "Alternate RCS Boration," injection of a total of 10400 gallons of RWST water would be necessary to ensure adequate shutdown margin at the limiting end-of-cycle condition at a core inlet temperature of 350 °F. If the RWST is not available, 3900 gallons of the concentrated boric acid solution from the BASTs may be used; in addition, portable boric acid mixing tanks are available as a suction source for injecting the necessary quantity of borated water to maintain RCS subcriticality. MPS, Unit 3 will perform checks every core reload to determine that any core design changes do not adversely impact the approved FLEX strategies, especially the analyses which demonstrate that no recriticality will occur during a FLEX RCS cooldown.

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 in analyzed cases where minimal RCS leakage occurs. The licensee stated that its calculations indicated that the volume of borated coolant necessary for adequate shutdown margin could be accommodated by the RCS free volume available following the inventory contraction associated with the planned RCS cooldown. As such, the licensee expected that its high-pressure BDB RCS injection pump could inject the necessary coolant volume under ELAP conditions without the need for venting the RCS. The NRC staff reviewed these calculations and noted that, although not considered in the licensee's calculations, accumulator injection during the actual event may refill a significant portion of the available RCS free volume. However, due in part to the lack of available instrumentation during the event, quantifying and relying upon the boron passively injected by the accumulators may not be a viable option for plant operators. Therefore, in addition to being desirable from the standpoint of limiting the potential for RCS pressure increases during FLEX injection, RCS venting may effectively become a practical necessity in an actual event due to the limited information available to plant operators. During the audit, the licensee indicated that the reactor head vent lines contain dc-powered valves that would initially be deenergized by load shedding activities during Phase 1 of the FLEX mitigating strategy to extend the life of station batteries. However, the licensee indicated that the head vents can be reenergized via FSG-8, if necessary, and opened remotely from the main control room under ELAP conditions to support the addition of borated coolant to ensure adequate reactor shutdown margin.

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

3.2.3.5 FLEX Pumps and Water Supplies

For SG makeup, the licensee described in its FIP, the BDB High Capacity pump, which is sized to provide AFW to both MPS, Unit 2 and MPS, Unit 3 TDAFW pumps and makeup water to MPS Unit 2 and MPS 3 SFP simultaneously. The BDB High Capacity pump is a trailer-mounted, diesel driven centrifugal pump and it is deployed by towing the trailer to a designated draft location near the selected water source as described in SE Section 3.10. The licensee stated that only one BDB High Capacity pump is required to implement the Phase 1 and Phase 2 reactor core cooling and heat removal strategy for both MPS, Unit 2 and MPS, Unit 3. Two BDB High Capacity pumps are stored in the BDB Storage Building and available to satisfy the N+1 requirement. The licensee also described in its FIP, the BDB AFW pump, which serves as a backup to the Unit 3 TDAFW pump if it is unavailable due to insufficient turbine inlet steam flow from the SGs. The BDB AFW pump is a trailer-mounted, diesel driven centrifugal pump that is deployed from the BDB Storage Building. The licensee stated that there are three BDB AFW pumps, one for each Unit and one additional pump, to satisfy the N+1 requirement in NEI 12-06.

For RCS makeup, the licensee described in its FIP, that the BDB RCS Injection pump is designated to provide RCS makeup at 100 psi above the current reactor vessel head to allow for RCS injection. The licensee indicated that Unit 3 is capable of receiving RCS makeup from either one BDB RCS Injection pump, which takes suction from the RWST or BASTs as described in SE Section 3.10. The licensee stated that there are two BDB RCS Injection pumps that are stored in the BDB Storage Building to meet the N+1 requirement for RCS makeup as described in NEI 12-06. The licensee also described in its FIP, the Portable Boric Acid Mixing tanks, which are deployed from the BDB Storage Building to provide a suction source for the Unit 3 BDB RCS Injection pump. Dilution water is added to the mixing tank by either a portable transfer pump, or from a branch line from the BDB High Capacity pump header taking suction from a clean water source. Bags of powdered boric acid are mixed with dilution water to achieve the proper concentration for maintaining adequate shutdown margin while making up RCS inventory. The clean water mixing tank dilution sources are used in the same priority as the potential AFW sources as described in SE Section 3.10.

Section 11.2 of NEI 12-06 states that design requirements and supporting analysis should be developed for portable equipment that directly performs a FLEX mitigation strategy for core, containment, and SFP that provides the inputs, assumptions, and documented analysis that the mitigation strategy and support equipment will perform as intended. During the audit review, the licensee provided a FLEX hydraulic calculation (Calculation 13-015, Rev. 0, "MP2 & MP3 FLEX Strategy Hydraulic Calculations”), which evaluated the use of the FLEX pumps providing makeups to the SG, RCS, and SFP respectively. The calculations indicate that the above portable FLEX pumps were capable of performing their functions after a BDBEE event.

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

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

3.2.3.6 Electrical Analyses

The licensee's FIP [Reference 56] defined strategies capable of mitigating a simultaneous loss of ac power and loss of normal access to the LUHS resulting from a BDBEE by providing the capability to maintain or restore core cooling at MPS, Unit 3. The licensee's strategy for RCS inventory control uses the same electrical strategy as 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. Furthermore, the electrical coping strategies are the same for all modes of operation.

The NRC staff reviewed the licensee's FIP to determine whether the FLEX strategies, if implemented appropriately, should maintain or restore core cooling, containment, and spent fuel pool cooling following a BDBEE. As part of its review, the NRC staff reviewed conceptual electrical single-line diagrams, summaries of calculations for sizing the FLEX diesel and turbine generators and station batteries, and summaries of calculations that addressed the effects of temperature on the electrical equipment credited in the FIP as a result of losing heating, ventilation, and air conditioning (HVAC) during an ELAP as a result of a BDBEE. The NRC staff also reviewed the separation and isolation of the FLEX generators from the Class 1E emergency diesel generators (EDGs) and procedures that direct operators how to align, connect, and protect associated systems and components.

According to the licensee's FIP, operators respond to the ELAP/LUHS event in accordance with emergency operating procedures (EOPs) to confirm RCS, secondary system, and containment conditions. A transition to EOP 35 ECA-0.0, "Loss of All AC Power," is made upon the diagnosis of the total loss of ac power. This procedure (along with referenced FSGs) directs isolation of RCS letdown pathways, confirmation of natural circulation cooling, verification of containment isolation, reduction of dc loads on the station Class 1E batteries, and establishment of electrical equipment alignment in preparation for eventual power restoration.

The MPS, Unit 3 Phase 1 FLEX mitigation strategy involves relying on installed plant equipment and onsite resources, such as use of installed Class 1E station batteries, vital inverters, and the Class 1E dc electrical distribution system. This equipment is considered robust and protected with respect to applicable site external hazards since they are located within safety-related, Class 1 structures. As part of its Phase 1 FLEX mitigation strategy, the licensee will monitor containment temperature procedurally and, if necessary, reduce containment temperature to ensure that key containment instruments remain within analyzed limits for equipment qualification (See Section 3.4.4.4 for further information on the licensee's containment cooling strategy). The dc power from the station batteries will be needed in an ELAP for loads such as shutdown system instrumentation, control systems, and re-powered AOVs and MOVs. FSG-4, "ELAP DC Bus Load Shed and Management," Rev. 0, directs operators to conserve dc power during the event by stripping, or load shedding, nonessential loads. The plant operators would commence load shedding of the nonessential dc loads within 45 minutes after the occurrence of an ELAP/LUHS event. The licensee expects load shedding to be completed within the next 30 minutes. The MPS, Unit 3 vital batteries contain 60 cells each and were manufactured by Exide Technologies (models NCN-27 with 1945 ampere-hour and NCN-11 with 825 ampere-hour). The licensee noted and the staff confirmed that the useable station battery capacity could be extended up to 14 hours for Unit 3 by load shedding non-essential loads.

In its FIP, the licensee noted that it had followed the guidance in NEI White Paper, "EA-12-049 Mitigating Strategies Resolution of Extended Battery Duty Cycles Generic Concern," (ADAMS Accession No. ML13241A186) when calculating the duty cycle of the batteries. This paper was endorsed by the NRC by letter dated September 16, 2013 (ADAMS Accession No. ML13241A188). In addition to the White Paper, the NRC sponsored testing at Brookhaven National Laboratory that resulted in the issuance of NUREG/CR-7188, "Testing to Evaluate Extended battery Operation in Nuclear Power Plants," in May of 2015. The testing provided additional validation that the NEI White Paper method was technically acceptable. The NRC staff reviewed the licensee's battery calculations and confirmed that they had followed the guidance in the NEI White Paper.

Based on the evaluation above, the NRC staff concludes that the MPS Unit 3 load shed strategy should ensure that the batteries have sufficient capacity to supply power to required loads for at least 14 hours.

During the onsite portion of the audit, the NRC staff reviewed the summary of the licensee's dc system analysis (Calculation 2013-ENG-04501E3, "MP3 BDB Battery Calculation," Rev. 0) to verify the capability of the dc system to supply the required loads during the first phase of the MPS 3 FLEX mitigation strategies plan. The licensee's evaluations identified the required loads and their associated ratings (ampere (A) and minimum required voltage) and the loads that would be shed within 75 minutes of event initiation to ensure battery operation for least 14 hours. The strategy for MPS, Unit 3 is to power loads with one battery until it is nearly depleted and then switch to the other battery until this battery is depleted.

Based on the staff's review of the licensee's analysis, the battery vendor's capacity and discharge rates for the batteries, and the licensee's procedures, the NRC staff finds that the MPS, Unit 3 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 re-powering vital 120 Vac buses within 14 hours using a portable 23.3 kilowatt (kW) 120/240 Vac FLEX diesel generator (DG) stored in a robust BDB storage building located onsite. The licensee's primary strategy is to use a portable 120/240 Vac FLEX DG to supply power to MPS, Unit 3 vital 120 Vac circuits providing continuity of key parameter monitoring prior to the depletion of the Class 1E 125 V dc batteries. A portable 500 kW 480 Vac FLEX DG is available as an alternate to the 120/240 Vac FLEX DG. The licensee would deploy cables from the BDB Storage Building along with the FLEX DGs.

The portable, trailer mounted 120/240 Vac FLEX DG would be deployed to an area north of MPS, Unit 3 Control Building beside the MPS, Unit 3 EDG Building. The cables to connect the 120/240 Vac FLEX DG to the MPS electrical distribution system would be run through designated penetrations in the North Wall of the MPS Unit 3 Control Building. The cables would be connected to permanently installed receptacles boxes located on 120 Vac panels VIAC-1 and VIAC-3. The connection boxes are hard wired to the 120 Vac buses. As an alternate connection point, the licensee has made modifications to the 120 Vac vital panels VIAC-2 and VIAC-4 to allow connection of the 120/240 Vac FLEX DG output cables in the same manner as VIAC-1 and VIAC-3. The licensee expects that deploying and placing the 120/240 Vac FLEX DG into service can be completed in approximately 4 hours after the activity is initiated (this includes an estimated 2 hour time allotment for debris removal). Based on this, the licensee's transition to Phase 2 would occur much earlier than the calculated depletion of the Class 1E 125 V dc batteries.

The licensee's alternate strategy for re-powering 120 Vac vital circuits is to deploy one portable 480 Vac FLEX DG and connect to 480 Vac bus 32T. The portable 480 Vac FLEX DG and the required color-coded power cables will be transported from the BDB Storage Building to its staging area north of the MPS, Unit 3 Control Building beside the MPS Unit 3 EDG Building. The cables would be routed through a designated penetration in the North Wall of the MPS, Unit 3 Control Building. The licensee installed a new breaker in a spare breaker cubicle on the 32T bus in order to connect the 480 Vac FLEX DG. Re-powering Bus 32T allows for the continued operation of the key parameter monitoring instrumentation, recharging of the Class 1E 125 V dc batteries, and the restoration of other selected ac loads. Additionally, Appendix 8 of FSG-20, "Energizing Bus 22F from a BDB 480 Vac Generator," Rev. 0, provides direction for ensuring proper phase rotation before attempting to power equipment from the 480 Vac FLEX DG. The licensee expects that deploying and placing the 480 Vac DG into service can be completed approximately 7 hours after the activity has been initiated (this includes an estimated 2 hour time allotment for debris removal). Based on this, the licensee's transition to Phase 2 would occur much earlier than the calculated depletion of the Class 1E 125 V dc batteries.

The licensee's FLEX DG sizing calculation 2013-ENG-04503E3, "MP3 BDB – FLEX Electrical 4160V, 480V, and 120Vac System Loading Analysis," Rev. 1, identified the required loads to be 278.9 kW for the 480 Vac FLEX DG and 6.16 kW for the 120/240 Vac FLEX DG.

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

For Phase 3, MPS, Unit 3 plans to continue the Phase 2 coping strategy with additional assistance provided from offsite equipment/resources. The offsite resources that will be provided by the NSRCs includes two 1-MW 4160 Vac combustion turbine generators, a distribution panel (including cables and connectors), and a 480 Vac combustion turbine generator per unit. Each 4160 Vac combustion turbine generator is capable of supplying approximately 1 megawatt (MW) but two combustion turbine generators will be operated in parallel to provide approximately 2 MW (2.5 MVA at .8 power factor). Per calculation 2013-ENG-04503E3, "MP3 BDB – FLEX Electrical 4160V, 480V, and 120Vac System Loading Analysis," Rev. 1, the total loads for Phase 3 equals 1300 kW.

One of the Class 1E 4160 Vac buses is required for each unit to repower the containment cooling. The staff reviewed a summary of results and conclusion of the calculation 2013-ENG-04503E3, "MP3 BDB – FLEX Electrical 4160V, 480V, and 120Vac System Loading Analysis," Rev. 1. The components necessary to implement the various containment cooling options and for continuation of the Phase 2 coping strategy have been included in the calculations to support the sizing of the 4160 Vac combustion turbine generators. EOP 35 FSG-15, "4160 Vac Generator / RHR Cooldown with 6 Attachments," Rev. 000-01, provides direction for ensuring proper phase rotation before attempting to power equipment from the 4160 Vac combustion turbine generators. The 480 Vac combustion turbine generator has a capacity of 800 kW and would serve as a backup to the Phase 2 480 Vac FLEX DG. Based on its review, the NRC staff finds that the 4160 Vac equipment being supplied from the NSRCs 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, if implemented appropriately, should maintain or restore core cooling during an ELAP event consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.3 Spent Fuel Pool Cooling Strategies

In NEI 12-06, Table 3-2 and Appendix D, summarize an acceptable approach consisting of three separate capabilities for the SFP cooling strategies. This approach uses a portable injection source to provide the capability for 1) makeup via hoses on the refueling floor capable of exceeding the boil-off rate for the design-basis heat load; 2) makeup via connection to spent fuel pool cooling piping or other alternate location capable of exceeding the boil-off rate for the design-basis heat load; and 3) spray via portable monitor nozzles from the refueling floor using a portable pump capable of providing a minimum of 200 gallons per minute (gpm) per unit (250 gpm if overspray occurs). During the event, the licensee selects the method to use based on plant conditions. This approach also requires a strategy to mitigate the effects of steam from the SFP, such as venting.

As described in NEI 12-06, Section 3.2.1.7 and JLD-ISG-2012-01, Section 2.1, strategies that must be completed within a certain period of time should be identified and a basis that the time can be reasonably met should be provided. NEI 12-06, Section 3 provides the performance attributes, general criteria, and baseline assumptions to be used in developing the technical basis for the time constraints. Since the event is beyond design basis, the analysis used to provide the technical basis for time constraints for the mitigation strategies may use nominal initial values (without uncertainties) for plant parameters, and best-estimate physics data. All equipment used for consequence mitigation may be assumed to operate at nominal setpoints and capacities. 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.

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

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

3.3.1 Phase 1

The licensee stated in its FIP, that no operator action is needed for Phase 1 other than monitoring the SFP level using instrumentation installed as required by NRC Order EA-12-051. The licensee's evaluation of the SFP concluded that without operator action following a loss of SFP cooling at the maximum design heat load, the MPS, Unit 3 SFP inventory reaches 212 °F in approximately 10 hours and boils off to a level of 10 ft. above the top of fuel in 50 hours from declaration of ELAP.

3.3.2 Phase 2

The licensee stated in its FIP, that the Phase 2 strategy is to initiate SFP makeup within 24 hours of the event by running a branch hose from the BDB High Capacity pump to the BDB SFP makeup connection located inside the MPS Unit 3 Fuel Building loading bay. The BDB SFP makeup connection piping ties into an existing open ended line which will discharge directly into the SFP. Makeup to the SFP will be provided from the RWST or from one branch of the MPS, Unit 3 distribution manifold being supplied from the BDB High Capacity pump. The BDB High Capacity pump is trailer mounted and is towed to an available draft point by one of the BDB tow vehicles also located within the protected BDB Storage Building. Additionally, a 100 ft. section of fire hose will be pre-staged adjacent to the SFP connection. Required hose lengths and fittings are located in the BDB Storage Building. In the event of an ELAP, the pre-staged hose will be connected to the FLEX SFP connection and deployed out the east personnel door as part of the initial deployment of BDB equipment specified in EOP 35 FSG-05 to ensure the hose connection location is accessible. Also, an available alternate FLEX strategy consists of deploying a hose directly to the spent fuel pool area. Additionally, as required by NEI 12-06, spray monitors and sufficient hose length required for the SFP Spray Option are located in the BDB Storage Building.

3.3.3 Phase 3

The licensee stated in its FIP, that the NSRC will provide additional Low Pressure/High Flow pumps to backup to the onsite BDB High Capacity pumps to continue to makeup to the SFP. The NSRC will also provide two 4160 Vac generators which can be used to re-power SFP cooling systems if emergency buses are available or restored.

3.3.4 Staff Evaluations

3.3.4.1 Availability of Structures, Systems, and Components

3.3.4.1.1 Plant SSCs

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

The NRC staff reviewed the licensee's calculation on habitability on the SFP refuel floor. The calculation and the FIP indicate that boiling begins at approximately 10 hours during a normal, non-outage situation. The staff noted that the licensee's sequence of events timeline in its FIP indicates that operators will deploy hoses and spray nozzles as a contingency for SFP makeup within 24 hours after event initiation to ensure the SFP area remains habitable for personnel entry.

As described in the licensee's FIP, the licensee's Phase 1 SFP cooling strategy does not require any anticipated actions. However, the licensee does establish a ventilation path to cope with temperature, humidity, and condensation from evaporation and/or boiling of the SFP. The operators are directed by the FSG-05 to open 5 doors in the Fuel Building after ELAP is declared and prior to the 6 hour mark for SFP boiling to begin. Two rollup doors are on the 24' - 6" level of the Fuel Building. The third rollup door connects the east side of the Shipping Cask Area on the 52' elevation to the lower 24' - 6" elevation of the Fuel Building. Additionally, there is a personnel door from the north side of the SFP cask area on the 55' - 9" elevation into a stairwell and another door from the stairwell to the roof at the same elevation. The opening of these doors provide both a vent path for steam and allows for a flow path of cool air to enter the area from the rollup doors on the 24'- 6" level and exit through the Shipping Cask Area door on the 55' - 9" elevation of the Fuel Building. As with Unit 2, the operators are also instructed by EOP 35 FSG-05 to obtain portable fans from the BDB Storage Building to place at the New Fuel Receiving area door to enhance the ventilation.

The licensee's Phase 2 and Phase 3 SFP cooling strategy involves use of the BDB High Capacity pump with associated hoses and fittings taking suction from RWST or from one branch of the MPS Unit 3 distribution manifold. The staff's evaluation of the robustness and availability of FLEX connections points for the FLEX pump is discussed in Section 3.7.3.1 below. Furthermore, the staff's evaluation of the robustness and availability of the UHS for an ELAP event is discussed in Section 3.10.3.

3.3.4.1.2 Plant Instrumentation

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

3.3.4.2 Thermal-Hydraulic Analyses

Section 11.2 of NEI 12-06 states, in part, that design requirements and supporting analysis should be developed for portable equipment that directly performs a FLEX mitigation strategy for core, containment, and SFP that provides the inputs, assumptions, and documented analysis that the mitigation strategy and support equipment will perform as intended. In addition, NEI 12-06, Section 3.2.1.6, Condition 4 states that SFP heat load assumes the maximum design basis heat load for the site. In accordance with NEI 12-06, the licensee performed a thermal-hydraulic analysis of the SFP as a basis for the inputs and assumption used in its FLEX equipment design requirements analysis. The licensee evaluated the SFP with the maximum design-basis heat loads to conclude that the minimum time to boiling is 10 hours with loss of normal SFP cooling with bulk boiling temperature of 212 °F in the SFP. During the audit, the licensee provided Calculation 13-015, Rev. 0, "MP2 & MP3 FLEX Strategy Hydraulic Calculations," which concluded that the flowrate of 90 gpm is needed to makeup to the SFP using the BDB High Capacity pump. The licensee concluded that the required SFP makeup is needed within 24 hours of a declaration of an ELAP. The staff evaluated the calculation during the audit and verified that the licensee's analysis of utilizing the BDB High Capacity pump is capable of providing the necessary flow needed for SFP makeup.

Based on the information contained in the FIP and the above hydraulic analysis, the NRC staff finds that the licensee has provided a thorough analysis that considered maximum design-basis SFP heat load during operating, pre-fuel transfer or post-fuel transfer operations, the basis for assumptions and inputs used in determining the design requirements for FLEX equipment used in SFP cooling consistent with NEI 12-06 Section 3.2.1.6, Condition 4 and Section 11.2.

3.3.4.3 FLEX Pumps and Water Supplies

As described in the FIP, the SFP cooling strategy relies on the BDB High Capacity pump to provide SFP makeup during Phase 2. In the FIP, Section 2.4.7 describes the hydraulic performance criteria (e.g., flow rate, discharge pressure) for the BDB High Capacity pump. The staff noted that the performance criteria of FLEX pumps supplied from an NSRC for Phase 3 would allow the NSRC pumps to fulfill the mission of the onsite FLEX pump if the BDB High Capacity pump was to fail. As stated in the FIP, the SFP makeup rate of 250 gpm and SFP spray rate of 250 gpm both meet or exceed the minimum SFP makeup requirements as outlined in the previous section of this SE.

3.3.4.4 Electrical Analyses

The licensee's FIP defines strategies capable of mitigating a simultaneous loss of all ac power and loss of normal access to the UHS, resulting from a BDBEE, by providing the capability to maintain or restore core cooling, containment, and spent fuel pool cooling at all units on the MPS site. Furthermore, the electrical coping strategies are the same for all modes of operation.

The NRC staff performed a comprehensive analysis of the licensee's electrical strategies, which includes the SFP cooling strategy. The only electrical components credited by the licensee as part of its FLEX mitigation strategies, outside of instrumentation to monitor spent fuel pool level (which is described in other areas of this safety evaluation), are two 4160 Vac combustion turbine generators and a distribution panel (including cables and connectors) that will be supplied by an NSRC. According to the licensee’s FIP, these generators could be used to re-power spent fuel pool cooling systems, if necessary. The staff reviewed calculation 2013-ENG-04503E3, “MP3 BDB – FLEX Electrical 4160V, 480V, and 120Vac System Loading Analysis,” Rev. 1, and determined that the 4160 Vac equipment being supplied from the NSRCs has sufficient capacity and capability to supply spent fuel pool cooling systems, if necessary.

3.3.5 Conclusions

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

3.4 Containment Function Strategies

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

In accordance with NEI 12-06, the licensee performed a containment evaluation referenced in ETE-CPR-2012-0008, Rev. 4, “BDB Guidance Document for ELAP Mitigating Strategies, Unit 3,” which was based on the boundary conditions described in Section 2 of NEI 12-06. The calculation concludes that the containment parameters of pressure and temperature remain well below the respective design limits of 45 psig and 260 °F (FSAR Section 2.2, Containment Systems) for a minimum of 7 days. In addition, essential instruments subject to the containment environment will remain functional for a minimum of 7 days. From its review of the evaluation, the NRC staff noted that the required actions to maintain containment integrity and required instrumentation functions have been developed, and are summarized below.

The NRC staff reviewed calculation MISC-11793, Rev.0, “Evaluation of Long Term Containment Pressure and Temperature Profiles Following Loss of Extended AC Power (ELAP).” The calculation uses the Generation of Thermal-Hydraulic Information for Containments (GOTHIC) Version 7.2a computer program. The calculation forecasts the Containment pressure and temperature (pressures and temperatures are highest in the reactor cavity compartment) initially rise on loss of normal containment cooling to approximately 17.5 psia and 142 °F, respectively. Approximately, after the first 20 minutes, the containment temperature and pressure gradually increases at a steady state. The maximum Containment pressure reached was calculated to be 28.46 psia (at 168 hours), remaining well below the design-basis limit of 45 psig. The calculation also indicates the maximum Containment temperature reached was 203.1 °F (at 168 hours), which remains below the design limit of 260 °F.

Eventual containment cooling and depressurization to normal values will utilize off-site equipment and resources during Phase 3 if onsite capability is not restored.

3.4.1 Phase 1

In its FIP, the licensee indicated that Phase 1 would involve initiating and verifying containment isolation as instructed in EOP 35 ECA-0.0, “Loss of All AC Power.” The licensee also stated that containment temperature and pressure would be monitored from the Main Control Room using installed instrumentation

The results of the containment analysis confirm that the Containment function is not challenged early in the event. Therefore, no Phase 1 actions are required to maintain Containment integrity.

3.4.2 Phase 2

In its FIP, the licensee indicated that Phase 2 activities would be to repower key instrumentation required to continue containment monitoring and also return the instrumentation necessary to monitor containment sump level. The operators will continue to monitor containment pressure and temperature using installed instrumentation.

3.4.3 Phase 3

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

The Phase 3 coping strategy, discussed above, is to obtain additional electrical capability and redundancy for on-site equipment until such time that normal power to the site can be restored. This capability will be provided by two mobile 1MW 4.16kV generators and a distribution panel from the NSRC for Unit 3. Two mobile 4.16kV generators will be brought in from the NSRC in order to supply power to the Class 1E 4.16kV Vac bus. The licensee also indicated that power can be restored to the Class 1E 480 Vac through the 4160/480 Vac transformers to power selected 480 Vac loads.

If the service water (SW) pumps are not available, then Low Pressure/High Flow diesel driven pumps (up to 5,000 gpm) from the NSRC are available to provide flow to existing site heat exchangers in order to remove heat from the containment atmosphere.

3.4.4 Staff Evaluations

3.4.4.1 Availability of Structures, Systems, and Components

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

3.4.4.1.1 Plant SSCs

The containment for Unit 3 consists of a cylindrical, painted carbon steel lined, reinforced concrete structure which encloses the components and major piping within the reactor coolant pressure boundary. The structure is designed to contain the radioactive fluids and fission products which may result from postulated accidents inside the containment.

The containment is a subatmospheric-type containment. During normal operation the containment structure is maintained at approximately atmospheric pressure to minimize containment leakage during normal plant operation.

The Reactor Plant Component Cooling Water (RPCCW) system is required to provide a heat sink for the containment air recirculation fans. It then transfers the heat load through the SW system to the UHS. The RPCCW flow is manually controlled by throttling valves to the components being cooled. The licensee indicated that power restoration to the MOVs will allow the RPCCW to be supplied to the CAR fan coolers instead of their normal chilled water supply in order to provide containment cooling.

The safety-related and seismic protected SW header and piping are used to deliver SW to the RPCCW Heat Exchanger by placing a blind flange adapter for the "A" EDG Heat Exchanger SW inlet end bell with multiple connection fittings to accommodate the NSRC low pressure/high flow pump. The low pressure/high flow diesel driven pump from the NSRC will be positioned to draw from the UHS to discharge water through multiple fire hoses to the "A" EDG Heat Exchanger SW inlet end bell adapter.

For the spray option, the licensee described in its FIP the use of the existing Quench Spray pump repowered to spray water into the containment if the RWST is available. Once sufficient sump level is obtained, then the existing Recirculation Spray pump would be used to continue the spray strategy option. If the RWST is not available, an adapter flange in place of an expansion joint on the inlet side of the "A" containment recirculation cooler will be used to connect the BDB High Capacity pump to the containment spray system to provide spray flow in containment.

3.4.4.1.2 Plant Instrumentation

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

The above essential instrumentation will be available prior to and after load stripping of the dc and ac buses during Phase 1. All indications will be in the Control Room (CR). Should any of the signal cabling to the CR indicators be damaged or dc power lost, all process parameters can be obtained at remote locations with portable meters. Procedure EOP 35 FSG-07 provides location and termination information in the CR for all essential instrumentation. Instrumentation providing containment sump level indication is available in the CR for Phases 2 and 3 for the containment cooling spray option. Also, instrumentation for use in Phase 3 containment cooling options, such as SW flow rate (either from plant equipment or portable pump), RPCCW flow rate, RPCCW temperature, and RPCCW pressure is available to the operators once the instruments are repowered from temporary generators installed prior to implementing this strategy. The use of these instruments is detailed in the associated FSGs for use of the equipment. These procedures are based on inputs from the equipment suppliers, operation experience, and expected equipment function in an ELAP.

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

3.4.4.2 Thermal-Hydraulic Analyses

The licensee stated in its FIP that the containment temperature and pressure remains below containment design limits and that key parameter instruments subject to the containment environment remains functional for a minimum of seven days. The licensee stated that the containment temperature is procedurally monitored and, if necessary, the containment temperature is reduced so that key containment instruments will remain within their analyzed limits for equipment qualification.

The licensee provided calculation MISC-11793, Rev.0, "Evaluation of Long Term Containment Pressure and Temperature Profiles Following Loss of Extended AC Power (ELAP)," during the audit. This calculation used the GOTHIC (Generation of Thermal-Hydraulic Information for Containments) 7.2a computer program. The analysis evaluates the containment response with the plant initially at full power in Mode 1 at the time of a BDBEE, and bounds plant configurations in Modes 1 through 4 with steam generators available. The limiting containment initial conditions (i.e. Pressure, Temperature and Humidity) are assumed to correspond to the value used for the plant specific limiting peak pressure analysis. The calculation modeled the containment pressure and temperature over a 168-hour period during an ELAP event.

The hydraulic analysis, as provided in calculation ENG-13-015, Rev.1, "MP2 and MP3 FLEX Strategy Hydraulic Calculation," describes the TDAFW pump supplying SG makeup at 600 seconds (10 minutes). A continuous source of SG secondary makeup is assumed to be available. Plant cooldown at a rate of 75 °F/hr commences at 7200 seconds (2 hours) by manual operation of ADVs. The assumed reactor coolant leakage is 21 gpm per RCP.

The maximum containment pressure reached for Unit 3 was calculated to be 28.46 psia, remaining well below the design-basis limit of 45 psig. The calculation also indicates the maximum Containment temperature reached for Unit 2 is 203.1 °F, which remains below the design limit of 260 °F. The NRC staff confirmed that the licensee's containment evaluation would be adequate for supporting FLEX strategies within 7 days.

3.4.4.3 FLEX Pumps and Water Supplies

The NSRC is providing a low pressure/high capacity pump which will be used to provide cooling flow from Long Island Sound to the SW system. The licensee also indicated in the FIP that a low pressure/medium flow pump would also be available from the NSRC.

3.4.4.4 Electrical Analyses

The licensee evaluated several options to provide the operators with the ability to reduce the containment temperature for Phase 3, such as establishment of CAR fan cooling or containment spray options utilizing the RS system utilizing clean water from the RWST.

The licensee indicated that to implement containment cooling using CAR fan option, the 4160 Vac turbine generators from the NSRC will need to be aligned to power a Class 1E 4160 Vac bus and a 480 Vac bus. The 4160 Vac turbine generators will provide power to the existing CC Water system and the SW pumps (if available), an IA system compressor, and either the CAR fan motors. For implementing containment cooling using the containment spray option, the 4160 Vac turbine generators will be aligned to power one of the Class 1E 4160 Vac and 480 Vac buses on each unit, which will provide power to the RS pump motor.

The licensee performed a containment evaluation based on the boundary conditions described in Section 2 of NEI 12-06. Based on the results of this analysis, the licensee developed required actions to ensure maintenance of containment integrity and required instrumentation function. With an ELAP initiated, while either MPS unit is in Modes 1-4, containment cooling for that unit is also lost for an extended period of time. Therefore, containment temperature and pressure will slowly increase. Structural integrity of the reactor containment building due to increasing containment pressure will not be challenged during the first several weeks of an ELAP/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 for a minimum of seven days. Therefore, actions to reduce containment temperature and pressure and to ensure continued functionality of the key parameters will not be required immediately.

The licensee's Phase 1 coping strategy for containment involves initiating and verifying containment isolation per EOP 35 ECA-0.0, "Loss of All AC Power." These actions ensure containment isolation following an ELAP/LUHS. Phase 1 also includes monitoring containment temperature and pressure using installed instrumentation. Control room indication for containment pressure and containment temperature is available for the duration of the ELAP/LUHS.

The licensee's Phase 2 coping strategy is to continue monitoring containment temperature and pressure using installed instrumentation. Phase 2 activities to repower key instrumentation are required to continue containment monitoring and also return the instrumentation necessary to monitor containment sump level.

The licensee evaluated several options to provide operators with the ability to reduce the containment temperature. Each of these options would require the restoration of multiple support systems to remove heat from the containment thus reducing containment temperature and pressure. The various containment cooling strategy options are discussed in Section 2.5.3 of the licensee's FIP. To reduce containment temperature and ensure continued functionality of the key parameters, the licensee will utilize existing plant systems that will be powered by a combination of onsite (480 Vac FLEX DG) and offsite equipment during Phase 3. This capability will be provided by two 1 MW, 4160 Vac combustion turbine generators and a distribution panel, which will be brought in from the NSRCs in order to supply power to the 34C Class 1E 4160 Vac buses. Additionally, by restoring the Class 1E 4160 Vac bus, power can be restored to the Class 1 E 480 Vac buses via the 4160/480 Vac transformers to power selected 480 Vac loads.

The NRC staff reviewed the summary of calculation 2013-ENG-04503E3, "MP3 BDB – FLEX Electrical 4160V, 480V, and 120Vac System Loading Analysis," Rev. 1, and determined that the electrical equipment available onsite (i.e., 480 Vac FLEX DG) coupled with the electrical equipment that will be supplied from the NSRCs (i.e., 480 Vac and 4160 Vac combustion turbine generators) has sufficient capacity and capability to supply the required loads to reduce containment temperature and pressure, if necessary, to ensure that key instrumentation remains functional.

3.4.5 Conclusions

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

3.5 Characterization of External Hazards

Sections 4 through 9 of NEI 12-06, Revision 0, provide the methodology to identify and characterize the applicable BDBEEs for each site. In addition, NEI 12-06 provides a process to identify potential complicating factors for the protection and deployment of equipment needed for mitigation of site-specific external hazards leading to an ELAP and loss of normal access to UHS.

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

The licensee reviewed the plant site against NEI 12-06 and determined that FLEX equipment should be protected from the following hazards: seismic; external flooding; severe storms with high winds; snow, ice and extreme cold; and extreme high temperatures. No external hazards, from those described in NEI 12-06, were screened out.

References to external hazards within the licensee's mitigating strategies and this SE are consistent with the guidance in NEI-12-06 and the related interim staff guidance in JLD-ISG-2012-01 [Reference 7]. Coincident with the issuance of the order, on March 12, 2012, the NRC staff issued a Request for Information Pursuant to Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f) [Reference 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.

The NRC staff requested Commission guidance related to the relationship between the reevaluated flooding hazards provided in responses to the requested information and the requirements for Order EA-12-049 and related rulemaking to address beyond-design-basis external events (see COMSECY-14-0037, Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards" [Reference 52].) The Commission provided guidance in a Staff Requirements Memorandum (SRM) to COMSECY-14-0037 [Reference 20]. The Commission approved the staff's recommendations that licensees need to address the reevaluated flooding hazards within their mitigating strategies for BDBEEs, and that licensees may need to address some specific flooding scenarios that could significantly impact the power plant site by developing scenario-specific mitigating strategies, possibly including unconventional measures, to prevent fuel damage in reactor cores or SFPs. The NRC staff did not request that the Commission consider making a requirement for mitigating strategies capable of addressing the reevaluated flooding hazards be immediately imposed, and the Commission did not require immediate imposition. In a letter to licensees dated September 1, 2015 [Reference 37], the NRC staff informed the licensees that the implementation of mitigation strategies should continue, as described in licensee's OIPs, and that the related NRC SEs and inspections will rely on the guidance provided in JLD-ISG-2012-01, Rev. 0 [Reference 7] and the related industry guidance in Revision 0 to NEI 12-06 [Reference 6]. The reevaluations may also identify issues to be entered into corrective action programs consistent with the OIPs submitted in accordance with Order EA-12-049.

The licensee has submitted its flood hazard reevaluation report (FHRR) [Reference 21], and the NRC staff has issued an Interim Staff Response Letter to provide a summary of the staff's assessment and the results are discussed in Section 3.5.2 below. The licensee developed its OIP for mitigation strategies in February 2013 [Reference 10] by considering the guidance in NEI 12-06 and its then-current design-basis hazards. Therefore, this SE makes a determination based on the OIP and FIP, and notes the possibility of future actions by the licensee if the licensee's FHRR identifies a flooding hazard that exceeds the current design-basis flooding hazard.

Per the 50.54(f) letter, licensees were also asked to provide a seismic hazard screening and evaluation report to reevaluate the seismic hazard at their site. The licensee submitted its seismic hazard screening report (SHSR) [Reference 22] in March 31, 2014, and the NRC staff has completed a review and the results are discussed in Section 3.5.1 below. Therefore, this SE makes a determination based on the OIP and FIP, and notes the possibility of future actions by the licensee if the licensee's SHSR identifies a seismic hazard that exceeds the current design-basis seismic hazard.

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

3.5.1 Seismic

In its FIP, the licensee stated that seismic hazards are applicable to the site. From the SHSR for MPS, Unit 3, a safe shutdown earthquake (SSE) of 0.17g in the horizontal direction and 2/3 of this value in the vertical direction, input at the bedrock surface, has been used as the design basis for seismic loading.

As previously discussed, the NRC issued a 50.54(f) letter [Reference 19] that requested facilities to reevaluate the site's seismic hazard. In addition, the 50.54(f) letter requested that licensees submit, along with the hazard evaluation, an interim evaluation and actions planned or taken to address the reevaluated hazard where it exceeds the current design-basis seismic hazard.

By letter dated March 31, 2014 [Reference 22], the licensee submitted its SHSR for MPS, Units 2 and 3 to the NRC. The licensee concluded in the report that the Individual Plant Examination of External Events (IPEEE) is adequate for seismic screening purposes and both MPS, Units 2 and 3 screen out of conducting additional seismic risk evaluations.

The NRC endorsed industry guidance "Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," provides the criteria used to determine if the licensee's IPEEE submittal is adequate to use for seismic screening purposes. If one or more of the criteria are not deemed adequate, the staff may still decide that the overall IPEEE analysis is adequate to support its use for seismic screening of MPS, Unit 3.

The NRC staff completed its review of the licensee's SHSR, as documented by letter dated December 15, 2015 [Reference 47]. This assessment was later supplemented by letter dated March 15, 2016 [Reference 28]. The NRC staff reviewed the information provided by the licensee for the reevaluated seismic hazard for the MPS site. Based on its review, the NRC staff concluded that the licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance, it appropriately characterized the site given the information available, and met the intent of the guidance for determining the reevaluated seismic hazard. The NRC staff concluded that the licensee demonstrated that the IPEEE plant level high confidence of low probability of failure (HCLPF) spectra (IHS) could be used for comparison with the ground motion response spectrum (GMRS) for the screening determination. Based on the preceding analysis, the staff concluded that the licensee provided an acceptable response to Requested Information Items (1) - (3), (5) - (7) and the comparison portion of (4) identified in Enclosure 1 of the 50.54(f) letter. Further, the licensee's reevaluated seismic hazard is acceptable to address other actions associated with NTTF Recommendation 2.1: Seismic.

In reaching this determination, and as stated in the October 27, 2015, letter, the NRC staff confirmed that a seismic risk evaluation (Item 8) is not merited. Further, the NRC staff confirmed the licensee's conclusion that the licensee's GMRS for the MPS site exceeds the IHS over the frequency range of above 10 Hertz. Therefore, the high-frequency HF confirmation portion of Item (4) is merited. A SFP evaluation (Item 9) is merited because the SFP was not included in the IPEEE program. A relay chatter evaluation will be needed for the IPEEE submittal to meet the SPID acceptance criteria if Dominion plans to rely on IPEEE results in its mitigation strategies assessment with respect to the reevaluated hazard.

The NRC review and acceptance of either a SFP evaluation and a HF confirmation or a SFP evaluation, HF confirmation and an IPEEE relay chatter review for MPS will complete the Seismic Hazard Evaluation identified in Enclosure 1 of the 50.54(f) letter. As the license's seismic reevaluation activities are completed, the licensee will address any potential safety issues by implementing appropriate corrective actions.

Based the information available for this review, the staff concludes that the licensee has appropriately screened in this external hazard and identified the hazard levels to be evaluated.

3.5.2 Flooding

In its FIP, the licensee described the limiting flooding for MPS, Unit 3. Since MPS is located on a peninsula projecting into Long Island Sound, it is subjected to tidal flooding from severe storms. The highest such flooding has resulted from the passage of hurricanes. For a probable maximum hurricane, the maximum still water level was determined to be +19.7 feet mean sea level (msl) with an associated wave runup elevation of +23.8 feet msl. Most safety-related equipment is protected from flooding since the site grade elevation is +24 feet msl. The service water pumps and motors are located at elevation +14.5 feet msl inside watertight cubicles of the pumphouse. The front wall of the intake structure extends to elevation +43 feet msl and is designed to withstand the forces of a standing wave or clapotis with a crest elevation of +41.2 feet msl.

In its March 2, 2015, six-month update [Reference 14] the licensee discussed internal flooding sources that are not seismically robust and do not require ac power and concluded that there are no credible internal flooding concerns that would impact implementation of FLEX.

The effect of local intense precipitation (LIP) has been evaluated onsite for existing structures containing safety-related equipment. It was determined that water accumulation from this precipitation event would not have an adverse effect on safety-related equipment.

The licensee stated in its FIP, that since there are no major rivers or streams in the vicinity of the station, the effects of potential seismically induced dam failures are not applicable.

The licensee has submitted its FHRR [Reference 21]. The flood reevaluation considered eight potential flood-causing mechanisms including a combined effect flood required by the 50.54(f) letter. The reevaluation showed that the current design-basis flood levels are exceeded for the following potential flood mechanisms: tsunami, LIP, and combined effect flood. The combined effects flooding due to storm surge is the bounding event that exceeds the current licensing basis flood level.

In its FHRR, the licensee stated that an integrated assessment will be performed in response to the results of the combined effects flood hazards for MPS, Unit 3 and the MPS, Unit 3 intake structure will be evaluated based on increased flood levels and new/increased structural loading.

The NRC staff plans to issue an Interim Staff Response Letter to provide a summary of the NRC Staff's assessment of the reevaluated flood-causing mechanisms described in the FHRR. The NRC staff also plans to issue a staff assessment documenting the detailed basis for the conclusions to be issued in the interim staff response letter at a later time.

As the licensee's flooding reevaluation activities are completed, the licensee will take action to address any potential safety issues. Based on the information available for this review, the licensee has appropriately screened in this external hazard and identified the hazard levels to be evaluated.

3.5.3 High Winds

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

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

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

In its FIP, regarding the determination of applicable extreme external hazards, the licensee stated that MPS is located on the north shore of the Long Island Sound. As such, it is exposed to tropical storms and hurricanes coming off the Atlantic Ocean. According to a statistical study by Simplon and Lawrence (1971), the 50-mile segment of coastline on which MPS is located, was crossed by five hurricanes during the 1886 to 1970 period. Based on observations from Montauk Point (located about 23 miles southeast of MPS on the eastern tip of Long Island), the maximum reported wind speed in the region was associated with the passage of a hurricane during which sustained winds of 115 mph, with short-term gusts up to 140 mph (Dunn and Miller 1960) were observed.

According to a study of tornado occurrences during the period of 1955 through 1967 (augmented by 1968 – 1981 storm data reports), the mean tornado frequency in the one-degree (latitude-longitude) square where the MPS site is located is determined to be approximately 0.704 per year. The design basis tornado for MPS, Unit 3 was developed from Regulatory Guide 1.76. The tornado model used for design purposes at MPS, Unit 3 has a 290 mph rotational velocity and a 70 mph translational velocity

The NRC staff referred to applicable guidance in NEI 12-06 to confirm the information provided in the FIP. Based on this review, the staff found that high-wind hazards are applicable to the plant site. Therefore, the licensee has appropriately screened in the high wind hazard and characterized the hazard in terms of wind velocities and wind-borne missiles.

3.5.4 Snow, Ice, and Extreme Cold

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

The MPS site is located north of the 35th Parallel. In its FIP, regarding snow, ice and extreme cold, the licensee stated that the mean annual snowfall at the present Bridgeport location is 25.3 inches, with totals (based on data from 1932 through 1990) ranging from 8.2 inches in the 1972-1973 season, to 71.3 inches in the 1933-1934 season. The maximum monthly snowfall, occurring in February 1934, was 47.0 inches. Since 1949, both the maximum measured snowfall in 24 hours (16.7 inches), and the greatest snowfall in one storm (17.7 inches) occurred during the same storm in February 1969. The maximum measured snowfall in 24 hours (16.7 inches) was matched again in January 1978. For the time period following the reported values in the FSAR, the National Weather Service reported a maximum measured snowfall in 24 hours of 18.5 inches in February 2013. An average of 18.5 hours of freezing rain and 8.5 hours of freezing drizzle occur annually in the region. In the 32-year period from 1949 to1980, all cases of freezing precipitation were reported as light (less than 0.10 inch per hour), except for 1 hour of moderate (0.10 to 0.30 inch per hour). Winters are moderately cold, but seldom severe. Minimum daily temperatures during the winter months are usually below freezing, but subzero readings are observed, on the average, less than one day every 2 years. Below zero temperatures have been observed in each winter month, with an extreme minimum of -20 °F occurring in February 1934.

The staff referred to applicable guidance in NEI 12-06 to confirm the information provided in the FIP was accurate. Based on the available local data and Figures 8-1 and 8-2 of NEI 12-06, the staff confirmed that the site does experience significant amounts of snow, ice, and extreme cold temperatures; therefore, the hazard is screened in. Therefore, the licensee has appropriately screened in the hazards of snow, ice, and extreme cold.

3.5.5 Extreme Heat

In the section of its FIP regarding the determination of applicable extreme external hazards, the licensee stated that, as per NEI 12-06 section 9.2, all sites are required to consider the impact of extreme high temperatures.

The licensee stated in its FIP, that due to the proximity of Long Island Sound and the Atlantic Ocean, the heat of summer is moderated. Temperatures of 90 °F or greater occur an average of seven days per year at Bridgeport, while temperatures of 100 °F or greater have occurred only in July and August; with an extreme maximum of 104 °F occurring in July 1957.

The NRC staff reviewed applicable guidance in NEI 12-06 to confirm that the information provided for this hazard was acceptable. Based on the available local data and the guidance in Section 9 of NEI 12-06, the NRC was able to confirm that the plant site does experience extreme high temperatures. Therefore, 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 adequately addresses the requirements of the order in regard to the characterization of external hazards.

3.6 Planned Protection of FLEX Equipment

3.6.1 Protection from External Hazards

In its FIP, the licensee stated that the BDB equipment is stored in a single 10,000 square foot concrete building that meets the plant's design-basis for tornado-missile and earthquake protection. The location is above the upper-bound flood stage elevation for MPS Unit 3. The BDB storage building was designed and constructed to protect the BDB equipment from the hazards applicable to MPS.

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

3.6.1.1 Seismic

In its FIP, the licensee stated that the BDB storage building was evaluated for the effect of local seismic ground motions consistent with the MPS GMRS developed for the original site licensing basis and found to have adequate structural margin to remain functional (i.e., collapse is not expected and access to the interior retained). Analysis of components stored in the BDB storage building has been performed to determine appropriate measures to prevent seismic interaction. The fire protection and HVAC systems in the BDB storage building are seismically installed. The lighting, conduits, electrical, and fire detection components are not seismically installed, but are considered not able to damage BDB equipment.

3.6.1.2 Flooding

In its FIP, the licensee stated that the BDB storage building is located on the northeast side of the northernmost overflow parking lot along the plant access road. This location is above the upper-bound flood stage elevation for MPS, Unit 3 (which is the limiting site evaluation).

In its FIP, the licensee stated that for a probable maximum hurricane, the maximum still water level was determined to be +19.7 feet msl with an associated wave runup elevation of +23.8 feet msl. Most safety-related equipment is protected from flooding since the site grade elevation is +24 feet msl. The service water pumps and motors are located at elevation +14.5 feet msl inside watertight cubicles of the pumphouse. The front wall of the intake structure extends to elevation +43 feet msl and is designed to withstand the forces of a standing wave or clapotis with a crest elevation of +41.2 feet msl. In addition, the effect of LIP has been evaluated onsite for existing structures containing safety-related equipment and it was determined that water accumulation from this precipitation would not have an adverse effect on safety-related equipment.

In its FIP, the licensee stated that the areas of the North American continent most susceptible to tsunamis are those bordering the Pacific Ocean and the Gulf of Mexico. MPS is located on the North Atlantic coastline where there is an extremely low probability of tsunamis. Therefore, in the original licensing and license renewal review processes, tsunamis were not considered to be credible natural phenomena which might affect the safety of either unit at the MPS site. Likewise, flooding due to ice jams was not considered a possibility since the site is not located on a river.

3.6.1.3 High Winds

In its FIP, the licensee stated that the BDB storage building meets the plant's design-basis for tornado-missile protection. The licensee also stated that debris removal equipment is available to clear haul paths of debris coming from high winds. This equipment is stored in the BDB storage building.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

In its FIP, the licensee indicated that HVAC equipment is installed in the BDB storage building. In response to an audit question the licensee stated that the BDB storage building would be temperature controlled.

3.6.2 Reliability of FLEX Equipment

In its FIP, the licensee stated that sufficient equipment has been purchased to address each function at the operating units, plus one additional spare, i.e., an N+1 capability. Therefore, where a single resource is sized to support the required function of both operating units a second resource has been purchased to meet the +1 capability. In addition, where multiple strategies to accomplish a function have been developed (e.g., two separate means to repower instrumentation), the equipment associated with each strategy does not require N+1 capability. The N+1 capability applies to the portable FLEX equipment that directly supports maintenance of the key safety functions identified in Table 3-2 of NEI 12-06. FLEX support equipment that indirectly supports maintenance of the key safety function only requires N capability. FLEX support equipment includes equipment used for debris removal, towing of FLEX equipment, lighting, fuel transfer, alternate connection adapters, and communications in support of maintenance of the key safety functions.

In its FIP, the licensee stated that in the case of hoses and cables associated with FLEX equipment required for FLEX strategies, an alternate approach to meet the N+1 capability has been selected. Details of this alternate strategy are discussed in Section 3.14.

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 equipment for RCS makeup and boration, SFP makeup, and maintaining containment consistent with the N+1 recommendation in Section 3.2.2 of NEI 12-06, with the exception of hoses and cables. Refer to Section 3.14 for acceptance of the alternate strategies.

3.6.3 Conclusions

Based on its 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, including alternative strategies, and should adequately address the requirements of the order.

3.7 Planned Deployment of FLEX Equipment

In its FIP, the licensee stated that the deployment of onsite BDB equipment in Phase 2 requires that pathways between the BDB storage building and various deployment locations be clear of debris resulting from BDB events. Pre-determined haul paths have been evaluated and are identified in the FLEX support guideline, EOP 35 FSG-05.

Phase 3 of the FLEX strategies involves the receipt of equipment from offsite sources including the NSRC and various commodities such as fuel and supplies. Delivery of this equipment can be through airlift or via ground transportation.

The licensee stated in its compliance letter that the NSRC local staging areas, access route evaluations, and transportation evaluations to the site have been completed and documented in the SAFER Trip Report for MPS. The SAFER Response Plan for MPS has also been finalized.

3.7.1 Means of Deployment

In its FIP, the licensee stated that the debris removal equipment includes mobile equipment such as a front-end loader and tow vehicles (tractors) equipped with front-end buckets and rear tow connections for moving or removing debris from the needed travel paths. A front-end loader is also available to deal with more significant debris conditions. Deployment of the debris removal equipment and the Phase 2 BDB equipment from the BDB storage building is not dependent on offsite power. The building equipment doors are hydraulically operated with a battery backup and can also be opened manually.

Debris removal for the pathway between the site and the NSRC receiving "staging areas" locations and from the various plant access routes may be required. The same debris removal equipment used for onsite pathways may also be used to support debris removal to facilitate road access to the site once necessary haul routes and transport pathways onsite are clear. In a letter dated September 22, 2014 (ADAMS Accession No. ML14268A245), the licensee described how personnel from the onshift staff have been designated and trained to accomplish the debris removal function. Therefore, the NRC staff concludes that debris removal could be accomplished in a timely manner in order to allow the deployment of FLEX equipment.

3.7.2 Deployment Strategies

In its FIP, the licensee stated that pre-determined haul paths have been evaluated and are identified in EOP 35 FSG-05. These haul paths have been reviewed for potential soil liquefaction and have been determined to be stable following a seismic event.

The UHS (Long Island Sound) is only used as a source of water as a last resort. MPS, Unit 3 has a number of available water sources for preferred use prior to utilizing the UHS, including the onsite freshwater pond with over 3,000,000 gallons available for use between MPS, Units 2 and 3. The BDB high capacity pump (150 psid at 1200 gpm capacity) will be positioned to take suction from city water / fire water, onsite freshwater pond, or Long Island Sound (as a last resort). For the onsite freshwater pond, a floating suction strainer is required to prevent debris from entering the suction hose during drafting operation of the pump. The hose network also contains inline strainers, in required locations, for finer particle removal.

Phase 3 of the FLEX strategies involves the receipt of equipment from offsite sources including the NSRC and various commodities such as fuel and supplies. Delivery of this equipment can be through airlift or via ground transportation. Debris removal for the pathway between the site and the NSRC receiving "Staging Areas" locations and from the various plant access routes may be required. The same debris removal equipment used for onsite pathways may also be used to support debris removal to facilitate road access to the site once necessary haul routes and transport pathways onsite are clear. Access to the UHS at the intake structure can be accomplished utilizing a low pressure/high flow pump provided by the NSRC.

In regards to frazil ice, the licensee stated during the audit process that both the Unit 2 and Unit 3 MPS FSARs discuss frazil ice in relation to the intake structure and indicate that at <2 feet per second (fps) frazil ice will form and float to the surface. Therefore, with the size of the installed suction strainer, flow is limited to ½ fps so frazil ice will not form around the strainer. Additionally, if a strainer gets clogged procedure “C OP 200.16, Attachment 7” identifies the need and process to change out the strainer.

3.7.3 Connection Points

3.7.3.1 Mechanical Connection Points

Core Cooling (SG) Primary and Alternate Connections

The licensee described the primary connection for SG makeup as a 4-inch pipe on the TDAFW pump discharge piping, which can feed all four SGs. The 4-inch connection is located in the ESF Building at elevation 24' - 6" within the TDAFW pump cubicle and is protected from the site applicable hazards. The hose connection piping up to the AFW system isolation valve is rated for at least 600- psig working pressure. A 1.5-inch diameter threaded fitting is used in the design to facilitate a rapid discharge hose connection to support rapid portable pump deployment. The alternate SG connection is described using the SG Blowdown system. The licensee indicated that the pre-fabricated connection fitting adapter facilitates a 2.5-inch diameter FLEX hose connection to one of two separate valves through bonnet removal (both 4-inch valves). These valves are located in the Main Steam Valve Building (MSVB), which is a seismic Category I structure and is missile protected. The operators would be required to manually open two fail closed AOVs on each SG Blowdown line (total of 8 valves). Four are opened using a handwheel and the other four require the use of a portable air bottle, all are which are stored inside the MSVB.

The licensee also described in its FIP, a connection on the DWST so it can be used as a suction source to portable equipment or to refill the DWST. The 4-inch pipe connection on the TDAFW pump suction piping is used for suction for the BDB AFW pump and is located in the ESF Building at elevation 24' - 6" within the TDAFW pump cubicle. The connection piping up to the AFW system isolation valve is rated for 150 psig working pressure. The DWST can also be refilled from available water sources as described in SE Section 3.10 to this 4-inch pipe connection.

RCS Inventory Control Primary and Alternate Connections

The licensee described the primary RCS makeup connection as a 3-inch diameter stainless steel pipe connection that tees into the existing 4-inch diameter discharge line for the "A" safety injection pump. The licensee indicated that the FLEX connection has a 2235 psig design pressure and 140 °F design temperature. The BDB RCS injection pump discharges into the 3-inch pipe connection and includes two manual isolation valves and a check valve. The RCS makeup primary connection is located inside the seismic Category I ESF Building, which also protects from high wind and missile hazards. The licensee described the alternate RCS makeup connection as through a valve located in the "B" Safety Injection pump cubicle. The valve is in the 4-inch discharge line from Safety Injection pump. The operators are required to remove the valve bonnet and replace it with a hose adapter and gasket from the BDB Storage Building. This connection is also located in the ESF building, protected from all applicable hazards.

The licensee also described an additional connection for the BDB RCS Injection pump injecting into the RCS from the Unit 3 RWST. The BDB RCS injection pump suction connection is a 4-inch pipe connection that tees into the existing 6-inch safety injection piping on the suction side of "A" Safety Injection pump and is located in the ESF Building at elevation 21'- 6". The connection has a 150-psig design pressure and 140 °F of design temperature (for the upstream piping). If the Unit 3 RWST is not available, the BDB RCS injection pump suction is capable of aligning to the Unit 3 BASTs through the existing 6-inch safety injection piping on the suction side of "A" Safety Injection pump. If the BASTs are not available, then a connection to the Unit 2's RWST can also provide a borated water source to the MPS, Unit 3 BDB RCS Injection pump through the portable Boric Acid Mixing Tanks. Alternately, if neither the RWSTs nor the MPS, Unit 3 BASTs are available, then the portable Boric Acid Mixing Tanks are available to batch non-borated water to provide borated water to the suction of the BDB RCS Injection pumps.

SFP Makeup Primary and Alternate Connections

The licensee described the primary SFP makeup connection as utilizing the SFP pipe connection that ties into an existing open ended line, which will discharge directly into the SFP using a hose. The hose connection is located inside of the Fuel Building on the south wall of the loading bay. The primary SFP hose connection is sufficiently sized to restore SFP level over an indefinite period of time with the loss of SFP cooling and a makeup rate of 250 gpm. The licensee described the alternate SFP makeup connection as using the portable spray monitors to provide flow to the SFP. The operators will have to connect a hose from the BDB High Capacity pump, through the Fuel Building door, and to the SFP operating deck. The hose can either be ran directly over the side of the pool or to portable spray monitors. The two spray monitors are connected through a Y connection that splits the pump discharge and spray water into the SFP to maintain water level.

3.7.3.2 <u>Electrical Connection Points</u>

In its FIP, the licensee stated that the 120/240 Vac and 480 Vac FLEX DGs and their connecting cables are stored in the BDB Storage Building and are, therefore, protected from the BDB external event hazards. For MPS, Unit 3, the primary strategy involves deploying one 120/240 Vac FLEX DG to the alleyway adjacent to the MPS, Unit 3 EDG Building. The 120/240 Vac FLEX DGs will have two output circuits. Each of the two output circuits on the 120/240 Vac FLEX DG includes an output breaker, weatherproof receptacle, flexible and weatherproof cable with weatherproof connectors at both ends. The cables would be run through penetrations in the North Wall of the MPS, Unit 3 Control Building specifically designated for the 120/240 Vac cables. The cable will then pass through the Cable Spreading Room and be placed through similarly designated penetrations through the floor to the East Switchgear Room below. The cables would then be connected to receptacle boxes located on two 120 Vac panels. The connection boxes are hard wired to the 120 Vac buses. The licensee's alternate Phase 2 electrical strategy would be to deploy one 480 Vac FLEX DG to the alleyway adjacent to the MPS 3 EDG Building near the location of the 120/240 Vac FLEX DG deployment. The 480 Vac FLEX DG has a set of color-coded cables that would be connected from the deployed generators to 480 Vac bus 32T. In accordance with the color-coded cables, Attachment 3 of EOP 35 FSG-04, "Restoring Power to a Portable Generator," Rev. 0, provides direction for ensuring proper phase rotation before attempting to power equipment from the 480 Vac FLEX DG. The cables would be run through penetrations in the North Wall at the MPS, Unit 3 Control Building specifically designated for the 480 Vac cables. The cables would then pass through the Cable Spreading Room and placed through similarly designated penetrations through the floor of the East Switchgear Room below.

In its FIP, the licensee also stated that in order to meet the required 4160 Vac load requirements during Phase 3, two 1 MW 4160 Vac combustion turbine generators and a distribution panel will be deployed to the area near the existing EDG buildings. The NSRC cables would be connected to the output breakers of the 1 MW 4160 Vac combustion turbine generators to the 4160 Vac distribution panel. Color-coded cables would run from the distribution panel through the north wall of the Cable Spreading Room and through the floor to the East Switchgear Room. The cables would be directly connected to a breaker which allows power from the portable generators to supply Bus 34A and 34C via a cross-tie. Guideline EOP 35 FSG-15, "4160 Vac Generator/RHR Cooldown with 6 Attachments," Rev. 0, provides direction for ensuring proper phase rotation before attempting to power equipment from the 4160 Vac combustion turbine generators.

3.7.4 Accessibility and Lighting

In its FIP, the licensee 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, a lighting study was completed. The licensee further stated that the areas reviewed contain emergency lighting fixtures (Appendix "R" lighting) designed to provide a minimum of 8 hours of lighting with no external ac power sources. Prior to the depletion of the Appendix "R" lighting units, portable battery powered remote area lighting system (RALS) would be deployed to support the FLEX strategy tasks. These RALSs are rechargeable LED lighting systems designed to power the LED lights for a minimum of seven hours at 6000 lumens or a maximum of 40 hours at 500 lumens. The large portable BDB 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, portable light plants are included in the FLEX strategies. These portable diesel powered light plants can be deployed from the BDB storage building as needed to support nighttime operations. Also, portable light plants are available from the NSRC. In addition, the BDB storage building also includes a stock of flashlights and headband lights to further assist the staff responding to an ELAP/LUHS event during low light conditions.

3.7.5 Access to Protected and Vital Areas

The licensee acknowledges the importance in maintaining the ability to open doors for implementation of the FLEX strategies. For that reason, the FIP states that certain doors will be opened and will remain open. Doors and gates relying on electric power are described to be of concern. The FIP explains that a contingency access plan implemented by security personnel would initiate after losing the electric power keeping these doors and gates closed. Based on the information provided in the FIP, 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, the licensee stated that the FLEX equipment is stored in the fueled condition. Fuel tanks are typically sized to hold 24 hours of fuel. During a BDB external event, a fuel transfer truck (Ford F-350) should refuel this equipment in the first 24 hours or sooner as required. The FIP states that general coping strategy for supplying fuel oil to the BDB portable pumps and generators is to draw fuel oil out of any available existing diesel fuel oil tanks on the MPS site.

The FIP states that fuel sources for the BDB portable pumps and generators during Phase 2 and Phase 3 are provided from diverse sources. As stated, some of these sources are two 12,000 gallon (TS minimum) seismic category I and missile protected day tanks located above the maximum postulated flood elevation. Also, fuel sources from two 32,760 gallon below-ground seismic category I and missile protected fuel oil storage tanks located above the maximum postulated flood elevation are accounted for.

Diesel fuel is routinely sampled and tested per ASTM standards. The fuel transfer truck has a capacity of 1,100 gallons and has a self-powered transfer pump. The fuel transfer truck is deployed from the BDB storage building to refill the diesel fuel tanks of BDB equipment and to the various diesel fuel tank storage locations where it is refueled by either gravity fill or pumped full.

Based on a fuel consumption study, a conservative combined fuel consumption rate for the Phase 2 BDB equipment was determined to be 120 gal/hr. At this conservative fuel consumption rate, the fuel oil storage tanks have adequate capacity to provide the onsite BDB equipment with diesel fuel for greater than 30 days. The NSRC is also able to provide diesel fuel for diesel-operated equipment, thus providing additional margin. Provisions for receipt of additional diesel fuel from offsite sources are in place to supply the diesel powered Phase 3 strategy equipment.

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 MPS SAFER Plan

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

There are two NSRCs, located near Memphis, TN and Phoenix, AZ established to support nuclear power plants in the event of a BDBEE.

By letter dated September 26, 2014 [Reference 23], the NRC staff issued its assessment of the NSRCs established in response to Order EA-12-049. In its assessment, the staff concluded that SAFER has procured equipment, implemented appropriate processes to maintain the equipment, and developed plans to deliver the equipment needed to support site responses to BDBEEs, consistent with NEI 12-06 guidance; therefore, the staff concluded in its assessment that licensees can reference the SAFER program and implement their SAFER Response Plans to meet the Phase 3 requirements of Order EA-12-049.

In its FIP, the licensee stated that it has established contracts with PEICo to participate in the process for support of the NSRCs as required. Each NSRC holds five sets of equipment, four of which can be fully deployed when requested while the fifth set has equipment in a maintenance cycle. In addition, onsite BDB equipment hose and cable end fittings are standardized with the equipment supplied from the NSRC.

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 and an Alternate, which are offsite areas (within about 25 miles of the plant) utilized for receipt of ground transported or airlifted equipment from the SAFER centers. From Staging Area C, an onsite Staging Area B is established for interim staging of equipment prior to it being transported to the final location for implementation in Phase 3 at Staging Area A. The staff confirmed the location of these staging areas in the MPS SAFER Response Plan.

In its FIP, the licensee stated that in the event of a BDBEE and subsequent ELAP/LUHS condition, equipment is moved from an NSRC to a local assembly area established by the SAFER team. From there, equipment can be taken to the MPS site and staged at the SAFER onsite Staging Area "B" near the BDB Storage Building by helicopter if ground transportation is unavailable. Communications are established between MPS and the SAFER team via satellite phones and required equipment moved to the site as needed. First arriving equipment is delivered to the site within 24 hours from the initial request. The order in which equipment is delivered is identified in the MPS's SAFER Response Plan. The FIP also states that, if required, debris can be removed from staging areas and pathways.

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 MPS, Unit 3, ventilation that provides cooling to occupied areas and areas containing required equipment will be lost. The key areas identified for all phases of execution of the FLEX strategy activities are the Main Control Room (MCR), Turbine Driven Auxiliary Feedwater (TDAFW) Pump Room, Main Steam Valve Building (MSVB, location of the ADVs, East and West dc Switchgear (SWGR) Rooms, East MCC Rod Drive Room, the Auxiliary Building at elevation 43'-6".

The NRC staff reviewed evaluation ETE-CPR-2012-0008, Rev.4, to verify that equipment remains operable as part of the MPS Unit 3 mitigation strategy for an ELAP and will not be adversely affected by increases in temperature as a result of loss of HVAC. The EOP-35-FSG-05 provides guidance to allow for personnel habitability after a loss of ventilation and cooling due to ELAP.

Main Control Room

For the MCR, the licensee noted that equipment operability for instrumentation cabinets will be ensured by maintaining the cabinet temperature below 120 °F, the design limit, by opening cabinet doors within 30 minutes after the onset of an ELAP event. The licensee's evaluation showed that these actions will maintain internal cabinet temperatures below 110 °F for the duration of the ELAP/LUHS scenario, which is below the conservative limit for MCR habitability of 110 °F as documented in NUMARC 87-00. The licensee also noted that the MCR doors can be opened to provide additional cooling if required.

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

TDAFW Pump Room

Calculation ETE-CPR-2012-0008, Rev.4 identified the maximum temperature limit for the TDAFW Pump Room as being 162 °F. The licensee's analysis showed that the temperature would not exceed 156 °F in 8 hours with no compensatory actions. The licensee plans to open multiple exterior doors within 8 hours to help lower the temperature. According to the licensee, if you assume the constant maximum summer outdoor design temperature of 86 °F, opening these doors would reduce the TDAFW Pump Room temperature to below 110 °F.

Based on temperatures remaining below the maximum room temperature limit of 162 °F and 120 °F (the temperature limit, as identified in NUMARC-87-00 for electronic equipment to be able to survive indefinitely), the NRC staff finds that the equipment in the TDAFW Pump Room will not be adversely impacted by the loss of ventilation as a result of an ELAP event.

MSVB (location of the Atmospheric Dump Valves (ADVs))

An ELAP at MPS, Unit 3 requires personnel entry into the MSVB for manual operation of the atmospheric dump bypass valves. The MSVB contains high-temperature piping and is normally cooled by exhaust fans. A loss of electrical power would disable the fans and cause the temperature in the MSVB to increase. Since these valves will be manually controlled, the licensee will not be relying on electrical equipment to operate the ADVs; and therefore, no review is necessary to determine the functionality of electrical equipment in the MSVB.

East and West DC SWGR Rooms

According the licensee's calculation, the maximum normal excursion design temperature for the East and West SWGR rooms is 104 °F. The licensee must open doors to the enclosed rooms and/or compartments located in the East and West SWGRs approximately 60 minutes after the event's onset to ventilate the area and to prevent local hot spots (e.g., Battery Rooms and areas housing the Inverters and the Battery Chargers). Considering these compensatory actions, the licensee's analysis determined that the temperature in the East and West SWGR Rooms will remain well below 120 °F and likely less than the design limit of 104 °F given the reduced heat loading in these rooms. The licensee plans to monitor room temperatures as directed by FSGs to insure equipment survivability. If needed, the licensee could utilize natural convection flow paths and/or portable ventilation fans if the temperature measurements indicated increasing trends that could challenge the design limit.

Based on temperatures remaining below the room design limit and 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," Rev. 1, for electronic equipment to be able to survive indefinitely), the NRC staff finds that the equipment in the East and West SWGR Rooms will not to be adversely impacted by the loss of ventilation as a result of an ELAP event given compensatory actions described above.

Battery Rooms

The Millstone Unit 3 safety-related batteries were manufactured by GNB. Two battery rooms are located in the East Switchgear room and two are in the West Switchgear room.

The battery vendor, NLI, informed the licensee that their batteries are capable of performing their function up to 120 °F, however, periodic monitoring of electrolyte level would be necessary to protect the battery since the battery may gas more at higher temperatures.

This licensee's analysis showed that at the onset of an ELAP event, the East and West dc Switchgear room temperatures will rise. Starting with a maximum room temperature of 104 °F, the predicted temperature rise will remain below 120 °F with the predicted heat gains due to the battery discharge, before the licensee exercises compensatory measures as directed by EOP 35 FSG-04. The compensatory measures include opening doors and operators periodically monitoring Switchgear room temperatures. These compensatory measures would restore temperatures to 104 °F or below.

Appendix EOP 35 FSG-5 establishes long term cooling and ventilation in the East and West Switchgear rooms. This procedure directs operators to monitor temperature in these areas every 4 hours and to provide compensatory measures to maintain a temperature of 104 °F or below. These compensatory measures would remain in place until normal ventilation for these areas are restored.

Based on its review of the licensee's Battery Room assessment, the NRC staff finds that the Millstone Unit 3 safety-related batteries should perform their required functions at the expected temperatures as a result of loss of ventilation during an ELAP event.

East MCC Rod Drive Room

The maximum normal excursion temperature in the East MCC Rod Drive Room is 120 °F. According to the licensee's calculation, during the initial 24 hours of an ELAP event, the heat input into the room is minimal. Therefore, no immediate compensatory actions are required to cool the room. To ensure long-term room temperature does not exceed 120 °F, the licensee plans to open doors within 24 hours of event initiation. For defense in depth, the licensee plans to monitor room temperatures as directed by FSGs to insure equipment survivability. If needed, the licensee could utilize a ventilation fan and flexible ducting, taking suction from the outside, if the area temperature measurements indicate increasing trends that could challenge the design limit.

Auxiliary Building at elevation 43'-6"

This area contains the spent fuel pool level instrumentation system. The environmental qualification temperature limit of this system is 140 °F. The licensee's analysis stated that there are no significant mechanical or electronic heat loads present in this area. Therefore, no immediate compensatory actions are necessary to reduce temperature as the temperature is not expected to exceed 140 °F. Since temperature may rise above the qualification limit after approximately 7 days, the licensee plans to establish ventilation paths no later than 5 days into the event as directed by the FSGs. The licensee also plans to monitor room temperatures periodically (once per shift) to insure equipment survivability. If needed, the licensee could utilize natural convection paths or portable ventilation fans if the area temperature measurements indicate increasing trends that could challenge the qualification limit.

3.9.1.2 Loss of Heating

The licensee indicated in its FIP, the utilization of heat tracing for FLEX components that require cold weather packages and small electrical generators. These components protect the FLEX equipment from damage due to extreme cold weather and help assure equipment reliability, as well as to power heat tape circuits. Heat tape and portable heating equipment are stored in the BDB Storage Building for additional low temperature mitigation. Based on the licensee's analysis, in the event of an ELAP, battery room temperatures are expected to rise due to discharge and nearby passive heat sinks with loss of ventilation. Therefore, reaching the minimum battery temperature limit of 60 °F is not expected.

Based on its review of the licensee's battery room assessment, the NRC staff finds that Millstone Unit 3 safety-related batteries should perform their required functions at the expected temperatures as a result of loss of heating during an ELAP event.

3.9.1.3 Hydrogen Gas Control in Vital Battery Rooms

An additional ventilation concern that is applicable to Phases 2 and 3, is the potential buildup of hydrogen in the battery rooms as a result of loss of ventilation during an ELAP event. Off-gassing of hydrogen from batteries is only a concern when the batteries are charging. In order to prevent a buildup of hydrogen in the battery rooms, the licensee's procedures direct plant operators to energize the battery room exhaust fans. These fans would be powered from the 480 Vac bus connected to the BDB 480 Vac FLEX DG. The battery room exhaust fans will exhaust battery room air through the normal exhaust flow path to prevent hydrogen accumulation.

In its FIP, the licensee stated that the major components for FLEX strategies are provided with cold weather packages and small electrical generators to protect the equipment from damage due to extreme cold weather and help assure equipment reliability as well as to power heat tape circuits, if necessary. Heat tape and portable heating equipment (BDB support equipment) are stored in the BDB Storage Building for additional low temperature mitigation, as needed.

Based on its review, the NRC staff finds that the licensee's evaluation demonstrated that hydrogen accumulation in the 125 V dc vital battery rooms should not reach the combustibility limit for hydrogen (4 percent) during an ELAP as a result of a BDBEE since the licensee plans to repower the battery room exhaust fans when the battery chargers are repowered during Phase 2 given compensatory actions described above.

3.9.2 Personnel Habitability

3.9.2.1 Main Control Room

The NRC staff reviewed calculation MISC-11802, Rev 0, "Main Control Room and Instrument Rack Room Heat-up Analysis Following an ELAP," which modeled the CR temperature transient through 72 hours following a beyond-design-basis external event resulting in an ELAP. The calculation uses the GOTHIC version 7.2a computer program (Generation of Thermal-Hydraulic Information for Containments). The acceptance criterion for the calculated temperatures is based on the guidance in NUMARC 87-00, Revision 1, which states that a CR temperature of 110 °F is an acceptable limit for CR personnel habitability.

Calculation 07-ENG-04264M2, Revision 0 demonstrates that the wall heat transmission losses to the outside air and the surroundings is sufficient to maintain the final area steady state temperatures below the acceptance limits.

Also, in accordance with the existing SBO procedures, instrumentation cabinet doors must be opened within 30 minutes after the onset of an ELAP event. This would allow for adequate air mixing and would maintain internal cabinet temperatures in equilibrium with the Control Room temperature which has been calculated to not exceed 110 °F during the initial 14 hours of the ELAP/LUHS scenario. The licensee also noted that the CR doors can be opened to provide additional cooling if needed.

3.9.2.2 Spent Fuel Pool Area

In its FIP, the licensee described the ventilation-related actions to prevent excessive steam accumulation utilizes 5 doors (3 rollup and 2 personnel doors) in the Fuel

Building. Two of the rollup doors are on the 24'-6" level of the Fuel Building. The third door is also a rollup door which connects the east side of the Shipping Cask Area on the 52' elevation to the lower 24'-6" elevation of the Fuel Building. Additionally, there is a personnel door from the north side of the SFP cask area on the 55'-9" elevation into a stairwell and another door from the stairwell to the roof at the same elevation. The opening of these doors provide both a vent path for steam and allows for a flow path of cool air to enter the area from the rollup doors on the 24'-6" level and exit through the Shipping Cask Area door on the 55'-9" elevation of the Fuel Building. If needed, portable fans can also be positioned at the New Fuel Receiving area door to enhance the ventilation. EOP 35 FSG-05 provides instructions for operators to implement this method of ventilation for the SFP and cooling for personnel habitability. The above actions would take place prior to the 6 hour mark for boiling in the SFP to begin and improve habitability for operators to later connect hoses and spray monitor for SFP makeup 22 hours into the ELAP event.

3.9.2.3 Other Plant Areas

Main Steam Valve House

The Unit 3 Main Steam Valve House (MSVH), the location of the ADVs, is located on the 71' elevation of the Main Steam Valve Building (MSVB). The licensee noted that the room could heat up to 225 °F in 2 hours following an ELAP event. However, during the audit, the NRC staff observed that the missile shield could affect ventilation and heat load in this room. The licensee revised the MSVH habitability analysis to evaluate the impact of the reinforced concrete missile shield. The door with the missile shield is located on the 71' elevation of the MSVH and connects the MSVH to the outside atmosphere. The licensee concluded in the revised analysis that by opening the door with the missile shield and four doors to the MSVB within 2 hours of declaration of ELAP, the room temperature of the MSVH would reduce down to 199 °F. The licensee stated that the personal protection equipment of turnout gear, ice vests or cool suits, and Self-Contained Breathing Aparatus gear would provide adequate protection for personnel who enter the MSVH to manually operate the ADVs. The licensee stated that the protective gear will be in use until the BDB 480 Vac DG is placed into service and restores ventilation to the MSVH. The licensee also noted that EOP-35-FSG-04 directs the operators to place one exhaust fan in the MSVH into service to assist in natural ventilation to further reduce temperatures in the room.

3.9.3 Conclusions

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

3.10 Water Sources

Identification of credited water sources for the FLEX response strategies is included in the previous sections for each individual strategy.

In its FIP, the licensee listed the available water sources as follows:

- Demineralized Water Storage Tank (DWST) – 312,800 gallons (protected against hazards considered in NEI 12-06 Rev 0)
- Long Island Sound (UHS) – unlimited supply (protected against hazards considered in NEI 12-06 Rev 0 – utilized as a last resort)
- Condensate Storage Tank - 230,000 gallons (protected against flooding and low/high temperatures)
- Primary Grade Storage Tanks (2) – 200,000 gallons total (protected against flooding and low/high temperatures)
- Condensate Hotwell – 81,000 gallons (protected against flooding, high winds/tornados, and low/high temperatures)
- Site Fire Water System – 490,000 gallons (protected against flooding and low/high temperatures)
- City Domestic Water Supply – unlimited supply (protected against flooding, tornado/hurricane, and low/high temperatures)
- Onsite Freshwater Pond – 3,000,000 gallons (protected against seismic, tornado/hurricane and low/high temperatures)
- Refueling Water Storage Tank – 1,116,000 gallons (protected against seismic, flooding, and low/high temperatures)

3.10.1 Steam Generator Make-Up

As discussed in the FIP, the DWST is the relied on supply of water to the TDAFW pump and is protected against all applicable hazards. The available clean water sources identified above are used to refill the DWST using the BDB high capacity pump. Although available as a water source, the FIP states that the UHS is not recommended for use in the SGs and would be used only as a last resort. There are sufficient onsite water sources to provide an adequate AFW supply source for a much longer time than would be required for the delivery and deployment of the Phase 3 NSRC reverse osmosis/ion exchange equipment to remove impurities from the onsite natural water sources.

The onsite freshwater pond is an untreated water source and requires the use of a suction strainer. For every foot of depth there are approximately 1.06 million gallons in the pond. Even at the driest times the pond should maintain a 3 feet minimum depth. Therefore, it is assumed that approximately 3 million gallons of storage capacity would be available. Assuming that this water is evenly divided between MPS, Units 2 and 3, 1,500,000 gallons of water would be available for use as an AFW water supply for MPS, Unit 3. In event of an extreme storm surge, there is a possibility that this water supply may become brackish due to the close proximity and limited elevation change to Long Island Sound. In this event, the onsite pond would be used only after other available clean onsite sources had been expended.

3.10.2 Reactor Coolant System Make-Up

As discussed in the FIP, there are three sources for borated water available onsite: the RWSTs (one per unit), the boric acid storage tanks (BASTs) and the portable BDB boric acid mixing tanks stored in the BDB storage building. Clean water sources for use in batching borated water in the BDB boric acid mixing tanks would be used in the same order of preference provided in for the AFW sources and dependent on availability.

MPS Unit 3 is equipped with one RWST located at grade level. The tanks are stainless steel, safety-related, seismic Category I storage tanks, but are not protected from tornado missiles. During "at power" operations, MPS Unit 3's RWST borated volume is maintained greater than 1,166,000 gallons at a boron concentration approximately 2700 ppm. The RWST is the preferred borated water source for the RCS injection strategies. Water with a higher boron concentration than the RWST may be available for RCS makeup from the BASTs. The two BAST tanks have a usable volume of 28,352 gallons at boron concentration of 6600 to 7175 ppm. The BAST tanks are located at elevation 43 feet in the auxiliary building. Gravity drain lines are provided from the boric acid tanks to the safety injection pump suction header. Due to its high boric acid concentration, the BAST is heated. The BAST minimum temperature is 67 °F in order to prevent precipitation. A locally installed thermometer can monitor the boric acid temperature.

In the event that both RWSTs and the BASTs are unavailable or become depleted, portable boric acid mixing tanks are available to provide a suction source for the BDB

RCS injection pumps. These mixing tanks will be deployed, as needed, from the onsite BDB storage building to a position near the MPS, Unit 3 BDB RCS injection pump. Dilution water will be added to the mixing tank by either a portable transfer pump, or from a branch line from the BDB high capacity pump header taking suction from a clean water source. Bags of powdered boric acid will be mixed with dilution water to achieve the proper concentration for maintaining adequate shutdown margin while making up RCS inventory. The tank is equipped with an agitator to facilitate mixing of the boric acid, although complete dissolution of the powdered boric acid is not required since agitation will continue throughout the injection process. The maximum boron concentration that will be mixed in one of these mixing tanks is less than the concentration at which precipitation concerns occur, even at temperatures down to 32 °F, however, a heater is also available to prevent tank freezing, if necessary.

3.10.3 Spent Fuel Pool Make-Up

In its FIP, the licensee indicated that makeup water to the SFP is through the BDB high capacity pump taking suction from Long Island Sound or from several other water sources that can be connected to the suction of the BDB high capacity pump. The license stated that the BDB High Capacity pump is deployed by towing the trailer to a designated draft location near the selected water source. The initial source designated in the FIP is the from a site fire system hydrant supplied by two fire water storage tanks, which have a useable volume of 245,000 gallons each. However, these tanks are non-seismic, nonsafety-related components and the treated water supply is supplied from a domestic water line fed from the city water system. The BDB High Capacity pump is also capable of taking direct suction from the fire hydrant connected to the city water supply if the fire water tanks are unavailable. The next available water source is the Onsite Freshwater Pond, which is an untreated water source and requires the use of a suction strainer. Access to the Onsite Freshwater pond is located from the west (plant side) side of the security barriers adjacent to the school house and contains about 1.06 million gallons per foot into the pond. The licensee estimated that the Onsite Freshwater Pond should have about 3 feet of minimum depth during the driest times on site. The last water source that is available for SFP makeup is the Long Island Sound, which is a saltwater source. The Long Island Sound is protected from all applicable hazards and will only be used if the onsite water sources are unavailable for SFP makeup.

3.10.4 Containment Cooling

In its FIP, the licensee stated that NRSC portable generators are used to restore power to one of the two Class 1E 4160 Vac busses. Additionally, by restoring the Class 1E 4160 Vac bus, power can be restored to the Class 1E 480 Vac via the 4160/480 Vac transformers to power selected 480 Vac loads. The preferred means to reduce containment temperature is through use of the CAR fans. Once power is restored to the 4160 Vac and 480 Vac busses from temporary generators, a SW pump, RPCCW pump and a CAR fan will be started, if available. The fans will circulate air through their heat exchangers transferring containment heat to the RPCCW system, which in turn will transfer the heat to the SW system and the ultimate heat sink. If a SW pump is unavailable, low pressure/high flow pumps from the NSRC will supply the SW header through hose connections to the "A" EDG heat exchanger SW inlet flange adapter.

In its FIP, the licensee also discussed the use of the spray option to cool the containment. The use of the spray option involves 3 basic steps: 1) Flood the containment sump; 2) provide cooling water to one of the recirculation spray system (RSS) heat exchangers; and 3) start an RSS pump. In the event that the SW system is unavailable, 4160 Vac temporary power can be supplied to the installed quench spray system (QSS) pump to inject water into containment, from the RWST through the spray nozzles, to fill the containment sump. When adequate sump level is established, the QSS pump is stopped and the containment recirculation spray pump is started on the 4160 Vac temporary power. The spray water is cooled by portable low pressure/high flow pumps tied into the "A" EDG heat exchanger service water adapter flange taking suction on Long Island Sound, supplying flow to the RSS heat exchanger service water side.

An alternate method to establish sufficient initial containment sump level will utilize installation of an adapter flange (in place of an expansion joint) on the inlet side of the "A" containment recirculation cooler. The BDB High Capacity pump will be utilized to provide flow if the RWST is unavailable due to missile damage.

3.10.5 Conclusions

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 50 hours are available to implement makeup before boil-off results in the water level in the SFP dropping far enough to 10 feet above fuel assemblies, and the licensee has stated that they have the ability to implement makeup to the SFP within that time.

When a plant is in a shutdown mode in which steam is not available to operate the steam-powered pump and allow operators to release steam from the SGs (which typically occurs when the RCS has been cooled below about 300 °F), another strategy must be used for decay heat removal. On September 18, 2013, NEI submitted to the NRC a position paper entitled “Shutdown/Refueling Modes” [Reference 40], which described methods to ensure plant safety in those shutdown modes. By letter dated September 30, 2013 [Reference 41], the NRC staff endorsed this position paper as a means of meeting the requirements of the order.

The position paper provides guidance to licensees for reducing shutdown risk by incorporating FLEX equipment in the shutdown risk process and procedures. Considerations in the shutdown risk assessment process include maintaining necessary FLEX equipment readily available and potentially pre-deploying or pre-staging equipment to support maintaining or restoring key safety functions in the event of a loss of shutdown cooling. The NRC staff concluded that the position paper provides an acceptable approach for demonstrating that the licensees are capable of implementing mitigating strategies in shutdown and refueling modes of operation. In its FIP, the licensee stated that MPS, Unit 3 is abiding by the NEI position paper.

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

3.12 Procedures and Training

In its FIP, the licensee stated that the FSGs provide guidance that can be employed for a variety of conditions. Criteria for entry into FSGs ensures that FLEX strategies are used only as directed for BDBEE conditions, and are not used inappropriately in lieu of existing procedures. When BDB equipment is needed to supplement EOPs or abnormal operating procedures (AOPs), the EOP or AOP directs the entry into and exit from the appropriate FSG procedure. The FIP states that FLEX support guidelines have been developed in accordance with PWROG guidelines. The FSGs provide instructions for implementing available, preplanned FLEX strategies to accomplish specific tasks in the EOPs or AOPs. FSGs should be used to supplement (not replace) the existing procedure structure that establishes command and control for the event. Procedural Interfaces have been incorporated into EOP 35 ECA-0.0, “Loss of All AC Power,” to the extent necessary to include appropriate reference to FSGs and provide command and control for the ELAP. Also, procedural interfaces have been incorporated into the following procedures to include appropriate reference to FSGs: Procedure AOP 3569, Severe Weather Conditions; EOP 3505A, Loss of Spent Fuel Pool Cooling; and EOP 3501, Loss of All AC Power (MODES 5, 6, AND Zero).

In its FIP the licensee stated that Dominion’s nuclear training program has been revised to assure personnel proficiency in utilizing FSGs and associated BDB equipment for the mitigation of BDB external events is adequate and maintained. The licensee states to have developed and implemented programs and controls in accordance with the systematic approach to training (SAT) process. The licensee also stated that initial training is in accordance with Section 11.6 of NEI 12-06, ANSI/ANS 3.5, “Nuclear Power

Plant Simulators for use in Operator Training", certification of simulator fidelity is considered to be sufficient for the initial stages of the BDB external event scenario. Full scope simulator models have not been upgraded to accommodate FLEX training or drills. Where appropriate, integrated FLEX drills are organized on a team or crew basis and conducted periodically; with all time-sensitive actions are evaluated over a period of not more than eight years. It is not required to connect/operate permanently installed equipment during these drills.

During the audit, the staff was able to see procedures and training documents. Based on the review of the license's submittal, the NRC staff finds that the licensee has developed procedures and a training program that, if implemented accordingly, should be in accordance with NEI 12-06, Section 11.6.

3.13 Maintenance and Testing of FLEX Equipment

As a generic issue, NEI submitted a letter to the NRC dated October 3, 2013 [Reference 42], which included Electric Power Research Institute (EPRI) Technical Report 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment." By letter dated October 7, 2013 [Reference 43], the NRC endorsed the use of the EPRI report and the EPRI database as providing a useful input for licensees to use in developing their maintenance and testing programs.

In its FIP, the licensee stated that factory acceptance testing and site acceptance testing, was conducted to ensure the portable FLEX equipment can perform its required FLEX strategy design functions. Factory acceptance testing was done to verify that the portable equipment performance conformed to the manufacturers rating for the equipment as specified in the purchase order. Also, vendor test documentation was verified as part of the receipt inspection process for each of the affected pieces of equipment and included in the applicable vendor technical manuals. Site acceptance testing confirmed factory acceptance testing to ensure portable FLEX equipment delivered to the site performed in accordance with the FLEX strategy functional design requirements. Portable BDB equipment that directly performs a FLEX mitigation strategy for the core cooling, containment, or SFP cooling is subject to periodic maintenance and testing in accordance with NEI 12-06 and Institute of Nuclear Power Operations (INPO) AP 913, "Equipment Reliability Process", to verify proper function. The licensee also stated that preventive maintenance will be provided for other FLEX support equipment.

The FIP states that the licensee uses EPRI's Preventive Maintenance (PM) Basis for FLEX Equipment guidance and maintenance templates for the major FLEX equipment including the portable diesel pumps and generators. Corresponding maintenance strategies were developed and documented. The performance of the PMs and test procedures are controlled through the site work order process. It is stated that performance verification of FLEX equipment is scheduled and performed as part of the PM process. The licensee stated that a fleet procedure was established to reduce the risk for unavailability of equipment and applicable connections that directly perform a

FLEX mitigation strategy for core cooling, containment, and SFP cooling. Maintenance/risk guidance were described to conform to the guidance of NEI 12-06.

After reviewing the licensee's programs, the NRC staff finds that, if implemented accordingly, the licensee's activities associated with FLEX equipment maintenance and testing will be in accordance with NEI 12-06, Section 11.5.

3.14 Alternatives to NEI 12-06, Revision 0

3.14.1 Reduced Set of Hoses and Cables As Backup Equipment

In its FIP, the licensee took an alternative approach to the NEI 12-06 guidance for hoses and cables. In NEI 12-06, Section 3.2.2 states that in order to assure reliability and availability of the FLEX equipment required to meet these capabilities, the site should have sufficient equipment to address all functions at all units on-site, plus one additional spare, i.e., an N+1 capability, where "N" is the number of units on-site. Thus, a single-unit site would nominally have at least two portable pumps, two sets of portable ac/dc power supplies, two sets of hoses and cables, etc. The NEI on behalf of the industry submitted a letter to the NRC [Reference 49] proposing an alternative regarding the quantity of spare hoses and cables to be stored on site. The alternative proposed was that that either a) 10 percent additional lengths of each type and size of hoses and cabling necessary for the N capability plus at least one spare of the longest single section/length of hose and cable be provided or b) that spare cabling and hose of sufficient length and sizing to replace the single longest run needed to support any FLEX strategy. The licensee has committed to following the NEI proposal. By letter [Reference 51], the NRC agreed that the alternative approach is reasonable, but the licensees may need to provide additional justification regarding the acceptability of various cable and hose lengths with respect to voltage drops, and fluid flow resistance. The NRC staff approves this alternative as being an acceptable method of compliance with the order. Based on the use of the alternative in accordance with the NRC's endorsement letter, the NRC staff approves this alternative for DNC as an acceptable method of compliance with the order.

3.15 Conclusions for Order EA-12-049

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

4.0 TECHNICAL EVALUATION OF ORDER EA-12-051

By letter dated February 28, 2013 [Reference 24], the licensee submitted its OIP for MPS in response to Order EA-12-051. By letter dated June 26, 2013 [Reference 25] the NRC staff sent a Request for Additional Information (RAI) to the licensee. The licensee provided a response by letter dated July 26, 2013 [Reference 26]. By letter dated October 29, 2013 [Reference 27], the NRC staff issued an ISE and RAI to the licensee.

The licensee provided a response by letter dated February 28, 2014 [Reference 31]. By letter dated November 17, 2014 [Reference 17], the NRC issued an audit report on the licensee's progress.

By letters dated October 25, 2012 [Reference 29], August 23, 2013 [Reference 30], February 28, 2014 [Reference 31], August 26, 2014 [Reference 32], March 2, 2015 [Reference 33], and August 24, 2015 [Reference 34], the licensee submitted status reports for the Integrated Plan. The Integrated Plan describes the strategies and guidance to be implemented by the licensee for the installation of reliable SFP level instrumentation which will function following a BDBEE, including modifications necessary to support this implementation, pursuant to Order EA-12-051. By letter dated December 3, 2015 [Reference 57], the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved.

The licensee has installed a SFP level instrumentation system designed by Westinghouse. The NRC staff reviewed the vendor's SFP level instrumentation system design specifications, calculations and analyses, test plans, and test reports. The staff issued an audit report on this technology on August 18, 2014 [Reference 36].

The staff performed an onsite audit to review the implementation of SFP level instrumentation related to Order EA-12-051. The scope of the audit included verification of (a) site's seismic and environmental conditions enveloped by the equipment qualifications, (b) equipment installation met the requirements and vendor's recommendations, and (c) program features met the requirements. By letter dated November 17, 2014 [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 [Reference 24], the licensee described the levels for Unit 3; Level 1 is elevation 46 feet 10 inches. Level 2 is elevation 35 feet 4 inches. Level 3 is elevation 25 feet 4 inches. The licensee stated in its letter date August 23, 2013 [Reference 30] that a calculation confirmed minimum net positive suction head for the SFP cooling pump is 46.7 feet. The licensee provided a table in its July 26, 2013, RAI response [Reference 26] illustrating the levels and the instrument span. The NRC staff previously confirmed these elements were consistent with the guidance criteria in the ISE.

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

4.2 Evaluation of Design Features

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

4.2.1 Design Features: Instruments

In its OIP, the licensee stated that the primary and backup instrument channels, for both units, would use fixed instruments providing a continuous level measurement over the entire range. The licensee stated that for Unit 3, from approximately elevation 50 ft. 4 in. to elevation 25ft. 4 in. (for a total indicated range of approximately 25ft. 0 in.).

In its letter dated July 26, 2013 [Reference 26], the licensee provided two tables (one for each unit) depicting the SFP elevations identified as Levels 1, 2, and 3 and the SFP level instrument span. These figures showed that the instrument range would be approximately 25ft. for MPS3.

Based on the discussion above, the NRC staff finds that, if implemented accordingly, the number of channels and measurement range for its SFP should 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

The primary and backup instruments are located at the south and north corners respectively at the west end of the Unit 3 SFP. Cabling for each channel travels a short distance west, exiting the SFP area into the adjacent aux building. Primary and backup transmitters and indicators are located on the east wall of the Aux Building 43'-6". The NRC staff observed the equipment locations during the on-site audit. During the SFP walkdown, the staff confirmed prompt accessibility. In its January 6, 2015, letter [Reference 57], the licensee stated the round trip time to access the indicator from the control room was 15 minutes. This is consistent with the staff's observation.

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

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

4.2.3 Design Features: Mounting

In its January 6, 2015 letter [Reference 57], the licensee stated:

> The level sensing probe is attached to the mounting bracket, which is anchored to the SFP structure at the concrete curb using concrete expansion anchors. The anchorage to the Seismic Category I SFP structure concrete curb is designed to meet the requirements of the MPS design and licensing basis for Seismic Category I components including seismic loads, static weight loads and hydrodynamic loads.
>
> Each of the additional SFP Level Instrumentation System components required to be mounted/anchored are attached to plant structures consistent with the MPS design and licensing basis for Seismic Category I components, and include consideration of design basis maximum seismic loads and static weight loads.

The NRC staff reviewed seismic analysis in Westinghouse calculation CN-PEUS-14-3 which covers generic design for Surry Power Station, Unit Nos. 1 and 2 (Surry), North Anna Power Station, Units 1 and 2 (North Anna), and MPS 3. Dominion calculation ENG-04069CG covers structural mounting details based on WEC analyses, including the hydrodynamic loading for the mounting brackets.

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

4.2.4 Design Features: Qualification

4.2.4.1 Augmented Quality Process

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

By letter dated February 28, 2013 [Reference 24], the licensee stated that instrument channel reliability shall be established by use of an augmented quality assurance process similar to that described in NEI 12-02.

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

4.2.4.2 Instrument Channel Reliability

NEI 12-02 states:

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

Equipment reliability performance testing was performed to (1) demonstrate that the SFP instrumentation will not experience failures during 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 qualification testing of the Westinghouse SFPLI during the vendor audit for temperature, humidity, seismic, radiation and EMI [Reference 36]. The staff further reviewed the anticipated site conditions for MPS during the on-site audit.

Temperature and Humidity

The anticipated temperature in the SFP area during a BDB event is 212 °F condensing based pool boil-off. In its December 3, 2015, letter [Reference 37], the licensee stated, in part, that the probe, cable and coupler were tested to 212 °F and 100 percent relative humidity for 185 hours.

In its January 6, 2015, letter [References 58], the licensee stated, in part, that the maximum temperature for Unit 3 primary electronics in the Unit 3 Auxiliary Building, Elevation 43'-6". Relative humidity will not exceed 95 percent. In Unit 3 Aux Building at 43'-6" location, the primary and secondary electronics will not exceed 120F during normal operations and 134F during BDB conditions. The electronics were tested to operate continuously at 120F 95 percent RH and up to 140F 95 percent RH under extreme conditions.

During the MPS on-site audit the NRC staff reviewed Dominion Gothic calculations MISC-11807 for Unit 3. The staff confirmed Dominion's basis for the peak temperatures for each of the condition locations. The staff confirmed the local equipment anticipated temperature and humidity are bounded by the WEC qualification testing.

Radiation

Radiation test results supplied by Westinghouse in test report EQ-QR-269 have qualified the coupler and coaxial connecting cable to greater than 10^7 RAD and the electronics were qualified to 10^3 RAD. The staff confirmed the Westinghouse testing during the Westinghouse vendor audit [Reference 36].

In its January 6, 2015 letter [Reference 57], the licensee stated regarding Unit 3:

> In the SFP area where the coupler and coaxial cable are located, the dose rate analysis resulted in a 7-day integrated dose of 4.6x1 06 RAD and a 40-year integrated dose of 880 RAD. In the Auxiliary Building where the SFP Level Instrumentation System sensor transmitters and displays cabinets are located, the dose rate analysis resulted in a 7-day integrated dose of 12 RAD and a 40-year integrated dose of 880 RAD.

During the on-site audit at MPS, the NRC staff performed a confirmatory review of Dominion Calculation CALC-RA-0046, Rev. 0, “Radiological Evaluation following a Beyond Design Basis MPS3 SFP Draindown for NEI 12-02” and verified that the source term was consistent with that stated in NEI 12-02 and that the calculated integrated 7 day dose is less than the tested values of 1E7 in the SFP area and 1E3 for the electronics in the Aux Bldg.

Seismic

The NRC staff reviewed the Westinghouse seismic qualification testing during the Westinghouse vendor audit. [Reference 36]. In its February 28, 2014, letter [Reference 53], the licensee stated:

> Testing and analysis is conducted by Westinghouse to provide assurance that the equipment will perform reliably under the worst-case credible design basis loading at the location where the equipment will be mounted. MPS Power Station Procurement Specification IC-1210, Rev. 1, provides the design requirements applicable to the installed location for the equipment. Section 7 of Westinghouse document WNA-PT-00188-GEN, Rev. 1, "Spent Fuel Pool Instrumentation System (SFPIS) Standard Product Test Strategy," provides the overall test strategy for the SFPIS system, and addresses the design criteria and methodology for seismic testing of the SFP instrumentation and the electronics units. The test strategy includes seismic response spectra that envelope the design basis maximum seismic loads and includes applicable hydrodynamic loading that could result from conditions such as seismic-induced sloshing effects. In accordance with WNA-PT-00188-GEN, the applicable guidance in Sections 7, 8, 9 and 10 of IEEE Standard 344-2004, "IEEE Recommended Practice for Seismic Qualification of Class IE Equipment for Nuclear Power Generating Stations," by testing.

During the on-site audit, the NRC staff reviewed the MPS Power Station Procurement Specification IC-1210, Rev. 1. The NRC staff also performed a confirmatory review of the seismic analysis in Westinghouse calculation CN-PEUS-14-3 which covers the generic design for Surry, North Anna and MPS 3 including the hydrodynamic loading for the mounting brackets. Dominion calculation ENG-04069CG covered structural mounting details based on the Westinghouse analyses.

Shock and Vibration

In its December 3, 2015, letter [Reference 37], the licensee stated:

> Components of both instrumentation channels are permanently installed and fixed to rigid, structural walls or floors of Seismic Category I structures and are not subject to anticipated shock or vibration inputs. The display enclosure utilizes a NEMA-4X rated stainless steel housing to aid in protecting internal components from vibration induced damage according to Westinghouse report WNA-TR-03149-GEN. Therefore, in accordance with Nuclear Regulatory Commission (NRC) Order EA-12-051, NEI guidance, and as clarified by the Interim Staff Guidance, the probe, coaxial cable, and mounting brackets are inherently resistant to shock and vibration loadings.

The NRC staff found this response acceptable, because the stainless steel housing should adequately address the potential reliability concern of SFP level instrumentation with respect to shock and vibration.

Electromagnetic Interference

The NRC reviewed the electromagnetic interference (EMI) qualification testing during the Westinghouse vendor audit [Reference 36]. During the on-site audit at MPS, the NRC staff raised a question regarding potential hand-held radio transmissions to interfere with the instrument probe.

In its December 3, 2015, letter [Reference 37], the licensee stated:

> The base configuration necessary to meet Criterion B (instrument will function before and after an Electro-Magnetic Compatibility (EMC) event) was confirmed during EMC qualification testing performed by Westinghouse. NRC representatives audited the Westinghouse test documents. As a result Westinghouse specified materials, installation, and grounding requirements necessary to ensure the installed SFPLI system meets the tested Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) qualifications. These requirements and characteristics are detailed in Westinghouse proprietary letter LTR-EQ-14-32, Rev. 2 dated August 1, 2014, which is available for review upon request.

> Additionally, placards have been installed in the Unit 3 Auxiliary Building. The placards read, "Be aware that use of hand-held radios within 3 ft. may cause interference with the SFP level channels. The reading returns to normal when radio usage is stopped."

The NRC staff found this response acceptable because it defines the distance to avoid potential SFP level channel disturbances caused by hand-held radios.

Based on the discussion above, the NRC staff finds that, if implemented accordingly, the licensee's proposed instrument qualification process should 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

The following location description compiled by the NRC staff is supported by sketches provided by the licensee in its December 3, 2015 and January 6, 2015, letters [References 37 and 58], sketches provided by the licensee during the on-site audit, and NRC staff observations during the on-site SFPLI system walkdowns:

The primary and backup instruments are located at the south and north corners respectively at the west end of the Unit 3 SFP. Cabling for each channel travels a short distance west, exiting the SFP area, through the wall, into the adjacent aux building. Primary and backup transmitters and indicators are located on the east wall of the Aux Building 43'-6".

The NRC staff noted, for both Unit 2 and Unit 3, there is sufficient channel separation within the SFP area between the primary and back-up level instruments 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.

In its December 3, 2015 and January 6, 2016, letters, the licensee stated, in part, that the instrument channels are normally powered from separate 120 Vac lighting panels that are powered from different 480 Vac buses. Use of these power sources ensures that, during normal operating conditions, the loss of one bus will not result in the functional loss of both instrument channels.

The NRC staff confirmed both the physical and electrical independence during the SFPLI walkdowns at the MPS on-site audit.

Based on the discussion above, the NRC staff finds that, if implemented accordingly, the instrument channel independence should be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.6 Design Features: Power Supplies

In its January 6, 2015, letter [Reference 57], the licensee stated:

> The instrument channels are normally powered from separate 120 Vac lighting panels that are powered from different 480 Vac buses. Use of these power sources ensures that, during normal operating conditions, the loss of one bus will not result in the functional loss of both instrument channels.
> Back-up power for each instrument channel is provided by a sealed lead acid battery located in each display cabinet, which is maintained in a charged state by commercial-grade UPS's (electrical switchover unit). At full charge, the batteries are capable of supporting the channel operations for approximately 101 hours or 4.2 days, per Westinghouse calculation WNA-CN-00300-GEN.
>
> Onsite BDB equipment includes several small electric generators, which can provide, if necessary, a portable power source within the 4.2 day battery operating timeframe and maintain instrument channel operation until off-site resources can be deployed. Each display cabinet is furnished with an external connection and manual transfer switch, which provides the ability to use an alternate 120 Vac power source to repower the channel.

The NRC staff confirmed the planned power sources during the on-site audit.

Based on the discussion above, the NRC staff finds that, if implemented accordingly, the licensee's proposed power supply design should 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 December 3, 2015, compliance letter [Reference 37], the licensee stated, in part, the level measurement channels provide measurement accuracy to within +/- 3 inches of the actual surface of the SEP water. Actual instrument channel accuracy is documented within Westinghouse calculation WNA-CN-00301-GEN. This accuracy is maintained without the need for recalibration following an interruption or change in power source as described in Westinghouse report WNATR- 03 149.

The NRC staff reviewed the accuracy of the Westinghouse system during the vendor audit and found the Westinghouse system meets the criteria in NEI 12-02. The staff's review is documented in the Westinghouse vendor audit report [Reference 36].

Based on the discussion above, the NRC staff finds that, if implemented accordingly, the licensee's proposed instrument accuracy should 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

The NRC staff reviewed the testability of the Westinghouse system during the Westinghouse vendor audit [Reference 36]. During the on-site audit at MPS, the NRC staff confirmed that the licensee will follow the vendor recommended procedures.

In its December 3, 2015, compliance letter, the licensee stated, in part, that the new SFPLI system is comprised of fixed sensors, transmitters, and display cabinets. This system can be tested and calibrated in-situ without removing the sensor probe from the pool or removing other equipment from the permanently installed locations, or may be remotely calibrated using a calibration fixture.

The licensee also stated, in part, in its December 3, 2015, compliance letter that procedures for calibration and test, maintenance, repair, operation, and normal and abnormal responses have been provided by Westinghouse. Corresponding site-specific procedures have been developed based on these vendor guidelines (see 4.3 below) and a Recurring Task Evaluation has been prepared and approved to evaluate, prepare, and implement the stated Preventative Maintenance procedures at the vendor recommended frequencies.

Based on the discussion above, the NRC staff finds that, if implemented accordingly, the licensee's proposed SFP instrumentation design should allow 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

The capabilities of the Westinghouse display were reviewed and found to meet the criteria of NEI 12-02 during the Westinghouse vendor audit [Reference 36].

Unit 3 primary and backup transmitters and indicators are located on the east wall of the Aux Building 43'-6". The NRC staff observed the equipment locations during the on-site audit. During the SFP walkdown, the staff confirmed prompt accessibility. In its January 6, 2015 letter [Reference 57], the licensee stated the round trip time to access the indicator from the control room was 15 minutes. This is consistent with the staff's observation.

Based on the discussion above, the NRC staff finds that, if implemented accordingly, the licensee's proposed location and design of the SFP instrumentation displays should 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 SFPI 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, for both units, in part, that the Systematic Approach to Training (SAT) will be used to identify the population to be trained and to determine both the initial and continuing elements of the required training.

In its December 3, 2015, letter [Reference 37], the licensee stated, in part, that to provide sufficient instructions for operation and use of the system by plant staff personnel, Knowledge Based Training is conducted during initial Operator Qualification and has been integrated into the Continuing Operations Training Program. Training includes FLEX Support Guideline, EOP 35 FSG-11, "Alternate SFP Makeup and Cooling", that defines the actions to be taken upon observation of system level indications, including actions to be taken at the levels defined in NEI 12-02. Guideline EOP 35 FSG-11 also addresses the alternate power provisions for the SFP level instruments.

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

4.3.2 Programmatic Controls: Procedures

In its January 6, 2015, letter [Reference 57], the licensee stated, in part, that procedures for system inspection, calibration and test, maintenance, repair, operation, and normal and abnormal responses have been provided by Westinghouse. Corresponding site specific procedures are being developed based on these vendor guidelines.

In its January 6, 2015 letter [Reference 57] the licensee also provided the following list of procedures with the technical objective for each:

> 1) System Inspection -- To verify the system components are in place, complete, and in the correct configuration, and that the sensor probe is free from significant boric acid deposition.
> 2) Calibration and Test -- To verify that the system is within specified accuracy, is functioning as designed, and is properly indicating SFP level.
> 3) Maintenance -- To establish and define scheduled and preventative maintenance requirements and activities necessary to minimize the possibility of interruption.

4) Repair -- To specify troubleshooting steps and component repair and replacement activities in the event of a system malfunction.
5) Operation -- To provide sufficient instructions for operation and use of the system by plant staff personnel.
6) FLEX Support Guideline (FSG) -- 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.

Based on the discussion above, the NRC staff finds that, if implemented accordingly, the licensee's procedure development should 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 January 6, 2015 letter, the licensee stated its approach for testing and calibration:

> If the plant staff determined a need to confirm that the two channels are performing as expected, the two channels may be read at their display locations. While the SFP is operating within design basis and at normal level, the indicators are compared to each other, and if a discrepancy exists can be compared to an existing narrow range SFP level instrument. The periodic calibration verification will be performed within 60 days prior to 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 Section 4.3 of NEI 12-02. Periodic calibration verification procedures provided by Westinghouse in WNA-TP-04709-GEN, "Spent Fuel Pool Instrumentation System Calibration Procedure" (Reference 10) are in place. Site specific calibration verification procedures are being developed based on Westinghouse document WNA-TP-04709-GEN, which is available for review upon request. Preventive maintenance procedures which include tests, inspection and periodic replacement of the backup batteries have been provided by Westinghouse. A corresponding site specific preventative maintenance is being developed using recommended vendor guidance.

Regarding out-of-service times for the SFPLI, the licensee stated in its January 6, 2015, letter [Reference 57] that:

> Provisions associated with out-of-service (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

> implement appropriate compensatory actions, including the use of alternate suitable equipment and/or supplemental personnel, within 72 hours.
>
> Sufficient spare parts will be maintained for the MPS3 SFP Level Instrumentation System, 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.

The NRC staff confirmed the Westinghouse testing and calibration approach during the Westinghouse vendor audit [Reference 36].

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

4.4 Conclusions for Order EA-12-051

In its letter dated January 6, 2015 [Reference 57], the licensee stated that they would meet the requirements of Order EA-12-051 by using methods described in JLD-ISG-2012-03. In the evaluation above, the NRC staff finds that, if implemented appropriately, the licensee has conformed to the guidelines of NEI 12-02, as endorsed, by JLD-ISG-2012-03. In addition, the NRC staff concludes that if the SFP level instrumentation is installed at MPS, Unit 3 according to the licensee's proposed design, it should adequately address the requirements of Order EA-12-051.

5.0 CONCLUSION

Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and proposed designs which, if implemented appropriately, will adequately address the requirements of Orders EA-12-049 and EA-12-051.

6.0 REFERENCES

53. Letter, Dominion Nuclear Connecticut, Inc., “Millstone Power Station Unit 3, Six-Month Status Report in Response to March 12, 2012, Commission Order to Modify Licenses With Regard To Requirements for Mitigation Strategies for Beyond Design Basis External Events (Order Number EA-12-049),” February 28, 2014 (ADAMS Accession No. ML14069A014)

54. Letter Dominion Nuclear Connecticut, Inc., “Millstone Power Station Unit 3, Six-Month Status Report in Response to March 12, 2012, Commission Order to Modify Licenses With Regard To Requirements for Mitigation Strategies for Beyond Design Basis External Events (Order Number EA-12-049),” August 28, 2014 (ADAMS Accession No. ML14251A023)

55. Letter, Dominion Nuclear Connecticut, Inc., “Millstone Power Station Unit 3, Six-Month Status Report in Response to March 12, 2012, Commission Order to Modify Licenses With Regard To Requirements for Mitigation Strategies for Beyond Design Basis External Events (Order Number EA-12-049),” March 2, 2015 (ADAMS Accession No. ML15069A232)

56. Letter, Dominion Nuclear Connecticut, Inc., “Millstone Power Station Unit 3 “Compliance Letter and Final Integrated Plan in Response to the March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design Basis External Events (Order Number EA-12-049)”, June 23, 2015 (ADAMS Accession No. ML15182A012)

57. Letter, Dominion Nuclear Connecticut, Inc., “Millstone Power Station Unit 3 Status of Required Actions for EA-12-051 Order Modifying Licenses With Regards to Reliable Spent Fuel Pool Instrumentation,” January 6, 2015 (ADAMS Accession No. ML15013A170)

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