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

December 28, 2016

Mr. Edward D. Halpin
Senior Vice President, Generation and
Chief Nuclear Officer
Pacific Gas and Electric Company
P. O. Box 56
Mail Code 104/6
Avila Beach, CA 93424

SUBJECT: DIABLO CANYON POWER PLANT, UNIT NOS. 1 AND 2 – SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 (CAC NOS. MF0958, MF0959, MF0963, AND MF0964)

Dear Mr. Halpin:

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 Modifying Licenses With Regard To Reliable Spent Fuel Pool Instrumentation," (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML12054A736 and ML12054A679, respectively). The orders require holders of operating reactor licenses and construction permits issued under Title 10 of the *Code of Federal Regulations* Part 50 to modify the plants to provide additional capabilities and defense-in-depth for responding to beyond-design-basis external events, and to submit for review Overall Integrated Plans (OIPs) that describe how compliance with the requirements of Attachment 2 of each order will be achieved.

By letter dated February 27, 2013 (ADAMS Accession No. ML13059A501), Pacific Gas and Electric Company, (PG&E, the licensee) submitted its OIP for Diablo Canyon Power Plant, Unit Nos. 1 and 2 (DCPP) 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 attached safety evaluation. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated February 3, 2014 (ADAMS Accession No. ML13364A192), and October 30, 2015 (ADAMS Accession No. ML15289A370), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated January 5, 2016 (ADAMS Accession No. ML16005A638), PG&E submitted a compliance letter for DCPP, Unit No. 1 and by letter dated July 28, 2016 (ADAMS Accession No. ML16221A390), and submitted a compliance letter and Final Integrated Plan (FIP) for DCPP, Unit Nos. 1 and 2, in response to Order EA-12-049. The later compliance letter stated that the licensee had achieved full compliance with Order EA-12-049.

By letter dated February 27, 2013 (ADAMS Accession No. ML13059A500), PG&E submitted its OIP for DCPP 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 attached safety evaluation. By letters dated November 25, 2013 (ADAMS Accession No. ML13311B362), and October 30, 2015 (ADAMS Accession No. ML15289A370), 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 letter dated January 05, 2016 (ADAMS Accession No. ML16005A637), PG&E submitted a compliance letter in response to Order EA-12-051. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-051.

The enclosed safety evaluation provides the results of the NRC staff's review of PG&E's strategies for DCPP. The intent of the safety evaluation is to inform PG&E on whether or not its integrated plans, if implemented as described, appear to adequately address the requirements of Orders EA-12-049 and EA-12-051. The 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. ML15257A188). 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-Olmeda, Orders Management Branch, DCPP Project Manager, at 301-415-2864 or at Milton.Valentin-Olmeda@nrc.gov.

Sincerely,

Mandy K Halter

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

Docket Nos.: 50-275 and 50-323

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

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

PACIFIC GAS AND ELECTRIC COMPANY

DIABLO CANYON POWER PLANT, UNIT NOS. 1 AND 2

DOCKET NOS. 50-275 AND 50-323

1.0 INTRODUCTION

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

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

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

Enclosure

2.0 REGULATORY EVALUATION

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

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

2.1 Order EA-12-049

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

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

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

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

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

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

On December 10, 2015, following submittals and discussions in public meetings with NRC staff, the Nuclear Energy Institute (NEI) submitted document NEI 12-06, Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," (ADAMS Accession No. ML16005A625) to the NRC to provide revised specifications for an industry-developed methodology for the development, implementation, and maintenance of guidance and strategies in response to the Mitigation Strategies order. The NRC staff reviewed NEI 12-06, Revision 2, and on January 22, 2016, issued Japan Lessons-Learned Division (JLD) Interim Staff Guidance (ISG) JLD-ISG-2012-01, Revision 1, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," (ADAMS Accession No. ML15357A163), endorsing NEI 12-06, Revision 2, with exceptions, additions, and clarifications, as an acceptable means of meeting the requirements of Order EA-12-049, and published a notice of its availability in the *Federal Register* (81 FR 10283).

2.2 Order EA-12-051

Order EA-12-051, Attachment 2, (ADAMS Accession No. ML12054A679) 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 SFP operating deck, and (3) level where fuel remains covered and actions to implement make-up water addition should no longer be deferred.

1. The SFP 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 SFP 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 SFP 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 SFP. 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 SFP area, and to utilize inherent shielding from missiles provided by existing recesses and corners in the SFP structure.

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

1.4 Qualification: The primary and backup instrument channels shall be reliable at temperature, humidity, and radiation levels consistent with the SFP 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 SFP 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 SFP water level.

2. The SFP 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 SFP 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 SFP level instrument channels to maintain the instrument channels at the design accuracy.

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

3.0 TECHNICAL EVALUATION OF ORDER EA-12-049

By letter dated February 27, 2013 (ADAMS Accession No. ML13059A501), Pacific Gas and Electric Company (PG&E, the licensee) submitted its Overall Integrated Plan (OIP) for Diablo Canyon Power Plant, Unit Nos. 1 and 2 (DCPP, Diablo Canyon) in response to Order EA-12-049. By letters dated August 22, 2013 (ADAMS Accession No. ML13235A097), February 26, 2014 (ADAMS Accession No. ML14058A221), August 21, 2014 (ADAMS Accession No. ML14233A636), February 23, 2015 (ADAMS Accession No. ML15054A628), August 26, 2015 (ADAMS Accession No. ML15238B884), and February 29, 2016 (ADAMS Accession No. ML16060A510), the licensee submitted six-month updates to the OIP. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated February 3, 2014 (ADAMS Accession No. ML13364A192), and October 30, 2015 (ADAMS Accession No. ML15289A370), the NRC issued an Interim Staff Evaluation (ISE) and an audit report on the licensee's progress. By letter dated January 5, 2016 (ADAMS Accession No. ML16005A638), the licensee reported full compliance with the requirements of Order EA-12-049 was achieved for Unit No. 1. By letter dated July 28, 2016 (ADAMS Accession No. ML16221A390), the licensee reported that full compliance with the requirements of Order EA-12-049 was achieved for Unit Nos. 1 and 2, and submitted a Final Integrated Plan (FIP).

3.1 Overall Mitigation Strategy

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

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

1. The reactor is assumed to have safely 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.

Diablo Canyon, Unit Nos. 1 and 2, are Westinghouse pressurized-water reactors (PWRs), with dry ambient pressure containments. The licensee's three-phase approach to mitigate a postulated ELAP event, as described in the FIP, is summarized below. Although the description is for one unit, the same description applies to the second unit as well.

At the onset of an ELAP, the reactor will trip from full power and will initially stabilize at no-load reactor coolant system (RCS) temperature and pressure conditions. The reactor decay heat removal system releases steam to the atmosphere through the main steam atmospheric dump valves (ADVs). Natural circulation of the RCS provides core cooling and the turbine driven auxiliary feedwater (TDAFW) pump starts automatically upon loss of offsite power to provide flow from the condensate storage tank (CST) to the steam generators (SGs) to make up for steam release. Each CST has a minimum usable capacity of approximately 222,600 gallons and will provide a suction source to the TDAFW pump for a minimum of 17 hours of RCS decay heat removal. Prior to depletion of the usable CST inventory, the TDAFW pump suction will be aligned to the seismically qualified, firewater storage tank (FWST). The FWST, which is common to both units, will provide water to support TDAFW pump operation in both units for an additional 12.5 hours. In addition, the recirculation configuration of the TDAFW pumps while taking suction from the FWST directs 50 gallons of water per minute back to the associated CST. As a result, the TDAFW pump suction would be realigned to the CSTs to gain an additional 10.4 hours of supply volume in each unit, for a total of 39.9 hours of cooling capability from seismically qualified water sources. If the TDAFW pump fails to start, the operators have approximately 30 minutes to restart the TDAFW pump to avoid SG dryout. Operators will respond to the event in accordance with emergency operating procedures (EOPs) and will transition to EOP ECA-0.0, "Loss of All AC Power," upon diagnosis of the total loss of AC power. This procedure directs isolation of RCS letdown pathways, 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 verify auxiliary feedwater (AFW) flow to all four SGs, take local manual control of TDAFW pump flowrate and take manual control of the ADVs to control steam release and RCS cooldown rate as necessary. The RCS cooldown rate will be initiated 28 minutes after the event starts, at a maximum rate of 100 degrees Fahrenheit (°F) per hour to a minimum SG pressure of 300 pounds per square inch gauge (psig) to allow for eventual AFW injection from the Phase 2 FLEX pump. The minimum established SG pressure is also high enough to prevent nitrogen gas from the safety injection (SI) accumulators from entering the RCS.

Load stripping of all non-essential loads would begin within 60 minutes after the occurrence of an ELAP/LUHS and be completed within the next 30 minutes. With load stripping, the useable station Class 1E battery life has been calculated to be 27 hours for each unit.

The Phase 2 strategy for RCS cooling and heat removal uses a combination of a common diesel-driven raw water reservoir (RWR) pump and a diesel-driven emergency auxiliary feedwater (EAFW) pump to continue to supply cooling water to the SGs. The common diesel-driven RWR pump will take a suction from the RWR through a suction hose equipped with a strainer and provide water to the FLEX suction header. As stated in the FIP, the RWR has two sections, each containing up to 2.5 million gallons of water. One section of the RWR, with a lowest expected volume (approximately 1.5 million gallons) of usable water, is capable of supplying both units' coping strategies for approximately 84 hours at the expected flow rates. The EAFW pump will draw water from the portable FLEX suction header and inject water into the associated unit's SGs through flexible hoses connected to permanent connections on plant installed systems.

The Phase 2 FLEX strategy for RCS cooling and heat removal also includes re-powering of the vital 120 volt alternating current (Vac) buses and the 125 volt direct current (Vdc) battery chargers circuits using FLEX 480 Vac diesel generators.

The Phase 3 strategy for RCS cooling and heat removal involves repowering and re-establishing one primary cooling train for the RCS (one residual heat removal pump and one component cooling water (CCW) pump) by use of 4160 Vac generators supplied from the National Strategic Alliance of FLEX Emergency Response (SAFER) Response Center (NSRC). The strategy also includes deploying two portable diesel-driven emergency auxiliary seawater (EASW) pumps (one for each unit) to restore the ultimate heat sink (UHS) function. With one train of cooling restored or functional, DCPP can restore a shutdown cooling loop and achieve cold shutdown.

Because of the installed low leakage RCS pump seals, adequate inventory is maintained within the RCS, and no RCS make-up is required during Phase 1. Without additional RCS inventory, single phase natural circulation will continue for approximately 44 hours after the ELAP.

For Phase 2 RCS inventory control, boration of the RCS is required to be completed within 24 hours after reactor shutdown to ensure subcriticality at xenon-free and cold conditions. An electric-driven emergency reactor coolant system (ERCS) pump powered by a FLEX 480 Vac diesel generator (DG) will take suction from the boric acid storage tanks (BASTs) and inject into one of the two connections in the SI system. Approximately 16,000 gallons of BAST water should be available for RCS inventory control prior to depleting the BASTs. Prior to depleting the BASTs, the suction will be shifted to the refueling water storage tank (RWST).

During Phase 3, if any additional RCS injection is required, the portable ERCS equipment with suction from the RWST should continue to be available.

There is no Phase 1 need for SFP cooling. Analysis of the SFP determined that boiling occurs at 13 hours, and boil off to a level 10 feet (ft.) above the fuel occurs in approximately 67 hours. To reduce the effects on the SFP area environment as a result of heating up of the pool, the procedures require various doors to be opened to establish a ventilation path early in the event. Early in Phase 1, some of the equipment used for Phase 2 of this strategy, including hoses, restraints, adaptors, and spray nozzles for the appropriate distribution configuration, will be deployed to the SFP deck before environmental conditions limit access.

The Phase 2 strategy for SFP cooling is to initiate SFP makeup in each unit using flexible hoses that deliver RWR water from the FLEX suction header. Additionally, two portable spray monitor nozzles for each unit will be available to provide spray capability.

For Phase 3 the SFP strategy is to repower an SFP cooling pump using 4160-V generators provided from the NSRC.

In the ELAP scenario, for Phases 1 and 2, pressure and temperature inside containment does not approach any containment integrity limits. Therefore, no Phase 1 or Phase 2 strategy is required to maintain containment integrity.

For Phase 3, the licensee has determined that restarting a containment fan cooler unit (CFCU) is necessary to control containment heat-up over an extended time and ensure no challenge to containment integrity. In Phase 3, a 4160-V generator supplied by the NSRC is used to restore CCW flow and provide power to a CFCU, which maintains long term containment temperature and pressure below allowable limits.

The staff notes that, while not credited in the licensee's strategies, the equipment (such as pumps and generators) from the NSRC has adequate capacity to substitute for the Phase 2 equipment, if needed.

Below are specific details on the licensee's strategies to restore or maintain core cooling, containment, and SFP cooling capabilities in the event of a BDBEE, and the results of the staff's review of these strategies. The NRC staff evaluated the licensee's strategies against the endorsed NEI 12-06, Revision 2, 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/LUHS. Although the ELAP results in an immediate trip of the reactor, sufficient core cooling must be provided to account for fission product decay and other sources of residual heat. Consistent with endorsed guidance from NEI 12-06, Phase 1 of the licensee's core cooling strategy credits installed equipment (other than that presumed lost to the ELAP/LUHS) that is robust in accordance with the guidance in NEI 12-06. In Phase 2, robust installed equipment is supplemented by onsite FLEX equipment, which is used to cool the core either directly (e.g., pumps and hoses) or indirectly (e.g., FLEX electrical generators and cables repowering robust installed equipment). The equipment available onsite for Phases 1 and 2 is further supplemented in Phase 3 by equipment transported from the NSRCs.

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

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

3.2.1 Core Cooling Strategy and RCS Makeup

3.2.1.1 Core Cooling Strategy

3.2.1.1.1 Phase 1

As stated in PG&E's July 28, 2016, FIP, the heat sink for core cooling in Phase 1 would be provided by the four SGs, which would be fed simultaneously by the unit's TDAFW pump with inventory initially supplied from the CST, which is robust for all applicable hazards. The licensee calculates that the CST water volume is sufficient to remove residual heat from the reactor for approximately 17 hours. Prior to depletion of the CST, an operator transfers the TDAFW pump suction to the FWST. One FWST is common to both units. The FWST has a minimum capacity of the 260,000 gallons and is robust to all applicable hazards. The licensee calculates that the FWST water volume is sufficient to remove residual heat for an additional 12.5 hours. Due to the configuration of the TDAFW pumps recirculation lines, 50 gallons per minute (gpm) will be recirculated back to each unit's CST. In order to fully utilize the plant's existing water supply, operators will transfer suction back to the CST prior to depletion of the FWST. The licensee calculates that this recirculated water will provide the TDAFW pump for an additional 10.4 hours providing cooling capacity for the first 39.9 hours of the event.

Following closure of the main steam isolation valves, as would be expected in an ELAP event, steam release from the SGs to the atmosphere would be accomplished via the main steam safety valves or the ADVs. The ADVs would typically be operated by the instrument air system which is assumed to be lost in the ELAP event. The ADVs will be locally operated by means of valve handwheels following the ELAP event. The licensee has confirmed that this flowpath is robust with respect to all applicable external hazards.

Diablo Canyon's Phase 1 strategy directs operators to initiate a cooldown and depressurization of the RCS within 28 minutes of the initiation of the ELAP/LUHS event. Over a period of approximately 2.3 hours, the licensee will cool down the RCS from post-trip conditions until a SG pressure of 300 psig is reached. A minimum SG pressure of 300 psig is set to avoid the injection of nitrogen gas from the SI accumulators into the RCS. Cooldown and depressurization of the RCS significantly extends the expected coping time under ELAP/LUHS conditions because allows coolant stored in the nitrogen-pressurized accumulators to inject into the RCS to offset system leakage without injection of nitrogen.

3.2.1.1.2 Phase 2

The licensee states, in its FIP, that the primary strategy for core cooling in Phase 2 would be to continue using the SGs as a heat sink, with SG secondary inventory being supplied by the diesel driven EAFW pump. Suction to the EAFW pump will be supplied by the diesel RWR pump. The RWR pump is common to both units and supplies water drawn from the RWR to each units EAFW pumps.

According to PG&E's calculations, the RWR contains a minimum of approximately 1.5 million gallons of water and is capable of supplying SG makeup for approximately 84 hours. To provide access to the RWR water supply in Phase 2, PG&E stated that the portable diesel-driven RWR pump will be deployed at the RWR. This pump would draw suction from the RWR through a suction hose equipped with a strainer and discharge into hoses routed to the common FLEX suction header and supplied by flexible hoses to each of the FLEX EAFW pumps suctions.

The licensee's FIP states that the RWR pump is rated for 1,200 gpm at 150 psid and the EAFW pumps are rated for 300 gpm at 245 psid. The EAFW pumps discharge to the SGs via either a primary or alternate FLEX connection to the AFW system. The primary connection point is located on the AFW piping on a crosstie between the two motor-driven auxiliary feedwater (MDAFW) pumps. The licensee has installed a isolation valve and threaded hose connection at this point. The alternate location is on the AFW supply lines to the SGs at one of two pre-identified check valves. Use of the alternate location will require the removal of the check valve bonnet and internals, and the installation of a valve cover equipped with a hose connection. Use of the combination of the RWR and EAFW pumps will require that the SGs have been depressurized to 300 psig.

3.2.1.1.3 Phase 3

According to its FIP, Diablo Canyon's core cooling strategy in Phase 3 is to transition to heat removal through the residual heat removal (RHR) system using additional offsite equipment and resources. In particular, the 4160 volt generators and distribution system supplied by the NSRC will be used to power one train in each unit of the class 1E distribution system. This will provide the electrical power necessary to operate an RHR pump and a CCW pump. Per the FIP, in order to complete the strategy for core cooling in Phase 3, accumulator isolation valves, RHR suction valves, and other valves inside containment are required to be manipulated. FLEX

Support Guidelines (FSGs) procedures provide that equipment deployed during this phase will provide power and the capability to manipulate these valves remotely. The UHS function will be restored by deploying portable diesel driven EASW pumps (one per unit) at the intake cove. These pumps will discharge seawater through rigid piping to connection points on the ASW piping. This flow will provide cooling for the CCW heat exchangers.

The licensee performed a calculation to show that nitrogen expansion due to containment heatup would not result in nitrogen injection into the RCS. As demonstrated in Calculation 9000042294-000-00, "Accumulator Gas Expansion and Isolation of Accumulators," the secondary side is maintained at or above 300 psig to prevent the accumulators from injecting nitrogen into the RCS. This pressure level is maintained until implementation of FSG 10, "Accumulator Isolation," which is the Phase 3 strategy to repower the accumulator valves remotely using the 4160 V generators provided by the NSRC. Per Table 4 of the FIP, this will occur prior to 121 hours into the event. At that time, the containment temperature in the accumulator compartment is expected to be approximately 170 °F. PG&E conservatively used 200 °F in the calculation as the containment temperature in the accumulator compartment. The results of this calculation show that the expanded volume of nitrogen does not exceed the total volume of the accumulators and no nitrogen will inject into the RCS.

3.2.1.2 RCS Makeup Strategy

3.2.1.2.1 Phase 1

Following the reactor trip at the start of the ELAP/LUHS event, operators will isolate RCS letdown pathways and confirm the existence of natural circulation flow in the RCS. A small amount of RCS leakage will occur through the low-leakage RCP seals, but because the expected inventory loss would not be sufficient to drain the pressurizer prior to the RCS cooldown, its overall impact on the RCS behavior will be minor. Although the RCS cooldown planned for completion at less than 3 hours into the event would be expected to drain the pressurizer and create a vapor void in the upper head of the reactor vessel, ample RCS volume should remain to support natural circulation flow throughout Phase 1. Likewise, there is no need to initiate boration during this period, since the reactor operating history assumed in the endorsed NEI 12-06 guidance implies that a substantial concentration of xenon-135 would be present in the reactor core. Additionally, as operators depressurize the RCS, the borated inventory from the nitrogen-pressurized accumulators would be expected to passively inject. The licensee's procedures direct accumulator isolation once electrical power is restored to the corresponding isolation valves during Phase 3 actions.

3.2.1.2.2 Phase 2

In Phase 2, RCS inventory control and boration are accomplished with a combination of pre-staged and portable equipment stored in the auxiliary building and the FLEX primary and secondary storage facilities. In the course of cooling and depressurizing the SGs to a target pressure of 300 psig, a fraction of the accumulator liquid inventory may inject into the RCS, filling volume vacated by the thermally induced contraction of RCS coolant and system leakage. However, crediting boration from the accumulators is challenging because actual RCS leakage may be quite small, and furthermore, dependent upon the rate of heat loss from the RCS (i.e., particularly from the reactor vessel upper head), RCS pressure may remain several hundred psi above the SG target pressure for multiple hours into the event. Thus, in order to ensure long-term subcriticality as positive reactivity is added from the RCS cooldown and xenon decay, RCS boration will be completed using a pre-staged FLEX pump no later than 20 hours into the ELAP/LUHS event. With low-leakage Westinghouse Generation 3 SHIELD RCP seals installed on all RCPs, PG&E calculates that FLEX RCS makeup is not necessary to prevent the loss of single phase natural circulation cooling for approximately 44 hours into the event. Therefore, the injection of borated RCS makeup water for reactivity control will be in progress long before entry into reflux cooling becomes a concern.

The method of boration and inventory control in Phase 2 is through the use of a pre-staged FLEX ERCS pump with a capacity of 30 gpm at 1,500 psig (one pump per unit). The pump is electrically powered by a portable DG rated for 150 kW at 480 Vac. One generator is common to both units and will power both of the pre-staged ERCS pumps. The pump will be aligned to take suction initially from the BAST. When the contents of the BAST are depleted the pump will be aligned to take suction from the RWST. Both of these sources are robust for all applicable natural hazards. The FLEX ERCS pump can be aligned to discharge to either a primary or alternate FLEX connection. The primary connection is located on a cold leg SI test vent on a header at penetration 33. The alternate connection is located on a cold leg SI test vent on a header at penetration 34.

3.2.1.2.3 <u>Phase 3</u>

According to its FIP, PG&E's Phase 3 strategy is to transition to decay heat removal through the RHR system using additional offsite equipment and resources. The 4160 volt generators and distribution system supplied by the NSRC will be used to power one train in each unit of the class 1E distribution system. This will provide the electrical power necessary to operate an RHR pump and a CCW pump. The UHS function will be restored by deploying portable diesel driven EASW pumps (one per unit) at the intake cove. These pumps will discharge seawater through hoses to connection points on the ASW headers. This flow will provide cooling for the CCW heat exchangers. The ERCS pump or an NSRC provided pump can draw suction from the RWST and discharge to the primary and alternate FLEX connections as necessary to maintain RCS inventory.

Per the list of NSRC equipment delivered to Diablo Canyon, there is no discussion of a means of water purification or boron mixing being provided to the site. The NRC staff recognize that the licensee's plan to transfer core cooling from the SG's to the RHR system will minimize water consumption at the site, and extend the coping time available given the quantity of borated water available in the RWST to much greater than 121 hours. As discussed in NEI 12-06, Revision 2, Section 3.3, FLEX strategies and/or resources are not required to be explicitly planned in advance for the period beyond 72 hours. At that point in time, it is expected that the site's Emergency Response Organization will be actively engaged in the response and can provide the required resources from off-site as required utilizing the staging locations established by the NSRC if needed. There is sufficient water supply in the RWST of each unit to allow for these activities to take place within the required timeframe.

3.2.2 Variations to Core Cooling Strategy for Flooding Event

In its FIP, the licensee stated that the Diablo Canyon site is not generally susceptible to external flooding. For the majority of the site, the FLEX storage buildings and deployment paths would not be adversely affected by the flooding events. The licensee's core cooling and makeup strategy implementation does not change if flooding occurs. The EASW pumps will be deployed in an area of the plant susceptible to flooding for the restoration of UHS. If these two pumps were damaged by flooding, there are two backup EASW pumps and associated equipment available in locations not susceptible to flooding. Refer to Section 3.5.2 of this safety evaluation (SE) for further discussion on flooding.

3.2.3 Staff Evaluations

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

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

3.2.3.1.1 Plant SSCs

Core Cooling

Phase 1

The licensee states that the TDAFW pump automatically starts and delivers AFW flow from the CST to the SGs following an ELAP/LUHS event. In Section 3.1.4.1 of its FIP, the licensee states that the TDAFW pump is located in a safety-related structure protected from all applicable design-basis external events. Furthermore, the Diablo Canyon updated final safety analysis report (UFSAR) Section 6.5.2.2, Revision 20, states the auxiliary feedwater pumps, piping and valves are Design Class I. Two normally open steam admission valves supply steam to the TDAFW pump. In the FIP, Section 3.1.4.1 states that, in the event the TDAFW pump fails to start, procedures direct the operators to manually reset and start the pump. The operators will remotely adjust feed control valves to maintain SG level initially (until load shedding is completed at about 90 minutes) using power from the 120 Vdc batteries. After load shedding SG level will be controlled manually at the feed control valves. The NRC staff finds that the TDAFW pump is robust and is expected to be available at the start of an ELAP event consistent with NEI 12-06, Section 3.2.1.3.

The licensee plans to vent steam from the SGs by manually controlling the ADVs and perform a controlled cooldown. As described in FIP Section 3.1.4.2, the ADVs are safety-related and seismically qualified valves. The ADVs will be manually throttled using handwheels. The ADVs are robust and are expected to be available at the start of an ELAP event consistent with NEI 12-06, Section 3.2.1.3. Further explanation and the NRC staff's evaluation of the robustness and availability of water sources for an ELAP event is discussed in Section 3.10 of this SE.

Phase 2

The licensee's Phase 2 core cooling strategy continues to use the SGs as the heat sink. Diablo Canyon will continue to use the TDAFW pump as long as possible, or the transition to an EAFW pump discharging through a primary or alternate connection point to the SGs. The licensee does not plan to rely on any installed plant SSCs other than installed systems with FLEX connection points and water sources discussed in SE Sections 3.7 and 3.10, respectively.

Phase 3

Once NSRC equipment arrives on site, the Diablo Canyon Phase 3 core cooling FLEX strategy relies on the use of portions of the RHR, CCW, and ASW sytems. The licensee will connect diesel driven EASW pumps to the ASW system prior to inlet to the CCW Heat Exchangers to provide core, containment and SFP cooling. The portions of these systems relied on for the Phase 3 core cooling strategy are safety-related and seismically analyzed to Design Class 1 criteria. The staff finds that the these system are robust and should be available during an ELAP event consistent with NEI 12-06, Section 3.2.1.3. The ASW FLEX connection is discussed in Sections 3.7 of this SE.

RCS Makeup

Phase 1

The licensee's Phase 1 RCS inventory control FLEX strategy relies on low leakage seals, and the licensee's analysis demonstrated that no FLEX RCS make up is needed within approximately 44 hours.

Phase 2

The licensee's Phase 2 RCS inventory strategy for Diablo Canyon will use an ERCS makeup pump and does not rely on any installed plant SSCs other than installed systems with FLEX connection points and borated water sources discussed in SE Sections 3.7 and 3.10, respectively.

Phase 3

The licensee's Phase 3 RCS inventory strategy for Diablo Canyon does not rely on any additional installed plant SSCs other than those discussed in the Phase 2 core cooling section.

3.2.3.1.2 Plant Instrumentation

According to the Diablo Canyon FIP, the following instrumentation will be relied upon to support the licensee's core cooling and RCS inventory control strategy. The following instruments are monitored from the control room and will be available throughout the event:

- SG level (wide range and narrow range)

- SG pressure
- AFW flow indication
- RCS hot-leg and cold-leg temperature
- RCS pressure (wide range)
- Core exit thermocouples (CET) temperature
- Wide range accumulator level
- Reactor vessel level indicating system (RVLIS)
- Pressurizer level
- Neutron flux
- CST level
- Firewater level is monitored locally (not in control room)

All of these instruments are powered by installed safety-related station batteries. To prevent a loss of vital instrumentation, operators will extend battery life to a minimum of 27 hours by shedding unnecessary loads and sequencing battery usage. The load shedding will begin within 60 minutes from the initiation of the ELAP event and will be completed within the next 30 minutes. A FLEX 480 Vac DG will be deployed to repower the battery chargers at an estimated time of 17.3 hours from ELAP event initiation. This provides for 9.7 hours margin until a loss of instrumentation could occur.

The licensee's FIP states that, as recommended by Section 5.3.3 of NEI 12-06, procedures have been developed to read the above instrumentation locally using portable instruments, where applicable. Guidance has been provided in procedure FSG 07, "Loss of Vital Instrumentation or Control Power."

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

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

3.2.3.2 Thermal-Hydraulic Analyses

Per the Diablo Canyon FIP, the licensee stated that its mitigating strategy for reactor core cooling is based, in part, on a generic thermal-hydraulic analysis performed for a reference Westinghouse four-loop reactor using the NOTRUMP computer code. The NOTRUMP code and corresponding evaluation model were originally submitted in the early 1980s as a method for performing licensing-basis safety analyses of small-break loss-of-coolant accidents (LOCAs) for Westinghouse PWRs. Although NOTRUMP has been approved for performing small-break LOCA analysis under the conservative Appendix K paradigm and constitutes the current evaluation model of record for many operating PWRs, the NRC staff had not previously examined its technical adequacy for performing best-estimate simulations of the ELAP event. Therefore, in support of mitigating strategy reviews to assess compliance with Order EA-12-049, the NRC staff evaluated licensees' thermal-hydraulic analyses, including a limited review of the significant assumptions and modeling capabilities of NOTRUMP and other thermal-hydraulic codes used for these analyses. The NRC staff's review included performing confirmatory analyses with the TRACE code to obtain an independent assessment of the duration that reference reactor designs could cope with an ELAP event prior to providing makeup to the RCS.

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

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

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

Although the NRC staff obtained confidence that the NOTRUMP code is capable of performing best-estimate ELAP simulations prior to the initiation of reflux cooling using the one-tenth flow-quality criterion discussed above, the 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, 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 time that would exist for specific plants.

During the audit, the NRC staff evaluated a comparison of the generic analysis values from WCAP-17601-P and PWROG-14064-P to the Diablo Canyon plant-specific values. The NRC staff concurred that the generic plant parameters were bounding for the analyzed event. Diablo Canyon has installed low-leakage SHIELD shutdown seals; therefore, the seal leakage expected for Diablo Canyon is significantly less than assumed in the generic NOTRUMP analysis case. The NRC staff concluded based on the licensee evaluation, that the licensee could maintain single phase natural circulation flow in the RCS for approximately 44 hours after the initiation of the ELAP event. The RCS makeup will be available per the licensee's mitigating strategy for shutdown margin at approximately 14.5 hours and no later than 20 hours following the initiation of the ELAP event. The licensee plans to align the ERCS pump suction to the RWST for additional RCS inventory injections at approximately 27.8 hours after the initiation of the ELAP event. Per its FIP, the licensee's strategy for RCS makeup provides sufficient margin to the onset of reflux cooling.

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

3.2.3.3 Reactor Coolant Pump Seals

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

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

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

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

This condition is satisfied because, as confirmed in the audit, the RCPs for Diablo Canyon Units 1 and 2 are Westinghouse Model 93A.

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

The maximum steady-state RCP seal temperature during an ELAP response is expected to be the RCS cold leg temperature corresponding to the lowest SG safety relief valve setting of 1,065 psia. This results in a RCS cold leg temperature of approximately 554 °F.

(3) The maximum RCS pressure during the ELAP (notwithstanding the brief pressure transient directly following the reactor trip comparable to that predicted in the applicable analysis case from WCAP-17601-P) is as follows: For Westinghouse Models 93 and 93A-1 RCPs, RCS pressure is limited to 2,250 psia; for Westinghouse Model 93A RCPs, RCS pressure is to remain bounded by Figure 7.1-2 of TR-FSE-14-1-P, Revision 1.

RCS pressure is expected to remain at or below the bounding pressure from Figure 7.1-2 of TR-FSE-14-1-P, Rev1 following the initial pressure transient following the reactor trip. During the initial pressure transient, RCS pressure is expected to remain below 2,500 psia which is the seal accident design pressure limit. Allowing for the possibility of a brief pressure transient directly following the reactor trip, the NRC staff concludes that the licensee's mitigating strategy of cooling the reactor core via the main steam 10 percent ADVs will maintain reactor pressure within the limiting value for Model 93A.

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

Diablo Canyon's FIP and supporting calculations assume a constant Westinghouse SHIELD RCP seal package leakage rate of 6 gpm per RCP for first 15 minutes following initiation of ELAP event and 1 gpm per RCP thereafter. The low leakage rate is assumed to result from the actuation of the seal as the temperature increases. The licensees calculation includes an additional RCS technical specification leak of 1 gpm. As noted previously, the licensee's calculation indicates that single phase natural circulation flow and inventory is maintained for a minimum of 43.7 hours into the event, even if FLEX RCS makeup flow were not provided as planned. In that Diablo Canyon's mitigating strategy directs RCS makeup to begin at approximately 14.5 hours and no later than 20 hours after the ELAP event initiation, ample margin exists to accommodate the small additional volume of leakage that is expected to occur before actuation of the SHIELD seal.

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

3.2.3.4 Shutdown Margin Analyses

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

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

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 NRC staff expects that any core design changes, such as those considered in a core reload analysis, will be evaluated to determine that they do not adversely impact the approved FLEX strategies, especially the analyses which demonstrate that recriticality will not occur during a FLEX RCS cooldown.

The NRC staff audited the licensee's shutdown margin calculations. After the ELAP event, cooldown and depressurization begin at cooldown rate of approximately 100 °F/hr. Below a threshold pressure, passive injection from the SI accumulators adds negative reactivity into the RCS. The licensee plans to use the BAST as a suction source using a 30 gpm, 1,500 psig FLEX pump to deliver the boration to the RCS. Diablo Canyon shutdown margin calculations concluded that the licensee would need 4,449 gallons of 7,000 parts per million (ppm) borated water from the BAST (the most conservative case for both units) in order to meet the shutdown margin requirements end-of-cycle condition. When using the BAST as a borated water source, venting of the RCS is not required. Per the FIP, in order to ensure adequate shutdown margin will be maintained, the addition of pumped boron must be completed by 24 hours after the initiation of the ELAP event due to xenon decay. The 24 hour time requirement is met by the licensee by the validation that RCS make-up can be initiated by 14.5 hours after the initiation of the ELAP event. This provides a 5.5 hour margin on the constraint time of 20 hours required to ensure meeting the 24 hour requirement.

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

> Condition 1: The required timing and quantity of borated makeup should consider conditions with no RCS leakage and with the highest applicable leakage rate.
>
> This condition is satisfied because the licensee's planned timing for establishing borated makeup acceptably considered both the maximum and minimum RCS leakage conditions expected for the analyzed ELAP event.
>
> Condition 2: Adequate borated makeup should be provided either (1) prior to the RCS natural circulation flow decreasing below the flow rate corresponding to single-phase natural circulation, or (2) if provided later, then the negative reactivity from the injected boric acid should not be credited until one hour after

the flow rate in the RCS has been restored and maintained above the flow rate corresponding to single-phase natural circulation.

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

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

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

During the audit review, PG&E confirmed that Diablo Canyon would comply with the August 15, 2013, position paper on boric acid mixing, including the above conditions imposed in the staff's corresponding endorsement letter. The NRC staff's audit review indicated that the licensee's shutdown margin calculations are generally consistent with the PWROG's position paper, including the three additional conditions imposed in the NRC staff's endorsement letter.

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

3.2.3.5 FLEX Pumps and Water Supplies

The licensee's FLEX strategy relies on three different portable pumps during Phase 2. Diablo Canyon relies on an EAFW Pump to provide makeup to the SGs; an ERCS makeup pump to provide low flow, high pressure makeup to the RCS; and a RWR pump supplies water to the EAFW pump, to the ERCS pump, and the SFP.

In Section 3.1.10 of its FIP, the licensee identified the performance criteria (e.g., flow rate, discharge pressure) for its Phase 2 portable pumps. The NRC staff noted that the performance criteria for the FLEX Phase 3 portable pumps are consistent with the FLEX Phase 2 portable pumps capacities. See Section 3.10 of this SE for a discussion of the availability and robustness of each water source.

The licensee relies on a RWR pump to provide water for long term AFW, RCS and SFP makeup. The licensee procured two trailer-mounted, diesel-driven pumps that are stored on the secondary FLEX storage facility located near the RWR. One RWR pump is required for both units so the licensee has two pumps to satisfy N+1. Section 3.1.10.1 of the FIP states that either RWR pump can provide 1,200 gpm (250 gpm to each SFP and 300 gpm of AFW to each unit). During the audit, the licensee provided calculation STA-294, "Fukushima Emergency Pump Sizing," Revision 4. The purpose of this calculation is to determine pump sizing (discharge pressure, flow and net positive suction head (NPSH) of the portable FLEX pumps (RWR, EAFW, and ERCS)).

During Phase 2, SG makeup can be transferred to a portable diesel-driven EAFW pump when the TDAFW pump is no longer available. The EAFW pump will take suction from the RWR FLEX suction header located on the 115 ft. elevation. A single pump provides full capability to feed all the generators in one unit, so Diablo Canyon has three portable EAFW pumps to satisfy N+1 as outlined in NEI 12-06. The FIP Section 3.1.10.2 states that the EAFW pump can provide 300 gpm with 566 ft. of head. As noted above, the licensee performed calculation STA-294 to determine the fluid system hydraulic performance, and to validate that the EAFW pumps have adequate performance characteristics. The NRC staff noted that this calculation assessed different possible lineups based on such variables as suction sources, connection points and hose paths to determine the flow to ensure that the EAFW pump is adequate for providing injection into the SGs at the required flow rate and discharge pressure.

Makeup to the RCS is provided by the ERCS makeup pump to compensate for RCS volume contraction during cool-down and RCS leakage such as RCP seal leakage. The pump for the associated unit is pre-staged inside the auxiliary building on the 100 ft. elevation and can take suction from the BAST or RWST. The FIP states that the ERCS pump can provide a minimum flow of 30 gpm at 1,500 psig. The licensee has a third ERCS pump mounted on a trailer (stored in warehouse B) that can provide makeup to either unit to meet N+1.

Lastly, during Phase 3, the licensee plans to deploy portable diesel-driven EASW pumps. As described in Section 3.1.10.3, the pumps are designed to provide 3,000 gpm to the CCW heat exchangers to provide cooling water for CCW and ultimately provide core cooling. Two pumps, one for each unit, would be staged at the near the intake cove and rigid pipe sections connected to the ASW vacuum breaker vault where they would be connected to the installed ASW system. During the audit, the licensee provided calculation STA-286, "Alternate ASW Pump," Revision 2. The purpose of this calculation was to provide the hydraulic requirements for the alternate source of ASW to the CCW heat exchanger. The calculation found the pump procured by the licensee is adequate for providing cooling water to the CCW heat exchangers.

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

3.2.3.6 Electrical Analyses

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

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

According to the licensee's FIP, operators will respond to the event in accordance with emergency operating procedures to confirm reactor coolant system, secondary system, and containment conditions. A transition to ECA-0.0, "Loss of All AC Power," will be made upon the diagnosis of the total loss of ac power. This procedure directs isolation of reactor coolant system letdown pathways, verification of containment isolation, reduction of dc loads on the Class 1E station batteries, and establishment of electrical equipment alignment in preparation for eventual power restoration.

The Diablo Canyon Phase 1 FLEX mitigation strategy involves relying on installed plant equipment and onsite resources, such as the 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, Category 1 structures. In its FIP, the licensee stated that initial load shedding of all non-essential loads will be initiated and completed within one and a half hours after the initiation of an ELAP. With load shedding, the licensee calculated the useable station battery capacity to be 27 hours for each DCPP unit. The licensee would conduct the load shed using FSG 04, "ELAP DC Load Shed and Management."

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 station 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.

The NRC staff reviewed the licensee's dc coping calculations (FLEX-015, "Diablo Canyon FLEX Battery 11 and 21 Coping Analysis," Revision 0, and Calculation 9000041622, "Diablo Canyon FLEX Battery Coping Analysis," Revision 00), which verified the capability of the dc system to supply the required loads during the first phase of the DCPP FLEX mitigation strategy plan for an ELAP as a result of a BDBEE.

Each DCPP unit's Class 1E 125 Vdc system consists of three independent batteries each having separate power distribution switchgear assemblies that include a 125-Vdc bus, circuit breakers, fuses, metering, and two distribution panels. Each of the three 125-Vdc switchgear buses has a battery charger. Batteries 11(21) and 12(22) have an additional swing charger that can be connected to either bus by manually closing one of the two interlocked breakers. The fifth battery charger is a backup charger for battery 13(23). The DCPP batteries were manufactured by C&D Technologies (LCUN-33) and are rated at 2,318 Ampere-hours (Ah) at an 8-hour discharge rate to a final voltage of 1.75-V/cell. The licensee's evaluation identified the required loads and their associated ratings (ampere (A) and minimum required voltage) and the non-essential loads that would be shed to ensure battery operation for least 27 hours.

Based on the review of the licensee's analyses, procedures, and the battery vendor's capacity and discharge rates for the Class 1E station batteries, the NRC staff finds that the DCPP dc systems should 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. This is based on the licensee energizing the battery chargers prior to the batteries depleting to the minimum acceptable voltage (105 V) and the dc load shedding being completed within the times assumed in the licensee's analysis.

The licensee's Phase 2 strategy includes re-powering of battery chargers within 27 hours to maintain availability of instrumentation to monitor key parameters. Prior to depletion of the 125 Vdc Class 1E station batteries, operators would repower the safety-related battery chargers using one of the portable 480 Vac, 275 kW FLEX DGs and a portable 480 Vac load center stored on-site. The licensee would deploy the portable 480 Vac, 275 kW FLEX DGs using FSG 005, "Initial Assessment and FLEX Equipment Staging."

The licensee's Phase 2 strategy also includes powering two electric driven ERCS make-up pumps from a 150 kW diesel generator. The licensee has two 150 kW FLEX DGs, but only one 150 kW FLEX DG is needed to support both unit's ERCS makeup pumps. The ERCS pump is needed within 20 hours of initiation of an ELAP event. The licensee expects to deploy and connect the ERCS pump within 14.5 hours of initiation of an ELAP event.

The NRC staff reviewed licensee calculation 9000041641, "FLEX Diesel-Driven Generator Sizing," Revision 00. The licensee's 480 Vac FLEX DGs being used to re-power the battery chargers have a continuous rating of 275 kW. According to the licensee's calculation, the maximum continuous load on the FLEX DG is expected to be 177.7 kW. The licensee's 480 Vac FLEX DGs being used to power the ERCS pump have a continuous rating of 150 kW. According to the licensee's calculation, the maximum continuous load on the FLEX DG is expected to be 116.9 kW. The licensee's calculations took the FLEX cable lengths into consideration (i.e., ensured that the voltage drop did not exceed the minimum voltage required at the limiting component).

Based on its review of 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 separation and isolation of the FLEX DGs from the Class 1E emergency diesel generators (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, the licensee will receive four (two per unit) 1-megawatt (MW) 4160 Vac combustion turbine generators (CTGs), two (one per unit) 1,100 kW 480 Vac CTGs, and distribution panels (including cables and connectors) from an NSRC. Each portable 4160 Vac CTG is capable of supplying approximately 1 MW, but two CTGs could be operated in parallel to provide a total of approximately 2 MW (per unit).

Diablo Canyon would use the NSRC supplied CTGs to repower one 4160 Vac bus on each unit to re-establish one primary cooling train for the RCS. By restoring the Class 1E 4160 Vac bus, power can be restored to the Class 1E 480 Vac system via the 4160/480 Vac transformers to power selected 480 Vac loads. The repowered 4160 Vac bus will power a RHR pump and CCW pump for each unit. The licensee would also utilize the portable ERCS equipment for RCS inventory control, if necessary.

The NRC staff reviewed licensee calculation 9000041641, which included an evaluation of the expected loads during Phase 3. According to the licensee's calculation, the maximum continuous load on the FLEX DG is expected to be 1,064.6 kW. This is within the rating of the NSRC supplied CTGs (2 MW combined). With regard to the portable ERCS equipment loading, the licensee's calculation showed that the maximum continuous loading is expected to be 116.9 kW. Therefore, an NSRC supplied 480 Vac, 1,100 kW CTG has adequate capacity to replace a 150 kW FLEX DG, if necessary. Similarly, the licensee's calculation showed that the maximum continuous loading to repower the battery chargers is expected to be 177.7 kW.

Therefore, an NSRC supplied 480 Vac 1,100 kW CTG has adequate capacity to replace a 275 kW FLEX DG, if necessary. The licensee's calculation took the FLEX cable lengths into consideration (i.e., ensured that the voltage drop did not result in voltage below the minimum required at the limiting component).

Based on the above, the NRC staff finds that the equipment being supplied from either of the NSRCs should have sufficient capacity and capability to supply the required loads during Phase 3.

3.2.4 <u>Conclusions</u>

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

3.3 <u>Spent Fuel Pool Cooling Strategies</u>

In NEI 12-06, Table 3-2 and Appendix D, summarize an approach consisting of two separate capabilities for the SFP cooling strategies. This approach uses a portable injection source to provide the capability for 1) makeup via hoses on the refueling floor capable of exceeding the boil-off rate for the design basis heat load; and 2) makeup via connection to SFP cooling piping or other alternate location capable of exceeding the boil-off rate for the design-basis heat load. However, in JLD-ISG-2012-01, Revision 1 (ADAMS Accession No. ML15357A163), the NRC staff did not fully accept this approach, and added another requirement to either have the capability to provide spray flow to the SFP, or complete an SFP integrity evaluation which demonstrates that a seismic event would have a very low probability of inducing a crack in the SFP or its piping systems so that spray would not be needed to cool the spent fuel. The evaluation must use the reevaluated seismic hazard described in Section 3.5.1 below if it is higher than the site's current safe-shutdown sarthquake. During the event, the licensee selects the SFP makeup method to use based on plant conditions. This approach also requires a strategy to mitigate the effects of steam from the SFP, such as venting.

As described in NEI 12-06, Section 3.2.1.7, and JLD-ISG-2012-01, Section 1.1, strategies that must be completed within a certain period of time should be identified and a basis that the time can be reasonably met should be provided. In NEI 12-06, 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 BDB, 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.

Guidance document 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 actions are required during ELAP Phase 1 for SFP makeup because the time to boil is sufficient to enable deployment of Phase 2 equipment. Adequate SFP inventory exists to provide radiation shielding for personnel well beyond the time of boiling. The licensee will monitor SFP water level using reliable SFP level instrumentation installed per Order EA-12-051.

3.3.2 Phase 2

In the FIP, Section 3.3.2 states that during Phase 2 operators will deploy a portable RWR pump to supply water from the RWR to the SFP(s). The RWR pump discharge can be routed to a connection to the SFP cooling system (not requiring refueling floor access), or routed to the refuel floor to provide direct makeup to the pool or provide spray flow via portable nozzles.

3.3.3 Phase 3

The licensee plans to repower the SFP cooling pump using the NSRC 4160 Vac generators to provide a heat removal capability.

3.3.4 Staff Evaluations

3.3.4.1 Availability of Structures, Systems, and Components

3.3.4.1.1 Plant SSCs

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

The staff reviewed the licensee's calculation on habitability on the SFP refuel floor. This calculation and the FIP indicate that boiling begins at approximately 13 hours during a non-outage situation with a maximum post-refueling decay heat load. 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 8 hours from 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 operator actions. However, the licensee does establish a ventilation path to cope with temperature, humidity and condensation from evaporation and/or boiling of the SFP. The operators are directed to open the SFP exterior roll-up door and personnel doors to establish the ventilation path.

The licensee's Phase 2 SFP cooling strategy involves the use of the RWR pump, with suction from the RWR, to supply water to the SFP. 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 RWR 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

As described in Section 3.15.3 of the FIP, the SFP will boil in approximately 6 hours and boil off to a level 10 ft. above the top of fuel in 30 hours from initiation of the event with no operator action at the maximum offload decay heat load.

Calculation number RE-20130204, "SFP Sloshing Impact on Heat Up Time Estimates," Revision 0, states that the two bounding scenarios analyzed are: (1) maximum post-reload heat load and (2) the maximum post-offload heat load which includes a full core offload. The heat loads, boil-off times, and makeup rates can be found in the table below.

	Heat Load	Time to boil to 10 ft. from top of fuel	Makeup rate
Full Core Offload	22 million Btu/hr	30 hrs	47 gpm

Therefore, the licensee conservatively determined that a SFP makeup flow rate of at least 47 gpm will maintain adequate SFP level above the fuel for an ELAP occurring during normal power operation. Consistent with this guidance in NEI 12-06, Section 3.2.1.6, the staff finds the licensee has considered the maximum design-basis SFP heat load.

3.3.4.3 FLEX Pumps and Water Supplies

As described in the FIP, the SFP cooling strategy relies on the RWR pump to provide SFP makeup during Phase 2. In the FIP, Section 3.1.10.1 describes the hydraulic performance criteria (e.g., flow rate, discharge pressure) for the RWR pump. As stated above, the RWR pump can provide SFP spray flow rate of 250 gpm to each unit which both meets and exceeds the maximum SFP makeup requirements. Furthermore, the staff finds analysis above is consistent with NEI 12-06 Section 11.2 and the FLEX equipment is capable of supporting the SFP cooling strategy and is expected to be available during an ELAP event.

3.3.4.4 Electrical Analyses

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

In its FIP, the licensee noted that SFP levels will be monitored in all 3 Phases by instrumentation installed in response to NRC Order EA-12-051. The SFP level instrumentation has an independent uninterruptable power supply. Instrument power for this equipment has battery capacity for 72 hours. An external connector and transfer switch is available to connect an external power source to provide power to the instrumentation and display panels and to recharge the backup battery, as necessary. The FSG procedures direct the installation of this external power supply to the FLEX DG provided to power the ERCS Pumps, or any other available FLEX generator prior to 72 hours.

Beyond the SFP level instrumentation, no additional electrical components are needed as part of the licensee's Phase 2 strategy.

For Phase 3, the licensee would connect the NSRC supplied 4160 Vac CTGs to energize the SFP cooling system to provide indefinite heat removal capability. The NRC staff reviewed licensee calculation 9000041641, which showed that the required Phase 3 SFP loading on the CTGs was within the design ratings of two NSRC supplied CTGs operated in parallel. Based on its review, the NRC staff determined that the 4160 Vac equipment being supplied from an NSRC should have sufficient capacity and capability to supply SFP cooling systems.

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. Diablo Canyon has a dry ambient pressure containment.

The licensee performed a containment evaluation, FLEX-011, "Diablo Canyon ELAP Containment Analysis," Revision 0, which was based on the boundary conditions described in Section 2 of NEI 12-06. The calculation analyzed the strategy of containment isolation and monitoring containment pressure using installed instrumentation and concluded that, even with the licensee taking no mitigating actions related to removing heat from containment, the containment parameters of pressure and temperature remain well below the respective UFSAR Section 6.2.1 design limits of 47 psig and 271 °F for more than 120 hours. From its review of the evaluation, the NRC staff noted that the required actions to maintain containment integrity and required instrumentation functions have been developed, and are summarized below.

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

3.4.1 Phase 1

The licensee's containment analysis shows that the structural integrity of the reactor containment building, due to increasing containment pressure, will not be challenged during the first five days of a BDBEE ELAP event. For Mode 1, the analysis shows that with no operator actions, containment pressure will slowly increase to 6.1 psig over 5 days and the maximum temperatures in all compartments stay below the containment temperature limit of 271 °F over the same 5 days. Since 6.1 psig is below the containment design pressure of 47 psig (UFSAR Section 6.2.1), no mitigation actions are necessary to maintain or restore containment cooling during Phases 1 or 2.

The Phase 1 coping strategy for containment involves verifying containment isolation per procedure ECA-0.0 and monitoring containment pressure using installed instrumentation. Containment pressure will be available via essential plant instrumentation.

3.4.2 Phase 2

The licensee's containment analysis shows that there are no mitigation actions necessary or planned, to maintain or restore containment cooling during Phase 2 for Modes 1 through 4. Containment temperature and pressure are expected to remain below design limits for more than 120 hours; however, containment status will be monitored.

The Phase 2 coping strategy is to continue monitoring containment pressure using installed instrumentation. Phase 2 activities to repower instruments are adequate to facilitate continued containment monitoring.

3.4.3 Phase 3

In Phase 3 the 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. The most significant need is to restart a CFCU to control containment heat-up over an extended time and ensure no challenge to containment integrity.

In Phase 3 of the core cooling and heat removal strategy, a core cooling loop is repowered using a 4160-V generator set and distribution center supplied by the NSRC. Restoration of this cooling loop provides cooling water and power to a CFCU, which maintains long-term containment temperature and pressure below allowable limits. No additional specific Phase 3 strategy is required for maintaining containment integrity.

3.4.4 Staff Evaluations

3.4.4.1 Availability of Structures, Systems, and Components

Guidance document 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. The baseline assumptions for the availability of SSCs for maintaining containment functions during an ELAP are provided in the following sub-sections.

3.4.4.1.1 Plant SSCs

Containment

In the UFSAR, Section 3.8.1.1 states that the containment is a seismic Category I steel-lined, reinforced concrete building of cylindrical shape with a dome roof that completely encloses the reactor and the RCS. It ensures that essentially no leakage of radioactive materials to the environment would result even if gross failure of the RCS were to occur as result of an earthquake of intensity twice the maximum postulated.

The exterior shell consists of a 142 ft. high cylinder, topped with a hemispherical dome. The minimum thickness of the concrete walls is 3.6 ft, and the minimum thickness of the concrete roof is 2.5 ft. Both have a nominal inside diameter of 140 ft. and a nominal inside height of 212 ft. The concrete floor pad has a diameter of 153 ft. and a minimum thickness of 14.5 ft, with the reactor cavity near the center. The inside of the dome, cylinder, and base slab is lined with welded steel plate, which forms a leak-tight membrane. The nominal thickness of the steel liner is 3/8-inch on the wall and dome and the nominal thickness of the steel liner on the base slab is 1/4-inch.

The internal concrete structure approximates a 106 ft. diameter, 51 ft. high cylinder, with a slab on top. However, there are multiple openings and walls, such as the reactor support and the stainless steel lined refueling canal, which complicate the shape. The walls and top slab are generally 3 ft. thick. This structure provides support for the reactor and components of the RCS, provides radiation shielding, and provides protection for the liner from postulated missiles originating from the RCS.

The staff noted that the containment structure is safety-related and seismically qualified to all applicable seismic criteria. It acts as a closed vessel, and is therefore not subject to external flooding issues. The site limited extreme temperatures will not have a significant effect on the containment as the containment is a large mass which will act as a heat sink to disperse any heating or cooling effects. It is therefore protected from all applicable hazards and is expected to be available during an ELAP event.

Containment Fan Cooling System

The containment fan cooler system (CFCS) is designed to provide sufficient heat removal capability to maintain the post-accident containment atmospheric pressure below the design value of 47 psig. The CFCS consists of five identical fan coolers, each including cooling coils, fan and drive motor, locked-open air flow dampers and pressure relief dampers, duct distribution system, instrumentation, and control. The CFCS was modified to delete the moisture separators and high efficiency particulate air filters. During operation, air is drawn into the cooling coils, cooled, and discharged back through the ductwork to the containment atmosphere. All of the fan coolers, the distribution ductwork, and cooling water piping are located outside the missile shield wall. This arrangement provides protection from missiles for all system components. The staff noted that the CFCS fan coolers are designed to Seismic Category I criteria and therefore protected from all applicable hazards and is expected to be available during an ELAP event.

3.4.4.1.2 Plant Instrumentation

In NEI 12-06, Table 3-2, specifies that containment pressure is a key containment parameter which should be monitored by repowering the appropriate instruments. The licensee's FIP states that for the containment pressure and containment temperature instrumentation, the normal power source and long–term power source are the 125-Vdc vital batteries. Indication is available in the Control Room (CR) or locally at the instrument throughout the event.

Procedure FSG 07, "Loss of Vital Instrumentation or Control Power," Revision 0, provides direction for reading this instrumentation locally, where applicable, using a portable instrument as required by NEI 12-06.

3.4.4.2 Thermal-Hydraulic Analyses

The NRC staff reviewed analysis FLEX-011, "Diablo Canyon ELAP Containment Analysis," Revision 0, which was based on the boundary conditions described in Section 2 of NEI 12-06. In this calculation, the licensee utilized the Generation of Thermal-Hydraulic Information for Containments (GOTHIC) version 7.2a code to model the containment subcompartment pressure and temperature response to an ELAP and was benchmarked against previous LOCA analyses. The only additions of heat and mass to the containment atmosphere under ELAP conditions are the heat loads from the reactor coolant system and main steam system (e.g., from the surfaces of hot equipment and the leakage of reactor coolant from the RCP seals). Specifically, the "No Active Mitigation Case" models the containment conditions for operating Modes 1 through 4 in which the SGs are available to remove RCS heat. The RCS heat sink is maintained in Phase 1, which relies on installed plant equipment and on-site resources, by feeding the SGs using the TDAFW pump while steaming to the atmosphere via the ADVs. A controlled cool-down and depressurization of the RCS is performed via the ADVs to a SG pressure of approximately 300 psig. The licensee installed new low leakage (SHIELD) RCP seals during the FLEX implementation refueling outages. The new low leakage seal limit the potential seal leakage to 1 gpm per each of the four RCPs, for a total RCS leakage rate of 4 gpm into containment.

Using the input described above, the containment pressure reaches 6.1 psig at the end of the 120-hour period and the maximum temperatures in all compartments stay below the containment temperature limit of 271 °F over the same period of time. The maximum values calculated are well below the UFSAR design parameters of 47 psig and 271 °F, so the licensee has adequately demonstrated that there is significant margin before a limit would be reached.

3.4.4.3 FLEX Pumps and Water Supplies

The EASW pump is discussed in Section 3.1. The Phase 3 strategy of repowering a CFCU uses the EASW to supply Pacific Ocean water to the component cooling water heat exchanger which provides cooling water to the CFCU.

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 DCPP 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 an ELAP event. However, with no cooling in the containment, temperatures in the containment are expected to rise sufficient enough to challenge equipment capability if left unmitigated. The expected rate of containment temperature rise is low such that no immediate actions are required. However, restoration of containment cooling using a cooling loop that provides cooling water and power to a CFCU fan within 121 hours post-ELAP initiation would ensure that temperature limits are not exceeded and necessary equipment, including credited instruments, located inside containment remains functional throughout an ELAP event.

The licensee's Phase 1 coping strategy for containment involves initiating and verifying containment isolation per ECA-0.0, and monitoring containment pressure using installed instrumentation. Control room indication using containment intermediate range pressure instruments will be available for the duration of the ELAP. The licensee's strategy to repower instrumentation using the Class 1E station batteries is identical to what was described in Section 3.2.3.6 of this SE and should be adequate to ensure continued containment monitoring.

The licensee's Phase 2 coping strategy is to continue monitoring containment pressure using installed instrumentation. The licensee's strategy to repower instrumentation using the 480 Vac, 275 kW FLEX DGs described in Section 3.2.3.6 of this SE and is adequate to ensure continued containment monitoring.

The licensee's Phase 3 coping strategy includes actions to reduce containment temperature and pressure utilizing existing plant systems restored by off-site equipment and resources. Specifically, the licensee plans to repower one Class 1E 4160 Vac bus in each unit to supply a CCW pump and a CFCU fan to support long-term containment temperature and pressure control. The NRC staff reviewed licensee calculation 9000041641, which showed that the required Phase 3 loading on the CTGs was within the design ratings of two NSRC supplied CTGs operated in parallel. Additionally, the NSRC supplied 480 Vac CTGs are adequately sized to replace a Phase 2 FLEX DG to maintain instrumentation and battery charging.

Based on the above, the NRC staff determined that the electrical equipment that will be supplied from an NSRC (i.e., 4160 Vac and 480 Vac CTGs) should have sufficient capacity and capability to supply the required loads to reduce containment temperature and pressure to ensure that key components and instrumentation remain functional.

3.4.5 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore containment functions following an ELAP event consistent with NEI 12-06 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 provide the methodology to identify and characterize the applicable BDBEEs for each site. In addition, NEI 12-06 provides a process to identify potential complicating factors for the protection and deployment of equipment needed for mitigation of applicable site-specific external hazards leading to an ELAP/LUHS.

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

The licensee reviewed the plant site against NEI 12-06 and determined that FLEX equipment should be protected from the following hazards: seismic; external flooding; extreme heat and extreme cold temperatures. The high wind (tornado & hurricane); snow, and ice hazards were screened out of the analysis.

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 NRC endorsement of NEI 12-06 in JLD-ISG-2012-01. Guidance document NEI 12-06 directed licensees to proceed with evaluating external hazards based on currently available information. For most licensees, this meant that the OIP used the current design-basis information for hazard evaluation. Coincident with the issuance of Order EA-12-049, on March 12, 2012, the NRC staff issued a Request for Information pursuant to Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f) (ADAMS Accession No. ML12053A340, hereafter referred to as the 50.54(f) letter), which requested that licensees reevaluate the seismic and flooding hazards at their sites using updated hazard information and current regulatory guidance and methodologies. Due to the time needed to reevaluate the hazards, and for the NRC to review and approve them, the reevaluated hazards were generally not available until after the mitigation strategies had been developed. The NRC staff has developed a proposed rule, titled "Mitigation of Beyond-Design-Basis Events," hereafter called the MBDBE rule, which was published for comment in the *Federal Register* on November 13, 2015 (80 FR 70610). The proposed MBDBE rule would make the intent of Orders EA-12-049 and EA-12-051 generically applicable to all present and future power reactor licensees, while also requiring that licensees consider the reevaluated hazard information developed in response to the 50.54(f) letter.

The NRC staff requested Commission guidance related to the relationship between the reevaluated flooding hazards provided in response to the 50.54(f) letter and the requirements for Order EA-12-049 and the MBDBE rulemaking (see COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards" (ADAMS Accession No. ML15089A236)). The Commission provided guidance in an SRM to COMSECY-14-0037 (ADAMS Accession No. ML14309A256). The Commission approved the staff's recommendations that licensees would need to address the reevaluated flooding hazards within their mitigating strategies for BDBEEs, and that licensees may need to address some specific flooding scenarios that could significantly damage the power plant site by developing scenario-specific mitigating strategies, possibly including unconventional measures, to prevent fuel damage in reactor cores or SFPs. The NRC staff did not request that the Commission consider making a requirement for mitigating strategies capable of addressing the reevaluated flooding hazards be immediately imposed, and the Commission did not require immediate imposition. By letter dated September 1, 2015 (ADAMS Accession No. ML15174A257), the NRC staff informed the licensees that the implementation of mitigation strategies should continue as described in licensee's OIPs, and that the NRC SEs and inspections related to Order EA-12-049 will rely on the guidance provided in JLD-ISG-2012-01, Revision 0, and the related industry guidance in NEI 12-06, Revision 0. The hazard reevaluations may also identify issues to be entered into the licensee's corrective action program consistent with the OIPs submitted in accordance with Order EA-12-049.

As discussed above, licensees are reevaluating the site seismic and flood hazards as requested in the NRC's 50.54(f) letter. After the NRC staff approves the reevaluated hazards, licensees will use this information to perform flood and seismic mitigating strategies assessments (MSAs) per the guidance in NEI 12-06, Revision 2, Appendices G and H (ADAMS Accession No. ML16005A625). The NRC staff endorsed Revision 2 of NEI 12-06 in JLD-ISG-2012-01, Revision 1 (ADAMS Accession No. ML15357A163). The licensee's MSAs will evaluate the mitigating strategies described in this safety evaluation using the revised seismic hazard information and, if necessary, make changes to the strategies or equipment. Licensees will submit the MSAs for NRC staff review.

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

3.5.1 Seismic

In its FIP, the licensee stated that the UFSAR includes the seismic criteria for three design-basis earthquake spectra (design earthquake, double design earthquake, and the postulated 7.5M Hosgri). Additionally, the UFSAR provides a discussion of the earthquakes postulated for the DCPP site and the effects of these earthquakes in terms of maximum free-field ground motion accelerations and corresponding response spectra at the DCPP site, as well as additional information on the seismic characteristics of the DCPP site. Details of these seismic events were also provided by letter dated March 11, 2015 (ADAMS Accession No. ML15070A607), with DCPP's response to the Request for Information pursuant to the 50.54(f) letter to address Recommendation 2.1, "Seismic."

The design earthquake is defined in UFSAR Section 2.5.3.10.1 for DCPP as the maximum size earthquake expected to occur at DCPP during the life of the reactor. It has a peak ground acceleration of 0.2g [acceleration of gravity] as shown in UFSAR Figure 2.5-21. The maximum ground acceleration and response spectra for the double design earthquake are twice those associated with the design earthquake. The postulated 7.5M Hosgri earthquake is described in UFSAR Section 2.5.3.10.3 as a magnitude 7.5 earthquake that could occur on the Hosgri fault at a point nearest to the Diablo Canyon site, as concluded by the U.S. Geological Survey and the NRC in 1977 (see DCPP UFSAR Section 2.5.3). The 7.5M Hosgri earthquake has a peak ground acceleration of 0.75g. Spectra used to develop the 7.5M Hosgri earthquake are shown in USFAR Figures 2.5-29 and 2.5-30.

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

3.5.2 Flooding

In its FIP, the licensee indicated that the maximum flood level for the site is so small that it cannot affect the plant and results in the majority of the site being not susceptible to external flooding. The DCPP site is located in a coastal terrace 85 ft. above sea level. The edge of the terrace is a near vertical cliff, which prevents accumulation of water. As stated in UFSAR Section 2.4.10, the site arrangement virtually eliminates all risks from flooding. However, the intake structure and its auxiliary saltwater pump (ASP) vaults may be exposed to external flooding from a storm or tsunami. The potential for this structure to be affected by external flooding has been mitigated by watertight vaults and ventilation snorkels, which are part of the DCPP design.

In its letter dated January 15, 2016 (ADAMS Accession No. ML16005A638), the licensee stated that groundwater mitigation is not required at the DCPP site because DCPP does not experience ground water intrusion into any safety-related facilities. By letter dated March 30, 2016 (ADAMS Accession No. ML16083A551), the NRC staff provided its interim response to the flood hazard reevaluation report submitted by PG&E (ADAMS Accession No. ML15071A045) in response to the 10 CFR 50.54(f) request for information regarding flooding. The staff interim response states, in part, that the information provided by the licensee is suitable for the MSAs. The interim staff response also states, in part, that the licensee is expected to submit an integrated assessment or a focused evaluation, as appropriate, to address the reevaluated flood hazards.

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

3.5.3 High Winds

Section 3.3.1 of the DCPP UFSAR states the design windspeed has a velocity of 80 mph. For tornadoes, Section 3.3.2 of the DCPP UFSAR states that, because of the low probability of tornadoes in California, PG&E conducted a review to establish capabilities of the Design Class I structures as designed and constructed to withstand tornado wind pressure and the associated atmospheric pressure drop and tornado-borne missile effects. For this review, the licensee used a tornado wind speed of 200 mph windspeed, a 157 mph rotational component, a 43 mph translational component, and a differential pressure of 0.86 psi applied at a rate of 0.36 psi per second. The consequences of tornado-induced failures on the ability to safely shut down the reactor, and/or limit radioactive releases to 10 CFR Part 100 guidelines, are discussed in UFSAR Section 3.3.2.

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

The screening for high wind hazard associated with tornadoes should be accomplished by comparing the site location to NEI 12-06, Figure 7-2, from U.S. NRC, "Tornado Climatology of the Contiguous United States," NUREG/CR-4461, Revision 2, February 2007; if the recommended tornado design wind speed for a 10^{-6}/year probability exceeds 130 mph, the site should address hazards due to extreme high winds associated with tornadoes using the current licensing basis for tornados or Regulatory Guide 1.76, "Design Basis Tornado for Nuclear Power Plants," Revision 1.

In its FIP, the licensee stated that as discussed in NEI 12-06, hurricanes are extremely uncommon on the west coast of the U.S. and are not considered to affect the DCPP site. When considering the applicability of tornadoes to specific sites, data from the NRC's latest tornado hazard study, NUREG/CR-4461, is used. Tornadoes with the capacity to do significant damage are generally considered to be those with winds above 130 mph. NEI 12-06, provides a map of the U.S. in 2° latitude/longitude blocks that shows the tornado wind speed expected to occur at a rate of 1-in-1 million chances per year. This clearly bounding assumption allows selection of plants with expected tornado wind speeds greater than 130 mph. All other plants are not required to address tornado hazards impacting FLEX deployment. In accordance with NEI 12-06, DCPP is not susceptible to tornadoes that generate wind speeds of 130 mph or more.

In summary, based on the NEI 12-06 guidance, the DCPP site would not experience winds at or exceeding 130 mph from severe weather. Therefore, the hazard screened out.

3.5.4 Snow, Ice, and Extreme Cold

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

In its FIP, the licensee stated that in accordance with the guidance in NEI 12-06, DCPP is considered susceptible to extreme cold temperatures, but not susceptible to significant ice or snow. As discussed in DCPP UFSAR, Section 1.2.1.3, the temperature along the central coast may be as low as 24 °F in the winter. Therefore, PG&E has considered the site minimum expected temperature of 24 °F in the specifications, storage, and deployment requirements for FLEX equipment.

In summary, based on the available local data and Figures 8-1 and 8-2 of NEI 12-06, the plant site does experience cold temperatures; but is not susceptible to severe snow or ice storms that may impact the availability of off-site power. The licensee has appropriately screened out the snow and ice hazards. Even thought the site does not experience extreme cold temperatures, the licensee has considered low temperatures (24 °F) for FLEX.

3.5.5 Extreme Heat

As discussed in NEI 12-06, Section 9.2, virtually every state in the lower 48 contiguous United States has experienced temperatures in excess of 110 °F. Many states have experienced temperatures in excess of 120 °F. Therefore, all sites will address the impact of high temperatures on the storage, deployment, and operation of the FLEX equipment.

In its FIP, the licensee stated that in accordance with NEI 12-06, all sites must address high temperatures. In the DCPP UFSAR, Section 1.2.1.3 indicates that the extreme high temperature along the central coast may be as high as 104 °F in the summer.

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

3.5.6 Conclusions

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

3.6 Planned Protection of FLEX Equipment

3.6.1 Protection from External Hazards

In its FIP, the licensee indicated that FLEX equipment is stored on-site in either the primary FLEX storage facility, the secondary FLEX storage facility, or the auxiliary building. The licensee also provided the following information for their FLEX storage facilities and locations:

The primary FLEX storage facility is located inside Building 113, commonly referred to as Warehouse B. This structural steel facility is located south of the main power block along the site's main access road, at an elevation of 150 ft. FLEX equipment stored in this building includes:

- EASW Pumps (two pumps, one per unit)

- EAFW Pumps (two pumps, one per unit)
- ERCS Make Up Pump (one backup)
- Portable Dewatering Pumps (three pumps)
- FLEX DGs (one common 275kW, one common 150kW, and two 20kW)
- FLEX Portable DGs (three 6.5kW)
- Safety Function Support (SFS) Load Centers (two common)
- Debris Removal Front Loader (one common)
- FLEX Diesel Powered Light Towers (five common)
- EASW Pipe Trailers (two pumps, one per unit)
- FLEX truck (one common)
- Emergency Communications and Commans Trailer (one common)

The secondary FLEX storage facility is a reinforced concrete pad located to the west of the 500KV switchyard, in an area previously designated as parking lot #10, at an elevation of 308 ft. The concrete slab is designed in accordance with American Society of Civil Engineers (ASCE) 7-10 code requirements. FLEX equipment on the concrete slab are:

- EASW Pumps number (two backup)
- EAFW Pump (one backup)
- Raw Water Reservoir (RWR) Pumps (two common)
- FLEX DGs (one common backup 275 kW and one common 150 kW)
- SFS Load Center (two common)
- Fuel Caddies (two common)
- Portable Diesel Fuel Oil (DFO) Transfer Pump (one common)
- Debris Removal Front Loader (one common)
- FLEX Truck (one common)
- FLEX Diesel Powered Light Towers (five common)
- FLEX Suction Headers (two common)
- Raw Water Reservoir (RWR) Hose Trailer (one common)
- RWR Discharge Manifolds (two common)
- Emergency Communications and Command Trailer (one common)
- EASW Pipe Trailers (two backup)

In addition, some FLEX equipment is permanently stored inside the power block in close proximity to the specified deployment location. A list of this equipment is included below:

- FLEX ERCS pumps (one per unit). These pumps (one per unit) are stored in their deployed location on elevation 100 ft. of the safety related auxiliary building.
- ERCS electrical power supply cables, hoses, fittings, and required tooling are staged in the common FLEX equipment storage rack. This rack is located in a hallway on elevation 115 ft. of the Unit 2 safety related auxiliary building.
- SFP hoses, spray nozzles, and required tooling is stored in dedicated storage boxes, one adjacent to each units' SFP on elevation 140 ft. of the safety related fuel handling buildings for each unit.

Below are additional details on how FLEX equipment is protected from each of the applicable external hazards while stored in the FLEX storage facilities or the auxiliary building.

3.6.1.1 Seismic

In its FIP, the licensee stated that the primary FLEX storage facility was evaluated for the effects of local seismic ground motions consistent with ASCE 7-10 code requirements, as well as the increased seismic spectra (1.25 times the 7.5M Hosgri ground response spectra at 5 percent damping). The licensee stated to have found adequate structural margin to remain functional (i.e., collapse is not expected and access to the interior of the structure is retained). The licensee also stated that the location of the primary FLEX storage facility was selected to preclude damage due to seismically-induced failures of nearby structures or components, seismically-induced small landslide debris flow, and because the location is not susceptible to flooding. Also, additional FLEX equipment is stored on custom designed steel equipment racks. The licensee stated that the racks and concrete anchorage were designed to the increased seismic spectra (1.25 times the 7.5M Hosgri earthquake). In addition, during the audit process, the licensee provided a report (Attachment No. 8 to DCN No. 2000001330, Revision 0, dated June 10, 2014) with geotechnical recommendations for modifications already made to the primary FLEX storage facility. The same report was supplemented by an addendum documenting that there is no risk of liquefaction below the storage facility.

With regards to the reinforced concrete pad utilized as the secondary FLEX storage facility, the licensee stated that the concrete slab is designed in accordance with ASCE 7-10 code requirements. The licensee stated that using the increased seismic spectra (1.25 times the 7.5M Hosgri earthquake) was not required for the design of the concrete pad. However, increased structural performance criteria were considered in the design of the slab (e.g. large differential settlements, sliding) to ensure equipment survivability. The location of the facility was selected to preclude damage associated with seismically-induced failures of nearby structures or components, seismically-induced small landslide debris flow, and because the location is not susceptible to flooding.

The licensee stated in its FIP that the portable FLEX equipment designated for storage at the primary and secondary FLEX storage facilities has been analyzed for overturning and sliding in all directions, and that tie-downs are provided. The concrete anchors and tie-down equipment (e.g. straps or chains) utilized for FLEX equipment storage were evaluated to withstand loading forces subject to seismic ground motion. The restraint system at these locations was conservatively designed to the increased seismic accelerations (1.25 times the 7.5M Hosgri earthquake).

The licensee stated that the items permanently stored inside the power block have been evaluated and restrained to withstand accelerations equivalent to 1.25 times the 7.5M Hosgri seismic event. Also, this equipment was described to be stored in locations where they are not impacted by any non-seismically qualified equipment.

In summary, the accelerations used to design the FLEX storage structures are equivalent to an earthquake stronger than the earthquake spectra described in the DCPP design basis. Based on the information provided in its FIP, the licensee seems to have evaluated the FLEX storage structures to seismic loads that exceed those coming from the design basis earthquake spectra, as defined in the UFSAR.

3.6.1.2 Flooding

In its FIP, the licensee indicated that the primary and secondary FLEX storage facilities are not susceptible to flooding. In addition, the installed plant equipment and connection points credited for mitigation of the BDBEE scenario are located in existing plant structures that have been evaluated for external flooding and found to not be susceptible. FLEX-credited portable equipment will be maintained in storage locations of the DCPP site considered dry and not susceptible to flooding.

3.6.1.3 High Winds

As previously stated, based on the NEI 12-06 guidance, the DCPP site would not experience winds at or exceeding 130 mph from severe weather. Therefore, the hazard screened out.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

In its FIP, the licensee indicated that the site maximum expected temperatures of 104 °F and the site minimum expected temperature of 24 °F was considered in the specifications, storage, and deployment requirements for FLEX equipment.

3.6.1.5 Conclusions

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

3.6.2 Availability of FLEX Equipment

Section 3.2.2.16 of NEI 12-06 states, in part, that in order to assure reliability and availability of the FLEX equipment, the site should have sufficient equipment to address all functions at all units on-site, plus one additional spare (i.e., an N+1 capability, where "N" is the number of units on site). It is also acceptable to have a single resource that is sized to support the required functions for multiple units at a site (e.g., a single pump capable of all water supply functions for a dual unit site). In this case, the N+1 could simply involve a second pump of equivalent capability. In addition, it is also acceptable to have multiple strategies to accomplish a function, in which case the equipment associated with each strategy does not require an additional spare.

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

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

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

In its FIP, the licensee stated that NEI 12-06 invokes an N+1 requirement for the FLEX equipment that directly performs a FLEX mitigation strategy for core cooling, containment, or SFP cooling in order to assure reliability and availability of the FLEX equipment required to meet the FLEX strategies. It is also stated in the FIP that sufficient equipment is available to address all functions at all units on-site, plus one additional spare, i.e., an N+1 capability, where "N" is the number of equipment required by FLEX strategies for all units on-site. Where a single resource is sized to support the required function of both units a second resource is available to meet the +1 capability. In addition, where multiple strategies to accomplish a function have been developed, the equipment associated with each strategy does not require N+1 capability.

The licensee further stated in its FIP, that 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. Other FLEX support equipment provided for mitigation of BDBEEs, but not directly supporting a credited FLEX strategy, is not required to have N+1 capability.

The licensee stated in its FIP 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 in accordance with Method 1 of NEI 12-06, Revision 2. These hoses and cables are passive components being stored in a protected facility. It is postulated that the most probable cause for degradation/damage of these components would occur during deployment of the equipment. Therefore the +1 capability is accomplished by having sufficient hoses and cables to satisfy the N capability +10 percent spares or at least 1 length of hose and cable. This 10 percent margin capability ensures that failure of any one of these passive components would not prevent the successful deployment of a FLEX strategy.

The licensee stated in its FIP, that the N+1 requirement does not apply to the FLEX support equipment, vehicles, and tools. However, these items are covered by an administrative procedure and are subject to inventory checks, requirements, and any maintenance and testing that are needed to ensure they can perform their required functions.

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

Based on the number of portable FLEX pumps, FLEX DGs, and support equipment identified in the FIP, the NRC staff finds that, if implemented appropriately, the licensee's FLEX strategies include a sufficient number of portable FLEX pumps, FLEX DGs, and sufficient lengths of hoses and cables for RCS makeup and boration, SFP makeup, and maintaining containment consistent with the N+1 recommendation in Section 3.2.2.16 of NEI 12-06.

3.7 Planned Deployment of FLEX Equipment

In its FIP, the licensee stated that pre-determined, preferred staging routes and deployment paths have been identified and documented in the FSGs. Figures 1 and 2 (of the FIP) show the deployment paths and staging locations for FLEX equipment from the primary and secondary FLEX storage facilities. These deployment paths have been evaluated for potential soil liquefaction, which determined that the FLEX staging routes and deployment paths are not subject to liquefaction hazards. Additionally, the deployment paths minimize travel through areas with trees, power lines, narrow passages and other potential debris to the extent practical.

The licensee stated that Phase 3 of the FLEX strategies involves 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" and from the various plant access routes may be required; however in this scenario, plans have been created to airlift equipment from the various pre-identified staging areas to the site.

3.7.1 Means of Deployment

The licensee stated in its FIP, that tow vehicles and debris removal equipment would support the deployment activities. Also, the licensee stated that the tow vehicles and debris removal equipment are protected from hazards such that these remain functional and deployable. Stored FLEX debris removal equipment includes front end loaders equipped with buckets and lifting forks to move or remove debris from deployment paths.

3.7.2 Deployment Strategies

The licensee stated in its FIP that a single portable RWR pump, stored in the secondary FLEX storage facility, should be moved to a staging location at the RWR and be placed in service. The RWR pump shall take suction from one section of the RWR through non-collapsible hose and connection fittings to ensure that the suction hose does not collapse as the pump operates. When staged for operation, the RWR pump and discharge manifold should be located outdoors near the RWR. The pump is self-priming and should be equipped with a 275 gallon fuel tank. The fuel tank should allow for a minimum of 18 hours of operation at the specified flow rate. The fuel tank shall be refilled as necessary by onsite fuel caddies or fuel trucks.

The licensee stated in its FIP, that the planned deployment paths between the staging locations and the source and/or supply plant connections have been walked down and evaluated to determine the potential for availability at the time of deployment. Potential for seismic interaction, integrity of the structures, and potential for debris were all considered by PG&E.

During the site audit, the NRC staff walked down the haul paths from the storage locations to the designated deployment sites and walked down haul routes from the designated staging areas for equipment that will be delivered from the NSRC. The staff noted that the licensee's ability to deploy FLEX equipment could be impacted if 500 kV power lines fall across the deployment paths following a BDBEE and requested the licensee to justify that the 500 kV line interference will not impact the ability of the licensee to successfully implement its FLEX strategies.

In response, PG&E stated to have performed an assessment of potential debris that could fall during a seismic event, affecting the FLEX deployment paths. The assessment is documented in the report titled “Staging and Deployment Walkdown,” Revision 2. The 500 kV transmission lines and towers were identified in this study, as well as any other structures, systems, or components that could potentially block the routes. This study shows that the 500 kV towers are seismically evaluated to the Hosgri criteria and are not expected to fall in a seismic event. However, the 500 kV transmission lines have not been evaluated and could potentially affect the deployment paths leading to the 115 ft. elevation radiologically controlled area staging location, the raw water reservoirs, and the secondary storage facility. Besides that, access to the primary FLEX storage facility would not be affected, and debris removal equipment is provided in this facility to remove any potential debris, including the transmission lines. While the transmission lines are expected to not be energized, PG&E has conservatively assumed that they cannot be cut or traversed until they are adequately grounded due to potential personnel safety concerns. Therefore, the required grounding equipment is stored in the primary storage facility. Procedures are in place to require appropriately trained personnel to arrive onsite 6 hours after the event to ground the transmission lines if needed.

3.7.3 Connection Points

Section 3.2.2.17 of NEI 12-06 states, in part, that diversity and flexibility should be considered in the connection points for the FLEX strategies. The intention of this guidance is to have permanent, installed connection points for FLEX fluid and electrical equipment. The FLEX fluid connections for core and SFP cooling functions are expected to have a primary and an alternate connection or delivery point (e.g., the primary means to put water into the SFP may be to run a hose over the edge of the pool). Electrical diversity can be accomplished by providing a primary and alternate method to repower key plant equipment and instruments utilized in FLEX strategies. At a minimum, the primary connection point should be an installed connection suitable for both the on-site and off-site FLEX equipment. The secondary connection point may require reconfiguration (e.g., removal of valve bonnets or breaker) if it can be shown that adequate time is available and adequate resources are reasonably expected to be available to support the reconfiguration. Both the primary and alternate connection points do not need to be available for all applicable hazards, but the location of the connection points should provide reasonable assurance of at least one connection being available. If separate strategies are used, then the two strategies do not each need a primary and alternate connection point provided the connection points for the two strategies are separate.

3.7.3.1 Mechanical Connection Points

Core Cooling

In the FIP, Section 3.1.5.1 states that the primary connection point for the EAFW pump injects into the AFW crosstie piping between the MDAFW pumps that feeds all SGs. The connection is on the existing AFW line that contains a hose connection and a normally shut isolation valve. As described in SE Section 3.2.3.1.1, the AFW system pumps and piping are Design Class I. In its FIP, the licensee stated that the primary AFW connection was located in the Auxiliary Building which is a Seismic Category I structure protected from all applicable hazards. Also, FIP Section 3.1.5.2 states that the alternate connection will connect to one of two check valves located on the AFW supply lines to the SGs. The licensee further states in FIP that the connection is also located in the Auxiliary Building.

In order to support long-term Phase 3 core cooling, the licensee will connect portable EASW pumps to the installed ASW system. The connection points are located in the ASW vacuum breaker vault, which is seismically robust because it houses Design Class 1 ASW piping. However, the licensee did procure two portable dewatering pumps to pump out any residual water in the vaults to allow opertors access to the vaults. These pumps are motor-driven and have dedicated DGs to power them.

RCS Inventory Control/Makeup

Section 3.2.5.1 of the FIP states that operators will connect the discharge from the ERCS makeup pump to the primary RCS connection into a cold leg SI test vent located in the 100 ft. elevation of the auxiliary building containment penetration area. In the FIP, Section 3.2.5.2 states that the alternate RCS connection connects into a different cold leg SI test vent located in the 100-ft elevation auxiliary building containment penetration area. The alternate connection feeds into all four cold legs of the RCS. The primary suction connections as stated in the FIP are located on the boric acid transfer pump suction crosstie piping located on 100 ft. elevation of the Auxiliary Building. All the RCS connections are protected from the applicable external hazards.

SFP Makeup

In the FIP, Section 3.3.4.1 describes the licensee's SFP makeup strategy connections. The license has two independent flow paths for providing SFP make up from the common RWR pump. The primary flow path utilizes hoses routed from the RWR pump discharge manifold to the FLEX suction header and then to the refueling floor and directly into the SFP to provide makeup or spray flow. The alternate flow path outlined in Section 3.3.4.2 utilizes a connection to the existing SFP cooling system. Specifically, hose is routed from the FLEX suction header to the SFP cooling system return line.

Given the design and location of the primary and alternate connection points, as described in the above paragraphs, the staff finds that at least one of the connection points should be available to support core and SFP cooling via a portable pump during an ELAP caused by an external event, consistent with NEI 12-06 Section 3.2.2.

3.7.3.2 Electrical Connection Points

Electrical connection points are only applicable for Phases 2 and 3 of the licensee's mitigation strategies for a BDBEE.

During Phase 2, the licensee has developed a primary and alternate strategy for supplying power to equipment required to maintain or restore core cooling, containment, and SFP cooling using a combination of permanently installed and portable components.

Two 480 Vac FLEX DGs (one 275 kW and one 150 kW), two load centers, and associated cables are stored in the FLEX primary storage facility. Two backup 480 Vac DGs (one 275 kW and one 150 kW), two load centers, and associated cables are stored in the FLEX secondary storage facility. The cables needed to power the ERCS make-up pumps are pre-staged inside the auxiliary building, as well as, on the load center trailers that are stored in the FLEX storage facilities.

There are two portable, trailer-mounted 480 Vac, 275 kW FLEX DGs, but only one 275 kW FLEX DG is needed to implement the licensee's strategy for both Units. The primary strategy for re-powering the 125 Vdc battery chargers circuits is to stage one 480 Vac, 275 kW FLEX DG west of the Unit 1 and Unit 2 Turbine building, centered between the two units, and connect it to each Unit's 480 Vac vital battery charger through preinstalled receptacle connections and transfer switch. The alternate strategy for re-powering the 125 Vdc vital battery chargers is to stage one 480 Vac, 275 kW FLEX DG west of the Unit 1 and Unit 2 Turbine building, centered between the two units, and connect the portable load center power cables directly to the input terminals of the battery chargers.

Each 275 kW FLEX DG has one output circuit, which supplies a load center with six 480 Vac output breakers, and a 3-phase 208/120 Vac distribution panel with breakers. Each circuit from the 480 Vac load center has a single FLEX designated output breaker, weatherproof cam lock type connectors, flexible and weatherproof cable with weatherproof connectors at both ends which connects to a receptacle panel located in the associated Unit's Bus H 480 Vac switchgear room (to support battery charging) and one in the Unit 1 cable spreading room (to support communications equipment). Once connected, the 480 Vac, 275 kW FLEX DG allows for recharging the Class 1E batteries and restoring other instrument ac loads in addition to providing power to key parameter monitoring instrumentation. All of the loads associated with the 275 kW FLEX DGs are not phase rotation dependent. The battery chargers and transformers associated with the telecommunications equipment are not phase rotation sensitive. Therefore, verification of phase rotation is not necessary for the 275 kW FLEX DGs.

There are two portable, trailer-mounted 480 Vac, 150 kW FLEX DGs, but only one 150 kW FLEX DG is needed to implement the licensee's strategy for both Units. The primary strategy is to stage this generator east of the auxiliary building on the 115-ft bench area of the radiation controlled area (RCA). The alternate strategy is to stage the generator west of the turbine building central to Unit 1 and 2. The alternate location would be utilized if the 500 kV lines have fallen on the 115-ft elevation, and grounding and removal of these lines cannot be accomplished in time to support deployment of this generator.

Each 150 kW FLEX DG and associated distribution center is interconnected through quick connect cables, color coded to maintain phasing, and in varying sizing and lengths to accommodate individual loads. The 480 Vac, 150 kW FLEX DG has one output circuit, which supplies a load center with six 480 Vac output breakers, and a 3-phase 208/120Vac distribution panel with breakers. Each circuit from the load center has a single FLEX designated output breaker, weatherproof cam lock type connectors, flexible and weatherproof cable with weatherproof connectors at both ends which connects to a receptacle panel on each Units' ERCS Pump skid, located in the associated Unit's hallway on the 100-ft elevation. The connection points are located in Class 1 structures; therefore, the connection points are protected against all applicable external hazards. The connecting cables for both Units are pre-staged in a common rack in the Unit 2 auxiliary building, 115-ft elevation with additional cables on the load center trailer. According to the FIP, the licensee verified proper phase rotation of the 480 Vac, 150 kW FLEX DG as part of its FLEX validation process. The licensee would utilize FSG-05 to deploy, stage, and connect the 480 Vac, 275 kW and 150 kW FLEX DGs.

Based on the above, the NRC staff finds that DCPP meets the intent of NEI 12-06 by having two diverse sets of electrical strategies that can be used to fulfill the required functions (N and N+1).

For Phase 3, the licensee will receive two 1-MW 4160 Vac CTGs per unit that will be connected to a distribution panel (also delivered from the NSRC) in order to meet the required Phase 3, 4160 Vac load requirements for each unit. The 4160 Vac CTGS will be deployed to areas near the existing EDG Rooms north (Unit 1) and south (Unit 2) of the DCPP Units. Cables would be run from the 4160 Vac CTGs into the turbine building at the 85-ft. level where these cables will be spliced into the output cables from the installed EDG Bus G (primary) or Bus H (alternate). The primary connection is at the plant installed EDG 1-2 for Unit 1 and 2-2 for Unit 2. If the primary connection is not available in Unit 1, EDG 1-1 will be used. Similarly, if the primary connection is not available in Unit 2, EDG 2-1 will be used. Each circuit from the NSRC load center has a single FLEX designated output breaker, weatherproof cam lock type connectors, flexible and weatherproof cable with weatherproof connectors at both ends which connect to the output cables of the plant's 4160 Vac EDG located in the associated Unit's 85-ft elevation Turbine Building. A connection fitting is required to be installed on the ends of the cable to connect to the tie-in point, and instructions are provided in the FSG for this purpose. The primary and alternate connection points are located in seismically robust structures; therefore, the connection points are protected against all applicable external hazards. FSG 05 directs plant operators to prepare for re-energizing a 4160 Vac bus upon receiving and placing in service the 4160 Vac CTGs from an NSRC. Procedure FSG 58, "Prepare 4kV Bus for Service," Revision 0, and FSG 59, "Placing the 4kV Bus in Service," Revision 0, includes steps necessary to energize the 4160 Vac buses and ensures that the FLEX 4160 Vac CTGs and switchgear have the termination of the cables between the FLEX equipment and DCPP result in the proper phase rotation.

In addition to the 4160 Vac CTGs being supplied by an NSRC, the licensee will receive two 480 Vac, 1,100 kW CTGs. These CTGs could be used as a replacement for the Phase 2 480 Vac, 275 kW FLEX DGs. Connectors had been provided in the FLEX storage facilities to be able to utilize the 480 Vac CTGs as backups to the Phase 2 FLEX DGs. Therefore the licensee could utilize FSG 05 to deploy, stage, and connect the NSRC supplied 480 Vac CTGs, if necessary.

The electric power system connections (Phases 2 and 3) to the DCPP, Unit Nos. 1 and 2, electrical distribution system are designed to provide diversity of reliable power sources which are physically and electrically isolated such that a failure will only affect a single power source and should not adversely affect alternate power sources.

3.7.4 Accessibility and Lighting

In its FIP, the licensee stated that the ability to open doors for ingress and egress, ventilation, or temporary cables/hoses routing is necessary to implement the FLEX coping strategies. The licensee described contingencies to maintain access during loss of all ac/dc power, which are part of the DCPP Security Plan. The contingencies consider access to buildings relied to implement the strategies, access to the protected area, and access to the FLEX storage facilities.

Also in its FIP, the licensee stated that various areas of the plant including the control room are equipped with emergency backup lighting ("Appendix R battery operated lights"), which is verified to be capable of illumination for at least 8 hours. Personal headlamps and flashlights are also staged in the control room, and additional battery powered light stands are provided in the FLEX storage facilities if needed. For outdoor lighting, the licensee stated that 120/240 Vac DG light towers will be deployed to provide light at the various FLEX staging and operating locations as required. These light towers are stored at the FLEX storage facilities.

During the on-site audit, NRC staff reviewed the licensee plans to assess adequate lighting, and personnel and equipment access to successfully implement the FLEX strategies.

3.7.5 Access to Protected and Vital Areas

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

3.7.6 Fueling of FLEX Equipment

In FIP Section 3.8.5, the licensee states that all FLEX equipment will be stored fueled with approximately 16 hours of fuel. Trailer mounted 100 gallon fuel caddies with self-powered pumps can be towed by any number of vehuchles to refuel FLEX equipment. The licensee has the ability to transfer fuel from the emergency diesel generator (EDG) diesel fuel oil tanks to the fuel caddies. The fuel oil storage tanks (two total) are located underground and protected from all applicable hazards. Between the two tanks with two units in Mode 1 through 4, there is a tech spec controlled minimum supply of 79,000 gallons of fuel. Based on the design and location of these EDG fuel tanks and protection, the staff finds the tanks are robust and the fuel oil contents should be available to support the licensee's FLEX strategies during an ELAP event.

As stated above, EDG diesel fuel tanks have the capacity of approximately 100,000 gallons total. In the FIP, Section 3.8.5 states that the licensee calculated that the Phase 2 FLEX equipment consumption is 68 gallons/hour. Fuel consumption increases significantly when the NSRC equipment is in operation. The licensee calculated that the fuel oil storage tanks should last for greater than 45 days. Given the information above, the licensee should have sufficient fuel onsite for diesel-powered equipment, and that diesel-powered FLEX equipment should be refueled to ensure uninterrupted operation to support the licensee's FLEX strategies.

Existing sampling requirements for the emergency fuel oil storage tanks meets ASTM requirements and maintains fuel oil quality in the EDG diesel fuel tanks. Therefore, the diesel fuel oil onsite should be maintained such that the diesel-driven equipment will be available during an ELAP.

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 DCPP SAFER Plan

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

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

By letter dated September 26, 2014 (ADAMS Accession No. ML14265A107), the NRC staff issued its assessment of the NSRCs established in response to the order. 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 the order.

In its FIP, the licensee stated that, in the event of a BDBEE and subsequent ELAP/LUHS condition, equipment will be moved from an NSRC to a local assembly area established by the SAFER team.

3.8.2 Staging Areas

In general, up to four staging areas for NSRC supplied Phase 3 equipment are identified in the SAFER Plans for each reactor site. These are a primary (Area C) and an alternate (Area D), if available, which are offsite areas (within about 25 miles of the plant) utilized for receipt of ground transported or airlifted equipment from the NSRCs. From Staging Areas C and/or D, the SAFER team will transport the Phase 3 equipment to the on-site Staging Area B for interim staging prior to it being transported to the final location in the plant (Staging Area A) for use in Phase 3. In its SAFER Plan, the licensee identified Camp San Luis Obispo, in San Luis Obispo, CA, located approximately 25 miles from the site, as the Staging Area C. Alternate Staging Area D is the Paso Robles Municipal Airport, approximately 53 miles from the site.
In its SAFER Plan, the licensee described the local assembly area (Staging Area "B") as the main DCPP parking lot (lot #7). From there, equipment can be delivered to the primary or alternate access location (Staging Area A) via the plant main gate. Communications will be established between the DCPP site and the SAFER team and required equipment moved to the site as needed. First arriving equipment will be delivered to the site within 24 hours from the initial request. Use of helicopters to transport equipment from Staging Area C to Staging Area B is recognized as a potential need within the DCPP SAFER Plan and is provided for.

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

The primary concern with regard to ventilation is the heat buildup which occurs with the loss of forced ventilation in areas that continue to have heat loads. The licensee performed several loss of ventilation analyses to quantify the maximum steady state temperatures expected in specific areas related to FLEX implementation to ensure the environmental conditions remain acceptable for personnel habitability and within equipment qualification limits.

The key areas identified for all phases of execution of the FLEX strategy activities are the CR, Cable Spreading Room (CSR), Battery Rooms, Battery Charger/Inverter Room, TDAFW Pump Room, SFP area, and the containment. The licensee evaluated these areas to determine the temperature profiles following an ELAP/LUHS event. The results of the licensee's room heat-up calculations have concluded that temperatures remain within acceptable limits based on conservative input heat load assumptions for all rooms/areas with no actions initially being taken other than opening various doors to achieve passive ventilation. Additionally, two 120/240 Vac DGs, ventilation fans, and associated electrical connection cables are stored at the FLEX storage facilities to support area ventilation, if needed.

Battery Charger/Inverter Rooms, Battery Rooms, CSR, and Control Room

The NRC staff reviewed calculation STA-295, "Battery Charger/Inverter Room and Control Room Heat-Up Evaluation due to loss of HVAC as a result of loss of complete AC Power," Revision 2, which modeled the battery charger/inverter rooms, the battery rooms, the cable spreading rooms and the CR temperature transient through 7 days following a BDBEE resulting in an ELAP. The calculation uses the GOTHIC computer program version 7.2b. Cooling via natural convection is achieved by opening doors within 1 to 1.5 hours of the BDBEE. In addition, by reducing the heat loads from the inverters to 33 percent of the total heat load, this will reduce heat generation, and allow natural convection to provide cooling to maintain room temperatures below their respective limits. The licensee's engineering calculation shows that there is no need to utilize forced convection (use of fans), if the doors are opened on time and the heat loads from the inverters are cut down to 33 percent of the total heat load. These actions will provide adequate natural convection flows to cool down equipment and plant personnel in the CR. Operator actions to perform the door opening strategy is provided in ECA-0.0.

The maximum inverter room temperature is 119 °F for about an hour and then cools to less than 95 °F (or for 90 minutes should it take that long to open the doors). Then slowly increases to about 115 °F at the end of the 7-day transient. Since the inverters are qualified to operate up to a maximum temperature of 50 °C (122 °F), it is concluded that the high room temperature in the inverter rooms will not have any impact on the performance or the capability of the inverters to perform their design functions.

The maximum battery room temperature is approximately 114 °F at the end of the 7 days. This is below the maximum temperature limit of 120 °F. It is noted that higher operating ambient temperature will reduce service life of the battery which would be undesirable for normal design condition. However, for a BDBEE, this is considered acceptable. Note also that higher temperature does not impact the performance of the battery, in fact, performance actually improves.

The maximum CSR temperature is 111 °F at the end of the 7 days, which includes the operator actions of opening doors within the timeframe stated above. This is below the maximum temperature limit of 120 °F.

The maximum control room temperature is 109 °F, including the cable spreading room heat loads and flow paths, which includes the operator actions of opening doors within the timeframe stated above. The acceptance criterion for the calculated temperatures is based on the guidance in NUMARC-87-00, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," Revision 1, which states that a CR temperature of 120 °F is an acceptable limit for equipment operability.

TDAFW Pump Room

The licensee's Phase 1 core cooling FLEX strategy relies on the TDAFW pump as the motive force for providing cooling water to the SGs. During the audit, the licensee provided the staff with calculation PG&E Calculation M-0912, "Fire Protection (Appendix R); Station Blackout (10 CFR 50.63)," Revision 6. The calculation showed the maximum temperature of the TDAFW pump room will peak at 166.4 ˚F, 72 hours into the event if all ventilation is lost and no active or passive temporary ventilation is established. During the audit, the licensee provided calculation M-911, "HVAC Interactions for Safe Shutdown, Room Heat-up Due to Loss of HVAC," Revision 4, which indicated that the TDAFW pump room can withstand temperatures of up to 180 ˚F without detrimental effects. Additionally, the licensee relies on the TDAFP for the first 40 hours after event and after that, the FLEX EAFW pump can provide makeup water to the SGs, if necessary. Furthermore, the licensee stated in the FIP that procedures direct operators to establish additional ventilation if necessary.

Spent Fuel Pool Area

The only electrical equipment in the SFP area of the Fuel Handling and Auxiliary Buildings that the licensee is relying on as part of its FLEX strategies is the SFP level instruments required by NRC Order EA-12-051. The capability of this instrumentation is described in Section 4.2.4 of this SE.

Containment

The NRC staff reviewed the licensee's loss of ventilation analysis (FLEX-011, "Diablo Canyon ELAP Containment Environment Analysis," Revision 0), which evaluated the containment pressure and temperature response during an ELAP event. This analysis considered an ELAP initiated during Modes 1 through 4. Based on the licensee's evaluation, both temperature and pressure will remain below the limits for electrical components being credited as part of the licensee's mitigating strategies during an ELAP. Additionally, as discussed in Section 3.4.4.4 of this SE, the licensee plans to restore containment cooling using a cooling loop to provide cooling water and power to a CFCU fan within 121 hours post-ELAP initiation using equipment supplied from an NSRC. Based on this information, the NRC staff finds that temperature limits should not be exceeded and necessary equipment, including credited instruments, located inside containment should remain functional throughout an ELAP event.

Based on its review of the essential station equipment required to support the FLEX mitigation strategy, which are primarily located in the Control Room, CSR, Battery Rooms, Battery Charger/Inverter Rooms, TDAFW Pump Rooms, the SFP area of the Fuel Handling and Auxiliary Buildings, and Containment, the NRC staff finds that the equipment should perform their required functions at the expected temperatures as a result of loss of ventilation during an ELAP/LUHS event.

3.9.1.2 Loss of Heating

The DCPP safety-related batteries are located inside concrete rooms within the Auxiliary Building and not directly subjected to outside ambient temperatures. The Auxiliary Building is essentially a massive heat sink; therefore temperatures in the middle of the structure would not be expected to widely fluctuate with external temperatures. Additionally, low temperatures on the central coast of California typically last for very short durations (and usually only overnight). Also, during battery discharge the battery will be producing heat, which will keep electrolyte temperature above the room temperature. Therefore, the NRC staff finds that the DCPP vital batteries should perform their required functions as a result of loss of heating during an ELAP event.

3.9.1.3 Hydrogen Gas Control in Vital Battery Rooms

An additional ventilation concern that is applicable to Phases 2 and 3, is the potential buildup of hydrogen in the Class 1E station battery rooms as a result of loss of ventilation during an ELAP event. Off-gassing of hydrogen from batteries is only a concern when the batteries are charging. The repowering of the battery room ventilation is performed in the same procedure as the repowering of the battery chargers to insure that the battery room ventilation is restored prior to recharging the batteries.

The NRC staff reviewed the licensee's battery room ventilation calculation (HVAC 83-46, "Battery Rooms Exhaust During a LOOP and/or Loss of Class II Ventilation System", Revision

5, which concluded that under both extreme high and low temperature conditions, with airflow only through the supply and exhaust vents in the rooms with no fans running, there is sufficient natural ventilation to maintain the battery rooms at a hydrogen concentration of less than 1 percent by volume with no operator action. Based on its review of the licensee's calculation, the NRC staff finds that this conclusion is acceptable and conservative since the doors would be opened within 1.5 hours of initiation of an ELAP event.

Based on its review, the NRC staff finds that the licensee's strategy should be sufficient to prevent hydrogen accumulation in the 125 Vdc Class 1E station battery rooms from reaching the combustibility limit for hydrogen (4 percent) during an ELAP as a result of a BDBEE.

3.9.2 Personnel Habitability

3.9.2.1 Main Control Room

As described above in Section 3.9.1.1, calculation STA-295 predicts that the maximum temperature reached in the CR to be 109 °F with no mitigating actions taken other than opening doors. Operator actions to perform the door opening strategy is provided in procedure ECA-0.0. Based on the licensee being able to maintain the CR temperatures below 110 °F (the temperature limit, as identified in NUMARC-87-00, for personnel habitability), the NRC staff finds that personnel in the MCR will not be adversely impacted by the loss of ventilation as a result of an ELAP event.

3.9.2.2 Spent Fuel Pool Area

See Section 3.3.4.1.1 above for the detailed discussion of ventilation and habitability considerations in the SFP Area. In general, the licensee plans to establish a Fuel Building ventilation path and deploy hoses before the SFP boiling affects habitability. The licensee also has the ability to add water to the SFP from the installed SFP cooling piping without accessing the refueling floor.

3.9.2.3 Other Plant Areas

TDAFW Pump Room

Although the TDAFW pump room gets as hot as 166 °F, the licensee's strategy does not involve prolonged manual operation in the TDAFW pump room. In the event that the TDAFW pump trips offline, operators will have to enter the room to attempt to restart the pump. Furthermore, as stated earlier, the licensee has procedures in place to establish temporary ventilation as necessary.

3.9.3 Conclusions

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

3.10 Water Sources

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

3.10.1 Steam Generator Make-Up

In Table 3 of its FIP, the licensee provides a list of potential water sources that may be used to provide cooling water to the SGs, capacities, and an availability following the applicable site hazards. Three of the water sources are identified as capable of surviving all applicable hazards at the DCPP and are credited for FLEX strategies. These are the seismically qualified CST, the FWST (also seismically qualified), and the seismically robust RWR.

The licensee states in its FIP, that each CST will supply the AFW for the respective unit. During the audit, the licensee provided Calculation RE-20111111, "Coping Time Estimates for IER L1-11-4, Item 1," Revision 5. The calculation assumed that each CST has a minimum usable capacity of approximately 222,600 gallons and determined that each CST can provide initially 17 hours of water. Prior to depletion of the usable CST inventory, the TDAFW pump suction will be aligned to the FWST. The FWST, which is common to both units, can provide water to support TDAFW pump operation in both Units for an additional 12.5 hours. In addition, the recirculation configuration of the TDAFW pumps while taking suction from the FWST directs 50 gpm of water back to the associated CST. As a result, the TDAFW pumps suction would be realigned to the CSTs to gain an additional 10.4 hours of supply volume in each unit, for a total of 39.9 hours of cooling capability from seismically qualified water sources.

The licensee indicated in its FIP that the Phase 2 strategy for each unit should continue cooling through the SGs using water from the RWR by use of a common RWR pump and diesel-driven EAFW pumps. The RWR pump should take suction from the RWR to supply water through flexible hoses to a portable common unit FLEX suction header. The EAFW pumps should draw suction from the FLEX suction header and provide water to each units SGs through flexible hoses connected to the feedwater (FW) system. The RWR will be procedurally maintained with a minimum of 1.5 million gallons of usable water to supply both units for approximately 84 hours.

The licensee states in its FIP that use of the three sources would allow the units to provide secondary side cooling for a minimum of 121 hours.

The licensee indicated in its FIP that non-seismically robust clean water sources such as the primary water storage tank and the condenser hotwell can be used for SG makeup if available. In addition, DCPP has a long term cooling strategy which was licensed with the plant and evaluated the use and access to various potential onsite sources for use in the secondary, including the use of the Pacific Ocean directly. The use of ocean water is not recommended due to degradation to SG tubes over time, but if required, the ocean is available as an indefinite source using onsite equipment and issued procedures.

3.10.2 Reactor Coolant System Make-Up

In Section 3.2.2 of its FIP, the licensee indicated that the initial borated water supply during Phase 2 comes from the safety-related, seismically qualified BASTs with the FLEX ERCS pump taking suction from the BAST and injecting into the chemical & volume control system (CVCS) (primary connection) or SI system (alternate connection). Each unit has two BASTs which have a capacity of 8,060 gallons (each tank) for a total capacity of 16,120 gallons per unit. The BASTs serve as the reservoir for 4 percent concentrated boric acid used by the CVCS for RCS boron concentration control.

In FIP Section 3.2.4, the licensee indicates that following injection from the BASTs, the safety-related and seismically qualified RWST will provide the required borated water to the FLEX ERCS pump. The licensee stated in its FIP, that during normal operations, operators maintain each RWST greater than 455,300 gallons with a boron concentration between 2,300 and 2,500 ppm.

The licensee indicated in its FIP that, for Phase 3, the RHR system is returned to operation and RCS temperature is maintained by that system utilizing the UHS and equipment provided from the NSRC . In addition, since it is possible that further adjustments in RCS inventory may be required, the portable ERCS equipment with suction aligned to the RWST will remain available.

3.10.3 Spent Fuel Pool Make-Up

In its FIP, the licensee states that any water source available is acceptable for use as makeup to the SFP. However, the primary source would be from the RWR via the RWR Pump as described above. Water quality is not a significant concern for makeup to the SFP. Likewise, boration is not a concern since boron is not being removed from the SFP when boiling.

3.10.4 Containment Cooling

For Phases 1 and 2 the licensee's calculations demonstrate that no actions are required to maintain containment pressure below design limits.

In its FIP for Phase 3, the licensee stated that restarting a CFCU is necessary to control containment heat-up over an extended time and ensure no challenge to containment integrity. In Phase 3 of the core cooling and heat removal strategy, a core cooling loop is repowered using a 4160-V generator set and distribution center supplied by the NSRC. Restoration of this cooling loop provides cooling water and power to a CFCU which maintains long term containment temperature and pressure below allowable limits

3.10.5 Conclusions

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

3.11 Shutdown and Refueling Analyses

Order EA-12-049 requires that licensees must be capable of implementing the mitigation strategies in all modes. In general, the discussion above focuses on an ELAP occurring during power operations. This is appropriate, as plants typically operate at power for 90 percent or more of the year. When the ELAP occurs with the plant at power, the mitigation strategy initially focuses on the use of the steam-driven TDAFW pump to provide the water initially needed for decay heat removal. If the plant has been shut down and all or most of the fuel has been removed from the RPV and placed in the SFP, there may be a shorter timeline to implement the makeup of water to the SFP. However, this is balanced by the fact that if immediate cooling is not required for the fuel in the reactor vessel, the operators can concentrate on providing makeup to the SFP. The licensee's analysis shows that following a full core offload to the SFP, about 30 hours are available to implement makeup before boil-off results in the water level in the SFP dropping 10 ft. over the 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 TDAFW pump and allow operators to release steam from the SGs (which typically occurs when the RCS has been cooled below about 300 °F), another strategy must be used for decay heat removal. The NRC-endorsed strategy is described in NEI 12-06. Section 3.2.3 provides guidance to licensees for reducing shutdown risk by incorporating FLEX equipment in the shutdown risk process and procedures. Considerations in the shutdown risk assessment process include maintaining necessary FLEX equipment readily available and potentially pre-deploying or pre-staging equipment to support maintaining or restoring key safety functions in the event of a loss of shutdown cooling. In its FIP, the licensee stated that it would follow this guidance. During the audit process, the NRC staff observed that the licensee had made progress in implementing this guidance.

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

3.12 Procedures and Training

3.12.1 Procedures

In its FIP, the licensee stated that, when FLEX equipment is needed to supplement EOPs or Abnormal Procedures (APs) strategies, the EOP or AP directs the entry into and exit from the appropriate FSG procedure. The FSGss have been developed in accordance with PWROG guidelines, and site specific FSGs have been developed to provide additional guidance as required. The FSGs provide instructions for implementing available, pre-planned FLEX strategies to accomplish specific tasks in the EOPs or APs. The FSGs are used to supplement the existing procedure structure that establishes command and control for the event. Procedural Interfaces have been incorporated into both units' ECA-0.0 to reference the FSGs and provide command and control for the ELAP. The licensee also stated that procedural interfaces have been incorporated into the following APs to include appropriate reference to FSGs:

- OP AP-11, "Malfunction of Component Cooling Water System," was revised to point to FSG 51, "Placing Emergency ASW Pumps in Service."

- OP AP-22, "Spent Fuel Pool Abnormalities," was revised to point to FSG 11, "Alternate SFP Makeup and Cooling."

- OP AP-23, "Loss of Vital DC Bus," was revised to point to FSG 04, "ELAP DC Bus Load Shed and Management," for ELAP response.

- OP AP SD-1, "Loss of AC Power," (Shutdown AP) was revised to point to FSG 05, "Initial Assessment and FLEX Equipment Staging," to enter the FSG network for an ELAP response during modes 5 or 6.

- OP AP SD-4, "Loss of Component Cooling Water," (Shutdown AP) was revised to point to FSG 51, "Placing Emergency ASW Pumps in Service."

The licensee also stated that the following plant procedures have been revised as a result of FSG development:

- OP L-6, "Cold Shutdown/Refueling," was revised to ensure preparations are completed during a plant transition to MODE 5 and 6 to support shutdown FSG 12, "Alternate Containment Cooling," prerequisites.

- Surveillance Test Procedure STP I-1C, "Routine Weekly Checks Required by Licenses," and OP F-3, "Raw Water System," series normal operating procedures were revised to ensure water inventory requirements are maintained to support FLEX assumptions.

- Extreme Damage Mitigation Guideline EDMG EDG-15, "Emergency ASW Pumps - Place in Service," was rescinded in favor of FSG 51, "Placing Emergency ASW Pumps in Service," for operating new FLEX EASW equipment which replaced that previously utilized for B.5.b compliance.

- OP K-9, "Instructions for Operation of the DCPP Radio System," was revised to remove instructions for operating Beyond Design Basis Communications equipment in favor of FSG 47, "Operation of FLEX Communications Equipment."

The licensee stated that FSG maintenance is performed in accordance with the DCPP administrative procedure control process. The FSGs have been reviewed and validated by the involved groups to the extent necessary to ensure that implementation of the associated FLEX strategy is feasible. Specific FSG validation was accomplished via table top evaluations and walk-throughs of the guidelines when appropriate.

3.12.2 Training

In its FIP, the licensee stated that DCPP's Training Program has been revised to assure personnel proficiency in utilizing FSGs and associated FLEX equipment for the mitigation of BDB external events is adequate and maintained. Programs and controls were developed and have been implemented in accordance with the Systematic Approach to Training (SAT) Process, as suggested in NEI 12-06 guidance for training.

3.12.3 Conclusions

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

3.13 Maintenance and Testing of FLEX Equipment

As a generic issue, NEI submitted a letter to the NRC dated October 3, 2013 (ADAMS Accession No. ML13276A573), which included Electric Power Research Institute (EPRI) Technical Report 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment." By letter dated October 7, 2013 (ADAMS Accession No. ML13276A224), the NRC endorsed the use of the EPRI report and the EPRI database as providing a useful input for licensees to use in developing their maintenance and testing programs. In its FIP, the licensee stated that they would conduct maintenance and testing of the FLEX equipment in accordance with the industry letter.

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

3.14 Alternatives to NEI 12-06, Revision 2

The licensee did not take any alternatives to NEI 12-06, Revision 2.

3.15 Conclusions for Order EA-12-049

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

4.0 TECHNICAL EVALUATION OF ORDER EA-12-051

By letter dated February 27, 2013 (ADAMS Accession No. ML13059A500), the licensee submitted its OIP for DCPP in response to Order EA-12-051. By letter dated July 3, 2013 (ADAMS Accession No. ML13178A364), the NRC staff sent a request for additional information (RAI) to the licensee. The licensee provided a response by letter dated July 18, 2013 (ADAMS Accession No. ML13200A123). By letter dated November 25, 2013 (ADAMS Accession No.

ML13311B362), the NRC staff issued an ISE and RAI to the licensee. The licensee provided a response by letter dated February 26, 2014 (ADAMS Accession No. ML14058A222). By letter dated October 30, 2015 (ADAMS Accession No. ML15289A370), the NRC issued an audit report on the licensee's progress.

By letters dated August 22, 2013 (ADAMS Accession No. ML13235A103), February 26, 2014 (ADAMS Accession No. ML14058A222), August 21, 2014 (ADAMS Accession No. ML14233A637), February 23, 2015 (ADAMS Accession No. ML15054A642), and August 26, 2015 (ADAMS Accession No. ML15238B883), 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 January 05, 2016 (ADAMS Accession No. ML16005A637), the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved.

The licensee has installed a SFP level instrumentation system designed by Westinghouse. The NRC staff reviewed the vendor's SFP level instrumentation system design specifications, calculations and analyses, test plans, and test reports. The staff issued an audit report on August 18, 2014 (ADAMS Accession No. ML14211A346).

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 October 30, 2015 (ADAMS Accession No. ML15289A370), the NRC issued an audit report on the licensee's progress. Refer to Section 2.2 above for the regulatory background for this section.

4.1 Levels of Required Monitoring

In its OIP, the licensee identified the SFP levels of monitoring as follows:

- Level 1 corresponds to 137 ft. - 8 inches (in.) plant elevation (23 ft. - 9 in. above the top of the spent fuel storage racks).

- Level 2 corresponds to 123 ft. - 11 in. plant elevation (10 ft. above the top of the spent fuel storage racks).

- Level 3 corresponds to 114 ft. - 11 in. plant elevation (1 foot above the top of the spent fuel storage racks).

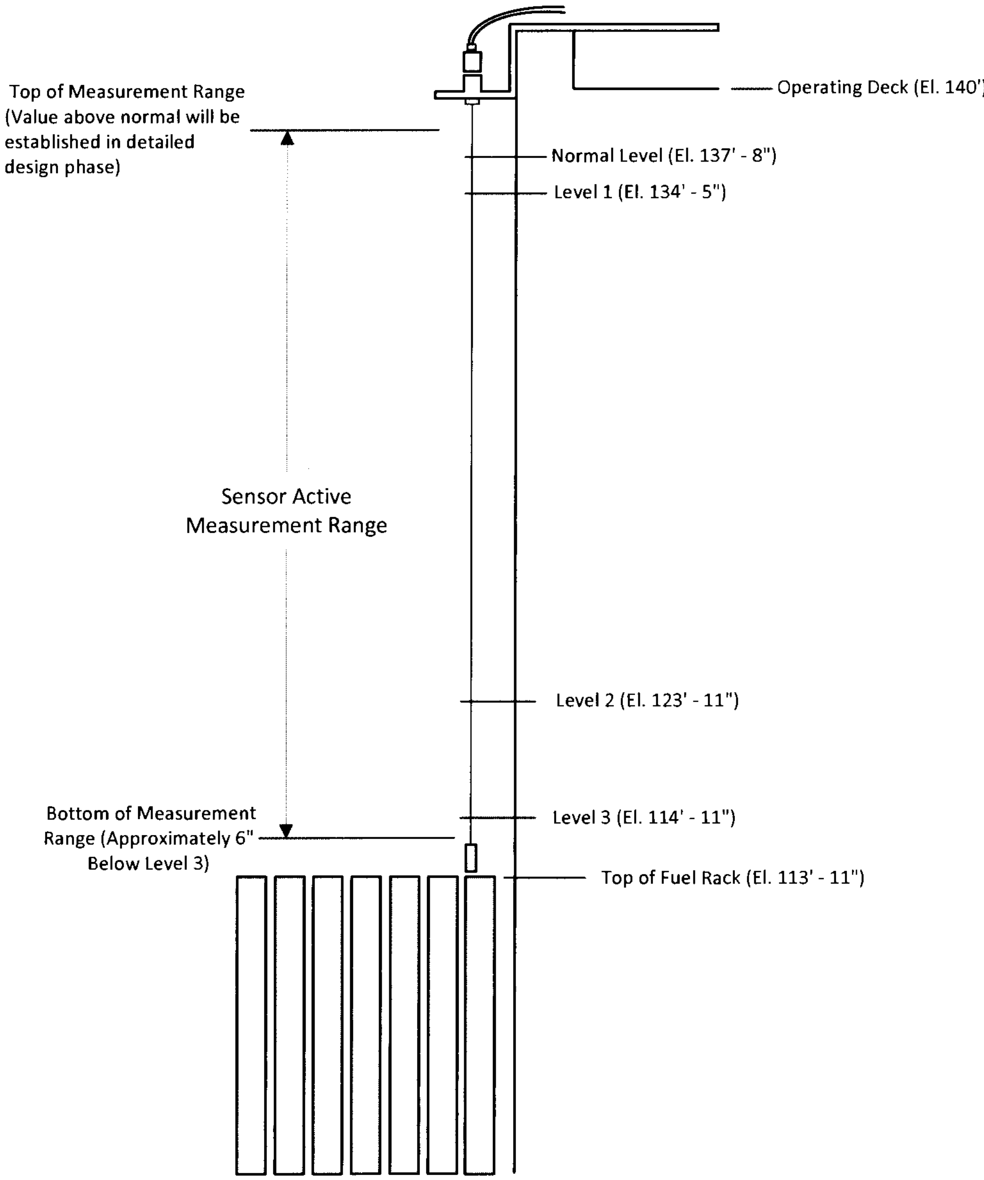

Figure 1 - Diablo Canyon SFP Levels of Monitoring (Units 1 and 2)

In its letter dated July 18, 2013 (ADAMS Accession No. ML13200A123), the licensee revised the Level 1 from 137 ft. - 8 in. to 134 ft. - 5 in. plant elevation based on the level at which suction loss occurs due to uncovering of the coolant inlet pipe at 134 ft. - 5 in. In the same letter, the licensee provided a sketch depicting the final SFP levels of monitoring and the measurement ranges for the primary and backup instrument channels as shown in Figure 1, "Diablo Canyon SFP Levels of Monitoring (Units 1 and 2)", in this evaluation.

For the revised Level 1, in its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee further provided the basis for the change. This basis stated that PG&E Calculation M-648, "Spent Fuel Pool Cooling Pump Hydraulic Performance Analysis," Revisions 1 and 2, performed an evaluation to determine the SFP cooling system pump's required net positive suction head (NPSH) to operate without cavitation at saturated conditions. Drawings 439503 (Unit 1) and 443467 (Unit 2) show the centerline of the 10-inch SFP cooling system inlet pipe is located at elevation 134 ft. Thus the top of the pipe is located at elevation 134 ft. - 5 in., which is Level 1. Calculation M-648, Revision 2, determined the NPSH available (NPSHa) for the SFP Cooling System Pump 1-2 is 21.9 ft. The NPSHa is based on a static head of 35.1 ft. as the difference of the minimum SFP level (Elevation 137 ft. - 4 in.) and the SFP pump inlet elevation (102 ft. - 3 in.). Calculation M-648, Revision 2, concludes that the NPSHa of 21.9 ft. is well above the NPSH required of 14 ft. This is a margin of 7.9 ft. Using Level 1 (Elevation 134 ft. - 5 in.) as the elevation where the SFP cooling system inlet pipe will uncover instead of the minimum SFP level (Elevation 137 ft. - 4 in.), the static head is reduced by 2 ft. - 11 in., which reduces the NPSHa margin from 7.9 ft. to approximately 5 ft. Therefore, sufficient NPSHa is available with a SFP water height at the Level 1 elevation of 134 ft. - 5 in.

The NRC staff's assessment of the licensee selection of the SFP levels of monitoring is as follows. Per NEI 12-02, Section 2.3.1, Level 1 will be the HIGHER of two points. The first point is the water level at which suction loss occurs due to uncovering of the spent fuel cooling inlet pipe. The second point is the water level at which loss of spent fuel cooling pump NPSH occurs under saturated conditions. Diablo Canyon designated Level 1 is the HIGHER of the above two points and therefore consistent with NEI 12-02; Level 2 is consistent with the first of the two NEI 12-02 options for Level 2, which is 10 feet (±1 foot) above the highest point of any fuel rack seated in the SFP; Level 3 is also consistent with NEI 12-02 Level 3, which is 1 foot above the highest point of any fuel rack seated in the SFP.

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

4.2 Evaluation of Design Features

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

4.2.1 Design Features: Instruments

For the SFP level instrument design, in its OIP, the licensee stated that the DCPP SFP instrumentation system (SFPIS) will utilize fixed primary and backup guided wave radar (GWR) sensors. The GWR technology uses the principle of time domain reflectometry to detect the SFP water level. A microwave signal is sent down the cable probe sensor, and when it reaches the water, it is reflected back to the sensor electronics. This is due to the difference between the dielectric constants of air and water. Using the total signal travel time, the sensor electronics embedded firmware computes the level of the water in the SFP. The probe, which is located in the SFP, is separated from the sensor electronics and connected by an interconnecting cable that is routed into an adjacent room or building. By placing the sensor electronics outside of the SFP area, it is not subject to the harsh environment resulting from the boiling or loss of water in the SFP during a postulated loss-of-inventory event that creates high humidity, steam, and/or radiation. The primary and backup instrument channels will provide continuous level indication from 12 in. above the top of the spent fuel storage racks at elevation 114 ft. -11 in. to the high SFP level at elevation 139 ft.

In its letter dated July 18, 2013 (ADAMS Accession No. ML13200A123), the licensee provided a sketch depicting the measurement ranges for the primary and backup instrument channels as shown in Figure 1 of this evaluation. The NRC staff noted that the instrument measurement ranges will cover Levels 1, 2, and 3, as described in Section 4.1 above.

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

4.2.2 Design Features: Arrangement

For Diablo Canyon SFP level instrument arrangement, in its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee stated that PG&E has diversely located the sensor probes of the primary and backup Spent Fuel Pool Level Instrument Systems in the SFP area to maintain physical channel separation. The cabling will be routed through separate areas of the fuel handling building and auxiliary building to the sensor electronic panels. The conduits in which the cable is routed are approximately 35 ft. from each other. The sensor electronic panels and level displays will be located within the seismically qualified concrete structure of the auxiliary building.

During the onsite audit, the NRC staff reviewed Design Change Notice (DCN) 2000001450 (DSK-5000044868), "Plan Below Elev. 185' – 0" Area "J"," Sheet 27, Revision 29 (Unit 1) and DCN 2000001451 (DSK-5000044991), "Plan Below Elev. 185' – 0" Area "J"," Sheet 34, Revision 0 (Unit 2). As depicted in these drawings, the Unit 1 primary and backup sensors are located at the south and north walls respectively and the Unit 2 primary and backup sensors are located at the north and south walls respectively. The staff noted, with verification by walkdown during the onsite audit, that there is sufficient channel separation within the SFP area between the primary and backup level instrument channels, sensor electronics, and routing cables to provide reasonable protection against loss of SFP level indication due to missiles that may result from damage to the structure over the SFP.

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

4.2.3 Design Features: Mounting

For Diablo Canyon SFP level instrument mounting design, in its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee stated that Westinghouse Calculation CN-

PEUS-14-27, "Seismic Analysis of the SFP Mounting Bracket at Diablo Canyon Power Plant Units 1 and 2," Revision 1, evaluates the structural integrity of the SFP mounting bracket for the SFP level instrumentation sensor probe. The bracket analyzed in this calculation represents the design of both the primary and backup mounting brackets for Unit Nos. 1 and 2. The calculation applies a load consisting of self-weight, dead load of the instrumentation, seismic load, and the hydrodynamic load due to the seismic effect. The seismic load was determined using DCPP-specific design earthquake, double design earthquake, and Hosgri earthquake response spectra. The calculation concludes that the SFP level instrumentation system bracket is appropriately designed and that all members, welds, and bolts meet their respective acceptance criteria. In addition, the licensee stated that per PG&E Calculation FLEX-012, Revision 0, the test response spectra for the level indication instrumentation bounds the spectra developed in this calculation for all frequencies. The level indicating sensor, sensor head unit, electronics enclosure and antenna are all mounted on rigid supports and have been shake table tested to meet the requirements of Institute of Electrical and Electronics Engineers (IEEE)-344 2004. All conduit supports were installed safety-related, Design Class 1 as specified in Design Change Notices (DCNs) 2000001450, Revision 0 and 2000001451, Revision 0, in accordance with PG&E Drawing 050030 and notes. Safety-related conduit supports are also evaluated for all DCPP design bases seismic events.

The NRC staff noted that the licensee adequately addressed the design criteria and methodology used to estimate and test the total loading on the mounting devices, including the design basis maximum seismic loads and the hydrodynamic loads that could result from pool sloshing. The seismic analyses demonstrated that the SFP level instrumentation's mounting design is satisfactory to allow the instrument to function per design following the maximum seismic ground motion.

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

4.2.4 <u>Design Features: Qualification</u>

4.2.4.1 <u>Augmented Quality Process</u>

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

In its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee stated that PG&E developed a new graded quality class "F", which implements the augmented quality requirements. The new graded quality program includes all requirements listed in NEI 12-02, Revision 1, Section A-1. The graded quality program is maintained in Interdepartmental Administrative Procedure OM5.ID6, "Quality Assurance Program for FLEX Equipment and Spent Fuel Pool Instruments."

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

4.2.4.2 Equipment Reliability

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

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

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

During the vendor audit (ADAMS Accession No. ML14211A346), the NRC staff reviewed the Westinghouse SFP level instrumentation's qualifications and testing for temperature, humidity, radiation, shock and vibration, and seismic. The staff further reviewed the anticipated Diablo Canyon's seismic, radiation, and environmental conditions during the on-site audit (ADAMS Accession No. ML15189A338). Below is the staff's assessment of the equipment reliability of Diablo Canyon SFP level instrumentation.

4.2.4.2.1 Radiation, Temperature, and Humidity

4.2.4.2.1.1 Radiation

For the radiological condition at the SFP area with regard to the SFP level instrument qualifications, in its letter dated July 18, 2013 (ADAMS Accession No. ML13200A123), the licensee stated that components subject to significant radiation under BDB conditions will be those in the SFP area. These include the sensor probe, bracket, coupler and interconnecting cable. The sensor probe and bracket will be stainless steel and will not be affected by the anticipated radiation. The coupler and interconnecting cable will be selected by design for the BDB radiation service. Supplemental radiation testing of the interconnecting cable will be completed to demonstrate operation for more than 1 week with SFP water at Level 3.

As for the radiological condition outside the SFP area, in its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee stated that the Units 1 and 2 primary instrument channels are located in the 100 ft. elevation containment penetration areas. Radiological survey maps were reviewed and dose rates in the area where the transmitter electronics will be mounted were found to not exceed 2 millirem per hour (mrem/hr). Assuming the instruments are in operation through the current operating license and a 20 year period of extended operation (approximately 30 years), the total integrated dose will be 526 rads (2 mrem/hr x 8,760 hr/yr x 30 years x 0.001 rad/mrem). The Units 1 and 2 secondary instrument channels are located in the 100-foot elevation fuel handling building ventilation area. Radiological survey maps were reviewed back to 2008 and dose rates in the area where the transmitter electronics are mounted were found to not exceed 0.2 mrem/hr and are therefore bounded by the primary instrument channel radiological conditions. Assuming the secondary instruments are in operation through the current operating license and a 20 year period of extended operation (approximately 30 years), the total integrated dose will be 52.6 rads ((0.2 mrem/hr x 8,760 hr/yr x 30 years x 0.001 rad/mrem). Per Westinghouse report WNA-TR-03149-GEN, Revision 2, "SFPIS Standard Product Final Summary Design Verification Report," the transmitter electronics must be able to withstand a total integrated dose of up to 1E3 rads. Since the maximum expected total integrated dose for the transmitter electronics is 526 rads, which is less than the specification requirement of 1E3 rads, the expected radiological conditions that the transmitter electronics will be exposed to are acceptable. During accident conditions with reduced level in the SFP, the maximum expected radiological conditions to which the transmitter electronics will be exposed are not expected to exceed normal dose rates and total integrated dose due to the location of the electronics.

4.2.4.2.1.2 <u>Temperature and Humidity</u>

For the temperature and humidity conditions at the SFP area with regard to the SFP level instrument qualifications, in its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee stated that Westinghouse Report WNA-DS-02957-GEN, Revision 3, "Spent Fuel Pool Instrumentation System (SFPIS) Standard Product System Design Specification," states that the BDB environmental conditions in the SFP area are 212 °F at 100 percent humidity (saturated steam) for a period of seven days. The SFP area will be vented to atmosphere and cooled by natural convection by opening doors in the fuel handling building in the case of a loss of SFP cooling which will preclude environmental conditions from exceeding 212 °F. The level sensor equipment (probe, coupler, and interconnecting cable) are the only SFP instrumentation system equipment located in the SFP area. Westinghouse Report WNA-TR-03149-GEN, Revision 2, states in part that "the level sensor electronics with the coupler and the coaxial cable attached performs accurately when the probe, coupler, and coaxial cable are exposed to the temperature range 50 °F to 212 °F with 100 percent humidity." Therefore, the equipment at the SFPs is qualified for the worst expected conditions in the fuel handling building. Westinghouse report EQ-QR-269, Revision 4, documents the thermal aging test results. The test specimens (consisting of the coupler and coaxial cable) were thermally aged at a temperature greater than 219 °F for more than 1,818 hours to simulate a lifetime of 10 years at 140 °F. Section 5.7 documents the steam test results in which the thermally-aged test specimens were immersed in saturated steam conditions at 212 °F for seven days.

As for temperature and humidity conditions outside the SFP area, in its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee stated that the other components that make up the SFP level instrumentation system aside from the level sensor equipment are located in mild locations. Westinghouse Report WNADS-02957-GEN, Revision 3, states that the assumed abnormal conditions outside the SFP area are 140 °F at a maximum of 95 percent humidity (noncondensing) for a period of 7 days. The normal conditions for the level sensor equipment outside the SFP area are in locations serviced by building ventilation and are at a temperature and humidity that will not adversely affect the equipment. The primary instrument electronics are located in the containment penetration area, on the 100 ft. elevation of the auxiliary building. The maximum temperature during normal operation in this area is 104 °F. The secondary instrument electronics are located in the 100 ft. elevation Area J near the fuel handling building ventilation equipment. The maximum temperature during normal operation in this area is 104 °F. Neither of these areas are expected to exceed 140 °F as they do not contain steam filled piping, electrical equipment that will be operating during an ELAP, or any other substantial heat sources. Both areas are entirely separate from the SFP area. Therefore, the equipment is not expected to experience greater than normal temperature or humidity levels.

In addition, the licensee stated that DCP 1000025055, Revision 0, for the Unit 1 SFP level instrumentation and DCP 1000025058, Revision 0, for the Unit 2 SFP level instrumentation each contain an evaluation of the temperatures in the auxiliary building locations where the SFP level electrical equipment is located following an ELAP. Under ELAP conditions, a total loss of auxiliary buildingHVAC is expected. The DCP evaluation concludes that the equipment will not experience temperatures in excess of 140 °F in the event of a loss of HVAC.

The NRC staff noted that the licensee adequately addressed the equipment reliability of SFP level instrumentation with respect to radiation, temperature, and humidity. The equipment qualifications envelop the expected Diablo Canyon's radiation, temperature, and humidity conditions during a postulated BDBEE. The equipment environmental testing demonstrated that the SFP instrumentation should maintain its functionality under expected BDB conditions.

4.2.4.2.2 Shock and Vibration

With regard to shock and vibration qualification of the SFP level instrument, in its letter dated July 18, 2013 (ADAMS Accession No. ML13200A123), the licensee stated that all SFP instrumentation system components located within the SFP will be passive components, inherently resistant to shock and vibration loadings. These include the stainless steel sensor cable probe, sensor bracket, coupler and interconnecting cable. Active electronic components, located outside the SFP area will be permanently and rigidly attached to seismic racks or structural walls and are not subject to shock and vibration loadings. However, assurance of reliability under conditions of shock and vibration will be supported by manufacturer operating experience, which will include use of components in high vibration installations, such as compressed air systems and transportation industries.

In its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee further stated that per Westinghouse Report WNA-DS-02957-GEN, components of both the primary and backup measurement channels are permanently installed and fixed to rigid structural walls or floors of seismic category 1 structures, and are not subject to anticipated shock or vibration inputs. The level sensor electronics are enclosed in a NEMA [National Electrical Manufacturers Association] -4X housing. The electronics panel utilizes a NEMA-4X rated stainless steel housing. These housings are mounted to a seismically qualified wall and aid in protecting the internal components from vibration induced damage. No additional vibration and shock testing is required.

The NRC staff noted that the licensee adequately addressed the equipment reliability of SFP level instrumentation with respect to shock and vibration.

4.2.4.2.3 Seismic

For Diablo Canyon SFP level instrument seismic qualification, in its letter dated July 18, 2013 (ADAMS Accession No. ML13200A123), the licensee stated that all active system components, including sensor electronics, system electronics, batteries, display and enclosures will be seismically tested based on rigid mounting conditions. Testing will be tri-axial, using random multi-frequency inputs, in accordance with IEEE 344-2004, "Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations." Analyses and testing will envelope the conditions at equipment mounting locations resulting from the design basis maximum ground motion. The active components of the SFP instrumentation system will be functionally tested before and after seismic simulation to assure that the components will remain functional following a seismic event. Water level inputs to the system will be simulated by grounding the system probe at selected; repeatable positions. Comparison of system output will be made both to pre-test results and to the measured position of the cable probe input.

The NRC staff noted that the licensee adequately addressed the equipment reliability of SFP level instrumentation with respect to seismic. The SFP level instrument was tested to the seismic conditions that envelop Diablo Canyon's design-basis maximum ground motion. Further seismic qualifications of the SFP level instrument mounting is addressed in Subsection 4.2.3, "Design Features: Mounting," of this evaluation.

4.2.4.2.4 Aging

Depending on the installation configurations, Westinghouse provided two types of SFP cable connectors, a straight connector or a 90-degree connector. Both of them originally were qualified for 15-month life. Westinghouse attempted to get the connectors qualified for 10-year life through testing. The test includes radiation aging, thermal aging and steam tests. While the 90-degree connector passed the initial tests, the straight connector failed the steam test due to leakage caused by the sealant around the connector. Westinghouse solution was to encapsulate the exposed epoxy of the connector with Raychem boots. The straight connector modification eventually passed the aging tests.

During the onsite audit, the NRC staff learned that Diablo Canyon utilizes the 90-degree connectors at the SFP level probes (pool side) and a straight connectors at the transmitters (dry side). Since modification is required only for straight connector if it is installed at the pool side, which is not applicable to Diablo Canyon, the NRC staff found Diablo Canyon cable connector design adequate.

In conclusion of the staff's assessment of the equipment reliability, the NRC staff finds the licensee's proposed instrument qualification process appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.5 Design Features: Independence

Regarding the SFP level instrument channel physical independence, in its letter dated July 18, 2013 (ADAMS Accession No. ML13200A123), the licensee stated that within the SFP area, the probes will be mounted on the South (primary) and North (back-up) sides of the pool for Unit 1 and the North (primary) and South (back-up) sides of the pool for Unit 2, as permanent plant structures allow. Placing the brackets and probes on opposite sides allows for natural protection from a single event or missile from disabling both systems. The cabling within the SFP area will be routed in separate hard-pipe conduit. All conduit routing and location of system components will be designed such that there will be no adverse seismic interactions. Primary and backup systems will be completely independent of each other, having no shared components.

As for the SFP level instrument channel electrical independence, in its letter dated July 18, 2013 (ADAMS Accession No. ML13200A123), the licensee stated that each system will be installed using completely independent cabling structures, including routing of the interconnecting cable within the SFP area in separate hard-pipe conduits. Power sources will be routed to the electronics enclosures from electrically separated sources ensuring the loss of one train or bus will not disable both channels. In its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee further stated that the normal power supply for each channel of the SFP level instrumentation system originates from separate non-vital 120 Vac panels that are powered by different nonvital buses.

The NRC staff noted, and verified during the walkdown, that the licensee adequately addressed the SFP level instrument channel independent. The primary instrument channel is physically and electrically independent of the backup instrument channel. Further discussion of the instrument channels' physical separation is described in Subsection 4.2.2, "Design Features: Arrangement" of this evaluation. With the licensee's proposed power arrangement, the electrical functional performance of each level measurement channel would be considered independent of the other channel, and the loss of one power supply would not affect the operation of other independent channel under BDB event conditions.

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

4.2.6 Design Features: Power Supplies

For the SFP level instrument power design, in its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee stated that the normal power supply for each channel of the SFP level instrumentation system originates from separate non-vital 120 Vac panels that are powered by different nonvital buses. In DCPP Unit 1, one channel is powered by 120 Vac panel PY16 and the other channel is powered by 120 Vac panel PY130. In DCPP Unit 2, one channel is powered by 120 Vac panel PY26 and the other channel is powered by 120 Vac panel PY230. The display enclosure for each channel contains an uninterruptible power supply and backup battery capable of powering the instruments for a minimum of 72 hours following a loss of ac power. The display enclosure for each channel also includes a 120 Vac 5-15P power receptacle to allow for the connection of an emergency power supply, such as a FLEX portable diesel generator, providing continuous operation during an ELAP. Procedure FSG 49, "Align RCS Injection for Inventory/Boration," contains steps to repower the SFP level instruments using a FLEX generator prior to the depletion of the installed batteries.

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

4.2.7 Design Features: Accuracy

In its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee stated that the channel accuracy for each SFP instrumentation system instrument channel is ±3 in. for the full level measurement range. This covers the normal SFP surface level, or higher, to within 6 in. of the fuel assembly under both normal and beyond-design-basis conditions. Both SFP primary and backup sensor electronics require periodic calibration verification to check that the channel's measurement performance is within the specified tolerance (±3 in.). If the difference is larger than the allowable tolerance during the verification process, an electronic output verification/calibration will be required. If the electronic output verification/calibration does not restore the performance, a calibration adjustment will be required. The electronic output verification/calibration will verify electronics are working properly using simulated probe signals. The calibration adjustment is performed to restore level measurement accuracy within the acceptance criteria at 0, 25, 50, 75, and 100 percentage points of the full span.

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

4.2.8 Design Features: Testing

Regarding the SFP level instrument calibration, in its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee stated that Westinghouse Report WNA-TP-04709-GEN, Revision 4, describes the methods available to perform testing and calibration on the SFP instrumentation system. PG&E developed surveillance and maintenance procedures that provide the guidance needed to perform the calibration verification adjustments in accordance with WNA-TP-04709-GEN, Revision 4. The verification of calibration is performed by attaching a sliding plate to the flat surface above the launch plate of the fixed bracket and placing a metal target against the probe cable above the water level. The verification also includes a visual waveform check to verify proper signal operation. The electronic output verification uses the digital to analog converter trim function and the loop test function, which are integrated into the level sensor electronics, to verify the sensor electronics are outputting the correct signal and that the electronic loop is operating correctly. The full-range calibration adjustment is performed by using a calibration test kit, which includes a replicate probe, coupler, launch plate, bracket, and moveable metal target. The calibration test kit enables the sensor electronics output display to be measured against the physical distance measured along the replicate probe to the moveable metal target. The electronic output and full-range calibrations would only be performed if the SFP instrumentation system fails either the channel check or the calibration verification by not meeting the calibration tolerance of plus or minus 3 in. There is no set frequency as the calibration will only need to be performed if the equipment is found to be not within tolerance.

As for the instrument channel checks, in its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee stated that Surveillance Test Procedure (STP) 1-1 C, "Routine Weekly Checks Required by Licenses," previously directed operators to check SFP level using the scale printed on the interior of the pool once a week. Procedure STP 1-1 C has been revised to direct operators to perform a channel check on both primary and backup SFP level instrumentation system instruments by comparing them against each other and to the actual SFP level. The channel check will be completed every week to ensure functionality and gross accuracy of the SFP level instrumentation system. This frequency is based on the existing technical specification surveillance requirement of ensuring normal SFP level.

The NRC staff finds the licensee's proposed SFP instrumentation design that allows for testing, including calibration verification and channel check, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.9 Design Features: Display

Regarding the radiological and environmental habitability of the SFP level instrument display locations, in its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee stated that the primary channel display is located in the 100 ft. elevation penetration area of the auxiliary building. The secondary channel display is located in the 100 ft. elevation of the fuel handling building hallway near the ventilation rooms. The paths that personnel might take were evaluated for potential radiological and environmental conditions. There were no radiological concerns identified along the paths taken from the control room to either local display with dose rates found not to exceed 5 mrem/hr and are not expected to be significantly higher following a BDBEE. It was identified that the most direct route to the secondary channel display panel is through the room containing the turbine driven auxiliary feedwater pump. The steam-filled piping and steam traps in this room will cause local temperature and humidity to rise after a loss of ac power. However, doors to adjacent areas will be opened early in the event to reduce temperatures and personnel will only be in the area for approximately 30 seconds.

For the accessibility of the SFP level instrument display locations, in its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee stated that It was identified that the most direct route to the secondary channel display panel is through the room containing the turbine driven auxiliary feedwater pump. Should the room be impassible, alternate routes through different areas of the building would be available. Operations personnel are required to have a flashlight while on watch. Additionally, radios and phones will be available for personnel locally checking SFP level to communicate with the control room. The auxiliary building and fueling handling building structures are seismically qualified structures and the routes from the control room to the display panels only pass through these structures. Therefore, building damage or collapse is not anticipated and will not impede the operators from reaching the display panels. An initial walk down under optimal conditions (normal lighting and impediments) was performed and found that it took approximately 6 minutes to travel from the control room to the furthest local display panel (alternate channel), including an assumed 2 minutes for issuance of emergency dosimetry. Taking into account possible debris caused by a seismic event, little to no lighting aside from a flashlight or head lamp, and 'other unexpected conditions, it is conservatively estimated to take a maximum of 30 minutes for an operator to travel from the CR to a local display panel and then report the indicated level to the control room by radio or phone.

The NRC staff noted that the licensee adequately addressed the display requirements. If implemented appropriately, the displays will provide continuous indication of SFP water level. The displays are located in seismically qualified buildings. Habitability and accessibility of these locations following a BDBEE are considered acceptable.

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

4.3 Evaluation of Programmatic Controls

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

4.3.1 Programmatic Controls: Training

In its OIP, the licensee stated that the SAT will be used to identify the population to be trained and to determine both the initial and continuing elements of the required training. Training will be completed prior to placing the instrumentation in service.

The NRC staff finds that the use of SAT to identify the training population and to determine both the elements of the required training is acceptable. The licensee's proposed plan to train personnel in the operation, maintenance, calibration, and surveillance of the SFPI and the provision of alternate power to the primary and backup instrument channels, including the approach to identify the population to be trained, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.3.2 Programmatic Controls: Procedures

For Diablo Canyon procedures related to the SFP level instrumentation, in its OIP, the licensee stated that procedures will be developed using guidelines and vendor instructions to address the maintenance, operation, and abnormal response issues associated with the new SFP instrumentation. FLEX support guidelines will address a strategy to ensure the SFP water makeup is initiated at an appropriate time consistent with implementation of NEI 12-06.

in its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee provided a list of Diablo Canyon procedures associated with SFP level instrument calibration, testing, maintenance, abnormal responses as shown below:

- OP AP-22, "Spent Fuel Pool Abnormalities" - This procedure has been revised to use the SFP instrumentation system to diagnose SFP problems to aid operators in making accurate decisions when mitigating failures of the SFP cooling system or SFP integrity.

- STP 1-1 C -"Routine Weekly Checks Required by Licenses" - This procedure has been revised to require a weekly channel check of both primary and backup SFP instrumentation system instrument channels to ensure the equipment is functional and is accurate within its calibration tolerance of plus or minus 3 in.
- STP I-13-L801, "Calibration of Spent Fuel Pool Level Channels" - This procedure has been developed to verify the sensor electronics are outputting the correct signal, to verify the instrument electronic loop is functioning, to provide calibration of the SFP instrumentation system instrument channels, and to provide guidance on how to perform the full-range calibration if the instrument is found to be out-of-tolerance. This procedure is based on calibration information provided by Westinghouse Report WNA-TR-04709-GEN, Revision 4.

- ECG 13.3, "Spent Fuel Pool Level Instrumentation System" - This procedure provides the equipment availability and surveillance requirements for the SFP instrumentation system. The procedure includes the required actions if one or both SFP instrumentation system channels are not functional and provides suggested compensatory actions if the channel(s) cannot be restored within the allowed out-of-service times.

- OP 0-13, "Transferring Equipment To/From Alternate Power Source"

- FSG 11, "Alternate SFP Makeup and Cooling," – This procedure provides guidance for providing makeup to the SFP in order to maintain decay heat removal. FSG 11 uses the wide range SFP level indicators to provide guidance to operators for when SFP makeup should be terminated.

The NRC staff noted that the licensee adequately addressed the SFP level instrument procedure requirements. The procedures had been established for the testing, surveillance, calibration, operation, and abnormal responses for the primary and backup SFP level instrument channels. The staff finds that the licensee's proposed procedures appear to be consistent with NEI 12-02, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.3.3 Programmatic Controls: Testing and Calibration

Regarding the SFP level instrument testing and calibration programs, in its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee stated that STP 1-1 C directs operators to perform a channel check on both primary and backup SFP level instruments by comparing them against each other and to the actual SFP level. The channel check will be completed every week to ensure functionality and gross accuracy of the SFP level instrumentation system. This frequency is based on the existing technical specification surveillance requirement of ensuring normal SFP level. The calibration verification will be completed within 60 days of a planned refueling outage, considering normal testing scheduling allowances (e.g., 25 percent). Guidance documentNEI 12-02 does not require this check to be performed more than once per 12 months. The electronic output and full-range calibrations would only be performed if the SFP instrumentation system fails either the channel check or the calibration verification by not meeting the calibration tolerance of plus or minus 3 in. There is no set frequency as the calibration will only need to be performed if the equipment is found to be not within tolerance.

For Diablo Canyon preventive maintenance program associated with the SFP level instrumentation, in its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee stated that the following preventive maintenance tasks are required to be performed during normal operation:

- The uninterruptible power supply batteries will be replaced on a 3-year frequency as specified in Westinghouse Report WNA-DS-02957-GEN, Revision 3.

- The sensor electronics housing assembly will be replaced on a 7-year frequency as specified in Westinghouse Report WNA-DS-02957-GEN, Revision 3.

- The coaxial cable assembly will be replaced on a 10-year frequency as specified in Westinghouse Report WNA-DS-02957-GEN, Revision 3.

As for the compensatory measures for the SFP level instrument channel(s) out-of-service, in its letter dated January 5, 2016 (ADAMS Accession No. ML16005A637), the licensee stated that one SFP instrumentation system may be taken out of service for testing, maintenance and/or calibration for short durations, consistent with current maintenance practices. Upon discovery of a nonfunctioning SFP level instrument, the issue will be placed in the Corrective Action Program. Attempts will be made to restore the non-functioning SFP level instrument to service as soon as possible and within 90 days. No compensatory actions will be taken while the one channel is nonfunctioning as long as the remaining instrument channel is available and it is anticipated that the nonfunctioning channel will be restored within 90 days. If the nonfunctional channel cannot be restored within 90 days, compensatory actions will be implemented, including, but not limited to, verification of narrow range SFP level instrumentation, increased visual monitoring of the SFP level, video cameras, or supplemental shift staffing. These requirements are contained in ECG 13.3.

The NRC staff finds that the licensee's proposed testing and calibration program appears to be consistent with NEI 12 02, 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 20, 2016 (ADAMS Accession No. ML16005A637), the licensee stated that they would meet the requirements of Order EA-12-051 by following the guidelines of NEI 12-02, as endorsed by JLD-ISG-2012-03. In the evaluation above, the NRC staff finds that, if implemented appropriately, the licensee has conformed to the guidance in NEI 12-02, as endorsed by JLD-ISG-2012-03. In addition, the NRC staff concludes that if the SFP level instrumentation is installed at Diablo Canyon Power Plan according to the licensee's proposed design, it should adequately address the requirements of Order EA-12-051.

5.0 CONCLUSION

In August 2013 the NRC staff started audits of the licensee's progress on Orders EA-12-049 and EA-12-051. The staff conducted an onsite audit in August 17-21, 2015 (ADAMS Accession No. ML15289A370). The licensee reached its final compliance date on July 28, 2016 (ADAMS Accession No. ML16221A390), and has declared that both of the reactors are in compliance with the orders. The purpose of this safety evaluation is to document the strategies and implementation features that the licensee has committed to. Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and proposed designs that, if implemented appropriately, should adequately address the requirements of Orders EA-12-049 and EA-12-051. The NRC staff will conduct an onsite inspection to verify that the licensee has implemented the strategies and equipment to demonstrate compliance with the orders.

Principal Contributors:
J. Miller
M. McConnell
B. Lee
K. Roche
M. Valentín
K. Nguyen

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DIABLO CANYON POWER PLANT, UNIT NOS. 1 AND 2 – SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051
DATED December 28, 2016

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