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10 CFR 50.4
10 CFR 2.202(b)

CNS-16-005

February 15, 2016

Attention: Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555-001

Duke Energy Carolinas, LLC (Duke Energy)
Catawba Nuclear Station (CNS), Units 1 and 2
Docket Number(s) 50-413 and 50-414
Renewed License Nos. NPF-35 and NPF-52

Subject: Final Notification of Full Compliance with Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design Basis External Events" and with Order EA-12-051, "Order to Modify Licenses With Regard To Reliable Spent Fuel Pool Instrumentation" for Catawba Nuclear Station

References:

1. Nuclear Regulatory Commission (NRC) Order Number EA-12-049, Order Modifying Licensees With Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events, Revision 0, dated March 12, 2012, Agencywide Documents Access and Management System (ADAMS) Accession No. ML12054A735

2. Catawba Nuclear Station (CNS) Overall Integrated Plan Submittal in Response to March 12, 2012, Commission Order to Modify Licenses With Regard To Requirements for Mitigation Strategies for Beyond Design Basis External Events (Order EA-12-049), dated February 28, 2013 (ADAMS Accession No. ML13066A173)

3. Catawba Nuclear Station, Units 1 and 2 - Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies), dated February 6, 2014 (ADAMS Accession No. ML13364A175)

4. NRC Order Number EA-12-051, Order to Modify Licenses With Regard To Reliable Spent Fuel Pool Instrumentation, dated March 12, 2012, (ADAMS Accession No. ML12054A679)

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5. Letter from Duke Energy to NRC Site Overall Integrated Plans in Response to March 12, 2012, Commission Order Modifying Licenses With Regard To Requirements for Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051), dated February 28, 2013 (ADAMS Accession No. ML13086A095)

6. Catawba Nuclear Station, Units 1 and 2 - Interim Staff Evaluation and Request for Additional Information Regarding the Overall Integrated Plan for Implementation of Order EA-12-051, Reliable Spent Fuel Pool Instrumentation, dated October 28, 2013 (ADAMS Accession No. ML13281A562)

7. Catawba Nuclear Station, Units 1 and 2, Report for the Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation to Orders EA-12-049 and EA-12-051, dated February 20, 2015 (ADAMS Accession No. ML15035A679)

8. Notification of Full Compliance with Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design Basis External Events" and with Order EA-12-051, "Order to Modify Licenses With Regard To Reliable Spent Fuel Pool Instrumentation" – Catawba Nuclear Station Unit 2, dated May 1, 2015 (ADAMS Accession No. ML15126A277)

Ladies and Gentlemen

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design-Basis External Events" and Order EA-12-051, "Order to Modify Licenses With Regard To Reliable Spent Fuel Pool Instrumentation," (Reference 1 and Reference 4, 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 submit for review, Overall Integrated Plans (OIPs) including descriptions of how compliance with the requirements of each Order will be achieved. By letter dated February 28, 2013 (Reference 2), the OIP for CNS in response to Order EA-12-049 was submitted. In a separate correspondence, the OIP for CNS in response to Order EA-12-051 was submitted by letter dated February 28, 2013 (Reference 5).

Order EA-12-049, Section IV.A.2 and Order EA-12-051, Section IV.A.2 requires completion of full implementation to be no later than two (2) refueling cycles after submittal of the overall integrated plan, as required by Condition C.1.a or December 31, 2016, whichever comes first. In addition, Section IV.C.3 of Orders EA-12-049 and EA-12-051 require that Licensees and CP holders report to the NRC when full compliance is achieved. For CNS Unit 1, the current requirement for full implementation of NRC Orders EA-12-049 and EA-12-051 was prior to restart from the 1EOC22 refueling outage.

On December 16, 2015, CNS Unit 1 entered Mode 2 (Startup) following the 1EOC22 refueling outage. As such, December 16, 2015 is the compliance date for CNS Unit 1 for being in full compliance with Orders EA-12-049 and EA-12-051 as demonstrated by this submittal and any other docketed correspondence concerning these Orders. This determination is based on the best available information and analyses that have been completed as of the date of this letter.

Notification of full compliance with Orders EA-12-049 and EA-12-051 for CNS Unit 2 was provided by Reference 8.

Attachment 1 provides a brief summary of the key elements associated with compliance to Orders EA-12-049 and EA-12-051 for CNS Unit 1. Attachment 2 provides the open and pending items from the Audit Report (Reference 7). For each open and pending item identified in Attachment 2, a brief summary response in support of closure is provided. As such, Duke Energy Carolinas, Inc. (Duke Energy) considers these items complete pending NRC closure. Attachment 3 provides all answers to the diverse and flexible strategies Interim Staff Evaluation open and confirmatory items contained in Reference 3. Attachment 4 provides all answers to the spent fuel pool (SFP) instrumentation Interim Staff Evaluation (ISE) Request For Additional Information contained in Reference 6. Attachment 5 provides the bridging document between vendor technical information and CNS specific considerations for SFP instrumentation, which compares CNS assumptions to the vendor's assumptions for the SFP instrumentation. Attachment 6 provides the CNS Final Integrated Plan. Attachment 7 provides the CNS RCP Seal Leakage Margin Assessment.

In support of the ongoing NRC Audit process, Duke Energy will continue working with the NRC staff in the issuance of a combined Safety Evaluation (SE) for both the Mitigation Strategies and the Spent Fuel Pool Level Instrumentation Orders.

There are no regulatory commitments contained in this letter or its attachments. Please address any comments or questions regarding this matter to Cecil Fletcher at 803-701-3622.

I declare under penalty of perjury that the foregoing is true and correct. Executed on February 15, 2016.

Sincerely,

Kelvin Henderson,
Vice President, Catawba Nuclear Station

Attachments:
1. CNS, Unit 1 Summary of Compliance Elements for Orders EA-12-049 and EA-12-051
2. CNS NRC Audit Report Open and Pending Items
3. CNS, Response to Diverse and Flexible Strategies Interim Staff Evaluation Open and Confirmatory Items
4. CNS, Response to Request for Additional Information Regarding the Overall Integrated Plan for Implementation of Order-12-051, Reliable Spent Fuel Pool Instrumentation
5. Design Bridge Document Between Vendor Technical Information and CNS Specific Considerations for Spent Fuel Pool Instrumentation
6. CNS, Final Integrated Plan
7. CNS, RCP Seal Leakage Margin Assessment

xc:

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ATTACHMENT 1

CNS, UNIT 1 SUMMARY OF COMPLIANCE ELEMENTS FOR ORDERS EA-12-049 AND EA-12-051

The elements identified below for CNS Unit 1, as well as the Overall Integrated Plans (OIP) for Orders EA-12-049 and EA-12-051 (References 2 and 10, respectively), the 6-Month Status Reports for Orders EA-12-049 and EA-12-051 (References 4 thru 8 and 12 thru 16, respectively), and any additional docketed correspondence, demonstrate compliance with Orders EA-12-049 and EA-12-051.

STRATEGIES - COMPLETE

CNS, Unit 1 strategies are in compliance with Order EA-12-049. All strategy related Open Items, Confirmatory Items, or Audit Questions/Audit Report Open Items have been addressed and are considered complete pending NRC closure.

MODIFICATIONS - COMPLETE

The modifications required to support the FLEX strategies for CNS, Unit 1 have been fully implemented in accordance with the station design control process. The design of the Spent Fuel Pool Level Instrumentation installed at CNS, Unit 1 complies with the requirements specified in the order and described in NEI 12-02, Revision 1, "Industry Guidance for Compliance with NRC Order EA-12-051". The instruments have been installed in accordance with the station design control process.

EQUIPMENT – PROCURED AND MAINTENANCE & TESTING - COMPLETE

The equipment required to implement the Mitigation Strategies and Reliable Spent Fuel Pool Level Instrumentation has been procured and is ready for use at CNS, Unit 1. Testing and Maintenance processes have been established through the use of Industry endorsed Electric Power Research Institute (EPRI) Guidelines and the CNS Preventative Maintenance program such that FLEX equipment reliability is achieved. Operating and maintenance procedures for the Spent Fuel Pool Instruments for CNS, Unit 1 have been developed, and integrated with existing procedures. These procedures have been verified and are available for use in accordance with the site procedure control program. Site processes have been established to ensure the Spent Fuel Pool Instruments are maintained at their design accuracy.

PROTECTED STORAGE - COMPLETE

The storage facility required to implement the FLEX strategies for CNS, Unit 1 has been completed and provides protection from the applicable site hazards. The equipment required to implement the FLEX strategies for CNS, Unit 1 is stored in its protected configuration and is ready for use.

PROCEDURES - COMPLETE

FLEX Support Guidelines (FSG) and procedures for the maintenance and use of the Spent Fuel Pool Level Instrumentation for CNS, Unit 1 have been developed in accordance with NEI 12-06, Section 3.2.2 and NEI 12-02, Revision 1, Section 4.2. The FSGs and affected existing procedures have been verified and are available for use in accordance with the site procedure control program.

TRAINING - COMPLETE

Training for CNS, Unit 1 has been completed using the CNS Systematic Approach to Training (SAT) as recommended in NEI 12-06, Revision 0, Section 11.6 and in NEI 12-02, Revision 1, Section 4.1.

STAFFING - COMPLETE

The staffing study for CNS has been completed in accordance with NEI 12-01, Revision 0 and 10CFR50.54(f), "Request for Information Pursuant to Title 10 of the Code of Federal Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force review of Insights from the Fukushima Dai-ichi Accident," Recommendation 9.3, dated March 12, 2012 (Reference 18), as documented in letter dated May 20, 2014 (Reference 19) and September 24, 2014 (Reference 20). The staffing study confirmed that CNS has adequate staffing to perform the actions to mitigate beyond design basis events.

NATIONAL SAFER RESPONSE CENTERS - COMPLETE

Duke Energy has established a contract with the Pooled Equipment Inventory Company (PEICo) and has joined the Strategic Alliance for FLEX Emergency Response (SAFER) Team Equipment Committee for off-site facility coordination. It has been confirmed that PEICo is ready to support CNS with Phase 3 equipment stored in the National SAFER Response Centers in accordance with the site specific SAFER Response Plan.

VALIDATION - COMPLETE

Duke Energy has completed performance of validation in accordance with industry developed guidance to assure required tasks, manual actions and decisions for FLEX strategies are feasible and may be executed within the constraints identified in the Overall Integrated Plans (OIP) for Order EA-12-049.

FLEX PROGRAM DOCUMENT - ESTABLISHED

The FLEX Program Document for CNS has been developed in accordance with the requirements of NEI 12-06, Revision 0.

REFERENCES

1. Nuclear Regulatory Commission Order Number EA-12-049, Order Modifying Licensees With Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events, Revision 0, dated March 12, 2012, ADAMS Accession No. ML12054A735
2. Catawba Nuclear Station, Overall Integrated Plan in Response to March 12, 2012, Commission Order to Modify Licenses With Regard To Requirements for Mitigation Strategies for Beyond Design Basis External Events (Order EA-12-049), dated February 28, 2013, ADAMS Accession No. ML13066A173
3. Catawba Nuclear Station, Units 1&2 - Interim Staff Evaluation -Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies), dated February 6, 2014, ADAMS Accession No. ML13364A175.
4. Catawba Nuclear Station First 6-Month Status Report for the Implementation of Mitigation Strategies for Beyond Design Basis External Events (Order EA-12-049), dated August 28, 2013, ADAMS Accession No. ML13298A010.
5. Catawba Nuclear Station Second 6-Month Status Report for the Implementation of Mitigation Strategies for Beyond Design Basis External Events (Order EA-12-049), dated February 28 2013, ADAMS Accession No. ML14065A038.
6. Catawba Nuclear Station Third 6-Month Status Report for the Implementation of Mitigation Strategies for Beyond Design Basis External Events (Order EA-12-049), dated August 28, 2014, ADAMS Accession No. ML14247A232.
7. Catawba Nuclear Station Fourth 6-Month Status Report for the Implementation of Mitigation Strategies for Beyond Design Basis External Events (Order EA-12-049), dated February 26, 2015, ADAMS Accession No. ML15061A124.
8. Catawba Nuclear Station Fifth 6-month Status Report for the Implementation of Mitigation Strategies for Beyond Design Basis External Events (Order EA-12-049), dated August 26, 2015, ADAMS Accession No. ML15240A066.
9. NRC Order Number EA-12-051, Order to Modify Licenses With Regard To Reliable Spent Fuel Pool Instrumentation, dated March 12, 2012, ADAMS Accession No. ML12054A679.
10. Duke Energy Letter, Duke Energy Carolinas, LLC, (Duke Energy) Overall Integrated Plans in Response to March 12, 2012, Commission Order Modifying Licenses With Regard To Requirements for Reliable Spent Fuel Pool Instrumentation (Order EA-12-051), dated February 28, 2013, ADAMS Accession No. ML13086A095.
11. Catawba Nuclear Station, Units 1 and 2 – Interim Staff Evaluation and Request for Additional Information Regarding the Overall Integrated Plan for Implementation of Order EA-12-051, Reliable Spent Fuel Instrumentation, dated October 28, 2013, ADAMS Accession No. ML13281A562.

12. Catawba Nuclear Station First 6-Month SFPLI Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order EA-12-051), dated October 28, 2013, ADAMS Accession No. ML13242A009.
13. Catawba Nuclear Station Second 6-Month SFPLI Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order EA-12-051), dated February 26, 2014, ADAMS Accession No. ML14063A279.
14. Catawba Nuclear Station Third 6-Month SFPLI Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order EA-12-051), dated August 14, 2014, ADAMS Accession No. ML14227A717.
15. Catawba Nuclear Station Fourth 6-Month SFPLI Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order EA-12-051), dated February 16, 2014, ADAMS Accession No. ML15051A366.
16. Catawba Nuclear Station Fifth 6-month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order EA-12-051), dated August 3, 2015, ADAMS Accession No. ML15217A007.
17. Catawba Nuclear Station, Units 1 and 2, Report for the Audit Regarding the Implementation of Mitigation Strategies and Reliable Spent Fuel Pool Instrumentation related to Orders EA-12-049 and EA-12-051, dated February 20, 2015, ADAMS Accession No. ML15035A679.
18. 10CFR50.54(f), "Request for Information Pursuant to Title 10 of the Code of Federal Regulations, Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force review of Insights from the Fukushima Dai-ichi Accident", Recommendation 9.3, dated March 12, 2012, ADAMS Accession No. ML12053A340.
19. Duke Energy Letter, Phase 1 Staffing Assessment pursuant to 10CFR50.54(f) regarding NTTF Recommendations 9.3, dated April 30, 2013.
20. Catawba Nuclear Station Phase 2 Staffing Assessment pursuant to 10CFR 50.54(f) regarding NTTF Recommendation 9.3, dated October 28, 2014, ADAMS Accession No. ML14303A259.
21. NEI 12-06, Revision 0 "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide", ADAMS Accession No. ML12242A378.
22. NEI 12-02, Revision 1 "Industry Guidance for Compliance with NRC Order EA-12-051, "To Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation", ADAMS Accession No. ML12240A307.
23. NEI 12-01, Revision 0 "Guideline for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities", ADAMS Accession No. ML12125A412.

ATTACHMENT 2
CNS NRC AUDIT REPORT OPEN AND PENDING ITEMS

Duke Energy affirms that CNS is in full compliance with Orders EA-12-049 and EA-12-051 as demonstrated by the docketed correspondences concerning these orders. Briefly, CNS FLEX Interim Staff Evaluation (ISE) Open and Confirmatory Items are complete pending NRC closure; CNS FLEX OIP Open Items are complete pending NRC Closure; CNS FLEX Audit Questions are complete pending NRC closure; CNS FLEX NRC Audit Report Open Items are complete pending NRC closure; and the CNS Request for Additional Information (RAI) provided in the Spent Fuel Pool Level Instrumentation (SFPLI) ISE are complete pending NRC closure.

Duke Energy provides the following response for the Audit Report Open and Pending Items and considers them to be complete pending NRC closure for Catawba Nuclear Station:

Item	Description	Summary Response
CI 3.1.1.3.A	Procedure Interfaces – Seismic Confirm completion of evaluation of potential Aux Building flooding and appropriate actions and procurement of sump pumps.	Catawba Response: Reference Attachment 3 for the response.
CI 3.2.4.1.A	Room Temperature Analyses – Auxiliary Building, SFP Building and Control Room Room temperature analyses being performed will provide a better idea of the environmental conditions expected during the event. Confirm completion of analyses and appropriate actions.	Catawba Response: Reference Attachment 3 for the response.
CI 3.2.4.3.A	Freeze Protection Evaluations to address the needs for freeze protection are in progress. Confirm completion of evaluations and appropriate actions.	Catawba Response: Reference Attachment 3 for the response.
CI 3.2.4.4.A	Lighting Analyses Confirm evaluations for additional lighting have been completed and appropriate actions taken.	Catawba Response: Reference Attachment 3 for the response.
CI 3.4.A	Offsite Resources – Confirm NEI 12-06 Section 12.2, Guidelines 2 through 10 are addressed with SAFER Complete SAFER Site specific plan.	Catawba Response: Reference Attachment 3 for the response.

AQ.26d	Reactor Coolant Pump O-rings Confirm that, beyond order compliance date, plant will use only high-temperature-qualified O-rings where applicable, or that steam generator relief valve will be operated to control temperature to 550 degrees F or below.	Catawba Response: Westinghouse Electric Company submitted letter LTR-RES-13-153 ("Documentation of 7228C O-Rings at ELAP Conditions") on October 31, 2013. The letter documents a Westinghouse evaluation of compound 7228C RCP O-rings at ELAP conditions up to 582°F (the same O-rings in use at Catawba), and concludes that they will not fail during an 8-hour ELAP event w/o seal cooling. The O-rings survived for an average of 18 hours, with the first failure occurring at 13 hours. The Catawba FLEX strategy for RCS make-up post-ELAP is to cooldown well below 582°F and align a FLEX portable RCS make up pump within about 12 hours. Therefore, the Catawba RCP O-ring integrity will be maintained and the assumption of a 21 gpm/pump leak rate remains valid. Reactor coolant pump seal drawing has been posted to the Catawba Fukushima Sharepoint noting high temperature o-ring material.
AQ.37	Direct Current (dc) load profile, load shedding, and dc bus voltage. The staff will complete a vendor audit of the batteries.	Catawba Response: Catawba understands the NRC will be auditing the battery vendor to close this item.
AQ.47	FLEX Diesel Generator Sizing Sizing calculations need to be completed and placed on Catawba Fukushima Sharepoint.	Catawba Response: Engineering Change Evaluation EC401541, FLEX Diesel Generator Loading Evaluation has been completed and placed on the Catawba Fukushima Sharepoint.
AQ.49	Battery Room Ventilation – Temperature Provide information on the adequacy of the ventilation provided in the battery room to protect the batteries from the effects of extreme high and low	Catawba Response: Catawba has purchased sufficient fans and spot coolers to perform Phase 1, 2, and 3 strategies, provide sufficient cooling for equipment operation/personnel habitability, and Hydrogen gas

	temperatures.	control based on a GOTHIC analysis performed by Zachry (Reference CNC -1211.00-00-0146 - Gothic Analysis For Extended Loss Of All AC Power (ELAP/FLEX)). Procedural guidance has been developed to implement the mitigation recommendations in the Zachry analyses. In addition, per Table 7-1 in the SAFER Response Plan and Table 9-1 in the National SAFER Response Center Equipment Technical Requirements Document (51-9199717-013), Catawba will receive one 3000 cfm ventilation fan and associated ducting per Unit from the NSRC. This ventilation equipment from the NSRC will be used on an as needed/as desired basis to provide additional air flow to any area in the plant. Calculation CNC-1211.00-00-0146 Gothic Analysis For Extended Loss Of All AC Power (ELAP/FLEX) has been placed on the Catawba Fukushima Sharepoint for review.
AQ.50	Diesel Fuel Oil Supply and Quality Describe plans for supplying fuel oil to FLEX equipment (i.e., fuel oil storage tank volume, supply pathway, etc.). Also, explain how fuel quality will be assured if stored for extended periods of time.	Catawba Response: Fuel oil consumption, stored volume, quality, and the need for refueling have been addressed in calculation CNC-1612.03-00-0001, FLEX Fuel Consumption Calculation. This calculation has been posted to the Catawba Fukushima Sharepoint.
AQ.51	Battery Room Ventilation – Hydrogen Accumulation Potential Provide a discussion of battery room ventilation to prevent hydrogen accumulation while recharging the batteries in phase 2 or 3. In your response, include a description of the exhaust path if it is different from the design basis.	Catawba Response: Catawba has purchased sufficient fans and spot coolers to perform Phase 1, 2, and 3 strategies, provide sufficient cooling for equipment operation/personnel habitability, and Hydrogen gas control based on a GOTHIC analysis performed by Zachry (Reference CNC -1211.00-00-0146 - Gothic Analysis For Extended Loss Of All AC Power

		(ELAP/FLEX). Procedural guidance has been developed to implement the mitigation recommendations in the Zachry analyses. In addition, per Table 7-1 in the SAFER Response Plan and Table 9-1 in the National SAFER Response Center Equipment Technical Requirements Document (51-9199717-013), Catawba will receive one 3000 cfm ventilation fan and associated ducting per Unit from the NSRC. This ventilation equipment from the NSRC will be used on an as needed/as desired basis to provide additional air flow to any area in the plant. Calculation CNC-1211.00-00-0146, Gothic Analysis For Extended Loss Of All AC Power (ELAP/FLEX), has been placed on the Catawba Fukushima Sharepoint for review.
OIP.32	Cooling Water Flow Model Develop flow model calculations to support the various FLEX strategies and document the available static water volume in the RN/CA piping.	Catawba Response: The following flow model calculations have been posted to the Catawba Fukushima Sharepoint; CNC-1223.02-00-0025, Flow Model of SNSWP to CA Connections For Phase 2 FLEX Strategies, CNC-1223.02-00-0026, Flow Model of SNSWP to RN Connections and CA for Phase 2 FLEX Strategies, CNC-1223.02-00-0027, Flow Model of RN to KC Hxs to Support RHR For Phase 3 FLEX Strategies, and CNC-1223.02-00-0028, Flow Model For U1/U2 NI Portable Pump Injection to RCS Phase 2 & 3 FLEX Strategies.
OIP.42	Determine Need for Containment Spray An analysis is needed to determine if containment spray for temperature/pressure control is not required over the long term.	Catawba Response: Calculation DPC-1552.08-00-0280, Extended Loss of AC Power (ELAP) - Ice Condenser Containment Response with FLEX Mitigation Strategies, has determined containment spray is not needed for long term temperature/pressure control.

		Calculation has been posted to the Catawba Fukushima Sharepoint.
OIP.43	SFP Level Instruments Provide redundant SFP level instruments	Catawba Response: Engineering change EC109414 and EC110934 were completed during 1EOC22. EC109414 installed the primary spent fuel pool level indication and EC110934 installed the backup spent fuel pool level indication.
OIP.56	Staffing NRC will review the Phase 2 Staffing Assessment.	Catawba Response: Phase 2 staffing assessment provided October 28, 2014. Reference ADAMS Accession No. ML14303A259.
SFPI.4	SFP Level Instrument Mounting Complete the "Intermediate Waveguide Mounting Support" calculation and place on the Catawba Fukushima Sharepoint.	Catawba Response: Reference Attachment 5, Item 13.
SFPI.6	SFP Level Instrument Mounting Complete the "Intermediate Waveguide Mounting Support" calculation and place on the Catawba Fukushima Sharepoint.	Catawba Response: Calculation CNC-1139.14-08-0001, Waveguide Antenna Support, has been added to the Catawba Fukushima Sharepoint
SFPI.7	SFP Level Instrument Reliability Complete the following and place on the Catawba Fukushima Sharepoint for review; - The justification for the shock and vibration test deviation - An assessment of potential susceptibilities of electromagnetic\radio frequency interference (EMI\RFI) in areas where the SFP instrument is located and how to mitigate those susceptibilities - The calibration procedure for the Back-up SFP Level	Catawba Response: Reference Attachment 5, Items 14, 20 and 22. PROCEDURE The calibration procedure for the Spent Fuel Pool Level Back Up instrument (IP/1/A/3120/031, Backup Spent Fuel Pool Level) has been completed and a copy has been posted on Catawba Fukushima Sharepoint. AREVA Document # 51-9202556-005, Qualification Analysis of

	Monitoring differential pressure transmitter	VEGAPULS 62 ER Through Air Radar, has been posted to the Catawba Fukushima Sharepoint as well.
SFPI.8	SFP Level Instrument Qualification Complete the calibration procedure for the Back-up SFP Level Monitoring differential pressure transmitter and place on Catawba Fukushima Sharepoint for review.	Catawba Response: IP/1/A/3120/031, Backup Spent Fuel Pool Level has been completed and posted to the Catawba Fukushima Sharepoint.
SFPI.11	SFP Level Instrument Calibration Complete the calibration procedure for the Back-up SFP Level Monitoring differential pressure transmitter and place on Catawba Fukushima Sharepoint for review.	Catawba Response: IP/1/A/3120/031, Backup Spent Fuel Pool Level has been completed and posted to the Catawba Fukushima Sharepoint.
SFPI.12	SFP Level Instrument Calibration Complete the calibration procedure for the Back-up SFP Level Monitoring differential pressure transmitter and place on Catawba Fukushima Sharepoint for review.	Catawba Response: IP/1/A/3120/031, Backup Spent Fuel Pool Level has been completed and posted to the Catawba Fukushima Sharepoint.
SFPI.15	SFP Level Instrument Maintenance and Test Complete the calibration procedure for the Back-up SFP Level Monitoring differential pressure transmitter and place on Catawba Fukushima Sharepoint for review.	Catawba Response: IP/1/A/3120/031, Backup Spent Fuel Pool Level has been completed and posted to the Catawba Fukushima Sharepoint.
SE.3	RCP Seal Leakage Please provide adequate justification for the seal leakage rates calculated according to the Westinghouse seal leakage model that was revised following the issuance of NSAL-14-1 or alternative model (e.g., MPR). The justification should include a discussion of the following factors:	Catawba Response: This is an ongoing generic NRC issue related to the ELAP RCP seal leakage issue and the RCP seal model used in evaluating the LOSC response. To address this item, the NRC requested sites using standard RCP seal packages to provide a RCP Seal Leakage Margin Assessment paper. This is included as Attachment 7.

	a) benchmarking of the seal leakage model against relevant data from tests or operating events, b) discussion of the impact on the seal leakage rate due to fluid temperatures greater than 550°F resulting in increased deflection at the seal interface, c) clarification whether the second-stage reactor coolant pump seal would remain closed under ELAP conditions predicted by the revised seal leakage model and a technical basis to support the determination, and, d) justification that the interpolation scheme used to compute the integrated leakage from the reactor coolant pump seals from a limited number of computer simulations (e.g., three) is realistic or conservative.	Reasonable assurance of compliance with endorsed guidance is achieved via in-house evaluations confirming Catawba's FLEX strategies are bounded by the WCAP-17601-P, revision 1 reference case as well subsequent PWROG evaluations. As such, closure of this issue is not a requirement for Unit startup. Calculation CNC-1223.04-00-0117, MPR RCP Seal Leakoff ELAP/FLEX Analysis has been placed on the Catawba Fukushima Sharepoint as supporting documentation. Duke Fleet Fukushima Response/PWROG continue to work with the NRC to close this generic issue.
SE.4	RCP Seal Leakoff Piping Perform additional piping and support analysis to ensure the seal leakoff line temperature and pressure seen during the ELAP event will be supported by the current configuration.	Catawba Response: This is an ongoing generic NRC issue related to the ELAP RCP seal leakage issue and the potential rupture of the #1 seal leak-off line. The current NRC position is that the leak-off piping should maintain integrity up to 2500 psia. To address this item, the NRC requested sites using standard RCP seal packages to provide a RCP Seal Leakage Margin Assessment paper. This has been included as Attachment 7. Reasonable assurance of compliance with endorsed guidance

		is achieved via in-house evaluations confirming Catawba's FLEX strategies are bounded by the WCAP-17601-P, revision 1 reference case as well subsequent PWROG evaluations. As such, closure of this issue is not a requirement for Unit startup. Calculation CNC-1223.04-00-0117, MPR RCP Seal Leakoff ELAP/FLEX Analysis has been placed on the Catawba Fukushima Sharepoint as supporting documentation. Duke Fleet Fukushima Response/PWROG continue to work with the NRC to close this generic issue.
SE.5	ELAP Calculations with NOTRUMP Please provide adequate basis that calculations performed with the NOTRUMP code (e.g., those in WCAP-17601-P, WCAP-17792-P) are adequate to demonstrate that criteria associated with the analysis of an ELAP event (e.g., avoidance of reflux cooling, promotion of boric acid mixing) are satisfied. NRC staff confirmatory analysis suggests that the need for implementing certain mitigating strategies for providing core cooling and adequate shutdown margin may occur sooner than predicted in NOTRUMP simulations.	Catawba Response: The PWR Owners Group has issued report PWROG-14064, "Application of NOTRUMP Code Results for Westinghouse Designed PWRs in Extended Loss of AC Power Circumstances". This report compares ELAP predictions from the NOTRUMP and TRACE computer codes. The results show that the NOTRUMP predicted results for the onset of reflux cooling and the loop flow under two-phase conditions agree well or are conservative with respect to the TRACE predicted results. The comparison shows that NOTRUMP provides a conservative estimate of the required time when the primary make-up pumps are required for an ELAP event as compared to TRACE. Therefore, it is concluded that NOTRUMP is acceptable for simulation of the ELAP event within the constraints listed herein with regards to reflux cooling and boron mixing.

		Duke has also performed independent predictions of the ELAP event for both Catawba units using RELAP, and the results are in good agreement with the NOTRUMP results in WCAP-17601-P.
SE.8	RCS Cooling & RCS Inventory Control Analysis Justification is needed to show that the WCAP 17601-P analysis used for CNS is representative and bounding of the actual plant conditions for the ELAP event. In particular the time to reach reflux cooling needs to be justified.	Catawba Response: The generic 4-loop NSSS model used in WCAP-17601 is representative of Catawba Unit 1 on all parameters. Each parameter of interest in LTR-LIS-14-219 in Table 1C has been reviewed and no additional assessment is required. As such, the time to reflux cooling provided in PWROG-14027-P is applicable. Catawba ELAP parameters table has been added to the Catawba Fukushima Sharepoint. The table contains Westinghouse analysis values and the corresponding Catawba Unit 1 parameters. Supporting calculations have been added to the Catawba Fukushima Sharepoint as well.
SE.9	RCS Cooldown and Prevention of Nitrogen Injection for Safety Injection Accumulators Specify whether CNS is using EOP Setpoint Number O-8 or O-11 for the cooldown. Also, the licensee needs to specify whether the plan for isolation of the Cold Leg Accumulators occurs prior to cooling down to Emergency Operating Procedure setpoint O-12 or O-13. Provide the footnote calculations for whichever setpoints are being used on the Catawba Fukushima Sharepoint for review.	Catawba Response: CNS uses setpoint O.08 (setpoint O.11 was calculated for CNS, but resulted in the same value, therefore no benefit in using the substitute). FSG-10 (Cold Leg Accumulator Isolation) is invoked as part of EP/1/A/5000/ECA-0.0, Loss of All AC Power, and isolates CLAs prior to reaching EP setpoint O.13. Cooldown will be initiated only when the CLAs are isolated or vented. ECA-0.0 has been added to the Catawba Fukushima Sharepoint. CNS uses footnotes O.08 and O.13 for target SG pressures during ELAP recovery.

		Excerpts from the Catawba Unit 1&2 EP setpoint calculation CNC-1552.08-00-0195, Emergency Procedure Setpoints, has been added to the Catawba Fukushima Sharepoint. Calculations for F.05 and O.07 were included as they provide input into the evaluation of Footnote O.08.

ATTACHMENT 3

CNS RESPONSE TO DIVERSE AND FLEXIBLE STRATEGIES INTERIM STAFF EVALUATION OPEN AND CONFIRMATORY ITEMS

Duke Energy provides the following response to the Interim Staff Evaluation (ISE) open and confirmatory items contained in NRC Letter, "CNS – Interim Staff Evaluation Relating to the Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies), (Agency-wide Documents Access and Management System (ADAMS) Accession No. ML13364A175).

Open Item #	Description	Response
ISE CI 3.1.1.3.A	Procedure Interfaces – Seismic Confirm completion of evaluation of potential Aux Building flooding and appropriate actions and procurement of sump pumps.	Catawba Response: Sump pumps have been procured and strategies developed to address internal flooding issues. Calculation CNC-1206.03-00-0001, Flood Levels for Structures Outside of the Reactor Building, has been completed and posted to the Catawba Fukushima Sharepoint. FLEX Support Guidelines FG/0/A/CFLX/FSG-20 (Electrical Distribution) and FG/0/A/CFLX/FSG-22 (Sump Pump Operation) provide electrical setup and placement of sump pumps. Both are located on the Catawba Fukushima Sharepoint.
ISE CI 3.2.4.1.A	Room Temperature Analyses – Auxiliary Building, SFP Building and Control Room Room temperature analyses being performed will provide a better idea of the environmental conditions expected during the event. Confirm completion of analyses and appropriate actions.	Catawba Response: Catawba has purchased sufficient fans and spot coolers to perform phase 1, 2, and 3 strategies, provide sufficient cooling for equipment operation/personnel habitability, and hydrogen gas control based on Gothic analysis performed by Zachry (Reference CNC-1211.00-00-0146 – Gothic Analysis for Extended Loss Of All AC Power (ELAP/FLEX)). Procedural guidance has been developed to implement the mitigation recommendations in the Zachry analyses. In addition, per Table 7-1 in the National SAFER Response Center Equipment Technical Requirements Document (51-9199717-013), Catawba will receive one 3000 cfm ventilation fan and associated ducting per Unit from the NSRC. This ventilation equipment from the NSRC will be used on as needed/as

Open Item #	Description	Response
		desired basis to provide additional air flow to any area in the plant.
ISE CI 3.2.4.3.A	Freeze Protection Evaluations to address the needs for freeze protection are in progress. Confirm completion of evaluations and appropriate actions.	Catawba Response: Other than components associated with monitoring FWST level, there is no other Flex related instrumentation located in the yard. The FWST level instrumentation is exposed and is normally freeze protected. As noted below, heat tracing equipment is kept in the Flex storage building and can be used to keep the FWST level instrumentation functional in extreme freezing conditions as directed by the FSGs. Some credited instrumentation components are located in the Doghouses, but they will not require freeze protection. During cold weather conditions the window sections of the Doghouses are covered by curtains. This, combined with heat by steam piping used in the Phase 1 and 2 response, eliminates freezing of instruments or impact to supporting equipment. Flex piping connections were reviewed and none were found to be affected by outside freezing conditions. Auxiliary Feedwater and Steam Generator Wet Layup (BW) connections in the Doghouse are "protected" in the same manner as the instrumentation discussed above. Most Flex piping connections are located in the Auxiliary Building where freezing is not credible. One train of RN connection is located outside, but within a below grade bunker. Inventory used from the FWST enters the plant through the normal system piping. Based on initial conditions and the design of the piping system, freezing

Open Item #	Description	Response
		is not projected to be a problem. Only the piping in the trench leaving the FWST is considered for use in the FLEX response. This piping along with the FWST is judged to be weather protected to the extent that freezing will not occur before FLEX strategies are implemented. The Fuel Building will remain above freezing due to the constant heat source of the spent fuel in the pool. As a contingency, Catawba has a roll of heating cable stored in the protected storage building. This self-regulating heat trace cable is provided along with the accessories for assembling multiple freeze protection circuits. These heating cables could be powered from any portable D/G supplying 120 VAC power. This equipment could be deployed if an unanticipated freeze protection need developed.
ISE CI 3.2.4.4.A	Lighting Analyses Confirm evaluations for additional lighting have been completed and appropriate actions taken.	Catawba Response: Lighting assessment has been completed and is available on the Catawba Fukushima Sharepoint for review.
ISE CI 3.4.A	Offsite Resources – Confirm NEI 12-06 Section 12.2, Guidelines 2 through 10 are addressed with SAFER Complete SAFER Site specific plan.	Catawba Response: Approved CNS SAFER Plan, CNSRP-1612.03-01, has been posted to the Catawba Fukushima Sharepoint for review.

ATTACHMENT 4

CNS RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING THE OVERALL INTEGRATED PLAN FOR IMPLEMENTATION OF ORDER EA-12-051, RELIABLE SPENT FUEL POOL INSTRUMENTATION

The CNS Response to the Request for Additional Information Regarding the Overall Integrated Plan for Implementation of Order EA-12-051, Reliable Spent Fuel Pool Instrumentation was provided initially to the NRC in Duke Letter, Duke Energy Carolinas, LLC, (Duke Energy), Response to Request for Additional Information Regarding Overall Integrated Plan in Response to order EA-12-051, "Reliable Spent Fuel Pool Instrumentation" dated July 23, 2013, (ADAMS Accession No. ML13206A384).

The NRC provided an Interim Staff Evaluation (ISE) and Request for Additional Information Regarding the Overall Integrated Plan for Implementation of Order EA-12-051, Reliable Spent Fuel Instrumentation dated October 28, 2013 (ADAMS Accession No. ML13281A562). The Requests For Additional Information (RAIs) were renumbered by the ISE.

The CNS Response to this Request for Additional Information Regarding the Overall Integrated Plan for Implementation of Order EA-12-051, Reliable Spent Fuel Instrumentation was provided through the Scientech eDocs Web Portal as allowed by NRC Letter, Nuclear Regulatory Commission Audits of Licensee Responses to Reliable Spent Fuel Pool Instrumentation Order EA-12-051, dated March 26, 2014 (ADAMS Accession No. ML14083A620).

No further information is required for this attachment.

ATTACHMENT 5

BRIDGING DOCUMENT BETWEEN VENDOR TECHNICAL INFORMATION AND CNS SPECIFIC CONSIDERATIONS FOR SPENT FUEL POOL INSTRUMENTATION

#	Topic	Parameter Summary	Vendor Design Reference Document #	Additional Comments	Test or Analysis Results	Licensee Evaluation
1	Design Specification	Customer technical requirements specification for SFPLI	Duke Technical Requirements Document DPR-1336.04-00-0001 Rev. 02 , Duke PO 171968 Rev, 003	EA-12-051, NEI-12-02	N/A	The vendor instrumentation design was reviewed and determined to adequately meet the specification requirements.
2	Test Strategy	Qualification is based on a combination of tests and analyses or similarity. Qualification tests and analyses are summarized in qualification analysis report 51-9202556-005.	Qualification analysis Doc. 51-9202556-005	EA-12-051, 1.4 NEI-12-02, 3.4	Test and analysis results meet requirements of EA 12-051, JLD-ISG-2012-03, and NEI 12-02 Rev. 1	The vendor qualification documentation was reviewed and concluded to adequately demonstrate the instrumentation could reliably function in its installed environment(s) during a postulated Beyond Design Basis External Event (BDBEE).
3	Environmental qualification for electronics enclosure with display	Temperature and humidity	Qualification Analysis Doc. 51-9202556-005, Section 2.3	NEI 12-02, 3.4	Temperature rating of Power Control Panel is 149°F allowing for 9°F rise in the panel above ambient. NEMA 4X enclosure prevents moisture intrusion. Radiation withstand analyzed to $1x10^3$ rads	The primary channel instrumentation electronics are located outside the SFP area. The vendor instrumentation design temperature and humidity limits bound the expected environmental conditions during a postulated BDBEE. See Section 7 of this document for discussion of dose limits. Refer to RAI #7 response posted to Catawba Fukushima Sharepoint.

#	Topic	Parameter Summary	Vendor Design Reference Document #	Additional Comments	Test or Analysis Results	Licensee Evaluation
4	Environmental testing for level sensor components in SFP area – Saturated steam & Radiation	Measurement capability through saturated steam and smoke. Testing performed to demonstrate the radar horn cover was effective at preventing moisture intrusion within the horn and wave guide pipe. Radar horn cover (fused silica glass), metal waveguide pipe and horn are not susceptible to radiation degradation. Manufacturer test data supports acceptable radiation degradation resistance for the radar horn cover adhesive.	Qualification Analysis Doc. 51-9202556-005, Section 2.3, 2.4, 2.5, 2.7, Appendix B and supporting references 66-9200846-002 51-9220845-001 51-9221032-000 66-9225632-000	EA-12-051, 1.4 NEI 12-02, 3.4	Initial testing (without horn cover) demonstrated successful measurement capability through steam and smoke. Subsequent testing of the radar horn and cover demonstrated adequate operation during sustained simulated SFP boiling conditions, and that the horn cover was effective in preventing moisture intrusion within the horn and wave guide pipe. The horn cover adhesive is a silicone elastomer manufactured by Dow Corning (Sylgard 170). The adhesive manufacturer radiation test data adequately demonstrates the adhesive would not experience unacceptable degradation for exposures up to 1.64 x10^8 Rads.	The final radar horn cover qualification report was not available when Catawba RAI responses were submitted. Areva Report No. 51-9221032-000 is the "Qualification Analysis For Vega Waveguide Horn Cover". The radar horn cover qualification testing adequately demonstrated acceptable operation during exposure to simulated SFP boiling conditions. The horn cover adhesive manufacturer radiation test data adequately demonstrated the adhesive would not experience unacceptable degradation for radiation exposure in excess of that expected for the postulated beyond design basis event over the required mission time.

ATTACHMENT 5

BRIDGING DOCUMENT BETWEEN VENDOR TECHNICAL INFORMATION AND CNS SPECIFIC CONSIDERATIONS FOR SPENT FUEL POOL INSTRUMENTATION

#	Topic	Parameter Summary	Vendor Design Reference Document #	Additional Comments	Test or Analysis Results	Licensee Evaluation
5	Environmental testing for level sensor electronics housing – outside SFP	Temperature and humidity testing and analysis of sensor and indicator	Qualification Analysis Doc. 51-9202556-005, Sections 2.3, 2.5, Appendix A and supporting references IEC 60068-2-30, 38-9218218-000, EN 60529:2000, 38-9218214-000, USNRC Bulletin 79-01B Table C-1, NUREG-173, Vol.1, Section 3.11.3.2.1, Reg. Guide 1.209	NEI 12-02, 3.4	Sensor and indicator are demonstrated to withstand the manufacturer ratings 80°C (sensor) and 70°C (indicator), 100% RH. Radiation withstand analyzed to $1x10^3$ rads.	Refer to RAI # 7 response posted to Catawba Fukushima Sharepoint. See Section 7 of this document for discussion of dose limits.
6	Thermal & Radiation Aging – organic components in SFP area	Radar horn cover (fused silica glass), metal waveguide pipe and horn are not susceptible to radiation degradation. Horn cover adhesive manufacturer radiation test data and temperature withstand specifications.	Qualification analysis Doc. 51-9202556-005, Section 2.5 51-9221032-000 66-9225632-000	EA-12-051, 1.4 NEI 12-02, 3.4	Thermal and radiation aging not applicable to metal waveguide in SFP area. The horn cover adhesive is a silicone elastomer manufactured by Dow Corning (Sylgard 170). The adhesive manufacturer radiation test data adequately demonstrates the adhesive would not experience unacceptable degradation for exposures up to $1.64 x10^8$ Rads. The silicone adhesive is rated to withstand temperatures extremes of -45 to 200°C, which adequately bound the postulated temperatures for sustained SFP boiling conditions.	The glass and metallic instrumentation components located within the SFP area are not susceptible to aging due to thermal and/or radiation effects. The horn cover adhesive manufacturer radiation test data adequately demonstrated the adhesive would not experience unacceptable degradation for radiation exposure in excess of that expected for the postulated beyond design basis event over the required mission time. The horn cover adhesive temperature ratings are acceptable and readily bound the expected conditions for the postulated beyond design basis event.
7	Basis for Dose Requirement	SFPLI remote transmitter, indicator and power control	AREVA Document No. 51-9202556-005, Qualification Analysis of VEGAPULS 62 ER	NEI 12-02, 3.4	A Catawba calculation shows that the electronics require periodic replacement.	A location specific dose calculation was performed for the remote electronics, which indicated these components must be replaced in less than 6 years. A periodic replacement

#	Topic	Parameter Summary	Vendor Design Reference Document #	Additional Comments	Test or Analysis Results	Licensee Evaluation
		panel qualified to $1x10^3$ rads based on industry operating experience. Based on engineering judgment, the expected total integrated dose for the radar horn cover adhesive would not exceed 1 $x10^8$ over the required mission time for the instrumentation.	Through Air Radar 51-9221032-000 66-9225632-000		The horn cover adhesive manufacturer radiation test data adequately demonstrates the adhesive would not experience unacceptable degradation for exposures up to 1.64 $x10^8$ Rads.	for the transmitter, power control panel and local indicator has been set up. Site specific radiation dose data is being collected for a future revision of the dose calculation. Refer to RAI #7 response posted to Catawba Fukushima Sharepoint. The horn cover adhesive manufacturer radiation test data adequately demonstrated the adhesive would not experience unacceptable degradation for radiation exposure in excess of that expected for the postulated beyond design basis event over the required mission time.
8	Seismic Qualification	Seismic withstand capability of VEGAPULS 62 ER sensor , indicators, power control panel, mounting brackets, waveguide pipe	Qualification analysis Doc. 51-9202556-005, Section 2.1, Appendix D and supporting references 11-9203036-000, IEEE STD 344-2004, EPRI TR-107330, 174-9213558-006	NEI 12-02, 3.4	VEGAPULS 62 ER sensor , indicator, power control panel, mounting brackets, and waveguide pipe are seismically qualified to RRS levels from EPRI TR-107330	The vendor instrumentation seismic testing adequately demonstrates the equipment is capable of reliably operating during a seismic event. Refer to RAIs #7 and #8 responses posted to Catawba Fukushima Sharepoint.
9	Sloshing	NRC RAIs indicated a SFP seismic induced sloshing analysis	Sloshing analysis was performed by an alternate vendor than the supplier of the	N/A	Seismic induced sloshing analysis concluded that the available SFP free-board readily enveloped the	Sloshing analysis determined seismic induced wave would not impact radar horn.

#	Topic	Parameter Summary	Vendor Design Reference Document #	Additional Comments	Test or Analysis Results	Licensee Evaluation
		is required. If wave impact is predicted, then the hydrodynamic forces should be included in the mounting design loading combinations.	radar level instrumentation (Reference Catawba calculation CNC-1336.04-00-0001).		maximum predicted wave height. The analysis determined wave impact on the radar horn would not occur.	
10	Spent Fuel Pool instrumentation system functionality test procedure	Functionality testing was performed during the factory acceptance test. See #16	VEGA Test Procedure AREVA Doc. 38-9219704-000, Factory Acceptance Test Report AREVA Doc. 66-9227809-002	N/A	Testing demonstrated that the SFPLI met the specification functional requirements.	The vendor factory acceptance test demonstrated reliable operation of the SFP level instrumentation under normal conditions and under various simulated test conditions (e.g. steam exposure). The testing demonstrated the instrumentation met design accuracy and repeatability specifications.
11	Boron Build-Up	N/A	Sloshing analysis was performed by an alternate vendor than the vendor whom supplied the radar level instrumentation (Reference Catawba calculation CNC-1336.04-00-0001).	N/A	Waveguide radar horn is not immersed in SFP water and therefore not susceptible to boron accumulation. During postulated SFP boiling, boron is not transported by rising steam/vapor. Seismic induced sloshing analysis concluded that the available SFP free-board readily enveloped the maximum predicted wave height. The analysis determined that a seismic induced wave would not impact the radar horn.	Licensee concurs that the wave guided radar instrumentation located in the SFP area is not susceptible to degradation due to postulated boron build-up. The wave guided radar horn is elevated above the SFP process and would not be susceptible to boron build-up on the horn during postulated SFP boiling conditions, nor is it credible that boron crystal accumulation on the perimeter of the SFP walls would impede the radar signal strength.
12	Pool-side Bracket Seismic Analysis	Seismic withstand	Qualification analysis Doc. 51-9202556-005 and supporting reference 174-9213558-006,	NEI 12-02, 3.4	Sensor brackets and electronic enclosure mounting are seismically qualified to EPRI TR-107330 or site-specific RRS.	Refer to RAIs #4 and #5 responses posted to Catawba Fukushima Sharepoint. The test and analysis of the horn cover and adhesive demonstrate adequate seismic

#	Topic	Parameter Summary	Vendor Design Reference Document #	Additional Comments	Test or Analysis Results	Licensee Evaluation
		Tests and analyses were performed for the horn cover and adhesive to demonstrate adequate seismic withstand capability. Perform seismic induced sloshing analysis to assess hydrodynamic wave force on the radar horn.	Calculations 32-9208751-002, 51-9221032-000 66-9225632-000 32-9221237-003 66-9225469-000 Sloshing analysis was performed by an alternate vendor than the vendor whom supplied the radar level instrumentation (Reference Catawba calculation CNC-1336.04-00-0001).		Testing and analysis of horn cover and adhesive support the components can tolerate horizontal and vertical accelerations up to 100g and SFP sloshing loads up to 3.37 psi. Seismic induced sloshing analysis concluded that the available SFP free-board readily enveloped the maximum predicted wave height. The analysis determined wave impact on the radar horn would not occur.	withstand capability. The stress analysis does not need to consider hydrodynamic sloshing forces in the design of the mounting brackets. The sloshing analysis determined seismic induced wave would not impact radar horn.
13	Additional Brackets (Sensor Electronics and Electronic Enclosure)	Seismic withstand of sensor brackets and electronic enclosure mounting	Qualification analysis Doc. 51-9202556-005, Section 2.1, Appendix D and supporting references 11-9203036-000, EPRI TR-107330, 174-9213558-006 Calculations 32-9208751-002, 32-9221237-003	NEI 12-02, 3.4	Sensor brackets and electronic enclosure mounting are seismically qualified to EPRI TR-107330 or site-specific RRS.	Refer to RAIs #4 and #8 responses posted to Catawba Fukushima Sharepoint.
14	Shock & Vibration	Shock and vibration withstand testing and analysis for sensor, displays, power control panel Tests and	Qualification Analysis Doc. 51-9202556-005, Sections 2.2 and supporting references MIL-S-901D, MIL-STD-167-1 38-9193058-000, EN 60068-2-27, 38-9218022-000,	NEI 12-02, 3.4	Sensor, displays, and power control panel have been tested and/or analyzed for shock and vibration. The test parameter values provided in IEC Standards, IEC 60068-2-6 (vibration) and IEC 60068-2-27	The shock and vibration testing performed for the SFP level instrumentation adequately demonstrates the sensor and power control panel will be reliable in the installed design location. The instrumentation is rigidly mounted to the Seismic Category I Auxiliary Building wall and would not be subjected to any significant shock or vibration during a postulated beyond design basis event, or

#	Topic	Parameter Summary	Vendor Design Reference Document #	Additional Comments	Test or Analysis Results	Licensee Evaluation
		analyses were performed for the horn cover and adhesive to demonstrate adequate shock withstand. Additional testing was performed for the power control panel assembly.	EN 60068-2-6, 38-9218023-000, MIL-STD-202 51-9221032-000 66-9225632-000 32-9221237-003 66-9225469-000 38-9228047-000		(shock), tables are recommendations and not mandatory testing levels. The test parameter values were selected to be consistent with previous shock and vibration testing performed on the VEGA supplied equipment. The test parameter values specified envelope the expected levels for the equipment installed location, due to the fact that the equipment is mounted to seismic structures within the plant. This approach is consistent with similar technology used in the same application at other installations. The vibration testing deviated from the IEC 60068-2-6 recommended frequency range and displacement magnitude for large power plant equipment (TABLE C.2). In-lieu of the 10-55 Hz and minimum displacement of 0.15 mm recommended in TABLE C.2, the power control panel vibration testing utilized a narrower frequency band (5-25 Hz) and a more limiting displacement magnitude (1.6 mm). These values were deemed to be acceptable and enveloping	during normal operation. The instrumentation is located within the Seismic Category I Auxiliary Building and is protected from external wind borne missile threats. The instrumentation installed design location is not susceptible to vibration from surrounding rotating equipment. The radar sensor and power control panel design location provides spatial separation from surrounding SSCs, such that potential seismic interaction with surrounding SSCs is also not a concern. The post modification testing will demonstrate reliable operation of the instrumentation, which confirms no damage occurred during shipping, handling and installation. Similarly, the performance of monthly channel functional comparisons will serve to confirm proper operation of the instrumentation, or provide a means of early detection of potential instrument degradation. Refer to RAI #7 response posted to Catawba Fukushima Sharepoint. The test and analysis of the horn cover and adhesive demonstrate adequate shock withstand capability.

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#	Topic	Parameter Summary	Vendor Design Reference Document #	Additional Comments	Test or Analysis Results	Licensee Evaluation
					for equipment rigidly mounted to a Seismic Category I structure, based on engineering judgment. The shock testing deviated from the IEC 60068-2-27 recommended peak acceleration and duration for land-based permanently installed equipment. In-lieu of the 15 g's peak acceleration and duration of 11 m-sec recommended in TABLE A.1, the power control panel vibration testing utilized an acceleration of 10g with a 6 m-sec duration. These values were deemed to be acceptable and enveloping for equipment rigidly mounted to a seismic Category I structure, based on engineering judgment. Testing and analysis of horn cover and adhesive support the components can tolerate horizontal and vertical accelerations up to 100g and SFP sloshing loads up to 3.37 psi.	
15	Requirements Traceability	Not required by order	N/A	N/A	N/A	N/A

ATTACHMENT 5

BRIDGING DOCUMENT BETWEEN VENDOR TECHNICAL INFORMATION AND CNS SPECIFIC CONSIDERATIONS FOR SPENT FUEL POOL INSTRUMENTATION

#	Topic	Parameter Summary	Vendor Design Reference Document #	Additional Comments	Test or Analysis Results	Licensee Evaluation
16	Factory Acceptance Test	Inspection of waveguide, test of functionality of power transfer to battery, sensor measurement accuracy and effects of steam and water in waveguide	VEGA Test Procedure AREVA Doc. 38-9219704-000, Factory Acceptance Test Report AREVA Doc. 66-9227809-002	N/A	Test demonstrates that specification requirements were met.	The vendor factory acceptance test demonstrated reliable operation of the SFP level instrumentation under normal conditions and under various simulated test conditions (e.g. steam exposure). The testing demonstrated the instrumentation met design accuracy and repeatability specifications.
17	Channel Accuracy	Normal and accident conditions SFP level measurement accuracy	AREVA Instruction manual Doc. 01-9223080-003, Section 11.6	EA-12-051, 1.7 NEI 12-02, 3.7	Normal conditions accuracy ±1 inch, error due to all effects including 212°F saturated steam ±3 inches. Accuracy verified during factory acceptance testing.	The vendor factory acceptance test demonstrated reliable operation of the SFP level instrumentation under normal conditions and under various simulated test conditions (e.g. steam exposure). The testing demonstrated the instrumentation met design accuracy and repeatability specifications. Refer to RAI #11 response posted on Catawba Fukushima Sharepoint.
18	Power Consumption	Lifetime of battery backup at full load	Qualification Analysis Doc. 51-9202556-005, Section 2.9, Instruction Manual 01-9223080-003, Section 11.7	EA-12-051, 1.6, NEI 12-02, 3.6	Battery capacity at full load is expected to readily exceed 7 days.	Based on vendor analysis the battery capacity is deemed sufficient to support reliable instrument channel operation until off-site resources can be deployed by the mitigating strategies in response to Order EA-12-049. Refer to RAI #10 response posted to Catawba Fukushima Sharepoint.
19	Technical Manual	Application-specific information on the installation, operation, and maintenance of the SFPLI	AREVA Doc. 01-9223080-003	N/A	N/A	The vendor technical manual has been reviewed, accepted and incorporated in the engineering change package.

Attachment 5

Bridging Document Between Vendor Technical Information and CNS Specific Considerations for Spent Fuel Pool Instrumentation

#	Topic	Parameter Summary	Vendor Design Reference Document #	Additional Comments	Test or Analysis Results	Licensee Evaluation
20	Calibration	Periodic indication checks, calibration checks, calibration	EA-12-051, 1.8 AREVA Doc. 01-9223080-003, Sections 7.0 and 9.1.1	EA-12-051, 1.8 NEI 12-02, 3.8 Based on negligible drift rate of VEGA electronics experienced over large user base, periodic calibration is not needed. Functional verification can be achieved using cross channel checks and functional checks per vendor manual.	N/A	Refer to RAIs #12 and #15 responses posted to Catawba Fukushima Sharepoint. In-lieu horn rotation and use of a portable target, periodic verification of proper radar channel functionality can be achieved by varying SFP water level (minimum 2 points) and proper level indication.
21	Failure Modes and Effects Analysis (FMEA)	N/A	N/A	N/A	N/A	The instrumentation is required to function to provide SFP level indication for a beyond design basis event. Performance of a FMEA is not warranted for this type of an application. Reasonable assurance that both channels are not susceptible to a common mode failure is provided by satisfying the NEI 12-02 guidance.
22	EMI Testing	Emissions and susceptibility testing for VEGAPULS 62 ER	Qualification Analysis Doc. 51-9202556-005, Section 2.6 and supporting references EN-61000-4 MIL-STD-461E,	N/A	VEGAPULS 62 ER has been tested for emissions to both MIL and IEC standards and for susceptibility to IEC standards	The EMI/RFI susceptibility and emissions testing performed for the waveguide radar transmitter provides adequate assurance the instrumentation will be compatible in the design location. The testing was conservatively performed with unshielded

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BRIDGING DOCUMENT BETWEEN VENDOR TECHNICAL INFORMATION AND CNS SPECIFIC CONSIDERATIONS FOR SPENT FUEL POOL INSTRUMENTATION

#	Topic	Parameter Summary	Vendor Design Reference Document #	Additional Comments	Test or Analysis Results	Licensee Evaluation
			58-9214362-000, 38-9219863-000, 38-9218965-000, 38-9218966-000, 38-9219862-000, 38-9218967-000, 38-9218968-000, 38-9218969-000, 38-9218970-000, 38-0218964-000			interconnecting wiring. The Catawba level channel design included shielded signal cabling, and grounding of the power control panel. Post-modification testing has demonstrated acceptable operation in the installed location. During a postulated BDBEE, it is possible that intermittent UHF radio operation could occur in the vicinity of the radar transmitter. Successful long-term SFP monitoring capability during a postulated BDBEE would not be inhibited by potential intermittent radio transmission interference.

NRC Order EA-12-049
FLEX FINAL INTEGRATED PLAN

Catawba Nuclear Station, Units 1 & 2

February 2016

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1. Background

In 2011, an earthquake-induced tsunami caused Beyond-Design-Basis (BDB) flooding at the Fukushima Dai-ichi Nuclear Power Station in Japan. The flooding caused the emergency power supplies and electrical distribution systems to be inoperable, resulting in an extended loss of AC power (ELAP) in five of the six units on the site. The ELAP led to (1) the loss of core cooling, (2) loss of spent fuel pool cooling capabilities, and (3) a significant challenge to maintaining containment integrity. All DC power was lost early in the event on Units 1 & 2 and after some period of time at the other units. Core damage occurred in three of the units along with a loss of containment integrity resulting in a release of radioactive material to the surrounding environment.

The U.S. Nuclear Regulatory Commission (NRC) assembled a Near-Term Task Force (NTTF) to advise the Commission on actions the U.S. nuclear industry should take to preclude core damage and a release of radioactive material after a natural disaster such as that seen at Fukushima. The NTTF report (Reference 1) contained many recommendations to fulfill this charter, including assessing extreme external event hazards and strengthening station capabilities for responding to beyond design basis external events (BDBEEs).

Based on NTTF Recommendation 4.2, the NRC issued Order EA-12-049 (Reference 2) on March 12, 2012 to implement mitigation strategies for BDBEEs. The order provided the following requirements for strategies to mitigate BDBEEs:

- Licensees shall develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and Spent Fuel Pool (SFP) cooling capabilities following a BDBEE.
- These strategies must be capable of mitigating a simultaneous loss of all AC power and loss of normal access to the ultimate heat sink (UHS) and have adequate capacity to address challenges to core cooling, containment and SFP cooling capabilities at all units on a site subject to the Order.
- Licensees 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 the Order.
- Licensees must be capable of implementing the strategies in all modes.
- Full compliance shall include procedures, guidance, training, and acquisition, staging or installing of equipment needed for the strategies.

The order specifies a three-phase approach for strategies to mitigate BDBEEs:

- Phase 1 - Initially cope relying on installed equipment and on-site resources.
- Phase 2 - Transition from installed plant equipment to on-site FLEX equipment.
- Phase 3 - Obtain additional capability and redundancy from off-site equipment and resources until power, water, and coolant injection systems are restored or commissioned.

NRC Order EA-12-049 (Reference 2) required licensees of operating reactors to submit an overall integrated plan, including a description of how compliance with these requirements would be achieved. The Order also required licensees to complete implementation of the requirements no later than two refueling cycles after submittal of the overall integrated plan or December 31, 2016, whichever comes first.

The Nuclear Energy Institute (NEI) developed NEI 12-06 (Reference 3), which provides guidelines for nuclear stations to assess extreme external event hazards and implement the mitigation strategies specified in NRC Order EA-12-049. The NRC issued Interim Staff Guidance JLD-ISG-2012-01 (Reference 4), dated August 29, 2012, which endorsed NEI 12-06 with clarifications on determining baseline coping capability and equipment quality.

Duke Energy (Duke) declared that Catawba Nuclear Station (CNS) Unit 2 was in compliance with Order EA-12-049 on March 31, 2015 following the 2EOC20 refueling outage, which is within two refueling cycles of the submittal of the OIP dated February 28, 2013 (Reference 5). Duke declared that CNS Unit 1 was in compliance with Order EA-12-049 on December 16, 2015 following the 1EOC22 refueling outage, also within two refueling cycles of the OIP submittal (Reference 6).

NRC Order EA-12-051 (Reference 7) required licensees to install reliable SFP instrumentation with specific design features for monitoring SFP water level. This order was prompted by NTTF Recommendation 7.1 (Reference 1).

NEI 12-02 (Reference 8) provided guidance for compliance with Order EA-12-051. The NRC determined that, with the exceptions and clarifications provided in JLD-ISG-2012-03 (Reference 9), conformance with the guidance in NEI 12-02 is an acceptable method for satisfying the requirements in Order EA-12-051.

Duke declared that CNS Unit 2 was in compliance with Order EA-12-051 on March 31, 2015 following the 2EOC20 refueling outage, which is within two refueling cycles of the submittal of the OIP dated February 28, 2013 (Reference 5). Duke declared that CNS Unit 1 was in compliance with Order EA-12-051 on December 16, 2015 following the 1EOC22 refueling outage, also within two refueling cycles of the OIP submittal (Reference 6).

2. Order Implementation

2.1 General Elements

The assumptions used for the evaluations of an ELAP/Loss of Ultimate Heat Sink (LUHS) event and the development of diverse and flexible coping strategies (FLEX strategies) are stated below.

Initial conditions and boundary conditions consistent with NEI 12-06 were established to support development of FLEX strategies, as follows:

- The reactor is initially operating at power, unless there are procedural requirements to shut down due to the impending event. The reactor was operating at 100% power for the past 100 days.
- The reactor is successfully shut down when required (i.e., all rods inserted, no Anticipated Transient Without Scram (ATWS)). Steam release to maintain decay heat removal upon shutdown functions normally, and reactor coolant system (RCS) overpressure protection valves respond normally, if required by plant conditions, and reseat.
- On-site staff is at site administrative minimum shift staffing levels.
- All personnel on-site are available to support site response.
- The reactor and supporting plant equipment are either operating within normal ranges for pressure, temperature and water level, or available to operate, at the time of the event consistent with the design and licensing basis.

- No specific initiating event is used. The initial condition is assumed to be a loss of off-site power (LOOP) with installed sources of emergency on-site AC power and station blackout (SBO) alternate AC power sources unavailable with no prospect for recovery. All AC power supplies were considered to fail concurrently at the beginning of the event.
- Cooling and makeup water inventories contained in systems or structures with designs that are robust with respect to seismic events, floods, and high winds and associated missiles are available.
- Normal access to the ultimate heat sink (UHS) is lost, but the water inventory in the UHS remains available and robust piping connecting the UHS to plant systems remains intact. The motive force for UHS flow, i.e., pumps, is assumed to be lost with no prospect for recovery.
- Permanent plant equipment that is contained in structures with designs that are robust with respect to seismic events, floods, and high winds and associated missiles, are available. SSCs were considered seismically robust if seismic requirements were imposed by licensing requirements. The portion of the fire protection system that is robust with respect to seismic events, floods, and high winds and associated missiles is available as a water source. Installed electrical distribution systems, including inverters and battery chargers, remain available since they are protected.
- Fuel for FLEX equipment stored in structures with designs that are robust with respect to seismic events, floods and high winds and associated missiles, remains available.
- No additional accidents, events, or failures are assumed to occur immediately prior to or during the event, including security events.
- Reactor coolant inventory loss consists of unidentified leakage at the upper limit of Technical Specifications, reactor coolant letdown flow (until isolated), and reactor coolant pump seal leak-off at normal maximum rate.
- For the SFP, all boundaries (e.g., liner, gates) and the SFP cooling system are assumed to be intact. The SFP heat load is assumed to be the maximum design basis heat load. In addition, inventory loss from sloshing during a seismic event does not preclude access to the pool area.

Additional key assumptions associated with design and implementation of FLEX strategies are as follows:

- Additional deployment resources are assumed to begin arriving at 6 hours and the site Emergency Response Organization (ERO) will be fully staffed at 24 hours after the event.
- The plant Technical Specifications contain the limiting conditions for normal unit operations to ensure that design safety features are available to respond to a design basis accident and direct the required actions to be taken when the limiting conditions are not met. The result of the BDBEE may place the plant in a condition where it cannot comply with certain Technical Specifications and/or with its Security Plan, and, as such, may warrant invocation of 10 CFR 50.54(x) and/or 10 CFR 73.55(p). (Reference 10)
- All installed AC power supplies (emergency on-site and SBO Alternate AC power sources as defined by 10CFR50.2) were considered not available and not immediately recoverable.

- Where non-safety, non-seismically designed, permanently installed equipment is used for FLEX strategies, SSCs were considered seismically robust if:
  - Seismic Qualification Utility Group (SQUG) methods are applied per the existing plant licensing basis.
  - Testing, analysis or experience-based methods are applied for the equipment class at design basis seismic levels.
  - Methodologies in EPRI 1019199, Experience Based Seismic Verification Guidelines for Piping and Tubing Systems, can be successfully applied relative to the Safe Shutdown Earthquake (SSE).
  - Other industry-recognized codes such as AWWA D100 are applied to demonstrate functionality at SSE level ground motion.
  - High Confidence of a Low Probability of Failure (HCLPF) capacities are determined (e.g., EPRI NP-6041 Rev 1) conservative compared to the SSE.
- Personnel access to and qualification of equipment that forms a part of the FLEX strategy assumed no core damage.
- Per NEI 12-06 Section 3.2.1.8, maximum environmental room temperatures for habitability or equipment operation may be based on NUMARC 87-00 guidance if other design basis information or industry guidance is not available. Extreme high temperatures are not expected to impact the utilization of offsite resources or the ability of personnel to implement the required FLEX strategies.
- Access through security fences, doors, and other barriers will be unimpeded and not require additional resources.

2.2 Strategies

The objective of the FLEX strategies is to establish indefinite coping capability in order to:

- Prevent damage to the fuel in the reactors
- Maintain the containment function
- Maintain cooling and prevent damage to fuel in the SFP

This indefinite coping capability will address an ELAP – loss of off-site power, emergency diesel generators (EDGs) and any alternate AC source, but not the loss of AC power to buses fed by station batteries through inverters – with a simultaneous LUHS. This condition could arise following external events that are within the existing design basis with additional failures and conditions that could arise from a BDBEE.

The plant indefinite coping capability is attained through the implementation of pre-determined strategies (FLEX strategies) that are focused on maintaining or restoring key plant safety functions. The FLEX strategies are not tied to any specific damage state or mechanistic assessment of external events. Rather, the strategies are developed to maintain the key plant safety functions based on the evaluation of plant response to the coincident ELAP/LUHS event. A safety function-based approach provides consistency with, and allows coordination with, existing plant emergency operating procedures (EOPs). FLEX strategies are implemented in support of EOPs using FLEX Support Guidelines (FSGs).

The strategies for coping with the plant conditions that result from an ELAP/LUHS event involve a three-phase approach:

- Phase 1 – Initially cope by relying on installed plant equipment and on-site resources.
- Phase 2 – Transition from installed plant equipment to on-site FLEX equipment.
- Phase 3 – Obtain additional capability and redundancy from off-site equipment and resources until power, water, and coolant injection systems are restored.

The transitions to Phase 2 and Phase 3 will occur at different times for different portions of the FLEX strategies.

The strategies described below are capable of mitigating an ELAP/LUHS resulting from a BDBEE by providing adequate capability to maintain or restore core cooling, containment, and SFP cooling capabilities at CNS. Though specific strategies have been developed, due to the inability to anticipate all possible scenarios, the strategies are also diverse and flexible to encompass a wide range of possible conditions. These pre-planned strategies developed to protect public health and safety are integrated into EOPs in accordance with established change processes, and their impact to the design basis capabilities of the unit are evaluated under 10 CFR 50.59.

2.3 Reactor Core Cooling Strategy

2.3.1 Phase 1

Following reactor and turbine trips of each operating unit, the Turbine Driven Auxiliary Feedwater Pump (TDAFWP) supplies water to the Steam Generators (SGs) secondary side to cool down the Reactor Coolant System (RCS). CNS will limit cool down to a rate near 100°F/hr to minimize RCS system inventory loss, while cooling the Reactor Coolant Pump (RCP) seals in a controlled manner. The SGs will be depressurized to 240 psig and RCS temperature will be maintained above 280°F. Maintaining SG pressure at this level prevents nitrogen injection from the Cold Leg Accumulators (CLAs) into the RCS

The TDAFWP will draw suction from the Upper Surge Tank (UST), the Auxiliary Feedwater Condensate Storage Tank (CACST), or the hotwell, which are condensate grade water sources. However, these sources are susceptible to damage from wind and seismic events and may not be available. The TDAFWP can also draw suction from buried piping in the Condenser Circulating Water (RC) system, which has been evaluated to be seismically robust and can supply sufficient water to support decay heat removal for at least 48 hours. The valve to enable TDAFW pump suction from embedded RC piping opens on a loss of control power or instrument air, and will provide flow when suction pressure from the UST or the hotwell drops below the RC static pressure. CNS will control SG level by throttling CA system flow control valves from the Control Room or starting and stopping the TDAFWP.

To remove heat, CNS will discharge steam through the SG Power Operated Relief Valves (PORVs), which can be operated from the control room using vital battery power and safety grade nitrogen backup for the valve actuators. The SG PORVs can also be manually operated.

The vital station batteries provide DC power for essential instrumentation. Vital battery load shedding will be initiated 2.5 hours into the event. The CNS load shedding strategy will maintain power supply from the A and D vital batteries for approximately 10 hours, and the B and C vital batteries for approximately 24 hours.

No action is necessary for managing RCS inventory or reactivity during Phase 1. CNS-specific analysis concluded that core uncovery will not occur until at least 72 hours into the event. Additionally, CNS determined that boration of the RCS to control reactivity is not needed until FLEX equipment can be deployed during Phase 2.

2.3.2 Phase 2

The Phase 2 core cooling strategy continues to use the SGs as the heat sink. CNS has multiple strategies for providing feedwater to the SGs using FLEX equipment:

- If the TDAFWP is still available after the RC piping static inventory has been depleted, CNS can use a portable low pressure pump to establish a new suction source. The low pressure pump will draw suction from the Standby Nuclear Service Water Pond (SNSWP) to a connection in the service water system (RN) piping. CNS will align valves to direct flow to the auxiliary feedwater (CA) system and the TDAFWP.
- When the TDAFWP is no longer available (e.g., steam pressure becomes too low), a portable, low pressure pump will provide feedwater by taking suction from the SNSWP and discharging into portable, medium pressure pumps located near the Exterior Doghouses of each Unit. The medium pressure pumps will discharge into connections in the Doghouses to establish flow to the SGs. CNS can establish a flow path using only hoses; fire protection system piping can also be used to reduce hose deployment.
- SGs may be fed directly from the FLEX Raw Water Distribution system (i.e., without the medium pressure pump). This approach requires depressurizing the SGs below the discharge pressure of the FLEX Raw Water Distribution System (approximately 150 psig). The option to use only low pressure pumps is less preferred because it provides less capacity and it requires feeding and steaming SGs that are close to dry. Additionally, this strategy is not preferred prior to CLA isolation, because of the potential for injection of nitrogen into the RCS, which may occur at 140 psig. CNS can establish a flow path using only hoses; fire protection system piping can also be used to reduce hose deployment.

CNS will deploy 600V diesel generators (DGs) to provide power for the FLEX strategies within 9 hours of the event.

- A back-feed receptacle connection on selected motor control centers (MCCs) allows re-powering key installed equipment, including battery chargers. The A vital battery charger will be re-powered within 11.5 hours and the D vital battery charger will be re-powered within 12.5 hours. Battery chargers will be aligned to the vital batteries prior to battery voltage dropping below acceptable values. The spare battery charger will provide redundancy as a backup for either safety train on the applicable unit. The B and C vital battery chargers will be repowered within 24 hours. This strategy allows all channels of vital instrumentation to be maintained.
- The 600V FLEX DGs will also be connected to the plant MCCs for re-powering via the FLEX 'Backbone,' which consists of permanently installed cables, portable panelboards, and transformers. If normal power supplies are not available, they will be disconnected to allow connection of alternate supply cables. The alternate cable(s) will be plugged directly into the MCCs via FLEX receptacles for the component. Cables will be routed out of the Auxiliary Building for connection to the FLEX DGs.

CNS will provide Phase 2 RCS makeup using a portable high pressure pump. Initially, CNS will use the reactor head vent valves to establish venting/letdown of the RCS. These valves will be re-powered using the MCC backfeed strategy and FLEX DGs. The high-pressure pump will draw suction from the Refueling Water Storage Tank (FWST) via a connection on the piping for makeup to the SFP. The high pressure pump will discharge into safety injection pump discharge piping. Sufficient borated water will be added to maintain the core sub-critical, in a xenon-free condition, at 350°F.

The CLA isolation valves will be closed to prevent nitrogen from being injected into the RCS prior to final cooldown and depressurization. The CLA isolation valves will be re-powered using the FLEX DGs. After the CLAs are isolated or vented, CNS will depressurize SGs to 160 psig at a rate that will limit cooldown to less than 100°F per hour.

A portable FLEX sump pump is placed in each CA TDAFWP pit to pump out normal drains input from the TDAFWP to the room sump before flooding impacts operation of the TDAFWP. The flooding impact could occur 7 hours into the event. Additionally, Groundwater Drainage System (WZ) sump pumps must be in operation by 10.6 hours into the event to prevent installed sump pump motors from being flooded. CNS can also deploy FLEX sump pumps in various locations (in addition to the TDAFWP pits) to manage groundwater intrusion.

2.3.3 <u>Phase 3</u>

After CNS has decreased RCS temperature to less than 350°F and RCS pressure to less than 385 psig, CNS will transition to cooling by Residual Heat Removal (RHR). CNS will repower the Component Cooling (KC) system pumps to provide cooling water to the RHR pumps.

The National SAFER Response Center (NSRC) will deliver equipment to CNS to establish and align RHR and KC systems.

- Two portable pumps will take suction from the SNSWP and discharge by hose to the supply piping of the RN system (one portable pump per RN train). The pressurized RN system will be manually aligned to supply flow to the KC system heat exchangers.
- Large portable DGs from the NSRC will power KC and RHR system pumps.

The RHR pumps can provide borated makeup water to the core by taking normal suction from the FWST. If needed, mobile boration units from the NSRC can be used to refill the FWST through existing vents.

The NSRC will deliver a water treatment skid that can provide a cleaner water source than the SNSWP.

Additional diesel fuel for portable equipment will be brought in from off-site resources when required.

2.3.4 <u>Availability of Systems, Structures, and Components</u>

The FLEX strategy for core cooling relies on various installed systems, structures, and components (SSCs). These SSCs are protected in regard to the applicable extreme external hazards as discussed below.

2.3.4.1 Structures

The FLEX strategy relies on selected site structures to provide protection from the applicable extreme external hazards. Specifically, the FLEX strategy relies on Containment, the Auxiliary Building, the Nuclear Service Water System Pumphouse, the SG Doghouses, and the Fuel Handling Building, which are all Seismic Category I structures.

2.3.4.2 Piping and Fittings

The FLEX strategy relies on installed piping and fittings in various plant systems to deliver water for core cooling. Such piping is either designed for safety-related service or was analyzed as part of development of the FLEX strategies to confirm availability following any of the applicable hazards (e.g., the RC piping).

Primarily, CNS relies on piping and components from the Reactor Coolant System (RCS), Auxiliary Feedwater (CA) system, Safety Injection (NI) system, Residual Heat Removal (RHR) system, the Nuclear Service Water (RN) system, the Component Cooling (KC) system, the Condenser Circulating Water (RC) system, the Main Steam to Auxiliary Equipment (SA) system, the Main Steam Vent to Atmosphere (SV) system, the Steam Generator Wet Layup Recirculation (BW) system, the Spent Fuel Pool Cooling (KF) system, and the Refueling Water (FW) system.

2.3.4.3 Turbine Driven AFW Pump (TDAFWP)

The CNS FLEX strategy relies on the TDAFWP to provide feedwater for the SGs during Phase 1. The TDAFWP and its flow control valves (FCVs) are safety-related, seismically-qualified components that are located in the Auxiliary Building, which is a Seismic Category I structure. These components are therefore protected from the applicable hazards.

2.3.4.4 Steam Generator Power Operated Relief Valves (PORVs)

The CNS FLEX strategy relies on the SG PORVs to remove heat during SG cooling, because cooling from the main condenser is not available. The SG PORVs are safety-related, seismically-qualified components located inside the SG Doghouses, which are Seismic Category I structures. These components are therefore protected from the applicable hazards.

2.3.4.5 Vital Station Batteries

The CNS FLEX strategy relies on vital station batteries to power vital instrumentation. The vital station batteries and associated DC distribution systems are located within the Auxiliary Building, which is a Seismic Category I structure. The vital batteries are therefore protected from the applicable hazards.

2.3.4.6 Electrical Distribution System

CNS uses selected plant electrical distribution equipment to repower installed components credited for the FLEX strategy. Electrical distribution components used for the FLEX strategy are located within Seismic Category I structures and will therefore be available following the applicable hazards.

2.3.4.7 Groundwater Drainage (WZ) Pumps

The CNS FLEX strategy relies on the WZ pumps to manage ground water in-leakage. These pumps will be re-powered by the 600V FLEX DGs. CNS has six WZ pumps (i.e., A1,A2, B1,B2, and C1,C2 pumps), which can all be powered simultaneously. The C groundwater sump and associated components are not seismically qualified; however, if the C WZ sump is intact, it is the preferred source. If the C WZ sump pump cannot be used, the A and B WZ sump pumps have adequate capacity to manage groundwater in-leakage. The A and B WZ sump pumps are protected from all hazards and will be available following a BDBEE.

2.3.4.8 Condenser Circulating Water (RC) Piping

Although the preferred water source for SG feedwater is a clean source (e.g., the UST or the hotwell), the CNS FLEX strategy credits the RC piping for cooling water because it is protected from all applicable hazards. The Unit 1 RC system has a total usable volume of approximately 982,000 gallons and the Unit 2 RC system has a total usable volume of approximately 1,280,000 gallons. These water inventories are sufficient to provide decay heat removal capability for at least 48 hours.

2.3.4.9 Standby Nuclear Service Water Pond (SNSWP)

After depletion of the inventory in the RC piping, CNS can use the SNSWP as a suction source for SG feedwater via the FLEX Raw Water Distribution System. The SNSWP is nuclear safety-related, seismically-protected, and contains sufficient inventory to support the FLEX strategy for an essentially indefinite duration (i.e., well into Phase 3).

2.3.4.10 Refueling Water Storage Tank (FWST)

The FWST is the credited source of makeup for the RCS. The minimum inventory of the intact FWST is 377,537 gallons and contains boron in accordance with CNS technical specifications. The FWST is seismically-qualified and the bottom portion is protected by a missile wall. If the top portion of the FWST is not damaged by the BDBEE, the initial inventory will be sufficient for RCS makeup for the duration of the event. If the top portion of the FWST is damaged, makeup to the FWST may be required within 52 hours.

If necessary, makeup to the FWST can be accomplished using the NSRC-supplied mobile boration skid or other borated water sources (e.g., trucking from McGuire Nuclear Station). Less preferred options for RCS makeup include recovery of borated water from the FWST annulus (if it was damaged) or preparing solution in a FLEX Portable Mixing Tank using borated water from the Boric Acid Tank (BAT) or barrels of dry boric acid.

2.3.5 FLEX Connections

FLEX connections for water and power are installed on various plant systems to facilitate use of portable FLEX equipment. Primary and alternate connections are available for each system used for FLEX. These connection points are protected from the applicable extreme external hazards as discussed below.

2.3.5.1 FLEX SG Feedwater Connections

CNS can provide SG feedwater using portable FLEX equipment and hoses to connect to installed systems. Connection points used to establish a flow path include the following:

- The primary SG feedwater connections are located on CA system piping in the SG Doghouses downstream of the containment isolation valves. A set of four connection points provides one connection for each of the four SGs. At each of the four connection points, CNS will replace a blind flange with a hose adapter to establish a flow path. These connections are located inside a Category I structure (i.e., the SG Doghouses) and are protected from the applicable hazards.
- The alternate SG feedwater connections are located on BW system piping, and are located in the SG doghouses. A set of four connection points provides one connection for each of the four SGs. At each of the alternate connection points, CNS will replace the blind flange with a hose adapter to establish a flow path. These alternate connections are located inside a Category I structure (i.e., the SG Doghouses) and are protected from the applicable hazards.

2.3.5.2 FLEX RN Connections

CNS can provide water through connections on the RN system supply headers to provide feedwater to the TDAFWP or to support long-term RHR during Phase 3. Connection points used to establish a flow path include the following:

- The primary RN connection is on RN Train B at a fill valve that is located in the RN Pumphouse. The RN Pumphouse is a Category I structure that provides protection to this connection point for all applicable hazards.
- The alternate RN connection is on RN Train A at an access plug in the yard. The plug is inside the protected area fence near the RN Pumphouse.

2.3.5.3 FWST Supply Connection for RCS Makeup

The suction supply for the portable high pressure pump will come from a connection on the FWST supply line for makeup to the SFP. This connection point is in the Auxiliary Building, which is a Seismic Category I structure. Therefore, the supply connection is protected from all applicable hazards.

The suction strategy will designate the FWST of one Unit as the primary common suction source for both Units and the other Unit's FWST as a spare. CNS will use a gated wye assembly to facilitate this approach.

2.3.5.4 FLEX RCS Connections

CNS will provide borated water to the RCS using a high pressure makeup pump. Connection points supporting this strategy are located on the NI pump discharge piping in the Auxiliary Building and can be aligned for cold leg or hot leg injection. Connections are available on both Train A and Train B, which provide primary and alternate connection points. These connections are located on safety-related piping and are in a Seismic Category I structure. Therefore, these connections are protected from the applicable hazards.

2.3.5.5 FLEX Electrical Connections

The CNS FLEX strategy relies on DGs to charge batteries, maintain vital instrumentation, and repower plant equipment. The following connections are available to support this strategy:

- Back-feed receptacle connections are available on selected MCCs, which can feed train A and B and spare battery chargers, thereby providing primary and alternate connections for battery charging.
- Connections to normal plant MCCs will enable re-powering via the FLEX Backbone, which consists of permanently installed cables, portable panelboards, and transformers. The alternate approach is to disconnect normal power supplies to enable connection of alternate supply cables, which can be connected at the portable DG.

To support power for vital instrumentation and other equipment, permanent cabling, receptacles, back-feed breakers and MCC's will be seismically qualified and located above anticipated flood level within Category I structures.

2.3.6 Plant Instrumentation

The following instrumentation is relied upon to support the FLEX core cooling strategy:

- RCS Hot Leg Temperature (T_{hot})
- RCS Wide Range (WR) Pressure
- SG Narrow Range (NR) Level
- Core Exit Thermocouple Temperature
- Pressurizer Level
- Reactor Vessel Level Indicating System
- TDAFW Pump Flow
- SG Pressure
- DC Bus Voltage
- Neutron Flux
- FWST Level
- Containment Sump Wide Range Level
- SG and Pressurizer Cavity Temperature
- RCP Seal Leakoff Flow

If the primary instrument is not available or cannot be powered via normal means, CNS will provide an alternate power source or use a portable instrument. CNS can dispatch operators to monitor parameters locally (e.g., CA flow, SG pressure via temporary gauges) or portable test equipment may be used to monitor parameters from inside the Process Control System 7300 cabinet (e.g., SG narrow range level, RCS pressure and temperature, Pressurizer level, FWST level). In addition, CNS has 120 VAC DGs that may be used to provide power for instrumentation if the power is not available by other means.

2.3.7 Thermal-Hydraulic Analysis

CNS performed Fathom analyses to demonstrate that the FLEX pumps have sufficient capability to supply water for the various demands associated with the FLEX strategies. Specific conclusions from these analyses included the following:

- A conservative bounding flow rate for SG feedwater demand at 6 hours into the event is 50 gpm per loop (total of 200 gpm per Unit). A conservative bounding flow for SG feedwater demand at 24 hours is 33 gpm per loop (total of 132 gpm per Unit).
- One FLEX low pressure pump, taking suction from the SNSWP, can supply (by hose) a FLEX medium pressure pump for each Unit for direct feedwater supply to all four SGs (at 50 gpm each; total of 400 gpm for both Units) and four control room spot coolers (at 10 gpm each; total of 40 gpm). SG feedwater supply is sufficient using either the primary or alternate connections.
- After 24 hours, one FLEX low pressure pump, taking suction from the SNSWP, can supply (by hose) a medium pressure pump for each Unit, which then directly feeds all four SGs (at 33 gpm each), boration equipment for each Unit (at 160 gpm total) and control room spot coolers (at 40 gpm total).
- One FLEX low pressure pump, taking suction from the SNSWP and discharging by hose to the RN system, can supply feedwater for all four SGs at both Units (maximum of 50 gpm each; 400 gpm total) and the SFPs at a rate significantly exceeding the most conservative steaming rate (96.8 gpm).
- During Phase 3, two NSRC low pressure pumps, taking suction from the SNSWP and discharging by hose to the RN system, can supply a KC Heat Exchanger for each unit at 3,457 gpm (via A Train) and 3,111 gpm (via B train).
- One FLEX high pressure pump, taking suction from a common FWST and discharging by hose connections into the Unit 1 and Unit 2 NI system piping, can supply the Unit 1 and Unit 2 RCS at least 40 gpm with back-pressure of 450 psia.
- The CNS FLEX strategies require approximately 489,000 gallons of water per Unit in the first 48 hours of the event.

Condensate grade water is required for SG makeup instead of raw water within 96 hours for Unit 2 based on sludge buildup and 275 hours for Unit 1 based on reaching the corrosion limit. (Unit 1 and Unit 2 have different types of SGs, and design differences result in the large difference in allowable service times with raw water.) CNS will deploy water treatment equipment as part of the Phase 3 FLEX strategy to provide a higher purity water source, if long-term SG feedwater is needed.

The minimum required SG pressure to operate the TDAFW pump is 125 psig. CNS procedures permit SG cool down resulting in a SG pressure of 160 psig following closure of the CLAs, which is well into Phase 2. Therefore, SG pressure will be sufficient to power the TDAFWP at least until the FLEX pumps are deployed.

CNS analysis concluded that a conservatively high inflow to the TDAFW pump sumps is 15 gpm. Accumulation of water at this rate would result in flooding the pump after 7 hours.

2.3.8 Reactor Coolant Pump Seals

CNS performed a modification to each of the RCP #1 seal leak-off lines to replace the flow orifices with a thicker component that would be suitable for higher differential pressure. Analyses of this modified configuration show that leak-off flow rates stay within the maximum limits of current WCAP-17601-P, Revision 1 assumptions (i.e., 21 gpm / seal). See Attachment 7 of the Final Compliance Submittal (Reference 6), "CNS Reactor Coolant Pump Seal Leakage Margin Assessment" for additional discussion on RCP seal leakage.

2.3.9 Shutdown Reactivity Analysis

CNS performed a shutdown reactivity analysis that incorporated the guidance provided in the Westinghouse position paper entitled "Westinghouse Response to NRC Generic Request for Additional Information (RAI) on Boron Mixing in Support of the Pressurized Water Reactor Owners Group (PWROG)" (ADAMS Accession Number ML13235A135) with the clarifications specified in the NRC endorsement of this approach (Reference 11). The CNS analysis included a one-hour mixing delay, in accordance with those clarifications.

The CNS analysis concluded that the FLEX high pressure pump, delivering FWST water at 40 gpm, must be started by 13.85 hours into the ELAP event to provide and maintain the necessary 1% shutdown margin and prevent a potential re-criticality during cooldown. To meet this criterion, CNS plans to deploy the high pressure pump prior to 9 hours into the event. For boration after initial cool down of both units, CNS requires delivery of a total of 28,100 gallons of FWST water into the RCS, which is well within the nominal FWST inventory of 377,537 gallons, even if damaged above the protective wall.

For the latest NOTRUMP reference case, the PWROG-14027-P, Revision 3 report indicates that reflux cooling may begin in four-loop plants like CNS after 15.6 hours. Addition of borated RCS makeup must occur before reflux cooling to ensure adequate mixing. The CNS timeline for deploying the high pressure pump satisfies this requirement.

2.3.10 FLEX Pumps

2.3.10.1 FLEX Low Pressure Pump

After the TDAFWP is secured, the CNS FLEX strategy relies on a portable, diesel-driven, low pressure, high volume pump to supply water from the SNSWP to the FLEX Raw Water Distribution System.

The FLEX low pressure pumps are portable, diesel-driven pumps that can supply a design flow of 3,000 gpm. The FLEX low pressure pump discharge pressure will be maintained at 250 to 275 psig. As discussed in Section 2.3.7, hydraulic analysis shows that the FLEX low pressure pumps have sufficient capacity to support the CNS FLEX strategies.

CNS has two portable FLEX low pressure pumps to satisfy the N+1 requirement.

2.3.10.2 FLEX Medium Pressure Pump

After the TDAFWP is secured, the CNS FLEX strategy relies on a portable medium pressure pump to provide makeup water to the SGs. The FLEX Medium Pressure Makeup Pump can also be used to provide RCS makeup if the event occurs when the plant is in modes 5 or 6.

The FLEX medium pressure pumps are portable, diesel-driven centrifugal pumps that can supply 300 gpm at a maximum pressure of 400 psig. As discussed in Section 2.3.7, hydraulic analysis shows that these pumps have sufficient capacity to support the CNS FLEX strategies.

CNS has three FLEX medium pressure pumps to satisfy the N+1 requirement.

The FLEX low pressure pump provides water to the FLEX medium pressure pump via hoses (and also fire protection piping, if desired).

2.3.10.3 FLEX High Pressure Pump

For an ELAP event initiating in Modes 1 - 4, the CNS FLEX strategy relies on a high pressure pump to provide RCS makeup and boration. The FLEX high pressure pumps are portable, diesel-driven, centrifugal pumps that can supply 40 gpm at 1700 psig, which is adequate to support the reactivity control and RCS system make-up requirements for the FLEX strategy.

CNS has three portable FLEX high pressure pumps to satisfy the N+1 requirement.

The credited water supply for the FLEX high pressure pump is the FWST.

2.3.10.4 CA TDAFW Pit Portable Sump Pumps

A portable sump pump is placed in the CA TDAFW pit to pump out normal drains input from the TDAFW pump to the room sump before flooding impacts operation of the TDAFWP. Each sump pump is electrically powered and requires 120 V, which can be supplied either via the FLEX Electrical Distribution System, or a 120V DG. The sump pumps can deliver 15 gpm flow at over 30 feet of head, which is adequate to prevent flooding of the TDAFW pit sumps.

CNS has three 120V sump pumps, which are sufficient to support the CNS FLEX strategies.

2.3.10.5 Auxiliary Building Portable Sump Pumps

CNS can deploy portable 600V sump pumps to manage internal flooding from potential pipe breaks. Each 600V sump pump can be powered by one of the 600V DGs, although a single DG may not have sufficient capacity for operation of all three sump pumps simultaneously.

CNS has three 600V sump pumps, which are sufficient to support the CNS FLEX strategies.

2.3.11 Electrical Analysis

2.3.11.1 Diesel Generators

CNS relies on DC systems for necessary electrical coping power during Phase 1 of the ELAP. To extend the coping capability of the vital station batteries, CNS will complete load shedding within 3.5 hours of the event to reduce battery discharge to only essential loads (e.g., vital instrumentation). This action will extend the functional capability of the vital station batteries to at least 11.5 hours for the limiting battery. The CNS FLEX strategy for repowering battery chargers with FLEX DGs will provide electric power prior to the end of battery life.

For longer term electrical power, CNS will deploy portable FLEX DGs (one for each Unit), and associated support equipment to establish the FLEX Electrical Distribution System. CNS has three FLEX 600 VAC DGs to satisfy the N+1 requirement. CNS performed an analysis, which verified that the FLEX DGs and planned cable routing arrangement were adequate to support the required loads. The rating of each 600V DG exceeds its total running load during FLEX deployment.

2.3.11.2 Lighting

Post-Fire Safe Shutdown lighting is available in many areas where manual actions are necessary. The Post-Fire Safe Shutdown lights have self-contained batteries with an 8-hour life. Additional portable lighting will be provided for use in the yard.

Lighting units included in the FLEX strategy are as follows:

1. LED tripod mounting Quad Pod LED lights. Units are rated at 20,000 lumens.
2. LED string lights
3. Miscellaneous helmet lights and flashlights. Typical units and approximate quantities include 50 D cell LED flashlights, 50 helmet lights, and 25 stand spot lights.

LED-mounted tripods will be deployed in many areas including, the Control Room, CA Pump Room(s), Motor Generator (MG) Set Room(s), Interior and Exterior Doghouses, Electrical Penetration Rooms, Battery Room(s), Technical Support Center, and General floor areas in the Auxiliary Building. String lights will also be used in the Control Room and the Technical Support Center. The lighting plan includes a total of 27 LED-mounted tripods and 3 string lights.

Four hard hats with lights are located at the Main Control Room (MCR) exit doors S400 and S406.

2.4 Spent Fuel Pool Cooling/Inventory Strategy

2.4.1 Phase 1

No actions are required during ELAP Phase 1 for SFP make-up because the time to boil is sufficient to enable deployment of Phase 2 equipment.

- For the worst case heat load scenario, the SFP will begin to boil after an ELAP/LUHS event in 8.8 hours. This scenario assumes a maximum starting SFP temperature of 125°F and a full core offload during an outage after 6 days.
- During normal operation (21 days after the beginning of a refueling outage and initial SFP temperature of 125°F), SFP level can be maintained at least 10 feet above the top of the fuel (above which personnel access to the SFP operating deck is still viable) for 202.9 hours with no makeup. For normal operating conditions, boiling will begin in 37.0 hours.

CNS will monitor SFP water level using SFP level instrumentation.

2.4.2 Phase 2

To compensate for SFP boil-off, CNS will provide makeup water by pumping raw water from the SNSWP using the FLEX low pressure pump.

The primary FLEX strategy for SFP cooling is to pressurize the RN system and then open an installed RN valve and an installed KF valve to establish a flow path to the SFP using installed piping.

The alternate FLEX strategy for SFP cooling is to pressurize the RN system and use a hose to connect RN piping to a valve in the KF skimmer loop. CNS will attach an adapter on the KF valve to facilitate the hose connection.

CNS does not have a FLEX strategy for spray makeup to the SFP. The CNS SFPs are in Category I structures and are connected to safety-related systems, so they are not susceptible to being drained. In accordance with NEI 12-06, Table D-3, spray makeup capability is not required for sites that have SFPs that cannot be drained.

2.4.3 Phase 3

Long term SFP cooling will be accomplished by re-powering the installed KF and KC pumps using a portable generator obtained from the NSRC to provide cooling via normal means. Cooling of KC will be from the RN system that is being supplied from the portable diesel driven pump located at the SNSWP. Additional diesel fuel for portable equipment will be brought in from off-site resources when required.

2.4.4 Availability of Structures, Systems, and Components

2.4.4.1 Structures

The CNS SFP cooling strategy relies on the SFP Building, the Auxiliary Building, and the RN Pumphouse, which are addressed in Section 2.3.4.1. All relevant structures are robust to the applicable external hazards.

2.4.4.2 Systems

The CNS SFP cooling strategy relies on the KF system, the KC system, and the RN system, which are addressed in Section 2.3.4.2. All relevant systems are robust to the applicable external hazards.

2.4.4.3 SNSWP

The CNS SFP cooling strategy provides SFP makeup water from the SNSWP, which is addressed in Section 2.3.4.9. The SNSWP is robust to the applicable external hazards and has sufficient inventory for long-term SFP cooling (among other demands).

2.4.4.4 FLEX Connections for SFP Makeup

The CNS SFP cooling strategy includes primary and alternate connections for delivering water, which meets the requirements of NEI 12-06.

- The primary strategy for SFP makeup relies on pressurizing the RN system using the FLEX low pressure pump. As discussed in Section 2.3.5.2, the B Train connection is located inside the RN Pumphouse, which is a Seismic Category I structure that is protected from all applicable hazards. The A Train connection provides a backup and is in the yard. RN and KF valves to be manually operated are located inside the Auxiliary Building, which is a Seismic Category I structure.
- The alternate strategy also relies on pressurizing the RN system, but uses a jumper hose to connect to the KF system skimmer loop. The skimmer loop flows through a manifold line around the SFP with a series of discharge points controlled by manual valves.

2.4.5 Ventilation

CNS will vent the SFP to outside to minimize the impact of condensed steam on auxiliary building habitability. Fuel building air temperature and humidity will begin to increase shortly after event initiation, and the building may become uninhabitable within a few hours. To limit pressure in the SFP building, selected doors will be opened within 6 hours. Additionally, CNS will take actions to prevent condensed steam from entering other parts of the Auxiliary Building outside of the selected vent path, such as securing doors and sealing door cracks.

2.4.6 Plant Instrumentation

The key parameter for the SFP cooling/inventory function is SFP level. Instrumentation is capable of identifying the following SFP water level conditions, in accordance with NRC Order EA-12-051:

- Level that is adequate to support operation of the normal fuel pool cooling system.
- Level that is adequate to provide substantial radiation shielding for a person standing on the SFP operating deck.
- Level where fuel remains covered and action to implement makeup water addition should no longer be deferred.

The SFP level instrumentation equipment was designed to perform its design function at temperature, humidity, and radiation levels consistent with SFP water at saturation conditions for an extended period following a BDBEE. Sensing components and cables located at the SFP were qualified to withstand peak and total integrated dose radiation levels for their installed locations based on post-event SFP water level equal to Level 3 for an extended period of time. (Level 3 is the water level where fuel remains covered but actions to implement make-up water addition should no longer be deferred based on the accuracy of the instrumentation and the highest point of any fuel rack.)

2.4.7 Thermal-Hydraulic Analysis

CNS performed thermal-hydraulic analysis to address the SFP cooling/inventory function under the most limiting conditions and configuration. Key conclusions from the analysis include the following:

- The worst case heat load corresponding to a full core off load 6 days after a shutdown will produce evaporation rates of 96.8 gpm per SFP.
- For the worst case heat load scenario, the SFP will begin to boil after an ELAP/LUHS event in 8.8 hours. This scenario assumes a maximum starting SFP temperature of 125°F and a full core offload during an outage after 6 days.
- During normal operation (21 days after the beginning of a refueling outage and initial SFP temperature of 125°F), SFP level can be maintained at least 10 feet above the top of the fuel (above which personnel access to the SFP operating deck is still viable) for 202.9 hours with no makeup. For normal operating conditions, boiling will begin in 37.0 hours.
- A FLEX low pressure pump, taking suction from the SNSWP and discharging by hose to connections on the RN system, can supply each of the SFPs at a rate significantly exceeding the most conservative steaming rate in addition to the all SGs at 50 gpm each.

In addition to the thermal-hydraulic analyses, the CNS SFP has been analyzed to remain subcritical with zero boron credited, i.e., a complete dilution scenario as long as the fuel assemblies remain covered and the parameters in CNS Technical Specification 4.3.1 remain in effect.

2.4.8 FLEX Pump and Water Supplies

The CNS FLEX strategy relies on FLEX low pressure pumps to supply raw water from the SNSWP via RN piping. See Section 2.3.10.1 for description of the pumps.

As discussed in Section 2.4.7, the FLEX low pressure pumps have more than enough capacity to maintain SFP levels.

2.4.9 Electrical Analysis

SFP level will be monitored by instrumentation installed to satisfy Order EA-12-051.

The instrumentation is normally powered from 120 V AC and upon an ELAP, the instrument will continue to operate upon switchover to a battery backup. The manufacturer-provided battery backup will last a minimum of 7 days from loss of off-site power, and those batteries can be replaced if necessary. SFP level instrumentation includes a backup channel that is powered from the vital inverters. FLEX strategies to restore power to vital battery chargers will ensure continued availability of the backup channel .

2.5 Containment Function Strategy

2.5.1 Phase 1

The CNS Reactor Building includes a metal containment vessel and annulus region between the metal containment and a reinforced concrete enclosure. The containment vessel design pressure is 15 psig.

Following an ELAP/LUHS, the CNS Containment is initially cooled by an ice condenser. Steam escaping the primary and/or secondary systems is cooled as it rises from lower containment through the ice condenser and into upper containment.

CNS performed a containment analysis, which demonstrated that containment pressure is expected to remain below the design pressure during Phase 1.

2.5.2 Phase 2

CNS will use the FLEX Electrical Distribution System to enable Phase 2 actions for the FLEX strategy to maintain Containment integrity.

- CNS will start a Hydrogen Skimmer Fan within 24 hours of event occurrence to limit the temperature increase in the SG and Pressurizer compartments. The SG and Pressurizer compartment temperature limits will be challenged before overall containment temperature limits. Abnormally high temperatures in these compartments could affect associated level indications due to reference leg flashing.
- Per NEI 12-06, Revision 0, plants with ice condenser containment designs such as CNS are required to repower hydrogen igniters to prevent buildup of hydrogen in case the ELAP event degrades to core damage. One train of hydrogen igniters will be re-powered and restored to service in Phase 2 using the back feed portable power strategy. The opposite train of hydrogen igniters can be repowered as an alternate.
- Manual containment isolation will also be completed by the end of Phase 2.

2.5.3 Phase 3

Following deployment of an NSRC 480V generator and energizing of the 600V MCCs, CNS will start two Lower Containment Ventilation Units (LCVUs) within 48 hours to limit the temperature increase in the SG and Pressurizer compartments. Additionally, one Containment Air Return Fan (CARF) will be started within 52 hours of the event to establish an air flow path through the ice condenser, reduce containment pressure, and limit further heatup of the SG and pressurizer compartments.

With the CARF operating, SG and Pressurizer compartment temperature will be maintained below 200°F and containment pressure will be less than 6 psig.

CNS will complete transition to RHR system cooling and cooldown to Mode 5 within 6 days of ELAP initiation to prevent challenging containment temperature and pressure limits following ice bed depletion.

2.5.4 Availability of Structures, Systems, Components

2.5.4.1 Structures

The FLEX strategy relies on site structures to provide protection for components, fluid and electrical connections, and deployment paths from applicable extreme external hazards. Specifically, the FLEX strategy for maintaining Containment integrity relies on the Reactor Building/Containment Vessel, along with MCCs located in the Auxiliary Building. The Reactor Building/Containment Vessel and Auxiliary Building are Seismic Category I structures that are designed to provide protection from the applicable extreme external hazards.

2.5.4.2 Components Inside Containment

CNS relies on repowering a set of fans (Hydrogen Skimmer fans, LCVUs, and CARFs) to maintain Containment temperature and pressure below acceptable limits. Hydrogen igniters are available to maintain hydrogen concentration below acceptable limits as defense in depth if the ELAP event degrades to core damage. All of these components are located inside the Reactor Building/Containment vessel, which is a Seismic Category I structure that protects equipment from external hazards.

2.5.4.3 Spray Strategy

Containment spray capability will not be required. An analysis was performed to validate that containment spray for temperature/pressure control is not required over the long term.

2.5.5 Plant Instrumentation

The key parameter for the Containment integrity function is containment wide range pressure. Instrumentation will be powered by the FLEX Electrical Distribution System or a portable 120 VAC generator.

2.5.6 Thermal-Hydraulic Analysis

CNS performed a thermal-hydraulic analysis to assess containment integrity using a GOTHIC model. Key conclusions from this analysis are as follows:

- Containment pressure is expected to remain below the design pressure during the Phase 1 response.
- The maximum pressure in containment will exceed the design pressure (15 psig) for a period of 12 hours (maximum of 17.5 psig). The Containment Vessel at CNS was initially pressure tested to 17.25 psig and has been analyzed to withstand a maximum of 72 psi. The temporary Containment pressure excursion beyond 15 psig during a BDBEE calculated by the GOTHIC model is therefore not significant.
- The maximum temperature inside the SG and Pressurizer compartments will remain at or below the 280°F limit for the duration of the event, considering the planned ventilation actions that are part of the CNS FLEX strategy. The 280°F limit was selected to ensure that reference leg flashing did not occur in the associated level indications.

- The annulus portion of the containment does not increase in pressure or temperature above design limits for the long term since it passively relieves through the annulus HVAC system exhaust dampers which fail open. The annulus calculation ensures the annulus pressure does not exceed the containment pressure and also ensures the annulus region can be accessed by personnel if necessary.

2.5.7 Electrical Analysis

Containment pressure instrumentation will be powered by the FLEX Electrical Distribution System or a portable 120 VAC generator.

Hydrogen Skimmer fans used for containment ventilation and hydrogen igniters will be powered by the FLEX Electrical Distribution System. The LCVU fans and CARF will be powered from NSRC equipment. The repowering strategy is addressed in Section 2.3.11.1.

CNS performed an analysis to ensure that the 600V FLEX DGs had sufficient capacity to support the Phase 2 FLEX strategies. The analysis included electrical loads relevant for maintaining Containment integrity, such as battery chargers, hydrogen igniters, and the Hydrogen Skimmer fans. CNS performed comparable analyses for the 480V and 4160V NSRC DGs and the planned loads during Phase 3. This analysis concluded that the DGs and planned cable routing arrangement were adequate to support operation of the required equipment.

2.6 Characterization of External Hazards

The following extreme external hazards were assessed for applicability for CNS:

- Seismic events
- External flooding
- Storms such as hurricanes, high winds, and tornadoes
- Extreme snow, ice, and cold
- Extreme heat

2.6.1 Seismic Events

The seismic hazard is applicable for CNS. Per NEI 12-06, Table 4-2, all sites will consider seismic events.

The CNS Updated Final Safety Analysis Report (UFSAR) states that the safe shutdown earthquake (SSE) has a ground acceleration design value of 0.15g acting horizontally and 0.10g acting vertically, and the operating basis earthquake (OBE) has a ground acceleration design value of 0.08g acting horizontally and 0.0533g acting vertically (FSAR, Section 3.1).

CNS is currently involved in the Expedited Seismic Evaluation Process (ESEP). The NRC has scheduled CNS to submit a Seismic Probabilistic Risk Assessment (SPRA) in 2019 to address the new Ground Motion Response Spectra (GMRS).

2.6.2 External Flooding

The external flooding hazard is applicable for CNS.

CNS is subject to external flooding from Probable Maximum Floods (PMFs) resulting from Probable Maximum Precipitation (PMP) events, Standard Project Floods (SPF) equal to 1/2 of the PMF, failures of upstream dams, a combination of dam failures and SPF's, seiche, hurricanes, and storm surge.

The CNS FLEX strategies reflect the site's current licensing basis. NTTF 2.3 flooding walkdowns and updated information on the flood hazard have resulted in a re-evaluation of the CNS flood hazard. CNS will assess potential impacts on the FLEX strategy resulting from this re-evaluation separately from this Final Integrated Plan (FIP).

CNS is susceptible to groundwater intrusion that may necessitate use of sump pumps to remove ground water from plant spaces.

2.6.3 Storms such as Hurricanes, High Winds, and Tornadoes

The high wind hazard is applicable for CNS.

As described in UFSAR Section 2.1.1, the CNS site is located at latitude 35°3'5" north and longitude 81°4'10". According to NEI 12-06, Revision 0, the location of CNS has a peak gust wind speed of 150-160 mph and a recommended tornado wind design speed of 175 mph. Based on the potential for winds in excess of 130 mph, the CNS site is susceptible to damage from severe winds from a hurricane or tornado.

2.6.4 Extreme snow, ice and cold

The extreme cold (including snow and ice) hazard is applicable for CNS.

The CNS UFSAR contains environmental data from 1940 to 1980 obtained from the National Oceanic and Atmosphere Administration. The minimum temperature from the Catawba site was -5°F. Because Catawba is in a temperate climate, storage and operation of the FLEX equipment in low temperatures is not considered to be an issue.

However, movement of FLEX equipment in snow and ice is a concern. CNS is located above the 35th parallel and is therefore subject to snowfall accumulation and extreme low temperatures per NEI 12-06, Revision 0. Based on NEI 12-06, the CNS site is also subject to the existence of an extreme amount of ice, and thus the potential for severe power line damage.

Based on UFSAR Section 2.4, water temperatures in the UHS will not reach a point where ice formation is an issue.

2.6.5 Extreme heat

NEI 12-06, Revision 0 states that virtually every state in the lower 48 contiguous United States has experienced temperatures in excess of 110°F and many in excess of 120°F. In accordance with NEI 12-06, all sites will address high temperatures.

The CNS UFSAR contains environmental data from 1940 to 1980 obtained from the National Oceanic and Atmosphere Administration. The maximum temperature from the Catawba site was 104°F. Because Catawba is in a temperate climate, storage and operation of the FLEX equipment in high temperatures is not considered to be an issue .

2.7 Planned Protection of FLEX Equipment

Storage and protection of FLEX equipment is discussed in this section. CNS evaluated the applicability of external hazards and addressed implementation considerations associated with each including:

- protection of FLEX equipment
- deployment of FLEX equipment
- procedural interfaces
- utilization of off-site resources

CNS has one structure (i.e., the FLEX Storage Facility) for storing FLEX equipment that is located on-site and protects FLEX equipment from all applicable hazards. The FLEX Storage Facility contains sufficient equipment to satisfy redundancy requirements of NEI 12-06, Revision 0 for reliability and availability.

2.7.1 FLEX Storage Facility

The FLEX Storage Facility at CNS is a single, large building located in the northwest area of the plant in a portion of the material lay-down storage area. This area is well above the flood level. The building is designed to resist seismic, wind forces, and tornado missiles of a magnitude that bounds all design basis hazards. The FLEX Storage Facility was seismically designed in accordance with the considerations presented in ASCE 7-10, and also meets the CNS SSE criteria.

The FLEX Storage Facility is a dome structure that has an outside diameter of 144 ft. It has two equipment doors on opposite sides of the building and two personnel access doors. The building is located outside of the protected area approximately 500 feet west of the Shipping and Receiving Warehouse.

To ensure the dome storage area is functional, a monthly walkdown will be conducted in accordance with CNS procedures. Any issues identified as a result of the periodic walkdowns will be addressed in the site corrective action program.

FLEX equipment stored in the FLEX Storage Facility includes low pressure pumps, medium pressure pumps, high pressure pumps, 120V DGs, 600V DGs, hose trailers, a fuel transfer trailer, a CAT 924K, a pickup truck, portable spot coolers, 600V sump pumps, 120V sump pumps, portable transformers, portable panelboards, ventilation fans, and 230v sump pumps.

2.8 Planned Deployment of FLEX Equipment

2.8.1 Haul Paths and Accessibility

CNS will use pre-defined deployment routes to transport FLEX equipment to the staging areas. The identified paths and deployment equipment positions will be accessible during all modes of operation. CNS will periodically perform walkdowns of the deployment paths to ensure pathways remain clear.

Transmission lines can impede deployment of FLEX equipment along the pre-determined haul paths. In this case, CNS will ground the power lines and move them out of the deployment path. For other debris potentially impeding FLEX deployment, CNS has a CAT 924 Loader that can be used for debris clearing on the deployment path.

Once deployment paths are clear, CNS will dispatch deployment teams to transport Phase 2 FLEX equipment from the FLEX Storage Facility to deployment locations. One team will use the CAT 924 Loader and the other will use a Dodge 5500 truck. CNS has developed guidance on an appropriate sequence of deployment actions for each team.

The deployment routes for FLEX equipment begin with passage through the Vehicle Barrier Access Port (VBAP) and proceed along five primary on-site deployment paths as follows:

- From the VBAP proceeding East along the southern bank of the SNSWP to the FLEX pump ramp access to the SNSWP.
- From the SNSWP ramp through Gate #47 next to the ISFSI Area into the Protected Area and then South to the East side of the Auxiliary and Reactor Buildings. Pump discharge hoses may be deployed along this path for deployment strategies requiring a pump taking suction from the SNSWP and discharging through hoses to the suction of a second pump located outside the Auxiliary Building (e.g., for SG feedwater to support core cooling).
- From the VBAP to the Vehicle Access Port (VAP) into the Protected Area proceeding East along the North side of Unit 2 connecting to the roadway along the east side of the Auxiliary Building.
- From the VBAP proceeding directly south along the interior road circling the site on the south side of Unit 1 to the east side of the Auxiliary Building. Enter rear Gate #17 on the northeast side of plant into the Protected Area to the path along the east side of the Auxiliary Building and/or other established routes.
- From the roadway on the East side of the Auxiliary Building inside the Protected Area, there are two paths that run west to FLEX equipment positions as follows:
    - West to the north side of Unit 2 Diesel Generator Building
    - West to the south side of Unit 1 Diesel Generator Building

The deployment paths were evaluated for seismic stability and liquefaction and determined to be acceptable. A flooding event may inundate portions of the site, but flood waters will recede from all deployment paths and staging areas in time for FLEX deployment to meet all time constraints. Any changes to the CLB resulting from the Flood Hazard Re-evaluation will be addressed separate from this FIP.

CNS has instituted administrative measures to ensure that deployment paths and FLEX equipment deployment sites (including paths for portable cables, hoses, etc.) are maintained clear of other equipment or interferences. CNS performs general rounds of various plant areas on a daily shift basis and will identify FLEX interferences. Additionally, CNS will periodically perform specific inspections of FLEX-related areas and ensure they are maintained clear.

2.8.2 Deployment of Strategies

CNS identified pre-determined deployment and staging locations for FLEX equipment necessary to support the FLEX strategies as discussed in the subsections below.

Human performance aids such as labels will be attached to specific portable FLEX equipment to identify the equipment with a unique number that agrees with FSGs.

2.8.2.1 Core Cooling

Makeup water for the CA system to the SGs via the TDAFWP will be supplied by the FLEX low pressure pump, which will be staged on a ramp at the edge of the SNSWP. Suction hoses with strainers will be attached to the pump and placed into the SNSWP. Water temperature in the SNSWP will not decrease to the point where access will be challenged due to ice formation.

SG feedwater will be delivered by a FLEX medium pressure pump that draws suction from the discharge of the low pressure pump. The Unit 1 medium pressure pump is normally deployed south of the Unit 1 Exterior Doghouse door. The Unit 2 medium pressure pump is normally deployed north of the Unit 2 FWST and west of the Unit 2 Containment Mechanical Equipment Building (CMEB). Discharge hoses from the FLEX medium pressure pump will be routed to the CA piping connections located in the Exterior and Interior Doghouses.

For Phase 3 deployment, procedures and FSGs were developed to connect NSRC equipment to station equipment. Use of portable pumps to supply feedwater to the SGs remains the same as Phase 2 until the RHR system is restored to service with supplemental power from the NSRC DGs or off-site power is restored.

2.8.2.2 RCS Makeup

Two FLEX high pressure pumps (one for each unit) with hoses/adapters will be deployed to support RCS boration and inventory control. For Unit 1, the normal staging location for the FLEX high pressure pump is south and west of door AX658A (Unit 1 Electrical Penetration Room). For Unit 2, the normal staging location for the FLEX high pressure pump is north of door AX656B (Unit 2 Electrical Penetration Room). Suction hoses will be deployed to connect the portable pump to KF system connections from the FWST. A single FWST will supply borated water to the portable pumps for both units using a gated wye connection. Discharge hoses from the FLEX high pressure pumps will be connected to the discharge piping of NI pumps in the Auxiliary Building to supply injection makeup to the RCS.

2.8.2.3 FLEX Electrical Distribution System

Two 600V portable DGs and cabling will be deployed to an area near the FWSTs of each Unit (one generator per Unit). The normal staging area for the Unit 1 FLEX 600V DG is east of the Unit 1 Turbine Building, in close proximity to the Unit 1 MG set room door. The normal staging area for the Unit 2 FLEX 600 V DG is east of the Unit 2 Turbine Building, in close proximity to the Unit 2 MG set room door. Alternate staging areas are near the waste shipping/auxiliary access point area doors, the hot machine shop area doors, and the Unit 1 RC Pit / Safe Shutdown Facility Area.

The portable 600V DGs will be connected to the normal plant MCCs for re-powering equipment via the FLEX Backbone using a combination of permanently installed cables, portable panelboards, and transformers. Cables and connectors of the FLEX 600V distribution system are color coded to ensure proper phase rotation.

During Phase 3, DGs from the NSRC will be available to provide additional power. For Unit 1, the NSRC 4160V DGs and switchgear will be staged south of the Diesel Generator Building and the NSRC 480V DGs will be staged south and west of the Auxiliary Building, near the FLEX high pressure pump. For Unit 2, the NSRC 4160V DGs and switchgear and the NSRC 480V DGs will be staged near the west side of the Diesel Generator Building.

2.8.2.4 Sump Pumps

CNS can deploy FLEX sump pumps to ensure that equipment for core cooling is not compromised by flooding. The normal FLEX Sump Pump staging area is at the rear of the Auxiliary Building near the Clean Trash Room. Alternate staging areas include the area outside the Unit 1 MG set room and the area outside the Unit 2 MG set room.

2.8.2.5 Small Diesel Generators

Eleven portable DGs (6 kW) are available to be deployed from the FLEX Storage Facility to the location where they are needed. These 6 kW DGs will be used to power battery chargers for hand-held radios and portable satellite phones, fans, small sump pumps, and other identified loads.

2.8.3 Fueling of Equipment

Diesel Fuel Oil (DFO) for the FLEX equipment will be obtained from the safety-related, underground Emergency Diesel Generator (EDG) fuel oil storage tanks. The diesel fuel will be pumped out of the underground tanks and transferred to the portable Diesel Fuel Storage Tank using a diesel driven Portable Transfer Pump or will be gravity drained into small containers in the EDG room and hand carried to the location needed. Connections on the piping from the EDG tanks that will be used for removing fuel oil are seismically qualified and located above the flood level in the yard. The portable fuel tank will be pulled by the FLEX Pickup Truck or other available vehicles to the various site locations for refueling portable diesel generators.

CNS performed a fuel consumption calculation to determine the estimated total fuel required to support FLEX equipment operation. The estimated fuel required to support FLEX equipment for 24 hours is 2,027 gallons. FLEX equipment will be stored full of DFO and refueled as necessary. The CNS fuel consumption calculation determined that 485 gallons of DFO would be required for refueling in the first 24 hours, which is well within the capacity of the EDG DFO storage tanks.

To avoid multiple pieces of FLEX equipment running out of fuel at the same time, CNS will attempt to maintain individual fuel tanks greater than half full. The small DGs may require refueling prior to the FLEX Diesel Fuel Transfer Trailer being available. If necessary, CNS will dispatch personnel to transport required fuel by hand.

During Phase 3, additional diesel fuel will be brought onsite from outside resources as required.

2.9 Sequence of Events and Staffing

2.9.1 Sequence of Events

The Table below presents a Sequence of Events (SOE) Timeline for an ELAP/LUHS event at CNS. CNS Simulator Observation was conducted to time-validate EOP and FSG actions. For other actions, time-validations involved combinations of local FSG time-validations, local (EOP) action time-validations, timed table-top procedure readings, and timed repetitive actions, such as cable and hose deployments. The analyses were conducted in incremental fashion, typically beginning with an assumed time of EOP or FSG implementation, and progressing through completion of the action or procedure. The analyses utilized ratio analysis to project times to complete actions such as deployment of multiple sections of cabling, hose, couplings, etc. Elements documented sequentially included observed and projected times to complete actions, time for procedural progression, decision making, necessary briefings for implementers, and time required to perform manual deployments and repetitive actions, such as walking to required destinations, towing equipment to required destinations, carrying and deploying cable and hose segments, etc.

All FSGs for FLEX strategies were validated per normal procedural requirements to ensure hands-on equipment/component verification and the mechanics of executing procedure steps were practical and accurate.

Sequence of Events Timeline			
Action	**Start Time (hours)**	**Completion Time (Hours)**	**Remarks / Applicability**
Event Starts	0	N/A	Plant @100% power
TDAFWP starts on SBO	0	N/A	Installed plant equipment. Automatic Action.
TDAFWP automatically aligns to embedded RC header piping if normal water sources are damaged.	0	48	Action occurs if normal water sources are damaged. Normal water sources are not robust to all hazards, so conservative timeline aligns to RC immediately. Embedded RC system has at least 48 hours of inventory.
Control SG level by starting / stopping TDAFWP with Trip and Throttle Valve from Control Room.	0.5	As needed	Maintain SG level. Control board manipulation.
Initial cooldown and depressurization of RCS (to a temperature and pressure that does not result in nitrogen injection)	0.6	2.6	Establish conditions for reactor makeup, reduce seal leakage, preserve seals. Installed plant equipment. Control Board manipulation.
Isolate Instrument Air to Containment	1	1.5	Time constraint (38 hr). Analysis shows containment pressure remains below design for the first 38 hours even if Instrument Air is not isolated.
Disconnect all non-critical loads from Vital Batteries	2.5	2.75	Time constraint (3.5 hr). Required to preserve Vital Batteries.
Open SFP bay personnel door	3	4.04	Time constraint (6 hr). Provides SFP vent path to outside of building to avoid adverse Auxiliary Building conditions due to SFP steam.
Provide pumping capacity to control level in TDAFWP put sump	3.66	5.66	Time constraint (7 hr)
Align charging to Channel A and D Vital Batteries (B and C included)	6	10.25	Time constraint (11.5 hr for A, 12.5 hr for D, 24 hr for B & C).
Align portable injection pump from FWST to NI System to provide RCS makeup and boration.	6.5	11.6	Time constraint (13.8 hr)

Sequence of Events Timeline			
Action	**Start Time (hours)**	**Completion Time (Hours)**	**Remarks / Applicability**
Provide portable lighting (beyond head and hand lamps and installed battery lighting)	8+	As needed	Ample handheld/headlamp lighting would be available at 0 hr with outside resources available to provide additional lighting and replacement batteries after 6 hr. Portable lighting would be placed into service as time and resources allow.
Re-power H2 igniters.	9	9.35	This action is required by NEI 12-06 as a contingency.
Power A and B WZ (Groundwater Drainage) Sump Pumps	10	10.25	Time constraint (10.6 hr). Prevents ground water from flooding Aux Bldg El. 543' and below.
Install portable fans in Control Room and Battery Rooms	11	13.43	Time constraint (504 hr)
Recharge communication system and satellite phone system	12	14	Time constraint (24 hr). Portable DG will be used to recharge batteries.
Install 600 V sump pump on the 522' elevation	12	16.6	Time constraint (36 hr)
Start Hydrogen Skimmer Fan	20	23.32	Time constraint (24 hr). Analysis of containment heat loads is basis for these actions.
Connect FLEX low pressure pump through RN piping to SFP skimmer loop to provide a means to make up to the SFP without entering the SFP area.	24	37.73	Time constraint (40 hr). Critical pool level assuming worst case heat load/evaporation rate is reached after 40 hours.
Install NSRC DGs.	24 - 48	As needed	
Isolate the CLAs.	42	44.1	Required prior to depressurizing the SGs below 240 psig to prevent gas intrusion to RCS that would disrupt natural recirculation cooling.
Evaluate need to provide freeze protection for instrumentation located in Doghouses and yard.	48	As needed	Time constraint (48 hr)
Start Lower Containment Ventilation Units	48	48	Time constraint (48 hr)
Start Containment Return Fan	48	52	Time constraint (52 hr)

2.9.2 Staffing

Using the methodology of NEI 12-01, *Guideline for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities*, an assessment of the capability of the on-shift staff and augmented ERO to respond to a BDBEE was performed.

The assumptions for the NEI 12-01 Phase 2 scenario postulate that the BDBEE involves a large-scale external event that results in:

- An extended loss of AC power
- An extended loss of access to ultimate heat sink
- Impact on units (all units are in operation at the time of the event)
- Impeded access to the units by off-site responders as follows:
  - 0 to 6 Hours Post Event – No site access.
  - 6 to 24 Hours Post Event – Limited site access. Individuals may access the site by walking, personal vehicle or via alternate transportation capabilities (e.g., private resource providers or public sector support).
  - 24+ Hours Post Event – Improved site access. Site access is restored to a near-normal status and/or augmented transportation resources are available to deliver equipment, supplies and large numbers of personnel.

The on-shift ERO analysis concluded that current CNS on-shift staffing present for the "no site access" 6-hour time period is sufficient to perform the EOP, FSG, and emergency response tasks.

The augmented ERO analysis concluded that sufficient personnel resources exist in the current CNS augmented ERO to fill positions for the expanded ERO functions. Thus, ERO resources and capabilities necessary to implement coping strategies after 6 hours exist in the current program.

To conduct the on-shift portion of the assessment, a team of subject matter experts from Operations, Maintenance, Security, Radiation Protection, Chemistry, Engineering, Emergency Preparedness, and industry consultants conducted tabletop exercises. The participants reviewed the assumptions and existing procedural guidance, including applicable draft FSGs for coping with a BDBEE using minimum on-shift staffing. Particular attention was given to the sequence and timing of each procedural step, its duration, and the on-shift individual performing the step to account for both the task and time motion analyses of NEI 10-05, Assessment of On-Shift Emergency Response Organization Staffing and Capabilities.

In the event of a natural or any other type disaster that renders roads and passage ways unusable, CNS essential staff will be airlifted from two preplanned landing zones. The northern landing zone would be the Duke Energy Shelby Operations Center. The southwest Landing zone would be the Duke Energy Chester Operations Center. The two landing zones are Duke Energy properties and can provide shelter, communications and storage capacity for necessary gear. The helicopter provider will be under a contract or agreement letter to provide support.

2.10 Offsite Resources

The Strategic Alliance for FLEX Emergency Response (SAFER) team is contracted by the nuclear industry through Pooled Equipment Inventory Corporation (PEICo) to establish National SAFER Response Centers (NSRC) operated by Pooled Inventory Management (PIM) and in collaboration with AREVA to purchase, store, maintain and deliver emergency response equipment in the case of a major nuclear accident or BDBEE in the United States.

The NRC letter dated September 26, 2014 (ADAMS Ascension No. ML14265A107) titled "Staff Assessment of National SAFER Response Centers Established in Response to Order EA-12-049" (Reference 12) endorsed NEI's White Paper titled "National SAFER Response Centers" (Reference 13). NRC concluded that SAFER 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 and the SAFER Response Plan to meet Phase 3 requirements of Order EA-12-049.

CNS relies on equipment stored off-site for Phase 3 of the FLEX strategy. Equipment may be provided from NSRCs. Another nuclear plant may also provide Phase 3 equipment, if response would be faster than from the NSRCs.

2.10.1 National SAFER Response Center (NSRC)

The SAFER Response Plan for CNS (Reference 14) contains (1) SAFER control center procedures, (2) National SAFER Response Center procedures, (3) logistics and transportation procedures, (4) staging area procedures, which includes travel routes between staging areas to the site, (5) guidance for site interface procedure development, and (6) a listing of site-specific equipment (generic and non-generic) to be deployed for FLEX Phase 3.

Two NSRC's are strategically located across the country in Memphis, TN and Phoenix, AZ. If possible, NSRC equipment would be delivered to CNS by trucks from the Memphis location.

If possible, NSRC equipment will be delivered to Staging Area C, which is the Kings Mountain Training Center (34 miles away from the CNS site by driving). When CNS is ready, NSRC equipment will then be delivered to Staging Area B, which is an on-site parking lot at the CNS site outside the protected area. NSRC Equipment can also be delivered directly to Staging Area B, if requested by CNS.

Primary and alternate driving routes from Staging Area C to Staging Area B have been identified. CNS will coordinate with local and state authorities to assess the condition of roads and bridges along the travel path. If ground transportation from Staging Area C to Staging Area B is not feasible, NSRC equipment can be delivered to Staging Area B by helicopter airlift.

Two access routes from Concord Road to Staging Area B have been identified: the primary access location is through the Main Entrance, Northwest Gate; the secondary access path is through the Main Entrance, Southwest Gate.

The SAFER Response Plan for CNS does not include a Staging Area D.

The first arriving equipment will be delivered to the site within 24 hours from initial contact and remaining equipment will be delivered within 72 hours from initial contact.

2.10.2 Equipment

The NSRC will provide equipment as listed in the response plan. The NSRC will deliver the first pieces of equipment within 24 hours from initial contact. Such priority equipment includes Medium Voltage Generators, a Low Voltage Generator, 4160 VAC Distribution System, a Low Voltage Step-Up Transformer, a Low Pressure / High Flow Dewatering Pump, Mobile Lighting Towers, a Diesel Fuel Transfer Pump, a Water Treatment System, and a Mobile Boration Unit. The generic set of NSRC equipment as identified in the plan provides back up to on-site FLEX equipment (e.g., pumps, DGs) and will be provided as lower priority items to arrive within 72 hours from initial contact. NSRC equipment connections to applicable hoses and/or plant equipment are compatible or necessary adapters are available.

Other offsite resources may be obtained as needed to support the event which may include diesel fuel oil, equipment from other nuclear plants, and equipment from vendors.

2.11 Habitability and Operations

2.11.1 Equipment Cooling

CNS performed HVAC analysis to evaluate temperature increases resulting from an ELAP / LUHS in the control room, TDAFWP room, and other rooms of the Auxiliary Building. Considering the actions planned to provide ventilation as part of the FLEX strategies (discussed below), these analyses concluded that temperatures would not challenge essential equipment.

To enhance MCR temperature margins and personnel comfort, various doors will be opened to provide an air exchange flow path with the outside. Additional cooling will be provided by four portable, water-cooled coolers powered from the FLEX Electrical Distribution System. The cooling water supply will be provided by a branch from the FLEX Raw Water Distribution System.

Analyses validated TDAFWP room temperatures remain acceptable with no additional action.

Portable fans will be placed in the vital battery area during battery charging to ensure hydrogen accumulation does not exceed flammability limits. Additional ventilation needs, such as fans, will be provided from the NSRC and used if required.

2.11.2 Freeze Protection

If freezing weather exists, CNS will take appropriate actions to ensure protection of the FLEX strategies from cold conditions. As necessary, CNS will start FLEX diesel-powered equipment early due to the potential for difficult starting and CNS will establish trickle drains from idle equipment and hoses to prevent formation of ice plugs.

CNS can also provide heat tracing for equipment in the FLEX Storage Facility, FWST level instrumentation, and pressure instruments in the Doghouses. Other than components associated with monitoring FWST level, there is no FLEX-credited instrumentation in the yard or exposed to cold temperature to the extent that freezing would be expected. Heat tracing equipment may be deployed from the FLEX Storage Building to maintain the FWST level instrumentation functional. Heat tracing may also be deployed for other instrumentation as a contingency. Heat tracing cables could be powered by any portable DG supplying 120V power.

2.11.3 Hydrogen Ventilation

The minimum concentration of hydrogen gas to result in an explosive mixture is 4%. Without mitigation, CNS determined that hydrogen concentrations in the battery rooms would not exceed 4% (i.e., the lower explosive limit) for at least 21 days. Regardless, CNS plans to deploy fans in the battery room areas as part of the FLEX strategy as time permits.

Battery rooms are ventilated by pulling outside air through the U2 MG set room, down the Unit 2 Auxiliary Building stairwell, through the battery rooms, and up the Service Building stairwell to outdoors through an open door, creating a chimney effect. CNS will open a series of doors to create this air flow path, all of which will be opened within 24 hours.

2.11.4 Personnel Habitability

CNS will set up spot coolers in the control room to maintain temperature less than 90°F. Cooling water will be provided to the spot coolers using 5-inch raw water distribution hose, the fire protection header, or the "B" train service water system. Coolers will start operating when the first source of water becomes available (most likely the 5-inch hose or the fire protection header).

For providing water from the 5-inch FLEX hose or the fire protection header, CNS will route hosing through door AX657 (Unit 2 Penetration Room) and AX657F (Control Room access to Unit 2 Auxiliary Building Corridor at 594'). For providing water from the "B" train RN system, CNS will route hose through AX657G (Control Room rear access). Cooling water that has been used by the room coolers will be routed through a water discharge manifold to a yard drain. CNS will also deploy a condensate drain manifold and hosing to route condensation from the spot coolers to a yard drain.

2.12 Water Sources

Discussion of credited water sources for the FLEX strategies is included in the sections above for each individual strategy.

2.12.1 SG Feedwater

For SG feedwater, CNS will provide water from any of the following sources:

- USTs
- CACST
- Hotwell
- RC system piping embedded volume
- SNSWP

The embedded RC system captured volume and the SNSWP are the credited sources of water because of their robustness to the applicable hazards. The USTs and the hotwell are not protected from external hazards. These tanks are normally aligned as a TDAFWP suction source, but automatic realignment to embedded RC system captured volume is provided if the default sources are not available.

The UST and hotwell have condensate grade water that will not degrade the SGs. CNS may switch to a raw water source for a limited duration, if necessary. In this case, water purification equipment from the NSRC will eventually be deployed to establish a clean water source prior to excessive exposure of the SGs to raw water. CNS will also consider actions to clean up the SGs including blowdowns or chemical additions.

2.12.2 RCS Makeup

For NC system boration during Phase 2, CNS will provide borated water from one or both of the following sources:

- FWSTs
- CLAs

Alternate sources of borated water include the following options:

- NSRC-supplied mobile boration skid
- Trucking from an off-site source (e.g., McGuire Nuclear Station)
- Recovery of borated water from the FWST annulus (if damaged)
- Portable FLEX drop tanks mixing boron and raw water

2.12.3 SFP Makeup

For inventory control of the SFP, CNS uses raw water from the RN system, which is pressurized by the FLEX low pressure pump using the SNSWP as the suction source. The SNSWP will be available following the applicable extreme external hazards.

During Phase 3, CNS may transition to a clean water source (e.g., NSRC-supplied water purification unit) when available.

2.13 Shutdown and Refueling Analysis

Order EA-12-049 requires that licensees must be capable of implementing the mitigation strategies in all modes. In general, the discussion above focuses on a BDBEE occurring during power operations. This is appropriate, as plants typically operate at power for 90 percent or more of the year. If the BDBEE occurs with the plant at power, the mitigation strategy initially focuses on the use of a pump coupled to a steam-powered turbine to provide the water initially needed for decay heat removal. If all or most of the fuel has been placed in the SFP, there is a shorter timeline to implement the strategy for providing SFP makeup water. 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 and the number of personnel on-site is much greater during an outage. CNS analysis shows that following a full core offload to the SFP, about 76 hours are available to implement makeup before boil-off results in the water level in the SFP dropping far enough to uncover fuel assemblies. About 48 hours are available prior to level decreasing to 10 feet above the top of the fuel assemblies. As previously discussed, CNS can provide SFP makeup in advance of these times.

When a plant is in a shutdown mode and steam is not available to operate the steam-powered pump, another strategy must be used for decay heat removal. On September 18, 2013, NEI submitted to the NRC a position paper entitled "Shutdown Refueling Modes" (Reference 15), which described methods to ensure plant safety in shutdown modes. By letter dated September 30, 2013 (Reference 16), the NRC staff endorsed this position paper as a means of meeting the requirements of the Order. In the third six-month update dated August 28, 2014 (Reference 17), CNS committed to follow the guidance in this position paper.

CNS's FLEX strategy in Modes 5 and 6 relies on a FLEX Medium Pressure Pump to provide borated makeup to the RCS. This pump will be staged locally at one of four potential locations around the Auxiliary Building. The suction supply for the portable pump will come from a connection on the FWST supply line for KF/FW makeup to the SFP (see Section 2.3.5.3). The discharge from the portable pump will be into the Train A NI pump discharge piping that feeds the RCS hot or cold legs (alternate connection on the Train B NI pump discharge piping) (see Section 2.3.5.4).

If the reactor vessel head is installed, RCS system depressurization will be initiated through the reactor vessel head vents.

FWST inventory may only last 40 hours if RCS feed and bleed cooling is utilized. FWST makeup, use of alternate borated water strategies, or RHR pump restoration will be provided prior to loss of FWST level.

For the containment integrity function, CNS would open the equipment hatch to establish an emergency vent path from containment, if possible. The equipment hatch would only be opened if core cooling is expected to be maintained.

2.14 Procedures and Training

2.14.1 Procedural Guidance

The inability to predict actual plant conditions that require the use of BDBEE equipment makes it impossible to provide specific procedural guidance. As such, the FSGs provide guidance that can be employed for a variety of conditions. FSGs, to the extent possible, provide pre-planned FLEX strategies for accomplishing specific tasks in support of EOPs and Abnormal Operating Procedures (AOPs). FSGs are used to supplement (not replace) the existing procedure structure that establishes command and control for the event.

Procedural interfaces were incorporated into ECA-0.0, "Loss of All AC Power" to the extent necessary to include appropriate reference to FSGs and provide command and control for the ELAP.

2.14.2 Training

Programs and controls were established to assure personnel proficiency in the mitigation of BDBEE is developed and maintained. The Systematic Approach to Training (SAT) process was utilized to evaluate, develop and implement training for applicable personnel.

Initial training was provided and continuing periodic training will be provided to site emergency response leaders on BDBEEs, emergency response strategies, and implementing guidelines. Personnel assigned to direct the execution of mitigation strategies for BDBEEs received the necessary training to ensure familiarity with the associated tasks, considering available job aids, instructions, and mitigating strategy time constraints.

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

A table top analysis was conducted by the Duke fleet ERO trainers using a graded Systematic Approach to Training. The analysis determined no impact on the existing ERO position specific Job Task Analyses (JTAs). Staffing resources for the expanded response capability ERO are provided from a qualified depth of ERO personnel. ERO depth is outlined and maintained per NSD117 (ERO Staffing Training and Responsibilities.) ETQS 3100 section 5.2 states, "Job Task Analysis (JTA) should be completed when no previous job data exist, is incomplete, or when revising a job." This analysis referenced the Duke Energy NEI 12-01, Phase 2 staffing assessment report. As a result of the analysis, no new skills, knowledge or tasks, were identified since current qualified ERO resources will be augmented for expanded response capability.

3. Acronyms

AOP - Abnormal Operating Procedure
ATWS - Anticipated Transient Without Scram
AWWA - American Water Works Association
BAT - Boric Acid Tank
BDB - Beyond Design Basis
BDBEE - Beyond Design Basis External Event
BW - Steam Generator Wet Layup Recirculation System
CA - Auxiliary Feedwater System
CACST - Auxiliary Feedwater Condensate Storage Tank
CARF - Containment Air Return Fan
CFR - Code of Federal Regulations
CLA - Cold Leg Accumulator
CMEB - Containment Mechanical Equipment Building
CNS - Catawba Nuclear Station
DG - Diesel Generator
EDG - Emergency Diesel Generator
ELAP - Extended Loss of AC Power
EOP - Emergency Operating Procedure
EPRI - Electric Power Research Institute
ERO - Emergency Response Organization
ESEP - Expedited Seismic Evaluation Process
FCV - Flow Control Valve
FIP - Final Integrated Plan
FLEX - Diverse Flexible Coping Strategies
FSG - FLEX Support Guideline
FW - Refueling Water System
FWST - Refueling Water Storage Tank
GMRS - Ground Motion Response Spectra
HCPLF - High Confidence of Low Probability of Failure
HVAC – Heating Ventilation and Air Conditioning
JTA - Job Task Analysis
KC - Component Cooling System
KF - Spent Fuel Pool Cooling System
LCVU - Lower Containment Ventilation Unit
LOOP - Loss of Offsite Power
LUHS - Loss of Ultimate Heat Sink
MCR - Main Control Room
MG - Motor Generator
NEI - Nuclear Energy Institute
NI - Safety Injection System
NR - Narrow Range
NRC - Nuclear Regulatory Commission

NSRC - National SAFER Response Center
NTTF - Near-Term Task Force
OBE - Operating Basis Earthquake
PEICo - Pooled Equipment Inventory Corporation
PIM – Pooled Inventory Management
PMF - Probable Maximum Flood
PMP - Probable Maximum Precipitation
PORV - Power Operated Relief Valve
RC - Condenser Circulating Water System
RCP - Reactor Coolant Pump
RCS - Reactor Coolant System
RHR - Residual Heat Removal System
RN - Nuclear Service Water System
SA - Main Steam to Auxiliary Equipment System
SAFER - Strategic Alliance for FLEX Emergency Response
SAT - Systematic Approach to Training
SBO - Station Blackout
SOE - Sequence of Events
SG - Steam Generator
SFP - Spent Fuel Pool
SNSWP - Standby Nuclear Service Water Pond
SQUG - Seismic Qualification Utility Group
SPF - Standard Project Flood
SPRA - Seismic Probabilistic Risk Assessment
SSE - Safe Shutdown Earthquake
SV - Main Steam Vent to Atmosphere System
TDAFWP - Turbine Driven Auxiliary Feedwater Pump
TIA - Task Interface Agreement
TS - Technical Specifications
UFSAR - Updated Final Safety Analysis Report
UHS - Ultimate Heat Sink
UST - Upper Surge Tank
WR - Wide Range

4. References

1. Recommendations for Enhancing Reactor Safety in the 21st Century; The Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, July 12, 2011
2. NRC Order EA-12-049, Issuance of Order to Modify Licenses with regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events, March 12, 2012. (ML12054A735)
3. NEI 12-06, Rev. 0, Diverse and Flexible Coping Strategies (FLEX) Implementation Guide, August 2012.
4. NRC Interim Staff Guidance JLD-ISG-2012-01, Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events. (ML12229A174)
5. Duke Energy (Henderson) letter CNS-15-035 dated May 1, 2015, "Notification of Full Compliance with Order EA-12-049, 'Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design Basis External Events' and with Order EA-12-051, 'Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation' - Catawba Nuclear Station Unit 2." (ML15126A277 is NRC ADAMS Database)
6. Duke Energy (Henderson) letter CNS-16-005, "Final Notification of Full Compliance with Order EA-12-049, 'Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design Basis External Events' and with Order EA-12-051, 'Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation' for Catawba Nuclear Station."
7. NRC Order EA-12-051, Issuance of Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation.
8. NEI 12-02, Rev. 1, Industry Guidance for Compliance with NRC Order EA-12-051 to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation, August 2012.
9. NRC Interim Staff Guidance JLD-ISG-2012-03, Compliance with Order EA-12-051, Reliable Spent Fuel Pool Instrumentation.
10. NRC letter dated September 12, 2006, "Final Response to Task Interface Agreement (TIA) 2004-04, 'Acceptability of Proceduralized Departures from Technical Specifics (TSs) Requirements at the Surry Power Station,' (TAC NOs. MC4331 and MC4332)." (ML060590273 in NRC ADAMS Database)
11. NRC (Davis) letter to PWROG (Stringfellow), dated January 8, 2014. (ML13276A183 in NRC ADAMS database)
12. NRC (Davis) letter to NEI (Pollock), dated September 26, 2014, "Staff Assessment of National SAFER Response Centers Established in Response to Order EA-12-049." (ML14265A107 in NRC ADAMS Database)
13. NEI (Pollock) letter to NRC (Davis), dated September 11, 2014, "National SAFER Response Center Operational Status," with Enclosure "White Paper; National SAFER Response Centers." (ML14259A222 & ML14259A223 in NRC ADAMS Database)
14. Areva, Inc. Engineering Information Record 51-9233066-0002, "Catawba SAFER Response Plan."

15. NEI Position Paper, "Shutdown / Refueling Modes", Rev. 0, dated September 18, 2013. (ML13273A514 in NRC ADAMS Database)

16. NRC (Davis) letter to NEI (Pollock), dated September 30, 2013. (ML13267A382 in NRC ADAMS Database)

17. Duke Energy letter CNS-14-086 dated August 28, 2014, "Third Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses With Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)." (ML14247A232 in NRC ADAMS database)

1. Background and Purpose

NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," required licensees to develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment and spent fuel pool cooling capabilities following a beyond-design-basis external event. To develop strategies for maintaining/restoring core cooling, licensees evaluated reactor coolant system (RCS) leakage from reactor coolant pump (RCP) seals during an extended loss of all AC power (ELAP).

NSAL-14-1, Revision 1 was issued by Westinghouse on September 8, 2014 and it documents that the nominal RCP seal leakage rate of 21 gallons per minute (gpm), as documented in WCAP-10541, Revision 2, may be not be applicable for all plants using Westinghouse RCPs with standard seal designs because of the various thermal-hydraulic conditions set up by plant-specific seal leak-off piping designs.

PWROG-14015-P, Revision 2 was issued by the PWR Owner's Group in April 2015 to determine revised No. 1 RCP seal leak-off flow rates following an ELAP.

PWROG-14027-P, Revision 3 was issued by the PWR Owner's Group in April 2015 to evaluate the time to enter reflux cooling and the time at which the core uncovers based on the revised seal leak-off flow rates during an ELAP.

Following issuance of the Watts Bar Mitigating Strategies Safety Evaluation dated March 27, 2015, the NRC requested via e-mail dated March 31, 2015 that licensees with standard Westinghouse RCP seal packages review the technical content therein and provide information addressing similar issues. Specifically, the NRC communication stated:

"At the present time the NRC staff is unable to conclude that Westinghouse's analytical modeling of RCP seal leakage is acceptable on its own merits. However, for the purposes of mitigating strategies, the staff can balance the modeling uncertainties and deficiencies of the model with the unique aspect of FLEX. To expedite individual plant resolution, licensees could provide a brief discussion about the margin for RCS makeup time, based on the favorable aspects of individual site mitigating strategies."

In addition, the NRC provided examples of pertinent information to include in the Margin Assessment.

The purpose of this Margin Assessment is to provide a discussion regarding the margin for RCS makeup time, specifically addressing the examples of pertinent information regarding seal leakage provided by the NRC.

2. RCP Seal Leak-Off Line Configuration

Catawba is a four-loop Westinghouse PWR utilizing Model 93A reactor coolant pumps, using standard Westinghouse seal packages. The Catawba RCS loops utilize inverted U-tube type steam generators. Catawba's Mitigating Strategies (FLEX) response is based on the established RCP seal leakage profile as identified in WCAP-17601-P, revision 1 "Reactor Coolant System Response to the Extended Loss of AC Power Event for Westinghouse, Combustion Engineering and Babcock & Wilcox NSSS Designs".

In late 2014 and early 2015, as a result of Westinghouse NSAL-14-1, Catawba contracted with MPR Associates to have the existing RCP No. 1 and No. 2 seals and the associated No. 1 seal leak-off piping evaluated for an extended loss of seal cooling event, such as an ELAP. Due to time constraints, this effort was performed in parallel with the on-going PWROG initiative to resolve issues associated with the established RCP seal leak-off rates during a Loss Of Seal Cooling (LOSC) event. The MPR RCP seal model is different from the Westinghouse seal model being used in the PWROG work, in that the MPR model accommodates a transient analysis for evaluation of known pressure spikes during the early stages of the LOSC event. The Westinghouse RCP seal model does not currently allow for evaluation of transient behavior.

As a result of the MPR seal analyses, Catawba determined that a modification to the No. 1 RCP seal leak-off piping 0.254 inch bore restriction orifice positioned downstream of the seal exit was required. This modification installed a thicker orifice plate to accommodate the higher differential pressures associated with an extended LOSC event. This modification did not change Catawba's leak-off configuration categorization discussed in the PWROG-14015-P, revision 2 report dated April 2015 (Catawba remained a Category 1 plant).

Catawba is not crediting the MPR analyses for ELAP response or compliance with Order EA-12-049 even though the officially credited PWROG work to resolve remaining open issues is not yet complete. The MPR analysis results for both seal leak rate and the attendant leak-off piping pressure-temperature conditions during an ELAP/LOSC event show Catawba seal leak rates (post orifice plate modification) to be bounded by the documented Westinghouse leakage results as identified in the PWROG-14027-P revision 3 report, dated April 2015. Additionally, in-house piping stress/support and component evaluations of the RCP No. 1 seal leak-off lines shows the modified system retains its integrity throughout the transient predicted by the MPR seal model, as well as at more extreme conditions.

During the October 2014 NRC FLEX Audit, the above information was discussed with the NRC audit team and with ONRR, and subsequently an information package was placed on the Catawba e-Portal (which has now been moved to a SharePoint) for technical staff information/use. Catawba has installed thicker 0.254 inch bore restriction orifices in all four RCP No.1 seal leak-off lines on each Unit and declared Unit 2 to be in compliance with Order EA-12-049 in March 2015 and Unit 1 to be in compliance in December 2015. The status of the Catawba response to elevated RCP No. 1 seal leak-off line conditions and orifice plate modification was updated in the EA-12-049 Fourth Six-month Status Report dated February 28, 2015.

In March 2015, specific transient conditions potentially requiring further evaluation of the RCP No. 1 seal leak-off piping were identified by PWROG via Westinghouse NSAL-15-2. This NSAL formally identifies the existence of a potential 2045 psia pressure spike that occurs at the No. 1 seal exit early in the LOSC transient and its potential effect on the seal leak-off line, a transient the Westinghouse seal model cannot specifically evaluate as noted previously. As a result of this model limitation, the NSAL recommends Licensees assume a conservatively high seal exit pressure and temperature in the leak-off piping to account for the pressure spike for evaluation of system response to an ELAP. While the current Catawba MPR ELAP transient analysis predicts lower pressure and temperature conditions than those recommended by NSAL-15-2, an additional analysis case was run by MPR with a 2045 psia pressure (the NSAL-15-2 recommendation) as a forced input at the seal exit and another analysis at 2500 psia. This analytical approach removes reliance on the MPR seal model entirely and allows for an independent thermal-hydraulic evaluation of the RCP No. 1 seal leak-off line. Based on the MPR evaluation and resulting piping and support analyses performed by Duke, the RCP No.1 seal leak-off piping remains adequately protected from this extreme pressure transient with the thicker restriction orifice plate installed. As such, the published PWROG Category 1 ELAP leak off rates still apply for Catawba.

3. Margin Assessment

This margin assessment was performed using the examples of pertinent information regarding seal leakage provided by NRC via e-mail dated March 31, 2015. This assessment highlights the favorable aspects of the Catawba FLEX strategy and identifies areas with margin.

3.1 Early RCS Cooldown

Per ECA-0.0 response, symmetric RCS cooldown/depressurization at Catawba is started within 1-2 hours of ELAP onset to minimize RCS inventory loss and protect the RCP seal packages. Post-event initiation, RCS conditions at Catawba will peak at 2485 psig and 568°F until cooldown commences. The Catawba RCP Model 93A seal packages contain O-rings made from 7228C elastomer material, which has been evaluated to withstand up to 582°F for eight hours. Early initiation of RCS cooldown therefore provides assurance the RCP seals will continue their function to limit leak off flow.

Additional Favorable Cooldown Information

Along with facilitating RCS conditions favorable for passive injection of highly borated water from the Cold Leg Accumulators, the Catawba RCS cooldown strategy over the first 24 hours of the ELAP event specifically supports the integrity of the RCP No. 2 seal consistent with Westinghouse guidance. Based on discussions from the October 27, 2015 audit between the NRC, AREVA, and the PWROG, it was agreed that No. 1 seal corrosion does not invalidate the conservatisms in the PWROG-14015-P, revision 2 leakage analysis when an early RCS cooldown is performed. Specifically, an RCS cooldown as specified in Appendix D of WCAP-17792-P, revision 0 is acceptable to mitigate corrosion of the No. 1 seal. Based on the results of the NRC audit on No. 1 seal corrosion, the first cooldown specified in TB-15-1 will not change from 450°F within 4 hours. The second cooldown requirement for cold leg parameters will be revised to 400°F and 800 psig within 24 hours. This revision allows margin to continue to rely on the Turbine Driven Auxiliary Feedwater pump for at least 24 hours following a loss of seal cooling. A temperature of 400°F also provides a favorable long term condition to prevent continued corrosion of the No. 1 seal.

3.2 Early RCS Makeup

In order to identify margin associated with the RCS makeup strategy, two characteristics related to RCS behavior are addressed: 1) Adequate boration capability/adequate boron mixing during two-phase natural circulation in the RCS to prevent a return to criticality, and 2) The predicted time to reflux cooling in the steam generators.

Adequate Boration Capability and Boron Mixing

For an ELAP scenario initiating while in Modes 1-4, RCS boration at Catawba will begin around 11.6 hours after the start of the event and is based on preventing a potential return to criticality calculated to be 13.85 hours rather than the predicted onset of reflux cooling in the SG tubes, which occurs later.

As noted previously, after the initiation of an ELAP event, the operators will cooldown and depressurize the RCS to approximately 420°F/400 psia within the first several hours in order to minimize RCP seal leakage and inventory loss. Operators will then ensure sufficient boration has been completed before continuing to cooldown further. The Catawba high pressure FLEX makeup pump has sufficient performance (40 gpm at 1700 psig) to ensure injection flow is greater than RCP seal leak off flow at the time of alignment to the RCS.

Endorsed NEI 12-06 guidance indicates normal plant operational parameters can be assumed prior to onset of an ELAP, in lieu of the more restrictive limits of a design basis analysis. In performing the in-house RELAP5 Catawba ELAP boration evaluation, credit for parameters in their nominally expected ranges was not generally taken (i.e., more limiting assumptions were made), which provides for a qualitative margin assessment as follows:

- For this evaluation all four RCP seal packages are assumed not to leak (i.e., they seal perfectly), minimizing RCS letdown and maximizing the boron injection requirement
- Boration requirements for Catawba RCS cooldown are based on an ELAP event occurring after a 500-day EFPD reactor run (EOC), with the most limiting equilibrium Xenon characteristics
- The assumed required final RCS boron concentration after FLEX makeup pump injection is conservatively high, which increases the amount of borated water volume injection to meet shutdown requirements
- Assumed decay heat is representative of EOC
- Minimum boron concentration allowed by Technical Specifications (TS) is assumed in the Cold Leg Accumulators
- Minimum cover pressure is assumed in the Cold Leg Accumulators
- Minimum boron concentration allowed by TS is assumed in the Refueling Water Storage Tank

- An hour is subtracted from the actual time to re-criticality (and hence the response time) to ensure adequate boron mixing occurs during FLEX pump make-up
- The time to start the FLEX make-up pump is calculated based on the required boron curve at an RCS temperature of 350°F; during boration activities operators would maintain the plant near 420°F. This conservatively requires the FLEX make-up pump to start earlier than necessary
- The Pressurizer is assumed to only be filled to 60% level prior to requiring RCS letdown through the RV head vents. Controlling the injection pump to RCS pressure in lieu of Pressurizer level would reduce the total boration time (and delay the boration start setpoint) by allowing additional RCS injection.

The margin inherent in the boration calculation assumptions/inputs therefore shows that any return to criticality during an ELAP event would reasonably be expected to occur well beyond the maximum 13.85 hour RCS make-up setpoint in the documented Catawba FLEX response.

Time to Reflux Cooling

For the latest NOTRUMP reference case, the PWROG-14027-P, revision 3 report dated April 2015 for 4-loop T_{cold} plants in Category 1, identifies that Catawba will enter reflux cooling at 15.6 hours with time to uncover the core at 43.9 hours during an ELAP event. Initiating RCS boration around 11.6 hours and no later than 13.85 hours after event initiation at Catawba therefore ensures that boration will occur with acceptable loop flow conditions.
Catawba initially performed an in-house analysis of the time to reflux cooling using the RELAP5 code to establish a setpoint for RCS boration during ELAP, using the seal leakage profile from WCAP-17601-P, revision 1. Subsequent to that analysis, sensitivity cases were also run in-house to evaluate the new seal leakage rates identified in PWROG-14015-P. Margin in the calculation of the predicted time to reflux cooling in the steam generator U-tubes is qualitatively identified in these analyses as noted below:

- For this evaluation, all four RCP seals are assumed to leak at their maximum flow rate, minimizing the time to reflux cooling in the steam generators
- Catawba-specific ELAP mass-energy release evaluation (RELAP5) shows a predicted time to reflux cooling well beyond the Westinghouse timeframe
- Catawba has installed new thicker restriction orifice plates in the RCP No. 1 seal leak-off lines. The thicker orifice plates ensure system integrity at the higher postulated pressures so that Catawba remains in PWROG Category 1.
- Catawba-specific ELAP mass-energy release sensitivity cases (RELAP5) adjusted for the revised PWROG Category 1 RCP seal leak-off profile show that the predicted time to reflux cooling in the steam generator tubes is still considerably delayed as compared to the reference case
- MPR analysis flowrates for the Catawba leak-off piping configuration (MPR site-specific models) have shown peak values less than those shown in the WCAP-17601-P, revision 1 or the PWROG-14015-P, revision 2 reference cases. Therefore, cumulative RCP seal leakage will likely be lower than identified for PWROG Category 1 plants
- Assumed decay heat is representative of EOC

3.3 Possessing the Capability to Initiate RCS Makeup within "X" Hours (Shorter than Planned Time)

RCS makeup during an ELAP event is a prioritized action per ECA-0.0, and relies on diesel-driven injection pumps that don't require FLEX electrical distribution to be set up first. Catawba stores the N+1 pumps in a single FLEX Building (dome) constructed to NEI 12-06 requirements to protect FLEX response capability. The maximum RCS injection time start setpoint is 13.85 hours based on DPC-1552.08-00-0278 revision 2. Pump deployment from the dome assumes maximum debris removal and pump deployment times (i.e., 3 hours for debris removal and deployment of pump starting at 6.5 hours). Current guidance located in Catawba's FSG-05 "Initial Assessment and FLEX Equipment Staging" directs responding Operators to identify availability of FLEX resources early in the event. This serves to minimize deployment times of prioritized actions such as RCS injection. Based on the Unit 1 and 2 Flex Strategy Timing Validation Study (Letter to File CN-1612.03), a reasonable timeframe for initiating boration following an ELAP is around 11.6 hours with additional margin if deployment can be started sooner than 6.5 hours based on site conditions and available resources.

3.4 Having an Abundant Supply of Borated Coolant Onsite and/or Having a Relatively Large Capacity for Injecting Coolant

Catawba has adequate onsite borated makeup capacity for at least 72 hours following the onset of an ELAP event in Modes 1-4. Catawba's FSG-08 "Alternate NC System Boration" directs responding Operators to utilize the borated inventory available in the FWST (Refueling Water Storage Tank) for RCS makeup (approximately 6 days worth if FWST is undamaged). Should the FWST be damaged by a wind-borne missile above the protective wall, further boration capability is afforded by using water in the protected Boric Acid Tanks (BATs) and/or mixing powdered boric acid with water from the Standby Nuclear Service Water Pond (Ultimate Heat Sink) in portable mixing tanks. Beyond 72 hours, equipment from the Memphis or Phoenix NSRC (i.e., mobile boration skid) is available.

Additionally, Catawba's Standby Nuclear Service Water Pond remains available as a clean (i.e., ≤ 16 ppm TSS) un-borated water source, and its use is proceduralized later in the ELAP event.

Use of the 40 gpm makeup pump and the FWST/BATs provides sufficient boration to reach the reactivity objective. The supply of borated coolant onsite provides several (≥ 3) days of boration capacity.

3.5 Having a High Capacity and/or High Pressure RCS FLEX Makeup Pump

The Catawba FLEX High Pressure Pump (diesel driven) has a capacity of 40 gpm at 1700 psig, and has a variable speed control for flow and pressure. The diesel driver provides the ability to increase injection flowrates by approximately 50% during RCS depressurization if needed without changing to a different pump.

3.6 Having the Ability to Monitor RCS Inventory during the Event and Attempting to Implement Makeup More Rapidly If Signs of Increased Leakage Were Detected

ECA-0.0 "Loss of All AC Power" lists the critical instruments required to be maintained during the ELAP transient. Available instrumentation related to monitoring RCS inventory includes:

- RCS wide range pressure
- RCS wide range hot leg temperature
- Core exit thermocouples
- RVLIS
- Pressurizer level
- Neutron flux

Current guidance located in ECA-0.0 "Loss of All AC Power" and FSG-8 "Alternate NC System Boration" instructs responding Operators to prioritize RCS injection and respond more quickly if high RCS leakage is suspected.

3.7 NSAL-15-2 Leak-Off Line Break

As noted previously, Catawba has evaluated the leak-off piping/components for a transient pressure spike at the No. 1 seal exit up to 2500 psia per the suggestion of the NRC to ensure system integrity is maintained. Results show the RCP No.1 seal leak-off piping remains adequately protected following installation of the thicker flow measurement orifice plates. As such, the published PWROG Category 1 ELAP leak-off rates still apply for Catawba.

3.8 Additional Considerations

There is additional qualitative margin associated with the PWROG analyses performed in support of this issue. The following items were specifically noted by the NRC in the Watts Bar Mitigating Strategies Safety Evaluation dated March 27, 2015:

- The PWROG's generic ITCHSEAL calculations contain known conservatisms such as the comparison of the results of the generic analysis to the Montereau test data and in the application of the generic leak-off line configuration assumptions for each maximum leakage analysis category to individual plants' leak-off lines.
- Although entry into reflux cooling is undesirable and has not been fully analyzed in the context of an ELAP event, the use of this threshold as an acceptance criterion provides significant margin to uncover and severely damage the core.